From: Audette, Lucie
Location: AA-Room-Office-N125-ConfRoom/AA-OTAQ-OFFICE
Importance: Normal
Subject: Aircraft CO2 Rulemaking - Workgroup Meeting Call-in Number: 866-299-3188 Conf. Code:7342144532
Start Date/Time: Tue 12/12/2017 6:00:00 PM
End Date/Time: Tue 12/12/2017 7:00:00 PM
Briefing_Aircraft CO2 Rule DRAFT 10-30-17.pptx

Dear Workgroup Members,

Thank you for your responses confirming your membership in the Aircraft CO2 Rulemaking workgroup. Since my last e-mail, and prior to the confirmation of Bill Wehrum as OAR's AA, we briefed OAR, OGC, and OP political leadership on November 2 regarding the history of our aircraft work, the planned NPRM Analyses, and the draft rule schedule. The briefing went well, and we are proceeding on refining the rulemaking schedule and developing the underlying analysis and outlines for the preamble and RIA. The briefing which we presented is attached.

As we move forward, John Mueller will assume the duties of workgroup chair as I will be retiring at the end of this year. I have checked your schedules and it appears that most everyone is available to meet on December 12 from 1-2pm. The purpose of this meeting will be to (1) review the briefing attached and answer your questions, (2) provide a status of the analysis work, (3) discuss next steps.

In advance, thank you for your help on this rulemaking. Lucie and John

Workgroup Members –

OTAQ: Workgroup Chair: John Mueller (alternate: Bryan Manning)

Julia Burch

OAP: Marcus Sarofim

OGC: Mike Thrift

OP: Charles Griffiths

Bruce Schillo

ORD: Tim Benner

Steve Dutton

Stephen McDow

Region 2: Dan Birkett (alternate: Marina Castro)

Region 4: Dale Aspy

Region 8: Tim Russ (alternate: Laura Farris)

To: OTAQ Materials[OTAQMaterials@epa.gov]
Cc: Charmley, William[charmley.william@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Mueller, John[mueller.john@epa.gov]; Yen, David[Yen.David@epa.gov]; Orlin, David[Orlin.David@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Iffland, JoNell[Iffland.JoNell@epa.gov]; Gonzalez, Gail[Gonzalez.Gail@epa.gov]; Lindsey, Leah[lindsey.leah@epa.gov]; Gerring, Holly[gerring.holly@epa.gov]
From: Samulski, Michael
Sent: Fri 1/5/2018 7:37:13 PM
Subject: Materials for Monday's 3:00 briefing with Chris on Aircraft CO2 standards
Briefing_Aircraft CO2 Rule DRAFT 1 5 18.pptx

Monday's meeting is a pre-brief for our January 17th meeting with Bill Wehrum. The attached file is a draft briefing that we would use with Bill W.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Krieger, Jackie[Krieger.Jackie@epa.gov]; Sutton, Tia[sutton.tia@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]
Cc: Haley, Mike[Haley.Mike@epa.gov]; Bullard, Pamela[Bullard.Pamela@epa.gov]; Hyde, Courtney[Hyde.Courtney@epa.gov]; Walters, Margaret[Walters.Margaret@epa.gov]; Lubetsky, Jonathan[Lubetsky.Jonathan@epa.gov]; Niebling, William[Niebling.William@epa.gov]
From: LaRue, Steven
Sent: Fri 7/29/2016 3:05:26 PM
Subject: MUR-aircraft GHG and WHI-TAR QFRs were already sent...
Revisions to SAC/HEC QFRs re: Aircraft and LD GHG

All,

I apologize for the multiple emails after having pulled the fire alarm yesterday over QFRs, but as I've learned only in the last few hours, HEC (with Rep. Whitfield) and SAC (with Sen. Murkowski) QFRs from the spring budget hearings have already been sent back to the Hill. Therefore, the message I sent this morning at 8:46a requesting revisions are no longer necessary.

Again, sorry for the confusion. Thanks, and please let me know if you have any questions.

- Steve

From: LaRue, Steven
Sent: Friday, July 29, 2016 11:00 AM
To: Boyd, Wyatt <Boyd.Wyatt@epa.gov>
Cc: Walsh, Ed <Walsh.Ed@epa.gov>; Diaz, Charlene <diaz.charlene@epa.gov>; Beg, Gul <Beg.Gul@epa.gov>; Niebling, William <Niebling.William@epa.gov>; Lubetsky, Jonathan <Lubetsky.Jonathan@epa.gov>
Subject: RE: SAC QFRs are done

Thanks, Wyatt. If we can have the final transmittal for our records that would be great. All that is left is SEPW, correct? Again to reiterate, I don't believe we have any to update, but I still would like to confirm with the OAR front office.

Thanks again, and sorry for the confusion - none of us were sure when the QFRs were stamped FINAL.

- Steve

From: Boyd, Wyatt
Sent: Friday, July 29, 2016 10:47 AM
To: LaRue, Steven <LaRue.Steven@epa.gov>
Cc: Walsh, Ed <Walsh.Ed@epa.gov>; Diaz, Charlene <diaz.charlene@epa.gov>; Beg, Gul <Beg.Gul@epa.gov>
Subject: SAC QFRs are done

Wyatt F. Boyd

Office of the Chief Financial Officer | Office of Budget

Phone: 202.564.8503 | **Email:** boyd.wyatt@epa.gov | PMF '08

To: Krieger, Jackie[Krieger.Jackie@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]; Sutton, Tia[sutton.tia@epa.gov]
Cc: Hyde, Courtney[Hyde.Courtney@epa.gov]; Walters, Margaret[Walters.Margaret@epa.gov]; Wolfe, Michael[Wolfe.Michael@epa.gov]; Lubetsky, Jonathan[Lubetsky.Jonathan@epa.gov]; Niebling, William[Niebling.William@epa.gov]; Haley, Mike[Haley.Mike@epa.gov]; Bullard, Pamela[Bullard.Pamela@epa.gov]
From: LaRue, Steven
Sent: Fri 7/29/2016 12:46:03 PM
Subject: Revisions to SAC/HEC QFRs re: Aircraft and LD GHG
SAC MUR-002_aircraft ghg_FINAL.DOCX
HEC WHI-028-032_Fuel Economy_FINAL.DOCX

All,

Please update the attached QFRs to reflect the recent announcements of the draft TAR for the light-duty GHG rule and the endangerment finding for GHGs from aircraft. From the four FY 2017 budget hearings last spring, only QFRs from the House Appropriations Committee have been transmitted to the Hill. We will continue to review previous submissions from HEC/SAC/SEPW to ensure that no other QFRs need revised.

Thanks, and please let us know if you have any questions.

- Steve

202.564.1304

To: Charmley, William[charmley.william@epa.gov]; Bunker, Byron[bunker.byron@epa.gov]; Simon, Karl[Simon.Karl@epa.gov]; Haugen, David[haugen.david@epa.gov]; Brusstar, Matt[brusstar.matt@epa.gov]; Sargeant, Kathryn[sargeant.kathryn@epa.gov]; Manners, Mary[manners.mary@epa.gov]; Moltzen, Michael[Moltzen.Michael@epa.gov]; Cook, Leila[cook.leila@epa.gov]; Blubaugh, Jim[Blubaugh.Jim@epa.gov]; France, Jennifer[france.jennifer@epa.gov]; Levin, David[Levin.David@epa.gov]; Dietrich, Gwen[Dietrich.Gwen@epa.gov]; Suarez, Patricia[suarez.patricia@epa.gov]; Haley, Mike[Haley.Mike@epa.gov]; Henning, Julie[henning.julie@epa.gov]; Cohen, Janet[cohen.janet@epa.gov]; Watkins, Erica[Watkins.Erica@epa.gov]
Cc: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Birgfeld, Erin[Birgfeld.Erin@epa.gov]; Argyropoulos, Paul[Argyropoulos.Paul@epa.gov]; Mylan, Christopher[Mylan.Christopher@epa.gov]; Richards, David[Richards.David@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]
From: Sutton, Tia
Sent: Wed 7/6/2016 12:17:19 PM
Subject: Weekly Regs & Communications Trackers - July 4th edition
OTAQ IO Regs Tracker.xlsx
OTAQ IO Communications Tracker.xlsx

Hi everyone,

Hope you all had a nice long holiday weekend! The Regs & Communications Trackers for this week are attached.

Also, couple reminders/announcements for this week:

•□□□□□□□□ Janet has a hearing with the House Energy & Commerce Committee's Energy & Power Subcommittee (same Subcommittee as her June 22nd RFS hearing) today at 10am on "EPA's Regulatory Activity During the Obama Administration: Energy and Industrial Sectors": **https://energycommerce.house.gov/hearings-and-votes/hearings/review-epas-regulatory-activity-during-obama-administration-energy-and**

•□□□□□□□□ And just a reminder that if you are aware of any items that should be added to our new "Petitions" tab (3rd tab of the Regs Tracker), please let us know.

Enjoy!

-Tia

To: Birgfeld, Erin[Birgfeld.Erin@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]; Argyropoulos, Paul[Argyropoulos.Paul@epa.gov]; Sutton, Tia[sutton.tia@epa.gov]; Scoville, Pat[Scoville.Pat@epa.gov]
From: Hengst, Benjamin
Sent: Tue 3/21/2017 1:06:58 PM
Subject: Abstracts for reg agenda--pls review
Spring 2017 Reg Agenda abstracts.docx

Hi folks—

I've attached a set of abstracts for review. Please review and send your edits to Erin (with a cc to others on this email) by COB today.

I'll be discussing these with ASD separately, too, just FYI.

Thanks

Ben

To: Charmley, William[charmley.william@epa.gov]; Bunker, Byron[bunker.byron@epa.gov]; Simon, Karl[Simon.Karl@epa.gov]; Haugen, David[haugen.david@epa.gov]; Brusstar, Matt[brusstar.matt@epa.gov]; Sargeant, Kathryn[sargeant.kathryn@epa.gov]; Manners, Mary[manners.mary@epa.gov]; Moltzen, Michael[Moltzen.Michael@epa.gov]; Cook, Leila[cook.leila@epa.gov]; Blubaugh, Jim[Blubaugh.Jim@epa.gov]; France, Jennifer[france.jennifer@epa.gov]; Levin, David[Levin.David@epa.gov]; Dietrich, Gwen[Dietrich.Gwen@epa.gov]; Suarez, Patricia[suarez.patricia@epa.gov]; Haley, Mike[Haley.Mike@epa.gov]; Henning, Julie[henning.julie@epa.gov]; Cohen, Janet[cohen.janet@epa.gov]; Watkins, Erica[Watkins.Erica@epa.gov]
Cc: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Birgfeld, Erin[Birgfeld.Erin@epa.gov]; Argyropoulos, Paul[Argyropoulos.Paul@epa.gov]; Mylan, Christopher[Mylan.Christopher@epa.gov]; Richards, David[Richards.David@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]
From: Sutton, Tia
Sent: Wed 9/28/2016 4:13:18 PM
Subject: Weekly Regs & Communications Trackers - week of September 26th
OTAQ IO Communications Tracker.xlsx
OTAQ IO Regs Tracker.xlsx

Hi everyone,

The Regs & Communications trackers for this week are attached.

As noted in last week's edition, Janet McCabe had a hearing on Thursday Sept. 22nd on the LD Midterm Evaluation. For those who weren't able to watch the hearing live on Thursday (or if you'd like to see the industry portion of the hearing), the video is still available on the hearing website: https://energycommerce.house.gov/hearings-and-votes/hearings/midterm-review-and-update-corporate-average-fuel-economy-program-and. The testimony from the other witnesses is also available on this site.

Enjoy!

-Tia

From: Audette, Lucie
Location: AA-Room-Office-N125-ConfRoom/AA-OTAQ-OFFICE
Importance: Normal
Subject: Aircraft CO2 Rulemaking - Workgroup Meeting Call-in Number: Ex. 6 - Personal Privacy Conf. Code: Ex. 6 - Personal Privacy
Start Date/Time: Tue 12/12/2017 6:00:00 PM
End Date/Time: Tue 12/12/2017 7:00:00 PM
Briefing_Aircraft CO2 Rule DRAFT 10-30-17.pptx

Dear Workgroup Members,

Thank you for your responses confirming your membership in the Aircraft CO2 Rulemaking workgroup. Since my last e-mail, and prior to the confirmation of Bill Wehrum as OAR's AA, we briefed OAR, OGC, and OP political leadership on November 2 regarding the history of our aircraft work, the planned NPRM Analyses, and the draft rule schedule. Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process The briefing which we presented is attached.

As we move forward, John Mueller will assume the duties of workgroup chair as I will be retiring at the end of this year. I have checked your schedules and it appears that most everyone is available to meet on December 12 from 1-2pm. The purpose of this meeting will be to (1) review the briefing attached and answer your questions, (2) provide a status of the analysis work, (3) discuss next steps.

In advance, thank you for your help on this rulemaking. Lucie and John

Workgroup Members –

OTAQ: Workgroup Chair: John Mueller (alternate: Bryan Manning)

Julia Burch

OAP: Marcus Sarofim

OGC: Mike Thrift

OP: Charles Griffiths

Bruce Schillo

ORD: Tim Benner

Steve Dutton

Stephen McDow

Region 2: Dan Birkett (alternate: Marina Castro)

Region 4: Dale Aspy

Region 8: Tim Russ (alternate: Laura Farris)

To: Farrar, Wanda[farrar.wanda@epa.gov]; Eagles, Tom[Eagles.Tom@epa.gov]; Muellerleile, Caryn[Muellerleile.Caryn@epa.gov]
Cc: Scoville, Pat[Scoville.Pat@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]; Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Sutton, Tia
Sent: Mon 3/19/2018 4:14:33 PM
Subject: RE: Reg Agenda passback from OMB - response due 3/15/2018
EPA Unified Agenda OMB Passback_OAR-OTAQ.docx

Wanda, Tom, and Caryn,

Attached are OTAQ's edits to the galleys – in track changes so you can see exactly what edits we made. There is one date edit (#50), and Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

Tia

From: Sutton, Tia
Sent: Monday, March 19, 2018 10:24 AM
To: Farrar, Wanda <farrar.wanda@epa.gov>; Eagles, Tom <Eagles.Tom@epa.gov>
Cc: Scoville, Pat <Scoville.Pat@epa.gov>
Subject: RE: Reg Agenda passback from OMB - response due 3/15/2018

Hi Wanda & Tom,

Our dates in ADP look good, so we're all set there, but we did find a few typos in the document. Can we still send track changes edits to the galleys for updating?

Thanks,

Tia

From: Farrar, Wanda
Sent: Tuesday, March 13, 2018 8:52 AM

To: Hockstad, Leif <Hockstad.Leif@epa.gov>; Iglesias, Amber <Iglesias.Amber@epa.gov>; Krieger, Jackie <Krieger.Jackie@epa.gov>; Lee, Raymond <Lee.Raymond@epa.gov>; Lubetsky, Jonathan <Lubetsky.Jonathan@epa.gov>; Henigin, Mary <Henigin.Mary@epa.gov>; Mcquilkin, Wendy <Mcquilkin.Wendy@epa.gov>; Scoville, Pat <Scoville.Pat@epa.gov>; Rush, Alan <Rush.Alan@epa.gov>; Morgan, Ruthw <morgan.ruthw@epa.gov>; Shaw, Betsy <Shaw.Betsy@epa.gov>; Shoaff, John <Shoaff.John@epa.gov>; Sutton, Tia <sutton.tia@epa.gov>; Eagles, Tom <Eagles.Tom@epa.gov>; Wright, Rhonda <Wright.Rhonda@epa.gov>
Subject: FW: Reg Agenda passback from OMB - response due 3/15/2018
Importance: High

Good Day Reg Contacts,

The OMB Reg Agenda galleys are attached. Please make track changes if needed to this document and send to me by noon Thursday, March 8, 2018. Also, these updates should be reflected in ADP Tracker.

Thank you,

Wanda

From the desk of:

Wanda Farrar

From: Muellerleile, Caryn
Sent: Monday, March 12, 2018 4:20 PM
Subject: Reg Agenda passback from OMB - response due 3/15/2018
Importance: High

Attached are OMB's comments and a few clarifying edits from OP, including recent FR dates and citations. You have only until **COB Thursday, March 15**, to respond to these comments/edits and make ANY ADDITIONAL CHANGES that your program would like to make. New actions may still be added after this week. Please enter your edits into a single

tracked changed document and save it with your AAship's name and return it to me. Also make the same edits are entered in ADP TRACKER.

Note: there could be additional comments from OMB on this document, as well as EPA's "pending" or inactive actions list. We will provide those edits as soon as we have them.

Caryn Muellerleile

Regulatory Management Division

Office of Policy

US Environmental Protection Agency

1200 Pennsylvania Ave NW (1803A)

Washington, DC 20460

(202) 564-2855

muellerleile.caryn@epa.gov

To: Charmley, William[charmley.william@epa.gov]; Bunker, Byron[bunker.byron@epa.gov]; Simon, Karl[Simon.Karl@epa.gov]; Haugen, David[haugen.david@epa.gov]; Brusstar, Matt[brusstar.matt@epa.gov]; Sargeant, Kathryn[sargeant.kathryn@epa.gov]; Manners, Mary[manners.mary@epa.gov]; Moltzen, Michael[Moltzen.Michael@epa.gov]; Cook, Leila[cook.leila@epa.gov]; Blubaugh, Jim[Blubaugh.Jim@epa.gov]; France, Jennifer[france.jennifer@epa.gov]; Levin, David[Levin.David@epa.gov]; Dietrich, Gwen[Dietrich.Gwen@epa.gov]; Suarez, Patricia[suarez.patricia@epa.gov]; Haley, Mike[Haley.Mike@epa.gov]; Henning, Julie[henning.julie@epa.gov]; Cohen, Janet[cohen.janet@epa.gov]; Watkins, Erica[Watkins.Erica@epa.gov]
Cc: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Birgfeld, Erin[Birgfeld.Erin@epa.gov]; Argyropoulos, Paul[Argyropoulos.Paul@epa.gov]; Mylan, Christopher[Mylan.Christopher@epa.gov]; Richards, David[Richards.David@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]
From: Sutton, Tia
Sent: Tue 9/13/2016 10:54:28 PM
Subject: Weekly Regs & Communications Trackers - week of August 12th
OTAQ IO Regs Tracker.xlsx
OTAQ IO Communications Tracker.xlsx

Hi everyone,

Attached are the Weekly Regs and Communications Trackers for this week.

Please note that we have a 3rd tab in the Reg Tracker - the "Petitions Tracker." If you are aware of any items missing from this list (or information that needs to be updated), please let us know.

Enjoy!

-Tia

To: OTAQ Materials[OTAQMaterials@epa.gov]
Cc: Charmley, William[charmley.william@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Mueller, John[mueller.john@epa.gov]; Yen, David[Yen.David@epa.gov]; Orlin, David[Orlin.David@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Iffland, JoNell[Iffland.JoNell@epa.gov]; Gonzalez, Gail[Gonzalez.Gail@epa.gov]; Lindsey, Leah[lindsey.leah@epa.gov]; Gerring, Holly[gerring.holly@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Manning, Bryan
Sent: Fri 1/12/2018 5:08:31 PM
Subject: Materials for Jan 17th 1:00 briefing with Bill Wehrum on Aircraft CO2 Standards Rule
Briefing_Aircraft CO2 Rule 1-17-18.pptx

Hi,

Attached are the materials for the January 17th meeting with Bill Wehrum at 1:00 on the aircraft CO2 standards rulemaking. This attached briefing is ready to go to Bill Wehrum.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: OTAQ Materials[OTAQMaterials@epa.gov]
Cc: Charmley, William[charmley.william@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Mueller, John[mueller.john@epa.gov]; Yen, David[Yen.David@epa.gov]; Orlin, David[Orlin.David@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Iffland, JoNell[Iffland.JoNell@epa.gov]; Gonzalez, Gail[Gonzalez.Gail@epa.gov]; Lindsey, Leah[lindsey.leah@epa.gov]; Gerring, Holly[gerring.holly@epa.gov]
From: Samulski, Michael
Sent: Fri 1/5/2018 7:49:56 PM
Subject: RE: Materials for Monday's 3:00 briefing with Chris on Aircraft CO2 standards
Briefing_Aircraft CO2 Rule DRAFT 1 5 18.pptx

Use this one instead. **Ex. 5 - Deliberative Process**

Ex. 5 - Deliberative Process

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Samulski, Michael
Sent: Friday, January 05, 2018 2:37 PM
To: OTAQ Materials <OTAQMaterials@epa.gov>
Cc: charmley.william@epa.gov; Manning, Bryan <manning.bryan@epa.gov>; Cullen Leggett (leggett.cullen@epa.gov) <leggett.cullen@epa.gov>; Mueller, John <mueller.john@epa.gov>; yen.david@epa.gov; Orlin, David <Orlin.David@epa.gov>; Thrift, Mike <thrift.mike@epa.gov>; JoNell Iffland (iffland.jonell@epa.gov) <iffland.jonell@epa.gov>; Gonzalez, Gail <Gonzalez.Gail@epa.gov>; Lindsey, Leah <lindsey.leah@epa.gov>; Gerring, Holly <gerring.holly@epa.gov>

Subject: Materials for Monday's 3:00 briefing with Chris on Aircraft CO2 standards

Monday's meeting is a pre-brief for our January 17th meeting with Bill Wehrum. The attached file is a draft briefing that we would use with Bill W.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Aspy, Dale[Aspy.Dale@epa.gov]; Benner, Tim[Benner.Tim@epa.gov]; Birkett, Daniel[Birkett.Daniel@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]; Castro, Marina[Castro.Marina@epa.gov]; Dutton, Steven[Dutton.Steven@epa.gov]; Griffiths, Charles[Griffiths.Charles@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; McDow, Stephen[McDow.Stephen@epa.gov]; Powell, Alan[Powell.Alan@epa.gov]; Russ, Timothy[Russ.Tim@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Sarofim, Marcus[Sarofim.Marcus@epa.gov]; Schillo, Bruce[Schillo.Bruce@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]
From: Mueller, John
Sent: Tue 2/27/2018 8:19:07 PM
Subject: Aircraft GHG Rule Work Group Update
Schedule_Aircraft CO2 Rule_2-26-18.pptx
ICF - EPA Aircraft CO2 Cost Assessment_Jan 16 2018.docx
ICF - EPA Aerospace Industry Characterization_Jan 16 2018.docx
Tech Response Spreadsheet_Jan 16 2018+README Tab_Feb 12 2018.xlsx
ICF_CO2 Analysis of CO2-Reducing Technologies for Aircraft_March 17 2015....pdf

Dear Work group Members,

This is a quick update to the status of the aircraft GHG rule effort.

Schedule: At our December 12, 2017 Work Group call, we presented a draft schedule Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

For your convenience, the current schedule is attached. Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Documents for Review: Attached are some documents we will be relying on for the NPRM. The .pdf is an original contractor report (March 2015) that we used in support of the 2015 ANPRM, and serves as a basis for updated analysis. One of the Word documents ("Aircraft CO2 Cost and Technology Refresh") is an updated draft version of that 2015 report, and the Excel spreadsheet is a companion to that draft report. The second Word document is a draft industry characterization. Both of these draft reports are currently undergoing peer review. Please let me know if you have any questions about them.

We anticipate having a draft emissions inventory analysis available for your review in late March.

Email Group: If you are on this email list by error or happen to notice that someone in your office isn't but should be, please let me know.

Thanks,

John Mueller

Work Group Chair

Cost Analysis of CO2-Reducing Technologies for Aircraft

Submitted to:

U.S. Environmental Protection Agency

March 17, 2015

Submitted by:

ICF International

PREFACE

This report has been composed for the US Environmental Protection Agency (EPA) to study the costs of developing and implementing Carbon dioxide (CO_2)-reducing technologies on new in-production aircraft as measured by CAEP's CO_2 metric. The International Civil Aviation Organization's (ICAO) Committee for Aviation Environmental Protection (CAEP) is working to establish an aircraft CO_2 emission standard for new aircraft designs by 2016[1]. However, further work is needed to support future decisions about the applicability of the CO_2 standard to new in-production aircraft. ICF's study examines the technologies applicable to new in-production aircraft and the projected costs to research and apply them to existing designs. ICF gathered data on some 70 technologies from a combination of public sources and confidential interviews, then applied an expected value methodology to develop projected CO_2 metric values and costs. ICF is grateful to its reviewers Dr. Nick Cumpsty of Imperial College, Rich Golaszewsi of GRA, Incorporated, Adam Klauber of ICF, Dr. Ian Poll of Cranfield University, and Fay Collier of NASA for their feedback. This report was prepared by Peter Zimm, Glenn McDonald, and Kevin Michaels of ICF, Mike Dill, and Dr. Joaquim Martins of the University of Michigan.

ASSESSMENT OF CO_2-REDUCING TECHNOLOGIES

1.1 INTRODUCTION

GROWTH OF AVIATION-PRODUCED CO_2 AND THE INTERNATIONAL RESPONSE

In 2012, global aircraft CO_2 emissions were 2% of total global aggregate CO_2 output,[2] (and 13% of global transportation CO_2 emissions in 2011[3], which is the most recent year that global transportation CO_2 emissions data is available). Aircraft CO_2 emissions are receiving increasing scrutiny because they have steadily increased due fleet growth and higher utilization. Globally, civil aircraft generated an estimated 1.44 trillion pounds[4] of CO_2 in 2012. Commercial air transport aircraft—encompassing the Very Large Aircraft, Large Twin Aisle, Small Twin Aisle, Single Aisle, and Regional Jet aircraft categories—generated approximately 96% of this total[5]. Furthermore, global commercial air transport CO_2 output will increase at an estimated 3.5% per annum over the next 10 years.[6] ICF estimates that global air transport CO_2 emissions will grow to 1.8 trillion pounds in 2021. The air transport aircraft categories will continue to dominate CO_2 output, and the output of two categories in particular—Single Aisle and Large Twin Aisle—will outpace the overall CO_2 emissions growth.

In response to this issue, the ICAO's CAEP has been working for over four years to establish an aircraft CO_2 emissions standard by 2016[7]. (At the 8th meeting of CAEP in February 2010, CAEP agreed to a future work program to establish aircraft CO_2 standards.) In November 2010, CAEP agreed that the standard would apply to subsonic jets and turboprops. More specifically, the criteria were an applicability weight threshold of maximum takeoff weight (MTOW) >5700kg (12,566lb) for subsonic jet aircraft and a weight threshold of MTOW>8618kg (19,000lb) for propeller-driven multi-engine aircraft (e.g., turboprops).[8] It was also agreed that the scope of applicability should include "new"[9] aircraft types, but not "in-service", and that "new in-production"[10] aircraft types should not be ruled out at this time. In February 2013, CAEP

---

[2] ICF International analysis.
[3] Climate Data Explorer of the World Resources Institute http://cait.wri.org. Accessed October 31, 2014. International Energy Agency, Data Services http://data.iea.org. Accessed October 22, 2014.
[4] ICF International analysis.
[5] ICF International analysis.
[6] ICF International analysis.
[7] It is expected that aircraft CO_2 standards will be adopted at the tenth meeting of CAEP in February 2016.
[8] ICAO, 2013: *CAEP/9 Agreed Certification Requirement for the Aeroplane CO_2 Emissions Standard*, Circular (Cir) 337, AN/192, Available at www.icao.int .
[9] *"New" aircraft types* - If airworthiness considers an aircraft to be a "new" type, then this same perspective will be adopted by the CO_2 requirement and the latest standard will be applied. This is a same approach to the current aircraft noise requirements.

[10] "In-production" aircraft types - aircraft types which have already received a Type Certificate, and appropriate Production Certificate, and for which manufacturers either have existing undelivered sales orders or would be willing to accept new sales orders.

agreed to a requirement that new aircraft be certified for their CO_2 emissions using a CO_2 metric system that measures these emissions.

The Metric Value (MV) is based on an instantaneous measure of the fuel burn per distance flown that is then adjusted by accounting for usable aircraft floor area. Three test points are considered in the calculation of the MV for each aircraft, representing flight at high, medium, and low gross weights. The fuel burn per unit distance of each aircraft is evaluated at these three points and then averaged to obtain the MV.[11] A more detailed description of the MV can be found in Section 1.3. For regulation purposes, the maximum allowed MV increases with the maximum takeoff mass (MTOM) of the aircraft, according a stringency function. Currently, CAEP is expected to set a CO_2 stringency standard that will go into effect in 2020 or 2023.

This study examines the applicability of the CO_2 standard to new in-production aircraft. In particular, it assesses the technological improvements to new in-production aircraft that are feasible, and the potential CO_2 emission reductions they could produce. The stringency function implications for 2020 and 2023 are also examined in light of the projected CO_2 emission reductions. Finally, we project the costs of realizing the projected CO_2 emission reductions.

DATA SOURCES

This study was conducted over a seven month period and ICF gathered data from a wide variety of sources to support this analysis. In general, four types of sources were used to develop technology cost and performance data:

1. secondary research
2. interviews
3. domain knowledge from past work/engagements
4. internal aircraft cost and performance modeling frameworks

Secondary Research

Secondary research provided a wealth of information about individual technologies and ongoing research programs. This was captured in the industry press, supplier and Original Equipment Manufacturer (OEM) press releases, conference proceedings, and news articles. University publications and websites also provided much information.

[11] ICAO, 2013: *CAEP/9 Agreed Certification Requirement for the Aeroplane CO_2 Emissions Standard*, Circular (Cir) 337, AN/192, Available at www.icao.int .

Market Interviews

ICF conducted a broad and thorough market interview program to gather feedback on technology performance, modeling approach and methodology, and commercial feasibility. Over 40 interviews were conducted with a wide cross-section of key individuals from throughout the industry – airframe, engine, and systems manufacturers, aircraft operators, and university and research organizations provided input and feedback on methodology, technology performance, and costs.

Current and former employees were interviewed from the following organizations:

Exhibit 1-1. Organizations Interviewed by ICF

Organizations Interviewed		
• Aerion	• GE	• PATS
• Aerodynamic Solutions	• Honeywell	• Pratt & Whitney
• Airbus	• Mitsubishi	• Rolls-Royce
• ATR	• MTU	• Volvo
• Boeing	• NASA	• United Airlines
• Bombardier	• Parker	• United Technologies

Domain Knowledge and ICF Internal Cost and Performance Models

The ICF team was able to leverage knowledge gained through past consulting engagements, as well as cost and performance models that had been developed to support market knowledge and ongoing project work. In some cases, knowledge was available from in depth cost and performance models used for particular technologies.

Through a combination of these sources, ICF was able to create comprehensive profiles of both the fuel burn impact and cost of a wide variety of technologies.

KEY ASSUMPTIONS

It is also important to note that the assumptions underlying this fuel burn reduction forecast include: fuel prices remaining at their current levels, no wholesale business model changes by aircraft, engine, or component manufacturers or airlines, and the current pace of technology development is not significantly changed. These assumptions are critical, since the pace of technology development will strongly depend on degree of improvement mandated by CO_2 emissions regulations, as well as programs offered to incentivize research and development.

Aircraft fuel consumption varies greatly depending on flight-specific operating conditions. Different payload weights (including passengers, cargo, and fuel) affect fuel burn metrics such as fuel burn per passenger mile. Air traffic control sophistication and efficiency also play an important role in driving fuel consumption. Excessive loitering, a "stepped" approach to climb and descent, and sub-optimal altitude or speed assignments all have the potential to significantly increase overall trip fuel consumption

Owing to the magnitude of analysis performed by ICF in this process, substantial sensitivity analysis was not performed on these assumptions. ICF expects that the final results of cost and fuel consumption impacts of individual technologies will be sufficiently accurate for the purposes of analyzing forecasting the cost and impact of CO_2 stringencies on the air transport market.

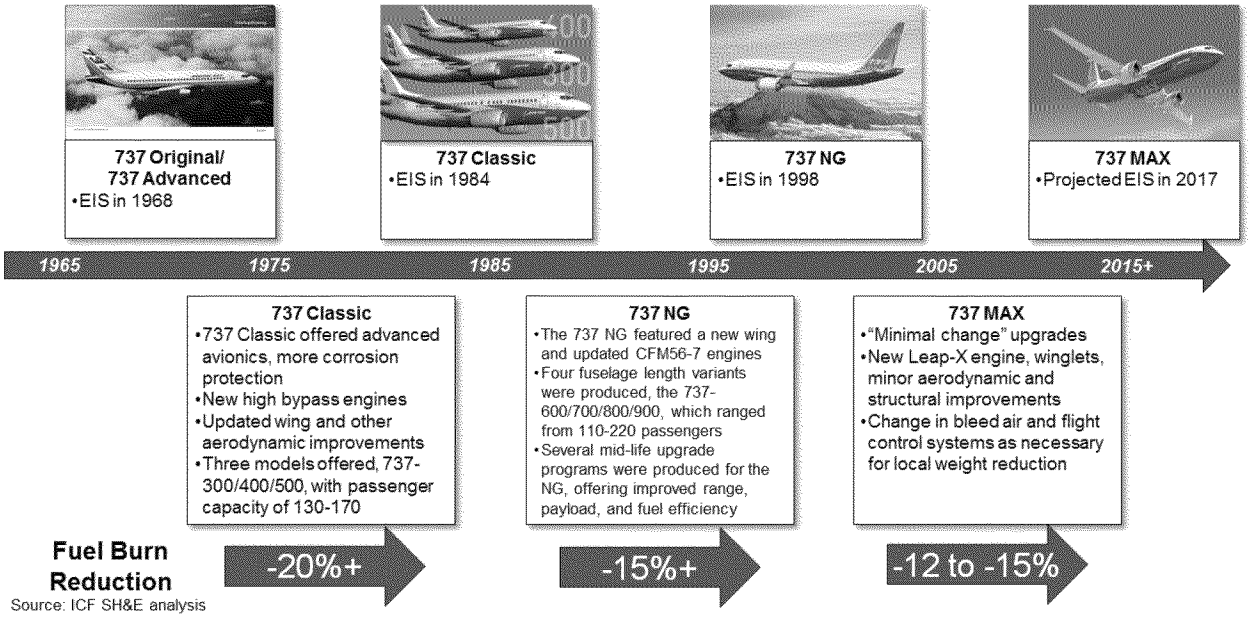
MAGNITUDE AND SOURCES OF HISTORICAL CO_2 REDUCTIONS

Since the advent of gas turbine engine powered air transport in 1958, aircraft fuel efficiency has improved about 1.5% per annum through a combination of major redesigns and incremental improvements. Major redesigns refer not only to completely redesigned aircraft, but also to significant partial redesigns – redesigned wings (re-winging) and re-engined aircraft. Incremental improvements are less extensive changes to the production standard of the aircraft, such as winglets or performance improvement packages (PIPs) that are introduced into airframes or engines mid-life. ICF research indicates that major redesigns account for as much as two-thirds of historical fuel burn reduction. By implication, incremental improvements account for about one-third of reductions, or about 0.5% per year. Furthermore, it appears more of the incremental reductions in recent times are due to improvements in aerodynamics than in engines. In contrast, engine technology has been the primary driver of major redesign aircraft efficiency improvements. Secondary research and interview input point to a 0.8 to 1.0% annual improvement in engine efficiency from major redesign technology while incremental improvements yield about 0.2% better fuel burn per annum.

THE NATURE OF TECHNOLOGY INSERTION

Major redesigns yield large fuel burn reductions – 10% to 20% over the prior generation they replace. As one might expect, the significant fuel burn reductions of major redesigns do not happen frequently. One of the best examples of this is the Boeing 737 program. Debuting in 1968 with two variants and powered by low bypass JT8D engines, the airplane has undergone major redesigns three times – they entered service in 1984, 1998, and will enter in 2017, respectively, or about every 16 years.

Exhibit 1-2. Major Redesign History of the Boeing 737

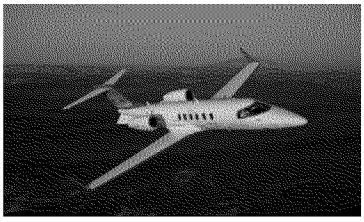


Source: ICF SH&E analysis

Insofar as we are going through a wave of major redesign and service entry now, prospects for further step-function improvements will be low in the coming 10-15 years. The outlook for major redesigns is described below in the Exhibit 1-3:

Exhibit 1-3. Outlook for Major Redesigns by Aircraft Category

Photo Example	Aircraft Category	Entry Into Service	Major Redesign	Major Redesign Outlook
	Very Large	*747-100 (1969)* *A380 (2007)*	*747-400 (1989)* *747-8 (2011)*	This category is experiencing sluggish sales. No other major redesign until after 2025.
	Large Twin Aisle	*777-200/300 (1995)*	*777-200LR (2004)* ***A350-900 (2015)***	**777-9X (2020)** **777-8X (2020)** No other major redesign until after 2030

	Small Twin Aisle	*767 (1982)* *A330 (1994)* *787-8 (2011)*	*767-400ER (2000)*	**A330neo (2017)** No other major redesign until after 2030
	Single Aisle	*737-100 (1968)* *A320 (1988)*	*737 Classic (1984)* *737NG (1998)*	**CS100 (2015), CS300 (2016)** **A320neo (2015)** **737MAX (2017)** **C919 (2018)** **MS-21 (2018)** The decision by Boeing and Airbus to re-engine the 737 and A320 will delay introduction of a major redesign western single-aisle until well beyond 2025
	Regional Jet	*CRJ-100 (1992)* ***E 170 (2004)***	*CRJ-700 (2001)*	The regional jet category was ripe for new major redesigns **ARJ21 (2015)** **MRJ (2017)** **Embraer E2 (2018)** Major redesigns can be expected in the 2025-2030 timeframe
	Large Bizjet	*Gulfstream V(1995)*	*G550 (2004)*	Contrary to all other aircraft size segments, business jets undergo frequent minor changes and somewhat frequent major redesigns
	**Small Bizjet**	***Learjet 40/45 (1998)***	***Learjet 70/75 (2013)***	Contrary to all other aircraft size segments, business jets undergo frequent minor changes and somewhat frequent major redesigns

	Turbo-prop	*Saab 340 (1983)* *Q400 (1997)*	*Saab 2000 (1994)* *ATR 72 (1989)* *ATR 42 (1985)* *Q400 Next Gen*	Major redesign expected by early 2020s, ATR 90[12] turboprop derivative possible before then

Furthermore, increasingly, technologies developed for major redesigns eventually make their way onto mature aircraft – first technologies are researched to technology readiness level (TRL) 6,[13] then they are incorporated into development programs where they are thoroughly tested and developed for applications on the aircraft. Lastly, they can be chosen to be incorporated into a PIP[14] on an existing aircraft. Finally, new development cycles are very lengthy. It is not unusual for new aircraft and engine designs to take 8-10 years to develop, from preliminary design to entry into service.

If past trends continue into the future, we can expect:

- Overall fuel efficiency to improve by 1.5% per annum
- Major redesign activities will contribute about two-thirds of this improvement; incremental technology introductions will reduce emissions by 0.5% per annum
- Engine technologies will drive major redesign aircraft improvements but aerodynamics will be a larger contributor of incremental improvements
- Major redesign activity will be infrequent and will not be seen for 10-15 years for most aircraft categories after the current redesign wave has passed
- Technologies researched and developed during the current wave of major redesign aircraft will be ripe for incorporation onto existing mature platforms (i.e., new in-production aircraft)
- The coming drought of major redesigns means incremental improvements to new in-production aircraft will be the primary lever for CO_2 reductions for the next 10-15 years.

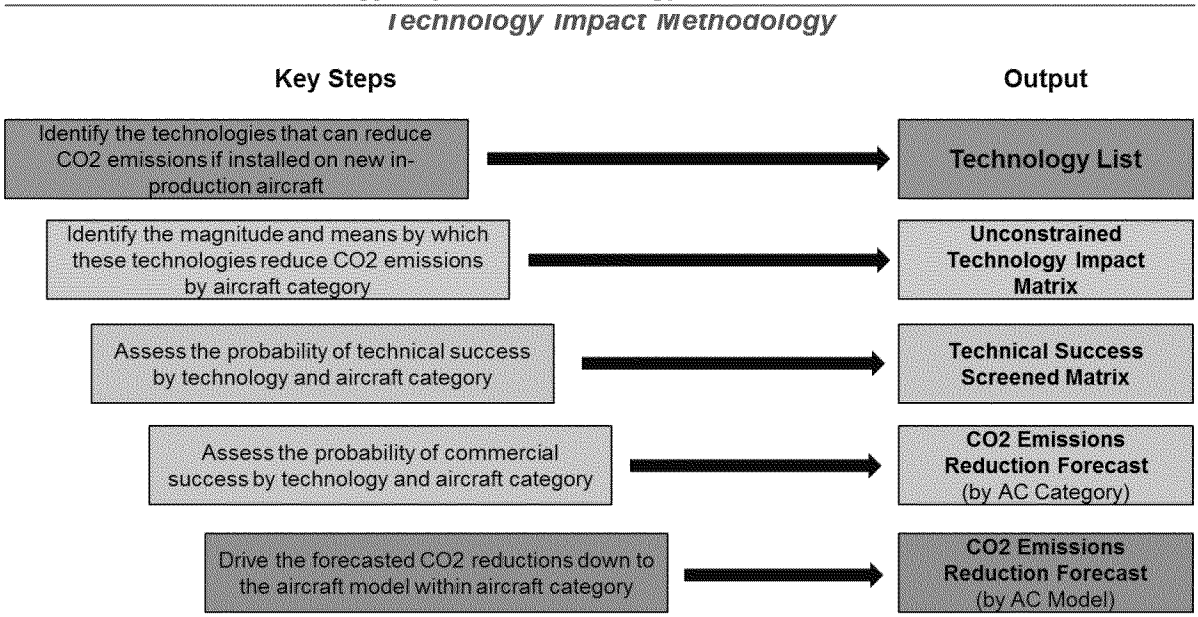
[12] ATR 90 refers to the ATR 90-seater turboprop.
[13] Technology readiness level 6 represents when the system/subsystem model or true dimensional test equipment is validated in a relevant environment. See the technology readiness section of the appendices for more information.
[14] Occasionally, PIP's are referred to at technology insertion packages or TI's.

1.2 TECHNOLOGY FUEL BURN IMPACT

METHODOLOGY

ICF developed a detailed methodological framework to analyze the potential impact of new technology introduction on aircraft fuel efficiency and CO_2 emissions. This framework involved five basic steps. First, we identified the technologies that could reduce CO_2 emissions of new in-production aircraft. Second, we then assessed each technology for the magnitude of potential CO_2 reduction and the mechanisms by which reduction is achieved. Both of these were analyzed by aircraft category. Third and fourth, the technologies were passed through technical success probability and commercial probability success screens, respectively. Last, individual aircraft differences were considered within aircraft category to develop a CO_2 emissions reduction forecast by technology by aircraft model. This entire methodological framework detailed above will be referred to henceforth as the expected value methodology.

Exhibit 1-4. ICF Technology Impact Methodology



ICF identified and evaluated some 70 engine and airframe technologies for their ability to reduce CO_2 emissions[15] on new, in-production aircraft.

Exhibit 1-5. ICF Airframe & Systems Technologies List

[15] Or fuel burn. The terms are used interchangeably throughout this report.

[16]

Airframe Technologies		
Aerodynamic	**Structural**	**Systems**
• Adaptive Trailing Edge • Advanced Wingtip Devices • Variable Camber Trailing Edge • Re-Wing • Riblet Coatings • Laminar Flow Control – Natural and Hybrid – Nacelle, Empennage, and Wing • Advanced Configurations • Environmental Control System (ECS) Inlet • Stab Control Law • Gap Reductions • Aft Body Redesign • Light Profile	• Advanced Metals • Increased Composite Application • Advanced Composites • Re-Wing • Advanced Configurations • Titanium Landing Gear • Lightweight Paint / Surface Treatment	• Lightweight Lightening Strike Protection • More Electric Systems • On demand Environmental Control Systems • Fuel cell Auxiliary Power Unit (APU) • Light interior • Fly By Wire • Carbon brakes

Exhibit 1-6. ICF Engine Technologies List

Engine Technologies

[16] Please refer to Appendix 2 for more information on these technologies

Materials	Architecture	Systems
• Titanium Aluminide (TiAl) turbine airfoils • TiAl compressor airfoils • Ceramic-matrix composites (CMC) turbine shrouds/ Outer Air Seal (OAS) • CMC High Pressure Turbine (HPT) blades/ vanes • CMC Low Pressure (LP) blades/ vanes • Organic Matrix Composite (OMC) fan blades • OMC case • CMC exhaust nozzle • Ceramic bearings • Turbine coatings • OMC stator • OMC comp. cases	• Ultra High By Pass(UHBP) engine (above 10 Bypass Ratio (BPR)) • UHBP (above 20 BPR) • Open rotor • Variable cycle • Intercooled compressors • Integrated propulsion system • Lightweight component fab techniques • Reduced hub-tip ratio fan • Fan drive gear • Next gen load sharing architecture	• Bleedless engines • Electric engine start • High Pressure Compressor (HPC) mod. Clearance control • Turbine mod. Clearance control • Clearance control w/ feedback • High Pressure (HP)/LP power extraction sharing • High eff. Oil/air cooler • Recuperative exhaust
Aerodynamics	**Sealing**	**Coating / Cooling**
• Next gen engine airfoil designs • Optimized fan root fairing • Scalloped fan exhaust • Low Pressure Ratio (PR) fan • Low drag inlet/nacelle	• Compressor blisks • Turbine blisks	• Compressor airfoil coating • Turbine air cooling air cooling • Next gen. turbine airfoil cooling design

RESULTS

Introduction to Results

Using the modeling framework described in the preceding section, ICF was able to develop a fuel consumption improvement forecast by both aircraft category and aircraft model. This forecast covers the twenty-year period from 2013-2033. This section presents a comprehensive view of both the current state of the fuel efficiency of aircraft, as well as the forecast by aircraft category and by select aircraft model. Detailed profiles of the technologies supplying the largest contributions to fuel efficiency gains are also presented here. The fuel burn numbers presented here were derived from the expected value methodology, and thus include the impact of both the technical and commercial feasibility percentages in the final results. While this provides a good overall forecast of fuel burn improvement percentage per year by aircraft category, the contributions by individual technology must be taken in the context of this expected value methodology. If a technology is actually fully implemented, however, it will of course provide the full benefit, and not the benefit discounted by the commercial feasibility percentage. This is part of the purpose of the expected value methodology; it decreases the model's reliance on the entry into service projections for specific technologies, and instead looks at the fuel burn forecast holistically, and thus, realistically.

Summary Results

Impact of Technologies

Based on its analysis of the pipeline of technologies that can incrementally reduce fuel consumption of new, in-production aircraft, ICF projects aircraft fuel consumption will decrease 0.50-0.65% per annum over the next 20 years for air transport categories (Regional Jet through Very Large Aircraft), resulting in a total decrease of 10-13% by 2033. For air transport turboprops and business jets, fuel consumption is expected to decrease 0.35-0.40% per annum, resulting in a total decrease of 7-8% by 2033.

Projected cumulative fuel burn reductions by 2020 and 2023 differ by aircraft category. A summary of the results is shown below in Exhibit 1-7.

Exhibit 1-7. Cumulative Fuel Burn Reduction Forecast Summary

Aircraft Category	Cumulative Fuel Burn % Reduction By:	
	2020	2023
Very Large Aircraft	4.2%	6.3%
Large Twin Aisles	4.0%	6.0%
Small Twin Aisles	3.7%	5.5%
Single Aisles	3.1%	4.6%
Regional Jets	3.2%	4.7%
Air Transport Turboprops	2.5%	3.7%
Large B&GA [17]Aircraft	3.3%	4.8%
Small B&GA Aircraft	3.0%	4.4%

Of the approximately 70 technologies evaluated, 80% of this projected improvement was generated by twelve airframe technologies. Because engine technologies are incorporated as a package and because no individual engine technology made the 80% group, they are treated as a package in the analysis. These top technologies are detailed in Exhibit 1-8.

[17] B&GA= Business and General Aviation

Exhibit 1-8. Most Impactful Fuel Burn Improvement Technologies by Aircraft Category

Technology	Cumulative Fuel Burn Reduction % by 2020							
	Very Large	Large Twin	Small Twin	Single Aisle	Region-al Jet	Large Bizjet	Small Bizjet	Turbo-prop
Engine Technologies	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	0.7%
Lighter Interiors	0.8%	0.8%	0.8%	0.6%	0.3%	0.3%	0.3%	0.3%
Advanced Wingtip Devices	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Aft Body Aerodynamics	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.4%
HLFC[18] – Empennage	0.1%	0.1%	0.1%	0.1%	<0.1%	<0.1%	<0.1%	<0.1%
ECS Aero and On-Demand ECS	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Adaptive Trailing Edge	0.1%	0.1%	0.1%	0.1%	<0.1%	0.1%	N/A	<0.1%
Titanium Landing Gear	0.1%	N/A	0.1%	0.1%	<0.1%	<0.1%	<0.1%	<0.1%
Composites – Current State	N/A	0.1%	0.1%	0.1%	<0.1%	<0.1%	<0.1%	<0.1%
More Electric Systems	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Carbon / Ceramic Brakes	N/A	N/A	0.1%	0.1%	0.1%	<0.1%	<0.1%	0.1%
Riblet Coatings	0.1%	0.1%	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
All Other Technologies[19]	0.4%	0.2%	N/A	N/A	0.2%	0.3%	0.2%	N/A
Total Average Reduction	**4.2%**	**4.0%**	**3.7%**	**3.1%**	**3.2**	**3.3%**	**3.0%**	**3.2%**

[18] HLFC = Hybrid Laminar Flow Control

[19] Note: totals are aircraft category averages, while not all technologies apply to every aircraft in category, thus "Other" is sometimes redundant, and listed technologies will have sum greater than "Total Average Reduction"

Results by Aircraft Category and by Aircraft

Due to the different magnitude of fuel burn reductions realized by different aircraft categories for each technology, meaningful differences in expected fuel burn benefit emerge for different categories. There are several different reasons for this scaling by aircraft category. Namely, the fuel burn benefits of many technologies scale with both aircraft size/weight and range. For instance, weight-saving technologies have a greater impact on cruise fuel efficiency for heavier/longer range aircraft, since weight (and the fuel required to carry that extra weight) has a compounding effect with greater distance.

Production forecasts were developed by aircraft model for the twenty year forecast period for the air transport aircraft, while ten year forecasts were developed for the Business and General Aviation (B&GA) aircraft. The expected fuel burn improvement percentage per year, especially the total fuel burn percentage improvement possible by 2020 and 2023, will be used as input into the future stringency line determination recommendations.

We profiled each of the aircraft categories, but for illustration purposes, we show the Single Aisle category in this report. For each of the Aircraft Categories, we profiled:

- The current in-production aircraft in the category and projected future build rates,
- Recent technology introductions that reduced fuel burn,
- Future fuel burn reduction forecast, and
- The top technical contributors to fuel burn reduction

Single Aisle Aircraft

Current single aisle aircraft include the Boeing 737NG family and the Airbus A320 family. The 737 family first entered service in 1968 with the 737-100. This was intended to be an aircraft for short haul domestic routes. It was shortly followed by the 737 Advanced. A major upgrade, the 737 Classic, was introduced in 1984. This featured new wings, high bypass engines, and new avionics. Another significant upgrade, the 737NG, entered service in 1998. This again featured a new wing, new engines, stretched airframe variants, and new avionics. The A320 first entered service in 1988, followed by the shortened A319 and the stretched A321 in 1996 and 1994, respectively. It was developed to incorporate advanced technology for the time to compete with the 737 Classic, including new high bypass engines, fly-by-wire flight controls, and advanced avionics.

This sector of the market will see a significant number of introductions of new or upgraded aircraft over the next several years. These include the 737 MAX, A320neo, Comac C919, Irkut MS-21[20], and Bombardier CSeries. Somewhat uniquely, except for the 737 MAX and A320neo, these aircraft are all clean sheet designs. This aircraft category is a prime target for manufacturers aspiring to enter the air transport

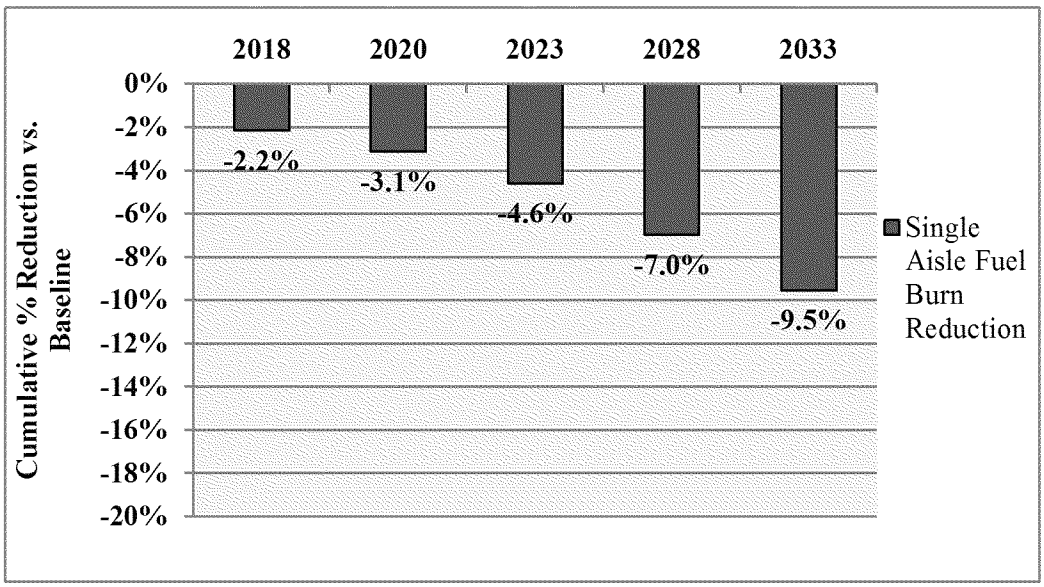
[20] Comac is a division of AVIC, the state-owned Chinese aviation conglomerate, and MS-21 is manufactured by United Aircraft, the Russian aviation conglomerate.

space, due to their high production rates, strong demand, and relatively modest development costs when compared to new twin-aisle aircraft. The C919, MS-21, and CSeries all make use of new technologies, including advanced engines, varying degrees of structural composites, and advanced systems. Due to the introduction of the 737 MAX and the A320neo, Boeing and Airbus are unlikely to introduce clean sheet single aisle aircraft before the end of the 2020s.

Because the 737NG and A320 compete intensely for most of the same customers, both have had several in-production upgrades developed. The 737NG was offered with blended winglets in 2001, first as an aftermarket retrofit option, then as a production option. These improved fuel burn by approximately 4-6%. Carbon brakes were offered on the 737NG in 2007, which saves weight and reduced fuel burn by 0.5%. In addition to these standalone items, a suite of fuel burn reducing technologies was introduced in 2011, called the 737 Enhancement Package (or PIP – Performance Improvement Package). This combined several aerodynamic and systems improvements to provide approximately 1% in fuel burn savings, in addition to greater than 1% savings offered by a simultaneous engine upgrade program, the CFM56-7BE. The A320 has also undergone numerous upgrades for fuel efficiency, as well as passenger comfort, maintenance cost reduction, and avionics capability.

Fuel efficiency is projected to improve 0.5% per year, on average, until 2033. By 2020, the fuel efficiency could be improved by 3.1%, while the projected improvement by 2023 is 4.6%.

Exhibit 1-9. Single Aisle Fuel Burn Reduction Forecast



The major technologies that contribute to this fuel consumption reduction are Engine Technology, Lighter Interiors, and Advanced Wingtip Devices.

Exhibit 1-10. Single Aisle Fuel Burn Reduction by Technology

Technology	2020 Reduction %	2023 Reduction %
• Engine Technology	• 1.4%	• 2.0%
• Advanced Wingtip Devices -	• 0.5%	• 0.7%
• Lighter Interiors	• 0.6%	• 0.8%
• Aerodynamic APU Fairing /	• 0.4%	• 0.5%
• ECS Aero and On Demand	• 0.2%	• 0.3%
• Control Surface - Optimal	• 0.1%	• 0.1%
• Adaptive Trailing Edge	• 0.1%	• 0.1%
• Riblet Coatings	• <0.1%	• 0.1%
• Control Surface - Optimal Control Laws for horizontal	• 0.1%	• 0.1%
• Carbon / Ceramic Brakes	• 0.1%	• 0.1%

EPA-HQ-2018-004348

1.3 TECHNOLOGY METRIC VALUE IMPACT

INTRODUCTION

The ultimate purpose of this report is to evaluate the cost of reducing aircraft CO_2 emissions, which are proportional to fuel burn. Experts at OEMs, airlines and in academia routinely report fuel burn numbers, so this was a natural metric to start with. ICF began its analysis by evaluating the impact of technologies on relative fuel burn reductions. The reductions listed in this report are those of a representative mission for the particular aircraft.

However, the CAEP certification procedure does not use fuel burn directly, but instead, defines a Metric Value (MV) that is related to fuel burn.

The MV is defined based on an instantaneous measure of fuel burn per distance flown and represents an attempt to develop a metric that correlates with fuel burn, while being independent of aircraft type, weight and utilization. The MV is based on the specific air range (SAR), which is an instantaneous measure of the distance flown per unit weight of fuel. The MV is obtained by inverting SAR (which yields the fuel weight required to travel a unit distance), and then dividing it by a non-dimensionalized floor area raised to an exponent, resulting in the following equation:[21]

$$□□ = \frac{1}{□□ \times (□/□)^{0.24}}$$

Where □ is the floor area, and □ is a reference area related to the fuselage planform. Since SAR depends on the instantaneous weight, which varies during flight and has a wide range depending on the mission. SAR can vary by as much as a factor of 2 for a given aircraft. Given this wide range of variation, the MV is highly dependent on the weight used in its calculation. To address this issue, CAEP defined three weight values over which the MV should be averaged to obtain a final value that is representative[22,23].

When converting fuel burn reductions to reductions in the MV, ICF assumed that the MV is based on SARs at a representative set of weights. Therefore, a 1% fuel burn reduction corresponds to 1% MV reduction.

One important characteristic regarding the MV is that reductions in aircraft empty weight[24] would not impact the MV. The rationale for this was that any reduction in empty weight would be canceled out by a corresponding increase in payload, fuel, or both. Thus, even though weight saving technologies and

---

[21] ICAO, 2013: *CAEP/9 Agreed Certification Requirement for the Aeroplane CO_2 Emissions Standard*, Circular (Cir) 337, AN/192, Available at www.icao.int .
[22] Ibid.
[23] [ICCT2013], "International Civil Aviation Organization's CO_2 Certification Requirement for New Aircraft", The International Council on Clean Transportation, Aug. 2013. http://www.theicct.org/co2-requirement-new-aircraft
[24] Refers to Operating Empty Weight is the basic weight of an aircraft including the crew, all fluids necessary for operation such as engine oil, engine coolant, water, unusable fuel and all operator items and equipment required for flight but excluding usable fuel and the payload.

ED_001734_00000097-00019

improvements increase the aircraft efficiency, this is not reflected in the MV. Therefore, ICF post-processed all the fuel burn reductions to remove the reductions due to weight. Across technologies, about 2/3 of the fuel burn impact is reflected in the MV, although this varies depending on the technology and the aircraft category.

RESULTS SUMMARY

Based on its analysis, ICF projects MVs for new, in-production aircraft will decrease 0.4-0.5% per annum over the next 20 years for air transport categories (Regional Jet through Very Large Aircraft), resulting in a total decrease of 8-10% by 2033. For air transport turboprops and business jets, fuel consumption is expected to decrease 0.3-0.4% per annum, resulting in a total decrease of 6-8% by 2033. Projected cumulative MV reductions by 2020 and 2023 differ by aircraft category. A summary of the results is shown below in Exhibit 1-11.

Exhibit 1-11. Metric Value Reduction Summary

Aircraft Category	Cumulative Metric Value % Reduction By:	
	2020	2023
Very Large Aircraft	3.0%	4.5%
Large Twin Aisles	2.8%	4.3%
Small Twin Aisles	2.6%	4.0%
Single Aisles	2.5%	3.6%
Regional Jets	2.7%	3.9%
Air Transport Turboprops	2.0%	2.9%
Large B&GA Aircraft	2.7%	4.0%
Small B&GA Aircraft	2.5%	3.6%

Technologies with the most beneficial impact on Metric Values are summarized in Exhibit 1-12.

Exhibit 1-12. Technologies Having Highest Impact on Metric Value Improvement by Aircraft Category

Technology	Cumulative Metric Value % Reduction by 2020							
	Very Large	Large Twin	Small Twin	Single Aisle	Region-al Jet	Large Bizjet	Small Bizjet	Turbo-prop

Engine Technologies	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	0.7%
Lighter Interiors	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Advanced Wingtip Devices	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
Aft Body Aerodynamics	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.4%
HLFC[25] – Empennage	0.1%	0.1%	0.1%	0.1%	<0.1%	<0.1%	<0.1%	<0.1%
ECS Aero and On-Demand ECS	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Adaptive Trailing Edge	0.1%	0.1%	0.1%	0.1%	<0.1%	0.1%	N/A	<0.1%
Titanium Landing Gear	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Increased use of composite parts	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
More Electric Systems	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Carbon / Ceramic Brakes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Riblet Coatings	0.1%	0.1%	0.1%	<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
All Other Technologies	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Reduction	**3.0%**	**2.8%**	**2.61%**	**2.5%**	**2.7%**	**2.7%**	**2.5%**	**2.0%**

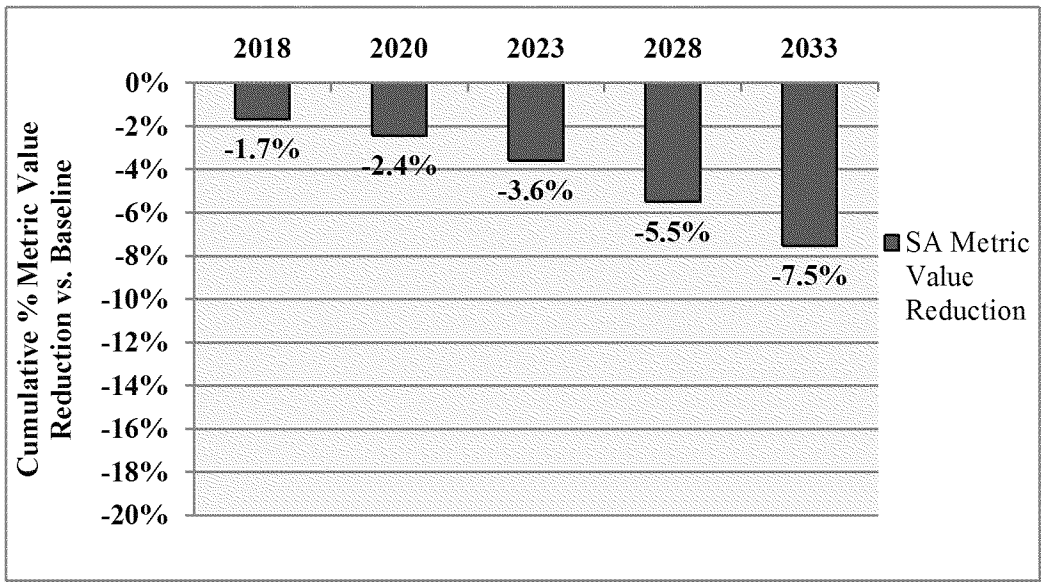
[25] HLFC = Hybrid Laminar Flow Control

RESULTS BY AIRCRAFT CATEGORY

Single Aisle Aircraft

Single Aisle aircraft MVs are projected to decrease at 0.38% per year, or 2.40% by 2020 and 3.59% by 2023.

Exhibit 1-13. Single Aisle Metric Value Reduction Forecast



Engine Technologies, Advanced Wingtip Devices, and Aft Body Aerodynamics contribute most to Single Aisle Metric Value reductions.

Exhibit 1-14. Single Aisle Metric Value Reduction Forecast by Technology

Technology	Cumulative Metric Value Reduction %	
	2020	2023
Engine Technologies	1.4%	2.0%
Advanced Wingtip Devices	0.5%	0.7%
Aft Body Aerodynamics	0.4%	0.5%
ECS Aero and On-Demand Schd.	0.2%	0.3%
All Other Technologies	<0.1%	0.1%
Total	**2.4%**	**3.6%**

DEVELOPMENT COSTS OF CO_2-REDUCING TECHNOLOGIES

1.4 TECHNOLOGY DEVELOPMENT COST

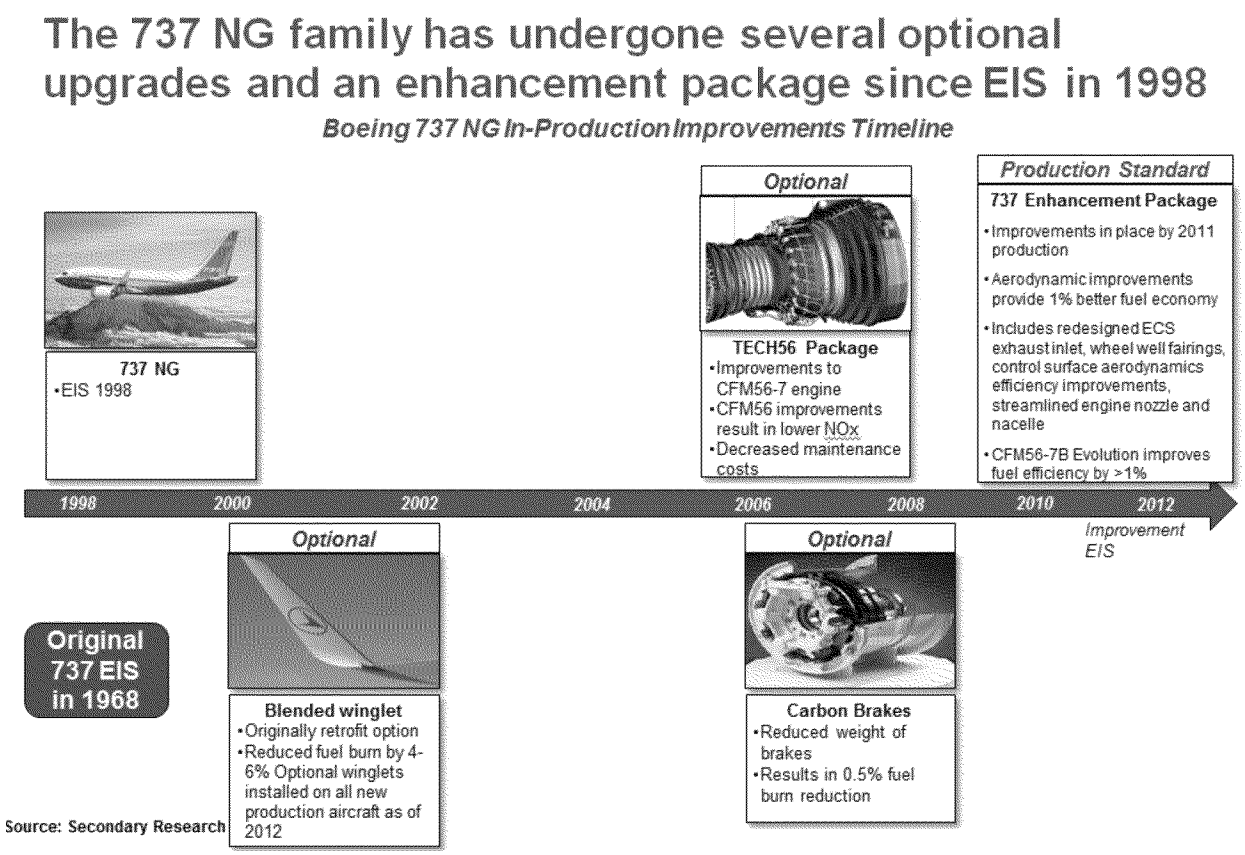
INTRODUCTION

High fuel prices are the primary driver of current fuel burn reduction efforts

Despite the slow recovery from the global downturn, oil prices have risen to over $100/barrel[26]. Jet fuel prices now exceed 30% of airline total cost and exceed 50% of airline operating cost. Consequently, fuel burn reducing technologies are much more valuable now than they were when fuel prices were much lower. The result of high fuel costs has been a flurry of recent and upcoming new program launches as well as incremental upgrades. New program launches include completely new "Major redesigns" such as the 787 and A350XWB to re-winged aircraft (with new engines as well) such as the 777-X and EMB-175/190 E2 to re-engine programs such as the A320 Neo and 737 MAX. These major redesign and significant redesign program launches are delivering sizable fuel burn improvements on the order of 10-20%+ per seat-mile. As has been discussed earlier in this paper, incremental technology insertions have also been made. Typical incremental upgrades include PIPs such as those released for the 737NG and the 777. As shown below, these PIPs include such discrete items as engine upgrades, weight reductions, and minor aerodynamic changes.

[26] Since this report was completed, oil has fallen to $55/barrel. However, it's too early to tell if this condition will be long-lived. For the time being, airlines are holding to their fleet renewal plans (indeed, due to hedging, airlines will not begin to realize substantial benefits from this reduction for another 18 months). Should these low prices endure, fuel would remain a substantial airline operating cost, but older airplanes would likely be flown longer (as before) and fleet renewal would slow.

Exhibit 1-15. Example of Incremental Technology Insertion – 737NG



Source ICF analysis, Boeing

Changes included in performance improvement packages offered in the aftermarket are typically adopted in the new production standard. Improvements in fuel burn from these incremental upgrades typically range from 0.5-4.0%. In some instances, a series of improvements or PIPs are grouped together into larger changes that yield up to 8-10% fuel burn reduction on a particular aircraft family.

Aircraft development activity is expensive

Aircraft development programs are expensive. Analysts estimate a new single aisle would have cost $10-12B to develop. The A380 and 787 are estimated to each have cost around $20B to develop; the A350 is estimated to have cost $15B, excluding engine development. Due to the large development cost of a totally new aircraft design, manufacturers are opting to re-wing or just re-engine their aircraft. Boeing is said to have budgeted $5B for the re-wing of the 777 and Airbus and Boeing have budgeted $1-2B each for the re-engine of the A320 and the 737, respectively (excluding engine development costs). Embraer has publically stated they will need to spend $1-2B to re-wing the EMB-175 and variants.

Large fuel burn reductions require large investments; a 15-25% improvement is required to trigger a brand new aircraft design

The obverse of expensive development programs is also true: Given the time, expense and risk of new technology development, a high level of potential improvement is required to trigger such significant investment. Thus, a pipeline of technologies has to be likely to deliver fuel burn reductions commensurate with the level of research and development (R&D) expense required to commercialize them. In total, airframe and engine manufacturers spent over $8.6B in 2012 year on R&D, $4.5B by the top 4 airframe manufacturers and $4.1B by the top 4 engine manufacturers. Some industry analysts have noted that the cost to develop new aircraft and engines may be rising.

METHODOLOGY

Introduction

ICF developed an independent bottom-up cost curve especially focused on categorizing the non-recurring cost of implementing minor (0-10% metric value) improvement on existing aircraft platforms. This area is of particular importance for determining the costs of compliance with a number of proposed stringency options, and was also an area neglected by previous non-recurring cost (NRC) methodologies. The results of the ICF curve were a supply-curve of available technology options and associated non-recurring costs for each aircraft platform. For most aircraft, this methodology was limited to predicting improvements in the 0-10% range. Also, ICF's research indicated that, given the lack of verifiable publically available cost data for small metric value improvements, it would be most effective to create bottom-up technology applicability and cost analyses by aircraft model, and then validate these through case studies, secondary research, and targeted interviews.

Metholodogy Overview

ICF developed the following methodology to estimate the non-recurring costs (NRC) by aircraft:

1. Categorize incremental technologies into groupings by impactful-ness – either Minor PIP or Large Incremental Update

2. Identify the elements of non-recurring cost
3. Develop baseline NRC element proportions by incremental technology category for single-aisle aircraft
4. Scale the baseline NRC elements to the other aircraft categories
5. Determined the NRC costs for single aisle aircraft and applied the scaled costs to the other aircraft categories
6. Compiled technology supply curves by aircraft model

Categorizing Incremental Technologies

Incremental technologies fall into two categories: minor PIPs and large incremental updates. Minor PIPs are aerodynamic cleanups (e.g., redesigned fairings, APU inlets, ECS exhausts, etc.) and other improvements that often can be certified by analysis without dedicated flight test aircraft, and with only minor ground, wind tunnel, and flight tests. Minor PIP costs scale only incrementally with aircraft size. Most of the technologies ICF researched were minor PIPs, providing in the range of 0-2% fuel burn improvement.

Large incremental updates are significant aerodynamic or structural improvements (e.g., winglets) that require flight test programs – usually with production aircraft. These types of improvements, singly or grouped into a large package, can provide from 2-10% fuel burn reduction. Tooling and facilities costs are not driving factors for these improvements. Large incremental upgrades scale highly with aircraft size.

Elements of Non-Recurring Cost

Non-recurring cost is fundamentally driven by three elements: engineering and integration, testing (flight and ground) and tooling, capital equipment, and infrastructure. Engineering and Integration (Engrg) includes the engineering and Research & Development (R&D) required to progress a given technology from its current TRL so it can be integrated onto a production airframe. It also includes all airframe and technology integration costs.

Flight and Ground Testing (Testing) includes fixed costs for test instrumentation, infrastructure, and program management and variable costs[27] related to the degree of flight and ground testing required.

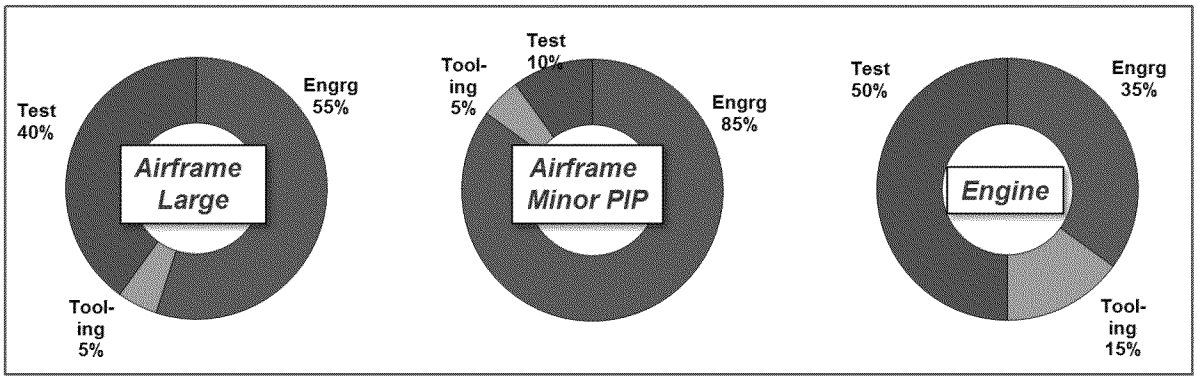
Tooling, Capital Equipment, and Infrastructure (Capital) includes tooling required to modify the production line to support the PIP, incorporates any capitalized changes to plant, property, and equipment, and includes other miscellaneous costs such as Information Technology (IT) system, supply chain system, and other costs associated with a particular design change.

Baseline Non-Recurring Cost Element Proportions

[27] Variable costs refer to the costs of flight and ground testing that scale with the amount of time spent testing. For instance, fuel costs and crew/test engineer salaries directly scale with the amount of time spent in flight and ground test.

For incremental technologies applicable to single aisle aircraft, the proportion of engineering and integration, flight and ground testing, and tooling, capital equipment, and infrastructure varies depending on whether it is an airframe or an engine technology and, for airframe technologies, whether the technology is a minor PIP or a large incremental update. Exhibit 1-16 illustrates the cost element proportions for single aisle aircraft. In general, engine PIP development costs are heavily driven by both flight and ground testing. This includes the cost of test hardware, recurring flight and ground test costs, test engineering and analysis, and the like. Small airframe PIPs, on the other hand, are dominated by engineering costs. This is because small airframe PIPs generally do not require a dedicated flight testing program. Therefore, costs are concentrated on the engineering design and analysis required to analytically verify the safety and performance of the PIP. Large airframe PIPs do require a flight test program, and therefore have a large portion of their total costs allocated to the testing effort.

Exhibit 1-16. Single Aisle NRC Cost Element Proportions



Non-Recurring Cost Scaling Factors

Non-recurring costs exhibit different scaling behavior with aircraft size. Engineering and integration cost for a given technology and metric value improvement is not strongly correlated with aircraft size; rather, it scales with a 5% differential of aircraft complexity. ICF used aircraft realized sale price to scale this element. Flight and ground testing scales with aircraft operating costs. ICF used direct block hour average operating costs to scale this element. Lastly, for Minor PIPs, tooling, capital equipment, and infrastructure costs are not strongly correlated with aircraft size. As with engineering, average realized aircraft sale price was used to scale this element.

ICF used independently verifiable data to calculate the NRC scaling factors, shown in Exhibit 1-17. Average realized sale price is the scaling parameter used for Engineering, as well as for Capital NRC. Average operating cost was used as the scaling parameter for Testing NRC. Testing scales with 100% of the operating cost differential, using single aisle as the baseline. Engineering and Capital scale by 15% of the differential in average realized sale price, using single aisle as the baseline.

Exhibit 1-17. Aircraft Cost Element Scaling Factor Sources

Aircraft Category	Average Realized Sale Price	Avg Operating Cost ($/Block Hour)
Small BGA	$10M	$1,340
Large BGA	$40M	$2,688
Turboprop	$25M	$2,016
Regional Jet	$30M	$2,688
Single Aisle	$45M	$4,538
Small Twin Aisle	$130M	$8,143
Large Twin Aisle	$165M	$10,500
Very Large Aircraft	$195M	$14,449

Source: Block hour operating cost and averaged realized price data from The Airline Monitor

The end result was factors that were used to scale the cost elements in reference to the baseline single aisle aircraft to every aircraft category, illustrated in Exhibit 1-18.

Exhibit 1-18. Non-Recurring Cost Element Scaling Factors

Aircraft Category	Engineering & Integration Cost	Flight & Ground Test	Tooling, Capital Equipment, & Infrastructure
Small BGA	0.88	0.30	0.88
Large BGA	0.98	0.59	0.98
Turboprop	0.93	0.44	0.93
Regional Jet	0.95	0.59	0.95
Single Aisle	1	1.00	1
Small Twin Aisle	1.28	1.79	1.28
Large Twin Aisle	1.40	2.31	1.40
Very Large Aircraft	1.50	3.18	1.50

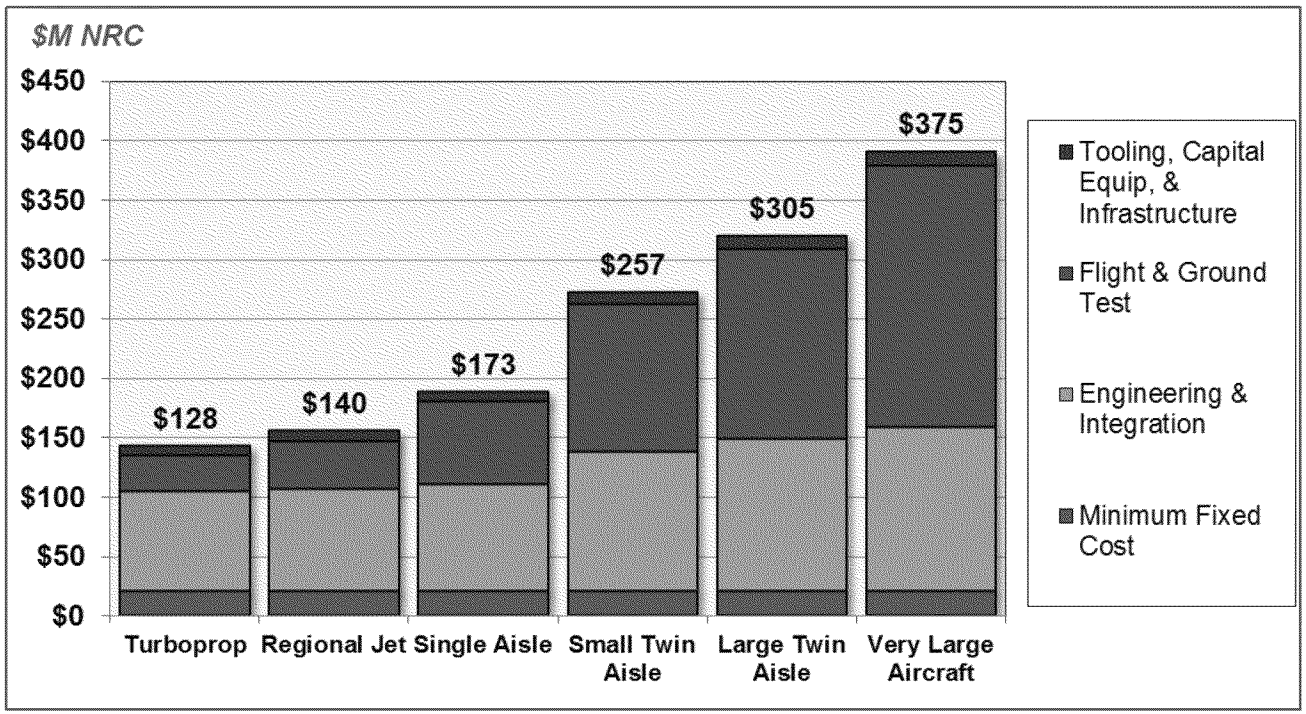
Cost Calculations

Applying the scaling factors, NRC was calculated for every technology across every aircraft category. An example is provided below.

Example: Large Incremental Update NRC (Wingtip Devices)

Wingtip devices are a "Large Incremental Update" –level technology. For the baseline single aisle aircraft, total cost is composed of 3% baseline fixed costs, 52% engineering & integration, 40% testing, and 5% capital equipment. The calculation assumes a minimum $5M fixed cost. (We used this amount for all of the incremental upgrades. It does not vary by technology or aircraft category.) This fixed cost is an allowance for basic program management overhead that accompanies any level of design change at an aircraft OEM. An example of this approach in practice is shown below in Exhibit 1-19, which in this case represents winglets. For this technology, interview input and secondary research indicated a total non-recurring cost for winglet implementation of $173M for single aisle aircraft. Given this known data point, ICF used the cost element breakdown shown in Exhibit 1-18 above to split the total NRC into the constituent elements. Note in Exhibit 1-19 below that Engineering and Capital NRCs exhibit only minor scaling factors.

Exhibit 1-19. Large Incremental Update Cost Scaling by Aircraft Category



RESULTS

Introduction

ICF calculated cost curves for individual aircraft, taking into account the costs of each technology applicable to that category of aircraft. The cost curve depictions are not intended to state that all these insertions will happen; rather, they are a menu of potential technology insertions organized from most cost effective to least based on our analysis. Note also that ICF's results are valid from 0-10% for most aircraft types. Technology improvements above 10% tend to take the form of significant redesigns such as re-engines or re-wings, often in combination with additional incremental technology insertion.

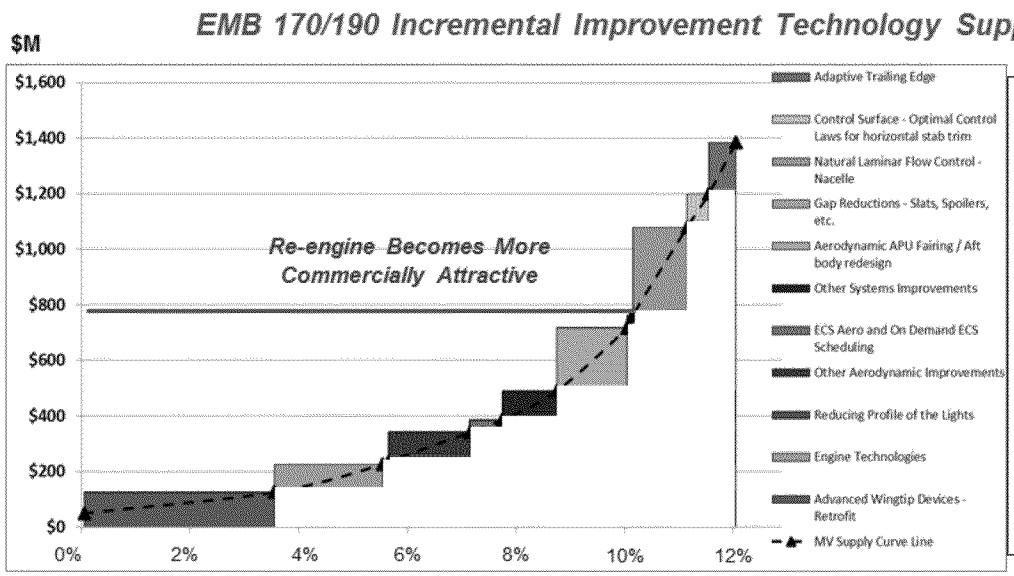
We use the A330 program to illustrate the presentation of the results of ICF's cost analysis for key aircraft platforms. The cost curve shown here are comprised of the costs and metric value improvement benefits for individual technologies. As discussed earlier in the technology evaluation methodology, each aircraft has a certain set of airframe and engine technologies that can be applied to it. This technology applicability matrix drives the cost curves and other results. Using the methodology described above, the cost of every technology is scaled to each aircraft size category. These costs are then applied to each aircraft as appropriate to develop the cost curves. In addition to using these curves to calculate an individualized cost curve for each aircraft model, these analyses can be used to generate a series of data points that can be used to generate a cost curve in the 0-10% metric value range.

Cost Results for Selected Aircraft Models

EMB 170/190 Family

The EMB-170/190 is a family of large regional jets manufactured by Embraer. The family has four in-production models of different sizes, the E-170, E-175, E-190, and E-195. The smaller E-170 and E-175 models have the GE CF34-8 engine, while the larger E-190 and E-195 models have the GE CF34-10 engine. ICF analyzed the current state of technology on the in-production EJet family, and then determined that nearly a dozen technologies could be incrementally applied to the current aircraft. The most cost-effective upgrades include advanced wingtip devices, engine technology insertion, and other aerodynamic and systems improvements. As a validation of the ICF analysis, Embraer announced in early 2013 that they would proceed with an EJet "enhanced" series of upgrades covering maintenance costs, passenger comfort, and fuel burn. Among the fuel burn-reducing devices proposed were advanced wingtip devices, gap reductions, ECS and APU optimization, and others systems and aerodynamics modifications. In total, these will yield between 3.5-5.5% fuel burn savings depending on the specific family model. ICF estimates that, in total, it would be economically feasible to improve the EJets ~10% ~$700M using only incremental technology. If a greater level of improvement was desired, it would be more economical to simply re-wing and re-engine the aircraft, instead of relying on incremental improvements. Indeed, this is what Embraer has decided to do with the EJet family, with a re-engined model planned for a 2018 EIS.

Exhibit 1-20. EJets Incremental Improvement Supply Curve



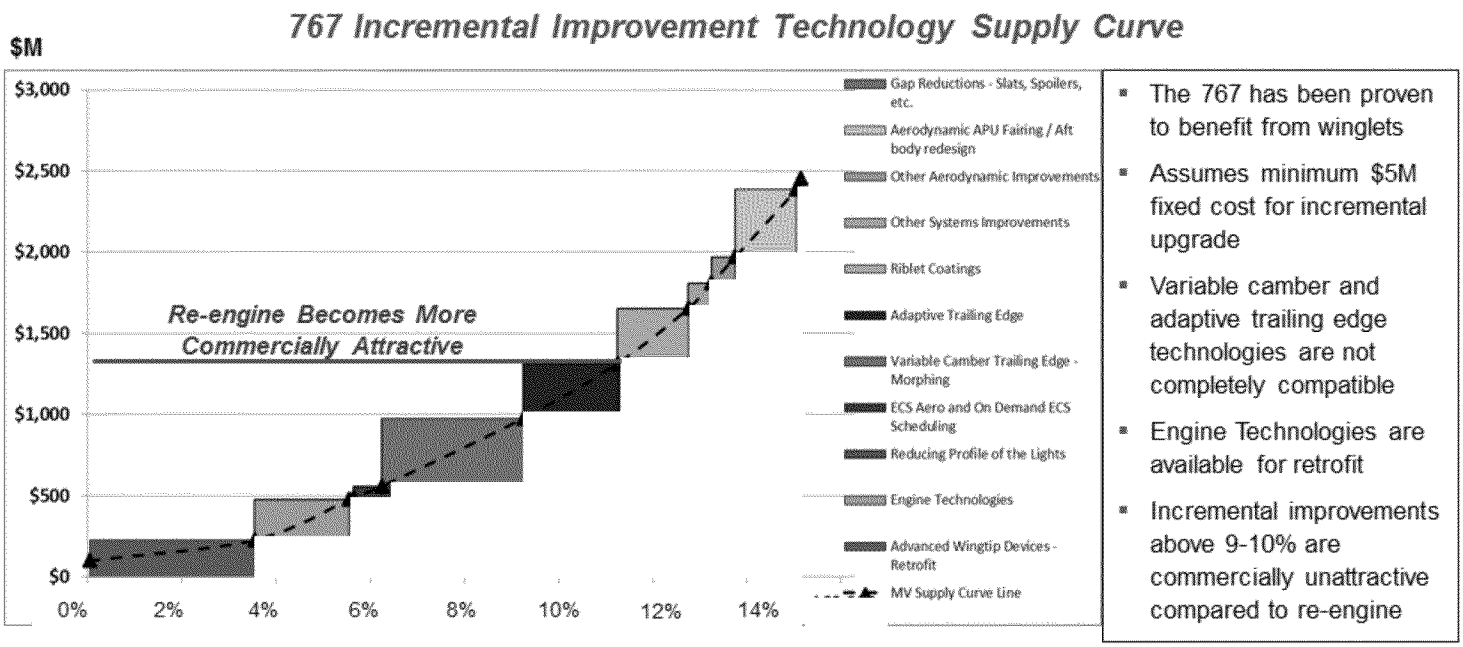
- The EMB170/190 family is undergoing a PIP yielding up to 5.5% fuel burn savings in 2014, incorporating many of these elements
- Assumes minimum $5M fixed cost for incremental upgrade
- Incremental engine PIPs available for CF34-8/10
- Improvements above 10-12% are commercially unattractive, hence Embraer's decision to proceed with E-Jet E2

- *Chart represents applicable tech insertions based on implementation feasibility and cost effectiveness*
- *There is a limit to the number of incremental techs a manufacturer would do – e.g., above a certain threshold, it makes more sense to re-engine (Commercially unattractive range)*
- *ICF technologies have been defined to be additive – obviously mutually exclusive technologies were avoided*

767 Family

The Boeing 767 family was introduced in the early 1980s and included a variety of models. Current in-production models include the 767-300ER passenger and freighter variants. While future production of the 767 will be focused on military tanker transport variants, the commercial versions are still available for sale. There are several available technologies that could make an immediate impact, including advanced wingtip devices, engine upgrades, reduced light profiles, ECS aerodynamics, and an adaptive trailing edge. These technology insertions could improve the 767 family's metric value by approximately 10% for an NRC of $1.3B. Some of the technologies listed here, such as winglets and engine upgrades, have been tested successfully but are not part of the current production standard. With the relatively slow sales of the commercial 767, it is understandable that these upgrades are not being undertaken.

Exhibit 1-21. 767 Incremental Improvement Supply Curve

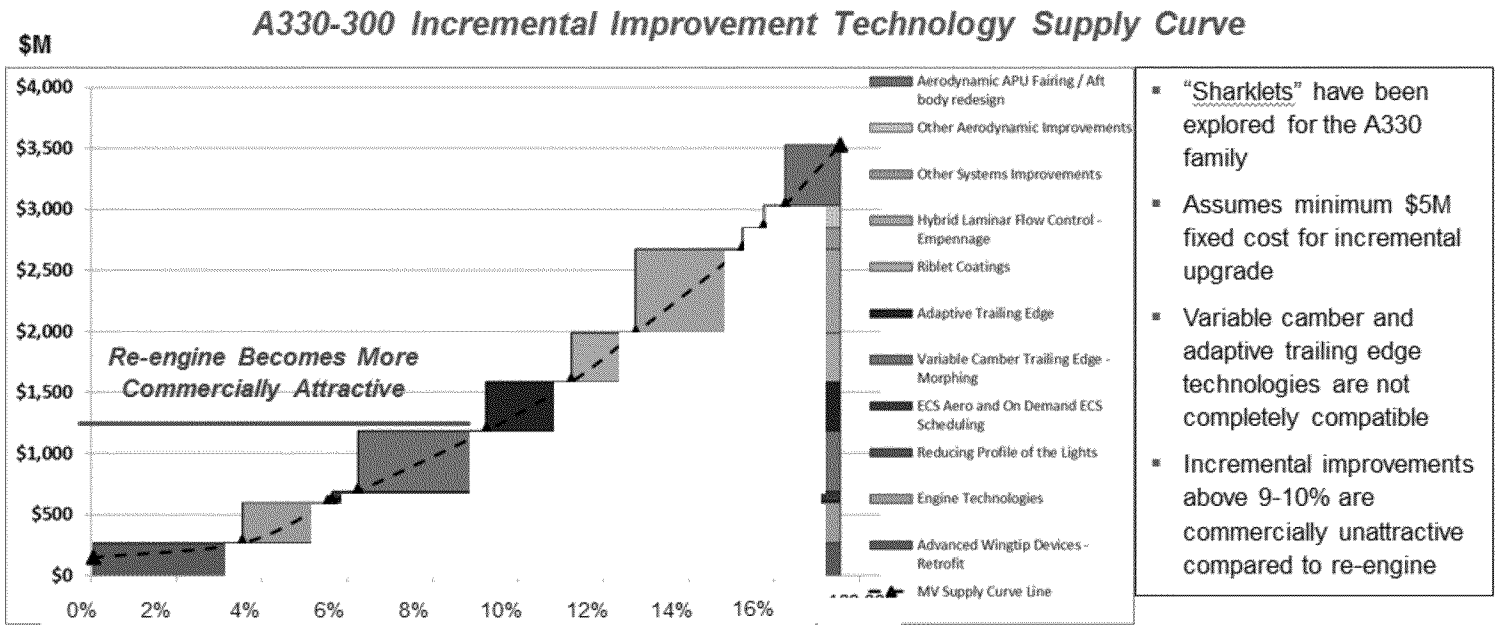


- *Chart represents applicable tech insertions based on implementation feasibility and cost effectiveness*
- *There is a limit to the number of incremental techs a manufacturer would do – e.g., above a certain threshold, it makes more sense to re-engine (Commercially unattractive range)*
- *ICF technologies have been defined to be additive – obviously mutually exclusive technologies were avoided*

A330

The Airbus A330 has been in service since the early 1990s. Many different incremental improvements have been introduced over the years, namely increased maximum takeoff weights. ICF estimated that a variety of incremental improvements could be applied to the A330, yielding an estimated 8-10% improvement for approximately $1.4B in NRC. ICF estimated that achieving improvements above this level would require a more substantial re-engining program. In July 2014, Airbus announced that they were proceeding with a re-engined version of the aircraft, the A330neo. It will achieve 12%-14% fuel burn reductions with an Airbus initial cost estimate of "between $1B-$2B Euros" ($1.4-2.7B). This subsequent Airbus announcement validates ICF cost projections .

Exhibit 1-22. A330 Incremental Improvement Supply Curve



- *Chart represents applicable tech insertions based on implementation feasibility and cost effectiveness*
- *There is a limit to the number of incremental techs a manufacturer would do – e.g., above a certain threshold, it makes more sense to re-engine (Commercially unattractive range)*
- *ICF technologies have been defined to be additive – obviously mutually exclusive technologies were avoided*

Cost Results Data Points

By running cost curve analysis for many aircraft platforms, ICF was able to develop a comprehensive set of data points to better inform the non-recurring cost curve for metric value improvements in the 0-10% range. Eight aircraft were analyzed, yielding fifty-six discrete data points[28]. These are shown below in Exhibit 1-23

Exhibit 1-23. ICF Metric Value and NRC Data Points

E-175		CSeries		A320		767		787-8		A330		777-300ER		A380	
MV%	NRC ($B)	MV%	NRC ($B)	MV%	NRC ($B)	MV%	NRC ($B)	MV%	NRC ($B)	MV%	NRC ($B)	MV%	NRC ($B)	MV%	NRC ($B)
<0.1%	<$01	<0.1%	<$0.1	<0.1%	<$0.1	<0.1%	<$0.1	<0.1%	<$0.1	<0.1%	<$0.1	<0.1%	<$0.1	<0.1%	<$0.1
3.5%	$0.1	3.5%	$0.2	3.5%	$0.2	3.5%	$0.2	3.5%	$0.2	3.5%	$0.3	3.5%	$0.3	3.5%	$0.3
5.5%	$0.2	5.5%	$0.3	5.5%	$0.3	5.5%	$0.5	5.5%	$0.5	5.5%	$0.6	5.5%	$0.6	5.5%	$0.7
5.7%	$0.2	5.7%	$0.3	5.7%	$0.3	5.7%	$0.5	8.5%	$0.9	5.7%	$0.6	5.7%	$0.6	5.7%	$0.7
7.2%	$0.3	6.3%	$0.4	6.3%	$0.4	6.3%	$0.6	10.0%	$1.2	6.3%	$0.7	8.7%	$1.1	6.3%	$0.8
7.8%	$0.4	8.0%	$0.7	8.0%	$0.7	9.3%	$1.0	-	-	9.3%	$1.2	10.7%	$1.5	9.3%	$1.4
8.8%	$0.5	9.3%	$0.9	9.3%	$0.9	11.3%	$1.3	-	-	11.3%	$1.6	-	-	11.3%	$1.9
10.0%	$0.7	10.3%	$1.1	10.5%	$1.2	-	-	-	-	-	-	-	-	-	-

[28] The number of data points for each aircraft depends on the maximum potential for improvement and the specific mix of available technologies.

CONCLUSIONS

EFFECTIVENESS OF INCREMENTAL TECHNOLOGY INSERTIONS ON FUEL BURN

- ICF analyzed over 70 incremental technologies that can incrementally reduce fuel consumption of new, in-production aircraft.
- For the air transport categories (Regional Jet through Very Large Aircraft), ICF projects incremental technologies will decrease aircraft fuel consumption 0.50-0.65% per annum (depending on the aircraft category) over the next 20 years, resulting in a total decrease of 10-13% by 2033.
- For air transport turboprops and business jets, incremental technologies are expected to reduce fuel consumption 0.35-0.40% per annum, resulting in a total decrease of 7-8% by 2033.
- Of the approximately 70 technologies evaluated, 80% of the projected improvement was generated by twelve airframe technologies plus the engine technologies (they are treated as a package in the analysis):
    - Engine Technologies
    - Lighter Interiors
    - Advanced Wingtip Devices
    - Aft Body Aerodynamics
    - HLFC – Empennage
    - ECS Aero and On-Demand ECS
    - Adaptive Trailing Edge
    - Titanium Landing Gear
    - Composites – Current State
    - More Electric Systems
    - Carbon / Ceramic Brakes
    - Riblet Coatings

EFFECTIVENESS OF INCREMENTAL TECHNOLOGY INSERTIONS ON METRIC VALUE

- For the air transport categories (Regional Jet through Very Large Aircraft), ICF projects incremental technologies will decrease aircraft metric value 0.4-0.5% per annum (depending on the aircraft category) over the next 20 years, resulting in a total decrease of 8-10% by 2033.
- For air transport turboprops and business jets, incremental technologies are expected to reduce fuel consumption 0.3-0.4% per annum, resulting in a total decrease of 6-8% by 2033.
- Six technologies accounted for the metric value improvements:
    - Engine Technologies
    - Advanced Wingtip Devices
    - Aft Body Aerodynamics
    - HLFC – Empennage
    - ECS Aero and On-Demand ECS
    - Adaptive Trailing Edge
    - Riblet Coatings

COST TO DEVELOP AND IMPLEMENT TECHNOLOGIES

- The cost to develop and incorporate new technologies varies depending on aircraft size category and the particular technology employed
- For regional jets, we estimate development costs to be $30-70M per 1% reduction in metric value
- For Single Aisle and Small Twin Aisle aircraft, we estimate development costs to be $60-120M per 1% reduction in metric value
- For Large Twin Aisle and Large Quad aircraft, we estimate development costs to be $90-170M per 1% reduction in metric value[29]

[29] ICF expects that the cost per 1% metric value improvement would increase substantially above 10% total improvement, as more extensive changes to the airframe or engine would be required.

2 APPENDIX

2.1 TECHNOLOGY READINESS LEVELS

[30]

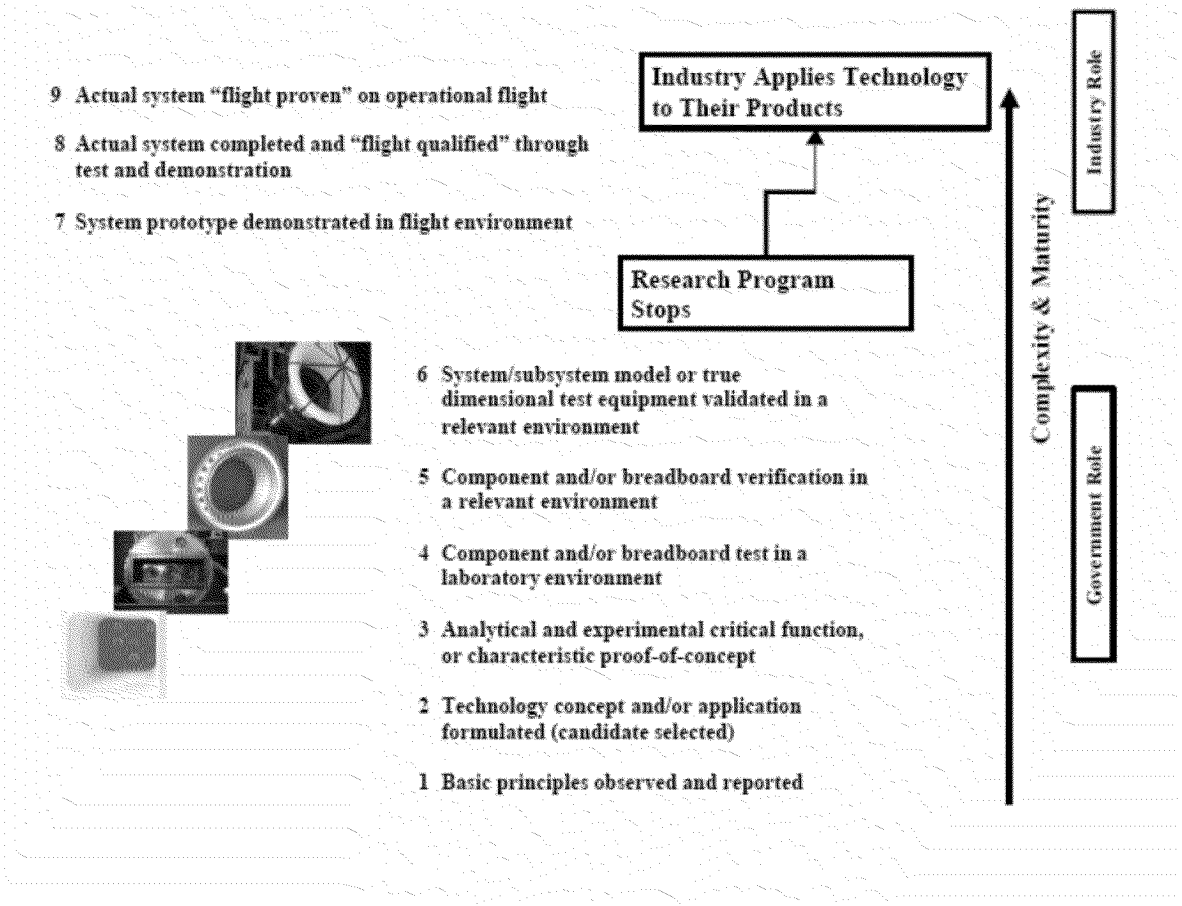


Figure 1. Technology readiness levels

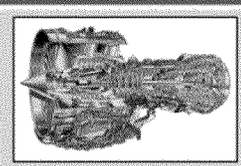
[30] "Definition Of Technological Feasibility In The Context Of Considering Revised Engine Exhaust Emissions Standards And Transition Goals To Standards", CAEP/7-WP/09, November 10, 2006

2.2 Complete Technology Profiles

Engine Technologies

Major engine OEMs are continually adding to their technology portfolio. Big Four OEMs are spending between $800M and $1.2B on R&D, so these types of upgrades are part of the ongoing business model to keep competitive in the aero-engine market. Engine technology insertion is targeted to address TSFC (Thrust Specific Fuel Consumption), Propulsion System Weight Reduction, Maintenance Cost reduction, Performance Improvement, or System Reliability. Engine technologies embody a range of innovations, including materials (e.g., ceramic matrix composite parts), architecture (e.g., optimizing thermal efficiency versus propulsive efficiency), airfoil aerodynamics, sealing (e.g., blade tip clearances), cooling (i.e., blade cooling to enable higher operating temperatures), and systems technologies (e.g., electric engine start). In practice, however, it is airfoil aerodynamics and sealing technologies that are applied to new in-production aircraft. The engine is a highly integrated set of systems that leaves little room for modifications post-entry into service (EIS).

Exhibit 2-1. Representative Engine "Tech Insertion" Packages

Trent 900	V2500	CFM56-5B / -7B
		

• Introduction of elliptical leading-edge modifications throughout the entire compression system
  • Improved high- and intermediate-pressure (HP/IP) compressor blades and vanes
  • Improved fan and outlet guide vanes
• Tweaks to the air management system
	• New software for electronic engine control (EEC)
	• New variable stator vane (VSV) and bleed valve schedules
	• HPC
	  • Improved airfoil technology
	  • Improved airfoil surface finish
	  • Controlled leading edge profile
	  • Latest design standards
	• Re-staggered first row of LPT vanes
	• New materials / coatings, advanced sealing, and airfoil cooling in the HPT
		• HPC Kit – improved blade aerodynamics
		• HPT Blade Kit – low shock airfoil with improved cooling
		• LPT Nozzle Kit – Improved cooling
		• Lower NOx Combustor

Furthermore, engine technologies rarely buy their way on individually; rather, engine OEM's create technology insertion (TI) "packages" that improve fuel burn, reduce maintenance cost, and/or improve performance (representative TI packages are illustrated in Exhibit 2-1). If fuel burn is the competitive requirement, a minimum of 0.5 to 1.0% fuel burn improvement is necessary to justify the development and certification costs in order to be marketable to airline customers. Integration of a suite of TRL-6 technologies into a propulsion system can cost the OEM in the ballpark of $100M per 1% fuel burn reduced, excluding any potential additional certification costs. Lower TRL technologies can add another $100 to $150M, and require additional years in development. These TI packages normally become the new production standard, and are sold for incorporation during normal engine maintenance activities. As stated by a major engine OEM executive "….there is 2 to 4 year financial return requirement (for technology insertion packages)…..anything that gets repaired or replaced (during normal maintenance) buys its way in….". Another consideration, especially for lessors, is residual value. Technology insertion is not only a short term cost/benefit analysis, but a consideration in future residual value of the aircraft and/or engine at future sale.

Traditionally, technology development generally revealed itself in mid-life upgrades to engine programs. With the plethora of new engine development going on, technologies developed for new engines (such as LEAP-X and Trent XWB) are being migrated back to prior versions of existing engines (e.g., technology developed for the Trent 1000 and 700EP were incorporated into a TI package for the Trent 900[31]). While TI packages will vary from engine to engine, technologies developed and tested in recent new engine programs (e.g., GEnx, Trent 1000/XWB, GTF, LEAP-X, etc.) will be incorporated into current engines. ICF projects engine upgrade packages will continue to be developed throughout the forecast period regardless of the source of technology development. While ICF forecasted 0.2% improvement per annum, some sources indicate that there is substantial upside to this number, with Pratt and Whitney claiming an average fuel burn improvement of 0.5%-1% for the geared turbofan (Warwick, Pratt and Whitney's Geared Turbofan).

[31] "Rolls-Royce Reveals Trent 900 Enhancement Package", Aviation Week & Space Technology, September 28, 2009, p. 41.

	Sources	Small BGA	Large BGA	Turbo -prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn	• Primary reduction mechanisms are Airfoil Aerodynamics and Sealing • Engine OEMs typically do not charge a premium for engine technology improvements • Based on interview feedback, ICF modeled this as a fixed percentage per year, rather than using commercial or technical probability built up from individual technologies	=[32]	=	-	=	=	=	=	=
		0.2% /yr	**0.2% /yr**	**0.1% /yr**	**0.2% /yr**	**0.2% /yr**	**0.2% /yr**	**0.2% /yr**	**0.2% /yr**
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*		
		Technical Feasibility	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*		
Cost Impact	• Engine OEMs typically do not charge a premium for engine technology improvements • Interviews indicated $100M of Non-Recurring Engineering Cost (NRE) for every 1% improvement (on single aisle-sized engines) for TRL 6+ • This was scaled by ICF (as described in the "methodology" section) to estimate the NRE required for other engine sizes	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0	$0	$0	$0	$0	$0	$0	$0
		Estimated Total NRE ($M) by Aircraft Category							
		$21	$86	$20	$71	$141	$277	$396	$440

[32] =: Technology has maximum benefit of average of minimum and maximum for that category
-: Technology has maximum benefit of 100% of minimum for that category

Variable Camber Trailing Edge

The idea of the variable camber trailing edge is to tailor the aerodynamics of the wing in flight to improve the performance over a range of flight conditions. Ideally aircraft would fly mostly at the nominal cruise flight condition for which the wing was designed for, but in practice, aircraft end up flying at a range of conditions dictated by operations. The air traffic control restriction that requires flight at a constant altitude in 2,000 ft. increments is particularly limiting. The drag penalty due to this restriction over the complete cruise segment can be as high as 7%. If these restrictions were to be reduced or eliminated in the future, as planned under Federal Aviation Administration (FAA)'s NextGen program, the penalties could reduce dramatically, and this technology might no longer be worthwhile.

Variable camber trailing edge technology is currently implemented in the Boeing 787 and the Airbus A350. In these implementations, both ailerons and flap positions are optimized for each flight condition to minimize the drag ((Norris, Boeing Unveils Plans for Trailing Edge Variable Camber on 787 to Reduce Drag, Save Weight)). The aileron mechanisms are similar to conventional ones, but the flap mechanisms had to be adapted to enable the required adjustments. This includes the ability of the spoilers to deflect downwards to close gaps opened when the flaps are slightly drooped. There is also the possibility of morphing the trailing edge without resorting to hinged surfaces, which we cover in the "Adaptive Morphing Trailing Edge" section.

	Sources	Small BGA	Large BGA	Turbo -prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn	• In service on 787, could be improved to provide further benefit on other aircraft • Greatest applicability to large/long-range aircraft • Fuel burn benefit determined from interview input from airframe OEMs • Fuel burn reduction mechanism: drag reduction	X[33]	+	-	-	=	+	+	+
		0.0%	*2.0%*	*0.5%*	*0.5%*	*1.3%*	*2.0%*	*2.0%*	*2.0%*
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*0%*	*4%*	*10%*	*20%*		
		Technical Feasibility	*80%*	*100%*	*100%*	*100%*	*100%*		
Cost Impact	• Used initial costs from ICF intellectual property (IP) (Aircraft Value Database), and assumed 20% additional unit cost to actuation and flight control system • 20% figure gained from interview input and ICF team consensus • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.1	$0.2	$0.1	$0.2	$0.2	$0.6	$0.8	$1.2
		Estimated Total NRE ($M) by Aircraft Category							
		$135	$180	$180	$180	$230	$270	$270	$270

[33] X: Technology doesn't apply to category for technical or economic reasons
+: Technology has maximum benefit of maximum for that category

Advanced Wingtip Devices

Wingtips devices are an effective way of increasing the lift-to-drag ratio of an aircraft. These can be winglets (single or split), or span extensions. Increasing the span or the vertical extent of the wing reduces the lift-induced drag by spreading the vorticity, weakening the adverse effect that this vorticity has on the rest of the wing. At the global level, this is expressed as a reduction in the kinetic energy associated with the vortex system. Adding wing tip devices also increases the lift, which improves field and climb performance. The penalty for adding a wing tip device is added viscous drag and weight. The degree to how much weight is added is highly dependent on how much margin there is in the structural design of the original wing. For an over-designed wing, it is possible to add wingtip devices with no structural reinforcement, but usually reinforcements are required in the rest of the wing.

The tradeoffs between extending the wing horizontally versus adding a winglet involve a careful multidisciplinary analysis. Aerodynamically, a wing horizontal extension is more effective in reducing the induced drag than an equivalent increase in the vertical extent of the wing. The fact that the equivalent horizontal extension can be made smaller for the same induced drag reduction further decreases the viscous drag penalty. However, the horizontal extension induces larger bending moments on the wing and thus leads to a heavier wing. This makes it more challenging to incorporate in a wing that has already been designed.

Given the trend to retrofit in-production aircraft with winglets, one must question why this was not done in the original design. After all, winglets are relatively mature technology. The reason has to do with the tradeoff between fuel burn and aircraft cost. Fuel burn depends on both weight and drag, but it is more sensitive to drag, while aircraft cost depends primarily on the weight and has no dependence on drag. Hence, as fuel prices increase, there is more incentive to decrease the fuel burn at the cost of a more expensive aircraft. This is a major factor when determining the optimal span and wingtip devices of an aircraft.

This trend can be seen in two of the most recent aircraft, the Boeing 787 and the Airbus 350, which exhibit significantly higher spans when compared to aircraft of the same weight. Further, the 777X is rumored to feature higher span wings, and Embraer just announced that they would extend the span of the E-175 (Caldas)

Gate code constraints play a major role in the decision of span and wingtip devices. It is no coincidence that the Airbus A350 has winglets while the Boeing 787 does not: the A350'span is just under the ICAO gate code E constraint, while the Boeing 787 is well under this constraint. An interesting note on this is

that the 777X is rumored to feature folding wingtips in order to increase its span while fitting in code E gates, further reinforcing the fact that we are now willing to trade higher penalties in weight and cost for lower drag and hence lower fuel burn.

The design of wing tip extensions is still progressing, as evidenced by the novel shape of the split winglets introduced by Boeing on the 737 MAX. Raked wingtip are also becoming more common and their shape is changing, as can be seen in the evolution of the original 777-200LR/300ER tips to the shape in the 787. Thus, further gains are expected from the shaping of wingtip devices.

	Sources	Small BGA	Large BGA	Turbo-prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn	• According to OEM statements, blended winglets realize 3-5% fuel burn improvements over non-winglet aircraft • New winglet technologies, such as split wingtips and Aviation Partners Boeing "Scimitar" winglets can yield 1-3% improvement compared to current generation winglet technologies • Winglets on 737MAX will offer 1-1.5% better fuel burn than 737NG blended winglets, depending on results of investigations into natural laminar flow	=	=	=	=	=	=	=	=
		3.5%	*3.5%*	*3.5%*	*3.5%*	*3.5%*	*3.5%*	*3.5%*	*3.5%*
				2013	**2018**	**2020**	**2023**	**2033**	
		Commercial Feasibility		1%	10%	14%	20%	50%	
		Technical Feasibility		80%	100%	100%	100%	100%	
Cost Impact	• Used publically available pricing and interview input to determine price of current technology winglets • Assumed next-generation winglets will have 10% increased price • NRE estimated based on interview input and some scaling relative to aircraft size • Advanced wingtip device NRE was used as a data point to scale other technology NREs	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.1	$0.2	$0.1	$0.2	$0.2	$0.6	$0.8	$1.2
		Estimated Total NRE ($M) by Aircraft Category							
		$105	$135	$135	$135	$175	$205	$205	$205

Adaptive Trailing Edge

The motivation for this technology is exactly the same as the one for the variable camber trailing edge described previously: to tailor the wing so as to minimize the drag at the various flight conditions. Instead of relying on hinged surfaces to alter the shape of the wing, morphing changes the shape of the structure continuously by using piezoelectric materials or by internal mechanisms. The result is a smooth variation in the shape with no need for gaps that would otherwise contribute to the overall drag. On the other hand, gaps are a desirable feature in the high-lift system (slats and flaps), since they enable higher maximum lift. This technology has been tested in the Boeing 737 ecoDemonstrator(Wilsey and Stoker).

The main tradeoff to be considered when employing morphing is whether the performance improvement is worth the added weight, cost, complexity and actuation energy. Morphing technology has been progressing in all these fronts and it is expected that this trade will become favorable at some point in the next 10 years. There are two possibilities to deploy the morphing trailing edge: one could have local morphing on the trailing edge or conventional moving surfaces to augment or replace the conventional adaptive trailing edge technology, or one could replace all control surfaces with morphing. The latter would have the advantage of eliminating the drag due to gaps, and it also allows for a finer control of the spanwise distribution of the trailing edge camber, which is very limited when using a conventional adaptive trailing edge.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• A full variable camber trailing edge would allow reduced structural weight due to load alleviation, as well as reduced control sizing and more efficient cruise configurations • Scaled benefit from adaptive trailing edge given aircraft OEM input and ICF team analysis • Fuel burn reduction mechanism: induced drag reduction	X	+	-	-	=	+	+	+
		0.0%	*3.0%*	*0.5%*	*0.5%*	*1.8%*	*3.0%*	*3.0%*	*3.0%*

	2013	2018	2020	2023	2033
Commercial Feasibility	*0%*	*0%*	*2%*	*3%*	*8%*
Technical Feasibility	*0%*	*0%*	*50%*	*100%*	*100%*

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Cost Impact	• Used initial costs from ICF IP (Aircraft Value Database), and assumed 50% additional unit cost to actuation and flight control system • 50% figure gained from ICF team consensus, and assumption of greater material and component costs in actuation system • Relative scaling "check" to reflect value of increased fuel savings • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.1	$0.2	$0.1	$0.2	$0.5	$1.5	$1.9	$3.0
		Estimated Total NRE ($M) by Aircraft Category							
		$135	$180	$180	$225	$280	$340	$340	$340

Riblet Coatings

Riblets are a pattern of tiny ridges that are aligned in the direction of the flow. They have been shown to reduce the skin friction due to a turbulent boundary layer by about 6.5% for the flight regime that is typical of commercial transport aircraft. Riblets work by reducing the turbulence at the surface in the direction perpendicular to the flow, reducing the skin friction drag. Although this is a well understood way of reducing skin frictiondrag, the issue with the use of this technology hinges on the cost of manufacturing, the curability in service and maintenance issues. Lufthansa Technik is currently researching riblet paint coatings (Gubisch). Given the increasing value of decreasing drag, there is a chance that this technology is deployed within the next 10 years.

	Sources	Small BGA	Large BGA	Turbo -prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Not currently in production, but has had concept validated • Potential issues with increased maintenance and cleaning costs, and practicality in field • Sources for information included publically available documents, secondary research, and confirmation from airframe OEM interview sources **(Gubisch)** • Fuel burn reduction mechanism: skin friction drag reduction	-	-	-	-	=	+	+	+
		0.5%	*0.5%*	*0.5%*	*0.5%*	*1.0%*	*1.5%*	*1.5%*	*1.5%*

	2013	2018	2020	2023	2033
Commercial Feasibility	*0%*	*0%*	*5%*	*10%*	*20%*
Technical Feasibility	*0%*	*25%*	*80%*	*100%*	*100%*

		Small BGA	Large BGA	Turbo -prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Cost Impact	• Riblet coatings would primarily affect manufacturing costs, after initial design NRE is performed to validate concept • Estimates from interviews/ICF team consensus • Unknown impact on maintenance costs • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.1	$0.2	$0.1	$0.2	$0.2	$0.6	$0.8	$1.2
		Estimated Total NRE ($M) by Aircraft Category							
		$135	$180	$180	$180	$230	$270	$270	$270

Natural Laminar Flow Control - Nacelle

Skin-friction drag is one of the primary sources of drag on an aircraft, usually accounting for just over 50% of the total drag at cruise. As mentioned previously, this drag is due to the friction caused by the boundary layer. Boundary layers can be either laminar or turbulent, and the former generate less friction, and thus lower drag. Laminar boundary layers are also thinner, contributing to a decrease in pressure drag as well. Due to the combination of high speed and scale of the aircraft, the boundary layers on transport aircraft all almost completely turbulent. It is particularly difficult to achieve a laminar boundary layer in this flow regime through passive means, especially in lifting surfaces that are swept. Although they start as laminar at the leading edges, they will quickly transition to turbulent unless the right technology is used.

Natural laminar flow (NLF) relies solely on the careful design of the aerodynamic shape so as to delay the transition of the boundary layer from laminar to turbulent as much as possible. This technology has been used in high-performance sailplanes for several decades, but the higher the speed and the longer the dimensions, the more difficult it is to achieve. Furthermore, wing sweep has an adverse effect. As a result, NLF is currently not feasible on wings of commercial transports flying at high subsonic speeds.

However, recent progress has made it possible to achieve NLF for a significant portion of engine nacelles, as is the case in the Boeing 787. NLF requires especially tight manufacturing tolerances as well as attention to the paint material and thickness. The 777X will also feature nacelles with NLF. (CITE Boeing PAS Widebody presentation).

	Sources	Small BGA	Large BGA	Turbo-prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Portion of 787 nacelle was designed for natural laminar flow, but full potential benefit is not currently being realized **(Norris, Boeing Plans Plain Grey Natural Laminar Flow Nacelles for 787s in Bid to Reduce Fuel Burn)** • Natural laminar flow easier to design into lower speed aircraft (regional jets, turboprops) • Interviews indicated <0.5% fuel burn benefit realized on 787, estimates scaled from that data point and internal team analysis • Fuel burn reduction mechanism: skin friction drag reduction	-	-	+	+	=	=	=	=
		0.1%	*0.1%*	*1.0%*	*1.0%*	*0.6%*	*0.6%*	*0.6%*	*0.6%*

	2013	2018	2020	2023	2033
Commercial Feasibility	*0%*	*0%*	*1%*	*3%*	*8%*
Technical Feasibility	*80%*	*100%*	*100%*	*100%*	*100%*

	Sources	Small BGA	Large BGA	Turbo-prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Cost Impact	• Used initial costs from ICF IP (Aircraft Value Database), and assumed 75% additional unit cost to nacelle • 75% estimate created from ICF team consensus, and assumption of greater design NRE and material finishing/processing costs • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment • Assumed much greater design/engineering NRE in the form of aerodynamic analysis, as well as additional testing to validate concept	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.2	$1.0	$0.1	$1.0	$1.1	$3.1	$3.4	$4.1
		Estimated Total NRE ($M) by Aircraft Category							
		$265	$355	$355	$310	$390	$470	$470	$470

Hybrid Laminar Flow Control – Empennage

As mentioned above, it is possible to achieve a significant amount of NLF on nacelles. However, the boundary layer will eventually transition when the streamwise distance is long enough. To increase the extent of laminar flow beyond what is possible with the passive means of NLF, or to ensure laminar flow with an adverse shape or flight condition, it is possible to use hybrid laminar flow control (HLFC).

HLFC uses suction to delay the transition from laminar to turbulent and thus create areas with a laminar boundary layer. This technology has been tested for the 787-9 vertical tail and will represent the first commercial application of HLFC. Usually, the suction is created by mechanical means and requires a source of power. The patent filed by Boeing seems to show a system that does not require mechanical power: it sucks the boundary layer in through tiny holes in the skin to a plenum, or hollow chamber, inside the leading edge vertical tail that is then connected to an area of lower pressure elsewhere. This reduces the complexity of the system and eliminates the power requirement, making it commercially more viable.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Public sources indicate implementation on very small portion of vertical stabilizer would yield ~0.5% fuel savings on 787-9, assumed that application to larger area of empennage would be possible • Possible issues with practicality (HLFC requires small ports in aircraft skin that may become frequently clogged in practice) • Fuel burn reduction mechanism: skin friction drag reduction	-	-	-	-	=	+	+	+
		0.3%	*0.3%*	*0.3%*	*0.3%*	*1.4%*	*2.5%*	*2.5%*	*2.5%*

	2013	2018	2020	2023	2033
Commercial Feasibility	*0%*	*3%*	*6%*	*10%*	*20%*
Technical Feasibility	*0%*	*80%*	*100%*	*100%*	*100%*

		Estimated Unit Cost Increase ($M) by Aircraft Category							
Cost Impact	• Used initial costs from ICF IP (Aircraft Value Database), and assumed 25% additional unit cost to empennage • 25% estimate created from ICF team consensus, and assumption of greater design NRE and greater system costs • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment	$0.4	$1.4	$0.8	$1.2	$1.6	$6.0	$6.9	$7.6
		Estimated Total NRE ($M) by Aircraft Category							
		$265	$355	$355	$310	$390	$470	$470	$470

Hybrid Laminar Flow Control – Nacelle

As mentioned above, it is possible to achieve a significant extent of NLF on nacelles. However, there might be desirable to increase the extent of laminar flow even further than it is possible with passive means. Given the possible application of HLFC to the empennage of the 787-9, and as this technology matures, it is likely that this will be applied to other components of the aircraft, including nacelles. The application to wings, however, remains a very challenging proposition for the reasons that were already mentioned.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fuel burn benefit depends on degree of implementation, this assumes implementation on as much of the nacelle as practical/cost effective • Public sources indicate implementation on small area of vertical stabilizer would yield ~0.5% fuel savings on 787-9, this data was scaled to nacelle implementation area and confirmed through aircraft OEM & aerodynamics expert interview input • Fuel burn reduction mechanism: skin friction drag reduction	-	-	-	-	=	+	+	+
		0.1%	*0.1%*	*0.1%*	*0.1%*	*0.7%*	*1.3%*	*1.3%*	*1.3%*

	2013	2018	2020	2023	2033
Commercial Feasibility	*0%*	*3%*	*6%*	*10%*	*20%*
Technical Feasibility	*0%*	*80%*	*100%*	*100%*	*100%*

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Cost Impact	• Used initial costs from ICF IP (Aircraft Value Database), and assumed 75% additional unit cost to nacelle • 75% estimate created from ICF team consensus, and assumption of greater design NRE and greater system costs • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment • Assumed much greater design/engineering NRE in the form of aerodynamic analysis, as well as additional testing to validate concept	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.1	$0.3	$0.1	$0.3	$0.4	$1.0	$1.2	$1.4
		Estimated Total NRE ($M) by Aircraft Category							
		$265	$355	$355	$270	$335	$405	$405	$405

Advanced Metallic Technologies – Al-Li, etc.

Although the use of carbon reinforced composite materials in primary structures has increased dramatically, and is seen as the way of the future, metal manufacturers have developed new metal alloys to remain competitive in the airframe material market. The most prominent of these new alloys is aluminum lithium (Al-Li), which is less dense than standard aluminum alloys, more durable, and less susceptible to corrosion. Alcoa claims that the use of Al-Li can reduce the aircraft structural weight by 10%. However, this alloy is currently much more expensive than conventional aluminum, and the manufacturing process is different enough from that of standard alloys that previous tooling cannot be reused. Bombardier selected Al-Li for the fuselage of the CSeries, and Boeing is rumored to be considering it for the fuselage of the 777X. In the future, we can also expect even more advanced metal technologies, including hybrid materials that combine metals with non-metallic fibers. Titanium-graphite hybrid composites, for example, promise to save weight in heavy attachment areas in the primary structure.

	Sources	Small BGA	Large BGA	Turbo -prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Technical challenges associated with increasing Al-Li raw material production, but technical feasibility will increase quickly with new facility investment taking place • Commercial feasibility remains low due to low cost/benefit for direct material substitution • Assumes direct material substitution, which gives 1-3% weight benefit vs. conventional Al alloys • Sources for fuel burn benefit include interviews with raw material OEMs and a previous comprehensive ICF study on the lifecycle costs and performance benefits of advanced metallic vs. composites • Fuel burn reduction mechanism: weight reduction	-	-	-	-	-	+	+	+
		1.0%	*1.0%*	*1.0%*	*1.0%*	*1.0%*	*2.0%*	*2.0%*	*2.0%*
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*3%*	*4%*	*5%*	*10%*		
		Technical Feasibility	*25%*	*100%*	*100%*	*100%*	*100%*		
Cost Impact	• Costs developed from bottom's up model of aerostructures manufacturing costs by material from previous ICF study • Assumed direct material substitution for density-based weight savings, and used estimated Al-Li per pound material pricing • Assumed very little NRE required for direct material substitution (assuming material is qualified)	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.5	$1.9	$1.0	$1.7	$2.3	$6.0	$10.6	$13.0
		Estimated Total NRE ($M) by Aircraft Category							
		$50	$50	$100	$100	$200	$200	$200	$200

Titanium Landing Gear

Traditionally, commercial aircraft landing gear have been made from steel. Steel is a heavy, but strong, metal, and large steel forgings are using for landing gear main beams and supporting braces. Titanium is much lighter than steel (up to 45% lighter for equivalent strength). It is also more resistant to corrosion. These properties, however, come with a steep price penalty, as titanium can be three to four times more expensive than titanium, by weight.

Titanium landing gear have long been found in military aircraft, but have only started to be incorporated recently in select large commercial aircraft. The 777 was the first aircraft to incorporate Ti landing gear, followed by new-generation aircraft such as the 787 and A350. Although there are no examples yet of titanium landing gear being retrofitted, it is conceivable that they could be applied to other aircraft categories as partof a block upgrade package.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Obtained current landing gear system prices from ICF Aircraft Value Database • Fuel burn reduction mechanism: weight reduction	-	-	-	-	=	+	+	+
		0.5%	*0.5%*	*0.5%*	*0.5%*	*1.3%*	*2.0%*	*2.0%*	*2.0%*
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*5%*	*7%*	*10%*	*20%*		
		Technical Feasibility	*80%*	*100%*	*100%*	*100%*	*100%*		
Cost Impact	• Obtained current landing gear system prices from ICF Aircraft Value Database • Assumed material/machining costs were 40% of total landing gear system price, and assumed this portion of total cost would increase proportionally to ratio of titanium/steel material prices (gives a price increase of 3X) • To fully take advantage of new material, redesign of landing gear would be required, so NRE reflects this	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.2	$0.8	$0.6	$0.6	$1.2	$3.6	$4.2	$7.2
		Estimated Total NRE ($M) by Aircraft Category							
		$105	$135	$135	$135	$175	$205	$205	$205

Lightweight Lightning Strike Protection

Aircraft are struck by lightning every 1,000 to 3,000 flight hours, on average (Black). This is an average of more than once per year for air transport aircraft. This is Traditional aircraft with metallic primary aerostructures can easily deal with lightning strikes, since the fuselage provides a natural conduit for the high current caused by a lightning strike. Since composite aircraft skins are poor conductors, a lightning strike to a carbon fiber or other composite part could result in significant structural heat damage and costly repairs, or more significant damage that could compromise the safety of the aircraft in flight. Thus, composite aircraft utilize several methods to account for this problem. Often, a thin metal foil or copper mesh is placed below the first layer of composite laminate, which provides an electrical conduit around the fuselage, and prevents any excessive heating or burn-through. These methods, however, are accompanied by a weight penalty, which can be quite significant.

Because of this weight penalty, many suppliers are looking for alternative methods to increase conductivity of composite structures, including metallic fibers interwoven with composite weave, conductive spray coatings, and other solutions. These have the potential to take a few percent of weight out an aircraft with composite primary aerostructures.

	Sources	Small BGA	Large BGA	Turbo-prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Applies only to composite aircraft • Fuel burn reduction mechanism is weight reduction	=	=	=	=	=	=	=	=
		0.5%	*0.5%*	*0.5%*	*0.5%*	*0.5%*	*0.5%*	*0.5%*	*0.5%*
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*6%*	*7%*	*10%*	*20%*		
		Technical Feasibility	*0%*	*80%*	*100%*	*100%*	*100%*		
Cost Impact	• Unit cost data from bespoke ICF study on advanced (Lightning Strike Protection) LSP concepts • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.2	$0.8	$0.6	$0.6	$1.2	$3.6	$4.2	$7.2
		Estimated Total NRE ($M) by Aircraft Category							
		$105	$135	$135	$135	$175	$205	$205	$205

More Electric Systems – Weight Reductions

Many modern aircraft have begun replacing mechanical equipment with electrical systems. These design philosophies are collectively known as the "more electric aircraft" paradigm. Specific examples of "more electric" designs and technologies include:

- higher pressure hydraulic systems that enable reduced conveyance equipment weight
- replacement of pneumatics with electric systems, allowing the removal of ducting and tubing weight
- electric actuation, especially for secondary, utility and backup actuation systems
- utilizing electric anti-ice systems, where possible

Many new aircraft are incorporating various elements of this design philosophy, especially in the actuation system. Air transport and large business aircraft generally have at least three redundant actuation and hydraulic systems for safety reasons. Many large air transport aircraft incorporate electric or electro-hydrostatic backup actuation systems. Electric brake actuation is becoming more common on new generation aircraft, such as the 787 and C-Series.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Further refinements to more electric systems, including high pressure hydraulic systems, electric bleed air control, elimination of one hydraulic system, Includes electric ECS, electric anti-ice; electric hydraulic pumps; electric primary, secondary, and high lift actuation; electric brake actuation • Fuel burn reduction mechanism: weight reduction	=	=	=	=	=	+	+	+
		1.2%	*1.2%*	*1.2%*	*1.2%*	*1.2%*	*2.0%*	*2.0%*	*2.0%*
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*3%*	*6%*	*10%*	*20%*		
		Technical Feasibility	*0%*	*100%*	*100%*	*100%*	*100%*		
Cost Impact	• Assumed that using more electric systems to reduce weight results in substantial increases in unit costs due to both NRE and use of more expensive components • Assumed resultant cost increases of approximately 2% of realized aircraft price • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.20	$0.80	$0.50	$0.60	$0.90	$2.60	$3.30	$3.90
		Estimated Total NRE ($M) by Aircraft Category							
		$105	$135	$135	$135	$175	$205	$205	$205

ECS Aerodynamic Cleanup and On-Demand ECS Scheduling

The environmental control system (ECS) of an aircraft provides air supply, thermal control and cabin pressurization for the crew and passengers. Avionics cooling, smoke detection and fire suppression are also commonly considered part of an aircraft's environmental control system. The Boeing 787 and Airbus A350 have made both aerodynamic and power-saving improvements to the ECS system (Sinnett). The inlet and outlet ducts to the system's compressor have been optimized to reduce the pressure drag. In addition, on-demand ECS scheduling now allows engines to power the system only when needed as opposed to an entire flight (Boeing Co.).

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fuel burn reduction mechanism is drag reduction (**(Thomson)**	=	=	=	=	=	=	=	=
		0.6%	*0.6%*	*0.6%*	*0.6%*	*0.6%*	*0.6%*	*0.6%*	*0.6%*
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*20%*	*28%*	*40%*	*80%*		
		Technical Feasibility	*80%*	*100%*	*100%*	*100%*	*100%*		
Cost Impact	• Assumed that refining ECS system would result in minor charges equal to 0.25% of realized aircraft sale price • Changes are mainly from amortized NRE and additional control electronics • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment • NRE is aerodynamics and software design engineering	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.1	$0.1	$0.1	$0.1	$0.1	$0.3	$0.4	$0.5
		Estimated Total NRE ($M) by Aircraft Category							
		$40	$50	$50	$50	$65	$75	$75	$75

Lighter Aircraft Interiors

Airplane seats, bathrooms, kitchens, and cabin bins are a large portion of aircraft interiors. Companies like Rockwell Collins and Zodiac Aerospace have been designing lighter furnishings to help decrease aircraft takeoff weight while maintaining size. Even smaller interior components such as flight manuals have been replaced by more efficient Electronic Flight Bags (EFB's). There have also been some initiatives towards replacing traditional electronic entertainment systems with mobile devices and using wireless streaming, which would not only reduce the weight (in both the device and the wiring), but reduce energy consumption as well. With a lighter plane, less fuel is burned because of a lower lift and thus lower induced drag, which translates into lower thrust. Alternatively, airlines can replace the saved weight with payload.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fuel burn reduction mechanism: weight reduction	-	-	-	-	=	+	+	+
		1.0%	*1.0%*	*1.0%*	*1.0%*	*2.0%*	*3.0%*	*3.0%*	*3.0%*
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*20%*	*28%*	*40%*	*80%*		
		Technical Feasibility	*80%*	*100%*	*100%*	*100%*	*100%*		
Cost Impact	• Baseline aircraft interiors costs obtained from ICF aircraft value database • Assumed that interiors were made lighter through heavy use of composites, resulting in over 100% increase in material/processingcosts • This results in 50% increase in total aircraft interiors cost • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment • Relatively low NRE involved in seat/galley/interiors design and certification	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.1	$0.3	$0.5	$0.5	$1.0	$4.6	$5.5	$8.4
		Estimated Total NRE ($M) by Aircraft Category							
		$105	$135	$135	$95	$120	$140	$140	$140

Fuel Cell APU Replacement

Aircraft auxiliary power units (APUs) are small gas turbine engines used to provide electrical power, air conditioning, hydraulic power, and pneumatic power both on the ground as a backup in flight. Several companies are conducting research to enable APUs to be replaced with fuel cells. Fuel cells take advantage of a chemical reaction of some hydrogen-based compounds with air to produce electricity. While this would likely not produce a direct weight reduction benefit, fuel cell APUs are an important element to enable further development of the "more electric aircraft" architecture discussed earlier in the report, as well as reducing fuel consumption and emissions for ground operations. Fuel cell APUs would have many ancillary benefits, including production of nitrogen as a byproduct, which could be used for the fuel tank inerting system. Fuel cells also produce water as a byproduct of the chemical reaction, which would allow airlines to begin a flight with less stored water for lavatories, further reducing weight (Breit).

	Sources	Small BGA	Large BGA	Turbo-prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fuel burn benefit estimate from interview with Tier 1[34] systems supplier • Many ancillary benefits to fuel cell APU, but probably will have little effect on *cruise* fuel burn	=	=	=	+	+	-	-	-
		0.0%	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*0%*	*0%*	*20%*	*45%*		
		Technical Feasibility	*0%*	*0%*	*0%*	*25%*	*100%*		
Cost Impact	• Fuel cell APU cost information obtained from interviews with Tier 1 aircraft system OEM involved in fuel cell research • Fuel cell APUs are projected to be less expensive to manufacture • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
		Estimated Total NRE ($M) by Aircraft Category							
		$135	$180	$180	$180	$230	$270	$270	$270

[34] Tier 1 suppliers are companies that provide major systems and usually have design authority.

Control Surface – Optimal Control Laws for Horizontal Stabilizer Trim

Maintaining trimmed flight efficiently requires clean, accurate, and dynamic control laws. There is room for improvement with contemporary control systems with regards to overshoot, rise time, and steady-state error. This technology complements the adaptive trailing edge technology, since if the trailing edge geometry changes, the trim settings should change at the same time.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Reduces trim drag • Fuel burn reduction estimate from airframe OEM interview, and team expert input • Fuel burn reduction mechanism: reduced induced/trim drag	**X**	=	=	=	=	=	=	=
		0.0%	*0.4%*	*0.4%*	*0.4%*	*0.4%*	*0.4%*	*0.4%*	*0.4%*
			2013		**2018**	**2020**		**2023**	**2033**
		Commercial Feasibility	*0%*		*10%*	*14%*		*20%*	*75%*
		Technical Feasibility	*25%*		*100%*	*100%*		*100%*	*100%*
Cost Impact	• Costs associated with new control laws are mainly in software development and new certification costs • Assumed 0.25% premium in aircraft realized price • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.0	$0.1	$0.1	$0.1	$0.1	$0.3	$0.4	$0.5
		Estimated Total NRE ($M) by Aircraft Category							
		$105	$135	$135	$135	$175	$205	$205	$205

Fly-By-Wire

Historically, aircraft flight controls have been actuated through a direct linkage between cockpit flight controls and the control surface actuators. This involves lengthy stretches of steel cable, pushrods, and linkages, which add weight to the aircraft. Fly-by-wire systems, on the other hand, use electrical signals to transfer inputs from the pilot's controls to control surface actuators. This approach removes much of the cabling, but requires very expensive design and certification efforts.

	Sources	Small BGA	Large BGA	Turbo-prop	Regional Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fly by wire weight savings available through secondary research and publically available documents • Translation from weight savings to fuel savings made from ICF previous project experience • Fuel burn reduction mechanism: weight savings	**X**	=	-	-	=	=	=	=
		0.0%	*0.4%*	*0.2%*	*0.2%*	*0.4%*	*0.4%*	*0.4%*	*0.4%*
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*20%*	*28*	*40%*	*80%*		
		Technical Feasibility	*80%*	*100%*	*100%*	*100%*	*100%*		
Cost Impact	• These costs (and benefit) represent installing fly-by-wire in limited applications in originally non fly-by-wire aircraft (rudder, spoilers, partial primary control surfaces) • Assumed 0.5% premium in aircraft realized price • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment • Primary NRE costs are certification, to a lesser extent software development costs	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.1	$0.2	$0.1	$0.2	$0.2	$0.7	$0.8	$1.0
		Estimated Total NRE ($M) by Aircraft Category							
		$265	$355	$355	$270	$335	$405	$405	$405

Gap Reductions & Aerodynamic Cleanup on Slats/Spoilers/Ailerons/ etc.

Hinged control surfaces such as ailerons, elevators and rudders, leave gaps on the aerodynamic surface that need to be sealed as much as possible to reduce drag. While some effort has been made to minimize this type of drag, this is an area of continuous improvement.

Spoilers and slats also incur some drag if their trailing edges are not perfectly flush with the shape of the wing. By making these trailing edges thinner, this source of drag can be reduced, as demonstrated in a recent next-generation 737 performance improvement package (Tesch, Next-Generation 737 Fuel Performace Improvement).

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Basic aerodynamic cleanup on control surfaces and across aircraft **(Thomson)** • Fuel burn estimate from ICF team analysis • Fuel burn reduction mechanism: drag reduction	-	-	=	=	=	=	=	=
		0.1%	*0.1%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*

	2013	**2018**	**2020**	**2023**	**2033**
Commercial Feasibility	*0%*	*25%*	*35%*	*50%*	*90%*
Technical Feasibility	*80%*	*100%*	*100%*	*100%*	*100%*

		Estimated Unit Cost Increase ($M) by Aircraft Category							
Cost Impact	• Assumed minor changes resulted in 0.25% increase in aircraft realized price • Majority of unit change costs are production related, not amortized NRE • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment • Low NRE costs, mostly related to aerodynamic analysis	$0.0	$0.1	$0.1	$0.1	$0.1	$0.3	$0.4	$0.5
		Estimated Total NRE ($M) by Aircraft Category							
		$40	$50	$50	$50	$65	$75	$75	$75

Reducing Profiles of Lights, Antennae, Sensors, etc.

Although the additional the lights, antennae and sensors protruding from the aircraft have relatively small dimensions, they can collectively add up to a significant amount of drag. It is well known that circular cross sections (such as those used in some anti-collision lights) exhibit a drag that is ten times higher of that of a streamlines shape with the same width. Therefore, several in-production aircraft have modified these details for in-production aircraft (Tesch, Next-Generation 737 Fuel Performace Improvement), (Caldas). Although the drag reductions are modest, they are generally low cost modifications.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fuel burn estimates developed from ICF team estimates and checked by interview input from airframe OEM • Fuel burn reduction mechanism: reduced excrescence drag	=	=	=	=	=	=	=	=
		0.2%	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*
			2013	**2018**		**2020**	**2023**		**2033**
		Commercial Feasibility	*0%*	*25%*		*35%*	*50%*		*95%*
		Technical Feasibility	*80%*	*100%*		*100%*	*100%*		*100%*
Cost Impact	• Assumed minor changes resulted in 0.25% increase in aircraft realized price • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment • Very low NRE costs, related to suppliers changing production standards and documentation	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.0	$0.1	$0.1	$0.1	$0.1	$0.3	$0.4	$0.5
		Estimated Total NRE ($M) by Aircraft Category							
		$5	$5	$5	$5	$10	$10	$10	$10

Carbon/Ceramic Brakes

Aircraft brake friction material has historically been made out of steel. Newer carbon/ceramic brake material is much lighter, as well as more wear-resistant. Ceramic brakes are easily retrofitted onto new in-production aircraft, and in fact are optional for most single aisle aircraft, and standard on twin aisle and large aircraft. For those aircraft that do not currently offer ceramic brakes, they can be installed with minimal recertification and testing effort.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fuel burn reduction mechanism is through reduced weight **(Milller, Allen and Preston)** • Weight savings estimates available from public documents	-	-	=	=	=	=	=	=
		0.1%	*0.1%*	*0.3%*	*0.3%*	*0.3%*	*0.3%*	*0.3%*	*0.3%*
			2013		**2018**	**2020**		**2023**	**2033**
		Commercial Feasibility	*0%*		*20%*	*28%*		*40%*	*80%*
		Technical Feasibility	*80%*		*100%*	*100%*		*100%*	*100%*
Cost Impact	• Changing brake material results in 0.25% increase in aircraft realized price • Change is due to increased material and production costs of carbon ceramics, compared to traditional steel brakes • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment • NRE costs are related to testing and qualification of the new material's strength and wear characteristics	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.0	$0.1	$0.1	$0.1	$0.1	$0.3	$0.4	$0.5
		Estimated Total NRE ($M) by Aircraft Category							
		$70	$95	$95	$50	$65	$75	$75	$75

Aft Body Redesign for Aerodynamics

There is room for aerodynamic improvements on the aft body of many contemporary aircraft. Understandably, the majority of aerodynamic analysis and design effort targets the wings. However, with recent skyrocketing fuel prices, opportunities for drag reduction on non-lifting parts such as the fuselage have also become a focus of aircraft OEMs. This has been seen on the 737 MAX (Boeing Co.)

For in-production aircraft, it is not feasible to perform a major redesign of the aft body, but it is possible to make modifications on the existing shape. The area where the horizontal and vertical tails join the fuselage is particularly critical when it comes to interference drag, and is a good target for redesign.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fuel burn benefit estimated from publically announcements about 737MAX fuel burn reduction technologies (**(Boeing Co.)** • Fuel burn reduction mechanism: induced drag reduction	-	=	=	=	=	=	=	=
		1.0%	*1.3%*	*1.3%*	*1.3%*	*1.3%*	*1.3%*	*1.3%*	*1.3%*
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*20%*	*28%*	*40%*	*80%*		
		Technical Feasibility	*50%*	*100%*	*100%*	*100%*	*100%*		
Cost Impact	• Significant design and production change for an aircraft program • ICF estimated that this would result in a 2% increase in realized price • Cost increase data scaled relatively to other known modification and checked through interview feedback • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment • Significant NRE related to design and changing production process	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.2	$0.8	$0.5	$0.6	$0.9	$2.6	$3.3	$3.9
		Estimated Total NRE ($M) by Aircraft Category							
		$170	$225	$225	$225	$280	$340	$340	$340

Composites – Current State, Increased Application

Decreasing aircraft weight without compromising drag is a sure way of reducing aircraft fuel burn. Composite materials have been known for decades and have been used in military airplanes for a long time, and exhibit strength to weight ratios higher than those of metals. However, composites have only recently been used in the primary structures of commercial transport aircraft (in the Boeing 787 and the Airbus A350). In spite of the knowledge gained over the years in the military applications, the current generation of composite structures in these new commercial aircraft has much room for improvement. For both airplanes, the predicted weight advantages of composites have not been fully realized and there have been growing pains in the development of these structures. This is due in part to complications in the fastening of the various parts (especially when interfacing composite parts with metal ones) and also due to the use of conservative design procedures to mitigate the risks in using a new material. Design and manufacturing techniques that enable a more detailed tailoring of the composite ply angles have the potential to reduce the weight further. There is room for improvementwhen it comes to reducing the cost of manufacturing composites. In addition to the weight reduction, composites a much less susceptible to corrosion and should reduce the maintenance cost in the long run. Finally, composites enable more freedom in the manufacture shape, which could improve the aerodynamics ofwings.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fuel burn benefit information came from detailed ICF study on enabling technologies for both weight reduction and cost of composites	-	-	-	-	=	+	+	+
		0.5%	0.5%	0.5%	0.5%	1.3%	2.0%	2.0%	2.0%
			2013	**2018**	**2020**	**2023**	**2033**		
		Commercial Feasibility	*0%*	*20%*	*28%*	*40%*	*80%*		
		Technical Feasibility	*50%*	*100%*	*100%*	*100%*	*100%*		
Cost Impact	• ICF estimated that manufacturing costs would remain the same, but NRE would be needed to develop and implement new production systems • NRE estimated from relative scaling	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		-	-	-	-	-	-	-	-
		Estimated Total NRE ($M) by Aircraft Category							
		$200	$270	$270	$270	$335	$405	$405	$405

Lightweight Paint/Surface Treatments

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fuel burn reduction information from ICF team analysis and secondary research • Fuel burn reduction mechanism: weight reduction	=	=	=	=	=	=	=	=
		0.2%	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*
			2013	**2018**		**2020**		**2023**	**2033**
		Commercial Feasibility	*0%*	*10%*		*14%*		*20%*	*40%*
		Technical Feasibility	*0%*	*100%*		*100%*		*100%*	*100%*
Cost Impact	• ICF estimated that this would not result in an increase in realized aircraft price • Cost increase data scaled relatively to other known modification and checked through interview feedback • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
		Estimated Total NRE ($M) by Aircraft Category							
		$70	$95	$95	$95	$120	$140	$140	$140

Zonal Drying

Zonal drying systems act to remove moisture that accumulates in the aircraft insulation after a series of flights. The interior of an aircraft is usually kept at a very low humidity to reduce the risk of corrosion. Due to the cold exterior skin of an aircraft at cruise, remaining moisture tends to condense and accumulate on the interior of the aircraft skin, and then gets trapped in the adjacent insulation blankets. Over time, this accumulated water adds a significant amount of weight to the aircraft, which negatively affects performance and fuel burn. Zonal drying systems are targeted dehumidifiers that expel this excess water from the aircraft. This weight decrease is hard to quantify, since it will not change any certificated weights, such as operating empty weight or maximum takeoff weight. It will, however, reduce real-world fuel burn in operation, which is why ICF felt it important to include.

	Sources	Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Fuel Burn Applicability	• Fuel burn benefit from derived from public sources regarding weight savings potential, interview input from airlines currently using zonal dryers, and ICF analysis • Fuel burn reduction mechanism: weight savings	=	=	=	=	=	=	=	=
		0.2%	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*	*0.2%*

	2013	2018	2020	2023	2033
Commercial Feasibility	*0%*	*10%*	*14%*	*20%*	*40%*
Technical Feasibility	*80%*	*100%*	*100%*	*100%*	*100%*

		Small BGA	Large BGA	Turbo -prop	Region al Jet	Single Aisle	Small Twin	Large Twin	Large Quad
Cost Impact	• Significant design and production change for an aircraft program • ICF estimated that this would not result in a 0.25% increase in realized aircraft price • Cost increase data scaled relatively to other known modification and checked through interview feedback • NRE estimates scaled relatively from known data points on program NRE scale according to ICF team judgment	**Estimated Unit Cost Increase ($M) by Aircraft Category**							
		$0.0	$0.1	$0.1	$0.1	$0.1	$0.3	$0.4	$0.5
		Estimated Total NRE ($M) by Aircraft Category							
		$70	$95	$95	$95	$120	$140	$140	$140

2.3 TECHNOLOGY DEVELOPMENT COST

In the following subsection are examples of the types of data points and accompanying analysis that were used to validate theICF cost curves.

As noted above, ICF relied on non-public information to develop its analysis. However, the publicly available data inputs corroborate our results.

767-300 Winglet

Situation / Facts

- 767-300 winglets were developed by Aviation Partners Boeing and entered service in 2008
- These winglets deliver 4.0-5.8% fuel burn improvement
- ICF estimates NRC of $250M for a 4% improvement
- 767-300 winglet shipset list price is $2.35M (excluding installation cost)
- 767-300 fleet in 2005 was 557 AC and was growing by 10 per year

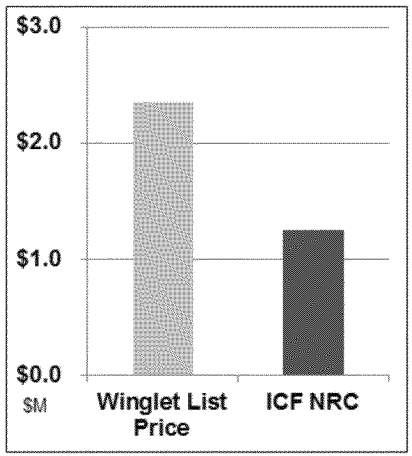
Assumptions

- A reasonable business case would only assume partial penetration of the fleet
- ICF assumed 25% penetration (139 AC)

Results

- ICF estimates winglet per shipset NRC is ~$1.2M - about 50% of list price

Per Shipset Price / Cost



At 50% of list price, ICF per shipset NRC leaves room for hardware cost and manufacturer profit

757-200 Winglet

Situation / Facts

- 757-200 winglets were developed by Aviation Partners Boeing and entered service in 2005
- These winglets deliver 3.5-5.2% fuel burn improvement
- ICF estimates $150M NRC for 3.5% improvement
- 757-200 winglet shipset list price is $1.1M (excluding installation cost)
- 757-200 fleet in 2005 was 1,016 AC and production had ceased in 2004

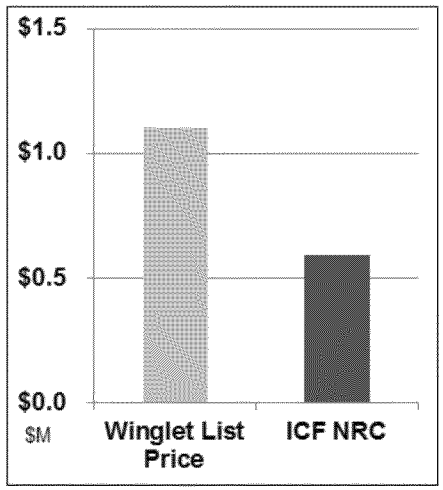
Assumptions

- A reasonable business case would only assume partial penetration of the fleet
- ICF assumed 25% penetration (254 AC)

Results

- ICF estimates winglet per shipset NRC is ~$0.6M - 50% of list price

Per Shipset Price / Cost



At 50% of list price, ICF per shipset NRC leaves room for hardware cost and manufacturer profit

Aviation Partners Boeing engineering employment

Situation / Facts

- In 2008, Aviation Partners Boeing had 100 people involved in product design and development activities
- At the time, they were likely working on two narrowbody winglets and one widebody winglet
- Average US aerospace engineering salary was $100K/year in 2013
- Overhead allocation for engineering-focused organizations ranges from 150-300%
- Per ICF NRC analysis, engineering and integration is 55% of Large Incremental Update NRC
- ICF estimates $150M NRC for 3.5% improvement

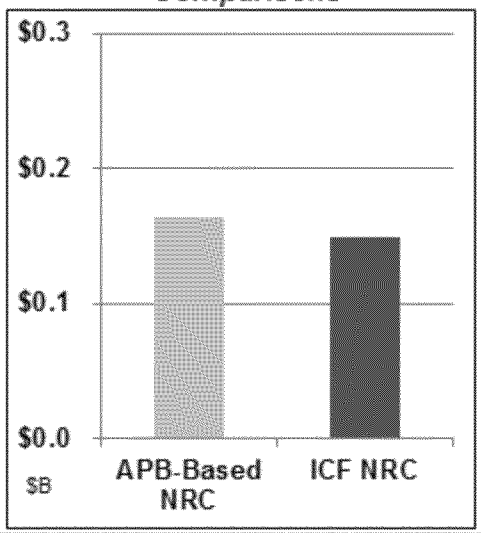
Assumptions

- $100K average salary at a 300% overhead burden rate (conservative)
- 3 year development period for each winglet design and all development staff 100% focused on one design (very conservative)
- Single Aisle Large Incremental Update (winglet) NRC cost structure – 55% Engineering, 40% Test, and 5% Tooling

Results

- Total design, development, and integration cost of $90M
- Implies total NRC of $164M

Single Aisle Large Incremental Update (Winglet) NRC Comparisons



Conservative analysis of APB disclosures results in a NRC similar to that of the ICF data points

GE90-115B PIP

Situation / Facts

- GE has steadily improved the GE90-115B from 2004-2011
- "GE ***and program partners combined*** have spent average of $50M per year to improve GE90-115B, ***including many improvements for reliability and maintenance cost"***
- From simple analysis of stated improvements, likely that 1/3 to ½ of improvements were actually to improve maintainability, cost, or durability
- Investments yielded 3.6% improved fuel burn over 7 years (possibly fewer)
- ICF cost estimates indicate $506M to achieve a 3.5% MV reduction on the 777-300ER

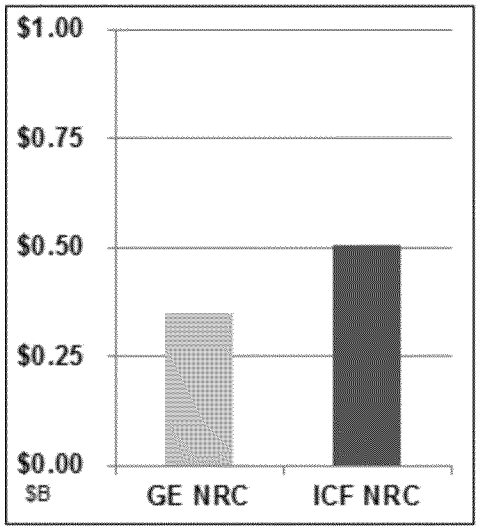
Assumptions

- 100% of stated cost was used for fuel burn-reducing technologies (conservative)

Results

- $350M total investment ($50M/yr over 7 years) is lower than ICF estimate

GE90-115B NRC Comparisons



GE NRC is known to include spend for items other than fuel burn improvements

737NG PIP

Situation / Facts

- 737NG PIP implemented between 2011 and 2013 improved fuel economy ~2%
- Aerodynamic improvements (~1%)
- Redesigned ECS exhaust inlet, wheel well fairings, control surface aerodynamics efficiency improvements, and streamlined engine nozzle and nacelle
- CFM56-7B Evolution (>1%)
- ICF estimates $100M NRC for a 2% improvement to the 737NG family

Analysis

- A 2% fuel savings has an net present value to airline operators of approximately +$1.4M over the aircraft lifetime
- Boeing's giveaways apply to complete 737 PIP

Results

- Some value-creating incremental technologies are being given away for free

"We can validate its improvement through each delivery flight performance monitoring and also daily flight operations monitoring to the extent of more than 2 percent fuel mileage improvement."
– Takeshi Katsurada, Japan Airlines
VP Flight Operations Engineering

"Best of all, PIP is offered to all of our customers at no extra charge"
– Randy Tinseth, Boeing Commercial Airplanes
VP Marketing

Technologies that are given away for free are unlikely to involve high development costs

3 BIBLIOGRAPHY

"Analysing the options for 757 replacement." *Aircraft Commerce* 42 (2005): 6.

Aviation Partners Boeing. "Split Scimitar Winglets." 2013. *Aviation Partners Boeing.* Document. 5 June 2013.

Black, Sara. "Lightning Strike Protection Strategies for Composite Aircraft." 1 May 2013. *www.compositesworld.com.* 1 June 2013.

Boeing Co. "Operational Efficiency and Environmental Performance." *Aero Magazine* (2009).

Boeing Co. "The 737 Max advantage." Technical Report. 2012.

Breit, Joe. "BCA Perspective on Fuel Cell APUs." 2010.

Caldas, Tobias. "Commercial Aviation Update." Business Overview. Embraer, 2013.

Cervenka, Michael. "The Rolls Royce Trent Engine." Presentation. Rolls Royce, 2000.

Clark, Stephen. "787 Propulsion System ." *Aero Magazine* (2012).

Dodson, Brian. ""Superjet" variable cycle jet engine could power future fighter aircraft." 6 January 2013. *Gizmag.* <http://www.gizmag.com/ge-aviation-develop-advent-variable-cycle-jet-engine/25556/>.

Duco Golhof, Allard de Groot, Jotham Hensen, Judie Ibrahim, Sander Mestemaker, Erik Portman, Iris Prinsen, Wouter Seignette. *737 Flight Control Modifications*. Design Report. Amsterdam University of Applied Sciences. Amsterdam, 2011.

Ebanga, Jean-Paul. "LEAP: Proven Breakthrough." Business Overview. CFM International, 2013.

GE Aviation. "Breaking the Mold: GE Makes Technology Review's Global List of Most Innovative Companies, Again." *GE Reports* (2013).

Gubisch, Michael. "Aircraft Paint Suppliers Explore Sharskin Coating." 31 January 2013. *Flightglobal.com.*

Hawker Beechcraft. "Introducing the factory completed Hawker 400XPr." Brochure. n.d.

Honeywell. "Advanced Materials & Processes." Technology Factbook. n.d.

ICF. "Fleet Forecasting with the Turkeys." 2012.

Jeffrey Berton, William Haller, Douglas Thurman, Kenneth Fisher. "Ultra High Bypass Ratio Propulsion Systems Studied." Press Release. NASA Glenn Research Center, 2013.

Kaminski-Morrow, David. "A380 near-term refinements include higher MTOW." *Flight Global* 12 May 2009.

Leeham News. *Boeing Refreshes 787*. 2009. 2012. <http://leehamnews.wordpress.com/2009/04/30/boeing-refreshes-737/>.

Milller, Trent, Tim Allen and Evan Preston. "Operational Advantages of Carbon Brakes." *Boeing AERO* QRT_03 2009. Electronic.

Nagpal, Dr. Vinod. "Cooled Ceramic Matrix Composite (CMC) High Pressure Turbine Vanes." n.d. *NASA Glenn Research Center.* 23 May 2013. <https://technology.grc.nasa.gov/techdays2012/TechDays_TOPsheets/PS-00921-1112_B117_AS.pdf>.

Norris, Guy. "Boeing May Boost MAX Fan As Battle With NEO Heats Up." *Aviation Week & Space Technology* (2012).

—. "Boeing Plans Plain Grey Natural Laminar Flow Nacelles for 787s in Bid to Reduce Fuel Burn." 11 July 2006. *www.flightglobal.com.* 15 April 2013.

—. "Boeing Starts 787 Drag Reduction Tests." 10 June 2011. *Aviation Week.* 23 May 2013. <http://www.aviationweek.com/Blogs.aspx?plckBlogId=Blog:7a78f54e-b3dd-4fa6-ae6e-dff2ffd7bdbb&plckPostId=Blog%3A7a78f54e-b3dd-4fa6-ae6e-dff2ffd7bdbbPost%3A060d6b30-ea24-4dd7-acd7-791949121fab>.

—. "Boeing Tests 747-8 Engine and Fuel System Updates." *Aviation Week & Space Technology* 21 May 2013.

—. "Boeing Unveils Plans for Trailing Edge Variable Camber on 787 to Reduce Drag, Save Weight." 12 June 2006. *www.flightglobal.com.* 1 March 2013.

"Proven Techniques to Reduce Fuel Burn." *Aicraft Commerce* 69 (2010): 5.

Russell, Edward. "PARIS: Embraer claims double-digit efficiency gains with E-Jet E2." *FlightGlobal* (2013).

Sinnett, Mike. "787 No Bleed Systems: Saving Fuel and Enhancing Operational Efficiencies ." *Aero Magazine* (2008).

Tesch, Dennis. "Next Generation 737 Fuel Performance Improvement." *Boeing AERO* December 2012: 12-17. Electronic.

—. "Next-Generation 737 Fuel Performace Improvement." *Aero Magazine* (2012): 5.

Thomson, Ken. "Delivering Fuel and Emissions Savings for the 777." *Boeing AERO* QTR_03 2009. Electronic.

Warwick, Graham. "Clean Sheet." *Aviation Week* (2012).

—. "Pratt and Whitney's Geared Turbofan." 1 July 2013. *Aviation Week.* 15 July 2013.

—. "Putting it Together." *Aviation Week* (2013): 2.

—. "Riblets - Back in the Groove." 7 June 2010. *Aviation Week.* 6 June 2013. <http://www.aviationweek.com/Blogs.aspx?plckBlogId=Blog:a68cb417-3364-4fbf-a9dd-4feda680ec9c&plckPostId=Blog%3Aa68cb417-3364-4fbf-a9dd-4feda680ec9cPost%3Ab5065dcb-10d0-447c-9b85-cf91c64363f1>.

Wilhelm, Steve. "Aluminum-lithium alloys may be used for Boeing 777X." *Pudget Sound Business Journal* (2013).

Wilsey, Craig and Robert Stoker. "Continuous Lower Energy, Emissions, and Noise (CLEEN) Technologies Development." Presentation. 2010. Document.

To: Sutton, Tia[sutton.tia@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]
From: Cyran, Carissa
Sent: Wed 11/1/2017 9:26:54 PM
Subject: RE: Sorry for the delay, things got a bit hectic with the CPP hearing notice. No changes on the aircraft rule briefing.
Briefing_Aircraft CO2 Rule_11-2-17.pptx

Ex. 5 - Deliberative Process

From: Cyran, Carissa
Sent: Wednesday, November 01, 2017 5:14 PM
To: Sutton, Tia <sutton.tia@epa.gov>; Burch, Julia <Burch.Julia@epa.gov>
Subject: Sorry for the delay, things got a bit hectic with the CPP hearing notice. No changes on the aircraft rule briefing.

Carissa Cyran

Office of Air and Radiation

U.S. Environmental Protection Agency
Phone: (202) 564-5437

To: OAR Briefings[OAR_Briefings@epa.gov]
Cc: Grundler, Christopher[grundler.christopher@epa.gov]; Sutton, Tia[sutton.tia@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]
From: Hengst, Benjamin
Sent: Mon 10/30/2017 6:01:01 PM
Subject: Revised Draft Aircraft CO2 Briefing
Briefing_Aircraft CO2 Rule DRAFT 10-30-17.pptx

OTAQ is to brief Mandy on aircraft CO2 standards on Thursday. When we pre-briefed Sarah on Oct 23, she asked for some minor edits to the briefing (add more on CBD litigation history and more detail on rule schedule). After making these edits, Sarah wanted us to send the briefing around again, for review, before our meeting with Mandy.

Revised briefing attached for Sarah's review.

Thanks,

Ben

To: OTAQ Materials[OTAQMaterials@epa.gov]
Cc: Iffland, JoNell[Iffland.JoNell@epa.gov]; Charmley, William[charmley.william@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]; Orlin, David[Orlin.David@epa.gov]; Mueller, John[mueller.john@epa.gov]; Sargeant, Kathryn[sargeant.kathryn@epa.gov]
From: Samulski, Michael
Sent: Mon 10/30/2017 4:03:04 PM
Subject: For Chris' Review: Revised Draft Aircraft CO2 Briefing
Briefing_Aircraft CO2 Rule DRAFT 10-30-17.pptx

We are scheduled to meet with Mandy G. on aircraft CO2 standards Thursday at 3:00.

When we pre-briefed Sarah on Oct 23, she asked for some minor edits to the briefing (add more on CBD litigation history and more detail on rule schedule). After making these edits, Sarah wanted us to send the briefing around again, for review, before our meeting with Mandy.

Here is the revised draft briefing.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Burch, Julia[Burch.Julia@epa.gov]
From: Manning, Bryan
Sent: Thur 10/19/2017 5:11:40 PM
Subject: FW: Materials for Oct 23 Briefing with Sarah on Aircraft CO2
Briefing_Aircraft CO2 Rule 10-19-17.pptx

Hi Julia,

See below/attached in case you missed it.

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Samulski, Michael
Sent: Thursday, October 19, 2017 1:09 PM
To: OTAQ Materials <OTAQMaterials@epa.gov>
Cc: Sargeant, Kathryn <sargeant.kathryn@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Mueller, John <mueller.john@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>; Yen, David <Yen.David@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Orlin, David <Orlin.David@epa.gov>; Thrift, Mike <thrift.mike@epa.gov>; Iffland, JoNell <Iffland.JoNell@epa.gov>; Charmley, William

<charmley.william@epa.gov>
Subject: Materials for Oct 23 Briefing with Sarah on Aircraft CO2

Here are the materials for Monday's meeting with Sarah. This version incorporates Chris' comments.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]
From: Burch, Julia
Sent: Thur 9/28/2017 1:51:39 PM
Subject: quick turnaround on Aircraft GHG one pager for AA confirmation
Aircraft Endangermen QA jb edits 092817.docx
6b. Aircraft Endangerment jb edits 9-28-17.docx

Morning!

As you may know, the confirmation hearing for OAR's AA was pushed back to Oct. 4. As a result, yesterday OCIR asked us to update any one pagers and Q&As that the nominee will be using to prepare for the hearing.

To make your task a little lighter I've taken a look at the aircraft GHG endangerment one- pager and Q&A and took a stab at adding some brief language to account for recent developments. Please take a look and feel free to correct. Please keep in mind that 1) we can only add info that is publically available (the fall reg/dereg agenda still isn't out) and 2) we need to keep these to one page.

I'll need your responses by noon tomorrow (Friday). Sorry for the quick turnaround!

If you have any questions please let me know.

Thanks!

Regards,

Julia Burch

Office of Transportation and Air Quality

U.S. Environmental Protection Agency

202-564-0961

To: Sutton, Tia[sutton.tia@epa.gov]; Charmley, William[charmley.william@epa.gov]; Bunker, Byron[bunker.byron@epa.gov]; Simon, Karl[Simon.Karl@epa.gov]; Haugen, David[haugen.david@epa.gov]; Brusstar, Matt[brusstar.matt@epa.gov]; Sargeant, Kathryn[sargeant.kathryn@epa.gov]; Manners, Mary[manners.mary@epa.gov]; Moltzen, Michael[Moltzen.Michael@epa.gov]; Cook, Leila[cook.leila@epa.gov]; Blubaugh, Jim[Blubaugh.Jim@epa.gov]; France, Jennifer[france.jennifer@epa.gov]; Levin, David[Levin.David@epa.gov]; Dietrich, Gwen[Dietrich.Gwen@epa.gov]; Suarez, Patricia[suarez.patricia@epa.gov]; Haley, Mike[Haley.Mike@epa.gov]; Henning, Julie[henning.julie@epa.gov]; Cohen, Janet[cohen.janet@epa.gov]; Watkins, Erica[watkins.erica@epa.gov]
Cc: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Birgfeld, Erin[Birgfeld.Erin@epa.gov]; Argyropoulos, Paul[Argyropoulos.Paul@epa.gov]; Mylan, Christopher[Mylan.Christopher@epa.gov]; Richards, David[Richards.David@epa.gov]
From: Burch, Julia
Sent: Mon 8/8/2016 7:25:47 PM
Subject: Weekly Regs & Communications Trackers - week of August 8th
OTAQ IO Communications Tracker.xlsx
OTAQ IO Regs Tracker.xlsx

Happy Monday!

The Regs and Communications Trackers for this week are attached.

Regards,

Julia Burch

Office of Transportation and Air Quality

U.S. Environmental Protection Agency

202-564-0961

To: OAR Briefings[OAR_Briefings@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
From: Burch, Julia
Sent: Tue 1/16/2018 3:31:44 PM
Subject: FW: Materials for Jan 17th 1:00 briefing with Bill Wehrum on Aircraft CO2 Standards Rule
Briefing_Aircraft CO2 Rule 1-17-18.pptx

Attached are the meeting materials for tomorrow's 1pm briefing with AA Wehrum on the aircraft CO2 standards rule.

Please let me know if you have any questions.

Thanks!

Regards,

Julia Burch

Office of Transportation and Air Quality

U.S. Environmental Protection Agency

202-564-0961

To: OTAQ Materials[OTAQMaterials@epa.gov]
From: Burch, Julia
Sent: Mon 10/23/2017 2:30:11 PM
Subject: FW: Materials for Oct 23 Briefing with Sarah on Aircraft CO2
Briefing_Aircraft CO2 Rule 10-19-17.pptx

Attached are briefing materials for the meeting with Sarah today at 4pm on Aircraft CO2.

Apologies for not sending sooner.

Regards,

Julia Burch

Office of Transportation and Air Quality

U.S. Environmental Protection Agency

202-564-0961

From: Burch, Julia
Sent: Thursday, October 19, 2017 2:07 PM
To: OAR Briefings <OAR_Briefings@epa.gov>
Cc: Samulski, Michael <samulski.michael@epa.gov>; Hengst, Benjamin <Hengst.Benjamin@epa.gov>
Subject: FW: Materials for Oct 23 Briefing with Sarah on Aircraft CO2

Attached are briefing materials for Sarah's review in preparation for the Monday 4pm meeting on Aircraft CO2.

Please let me know if you have any questions.

Thanks!

Regards,

Julia Burch

Office of Transportation and Air Quality

U.S. Environmental Protection Agency

202-564-0961

To: OAR Briefings[OAR_Briefings@epa.gov]
Cc: Samulski, Michael[samulski.michael@epa.gov]; Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Burch, Julia
Sent: Thur 10/19/2017 6:06:15 PM
Subject: FW: Materials for Oct 23 Briefing with Sarah on Aircraft CO2
Briefing_Aircraft CO2 Rule 10-19-17.pptx

Attached are briefing materials for Sarah's review in preparation for the Monday 4pm meeting on Aircraft CO2.

Please let me know if you have any questions.

Thanks!

Regards,

Julia Burch

Office of Transportation and Air Quality

U.S. Environmental Protection Agency

202-564-0961

To: Charmley, William[charmley.william@epa.gov]
Cc: Samulski, Michael[samulski.michael@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Manning, Bryan
Sent: Wed 10/25/2017 4:28:45 PM
Subject: Revised Aircraft CO2 Rule Briefing (for Mandy on Nov 2)
Briefing_Aircraft CO2 Rule 10-25-17.pptx

Hi Bill,

Attached please find a revised Mandy briefing on the aircraft CO2 rule. Mike is out of the office today, and he asked me to send this updated briefing to you. As you know, we pre-briefed Sarah on Oct 23, and she asked for some minor edits to the briefing (add more on CBD litigation history and more detail on rule schedule). After making these edits, Sarah and Chris wanted us to send the briefing around again before our meeting with Mandy on Nov 2. Note, the meeting with Mandy was pushed back a few days so that we would have some time between the Oct 31 Boeing/GE meeting and the Mandy briefing – to incorporate any new information. Let us know if you have any comments or questions.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Grundler, Christopher[grundler.christopher@epa.gov]; Charmley, William[charmley.william@epa.gov]
Cc: Sargeant, Kathryn[sargeant.kathryn@epa.gov]
From: Hengst, Benjamin
Sent: Wed 6/21/2017 7:49:58 PM
Subject: FW: SAB prep call
Aviation GHG Pages from Fall 2016 WkGrp Memo Appendix.pdf
Agenda SAB-June 29 post.pdf
SAB - Aircraft GHG Emissons Standards.docx
Fall 2016 WkGrp Memo attAB.PDF

Bill, Chris:

I think we should raise this tomorrow with Sarah, after the CSL meeting. We need to make sure this doesn't come as a surprise to the 3rd floor, and

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

From: Samulski, Michael
Sent: Wednesday, June 21, 2017 3:40 PM
To: Charmley, William <charmley.william@epa.gov>; Hengst, Benjamin <Hengst.Benjamin@epa.gov>
Cc: Sargeant, Kathryn <sargeant.kathryn@epa.gov>; Burch, Julia <Burch.Julia@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>; Schenk, Ruth <schenk.ruth@epa.gov>
Subject: SAB prep call

Bill and Ben,

We just had a call with John Shoaff and Carl Mazza at OAPPS (formerly OPAR) on preparing for the upcoming SAB teleconference next week. The OTAQ attendees are copied on this message.

Carl Mazza did say that Jim Democker (OAPPS) mentioned the upcoming SAB call at a recent

senior staff meeting. However, we do not know at what level of detail.

Ex. 5 - Deliberative Process

Julia, is there anything you would like to add?

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Shoaff, John
Sent: Tuesday, June 20, 2017 2:57 PM
To: Shoaff, John; Sargeant, Kathryn; Samulski, Michael; Manning, Bryan; Audette, Lucie; Mazza, Carl
Cc: Charmley, William
Subject: SAB Prep Call
When: Wednesday, June 21, 2017 2:00 PM-3:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: teleconference Ex. 6 - Personal Privacy conf. code

Added supplementary info, scroll down under original note below, and attachments.

All,

In follow-up to Leif's note on Friday at 2:39 (see also for background re: SAB agenda and supporting docs), I wanted to schedule a quick call to check in on the typical process for these SAB discussions and strategize on how we might wish to prepare for the discussion as needed.

Carl is also reviewing the SAB's peer review suggestions vs. the PR Handbook to see how they might jive with time frames and in order to assist with potential clarifications or responses.

Thanks!

John

Supplementary info. for our conversation:

Estimated timing & cost of contractor-led panel peer reviews (per OW colleague and under the 2013 EPA *Conflict of Interest Review Process for Contractor-Managed Peer Reviews of EPA HISA and ISI* policy based on 2004 OMB *Final Information Quality Bulletin for Peer Review* under the Information Quality Act).

Timeframe

We currently have 2 under way (Perchlorate part 2 and Lead modeling) and completed 2 (PFOA/PFOS and perchlorate part 1).

Typical timeframes from start to finish are 9 – 12 months with all of the FR notices and comment periods required.

Cost

Estimated cost is $25K per review using both ERG and Versar – their rates are comparable.

Fall 2016 SAB WG Memo - Work Group Recommendations Regarding Planned EPA Actions of Interest to the SAB

Control of Air Pollution from Aircraft and Aircraft Engines: Proposed GHG Emissions Standards and Test Procedures (2060-AT26) is listed as a long term action, with a notice of proposed rulemaking due January 2018 and a final rule due December 2018. The Work Group finds that the planned action is significant and would benefit from SAB advice and comment. The Work Group notes that there are temporal constraints on completing the rulemaking and recommends the SAB provide advice on this issue, or at a minimum, the EPA should conduct a panel review that allows communication across the two proposed peer review panels in order to encourage synergistic understanding among the disciplines involved.

The Work Group notes the SAB previously reviewed *Proposed Finding that Greenhouse Gas Emissions from Aircraft Cause or Contribute to Air Pollution that May Reasonably be Anticipated to Endanger Public Health and Welfare and Advanced Notice of Proposed Rulemaking (2060-AS31)* in the Fall 20142 Regulatory Review and found that subsequent steps

in the regulatory process will involve substantive scientific issues that may warrant SAB consideration. The Work Group recommends that the SAB ask the agency to regularly inform the SAB about the status of subsequent steps on this topic and also asks the EPA to provide it with briefings on the science underlying agency approaches to address greenhouse gas emissions and related climate change actions.

Attachments

1. Key Pages from SAB WG Memo Appendix
2. SAB Agenda
3. Full SAB WG Memo & Appendices
4. GHG Aviation Template submitted in follow up to Fall 2016 Reg Agenda

To: Charmley, William[charmley.william@epa.gov]; Hengst, Benjamin[Hengst.Benjamin@epa.gov]
Cc: Sargeant, Kathryn[sargeant.kathryn@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Schenk, Ruth[schenk.ruth@epa.gov]
From: Samulski, Michael
Sent: Wed 6/21/2017 7:39:43 PM
Subject: SAB prep call
Aviation GHG Pages from Fall 2016 WkGrp Memo Appendix.pdf
Agenda SAB-June 29 post.pdf
SAB - Aircraft GHG Emissons Standards.docx
Fall 2016 WkGrp Memo attAB.PDF

Bill and Ben,

We just had a call with John Shoaff and Carl Mazza at OAPPS (formerly OPAR) on preparing for the upcoming SAB teleconference next week. The OTAQ attendees are copied on this message.

Carl Mazza did say that Jim Democker (OAPPS) mentioned the upcoming SAB call at a recent senior staff meeting. However, we do not know at what level of detail.

Ex. 5 - Deliberative Process

Julia, is there anything you would like to add?

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Shoaff, John
Sent: Tuesday, June 20, 2017 2:57 PM
To: Shoaff, John; Sargeant, Kathryn; Samulski, Michael; Manning, Bryan; Audette, Lucie; Mazza, Carl
Cc: Charmley, William
Subject: SAB Prep Call
When: Wednesday, June 21, 2017 2:00 PM-3:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: teleconference Ex. 6 - Personal Privacy conf. code

Added supplementary info, scroll down under original note below, and attachments.

All,

In follow-up to Leif's note on Friday at 2:39 (see also for background re: SAB agenda and supporting docs), I wanted to schedule a quick call to check in on the typical process for these SAB discussions and strategize on how we might wish to prepare for the discussion as needed.

Carl is also reviewing the SAB's peer review suggestions vs. the PR Handbook to see how they might jive with time frames and in order to assist with potential clarifications or responses.

Thanks!

John

Supplementary info. for our conversation:

Estimated timing & cost of contractor-led panel peer reviews (per OW colleague and under the 2013 EPA *Conflict of Interest Review Process for Contractor-Managed Peer Reviews of EPA HISA and ISI* policy based on 2004 OMB *Final Information Quality Bulletin for Peer Review* under the Information Quality Act).

Timeframe

We currently have 2 under way (Perchlorate part 2 and Lead modeling) and completed 2 (PFOA/PFOS and perchlorate part 1).

Typical timeframes from start to finish are 9 – 12 months with all of the FR notices and comment periods required.

Cost

Estimated cost is $25K per review using both ERG and Versar – their rates are comparable.

Fall 2016 SAB WG Memo - Work Group Recommendations Regarding Planned EPA Actions of Interest to the SAB

Control of Air Pollution from Aircraft and Aircraft Engines: Proposed GHG Emissions Standards and Test Procedures (2060-AT26) is listed as a long term action, with a notice of proposed rulemaking due January 2018 and a final rule due December 2018. The Work Group finds that the planned action is significant and would benefit from SAB advice and comment. The Work Group notes that there are temporal constraints on completing the rulemaking and recommends the SAB provide advice on this issue, or at a minimum, the EPA should conduct a panel review that allows communication across the two proposed peer review panels in order to encourage synergistic understanding among the disciplines involved.

The Work Group notes the SAB previously reviewed *Proposed Finding that Greenhouse Gas Emissions from Aircraft Cause or Contribute to Air Pollution that May Reasonably be Anticipated to Endanger Public Health and Welfare and Advanced Notice of Proposed Rulemaking (2060-AS31)* in the Fall 20142 Regulatory Review and found that subsequent steps in the regulatory process will involve substantive scientific issues that may warrant SAB consideration. The Work Group recommends that the SAB ask the agency to regularly inform the SAB about the status of subsequent steps on this topic and also asks the EPA to provide it with briefings on the science underlying agency approaches to address greenhouse gas emissions and related climate change actions.

Attachments

1. Key Pages from SAB WG Memo Appendix
2. SAB Agenda
3. Full SAB WG Memo & Appendices
4. GHG Aviation Template submitted in follow up to Fall 2016 Reg Agenda

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Charmley, William[charmley.william@epa.gov]
From: Orlin, David
Sent: Tue 1/24/2017 2:29:10 PM
Subject: FW: FYI/For your review by 2 pm 1/25: Draft info to SAB for their screening of scientific basis for major agency planned actions
SAB Review for 2018 RFS annual rule otaq v1.docx
EPA action description Aviation Lead Endangerment otaq v1.docx
EPA action description Aircraft GHG rule 1-23-17.docx

Ex. 5 - Attorney Client

David Orlin

U.S. EPA, Office of General Counsel

(202) 564-1222

From: Sargeant, Kathryn
Sent: Tuesday, January 24, 2017 9:07 AM
To: Orlin, David <Orlin.David@epa.gov>; Thrift, Mike <thrift.mike@epa.gov>; Dubois, Roland <Dubois.Roland@epa.gov>
Subject: FYI/For your review by 2 pm 1/25: Draft info to SAB for their screening of scientific basis for major agency planned actions
Importance: High

Dear all,

As you can see from my message below, we have received the call for info to the SAB on our planned regulatory actions.

Attached are the documents we intend to submit (on the RFS annual rule, aircraft Pb endangerment, and aircraft GHG standards).

These have been developed by the teams and reviewed by Machiele, Hoyer, Samulski (respectively), and me.

These obviously don't focus on any legal issues but I wanted to be sure you (a) know this process is happening; and (b) have an opportunity to look at them if you'd like (they're very short).

Will you let me know by 2 pm on Weds if you have any comments or concerns? Obviously I'm happy to answer any questions you might have, at any time.

Thanks in advance!!

From: Sargeant, Kathryn
Sent: Tuesday, January 24, 2017 8:42 AM
To: Charmley, William <charmley.william@epa.gov>; Grundler, Christopher <grundler.christopher@epa.gov>; Hengst, Benjamin <Hengst.Benjamin@epa.gov>; Burch, Julia <Burch.Julia@epa.gov>
Cc: Simon, Karl <Simon.Karl@epa.gov>; Cook, Leila <cook.leila@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>; Hoyer, Marion <hoyer.marion@epa.gov>; Machiele, Paul <machiele.paul@epa.gov>; Parsons, Christy <Parsons.Christy@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Burkholder, Dallas <burkholder.dallas@epa.gov>
Subject: FYI/For your review: Draft info to SAB for their screening of scientific basis for major agency planned actions

As you likely recall, EPA provides the Science Advisory Board (SAB) with an opportunity to give advice on the science that supports rules identified in EPA's semiannual Regulatory Agenda.

This involves EPA developing descriptions of planned actions (according to previously developed templates) for SAB consideration.

The Fall 2016 Reg Agenda had three OTAQ actions that require a description to be provided to the SAB:

--RFS standards for 2018 and biomass based diesel volume for 2019

--Aircraft lead endangerment finding

--Aircraft GHG emissions standards

I am attaching the descriptions that I recommend sending up through the process.

They are due to OAR/OAPPS tomorrow (Jan. 25), where they will be reviewed and then sent up for EPA's transmittal to SAB, which convenes a Work Group to review them.

Will you please let me know by <u>2 pm Weds. the 25th</u> if you have any comments, questions, or concerns?

I will be sending them to OAPPS Weds. afternoon and providing OGC an opportunity for review in parallel with yours.

Thanks,

Kathryn

To: OTAQ Materials[OTAQMaterials@epa.gov]
Cc: Sargeant, Kathryn[sargeant.kathryn@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Mueller, John[mueller.john@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Yen, David[Yen.David@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Orlin, David[Orlin.David@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Iffland, JoNell[Iffland.JoNell@epa.gov]; Charmley, William[charmley.william@epa.gov]
From: Samulski, Michael
Sent: Thur 10/19/2017 5:08:37 PM
Subject: Materials for Oct 23 Briefing with Sarah on Aircraft CO2
Briefing_Aircraft CO2 Rule 10-19-17.pptx

Here are the materials for Monday's meeting with Sarah. This version incorporates Chris' comments.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Charmley, William[charmley.william@epa.gov]
Cc: Audette, Lucie[audette.lucie@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]
From: Samulski, Michael
Sent: Thur 9/21/2017 4:57:02 PM
Subject: Early Guidance Briefing
Early Guidance Briefing_Aircraft GHG Std_October 25 2016.pptx

Bill,

You had mentioned giving us your thoughts on revisions to the early guidance briefing, with a view to us having something to discuss with Chris at Monday's peer review briefing.

Do you anticipate having a chance to do that, or would you like us to take a crack at updating the briefing?

I will be out of the office tomorrow, but Bryan and Lucie will be here to make any revisions.

For your convenience, last year's Early Guidance Briefing is attached. This should be the same document that Bryan handed you a paper copy of.

Thanks,

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Charmley, William[charmley.william@epa.gov]; Grundler, Christopher[grundler.christopher@epa.gov]; Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]
Cc: Simon, Karl[Simon.Karl@epa.gov]; Cook, Leila[cook.leila@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Hoyer, Marion[hoyer.marion@epa.gov]; Machiele, Paul[machiele.paul@epa.gov]; Parsons, Christy[Parsons.Christy@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Burkholder, Dallas[burkholder.dallas@epa.gov]
From: Sargeant, Kathryn
Sent: Tue 1/24/2017 1:41:45 PM
Subject: FYI/For your review: Draft info to SAB for their screening of scientific basis for major agency planned actions
SAB Review for 2018 RFS annual rule otaq v1.docx
EPA action description_Aviation Lead Endangerment otaq v1.docx
EPA action description Aircraft GHG rule 1-23-17.docx

As you likely recall, EPA provides the Science Advisory Board (SAB) with an opportunity to give advice on the science that supports rules identified in EPA's semiannual Regulatory Agenda.

This involves EPA developing descriptions of planned actions (according to previously developed templates) for SAB consideration.

The Fall 2016 Reg Agenda had three OTAQ actions that require a description to be provided to the SAB:

--RFS standards for 2018 and biomass based diesel volume for 2019

--Aircraft lead endangerment finding

--Aircraft GHG emissions standards

I am attaching the descriptions that I recommend sending up through the process.

They are due to OAR/OAPPS tomorrow (Jan. 25), where they will be reviewed and then sent up for EPA's transmittal to SAB, which convenes a Work Group to review them.

Will you please let me know by 2 pm Weds. the 25th if you have any comments, questions, or concerns?

I will be sending them to OAPPS Weds. afternoon and providing OGC an opportunity for review in parallel with yours.

Thanks,

Kathryn

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Charmley, William[charmley.william@epa.gov]
From: Grundler, Christopher
Sent: Fri 3/11/2016 1:08:54 PM
Subject: Fwd: Draft for Climate Approaches meeting
2016 Actions jm 3-10-16.docx
ATT00001.htm

Christopher Grundler, Director
Office of Transportation and Air Quality
U.S. Environmental Protection Agency
202.564.1682 (Washington)
734.214.4207 (Ann Arbor)
www.epa.gov/otaq

Begin forwarded message:

From: "Stewart, Lori" <Stewart.Lori@epa.gov>
Date: March 11, 2016 at 8:08:20 AM EST
To: "Page, Steve" <Page.Steve@epa.gov>, "Dunham, Sarah" <Dunham.Sarah@epa.gov>, "Grundler, Christopher" <grundler.christopher@epa.gov>
Cc: "Goffman, Joseph" <Goffman.Joseph@epa.gov>
Subject: Draft for Climate Approaches meeting

Here is Janet's latest cut at the paper for Monday's discussion. We'll do some clean up edits/formatting but wanted to share this with you for a last look to be sure nothing is missing or inaccurate. Thanks.

To: OTAQ Materials[OTAQMaterials@epa.gov]
Cc: Charmley, William[charmley.william@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Samulski, Michael
Sent: Thur 10/19/2017 4:42:09 PM
Subject: FOR CHRIS' REVIEW: Draft Materials for Monday Meeting with Sarah on Aircraft
Briefing_Aircraft CO2 Std_for Mandy Gunasekara_10-19-17.pptx

Chris,

Here is a draft aircraft briefing for your review. I was just made aware that Sarah would like to have this by 4:00 today. My apologies for the short turnaround time.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Charmley, William[charmley.william@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Samulski, Michael
Sent: Wed 10/18/2017 5:29:05 PM
Subject: RE: Aircraft update - request from Mandy for a briefing
Briefing_Aircraft CO2 Std_for Mandy Gunasekara_10-18-17 - mjs.pptx

Bill,

Here is a revised draft of the briefing, which incorporates the feedback from you and Chris we received at Monday's briefing.

This has been reviewed by OGC (Mike Thrift).

Please let me know if you have any comments and if you think Chris will want to look at it again.

We are on Sarah's calendar for 4:00 Monday. Have you heard if a meeting with Mandy G. has been set up?

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Charmley, William
Sent: Tuesday, October 17, 2017 5:53 AM
To: Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>
Subject: Aircraft update - request from Mandy for a briefing

Dear Mike, Bryan and Lucie –

Ben sent the information below to Chris and I yesterday afternoon regarding a request from Mandy Gunasekara regarding aircraft.

Do you 3 feel like you have enough information to update the briefing as a pre-brief for Sarah and then a briefing for Mandy? If not, let's sit down later this week to discuss.

Thanks

Bill

<< Note from Ben, regarding what he heard from OAR Chief of Staff Josh Lewis >>

1. Mandy wants a meeting on aircraft CO2.

•□□□□□□□□ She wants a meeting to cover basics and next steps. It sounds like what we spoke about this morning is in order. She'd like to do this maybe mid-next week. Mandy called it a "preliminary" meeting on the issue.

•□□□□□□□□ It sounds like having a pre-brief with Sarah is still needed (according to Josh). We looked at calendars and the pre-brief will likely be moved to next Monday at 4pm.

- Bill, I can work with you to send in a meeting request for the meeting with Mandy on this, but we'd target 10/24 or 10/25 or thereabouts

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
Cc: Charmley, William[charmley.william@epa.gov]
From: Samulski, Michael
Sent: Wed 12/17/2014 5:21:51 PM
Subject: RE: Updated notes for Janet
Notes for Meeting with Rich Swayze 12 17 14.docx

Here it is with the MBM 1-pager tacked on the end.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Hengst, Benjamin
Sent: Wednesday, December 17, 2014 12:20 PM
To: Samulski, Michael
Subject: Re: Updated notes for Janet

Mike, can you append the modified one pager on market mechanisms? Or did I miss that.

From: Samulski, Michael

Sent: Wednesday, December 17, 2014 12:15 PM

To: Hengst, Benjamin

Cc: Charmley, William

Subject: Updated notes for Janet

Ben,

Here are updated notes for Janet's meeting with Rich Swayze. These incorporate the comments from last night's meeting.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
Cc: Charmley, William[charmley.william@epa.gov]
From: Samulski, Michael
Sent: Wed 12/17/2014 5:15:34 PM
Subject: Updated notes for Janet
Notes for Meeting with Rich Swayze 12 17 14.docx

Ben,

Here are updated notes for Janet's meeting with Rich Swayze. These incorporate the comments from last night's meeting.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

February 6, 2015

The Honorable Gina McCarthy
Administrator, U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

The Honorable Michael P. Huerta
Administrator, Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Dear Administrators McCarthy and Huerta:

We write to reconfirm our commitment to a global sectoral approach to aviation and climate change under the International Civil Aviation Organization (ICAO) and to the development of appropriate regulatory provisions under U.S. law to help implement that approach. An aircraft standard for carbon dioxide (CO_2) that meets the ICAO Committee on Aviation Environmental Protection (CAEP) Terms of Reference can be an important part of that package.

As the record of the U.S. aviation sector demonstrates, we take our role in controlling greenhouse gas (GHG) emissions very seriously. For the past several decades, U.S. airlines and aircraft operators have dramatically improved fuel efficiency and reduced CO_2 emissions by investing billions in fuel-saving aircraft and engines, innovative technologies like winglets (which improve aerodynamics) and cutting-edge route-optimization software. As a result of our efforts, U.S. airlines have improved their fuel efficiency 120 percent since 1978 and together with other aircraft operators account for only 2 percent of the nation's GHG inventory,[1] while driving 5 percent of the nation's GDP.

Despite our strong record to date, we are not stopping there. Our organizations participate in a global aviation coalition that has committed to 1.5% annual average fuel efficiency improvements through 2020 and carbon neutral growth from 2020, subject to critical aviation infrastructure and technology advances achieved by government and industry. We are keenly focused on these advances, both at the national and international levels. For example, we are partnering to modernize the air traffic management system and to reinvigorate research and development in aviation environmental technology. And we are dedicated to developing commercially viable, sustainable alternative aviation fuel, which could be a game-changer in terms of aviation's output of GHG emissions while enhancing U.S. energy independence and security.

---

[1] U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012* (April 2014) at ES-2, Table 2-5, and Table 3-12, available at http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html#fullreport.

But as aviation is a global industry, with airlines and aircraft operators operating internationally and aircraft manufacturers selling their aircraft in international markets, it is critical that aircraft emissions standards continue to be agreed at the international level. Accordingly, we appreciate the direct engagement of your organizations in the development of the CO_2 certification standard at ICAO.[2]

As you know, ICAO has a proven track record for developing and advancing rigorous aircraft environmental standards, with the aircraft standard for oxides of nitrogen having been tightened significantly in 2005 and 2011 and a new noise standard adopted in 2014.[3] As EPA and FAA have done with other ICAO emissions standards, we urge you to ensure that any standard that moves forward for final approval at ICAO meets the CAEP Terms of Reference for technological feasibility, economic reasonableness, environmental benefit and consideration of the interrelationships between the various emissions parameters and noise. Besides being well-established for international standard-setting, the CAEP Terms of Reference and the ICAO/CAEP standard-setting process align well with the bases for the adoption of aircraft engine emission standards under Section 231 of the Clean Air Act.

We understand from the Information Paper that the U.S. submitted at the CAEP Steering Group last September and from the U.S. regulatory agenda that the EPA, with input from the FAA, plans to issue proposed "endangerment" and "cause or contribute" findings for the U.S. regulation of aircraft GHG emissions this spring. We concur with the observation the U.S. made in the CAEP Information Paper that such findings are a prerequisite to U.S. adoption of the expected ICAO CO_2 standard for aircraft.[4] We urge you to rely on well-established science and to keep our industry's strong fuel efficiency and emissions-savings record, relative GHG emissions contribution and global sectoral approach commitment squarely in mind as you proceed to proposal.

Sincerely yours,

Nicholas E. Calio
President and Chief Executive Officer
Airlines for America

Marion C. Blakey
President and Chief Executive Officer
Aerospace Industries Association

Stephen A. Alterman
President
Cargo Airline Association

Peter J. Bunce
President and CEO
General Aviation Manufacturers Association

Ed Bolen
President and Chief Executive Officer
National Business Aviation Association

---

[2] We also support the work being undertaken in ICAO to develop proposals for a potential global market-based measure to serve as a "gap-filler" should we not be able to achieve carbon neutral growth from 2020 through concerted industry and government investments in technology, operations and infrastructure.

[3] These standards, which were only the latest in a long series of ICAO noise and emissions standards, were respectively developed and recommended for ICAO adoption by CAEP/6, CAEP/8 and CAEP/9.

[4] U.S. Aircraft Greenhouse Gas Rulemaking Process, CAEP-SG/20142-IP/13.

To: Charmley, William[charmley.william@epa.gov]; Iffland, JoNell[Iffland.JoNell@epa.gov]
Cc: Samulski, Michael[samulski.michael@epa.gov]
From: Audette, Lucie
Sent: Mon 2/23/2015 3:56:06 PM
Subject: Joint EPA/FAA letters to A4A and CBD
Assns Letter to EPA-FAA re Aircraft CO2-2-6-15.pdf
Envt NGO Aircraft Letter 1-22-15.pdf
AX-15-000-4615 CBD v2.docx
AX-15-000-5135 Airlines for America_v2.docx

Bill, FAA has a deadline by end of this week for responding to these two letters. Attached are the draft response letters that has been reviewed by Mike and Mike Thrift before we send over to FAA we want to give you an opportunity to review. Given that you are meeting with A4A is seems like you would be the appropriate signatory for both of these. Are you OK with that? Thanks. Lucie

JoNell, Could you print these off for Bill. Thanks.

To: OTAQ Materials[OTAQMaterials@epa.gov]
Cc: Charmley, William[charmley.william@epa.gov]; Iffland, JoNell[Iffland.JoNell@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]
From: Samulski, Michael
Sent: Mon 12/15/2014 7:48:47 PM
Subject: Materials for tomorrow's 5:00 aircraft meeting with Janet
Notes for Meeting with Rich Swayze 12 15 14.docx

Here are draft briefing materials for Janet, to get her ready for her Thursday meeting with FAA's Rich Swayze.

Can you make sure this goes up to Janet's office as well?

Thanks,

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Charmley, William[charmley.william@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Sargeant, Kathryn[sargeant.kathryn@epa.gov]
From: Samulski, Michael
Sent: Fri 9/15/2017 7:07:19 PM
Subject: aircraft peer review
Peer Review Options for Aircraft Products v.3.docx
Overall Schedule 9-13-17.pptx

Bill,

We are on your calendar Monday to discuss the approach to peer reviewing two aircraft technical documents. We would also like to get your views on the broader approach to the NPRM.

In case you have time to look at this before Monday, I am sending you a 3 page "one-pager" that we could use with Chris on peer review options. I am also attaching a revised draft NPRM schedule. We will also bring paper copies on Monday.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Charmley, William[charmley.william@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Samulski, Michael
Sent: Wed 12/16/2015 2:47:55 PM
Subject: Draft Aircraft CO2 Materials for Janet
Materials for Janet on Aircraft CO2 - draft 12 16 15.docx

Bill,

Here are the draft materials for your review.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: McCabe, Janet[McCabe.Janet@epa.gov]
Cc: Grundler, Christopher[grundler.christopher@epa.gov]; Stewart, Lori[Stewart.Lori@epa.gov]; Charmley, William[charmley.william@epa.gov]
From: Hengst, Benjamin
Sent: Fri 7/10/2015 12:56:49 AM
Subject: current draft of ICAO briefing for WH meeting next Tuesday
FAA-EPA CO2 Standard briefing_8July2015_FAAredline+EPA.docx

Hi Janet,
The back-and-forth with FAA on this briefing is not yet complete, but we are sending now to give you a sense of where it stands. You'll see from this version that we are still working through issues with FAA on this. WH staff have asked that we send this back by COB tomorrow.

We are hopeful that we will wrap things up tomorrow morning. Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

None of the material in this briefing should come as a surprise to you, given what you know about the ANPRM and after today's call with Rick and Dan. It covers the same ground.

We will send you talking points for your chat with Swayze next.

thanks, Ben

To: OTAQ Materials[OTAQMaterials@epa.gov]
Cc: Samulski, Michael[samulski.michael@epa.gov]; Charmley, William[charmley.william@epa.gov]
From: Hengst, Benjamin
Sent: Thur 11/2/2017 6:05:34 PM
Subject: Fwd: Revised Draft Aircraft CO2 Briefing
Briefing_Aircraft CO2 Rule DRAFT 10-30-17.pptx
ATT00001.htm

Just recirculating final materials for today's 3pm.

Bill, I won't be attending but I've asked Julia to sit in.

Thanks. Ben

Begin forwarded message:

From: "Hengst, Benjamin" <Hengst.Benjamin@epa.gov>
To: "OAR Briefings" <OAR_Briefings@epa.gov>
Cc: "Grundler, Christopher" <grundler.christopher@epa.gov>, "Sutton, Tia" <sutton.tia@epa.gov>, "Burch, Julia" <Burch.Julia@epa.gov>
Subject: Revised Draft Aircraft CO2 Briefing

OTAQ is to brief Mandy on aircraft CO2 standards on Thursday. When we pre-briefed Sarah on Oct 23, she asked for some minor edits to the briefing (add more on CBD litigation history and more detail on rule schedule). After making these edits, Sarah wanted us to send the briefing around again, for review, before our meeting with Mandy.

Revised briefing attached for Sarah's review.

Thanks,
Ben

To: Leggett, Cullen[Leggett.Cullen@epa.gov]; Charmley, William[charmley.william@epa.gov]; Birgfeld, Erin[Birgfeld.Erin@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
From: Audette, Lucie
Sent: Mon 2/8/2016 2:15:58 PM
Subject: RE: For your input
ICAO GHG Standard v2+CL .docx
ICAO CO2 Standard Q and A_2-8-16 850am +lca .docx

I have no additional comments on the Fact Sheet. I agree with Cullen's comment that the use of

Ex. 5 - Deliberative Process

From: Leggett, Cullen
Sent: Monday, February 08, 2016 8:39 AM
To: Charmley, William <charmley.william@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>; Birgfeld, Erin <Birgfeld.Erin@epa.gov>
Cc: Manning, Bryan <manning.bryan@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>
Subject: RE: For your input

Morning,

These look like they are in good condition over all. Two comments though:

Ex. 5 - Deliberative Process

Attached are my edits to the documents. I've tried to keep them as simple as possible, and to reuse other language from the documents.

Cullen

(c) 602-616-7474

From: Charmley, William
Sent: Monday, February 08, 2016 6:03 AM
To: Audette, Lucie <audette.lucie@epa.gov>; Birgfeld, Erin <Birgfeld.Erin@epa.gov>
Cc: Manning, Bryan <manning.bryan@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>
Subject: Fwd: For your input

This is the last update to the communication material I see from Sunday evening.

Sent from my iPhone

Begin forwarded message:

From: "Vahlsing, Candace M. EOP/WHO" Ex. 6 - Personal Privacy
Date: February 8, 2016 at 12:23:39 AM EST
To: "Ralph.Iovinelli@faa.gov" <Ralph.Iovinelli@faa.gov>, "manning.bryan@epa.gov" <manning.bryan@epa.gov>, "charmley.william@epa.gov" <charmley.william@epa.gov>, "Welsh, Kevin W. EOP/NSC" Ex. 6 - Personal Privacy "Lourdes.Maurice@faa.gov" <Lourdes.Maurice@faa.gov>, "samulski.michael@epa.gov" <samulski.michael@epa.gov>, "bonnefoy_philippe@bah.com" <bonnefoy_philippe@bah.com>
Subject: RE: For your input

Please use these versions instead.

-----Original Message-----
From: Vahlsing, Candace M. EOP/WHO
Sent: Monday, February 8, 2016 12:15 AM
To: 'Ralph.Iovinelli@faa.gov' <Ralph.Iovinelli@faa.gov>; manning.bryan@epa.gov; charmley.william@epa.gov; Welsh, Kevin W. EOP/NSC
Ex. 6 - Personal Privacy Lourdes.Maurice@faa.gov; samulski.michael@epa.gov;

bonnefoy_philippe@bah.com
Subject: RE: For your input

Updated version here. Talk to you in the morning.

Also attached the start of a Q and A, mostly done by EPA.

Let's focus on the fact sheet first.

-----Original Message-----
From: Ralph.Iovinelli@faa.gov [mailto:Ralph.Iovinelli@faa.gov]
Sent: Sunday, February 7, 2016 10:31 PM
To: Vahlsing, Candace M. EOP/WHO <Ex. 6 - Personal Privacy
manning.bryan@epa.gov; charmley.william@epa.gov; Welsh, Kevin W. EOP/NSC
Ex. 6 - Personal Privacy Lourdes.Maurice@faa.gov; samulski.michael@epa.gov;
bonnefoy_philippe@bah.com
Subject: RE: For your input

Attached are a few edits for your consideration...

-----Original Message-----
From: Vahlsing, Candace M. EOP/WHO [Ex. 6 - Personal Privacy
Sent: Sunday, February 07, 2016 8:19 PM
To: Manning, Bryan; Charmley, William; Welsh, Kevin W. EOP/NSC; Iovinelli, Ralph (FAA); Maurice, Lourdes (FAA); Samulski, Michael; bonnefoy_philippe@bah.com
Subject: Re: For your input

Thank you!

Original Message
From: Manning, Bryan
Sent: Sunday, February 7, 2016 8:09 PM
To: Vahlsing, Candace M. EOP/WHO; Charmley, William; Welsh, Kevin W. EOP/NSC; Ralph.Iovinelli@faa.gov; Lourdes.Maurice@faa.gov; Samulski, Michael; bonnefoy_philippe@bah.com
Subject: RE: For your input

Hello Candace,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

For question #1, Mike and I will work with FAA on the numbers for the clause, "improve

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning
U.S. EPA Office of Transportation and Air Quality Large Marine and Aviation Center
2000 Traverwood Drive
Ann Arbor, MI 48105
(ph) 734-214-4832 (fax) 734-214-4816
manning.bryan@epa.gov

-----Original Message-----
From: Vahlsing, Candace M. EOP/WHO [Ex. 6 - Personal Privacy
Sent: Sunday, February 07, 2016 6:52 PM
To: Charmley, William <charmley.william@epa.gov>; Welsh, Kevin W. EOP/NSC
Ex. 6 - Personal Privacy >; Ralph.Iovinelli@faa.gov; Lourdes.Maurice@faa.gov;
Samulski, Michael <samulski.michael@epa.gov>; Manning, Bryan
<manning.bryan@epa.gov>; bonnefoy_philippe@bah.com
Subject: Re: For your input

Thanks for the input.

Two questions we'll need to resolve for the version tonight.

1. On this section, how many countries will have to adhere to the standard?

Ex. 5 - Deliberative Process

From: Charmley, William
Sent: Sunday, February 7, 2016 5:46 PM
To: Welsh, Kevin W. EOP/NSC; Vahlsing, Candace M. EOP/WHO; Ralph.Iovinelli@faa.gov; Lourdes.Maurice@faa.gov; Samulski, Michael; Manning, Bryan; bonnefoy_philippe@bah.com
Subject: RE: For your input

Kevin and Candice,

The edits Kevin made to the first draft addressed most of my comments and suggested edits, so in the attached I have only a few edits/comments.

Ex. 5 - Deliberative Process

Sentence in previous draft Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Bill Charmley's comment on this sentence (which is not in the revised draft)

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Overall I am good with the updated draft.

Thanks

Bill

-----Original Message-----
From: Welsh, Kevin Ex. 6 - Personal Privacy

Sent: Sunday, February 07, 2016 2:49 PM
To: Vahlsing, Candace; Ralph.Iovinelli@faa.gov; Lourdes.Maurice@faa.gov; Samulski, Michael; Charmley, William; Manning, Bryan; bonnefoy_philippe@bah.com
Subject: RE: For your input

All, here is an updated version of the fact sheet. I would appreciate any input from the EPA team as soon as possible, and I will work with Ralph, Philippe and Mike to round out the facts and data points. Candace, you also mentioned a Q&A. Happy to start working that.

-----Original Message-----

From: Vahlsing, Candace

Sent: Friday, February 05, 2016 10:18 PM

To: Ralph.Iovinelli@faa.gov<mailto:Ralph.Iovinelli@faa.gov>; Lourdes.Maurice@faa.gov<mailto:Lourdes.Maurice@faa.gov>; samulski.michael@epa.gov<mailto:samulski.michael@epa.gov>; charmley.william@epa.gov<mailto:charmley.william@epa.gov>; Manning.Bryan@epamail.epa.gov<mailto:Manning.Bryan@epamail.epa.gov>

Cc: Welsh, Kevin

Ex. 6 - Personal Privacy

Subject: For your input

Hi Team,

A draft of the White House fact sheet is attached. We will need your help filling in the details. We need to send a sketch of this to the White House, FAA, and EPA comms teams to review on Monday. They understand all of the details will not be complete.

After we have a solid version with the input of this group, we'll send it to Rick, Paul, and Dan for review. It would be great if that could happen on Sunday evening, but I know you all have been working really hard so let me know what is realistic.

We'll also need to develop a Q and A.

Great job this week!!

To: OTAQ Materials[OTAQMaterials@epa.gov]
Cc: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Charmley, William[charmley.william@epa.gov]; Iffland, JoNell[Iffland.JoNell@epa.gov]; Miller, Debra L.[Miller.DebraL@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Tue 10/21/2014 5:18:40 PM
Subject: Revised Pre-Brief for Chris on ICAO Progress (Janet McCabe Briefing) - today at 4:00
McCabe Update on ICAO progress Grundler Prebrief October 21.docx

Hello,

Attached please find revised materials for a pre-brief for Chris on ICAO Progress, which is scheduled today (Oct 21) at 4:00 -- prior to briefing Janet McCabe on Oct 23. The revision to the materials is the addition of a plot on page 4 of the briefing. If possible, please print this briefing out in color so that the plot can be read properly.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: OTAQ Materials[OTAQMaterials@epa.gov]
Cc: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Charmley, William[charmley.william@epa.gov]; Iffland, JoNell[Iffland.JoNell@epa.gov]; Miller, Debra L.[Miller.DebraL@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Mon 10/20/2014 9:43:08 PM
Subject: Pre-Brief for Chris on ICAO Progress (Janet McCabe Briefing) - Oct 21 at 4:00
McCabe Update on ICAO progress Grundler Prebrief Oct 20.docx

Hello,

Attached please find the materials for a pre-brief for Chris on ICAO Progress, which is scheduled tomorrow (Oct 21) at 4:00 -- prior to briefing Janet McCabe on Oct 23. Note, we have a placeholder on page 3 for a graph we will provide tomorrow. Let me know if you have any questions.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Charmley, William[charmley.william@epa.gov]
Cc: Sargeant, Kathryn[sargeant.kathryn@epa.gov]; Hoyer, Marion[hoyer.marion@epa.gov]; Davidson, Ken[Davidson.Ken@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]
From: Samulski, Michael
Sent: Fri 11/13/2015 3:21:47 PM
Subject: FW: Summary of issues with FAA/MIT cost-benefit analysis (ICAO aircraft CO2 standard) - PLEASE REVIEW
Overview of FAA CBA for Laura (11 12 15) v2.docx

Bill,

I just got off the phone with Kate Shouse at OAP.

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Mike

Ex. 5 - Deliberative Process

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Shouse, Kate
Sent: Friday, November 13, 2015 10:01 AM
To: Samulski, Michael
Cc: Manning, Bryan
Subject: RE: Summary of issues with FAA/MIT cost-benefit analysis (ICAO aircraft CO2 standard) - PLEASE REVIEW

Thanks, Mike, for reaching out.

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,
Kate

To: Audette, Lucie[audette.lucie@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]
From: Charmley, William
Sent: Mon 4/11/2016 6:36:55 PM
Subject: FW: Intersection between aircraft CO2 standards and the ICAO MBM process: recent Administrator McCarthy comments

Dear all -

Below is the email I sent to Chris and Sarah Dunham. **Ex. 5 - Deliberative Process**

Ex. 5 - Deliberative Process

Lucie – thanks for helping me with this earlier today.

Bill

From: Gunning, Paul
Sent: Monday, April 11, 2016 12:27 PM
To: Charmley, William <charmley.william@epa.gov>; Grundler, Christopher <grundler.christopher@epa.gov>; Dunham, Sarah <Dunham.Sarah@epa.gov>
Cc: Hengst, Benjamin <Hengst.Benjamin@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>; Birnbaum, Rona <Birnbaum.Rona@epa.gov>
Subject: RE: Intersection between aircraft CO2 standards and the ICAO MBM process: recent Administrator McCarthy comments

Bill, thanks for flagging this as we were not aware of the remarks. Looping in Rona too as we are beginning internal review of the preamble language.

Paul

From: Charmley, William
Sent: Monday, April 11, 2016 11:02 AM
To: Grundler, Christopher <grundler.christopher@epa.gov>; Dunham, Sarah <Dunham.Sarah@epa.gov>; Gunning, Paul <Gunning.Paul@epa.gov>
Cc: Hengst, Benjamin <Hengst.Benjamin@epa.gov>; Gunning, Paul <Gunning.Paul@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>
Subject: Intersection between aircraft CO2 standards and the ICAO MBM process: recent Administrator McCarthy comments

Dear Chris, Sarah, and Paul

Ex. 5 - Deliberative Process

The article has the title "**McCarthy Warns EPA Could Issue Stronger Aircraft GHG Rule If Global Talks Slip**"

This article includes the following:

After the ICAO council endorses the CO2 standard in June and the full assembly approves the m
member countries must codify it into their domestic law.

EPA began that process last summer, issuing a proposed endangerment finding -- a legal prereq
GHG regulation -- as well as an advanced notice of proposed rulemaking that took comment on s
debated in the ICAO negotiations. The agency intends to finalize its endangerment finding this su

That endangerment finding, McCarthy said during an April 7 event in Ottawa, Canada, can be use
translate the ICAO standard into domestic law. But, "[i]f the ICAO process is not sufficient, it is an
independently move forward," the administrator added.

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Please let me know if you have any comments or questions on this topic.

Thanks

Bill

<< language on EPA and ICAO CO2 standards and the to be developed EPA NPRM for aircraft engine CO2 standards from the Draft Final Endangerment Finding >>

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

To: Gonzalez, Gail[Gonzalez.Gail@epa.gov]
From: Charmley, William
Sent: Tue 1/24/2017 2:52:16 PM
Subject: FW: FYI/For your review: Draft info to SAB for their screening of scientific basis for major agency planned actions
SAB Review_for 2018 RFS annual rule otaq v1.docx
EPA action description_Aviation Lead Endangerment otaq v1.docx
EPA action description Aircraft GHG rule 1-23-17.docx

Gail –

Please print off each of the attachments for me.

Thanks

Bill

From: Sargeant, Kathryn
Sent: Tuesday, January 24, 2017 8:42 AM
To: Charmley, William <charmley.william@epa.gov>; Grundler, Christopher <grundler.christopher@epa.gov>; Hengst, Benjamin <Hengst.Benjamin@epa.gov>; Burch, Julia <Burch.Julia@epa.gov>
Cc: Simon, Karl <Simon.Karl@epa.gov>; Cook, Leila <cook.leila@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>; Hoyer, Marion <hoyer.marion@epa.gov>; Machiele, Paul <machiele.paul@epa.gov>; Parsons, Christy <Parsons.Christy@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Burkholder, Dallas <burkholder.dallas@epa.gov>
Subject: FYI/For your review: Draft info to SAB for their screening of scientific basis for major agency planned actions

As you likely recall, EPA provides the Science Advisory Board (SAB) with an opportunity to give advice on the science that supports rules identified in EPA's semiannual Regulatory Agenda.

This involves EPA developing descriptions of planned actions (according to previously developed templates) for SAB consideration.

The Fall 2016 Reg Agenda had three OTAQ actions that require a description to be provided to the SAB:

--RFS standards for 2018 and biomass based diesel volume for 2019

--Aircraft lead endangerment finding

--Aircraft GHG emissions standards

I am attaching the descriptions that I recommend sending up through the process.

They are due to OAR/OAPPS tomorrow (Jan. 25), where they will be reviewed and then sent up for EPA's transmittal to SAB, which convenes a Work Group to review them.

Will you please let me know by 2 pm Weds. the 25th if you have any comments, questions, or concerns?

I will be sending them to OAPPS Weds. afternoon and providing OGC an opportunity for review in parallel with yours.

Thanks,

Kathryn

To: Storhok, Ines[storhok.ines@epa.gov]; Kathryn Sargeant (sargeant.kathryn@epa.gov)[sargeant.kathryn@epa.gov]
From: Charmley, William
Sent: Mon 6/19/2017 12:12:16 PM
Subject: FW: a handful of budget questions
Response to June 16 Budget Questions from Lee, draft 1.docx

Ines and Kathryn -

Lee has scheduled a 2 hour Division Directors meeting on Tuesday afternoon to discuss the FY2017 budget. As you know, OTAQ has not yet received a final allocation.

I let Lee know that I can't attend on Tuesday, as I have a meeting with some outside stakeholders. As a result, Lee was able to send me some of her questions on Friday afternoon.

In the attached I have drafted responses to several of these.

Ex. 5 - Deliberative Process

Ines – can you take the lead on updating this document. I would like to send this back to Lee by the end of today.

Thanks

Bill

From: Cook, Leila
Sent: Friday, June 16, 2017 2:53 PM
To: Charmley, William <charmley.william@epa.gov>
Subject: a handful of budget questions

Bill,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks Bill,

Lee

Ex. 6 - Personal Privacy

To: Samulski, Michael[samulski.michael@epa.gov]; Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Charmley, William
Sent: Tue 12/9/2014 10:00:20 PM
Subject: RE: Contact information for Rich Swayze's Office at FAA
Notes for Meeting with Rich Swayze 12 9 14.docx

Mike,

Thanks for this draft to prepare Janet for this meeting next week.

Yes, I think we should try and schedule a 30 minute discussion with Janet to get her prepared before this meeting.

Thanks

Bill

From: Samulski, Michael
Sent: Tuesday, December 09, 2014 4:09 PM
To: Charmley, William
Subject: FW: Contact information for Rich Swayze's Office at FAA

Bill,

Attached is a draft briefing document to prepare Janet for her meeting with Rich Swayze, FAA, on aircraft CO2 standards coordination. Her meeting is scheduled for 12/18 at 10:00am.

Ex. 5 - Deliberative Process

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Samulski, Michael
Sent: Monday, December 01, 2014 3:49 PM
To: Charmley, William
Subject: FW: Contact information for Rich Swayze's Office at FAA

Bill,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Hengst, Benjamin
Sent: Monday, December 01, 2014 3:28 PM
To: Samulski, Michael
Cc: Charmley, William
Subject: Re: Contact information for Rich Swayze's Office at FAA

Just got scheduled one minute ago. Thursday the 18th at 10 am. Scheduled to take place here at EPA. Carl, Lourdes, and Rich are invited on the invite. Do you guys think we will need a pre-brief with Janet, or can we do it via email?

From: Samulski, Michael

Sent: Monday, December 1, 2014 11:41 AM

To: Hengst, Benjamin

Cc: Charmley, William

Subject: RE: Contact information for Rich Swayze's Office at FAA

Ben,

Do you know if this meeting was ever set up? According to Lourdes (we had a call with FAA last Wednesday), a request came in to FAA from Janet's office for Dec 16th, but FAA had a conflict and countered with Dec 17th or 18th.

Also, you had asked me who FAA planned to have in the room. Lourdes said she expected it would be her and Richard Swayze on their end.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Hengst, Benjamin
Sent: Thursday, November 20, 2014 6:26 PM
To: Charmley, William; Samulski, Michael
Subject: FW: Contact information for Rich Swayze's Office at FAA

FYI

From: Hengst, Benjamin
Sent: Thursday, November 20, 2014 6:25 PM
To: Lori Stewart; Atkinson, Emily
Cc: Knapp, Kristien; Grundler, Christopher; Stewart, Gwen
Subject: RE: Contact information for Rich Swayze's Office at FAA

+ Gwen

From: Hengst, Benjamin
Sent: Thursday, November 20, 2014 6:25 PM
To: Lori Stewart; Atkinson, Emily
Cc: Knapp, Kristien; Grundler, Christopher
Subject: Contact information for Rich Swayze's Office at FAA

Emily, Lori:

This is what I mentioned to you both today. The plan would be for Janet to schedule a meeting with Richard Swayze at FAA; his assistant's email and phone are below. They are expecting the

request for a meeting – Lourdes at FAA has been in touch with them. For now, the only participant from OTAQ would be Chris.

I think the next step on this is to clear it with Janet and then move forward with scheduling the meeting. I know that Chris is not in DC the week of 12/8, but other than that I'm not entirely sure so I've copied Gwen here.

Please let me know if you have any questions. Thanks, Ben

From: Samulski, Michael
Sent: Monday, November 17, 2014 8:37 AM
To: Hengst, Benjamin; Charmley, William
Cc: Manning, Bryan
Subject: Contact information for Rich Swayze's Office at FAA

Ex. 5 - Deliberative Process

Natasha Dandridge

staff assistant

202-267-3927

Natasha.Dandridge@faa.gov

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Audette, Lucie[audette.lucie@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]
From: Charmley, William
Sent: Thur 12/17/2015 8:45:28 PM
Subject: Fwd: Aircraft--Prep for WH Meeting on 12/22
Materials for Janet on Aircraft CO2, 12 176 15.docx
ATT00001.htm

Sent from my iPhone

Begin forwarded message:

From: "Grundler, Christopher" <grundler.christopher@epa.gov>
Date: December 17, 2015 at 1:36:22 PM EST
To: "McCabe, Janet" <McCabe.Janet@epa.gov>
Cc: "Hengst, Benjamin" <Hengst.Benjamin@epa.gov>, "Charmley, William" <charmley.william@epa.gov>
Subject: Aircraft--Prep for WH Meeting on 12/22

Dear Janet,

Ex. 5 - Deliberative Process

Several of the EPA team will be on the call next week, including Bill Charmley, Mike Samulski, and Bryan Manning.

Thanks

Chris

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
From: Charmley, William
Sent: Fri 11/13/2015 7:07:01 PM
Subject: FW: EPA concerns with draft FAA paper on CO2 cost-benefit analysis

From: Charmley, William
Sent: Friday, November 13, 2015 2:07 PM
To: 'Lourdes.Maurice@faa.gov'
Subject: EPA concerns with draft FAA paper on CO2 cost-benefit analysis

Dear Lourdes,

I hope all is going well for you in Montreal.

Mike brought me up to speed in the last few days regarding the current dialog between our teams on the FAA sponsored work at MIT on cost-benefit assessment of the CO2 stringency options.

Ex. 5 - Deliberative Process

I wanted to explain to you that these issues are being elevated within EPA in offices other than my (Chris's) office. If you have time for a short call this afternoon or evening I would appreciate it – you can call me on my cell phone Ex. 6 - Personal Privacy).

Thanks

Bill

Bill Charmley

Director

Assessment and Standards Division

Office of Transportation and Air Quality

U.S. Environmental Protection Agency

National Vehicle and Fuel Emissions Laboratory

2000 Traverwood Drive

Ann Arbor, MI 48105

desk ph. 734-214-4466

cell ph. Ex. 6 - Personal Privacy

e-mail: charmley.william@epa.gov

To: Samulski, Michael[samulski.michael@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Charmley, William
Sent: Wed 10/14/2015 10:52:30 AM
Subject: RE: Draft Talking Points for Janet
Aircraft CO2 talking points.docx

Mike

Ex. 5 - Deliberative Process

That it. I would like Lucie to review as well, and of course Ben and Chris. I won't be able to spend any meaningful time on this between now and Thursday, but I will be trying to look at emails when I can.

Good luck on Thursday.

From: Samulski, Michael
Sent: Tuesday, October 13, 2015 3:00 PM
To: Charmley, William

Cc: Manning, Bryan; Leggett, Cullen
Subject: Draft Talking Points for Janet

Bill,

Here are the draft talking points for Gina. I'm copying them below as well, in the hope that you can read them that way on your phone. We will plan on sending this to Ben in the morning.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

To: Gonzalez, Gail[Gonzalez.Gail@epa.gov]
From: Charmley, William
Sent: Thur 11/2/2017 12:34:01 PM
Subject: Gail, please print 1 color copy for me. 2 slides per page, 2-sided. Thanks, Bill
Briefing_Aircraft CO2 Rule DRAFT 10-30-17.pptx
ATT00001.txt

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
Cc: Samulski, Michael[samulski.michael@epa.gov]
From: Charmley, William
Sent: Tue 2/28/2017 2:25:54 PM
Subject: RE: icymi-- greenwire article on aircraft GHG stds

Ben –

That sounds great. And I know you and I have a general today from 4-5pm, lets spend just a few minutes on this topic during that call.

Bill

From: Hengst, Benjamin
Sent: Tuesday, February 28, 2017 8:58 AM
To: Charmley, William <charmley.william@epa.gov>
Cc: Samulski, Michael <samulski.michael@epa.gov>
Subject: RE: icymi-- greenwire article on aircraft GHG stds

Thanks, Bill.

I'm supposed to have a quick chat with Pete Pagano on Friday. **Ex. 5 - Deliberative Process** **Ex. 5 - Deliberative Process** I'll report back to you guys if there's anything worth noting.

From: Charmley, William
Sent: Tuesday, February 28, 2017 7:57 AM
To: Grundler, Christopher <grundler.christopher@epa.gov>; Hengst, Benjamin <Hengst.Benjamin@epa.gov>
Subject: Fwd: icymi-- greenwire article on aircraft GHG stds

This article is worth reading.

Sent from my iPhone

Begin forwarded message:

From: "Samulski, Michael" <samulski.michael@epa.gov>
Date: February 28, 2017 at 7:36:55 AM EST
To: "Charmley, William" <charmley.william@epa.gov>
Cc: "Manning, Bryan" <manning.bryan@epa.gov>
Subject: FW: icymi-- greenwire article on aircraft GHG stds

The below article speaks on industry and NGO support for aircraft CO2 standards and CORSIA.

From: Orlin, David
Sent: Monday, February 27, 2017 5:11 PM
To: Thrift, Mike <thrift.mike@epa.gov>; Williams, Melina <Williams.Melina@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>
Subject: icymi-- greenwire article on aircraft GHG stds

To Woo Trump, Backers Pitch 'Business Case' For Global Aircraft GHG Deals

February 27, 2017

Environmentalists and industry groups are urging EPA and the Department of Transportation (DOT) to craft rules to implement two international agreements reached last year curbing aircraft greenhouse gases (GHGs), pitching a “business case” for the deals and arguing that they are less controversial than carbon controls directed at other industries, such as the power sector.

However, it is largely undetermined how the new administration will proceed, particularly since participation in the agreements would require EPA to promulgate GHG standards for aircraft engines -- at a time when the Trump team is looking to roll back many Obama-era climate rules and potentially target the agency's authority to regulate in that space.

In addition, aircraft industry representatives have said legislation will be needed implement one of the deals, though there is debate with some environmentalists over whether this is necessary. If Congress does need to act, it may be difficult to find enough Republican support for any legislation given many GOP lawmakers' opposition to GHG controls.

The two agreements were adopted by the United States and nearly 190 countries under the International Civil Aviation Organization (ICAO) last year. The first, a certification standard -- known as the carbon dioxide standard -- covering new and in-production aircraft, was adopted in February.

The second, adopted in October, is a global market-based measure (MBM) limiting emissions from existing aircraft. That measure functions as an offset system, under which airlines would cap their GHG emissions at 2020 levels and purchase offsets to cover any emissions from international flights beyond that level they are unable to reduce through other measures like fuel efficiency, technology improvements and sustainable alternative jet fuels.

The U.S. aircraft industry broadly views the two global policies as part of a larger strategy to address GHG emissions from the sector and to meet an overall industry-wide goal of carbon-neutral growth after 2020. The sector was heavily involved in the ICAO negotiations crafting both the CO2 standard and the MBM, and it strongly supports both outcomes.

And industry groups and other observers warn that if the United States declines to participate in the agreements -- particularly the CO2 standard -- it could carry risks, potentially limiting manufacturers' ability to sell their aircraft to other countries and restricting airlines' ability to fly internationally.

The Obama EPA initiated the process of adopting the CO2 standard into law, finalizing a finding that aircraft GHGs endanger public health and welfare -- which serves as a legal prerequisite to any regulation of the sector's emissions. In the finding, the agency said it would craft GHG limits that are "at least as stringent" as the global CO2 standard.

It remains an open question whether the Trump EPA, under the control of Scott Pruitt, will move forward with the standards, or whether the administration in general will adhere to the MBM deal. The Trump team has already pledged to roll back or weaken several of the Obama administration's GHG controls, including those for existing power plants and for light-duty vehicles.

'Differently Situated'

But supporters of the aircraft deals, including industry and environmentalists, are attempting to paint the aviation standards as noncontroversial, particularly given the strong support from industry and the global dynamic, thus decoupling the issue from the heated debate to come over whether and how EPA should regulate GHGs.

The decision in front of EPA to regulate GHGs from aircraft engines, by adopting into domestic law ICAO's CO2 standard, "is not a political statement. It is more of a business case" involving "industry certainty," said Suzanne Murray, a former EPA Region 6 counsel who now works as an attorney for Haynes and Boone.

Speaking at a Feb. 22 conference hosted by the International Air Transport Association, Murray said she believes the aviation industry is "very differently situated" than other industries like the power sector in part because "you have recognition of the ICAO efforts in the U.S. Regulation."

She also noted the involvement of the DOT's Federal Aviation Administration (FAA), which is charged with implementing the CO2 certification standard EPA would set. Thus, if the Trump EPA declines to adopt ICAO's CO2 standard into domestic law, it could place the FAA, which has to have "some certainty and . . . clarity about what they're certifying to," in a "precarious position," Murray said.

DOT and FAA's involvement in implementing the standards could ultimately help them get across the regulatory finish line, should the Trump administration decide the issue falls in the realm of transportation policy and not environmental policy, Annie Petsonk of the Environmental Defense Fund (EDF) suggested.

"If the Department of Transportation has the lead" on these issues "as a policy matter within the administration, and if industry is saying, . . . 'This is our chance to get a set of regulations for ourselves that we think address the problem and we can live with economically,' then I think it has a chance to survive," Petsonk said.

Although the Trump administration has not yet publicly addressed aircraft GHG policy or the ICAO agreements, advisers have suggested the Trump EPA could attempt to target the agency's 2009 GHG endangerment finding, which underpins EPA's climate regulations including the aircraft risk finding and any potential standards for that sector.

But Murray said she finds it "unlikely" that the Trump administration will ultimately target the underlying endangerment finding. Instead, she suggested the Trump EPA is more likely "going to do an analysis of the endangerment finding and regulation of carbon industry-by-industry."

Such a scenario, she suggested, could benefit the aviation industry. Analysis of carbon regulation for a sector like the power industry, for example, "could be very different from the analysis you would do on regulation of carbon from the aviation industry where you have . . . already made some decisions about cost effectiveness, about technology, about how you want to participate in the global market," Murray said. She added: "I think that may weigh differently in the analysis of how this regulation may move forward."

'Love Sonnet'

Aircraft industry groups are also perfecting their pitch to the new administration in support of the ICAO deals.

Nancy Young of Airlines for America said if she were writing a “love sonnet” to the Trump administration to persuade it to pursue the ICAO deals, her message would “come back to technology, operations and infrastructure.”

She described the MBM in particular as a “critical gap filler for our ability to do business internationally under a common set of goals,” noting that message should speak to the administration's “business” and “America first” interests.

However, she cautioned that industry's “love sonnet” to the Trump administration “is a different story” if other countries do not adhere to the notion that the MBM is the sole international deal to limit existing aircraft GHGs -- which was a crucial request of industry during the negotiations.

Young criticized efforts like a proposed international aviation tax being floated in Sweden and the European Union's Emissions Trading System -- should it continue to cover intra-Europe flights after 2021 when the MBM takes hold -- noting industry's message to the Trump team is about the whole “package and the ability to do this right for business.”

Young, as well as Murray, warned of a “worst-case scenario” if the Trump administration were to not move forward with GHG standards for aircraft engines.

Young noted that if the United States did not adopt the ICAO CO2 standard into law so that American manufacturers such as Boeing can ensure their aircraft are properly certified, “other countries could use the technique of, 'We won't let those aircraft into our air space because it's an air worthiness standard that it doesn't meet.'” That refers to a seldom-used provision under the Chicago Convention, the 1944 treaty establishing ICAO, that gives

countries the ability to not allow another country's aircraft to enter their air space if that country is not complying with ICAO standards.

Such enforcement of the MBM, covering existing aircraft, is more complicated, however, because that measure applies to airlines and to countries, and functions as an offsetting program rather than a technology-based certification standard, making it more difficult to respond when parties are not "living up to the real deal" of the MBM.

Young said instead that enforcement of the MBM will "rely on the will of the states and the bilateral process for consultation to make sure that that happens right," adding that industry groups will also play a "persuasive role."

EDF's Petsonk also noted the importance of self-regulation by industry, arguing "that kind of culture will be crucial" to the MBM's implementation. She suggested another important aspect to enforcement of the aircraft GHG limits could be an "increasing consciousness among the flying public that this is an issue that must be dealt with." Petsonk noted "that is true not only for the customers flying in travel terms, but also in freight terms." The latter dynamic could also come into play as countries and localities committed to GHG reductions seek to import products with a low carbon impact.

California and several other national and subnational markets "want to know the carbon footprint of the products they are buying," Petsonk said, "and if [the products] are flown in, they want to know how the airline is dealing" with its GHG emissions. -- *Abby Smith* (**asmith@iwpnews.com**)

Related News | Mid Day E-mail | Transition 2016-2017 | Air | Climate Policy Watch |

To: Grundler, Christopher[grundler.christopher@epa.gov]; Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Charmley, William
Sent: Tue 2/28/2017 12:57:07 PM
Subject: Fwd: icymi-- greenwire article on aircraft GHG stds

This article is worth reading.

Sent from my iPhone

Begin forwarded message:

From: "Samulski, Michael" <samulski.michael@epa.gov>
Date: February 28, 2017 at 7:36:55 AM EST
To: "Charmley, William" <charmley.william@epa.gov>
Cc: "Manning, Bryan" <manning.bryan@epa.gov>
Subject: FW: icymi-- greenwire article on aircraft GHG stds

The below article speaks on industry and NGO support for aircraft CO2 standards and CORSIA.

From: Orlin, David
Sent: Monday, February 27, 2017 5:11 PM
To: Thrift, Mike <thrift.mike@epa.gov>; Williams, Melina <Williams.Melina@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>
Subject: icymi-- greenwire article on aircraft GHG stds

To Woo Trump, Backers Pitch 'Business Case' For Global Aircraft GHG Deals

February 27, 2017

Environmentalists and industry groups are urging EPA and the Department of Transportation (DOT) to craft rules to implement two international agreements reached last year curbing aircraft greenhouse gases (GHGs), pitching a “business case” for the deals and

arguing that they are less controversial than carbon controls directed at other industries, such as the power sector.

However, it is largely undetermined how the new administration will proceed, particularly since participation in the agreements would require EPA to promulgate GHG standards for aircraft engines -- at a time when the Trump team is looking to roll back many Obama-era climate rules and potentially target the agency's authority to regulate in that space.

In addition, aircraft industry representatives have said legislation will be needed implement one of the deals, though there is debate with some environmentalists over whether this is necessary. If Congress does need to act, it may be difficult to find enough Republican support for any legislation given many GOP lawmakers' opposition to GHG controls.

The two agreements were adopted by the United States and nearly 190 countries under the International Civil Aviation Organization (ICAO) last year. The first, a certification standard -- known as the carbon dioxide standard -- covering new and in-production aircraft, was adopted in February.

The second, adopted in October, is a global market-based measure (MBM) limiting emissions from existing aircraft. That measure functions as an offset system, under which airlines would cap their GHG emissions at 2020 levels and purchase offsets to cover any emissions from international flights beyond that level they are unable to reduce through other measures like fuel efficiency, technology improvements and sustainable alternative jet fuels.

The U.S. aircraft industry broadly views the two global policies as part of a larger strategy to address GHG emissions from the sector and to meet an overall industry-wide goal of carbon-neutral growth after 2020. The sector was heavily involved in the ICAO negotiations crafting both the CO2 standard and the MBM, and it strongly supports both outcomes.

And industry groups and other observers warn that if the United States declines to participate in the agreements -- particularly the CO2 standard -- it could carry risks, potentially limiting manufacturers' ability to sell their aircraft to other countries and

restricting airlines' ability to fly internationally.

The Obama EPA initiated the process of adopting the CO2 standard into law, **finalizing a finding** that aircraft GHGs endanger public health and welfare -- which serves as a legal prerequisite to any regulation of the sector's emissions. In the finding, the agency said it would craft GHG limits that are “at least as stringent” as the global CO2 standard.

It remains an open question whether the Trump EPA, under the control of Scott Pruitt, will move forward with the standards, or whether the administration in general will adhere to the MBM deal. The Trump team has already pledged to roll back or weaken several of the Obama administration's GHG controls, including those for existing power plants and for light-duty vehicles.

'Differently Situated'

But supporters of the aircraft deals, including industry and environmentalists, are attempting to paint the aviation standards as noncontroversial, particularly given the strong support from industry and the global dynamic, thus decoupling the issue from the heated debate to come over whether and how EPA should regulate GHGs.

The decision in front of EPA to regulate GHGs from aircraft engines, by adopting into domestic law ICAO's CO2 standard, “is not a political statement. It is more of a business case” involving “industry certainty,” said Suzanne Murray, a former EPA Region 6 counsel who now works as an attorney for Haynes and Boone.

Speaking at a Feb. 22 conference hosted by the International Air Transport Association, Murray said she believes the aviation industry is “very differently situated” than other industries like the power sector in part because “you have recognition of the ICAO efforts in the U.S. Regulation."

She also noted the involvement of the DOT's Federal Aviation Administration (FAA), which is charged with implementing the CO2 certification standard EPA would set. Thus, if

the Trump EPA declines to adopt ICAO's CO2 standard into domestic law, it could place the FAA, which has to have "some certainty and . . . clarity about what they're certifying to," in a "precarious position," Murray said.

DOT and FAA's involvement in implementing the standards could ultimately help them get across the regulatory finish line, should the Trump administration decide the issue falls in the realm of transportation policy and not environmental policy, Annie Petsonk of the Environmental Defense Fund (EDF) suggested.

"If the Department of Transportation has the lead" on these issues "as a policy matter within the administration, and if industry is saying, . . . 'This is our chance to get a set of regulations for ourselves that we think address the problem and we can live with economically,' then I think it has a chance to survive," Petsonk said.

Although the Trump administration has not yet publicly addressed aircraft GHG policy or the ICAO agreements, advisers have suggested the Trump EPA could attempt to target the agency's 2009 GHG endangerment finding, which underpins EPA's climate regulations including the aircraft risk finding and any potential standards for that sector.

But Murray said she finds it "unlikely" that the Trump administration will ultimately target the underlying endangerment finding. Instead, she suggested the Trump EPA is more likely "going to do an analysis of the endangerment finding and regulation of carbon industry-by-industry."

Such a scenario, she suggested, could benefit the aviation industry. Analysis of carbon regulation for a sector like the power industry, for example, "could be very different from the analysis you would do on regulation of carbon from the aviation industry where you have . . . already made some decisions about cost effectiveness, about technology, about how you want to participate in the global market," Murray said. She added: "I think that may weigh differently in the analysis of how this regulation may move forward."

'Love Sonnet'

Aircraft industry groups are also perfecting their pitch to the new administration in support of the ICAO deals.

Nancy Young of Airlines for America said if she were writing a “love sonnet” to the Trump administration to persuade it to pursue the ICAO deals, her message would “come back to technology, operations and infrastructure.”

She described the MBM in particular as a “critical gap filler for our ability to do business internationally under a common set of goals,” noting that message should speak to the administration's “business” and “America first” interests.

However, she cautioned that industry's “love sonnet” to the Trump administration “is a different story” if other countries do not adhere to the notion that the MBM is the sole international deal to limit existing aircraft GHGs -- which was a crucial request of industry during the negotiations.

Young criticized efforts like a proposed international aviation tax being floated in Sweden and the European Union's Emissions Trading System -- should it continue to cover intra-Europe flights after 2021 when the MBM takes hold -- noting industry's message to the Trump team is about the whole “package and the ability to do this right for business.”

Young, as well as Murray, warned of a “worst-case scenario” if the Trump administration were to not move forward with GHG standards for aircraft engines.

Young noted that if the United States did not adopt the ICAO CO2 standard into law so that American manufacturers such as Boeing can ensure their aircraft are properly certified, “other countries could use the technique of, 'We won't let those aircraft into our air space because it's an air worthiness standard that it doesn't meet.'” That refers to a seldom-used provision under the Chicago Convention, the 1944 treaty establishing ICAO, that gives countries the ability to not allow another country's aircraft to enter their air space if that country is not complying with ICAO standards.

Such enforcement of the MBM, covering existing aircraft, is more complicated, however, because that measure applies to airlines and to countries, and functions as an offsetting program rather than a technology-based certification standard, making it more difficult to respond when parties are not "living up to the real deal" of the MBM.

Young said instead that enforcement of the MBM will "rely on the will of the states and the bilateral process for consultation to make sure that that happens right," adding that industry groups will also play a "persuasive role."

EDF's Petsonk also noted the importance of self-regulation by industry, arguing "that kind of culture will be crucial" to the MBM's implementation. She suggested another important aspect to enforcement of the aircraft GHG limits could be an "increasing consciousness among the flying public that this is an issue that must be dealt with." Petsonk noted "that is true not only for the customers flying in travel terms, but also in freight terms." The latter dynamic could also come into play as countries and localities committed to GHG reductions seek to import products with a low carbon impact.

California and several other national and subnational markets "want to know the carbon footprint of the products they are buying," Petsonk said, "and if [the products] are flown in, they want to know how the airline is dealing" with its GHG emissions. -- *Abby Smith* (**asmith@iwpnews.com**)

Related News | Mid Day E-mail | Transition 2016-2017 | Air | Climate Policy Watch |

To: Dravis, Samantha[dravis.samantha@epa.gov]; Bolen, Brittany[bolen.brittany@epa.gov]
Cc: Lovell, Will (William)[lovell.william@epa.gov]; Nickerson, William[Nickerson.William@epa.gov]; Muellerleile, Caryn[Muellerleile.Caryn@epa.gov]; Kime, Robin[Kime.Robin@epa.gov]
From: Owens, Nicole
Sent: Tue 2/20/2018 4:17:09 PM
Subject: Regulatory Agenda entries for your review
Priority-RegAgenda_02-20-2018 for IO.xlsx

Hello-

The attached file contains Regulatory Agenda entries for your review. The material is due to OMB on Friday, if it would be possible to have comments by Thursday, we would appreciate it it.

Ex. 5 - Deliberative Process

If you have any questions, let us know.

Nicole

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

To: McCabe, Janet[McCabe.Janet@epa.gov]
From: Grundler, Christopher
Sent: Fri 10/21/2016 5:09:10 PM
Subject: Offer for One Less Meeting Next Week
Early Guidance Briefing_Aircraft GHG Std_October 25 2016.pptx

Hi Janet,

I should have made this offer before your scheduling meeting, but today is pretty crazy because it is Lee's last day for a while so we had much to cover, including her PARS. But on Monday we scheduled a Pre-Meeting with you for Tuesday's Early Guidance Meeting (with the workgroup) on the aircraft GHG standards NPRM is scheduled for Tuesday. Attached are the materials for this meeting. Since the briefing materials are uncontroversial and straight forward, I suggest that we cancel the Monday meeting, which will free up time on your schedule. We are happy to go through the Early Guidance briefing twice if you prefer, but we do not think it is necessary. If you have any comments over the weekend on the materials, pass them along, and we will make the revisions in time for the Tuesday meeting. Let me know if you have any questions.

Thanks,

Chris

Christopher Grundler, Director

Office of Transportation and Air Quality

U.S. Environmental Protection Agency

202.564.1682 (Washington, DC)

734.214.4207 (Ann Arbor, MI)

To: OAR Briefings[OAR_Briefings@epa.gov]
Cc: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Sutton, Tia
Sent: Thur 10/27/2016 1:37:45 PM
Subject: Materials for Friday 12pm Aircraft GHG briefing
Aircraft Petitions briefing for Janet_102516 clean.pptx

Good morning!

Attached are materials for tomorrow's 12pm briefing with Janet "Petitions for Reconsideration and Review of Final Greenhouse Gas Endangerment and Cause or Contribute Findings Under CAA Section 231 for Aircraft."

Thank you!

-Tia

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Orlin, David
Sent: Wed 10/26/2016 6:03:49 PM
Subject: RE: Weekly fuels mtg with Chris tomorrow
Aircraft Petitions briefing for Janet_102516 clean.pptx

This is not fuels related, and I don't think it should require a separate Chris briefing, but OGC/OAP/OTAQ are briefing Janet on Friday about the petition for reconsideration on aircraft GHG.

David Orlin
U.S. EPA, Office of General Counsel
(202) 564-1222

-----Original Message-----
From: Hengst, Benjamin
Sent: Wednesday, October 26, 2016 2:01 PM
To: Machiele, Paul <machiele.paul@epa.gov>; Argyropoulos, Paul <Argyropoulos.Paul@epa.gov>; Sutton, Tia <sutton.tia@epa.gov>; Manners, Mary <manners.mary@epa.gov>; Korotney, David <korotney.david@epa.gov>; Burkholder, Dallas <burkholder.dallas@epa.gov>; Orlin, David <Orlin.David@epa.gov>; Dubois, Roland <Dubois.Roland@epa.gov>; Reid, Lauren <Reid.Lauren@epa.gov>; Lie, Sharyn <Lie.Sharyn@epa.gov>; Simon, Karl <Simon.Karl@epa.gov>
Subject: Weekly fuels mtg with Chris tomorrow

Hi all -- I'm putting on the table the motion to cancel tomorrow's fuels weekly. Any objections? Please let me know if I'm forgetting something we need to update him on. My thinking is that we covered what we needed to with Janet today.

Thanks. Ben

To: Sutton, Tia[sutton.tia@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
Cc: Samulski, Michael[samulski.michael@epa.gov]; Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Manning, Bryan
Sent: Wed 12/9/2015 6:17:10 PM
Subject: RE: OAP draft response letter to aircraft control
16-000-0271_Lieu Aircraft DRAFT + OTAQ.docx

Hello Tia,

Attached please find our comments. If possible, could you ask OAP to Cc: us on any correspondence with OGC?

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Sutton, Tia
Sent: Monday, December 07, 2015 6:36 PM
To: Audette, Lucie <audette.lucie@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>
Cc: Samulski, Michael <samulski.michael@epa.gov>; Hengst, Benjamin <Hengst.Benjamin@epa.gov>
Subject: FW: OAP draft response letter to aircraft control

All,

Please see attached Congressional control on the aircraft ANPRM and a draft response from OAP for OTAQ review. As Kristina noted in the email below, they would like any feedback we have within the next day or 2 if possible (but they'll handle processing the letter, etc.).

Thanks,

Tia

From: Friedman, Kristina
Sent: Monday, December 07, 2015 6:29 PM
To: Sutton, Tia <sutton.tia@epa.gov>
Subject: draft letter

Hi Tia,

Sorry for the delay, but here's a draft response to the Lieu control on aircrafts. Do you guys want to take a look and send me any revisions within the next day or so? Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process As a reminder, I've included the incoming as well. As soon as you guys review and approve, we'll process the letter and send it forward to the IO.

Thanks,

Kristina

Kristina Friedman

Office of Atmospheric Programs

U.S. Environmental Protection Agency

Phone: (202) 343-9281

To: Birgfeld, Erin[Birgfeld.Erin@epa.gov]; Mylan, Christopher[Mylan.Christopher@epa.gov]; Millett, John[Millett.John@epa.gov]; Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: StClair, Christie
Sent: Wed 6/10/2015 7:01:47 PM
Subject: RE: Aircraft Emissions Standards Clips 6/10

Thanks. Checking with Liz on how she'd like to handle NYT and others "reporting" the same thing.

Christie St. Clair

Office of Public Affairs

Environmental Protection Agency

Washington, DC

o: 202-564-2880

Ex. 6 - Personal Privacy

From: Birgfeld, Erin
Sent: Wednesday, June 10, 2015 2:59 PM
To: StClair, Christie; Mylan, Christopher; Millett, John; Hengst, Benjamin
Subject: RE: Aircraft Emissions Standards Clips 6/10

This is inaccurate reporting.

From: StClair, Christie
Sent: Wednesday, June 10, 2015 2:54 PM
To: Mylan, Christopher; Birgfeld, Erin; Millett, John
Subject: FW: Aircraft Emissions Standards Clips 6/10

Do y'all take issue with this lede?

Christie St. Clair

Office of Public Affairs

Environmental Protection Agency

Washington, DC

o: 202-564-2880

Ex. 6 - Personal Privacy

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 2:52 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

New York Times (update)

http://www.nytimes.com/2015/06/11/business/energy-environment/epa-says-it-will-set-rules-for-airplane-emissions.html

-

E.P.A. Says It Will Set Rules for Airplane Emissions

By JAD MOUAWAD and CORAL DAVENPORTJUNE 10, 2015

The Obama administration on Wednesday said it is taking the first steps toward would regulating greenhouse gas emissions from airplanes, a move that could significantly strengthen President Obama's environmental legacy but that also presents major new challenges for the airline industry.

The Environmental Protection Agency proposed to find that….[~~found that~~ emissions from airplanes endanger human health because of their contribution to global warming]. That finding does not yet impose specific new requirements on airlines, but instead if finalized would requires the agency to develop the new rules, as it has done for motor vehicles and power plants.

The announcement represents the latest of Mr. Obama's major initiatives to combat global warming. Next week, the agency is expected to propose new rules on emissions from heavy-duty trucks, and in August it is expected to announce new rules to rein in power plant pollution.

"With today's announcement, President Obama has a unique and extremely important opportunity to demonstrate leadership not only domestically but around the world," said William Becker, executive director of the National Association of Clean Air Agencies.

But the airline industry contends that it has already worked aggressively to reduce fuel use and increase efficiency, and that demands to do even more could raise costs. Already, airlines are looking into new technologies and alternatives like carbon-neutral — but expensive — biofuels.

In their never-ending drive to reduce fuel costs, airlines have turned to a variety of strategies, like taxiing with a single engine, fitting winglets to improve plane aerodynamics, or using lighter material for seats, galleys or in-flight magazines. Since every pound matters, some have cut back on the ice they bring on board.

Each 5.5 pounds of weight reduced on an airplane means a one-ton reduction in carbon emissions per year, according to calculations by the International Air Transport Association.

But making big cuts in greenhouse gas emissions is a hard task. The industry's efforts to improve fuel efficiency and reduce carbon emissions have been more than offset by the growth of the aviation sector around the world.

Aviation accounts for about 2 percent of global emissions, but it is among the fastest-growing sources of global greenhouse gas emissions as air travel becomes more affordable and more people travel around the world. By 2020, international aviation emissions could be 70 percent higher than in 2005, even if fuel efficiency improves by 2 percent a year, according to estimates cited by the European Commission.

Given the global nature of the business, airlines have argued the rules should be global. In 2012, the European Union sought to force foreign carriers to participate in its emissions trading scheme. The move was thwarted by the United States, China and other nations that said they would retaliate if their airlines were forced to do so. The Obama administration said it would bar United States airlines from participating.

Instead, airlines, plane makers, and regulators turned to the International Civil Aviation Organization, the United Nations agency that sets rules for airlines around the world, to come up with a new international carbon emission standard that would apply to all new planes.

That agreement, which is expected to be approved in 2016, will set a new benchmark for jet engine efficiency as well as the use of lighter composite materials for aircraft frames. Airline representatives said they expected the E.P.A., which has been involved in those international negotiations, to use the same standards for domestic aviation as the rest of world does.

Separately, commercial airlines have voluntarily committed to limit the growth of their carbon emissions to 2 percent a year through 2020, then cap emission growth after that. By 2050, the industry hopes to cut its greenhouse gas emissions to half their 2005 levels, according to I.A.T.A.

"We are driven to be really fuel-efficient because fuel is usually our No. 1 cost," said Nancy Young, the vice president for regulatory affairs at Airlines for America, the industry's trade group. "So, we are driven to be very carbon-efficient as well. We are doing everything we can through technology and operations to reduce our emissions."

In 2014, domestic carriers burned 8 percent less fuel than they did in 2000, while carrying 20 percent more passengers and cargo, she said.

"The challenge is an important economic opportunity," Ms. Young said. "More and more people around the world want the benefit of air travel and all the good things that aviation brings. So there has been growth in aviation and this has increased emissions despite the fact that we are more efficient."

Buying new planes with more efficient engines remains the most effective path to reducing an airline's fuel costs. The newest generation of airplanes, like the Boeing 787 Dreamliner and the Airbus A350, promise about 20 percent better fuel economy thanks to new engines and lighter airframes.

So far, Boeing has delivered over 280 of its 787s to airlines around the world, out of more than 1,100 planes it has on order. Airbus has 780 A350s on order and has, so far, delivered just three.

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 2:45 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Io9 blog:

http://io9.com/epa-to-establish-rules-for-airplane-emissions-1710405170

EPA To Establish Rules For Airplane Emissions

Robbie Gonzalez

The New York Times reports the Environmental Protection Agency will soon establish emissions rules for airplanes, as it has for motor vehicles and power plants, to limit airlines' contributions to global warming.

The announcement represents the latest of Mr. Obama's major initiatives to combat global warming. Next week, the agency is expected to propose new rules on emissions from heavy-duty trucks, and in August it is expected to announce new rules to rein in power plant pollution.

Environmentalists hailed the announcement, saying that it could drive aircraft manufacturers to research innovative new ways to reduce emissions from a major source of pollution.

"With today's announcement, President Obama has a unique and extremely important opportunity to demonstrate leadership not only domestically but around the world," said William Becker, executive director of the National Association of Clean Air Agencies.

Don't expect the airlines to take this lying down. According to the Times, the industry has made big moves in recent years to reduce its greenhouse gas emissions, though "improve fuel efficiency and reduce carbon emissions have been more than offset by the growth of the aviation sector around the world."

One wonders what restrictions the EPA can put in place to curb the industry's environmental impact in a meaningful way, and if there aren't bigger-impact solutions to be had elsewhere. "Carbon-neutral" biofuels? Electric aircraft? Intercontinental hyperloops?

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 2:41 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan

Subject: RE: Aircraft Emissions Standards Clips 6/10

Business Wire:

http://www.businesswire.com/news/home/20150610006215/en/Airlines-America-Supports-Ongoing-Work-International-Aircraft#.VXiEAflVhHw

Airlines for America Supports Ongoing Work on International Aircraft Emissions Standard

June 10, 2015 02:24 PM Eastern Daylight Time

WASHINGTON--(BUSINESS WIRE)--Airlines for America (A4A), the industry trade organization for the leading U.S. airlines, today issued the following statement in response to the Environmental Protection Agency's (EPA) announced finding, as required under the Clean Air Act and Advance Notice of Proposed Rulemaking on aircraft greenhouse gas (GHG) emissions.

"The technology, operations and infrastructure initiatives that our airlines are undertaking to further address GHG emissions are designed to responsibly and effectively limit their carbon emissions and potential climate change impacts while allowing them to continue to serve as drivers of U.S. and global economies."

U.S. airlines drive 5 percent of U.S. economic activity but account for only 2 percent of the nation's GHG emissions. A4A and our members support the work at the International Civil Aviation Organization (ICAO) to develop a carbon dioxide (CO2) certification standard for new type aircraft, as it will further support our global aviation coalition's emissions goals to achieve 1.5% annual average fuel efficiency improvements through 2020 and carbon neutral growth from 2020, subject to critical aviation infrastructure and technology advances achieved by government and the industry. Before EPA may adopt the future international standard into U.S. law, the Clean Air Act requires the Agency to have made the proposed finding that aircraft GHG emissions "cause or contribute" to the climate change effects generally posed by GHG emissions. EPA made that general finding in 2009 and has been conducting the Clean Air Act-required assessments on a sector-by-sector basis in the years since.

"Aviation is a global industry, making it critical that aircraft emissions standards continue to be agreed upon at the international level," said A4A Vice President, Environmental Affairs Nancy Young. "While we believe that any regulatory action must be consistent with both the agency's authority under the Clean Air Act and the future ICAO standard, today's action reconfirms the EPA's commitment to the ICAO process for achieving a global CO2 standard for new aircraft."

Young noted the U.S. aviation industry's exceptional environmental track record, having improved fuel efficiency over 120 percent since 1978, and saving over 3.8 billion metric tons of CO2, the equivalent to taking 23 million cars off the road each of those years. Further, the U.S. airlines carried 20 percent more passengers and cargo in 2014 than they did in 2000, while emitting 8 percent less CO2.

"U.S. airlines are green and we are getting even greener," said Young. "The technology, operations and infrastructure initiatives that our airlines are undertaking to further address GHG emissions are designed to responsibly and effectively limit their carbon emissions and potential climate change impacts while allowing them to continue to serve as drivers of U.S. and global economies."

The ICAO work on an aircraft CO2 certification standard for new aircraft commenced in 2010 under the Committee on Aviation Environmental Protection. EPA and the U.S. Federal Aviation Administration are key participants in this work, which is expected to culminate in February 2016 with a recommended international aircraft standard.

ABOUT A4A

Annually, commercial aviation helps drive nearly $1.5 trillion in U.S. economic activity and more than 11 million U.S. jobs. Airlines for America (A4A) vigorously advocates on behalf of the American airline industry as a model of safety, customer service and environmental responsibility and as the indispensable network that drives our nation's economy and global competitiveness. Our member carriers and their affiliates transport more than 90 percent of all U.S. airline passenger and cargo traffic.

America needs a cohesive National Airline Policy that will support the integral role the nation's airlines play in connecting people and goods globally, spur the nation's economic growth and

create more high-paying jobs. A4A works collaboratively with the airlines, labor groups, Congress and the Administration to improve air travel for everyone.

For more information about the airline industry, visit our website airlines.org and our blog, A Better Flight Plan, at airlines.org/blog.

To learn how you can support a National Airline Policy, a better flight plan for everyone, visit www.nationalairlinepolicy.com.

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 2:37 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Daily Caller:

http://dailycaller.com/2015/06/10/obama-moves-to-regulate-co2-from-airplanes/

Obama Moves To Regulate CO2 From Airplanes

Photo of Michael Bastasch

MICHAEL BASTASCH

First tailpipes, then power plants and now airplanes. The Obama administration announced another major effort to regulate carbon dioxide emissions from airplanes after the Environmental Protection Agency linked airliners to global warming.

The EPA issued a proposal Wednesday declaring that CO2 from airliners threatens public health because it contributes to global warming. The agency says it's doing this in conjunction with an international effort to bring the airline industry under global carbon dioxide standards for commercial jets.

Republicans have already vowed to challenge the EPA's proposal to regulate airline emissions, saying new federal regulations would increase travel costs and fuel prices.

"The sky is the limit when it comes to how much of the U.S. economy the EPA wants to control," Texas Republican Rep. Lamar Smith said in a statement.

"The EPA today released a finding that emissions from commercial airplanes are harmful to human health, which opens the door for new regulations," Smith added. "Such regulations would increase the price of airfare for Americans and harm our domestic carriers."

Environmentalists, on the other hand, celebrated the news, arguing regulating airline emissions is necessary to fighting global warming.

"With today's announcement, President Obama has a unique and extremely important opportunity to demonstrate leadership not only domestically but around the world," William Becker, executive director of the National Association of Clean Air Agencies, told The New York Times.

The EPA says international rules over airline emissions are expected to be completed in 2016, adding that the U.S. proposal will set "the necessary foundation for the development and implementation of a domestic aircraft standard."

This marks another major effort by the Obama administration to "green up" the U.S.'s image ahead of United Nations climate talks in Paris slated for later this year. The administration also recently announced carbon dioxide standards for heavy trucks and is set to finalize CO2 limits

for power plants this summer.

The EPA says airliners "emit roughly 11 percent of [greenhouse gas] emissions from the U.S. transportation sector and 29 percent of [greenhouse gas] emissions from all aircraft globally."

"Today's action supports the goals of the President's Climate Action Plan to reduce emissions from large sources of carbon pollution," the agency said in a press release.

The airline industry says it's already working on ways to lower its carbon footprint by increasing fuel efficiency and decreasing use. Some airline companies are looking into using biofuels to power their aircraft, but biofuels are expensive and less dense when it comes to energy output.

The New York Times notes the challenges airlines already face in trying to reduce emissions. The Times reports that the aviation sector "is among the fastest--growing sources of global greenhouse gas emissions as air travel becomes more affordable and more people travel around the world."

"Over the last fifty years, the fuel efficiency of jetliners has increased by 70 percent. Incentives are already in place to make air travel more energy efficient," Smith said. "This proposal is the next leg of a nonstop journey by the EPA to control how Americans live, work and travel."

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 2:36 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

New Jersey.com:

http://www.nj.com/news/index.ssf/2015/06/epa_to_regulate_aircraft_emmissions.html

EPA takes first step toward regulating aircraft emissions

Print Email Steve Strunsky | NJ Advance Media for NJ.com By Steve Strunsky | NJ Advance Media for NJ.com

Email the author | Follow on Twitter

on June 10, 2015 at 2:24 PM, updated June 10, 2015 at 2:30 PM

WASHINGTON – The Environmental Protection Agency (EPA) is trying to keep air craft from polluting the air.

For the first time, the EPA has proposed regulating carbon emissions from commercial aircraft in the United States. The EPA said the move was consistent with steps already underway by the international community to limit aircraft emissions.

In inviting public comment on the proposal, the EPA is taking an initial step toward regulating aircraft emissions following a 2007 petition from the environmental law group Earth Justice, which jumped ahead of the agency Wednesday in announcing the EPA's decision.

In an announcement on Wednesday, the EPA said it was,

"proposing to find under the Clean Air Act that greenhouse gas (GHG) emissions from commercial aircraft contribute to the pollution that causes climate change endangering the health and welfare of Americans."

"At the same time, the agency is releasing information about the international process already underway by the International Civil Aviation Organization (ICAO) for developing carbon dioxide (CO2) standards for aircraft and EPA's participation in that process," the agency said. "EPA is now seeking public input to inform future steps by the agency."

The EPA said it had been working with the aviation industry on the issue for the past five years. The main industry group, Airlines for America, did not immediately respond to a

request for comment.

Earth Justice issued a statement commending the EPA for moving forward on regulation, but urged the agency to use its authority under the federal Clean Air Act to take more definitive action.

"We commend EPA for completing this important first step in regulating carbon pollution from airplanes, but unfortunately, given the magnitude of aircraft's contribution to climate change, the tentative approach that EPA is considering is not up to the task," Earth Justice said. "The EPA's Endangerment Finding confirms that aircraft are a significant source of climate pollution, emitting approximately 700 million metric tonnes per year. This makes global aviation, if it were equivalent to a country, the 7th largest global emitter, just below Germany and more than Korea and Canada."

Steve Strunsky may be reached at sstrunsky@njadvancemedia.com. Follow hin on Twitter @SteveStrunsky. Find NJ.com on Facebook.

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 2:29 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Demajo:

http://www.demanjo.com/news/world/2055396/u-s--epa-takes-first-step-to-regulate-aircraft-greenhouse-gas-emissions.html

EPA says it intends to regulate emissions by US airliners

Demanjo NewsDesk - Last Updated: 13 minutes ago

EPA says it intends to regulate emissions by US airliners

The U.S. Environmental Protection Agency on Wednesday said greenhouse gases from aircraft endanger human health, taking the first step toward regulating emissions from the domestic aviation industry.

The EPA's endangerment finding kicks off a process to regulate greenhouse gas emissions from the aviation industry, the latest sector to be regulated under the Clean Air Act after cars, trucks and large stationary sources like power plants.

The International Civil Aviation Organization, or ICAO, a U.N. agency, has been working for several years on developing global aircraft emissions standards for the first time.

Airlines, aircraft makers and the Federal Aviation Administration have also been working with biofuels companies to develop alternatives to jet fuel that could potentially reduce the aviation's industry's vulnerability to the ups and downs of oil supplies and prices, as well as reduce carbon emissions.

Since 2009 and 2010, when Mr. Obama first proposed emissions restrictions on the automotive sector, the EPA said new scientific research has determined that aircraft emissions also are a danger to public health.

"The body of science on human-induced climate change has strengthened, supporting today's proposed finding — under a different section of the Clean Air Act — that [greenhouse gases] emitted from aircraft engines contribute to pollution that causes climate change endangering public health and welfare," the agency said.

The center is one of several environmental groups that sued the EPA to force the agency to issue its finding that emissions endanger public health.

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 2:24 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

The Week:

http://theweek.com/speedreads/559833/epa-regulate-airplanes-greenhouse-gas-emissions

The EPA will regulate airplanes' greenhouse gas emissions

1:34 p.m. ET

Meghan DeMaria

The Obama administration announced Wednesday that it plans to regulate greenhouse gas emissions. The emissions contribute to climate change and threaten public health, according to the Environmental Protection Agency (EPA).

The move marks the administration's first step toward applying climate change regulations to the airline industry, though it remains to be seen how strict the EPA's airplane regulations will be. Wednesday's announcement didn't include specific requirements for airlines operating in the U.S., but the EPA is expected to finalize its "endangerment finding" on airplanes' greenhouse

gases next year. The New York Times also notes that the proposal will affect commercial aircraft, not recreational and military planes.

While airplanes only account for three percent of greenhouse gas emissions, the U.S. is responsible for 30 percent of global emissions, the Times explains. A 2012 court order forced the EPA to issue Wednesday's endangerment finding.

The announcement accompanies other actions by President Obama to address climate change, including new rules on power plant emissions that will be released in August

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 2:20 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Washington Examiner:

http://www.washingtonexaminer.com/epa-aircraft-emissions-endangers-americans-causes-global-warming/article/2565972

EPA: Aircraft emissions endangers Americans, causes global warming

BY JOHN SICILIANO | JUNE 10, 2015 | 2:04 PM

The Environmental Protection Agency announced Wednesday that emissions from commercial jets cause climate change, endangering the public's health and welfare.

"Today's action supports the goals of the President's Climate Action Plan to reduce emissions from large sources of carbon pollution," the EPA said in a press release.

The announcement is the first step in regulating the emissions from commercial airlines that most scientists say are to blame for manmade climate change. The regulations fall in step with the agency's efforts to regulate the emissions from cars, trucks and power plants. The EPA says it is excluding military and smaller aircraft from the regulations.

The agency also is taking action to support a United Nations process for regulating carbon dioxide from jets by 2016, called the International Civil Aviation Organization.

The EPA's power plant rules have been contentious for the potential impact they would have on energy prices. Some says the aircraft rules, as well, could lead to higher airfares.

Commercial aircraft account for 11 percent of the nation's carbon emissions and 29 percent of global emissions, according to the EPA.

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 2:16 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

International Business Times:

http://www.ibtimes.com/epa-regulate-airlines-environmental-risk-human-health-1961060

EPA To Regulate Airlines For Environmental 'Risk' To Human Health

By Eben Blake @ebenblake on June 10 2015 2:07 PM EDT

The Obama administration plans to begin regulating greenhouse gas emissions from aircrafts

after an Environmental Protection Agency report published Wednesday found that airline emissions pose a serious risk to human health in part because they contribute to global warming. But the enforcement of any environmental regulations is expected to be difficult and complex as international flights and airlines could be outside of the EPA's jurisdiction.

"If you're a big airline and you're flying to 100 countries a day, then complying with all those different regimes is an administrative nightmare," Paul Steele, senior vice president at the International Air Transport Association, the industry's main global organization, told Reuters.

The aviation industry is responsible for roughly 11 percent of greenhouse gas emissions in America's transportation sector and 3 percent of the United States' total output, according to coverage by International Business Times last week. Airlines have been placed under the Clean Air Act in part because of a lawsuit in 2012 against the EPA by environmental groups to regulate the industry.

"With today's announcement, President Obama has a unique and extremely important opportunity to demonstrate leadership not only domestically but around the world," William Becker, executive director of the National Association of Clean Air Agencies, told the New York Times.

While the administration has not announced any new rules or regulations on airlines with the "endangerment finding" by the EPA, the announcement puts the United States ahead of the United Nations' International Civil Aviation Organization, which is set to release its CO2 standard for aircrafts in February 2016. Those regulations are expected to apply only to new aircraft designs released after 2020, leaving out many older planes that could still be in the air for another 20 to 30 years, according to Reuters.

The aviation industry generally prefers internal or international regulation rather than different national standards in order to not have to deal with multiple governmental and bureaucratic complexities. And many airlines have been trying to implement energy and fuel efficient measures on their own, in part because of high fuel costs. Each 5.5 pounds of weight reduced on an airplane translates to a one-ton reduction in carbon emissions per year, according to the IATA.

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 2:08 PM

To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Associated Press:

http://www.wowktv.com/story/29287418/epa-says-it-intends-to-regulate-emissions-by-us-airliners

EPA says it intends to regulate emissions by US airliners

By JOAN LOWY Associated Press

WASHINGTON (AP) - The Obama administration proposed Wednesday to regulate aircraft emissions in much the same way as power plants, saying they are a threat to human health because they contain pollutants that help cause global warming.

Using its authority under The Clean Air Act, the Environmental Protection Agency finding of endangerment to human health clears the way for possible U.S. adoption of international emissions standards.

The International Civil Aviation Organization, or ICAO, a U.N. agency, has been working for several years on developing global aircraft emissions standards for the first time. Final agreement on those standards is expected in February of next year.

U.S. regulations would apply only to large planes like airliners and cargo jets and turboprop aircraft, and not to smaller jet aircraft, piston-engine planes, helicopters or military aircraft.

While negotiations on the standards are still underway, they aren't expected to go into effect until 2020 or afterward, and possibly as late as 2025, say environmentalists following the matter.

The ICAO standards are also not expected to apply to airliners in service today or those that might be purchased before the effective date, said Vera Pardee, an attorney with the Center for Biological Diversity. The center is one of several environmental groups that sued the EPA to force the agency to issue its finding that emissions endanger public health.

Airlines typically fly planes for 20 years or more before replacing them. That means it's likely to be decades before planes that meet the anticipated global standards are in widespread use.

Airline emissions account for about 2 percent of total annual global greenhouse gas emissions. That sounds small, but it's nearly as much as the emissions produced by Germany, the sixth-greatest greenhouse gas producing country, according to a study released last year by The International Council on Clean Transportation, an environmental group with offices in the U.S. and Germany.

Aircraft manufacturers have already made significant strides in increasing fuel efficiency. Since the early years of the jet age in the 1960s, the fuel efficiency of airliners has increased 70 percent, according to Boeing. There's plenty of incentive to be as efficient as possible: Fuel typically vies with labor as airlines' greatest expense.

The U.S. airline industry has a set a target of an average annual improvement in fuel efficiency of 1.5 percent, and so far has been successful in meeting that goal, said Nancy Young, vice president for environmental affairs at Airlines for America, trade association for major carriers.

Alaska, Frontier and Spirit airlines were tied for most fuel-efficient U.S. airlines, the study found. The least fuel efficient was American, which operates a fleet of MD-80 airliners, an older design that is being phased out.

Changes in the operating strategies of airlines in recent years have also contributed to greater efficiency. Airlines are packing more people into fewer flights.

However, global aviation emissions are rising because there is more air travel overall. U.S. airlines, which include several of the world's largest carriers, account for about 29 percent of global airline carbon emissions if both domestic and international flights are included.

The world's two largest aircraft makers have recently introduced into service more fuel-efficient planes designed for long-distance international routes - the Boeing 787 and the Airbus A350.

Airlines, aircraft makers and the Federal Aviation Administration have also been working with biofuels companies to develop alternatives to jet fuel that could potentially reduce the aviation's industry's vulnerability to the ups and downs of oil supplies and prices, as well as reduce carbon emissions.

"We're not dragging our feet," said Tim Neale, a spokesman for Boeing. "We're hard at work on lighter airplanes, and GE is hard at work on more efficient engines. And we're working a lot of these operational issues with the carriers so they operate the planes more efficiently."

Boeing and airline industry officials say they support ICAO's effort to develop a single global standard, since airlines fly globally. But Pardee said environmentalists hope that if the ICAO standard turns out to be weak, the EPA will move forward with stronger standards for U.S. airlines.

___

Follow Joan Lowy on Twitter at http://twitter.com/AP_Joan_Lowy

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 1:57 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Popular Mechanics:

http://www.popularmechanics.com/flight/a15973/epa-will-regulate-airplane-emissions/

The EPA Will Regulate Emissions From Airplanes

The Obama Administration says it will write new rules to make flying more efficient

By Andrew Moseman

Barack Obama Has To Tweet From a Borrowed iPhone

The Environmental Protection Agency will set new rules to regulate emissions from the aviation industry, The New York Times reports today. It's an expected move by the Obama Administration, and part of what could be a big year for setting up new environmental rules:

The announcement represents the latest of Mr. Obama's major initiatives to combat global warming. Next week, the agency is expected to propose new rules on emissions from heavy-duty trucks, and in August it is expected to announce new rules to rein in power plant pollution.

EPA hasn't said what the new regulations will be and when they'll be enforced. Basically, this announcement is the agency telling the world that yes, they're going to write some rules, so get ready.

The Times article contains your typical expected boilerplate responses to this move, with environmental groups praising it and aviation groups saying the industry has already been cutting its fuel usage an emissions without having to be told to do so by the federal government. (After all, fuel is money, and airlines desperately need to save money.)

Whatever EPA decides to do, it had better do it fast.

Aviation accounts for about 2 percent of global emissions, but it is among the fastest-growing sources of global greenhouse gas emissions as air travel becomes more affordable and more people travel around the world.

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 1:49 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Reason.com (Hit & Run Blog):

http://reason.com/blog/2015/06/10/obama-wants-you-to-fly-the-carbon-friend

Obama Wants to Make You to Fly the Carbon-Friendly Skies

New regs will not inconvenience Paris climate conference attendees in December

Ronald Bailey|Jun. 10, 2015 1:32 pm

The Environmental Protection Agency is issuing a scientific finding the emissions from aircraft boost global warming and thus endanger the health of Americans. As result the agency is asserting authority to regulate (reduce) such emissions. Reuters reports:

An "endangerment finding" by the Environmental Protection Agency would allow the administration to implement a global carbon dioxide emissions standard being developed by the United Nations' International Civil Aviation Organization. ...

The ICAO is due to release its CO2 standard for comment in February 2016, with the aim of adopting it later that year. But the requirement is expected to apply only to new aircraft designs

certified from 2020, leaving most of the world's existing fleets unaffected for years to come.

Aviation accounted for 11 percent of energy-related carbon dioxide emissions from the transportation sector in 2010 in the United States, according to the International Council on Clean Transportation.

On the other hand, I earlier reported a recent University of Michigan study that found that airline travel - considering how much fuel it takes to transport a person a given distance - is much more fuel efficient than automobile travel.

I also noted that those folks especially worried about their carbon sins can always buy carbon indulgences.

In any case, the new EPA regulations will not be adopted in time to inconvenience the diplomats and activists who need to fly over the pond to attend the big United Nations climate change conference in Paris this December.

Ronald Bailey is a science correspondent at Reason magazine and author of Liberation Biology (Prometheus).

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 1:41 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Bloomberg Business:

http://www.bloomberg.com/news/articles/2015-06-10/aircraft-spew-3-of-greenhouse-gases-epa-says-in-emissions-plan

Aircraft Spew 3% of Greenhouse Gases, EPA Says in Emissions Plan

by Jim Snyder

June 10, 2015 — 1:32 PM EDT

Aircraft account for 3 percent of all U.S. greenhouse-gas emissions and warrant regulation, the Environmental Protection Agency said as it expanded a fight against climate change beyond automobiles and power plants.

As a first step, the EPA on Wednesday said it intended to declare that burning jet fuel endangered human health and welfare. The agency will take public comments before a final recommendation.

The agency also announced plans to write a rule to limit or offset the emissions, and said it would coordinate with an effort by the United Nations' International Civil Aviation Organization to issue new limits on aircraft exhaust.

Environmental groups pushed the EPA since 2007 to regulate aircraft emissions. The agency said U.S. planes account for 11 percent of greenhouse gases from U.S. transportation activity annually and 29 percent from all aircraft globally.

"President Obama is taking an important step on climate once again by finding that carbon pollution from airplanes poses the same danger to our climate as carbon pollution from other sources," Joanne Spalding, an attorney with the Sierra Club, an environmental group, said in a statement.

President Barack Obama, who has made fighting climate change a top priority of his final years in office, is also planning to limit emissions from heavy-duty trucks.

Groups Concerned

Some environmental groups expressed concern that the agency's work on aircraft will be linked to ICAO's, which they worry won't be strong enough.

"It is critical that EPA and the rest of the world, through the International Civil Aviation Organization, move quickly and seek meaningful greenhouse gas emission reductions," William Becker, executive director of the National Association of Clean Air Agencies, which represents the air pollution control agencies from 42 states, said in a statement.

Airlines for America, the main lobby group for the airline companies, said its important that the EPA not act on its own given the global nature of the industry.

"It is critical that aircraft emissions standards continue to be agreed at the international level," Vaughn Jennings, a spokesman for the group, said in a statement before the announcement.

The EPA plans to hold a public hearing on the aircraft proposal on Aug. 11 in Washington. The public will have 60 days to comment before the EPA issues a final decision.

The EPA issued a finding in 2009 that greenhouse gases were a danger to public health, part of the agency's effort to establish fuel-economy standards for automobiles and trucks. The same finding was used last year in proposing regulations for power plants.

From: Cox, Taylor
Sent: Wednesday, June 10, 2015 1:36 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan; Kowalski, Kennedy
Subject: RE: Aircraft Emissions Standards Clips 6/10

Washington Times:

http://www.washingtontimes.com/news/2015/jun/10/epa-regulate-emissions-aircraft/

Obama, EPA target emissions from aircraft

By Ben Wolfgang - The Washington Times - Wednesday, June 10, 2015

The Obama administration said Wednesday it will restrict greenhouse-gas emissions from commercial aircraft, the latest in a long line of steps the White House has taken to address climate change.

The announcement from the Environmental Protection Agency does not lay out the specific emissions standards. The EPA says it will begin crafting standards and expects to formally adopt them early next year.

U.S. aircraft account for about 11 percent of greenhouse-gas emissions from the transportation

sector, the agency said. Since 2009 and 2010, when Mr. Obama first proposed emissions restrictions on the automotive sector, the EPA said new scientific research has determined that aircraft emissions also are a danger to public health.

"The body of science on human-induced climate change has strengthened, supporting today's proposed finding — under a different section of the Clean Air Act — that [greenhouse gases] emitted from aircraft engines contribute to pollution that causes climate change endangering public health and welfare," the agency said. "Today's action supports the goals of the president's climate action plan to reduce emissions from large sources of carbon pollution."

The regulations will not apply to small aircraft used for recreational purposes, the agency said.

From: Cox, Taylor
Sent: Wednesday, June 10, 2015 1:14 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan; Kowalski, Kennedy
Subject: RE: Aircraft Emissions Standards Clips 6/10

The Hill:

http://thehill.com/policy/energy-environment/244550-obama-to-seek-climate-rules-for-airplanes

-

Obama to seek climate rules for airplanes

The Obama administration wants to declare that the greenhouse gas emissions from airplanes are harmful, which would set up regulations to limit the pollution.

The Environmental Protection Agency (EPA) released a proposed "endangerment finding" Wednesday that would formally conclude that carbon dioxide and any other greenhouse gases

from commercial airplanes contribute to climate change and harm the public health and welfare.

The move is a major win for environmentalists, since aircraft are the largest source of greenhouse gases that the EPA is not either regulating or planning to regulate.

But the EPA's proposed solution to the airplane climate problem — adopting upcoming international standards for aircraft — received quick condemnation from environmentalists who predict that the worldwide rules will be weak.

And Republicans were immediately skeptical of the Obama administration extending its climate regulations over another major sector.

Along with the proposed endangerment finding, the EPA set the stage Wednesday for eventually writing a formal regulation limiting airplanes' emissions, which it said would likely align with International Commercial Aviation Organization (ICAO) rules due out in February 2016. ICAO, a United Nations agency, is the main regulatory body for international air travel.

Airplanes in the United States emit about 11 percent of the transportation sector's carbon, or about 29 percent of the carbon from the worldwide aviation industry. But their emissions are only 3 percent of the total greenhouse gases in the country.

The EPA's action mirrors similar endangerment findings it made starting in 2009 regarding greenhouse gases from cars, trucks and power plants.

The early action from the EPA did not set any particular targets for reducing planes' carbon output, nor what measures could be used to cut it.

Environment America applauded the move, but urged stronger standards than the international ones.

"Since today's announcement will likely cause a fight in Congress, we hope the president makes this a fight worth having by requiring real cuts in airplane pollution," Anna Aurilio, director of the group's global warming program, said in a statement. "Bold action on climate should solve the problem of pollution from airplanes, not just acknowledge it."

Rep. Mike Pompeo (R-Kan.) blasted the EPA's action.

"If there is any endangerment finding that needs to be released it is on the danger the EPA poses to the American economy," he said in a statement. "This regulation will only serve to hurt Kansas aviation workers and their families, while doing nothing to achieve any measurable reduction in carbon emissions."

National Journal

http://www.nationaljournal.com/energy/the-epa-wants-to-ground-soaring-airplane-emissions-20150610

The EPA Wants To Ground Soaring Airplane Emissions

Government says aviation emissions cause climate change, pose public health threat.

Having gone after power plants, refineries and cars, the EPA has turned its sights to another source of the greenhouse gas emissions: airplanes.

The EPA Wednesday said that the greenhouse gas emissions from the airline industry pose a threat to public health and opened the door to regulating the industry for the first time.

According to the agency's draft "endangerment finding," the emissions from commercial aircraft contribute to climate change, "endangering the health and welfare of Americans." That opens the door for further action, similar to the regulations EPA has imposed on light duty cars and trucks, although the agency did not propose such action today.

Airline emissions contribute about 2 percent of the world's greenhouse gas emissions and 3 percent of the country's total emissions. According to the EPA, U.S. aircraft account for 11 percent of the country's greenhouse gas emissions and make up 29 percent of the world's airline emissions.

But thanks to growth in the industry at home and abroad -- American airlines are expecting record numbers this year -- those numbers are expected to grow. The International Council on Clean Transportation says emissions are rising at a rate of 3 to 4 percent a year, with the potential to quadruple by 2050.

The regulations come amid international action on airline emissions from the International Civil Aviation Organization (ICAO), which has been slowly looking at a global emissions strategy. ICAO is scheduled to release its own CO2 standard for aircraft in February 2016 for public comment, with adoption later that year.

An airline industry official told *Reuters* that ICAO is weighing either a market-based system that would allow airlines to buy carbon offsets to balance emissions, or a global emission standard for aircraft.

Given the global nature of the industry, airlines say they'd like to see one international standard rather than individual countries.

They'd like to avoid, for example, further action by the European Union, which put a fee on greenhouse gas emissions for flights in and out of Europe. That system faced opposition from companies and countries who bristled at paying into a scheme they didn't participate in (the U.S. passed a law exempting domestic airlines), and the EU backtracked to confine the regulations only to flights within the European Economic Area until ICAO takes further action.

In a statement, EPA said it was working with ICAO and that the agency's action "lay the necessary foundation for the development and implementation of a domestic aircraft standard, in accordance with U.S. law and the ICAO process."

Environmentalists say that ICAO is moving far too slowly to check airline emissions and that the standards being considered by the body just aren't sufficient.

Vera Pardee, a senior attorney at the Center for Biological Diversity, said her group is "especially concerned" about ICAO's laxity, especially if it produces a rumored standard that would apply only to newly designed aircraft. That, Pardee said, could leave ICAO regulating as little as 5 percent of the fleet in a few decades, since aircraft have a lifespan of 25-30 years.

CBD, along with Friends of the Earth and Earthjustice, petitioned EPA for action on aviation last spring, saying that the agency had been required under a 2010 court order to crack down. That action prompted the rulemaking, although greens say they'd like to see EPA move quickly to ensure the regulations take effect soon.

"President Obama is taking an important step on climate once again by finding that carbon pollution from airplanes poses the same danger to our climate as carbon pollution from other sources," said Sierra Club attorney Joanne Spalding. "This finding paves the way for action next year to create safeguards that will result in more efficient airplanes which pollute less while saving airlines and air travelers money on fuel costs."

From: Cox, Taylor
Sent: Wednesday, June 10, 2015 1:04 PM

To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan; Kowalski, Kennedy
Subject: RE: Aircraft Emissions Standards Clips 6/10

USA Today:

http://www.usatoday.com/story/news/2015/06/10/epa-airlines-greenhouse-gas-emissions-a4a-iata-icao/28487755/

EPA proposes to limit greenhouse-gas emissions from airlines

WASHINGTON -- Airline emissions threaten human health by contributing to climate change, theEnvironmental Protection Agency proposed Wednesday.

The proposal for a so-called "endangerment finding" under the Clean Air Act is a precursor to the EPA proposing regulations to limit heat-trapping emissions from plane exhaust. The agency will hold a hearing Aug. 11 about the proposal.

But airlines have bridled at national or regional rules for curbing emissions, preferring worldwide standards for the competitive industry. Airlines worldwide agreed in 2013 to halt the growth in emissions from international flights by 2020.

"As aviation is a global industry, with airlines and aircraft operators operating internationally and aircraft manufacturers selling their aircraft in international markets, it is critical that aircraft emissions standards continue to be agreed to at the international level," said Melanie Hinton, spokeswoman for Airlines for America, a trade group representing the country's largest carriers. "Any regulatory action EPA takes must be consistent with both the agency's authority under the Clean Air Act, as well as the expected" standard from the International Civil Aviation Organization, a branch of theUnited Nations.

The EPA rule applies to commercial planes, but not general aviation and the military.

Airlines produce about 11% of the country's greenhouse gases from transportation sources, or about 3% of total greenhouse-gas emissions, according to an analysis of EPA data by the International Council on Clean Transportation.

Environmentalists have praised President Obama for using the Clean Air Act to develop regulations reducing emissions from cars and power plants. But critics including Republicans in Congress have fought the rules.

Environmental groups – Earthjustice, Center for Biological Diversity and Friends of the Earth –filed a lawsuit in 2010 and the the U.S. Circuit Court of Appeals for the District of Columbia ruled in 2012 that the Clean Air Act required the EPA to act.

The groups warned that after domestic emissions were cut in half from 1993 to 2010, emissions have

stagnated since then and could quadruple from growth by 2050, according to an analysis by the International Council on Clean Transportation.

Airlines have worked voluntarily for years to curb carbon emissions. Strategies include flying planes that burn less fuel because of composite hulls, developing shorter routes and adding extensions to the ends of wings called winglets that make flight more efficient.

The International Civil Aviation Organization, a branch of the United Nations that recommends policies, said the 2013 agreement to halt the growth in emissions by 2020 will allow airlines to support the economy and tourism.

Talks continue on details of the policy. But the group's goal is to adopt the specific policy by fall 2016, which airlines would then decide individually how to meet.

The International Air Transport Association, which represents 250 airlines worldwide; Airports Council International representing 1,860 airports; the Civil Air Navigation Services Organization; and the International Business Aviation Council agreed last year to the broad goal of halting emissions growth. The agreement calls for:

--Developing more efficient alternative fuels.

--Improving flight operations.

--Managing air traffic better.

--Designing a market-based measure for international flights.

But that last point has been contentious. For example, emissions limits adopted for flights the European Union caused a rift until U.S. flights to the continent were exempted.

New York Times:

http://www.nytimes.com/2015/06/11/business/energy-environment/epa-says-it-will-set-rules-for-airplane-emissions.html?_r=0

E.P.A. Says It Will Set Rules for Airplane Emissions

By JAD MOUAWAD and CORAL DAVENPORT JUNE 10, 2015

The Obama administration on Wednesday said it would regulate greenhouse gas emissions from airplanes, a move that could significantly strengthen President Obama's

environmental legacy, but also present major new challenges for the airline industry.

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 12:45 PM
To: Cox, Taylor
Subject: FW: Aircraft Emissions Standards Clips 6/10

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 12:22 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Junk Science:

http://junkscience.com/2015/06/10/a-big-propaganda-announcement-without-much-effect/

A big propaganda announcement without much effect

Posted on June 10, 2015 by Bob Greene | 1 Comment

The White House has announced approval of the EPA's endangerment finding for CO2 emissions from aviation. Reducing CO2 emissions from aviation are unlikely to have any measurable effect on global warming. The Hill announcement of OMB's approval of the EPA's aviation endangerment finding on GHG emissions from aviation. So, how much global warming do we get from commercial aviation? It's hard to find an answer. When I search for a number can find a tap dance on particulate from contrails, increased forcing and other nasty things, but not X°C. I did find a 2009 article in Nature suggesting 8% to surface temperature or 0.03-

0.06°C since 1850. Not much per year, but then we weren't doing much flying in 1850.

In 2013, the estimated CO2 from all commercial aviation was 705 million metric tonnes. At 0.0000000000015°C/tonne that's 0.001°C. The EPA estimated 114.4 Tg of CO2 equivalent from commercial aviation. That's 114.4 million tonnes, or 0.00017°C contribution to global warming. Since any rule making will only reduce GHG's from U. S. aviation by a fraction. So, the whole thing is all for show, everyone doing his part and the shoulder-to-shoulder push for propaganda. The regulations will make aviation more expensive.

As a wise man once said, more and more regulations about less and less.

If anyone has a different number for global warming for a tonne of CO2, let me know. I doubt it will bring this into a measurable change.

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 12:01 PM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

CNBC Video:

http://www.nbcnews.com/video/cnbc/57480999/#57480999

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 11:58 AM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Reuters:

http://uk.reuters.com/article/2015/06/10/usa-aviation-carbon-idUKL1N0YW0HY20150610

UPDATE 2-U.S. EPA moves toward regulating aircraft emissions

(Adds details throughout, recasts first paragraph)

By Valerie Volcovici

(Reuters) - The Obama administration is expected on Wednesday to release a scientific finding that greenhouse gases from aircraft pose a risk to human health, paving the way for regulating emissions from the U.S. aviation industry.

An "endangerment finding" by the Environmental Protection Agency would allow the administration to implement a global carbon dioxide emissions standard being developed by the United Nations' International Civil Aviation Organization.

The finding had been under review at the White House Office of Management and Budget and returned to the EPA for final release.

The ICAO is due to release its CO2 standard for comment in February 2016, with the aim of adopting it later that year. But the requirement is expected to apply only to new aircraft designs certified from 2020, leaving most of the world's existing fleets unaffected for years to come.

Aviation accounted for 11 percent of energy-related carbon dioxide emissions from the transportation sector in 2010 in the United States, according to the International Council on Clean Transportation.

The EPA's ruling will mark the first step toward regulating aviation's greenhouse gas emissions,

and aviation will become the latest industrial sector to be regulated under the Clean Air Act after cars, trucks and large stationary sources like power plants.

But it came only after a federal court ruled in 2012 in favor of environmental groups that had sued the EPA, saying it was obligated to regulate aircraft emissions under the law.

The airline industry favors a global standard over individual national standards since carriers operate all over the world and want to avoid a patchwork of rules and measures, such as taxes, charges and emissions trading programs.

"If you're a big airline and you're flying to 100 countries a day, then complying with all those different regimes is an administrative nightmare," said Paul Steele, senior vice president at the International Air Transport Association, the industry's main global organization.

But some environmental groups are concerned that the standard being discussed at ICAO will do little to change the status quo right now.

"The stringency being discussed at ICAO is such that existing aircraft are already meeting the standard they are weighing," said Sarah Burt, a lawyer at Earthjustice, one of several groups that sued the EPA.

Planes generally stay in service for 20 or 30 years, she added.

International Council on Clean Transportation Program Director Dan Rutherford said that to ensure real emissions reductions from airlines, ICAO should apply a carbon dioxide standard to all new aircraft delivered after 2020.

But ICAO is weighing a standard that would apply only to new designs certified after the expected application date of Jan. 1, 2020.

Such an approach would mean the standard would only cover about 5 percent of the global aircraft fleet in 2030, he said. (Reporting by Valerie Volcovici; additional reporting by Victoria Bryan in Miami; Editing by Bruce Wallace and Lisa Von Ahn)

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 11:36 AM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Reuters:

http://in.reuters.com/article/2015/06/10/usa-aviation-carbon-idINL1N0YW0HY20150610

UPDATE 1-U.S. EPA takes first step to regulate aircraft greenhouse gas emissions

(Adds background)

By Valerie Volcovici

(Reuters) - The U.S. Environmental Protection Agency on Wednesday said greenhouse gases from aircraft endanger human health, taking the first step toward regulating emissions from the domestic aviation industry.

The EPA's endangerment finding kicks off a process to regulate greenhouse gas emissions from the aviation industry, the latest sector to be regulated under the Clean Air Act after cars, trucks and large stationary sources like power plants.

The finding allows the EPA to implement domestically a global carbon dioxide emissions standard being developed by the International Civil Aviation Organization (ICAO).

The U.N. agency is due to release its CO2 standard for comment in February 2016 and adopt it later that year.

The EPA had been under pressure from environmental groups who first petitioned it to regulate aircraft emissions under the Clean Air Act in 2007 and sued it in 2010. A federal court ruled in favor of those green groups in 2012.

Aviation accounted for 11 percent of energy-related carbon dioxide emissions from the transportation sector in 2010 in the United States, according to the International Council on Clean Transportation.

The airline industry has favored a global standard over individual national standards since airlines operate all over the world and want to avoid a patchwork of rules and measures, such as taxes, charges and emissions trading programs.

"If you're a big airline and you're flying to 100 countries a day, then complying with all those different regimes is an administrative nightmare," said Paul Steele, senior vice president at the International Air Transport Association, the main global airline industry group.

But some environmental groups are concerned that the standard being discussed at ICAO will do little to change the status quo since it would only apply to new and newly designed aircraft that will not be in operation for several years.

"The stringency being discussed at ICAO is such that existing aircraft are already meeting the standard they are weighing," said Sarah Burt, an attorney at Earthjustice, one of several groups that sued the EPA to regulate aircraft. (Reporting By Valerie Volcovici; additional reporting by Victoria Bryan in Miami; Editing by Susan Heavey and Doina Chiacu)

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 11:31 AM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

The Hill:

http://thehill.com/policy/energy-environment/244505-white-house-approves-epas-airplane-emissions-plan

White House approves EPA's airplane emissions plan

By Timothy Cama -

The White House has approved a plan that would allow the Obama administration to regulate carbon dioxide emissions from airplanes.

The White House Office of Management and Budget (OMB) review is the last step before the Environmental Protection Agency releases the finding publicly.

EPA will solicit public comments on the finding after its release, and then proceed to write a regulation.

OMB on Wednesday announced it had approved the EPA "endangerment finding" that analyzed the extent to which carbon from planes is harmful.

The administration has not revealed exactly what is in the analysis, but the EPA is expected to conclude that carbon from airplanes is harmful because it contributes to climate change — a similar finding to what it has said about carbon from cars, trucks and power plants.

The agency is likely to align its policies with regulations that the International Civil Aviation Organization, an agency of the United Nations, is developing. Those international rules are due to be announced in February 2016.

But environmentalists have already objected to that strategy, fearing that the international rules will not be strong enough to make a significant dent in the aviation sector's greenhouse gases. Greens say the EPA has the power and responsibility to go further than the international standards.

The commercial airlines want the EPA to align with international rules, fearing that anything else would put them at a disadvantage with their competitors in other countries.

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 11:25 AM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

NY Mag:

http://nymag.com/daily/intelligencer/2015/06/epa-will-regulate-chemtrails.html

EPA This Close to Admitting Kylie Jenner Was Right About Chemtrails

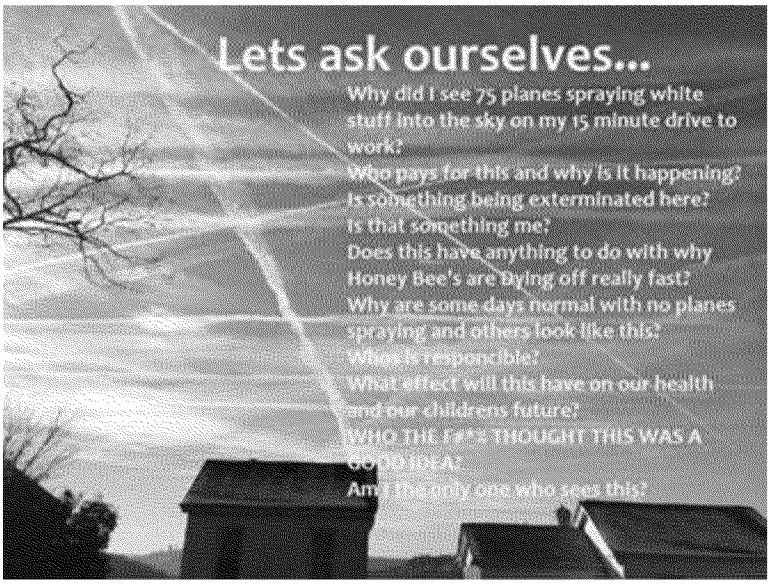
By Jessica Roy

The U.S. Environmental Protection Agency announced today that the greenhouse gases emitted from aircrafts could pose a health risk to humans. Soooo ... Kylie Jenner was right?

Now that the EPA has established their danger, aircraft emissions will begin to be regulated under the Clean Air Act, with airlines forced to comply with global carbon-dioxide-emissions

standards.

Just to be clear, this doesn't mean "chemtrails" are poisoning crops or controlling the weather, but it does mean aircraft emissions aren't that great for us or the environment. Sadly, despite Kylie Jenner's attempt at raising awareness, we still do not know who is responsible.



(for reference)

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 11:02 AM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura; Abrams, Dan
Subject: RE: Aircraft Emissions Standards Clips 6/10

Seeking Alpha:

http://seekingalpha.com/news/2571925-epa-takes-step-toward-regulation-of-greenhouse-gas-emissions-by-aircraft

EPA takes step toward regulation of greenhouse gas emissions by aircraft

Jun 10 2015, 10:30 ET | By: Carl Surran, SA News Editor

The EPA says greenhouse gases from aircraft endanger human health, a finding that begins a process to regulate greenhouse gas emissions from the aviation industry, the latest sector to be regulated under the Clean Air Act after cars, trucks and power plants.The endangerment finding allows the EPA to implement domestically a global carbon dioxide emissions standard being developed by the International Civil Aviation Organization; the airline industry favors a global standard over individual national standards since airlines operate all over the world and want to avoid a patchwork of rules and measures.GEVO, which has been working on renewable fuels for airplanes, is +3.5% today and +27% so far this month in anticipation of the EPA findings.Potential related stocks: AAL, UAL, SAVE, DAL, ALK, HA, SKYW, LUV, JBLU, VA

From: Kowalski, Kennedy
Sent: Wednesday, June 10, 2015 10:48 AM
To: DeLuca, Isabel; Hengst, Benjamin; Purchia, Liz; Harrison, Melissa; Millett, John; Birgfeld, Erin; Grundler, Christopher; Mylan, Christopher; Reynolds, Thomas; StClair, Christie; Allen, Laura
Subject: Aircraft Emissions Standards Clips 6/10

Wall Street Journal:

http://www.wsj.com/articles/obama-administration-to-take-aim-at-airline-emissions-1433946834

Obama Administration to Take Aim at Airline Emissions

EPA to conclude aircraft carbon emissions contribute to climate change

WASHINGTON—The U.S. Environmental Protection Agency is set to issue on Wednesday a scientific finding concluding that carbon emissions from airlines contribute to climate change, according to a person familiar with the news, a move that will set off a yearslong effort to clamp

down on airline emissions.

The finding lays the foundation for the agency to use rules being drafted by the International Civil Aviation Organization, a branch of the United Nations, as a template for domestic carbon regulations.

Aviation today represents about 2% of total global carbon emissions and airline operations generally improve efficiency by roughly 1.5% each year, according to aircraft and engine manufacturers. However, global air travel grows at roughly 5% each year, doubling every two decades, according to Boeing Co., outpacing improvements in the industry's carbon footprint.

The aviation industry has set a goal of achieving carbon-neutral growth by 2020 and aims to halve its 2005-level emissions by 2050, with a significant move toward the use of biofuels.

Wednesday's announcement is the latest in a string of actions by the Obama administration to address climate change. The agency is on a path to issue a suite of final regulations in August cutting carbon emissions from U.S. power plants, including those operating today and those not yet built and significantly modified.

These rules, which are facing an onslaught of congressional and legal scrutiny, represent the cornerstone of President Barack Obama's climate agenda. The power-plant sector accounts for about one-third of total U.S. carbon emissions, according to the EPA.

The move was prompted by a lawsuit brought by environmentalists in 2010 urging the government to regulate aircraft carbon emissions.

The EPA isn't expected to announce Wednesday a specific timetable for proposing the rules. Most of the heavy regulatory lifting will likely fall to Mr. Obama's successor, with rules drafted by the ICAO not expected to be completed until late 2016, according to an industry official.

Still undecided is whether ICAO's rules would regulate the emissions of previously certified aircraft or only apply to all-new aircraft certified after a certain date. Industry and environmental activists say doing the former would have significant implications for the existing fleet of more than 20,000 jetliners.

All the major manufacturers in the U.S., Europe, Canada and Brazil are currently developing all-new models or updated models with new engines that significantly reduce fuel consumption as much as 20% per seat over today's comparably sized jets.

Airline economics, as opposed to environmental concerns, have been the primary driver behind lower fuel consumption, operators' single biggest variable cost when flying an aircraft. Aircraft manufacturers globally cannot compete for the attention of cost-conscious airlines without prioritizing fuel savings.

The U.S. is seeking to strike a delicate industrial and diplomatic balance by favoring a global approach to aviation emissions.

China threatened to cancel plans to buy as many as 45 jetliners from Airbus Group SE after the proposed implementation of the European Union's Emissions Trading Scheme that would have roped in airlines transiting through, but not landing in, European airspace. The European Union in October 2013 suspended the ETS requirements for flights to and from non-European countries.

Write to Jon Ostrower at jon.ostrower@wsj.com and Amy Harder at amy.harder@wsj.com

Kennedy Kowalski

Intern, Office of Public Affairs

United States Environmental Protection Agency

Office Phone: (202) 564-8302

To: Davidson, Ken[Davidson.Ken@epa.gov]; Kopits, Elizabeth[Kopits.Elizabeth@epa.gov]; Griffiths, Charles[Griffiths.Charles@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]; Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Rennert, Kevin[Rennert.Kevin@epa.gov]
From: Samulski, Michael
Sent: Tue 2/16/2016 8:39:03 PM
Subject: RE: Check-in re: Thursday's Aircraft CO2 Standard Discussion w/ OIRA/FAA

I do not have a meeting on my calendar or a call-in number, but do have an email invitation from Ralph Iovinelli (copied below). I sent Ralph an email this morning asking for a call-in number, but have not heard back from him yet. I will forward the call-in information once I get it.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Ralph.Iovinelli@faa.gov [mailto:Ralph.Iovinelli@faa.gov]
Sent: Friday, January 29, 2016 5:43 PM
To: Ex. 6 - Personal Privacy
Lourdes.Maurice@faa.gov; Samulski, Michael; Manning, Bryan; McCabe, Janet;
Ex. 6 - Personal Privacy
Ex. 6 - Personal Privacy; Hengst, Benjamin; Charmley, William; LeFranc, Maurice; Rich.Swayze@faa.gov; carl.burleson@faa.gov; shoshana.lew@dot.gov; Atkinson, Emily;
Ex. 6 - Personal Privacy
Cc: Ex. 6 - Personal Privacy; Arthur.Rypinski@dot.gov;
Ex. 6 - Personal Privacy; Laszlo.Windhoffer@faa.gov; maryalice.locke@faa.gov; curtis.holsclaw@faa.gov

Subject: Int'l Aircraft CO2 Emissions Standard to US Domestic Regulation

Dear All,

First, please pass this invitation to those I missed.

This email follows-up on the action item and discussions from the EOP telecon on Tuesday, 1/26 at 530pm. There will be a joint OIRA/EPA/FAA meeting at the OIRA offices located at **1800 G Street, NW, 9th floor** on **Thursday, February 18** from **11am to 12:30pm**.

Ex. 5 - Deliberative Process

Please do not hesitate to contact Chad Whiteman (**Ex. 6 - Personal Privacy**) or myself with questions.

Best Regards,

Ralph Iovinelli

From: Davidson, Ken
Sent: Tuesday, February 16, 2016 3:13 PM
To: Kopits, Elizabeth; Griffiths, Charles
Cc: Samulski, Michael; Manning, Bryan; Hengst, Benjamin; Rennert, Kevin
Subject: RE: Check-in re: Thursday's Aircraft CO2 Standard Discussion w/ OIRA/FAA

I actually don't have the formal meeting invite on my calendar yet. We've also asked about setting up a conference line. I'll pass along more info if/when I receive it.

Mike – do you have a meeting notice on your calendar?

Here's what we received from Ralph Iovinelli @ FAA:

Dear All,

First, please pass this invitation to those I missed.

This email follows-up on the action item and discussions from the EOP telecon on Tuesday, 1/26 at 530pm. There will be a joint OIRA/EPA/FAA meeting at the OIRA offices located at **1800 G Street, NW, 9th floor** on **Thursday, February 18** from **11am to 12:30pm**.

Ex. 5 - Deliberative Process

Please do not hesitate to contact Chad Whiteman Ex. 6 - Personal Privacy or myself with questions.

Best Regards,

Ralph Iovinelli

Manager, Emissions Division (AEE-300)

Office of Environment and Energy

Federal Aviation Administration

800 Independence Ave., SW

Washington, DC 20591

+1-202-267-3566 office

Ex. 6 - Personal Privacy

ralph.iovinelli@faa.gov

Kenneth Davidson

U.S. Environmental Protection Agency

Office of Transportation and Air Quality/Region 9 Air Division

75 Hawthorne St. (AIR-6)

San Francisco, CA 94105

Phone: 415-972-3633

FAX: 415-947-3583

From: Kopits, Elizabeth
Sent: Tuesday, February 16, 2016 12:06 PM
To: Davidson, Ken <Davidson.Ken@epa.gov>; Griffiths, Charles <Griffiths.Charles@epa.gov>
Cc: Samulski, Michael <samulski.michael@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Hengst, Benjamin <Hengst.Benjamin@epa.gov>; Rennert, Kevin <Rennert.Kevin@epa.gov>
Subject: RE: Check-in re: Thursday's Aircraft CO2 Standard Discussion w/ OIRA/FAA

Hi Ken,

Yes, that plan makes sense. Would you mind sending us the invite? I never heard back from Chad so Charles and I don't have the meeting details.

Thanks,

Elizabeth

From: Davidson, Ken
Sent: Tuesday, February 16, 2016 3:02 PM
To: Kopits, Elizabeth <Kopits.Elizabeth@epa.gov>; Griffiths, Charles <Griffiths.Charles@epa.gov>
Cc: Samulski, Michael <samulski.michael@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Hengst, Benjamin <Hengst.Benjamin@epa.gov>
Subject: Check-in re: Thursday's Aircraft CO2 Standard Discussion w/ OIRA/FAA

Hi Charles and Elizabeth,

Ex. 5 - Deliberative Process

Hope that makes sense. Let us know if you have any questions. Best,

Ken

Kenneth Davidson

U.S. Environmental Protection Agency

Office of Transportation and Air Quality/Region 9 Air Division

75 Hawthorne St. (AIR-6)

San Francisco, CA 94105

Phone: 415-972-3633

FAX: 415-947-3583

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Stewart, Gwen
Sent: Mon 12/15/2014 8:03:30 PM
Subject: FW: Materials for tomorrow's 5:00 aircraft meeting with Janet
Notes for Meeting with Rich Swayze 12 15 14.docx

Ben –

Will you take care of sending this to Janet's Office – OAR BRIEFINGS?

Gwen Stewart

Office of Transportation and Air Quality

202 564-1682 – Telephone

202 564-1686 – Fax Number

Stewart.gwen@epa.gov

From: Samulski, Michael
Sent: Monday, December 15, 2014 2:49 PM
To: OTAQ Materials
Cc: Charmley, William; Iffland, JoNell; Audette, Lucie; Manning, Bryan
Subject: Materials for tomorrow's 5:00 aircraft meeting with Janet

Here are draft briefing materials for Janet, to get her ready for her Thursday meeting with FAA's Rich Swayze.

Can you make sure this goes up to Janet's office as well?

Thanks,

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Charmley, William[charmley.william@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
Cc: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Stewart, Lori
Sent: Thur 9/11/2014 6:46:03 PM
Subject: FW: Airlines
ICAO Aviation GHG Announcement Background & Statement.docx

Bill, I haven't been able to reach Ben to see if this is work in progress so I wanted to make sure

Ex. 5 - Deliberative Process

From: Stewart, Lori
Sent: Thursday, September 11, 2014 12:07 PM
To: McCabe, Janet
Cc: Grundler, Christopher; Hengst, Benjamin
Subject: RE: Airlines

I sent the excerpt from the roll-out plan to Chris and Ben so we can still rework that to add some background on internal conversations before we send forward.

From: McCabe, Janet
Sent: Thursday, September 11, 2014 11:57 AM
To: Stewart, Lori
Cc: Grundler, Christopher; Hengst, Benjamin
Subject: Re: Airlines

What occurred to me on the plane is that we should take this opportunity to remind her of the path she concurred with back a number of months ago.

Sent from my iPhone

On Sep 11, 2014, at 8:17 AM, "Stewart, Lori" <Stewart.Lori@epa.gov> wrote:

> I sent Amy the rollout plan, but the first two pages provide a good overview. We could extract those into a separate document and forward to the Administrator (thru Amy again). Chris/Ben, I can do that if you concur.

From: McCabe, Janet
Sent: Thursday, September 11, 2014 8:08 AM
To: Grundler, Christopher; Stewart, Lori
Subject: Fwd: Airlines

Chris, Lori--see Gina's note. I don't know if the paper we sent to Gwen last week will fit the bill for this--can you check and see please?

Thanks

Sent from my iPhone

Begin forwarded message:

> **From:** "Adm13McCarthy, Gina" <Adm13McCarthy.Gina@epa.gov>
> **Date:** September 11, 2014 at 8:00:27 AM EDT
> **To:** "McCabe, Janet" <McCabe.Janet@epa.gov>
> **Subject: Airlines**
>
> Janet I have lost track of the airline ghg emission issue. Can you have someone send me me a one pager?
>
> Gina McCarthy

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Etchells, Elizabeth
Sent: Thur 4/9/2015 5:58:50 PM
Subject: MSTRS Agenda
May5 2015Agenda.docx

Here's the draft agenda and I'll add you to the listserv. It's at the Hilton Old Town Alexandria.

Thanks!

Liz Etchells

US EPA, Office of Transportation and Air Quality

Transportation and Climate Division

"Driving Innovation in Clean Transportation"

Phone - 202.343.9231

Email - etchells.elizabeth@epa.gov

Federal Advisory Committee Act

Clean Air Act Advisory Committee

Mobile Sources Technical Review Subcommittee

May 5, 2015

8:30 – 9:00 am	**Registration**	
9:00 – 9:30	**Introductions, Opening Remarks** **Approval of 12/14 Meeting Minutes**	Drew Kodjak & Gay MacGregor
9:30 – 10:00	**Office Director Remarks**	Chris Grundler
10:00-10:30	**Ports Work Group Report Out**	Lee Kindberg, Maersk Mike Geller, EPA & others
10:30-11:00	**Break**	
11:00—11:30	**Air Craft Emissions Update** • Lead in aviation gas for piston aircraft • CO2 standards development • PM standards development	Mike Samulski, EPA
11:30-1:00	**Lunch on your own**	

1:00-2:15	**Raising Gasoline Octane – The Opportunities**
	• Autos (GM or Ford on the anticipated benefits to new vehicles and the existing fleet of higher octane and the timing for when vehicles could fully take advantage of it)
	  o Ford – Cynthia Williams (John Viera not coming)
	  o GM – Bob Babik Coleman Johnson (flight at 3:15?)
	  o Send email to Ford and GM to coordinate?
	• DOE - Energy Security and the Optima Program– Karl emailed Reuben at DOE 3/24/15
	• CARB on the potential impact on their state GHG program
	  o Someone from CARB – who, remind Alberto?
	• NRDC on the potential to go beyond the current LDGHG regulations
	  o Luke Tonachel confirmed	

2:15-2:45	**Break**	

2:45-4:00	**Raising Gasoline Octane – The Considerations**
	• Abengoa on the ability to leverage ethanol to raise in-use octane
	  o Chris Standlee confirmed
	• Marathon or Chevron on the ability of, implications of, and potential timing of the refiners to support higher octane gasoline
	  o Chevron not available	

- Dan Short checking with his mgmt
- Magellan (pipeline and terminal system) on the considerations needed for rolling out higher octane gasoline
  - Bruce Heine confirmed
- EDF avoiding historic public health problems with higher octane fuels – check in with Pam
- EPA (Paul M) to provide an overview of our statutory authority

4:00-4:15	**Closing Remarks & Adjourn**	Drew & Gay

To: Mylan, Christopher[Mylan.Christopher@epa.gov]; Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Birnbaum, Rona[Birnbaum.Rona@epa.gov]; DeAngelo, Ben[DeAngelo.Ben@epa.gov]; Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]; DeLuca, Isabel[DeLuca.Isabel@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
Cc: Suarez, Patricia[suarez.patricia@epa.gov]
From: Birgfeld, Erin
Sent: Wed 9/3/2014 4:26:24 AM
Subject: EPA Aircraft endangerment website
FOE-CBD-EJ-Oc Aircraft_GHG_Petition - 12-5-2007.pdf
OAR-12-001-0157_aircraft petition_signed response.pdf
OAR-12-001-0157_Aircraft Petition_Enclosure.docx
CBD_Order_on_SJ_motion.pdf
CBD_Order_on_recon_motion.pdf
CAEPSG 20142 IP xx US GHG Endangerment_ANPR 8-28-14 final.docx
Web Markup Aircraft GHGs.docx

All,

Attached are materials to include with the website along with a doc titled "Web markup aircraft GHGs" which provides a redline markup on the materials that we intend to put up.

Please send me and Chris Mylan comments by 11 pm Wednesday 9-4 so we can incorporate and have the web team update for imminent release on Thursday.

-Erin

Erin Birgfeld

Director of Communications

Office of Transportation and Air Quality

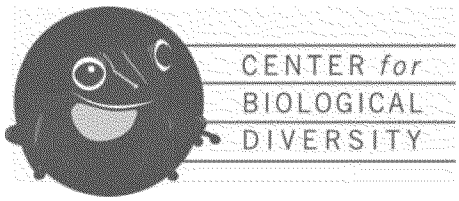
Tel: 202.564.6741

Cell: 202.255.4434

From: Audette, Lucie
Sent: Tuesday, September 02, 2014 3:56 PM
To: Birgfeld, Erin; Mylan, Christopher; Hengst, Benjamin; Birnbaum, Rona; DeAngelo, Ben; Jantarasami, Lesley; DeLuca, Isabel; Samulski, Michael; Thrift, Mike; Manning, Bryan; Maeroff, Bruce
Subject: Potential Documents for Website

All, We agreed that it would be a good idea to review the attached documents in advance of posting them to EPA's web and identify issues that need Q & As drafted. Here are the aircraft documents we've discussed for your review. Lucie

Embargoed for use until Wednesday, Dec 5, 2007 12:01AM Central Standard Time



December 5, 2007

Hon. Stephen L. Johnson
Administrator
United States Environmental Protection Agency
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Mail Code 1101A
Washington, DC 20460

Re: Petition for Rulemaking Under the Clean Air Act to Reduce the Emission of Air Pollutants from Aircraft that Contribute to Global Climate Change

Dear Administrator Johnson:

Global warming is one of the most pressing environmental challenges of our time. Concentrations of greenhouse gases,[1] primarily from society's burning of fossil fuels and the destruction of forests, are increasing in the Earth's atmosphere, trapping solar energy that would otherwise be radiated back into space. This phenomenon is having profound impacts on the Earth and its inhabitants, including a rise in global temperatures, more extreme weather events, severe flooding and droughts, the spread of infectious diseases, and the extinction of numerous species. As one of the world's largest emitters of greenhouse gases, the United States must act to address this urgent situation by reducing emissions from all sectors of its economy.

Aircraft engines represent an increasing and potent source of greenhouse gas emissions, due in part to the unprecedented growth in air travel in the United States and internationally. In 2005, aircraft accounted for three percent of the United States' total carbon dioxide emissions

[1] "Greenhouse gases" are atmospheric gases responsible for causing global warming and climate change. The major greenhouse gases are carbon dioxide ("CO_2"), methane ("CH_4") and nitrous oxide ("N_2O").

and 12 percent of such emissions from the U.S. transportation sector.[2] In fact, the United States is responsible for almost *half* of worldwide carbon dioxide emissions from aircraft, nearly five times the amount of the next largest emitter.[3] Moreover, aircraft emissions are projected to substantially increase in the coming decades, and globally, are expected to more than triple by mid-century.[4] Recent reports show that at altitude, aircraft emissions have a greater impact on global warming than previously understood, and are more harmful than land-based fuel combustion.[5] While some countries have already begun taking steps in response to these challenges,[6] the United States has thus far ignored its responsibility to address this growing source of greenhouse gas emissions.

Therefore, pursuant to the Administrative Procedure Act, 5 U.S.C. § 553(e), and the Clean Air Act, 42 U.S.C. § 7571, Petitioners file this Petition for Rulemaking and respectfully request that you undertake the following mandatory duties:

(1) Make a finding that greenhouse gas emissions from aircraft engines may reasonably be anticipated to endanger public health and welfare pursuant to Section 231(a)(2)(A) of the Clean Air Act, 42 U.S.C. § 7571(a)(2)(A);

(2) Issue proposed standards for greenhouse gas emissions from aircraft engines pursuant to Section 231(a)(2)(A) of the Clean Air Act, 42 U.S.C. § 7571(a)(2)(A); and

(3) Promulgate final regulations within 90 days of the issuance of such proposed standards pursuant to Section 231(a)(3) of the Clean Air Act, 42 U.S.C. § 7571(a)(3).

Given the urgent threats to public health and welfare posed by global climate change, prompt consideration must be given to this petition. Therefore, Petitioners hereby request a substantive response to this petition within one hundred eighty (180) calendar days. Petitioners

---

[2] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2005*, (2007), at 2-1, *available at*: http://www.epa.gov/climatechange/emissions/downloads06/07CR.pdf [hereinafter "EPA *Inventory*"].

[3] ROYAL AERONAUTICAL SOCIETY, AIR TRAVEL – GREENER BY DESIGN, Report of the Greener Design Science and Technology Sub-Group (July 2005) at 7 Fig. 7, *available at*: http://www.greenerbydesign.org.uk/_FILES/publications/GbD%20-%202005%20Science%20and%20Technology%20Report.pdf [hereinafter Greener by Design Report].

[4] Sir Nicholas Stern, STERN REVIEW ON THE ECONOMICS OF CLIMATE CHANGE, Cambridge University Press (Oct. 30, 2006) at 172, *available at*: www.sternreview.org.uk, [hereinafter Stern Report].

[5] Ian A. Waitz, *et al.*, AVIATION AND THE ENVIRONMENT: A NATIONAL VISION STATEMENT, FRAMEWORK FOR GOALS AND RECOMMENDED ACTIONS, Report to the United States Congress (Dec. 2004) at 18, *available at*: http://web.mit.edu/aeroastro/partner/reports/congrept_aviation_envirn.pdf [hereinafter AVIATION AND THE ENVIRONMENT].

[6] *Commission Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community*, 2006/0304 (COD), COM(2006) 818 final (Dec. 20, 2006), *available at*: http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=COMfinal&an_doc=2006&nu_doc=818.

will consider litigating to compel a response that is unreasonably delayed in order to achieve the requested agency action.[7]

PETITIONERS

Friends of the Earth is a public interest, non-profit advocacy organization, whose mission is to defend the environment and champion a just and healthy world. The organization works to stop environmental damage from the current model of economic and corporate globalization, and to protect human health and the planet by reducing dependence on fossil fuels. Founded in San Francisco in 1969 by David Brower, Friends of the Earth now maintains its headquarters in Washington, D.C. and is the U.S. voice of the world's largest network of grassroots environmental groups, with affiliates in 70 countries.

Oceana is a non-profit international advocacy organization dedicated to protecting and restoring the world's oceans through policy, advocacy, science, law, and public education. Oceana has over 280,000 members and supporters around the world. Oceana is organized under the laws of the District of Columbia, and maintains its headquarters in Washington, D.C. It has offices or staff in five states (Alaska, California, Massachusetts, New York, and Oregon) and three foreign countries (Chile, Belgium, and Spain). Through its policy, scientific, litigation, and grass-roots activities, Oceana has been a prominent advocate for protecting threatened and endangered marine species and marine ecosystems. Many marine ecosystems and species, such as the loggerhead sea turtle and species of deep sea corals, are threatened by global warming and ocean acidification.

The Center for Biological Diversity ("the Center") is a non-profit organization with offices in San Francisco, Los Angeles, and Joshua Tree, California, Phoenix and Tucson, Arizona, Silver City, New Mexico, Portland, Oregon, and Washington, D.C. The Center is a national membership organization with over 35,000 members in the United States. The Center's mission is to ensure the preservation, protection, and restoration of biodiversity, native species, ecosystems, public lands and waters, and public health. Because climate change from society's production of greenhouse gases is one of the foremost threats to the earth's biodiversity, the environment, and public health, the Center's Climate, Air, and Energy Program works to reduce United States greenhouse gas emissions in order to protect these resources. The Center has advocated in local, state, and federal forums for the reduction of greenhouse gas pollution. The Center has petitioned to have some of the first species to be threatened by global warming listed under the U.S. Endangered Species Act, including the polar bear, staghorn and elkhorn corals in the Caribbean, twelve of the world's penguin species, the American pika, and the Kittlitz's murrelet, a small seabird that feeds at the base of tidewater glaciers in Alaska. These species will not survive unless the United States substantially reduces its greenhouse gas emissions. The Center has previously requested that EPA regulate greenhouse gases from automobiles under

[7] This petition follows the petition for rulemaking under Section 213(a)(4) of the Clean Air Act, 42 U.S.C. § 7547(a)(4), to regulate greenhouse gas emissions from marine vessels submitted by Petitioners on October 3, 2007. As described in that petition, marine engines contribute approximately five percent of total domestic carbon dioxide emissions from transportation-related fossil fuel combustion, and shipping worldwide is estimated to account for almost three percent of global greenhouse gas emissions. Moreover, global warming emissions from marine vessels are expected to triple by 2030.

Section 202 of the Clear Air Act, and was a party in the successful case overturning EPA's decision not to do so. The Center submits this petition on behalf of itself and its adversely affected members.

STATEMENT OF LAW

The Clean Air Act, 42 U.S.C. §§ 7401 *et seq.* (the "Act"), provides the Administrator of the U.S. Environmental Protection Agency ("EPA") with the exclusive authority to regulate air pollutants from aircraft engines. Pursuant to Section 231(a)(2)(A):

> The Administrator shall, from time to time, issue proposed emission standards applicable to the emission of any air pollutant from any class or classes of aircraft engines which in his judgment causes, or contributes to, air pollution which may reasonably be anticipated to endanger public health or welfare.

42 U.S.C. § 7571(a)(2)(A). In doing so, the Administrator is required to consult with the Administrator of the Federal Aviation Administration ("FAA"). *Id.* at § 7571(a)(2)(B). The Act further requires EPA to promulgate final regulations within 90 days of the issuance of its proposed emissions standards. *Id.* at § 7571(a)(3). In addition, Section 232 of the Act requires the Secretary of Transportation, acting through the FAA, to prescribe regulations that ensure compliance with the standards issued by EPA under section 231. *Id.* at § 7572(a); *see* 49 C.F.R. § 1.47(g). States and other political subdivisions are prohibited from adopting or attempting to enforce any emissions standards for aircraft engines unless they are identical to standards promulgated by EPA. 42 U.S.C. § 7573.

Although EPA has occasionally issued standards regulating air pollution from aircraft engines under Section 231,[8] it has not previously considered limiting emissions from aircraft based on the contribution of those emissions to global warming. However, it is clear that EPA's authority under Section 231 extends to greenhouse gas emissions from aircraft engines. Section 302(g) of the Clean Air Act broadly defines the term "air pollutant" to include:

> [A]ny air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material, and byproduct material) substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent the Administrator has identified such precursor or precursors for the particular purpose for which the term 'air pollutant' is used.

Id. at § 7602(g). The U.S. Supreme Court has firmly established that greenhouse gases – including carbon dioxide – constitute air pollutants under Section 302(g) of the Act. *Massachusetts, et al. v. EPA, et al.,* 127 S. Ct. 1438, 1462 (2007) ("*Mass. v. EPA*") ("Greenhouse gases fit well within the Clean Air Act's capacious definition of 'air pollutant' in

[8] *See, e.g.*, EPA Final Rule for Control of Air Pollution From Aircraft and Aircraft Engines; Emission Standards and Test Procedures, 70 Fed. Red. 69,664, 69,666 (Nov. 17, 2005) (establishing new emission standards for oxides of nitrogen ("NOx")and discussing history of EPA's regulation of aircraft engine emissions).

section 302(g)").[9] Following that decision, the President confirmed the need for EPA to use its authority to protect the environment from greenhouse gas emissions from mobile engine sources. *See* Executive Order 13432: Cooperation Among Agencies in Protecting the Environment with Respect to Greenhouse Gas Emissions From Motor Vehicles, Nonroad Vehicles, and Nonroad Engines, 72 Fed. Reg. 27,717 (May 16, 2007).

Given these mandates, EPA has the authority to regulate greenhouse gas emissions from aircraft engines as "air pollutants" pursuant to Section 231(a)(2)(A) of the Act. Moreover, as demonstrated below, given the rapidly increasing contribution of greenhouse gas emissions from aircraft, combined with mounting evidence that these emissions, at altitude, have a significantly greater global warming impact than land-based fuel combustion, it is EPA's clear statutory duty to do so.

STATEMENT OF FACTS

A. Global Climate Change Background.

There is no longer any scientific dispute that human production of greenhouse gases, including carbon dioxide, methane, and nitrous oxide, are responsible for the unprecedented rate of warming observed over the past century.[10] According to the Intergovernmental Panel on Climate Change ("IPCC"),[11] "[w]arming of the climate system is unequivocal, as is now evident from observations of increases in global air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."[12] Moreover, "[m]ost of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations."[13] Thus, the world's leading scientific body on the subject has now concluded, with greater than 90 percent certainty, that emissions of greenhouse gases are responsible for climate change.[14]

---

[9] While that decision dealt with the regulation of motor vehicles pursuant to Section 202(a)(1), 42 U.S.C. § 7521(a)(1), the definition of "air pollutant" in Section 302(g) applies throughout the Act.

[10] *See* EPA, Climate Change – Science, http://www.epa.gov/climatechange/science/index.html; GOVERNMENT ACCOUNTABILITY OFFICE, CLIMATE CHANGE: AGENCIES SHOULD DEVELOP GUIDANCE FOR ADDRESSING THE EFFECTS ON FEDERAL LAND AND WATER RESOURCES (August 2007) at 10, *available at*: http://www.gao.gov/new.items/d07863.pdf [hereinafter GAO Report].

[11] The IPCC was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme to provide an authoritative international statement of scientific understanding of climate change. Its various Working Group and Assessment Reports on climate change are available at: http://www.ipcc.ch/.

[12] IPCC, SUMMARY FOR POLICYMAKERS: CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS; CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Feb. 2007) at 5 [hereinafter Working Group I Summary]. In particular, the IPCC found in its recent reports that total global surface temperature increased 0.76°C (1.37°F) between 1850-1899 and 2001-2005. *Id.* In the Arctic, temperatures at the top of the permafrost layer have increased since the 1980s by up to 3°C (5.4°F), while annual average artic sea ice has shrunk by 2.7 percent per decade, with even larger decreases in summer of 7.4 percent per decade. *Id.* Global sea levels rose at an average rate of 1.8 millimeters per year between 1961 and 2003. *Id.*

[13] *Id.* at 10 (emphasis in original).

[14] *See id.* at 3 n.6 (explaining the use of the term "very likely").

In the words of the IPCC, carbon dioxide is "the most important anthropogenic greenhouse gas."[15] The primary source of carbon dioxide emissions since the pre-industrial period has been the combustion of fossil fuels, with land-use changes responsible for another significant but smaller contribution.[16] Not surprisingly, the global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 parts per million ("ppm") to 379 ppm in 2005, by far exceeding the natural range over the last 650,000 years (180 to 300 ppm), as estimated by ice core samples.[17]

The United States is responsible for over 20 percent of the world's greenhouse gas emissions, and remains one of the largest emitters on a per capita basis.[18] As the largest source of domestic greenhouse gas emissions, carbon dioxide from fossil fuel combustion alone accounted for 79 percent of total warming emissions in 2005.[19] One of the primary sources of such emissions is from the transportation sector, which in 2005 accounted for 33 percent of carbon dioxide emissions in the United States and about 28 percent of all greenhouse gas emissions from anthropogenic activities.[20] According to the IPCC, greenhouse gas emissions from transport are expected to increase 80 percent between 2002 and 2030.[21]

B. Aircraft Engines Emit Greenhouse Gases and Have a Disproportionate Impact on Global Warming.

Aircraft engine emissions are composed of approximately 70 percent carbon dioxide, 30 percent water vapor, and less than one percent each of oxides of nitrogen ("NO_X"), carbon monoxide, oxides of sulfur, and other trace components including hydrocarbons such as methane and soot.[22] These emissions contribute to global warming in several ways. First, aircraft emit significant amounts of carbon dioxide, the primary greenhouse gas produced by anthropogenic activities in the United States and globally. In 2005, aircraft contributed three percent of the United States' total carbon dioxide emissions, and 12 percent of such emissions from the

---

[15] *Id.* at 2; *see* EPA *Inventory*, *supra* note 2, at 2-1.

[16] Working Group I Report Summary, *supra* note 12, at 2.

[17] *Id.*

[18] United Nations Environment Programme /GRID-Arendal, *National carbon dioxide (CO2) emissions per capita; CO2 2002, available at*: http://maps.grida.no/go/graphic/national_carbon_dioxide_co2_emissions_per_capita.

[19] EPA *Inventory*, *supra* note 2, at 2-1.

[20] *Id.* at 2-10, 2-23.

[21] IPCC, CLIMATE CHANGE 2007: MITIGATION OF CLIMATE CHANGE; CONTRIBUTION OF WORKING GROUP III TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (May 2007) at 357 [hereinafter WORKING GROUP III REPORT].

[22] FAA, OFFICE OF ENVIRONMENT AND ENERGY, AVIATION AND EMISSION: A PRIMER (Jan. 2005) at 1, *available at*: http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/aeprimer.pdf [hereinafter FAA Report].

transportation end-use sector.[23] However aircraft carbon dioxide emissions, if measured at ground level, are only "a fraction" of aviation's total contribution to climate change.[24]

NO_X emissions from aircraft contribute to the formation of ozone, a greenhouse gas. Moreover, emissions of NO_X in the upper troposphere and tropopause, where most aviation emissions occur, result in greater concentrations of ozone than ground-level emissions.[25] Aircraft also contribute to climate change by altering cloud cover patterns. Aircraft engines emit water vapor, a greenhouse gas that forms condensation trails, or "contrails," when released at high altitude. Contrails are visible line clouds that form in cold, humid atmospheres and contribute to the global warming impact of aircraft.[26] In addition, the persistent formation of contrails is associated with the spread of cirrus clouds.[27] An increase in cirrus cloud cover tends to warm the surface of the Earth, further contributing to global warming.[28]

Therefore, greenhouse gas emissions from aircraft at altitude have a greater global warming impact than their carbon dioxide emissions alone, or than emissions of greenhouse gases at ground level. In fact, a recent report by the UK Royal Commission on Environmental Protection stated that the net effect of ozone, contrail, and aviation-induced cirrus is expected to be three times the radiative forcing due to the CO_2 emitted from aircraft.[29] The report concludes that if these estimates are correct and the anticipated growth in aviation realized, aviation may be responsible for between six and ten percent of anthropogenic forcing of climate by 2050.[30]

C. Aviation's Impact on Global Warming Is Predicted to Increase Dramatically in the Next Few Decades.

Greenhouse gas emissions from aircraft are anticipated to increase substantially in the coming decades because of a projected growth in air transport both in the United States and

---

[23] EPA *Inventory*, *supra* note 2, at 3-8.e, Table 3-7.

[24] Bows, Alice, Kevin Anderson and Paul Uphan, *Technical Report: Contraction and Convergence: UK carbon emissions and the implications for UK air traffic*, TYNDALL CENTRE FOR CLIMATE CHANGE RESEARCH (Feb. 2006) at 18, *available at* http://www.tyndall.ac.uk/research/theme2/project_overviews/t3_23.shtml, click link at "Technical Report". *See also*, IPCC, TECHNICAL SUMMARY; CONTRIBUTION OF WORKING GROUP III TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, (May 2007) at 51 [hereinafter Working Group III Technical Summary].

[25] EPA *Inventory*, *supra* note 2, at 1-4; *see also* IPCC, AVIATION AND THE GLOBAL ATMOSPHERE (1999) at Chapter 1.3.3, *available at*: http://www.grida.no/climate/ipcc/aviation/index.htm [hereinafter IPCC Aviation Report].

[26] IPCC, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS; CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Feb. 2007) at 186 [hereinafter Working Group I Report].

[27] IPCC, AVIATION AND THE GLOBAL ATMOSPHERE, (June 1999) at Summary for Policymakers, 4.5 [hereinafter IPCC Aviation Report].

[28] *Id.*

[29] ROYAL COMMISSION ON ENVIRONMENTAL PROTECTION (RCEP), THE ENVIRONMENTAL EFFECTS OF CIVIL AIRCRAFT IN FLIGHT, London, UK (Nov. 29, 2002) at 18, *available at*: http://www.rcep.org.uk/avreport.htm.

[30] *Id.* at 19.

worldwide.[31] According to the FAA, greenhouse gas emissions from domestic aircraft are expected to increase 60 percent by 2025.[32] The IPCC estimates that increases in air transport over the next 50 years will result in a three-fold increase in aircraft CO_2 emissions, a 13 percent increase in ozone, a growth in contrail cover at a rate faster than that of the growth in aviation fuel consumption, and cirrus cloud increases by a factor of four.[33]

International air transport agreements ("ATAs") negotiated by the United States facilitate these increases. For example, the United States recently signed an agreement with China to amend the countries' existing ATA to *double* passenger flights by 2012, and give U.S. and Chinese cargo carriers unfettered access to markets.[34] Similarly, the United States recently amended its ATA with the European Union (the "Open Skies Agreement") to authorize every U.S. and EU airline to fly between every city in the European Union and the United States, and to operate without restriction on the number of flights, aircraft, and routes.[35]

In short, there is an unrelenting global demand for increased air transport of both passengers and goods – a demand that appears undeterred by escalating flight delays and new terrorist threats, and one that is being facilitated by the policies of the United States government and its trading partners. It should therefore come as no surprise that globally, carbon dioxide emissions from aircraft could grow by more than three-fold by mid-century, making air travel one of the fastest-growing producers of greenhouse gases.[36]

D. Existing and Developing Aviation Procedures and Technologies Can Reduce Greenhouse Gas Emissions.

Given that aircraft require a significant amount of fuel to operate, and that each gallon of jet fuel contributes 21 pounds of carbon dioxide when burned,[37] relatively minor improvements in fuel efficiency can result in significant reductions in greenhouse gases. As described below, aviation procedures and aircraft designs are available today that can significantly increase fuel efficiency and decrease greenhouse gas emissions. Technologies currently being developed are expected to result in even further improvements within the next few years. In fact, according to a recent assessment, with total fuel consumption as an objective, design, operational and

---

[31] Air transport in the United States is expected to increase by 3.5 percent annually over the next decade, and approximately five percent per year worldwide. AVIATION AND THE ENVIRONMENT, *supra* note 5, at 21; ICAO Working Paper, *Towards a Carbon Neutral and Eventually Carbon Free Future,* INT'L AIR TRANSPORT ASS'N, A36-WP/85 EX/33, (Aug. 28, 2007) at ¶ 2.2.

[32] FAA Report, *supra* note 22, at 10.

[33] IPCC Aviation Report, *supra* note 27, at Summary for Policymakers 4.1, 4.2, 4.5, and 4.6.

[34] Fact Sheet, U.S. Department of Treasury, Second Meeting of the U.S.-China Strategic Economic Dialogue (May 23, 2007), *available at*: http://www.treas.gov/press/releases/hp417.htm.

[35] Statement by U.S. Department of Transportation Secretary Peters on the U.S. – EU Open Skies Agreement (Mar. 22, 2007), *available at*: http://www.dot.gov/affairs/peters032207.htm.

[36] Stern Report, *supra* note 4, at 172.

[37] Energy Information Association, Voluntary Reporting of Greenhouse Gases Program, *available at*: http://www.eia.doe.gov/oiaf/1605/factors.html.

technology improvements could result in a ten percent reduction over 2005 levels in carbon dioxide and other fuel-related emissions from aircraft.[38]

Voluntary measures alone will not be sufficient to bring about the changes that are needed to address the significant and growing climate impacts of aviation.[39] Regulations that set mandatory and increasingly stringent standards are needed not only to ensure that existing technologies and operations are implemented in the near-term, but also to increase incentives for the development of new technologies and procedures in the future.[40] EPA itself has acknowledged that Section 231 of the Clean Air Act authorizes it to set "technology-forcing" standards for aircraft engines as long as the standards give manufacturers sufficient lead time. Final Rule for Control of Air Pollution From Aircraft and Aircraft Engines; Emission Standards and Test Procedures, 70 Fed. Red. 69,664, 69,676 (Nov. 17, 2005). Thus, it is imperative that the agency set standards to force the adoption and use of these existing measures, and also to encourage development of improved technologies and procedures that will reduce emissions even further.

1. Improved Aviation Operations and Procedures Can Reduce Greenhouse Gas Emissions Significantly.

There are numerous existing operational measures that can reduce fuel use, and consequently, greenhouse gas emissions from aircraft. Mandating the use of these procedures will result in immediate, near-term, and meaningful improvements in aviation's climate impact.[41] The IPCC estimates that improved aircraft operational practices can reduce greenhouse gas emissions by six to twelve percent.[42] Some operational measures for reducing emissions include:

---

[38] Nicolas Antoine and Ilan Kroo, *Framework for Aircraft Conceptual Design and Environment Performance Studies,* AIAA JOURNAL, Vol. 43, No. 10, 2108 (Oct. 2005).

[39] According to the IPCC, given the anticipated five percent annual growth in aviation, increases in greenhouse gas emissions from aircraft will outpace improvements that can be expected through evolutionary changes in engine and aircraft design. WORKING GROUP III REPORT, *supra* note 21, at 326.

[40] The European Commission's proposal to include aviation emissions in the European carbon trading system illustrates how such regulatory standards can spur industry to more rapidly develop and deploy cleaner aircraft. Under the proposal, greenhouse gas emissions from aviation would be capped and airlines that are unable to meet emission standards would be required to purchase carbon dioxide allowances or offsets. *Commission Directive amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community*, 2006/0304 (COD), COM(2006) 818 final (Dec. 20, 2006), *available at*: http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=COMfinal&an_doc=2006&nu_doc=818. Many European airlines are taking steps to modernize their fleets and to purchase more fuel efficient aircraft, but the U.S. airline industry's fleets remain outdated and domestic airline companies have been slow to order newer, more fuel efficient aircraft. Kyle Peterson, *U.S. airlines bide their time as fleet needs grow*, REUTERS (June 12, 2007), *available at*: http://uk.reuters.com/article/basicIndustries/idUKN1226568120070612.

[41] AVIATION AND THE ENVIRONMENT, *supra* note 5, at 33-34.

[42] Working Group III Technical Summary, *supra* note 24, at 51.

- minimizing engine idling time on runways[43] and employing single engine taxiing;[44]
- reducing engine thrust and reverse during high-intensity periods such as take-off and landing;[45]
- optimizing timetables, route networks, and flight frequencies to reduce stopovers, especially for short- and medium-haul flights,[46] and to make possible the selection of more fuel-efficient routes;[47]
- reducing the use of auxiliary power units;[48]
- reducing the amount of excess fuel carried;[49]
- more regular maintenance and cleaning of engines and airframes to correct minor deterioration;[50]

Additionally, designing aircraft to operate at lower altitudes and reduced speed could help avoid contrails and cirrus cloud formation, thereby further reducing environmental impacts.[51]

A 2004 Report to Congress, prepared on behalf of the FAA and the National Aeronautics and Space Administration ("NASA"), outlined numerous available operational changes that could be implemented to reduce the global warming impacts of aircraft.[52] In addition to those mentioned above, these measures include continuous descent approach procedures which have been shown not only to reduce noise impacts by keeping aircraft higher for longer, but also to reduce fuel burn and emissions of pollutants.[53] Another example successfully piloted at San Francisco International Airport combined existing technologies to increase the number of landings per hour, with the aim of reducing delays by 25 percent and decreasing the need for aircraft to circle while awaiting clearance for landing.[54]

---

[43] CONTROLLING AIRPORT RELATED POLLUTION, CCAP & NESCAUM (June 2003) at III-8, *available at*: http://bronze.nescaum.org/workgroup/aircraftport/Aviation_Final_Report.pdf, [hereinafter CCAP Report].

[44] AVIATION AND THE ENVIRONMENT, supra note 5, at 34.

[45] CCAP Report, *supra* note 43, at III-9-11.

[46] For the purposes of this petition, short-haul flights refer to flights between 300 and 600 miles. Medium-haul flights refer to flights between 600 and 1,000 miles. Long-haul flights refer to flights greater than 1,000 miles.

[47] CCAP Report, *supra* note 43, at III-9-11; *see also* AVIATION AND THE ENVIRONMENT, *supra* note 5, at 34.

[48] AVIATION AND THE ENVIRONMENT, *supra* note 5, at 34.

[49] *Id.*

[50] *Id.*

[51] Antoine *et al., supra* note 38, at 2102 and 2109.

[52] AVIATION AND THE ENVIRONMENT, *supra* note 5, at 34.

[53] *Id.*

[54] *Id.*

Measures to reduce the global warming impact of aviation should be a central consideration in the development of new air traffic management systems.[55] Improvements in air traffic management procedures alone could reduce aviation fuel use by between six and eighteen percent, and other operations measures could result in a further two to six percent improvement in efficiency.[56] Unfortunately, the Next Generation Air Transportation System ("NextGen"), the U.S. government's most recent initiative to update and improve America's air traffic system,[57] currently does not include any measures to address the climate change impacts of aviation. In fact, neither the 2005 nor the 2006 NextGen progress report contains a single reference to climate change.[58]

2. Existing, More Efficient Aircraft Designs Can Reduce Greenhouse Gas Emissions.

The airline industry could also meet requirements to reduce greenhouse gas emissions by adopting more efficient aircraft designs and technologies. In fact, designs and technologies are available today that can increase the fuel efficiency of aircraft and minimize such emissions.

One way to reduce the fuel consumption of aircraft is to reduce their weight.[59] One way to achieve such reductions is through the use of lighter composite materials for airframes.[60] For example, the frame of the Boeing 787 Dreamliner, which is scheduled to enter service in 2008, is made primarily from carbon composite, making the aircraft much lighter and 20 percent more fuel efficient than any metal aircraft of similar size.[61]

Weight could also be removed from the nacelle of the aircraft, which holds the engine, fan, thruster and exhaust of a jet engine. The use of lighter materials for the nacelle, and the application of design techniques which can help offset the weight of the engine and fan, can reduce drag and fuel burn, thus improving aircraft efficiency.[62] Another option for reducing weight is the use of efficiently designed propeller aircraft, which are generally lighter than jet-propelled aircraft, for short-haul flights.[63]

---

[55] Thea Sebastian & Rick Pitz, *NextGen Air Transportation System Progress Reports Ignore Climate Change,* CLIMATE SCIENCE WATCH (July 2007), *available at*: http://www.climatesciencewatch.org/file-uploads/NextGen_final_18jul07.pdf.

[56] International Civil Aviation Organization, ENVIRONMENTAL REPORT 2007 (2007) at 108, available at http://www.icao.int/icao/en/env/pubs/Env_Report_07.pdf [hereinafter ICAO ENVIRONMENTAL REPORT].

[57] NextGen is comprised of representatives of the Department of Transportation (with FAA as the lead planning agency), Homeland Security, the Departments of Defense and Commerce, NASA, and the White House Office of Science and Technology Policy, with the oversight of the Joint Planning and Development Office ("JPDO").

[58] Sebastian & Pitz, *supra* note 55, at 7.

[59] Greener by Design Report, *supra* note 3, at 15.

[60] Antoine *et al., supra* note 38, at 2107.

[61] Boeing, Boeing 787 Dreamliner Will Provide New Solutions for Airlines, Passengers, http://www.boeing.com/commercial/787family/background.html [hereinafter Boeing 787 Dreamliner Background].

[62] Greener by Design Report, *supra* note 3, at 10.

[63] Greener by Design Report, *supra* note 3, at 12

Other technological adjustments also show promise for marked improvements. The 787, for example, uses advances in engine technology, including the lightest fan system currently certified in the industry, a more fuel-efficient compressor, and a contra-rotating system,[64] that Boeing claims will contribute as much as eight percent of the increased efficiency of the new airplane.[65] Small changes to the bodies of aircraft, such as winglets on the tips of aircraft wings that improve aerodynamics,[66] the use of electric fuel and air pumps inside planes, disk and airfoil blade materials that can withstand higher operating pressures and temperatures,[67] and the employment of unducted-fan engines,[68] are all available technologies that can achieve significant fuel savings and lower emissions. Given the fact that aircraft use large amounts of fuel, even incremental improvements in fuel efficiency can result in significant emissions reductions.

While these technologies are currently available, there are many more advances in aircraft design in the works. Boeing and NASA, for example, are working on the development of a "blended wing" aircraft.[69] Blended wing designs incorporate the engine, wings, and body of an aircraft into a single lifting surface and result in increased fuel efficiency and fewer emissions.[70] This type of aircraft could reduce fuel burn by 20 to 30 percent over an equivalent sized conventional aircraft carrying the same load.[71] In July 2007, the NASA development group successfully tested a blended wing aircraft.[72] Although current blended wing designs are not as comfortable as existing passenger aircraft, the use of a blended wing design for freighter or tanker aircraft transport could reduce emissions in the near term.[73] Another promising technology is a "silent aircraft" being developed by the Massachusetts Institute of Technology and Cambridge University that would burn 25 percent less fuel than current planes, simultaneously achieving the environmental goals of reducing greenhouse gas emissions and reducing noise.[74]

---

[64] Rolls Royce, Trent 1000, Leading Technology, *available at*: http://www.rolls-royce.com/civil_aerospace/products/airlines/trent1000/technology_flash.jsp.

[65] Boeing 787 Dreamliner Background, *supra* note 63.

[66] FAA Report, *supra* note 22, at 19. The IPCC has recently estimated that winglets can reduce fuel consumption by around seven percent. Working Group III Report, *supra* note 21, at 354.

[67] NASA Fact Sheet, Safeguarding Our Atmosphere; Glenn Research Reduces Harmful Aircraft Emissions, *available at:* http://www.nasa.gov/centers/glenn/about/fs10grc.html.

[68] *Green Fingers; Rolls-Royce pitches open-rotor concept for Europe's Nacre*, AVIATION WEEK & SPACE TECHNOLOGY; AIR TRANSPORT, p. 49, Vol. 165, No. 14.

[69] NASA, X-48 Blended Wing Body, *available at*: http://www.nasa.gov/centers/dryden/research/X-48B/index.html.

[70] Greener by Design Report, *supra* note 3, at 22.

[71] Working Group III Report, *supra* note 21, at 354.

[72] *X-48B Blended Wing Body Aircraft makes first flight*, ASSOC. PRESS (July 27, 2007), *available at:* http://www.komotv.com/news/boeing/8763787.html.

[73] Greener by Design Report, *supra* note 3, at 20.

[74] The Silent Aircraft Initiative, MIT-Cambridge Institute, *available at*: http://silentaircraft.org/efficiency/.

Advances in aircraft fuel efficiency can have multiple benefits by facilitating improvements in operational practices. For example, more fuel efficient aircraft may help reduce or eliminate stopovers that require additional take-off periods, the most fuel consumptive stage during short- and medium-haul flights.[75]

These technology improvements, combined with aircraft design improvements and operational changes, have the potential to achieve significant reductions in greenhouse gas emissions. The 2004 Report to Congress concluded, however, that without more funding and the development of goals to specifically address the global warming impacts of aircraft, future emissions reductions goals – while technologically feasible – may not be met because an insufficient number of technology options will be brought to a readiness level that would allow them to be transitioned into the industry.[76] Thus, the report recommends that "[f]or the long term, but commencing immediately, integrated programs should be strengthened to bring economically reasonable advanced technologies to levels of development that allow more rapid insertion into aircraft and engines."[77]

3. The Use of Alternative Fuels Could Further Reduce Greenhouse Gas Emissionsfrom Aviation.

Efforts are currently underway to develop and certify alternative fuels that could reduce the global warming impact of aircraft. In April of 2007, Boeing, Virgin Atlantic, and GE Aviation announced an environmental partnership to develop alternative aviation fuels.[78] The consortium is planning to test an alternative-fueled flight in 2008.[79] Boeing also recently entered into an agreement with Air New Zealand and Rolls-Royce to conduct a biofuel demonstration flight in the second half of 2008 using an Air New Zealand Boeing 747-400 equipped with Rolls-Royce engines.[80] According to Air New Zealand's Chief Executive, advances in technology have made biofuels a viable possibility for use in aviation far sooner than anticipated.[81] Academic and private institutes in the United States and around the world are also working to find sustainable ways to produce biofuels suitable for use in aviation.[82]

---

[75] Greener by Design Report, *supra* note 3, at 8, Figure10 and Figure 11.

[76] AVIATION AND THE ENVIRONMENT, supra note 5, at 36.

[77] *Id.*

[78] *Boeing and Virgin Atlantic Announce Environmental Partnership*, NAFTC ENEWS (May 2007), *available at*: http://www.naftc.wvu.edu/eNews/May07/virgin.html.

[79] Anita LaFond, *Boeing, Virgin Atlantic Join For Biofuel Development; Virgin Atlantic Puts In Big Order For Boeing's Dreamliners*, MANUFACTURING.NET; MANAGEMENT NEWS NOW (Apr. 24, 2007), *available at*: http://www.manufacturing.net/article.aspx?id=140037&menuid=272.

[80] Richard Black, *Biofuel Trial Flight Set for 747*, BBC NEWS ONLINE (Sept. 28, 2007), *available at*: http://news.bbc.co.uk/2/hi/science/nature/7017694.stm.

[81] *Id.*

[82] *See, e.g.*, Baylor Institute for Air Sciences, *available at*: http://www.baylor.edu/bias/; *see also Boeing and Virgin launch biofuel efforts*, MACHINE DESIGN (June 21, 2007), *available at*: http://machinedesign.com/ContentItem/67970/BoeingandVirginlaunchbiofueleffort.aspx.

Although the benefits of requiring the use of biofuels for any transportation sector remain uncertain,[83] to the extent that concerns are sufficiently addressed, the development of alternative fuels for use in aircraft is promising. Regulatory measures limiting greenhouse gas emissions from aircraft would increase the incentives to develop and use alternative fuels that could significantly reduce the global warming impacts of aviation.

ARGUMENT

Pursuant to the Clean Air Act, EPA is required to prescribe emission standards for air pollutants from aircraft engines when such emissions cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare. 42 U.S.C. § 7571(a)(2)(A). As discussed herein, it is indisputable that greenhouse gas emissions, including those from aircraft engines, are air pollutants that are causing and contributing to global climate change with severe environmental consequences for the planet and all of its inhabitants. EPA has broad discretion in promulgating regulations to limit greenhouse gases from aviation. Moreover, numerous measures are currently available that can reduce the global warming impacts of aircraft emissions, and new technologies and other procedures under development can be brought online to further reduce emissions within reasonable timeframes. Consequently, Petitioners request that EPA undertake its mandatory duty to regulate greenhouse gas emissions from aircraft engines.

A. Greenhouse Gas Emissions from Aircraft Engines Are Air Pollutants Under the Clean Air Act.

Under Section 302(g) of the Clean Air Act, an "air pollutant" is defined as "any air pollution agent or combination of such agents, including any physical, [or] chemical…substance or matter which is emitted into or otherwise enters the ambient air." 42 U.S.C. § 7602(g). This definition has long been interpreted by courts in an extremely broad manner. *See, e.g., Alabama Power Co. v. Costle*, 636 F.2d 323, 353 n. 60 (D.C. Cir. 1979). Furthermore, the Supreme Court recently held that carbon dioxide and other greenhouse gases "are without a doubt 'physical [and] chemical…substance[s] which [are] emitted into…the ambient air.'" *Mass. v. EPA*, 127 S. Ct. at 1460. As a result, the greenhouse gases that Petitioners here request EPA to regulate under Section 231 of the Clean Air Act fall within the definition of "air pollutant" under Section 302(g).

B. Emissions of Greenhouse Gases from Aircraft Engines Endanger Public Health and Welfare.

Pursuant to the requirements of Section 231, greenhouse gas emissions from aircraft engines must be regulated under the Clean Air Act because they cause or contribute to the endangerment of public health and welfare. As discussed above, there is now substantial

[83] Many issues, primarily those of land available for growing biostocks, the costs of processing and refining them, as well as lifecycle greenhouse gas emissions from biofuels, remain to be resolved before the widespread introduction of biofuels to transportation industries could be sustainable or result in life-cycle net reductions in greenhouse gas emissions.

evidence that greenhouse gas emissions from anthropogenic sources are resulting in changes to the global climate, with profound implications for all life on the planet. These impacts include increased global air and water temperatures, rising sea levels, the spread of infectious diseases, an increased number of extreme weather events, impacts on air quality and the availability of drinking water, changes in ecosystems and wildlife habitat, and the potential extinction of countless species.

The Clean Air Act does not require proof of actual harm when determining what constitutes an endangerment to public health and welfare. Rather, EPA is required to take a precautionary approach in regulating pollution that "may reasonably be anticipated to endanger public health or welfare." 42 U.S.C. § 7571(a)(2)(A); *see Mass. v. EPA*, 127 S. Ct. at 1463 ("Nor can EPA avoid its statutory obligation by noting the uncertainty surrounding various features of climate change and concluding that it would therefore be better not to regulate at this time"); *Lead Industries Ass'n v. EPA*, 647 F.2d 1130, 1155 (D.C. Cir. 1980) ("requiring EPA to wait until it can conclusively demonstrate that a particular effect is adverse to health before it acts is inconsistent with both the Act's precautionary and preventive orientation and the nature of the Administrator's statutory responsibilities"). Regardless, there is now substantial evidence that greenhouse gas emissions, including those contributed by aircraft engines, may reasonably be anticipated to endanger public health and welfare.[84]

1. Aircraft Greenhouse Gas Emissions Cause and Contribute to the Endangerment of Public Health.

Global climate change is expected to have significant impacts on human health in numerous ways, including increased heat-related mortalities, the spread of infectious disease vectors, greater air and water pollution, an increase in malnutrition, and greater casualties from fires, storms, and floods.[85] As EPA itself has stated:

> Throughout the world, the prevalence of some diseases and other threats to human health depend largely on local climate. Extreme temperatures can directly lead to loss of life, while climate-related disturbances in ecological systems, such as changes in the range of infective parasites, can indirectly impact the incidence of serious infectious diseases. In addition, warm temperatures can increase air and water pollution, which in turn harm human health.[86]

---

[84] In fact, EPA found more than a decade ago that aircraft NOx emissions at cruise altitudes are "directly harmful to human health and the environment" since they are "considered to be a precursor of tropospheric ozone and a contributor to greenhouse gas." 62 Fed. Reg. 25,356, 25,358 (May 8, 1997).

[85] IPCC, SUMMARY FOR POLICYMAKERS: CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY, WORKING GROUP II CONTRIBUTION TO THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE FOURTH ASSESSMENT REPORT (April, 2007) at 3 [hereinafter Working Group II Report]; *see generally* Paul R. Epstein and Evan Mills, CLIMATE CHANGE FUTURES: HEALTH, ECOLOGICAL AND ECONOMIC DIMENSIONS (Nov. 2005), *available at*: http://www.climatechangefutures.org/report/index.html [hereinafter Epstein & Mills].

[86] EPA, Climate Change, Health and Environmental Effects; *available at*: http://www.epa.gov/climatechange/effects/health.html [hereinafter EPA Climate Change Effects].

Negative health effects from rising temperatures and sea levels worldwide, especially in developing countries, are expected to outweigh any anticipated benefits of climate change on human health in temperate areas.[87] Even though such impacts may be mediated through complex interactions of physical, ecological, and social factors, the World Health Organization ("WHO") has previously estimated that climate change was responsible for at least 154,000 deaths worldwide in 2000.[88]

Climate change is expected to increase the risk from certain infectious diseases, especially vector-born diseases spread by mosquitoes such as malaria, dengue fever, yellow fever, and encephalitis in warm areas.[89] In the northeastern United States, hotter, longer, and drier summers punctuated by heavy rainstorms may also create more favorable conditions for outbreaks of West Nile Virus.[90] Furthermore, the spread of warmer winters is expected to create ideal conditions for the northward expansion of Lyme disease from the United States into southern Canada.[91]

An increase in the frequency and severity of extreme weather events, such as hurricanes, heat waves, and floods, resulting from climate change may result in more deaths, injuries, and stress-related disorders.[92] For example, in heavily populated delta regions, coastal areas, and small islands, sea level rise is anticipated to exacerbate flooding, storm surges, beach erosion, and other hazards, thus threatening vital infrastructure and settlements.[93] In the United States, sea levels have already risen five to six inches more than the global average along the Mid-Atlantic and Gulf Coast during the last century due to coastal lands that are subsiding.[94] By the end of this century, coastal flooding in New York City that now occurs once every 100 years could strike once each decade, while Atlantic City and Boston could experience such flooding every other year.[95]

Moreover, cities that already experience hot summers are expected to be further challenged by an increasing number, intensity, and duration of heat waves during the 21st century and a resulting increase in heat-related illnesses and deaths.[96] Temperatures in the northeastern United States are expected to increase between 2.5°F to 4.5°F in the winter months and 1.5°F to 3.5°F in the summer by the end of the century, with cities such as Hartford and

---

[87] Working Group II Report, *supra* note 85, at 7.

[88] WHO, THE WORLD HEALTH REPORT 2002: REDUCING RISKS, PROMOTING HEALTHY LIFE (Oct. 2002) at 72, *available at*: http://www.who.int/whr/2002/en/.

[89] Epstein & Mills, *supra* note 85, at 32-47; EPA Climate Change Effects, *supra* note 85.

[90] PETER C. FRUMHOFF, *ET AL.*, CONFRONTING CLIMATE CHANGE IN THE U.S. NORTHEAST: SCIENCE, IMPACTS, AND SOLUTIONS (July 2007) at xi, *available at*: http://www.climatechoices.org/ne/resources_ne/nereport.html [hereinafter Northeast Report].

[91] Epstein & Mills, *supra* note 85, at 46.

[92] *Id.* at 53-64.

[93] Working Group II Report, *supra* note 85, at 8-11.

[94] EPA Climate Change Effects, *supra* note 86.

[95] Northeast Report, *supra* note 90, at x-xi.

[96] Working Group II Report, *supra* note 85, at 10.

Philadelphia averaging more than 30 days with high temperatures above 100°F each year.[97] Segments of the population that are particularly vulnerable, such as those with heart problems, asthma, the elderly, infants, and the homeless, can be especially at risk to extreme heat.[98]

In addition to an increase in the frequency and severity of heat waves, higher temperatures and sunlight, combined with other pollutants such as NO_X and volatile organic compounds, may increase concentrations of ground-level ozone.[99] In Philadelphia, for instance, the number of days failing to meet federal air quality standards for ozone is expected to quadruple by the end of the century.[100] Breathing ozone can trigger a variety of health problems, including chest pain, coughing, throat irritation, and congestion, and repeated exposure can lead to bronchitis, emphysema, asthma, and permanent scarring of lung tissue.[101]

Climate change may also indirectly affect the concentration of particulate matter in the air by increasing sources such as wildfires and dust from dry soils.[102] Exposure to such particles can affect both the lungs and heart and has been linked to a variety of problems, including increased respiratory symptoms such as irritation of the airways, coughing or difficulty breathing, decreased lung function, aggravated asthma, development of chronic bronchitis, irregular heartbeat, nonfatal heart attacks, and premature death in people with heart or lung disease.[103] As with other forms of air pollution, certain vulnerable segments of the population, such as children with asthma and the elderly, are the most likely to be affected.[104]

Warming in the western United States is projected to decrease snowpack, cause more winter flooding and reduced summer flows, and exacerbate competition for already over-allocated freshwater resources.[105] Moreover, rising sea levels are expected to increase the salinity of surface and ground water through salt water intrusion, threatening drinking water supplies in places like New York City, southern Florida, and California's Central Valley.[106]

Together, these findings amply demonstrate that global warming presents an unprecedented, long-term, and wide-ranging threat to public health. Reducing greenhouse gas emissions from aircraft is a necessary step towards addressing these impacts.

---

[97] Northeast Report, *supra* note 90, at ix-x.

[98] EPA Climate Change Effects, *supra* note 86.

[99] *Id.*

[100] Northeast Report, *supra* note 90, at x.

[101] EPA, Ground Level Ozone, Health and Environment, *available at*: http://www.epa.gov/air/ozonepollution/health.html.

[102] EPA Climate Change Effects, *supra* note 86.

[103] EPA, Particulate Matter, Health and Environment, *available at*: http://www.epa.gov/air/particlepollution/health.html.

[104] *Id.*

[105] Working Group II Report, *supra* note 85, at 10.

[106] EPA Climate Change Effects, *supra* note 86.

2. Aircraft Greenhouse Gas Emissions Cause and Contribute to the Endangerment of Public Welfare.

Emissions of greenhouse gases from aircraft engines are also endangering public welfare,[107] and many of these effects are directly related to the public health impacts discussed above. For example, global climate change is already resulting in well-documented impacts on climate and weather, including air and ocean temperature increases, widespread melting of snow and ice, changes in precipitation amounts and wind patterns, and more frequent extreme weather events such as hurricanes, heat waves, floods, and droughts.[108] Coastal areas are projected to be exposed to increased risk, such as erosion and flooding, due to climate change and sea level rise.[109] As the IPCC has stated, "[m]any millions more people are projected to be flooded every year due to sea-level rise by the 2080s."[110]

In its recent assessment, the IPCC concluded that "[o]bservational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases."[111] With regard to natural systems involving snow, ice, and frozen ground such as permafrost, the evidence shows an enlargement and increased number of glacial lakes, increasing ground instability in permafrost regions, and rock avalanches in mountain regions.[112] In Glacier National Park, the estimated number of glaciers has dropped from 150 to 26 since 1850, and the remaining glaciers will be gone in the next 25 to 30 years if the current rate of melting continues.[113] It is also likely that temperature increases associated with global climate change will alter the disturbance regimes of northern hemisphere forests, resulting in earlier and longer fire seasons, an increase in disease and pests, and a greater amount of areas burned and experiencing high to extreme fire danger.[114] Climate change is expected to alter the geographic distribution of these forests, including New England sugar maples and boreal forests in Alaska, which may shift northward or to higher elevations.[115]

Sea level rise is also resulting in the loss of wetlands and increasing damage from coastal flooding in many areas.[116] Coastal wetlands, including salt marshes and mangroves, are projected to be negatively affected by sea level rise, especially where they are constrained on their landward side or starved of sediment.[117] Wetlands can provide habitat for numerous

---

[107] "Welfare" is defined under the Clean Air Act to include "effects on soil, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility and climate." 42 U.S.C. § 7602(h).

[108] Working Group I Report Summary, *supra* note 12, at 5-9; *see* GAO REPORT, *supra* note 10, at 5-6.

[109] Working Group II Report, *supra* note 85, at 6.

[110] *Id.* at 7.

[111] *Id.* at 1.

[112] *Id.*

[113] GAO REPORT, *supra* note 10 at 18.

[114] Working Group II Report, *supra* note 85, at 3.

[115] EPA Climate Change Effects, *supra* note 86.

[116] Working Group II Report, *supra* note 85, at 3.

[117] *Id.* at 6-7.

species and nursery areas for fish, serve as a basis for many communities' economic livelihoods, provide recreational opportunities, and protect local areas from flooding.[118] During the 21st century, sea level rise could convert as much as 22 percent of the world's coastal wetlands into open water.[119] EPA has estimated that a two foot rise in sea level could eliminate 17-43 percent of wetlands in the United States, with more than half of the loss occurring in Louisiana.[120]

Global climate change directly affects terrestrial biological systems, as evidenced by the poleward and upward shifts in the ranges of numerous plant and animal species, as well as the earlier timing of spring events such as bird migration and egg-laying.[121] As the IPCC has found, "[t]he resilience of many ecosystems is likely to be exceeded in this century by an unprecedented combination of climate change, associated disturbances (*e.g.*, flooding, drought, wildfire, insects, ocean acidification)," and other global change drivers such as pollution and over exploitation of resources.[122] In the Arctic, detrimental effects are expected to mammals, migratory birds, and other organisms from reductions in sea ice,[123] increased coastal erosion, and an increase in the depth of seasonal thawing of permafrost.[124] Not surprisingly, approximately 20-30 percent of plant and animal species assessed so far will be at an increased risk of extinction if global average temperatures exceed 1.5-2.5°C (2.7-4.5°F).[125] According to one estimate, up to 35 percent of species in the regions sampled will be committed to extinction by 2050 under a high climate-warming scenario.[126]

Changes in global climate are also expected to have numerous impacts on marine and freshwater biological systems, such as shifts in ranges and changes in algal, plankton, and fish abundance in high latitude oceans, increases in algal and zooplankton abundance in high-latitude and high-altitude lakes, and range changes and earlier migrations of fish in rivers.[127] In addition, the acidification of the oceans, which has already decreased in pH by 0.1 units on average due to the absorption of increasing atmospheric levels of carbon dioxide, is expected to harm marine shell forming organisms and species dependant on them.[128]

Corals are particularly vulnerable to thermal stress and already have low adaptive capacity to changes in their ecosystem.[129] For example, an increase in sea surface temperature

---

[118] EPA Climate Change Effects, *supra* note 86.

[119] *Id.*

[120] *Id.*

[121] Working Group II Report, *supra* note 85, at 2.

[122] *Id.* at 5.

[123] This is especially true for species like the polar bear, which is evolutionarily adapted to life on the sea ice and spends only short periods on land. *See* 72 Fed Reg. 1,064 (Jan. 9, 2007) (Proposed Rule To List the Polar Bear as Threatened Under the Endangered Species Act).

[124] Working Group II Report, *supra* note 85, at 11.

[125] *Id.* at 6.

[126] Chris D. Thomas, *et al.*, *Extinction Risk From Climate Change*, NATURE 427 (Jan. 8, 2004) at 145-48.

[127] Working Group II Report, *supra* note 85 at 2.

[128] *Id.* at 6; *see* GAO REPORT, *supra* note 10, at 22.

[129] Working Group II Report, *supra* note 85, at 6.

of approximately 1-3°C (1.8-5.4°F) is projected to result in more frequent coral bleaching events and widespread mortality.[130] This is because even slightly elevated ocean temperatures can destroy the symbiotic relationship in corals between algae and animal polyps, leading to the collapse of entire reefs.[131] As the GAO has reported, continued increases in water temperatures in the Florida Keys may result in more coral bleaching events and will adversely affect the area's tourism and fishing industries.[132] In addition, the lobster fisheries in Long Island Sound and the coastal waters off Rhode Island and South Cape Cod are likely to decline significantly by 2050, while cod is expected to disappear by the end of the century.[133]

Agriculture is highly sensitive to changes in climate, including increased temperatures and shifting rainfall patterns, as well as weather extremes, such as droughts, floods, and severe storms. The IPCC reports that temperature increases resulting from greenhouse gas emissions are likely to impact agricultural practices in the northern hemisphere, such as an earlier spring planting of crops.[134] Parts of Massachusetts, New Jersey, and Pennsylvania are likely to become unsuitable for growing popular varieties of apples, blueberries, and cranberries, while milk production across the northeastern United States is projected to decline between five and 20 percent during certain months.[135] In addition, an increase in the frequency of droughts and floods is also expected to negatively affect crop production, especially at low latitudes.[136] Crop losses attributed to pests, pathogens, and weeds could also increase from the current 42 percent to over 50 percent of potential yields within the coming decade.[137]

In sum, there is no dispute that global warming presents an unprecedented and wide-ranging threat to public welfare. As a result, EPA must take the necessary steps toward regulating greenhouse gas emissions from aircraft engines pursuant to Section 231 of the Clean Air Act.

C. EPA Has Broad Discretion in Promulgating Regulations to Limit Greenhouse Gas Emissions from Aircraft Engines.

---

[130] *Id.* The National Marine Fisheries Service has found that shallow reef habitats are especially vulnerable to increases in global air and sea temperatures due to coral bleaching. 76 Fed. Reg. 26,852, 26,858 (May 9, 2006) (Final Rule to List Elkhorn (*Acropora palmata*) and Staghorn (*A. cervicornis*) Corals as Threatened Under the Endangered Species Act). *See also* International Coral Reef Initiative, Okinawa Declaration on Conservation and Restoration of Endangered Coral Reefs of the World (July 2, 2004) (finding that "the increase in sea surface temperatures, the decrease in carbonate levels as well as sea-level rise, caused by increasing anthropogenic CO2 in the atmosphere, all act synergistically to stress coral reefs, which lead to severe bleaching and extensive coral mortality"), *available at*: http://www.icriforum.org/secretariat/oki_declaration.html.

[131] Epstein & Mills, *supra* note 85, at 10, 77-79.

[132] GAO REPORT, *supra* note 10, at 30-31.

[133] Northeast Report, *supra* note 90, at xi.

[134] Working Group II Report, *supra* note 85, at 3.

[135] Northeast Report, *supra* note 90, at xi.

[136] Working Group II Report, *supra* note 85, at 6.

[137] Epstein & Mills, *supra* note 85, at 29.

While EPA's determination of whether greenhouse gas emissions from aircraft endanger public health or welfare presents a straightforward "yes or no" question, the realm of potential regulatory responses to an affirmative finding is quite broad. This flexibility stems from Congress' recognition, in drafting the Clean Air Act, that not all pollutants could be controlled in the same manner. *See, e.g.*, 42 U.S.C. § 7408(b) (requiring EPA to provide information regarding air pollution control techniques for criteria pollutants, including "available technology and alternative methods of prevention and control of air pollution," as well as "data on alternative fuels, processes, and operating methods which will result in elimination or significant reduction of emissions"). Accordingly, Congress provided EPA with broad authority to craft emissions standards that utilize multiple approaches in achieving pollution reductions. *See Mass. v. EPA*, 127 S. Ct. at 1462 (once EPA makes a finding of endangerment regarding greenhouse gas emissions from motor vehicles, it "no doubt has significant latitude as to the manner, timing, content, and coordination of its regulations with those of other agencies").

Specifically, Section 231 of the Act requires EPA to "issue proposed emission standards" applicable to any air pollutants from aircraft engines that contribute to air pollution that may reasonably be anticipated to endanger public health or welfare. 42 U.S.C. § 7571(a)(2)(A). The Act broadly defines "emission standard" as:

> a requirement established by the State or the Administrator which limits the quantity, rate, or concentration of emissions of air pollutants on a continuous basis, including any requirement relating to the operation or maintenance of a source to assure continuous emission reduction, and any design, equipment, work practice or operational standard promulgated under this chapter.

Id. at § 7602(k).

As this definition demonstrates, EPA has the authority to regulate greenhouse gas emissions from aircraft through the use of operational or maintenance requirements, and any design, equipment, work practice or operational standards. *See, e.g.*, *Engine Mfrs. Ass'n v. South Coast Air Quality Mgmt. Dist.*, 541 U.S. 246, 252-53 (2004) (state rule prohibiting the purchase or lease of vehicles that fail to meet stringent emission requirements constituted a "standard relating to the control of emissions" under Section 209(a); such a broad interpretation was "consistent with the use of 'standard' throughout Title II of the CAA"). In fact, the only limitation on EPA's discretion to set "emission standards" for aircraft engines is the Act's restriction on changes that "would significantly increase noise or adversely affect safety." *Id.* at § 7571(a)(2)(B)(ii).

Moreover, Section 231 allows EPA to limit emissions by establishing technology-forcing standards for aircraft engines. Congress deliberately chose such an approach in the Clean Air Act to require EPA to "'press for the development and application of improved technology rather than be limited by that which exists today,'" *Natural Resources Defense Council v. U.S. EPA*, 655 F.2d 318, 328 (D.C. Cir. 1981) (quoting S. Rep. No. 91-1196, 91st Cong., 2d Sess. 24 (1970)), and to force the industry "to develop pollution control devices that might at the time appear to be economically or technologically infeasible." *Union Elec. Co. v. EPA*, 427 U.S. 246, 257 (1976). Although Section 231 does place a greater emphasis on safety considerations

than other provisions in the Act, EPA has agreed that "section 231(b)'s forward-looking language" does not preclude the agency from setting technology-forcing standards. *See* 70 Fed. Reg. at 69,676 ("EPA does not agree that a technology-forcing standard would be precluded by section 231, in light of section 231(b)'s forward-looking language. Nor would EPA have to demonstrate that a technology is currently available universally or over a broad range of aircraft in order to base a standard on the emissions performance of such technology – the Agency is not limited in identifying what is 'technologically feasible' as what is already technologically achieved.").

EPA also has broad authority to regulate emissions from all classes of aircraft, including both new and in-use aircraft and aircraft engines. 42 U.S.C. § 7571(a)(2)(A) (authorizing EPA to issue proposed emission standards for air pollutants from "any class or classes of aircraft engines"); *see, e.g.,* 40 C.F.R. § 87.10 (prescribing fuel venting emissions standards for new and in-use aircraft). While Congress limited EPA's authority to regulate only "new" motor vehicles and engines under Sections 202 and 213 of the Clean Air Act, 42 U.S.C. §§ 7521 & 7547, Section 231 contains no such restriction. "[W]here Congress includes particular language in one section of a statute but omits it in another section of the same Act, it is generally presumed that Congress acts intentionally and purposely in the disparate inclusion or exclusion." *Bates v. United States*, 522 U.S. 23, 29-30 (1997) (quotations omitted); *see Reiter v. Sonotone Corp.*, 442 U.S. 330, 339 (1979) ("In construing a statute we are obliged to give effect, if possible, to every word Congress used.").

The duty to regulate air pollution from aviation has not been left to EPA alone. Instead, Section 231 of the Act requires EPA to consult with the FAA in developing emissions standards for aircraft engines. 42 U.S.C. § 7571(a)(2)(B)(i). The FAA is also required by Section 232 to promulgate its own regulations "to insure compliance with all standards prescribed under section 7571" by EPA. *Id.* at § 7572(a). In issuing such regulations, the FAA "may execute any power or duty vested in [the FAA Administrator] by any other provision of law." *Id. See, e.g.*, 49 U.S.C. §§ 40103(b) (authorizing FAA to prescribe air traffic regulations for using navigable airspace efficiently); 44505(a) (FAA shall develop and evaluate systems, procedures, facilities, and devices to provide for safe and efficient navigation and air traffic control); 44704 (requiring FAA to control or eliminate emissions from aircraft fuels that EPA finds endanger public health or welfare); 47107(a)(16) (authorizing FAA to condition approval of airport development projects or alterations based on operational efficiency).

D. EPA's Authority to Address the Global Warming Impacts of Aircraft is Consistent with International Law.

The Convention on International Civil Aviation (the "Chicago Convention"),[138] to which the United States is a Party, supports EPA's discretion to regulate greenhouse gas emissions from aircraft. While the convention encourages parties to cooperate in securing the highest practicable degree of uniformity,[139] Article 38 recognizes the right of States to depart from

[138] Convention on International Civil Aviation, Dec. 7, 1944, T.I.A.S. 1591, 61 Stat. 1180.

[139] Article 37 provides: "Each contracting State undertakes to collaborate in securing the highest practicable degree of uniformity in regulations, standards, procedures, and organization in relation to aircraft, personnel, airways and auxiliary services in all matters in which such uniformity will facilitate and improve air navigation."

international airworthiness standards and procedures where they deem necessary by giving notice to the International Civil Aviation Organization ("ICAO")[140]: "Any State ... which deems it necessary to adopt regulations or practices differing in any particular respect from those established by an international standard, shall give immediate notification to the [ICAO] of the differences between its own practice and that established by the international standard." As EPA itself has recognized:

> The Chicago Convention does not require all Contracting States to adopt identical airworthiness standards. Although the Convention urges a high degree of uniformity, it is expected that States will adopt their own airworthiness standards, and it is anticipated that some states may adopt standards that are more stringent than those agreed upon by ICAO.

70 Fed. Reg. at 69,667. Thus, the convention permits countries to adopt aircraft emissions standards that are more stringent than the ICAO standards, and EPA, in consultation with the FAA, "retains the discretion to adopt more stringent emissions standards if the international consensus standards ultimately prove insufficient to protect U.S. air quality." *Id.* at 69,664.

In fact, the ICAO is strongly encouraging States to adopt programs to address the significant and increasing climate impacts from aircraft. During the most recent meeting of the ICAO Assembly in September 2007, the Assembly amended its policies and practices related to environmental protection to encourage States to proactively address aviation's contribution to global warming.[141] Pursuant to a new Appendix K – "*ICAO Programme of Action on international aviation and climate change*," the ICAO Assembly is urging States to undertake an array of measures to address the climate impacts of aircraft including by: (1) encouraging development of "more environmentally friendly efficient engine and aircraft designs"; (2) accelerating "the development and implementation of fuel efficient routings and procedures to reduce aviation emissions"; (3) accelerating efforts "to achieve environmental benefits through the application of satellite-based technologies that improve the efficiency of air navigation";[142] and (4) reducing barriers "to enable implementation of new ATM operating concepts for environmentally efficient use of airspace."[143] A comprehensive program specifically designed to address the climate impacts of all aircraft operating in the United States is clearly needed.

Finally, adopting standards to address the climate impact of aviation is consistent with the United States' obligation under the UN Framework Convention on Climate Change

---

[140] The ICAO, a UN specialized agency established pursuant to the Chicago Convention, is responsible for coordinating and regulating international aviation.

[141] *See* Resolution 17/1: *Consolidated statement of continuing ICAO policies and practices related to environmental protection* (amending Resolution A35-5 (WP/35)), A/36-WP/355 P/53 (Sept. 9, 2007), *available at*: http://www.icao.int/icao/en/assembl/a36/wp/wp355_en.pdf.

[142] The FAA recently announced that it was proposing a new rule requiring all aircraft flying in the nation's busiest airspace to have satellite-based navigation. 72 Fed. Reg. 56,947 (Oct. 5, 2007). However, more is needed in both the near- and long-term to address greenhouse gas emissions from aircraft. For example, while FAA estimates that the rule will result in approximately nineteen million metric tons less carbon dioxide emissions, the vast majority of this reduction, eighteen million tons, would not take place until between 2017 and 2035. *Id.* at 56,965.

[143] *Id.* at Appendix K, ¶ 14.

("UNFCCC"). Article 4 of the UNFCCC obligates the United States to "adopt national policies and take corresponding measures on the mitigation of climate change, by limiting anthropogenic emissions of greenhouse gases."[144]

E. EPA Has the Authority Under Both the Clean Air Act and International Law to Regulate Greenhouse Gas Emissions from Foreign Aircraft Operating in the United States.

As described above, *all* aircraft operating in the United States contribute to global warming. Therefore, EPA must regulate greenhouse gas emissions from not only U.S. certified aircraft, but also foreign aircraft arriving in and departing from the United States.

Designing a regulatory program to address the climate impacts from aviation that extends to foreign aircraft operating within the United States is consistent with U.S. law. First, the Clean Air Act gives EPA unambiguous authority to regulate air pollutants from both U.S.-certified aircraft and foreign aircraft. Pursuant to Section 231(2)(A) of the Act, EPA is authorized to set emission standards from "any class or classes of aircraft engines." 42 U.S.C. § 7571(a)(2)(A). The EPA regulations define "aircraft" as "any airplane for which a U.S. standard airworthiness certificate or equivalent foreign airworthiness certificate is issued." 40 C.F.R § 87.1. The FAA, which is responsible under the Act for prescribing regulations to implement emission standards for aircraft established by EPA, 42 U.S.C. § 7572(a), also has authority to regulate foreign aircraft. *See, e.g.*, 14 C.F.R. § 129.11 (operation specifications for foreign air carriers and foreign operators of U.S.-registered aircraft engaged in common carriage); 14 C.F.R. § 91.711 (special rules for foreign civil aircraft).

In addition, establishing greenhouse gas emission standards for foreign aircraft operating within U.S. airspace is consistent not only with general principles of international law but also the United States' obligations under both the UNFCCC and the Chicago Convention. International law requires nations to ensure that activities within their territory do not cause transboundary environmental harm. For example, in adopting the 1972 Declaration of the United Nations Convention on the Human Environment ("Stockholm Declaration") and the 1992 Rio Declaration on Environment and Development, the United States and 179 other nations agreed that States must "ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."[145] The preamble to the UNFCCC, to which the United States is a party, applies this well-established principle to greenhouse gas emissions.[146] Allowing aircraft flying within

---

[144] United Nations Framework Convention on Climate Change (UNFCCC), art. 4, § 2(a), May 9, 1992, Doc. A/AC.237/18, (Part 11)/Add.1 and Corr.1, 31 I.L.M. 848.

[145] Stockholm Declaration of the United Nations Conference on the Human Environment, Principle 21, G.A. Res. 2997, U.N. GAOR, 27th Sess., U.N. Doc. A/ Conf.48/14/Rev/1, 11 I.L.M. 1416 (1972); Rio Declaration on Environment and Development, *supra*, at Principle 2. The Heavy Metals Protocol to the Convention on Long-Range Transboundary Air Pollution, which the United States has accepted, echoes the Rio Declaration's agreement that states must prevent transboundary harm. Heavy Metals Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Heavy Metals, preamble, June 24, 1998, U.N. Doc. E/ECE/EB.AIR/66/1999, U.N. Sales No. E.99.II.E.21 (1999).

U.S. airspace, whether U.S. or foreign, to continue to emit significant and increasing levels of greenhouse gases that are contributing to global climate change contravenes this principle.

International law also recognizes the sovereign right of nations to regulate activities within their jurisdiction or control, especially where those activities adversely affect the health and welfare of their own citizens.[147] Therefore, EPA has the authority not only to regulate and establish emissions standards for aircraft certified pursuant to U.S. laws and regulations – whether traveling domestically or abroad – but also to address greenhouse gas emissions from foreign aircraft operating within U.S. territory.

Finally, the United States' obligations under the Chicago Convention do not constrain EPA's authority to adopt a program to address aviation's global warming impacts that includes foreign aircraft as well. In fact, numerous State Parties to the Chicago Convention have endorsed this view. For example, the European Commission, recognizing climate change as "the most significant adverse impact of aviation,"[148] adopted a proposal in December 2006 to include greenhouse gas emissions from all domestic and international flights arriving in and departing from EU airports, including U.S.-certified aircraft, in the EU Emissions Trading Scheme ("ETS").[149] The European Parliament recently voted to strengthen the proposal by moving the compliance date from 2012 to 2011.[150] If the proposal is adopted, aircraft from non-EU countries not meeting the emission standards established within the EU will be required to purchase greenhouse gas emission allowances in order to land at and take off from European airports.

In addition, a wide array of measures is available to address the climate impacts from aircraft, including many endorsed by the ICAO, such as developing new operational and procedural measures. Many of these could be applied to foreign aircraft without imposing more

---

[146] UNFCCC Preamble, *supra* note 144 ("States have, in accordance with the Charter of the United Nations and the principles of international law…the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction"); *see also United States v. Canada*, Arbitral Tribunal, 1941, 3 UN Rep. Int'l Arb. Awards (1941) ("under the principles of international law, as well as the law of the United States, no State has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the properties or persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence.")

[147] Restatement of the Law Third, The Foreign Relations Law of the United States, The American Law Institute, Vol. 1 § 402 (stating that "[A] state has jurisdiction to prescribe law with respect to... conduct that, wholly or in substantial part, takes place within its territory."

[148] AVIATION AND THE ENVIRONMENT, *supra* note 5, at 12.

[149] *Commission Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community*, 2006/0304 (COD), COM(2006) 818 final (Dec. 20, 2006), *available at*: http://eur-lex.europa.eu/LexUriServ/site/en/com/2006/com2006_0818en01.pdf.

[150] Resolution on the proposal for a directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community, EUR. PARL. DOC. (COM(2006)0818 – C6-0011/2007 – 2006/0304(COD)) (Nov. 13, 2007), *available at*: http://www.europarl.europa.eu/sides/getDoc.do?Type=TA&Reference=P6-TA-2007-0505&language=EN.

stringent airworthiness standards as provided under Article 33 of the convention.[151] Finally, EPA must recognize that its primary responsibility is to protect U.S. public health and welfare, and the United States' obligations under international agreements such as the Chicago Convention are applicable only to the extent they do not endanger U.S. public health and welfare.

In sum, EPA has a clear and unambiguous mandate under the Clean Air Act to set emissions standards for aircraft, including foreign aircraft, necessary to prevent the significant harm that will occur as a result of global warming.

CONCLUSION

Based on the foregoing, Petitioners respectfully request that EPA:

(1) Make a finding that greenhouse gas emissions from aircraft engines may reasonably be anticipated to endanger public health and welfare pursuant to Section 231(a)(2)(A) of the Clean Air Act, 42 U.S.C. § 7571(a)(2)(A);

(2) Issue proposed standards for greenhouse gas emissions from aircraft engines pursuant to Section 231(a)(2)(A) of the Clean Air Act, 42 U.S.C. § 7571(a)(2)(A); and

(3) Promulgate final regulations within 90 days of the issuance of such proposed standards pursuant to Section 231(a)(3) of the Clean Air Act, 42 U.S.C. § 7571(a)(3).

Sincerely,

Alice R. Thomas
George M. Torgun
Martin Wagner
Earthjustice
426 17th Street, 6th Floor
Oakland, CA 94612
(510) 550-6700

Attorneys for Petitioners Friends of the Earth, Oceana, and the Center for Biological Diversity

[151] Convention on International Civil Aviation, art. 33, Dec. 7, 1944, T.I.A.S. 1591, 61 Stat. 1180 ("Certificates of airworthiness and certificates of competency and licenses issued or rendered valid by the contracting State in which the aircraft is registered, shall be recognized as valid by the other contracting States, provided that the requirements under which such certificates or licenses were issued or rendered valid are equal to or above the minimum standards which may be established from time to time pursuant to this Convention.").

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Burch, Julia[Burch.Julia@epa.gov]
From: Sargeant, Kathryn
Sent: Wed 6/21/2017 5:17:04 PM
Subject: FYI: mtg w/OAPPS on SAB and aircraft GHG (today at 2)
Aviation GHG Pages from Fall 2016 WkGrp Memo Appendix.pdf
Agenda SAB-June 29 post.pdf
Fall 2016 WkGrp Memo attAB.PDF
SAB - Aircraft GHG Emissons Standards.docx

I wanted to be sure you were aware that the SAB workgroup is recommending that SAB provide advice and comment on the aircraft GHG work. Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

We'll be filling Bill in afterwards (and can keep you posted as well), but you are also free to join the call directly if you'd like. Logistics are below.

Subject:	SAB Prep Call
Location:	teleconference Ex. 6 - Personal Privacy conf. code
Start:	Wed 6/21/2017 2:00 PM
End:	Wed 6/21/2017 3:00 PM
Recurrence:	(none)
Meeting Status:	Accepted
Organizer:	Shoaff, John
Required Attendees:	Sargeant, Kathryn; Samulski, Michael; Manning, Bryan; Audette, Lucie; Mazza, Carl
Optional Attendees:	Charmley, William

Added supplementary info, scroll down under original note below, and attachments.

All,

In follow-up to Leif's note on Friday at 2:39 (see also for background re: SAB agenda and supporting docs), I wanted to schedule a quick call to check in on the typical process for these SAB discussions Ex. 5 - Deliberative Process to prepare for the discussion as needed.

Ex. 5 - Deliberative Process

Thanks!

John

Supplementary info. for our conversation:

Estimated timing & cost of contractor-led panel peer reviews (per OW colleague and under the 2013 EPA *Conflict of Interest Review Process for Contractor-Managed Peer Reviews of EPA HISA and ISI* policy based on 2004 OMB *Final Information Quality Bulletin for Peer Review* under the Information Quality Act).

Timeframe

We currently have 2 under way (Perchlorate part 2 and Lead modeling) and completed 2 (PFOA/PFOS and perchlorate part 1).

Typical timeframes from start to finish are 9 - 12 months with all of the FR notices and comment periods required.

Cost

Estimated cost is $25K per review using both ERG and Versar - their rates are comparable.

Fall 2016 SAB WG Memo - Work Group Recommendations Regarding Planned EPA Actions of Interest to the SAB

Control of Air Pollution from Aircraft and Aircraft Engines: Proposed GHG Emissions

Standards and Test Procedures (2060-AT26) is listed as a long term action, with a notice of proposed rulemaking due January 2018 and a final rule due December 2018. The Work Group finds that the planned action is significant and would benefit from SAB advice and comment. The Work Group notes that there are temporal constraints on completing the rulemaking and recommends the SAB provide advice on this issue, or at a minimum, the EPA should conduct a panel review that allows communication across the two proposed peer review panels in order to encourage synergistic understanding among the disciplines involved.

The Work Group notes the SAB previously reviewed *Proposed Finding that Greenhouse Gas Emissions from Aircraft Cause or Contribute to Air Pollution that May Reasonably be Anticipated to Endanger Public Health and Welfare and Advanced Notice of Proposed Rulemaking (2060-AS31)* in the Fall 20142 Regulatory Review and found that subsequent steps in the regulatory process will involve substantive scientific issues that may warrant SAB consideration. The Work Group recommends that the SAB ask the agency to regularly inform the SAB about the status of subsequent steps on this topic and also asks the EPA to provide it with briefings on the science underlying agency approaches to address greenhouse gas emissions and related climate change actions.

Attachments

1. Key Pages from SAB WG Memo Appendix
2. SAB Agenda
3. Full SAB WG Memo & Appendices
4. GHG Aviation Template submitted in follow up to Fall 2016 Reg Agenda

-

-

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Scoville, Pat
Sent: Mon 3/20/2017 4:06:06 PM
Subject: Here are the abstracts from the reg agenda
REG AGNDA ABSTRACTS.docx

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Sutton, Tia
Sent: Mon 3/13/2017 9:41:20 PM
Subject: Rule spreadsheet w/ Reg Agenda column
List of OTAQ Actions.xlsx

Hey Ben,

Attached is the workbook that I did for the 2:1 exercise, updated to include a "2017 Reg Agenda" column. I kept it in the same format of having 3 separate tabs (Statutory/Required actions; Currently tiered/pending actions; other actions), but I can collapse these onto one spreadsheet if that's easier for using with the SLT. Just let me know.

Some folks missed it last time we went over this, but the column headings are important – they note if stuff is currently in the Reg Agenda and what priority is listed there. And I included all actions, not just the significant ones that Pat flagged today. Pat is also going to list the random Pathways actions we have floating around out there, so I'll add those tomorrow as soon as I get them from her.

Ex. 5 - Deliberative Process

Ex. 6 - Personal Privacy

-Tia

To: Moltzen, Michael[Moltzen.Michael@epa.gov]; Sargeant, Kathryn[sargeant.kathryn@epa.gov]; Cohen, Janet[cohen.janet@epa.gov]; Manners, Mary[manners.mary@epa.gov]; Brusstar, Matt[brusstar.matt@epa.gov]
Cc: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Argyropoulos, Paul[Argyropoulos.Paul@epa.gov]; Richards, David[Richards.David@epa.gov]; Simon, Karl[Simon.Karl@epa.gov]; Bunker, Byron[bunker.byron@epa.gov]; Charmley, William[charmley.william@epa.gov]; Sutton, Tia[sutton.tia@epa.gov]
From: Birgfeld, Erin
Sent: Thur 11/10/2016 1:34:30 PM
Subject: OTAQ 101 - for quick input and review by 2 pm today if possible.
OTAQ101 Traditional v2-elb.pptx

Hi Deputies,

We are working on an OTAQ 101 for the transition team that is coming in and would love for you to review and provide input into this working draft.

The team may be here as early as Monday so input today would be very helpful. I'm copying the DD too in case they have time to focus on this as well.

Chris will be giving this so I anticipate he'll essentially want a framework to walk through without getting into too many details in this first round. Ben, I invite you to add further guidance if needed.

If you can provide comments by 2 pm today we can incorporate for Chris's reading materials for the weekend.

Thanks,

Erin

Erin Birgfeld

Communications Director

Office of Transportation and Air Quality

U.S. EPA

202-564-6741 (work)

202-255-4434 (cell)

Work Schedule:

8-6 M,T,Th

8-2:30 W,F

Flexiplace every Wed (call 202-255-4434 to reach me on Wednesday).

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]
From: Richards, David
Sent: Mon 11/7/2016 6:55:35 PM
Subject: RE: Transition slides
OTAQ101 Creative.pptx
OTAQ101 Traditional.pptx

Hey Ben,
I was just about to send it over. Here are draft powerpoints for either the creative route or traditional route. Let me know if you want to discuss them. Thanks.
David

-----Original Message-----
From: Hengst, Benjamin
Sent: Monday, November 07, 2016 1:53 PM
To: Richards, David <Richards.David@epa.gov>
Subject: Transition slides

Hey David--can you let me know when you think the draft 101 slides will be ready for review? Thanks.

To: Grundler, Christopher[grundler.christopher@epa.gov]; William Charmley (charmley.william@epa.gov)[charmley.william@epa.gov]
Cc: Kathryn Sargeant[Sargeant.Kathryn@epa.gov]
From: Hengst, Benjamin
Sent: Wed 6/21/2017 7:49:59 PM
Subject: FW: SAB prep call
Aviation GHG Pages from Fall 2016 WkGrp Memo Appendix.pdf
Agenda SAB-June 29 post.pdf
SAB - Aircraft GHG Emissons Standards.docx
Fall 2016 WkGrp Memo attAB.PDF

Bill, Chris:

I think we should raise this tomorrow with Sarah, after the CSL meeting. We need to make sure this doesn't come as a surprise to the 3rd floor, and I'm not convinced that OAPPS/DeMocker has communicated this in the way that we might have wanted.

From: Samulski, Michael
Sent: Wednesday, June 21, 2017 3:40 PM
To: Charmley, William <charmley.william@epa.gov>; Hengst, Benjamin <Hengst.Benjamin@epa.gov>
Cc: Sargeant, Kathryn <sargeant.kathryn@epa.gov>; Burch, Julia <Burch.Julia@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>; Schenk, Ruth <schenk.ruth@epa.gov>
Subject: SAB prep call

Bill and Ben,

We just had a call with John Shoaff and Carl Mazza at OAPPS (formerly OPAR) on preparing for the upcoming SAB teleconference next week. The OTAQ attendees are copied on this message.

Carl Mazza did say that Jim Democker (OAPPS) mentioned the upcoming SAB call at a recent

senior staff meeting. However, we do not know at what level of detail.

Ex. 5 - Deliberative Process

Julia, is there anything you would like to add?

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Shoaff, John
Sent: Tuesday, June 20, 2017 2:57 PM
To: Shoaff, John; Sargeant, Kathryn; Samulski, Michael; Manning, Bryan; Audette, Lucie; Mazza, Carl
Cc: Charmley, William
Subject: SAB Prep Call
When: Wednesday, June 21, 2017 2:00 PM-3:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: teleconference Ex. 6 - Personal Privacy conf. code

Added supplementary info, scroll down under original note below, and attachments.

All,

In follow-up to Leif's note on Friday at 2:39 (see also for background re: SAB agenda and supporting docs), I wanted to schedule a quick call to check in on the typical process for these SAB discussions and strategize on how we might wish to prepare for the discussion as needed.

Carl is also reviewing the SAB's peer review suggestions vs. the PR Handbook to see how they might jive with time frames and in order to assist with potential clarifications or responses.

Thanks!

John

Supplementary info. for our conversation:

Estimated timing & cost of contractor-led panel peer reviews (per OW colleague and under the 2013 EPA *Conflict of Interest Review Process for Contractor-Managed Peer Reviews of EPA HISA and ISI* policy based on 2004 OMB *Final Information Quality Bulletin for Peer Review* under the Information Quality Act).

Timeframe

We currently have 2 under way (Perchlorate part 2 and Lead modeling) and completed 2 (PFOA/PFOS and perchlorate part 1).

Typical timeframes from start to finish are 9 – 12 months with all of the FR notices and comment periods required.

Cost

Estimated cost is $25K per review using both ERG and Versar – their rates are comparable.

Fall 2016 SAB WG Memo - Work Group Recommendations Regarding Planned EPA Actions of Interest to the SAB

Control of Air Pollution from Aircraft and Aircraft Engines: Proposed GHG Emissions Standards and Test Procedures (2060-AT26) is listed as a long term action, with a notice of proposed rulemaking due January 2018 and a final rule due December 2018. The Work Group finds that the planned action is significant and would benefit from SAB advice and comment. The Work Group notes that there are temporal constraints on completing the rulemaking and recommends the SAB provide advice on this issue, or at a minimum, the EPA should conduct a panel review that allows communication across the two proposed peer review panels in order to encourage synergistic understanding among the disciplines involved.

The Work Group notes the SAB previously reviewed *Proposed Finding that Greenhouse Gas Emissions from Aircraft Cause or Contribute to Air Pollution that May Reasonably be Anticipated to Endanger Public Health and Welfare and Advanced Notice of Proposed Rulemaking (2060-AS31)* in the Fall 20142 Regulatory Review and found that subsequent steps

in the regulatory process will involve substantive scientific issues that may warrant SAB consideration. The Work Group recommends that the SAB ask the agency to regularly inform the SAB about the status of subsequent steps on this topic and also asks the EPA to provide it with briefings on the science underlying agency approaches to address greenhouse gas emissions and related climate change actions.

Attachments

1. Key Pages from SAB WG Memo Appendix
2. SAB Agenda
3. Full SAB WG Memo & Appendices
4. GHG Aviation Template submitted in follow up to Fall 2016 Reg Agenda

To: Sutton, Tia[sutton.tia@epa.gov]
From: Hengst, Benjamin
Sent: Tue 3/14/2017 12:05:36 PM
Subject: Re: Rule spreadsheet w/ Reg Agenda column
List of OTAQ Actions, Spring 2017 Reg Agenda.xlsx

Thanks. This looks good. I made a few edits to the last column. I'll plan on sending this to the DDs later today--any edits you want to make before I send it?

BTW, I still can't access the x-drive from home. But I'll put an updated version in when I'm back in the office.

From: Sutton, Tia
Sent: Monday, March 13, 2017 5:41:20 PM
To: Hengst, Benjamin
Subject: Rule spreadsheet w/ Reg Agenda column

Hey Ben,

Attached is the workbook that I did for the 2:1 exercise, updated to include a "2017 Reg Agenda" column. I kept it in the same format of having 3 separate tabs (Statutory/Required actions; Currently tiered/pending actions; other actions), but I can collapse these onto one spreadsheet if that's easier for using with the SLT. Just let me know.

Some folks missed it last time we went over this, but the column headings are important – they note if stuff is currently in the Reg Agenda and what priority is listed there. And I included all actions, not just the significant ones that Pat flagged today. Pat is also going to list the random Pathways actions we have floating around out there, so I'll add those tomorrow as soon as I get them from her.

Ex. 5 - Deliberative Process

Ex. 6 - Personal Privacy

-Tia

To: OAR Briefings[OAR_Briefings@epa.gov]
Cc: Niebling, William[Niebling.William@epa.gov]
From: Hengst, Benjamin
Sent: Wed 12/17/2014 7:06:07 PM
Subject: For FAA meeting tomorrow
Notes for Meeting with Rich Swayze 12 17 14.docx

All, this reflects comments from our meeting with Janet yesterday. Thanks, Ben.

To: OAR Briefings[OAR_Briefings@epa.gov]
Cc: Stewart, Gwen[Stewart.Gwen@epa.gov]
From: Hengst, Benjamin
Sent: Mon 12/15/2014 8:45:16 PM
Subject: Fw: Materials for tomorrow's 5:00 aircraft meeting with Janet
Notes for Meeting with Rich Swayze 12 15 14.docx

Hi all, these are for tomorrow. Thanks.

[redacted]

Here are draft briefing materials for Janet, to get her ready for her Thursday meeting with FAA's Rich Swayze.

Can you make sure this goes up to Janet's office as well?

Thanks,

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Lori Stewart[Stewart.Lori@epa.gov]
From: Hengst, Benjamin
Sent: Thur 12/11/2014 7:25:00 PM
Subject: FW: Contact information for Rich Swayze's Office at FAA
Notes for Meeting with Rich Swayze 12 9 14.docx

Lori – this may change between now and Tuesday but here is what we have.

From: Charmley, William
Sent: Tuesday, December 09, 2014 5:00 PM
To: Samulski, Michael; Hengst, Benjamin
Subject: RE: Contact information for Rich Swayze's Office at FAA

Mike,

Thanks for this draft to prepare Janet for this meeting next week.

Yes, I think we should try and schedule a 30 minute discussion with Janet to get her prepared before this meeting.

Thanks

Bill

From: Samulski, Michael
Location: AA-Room-Office-N66-ConfRoom/AA-OTAQ-OFFICE
Importance: Normal
Subject: CO2 drafting schedule
Categories: CO2 FRM
Start Date/Time: Tue 3/27/2018 6:30:00 PM
End Date/Time: Tue 3/27/2018 7:00:00 PM
Outline_Assignments_Preamble__Aircraft CO2 Stds NPRM.docx
Outline_Assignments_RIA_Aircraft CO2 Stds NPRM.docx

I have a conflict, so am rescheduling for tomorrow just before the team meeting.

Mike

****

Time is getting short to get the preamble and RIA drafted. I would like to pin down dates that first drafts done of the different sections will be ready for my review.

Thanks,

Mike

To: Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]
From: Audette, Lucie
Sent: Tue 4/12/2016 8:36:36 PM
Subject: FW: CBD complaint for unreasonable delay in finalizing aircraft endangerment and issuing standards
Courtlink_Docket_US_DIS_DCD_1.16cv681_04.12.2016.pdf
Courtlink_Docket_US_DIS_DCD_1.16cv681_04.12.2016.htm

Thought you would be interested in knowing that CBD file a court complaint against EPA for delay in issuing aircraft GHG endangerment finding and issuing standards.

From: Charmley, William
Sent: Tuesday, April 12, 2016 3:17 PM
To: Audette, Lucie <audette.lucie@epa.gov>; Birgfeld, Erin <Birgfeld.Erin@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>
Subject: FW: CBD complaint for unreasonable delay in finalizing aircraft endangerment and issuing standards

Erin –

Bryan Manning is going to give you a call on this topic.

Thanks

Bill

From: Orlin, David
Sent: Tuesday, April 12, 2016 2:57 PM
To: Birnbaum, Rona <Birnbaum.Rona@epa.gov>; Jantarasami, Lesley <Jantarasami.Lesley@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>; Charmley, William <charmley.william@epa.gov>; Hengst, Benjamin <Hengst.Benjamin@epa.gov>

Cc: Williams, Melina <Williams.Melina@epa.gov>; Thrift, Mike <thrift.mike@epa.gov>; Srinivasan, Gautam <Srinivasan.Gautam@epa.gov>
Subject: CBD complaint for unreasonable delay in finalizing aircraft endangerment and issuing standards

CBD's complaint filed today is attached.

David Orlin

U.S. EPA, Office of General Counsel

(202) 564-1222

To: Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Mueller, John[mueller.john@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Yen, David[Yen.David@epa.gov]
From: Maeroff, Bruce
Sent: Wed 8/10/2016 10:48:11 AM
Subject: Opinion: The Uncomfortable Truth About Aviation Emissions

Opinion: The Uncomfortable Truth About Aviation Emissions

The aviation community must face the truth about CO2

Aug 10, 2016 Antoine Gelain | **Aviation Week & Space Technology**

When it comes to sustainability of air travel, the aviation community is lying to itself. There is an elephant in the room and nobody wants to see it. Without more significant efforts—some would call them sacrifices—air travel will continue to be a huge contributor to this planet's pollution and global warming, with dire consequences for future generations, whether they are air travelers or not.

Last month, the U.S. Environmental Protection Agency (EPA) for the first time officially acknowledged its duty to promulgate standards applicable to greenhouse gas (GHG) emissions from commercial aircraft. Indeed, aircraft remain the single largest GHG-emitting transportation source not yet subject to GHG standards in the U.S.

Facing Facts

Air travel and related emissions have doubled in the past 15 years

Aircraft is the largest transportation source not subjected to U.S. greenhouse gas standards

Forecasted growth in air travel is unsustainable if climate change is to be tackled

The uptake of sustainable alternative fuels, which are meant to be a large part of the solution by 2050, has been extremely slow, with only two airports in the world—Oslo and Los Angeles—offering biofuels to airlines.

As for the International Civil Aviation Organization's (ICAO) progress on setting a CO_2 emissions standard, it is as slow as it can get. Having set some "aspirational" goals in 2010 for global net carbon emissions, it is only now getting to the point of recommending that new aircraft models entering service after 2020 and existing aircraft models coming off the production line after 2023 meet the new technical standard—which has yet to be introduced.

The bottom line is that with all the talk about the aviation community being committed to action on climate change (see, for example, the Air Transport Action Group's position paper signed by aviation industry leaders in 2012) and about how various supply-driven measures will improve air travel's sustainability, everybody knows that serious progress will not be achieved unless we address the other part of the equation, aviation's "sacred cow"—demand.

Air travel has essentially doubled in the past 15 years (and so have related CO_2 emissions) and is expected to double again over the next 15 years. There is just no way supply-based measures such as technology and infrastructure improvements will come close to offsetting such rapid growth and its impact on the environment. As for the so-called "market-based measures," such as the European Union's Emissions Trading System or other carbon-offsetting schemes, they are just gap-filling measures that make people feel good without really changing the fundamental dynamics of the industry.

These dynamics are essentially about convincing as many people as possible to fly as often as possible. This is achieved in two ways: First, by making air travel affordable for mass consumption and second, by enticing business travelers with all sorts of bells and whistles.

The low-fare airline model has certainly made air travel more accessible to many, but in that process it has contributed to its excessive commoditization. And while it may be "low-fare," it certainly is not "low-cost" as far as the environment is concerned. In that respect, air travel is very much akin to fast food: It may seem to be a bargain, but it passes the true cost on to the public health and purse and pushes it into the future.

As for major airlines, they are just milking the top of the market by catering to the desires of an international business community that is self-important enough to believe it deserves nothing less than increasingly dedicated and expensive services such as all-business-class flights, upscale cabins, exclusive lounges and loyalty rewards. Yet frequent-flier programs themselves create the wrong incentives, as they encourage business customers—most of which do not pay for their tickets themselves—to fly more and spend more on flights than may be necessary.

If we in the aviation community are really serious about addressing climate change, we first need to accept that the current and forecasted demand for air travel is unsustainable and therefore must be dampened. We as air travelers must become wiser customers: Do we actually need to fly to all these business conferences? Is it worth paying 10 times the price of an economy ticket for better wine, free lounge food and a more comfortable seat? Do we really believe a €20 ($22) trip from London to Copenhagen covers its true cost and true value?

Traveling to different countries can be one of the most enriching experiences in life. Let's not trivialize it to the point where we do not think twice before buying a cheap air ticket. Let's be honest with ourselves and accept the basic but uncomfortable truth that to make air travel sustainable, we first need to change our individual behaviors and become more discerning consumers. In the must-win fight for sustainability, there cannot be gain without pain.

Antoine Gelain is the managing director of Paragon European Partners. He is based in London.

Bruce Maeroff

Senior Service America, Inc.

Supporting the U.S. EPA through a Cooperative

Agreement under the SEE Program,

Assessment and Standards Division,

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105 U.S.A.

Cube N130

ph (734) 214-4404 fax (734) 214-4816

maeroff.bruce@epa.gov

To: Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Arrowsmith Stephen
Sent: Tue 10/20/2015 12:45:03 PM
Subject: CO2DB Introduction Text
CAEP10_WG3_CO2-10_WP08_Appendix D_CO2DB Introduction text_Final.docx

Best Regards

Steve

Stephen Arrowsmith

Environmental Protection Officer

European Aviation Safety Agency

EASA

Tel.: +49 221 89990 5016

Postal: Postfach 10 12 53, 50452 Cologne, Germany

An agency of the European Union

Good planets are hard to come by. Please think of our environment before you print this email.

Disclaimer: This message is intended for the use of the addressee only and may contain information that is privileged and confidential. If you are not the intended recipient, you are notified that any dissemination of this communication is strictly prohibited. If you have received this communication in error, please notify us immediately by returning this email. This communication does not constitute any formal commitment on behalf of the European Aviation Safety Agency unless explicitly so stated.

To: Samulski, Michael[samulski.michael@epa.gov]
Cc: Audette, Lucie[audette.lucie@epa.gov]; Yen, David[Yen.David@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Thur 11/12/2015 4:22:41 PM
Subject: US IP on EPA aircraft GHG endangerment/ANPR (for CAEP10)
CAEP10_IPXX_Update on US Aircraft GHG Rulemaking Process.docx

Hello Mike,

Attached please find the slightly updated US IP on the aircraft GHG endangerment/ANPR for CAEP10 (per the request of Lourdes). Let me know if you have any comments before I send it to Ralph.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Thrift, Mike[thrift.mike@epa.gov]
Cc: Leggett, Cullen[Leggett.Cullen@epa.gov]; Mueller, John[mueller.john@epa.gov]
From: Manning, Bryan
Sent: Thur 1/21/2016 4:16:45 PM
Subject: Response to Comment Question: aircraft GHG endangerment FRM (what is US covered aircraft?)

Hello Mike,

Ex. 5 - Attorney Client

****

Ex. 5 - Attorney Client

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: David Cooley[David_Cooley@abtassoc.com]; Brunner, Christine[brunner.christine@epa.gov]
Cc: Molly Teague[Molly_Teague@abtassoc.com]; Barbara J. Bauer[Barbara_Bauer@abtassoc.com]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Manning, Bryan
Sent: Mon 5/23/2016 5:36:15 PM
Subject: RE: Completed Move Requests: New Subsections for 1.4.2 and 1.4.3 - Aircraft CERT

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: David Cooley [mailto:David_Cooley@abtassoc.com]

Sent: Monday, May 23, 2016 1:16 PM
To: Manning, Bryan <manning.bryan@epa.gov>; Brunner, Christine <brunner.christine@epa.gov>
Cc: Molly Teague <Molly_Teague@abtassoc.com>; Barbara J. Bauer <Barbara_Bauer@abtassoc.com>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Jantarasami, Lesley <Jantarasami.Lesley@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>
Subject: RE: Completed Move Requests: New Subsections for 1.4.2 and 1.4.3 - Aircraft CERT

Hi Chris and Bryan,

We have completed most of the comment moves, but we have a couple of questions on some of them:

Ex. 5 - Deliberative Process

Feel free to give me a call if it's easier to discuss this by phone.

Thanks,

David

--------**David Cooley**

Senior Analyst | Environment and Natural Resources | **Abt Associates**

5001 South Miami Boulevard, Suite 210, Durham, NC 27703

T: 919-294-7793 | F: 617-386-7613

www.abtassociates.com

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Friday, May 20, 2016 4:41 PM
To: Brunner, Christine
Cc: Molly Teague; Barbara J. Bauer; Maeroff, Bruce; Jantarasami, Lesley; Leggett, Cullen; Audette, Lucie; David Cooley
Subject: Completed Move Requests: New Subsections for 1.4.2 and 1.4.3 - Aircraft CERT

Hello,

Ex. 5 - Deliberative Process

Thanks,

Bryan

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: David Cooley [mailto:David_Cooley@abtassoc.com]
Sent: Thursday, May 19, 2016 4:41 PM
To: Manning, Bryan <manning.bryan@epa.gov>; Brunner, Christine <brunner.christine@epa.gov>
Cc: Molly Teague <Molly_Teague@abtassoc.com>; Barbara J. Bauer <Barbara_Bauer@abtassoc.com>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Jantarasami, Lesley <Jantarasami.Lesley@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>
Subject: RE: New subsections for sections 1.4.2 and 1.4.3 - Aircraft CERT site

Hi Chris and Bryan,

I have added these new blank subsections to CERT. Feel free to make comment move requests to populate those sections. Please let me know if you have any questions or if you would like any help in moving the comments.

Thanks,

David

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Thursday, May 19, 2016 3:57 PM
To: Brunner, Christine
Cc: Molly Teague; Barbara J. Bauer; Maeroff, Bruce; David Cooley; Jantarasami, Lesley; Leggett, Cullen; Audette, Lucie
Subject: New subsections for sections 1.4.2 and 1.4.3 - Aircraft CERT site

Hello,

As we discussed earlier, can you revise the outline of the Aircraft CERT site by adding the below sub-sections to 1.4.2 and 1.4.3? See yellow highlighted text below for new subsections.

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

Bryan

Ex. 5 - Deliberative Process

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: David Cooley [mailto:David_Cooley@abtassoc.com]
Sent: Thursday, May 19, 2016 11:11 AM
To: Manning, Bryan <manning.bryan@epa.gov>
Cc: Molly Teague <Molly_Teague@abtassoc.com>; Barbara J. Bauer <Barbara_Bauer@abtassoc.com>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Brunner, Christine <brunner.christine@epa.gov>
Subject: RE: Are you available for a call this morning

Hi Chris and Bryan,

I'm available to talk now, if that works for you. Feel free to call the number below. Or let me know a time that works better for you.

Thanks,

David

--------**David Cooley**

Senior Analyst | Environment and Natural Resources | **Abt Associates**

5001 South Miami Boulevard, Suite 210, Durham, NC 27703

T: 919-294-7793 | F: 617-386-7613

www.abtassociates.com

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Thursday, May 19, 2016 11:06 AM
To: David Cooley
Cc: Molly Teague; Barbara J. Bauer; Maeroff, Bruce; Brunner, Christine
Subject: Are you available for a call this morning

Hello David,

Are you available for a call this morning? I have a question about Aircraft CERT, and Chris is not in the office.

Thanks,

Bryan

From: David Cooley [mailto:David_Cooley@abtassoc.com]
Sent: Wednesday, May 18, 2016 3:14 PM
To: Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Brunner, Christine <brunner.christine@epa.gov>
Cc: Molly Teague <Molly_Teague@abtassoc.com>; Manning, Bryan <manning.bryan@epa.gov>; Jantarasami, Lesley <Jantarasami.Lesley@epa.gov>; Barbara J. Bauer <Barbara_Bauer@abtassoc.com>
Subject: RE: Request to add 2 Comments contained in Docket and not in Abt's CERT document

Hi Chris,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

David

From: Maeroff, Bruce [mailto:Maeroff.Bruce@epa.gov]
Sent: Wednesday, May 18, 2016 2:38 PM
To: Brunner, Christine
Cc: David Cooley; Molly Teague; Manning, Bryan
Subject: Request to add 2 Comments contained in Docket and not in Abt's CERT document

Hi Chris,

Ex. 5 - Deliberative Process

Bruce Maeroff

Senior Service America, Inc.

Supporting the U.S. EPA through a Cooperative

Agreement under the SEE Program,

Assessment and Standards Division,

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105 U.S.A.

Cube N130

ph (734) 214-4404 fax (734) 214-4816

maeroff.bruce@epa.gov

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your system.

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your system.

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your

system.

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your system.

To: Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Wed 6/15/2016 1:47:55 PM
Subject: FAA's comments - aircraft GHG endangerment FRM
EO12866_Review-EPA Aircraft Endangerment Finding - Final Rule_5_6_2016_FAAv5.docx

For your convenience (and a friendly reminder), attached are FAA's comments they submitted to OMB on 5/23. Thanks.

Bryan

From: Samulski, Michael
Sent: Tuesday, May 24, 2016 8:40 AM
To: Manning, Bryan <manning.bryan@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; A udette, Lucie <audette.lucie@epa.gov>
Subject: FW: Just circulated EPA's aircraft endangerment finding for OMB review

Here's an early look at FAA's comments on the FRM.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Ralph.Iovinelli@faa.gov [mailto:Ralph.Iovinelli@faa.gov]
Sent: Monday, May 23, 2016 4:09 PM
To: Samulski, Michael <samulski.michael@epa.gov>
Subject: FW: Just circulated EPA's aircraft endangerment finding for OMB review

Hi Mike,

Ex. 5 - Deliberative Process

Best Regards,

Ralph Iovinelli

Manager, Emissions Division (AEE-300)

Office of Environment and Energy

Federal Aviation Administration

800 Independence Ave., SW

Washington, DC 20591

+1-202-267-3566 office

+1-202-288-6372 mobile

ralph.iovinelli@faa.gov

From: Iovinelli, Ralph (FAA)

Sent: Monday, May 23, 2016 4:00 PM
To: 'Whiteman, Chad'
Subject: RE: Just circulated EPA's aircraft endangerment finding for OMB review

Dear Chad,

Ex. 5 - Deliberative Process

Best Regards,

Ralph Iovinelli

Manager, Emissions Division (AEE-300)

Office of Environment and Energy

Federal Aviation Administration

800 Independence Ave., SW

Washington, DC 20591

+1-202-267-3566 office

+1-202-288-6372 mobile

ralph.iovinelli@faa.gov

From: Whiteman, Chad Ex. 6 - Personal Privacy
Sent: Monday, May 09, 2016 11:07 AM
To: Iovinelli, Ralph (FAA)
Subject: Re: Just circulated EPA's aircraft endangerment finding for OMB review

Comments are due the 23rd to me. Scheduling the interagency briefing and will notify folks once it is on the calendar.

Sent from my BlackBerry 10 smartphone on the Verizon Wireless 4G LTE network.

From: Ralph.Iovinelli@faa.gov

Sent: Monday, May 9, 2016 10:13 AM

To: Whiteman, Chad

Subject: RE: Just circulated EPA's aircraft endangerment finding for OMB review

Chad,

Quick question --- what is the schedule for review? Any interagency telecon/WebEx planned or expected? When does everything need to be returned to OMB? We want to make sure we are timely.

Thanks,

Ralph

From: Whiteman, Chad Ex. 6 - Personal Privacy
Sent: Friday, May 06, 2016 5:34 PM
To: Iovinelli, Ralph (FAA)
Subject: Just circulated EPA's aircraft endangerment finding for OMB review

Ralph,

How are you doing?

Ex. 5 - Deliberative Process

Regards,

Chad

Chad Whiteman

Policy Analyst | Office of Information and Regulatory Affairs

Office of Management and Budget | Executive Office of the President

Ex. 6 - Personal Privacy Ex. 6 - Personal Privacy

To: Manning, Bryan[manning.bryan@epa.gov]; Brunner, Christine[brunner.christine@epa.gov]
Cc: Molly Teague[Molly_Teague@abtassoc.com]; Barbara J. Bauer[Barbara_Bauer@abtassoc.com]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: David Cooley
Sent: Mon 5/23/2016 1:17:21 PM
Subject: RE: Completed Move Requests: New Subsections for 1.4.2 and 1.4.3 - Aircraft CERT

Hi Chris and Bryan,

We are executing those comment move requests and will have them completed by close of business today.

Thanks,

David

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Friday, May 20, 2016 4:41 PM
To: Brunner, Christine
Cc: Molly Teague; Barbara J. Bauer; Maeroff, Bruce; Jantarasami, Lesley; Leggett, Cullen; Audette, Lucie; David Cooley
Subject: Completed Move Requests: New Subsections for 1.4.2 and 1.4.3 - Aircraft CERT

Hello,

For the new subsections, which were added to CERT yesterday, I have finished making the comment move requests to populate these subsections.

Thanks,

Bryan

Ex. 5 - Deliberative Process

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: David Cooley [mailto:David_Cooley@abtassoc.com]
Sent: Thursday, May 19, 2016 4:41 PM
To: Manning, Bryan <manning.bryan@epa.gov>; Brunner, Christine <brunner.christine@epa.gov>

Cc: Molly Teague <Molly_Teague@abtassoc.com>; Barbara J. Bauer <Barbara_Bauer@abtassoc.com>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Jantarasami, Lesley <Jantarasami.Lesley@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>
Subject: RE: New subsections for sections 1.4.2 and 1.4.3 - Aircraft CERT site

Hi Chris and Bryan,

I have added these new blank subsections to CERT. Feel free to make comment move requests to populate those sections. Please let me know if you have any questions or if you would like any help in moving the comments.

Thanks,

David

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Thursday, May 19, 2016 3:57 PM
To: Brunner, Christine
Cc: Molly Teague; Barbara J. Bauer; Maeroff, Bruce; David Cooley; Jantarasami, Lesley; Leggett, Cullen; Audette, Lucie
Subject: New subsections for sections 1.4.2 and 1.4.3 - Aircraft CERT site

Hello,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

Bryan

Ex. 5 - Deliberative Process

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: David Cooley [mailto:David_Cooley@abtassoc.com]
Sent: Thursday, May 19, 2016 11:11 AM
To: Manning, Bryan <manning.bryan@epa.gov>
Cc: Molly Teague <Molly_Teague@abtassoc.com>; Barbara J. Bauer <Barbara_Bauer@abtassoc.com>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Brunner, Christine <brunner.christine@epa.gov>
Subject: RE: Are you available for a call this morning

Hi Chris and Bryan,

I'm available to talk now, if that works for you. Feel free to call the number below. Or let me know a time that works better for you.

Thanks,

David

--------**David Cooley**

Senior Analyst | Environment and Natural Resources | **Abt Associates**

5001 South Miami Boulevard, Suite 210, Durham, NC 27703

T: 919-294-7793 | F: 617-386-7613

www.abtassociates.com

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Thursday, May 19, 2016 11:06 AM
To: David Cooley
Cc: Molly Teague; Barbara J. Bauer; Maeroff, Bruce; Brunner, Christine
Subject: Are you available for a call this morning

Hello David,

Are you available for a call this morning? I have a question about Aircraft CERT, and Chris is not in the office.

Thanks,

Bryan

From: David Cooley [mailto:David_Cooley@abtassoc.com]
Sent: Wednesday, May 18, 2016 3:14 PM
To: Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Brunner, Christine <brunner.christine@epa.gov>
Cc: Molly Teague <Molly_Teague@abtassoc.com>; Manning, Bryan <manning.bryan@epa.gov>; Jantarasami, Lesley <Jantarasami.Lesley@epa.gov>; Barbara J. Bauer <Barbara_Bauer@abtassoc.com>
Subject: RE: Request to add 2 Comments contained in Docket and not in Abt's CERT document

Hi Chris,

Ex. 5 - Deliberative Process

Thanks,

David

From: Maeroff, Bruce [mailto:Maeroff.Bruce@epa.gov]
Sent: Wednesday, May 18, 2016 2:38 PM
To: Brunner, Christine
Cc: David Cooley; Molly Teague; Manning, Bryan
Subject: Request to add 2 Comments contained in Docket and not in Abt's CERT document

Hi Chris,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Bruce Maeroff

Senior Service America, Inc.

Supporting the U.S. EPA through a Cooperative

Agreement under the SEE Program,

Assessment and Standards Division,

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105 U.S.A.

Cube N130

ph (734) 214-4404 fax (734) 214-4816

maeroff.bruce@epa.gov

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your system.

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended

recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your system.

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your system.

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your system.

To: Brunner, Christine[brunner.christine@epa.gov]
Cc: Molly Teague[Molly_Teague@abtassoc.com]; Barbara J. Bauer[Barbara_Bauer@abtassoc.com]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; David Cooley[David_Cooley@abtassoc.com]
From: Manning, Bryan
Sent: Fri 5/20/2016 8:40:42 PM
Subject: Completed Move Requests: New Subsections for 1.4.2 and 1.4.3 - Aircraft CERT

Hello,

Ex. 5 - Deliberative Process

Thanks,

Bryan

Ex. 5 - Deliberative Process

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: David Cooley [mailto:David_Cooley@abtassoc.com]
Sent: Thursday, May 19, 2016 4:41 PM
To: Manning, Bryan <manning.bryan@epa.gov>; Brunner, Christine <brunner.christine@epa.gov>
Cc: Molly Teague <Molly_Teague@abtassoc.com>; Barbara J. Bauer <Barbara_Bauer@abtassoc.com>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Jantarasami, Lesley <Jantarasami.Lesley@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>
Subject: RE: New subsections for sections 1.4.2 and 1.4.3 - Aircraft CERT site

Hi Chris and Bryan,

Ex. 5 - Deliberative Process

Thanks,

David

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Thursday, May 19, 2016 3:57 PM
To: Brunner, Christine
Cc: Molly Teague; Barbara J. Bauer; Maeroff, Bruce; David Cooley; Jantarasami, Lesley; Leggett, Cullen; Audette, Lucie
Subject: New subsections for sections 1.4.2 and 1.4.3 - Aircraft CERT site

Hello,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

Bryan

Ex. 5 - Deliberative Process

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: David Cooley [mailto:David_Cooley@abtassoc.com]
Sent: Thursday, May 19, 2016 11:11 AM
To: Manning, Bryan <manning.bryan@epa.gov>
Cc: Molly Teague <Molly_Teague@abtassoc.com>; Barbara J. Bauer <Barbara_Bauer@abtassoc.com>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Brunner, Christine <brunner.christine@epa.gov>

Subject: RE: Are you available for a call this morning

Hi Chris and Bryan,

I'm available to talk now, if that works for you. Feel free to call the number below. Or let me know a time that works better for you.

Thanks,

David

--------**David Cooley**

Senior Analyst | Environment and Natural Resources | **Abt Associates**

5001 South Miami Boulevard, Suite 210, Durham, NC 27703

T: 919-294-7793 | F: 617-386-7613

www.abtassociates.com

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Thursday, May 19, 2016 11:06 AM
To: David Cooley
Cc: Molly Teague; Barbara J. Bauer; Maeroff, Bruce; Brunner, Christine
Subject: Are you available for a call this morning

Hello David,

Are you available for a call this morning? I have a question about Aircraft CERT, and Chris is

not in the office.

Thanks,

Bryan

From: David Cooley [mailto:David_Cooley@abtassoc.com]
Sent: Wednesday, May 18, 2016 3:14 PM
To: Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Brunner, Christine <brunner.christine@epa.gov>
Cc: Molly Teague <Molly_Teague@abtassoc.com>; Manning, Bryan <manning.bryan@epa.gov>; Jantarasami, Lesley <Jantarasami.Lesley@epa.gov>; Barbara J. Bauer <Barbara_Bauer@abtassoc.com>
Subject: RE: Request to add 2 Comments contained in Docket and not in Abt's CERT document

Hi Chris,

These are both citizen comments, and we typically don't include these types of comments in CERT because they are pretty insubstantial. Generally, we just include comments from organizations and the more substantial citizen comments.

We'd be happy to add these two comments to CERT if you'd like, but I wanted to double check that with you before we do. I've attached them here for your reference.

Thanks,

David

From: Maeroff, Bruce [mailto:Maeroff.Bruce@epa.gov]
Sent: Wednesday, May 18, 2016 2:38 PM
To: Brunner, Christine
Cc: David Cooley; Molly Teague; Manning, Bryan
Subject: Request to add 2 Comments contained in Docket and not in Abt's CERT document

Hi Chris,

Ex. 5 - Deliberative Process

Bruce Maeroff

Senior Service America, Inc.

Supporting the U.S. EPA through a Cooperative

Agreement under the SEE Program,

Assessment and Standards Division,

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105 U.S.A.

Cube N130

ph (734) 214-4404 fax (734) 214-4816

maeroff.bruce@epa.gov

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your system.

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your system.

This message may contain privileged and confidential information intended solely for the addressee. Please do not read, disseminate or copy it unless you are the intended recipient. If this message has been received in error, we kindly ask that you notify the sender immediately by return email and delete all copies of the message from your system.

To: Manning, Bryan[manning.bryan@epa.gov]
Cc: Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Brunner, Christine[brunner.christine@epa.gov]
From: Jantarasami, Lesley
Sent: Wed 5/18/2016 9:23:17 PM
Subject: Re: Potentially Revise Outline of section 1.4 of Aircraft CERT site (aircraft GHG endangerment FRM)

Ex. 5 - Deliberative Process

Sent from my iPhone

On May 18, 2016, at 3:15 PM, Manning, Bryan <manning.bryan@epa.gov> wrote:

Hello,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
Cc: Brunner, Christine[brunner.christine@epa.gov]
From: Manning, Bryan
Sent: Wed 5/18/2016 7:15:08 PM
Subject: Potentially Revise Outline of section 1.4 of Aircraft CERT site (aircraft GHG endangerment FRM)

Hello,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Manning, Bryan[manning.bryan@epa.gov]
Cc: Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Sutton, Tia
Sent: Wed 12/16/2015 8:48:15 PM
Subject: RE: Final Aircraft GHG Endangerment - Preamble to start drafting with
FW: Aircraft Package Federal Register Revisions

Hi Bryan,

I believe this is the correct file.

Ex. 5 - Deliberative Process

Thanks,

Tia

From: Manning, Bryan
Sent: Wednesday, December 16, 2015 2:53 PM
To: Sutton, Tia <sutton.tia@epa.gov>
Cc: Jantarasami, Lesley <Jantarasami.Lesley@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: Final Aircraft GHG Endangerment - Preamble to start drafting with

Hello Tia,

As you know, we plan to issue a final aircraft GHG endangerment about spring 2016. To begin our drafting of the FRM, Lesley and I thought it would be good to start with the MS Word document that most closely matches the July 1, 2015 federal register version of the NPRM (and ANPR). Attached is a MS Word version we found that was after Gina's signature (it was dated June 15, 2015 at 2:01 pm), but I am not sure that it matches the latest-federal register version. Do you know if this attached version is the latest MS Word version we have, or do you have a later MS Word version that matches (or more closely matches) the July 1, 2015 federal register version?

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Stout, Alan[stout.alan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Mueller, John[mueller.john@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Manning, Bryan
Sent: Wed 11/22/2017 2:30:06 PM
Subject: Documents for 10:00 mtg on regulations: aircraft CO2 rule
SL 17-50-AX16-Vol III-Adoptin of First Edition.pdf
40 CFR Part 87_Aircraft Engine Regulations_11-22-17.docx
SL 17-49--AX16-Vol II-Adoption of Amendment 9.pdf

Hi,

Ex. 5 - Deliberative Process

Below are a few agenda items to consider for the 10:00 meeting.

Ex. 5 - Deliberative Process

-AOB

See you soon.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Yen, David[Yen.David@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Mueller, John[mueller.john@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Manning, Bryan
Sent: Wed 11/15/2017 8:45:19 PM
Subject: Latest Updated Preamble & RIA Outlines/Assignments: aircraft CO2 NPRM
Outline_Assignments_Preamble_Aircraft CO2 Stds NPRM 11-7-17.docx
Outline_Assignments_RIA_Aircraft CO2 Stds NPRM_11-15-17.docx

Hi,

Thanks for reviewing the outlines/assignments for the preamble and RIA. Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Next, I will work with Joe Simon to update the document templates in SharePoint/Aircraft CO2 Proposal - Documents/1.1 NPRM-Preamble for the preamble, and SharePoint/Aircraft CO2 Proposal – Documents/1.2 NPRM-RIA for the RIA.

In addition, I plan to schedule a meeting next week to discuss all the items/issues/questions discussed within the comment bubbles in the outlines. Look for a calendar invite for this meeting.

Let me know if you have any questions.

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Zimm, Peter[Peter.Zimm@icf.com]; Harli, Kent[Kent.Harli@icf.com]; Joaquim R.R.A. Martins[jrram@umich.edu]
Cc: Mueller, John[mueller.john@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Yen, David[Yen.David@epa.gov]; Lindsey, Leah[lindsey.leah@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Fri 11/3/2017 8:33:49 PM
Subject: Slight Revisions to Tech/Cost Section of aircraft CO2 report (keep this version of the report for your records)
ICF - EPA 2017 Aircraft CO2 Cost Assessment 11.3.2017 CLEAN VERSION.docx

Hi,

I found a few typos in the tech/cost section of the aircraft CO2 report. For pages 6, 16, 32, and 44, I changed the section descriptions in the text so the appropriate roman numeral was out front: e.g., "section 4.1" on page 6 was changed to "section IV.1." This helped me track/find things better throughout the report. Also, on page 62, I changed the text stating "Exhibit 4-1" to "Exhibit 6-1" to match the exhibit number in that section. See the attached for your records.

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Manning, Bryan[manning.bryan@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Mueller, John[mueller.john@epa.gov]
Cc: Samulski, Michael[samulski.michael@epa.gov]
From: Stout, Alan
Sent: Thur 3/22/2018 8:55:45 PM
Subject: RE: Mike Thrift Initial Feedback: Regulations for aircraft CO2 standard NPRM (engine vs airplane)

Bryan,

That should be no problem. I'll try to get the wording straightened out tomorrow.

Alan

From: Manning, Bryan
Sent: Thursday, March 22, 2018 4:03 PM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>; Mueller, John <mueller.john@epa.gov>; Stout, Alan <stout.alan@epa.gov>
Cc: Samulski, Michael <samulski.michael@epa.gov>
Subject: Mike Thrift Initial Feedback: Regulations for aircraft CO2 standard NPRM (engine vs airplane)

Hi Alan, Cullen, and John,

Ex. 5 - Attorney Client

Ex. 5 - Attorney Client

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Yen, David[Yen.David@epa.gov]
Cc: Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Mon 8/29/2016 8:25:53 PM
Subject: FW: CO2 EF for Aircraft GHG Rule?

David,

See below. I thought 3.15 kg CO2/kg jet fuel or 3.16 kg CO2/kg jet fuel was the emission factor folks were using. 1.131 kg CO2/kg jet fuel does not seem to align with anything I have run across in the last 10 years. Any thoughts? Thanks. Bryan

From: Herzog, Erik
Sent: Monday, August 29, 2016 4:08 PM
To: Manning, Bryan <manning.bryan@epa.gov>
Subject: CO2 EF for Aircraft GHG Rule?

Bryan,

In the SmartWay Air Tool, we've been using an emission factor of 1.131 kg CO2/kg jet fuel. FAA has recommended we us a factor of 1.16. We are also trying to harmonize with an IATA protocol that uses a factor of 3.15.

In trying to sort this out, it would be very useful to know what EF we are planning to use in the Aircraft GHG Rule we are planning to release next year. Do you know what that number will be? I appreciate any information you can share.

Erik Herzog

EPA SmartWay Transport Partnership

ph: 734-214-4487

fx: 734-214-4052

To: Samulski, Michael[samulski.michael@epa.gov]; Sargeant, Kathryn[sargeant.kathryn@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Yen, David[Yen.David@epa.gov]; Davidson, Ken[Davidson.Ken@epa.gov]; Zawacki, Margaret[zawacki.margaret@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
Cc: Mueller, John[mueller.john@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Hoyer, Marion[hoyer.marion@epa.gov]
From: Audette, Lucie
Sent: Thur 7/14/2016 12:50:51 PM
Subject: RE: Draft briefing on Aircraft CO2 analyses
Rulemaking Analyses for Aircraft CO2 Standard Rule - Draft 7 13 16 _+lca .pptx

Ex. 5 - Deliberative Process

From: Samulski, Michael
Sent: Thursday, July 14, 2016 8:35 AM
To: Sargeant, Kathryn <sargeant.kathryn@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>; Yen, David <Yen.David@epa.gov>; Davidson, Ken <Davidson.Ken@epa.gov>; Zawacki, Margaret <zawacki.margaret@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>
Cc: Mueller, John <mueller.john@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Hoyer, Marion <hoyer.marion@epa.gov>
Subject: RE: Draft briefing on Aircraft CO2 analyses

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Sargeant, Kathryn
Sent: Wednesday, July 13, 2016 4:30 PM
To: Samulski, Michael <samulski.michael@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>; Yen, David <Yen.David@epa.gov>; Davidson, Ken <Davidson.Ken@epa.gov>; Zawacki, Margaret

<zawacki.margaret@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>
Cc: Mueller, John <mueller.john@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Hoyer, Marion <hoyer.marion@epa.gov>
Subject: RE: Draft briefing on Aircraft CO2 analyses

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

From: Samulski, Michael
Sent: Wednesday, July 13, 2016 4:10 PM
To: Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>;

Yen, David <Yen.David@epa.gov>; Davidson, Ken <Davidson.Ken@epa.gov>; Zawacki, Margaret <zawacki.margaret@epa.gov>; Sargeant, Kathryn <sargeant.kathryn@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>
Cc: Mueller, John <mueller.john@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Hoyer, Marion <hoyer.marion@epa.gov>
Subject: Draft briefing on Aircraft CO2 analyses

Here is an updated briefing based on yesterday's discussion. Please let me know if you have any comments.

The meeting tomorrow is at 1:00 ET. I asked Gail to add a call-in number (and invite Ken and Molly).

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Manning, Bryan[manning.bryan@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Yen, David[Yen.David@epa.gov]; Davidson, Ken[Davidson.Ken@epa.gov]
Cc: Mueller, John[mueller.john@epa.gov]; Zawacki, Margaret[zawacki.margaret@epa.gov]; Hoyer, Marion[hoyer.marion@epa.gov]; Sargeant, Kathryn[sargeant.kathryn@epa.gov]
From: Samulski, Michael
Sent: Thur 7/7/2016 7:07:10 PM
Subject: Aircraft CO2 Rulemaking Analyses
Rulemaking Analyses for Aircraft CO2 Standard Rule - Draft 7 7 16.pptx

A number of you have gotten an invitation to brief Bill on our plans for the aircraft CO2 rulemaking analyses (Thursday 7/14 at 1:00). If you were not on the invitation list and would like to be, please let me know and I will ask Gail to add you.

I am sending the draft briefing to you for your feedback. You will see that there are a number of open questions, some marked in red. Cullen is already following up on the questions noted for FAA.

Ex. 5 - Deliberative Process

Thanks,

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Manning, Bryan[manning.bryan@epa.gov]; Joaquim R.R.A. Martins[jrram@umich.edu]; Harli, Kent[Kent.Harli@icf.com]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Yen, David[Yen.David@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Lindsey, Leah[lindsey.leah@epa.gov]
From: Zimm, Peter
Sent: Wed 9/20/2017 9:19:23 AM
Subject: RE: ICF/EPA Call (2040 extension results & aircraft CO2 report): Call Ex. 6 - Personal Privacy
Ex. 6 - Personal Privacy
ICF - EPA - Aircraft CO2 Cost Assessment 2017 - DRAFT 2017-08-25 v1 - PZ reviewed.docx

Bryan,

Please see attached current version of the Tech Response paper which addresses all prior comments. Only the of 2040 extension writeup remains to be added.

Best regards,

PETER C. ZIMM | Principal | +1.347.843.9746 mobile | peter.zimm@icf.com
ICF | 630 Third Avenue, 11th Floor, New York, NY 10017 USA | icf.com/aviation

Learn how ICF makes big things possible for its clients.

-----Original Appointment-----
From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Wednesday, September 13, 2017 9:32 AM
To: Manning, Bryan; Zimm, Peter; Joaquim R.R.A. Martins; Harli, Kent; Maeroff, Bruce; Yen, David; Leggett, Cullen; Lindsey, Leah
Subject: ICF/EPA Call (2040 extension results & aircraft CO2 report): Call Ex. 6 - Personal Privacy
Ex. 6 - Personal Privacy
When: Monday, September 18, 2017 11:00 AM-12:30 PM (UTC-05:00) Eastern Time (US & Canada).
Where: AA-Room-Office-N62-ASDCDConfRoom/AA-OTAQ-OFFICE

Call Ex. 6 - Personal Privacy We may not need the full 1.5 hours, but I thought I should schedule it just in case. Also, I am not sure if all ICF folks can be on the line after 12:00, but at least we have the conference room for longer (at EPA) if needed.

Thanks,

Bryan

To: Zimm, Peter[Peter.Zimm@icf.com]
Cc: Yen, David[Yen.David@epa.gov]; Harli, Kent[Kent.Harli@icf.com]; Joaquim R.R.A. Martins[jrram@umich.edu]; Mueller, John[mueller.john@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
From: Manning, Bryan
Sent: Thur 6/15/2017 9:47:48 PM
Subject: 2nd round of Comments on tech/costs sections of report
ICF - EPA - Aircraft CO2 Cost Assessment 2017 - DRAFT 2017-06-09 v2.1+dy+BM.docx

Hi Peter,

Ex. 5 - Deliberative Process

Let me know if you have any questions or thoughts.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Zimm, Peter [mailto:Peter.Zimm@icf.com]
Sent: Monday, June 12, 2017 1:58 AM
To: Manning, Bryan <manning.bryan@epa.gov>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>
Subject: RE: NDA for peer review contract

Bryan,

Ex. 5 - Deliberative Process

Best regards,

PETER C. ZIMM | Principal | +1.347.843.9746 mobile | peter.zimm@icf.com

ICF | 630 Third Avenue, 11th Floor, New York, NY 10017 USA | icf.com/aviation

Learn how ICF makes big things possible for its clients.

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Wednesday, June 07, 2017 11:46 AM
To: Zimm, Peter <Peter.Zimm@icf.com>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>
Subject: NDA for peer review contract

Hi Peter,

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Zimm, Peter[Peter.Zimm@icf.com]; Harli, Kent[Kent.Harli@icf.com]; Joaquim R.R.A. Martins[jrram@umich.edu]
Cc: Yen, David[Yen.David@epa.gov]; Lindsey, Leah[lindsey.leah@epa.gov]; Gerring, Holly[gerring.holly@epa.gov]; Mueller, John[mueller.john@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Tue 1/9/2018 8:47:53 PM
Subject: Additional minor edits to tech/cost section of report
ICF - EPA Aircraft CO2 Cost Assessment_1-9-2018.docx
ICF - EPA 2017 Aircraft CO2 Cost Assessment_11-3-2017_HGDecEdits+DY.docx

Hi Peter,

It his taken a bit longer than we anticipated for the peer review contractor to select the peer reviewers, etc. This contractor now expects to have things in place in the next few weeks. In any event, for editing purposes, we took this opportunity to have a new person from our team, Holly Gerring, read through the tech/cost section of the report (once again for the team). We noticed a few minor items that needed to be revised (minor edits), and we went ahead and revised them. See the first attachment. This first attachment is the latest clean version of the tech/cost section that we plan to send the peer reviewers. You do not have to do anything to this tech/cost section of the report. We just wanted to make sure that you have the latest version of the tech/cost section.

For your convenience, see Holly's comments in track changes in the second attachment. Please note that we only made some of the revisions that Holly suggested (not all revisions). Let us know if you have any questions.

Note, we plan to send a second email later today with Holly's comments on the industry characterization section.

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Zimm, Peter[Peter.Zimm@icf.com]
Cc: Joaquim R.R.A. Martins[jrram@umich.edu]; Mueller, John[mueller.john@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Lindsey, Leah[lindsey.leah@epa.gov]; Yen, David[Yen.David@epa.gov]; Harli, Kent[Kent.Harli@icf.com]
From: Manning, Bryan
Sent: Fri 10/6/2017 6:03:35 PM
Subject: RE: ICF - EPA Final Deliverables (Minor revision to tech/cost section)
ICF - EPA 2017 Aircraft CO2 Cost Assessment 10.6.2017 CLEAN VERSION.docx

Hi Peter,

As we discussed, attached please find a slightly revised version of the final draft of the tech/cost section. I just fixed the typo I mentioned a few days ago, and I am providing this revised version to you for your records. **Ex. 5 - Deliberative Process**

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Harli, Kent [mailto:Kent.Harli@icf.com]
Sent: Friday, September 29, 2017 5:00 PM

To: Manning, Bryan <manning.bryan@epa.gov>; Yen, David <Yen.David@epa.gov>
Cc: Zimm, Peter <Peter.Zimm@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Lindsey, Leah <lindsey.leah@epa.gov>
Subject: ICF - EPA Final Deliverables

Hi Bryan and David,

Please find attached and listed below our final versions of the project deliverables based on finishing up the remaining action items:

1. Redline (with commentary) and clean (without commentary) version of the Tech Response Paper

2. Redline and clean version of the Industry Characterization Paper

3. Updated and finalized version of Tech Response Spreadsheet

Please also find below my responses in red to the remaining ICF action items that we have completed:

ICF ACTION ITEMS

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Best regards,

Kent

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Thursday, September 28, 2017 8:58 AM
To: Zimm, Peter <Peter.Zimm@icf.com>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A.

Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Lindsey, Leah <lindsey.leah@epa.gov>
Subject: Follow-up from today's call: Remaining Tasks for ICF aircraft CO2 report (one more minor item)

Hi Peter,

Ex. 5 - Deliberative Process

Thank you,

Bryan

Hi Peter,

As a follow-up to our call earlier this afternoon, below is list of the remaining action items. Let me know if I missed or mischaracterized anything.

****

ICF ACTION ITEMS

Ex. 5 - Deliberative Process

EPA ACTION ITEMS

- Send table to ICF on replacement/reference aircraft for tech response spreadsheet. After sending this table, quickly iterate with ICF by COB Sept 28.

****

Thanks,

Bryan,

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Manning, Bryan
Sent: Monday, September 18, 2017 5:32 PM
To: 'Zimm, Peter' <Peter.Zimm@icf.com>
Cc: Yen, David <Yen.David@epa.gov>; 'Harli, Kent' <Kent.Harli@icf.com>; 'Joaquim R.R.A. Martins' <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Wolfe, Philip <wolfe.philip@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>; Gerring, Holly <gerring.holly@epa.gov>; Lindsey, Leah <lindsey.leah@epa.gov>
Subject: Follow-up from today's call: Update- Remaining tasks for ICF aircraft CO2 report

Hi Peter,

As a follow-up to our call this morning, below is an update to the tasks remaining to complete the aircraft CO2 report by Sept 30. See all CAPS font ("UPDATE"). Let me know if I missed or mischaracterized anything. I just thought it would be a good idea to capture our discussion this morning.

****

ICF ACTION ITEMS

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

****

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Zimm, Peter [mailto:Peter.Zimm@icf.com]

Sent: Wednesday, July 19, 2017 12:08 PM
To: Manning, Bryan <manning.bryan@epa.gov>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Wolfe, Philip <wolfe.philip@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>; Gerring, Holly <gerring.holly@epa.gov>; Lindsey, Leah <lindsey.leah@epa.gov>; Harli, Kent <Kent.Harli@icf.com>
Subject: RE: EPA comments on draft industry characterization section (aircraft CO2 report)

Bryan,

Please see attached revised Industry Characterization report.

Best regards,

PETER C. ZIMM | Principal | +1.347.843.9746 mobile | peter.zimm@icf.com

ICF | 630 Third Avenue, 11th Floor, New York, NY 10017 USA | icf.com/aviation

Learn how ICF makes big things possible for its clients.

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Wednesday, June 21, 2017 5:02 PM
To: Zimm, Peter <Peter.Zimm@icf.com>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Wolfe, Philip <wolfe.philip@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>; Gerring, Holly <gerring.holly@epa.gov>; Lindsey, Leah <lindsey.leah@epa.gov>
Subject: EPA comments on draft industry characterization section (aircraft CO2 report)

Hi Peter,

Thank you for sending us the draft industry characterization section. It is in fairly good shape. Attached please find our comments. Primarily, our comments focus on wording things a bit differently in some areas. Also, a few of our comments ask you to add tables from your May 12 slide deck (an industry characterization slide deck). Let us know if you have any questions.

We realize that you are very busy the next few weeks, but if you have some time to incorporate these comments in the near future (and send out a revised ind. characterization), it would be helpful to our schedule.

Thanks again,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Zimm, Peter [mailto:Peter.Zimm@icf.com]
Sent: Friday, June 09, 2017 6:26 PM
To: Manning, Bryan <manning.bryan@epa.gov>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>
Subject: RE: NDA for peer review contract

Bryan,

Please see attached write-up for the industry characterization. Please note the turboprop market segment is still under review so the content on page 13 may change.

Tech response paper is being finalized and we expect to send it soon.

Best regards,

PETER C. ZIMM | Principal | +1.347.843.9746 mobile | peter.zimm@icf.com

ICF | 630 Third Avenue, 11th Floor, New York, NY 10017 USA | icf.com/aviation

Learn how ICF makes big things possible for its clients.

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Wednesday, June 07, 2017 11:46 AM
To: Zimm, Peter <Peter.Zimm@icf.com>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>
Subject: NDA for peer review contract

Hi Peter,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Zimm, Peter[Peter.Zimm@icf.com]
Cc: Yen, David[Yen.David@epa.gov]; Harli, Kent[Kent.Harli@icf.com]; Joaquim R.R.A. Martins[jrram@umich.edu]; Mueller, John[mueller.john@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Wolfe, Philip[wolfe.philip@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Gerring, Holly[gerring.holly@epa.gov]; Lindsey, Leah[lindsey.leah@epa.gov]
From: Manning, Bryan
Sent: Fri 8/4/2017 1:57:31 PM
Subject: EPA's minor edits to cost/technolgy section (aircraft CO2 report)
ICF - EPA - Aircraft CO2 Cost Assessment 2017 - DRAFT 2017-07-14+EPA.docx

Hi Peter,

As promised, attached please find the minor edits to the costs/technology section of the report. These edits are in track changes, with a few comment bubbles. Of course, there are few items where we need you to add text (or a table) to the report. Let me know if you have any questions.

I will soon send you the minor edits for the industry characterization section.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Manning, Bryan[manning.bryan@epa.gov]; Zimm, Peter[Peter.Zimm@icf.com]; Joaquim R.R.A. Martins[jrram@umich.edu]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Yen, David[Yen.David@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Lindsey, Leah[lindsey.leah@epa.gov]
Cc: Mueller, John[mueller.john@epa.gov]
From: Harli, Kent
Sent: Thur 9/21/2017 2:09:48 PM
Subject: RE: RESEND: 2 Quick questions - Tech Response paper (aircraft CO2 report)
ICF - EPA - Aircraft CO2 Cost Assessment 2017 - DRAFT 2017-09-21.docx

Hi Bryan,

Please see attached for the updated draft, as well as the responses to your questions below in red:

Ex. 5 - Deliberative Process

Please let us know if you have any further questions!

Best,

Kent

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Thursday, September 21, 2017 9:27 AM
To: Zimm, Peter <Peter.Zimm@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Harli, Kent <Kent.Harli@icf.com>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Yen, David <Yen.David@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Lindsey, Leah <lindsey.leah@epa.gov>
Cc: Mueller, John <mueller.john@epa.gov>
Subject: RESEND: 2 Quick questions - Tech Response paper (aircraft CO2 report)

Hi Peter or Kent,

I am resending this below message in case you did not receive it. If you can answer these two questions, then I can turn around the tech response paper with my latest redline and clean versions of my comments. Then, there should not be much left for you to do on the tech response paper, except for some potential formatting issues.

****

Thanks again for sending us the latest version of the tech response paper.

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

****

Kind regards,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Zimm, Peter [mailto:Peter.Zimm@icf.com]
Sent: Wednesday, September 20, 2017 5:19 AM
To: Manning, Bryan <manning.bryan@epa.gov>; Joaquim R.R.A. Martins <jrram@umich.edu>; Harli, Kent <Kent.Harli@icf.com>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Yen, David <Yen.David@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Lindsey, Leah <lindsey.leah@epa.gov>
Subject: RE: ICF/EPA Call (2040 extension results & aircraft CO2 report): Call Ex. 6 - Personal Privacy code Ex. 6 - Personal Privacy

Bryan,

Ex. 5 - Deliberative Process

Best regards,

PETER C. ZIMM | Principal | +1.347.843.9746 mobile | peter.zimm@icf.com

ICF | 630 Third Avenue, 11th Floor, New York, NY 10017 USA | icf.com/aviation

Learn how ICF makes big things possible for its clients.

-----Original Appointment-----
From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Wednesday, September 13, 2017 9:32 AM
To: Manning, Bryan; Zimm, Peter; Joaquim R.R.A. Martins; Harli, Kent; Maeroff, Bruce; Yen, David; Leggett, Cullen; Lindsey, Leah
Subject: ICF/EPA Call (2040 extension results & aircraft CO2 report): Call Ex. 6 - Personal Privacy code Ex. 6 - Personal Privacy
When: Monday, September 18, 2017 11:00 AM-12:30 PM (UTC-05:00) Eastern Time (US & Canada).
Where: AA-Room-Office-N62-ASDCDConfRoom/AA-OTAQ-OFFICE

Call Ex. 6 - Personal Privacy. We may not need the full 1.5 hours, but I thought I should schedule it just in case. Also, I am not sure if all ICF folks can be on the line after 12:00, but at least we have the conference room for longer (at EPA) if needed.

Thanks,

Bryan

To: Manning, Bryan[manning.bryan@epa.gov]; Yen, David[Yen.David@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Mueller, John[mueller.john@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Lindsey, Leah[lindsey.leah@epa.gov]; Gerring, Holly[gerring.holly@epa.gov]
From: Samulski, Michael
Sent: Tue 1/2/2018 2:53:31 PM
Subject: Draft Materials for Aircraft Pre-Brief with Bill
Briefing_Aircraft CO2 Rule DRAFT 1 3 18.pptx

Here is the draft briefing we will discuss with Bill at 1:00 tomorrow. It is largely the same as the Sarah Dunham briefing, with some updates to reflect our discussions with Boeing/GE.

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Leggett, Cullen[Leggett.Cullen@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
Cc: Yen, David[Yen.David@epa.gov]
From: Manning, Bryan
Sent: Mon 7/6/2015 7:25:17 PM
Subject: Our comments on latest WH briefing
FAA-EPA CO2 Standard briefing_30 June 2015_EPA2 comments clean -FAAcomments.docx

Hello Cullen and Lucie,

Attached please find Lucie and my comments on the latest version of the WH briefing from FAA. Cullen, could you add in the new cumulative reduction and 2025 snapshot figures? Note, Lucie and I revised the title for the cumulative reduction figure. Also, I added a placeholder for the 2025 snapshot figure -- for your convenience in finding the location for it.

Let us know if you have any additional comments.

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Audette, Lucie[audette.lucie@epa.gov]
Cc: Leggett, Cullen[Leggett.Cullen@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
From: Manning, Bryan
Sent: Mon 6/8/2015 3:29:14 PM
Subject: FW: Updated Email blast list 6-8-15 and cover email note (one more thing)
Broad Email to Stakeholders 6-4-15.docx
Contact list 6-8-15.xls

Oops. I forgot to mention that we would need to attach the fact sheet with the email blast (the final version of the fact sheet). Sorry I forgot to mention this earlier.

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Manning, Bryan
Sent: Monday, June 08, 2015 11:24 AM
To: Audette, Lucie
Cc: Samulski, Michael; Leggett, Cullen
Subject: Updated Email blast list 6-8-15 and cover email note

Hello Lucie,

In case I am out of the office (for some reason) when the rule is signed, below is the updated email list for our blast email to stakeholders after the aircraft GHG endang/ANPR is signed -- it now includes Paul Fuda. As I mentioned earlier, you would just need to copy and paste this list into the "Bcc:" part of the email. Also, attached is the cover email and an Excel spreadsheet of the contact list (also, both documents are located at H:\ASD\Aircraft-Documents\1_Aircraft GHG Endangerment and ANPRM\1_NPRM_ANPR\Communication Rollout). Let me know if you have any questions. Thanks. Bryan

daniel.m.allyn@boeing.com; salterman@cargoair.org; david.anvid@delta.com; stephen.arrowsmith@easa.europa.eu; aspy.dale@epa.gov; steven.l.baughcum@boeing.com; wendy.bailey@tc.gc.ca; bbecker@4cleanair.org; abenito@aero.upm.es; paul.billings@lung.org; bonnefoy_philippe@bah.com; arnaud.bonnet@embraer.com.br; sburt@earthjustice.org; pcampos@edf.org; chew_choong_Cheng@caas.gov.sg; jcondevaux@williams-int.com; fayette.s.collier@nasa.gov; Ecotti@NBAA.org; davidson.ken@epa.gov; wdesrosier@gama.aero; ndickson@icao.int; nicole.didyk@faa.gov;

doddh@atag.org; WCDolejsi@cessna.textron.com; douglas.p.dubois@boeing.com; rudolph.dudebout@honeywell.com; ricardo.Dupont@anac.gov.br; meisenstein@nata.aero; alan.epstein@pw.utc.com;

charles.etter@gulfstream.com; chris@limitedskies.com; Gregg.Fleming@dot.gov; angela.foster-rice@united.com; fujiwara.hitoshi@jaxa.jp; Benjamin.gardette@dassault-aviation.com; Mike.garrison@boeing.com; mark.d.guynn@nasa.gov; robert.hackman@aopa.org; william.j.haller@grc.nasa.gov; Sebastien.harquel@embraer.com.br; bill.hemmings@transportenvironment.org; Erika.herms@easa.europa.eu; mhiggins@ucsusa.org; werner.hoermann@easa.europa.eu; curtis.holsclaw@faa.gov; Olivier.husse@airbus.com; Ralph.Iovinelli@faa.gov; daniel.jacob@faa.gov;

dmjensen@fedex.com; jkaltenstein@foe.org; rich.kassel@gladstein.org; karin@theicct.org; king.suzanne@epa.gov; michelle.kirby@ae.gatech.edu; jean-luc.kittery@aviation-civile.gouv.fr; drew@theicct.org;

nkruger@4cleanair.org; irene@theicct.org; d.s.lee@mmu.ac.uk; shamsul_leman@Singaporeair.com.sg; maryalice.locke@faa.gov; sam.long@epa.state.il.us; blongstreth@nrdc.org; michael.lunter@minienm.nl;

david.lye@aero.bombardier.com; amarin@nescaum.org; dmarshall@catf.us; paul.madden@rolls-royce.com; Matsukawa-h2fg@mlit.go.jp; lourdes.maurice@faa.gov; kian.mccaldon@pwc.ca;

GMcDonald@icfi.com; jmcgraw@nata.aero; randal.mckinney@pw.utc.com; KMichaels@icfi.com; mirzoyan@ciam.ru; magnus.molitor@transportstyrelsen.se; matthew.r.muehlhausen@boeing.com;

bengt-olov@nace.se; vincent_ng@caas.gov.sg; cleanairfrank@cleanairwatch.org; b.owen@mmu.ac.uk; vpardee@biologicaldiversity.org; vpatton@edf.org; peeters.p@nhtv.nl; olivier.penanhoat@snecma.fr;

thierry.percheron@dassault-aviation.com; Peter.Zimm@icfi.com; robert.m.peterson@boeing.com; apetsonk@edf.org; dpettit@nrdc.org; lpiccione@nbaa.org; Martin.Plohr@dlr.de; tpohle@airlines.org;

kpreston@aci-na.org; Thomas.F.Richardson@rolls-royce.com; leslie.riegle@aia-aerospace.org; Theo.Rindlisbacher@bazl.admin.ch; RoetgerT@iata.org; muni.majjigi@ge.com; Dan@theicct.org;

Marcelo.saito@anac.gov.br; dsalardi@arb.ca.gov; jerome.sarda@aviation-civile.gouv.fr; tsax@arb.ca.gov; domingo.Sepulveda@pw.utc.com; hilary@redmtngroup.com; Greg.Smallwood@nrc-cnrc.gc.ca;

hans.smit@airbus.com; esmith@gama.aero; simon.smith@rolls-royce.com; frederic.soum@airbus.com; joanne.spalding@sierraclub.org; Inger.sturm@cph.dk; ltonachel@nrdc.org; Eric.Upton@gulfstream.com;

frank.viele@tc.gc.ca; sandy@environmental.assistant.com; Frank.Wetzel@uba.de; laszlo.windhoffer@faa.gov; Roger.worth@dft.gsi.gov.uk; xiaojunyoung@hotmail.com; nyoung@airlines.org; byutko@mit.edu;

joseph.zelina@ge.com ; erik.white@arb.ca.gov ; Liz.perera@sierraclub.or; EdCrupi@ec.gc.ca; pfuda@yahoo.com;

To: Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Mon 3/23/2015 1:14:54 PM
Subject: FW: ERG Small jet report (GA jet fuel breakout)
GHG Small Jet Inventory 3-20-15 master.docx

Hello,

Attached please find the latest draft of ERG's GA jet fuel breakout report. Thanks.

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Richard Billings [mailto:Richard.Billings@erg.com]
Sent: Friday, March 20, 2015 3:12 PM
To: Manning, Bryan; Yen, David; Maeroff, Bruce
Subject: Small jet report

Joe is still putting out fires so the peer review report is still pending – he is planning on working on it over the weekend, so we can send that to you Monday morning.

Richard Billings
Eastern Research Group
1600 Perimeter Park Drive, Morrisville, NC 27560
(919) 468-7812

Jet Fuel Use and CO_2 Emissions Inventory for Aircraft below ICAO GHG Program Thresholds

Final Report

Prepared for:

U.S. Environmental Protection Agency
Laurel Driver
U.S. Environmental Protection Agency
Office of Air Quality Standards and Planning
109 TW Alexander Drive
Research Triangle Park, NC 27711

Prepared by:

Eastern Research Group, Inc.
1600 Perimeter Park Drive
Suite 200
Morrisville, NC 27560

March 20, 2015

This page is intentionally left blank.

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	T-100	4
3.0	GAATA	15
4.0	COMPARISONS	18
5.0	PROJECTIONS	19
6.0	QA/QC	21
7.0	REFERENCES	25

LIST OF TABLES

Page

Table 2-1. Number of Aircraft in each Aircraft Category 5

Table 2-2. Time and Mode Data 6

Table 2-3. Engine Assignments by Aircraft Make and Model 8

Table 2-4. Summary ofT-100Activity Data 10

Table 2-5. Aircraft and Engine Specific Emission Factors from EDMS Run 11

Table 2-6. Aircraft and Engine Specific Cruising Fuel Consumption Rates 12

Table 2-7. 2012 T-100AircraftandEngine Specific Fuel Use and CO_2Emissions 14

Table 3-1. FAA Registry Aircraft Population by MTOM Range 15

Table 3-2. Finalized GAATA Activity for Aircraft Below the MTOM Thresholds 16

Table 3-3. GAATA Fuel Consumption Rates by Aircraft Type (Block fuel/Block time) 16

Table 3-4. 2012 Fuel Use and CO_2 Emission Estimates by Aircraft Below the MTOM Thresholds by Type and Mode 17

Table 4-1. T-100 and GAATA Combine CO_2 Emissions (tons) Summary 18

Table 5-1. Historical Fraction of Jet, Turboprop Powered Aircraft, and Helicopters Below the MTOM Thresholds for the ICAO CO_2 Standards 19

Table 5-2. Adjustment Factors for General Aviation Aircraft Based on Jet Fuel Energy Consumption 20

Table 5-3. Growth Factors Based on Forecasted Jet Fuel Energy Consumption 20

Table 5-4. Backcasted/Forecasted Small Jet, Turboprop, and Helicopter CO_2 Emissions (tons). 21

Table 6-1. QA Summary Table 23

LIST OF FIGURE

Page

Figure 1-1. Summary of Activity Data Used to Quantify Fuel and CO_2 Emissions from Aircraft Below ICAO Reporting Thresholds..... 3

1.0 Introduction

In 2010, the International Civil Aviation Organization's Committee on Aviation Environmental Protection (CAEP), with the U.S. Environmental Protection Agency (EPA) participation, agreed to develop an aircraft carbon dioxide (CO_2) standard, and CAEP expects to finalize the standard in February 2016. In November 2010, CAEP decided that the CO_2 standard will be applicable to subsonic jets with a weight threshold of maximum takeoff mass (MTOM) greater than 5,700 kg (12,566 lbs) and aircraft equipped with turboprop engines with a MTOM greater than 8,618 kg (19,000 lbs). Applying these MTOM thresholds, the EPA has identified four categories of aircraft, large transport jets, regional jets, large turboprops, and large business jets[1] that correspond to the applicability thresholds that CAEP has agreed to for the aircraft CO_2 standard. The EPA has also identified the aircraft categories that do not meet the CAEP applicability thresholds into the following aircraft classes: small turboprops and small business jets. In addition, CAEP's applicability thresholds exclude piston-engine aircraft[2] and helicopters, and because CAEP requirements apply only to civil aircraft, the aircraft CO_2 standard also does not apply to military aircraft. The objective of this study is to estimate jet fuel usage and CO_2 emissions (from this jet fuel usage) in the United States for aircraft below the CAEP MTOM thresholds (excluding jet fuel usage by military aircraft).

To evaluate the current and projected CO_2 emissions for the aircraft (that us jet fuel) below the CAEP MTOM thresholds, fuel use and CO_2 emissions were developed for aircraft below the MTOM thresholds for domestic flights and international flights that originate from a U.S. airport. Emissions estimates were calculated for the base year 2012 and projected for years 2020, 2030, and 2040 using Federal Aviation Administration Forecast data. The draft 2015 EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (EPA, 2015) report includes a category for emissions from general aviation aircraft jet fuel. The category includes large and small business jets, large and small turboprops, and helicopters (with gas turbine engines), which is more inclusive than the CAEP applicability thresholds. Data from the draft 2015 EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (EPA, 2015) was used to back cast 2012 emissions to 1990, 1995, 2000, 2005, 2010 and to develop 2013 estimates.

---

[1] The classes of aircraft are broken down in a general manner for the purpose of showing which aircraft are included and excluded from the ICAO aircraft CO_2 standard. As described earlier, CAEP has specifically identified MTOM thresholds for subsonic jet and turboprop aircraft that clearly indicate which aircraft will be covered by the international CO_2 standard being developed (and which aircraft will not be covered by the international standard). For the aircraft classes that will be covered by the CAEP CO_2 standard, ICAO generally refers to them as follows: turboprops, business jets, regional jets, single aisle aircraft, small twin aisle aircraft, large twin aisle aircraft, and large quad aircraft. However, a subset of turboprops and business jets will not be included in the CO_2 standard (based on the MTOM thresholds).

[2] Piston-engine aircraft primarily operate using aviation gasoline, though it is recognized that a small number use Jet A fuel (i.e., diesel-powered piston aircraft).

The 2015 EPA Draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (EPA 2015) states that any fuel purchased within the United States is attributed to U.S. emissions, while any fuel purchased outside of the United States is attributed to international bunker fuel emissions. This means that outgoing flights from the United States are most likely to be attributed to United States emissions and incoming flights to the United States are most likely attributed to international bunker fuel emissions. To ensure the products of this project align with data used in the 2015 Draft *GHG Emission and Sinks* document, data obtained from the Federal Aviation Administration's (FAA) 2012 General Aviation Part 135 Activity Surveys (GAATA, 2013) was assumed to be fuel purchased and used within the United States. Data obtained from the Bureau of Transportation Statistics (BTS) T-100 Domestic Segment also accounted of activity within the United States; while the International Segment accounted for aircraft leaving the U.S. (assumed to be domestic fuel consumption and aircraft arriving from a foreign airport (assumed to be included in the international bunker fuel (FAA, 2012).

In general, aviation activities can be classified as:

- Part 91 – non-commercial general aviation, corporate flight departments, limited for-hire activity (flight training, etc)
- On-Demand Part 135 operations
- Scheduled Part 135 operations
- Part 121 (large aircraft)

The GAATA survey covers Part 91 and On-Demand Part 135, while the T-100 dataset covers Part 121 and Part 135 operators with more than $20 Million in annual revenue. This provides both an overlap and a gap between the two datasets. The overlap occurs between GAATA and T-100 for large On-Demand Part 135 operators with more than $20M in annual revenue that include commercial air taxi operations. Conversely, neither database covers smaller Part 135 Scheduled operators with less than $20 million in revenue. Regarding the overlap, adjustments were made to the GAATA data to account for air taxis reported in the T-100 data. However, note that the missing scheduled Part 135 operators with revenues less $20 million may have higher utilization levels and fuel consumption rates than represented in the GAATA survey. It is believed that the aircraft with MTOM less than the ICAO GHG thresholds are anticipated to be a relatively small portion of the Part 135 operators with revenues less than $20 million.

The GAATA data include all activity (by aircraft type) for general aviation and air taxis, while the T-100 dataset include commercial activity by specific aircraft make and model, which include air taxis but not non-commercial general aviation. Aircraft fleet data sources were also used in this analysis including aircraft and airline data from the Ascend Online Fleets Database, (Ascend, 2015), and aircraft registration information from the Federal Aviation Administration (FAA) Aircraft Registry–Releasable Aircraft Database Download (FAA, 2014a).[3] Figure 1-1

shows how the different sources of activity data were integrated to generate CO_2 emission estimates for this analysis.

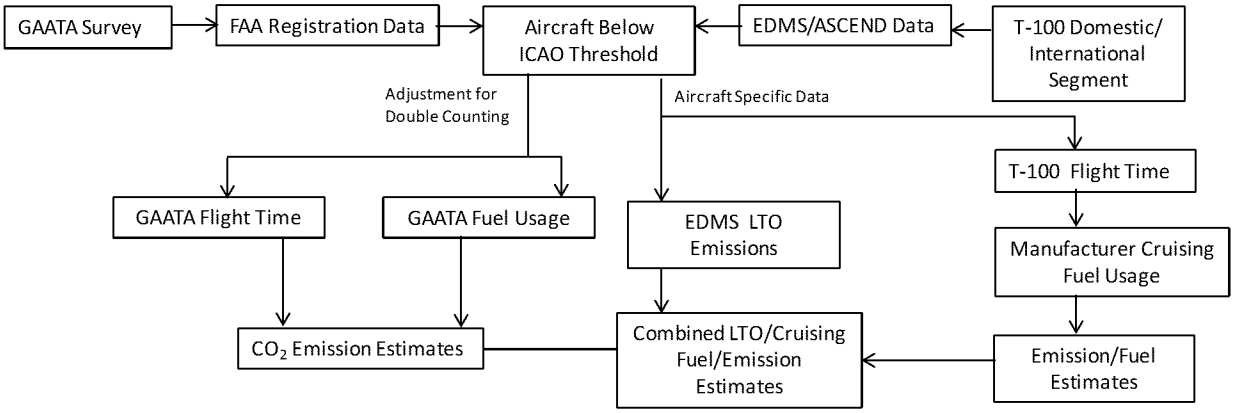


Figure 1-1. Summary of Activity Data Used to Quantify Fuel and CO_2 Emissions from Aircraft Below ICAO Reporting Thresholds

Because the T-100 dataset provides aircraft-specific data, priority was given to include these data in this analysis. Where possible, adjustments were made to the GAATA aircraft type data to avoid double counting. GAATA data do not differentiate aircraft type by takeoff weight categories. Therefore, different approaches were used for jets, turboprop, and helicopter estimates. For example, to approximate the weight categories for the U.S. general aviation and air taxi jet-powered fleet, the percentage of active business jets below the MTOM threshold was determined using the latest FAA Aircraft Registry data (FAA, 2014a).[4] A different approach was taken to determine the turboprop activity data below the MTOM threshold. For turboprops, the aircraft make and model from the T-100 dataset above and below the MTOM threshold were determined using the MTOM listed for each aircraft make and model in the FAA's Emissions Dispersion Modeling System (EDMS) system tables (FAA, 2013). Because both the GAATA data includes commercial air taxi activities and the T-100 dataset also includes commercial flights, including commercial air taxis, the T-100 turboprop annual landing takeoff (LTO) and annual air time values for aircraft below the ICAO threshold were subtracted from the GAATA turboprop annual LTO and annual airtime values for turboprop aircraft below the ICAO threshold to avoid double counting.

In comparing the active turboprop aircraft above the MTOM threshold in Ascend and the T-100 data, all but two airframe models could be matched in the two datasets.[5] This matching suggested

[3] The FAA Aircraft Registry–Releasable Aircraft Database Download provides information about current registered aircraft owners, documents filed, aircraft dealers, and more.

[4] The FAA Aircraft Registry data provides data by the following MTOM thresholds: up to 5,699 kg, 5,670 – 9, 071 kg, and 9,072 kg.

[5] Ascend data documents 64 Jetstream J41 and one Nord N 262 were active, but not included in the T-100 data.

that except for these two aircraft models, all of the remaining turboprop aircraft in GAATA annual LTOs were less than the MTOM threshold. Note that this assumption slightly overestimates activity below the MTOM threshold because the GATA data include the two unmatched aircraft and any turboprops above the MTOM threshold but not used in commercial activities. It is believed that this later group is likely to be small due to the economics of aircraft ownership.

The remaining GAATA turboprop data were combined with the T-100 activity data identified as being less than the MTOM threshold, providing the activity data used to estimate annual fuel usage and emissions from turboprops included in this analysis (below the MTOM threshold).

The emissions for the small business jets and turboprops below the MTOM threshold were calculated by applying fuel consumption rates and CO_2 emission factors[6] to the activity data. Emissions from aircraft below the MTOM threshold were calculated separately for the LTO cycle as well as the cruising mode.

Section 2 describes the emission inventory development associated with the T-100 data, and Section 3 describes the development of the GAATA emission inventory. Section 4 compares the 2012 results of this study with data presented in the 2015 EPA Draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (EPA 2015). Section 5 documents how the projections were developed and Section 6 discusses QA/QC activities implemented.

2.0 T-100

Activity

For base year 2012, the T-100 activity data include annual air time and LTO by specific aircraft make and model (FAA, 2012). The aircraft are categorized based on aircraft type (e.g., aviation gas powered propeller, helicopter, turboprop, and jet) and linked to their MTOM information obtained from the EDMS system tables. Table 2-1 shows the number of smaller aircraft models in each category, average MTOMs from EDMS, and the MTOM threshold categories used in this analysis. Note the average MTOM values presented in Table 2-1 represent a wide range of individual aircraft values.

Five additional aircraft models were directly matched to equivalent aircraft in the EDMS list of aircraft. One aircraft (Helio H-250/295/395) (Plane & Pilot, 2010) was matched to an alternative model in EDMS aircraft characteristics list (included in Table 2-1 under the small turboprop category). Three aircraft were out of scope: two were piston engines, and one was a military aircraft. The single remaining aircraft, Quest Kodiak 100, was identified as a small turboprop. The MTOM was obtained from the manufacturer (Quest, 2014), and the aircraft type was pulled from the T-100 dataset.

[6] EPA CO_2 emission factors are in terms of the carbon content of the fuel and are presented as kgs of CO_2 per gallon of fuel.

Table 2-1. Number of Aircraft in each Aircraft Category

General Aircraft Category	EDMS Category	Number of Aircraft Models	Average MTOM (lbs)	MTOM Threshold Categories (lbs)
Piston powered aircraft	Propeller	17	3,652	N/A
Helicopter[a]	Light Helicopter	1	-	N/A
Large Business Jet[b]	Business Jet	21	37,374	>12,566
Large Business Jet[b]	Large Jet	18	766,683	>12,566
Large Business Jet[b]	Medium Jet	20	390,678	>12,566
Large Business Jet[b]	Regional Jet	21	77,249	>12,566
Large Business Jet[b]	Small Jet	19	178,423	>12,566
Larger Turboprop[b]	Turboprop	18	50,391	>19,000
Smaller Turboprop[a]	Turboprop	18	11,984	<19,000

[a] Aircraft below weight thresholds included in this study.
[b] Aircraft above the weight thresholds used to adjust the GAATA activity data in Section 3.

The annual LTO cycles are a summation of the number of departures for each aircraft make and model listed in the T-100 dataset. The annual cruising time was calculated by subtracting the airborne portion of the annual LTO cycle based on the average takeoff, climbout, and approach time from EDMS (see Table 2-2) from the airtime listed in the T-100 dataset. Because the Quest Kodiak 100 did not have aircraft information in EDMS, comparable values were used from a similar aircraft in EDMS.

Engine makes and models for the aircraft were needed to ensure proper matching with EDMS emission factors. For the aircraft types below the MTOM threshold, weighted emission factors were based on engine market share reported in the Ascend data. This approach was limited to the nine small aircraft that encompassed 90% of the LTO activity. The remaining aircraft below the MTOM threshold were assigned engines from the most popular aircraft engine combination listed in the Ascend data. For two cases where aircraft were not included in the Ascend data, engine assignments were made that represent conservative aircraft engine combination in EDMS based on the highest CO_2 emission factor. The aircraft makes and models above the MTOM threshold were assigned engines from the most popular aircraft engine combination listed in the Ascend data, or from the only valid aircraft engine combination listed in EDMS. Where the engines from the most popular aircraft engine combination listed in Ascend but were not listed in EDMS, a comparable engine was assigned. For the aircraft makes and models above the MTOM threshold that were not listed in the Ascend data, typical engines based on Internet research (Section 6) were assigned. Table 2-3 lists the engine assignments for each aircraft make and model and the basis for assigning each engine.

The finalized activity data are summarized by aircraft and engine combination in Table 2-4.

Table 2-2. Time and Mode Data

Aircraft Type	Aircraft Code	Engine Type	Engine ID	Time in Mode (minutes)					
				Approach	Climbout	Startup	Takeoff	Taxi In	Taxi Out
Aerospatiale/Aeritalia ATR-42	ATR42-4	PW121	PW121	4.5	2.2	1	0.5	7	9
Aerospatiale/Aeritalia ATR-72	ATR72-2	PW124B	PW124B	4.5	2.2	1	0.5	7	9
Beech 1900 A/B/C/D	BEECH1900-C	PT6A-65B	PT6A6B	4.5	2.2	1	0.5	7	9
Beech 200 Super Kingair	BEECH200	PT6A-41	PT6A41	4.5	2.2	1	0.5	7	9
Beech 99 Airliner	BEECH99	PT6A-20	PT6A20	4.5	2.2	1	0.5	7	9
Beech C99	BEECH99	PT6A-36	PT6A36	4.5	2.2	1	0.5	7	9
British Aerospace Jetstream 31	J31	TPE331-10U	TPE10U	4.5	2.2	1	0.5	7	9
Casa 235	CN235-2	CT7-9B	CT79B	4.5	2.2	1	0.5	7	9
Casa/Nurtanio C212 Aviocar	CASA212-1	PT6A-28	PT6A28	4.5	2.2	1	0.5	7	9
Cessna 208 Caravan	CNA208	PT6A-114	PT6A14	4.5	2.5	1	0.5	7	9
Cessna 208 Caravan	CNA208	PT6A-114A	P6114A	4.5	2.5	1	0.5	7	9
Cessna 406 Caravan II	REIMS406	PT6A-112	PT6112	4.5	2.2	1	0.5	7	9
Cessna C208B/Grand Caravan	CNA208	PT6A-114A	P6114A	4.5	2.5	1	0.5	7	9
Convair CV-580	CV580	501 D13 alternative 1	501DA1	4.5	2.2	1	0.5	7	9
De Havilland DHC8-100 Dash-8	DHC8Q-1	PW120A	PW120A	4.5	2.2	1	0.5	7	9
De Havilland DHC8-200Q Dash-8	DHC8Q-2	PW123D	PW123D	4.5	2.2	1	0.5	7	9
De Havilland DHC8-300 Dash 8	DHC8Q-3	PW123	PW123	4.5	2.2	1	0.5	7	9
De Havilland DHC8-400 Dash-8	DHC8Q-4	PW150A	PW150A	4.5	2.2	1	0.5	7	9
De Havilland Twin Otter DHC-6	DHC6-1	PT6A-20	PT6A20	4.5	2.2	1	0.5	7	9
De Havilland Twin Otter DHC-6	DHC6-1	PT6A-27	PT6A27	4.5	2.2	1	0.5	7	9

Dornier 228	DO228-1	TPE331-5A	TPE5A	4.5	2.2	1	0.5	7	9
Dornier 328	DO328-1	PW119C	PW119C	4.5	2.2	1	0.5	7	9
Embraer EMB-120 Brasilia	EMB120	PW118B	PW118B	4.5	2.2	1	0.5	7	9
Eurocompter AS350 B2 AStar	SA350	TPE331-3	TPE3	6.5	4.33	1	2.17	7	9
Grumman G-21A (Goose)	G21G	TPE331-2UA	TP2UA	4.5	2.2	1	0.5	7	9
Gulfstream I	GULF1	RDa.7	RDA7	4.5	2.2	1	0.5	7	9
Helio H-250/295/395	MIL-U10	PT6A-27	PT6A27	3.5	0.8	1	0.4	7	9
Pilatus Britten-Norman BN2/A Islander	BN2	250B17B	250B17	4.5	2.5	1	0.5	7	9
Pilatus PC-12	PC12	PT6A-67B	PT67B	4.5	2.5	1	0.5	7	9
Quest Kodiak 100	CNA208	PT6A-114A	P6114A	4.5	2.5	1	0.5	7	9
Saab-Fairchild 340/A	SAAB340-A	CT7-5A2	CT75A2	4.5	2.2	1	0.5	7	9
Saab-Fairchild 340/B	SAAB340-B	CT7-9B	CT79B	4.5	2.2	1	0.5	7	9
Shorts 330	SD330	PT6A-45A	PT6A4A	4.5	2.2	1	0.5	7	9
Shorts 360	SD360-1	PT6A-65R	PT6A6R	4.5	2.2	1	0.5	7	9
Shorts Harland SC-7 Skyvan	SC7-3-1	TPE331-2	TPE2	4.5	2.2	1	0.5	7	9
Socata TBM850	TBM-850	PT6A-66	PT6A66	4.5	2.2	1	0.5	7	9

Table 2-3. Engine Assignments by Aircraft Make and Model

Aircraft Make/ Model	EDMS Aircraft Code	Engine Make/ Model	EDMS Engine Code	Engine Assignment Basis
Below the MTOM Threshold				
Pilatus Britten-Norman BN2/A Islander	BN2	250B17B	250B17	Weight factors based engine market share
Cessna 208 Caravan	CNA208	PT6A-114	PT6A14	Weight factors based engine market share
Cessna 208 Caravan	CNA208	PT6A-114A	P6114A	Weight factors based engine market share
De Havilland Twin Otter DHC-6	DHC6-1	PT6A-20	PT6A20	Weight factors based engine market share
De Havilland Twin Otter DHC-6	DHC6-1	PT6A-27	PT6A27	Weight factors based engine market share
Beech 1900 A/B/C/D	BEECH1900-C	PT6A-65B	PT6A6B	Weight factors based engine market share
EurocopterAS350 B2AStar	SA350	TPE331-3	TPE3	Weight factors based engine market share
Grumman G-21A (Goose)	G21G	TPE331-2UA	TP2UA	Weight factors based engine market share
SocataTBM850	TBM-850	PT6A-66	PT6A66	Weight factors based engine market share
Beech King Air C-90	BEECH90	PT6A-60	PT6A60	Most Popular Engine in Ascend
Beech 200 SuperKingair	BEECH200	PT6A-41	PT6A41	Most Popular Engine in Ascend
Beech 99 Airliner	BEECH99	PT6A-20	PT6A20	Most Popular Engine in Ascend
Beech C99	BEECH99	PT6A-36	PT6A36	Most Popular Engine in Ascend
Cessna C208B/Grand Caravan	CNA208	PT6A-114A	P6114A	Most Popular Engine in Ascend
Dornier 228	DO228-1	TPE331-5A	TPE5A	Most Popular Engine in Ascend
British Aerospace Jetstream 31	J31	TPE331-10U	TPE10U	Most Popular Engine in Ascend
Pilatus PC-12	PC12	PT6A-67B	PT67B	Most Popular Engine in Ascend
Cessna 406 Caravan II	REIMS406	PT6A-112	PT6112	Most Popular Engine in Ascend
Shorts Harland SC-7Skyvan	SC7-3-1	TPE331-2	TPE2	Most Popular Engine in Ascend
Casa/NurtanioC212Aviocar	CASA212-1	PT6A-28	PT6A28	Conservative Engine Assignment Based on CO_2 EF
HelioH-250/295/395	MIL-U10	PT6A-27	PT6A27	Conservative Engine Assignment Based on CO_2 EF
Quest Kodiak 100	N/A	N/A	N/A	N/A
Above the MTOM Threshold				
Shorts 360	SD360-1	PT6A-65R	PT6A6R	Most Popular Engine in Ascend
De Havilland DHC8-100 Dash-8	DHC8Q-1	PW120A	PW120A	Most Popular Engine in Ascend
De Havilland DHC8-200Q Dash-8	DHC8Q-2	PW123D	PW123D	Most Popular Engine in Ascend
De Havilland DHC8-300 Dash 8	DHC8Q-3	PW123	PW123	Most Popular Engine in Ascend
De Havilland DHC8-400 Dash-8	DHC8Q-4	PW150A	PW150A	Most Popular Engine in Ascend
Embraer EMB-120 Brasilia	EMB120	PW118B	PW118B	Most Popular Engine in Ascend

Saab-Fairchild 340/A	SAAB340-A	CT7-5A2	CT75A2	Most Popular Engine in Ascend
Saab-Fairchild 340/B	SAAB340-B	CT7-9B	CT79B	Most Popular Engine in Ascend
Dornier 328	DO328-1	PW119C	PW119C	Comparable Engine to Most Popular Engine in Ascend
Gulfstream I	GULF1	RDa.7	RDA7	One Valid EDMS Aircraft Engine Combination
ConvairCV-580	CV580	501 D13 alternative 1	501DA1	One Valid EDMS Aircraft Engine Combination
Casa 235	CN235-2	CT7-9B	CT79B	Typical Engine based on internet search
Shorts 330	SD330	PT6A-45A	PT6A4A	Typical Engine based on internet search
Aerospatiale/AeritaliaATR-42	ATR42-4	PW121	PW121	Typical Engine based on internet search
Aerospatiale/AeritaliaATR-72	ATR72-2	PW124B	PW124B	Typical Engine based on internet search

Table 2-4. Summary ofT-100Activity Data

Aircraft Make/Model	EDMS Aircraft Code	LTO	Cruising Time (minutes)	Category
Below the MTOMThreshold				
EurocopterAS350 B2AStar	SA350	692	11,058	Helicopter
Beech 1900 A/B/C/D	BEECH1900-C	169,145	7,256,113	Turboprop
Beech 200 SuperKingair	BEECH200	4,841	131,106	Turboprop
Beech 99 Airliner	BEECH99	139	3,723	Turboprop
Beech C99	BEECH99	125	3,600	Turboprop
British Aerospace Jetstream 31	J31	3	230	Turboprop
Casa/NurtanioC212Aviocar	CASA212-1	7,841	198,022	Turboprop
Cessna 208 Caravan	CNA208	233,899	8,004,766	Turboprop
Cessna 406 Caravan II	REIMS406	4,367	110,714	Turboprop
Cessna C208B/Grand Caravan	CNA208	10,030	457,983	Turboprop
De Havilland Twin Otter DHC-6	DHC6-1	37,245	900,000	Turboprop
Dornier 228	DO228-1	4,585	152,302	Turboprop
Grumman G-21A (Goose)	G21G	582	10,860	Turboprop
HelioH-250/295/395	MIL-U10	113	9,996	Turboprop
Pilatus Britten-Norman BN2/A Islander	BN2	15,513	146,131	Turboprop
Pilatus PC-12	PC12	15,523	637,144	Turboprop
Quest Kodiak 100		778	25,045	Turboprop
Shorts Harland SC-7Skyvan	SC7-3-1	922	16,319	Turboprop

SocataTBM850	TBM-850	66	3,715	Turboprop
Beech King Air C-90	BEECH90	19	1,543	Turboprop
Total		***506,428***	***18,080,370***	
Above the MTOM Threshold[a]				
Casa 235	CN235-2	26	3,805	Turboprop
ConvairCV-580	CV580	1,548	135,602	Turboprop
Gulfstream I	GULF1	40	3,653	Turboprop
Shorts 330	SD330	898	36,115	Turboprop
Shorts 360	SD360-1	885	14,407	Turboprop
Aerospatiale/AeritaliaATR-42	ATR42-4	7689	310,233	Turboprop
Aerospatiale/AeritaliaATR-72	ATR72-2	14387	549,501	Turboprop
De Havilland DHC8-100 Dash-8	DHC8Q-1	116034	4,795,594	Turboprop
De Havilland DHC8-200Q Dash-8	DHC8Q-2	34930	1,386,025	Turboprop
De Havilland DHC8-300 Dash 8	DHC8Q-3	43494	1,764,646	Turboprop
De Havilland DHC8-400 Dash-8	DHC8Q-4	140083	7,149,258	Turboprop
Dornier 328	DO328-1	1360	44,760	Turboprop
Embraer EMB-120 Brasilia	EMB120	128476	5,265,448	Turboprop
Saab-Fairchild 340/A	SAAB340-A	1825	173,891	Turboprop
Saab-Fairchild 340/B	SAAB340-B	59064	2,955,215	Turboprop
Total		550,739	24,588,154	

[a] Turboprop activity for aircraft above the weight thresholds were used to adjust the GAATA activity data in Section 3.

Emission Factors

Annual LTO emissions were estimated using the FAA's EDMS (FAA, 2013). The aircraft and engine-specific fuel consumption rates and CO_2 emission rates from EDMS are summarized in Table 2-5.

Table 2-5. Aircraft and Engine Specific Emission Factors from EDMS Run

Category	Aircraft Make/Model	EDMS Aircraft Code	Engine Make/ Model	EDMS Engine Code	Fuel Consumption Rate (lbs/LTO)	CO_2Emission Rate (lbs/LTO)
Helicopter	EurocopterAS350 B2AStar	SA350	TPE331-3	TPE3	170	537
Small Turboprop	Grumman G-21A (Goose)	G21G	TPE331-2UA	TP2UA	170	537
Small Turboprop	SocataTBM850	TBM-850	PT6A-66	PT6A66	130	410
Small Turboprop	Pilatus Britten-Norman BN2/A Islander	BN2	250B17B	250B17	119	376
Small Turboprop	Cessna 208 Caravan	CNA208	PT6A-114	PT6A14	86	273
Small Turboprop	Cessna 208 Caravan	CNA208	PT6A-114A	P6114A	96	301
Small Turboprop	De Havilland Twin Otter DHC-6	DHC6-1	PT6A-20	PT6A20	168	531
Small Turboprop	De Havilland Twin Otter DHC-6	DHC6-1	PT6A-27	PT6A27	206	651
Small Turboprop	Beech 1900 A/B/C/D	BEECH1900-C	PT6A-65B	PT6A6B	275	866
Small Turboprop	Beech 200 SuperKingair	BEECH200	PT6A-41	PT6A41	231	729
Small Turboprop	Beech 99 Airliner	BEECH99	PT6A-20	PT6A20	168	531
Small Turboprop	Beech C99	BEECH99	PT6A-36	PT6A36	219	691
Small Turboprop	Cessna C208B/Grand Caravan	CNA208	PT6A-114A	P6114A	96	301
Small Turboprop	Dornier 228	DO228-1	TPE331-5A	TPE5A	185	582
Small Turboprop	British Aerospace Jetstream 31	J31	TPE331-10U	TPE10U	206	651
Small Turboprop	Pilatus PC-12	PC12	PT6A-67B	PT67B	153	484
Small Turboprop	Cessna 406 Caravan II	REIMS406	PT6A-112	PT6112	150	473

Small Turboprop	Shorts Harland SC-7Skyvan	SC7-3-1	TPE331-2	TPE2	205	648
Small Turboprop	Casa/NurtanioC212Aviocar	CASA212-1	PT6A-28	PT6A28	206	651
Small Turboprop	HelioH-250/295/395	MIL-U10	PT6A-27	PT6A27	83	263
Small Turboprop	EADSSocataTBM-700[a]	TBM700	PT6A-64*	PT6A64	125	393
Small Turboprop	Beech King Air C-90	BEECH90	PT6A-60	PT6A60	264	833

[a] The LTO emissions for the Quest Kodiak 100 were estimated by applying the fuel consumption rate and CO_2emission rate from a comparable EDMS aircraft engine combination based on MTOM and engine thrust. The comparable aircraft selected was Cessna 208 Caravan.

The cruising emissions for aircraft below the MTOM threshold were estimated based on the annual cruising air time, fuel consumption rates obtained from the manufacture or from literature, Internet searches or EDMS fuel-based CO_2 emission index. The aircraft and engine specific fuel consumption rates used in this analysis are listed in Table 2-6. To calculate the CO_2 emissions, the EDMS fuel-based CO_2 emission index of 3.15 lbs of CO_2 per lb of jet fuel was used. Note the EDMS CO_2 factors match those used in the 2015 EPA Draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.

Table 2-6. Aircraft and Engine Specific Cruising Fuel Consumption Rates

Aircraft Make/Model	EDMS Aircraft Code	Engine Make/Model	EDMS Engine Code	Fuel Consumption Rate (lb/min)
Beech 1900 A/B/C/D	BEECH1900-C	PT6A-65B	PT6A6B	8.58
Beech 200 SuperKingair	BEECH200	PT6A-41	PT6A41	10.25
Beech 99 Airliner	BEECH99	PT6A-20	PT6A20	7.40
Beech C99	BEECH99	PT6A-36	PT6A36	7.40
Pilatus Britten-Norman BN2/A Islander	BN2	250B17B	250B17	3.17
Casa/NurtanioC212Aviocar	CASA212-1	PT6A-28	PT6A28	7.69
Cessna 208 Caravan	CNA208	PT6A-114	PT6A14	6.92
Cessna 208 Caravan	CNA208	PT6A-114A	P6114A	6.92
Cessna C208B/Grand Caravan	CNA208	PT6A-114A	P6114A	6.92
De Havilland Twin Otter DHC-6	DHC6-1	PT6A-20	PT6A20	9.67
De Havilland Twin Otter DHC-6	DHC6-1	PT6A-27	PT6A27	9.67
Dornier 228	DO228-1	TPE331-5A	TPE5A	7.83
Grumman G-21A (Goose)	G21G	TPE331-2UA	TP2UA	4.51
British Aerospace Jetstream 31	J31	TPE331-10U	TPE10U	10.00
HelioH-250/295/395	MIL-U10	PT6A-27	PT6A27	7.69
Pilatus PC-12	PC12	PT6A-67B	PT67B	7.40
Cessna 406 Caravan II	REIMS406	PT6A-112	PT6112	7.69
EurocompterAS350 B2AStar	SA350	TPE331-3	TPE3	5.65
Shorts Harland SC-7Skyvan	SC7-3-1	TPE331-2	TPE2	7.69
SocataTBM850	TBM-850	PT6A-66	PT6A66	5.97
Beech King Air C-90	BEECH90	PT6A-60	PT6A60	7.33
Quest Kodiak 100	N/A	N/A	N/A	48[a]

[a] Fuel consumption rate in gallons per hour(gal/hr).
[b] Sources for fuel consumption rates can be found in the Reference Section.

Emission Calculations

Base year 2012 fuel use and CO_2 emission estimates for aircraft below the MTOM threshold were developed by applying the appropriate fuel use and CO_2 emission factors to the T-100 activity data for both the annual LTO cycle and cruising segment of the trip. The emissions were calculated using the following equation:

$$E = A \times EF \times CF$$

Where:

E = emissions (tons)
A = activity (number of LTOs or minutes of cruising time)
EF = emission factor (lbs/LTO or gal/hr)
CF = conversion factor
Fuel density = 6.84 lbs/gallons of jet fuel;
1 lb = 0.0005 ton;
1 g = 1.10231 E-6 ton

Example Calculation:

In 2012, for the Eurocopter AS350 B2 AStar, the total annual minutes of cruising time was 11,058 minutes and the fuel use rate is 5.65 lbs/min.

$E = A \times EF \times CF$
$E = 11{,}058 \text{ minutes} \times 5.65 \text{ lb/min} \times 0.0005 \text{ ton/lbs}$
$E = 31 \text{ tons of jet fuel}$

The aircraft specific fuel use and CO_2 emission estimates for 2012 are summarized in Table 2-7.

Table 2-7. 2012 T-100AircraftandEngine Specific Fuel Use and CO_2Emissions

Category	Aircraft Make/Model	EDMS Aircraft Code	Engine Make/ Model	EDMS Engine Code	LTO		Cruising		Total	
					Fuel Use (tons)	CO_2(tons)	Fuel Use (tons)	CO_2(tons)	Fuel Use (tons)	CO_2(tons)
Helicopter	EurocopterAS350 B2AStar	SA350	TPE331-3	TPE3	59	186	31	99	90	284
Turboprop	Beech 1900 A/B/C/D	BEECH1900-C	PT6A-65B	PT6A6B	23,222	73,265	31,139	98,244	54,361	171,509
Turboprop	Beech 200 SuperKingair	BEECH200	PT6A-41	PT6A41	559	1,763	672	2,120	1.231	3,884
Turboprop	Beech 99 Airliner	BEECH99	PT6A-20	PT6A20	12	37	14	43	25	80
Turboprop	Beech C99	BEECH99	PT6A-36	PT6A36	14	43	13	42	27	85
Turboprop	British Aerospace Jetstream 31	J31	TPE331-10U	TPE10U	0.31	0.98	1.16	3.63	1.46	4.62
Turboprop	Casa/NurtanioC212Aviocar	CASA212-1	PT6A-28	PT6A28	809	2,554	761	2,401	1,571	4,955
Turboprop	Cessna 208 Caravan	CNA208	PT6A-114	PT6A14	4,238	13,370	11,609	36,627	15,847	49,997
Turboprop	Cessna 208 Caravan	CNA208	PT6A-114A	P6114A	6,486	20,462	16,074	50,714	22,559	71,176
Turboprop	Cessna 406 Caravan II	REIMS406	PT6A-112	PT6112	327	1,033	425	1,342	753	2,376
Turboprop	Cessna C208B/Grand Caravan	CNA208	PT6A-114A	P6114A	479	1,511	1,584	4,997	2,063	6,508
Turboprop	De Havilland Twin Otter DHC-6	DHC6-1	PT6A-20	PT6A20	2,960	9,337	4,109	12,962	7,068	22,298
Turboprop	De Havilland Twin Otter DHC-6	DHC6-1	PT6A-27	PT6A27	214	674	242	762	455	1,436
Turboprop	Dornier 228	DO228-1	TPE331-5A	TPE5A	423	1,335	597	1,882	1,020	3,217
Turboprop	Grumman G-21A (Goose)	G21G	TPE331-2UA	TP2UA	50	156	24	77	74	234
Turboprop	HelioH-250/295/395	MIL-U10	PT6A-27	PT6A27	5	15	38	121	43	136
Turboprop	Pilatus Britten-Norman BN2/AIslander	BN2	250B17B	250B17	924	2,916	231	730	1,156	3,645
Turboprop	Pilatus PC-12	PC12	PT6A-67B	PT67B	1,190	3,754	2,357	7,438	3,547	11,192
Turboprop	Shorts Harland SC-7Skyvan	SC7-3-1	TPE331-2	TPE2	95	299	63	198	157	496
Turboprop	SocataTBM850	TBM-850	PT6A-66	PT6A66	4	13	11	35	16	48
Turboprop	Beech King Air C-90	BEECH90	PT6A-60	PT6A60	3	8	6	18	9	26
Turboprop	Quest Kodiak 100	N/A	N/A	N/A	49	153	69	216	59	630
								Total	***110,903***	***354,217***

3.0 GAATA

Activity

Turbojet/Turbofan

The GAATA activity data include all general aviation and air taxi activities. The percentage of aircraft equipped with turbojet or turbofan engines below the MTOM threshold (MTOM<5,700 kg for jets) in the GAATA data was estimated using the FAA's Registry data (FAA, 2014a). Table 3-1 shows the aircraft population breakout based on the maximum takeoff weight range from the FAA Registry data:

Table 3-1. FAA Registry Aircraft Population by MTOM Range

Aircraft Type	Maximum Takeoff Weight (kg, Range)	Aircraft Population	Percent (%) of Aircraft Population[a]
Turbo-jet/Turbo-fan	**Up to 5,669**	**3,046**	**16%**
	5,670 - 9,071	5,478	29%
	9,072 and over	10,335	55%

[a] Percentage of the jet and turboprop population that are Below the ICAO weight thresholds.

The GAATA data were adjusted to include only the percentage of business jets below the MTOM threshold based on the aircraft registration. Note that use of the 16% value likely overestimates activity for jets below the MTOM threshold because aircraft above the MTOM threshold are likely to be used more frequently and for longer trips than aircraft below the threshold, but the GAATA data does not account for these differences. Efforts were made to use the T-100 data to quantify operations of business jets, but the T-100 dataset did not include corporate jets not used in commercial passenger travels.

Turboprops

As noted earlier, a number of turboprop aircraft models appear to be included in the T-100 data. To avoid double counting between the T-100 and GAATA turboprops, the total T-100 turboprop annual LTO and cruising time activity (above and below the threshold) were subtracted from the total GAATA turboprop activity. The final adjusted activity data from GAATA are listed in Table 3-2.

Helicopters

No adjustment was needed for helicopters because there is no weight threshold for this aircraft category.

Table 3-2. Finalized GAATA Activity for Aircraft Below the MTOM Thresholds

Aircraft Type	Annual Cruising Time (Hours)
Turboprop	1,924,033
Jet	552,104
Helicopter	2,722,511
Total	***5,198,648***

Emission Factors

Fuel use and CO_2 emissions were calculated based on fuel consumption rates in the GAATA data Survey, listed in Table 3-3, and EPA's jet fuel CO_2 factor, 9.75 kg CO_2/gal of fuel (EPA, 2015). Note that fuel usage reported in the GAATA survey, is provided as block fuel usage, so it includes fuel consumption associated with the LTO cycle. The GAATA data aggregate fuel usages rates by aircraft type, thus actual fuel usage for specific aircraft may be higher or lower than the average values presented in Table 3-3; for example, it is likely that smaller business jets such as the Citation 500 Series would be approximately 125 gallons per hour compared to the 315.1 value noted in the GAATA average fuel consumption data.

Table 3-3. GAATA Fuel Consumption Rates by Aircraft Type (Block fuel/Block time)

Aircraft Type	Average Fuel Consumption Rate (Gallons per Hour per Aircraft)
Small Turboprop	76.4
Small Business Jet	315.1
Helicopter	54.7

Emission Calculations

Base year 2012 fuel use and CO_2 emission estimates were developed by applying the fuel use and CO_2 factors to the GAATA air time data. The emissions were calculated using the following equation:

$$E = A \times EF \times CF$$

Where:

E = Emissions (tons)
A = Activity (hours of airtime)
EF = Emission factor (gal/hr)
CF = Conversion factor
1 lb = 6.84 gal;
1 lb = 0.0005 tons;
g = 1.10231 E-6 ton)

Example Calculation:

In 2012, for small turboprops, the total annual cruising time was 1,924,033 hours and the fuel use rate is 76.4 gal/hr.

$E = A \times EF \times CF$
$E = 1{,}924{,}033 \text{ hours} \times 76.4 \text{ gal/hr} \times 6.84 \text{ lbs/gal} \times 0.0005 \text{ tons/lbs}$
$E = 502{,}727$ tons of jet fuel

The fuel use and CO_2 emission estimates are summarized in Table 3-4.

Table 3-4. 2012 Fuel Use and CO_2 Emission Estimates by Aircraft Below the MTOM Thresholds by Type and Mode

Aircraft Type	Total	
	Fuel Use (tons)	CO_2 (tons)
Turboprop	502,727	1,579,844
Business Jet	594,970	1,869,724
Helicopter	509,311	1,600,535

4.0 Comparisons

The combined T-100 and GAATA CO_2 emission estimates are summarized in Table 4-1. These combined data for aircraft below the ICAO thresholds are compared to the estimates in the *U.S. EPA draft 2015 Inventory of U.S. GHG Emissions and Sinks* to quantify the fraction of CO_2 emissions associated with this group of aircraft relative to all aviation emissions. Collectively these aircraft account for approximately 2.52 percent of total aviation jet CO_2 emissions. Conversely aircraft subject to the ICAO GHG rule would account for 207,167,221 of the 212,525,619 tons of CO_2 or 97.48 percent of total jet fuel combusted in 2012.

Table 4-1. T-100 and GAATA Combine CO_2 Emissions (tons) Summary

Aircraft Type	Commercial		General Aviation	Domestic Total	International Total	Total
	Domestic (T-100)	Commercial International (T-100)	GAATA Survey [a,b]			
Turboprop (less than 8,618 kg MTOM)	321,784	31,854	1,534,216	1,856,000	31,854	1,887,854
Jet (less than 5,700 kg MTOM)	0	0	1,869,724	1,869,724	0	1,869,724
Helicopter	284	0	1,600,535	1,600,820	0	1,600,820
Total CO_2 (less than MTOM threshold)	322,068	31,854	5,004,476	5,326,544	31,854	5,358,398
U.S. EPA Inventory of U.S. GHG Emissions and Sinks: 1990-2012						
Total CO_2 Aviation jet fuel - domestic	124,891,870	N/A	19,841,603	144,733,474	N/A	144,733,474
Total CO_2 Aviation jet fuel - International Bunker	N/A	67,792,145	N/A	N/A	67,792,145	67,792,145
Total aviation CO_2 (tons)	124,891,870	67,792,145	19,841,603	144,733,474	67,792,145	212,525,619
% (less than MTOM threshold)	0.26%	0.05%	25.22%	3.68%	0.05%	2.52%

To avoid double counting, the T-100 commercial activity was removed from the GAATA data.
The general aviation international segment is unknown, may be included in the GAATA Survey data.

5.0 Backcasting and Forecasting

Before "backcasting" or "forecasting" the 2012 CO_2 emission estimates to past and future years, an assessment of Ascend data was performed to quantify the fraction of the fleet that was below the threshold to determine whether the fraction of jet, turboprop powered aircraft, and helicopters below the MTOM thresholds for the ICAO CO_2 standards of the aviation fleet remained fairly constant over the years leading up to 2012 (Table 5-1). A constant fraction would yield reasonable forecast and backcast emission estimates.

Our assessment showed that only the jet population showed a significant change in the fleet, increasing from 28 aircraft in 2005 to 477 in 2010. However, even with this increase, the jet population still represent only 3 percent of fixed wing aircraft and helicopters below the ICAO threshold. Since 2000, these aircraft account for 23 to 25 percent of the fixed wing fleet (excluding helicopters). If helicopters are included, then the value increases to 44 to 46 percent of the total fleet. This information supports the assumption that the fraction of the fleet below the ICAO threshold has remained fairly constant; therefore extrapolation of 2012 data to other years based on changes to the total general aviation fleet is expected to provide reasonable estimates. Note the 2015 values presented in Table 5-1 represent the current fleet.

Table 5-1. Historical Fraction of Jet, Turboprop Powered Aircraft, and Helicopters Below the MTOM Thresholds for the ICAO CO_2 Standards

Threshold	Aircraft Type	Year							
		1990	2000	2005	2010	2011	2012	2013	2015
< 8619 kgs	Turboprop	4,623	6,253	6,802	6,953	6,899	6,854	6,914	7,092
< 5701 kgs	Jets	15	16	28	477	528	587	645	706
All	Helicopters	4,962	5,631	6,118	6,414	6,290	6,269	6,153	6,159
Total aircraft below ICAO threshold (excluding helicopters)		4,638	6,269	6,830	7,430	7,427	7,441	7,559	7,798
Percent of aircraft below ICAO threshold (excluding helicopters)		25%	24%	23%	25%	24%	25%	25%	25%
Total aircraft below ICAO threshold (including helicopters)		9,600	11,900	12,948	13,844	13,717	13,710	13,712	13,957
Percent of aircraft below ICAO threshold (including helicopters)		51%	45%	44%	46%	45%	45%	45%	44%
Total aircraft in fleet (that use jet fuel)		18,775	26,185	29,321	30,297	30,334	30,356	30,813	31,412

Note that the Ascend data primarily includes commercial and business aircraft powered by jet engines with a seat count greater than four. The general aviation data may not be as complete as the commercial aircraft data.

In order to be consistent with the 2015 draft *Inventory of U.S. GHG Emissions and Sinks* (EPA 2015), historical general aviation jet fuel usage (in terms of British Thermal Units (Btus) from

the report, was used to develop adjustment factors relative to the inventory year of 2012, for backcasting to 1990, 1995, 2000, 2005, 2010, and 2013 as noted in Table 5-2.

Table 5-2. Adjustment Factors for General Aviation Aircraft Based on Jet Fuel Energy Consumption

Year	General Aviation Jet Fuel Energy Consumption (TBtu)[1]	Adjustment Factor (relative to 2012)[2]
1990	544.566	2.431
1995	453.669	2.026
2000	427.013	1.907
2005	483.735	2.160
2010	313.523	1.400
2012	223.969	1.000
2013	271.335	4.211

1 2015 draft *Inventory of U.S. GHG Emissions and Sinks* (EPA 2015), actual energy usage may be higher because the GA value does not include air taxis equipped with turboprops which are included in the commercial jet fuel data.

2 Year 2012 is the reference year, and thus provides a growth factor of 1. The growth factors for each of the other years are a ratio of the fuel consumption of the year of interest divided by the fuel consumption for 2012 for each aircraft type. Where fuel usage was less than the reference year, the values were a fraction less than 1 and where fuels consumption was great than the reference year, the growth factors were greater than 1.

To forecast future emissions from jet, turboprop, and helicopter activities below the ICAO thresholds, ERG obtained projected general aviation fuel usage data from the FAA's Aerospace Forecast, 2014-2034 (FAA, 2014b). Note that the FAA Forecast projects to year 2034. In order to estimate fuel usage for 2040, ERG applied the average annual growth for the period from 2013 to 2034 to the 2034 fuel data to approximate fuel usage in 2040. These fuel data were used to develop the growth factors noted in Table 5-3 that could be applied to the 2012 data to estimate 2020, 2030, and 2040 CO_2 emissions.

Table 5-3. Growth Factors Based on Forecasted Jet Fuel Energy Consumption

Year	Millions of gallons			Growth Factors (from 2012)		
	Turbo-prop	Turbo-jet	Turbine Rotorcraft	Turbo-prop	Turbo-jet	Turbine Rotorcraft
2012	208.8	1,077.2	148.9	1.0000	1.0000	1.0000
2020	213.0	1,427.0	182.8	1.0201	1.3247	1.2277
2030	250.2	1,914.6	229.2	1.1983	1.7774	1.5393
2040	301.9	2,545.1	299.3	1.4459	2.3627	2.0101

Table 31 FAA Aerospace Forecast 2014-2034.

The backcast and forecast factors presented in Tables 5-2 and 5-3 were applied to the 2012 CO_2 emissions to approximate CO_2 emissions from 1990 to 2040 in Table 5-4.

Table 5-4. Backcasted/Forecasted Small Jet, Turboprop, and Helicopter CO_2 Emissions (tons)

Year	CO_2 Emissions (tons)		
	Turbo-prop	Jet	Turbine Rotorcraft
1990	4,590,197	4,546,116	3,892,292
1995	3,824,020	3,787,296	3,242,606
2000	3,599,329	3,564,764	3,052,078
2005	4,077,448	4,038,291	3,457,503
2010	2,642,711	2,617,332	2,240,907
2012	1,887,854	1,869,724	1,600,820
2013	2,287,107	2,265,143	1,939,369
2020	1,925,828	2,476,881	1,965,278
2030	2,262,170	3,323,221	2,464,123
2040	2,729,613	4,417,597	3,217,766

6.0 QA/QC

To ensure the quality of data used in the study and reasonableness of the results, the following quality assurance checks were implemented:

- Checked data compilation to ensure that the datasets matched the original data and were not corrupted during data transfer. No issues with data transfer or transcription were found.
- Compared LTO fuel usage rates to aircraft average data to identify and evaluate aircraft that were significantly different for the average values. LTO fuel usage was only used for the T-100 data that were applied to EDMS, which includes separate fuel usage data for aircraft make/model engine make/model combinations. No alternative LTO fuel usage data sources were identified or used in this study.
- Compared CO_2 fuel fractions found in EDMS (9.75 kg CO_2/gal), the 2008 Climate Leaders GHG Guidance (9.57 kg CO_2/gal) (EPA, 2008), the 2014 EPA Fast Facts: National-Level U.S. Greenhouse Gas Inventory summaries (EPA, 2014b), and the 2015 draft *Inventory of U.S. GHG Emissions and Sinks* report (9.75 kg/CO_2) (EPA, 2015). The EPA recommended using the 9.75 kg/CO_2 because it was based on the most recent data and was consistent with the EDMS factor.
- Ensured that the LTO data used in the EDMS runs matched the data compiled from the T-

100 data.

- Compared fuel usage rates for cruising to Project Interactive Analysis and Optimisation (PIANO) data provided by the EPA. The piano fuel usage rate data were only applicable for aircraft above the MTOM threshold and were not used directly in this assessment of aircraft below the MTOM threshold.
- Assessed the fraction of CO_2 emissions associated with the aircraft relative to total jet CO_2 emissions in the 2015 draft *Inventory of U.S. GHG Emissions and Sinks* (2015) and Fast Facts: National-Level U.S. Greenhouse Gas Inventory (EPA, 2014).
- Compared the aircraft counts from the GAATA survey, the FAA Registry, and the Ascend database.

Table 6-11 shows general QA assessment factors and how they were considered in this study. In addition to these internal quality checks, the documentation and data were provided to two external reviewers who are experienced with aviation emission inventory studies. The external reviewers' comments and observations are documented in a separate report that compiles all comments and revisions made to the report. No changes were recommended for the data developed in this study.

Table 6-1. QA Summary Table

General Assessment Factor	Definition	How the Factor was Considered
Soundness	The extent to which the scientific and technical procedures, measures, methods or models employed to generate the information are reasonable for, and consistent with, the intended application.	ERG used accepted inventory procedures to compile available data and calculate emissions. The emission calculations follow similar methods used in the EPA's 2011 National Emission Inventory.
Applicability and Utility	The extent to which the information is relevant for the Agency's intended use.	ERG staff worked closely with the EPA staff, communicating at least two weeks (often more frequently) to ensure that final products for this study met the EPA's expectations and needs.
Clarity and Completeness	The degree of clarity and completeness with which the data, assumptions, methods, quality assurance, sponsoring organizations and analyses employed to generate the information are documented.	Throughout the process, data were provided to the EPA to show how the datasets were being developed, including summary comparisons and analysis. The quality checks implemented in this study were included in the project Quality Assurance Project Plan (QAPP). This document, in conjunction with the project datasets were developed to allow for independent replication of the procedures used.

Uncertainty and Variability	The extent to which the variability and uncertainty (quantitative and qualitative) in the information or in the procedures, measures, methods or models are evaluated and characterized.	The data used in this study were either detailed and specific such as the T-100 and EDMS factors or highly aggregated data such as the GAATA activity data; making it difficult to quantitatively assess uncertainty. To the extent possible, information was provided in this report to qualitatively indicate whether the data over-or under-estimated actual fuel usage or emissions.
Evaluation and Review	The extent of independent verification, validation and peer review of the information or of the procedures, measures, methods, or models.	Internally, data were reviewed at critical points of the project to insure that data were compiled and calculations were implemented correctly. The EPA implemented a comprehensive review of the report and data; all recommended changes were included in this final report. ICF and an independent contractor provided an external review of the methodology used and preliminary results. Suggested changes were addressed in the current version of this report.

7.0 References

Air Charter Service, 2003. Shorts SD 330 Cargo aircraft facts. http://www.aircharterservice.ae/aircraft/sd330_shorts.htm

Airlines Inform, 2008-2012. ATR 42. http://www.airlines-inform.com/commercial-aircraft/ATR-42.html

Airlines Inform, 2008-2012. Embraer EMB-120 Brasilia. http://www.airlines-inform.com/commercial-aircraft/Embraer-120-Brasilia.html

American Museum of Aviation. Convair 580 Technical Specifications. http://www.prop-liners.com/c580tech.htm

AOPA Turbine Pilot, 2012.TBM 850 By The Numbers. http://www.tbm850.com/2014/images/tbm/newsstand/files/2012-01%20AOPA%20Pilot.pdf

ATR, 2014. ATR 72-600. http://www.atraircraft.com/products_app/media/pdf/Fiche_72-600_septembre%202014.pdf

Australian Government Civil Aviation Safety Authority, 2010. Standard Economic Values Guidelines: Aircraft Operational Values. http://www.casa.gov.au/wcmswr/_assets/main/manuals/regulate/acm/256r003.pdf

Aviation English Academy. SAAB 340. http://aviationenglishacademy.com.au/resources/saab-340/

Blackhawk, 2009. Financial Analysis of the Blackhawk King Air 200 XP_{42} Engine Upgrade. http://www.banyanair.com/pdf/conklinxp42-200.pdf

BLM National Aviation Office. EADS CASA CN-235: Preliminary Aircraft Evaluation for SASEB. http://www.nifc.gov/aviation/av_documents/av_SASEB/CN235Report.pdf

Bramson, Alan, 1977. Pilot Flight Check: HS 125 Series 700. http://www.aeroresourcesinc.com/store_/images/classifieds/456-1.pdf

EPA, 2008. *Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance: Direct Emissions from Mobile Combustion Sources*, EPA430-K-08-004, United States Environmental Protection Agency, Office of Air and Radiation. May 2008. Internet address: http://www.epa.gov/climateleadership/documents/resources/mobilesource_guidance.pdf

EPA, 2015. *Draft Inventory of U.S. GHG Emissions and Sinks: 1990-2012*, Spring 2015 (pre-release version).

EPA, 2014. *Fast Facts, National-Level U.S. Greenhouse Gas Inventory*, EPA 430-F-14-014, May 2014.

FAA, 2012. U.S. Department of Transportation, Federal Aviation Administration, T-100 Forms, 2012.

FAA, 2013. *Emissions and Dispersion Modeling Systems* (EDMS), Version 5.1.4.1. Federal Aviation Administration. August. Internet address: http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/

FAA, 2014a. *Aircraft Registry–Releasable Aircraft Database Download*. Federal Aviation Administration. September 5, 2014.

FAA, 2014b. *FAA Aerospace Forecasts FY 2014-2034*. Internet address: https://www.faa.gov/about/office_org/headquarters_offices/apl/aviation_forecasts/aerospace_forecasts/2014-2034/

Flightglobal, Ascend Online Fleets Database, Aircraft and Airline Data, U.S. historical fleet as of December 31, 2012, accessed on September 17, 2014, the data files were updated in 2015 to account for 2013 and current fleet composition.

Flight International, 1969. In The Air: Beechcraft 99A Airliner. http://www.flightglobal.com/FlightPDFArchive/1969/1969%20-%202689.PDF

GAATA, 2013. *General Aviation and Part 135 Activity Surveys*, U.S. Department of Transportation, Federal Aviation Administration, FY 2012, December 16, 2013.

Grumman Aircraft Engineering Corporation, 1938. Erection and Maintenance Instructions for Grumman Amphibian Model G-21A. http://www.seawings.co.uk/images/manuals/Goose/Grumman%20G-21A%20Erection%20&%20Maintenance%20Manual.pdf

Jet Advisors, 2014. Bombardier Learjet 45. http://jetadvisors.com/learjet-45-performance/

Jet Advisors, 2014. Cessna Citation II Performance. http://jetadvisors.com/cessna-citation-ii-performance/

Jet Advisors, 2014. Citation Excel Performance. http://jetadvisors.com/citation-excel-performance/

Jetstream Central. J31. http://www.jetstreamcentral.com/j31/

Lufttransport, 2011. Dornier Do228. http://www.lufttransport.no/index.php?option=com_content&view=article&id=34&Itemid=16

Maritime Air Charter Limited, 2014. BN-2A-21 Britten-Norman Islander. http://www.maritimeair.com/islander.php

Pilatus Aircraft. Just The Facts: Pilatus PC-12 NG. http://www.prostarpilatuscenter.com/pdf/PC-12_Just_The_Facts.pdf

Plane & Pilot, 2010. *Helio Courier H-295/395/391, 1955-78*, Plane & Pilot, April 16, 2010. Internet address: http://www.planeandpilotmag.com/aircraft/international-aircraft-directory/single-engine-aircraft/helio-courier-h-295-395-391.html#.VC1-iGdOWUk

Premier Jet Aviation, 2013. Fairchild Dornier DO-328-120 Performance Specs. http://jetav.com/fairchild-dornier-do-328-120-performance-specs/

Quest, 2014. *Quest Aircraft*, April 2014. Internet address: http://questaircraft.com/wp-content/uploads/2014/04/Quest_Electronic_Brochure_April_2014.pdf

Twombly, Mark R, 1991. Cessna 208B – Grand Caravan. AOPA. http://www.aopa.org/Pilot-Resources/Aircraft-Ownership/Aircraft-Fact-Sheets/Cessna-208B-Grand-Caravan

Universal Helicopters, 2012. Eurocopter AS350 B2. http://www.uhnl.nf.ca/our-fleet/eurocopter-as350-b2

US NOAA. DeHavilland Twin Otter (DHC-6). http://www.aoc.noaa.gov/aircraft_otter.htm

To: Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Eric.Upton@gulfstream.com
Sent: Thur 4/30/2015 7:47:49 PM
Subject: Re: Papers for Belfast
ICAO Aircraft CO2 Emissions Databank Introduction Text - v5.docx

And here's a version of the intro...

I hope you're enjoying the Kolsch :-)

Eric Upton, PhD
Environmental/Performance Specialist
Gulfstream Aerospace Corporation
Eric.Upton@gulfstream.com
ph: 912-395-8458
fax: 912-965-8850

This e-mail message, including all attachments, is for the sole use of the intended recipient(s) and may contain Personal Information under General Dynamics policy CP 07-105 and/or legally privileged and confidential information. Any Personal Information can be accessed only by authorized personnel of General Dynamics and its approved service providers and may be used only as permitted by General Dynamics and its policies. Contractual restrictions apply to third parties. If you are not an intended recipient, you are hereby notified that you have either received this message in error or through interception, and that any review, use, distribution, copying or disclosure of this message or its attachments is strictly prohibited and is subject to criminal and civil penalties. All personal messages express solely the sender's views and not those of Gulfstream Aerospace Corporation.
If you received this message in error, please contact the sender by reply e-mail and destroy all copies of the original message.

To: Manning, Bryan[manning.bryan@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]
From: Audette, Lucie
Sent: Tue 6/30/2015 4:15:48 PM
Subject: For Review: Revised WH Briefing
FAA-EPA CO2 Standard briefing_ 24 June 2015_epa+BM +CL+ lcacomments.docx
FAA-EPA CO2 Standard briefing_Dec2014_revised June 23 2015 - 24 June 2015.docx

I'm attaching the original FAA version in case you want to compare. I would suggest you work in Simple Markup format since it is pretty messy otherwise (ie difficult to review). Once we are OK with this we should share with Bill to get his feedback. Lucie

To: Manning, Bryan[manning.bryan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Audette, Lucie
Sent: Thur 6/11/2015 7:58:08 PM
Subject: RE: Update: Draft IP for CAEP SG15: Aircraft GHG endang/ANPR (PLEASE REVIEW)
CAEPSG 20153 IP US Endang Finding_ANPR YY en_6-11-15+lca.docx

Bryan, I've made a few minor comments in the attached.

From: Manning, Bryan
Sent: Thursday, June 11, 2015 11:49 AM
To: Samulski, Michael; Leggett, Cullen; Audette, Lucie
Subject: Update: Draft IP for CAEP SG15: Aircraft GHG endang/ANPR (PLEASE REVIEW)

Hello,

Based on revisions to fact sheets, etc, attached please find a revised draft information paper (IP) for the CAEP Steering Group meeting in July, in regard to the aircraft GHG endang/ANPR signed yesterday. As you know, this IP was updated from a similar IP we provided to the Steering Group last year. Let me know if you have any comments.

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Thrasher, Theodore[TThrasher@icao.int]; Dickson, Neil[NDickson@icao.int]; Peterson B (rmpaero@frontier.com)[rmpaero@frontier.com]; Adam M[adamm@iata.org]; Olivier.husse@airbus.com[Olivier.husse@airbus.com]; Anastasia Kharina[karin@theicct.org]; Leggett, Cullen[Leggett.Cullen@epa.gov]; tpohle@airlines.org[tpohle@airlines.org]
From: Chris Eyers
Sent: Wed 3/4/2015 11:08:11 AM
Subject: RE: Communication of CO2 Standard Effectiveness Proposal Part 1 - Communication to CAEP Members
CO2 Effectiveness Communication Proposal (Part 1) V2 (cje4Mar).docx
CO2 Effectiveness Communication Proposal (Part 1) V2 (cje4Mar)redline.docx

Effectiveness colleagues,

I have updated the Part 1 effectiveness proposal to take on the comments made in Monday's telecom. Clean and redline versions are attached. Main changes are adding clarifications and context in the text and in Figure 2. Clarifications on Figure 1 are awaited over the next few days.

Best regards

Chris

To: Hengst, Benjamin[Hengst.Benjamin@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
Cc: Birgfeld, Erin[Birgfeld.Erin@epa.gov]; Sutton, Tia[sutton.tia@epa.gov]
From: Audette, Lucie
Sent: Wed 6/3/2015 4:24:28 PM
Subject: RE: NYTimes: E.P.A. to Set New Limits on Airplane Emissions
Roll Out -aircraft (incl QA) v5 + ASD comments.docx

Attached are our draft responses to each of the new Questions.

-----Original Message-----
From: Hengst, Benjamin
Sent: Wednesday, June 03, 2015 9:27 AM
To: Audette, Lucie; Samulski, Michael; Manning, Bryan; Leggett, Cullen
Cc: Birgfeld, Erin
Subject: RE: NYTimes: E.P.A. to Set New Limits on Airplane Emissions

Hi gang --

Yes, we are scrambling a bit here this morning as a result of that article.

I just tacked on half a dozen Q&As to the roll-out plan. Can you guys take a crack at them? They are at the very end of the document. We should expect that we will get more of these today, too, so consider yourself warned! Ben

-----Original Message-----
From: Audette, Lucie
Sent: Wednesday, June 03, 2015 9:24 AM
To: Birgfeld, Erin; Hengst, Benjamin; Sutton, Tia; Mylan, Christopher
Subject: FW: NYTimes: E.P.A. to Set New Limits on Airplane Emissions

Assume you have seen this. Front page this morning.
-----Original Message-----
From: Lucie Audette [mailto:laudette125@hotmail.com]
Sent: Wednesday, June 03, 2015 8:04 AM
To: Audette, Lucie; Samulski, Michael; Manning, Bryan; Charmley, William; Leggett, Cullen
Subject: NYTimes: E.P.A. to Set New Limits on Airplane Emissions

http://www.nytimes.com/2015/06/03/business/energy-environment/epa-to-set-new-limits-on-airplane-emissions.html?smprod=nytcore-ipad&smid=nytcore-ipad-share

The Environmental Protection Agency is expected to report as early as Friday that greenhouse gas emissions from airplanes endanger human health through global warming.

Sent from my iPad

To: Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Manning, Bryan
Sent: Wed 12/10/2014 10:56:32 PM
Subject: RE: CO2db parameters justification _ draft EPA input
Copy of CO2Db Parameters v3_Nov5_DY+CL+BM.xlsx

Thank you for your work on this David and Cullen. Nice job! Attached please find my comments in blue and strikeout font.

Thanks again,

Bryan

From: Leggett, Cullen
Sent: Monday, December 08, 2014 6:08 PM
To: Yen, David; Manning, Bryan; Maeroff, Bruce
Subject: RE: CO2db parameters justification _ draft EPA input

Here are my comments

Cullen Leggett

734-214-4514

From: Yen, David
Sent: Friday, November 21, 2014 2:04 PM
To: Leggett, Cullen; Manning, Bryan; Maeroff, Bruce
Subject: CO2db parameters justification _ draft EPA input

Hello team,

Here is my initial draft of the justification of EPA input for the requested CO2db parameters. Please edit and augment it as you see fit.

Thanks,

David

To: Leggett, Cullen[Leggett.Cullen@epa.gov]
Cc: DE LEPINAY Ivan[ivan.de-lepinay@easa.europa.eu]; Arrowsmith Stephen[Stephen.Arrowsmith@easa.europa.eu]
From: Chris Eyers
Sent: Fri 4/10/2015 8:08:45 AM
Subject: Thoughts for this todays Effectiveness call
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft8_Clean +CJE.DOCX

Cullen,

In the attached version of Ted's paper, I've added my thoughts in preparation for today's call. For the comments on your Fig 1 they should tie up with my email sent a few minutes ago

Speak later

Chris

To: Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Manning, Bryan
Sent: Wed 6/10/2015 3:36:04 PM
Subject: RE: Final Q&As (one last item)

Hello,

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Hengst, Benjamin
Sent: Wednesday, June 10, 2015 11:16 AM
To: Grundler, Christopher; Samulski, Michael; Audette, Lucie; Leggett, Cullen; Manning, Bryan; Birnbaum, Rona; Gunning, Paul; DeAngelo, Ben
Cc: Charmley, William; Birgfeld, Erin; Mylan, Christopher; DeLuca, Isabel; Millett, John; StClair, Christie
Subject: Final Q&As

Ex. 5 - Deliberative Process

Just as a reminder: here's the schedule:

12:30 pm - web goes live
1 pm - press release (to HQ Environmental, Top-Tier, Aircraft lists)

1:10 - external calls
2 pm - press call

Ben

******

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

To: Hoyer, Marion[hoyer.marion@epa.gov]
Cc: Davidson, Ken[Davidson.Ken@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Yen, David
Sent: Tue 6/20/2017 1:27:37 PM
Subject: RE: FAA piece on reduced form benefits for ICAO meeting
IP01_CAEP11_FESG-MDG04_List of Papers_2017-06-17.pdf
IP05_CAEP11_FESG-MDG04_APMT-Impacts Tools for CBA.pdf
WP14_CAEP11_FESG-MDG04 CBA Group Updates_2017-06-09.pdf
WP14_CAEP11_FESG-MDG04 CBA Tool Documentation_2017-06-09.xlsx
IP04_CAEP11_FESG-MDG04 CBA Scoping Study.pdf

Hi Marion,

Ex. 5 - Deliberative Process

Thanks,

David

From: Hoyer, Marion
Sent: Monday, June 19, 2017 1:57 PM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>; Yen, David <Yen.David@epa.gov>
Cc: Davidson, Ken <Davidson.Ken@epa.gov>
Subject: FAA piece on reduced form benefits for ICAO meeting

Ex. 5 - Deliberative Process

Thanks,

Marion

To: Birnbaum, Rona[Birnbaum.Rona@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; DeAngelo, Ben[DeAngelo.Ben@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Schillo, Bruce[Schillo.Bruce@epa.gov]; Benner, Tim[Benner.Tim@epa.gov]; Dutton, Steven[Dutton.Steven@epa.gov]; McDow, Stephen[McDow.Stephen@epa.gov]; Sarofim, Marcus[Sarofim.Marcus@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Wolverton, Ann[Wolverton.Ann@epa.gov]; Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Gordon, Jessica M[Gordon.Jessica@epa.gov]; AA-Network-Office-Connection-2/Net-Connection/AA-OTAQ-OFFICE[AA-Network-Office-Connection-2@epa.gov]; Hockstad, Leif[Hockstad.Leif@epa.gov]; Williams, Melina[Williams.Melina@epa.gov]
Cc: Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]
From: Audette, Lucie
Sent: Wed 9/24/2014 8:09:33 PM
Subject: Agenda and Materials for Aircraft Workgroup Meeting - September 25, 9:15am
Draft Proposed Rule Preamble_ANPR Outline 9-24-14.docx
Summary Early Guidance Direction_Potential Scope__Key Rule Milesetones Sept 2014.pptx

Dear Workgroup members,

We look forward to our call with you tomorrow morning, Thursday at 9:15 am. Lesley will be sending the Final Analytic Blueprint out shortly. Our proposed agenda includes the following:

1. Review key direction from Early Guidance Meeting (see attachment)
2. Review and discuss draft Preamble/ANPRM outline (see attachment)
3. Update on submittal of ICAO Information Paper
4. Update on ERG work assignment to refine jet fuel inventory for general aviation
5. Review of Rulemaking Schedule (see attachment)
6. Other?

Call in number: **Ex. 6 - Personal Privacy**

Lucie and Lesley

To: Manning, Bryan[manning.bryan@epa.gov]
Cc: Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]
From: Samulski, Michael
Sent: Tue 6/23/2015 4:56:31 PM
Subject: RE: Janet Talking Pts for conversations
Summary of Issues ICAO CO2 Standard 6-22-15.docx

Here's what I sent on to Bill as an "Issues Table."

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Manning, Bryan
Sent: Tuesday, June 23, 2015 12:12 PM
To: Samulski, Michael
Cc: Audette, Lucie; Leggett, Cullen; Yen, David
Subject: Janet Talking Pts for conversations

Hello Mike,

Attached p
Reporting/
you think c
not include
industry's p

CO2 Repor
Exemption

Ex. 5 - Deliberative Process

Not all pass

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Audette, Lucie[audette.lucie@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Tue 12/9/2014 7:37:31 PM
Subject: RE: Draft Talking Points for Janet's Meeting with Rich Swayze

Ex. 5 - Attorney Client

Thank you,

Bryan

From: Audette, Lucie
Sent: Tuesday, December 09, 2014 2:24 PM
To: Samulski, Michael; Manning, Bryan; Leggett, Cullen
Subject: RE: Draft Talking Points for Janet's Meeting with Rich Swayze

Hi Mike, This look great, just one change include in document.

From: Samulski, Michael
Sent: Tuesday, December 09, 2014 10:27 AM
To: Manning, Bryan; Audette, Lucie; Leggett, Cullen
Subject: Draft Talking Points for Janet's Meeting with Rich Swayze

Here are draft talking points for your review. I tacked a cleaned up version of the FAA/EPA

status document on to this as an attachment.

I would like to get your feedback by COB tomorrow. They are scheduled to talk on Thurs, 12/18/14. Right now, there is no pre-brief for Janet, so I want to get this up sooner rather than later in case she wants to discuss this.

Thanks,

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Thrasher, Theodore[TThrasher@icao.int]; Anastasia Kharina[karin@theicct.org]; chris@limitedskies.com[chris@limitedskies.com]; Dickson, Neil[NDickson@icao.int]; Peterson B (rmpaero@frontier.com)[rmpaero@frontier.com]; Olivier.husse@airbus.com[Olivier.husse@airbus.com]; tpohle@airlines.org[tpohle@airlines.org]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: ADAM Michel
Sent: Tue 4/7/2015 1:31:03 PM
Subject: RE: Communication of CO2 Effectiveness Next Steps
CAEP10_MDG09_WPxx_Communicationof Effectiveness_Draft7+AK+IATA.DOCX
smime.p7s

Ex. 5 - Deliberative Process

Thanks and best regards,

Michel

Michel ADAM

Manager, Environmental Policy

Tel: + 41 22 770 2487 | Mob: +41 79 735 1053

adamm@iata.org | www.iata.org

International Air Transport Association

33 Route de l'Aéroport, 1215 Geneva 15 Airport, Switzerland

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: 07 April 2015 02:24
To: Anastasia Kharina; chris@limitedskies.com; Dickson, Neil; Peterson B (rmpaero@frontier.com); ADAM Michel; Olivier.husse@airbus.com; tpohle@airlines.org; Leggett (leggett.cullen@epa.gov)
Subject: RE: Communication of CO2 Effectiveness Next Steps

Ex. 5 - Deliberative Process

Best regards,

Ted

From: Anastasia Kharina [mailto:karin@theicct.org]
Sent: 6-Apr-15 1:36 PM
To: Thrasher, Theodore
Cc: chris@limitedskies.com; Dickson, Neil; Peterson B (rmpaero@frontier.com); Adam M; Olivier.husse@airbus.com; tpohle@airlines.org; Leggett (leggett.cullen@epa.gov)
Subject: Re: Communication of CO2 Effectiveness Next Steps

All,

Ex. 5 - Deliberative Process

Karin

Anastasia Kharina

karin@theicct.org | (415) 202-5738

The International Council on Clean Transportation

One Post Street, San Francisco CA 94104

www.theicct.org

On Apr 1, 2015, at 1:59 PM, "Thrasher, Theodore" <TThrasher@icao.int> wrote:

Hi Everyone,

Ex. 5 - Deliberative Process

Looking forward to talking with you next Tuesday.

Best regards,

Ted

From: Thrasher, Theodore
Sent: 26-Mar-15 3:00 PM
To: 'chris@limitedskies.com'; Dickson, Neil; 'Peterson B (rmpaero@frontier.com)'; 'Adam M'; 'Olivier.husse@airbus.com'; 'Anastasia Kharina'; 'tpohle@airlines.org'; Leggett (leggett.cullen@epa.gov)
Subject: Communication of CO2 Effectiveness Next Steps

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Kind regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

<CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft7.docx>

CONFIDENTIAL NOTICE
The content of this email is confidential and intended only for the individual to which it is addressed. If you are not the named addressee, you should not disseminate, distribute or copy this e-mail. Please notify the sender and delete this email from your system if received in error. This email contains a digital signature certified by Global Sign to verify its authenticity and origin. If you receive a suspicious email, please forward it to information.security@iata.org. For more information, please refer to http://www.iata.org/Pages/fraudulent-email.aspx.

To: Thrasher, Theodore[TThrasher@icao.int]; 'ADAM Michel'[adamm@iata.org]; 'Anastasia Kharina'[karin@theicct.org]; Dickson, Neil[NDickson@icao.int]; 'Peterson B (rmpaero@frontier.com)'[rmpaero@frontier.com]; 'Olivier.husse@airbus.com'[Olivier.husse@airbus.com]; 'tpohle@airlines.org'[tpohle@airlines.org]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Chris Eyers
Sent: Tue 6/2/2015 6:05:10 AM
Subject: RE: Communication of Effectiveness... any new text?
Update of Final Paper to FESG/MDG from Communication of Effectivenes ad hoc group

Ted et al,

Ex. 5 - Deliberative Process

Chris

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: 02 June 2015 03:42
To: 'ADAM Michel'; 'Anastasia Kharina'; Chris Eyers; Dickson, Neil; 'Peterson B (rmpaero@frontier.com)'; 'Olivier.husse@airbus.com'; 'tpohle@airlines.org'; 'Leggett (leggett.cullen@epa.gov)'
Subject: Communication of Effectiveness... any new text?

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks and best regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Thrasher, Theodore[TThrasher@icao.int]
Cc: Dickson, Neil[NDickson@icao.int]; Adam M[adamm@iata.org]; Olivier.husse@airbus.com[Olivier.husse@airbus.com]; Anastasia Kharina[karin@theicct.org]; tpohle@airlines.org[tpohle@airlines.org]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Peterson B (rmpaero@frontier.com)[rmpaero@frontier.com]
From: Chris Eyers
Sent: Mon 5/4/2015 5:59:52 AM
Subject: Update of Final Paper to FESG/MDG from Communication of Effectivenes ad hoc group
CAEP10_MDG09_WP10_Report from ahg on Communication of Effectiveness_Draf....docx

Ted et al,

Ex. 5 - Deliberative Process

Chris

EASA Contractor

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: 16 April 2015 21:31
To: Chris Eyers; Dickson, Neil; Adam M; Olivier.husse@airbus.com; Anastasia Kharina;

tpohle@airlines.org; Leggett (leggett.cullen@epa.gov); Peterson B (rmpaero@frontier.com)
Subject: Final Paper to FESG/MDG from Communication of Effectivenes ad hoc group

Ex. 5 - Deliberative Process

Best regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Samulski, Michael[samulski.michael@epa.gov]
Cc: Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]
From: Manning, Bryan
Sent: Tue 6/23/2015 4:11:43 PM
Subject: Janet Talking Pts for conversations
Janet Talking Points ICAO CO2 Standard 6-22-15.docx

Hello Mike,

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: 'ADAM Michel'[adamm@iata.org]; 'Anastasia Kharina'[karin@theicct.org]; 'chris@limitedskies.com'[chris@limitedskies.com]; Dickson, Neil[NDickson@icao.int]; 'Peterson B (rmpaero@frontier.com)'[rmpaero@frontier.com]; 'Olivier.husse@airbus.com'[Olivier.husse@airbus.com]; 'tpohle@airlines.org'[tpohle@airlines.org]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Thrasher, Theodore
Sent: Tue 6/2/2015 1:42:20 AM
Subject: Communication of Effectiveness... any new text?
WP10_MDG09_Report from ahg on Communication of Effectiveness.docx

Dear Communication of Effectiveness ad hoc group members,

Ex. 5 - Deliberative Process

Thanks and best regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Anastasia Kharina[karin@theicct.org]; chris@limitedskies.com[chris@limitedskies.com]; Dickson, Neil[NDickson@icao.int]; Peterson B (rmpaero@frontier.com)[rmpaero@frontier.com]; Adam M[adamm@iata.org]; Olivier.husse@airbus.com[Olivier.husse@airbus.com]; tpohle@airlines.org[tpohle@airlines.org]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Thrasher, Theodore
Sent: Tue 4/7/2015 12:23:44 AM
Subject: RE: Communication of CO2 Effectiveness Next Steps
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft7-RMP.DOCX
Table to be added to Communications WP.DOCX

In addition, attached is input from Bob. We will discuss both of these proposals during tomorrow's call.

Best regards,

Ted

From: Anastasia Kharina [mailto:karin@theicct.org]
Sent: 6-Apr-15 1:36 PM
To: Thrasher, Theodore
Cc: chris@limitedskies.com; Dickson, Neil; Peterson B (rmpaero@frontier.com); Adam M; Olivier.husse@airbus.com; tpohle@airlines.org; Leggett (leggett.cullen@epa.gov)
Subject: Re: Communication of CO2 Effectiveness Next Steps

All,

First off, thank you Cullen and Chris for continuing to revise the paper.

Attached is my revision (and some suggestions) on the paper for discussion tomorrow.

Karin

Anastasia Kharina

karin@theicct.org | (415) 202-5738

The International Council on Clean Transportation

One Post Street, San Francisco CA 94104

www.theicct.org

On Apr 1, 2015, at 1:59 PM, "Thrasher, Theodore" <TThrasher@icao.int> wrote:

Hi Everyone,

With sincere appreciation for the extra effort put in by Chris and Cullen, please find attached an updated draft that will be the basis of discussion during our call on 7 April. As I mentioned before, I would very much like to arrive at a consensus view to present to the FESG/MDG meeting. With that in mind, any suggestions for improvement are welcome – please send them via track changes to the entire group.

Looking forward to talking with you next Tuesday.

Best regards,

Ted

From: Thrasher, Theodore
Sent: 26-Mar-15 3:00 PM
To: 'chris@limitedskies.com'; Dickson, Neil; 'Peterson B (rmpaero@frontier.com)'; 'Adam M'; 'Olivier.husse@airbus.com'; 'Anastasia Kharina'; 'tpohle@airlines.org'; Leggett (leggett.cullen@epa.gov)
Subject: Communication of CO2 Effectiveness Next Steps

Ex. 5 - Deliberative Process

Our next call will be **Tuesday, 7 April at 10:00 EDT.** At this point the WP should be very close to final for the FESG/MDG meeting.

Remember, we want to "solve" the discussion within our group so that the presentation to the broader FESG and MDG meeting goes smoothly.

Thank you all for your inputs on this important element of the CO2 Standard work.

Kind regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

<CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft7.docx>

To: Manning, Bryan[manning.bryan@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Kraft, Isobel[Kraft.Isobel@epa.gov]
Cc: Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Schwimmer, Sergio[Schwimmer.Sergio@epa.gov]; DCJSAPPS01/DC/USEPA/US[DCJSAPPS01/DC/USEPA/US@epamail.epa.gov]
From: Yen, David
Sent: Wed 4/23/2014 1:02:50 PM
Subject: Trip Report
MDG_FESG-STG05_Trip Report_2014-04-21.docx

Hi all,

Here is the trip report to the 5th Joint MDG/FESG-STG Meeting in London. All the papers and documents are uploaded in the H: drive for your reference. EPA specific action items are outlined in section 2. Let me know if you have any questions.

Best,

David

To: Samulski, Michael[samulski.michael@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Wed 6/10/2015 1:08:08 PM
Subject: RE: New tough aircraft Q

Hello Mike,

Ex. 5 - Deliberative Process

Let me know if you have any questions or comments. Thanks.

Bryan

Bryan Manning
U.S. EPA Office of Transportation and Air Quality
Large Marine and Aviation Center
2000 Traverwood Drive
Ann Arbor, MI 48105
(ph) 734-214-4832 (fax) 734-214-4816
manning.bryan@epa.gov

-----Original Message-----
From: Samulski, Michael
Sent: Wednesday, June 10, 2015 7:08 AM
To: Audette, Lucie; Manning, Bryan; Leggett, Cullen
Subject: FW: New tough aircraft Q

Some more questions from Chris below.

****
Michael Samulski
U.S. Environmental Protection Agency
Office of Transportation and Air Quality Director, Large Marine and Aircraft Center
1 (734) 214-4532
samulski.michael@epa.gov
****

-----Original Message-----
From: Grundler, Christopher
Sent: Wednesday, June 10, 2015 1:40 AM
To: Hengst, Benjamin; Birgfeld, Erin; Charmley, William; Samulski, Michael
Subject: New tough aircraft Q

Ex. 5 - Deliberative Process

Christopher Grundler, Director
Office of Transportation and Air Quality U.S. EPA
202-564-1682 (DC)
734-214-4207 (Ann Arbor)

To: Leggett, Cullen[Leggett.Cullen@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Yen, David[Yen.David@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Manning, Bryan
Sent: Mon 7/20/2015 9:10:13 PM
Subject: FW: Aviation Week editorial on emissions?

See the below article forwarded to me by Dan Rutherford, in case you have not seen it already. Thanks. Bryan

From: Daniel Rutherford [mailto:dan@theicct.org]
Sent: Monday, July 20, 2015 4:24 PM
To: Manning, Bryan
Cc: Samulski, Michael
Subject: Fwd: editorial on emissions?

Bryan,

The Aviation Week editorial I referred to just now. Graham Warwick is an editor there. A good guy, a skeptic on averaging, but quite persuadable based upon personal experience.

Dan

Begin forwarded message:

From: "Warwick, Graham" <warwick@aviationweek.com>

Subject: Re: editorial on emissions?

Date: June 22, 2015 at 4:33:41 PM GMT-4

To: Daniel Rutherford <dan@theicct.org>

Here you go:

Editorial: Push Industry Harder To Cut Aircraft Emissions

Jun 19, 2015

Give Industry a Push To Cut Aircraft Emissions

The first carbon-dioxide emissions standard for aircraft is being developed. It is scheduled to be finalized by the International Civil Aviation Organization (ICAO) in February 2016. It has been a long process. How CO2 emissions will be measured has been agreed. That was hard enough. But what the limits will be, to which aircraft they will apply and when they take effect all still must be hammered out.

It matters because aviation has a problem. It may account for only 2% of global CO2emission but, where other modes of transport are reducing their greenhouse-gas footprints, aviation's is increasing simply because air travel is growing.

At the extremes, the industry could end up with a CO2 standard that forces manufacturers to modify all in-production aircraft to comply or one that has no impact on any aircraft before 2025 at the earliest, even those now just in development. At issue is whether the standard should "force" technology or simply "follow" the improvements industry makes, locking them in to prevent backsliding.

The argument against a tough standard is that emissions come from burning fuel, and there is plenty of economic incentive for manufacturers to ensure fuel burn continues its downward trend. But the airlines themselves acknowledge that will not be enough to offset the increase in emissions from the forecast growth in air

That is why the international aviation community is pursuing a basket of measures to slow and hopefully reverse the expected rise in emissions, including new technologies, the CO2 standard, emissions-trading and biofuels. But all of these must work if aviation is to achieve its stated goal of reducing emissions 50% by 2050. Slow progress in fielding NextGen air traffic modernization and commercializing biofuels underlines the need to pursue all avenues simultaneously—and aggressively.

The U.S. has taken a lead, first in getting ICAO to agree that the intent of the CO2standard is to achieve emissions reductions beyond "business as usual," to levels lower than would be accomplished in the absence of a standard. Now the U.S. is the first to begin the regulatory process to adopt the ICAO standard, once it is ready—and if it is sufficient.

In the negotiations at ICAO over the months to come, it is important that the U.S.

strengthen its position that the global CO2standard must be “meaningful.” And it is important that, through the public comment process launched by the U.S. Environmental Protection Agency, a case is built for a technology-forcing standard. It may not be popular with industry now, but it will strengthen aviation in the long run.

Sent from my iPhone

On Jun 22, 2015, at 2:18 PM, "Daniel Rutherford" <dan@theicct.org> wrote:

Graham,

Any chance you could forward the text of this editorial, also behind your paywall?

http://aviationweek.com/commercial-aviation/editorial-push-industry-harder-cut-aircraft-emissions

Thanks!

Dan

To: Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Manning, Bryan
Sent: Tue 6/9/2015 9:44:39 PM
Subject: Draft IP for CAEP SG15: Aircraft GHG endang/ANPR (PLEASE REVIEW)
CAEPSG.20153.IP.US Endang Finding_ANPR.YY.en.docx

Hello,

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: chris@limitedskies.com[chris@limitedskies.com]; Dickson, Neil[NDickson@icao.int]; Peterson B (rmpaero@frontier.com)[rmpaero@frontier.com]; Adam M[adamm@iata.org]; Olivier.husse@airbus.com[Olivier.husse@airbus.com]; Anastasia Kharina[karin@theicct.org]; tpohle@airlines.org[tpohle@airlines.org]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Thrasher, Theodore
Sent: Wed 4/1/2015 8:59:16 PM
Subject: RE: Communication of CO2 Effectiveness Next Steps
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft7.docx

Hi Everyone,

Ex. 5 - Deliberative Process

Looking forward to talking with you next Tuesday.

Best regards,

Ted

From: Thrasher, Theodore
Sent: 26-Mar-15 3:00 PM
To: 'chris@limitedskies.com'; Dickson, Neil; 'Peterson B (rmpaero@frontier.com)'; 'Adam M'; 'Olivier.husse@airbus.com'; 'Anastasia Kharina'; 'tpohle@airlines.org'; Leggett (leggett.cullen@epa.gov)
Subject: Communication of CO2 Effectiveness Next Steps

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Kind regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Yang, Ching-Shih[Yang.Ching-Shih@epa.gov]; Kraft, Isobel[Kraft.Isobel@epa.gov]
Cc: Leggett, Cullen[Leggett.Cullen@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]
From: Yen, David
Sent: Wed 4/23/2014 6:19:03 PM
Subject: GHG Modeling tasks
CAEP10_MDG05_Flimsy05_GHG_Fuelburn_Comparison_as-disscussed-in-mtg.docx

Hi Ching-shih and Isobel,

Ex. 5 - Deliberative Process

David

To: Audette, Lucie[audette.lucie@epa.gov]
Cc: Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Mon 7/13/2015 1:55:59 PM
Subject: FW: Materials for aircraft meetings next Monday and Tuesday
FAA-EPA CO2 Standard briefing_10 July 2015_final.docx
Notes for Call with Rich Swayze 7-13-15.docx

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Hengst, Benjamin
Sent: Friday, July 10, 2015 1:55 PM
To: Charmley, William; Samulski, Michael; Manning, Bryan
Cc: Grundler, Christopher
Subject: FW: Materials for aircraft meetings next Monday and Tuesday

Just so you have what is being sent forward for next week.

Thanks,

Ben

From: Hengst, Benjamin

Sent: Friday, July 10, 2015 1:50 PM
To: OAR Briefings
Cc: Sutton, Tia
Subject: Materials for aircraft meetings next Monday and Tuesday

Hello,

Ex. 5 - Deliberative Process

Thanks,

Ben

Environmental Science & Technology

ARTICLE

pubs.acs.org/est

Aircraft Emissions of Methane and Nitrous Oxide during the Alternative Aviation Fuel Experiment

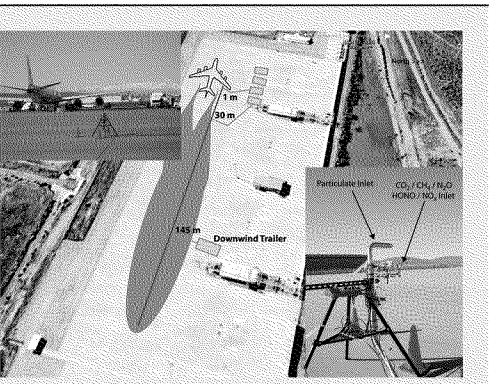
Gregory W. Santoni,*,† Ben H. Lee,† Ezra C. Wood,‡,§ Scott C. Herndon,‡ Richard C. Miake-Lye,‡ Steven C. Wofsy,† J. Barry McManus,‡ David D. Nelson,‡ and Mark S. Zahniser‡

†School of Engineering and Applied Sciences and Department of Earth and Planetary Sciences, Harvard University, 20 Oxford St., Cambridge, Massachusetts 02138, United States

‡Center for Aero-Thermodynamics and the Center for Atmospheric and Environmental Chemistry, Aerodyne Research, Inc., 45 Manning Rd., Billerica, Massachusetts 01821, United States

b Supporting Information

ABSTRACT: Given the predicted growth of aviation and the recent developments of alternative aviation fuels, quantifying methane (CH_4) and nitrous oxide (N_2O) emission ratios for various aircraft engines and fuels can help constrain projected impacts of aviation on the Earth's radiative balance. Fuel-based emission indices for CH_4 and N_2O were quantified from CFM56 2C1 engines aboard the NASA DC-8 aircraft during the first Alternative Aviation Fuel Experiment (AAFEX-I) in 2009. The measurements of JP-8 fuel combustion products indicate that at low thrust engine states (idle and taxi, or 4% and 7% maximum rated thrusts, respectively) the engines emit both CH_4 and N_2O at a mean (1σ rate of 170 (160 mg CH_4 (kg Fuel) ^{1} and 110 (50 mg N_2O (kg Fuel) ^{1}, respectively. At higher thrust levels corresponding to greater fuel flow and higher engine temperatures, CH_4 concentrations in engine exhaust were lower than ambient concentrations. Average emission indices for JP-8 fuel combusted at engine thrusts between 30% and 100% of maximum rating were 54 (33 mg CH_4 (kg Fuel) ^{1} and 32 (18 mg N_2O (kg Fuel) ^{1}, where the negative sign indicates consumption of atmospheric CH_4 in the engine. Emission factors for the synthetic Fischer Tropsch fuels were statistically indistinguishable from those for JP-8.



INTRODUCTION

Methane (CH_4) is a radiatively active gas in Earth's emission spectrum, roughly 25 times more effective on a per-molecule level than CO_2 in terms of its integrated greenhouse effect at hundred-year time scales.[1] Nitrous oxide (N_2O) has an even larger per-molecule global warming potential, roughly 300 times higher than CO_2 on these time scales. This is partly because its atmospheric lifetime is ~120 years, compared to the ~9 year methane lifetime.[2] The concentration of these two species in the atmosphere is determined primarily by a balance between surface sources and atmospheric losses. Atmospheric destruction of CH_4 occurs largely via reaction with the hydroxyl radical (OH) while loss of atmospheric N_2O mainly proceeds via stratospheric photodissociation.[3,4] Since 1750, when atmospheric CH_4 concentrations hovered around 700 nmol/mol, anthropogenic activities have increased CH_4 abundances to ~1850 nmol/mol.[2] CH_4 growth rates leveled off in the mid-1980s and early part of the 21st century,[5] but recent studies have shown renewed growth.[6,7] In that same time-period, the atmospheric abundance of N_2O has increased from 270 nmol/mol to its present value of ~320 nmol/mol.[8]

Given their radiative importance and long atmospheric lifetimes, quantifying the impact of the airline industry on climate change must include accurate accounting of CH_4, N_2O, and CO_2. Many studies have measured CO_2 emissions from aircraft engines,[9] but fewer have examined CH_4 and N_2O emissions. Direct aircraft emissions of these species have the potential to affect global budgets, particularly given the growth of the aviation industry in the recent decades. Nitrogen oxide emissions also indirectly decrease the lifetime of CH_4 in the atmosphere via chemical feedbacks involving ozone (O_3) and OH.[10] A competing effect exists with carbon monoxide (CO) emissions, as feedbacks with CO and OH can increase the atmospheric lifetime of CH_4.[10] Aircraft emissions are also noteworthy in that most of the emissions occur at altitude.

Previous studies have highlighted the large variability of CH_4 concentrations seen at the exit of engines operating at different conditions. Spicer et al.[11,12] were among the first to give detailed aircraft exhaust emission concentrations for a variety of organic species in military and commercial aircraft engines. Wiesen et al.[13] examined CH_4 and N_2O emissions from different commercial jet engines using different fuels during the AERO-NOx campaign. The main finding emphasized in these studies was the consumption of atmospheric CH_4 at high engine thrust

Received: March 17, 2011
Accepted: July 5, 2011
Revised: June 23, 2011
Published: July 05, 2011

ACS Publications r 2011 American Chemical Society

EPA-HQ-2018-004348

conditions, the production of CH_4 at low-power conditions, and the production of N_2O irrespective of engine mode. This suggested that aircraft emissions had negligible impacts on the global CH_4 budget. They also found that N_2O emissions were smaller than those of lower-temperature combustion power plants[14] and concluded that aircraft emissions of N_2O had a negligible impact on the global N_2O budget.

CH_4 emissions at idle and taxi conditions, however, varied by 500%, dependent on engines used and fuels consumed. Spicer et al.[12] showed enhancements of upward of 9 μmol/mol in undiluted exhaust, roughly 5 times ambient concentrations, whereas Spicer et al.[11] measured CH_4 concentrations of 1.8 μmol/mol in the exhaust, most of which was likely from the ambient air flushed through the turbine engines. The ambient CH_4 concentration is currently 1.85 μmol/mol, though it was closer to 1.7 μmol/mol in 1992.[15] While there has been a consensus on the overall trends, quantitative assessments of CH_4 emissions as a function of engine thrust remain poorly constrained.

AAFEX provided a means to quantify non-CO_2 greenhouse gas emission data for a variety of fuels, ambient conditions, and modes of engine operation. Preliminary results from AAFEX were presented in the NASA AAFEX report (ref 16, Appendix E for the present study) and analysis of the AAFEX data set is intended to guide the aviation industry in addressing the most important emission issues associated with alternative fuels.

EXPERIMENTAL SECTION

Rising concerns regarding air quality and continued dependence on foreign oil have generated interest in the development of alternative aviation fuels. AAFEX provided a means of comprehensive testing of the effects of different fuels on engine operation and exhaust composition. The tests were performed on the ground in Palmdale, CA on the same CFM56 2C1 engine studied during APEX-1[20] and were intended to simulate the engine operating conditions during flight. AAFEX included three chemically distinct fuels: JP-8, representative of the Jet-A fuels currently used throughout the world, a Fischer Tropsch (FT-1) fuel derived from a natural gas feedstock and synthesized by Shell, and a second Fischer Tropsch (FT-2) fuel derived from a gasified coal feedstock and synthesized by Sasol. The fuels were analyzed for content and material properties by the Air Force Research Lab.[16] In addition to the pure fuels, 50/50-by-volume blends of the fuels were tested. During all tests, engines 2 and 3 (the two engines closest to the fuselage) were active and were sampled at 1 and 30 m probes. Engine 2 (inboard left engine) served as a reference as it burned JP-8 for the entire test duration while engine 3 (inboard right engine) burned either JP-8 or the synthetic fuel depending on the test day. Both trace gas and particulate measurements were made at multiple distances from the inlet to characterize aging of the various emissions. Gas phase measurements included CO_2, CO, NO_x, SO_2, CH_4, N_2O, HONO, total and speciated hydrocarbons, and hazardous air pollutants while particle measurements included number density, size distribution, mass, aerosol chemical composition, and black carbon composition.[16] Advected plume emissions presented in this study were sampled downwind of the plane at the 145 m probe (see TOC art). The daily AAFEX test activities are summarized in Table 1.

The majority of instrumentation at AAFEX was located on the starboard side of the plane. The downwind trailers housed instrumentation to measure CH_4, CO_2, O_3, NO_x, HONO, N_2O, and particulates, and were positioned 145 m away from the engine output in the direction of the predominant wind and 1.3 m above the ground. This positioning was critical to measure advected plumes of engine exhaust at low power conditions, when exit velocities of engine emissions did not have sufficient momentum to reach the downwind trailer inlet. The inlet was designed to eliminate the need of filters which would corrupt the HONO measurement, but still remove particulates by inertial separation, thereby eliminating potential degradation of the sampling cell mirrors.

Table 1. Fuel Used, Average Ambient Temperature, And Relative Humidity for Each Experiment During AAFEX.[a]

date (2009)	experiment	fuel	start	end	temp (°C)	RH (%)
1/26	JP-8 initial test	JP-8	16:00	19:20	5	60
1/27	JP-8 warm	JP-8	12:40	15:30	10	30
1/28	JP-8 cold	JP-8	06:00	09:30	3	30
1/28	FT1 warm	FT1	12:30	15:40	10	30
1/29	FT1 cold	FT1	05:40	08:30	0	60
1/30	FT1 blend	JP-8/FT1	06:15	09:40	2	55
1/30	FT2 warm	FT2	10:50	13:40	14	25
1/31	FT2 cold	FT2	05:45	07:00	0	75
1/31	FT2 blend	JP-8/FT2	08:30	10:40	14	30
1/31	JP-8 warm	JP-8	12:40	15:30	17	20
2/1	DAY OFF					
2/2	JP-8 cold	JP-8	07:11	09:00	2	60

[a] When two fuels are listed, these represent 50/50-by-volume blends. Ambient temperature and relative humidity were found to have no significant effect on either CH_4 or N_2O emission indices.

Advances in laser and detector technology have allowed for greater sensitivity in high-resolution absorption spectroscopy.[17] Zahniser et al.[18] and Lee et al.,[19] provide a description of the spectrometers used at AAFEX to measure CH_4 and N_2O with in-field 1-Hz precisions of 0.6 nmol/mol and 0.3 nmol/mol, respectively. Briefly summarizing, the CH_4 spectrometer consists of a mid-infrared continuous-wave Quantum Cascade Laser (QCL, Alpes Lasers) that is tuned across an absorption line for CH_4 in the 1294 1295 cm^{-1} region. Light from the QCL is directed into an astigmatic multipass sampling cell operated at low pressure (<50 Torr) and detected by a thermoelectrically cooled 8 μm detector. To achieve this precision on the CH_4 line, two mirrors spaced 88.23 cm apart are housed in a 5 L sample cell such that 238 passes between the astigmatic mirrors result in an effective optical path length of 210 m. A flow rate of 11 slpm, corresponding to a cell time constant of 1.05 s, was achieved during AAFEX measurements using a 600 L/min scroll pump. The N_2O measurement was made using a second very similar instrument. Simultaneous measurements of CO_2 were made using a commercially available Licor LI-6262 infrared gas analyzer. By making highly time-resolved measurements of CH_4 and CO_2, the concentrations of each are quantified in both the exhaust plume and in the background air unaffected by the exhaust.

RESULTS AND DISCUSSION

Figure 1 shows time series data from January 26, 2009 showing the different correlations between CH_4, N_2O and

ED_001734_00021049-00002

EPA-HQ-2018-004348

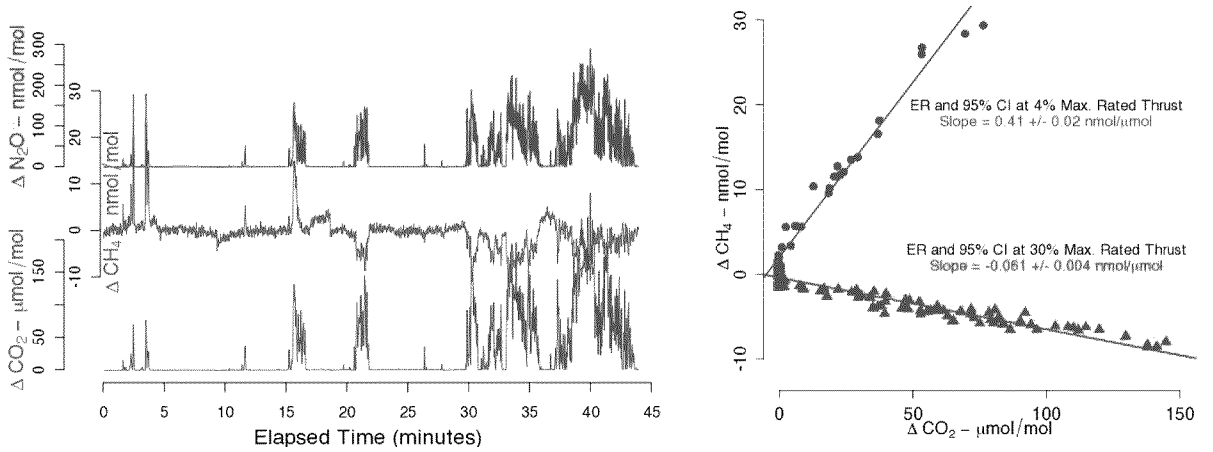


Figure 1. (left) Time series (January 26th, 2009, 2 pm local time) of the enhancement above background values (ΔCH_4, ΔN_2O, ΔCO_2) of ambient plume AAFEX data illustrating positive correlation between CH_4 and CO_2 at idle conditions (before minute 20), and negative correlation at higher thrusts (after minute 20). N_2O is positively correlated with CO_2 at all thrust conditions. (right) Two examples of emission ratio (ER) regressions at 4% (idle) and 30% (approach) maximum rated thrust using CH_4 and CO_2 data from the left panel.

CO_2 concentrations. During idle conditions, CH_4 plumes of 30 nmol/mol correspond to 70 µmol/mol CO_2 plumes. At 30% thrust conditions, this relation changes noticeably, with larger 200 µmol/mol CO_2 plumes corresponding to CH_4 depletions of 10 nmol/mol below the background atmospheric mixing ratio. Fuel-based emission ratios in units of nmolCH_4/µmolCO_2 can be calculated by regressing CH_4 against CO_2 in individual plumes, as shown in Figure 1. Fuel-based emission indices are then calculated according to Herndon et al.:[21]

$$EI_{CH_4} \;¼\; F_c 3 \frac{M_{CH_4}}{M_{CO_2}} 3 \frac{\Delta CH_4}{\Delta CO_2} \qquad ð1Þ$$

where M represents the molecular mass and F_c represents the stoichiometric calculation of CO_2 produced per kilogram of fuel consumed (with units g CO_2 (kg Fuel) ^{1}) assuming complete combustion and given a particular hydrogen to carbon ratio. The hydrogen contents by mass for JP-8, FT1, and FT2 are 13.6%, 15.5%, and 15.1% hydrogen, respectively, corresponding to F_c values of 3160, 3090, and 3110 g CO_2 (kg fuel) ^{1}.[1,16,22] Identical emission index calculations are carried out for N_2O by accounting for the molecular mass differences. These emission indices of CH_4 and N_2O were calculated for 1480 plumes at various engine thrust modes, of which only the plumes with a variance on the regression smaller than 0.2 were used (n = 1103) in subsequent analysis.

The number of plumes observed at low power conditions is typically fewer than those at higher engine thrusts (see also Supporting Information Figure 1) because advection of the plumes of engine exhaust was facilitated by the wind velocities generated by higher thrusts. The figure also illustrates the broader distributions observed at idle (4%) and taxi (7%) conditions in comparison with those at higher engine thrusts, with the latter constrained by the limited amount of atmospheric CH_4 available to combust. Figure 2 and Table 2 summarize CH_4 and N_2O emission indices as well as undiluted carbon dioxide concentrations observed at the engine exhaust plane (EEP).[23] Two sample t tests were performed between each fuel (JP-8 vs FT-1, JP-8 vs FT-2, and FT1 vs FT2) at each of the 7 engine thrust conditions shown in Table 2. Of the 21 population comparisons for CH_4, 5 were significant at the p = 0.05 level, but the mean p-value was 0.30. For N_2O, 10 of the 21 tests had p-values below 0.05, but the mean p-value was 0.15, also suggesting that the emission indices of the different fuels were statistically indistinguishable. We note that N_2O emission indices for FT-1 are consistently higher than JP-8 while those of FT-2 are consistently lower. Table 2 also shows emission rates for N_2O and CH_4 calculated using median fuel flow rates recorded in the cockpit during each test.

To validate ambient plume measurements and explain the discrepancies between studies at both high and low engine thrust conditions, two subsamples (one at 4 7% and one at 100% thrust) of core flow aircraft exhaust were taken from the 1 m inlet during each simulated flight and analyzed with the same instrumentation while the aircraft engines were off. The subsamples were introduced into evacuated 2 L steel canisters and then diluted down with ultrahigh purity helium to pressurize the canisters. These subsamples were then overblown across the 145 m inlet of the spectrometers to validate the emission ratios calculated from the advected plume data. Only two samples were done for each simulated flight because of the limited time available between fuel experiments to evacuate, pressurize, and sample the canisters. Corrections for the dilution were made by multiplying the CH_4 values with the ratio of CO_2 values observed at the EEP (Figure 2) to the equilibrated concentration measured while sampling the canister. Corresponding CH_4 emission indices are shown in Figure 2 for 11 canisters collected in this way. It should be noted that emission indices at 100% thrust calculated from subsamples in this way can never be less than zero, as the subsamples at 100% thrust contain no CH_4 and the values recorded by the spectrometer were within the detection limit of the CH_4 measurement. The emission indices derived from plume regressions are negative at high thrusts only because the engine is consuming atmospheric CH_4. In the absence of background atmospheric CH_4, these plume measurements would also be zero. The canister measurements depend on the accuracy, as opposed to the precision, of both the CH_4 and CO_2 measurements, and therefore have much larger error bars. Nevertheless, they validate the finding of CH_4 production at low engine power settings and CH_4 consumption at high engine power settings.

The canister data also demonstrate the importance of engine history on CH_4 emissions. Two subsamples taken from the same

ED_001734_00021049-00003

EPA-HQ-2018-004348

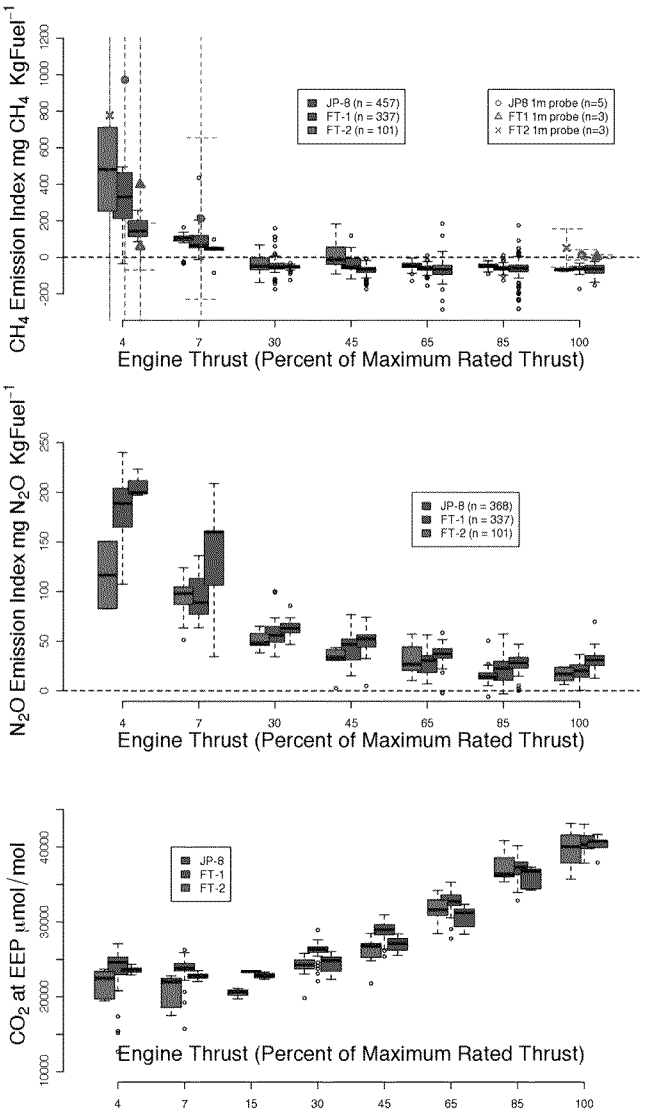


Figure 2. CH_4 emission indices (top), N_2O emission indices (middle), and CO_2 concentration at the Engine Exhaust Plane (bottom, courtesy of Changlie Wey) binned by fuel and percent maximum rated engine thrust. The latter is used to calculate plume dilution of canister samples taken from the 1-m probe which are shown superimposed on the CH_4 EI plot (top). Black bars represent the median, boxes extend from the first to the third quartile, and whiskers represent 1.5 interquartile ranges. Outliers are shown as black circles.

inlet at 7% engine thrusts, the first being sampled while the engine was starting from a cold state, and the latter sampled after the engine had operated for 40 min at higher thrusts, show vastly differing CH_4 emission indices. The former is off the range of Figure 2, whereas the latter is indistinguishable from zero. This partially explains the variability seen in advected plume derived emission indices (see SF1) as the timing of the change in engine thrust condition is not coincident with the detection of the plume at the 145-m inlet.

The total amount of CH_4 and N_2O emitted or consumed during a hypothetical landing takeoff cycle or a simulated hour of cruising can be calculated by multiplying the above emission rates by the time-in-mode for each segment of a flight. Table 3 shows this calculation using the time-in-modes for a standard International Civil Aviation Organization (ICAO) landing takeoff (LTO) cycle as well as one hour of cruising (65% maximum rated thrust) engine power. The calculation indicates that there are slight net CH_4 emissions during this hypothetical LTO cycle, but that even just 1 h of cruise conditions (65% thrust) leads to far more atmospheric CH_4 destruction. N_2O emissions, in contrast, are positive throughout the LTO cycle, but represent a negligible global N_2O source to the atmosphere. Scaling up the emission rate of N_2O from the 20 billion gallons of fuel consumed by the airline industry annually results in a yearly N_2O flux of ~4 Gg N_2O yr^{-1}, or roughly 0.025% of the total source term of 17.7 Tg N yr^{-1}.[12] Aircraft CH_4 emissions, in contrast to N_2O, represent a net atmospheric sink term, consuming roughly 3.5 Gg CH_4 yr^{-1}, completely negligible in terms of the global source and sink terms, each on the order of 580 Tg CH_4 yr^{-1}.[12]

A discussion of this work in the context of previous studies is helpful. Wiesen et al.[13] and Heland and Schafer[24] are the only studies, to our knowledge, that present N_2O emissions data. The results of past studies and the present AAFEX work are presented as mean engine exhaust concentrations of N_2O in Figure 3. Wiesen et al.[13] measured N_2O offline from exhaust filled cylinders and reported a mean (1σ N_2O emission index of 0.11 (0.0098 g N_2O (kg Fuel)$^{-1}$ across all thrust settings. This was not corrected for ambient N_2O concentrations, which, if accounted for, would decrease the average emission index by ~30% to a value closer to 0.077 g N_2O (kg fuel)$^{-1}$, still slightly higher than the average value across all thrust settings of 0.066 (0.0018 g N_2O (kg Fuel)$^{-1}$ in this study. The trend of increasing N_2O emissions with increasing thrust is the reverse of the trend at AAFEX. A potential explanation of this trend is that nitrogen oxides (NO_x) can convert to N_2O in these engine plumes, especially in the presence of acid aerosols.[13] Such a mechanism could explain the differences at lower thrusts seen during AAFEX, as these plumes had longer lifetimes than those sampled at higher powers where advection was aided by larger engine exit velocities. The gross agreement with Wiesen et al.,[13] however, suggests that this effect is small. Heland and Schafer[24] measured N_2O emissions of aircraft exhaust using a passive FTIR spectrometer. This technique relies heavily on good spectroscopic parameters for the various absorbers present and good background spectra to normalize out the absorption due to molecules present in the instrument aperture but not in the plume. They reported an emission index for higher-thrust levels of 1.3 g N_2O (kg Fuel)$^{-1}$, a full order of magnitude greater than those of Wiesen et al.[13] and this study, but also state that N_2O mixing ratios were below the detection limit at idle power conditions. The engine probed in Heland and Schafer[24] is the same as that of AAFEX. The large discrepancy between the emission ratios reported and the lack of data at idle conditions when N_2O emissions have been shown not significantly different from other power conditions call into question the instrument precisions of N_2O possible with a passive spectrometer.

Other studies mention N_2O aircraft emissions but do not report data. Vay et al.,[22] for instance, measured contrail plumes behind a T-39 and a B-757 aircraft but did not report the N_2O data, finding that it was not an important exhaust constituent. During the Airbone Arctic Stratospheric Expedition, Zheng et al.[25] examined 20 plumes of NO_y, 5 of which correlated to CO_2 enhancements. Of those 5 plumes, they found no significant increases for either N_2O or CH_4, and argue that a CH_4 depletion would not have been persistent long enough in the atmosphere to be observed. These findings are consistent with our results.

ED_001734_00021049-00004

EPA-HQ-2018-004348

Table 2. Calculated Emission Indices for CH_4 and N_2O According to Percentage Maximum Rated Engine Thrust Condition and Fuel Type[a]

percent thrust (LTO cycle)	fuel	fuel flow (kgFuel/h)	CH_4 EI mg/(kgFuel)	CH_4 emission rate (g/h)	N_2O EI mg/(kgFuel)	N_2O emission rate (g/h)	CO_2 emission rate (kg/h)
4% (idle)	JP-8	428	331 (165 ((87)	142	189 (41 ((24)	81	1350
	FT-1		143 (87 ((98)	61	200 (14 ((16)	86	1320
	FT-2		483 (323 ((448)	207	117 (48 ((66)	50	1330
7% (taxi)	JP-8	456	66 (84 ((30)	30	89 (21 ((8)	40	1440
	FT-1		46 (69 ((60)	21	160 (67 ((58)	73	1410
	FT-2		107 (59 ((28)	49	98 (19 ((9)	45	1420
30% (approach)	JP-8	1134	51 (54 ((13)	57	56 (13 ((3)	64	3580
	FT-1		51 (17 ((6)	58	63 (8 ((3)	71	3500
	FT-2		47 (68 ((50)	53	48 (9 ((7)	55	3530
45% (approach)	JP-8	1545	52 (44 ((11)	81	47 (14 ((4)	72	4880
	FT-1		64 (34 ((7)	100	53 (13 ((3)	81	4770
	FT-2		14 (106 ((93)	21	34 (16 ((14)	52	4800
65% (cruise)	JP-8	2200	60 (19 ((3)	132	31 (11 ((2)	68	6950
	FT-1		66 (59 ((13)	144	38 (10 ((2)	83	6800
	FT-2		45 (23 ((7)	98	27 (14 ((4)	59	6840
85% (climb-out)	JP-8	2934	58 (18 ((3)	170	23 (13 ((3)	66	9270
	FT-1		59 (68 ((13)	172	28 (8 ((2)	83	9070
	FT-2		49 (17 ((7)	145	14 (10 ((4)	42	9130
100% (take-off)	JP-8	3320	59 (26 ((10)	195	20 (10 ((4)	68	10500
	FT-1		62 (31 ((11)	207	31 (10 ((4)	103	10300
	FT-2		67 (6 ((4)	221	17 (7 ((6)	56	10300

[a] Median values (1σ are given and the 95% confidence intervals are shown in parentheses. Emission rates for CH_4 and N_2O are calculated by multiplying median fuel flows by emission indices. Errors can also be calculated using this scaling. The emission rate for CO_2 is derived from each fuel's percent hydrogen by mass (and consequently the carbon content) as well as the median fuel flow rate.

In addition to the present work, seven other studies have characterized aircraft CH_4 emission data, and the results of these experiments are presented as mean pure engine CH_4 exhaust concentrations in Figure 3 and in Supporting Information Table 1. Pure exhaust concentrations are calculated by multiplying emission ratios of eq 1 by the difference between CO_2 values at the EEP and ambient values and adding ambient concentrations. Spicer et al.[11] were among the first to report detailed organic species as well as CO, CO_2, and nitrogen oxides for aircraft engine emissions. The 1992 study[11] published data using JP-4 fuel in F-101 and F-110 engines, used primarily on the B1 B and F-16 airplanes, respectively. The 1994 paper[12] focused on engines used in more commercial transport aircraft such as the Boeing 737, the CFM-56 and TF-39. Interestingly, the core engine of the CFM-56 is the same as that of the F-101 engine used in the 1992 study. Nevertheless, the two engines seemingly produced very different CH_4 emission indices particularly at idle. Wiesen et al.[13] report positive CH_4 emission indices at all powers but also present exhaust concentrations which are always influenced by ambient atmospheric CH_4. Their emission indices are positive at high thrusts only because CH_4 is present in the air used in the aircraft engines. Given their extractive sampling technique, removing the influence of background atmospheric CH4 abundance was not possible, but their emission indices are misleading because background air samples were not characterized. Only the exhaust concentrations are used when comparing across studies in Figure 3.

During the NASA Experiment to Characterize Aircraft Volatile Aerosol and Trace-species Emissions (EXCAVATE), Anderson et al.[26] measured CH_4 with a 1-Hz precision of 1 nmol/mol on the Rolls Royce RB211 535E4 engine using two different JP-5 fuels and reported CH_4 emission concentrations as well as upper limits of emission indices. They chose not to report possibly negative emission indices, as these represent consumption of CH_4, but present exhaust concentrations of CH_4 that are similar to ambient values around 1.8 μmol/mol. Their emission indices are dependent on the instrumental accuracy, which they report as 1% (as opposed to a precision of 0.1%) meaning that nearly all of their reported exhaust CH_4 concentrations are within 20 nmol/mol of ambient CH_4 concentrations. In contrast with direct exhaust canister sampling, the advected plume method employed in this study relies only on the instrument precision, as it is the relative changes in CH_4 that determine emission indices. Our instrument precision is 0.03%. The emission indices of JP-8 fuel during low power during the AAFEX mission were higher by an order of magnitude than during the EXCAVATE mission, most likely attributable to the different engine, fuel, and engine history before sampling. EXCAVATE low power results most closely resemble those of Spicer et al.,[11] while AAFEX low power results are more similar to those of Spicer et al.[12]

One research question that persists in many of these simulated flight engine emission studies is whether the results are representative of actual flight conditions. Vay et al.[22] sought to answer this during the SUCCESS (Subsonic Aircraft: Contrail and Cloud Effects Special Study) campaign by sampling CO, CH_4 (with reported 1-s precision of 1 nmol/mol), N_2O, and H_2O from inlets aboard the NASA DC-8 (the same plane used as the emission source in AAFEX) flying behind a T-39 and B-757 aircraft. They reported that 81% of the plume crossings exhibited

ED_001734_00021049-00005

EPA-HQ-2018-004348

Table 3. Estimates of Total CH_4, N_2O, and CO_2 Emissions for a Simulated Landing-Take-Off (LTO) Cycle and a Simulated 1 h Flight at Cruise Thrust Using JP-8 Fuel[a]

mode	CH_4 emission rate (g/h)	N_2O emission rate (g/h)	CO_2 emission rate (kg/h)	time in mode (hrs)	total CH_4 emitted (g) (CO_2(e) (g))	total N_2O emitted (g) (CO_2(e) (g))	total CO_2 emitted (g)
approach (30% thrust)	57	+64	+3580	0.067	3.8 (95)	+4.3 (1300)	2.4×10^5
taxi (7%)	+30	+40	+1440	0.433	+13 (320)	+17 (5100)	6.2×10^5
take-off (100%)	195	+68	+10 500	0.012	2.3 (60)	+0.8 (240)	1.3×10^5
climb-out (85%)	170	+66	+9300	0.037	6.3 (160)	+2.4 (720)	3.4×10^5
total for ICAO LTO					+0.6 (3)	+25 (7500)	1.3×10^6
cruise (65%)	132	+68	+7000	1	132 (3300)	+68 (2.0×10^4)	7.0×10^6
total for flight					131 (3280)	+93 (2.7×10^4)	8.3×10^6

[a] CH_4 and N_2O are also presented as CO_2(e) for ease of comparison of radiative forcing changes attributed to the emissions relative to CO_2.

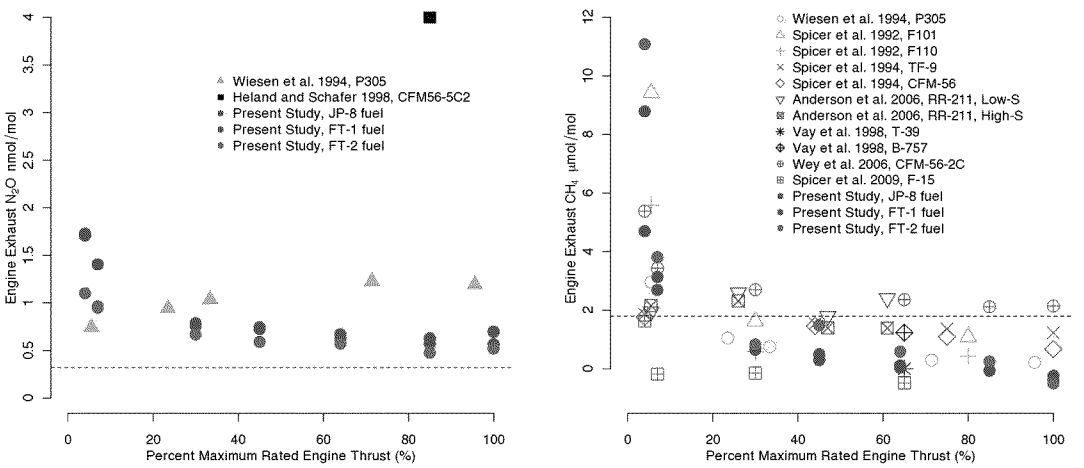


Figure 3. Mean engine exhaust concentrations of CH_4 and N_2O for various aircraft emission studies compared to the present AAFEX study. Atmospheric mixing ratios of CH_4 and N_2O are shown as dashed lines for reference.

a negative correlation between CH_4 and CO_2, illustrating consumption of atmospheric CH_4. Their reported emission indices ranged from 1.6 to 1.2 g CH_4 (kg Fuel) [1], with the positive values attributed to transient engine conditions (i.e., changing from 65% to 85% maximum rated thrust). The range of values observed at AAFEX were much smaller in magnitude than the 1.6 value, though we note that only 12 plumes were quantified during SUCCESS. Their findings further validate previous ground-based simulated flight CH_4 exhaust emission studies. Furthermore, Wiesen et al.[13] showed that CH_4 depletion at high power was observed from aircraft both at a ground-level test facility and at a special altitude-simulation test cell.

It is important to note that aircraft NO_x emissions at altitude have a greater potential to impact global CH_4 budgets than the levels of CH_4 emissions quantified in these various studies, whether positive or negative.[2] Stevenson and Derwent,[27] for instance, used a global lagrangian chemistry transport model to calculate that aircraft NO_x emissions amounting to an integrated pulse of 1 Tg NO_2 at altitude resulted in an eventual removal of 2.5 Tg CH_4 from the system, or less than 0.5% of total CH_4 sink terms. Because high thrust (>30% maximum rated thrust) NO_x emission indices are a factor of ~200 greater than the equivalent magnitude of CH_4 emission indices, the indirect CH_4 consumption due to chemical cycling through NO_x, O_3, OH, etc. affects CH_4 distributions more than the direct CH_4 consumption in the engine.[28]

Two studies differ markedly from the aforementioned experiments and the present AAFEX results. Measurements during the Aircraft Particle Emissions eXperiment (APEX) reported positive CH_4 emission indices at higher engine power (Wey et al. 2006). CH_4 was measured with a multigas analyzer. Due to its relatively broad spectroscopic resolution, this instrument does not have the specificity to CH_4 that other measurement techniques have, and may have been subject to interference from other species present in the exhaust. Spicer et al.[29] also present CH_4 emission indices for both a C-130 aircraft and a F-15 aircraft. The corrigendum to the study[30] noted an error in the algorithm used to calculate emission factors which decreased the CH_4 emission factors by ~15% for the C-130 and changed the sign on the F-15 factors. Only the F-15 emission indices are presented in Figure 3 as the emission factors for the C-130 aircraft are so high that corresponding CH_4 exhaust concentrations at all power settings would be on the order of 20 30 µmol/mol, well beyond the range of the figure. We also note that their equation for determining emission factors effectively removes the CO_2 concentrations measured from the emission factor calculation by assuming that all of the fuel carbon is converted to either CO_2, CO or other hydrocarbons. Because the equation then depends on the emission factors of other chemical species, many of which have much lower measurement precisions, these values are not directly comparable to other CH_4 emission indices, which may be an additional reason why the C-130 values are beyond the range of expected emission indices and exhaust concentrations.

Although low power emissions of CH_4 seem to vary by almost an order of magnitude, these studies agree, with the exception of

ED_001734_00021049-00006

EPA-HQ-2018-004348

Spicer et al.,[30] on the general trend of CH_4 consumption at power conditions greater than idle and taxi, the predominate mode of engine operation. Data presented here further confirms CH_4 emission results from previous aircraft exhaust studies and demonstrates that the adoption of alternative fuels by the airline industry will have negligible end-use effects on these long-lived greenhouse gases. Increased use of fertilizer to produce Fischer Tropsch feedstock, however, may increase the N_2O emissions associated with the total life-cycle emissions from FT fuels.

This AAFEX study, in conjunction with previous CH_4 and N_2O exhaust studies, provides another robust constraint on long-lived greenhouse gas emissions of commercial aircraft engines in operation today. Furthermore, CH_4 emissions are essential to understanding the speciation of total hydrocarbons, a variable more commonly measured during engine certification. Accounting for speciation of organic emissions including CH_4, particularly at low power settings, helps constrain the correct proportions of individual compounds that contribute the most risk to human health and welfare. The measurement precisions of both CH_4 and N_2O presented in this study are the best to date, more than a factor of 2 times better than previous studies. By considering a representative flight LTO cycle, the net contributions to global CH_4 from aviation due to direct CH_4 emissions are negative, indicating a net CH_4 consumption. NO_x emissions at altitude, however, have a greater impact on the global CH_4 budget than direct CH_4 emissions, whether positive or negative.

' ASSOCIATED CONTENT

b Supporting Information. Table S1 with reported values and experimental details corresponding to Figure 3 and Figure S1 which presents histograms of calculated emission indices of CH_4 for each percent maximum rated engine thrust. This material is available free of charge via the Internet at http://pubs.acs.org.

' AUTHOR INFORMATION

Corresponding Author
*E-mail: gsantoni@gmail.com.

Present Addresses
[§]School of Public Health and Health Sciences, University of Massachusetts at Amherst, Amherst, Massachusetts, United States.

' ACKNOWLEDGMENT

Parts of this reasearch are supported by the Department of Energy, Small Business Innovation Research Award DE-FG02-07ER84889, the PARTNER Center of Excellence (jointly sponsored by the FAA, NASA and Transport Canada) via Missouri University of Science and Technology, and the National Science Foundation Graduate Research Fellowship Program. The authors also greatly acknowledge W. Berk Knighton of Montana State University, Michael T. Timko and Zhenhong Yu of Aerodyne Research Inc., and Changlie Wey of ASRC Aerospace Corp. They would also like to thank Bruce Anderson, Robert Howard, Dan Bulzan, Frank Cutler, Mike Bereda, members of the Air Force Research Lab, and the entire DC-8 crew that made these measurements possible. They are also grateful for the comments and suggestions of the reviewers.

' REFERENCES

(1) Lelieveld, J.; Crutzen, P. J.; Dentener, F. J. Changing concentration, lifetime and climate forcing of atmospheric methane. Tellus, Ser. B 1998, 50, 128–150.

(2) Denman, K., Brasseur, G.; Chidthaisong, A.; Ciais, P.; Cox, P.; Dickinson, R.; Hauglustaine, D.; Heinze, C.; Holland, E.; Jacob, D.; Lohmann, U.; Ramachandran, S.; P. da Silva Dias, Wofsy, S.; , Zhang, X. Couplings Between Changes in the Climate System and Biogeochemistry. In Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: New York, 2007.

(3) Quay, P.; Stutsman, J.; Wilbur, D.; Snover, A.; Dlugokencky, E.; Brown., T. The isotopic composition of atmospheric methane. Global Biogeochem. Cycles. 1999, 13, 445–461.

(4) Prather, M. J. Time scales in atmospheric chemistry: Coupled perturbations to N_2O, NO_y, and O_3. Science 1998, 279, 1339–1341.

(5) Lassey, K. R.; Etheridge, D. M.; Lowe, D. C.; Smith, A. M.; Ferretti, D. F. Centennial evolution of the atmospheric methane budget: what do the carbon isotopes tell us? Atmos. Chem. Phys. 2007, 7, 2119–2139.

(6) Dlugokencky, E. J.; Bruhwiler, L.; White, J. W. C.; Emmons, L. K.; Novelli, P. C.; Montzka, S. A.; Masarie, K. A.; Lang, P. M.; Crotwell, A. M.; Miller, J. B.; Gatti, L. V. Observational constraints on recent increases in the atmospheric CH_4 burden. Geophys. Res. Lett. 2009, 36, L18803.

(7) Rigby, M.; Prinn, R. G.; Fraser, P. J.; Simmonds, P. G.; Langenfelds, R. L.; Huang, J.; Cunnold, D. M.; Steele, L. P.; Krummel, P. B.; Weiss, R. F O'Doherty, S.; Salameh, P. K.; Wang, H. J.; Harth, C. M.; Muhle, J.; Porter, L. W. Renewed growth of atmospheric methane. Geophys. Res. Lett. 2008, 35, 6.

(8) Kroeze, C.; Mosier, A.; Bouwman, L. Closing the global N_2O budget: A retrospective analysis 1500 1994. Global Biogeochem. Cycles 1999, 13, 1–8.

(9) Brasseur, G. P.; Cox, R. A.; Hauglustaine, D.; Isaksen, I.; Lelieveld, J.; Lister, D. H.; Sausen, R.; Schumann, U.; Wahner, A.; Wiesen, P. European scientific assessment of the atmospheric effects of aircraft emissions. Atmos. Environ. 1998, 32, 2329–2418.

(10) Prather, M. J.; Hsu, J. Coupling of Nitrous Oxide and Methane by Global Atmospheric Chemistry. Science. 2010, 330, 952–954.

(11) Spicer, C.; Holdren, M.; Smith, D.; Hughes, D.; Smith, M. Chemical composition of exhaust from aircraft turbine engines. J. Eng. Gas Turbines Power. 1992, 114, 111–117.

(12) Spicer, C.; Holdren, M.; Riggin, R.; Lyon, T. Chemical composition and photochemical reactivity of exhaust from aircraft turbine engines. Ann. Geophys. 1994, 12, 944–955.

(13) Wiesen, P. J.; Kleffmann, J.; Kurtenbach, R.; Becker, K. Nitrous oxide and methane emissions from aero engines. Geophys. Res. Lett. 1994, 21, 2027–2030.

(14) Laird, C. K.; Sloan, S. A. Nitrous-oxide emissions from U.K. power-stations. Atmos. Environ., Part A 1993, 27, 1453–1457.

(15) Dlugokencky, E. J.; Masarie, K. A.; Lang, P. M.; Tans, P. P. Continuing decline in the growth rate of the atmospheric methane burden. Nature. 1998, 393, 447–450.

(16) Anderson, B. E.; et al. Alternative Aviation Fuel Experiment (AAFEX), NASA TM-2011-217059, 2011.

(17) Tuzson, B.; Mohn, J.; Zeeman, M. J.; Werner, R. A.; Eugster, W.; Zahniser, M. S.; Nelson, D. D.; McManus, J. B.; Emmenegger, L. High precision and continuous field measurements of delta C-13 and delta O-18 in carbon dioxide with a cryogen-free QCLAS. Appl. Phys. B: Lasers Opt. 2008, 92, 451–458.

(18) Zahniser, M. S., Nelson, D. D.; McManus, J. B.; Herdon, S. C.; Wood, E. C.; Shorter, J. H.; Lee, B. H.; Santoni, G. W.; Jimnez, R.; Daube, B. C.; Park, S.; Kort, E. A.; , Wofsy, S. C.; . Infrared qc laser applications to field measurements of atmospheric trace gas sources and sinks in environmental research: enhanced capabilities using continuous wave QCLS. SPIE 2009, 7222; DOI: 10.1117/12.815172.

ED_001734_00021049-00007

EPA-HQ-2018-004348

(19) Lee, B. H.; Wood, E. C.; Zahniser, M. S.; McManus, J. B.; Nelson, D. D.; Herdon, S. C.; Santoni, G. W.; Wofsy, S. C.; Munger, J. W. Simultaneous measurements of atmospheric HONO and NO_2 via absorption spectroscopy using tunable mid-infrared continous-wave quantum cascade lasers. Appl. Phys. B: Lasers Opt. 2010, 102, 417–423.

(20) Wey, C. C., Anderson, B. E.; Hudgins, C.; Wey, C.; X. Li-Jones, Winstead, E.; Thornhill, L. K.; Lobo, P.; Hagen, D.; Whitefield, P.; Yelvington, P. E.; Herndon, S. C.; Onasch, T. B.; R. C. Miake-Lye, Wormhoudt, J. W.; Knighton, B.; Howard, R.; Bryant, D.; Corporan, E.; Moses, C.; Holve, D.; , Dodds, W.; . Aircraft particle emissions experiment (APEX), NASA/TM-2006-214382. 2006; DOI: 10.1117/12.815172.

(21) Herndon, S.; Shorter, J.; Zahniser, M.; Nelson, D.; Jayne, J.; Brown, R.; Miake-Lye, R. C.; Waitz, I.; Silva, P.; Lanni, T.; Demerjian, K.; Kolb., C. NO and NO_2 emission ratios measured from in-use commercial aircraft during taxi and takeoff. Environ. Sci. Technol. 2004, 38, 6078–6084.

(22) Vay, S.; Anderson, B.; Sachse, G. W.; Collins, J. E.; Podolske, J. R.; Twohy, C. H.; Gandrud, B.; Chan, K. R.; Baughcum, S. L.; Wallio, H. A. DC-8-based observations of aircraft CO, CH_4, N_2O, and $H_2O(g)$ emission indices during SUCCESS. Geophys. Res. Lett. 1998, 25, 1717–1720.

(23) Yelvington, P. E.; Herndon, S. C.; Wormhoudt, J. C.; Jayne, J. T.; Miake-Lye, R. C.; Knighton, W. B.; Wey, C. Chemical speciation of hydrocarbon emissions from a commercial aircraft engine. J. Propul. Power 2007, 23, 912–918.

(24) Heland, J.; Schafer, K. Determination of major combustion products in aircraft exhausts by FTIR emission spectroscopy. Atmos. Environ. 1998, 32, 3067–3072.

(25) Zheng, J.; Weinheimer, A. J.; Ridley, B. A.; Liu, S. C.; Sachse, G. W.; Anderson, B. E.; Collins, J. E. An analysis of aircraft exhaust plumes from accidental encounters. Geophys. Res. Lett. 1994, 21, 2579–2582.

(26) Anderson, B.; Chen, G.; Blake, D. Hydrocarbon emissions from a modern commercial airliner. Atmos. Environ. 2006, 40, 3601–3612.

(27) Stevenson, D. S.; Derwent, R. G. Does the location of aircraft nitrogen oxide emissions affect their climate impact? Geophys. Res. Lett. 2009, 36, L17810.

(28) Stevenson, D. S.; Doherty, R. M.; Sanderson, M. G.; Collins, W. J.; Johnson, C. E.; Derwent, R. G. Radiative forcing from aircraft NOx emissions: Mechanisms and seasonal dependence. J. Geophys. Res., [Atmos.] 2004, 109, D17.

(29) Spicer, C. W.; Holdren, M. W.; Cowen, K. A.; Joseph, D. W.; Satola, J.; Goodwin, B.; Mayfield, H.; Laskin, A.; Alexander, M. L.; Ortega, J. V.; Newburn, M.; Kagann, R.; Hashmonay, R. Rapid measurement of emissions from military aircraft turbine engines by downstream extractive sampling of aircraft on the ground: Results for C-130 and F-15 aircraft. Atmos. Environ. 2009, 43, 2612–2622.

(30) Spicer, C. W.; Holdren, M. W.; Cowen, K. A.; Joseph, D. W.; Satola, J.; Goodwin, B.; Mayfield, H.; Laskin, A.; Alexander, M. L.; Ortega, J. V.; Newburn, M.; Kagann, R.; Hashmonay, R. Corrigendum to: Rapid measurement of emissions from military aircraft turbine engines by downstream extractive sampling of aircraft on the ground: Results for C-130 and F-15 aircraft. Atmos. Environ. 2009, 43, 6120–6120.

ED_001734_00021049-00008

To: Audette, Lucie[audette.lucie@epa.gov]
Cc: Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]
From: Manning, Bryan
Sent: Fri 7/10/2015 6:20:05 PM
Subject: FW: Materials for aircraft meetings next Monday and Tuesday
FAA-EPA CO2 Standard briefing_10 July 2015_final.docx
Notes for Call with Rich Swayze 7-13-15.docx

FYI, see below/attached. Thanks. Bryan

From: Hengst, Benjamin
Sent: Friday, July 10, 2015 1:55 PM
To: Charmley, William; Samulski, Michael; Manning, Bryan
Cc: Grundler, Christopher
Subject: FW: Materials for aircraft meetings next Monday and Tuesday

Just so you have what is being sent forward for next week.

Thanks,

Ben

From: Hengst, Benjamin
Sent: Friday, July 10, 2015 1:50 PM
To: OAR Briefings
Cc: Sutton, Tia
Subject: Materials for aircraft meetings next Monday and Tuesday

Hello,

Ex. 5 - Deliberative Process

Thanks,

Ben

To: Thrasher, Theodore[TThrasher@icao.int]
Cc: Dickson, Neil[NDickson@icao.int]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Chris Eyers
Sent: Wed 4/1/2015 4:47:17 PM
Subject: RE: Communication of CO2 Effectiveness Next Steps
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft6+CL (alternate).docx

Ted,

Ex. 5 - Deliberative Process

Thanks

Chris

From: Leggett, Cullen [mailto:Leggett.Cullen@epa.gov]
Sent: 01 April 2015 17:15
To: Thrasher, Theodore; Chris Eyers
Cc: Dickson, Neil
Subject: RE: Communication of CO2 Effectiveness Next Steps

Ex. 5 - Deliberative Process

Cullen

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: Tuesday, March 31, 2015 11:26 AM
To: Chris Eyers; Leggett, Cullen
Cc: Dickson, Neil
Subject: RE: Communication of CO2 Effectiveness Next Steps

Ex. 5 - Deliberative Process

Thanks,

Ted

From: Thrasher, Theodore

Sent: 30-Mar-15 5:06 PM
To: 'Chris Eyers'; Leggett, Cullen
Cc: Dickson, Neil
Subject: RE: Communication of CO2 Effectiveness Next Steps

Hi Chris and Cullen,

Ex. 6 - Personal Privacy

Thanks,

Ted

From: Chris Eyers [mailto:chris@limitedskies.com]
Sent: 30-Mar-15 4:17 PM
To: Thrasher, Theodore
Cc: Leggett, Cullen; Dickson, Neil
Subject: RE: Communication of CO2 Effectiveness Next Steps

Ted,

Ex. 5 - Deliberative Process

Chris

Sent from Outlook

From: Thrasher, Theodore <tthrasher@icao.int>
Sent: Monday, March 30, 2015 22:08
Subject: RE: Communication of CO2 Effectiveness Next Steps
To: Leggett, Cullen <leggett.cullen@epa.gov>, Chris Eyers <chris@limitedskies.com>
Cc: Dickson, Neil <ndickson@icao.int>

Cullen and Chris,

Ex. 5 - Deliberative Process

Thanks,

Ted

From: Leggett, Cullen [mailto:Leggett.Cullen@epa.gov]
Sent: 30-Mar-15 1:35 PM
To: Thrasher, Theodore
Cc: Chris Eyers
Subject: RE: Communication of CO2 Effectiveness Next Steps

Ted,

Ex. 5 - Deliberative Process

Cullen

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: Thursday, March 26, 2015 3:00 PM
To: chris@limitedskies.com; Dickson, Neil; Peterson B (rmpaero@frontier.com); Adam M; Olivier.husse@airbus.com; Anastasia Kharina; tpohle@airlines.org; Leggett, Cullen
Subject: Communication of CO2 Effectiveness Next Steps

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Kind regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

Anastasia Kharina
karin@theicct.org | (415) 202-5738
The International Council on Clean Transportation
One Post Street, San Francisco CA 94104
www.theicct.org

On Dec 3, 2014, at 12:30 PM, "Leggett, Cullen" <Leggett.Cullen@epa.gov> wrote:

Karin,

Were you able to touch base with Paul yet?

Cullen Leggett
734-214-4514

From: Leggett, Cullen
Sent: Monday, December 01, 2014 3:26 PM
To: 'Anastasia Kharina'
Subject: RE: Case 1 paper

I'm glad to hear we are on the same page. E6 is the appropriate graph to show. As we are currently modeling it, all of the fuelburn savings are attributable to the standard, thus they should be included in E6 and E7.

I think we likely should be subtracting some portion of fuel that would be improved in a BAU scenario. But since we currently are not allowed/don't know how to model that, everything should go in.

Yes I am going to be participating in that. I'm going to have to review my PATR stuff. I'm pretty rusty on it. I'm interested to see how they are going to suggest we model this without having to redo the modeling. I'm also a bit confused on their thought that PATR and the incremental build cost are different. Shouldn't an increased airplane cost, include any incremental build costs?

Are you going to participate? It could actually be beneficial to not have a big background. Then you can recognize when truly ridiculous things are being proposed that. Lol

From: Anastasia Kharina [mailto:karin@theicct.org]
Sent: Monday, December 01, 2014 2:10 PM
To: Leggett, Cullen
Subject: Re: Case 1 paper

Yes, it's already in my agenda to reach out to him and try to convince him to take it off.

I personally think we have a better chance to work on Figure E6. Will keep you updated on this one.

On a different note: are you thinking about participating in the PATR talk? I think it's ridiculous that we are coming back to this, but I don't think I have a good enough background / expertise to contribute.

Karin

Anastasia Kharina
karin@theicct.org | (415) 202-5738
The International Council on Clean Transportation
One Post Street, San Francisco CA 94104
www.theicct.org

On Dec 1, 2014, at 10:43 AM, Anastasia Kharina <karin@theicct.org> wrote:

If you are talking about Figure E.2.4, I'm afraid that I would have to get back to you after discussing with Paul Peeters (he's the one that proposed this, and we unfortunately didn't have time to sit down and look at the resulting graph before it went out). Is this what you wanted to discuss?

Anastasia Kharina
karin@theicct.org | (415) 202-5738
The International Council on Clean Transportation
One Post Street, San Francisco CA 94104
www.theicct.org

On Dec 1, 2014, at 10:38 AM, "Leggett, Cullen" <Leggett.Cullen@epa.gov> wrote:

No I don't think so. I'm mostly just wanting to get a better handle on your alternative cost plots and why you are thinking that is a better way to show the data.

From: Anastasia Kharina [mailto:karin@theicct.org]
Sent: Monday, December 01, 2014 1:37 PM
To: Leggett, Cullen
Subject: Re: Case 1 paper

3 is fine.
I don't think this would take too long, do you?

Anastasia Kharina
karin@theicct.org | (415) 202-5738
The International Council on Clean Transportation
One Post Street, San Francisco CA 94104
www.theicct.org

On Dec 1, 2014, at 10:36 AM, "Leggett, Cullen" <Leggett.Cullen@epa.gov> wrote:

Haha happens, that would be the one other time I have a meeting today. 3? Or do you want to do 4 so you can have lunch?

From: Anastasia Kharina [mailto:karin@theicct.org]
Sent: Monday, December 01, 2014 1:32 PM
To: Leggett, Cullen
Subject: Re: Case 1 paper

Looks like we're playing tag.
I thought you were having lunch, so I made my way to the office.
Would 2pm eastern work?

Karin

Anastasia Kharina
karin@theicct.org | (415) 202-5738

The International Council on
Clean Transportation
One Post Street, San Francisco
CA 94104
www.theicct.org

On Dec 1, 2014, at 9:36 AM,
"Leggett, Cullen"
<Leggett.Cullen@epa.gov>
wrote:

Give me like 30 to eat
lunch? 1 eastern, 10
pacific?

From: Anastasia
Kharina
[mailto:karin@theicct.org]
Sent: Monday,
December 01, 2014
12:19 PM
To: Leggett, Cullen
Subject: Re: Case 1
paper

Yes,
should I call you
now?

Karin

Anastasia Kharina
karin@theicct.org |
(415) 202-5738
The International
Council on Clean
Transportation
One Post Street,
San Francisco CA
94104
www.theicct.org

On Dec 1, 2014, at 9:17 AM, "Leggett, Cullen" <Leggett.Cullen@epa.gov> wrote:

Karin,

Do you have a few minutes to talk today? I have a couple of questions about the ICSA comments on the Case 1 paper.

Thanks,
Cullen
734-214-4514

To: Richard Billings[Richard.Billings@erg.com]
Cc: James Chesnut[James.Chesnut@erg.com]; Jennifer Sellers[Jennifer.Sellers@erg.com]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Yen, David[Yen.David@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Mon 3/30/2015 4:12:01 PM
Subject: FW: Revised ERG report - GA GHG jet fuel breakout (OAP Comments)
Documentation Small Jet Review Process_LJ.docx
GHG Small Jet Inventory-3-20-15 master-tracked_LJ.docx

Hello Richard,

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Jantarasami, Lesley
Sent: Friday, March 27, 2015 4:46 PM
To: Manning, Bryan
Cc: Audette, Lucie
Subject: RE: Revised ERG report - GA GHG jet fuel breakout

Hi Bryan,

Ex. 5 - Deliberative Process

Lesley

From: Manning, Bryan
Sent: Thursday, March 26, 2015 6:11 PM
To: Jantarasami, Lesley
Cc: Audette, Lucie
Subject: FW: Revised ERG report - GA GHG jet fuel breakout

Hello Lesley,

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Manning, Bryan
Sent: Monday, March 23, 2015 1:44 PM
To: Jantarasami, Lesley
Cc: Audette, Lucie
Subject: Revised ERG report - GA GHG jet fuel breakout

Hello Lesley,

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Richard Billings [mailto:Richard.Billings@erg.com]
Sent: Monday, March 23, 2015 12:05 PM
To: Manning, Bryan; Maeroff, Bruce; Yen, David
Cc: Jody Tisano; James Chesnut; Jennifer Sellers
Subject: FW: Files attached...

Bryan,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Richard

Richard Billings
Eastern Research Group
1600 Perimeter Park Drive, Morrisville, NC 27560
(919) 468-7812

To: Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Wed 10/29/2014 12:53:14 PM
Subject: FW: Options selection pre-brief for Sarah (for 9:30 call this morning)
Options Selection_Aircraft for Sarah_10-29-14_final.pptx

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Jantarasami, Lesley
Sent: Tuesday, October 28, 2014 5:38 PM
To: Audette, Lucie; Manning, Bryan; Hengst, Benjamin
Subject: FW: Options selection pre-brief for Sarah

Ex. 5 - Deliberative Process

Thanks,

Lesley

From: Jantarasami, Lesley
Sent: Tuesday, October 28, 2014 5:36 PM
To: Gunning, Paul
Cc: Rona Birnbaum; Kocchi, Suzanne
Subject: Options selection pre-brief for Sarah

Hello Paul,

Ex. 5 - Deliberative Process

Thanks,

Lesley

Lesley Jantarasami

U.S. EPA, Climate Change Division

jantarasami.lesley@epa.gov

(202)-343-9929

To: Audette, Lucie[audette.lucie@epa.gov]; Birnbaum, Rona[Birnbaum.Rona@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; DeAngelo, Ben[DeAngelo.Ben@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Schillo, Bruce[Schillo.Bruce@epa.gov]; Benner, Tim[Benner.Tim@epa.gov]; Dutton, Steven[Dutton.Steven@epa.gov]; McDow, Stephen[McDow.Stephen@epa.gov]; Sarofim, Marcus[Sarofim.Marcus@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Wolverton, Ann[Wolverton.Ann@epa.gov]; Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Gordon, Jessica M[Gordon.Jessica@epa.gov]; Hockstad, Leif[Hockstad.Leif@epa.gov]; Williams, Melina[Williams.Melina@epa.gov]
From: Jantarasami, Lesley
Sent: Thur 9/4/2014 9:52:53 PM
Subject: RE: Aircraft GHG Workgroup Update
20140828_Aircraft final ABP.docx

Ex. 5 - Deliberative Process

Best,

Lesley

From: Audette, Lucie
Sent: Thursday, September 04, 2014 11:46 AM
To: Birnbaum, Rona; Samulski, Michael; Manning, Bryan; DeAngelo, Ben; Thrift, Mike; Schillo, Bruce; Benner, Tim; Dutton, Steven; McDow, Stephen; Sarofim, Marcus; Leggett, Cullen; Wolverton, Ann; Yen, David; Maeroff, Bruce; Gordon, Jessica M; Hockstad, Leif; Williams, Melina; Audette, Lucie
Cc: Jantarasami, Lesley
Subject: Aircraft GHG Workgroup Update

Dear workgroup members,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

--Lucie & Lesley

To: Birnbaum, Rona[Birnbaum.Rona@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; DeAngelo, Ben[DeAngelo.Ben@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Schillo, Bruce[Schillo.Bruce@epa.gov]; Benner, Tim[Benner.Tim@epa.gov]; Dutton, Steven[Dutton.Steven@epa.gov]; McDow, Stephen[McDow.Stephen@epa.gov]; Sarofim, Marcus[Sarofim.Marcus@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Wolverton, Ann[Wolverton.Ann@epa.gov]; Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Gordon, Jessica M[Gordon.Jessica@epa.gov]; Hockstad, Leif[Hockstad.Leif@epa.gov]; Williams, Melina[Williams.Melina@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
Cc: Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]
From: Audette, Lucie
Sent: Thur 9/4/2014 3:46:17 PM
Subject: Aircraft GHG Workgroup Update
ICAO Aviation GHG Announcement - Roll out - v8 - FINAL.docx
Task Descript ERG WA_GA Jet Fuel GHG Inv 8-14-14b.docx

Dear workgroup members,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

--Lucie & Lesley

To: Chris Eyers[chris@limitedskies.com]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Chris Eyers
Sent: Fri 3/27/2015 12:34:52 PM
Subject: RE: Effectiveness - next steps?
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft5+cjeV2.docx

Ex. 5 - Deliberative Process

Thanks

Chris

From: Chris Eyers
Sent: 27 March 2015 13:19
To: 'Leggett (leggett.cullen@epa.gov)'
Subject: RE: Effectiveness - next steps?
Importance: High

Cullen,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks

Chris

+44 7771 965638

From: Chris Eyers
Sent: 27 March 2015 10:50
To: Leggett (leggett.cullen@epa.gov)
Subject: Effectiveness - next steps?
Importance: High

Morning Cullen,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Best regs

Chris

Chris Eyers

Mobile: +44 7771 965638

To: chris@limitedskies.com[chris@limitedskies.com]; Dickson, Neil[NDickson@icao.int]; Peterson B (rmpaero@frontier.com)[rmpaero@frontier.com]; Adam M[adamm@iata.org]; Olivier.husse@airbus.com[Olivier.husse@airbus.com]; Anastasia Kharina[karin@theicct.org]; tpohle@airlines.org[tpohle@airlines.org]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Thrasher, Theodore
Sent: Thur 3/26/2015 6:59:41 PM
Subject: Communication of CO2 Effectiveness Next Steps
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft5.docx

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Kind regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: chris@limitedskies.com[chris@limitedskies.com]; Dickson, Neil[NDickson@icao.int]; Peterson B (rmpaero@frontier.com)[rmpaero@frontier.com]; Adam M[adamm@iata.org]; Olivier.husse@airbus.com[Olivier.husse@airbus.com]; Anastasia Kharina[karin@theicct.org]; tpohle@airlines.org[tpohle@airlines.org]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Thrasher, Theodore
Sent: Wed 3/25/2015 9:34:02 PM
Subject: CO2 Effectiveness Communication Call 26 March
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft4.docx

Hello Everyone,

Ex. 5 - Deliberative Process

Ex. 6 - Personal Privacy

Ex. 6 - Personal Privacy

Best regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Thrasher, Theodore[TThrasher@icao.int]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Chris Eyers
Sent: Wed 3/25/2015 4:16:27 PM
Subject: RE: Draft Report of CO2 Effectiveness Comms ad hoc group
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft3 +CJE.docx

Ted, Cullen,

Ex. 5 - Deliberative Process

Chris

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: 25 March 2015 15:48
To: Leggett (leggett.cullen@epa.gov); Chris Eyers
Subject: Draft Report of CO2 Effectiveness Comms ad hoc group

Cullen and Chris,

Ex. 5 - Deliberative Process

Thanks,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Giannelli, Bob[Giannelli.Bob@epa.gov]; Guerra, Zuimdie[Guerra.Zuimdie@epa.gov]; Hoyer, Marion[hoyer.marion@epa.gov]; Kraft, Isobel[Kraft.Isobel@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Mueller, John[mueller.john@epa.gov]; Passavant, Glenn[passavant.glenn@epa.gov]; Pedde, Meredith[pedde.meredith@epa.gov]; Reichle, Lawrence[Reichle.Lawrence@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Yen, David[Yen.David@epa.gov]
From: Maeroff, Bruce
Sent: Fri 1/31/2014 1:04:42 PM
Subject: European Parliament Panel Advances Limited Re-inclusion of International Aviation in ETS

European Parliament Panel Advances Limited Re-inclusion of International Aviation in ETS

By Stephen Gardner

Jan. 30 — The European Parliament's Environment Committee on Jan. 30 backed the temporary re-inclusion of intercontinental airlines in the European Union's Emissions Trading System (ETS) for the portions of their flights that cross EU territory, potentially reigniting a disagreement between the EU and the U.S. on the extent to which the ETS should cover aviation.

At a meeting in Brussels, committee members voted 46-6 with one abstention to open talks on the measure with the EU Council, which represents the governments of EU member states. The committee also approved draft measures on the monitoring of greenhouse gas emissions from shipping and on restriction of fluorinated gases with high global warming potential.

On aviation, the committee supported a proposal published by the European Commission in October 2013 to amend the EU ETS Directive (2003/87/EC) so that flights that take off from or land at EU airports are included in the ETS for the portion of each flight that takes place in EU airspace. The measure would apply no matter what the country of origin of the airline involved (201 DEN A-2, 10/17/13).

Aviation was first included in the ETS under a 2008 directive (2008/101/EC) that amended the 2003 ETS Directive and required airlines to obtain sufficient carbon allowances to cover the entirety of their flights to and from EU airports. However, this full coverage requirement was temporarily suspended in the face of opposition from the U.S., China, India, Russia and a number of other countries that said that cuts to aviation emissions should be agreed on within the International Civil Aviation Organization (ICAO).

The commission's 2013 proposal was designed to replace the measure suspending the inclusion of international flights in the ETS with a compromise solution.

Participants in the ETS, which covers power plants and heavy industry as well as aviation, are subject to an overall greenhouse gas emissions cap and each year must surrender sufficient carbon allowances to cover their emissions.

Measure Would Last Through 2016

The Environment Committee lawmakers modified the commission's October 2013 proposal on aviation emissions by making it temporary until 2016, the year by which ICAO, at its 38th assembly, agreed to adopt a market-based system to cut aviation emissions, which would come into effect in 2020 (194 DEN A-9, 10/7/13).

In addition, the committee said revenues from the sale of carbon allowances to airlines should be spent on climate change mitigation efforts decided on at the international level.

Peter Liese, a German center-right lawmaker who is responsible for seeing the aviation ETS dossier through the European Parliament, said in a statement that the non-inclusion of the portions of flights outside EU airspace should continue only through 2016 because "we need to be prepared to fully implement our scheme after 2016 in case there is no global agreement" within ICAO.

If an ICAO agreement is finalized in 2016, new EU legislation could be adopted that exempts airlines from the EU ETS on the basis that they are included in an ICAO scheme with equivalent effect, according to the Environment Committee position.

Liese said the earmarking of revenues for international climate mitigation projects is "important to get third countries included in the process. We need to try to get acceptance for the airspace approach and pave the way for a real effective international agreement."

Liese added that "in my meetings with third countries I always hear the argument that the revenues are reserved for the national finance ministers in the EU member states. This is a weak point in our legislation which Parliament intends to change."

May Deadline to Implement Measure

The current, temporary measure exempting international flights from the EU ETS lasts until May 1. If a new law is not finalized by this date, international airlines would be bound by the 2008 law including aviation in the ETS to surrender carbon allowances to cover all their 2013 emissions for flights into, out of and within the EU.

The full European Parliament is scheduled to vote April 3 on the amending directive that will restrict coverage of international flights to EU airspace. This could allow finalization of the measure before the end of April.

It is unclear, however, if the countries that protested the original EU plan to include all international flights within the ETS will accept the revised law.

Members of the U.S. House Transportation and Infrastructure Committee in November asked Transportation Secretary Anthony Foxx to keep U.S. airlines out of the ETS pending the development of an international scheme by ICAO (227 DEN A-15, 11/25/13).

Airlines Concerned About Retaliation

The Association of European Airlines (AEA), which represents airlines including British Airways, KLM, Lufthansa and Turkish Airlines, said in a statement Jan. 30 that the continued inclusion of intercontinental flights in the ETS, even if restricted to the portions within EU airspace, "will jeopardize progress at ICAO level."

"If the international controversy around the EU ETS continues, EU-registered airlines serving destinations beyond the EU could be exposed to retaliatory measures," the AEA said.

Transport & Environment (T&E), an environmental advocacy group, said that covering flights only in EU airspace would cover only 35 percent of the emissions that would have been covered if intercontinental flights were included in their entirety.

Bill Hemmings, T&E aviation manager, said the Environment Committee vote "reinforces EU sovereignty."

Shipping Emissions

Separately, the Environment Committee voted 44-6 with five abstentions in favor of a draft regulation, published by the European Commission in June 2013, that would require shipping companies using EU ports to monitor and report their greenhouse gas emissions (126 DEN A-6, 7/1/13).

The requirement would apply starting in January 2018, and would cover emissions of carbon dioxide and nitrogen oxides from ships of 400 gross metric tons or more, whatever their country of origin.

The regulation would be reviewed if there is any agreement within the International Maritime Organization to regulate greenhouse gas emissions from shipping.

The Environment Committee said European Parliament negotiators should seek agreement with the EU Council on the draft regulation, with any agreement potentially being put to a vote of the full Parliament in mid-April.

Green Light for F-Gas Revision

The Environment Committee also voted 46-1 with three abstentions to advance a draft revision of a 2006 EU regulation on fluorinated gases (the F-gas Regulation, (EC) No. 842/2006).

The update to the F-gas Regulation would limit sales of hydrofluorocarbons (HFCs) in the EU to 21 percent of their current level by 2030, and would progressively ban f-gases in a range of equipment, including commercial refrigeration by 2022 and stationary air conditioning by 2025.

The revision of the regulation has already been informally agreed on between the European Parliament and EU Council (244 DEN A-13, 12/19/13).

The full European Parliament is scheduled to vote to finalize it March 11, and the EU Council

will formally adopt it thereafter.

Andrea Voigt, the director general of the European Partnership for Energy and the Environment, an industry group representing companies involved in refrigeration such as DuPont, GE, Honeywell and Mitsubishi, welcomed the vote and said the revised F-gas Regulation "will help industry move towards alternative solutions in a safe and efficient way."

To contact the reporter on this story: Stephen Gardner in Brussels at correspondents@bna.com

To contact the editor responsible for this story: Larry Pearl at lpearl@bna.com

Bruce Maeroff

Senior Service America, Inc.

Supporting the U.S. EPA through a Cooperative

Agreement under the SEE Program,

Assessment and Standards Division,

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105 U.S.A.

Cube N130

ph (734) 214-4304 fax (734) 214-4816

maeroff.bruce@epa.gov

To: Samulski, Michael[samulski.michael@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Mueller, John
Sent: Wed 1/28/2015 8:34:38 PM
Subject: FW: CAEP/10 WG3 Meeting 8 CTG Papers - final

CAEP10_WG3-8_CTG-8_WP05 [Status of Work on Impacts of Naphthalene] 150128.pdf
CAEP10_WG3-8_CTG-8_WP06 [ETM Guidance text] 150128.docx
CAEP10_WG3-8_CTG-8_WP07 [ICCAIA Focus Teams].docx
CAEP10_WG3-8_CTG-8_WP07 [ICCAIA Focus Teams].pdf
CAEP10_WG3-8_CTG-8_WP08 [Doc9889-Update_2015-01-22].docx
CAEP10_WG3-8_CTG-8_WP08 [Doc9889-Update_2015-01-22].pdf
CAEP10-WG3-PMTG8-WP12 [A-PRIDE_7_fuel_sensitivity_test results].pdf
2015-1-23_Doc9889_complete_redline.docx
2015-1-23_Doc9889_complete_redline.pdf
CAEP10_WG3-8_CTG-8_IP01 [List of Papers] 150128.docx
CAEP10_WG3-8_CTG-8_IP01 [List of Papers] 150128.pdf
CAEP10_WG3-8_CTG-8_IP02 [napthalene closer look].docx
CAEP10_WG3-8_CTG-8_IP02 [napthalene closer look].pdf
CAEP10_WG3-8_CTG-8_IP03 [WG3 ad-hoc group telecon schedule_141208] 150128.pdf
CAEP10_WG3-8_CTG-8_IP03 [WG3 ad-hoc group telecon schedule_141208] 150128.xlsx
CAEP10_WG3-8_CTG-8_WP01 [Agenda Draft] 150128.docx
CAEP10_WG3-8_CTG-8_WP01 [Agenda Draft] 150128.pdf
CAEP10_WG3-8_CTG-8_WP02 [DRAFT Report of CTG-7 Meeting] 150128.docx
CAEP10_WG3-8_CTG-8_WP02 [DRAFT Report of CTG-7 Meeting] 150128.pdf
CAEP10_WG3-8_CTG-8_WP03 [Progress of CTG Work] 150128.docx
CAEP10_WG3-8_CTG-8_WP03 [Progress of CTG Work] 150128.pdf
CAEP10_WG3-8_CTG-8_WP04 [Applicability concepts and options] 150128.docx
CAEP10_WG3-8_CTG-8_WP04 [Applicability concepts and options] 150128.pdf
CAEP10_WG3-8_CTG-8_WP05 [Status of Work on Impacts of Naphthalene] 150128.docx

Here are the CTG papers, in case you want to look them over. If you only look at one, make it WP04 (applicability concepts).

From: Nicole.Didyk@faa.gov [mailto:Nicole.Didyk@faa.gov]
Sent: Wednesday, January 28, 2015 3:27 PM
To: ajaria96@yahoo.co.id; benjamin.gardette@dassault-aviation.com; daniel.m.allyn@boeing.com; dax.au@airbus.com; Nicole.Didyk@faa.gov; domingo.sepulveda@pw.utc.com; erika.herms@easa.europa.eu; frank.viele@tc.gc.ca; fuji@chofu.jaxa.jp; fujiwara.hitoshi@jaxa.jp; warren.gillette@faa.gov; Ralph.Iovinelli@faa.gov; jcondevaux@williams-int.com; jean-luc.kittery@aviation-civile.gouv.fr; jonathan.gilad@aviation-civile.gouv.fr; joseph.burguburu@snecma.fr; joseph.zelina@ge.com; kian.mccaldon@pwc.ca; Maeroff, Bruce; martin.plohr@dlr.de; martin.schaefer@dlr.de; michael.lunter@minienm.nl; Mueller, John; NDickson@icao.int; olivier.penanhoat@snecma.fr; paul.madden@rolls-royce.com; ricardo.dupont@anac.gov.br; roger.worth@dft.gsi.gov.uk; rudolph.dudebout@honeywell.com; sebastien.harquel@embraer.com.br; Stephen.Arrowsmith@easa.europa.eu; theo.rindlisbacher@bazl.admin.ch; tsuboi.katsutoshi@gmail.com; wendy.bailey@tc.gc.ca; werner.hoermann@easa.europa.eu; xiaojunyoung@hotmail.com; yusfandrigona@dephub.go.id; tsuboi-k2wc@mlit.go.jp
Subject: CAEP/10 WG3 Meeting 8 CTG Papers - final

Hi

Attached are the final CTG papers (I hope). I've incorporated the comments I've received thus far.

Safe Travels.

Nicole Didyk
Environmental Engineer

Federal Aviation Administration
Office of Environment and Energy
Emissions Division
(AEE-300)
800 Independence Ave SW
Building 10A Room 902
Washington, DC 20591
(p) 202.267.4159
(f) 202.267.5594
(e) Nicole.Didyk@faa.gov

To: Samulski, Michael[samulski.michael@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Manning, Bryan
Sent: Wed 10/22/2014 3:06:24 PM
Subject: Revised Janet ICAO Brfg (PLEASE REVIEW)
McCabe Update on ICAO progress October 22.docx

Hello,

Attached please find the revised briefing for Janet, which incorporates Chris' comments (and Cullen and Lucie's revisions). Let me know if you have any final comments before we send this to Bill (he wanted to review Next Steps section before it went to Janet).

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Samulski, Michael
Sent: Wednesday, October 22, 2014 10:23 AM
To: Manning, Bryan; Audette, Lucie; Leggett, Cullen
Subject: RE: For Review: Briefings "Recommended Next Steps"

Thanks to all of you. I only have a couple of minor edits based on comments I heard from Chris/Bill yesterday:

Ex. 5 - Deliberative Process

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

From: Manning, Bryan
Sent: Wednesday, October 22, 2014 9:14 AM
To: Audette, Lucie; Samulski, Michael; Leggett, Cullen
Subject: RE: For Review: Briefings "Recommended Next Steps"

Ex. 5 - Deliberative Process

Thanks again,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Audette, Lucie
Sent: Tuesday, October 21, 2014 5:53 PM
To: Samulski, Michael; Manning, Bryan; Leggett, Cullen
Subject: For Review: Briefings "Recommended Next Steps"

I've tried to rework this section to take in Chris/Bill's comments. See what you think. LUcie

To: Leggett, Cullen[Leggett.Cullen@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Yen, David
Sent: Fri 11/21/2014 7:03:30 PM
Subject: CO2db parameters justification _ draft EPA input
CO2Db Parameters v3_Nov5_DY.xlsx

Hello team,

Here is my initial draft of the justification of EPA input for the requested CO2db parameters. Please edit and augment it as you see fit.

Thanks,

David

To: Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Kraft, Isobel[Kraft.Isobel@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
From: Manning, Bryan
Sent: Mon 3/3/2014 5:42:41 PM
Subject: Agenda: Aviation CO2 subgroup meeting (N66)
Agenda CO2 group mtg 3-3-14.docx

Hello,

Attached please find the agenda for today's CO2 subgroup meeting (right after Aviation Team meeting). Let me know if you have anything to add.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]; Birnbaum, Rona[Birnbaum.Rona@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]
From: Audette, Lucie
Sent: Fri 2/28/2014 9:25:48 PM
Subject: Status of Tiering for Aircraft Endangerment/ANPRM
Agency Action Tiering Form for Aircraft GHGs feb 28 2014.docx

Hello everyone,

Today OTAQ sent the Tiering Form to OAR for approval and things are in line for the Regulatory Steering Committee (RSC) meeting on March 5. I'm attaching the final language that was uploaded in the ADP Tracker. There were a few changes, notably we were asked to put a bit more description in the title with regard to the ANPRM (this can always be changed later).

With regard to workgroup members we've listed only 3 offices- OGC, OP and ORD. I assume for OGC that will be Mike Thrift who is the Aircraft attorney. Lesley and Rona, is there anyone in OGC that focuses on Endangerment? Should we extend an invitation to that individual? Also could you reach out to your ORD contacts to determine who would be best to have on the workgroup? I assume OP will assign someone to this action once it is approved and tiered. And there may be other offices that raise their hand to participate at the RSC meeting next week.

Our first milestones are set for April 10-30 when we hold our workgroup kickoff meeting (April 10-17) and our Preliminary Analytic Blueprint for the NPRM is completed (April 10-30). Lesley, let's try to talk later next week, maybe Thursday afternoon, to discuss next steps.

I will be on sick leave Monday through noon Thursday, but in case of an emergency I can be reached at (734)717-8062. Thanks everyone.

Lucie

To: Manning, Bryan[manning.bryan@epa.gov]
Cc: Yen, David[Yen.David@epa.gov]; Harli, Kent[Kent.Harli@icf.com]; Joaquim R.R.A. Martins[jrram@umich.edu]; Mueller, John[mueller.john@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
From: Zimm, Peter
Sent: Tue 7/18/2017 5:19:00 AM
Subject: RE: 2nd round of Comments on tech/costs sections of report
ICF - EPA - Aircraft CO2 Cost Assessment 2017 - DRAFT 2017-07-14.docx

Bryan,

Please see attached revised Tech Response report for the peer reviewers. Let me know if you have any questions.

Best regards,

PETER C. ZIMM | Principal | +1.347.843.9746 mobile | peter.zimm@icf.com

ICF | 630 Third Avenue, 11th Floor, New York, NY 10017 USA | icf.com/aviation

Learn how ICF makes big things possible for its clients.

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Thursday, July 13, 2017 12:42 PM
To: Zimm, Peter <Peter.Zimm@icf.com>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>
Subject: 2nd round of Comments on tech/costs sections of report

Hi Peter,

See the below message, which I sent back on June 15. I realize that you have been out of the office a fair amount over the last month. Any updates on incorporating the below/attached comments? Any questions or thoughts?

Thanks,

Bryan

****

Hi Peter,

Nice job on the revised version of the tech/costs sections of the report. We are very close. See our general comments in comment bubbles on the first page -- highlighted in yellow. Then see our redline/strikeout comments throughout the report. Also, I have comment bubbles throughout the report, but these comment bubbles are not highlighted in yellow (so be careful to not miss them).

Ex. 5 - Deliberative Process

Let me know if you have any questions or thoughts.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Zimm, Peter [mailto:Peter.Zimm@icf.com]
Sent: Monday, June 12, 2017 1:58 AM
To: Manning, Bryan <manning.bryan@epa.gov>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>
Subject: RE: NDA for peer review contract

Bryan,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

I am in a lot of meetings tomorrow and Tuesday but re-emerge late Tuesday afternoon if you need to talk.

Best regards,

PETER C. ZIMM | Principal | +1.347.843.9746 mobile | peter.zimm@icf.com

ICF | 630 Third Avenue, 11th Floor, New York, NY 10017 USA | icf.com/aviation

Learn how ICF makes big things possible for its clients.

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Wednesday, June 07, 2017 11:46 AM
To: Zimm, Peter <Peter.Zimm@icf.com>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>
Subject: NDA for peer review contract

Hi Peter,

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Zimm, Peter[Peter.Zimm@icf.com]
Cc: Yen, David[Yen.David@epa.gov]; Harli, Kent[Kent.Harli@icf.com]; Joaquim R.R.A. Martins[jrram@umich.edu]; Mueller, John[mueller.john@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
From: Manning, Bryan
Sent: Thur 7/13/2017 4:42:00 PM
Subject: 2nd round of Comments on tech/costs sections of report
ICF - EPA - Aircraft CO2 Cost Assessment 2017 - DRAFT 2017-06-09 v2.1+dy+BM.docx

Hi Peter,

See the below message, which I sent back on June 15. I realize that you have been out of the office a fair amount over the last month. Any updates on incorporating the below/attached comments? Any questions or thoughts?

Thanks,

Bryan

****

Hi Peter,

Nice job on the revised version of the tech/costs sections of the report. We are very close. See our general comments in comment bubbles on the first page -- highlighted in yellow. Then see our redline/strikeout comments throughout the report. Also, I have comment bubbles throughout the report, but these comment bubbles are not highlighted in yellow (so be careful to not miss them).

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Let me know if you have any questions or thoughts.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Zimm, Peter [mailto:Peter.Zimm@icf.com]
Sent: Monday, June 12, 2017 1:58 AM
To: Manning, Bryan <manning.bryan@epa.gov>

Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>
Subject: RE: NDA for peer review contract

Bryan,

Ex. 5 - Deliberative Process

Best regards,

PETER C. ZIMM | Principal | +1.347.843.9746 mobile | peter.zimm@icf.com

ICF | 630 Third Avenue, 11th Floor, New York, NY 10017 USA | icf.com/aviation

Learn how ICF makes big things possible for its clients.

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Wednesday, June 07, 2017 11:46 AM
To: Zimm, Peter <Peter.Zimm@icf.com>
Cc: Yen, David <Yen.David@epa.gov>; Harli, Kent <Kent.Harli@icf.com>; Joaquim R.R.A. Martins <jrram@umich.edu>; Mueller, John <mueller.john@epa.gov>
Subject: NDA for peer review contract

Hi Peter,

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Manning, Bryan[manning.bryan@epa.gov]; Yen, David[Yen.David@epa.gov]
Cc: Samulski, Michael[samulski.michael@epa.gov]
From: Leggett, Cullen
Sent: Mon 8/8/2016 4:52:01 PM
Subject: RE: ICF's Jaquim Martin

I'm fine with them publishing something. In fact it may give us a good public reference to use for the CO2 analysis.

Best regards,

Cullen Leggett

+1 734-214-4514

From: Manning, Bryan
Sent: Monday, August 08, 2016 12:30 PM
To: Yen, David <Yen.David@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>
Cc: Samulski, Michael <samulski.michael@epa.gov>
Subject: ICF's Jaquim Martin

David and Cullen,

See the below message that includes an item about ICF's Jaquim Martin. Any thoughts? Let's discuss later.

Thanks,

Bryan

From: Zimm, Peter [mailto:Peter.Zimm@icfi.com]
Sent: Monday, August 08, 2016 12:22 PM
To: Manning, Bryan <manning.bryan@epa.gov>
Subject: RE: EPA Finalizes First Steps to Address Greenhouse Gas Emissions from Aircraft

Engines

Bryan,

Glad to hear you were able to get away and recharge.

I am doing well. So far, owing to trips to Maine, NYC, UK, and Minnesota, I've been able to spend about 3.5 weeks of summer out of the furnace which is a welcome respite.

ICF is doing well. Kevin is missed but left behind a great legacy of expertise and excellence of which I and others are now the keepers.

Question for you: Quim is interested in publishing a paper based on the project work we did for you. I anticipate it will only help keep up the drumbeat of our findings from the study. Would you be OK with this? ICF is prepared to support Quim's paper but want to make sure you are OK with it.

One of the unfortunate side effects of things going well for me is that I don't make my way to Ann Arbor as often any more. I'll let you know when I'm going to be back in town.

Best regards,

Peter

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Wednesday, August 03, 2016 5:26 PM

To: Zimm, Peter <Peter.Zimm@icfi.com>
Subject: RE: EPA Finalizes First Steps to Address Greenhouse Gas Emissions from Aircraft Engines

Thanks for the reply, Peter. Things are going well here. I just returned from a family vacation in Maine, so I am a bit refreshed now. How are you doing? How is your family? How is the depths of summer treating you in AZ? Have you been back to MN this summer?

I see Kevin Michaels is now with AeroDynamic Advisory. Of course, I am sure he is missed at ICF. How are things going at ICF these days?

Thanks again,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Zimm, Peter [mailto:Peter.Zimm@icfi.com]
Sent: Monday, July 25, 2016 11:55 AM
To: Manning, Bryan <manning.bryan@epa.gov>
Subject: RE: EPA Finalizes First Steps to Address Greenhouse Gas Emissions from Aircraft Engines

Congratulations, Bryan! Thanks for keeping me in the loop.

Things go well for you? I hope so.

Best regards,

Peter

From: Audette, Lucie [mailto:audette.lucie@epa.gov]
Sent: Monday, July 25, 2016 11:18 AM
Cc: Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>
Subject: EPA Finalizes First Steps to Address Greenhouse Gas Emissions from Aircraft Engines

To All Interested Parties:

The U.S. Environmental Protection Agency (EPA) today finalized findings under section 231 of the Clean Air Act that greenhouse gas (GHG) emissions from certain types of aircraft engines (primarily used on commercial aircraft) contribute to the pollution that causes climate change and endangers Americans' health and environment. These findings are for the six well-mixed GHGs that together represent the largest driver of human-caused climate change: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The EPA is not issuing standards for aircraft engines in this action.

The EPA's final endangerment and contribution findings for aircraft engine GHG emissions are an important step that EPA must take prior to adopting domestic GHG engine standards. The domestic rulemaking process for standards will provide opportunities for industry, NGOs, and other interested parties to provide their input through public review and comment.

Today's findings do not apply to small piston-engine planes (the type of plane often used for recreational purposes), or to military aircraft.

For more information on the final aircraft endangerment and cause or contribute findings, see the attached fact sheet or visit http://epa.gov/otaq/aviation.htm.

Sincerely yours,

Bryan Manning

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Lucie Audette (audette.lucie@epa.gov)[audette.lucie@epa.gov]
From: Leggett, Cullen
Sent: Mon 7/25/2016 5:55:14 PM
Subject: FW: T&E PR;: EPA Finalizes First Steps to Address Greenhouse Gas Emissions from Aircraft Engines

From: Bill Hemmings [mailto:bill.hemmings@transportenvironment.org]
Sent: Monday, July 25, 2016 1:41 PM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: FW: T&E PR;: EPA Finalizes First Steps to Address Greenhouse Gas Emissions from Aircraft Engines

From: Bill Hemmings [mailto:bill.hemmings@transportenvironment.org]
Sent: 25 July 2016 18:13
To: 'Manning, Bryan' <manning.bryan@epa.gov>
Cc: 'Grundler, Christopher' <grundler.christopher@epa.gov>; 'Audette, Lucie' <audette.lucie@epa.gov>
Subject: T&E PR;: EPA Finalizes First Steps to Address Greenhouse Gas Emissions from Aircraft Engines

Great news Bryan,

Its imperative that the EPA and enlightened voices in the EU work to abolish the perverse Option 3.

Why should the world suffer just so the KC46 and A380 problem aircraft can be accommodated? It's a sham and a scandal whose truth will come out.

The EASA Basic Regulation revision is key.

Regards Bill

EPA ruling an opportunity for EU and America to cooperate on aviation emissions

For immediate release – Brussels, 25 July 2016

Link to PR: http://bit.ly/2aqABLn

Today's finding by the US Environmental Protection Agency (EPA) that it will regulate US greenhouse gas emissions from aircraft is an opportunity for bilateral action between America and the EU to reduce aviation's growing climate impact, Transport & Environment has said. The Brussels-based sustainable transport group welcomed the EPA's decision to set a CO2 standard that is "at least" equivalent to the one agreed at UN-level.

A series of lawsuits by US NGOs forced the EPA to issue today's ruling that it must act to regulate US aviation GHG emissions. The ruling comes after agreement last february at the UN aviation body ICAO on a CO2 standard for new aircraft that will have no impact on reducing emissions. One of the possible courses of action for the EPA is to introduce a more effective US standard that would apply to US-built aircraft and other aircraft sold to US registered airlines.

Bill Hemmings, aviation director at Transport & Environment, said: *"We now have the real possibility of the EU and the US cooperating to fix the deeply-flawed UN aviation efficiency standard. The European transport commissioner Violeta Bulc should grab this opportunity with both hands."*

In contrast to this long-awaited first sign of US ambition on reducing aviation emissions, the EU transport decarbonisation strategy, published last week, was disappointingly silent on what will be done in Europe to reduce aviation's climate impact. However, the EPA ruling creates a possibility for effective EU-US cooperation. Both markets account for over half of global aviation emissions, and Boeing (US) and Airbus (EU) aircraft are responsible for over 90% of global aviation CO2.

ENDS

For more information, contact:

Bill Hemmings,

Aviation director, Transport & Environment

bill.hemmings@transportenvironment.org

+32 (0)2 851 02 15 / +32 (0)487 582 706

From: Audette, Lucie [mailto:audette.lucie@epa.gov]
Sent: 25 July 2016 17:18
Cc: Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>

Subject: EPA Finalizes First Steps to Address Greenhouse Gas Emissions from Aircraft Engines

To All Interested Parties:

The U.S. Environmental Protection Agency (EPA) today finalized findings under section 231 of the Clean Air Act that greenhouse gas (GHG) emissions from certain types of aircraft engines (primarily used on commercial aircraft) contribute to the pollution that causes climate change and endangers Americans' health and environment. These findings are for the six well-mixed GHGs that together represent the largest driver of human-caused climate change: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The EPA is not issuing standards for aircraft engines in this action.

The EPA's final endangerment and contribution findings for aircraft engine GHG emissions are an important step that EPA must take prior to adopting domestic GHG engine standards. The domestic rulemaking process for standards will provide opportunities for industry, NGOs, and other interested parties to provide their input through public review and comment.

Today's findings do not apply to small piston-engine planes (the type of plane often used for recreational purposes), or to military aircraft.

For more information on the final aircraft endangerment and cause or contribute findings, see the attached fact sheet or visit http://epa.gov/otaq/aviation.htm.

Sincerely yours,

Bryan Manning

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

Virus-free. www.avast.com

Virus-free. www.avast.com

To: Manning, Bryan[manning.bryan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Yen, David[Yen.David@epa.gov]; Mueller, John[mueller.john@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Leggett, Cullen
Sent: Mon 5/16/2016 7:43:50 PM
Subject: FW: Draft CO2 Standard Exemption Proposals - WG3 review...
CAEP11_WG3-2_WPXX_RF_Exememptions Tables.pdf

Russian paper

From: Артур Мирзоян [mailto:mirzoyan1955@yandex.ru]
Sent: Monday, May 16, 2016 3:42 PM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Cc: Dickson Neil <ndickson@icao.int>
Subject: Re: Draft CO2 Standard Exemption Proposals - WG3 review...

Dear Cullen,

Ex. 5 - Deliberative Process

Thank you for cooperation,

Best regards,

Artur

16.05.2016, 22:05, "Leggett, Cullen" <leggett.cullen@epa.gov>:

Arthur,

Ex. 5 - Deliberative Process

Best regards,

Cullen

From: Artur Mirzoyan [mailto:mirzoyan@ciam.ru]
Sent: Wednesday, May 11, 2016 7:29 AM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: Re: Draft CO2 Standard Exemption Proposals - WG3 review...

Dear Cullen,

Ex. 5 - Deliberative Process

Best Regards,
Cullen Leggett
+1 (734) 214-4514
US Environmental Protection Agency

From: Dickson, Neil [mailto:NDickson@icao.int]

Sent: Friday, April 29, 2016 5:42 PM
To: emanuel.fleuti@zurich-airport.com; jscavuzzi@aci.aero; Inger.sturm@cph.dk; ricardo.dupont@anac.gov.br; Marcelo.saito@anac.gov.br; wendy.bailey@tc.gc.ca; david.bilcock(tc.gc.ca; yves.cousineau@tc.gc.ca; Greg.Smallwood@nrc-cnrc.gc.ca; xiaojunyoung@ hotmail.com; stephen.arrowsmith@easa.europa.eu; ivan.de-lepinay@easa.europa.eu; chris@ limitedskies.com; willem.franken@easa.europa.eu; Erika.herms@easa.europa.eu; werner.hoermann@easa.europa.eu; guy.readman@easa.europa.eu; jonathan.gilad@aviation-civile.gouv.fr; jean-luc.kittery@aviation-civile.gouv.fr; jerome.sarda@aviation-civile.gouv.fr; Martin.Plohr@dlr.de; martin.schaefer@bmvi.bund.de; Frank.Wetzel@uba.de; david.anvid@ delta.com; HardemanA@iata.org; tpohle@airlines.org; RoetgerT@iata.org; daltherr@ aerioncorp.com; Ecotti@NBAA.org; charles.etter@gulfstream.com; Dickson, Neil <NDickson@ icao.int>; arif_fajari@dephub.go.id; denise.ahrens@rolls-royce.com; daniel.m.allyn@ boeing.com; frank.bachman@ge.com; steven.l.baughcum@boeing.com; MBeauregard@AIA C.ca; arnaud.bonnet@embraer.com.br; daniel.carnelly@airbus.com; dominique.collin@ snecma.fr; francis.couillard@safran.fr; guillaume.dehestru@dassault-aviation.com; WCDolejsi@ cessna.textron.com; Jim Dow <Jdow@iccaia.org>; rudolph.dudebout@honeywell.com; Galotti, Vincent <Vgalotti.iccaia@gmail.com>; Mike.garrison@boeing.com; sebastien.harquel@ embraer.com.br; mhinderberger@aerioncorp.com; james.hoke@pw.utc.com; DDHornbaker@ txtav.com; mark.huising@aero.bombardier.com; Olivier.husse@airbus.com; mark.johnson3@ rolls-royce.com; keisuke_nakahama@mitsubishiaircraft.com; david.lye@aero.bombardier.com; paul.madden@rolls-royce.com; muni.majjigi@ge.com; jrmatisheck@aerioncorp.com; kian.mccaldon@pwc.ca; randal.mckinney@pw.utc.com; yoann.mery@snecma.fr; john.morgenstern@lmco.com; hideki_moriai@mhi.co.jp; kevin.morris@adsgroup.org.uk; matthew.r.muehlhausen@boeing.com; krisha.nobrega@embraer.com.br; olivier.penanhoat@ snecma.fr; Thierry.Percheron@dassault-aviation.com; rmpaero@frontier.com; charles.renard@ airbus.com; leslie.riegle@aia-aerospace.org; tim.roesler@liberty.rolls-royce.com; CAMILLE.SA GUES@airbus.com; domingo.Sepulveda@pw.utc.com; simon.smith@rolls-royce.com; frederic.soum@airbus.com; cheikhdjiby.sow@snecma.fr; sturdza@aerioncorp.com; Eric.Upton@ gulfstream.com; yuji_yamamoto@mhi.co.jp; joseph.zelina@ge.com; bill.hemmings@ transportenvironment.org; karin@theicct.org; paul.peeters1000@gmail.com; Dan@theicct.org; kartikadinakartika@gmail.com; fuji@chofu.jaxa.jp; matsukawa-h2fg@mlit.go.jp; h-hashimoto@ aeif.or.jp; michael.lunter@minienm.nl; yuriy.medved@gmail.com; mirzoyan@ciam.ru; sipatov@ avid.ru; Volkov@ciam.ru; vincent_ng@caas.gov.sg; archillapv@inta.es; arturo.benito@upm.es; aiglesias@mfom.es; thobias.log@transportstyrelsen.se; marie.hankanen@ transportstyrelsen.se; Theo.Rindlisbacher@bazl.admin.ch; keremdenk@gmail.com; gursu.tasar(tai.com.tr; chemmotology@ukr.net; V.Deniskov@antonov.kiev.ua; progress@ivchenko-progress.com; 03503@ivchenko-progress.com; Zainal.abidin@emirates.com; s.christie@ mmu.ac.uk; hayley.gowen@bis.gsi.gov.uk; d.s.lee@mmu.ac.uk; b.owen@mmu.ac.uk; tom.white dft.gsi.gov.uk; bonnefoy_philippe@bah.com; rebecca.cointin@faa.gov; nicole.didyk@faa.gov; John.Fisher@faa.gov; Gregg.Fleming@dot.gov; Giannelli, Bob <Giannelli.Bob@epa.gov>; warren.gillette@faa.gov; James.Hileman@faa.gov; curtis.holsclaw@faa.gov; Ralph.Iovinelli@ faa.gov; daniel.jacob@faa.gov; Leggett, Cullen <Leggett.Cullen@epa.gov>; maryalice.locke@ faa.gov; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Manning, Bryan <manning.bryan@ epa.gov>; julie.marks@faa.gov; lourdes.maurice@faa.gov; McConnachie_Dominic@bah.com; rick@aerodyne.com; Mueller, John <mueller.john@epa.gov>; Samulski, Michael <samulski.michael@epa.gov>; donald.scata@faa.gov; Stevens, JeffreyA <Stevens.JeffreyA@ epa.gov>; Adrienne.Vanek@faa.gov; laszlo.windhoffer@faa.gov; Yen, David <Yen.David@ epa.gov>
Subject: Draft CO2 Standard Exemption Proposals - WG3 review...

Dear WG3,

Ex. 5 - Deliberative Process

Neil

Dr Neil Dickson
Environmental Officer
International Civil Aviation Organization (ICAO)
Air Transport Bureau

tel: +1 514-954-8219 (x6042)
mobile: +1 514-812-0737
email: NDickson@icao.int

Consider the environment before printing this e-mail

--
С уважением,
Artur mailto:mirzoyan@ciam.ru

To: Manning, Bryan[manning.bryan@epa.gov]
From: Leggett, Cullen
Sent: Wed 4/13/2016 4:46:32 PM
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Ya that looks good to me

From: Manning, Bryan
Sent: Wednesday, April 13, 2016 12:38 PM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Nice job, Cullen. I just had a few tweaks in redline/strikeout (check them out if you like). Many thanks.

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Leggett, Cullen
Sent: Wednesday, April 13, 2016 10:56 AM
To: Manning, Bryan <manning.bryan@epa.gov>
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Bryan,

Just added the footnote to page 35 and changed the charts. Ended up being a bit longer than I thought it would be. Let me know if you have any comments.

From: Manning, Bryan
Sent: Wednesday, April 13, 2016 8:57 AM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Cullen,

Sounds like we need to add the units and a related paragraph or footnote to describe the metric value units. Let me know if you have any questions.

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Leggett, Cullen
Sent: Wednesday, April 13, 2016 8:47 AM
To: Manning, Bryan <manning.bryan@epa.gov>
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Ex. 5 - Deliberative Process

From: Manning, Bryan
Sent: Tuesday, April 12, 2016 1:33 PM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Hello Cullen,

Ex. 5 - Deliberative Process

Ex. 5 - Attorney Client

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Manning, Bryan[manning.bryan@epa.gov]
From: Leggett, Cullen
Sent: Wed 4/13/2016 2:55:54 PM
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Bryan,

Just added the footnote to page 35 and changed the charts. Ended up being a bit longer than I thought it would be. Let me know if you have any comments.

From: Manning, Bryan
Sent: Wednesday, April 13, 2016 8:57 AM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Cullen,

Sounds like we need to add the units and a related paragraph or footnote to describe the metric value units. Let me know if you have any questions.

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Leggett, Cullen
Sent: Wednesday, April 13, 2016 8:47 AM
To: Manning, Bryan <manning.bryan@epa.gov>
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Ex. 5 - Deliberative Process

From: Manning, Bryan
Sent: Tuesday, April 12, 2016 1:33 PM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Hello Cullen,

Ex. 5 - Deliberative Process

Ex. 5 - Attorney Client

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Manning, Bryan[manning.bryan@epa.gov]
From: Leggett, Cullen
Sent: Wed 4/13/2016 1:15:15 PM
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

I'll make those changes today. Did you confirm with Leslie what version we are supposed to work off of?

From: Manning, Bryan
Sent: Wednesday, April 13, 2016 8:57 AM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Cullen,

Sounds like we need to add the units and a related paragraph or footnote to describe the metric value units. Let me know if you have any questions.

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Leggett, Cullen
Sent: Wednesday, April 13, 2016 8:47 AM
To: Manning, Bryan <manning.bryan@epa.gov>
Subject: RE: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Ex. 5 - Deliberative Process

From: Manning, Bryan
Sent: Tuesday, April 12, 2016 1:33 PM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: aircraft GHG endang FRM: Workgroup comments on CO2 Standard figures

Hello Cullen,

Ex. 5 - Deliberative Process

Ex. 5 - Attorney Client

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Manning, Bryan[manning.bryan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
Cc: Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Mueller, John[mueller.john@epa.gov]
From: Leggett, Cullen
Sent: Wed 9/30/2015 6:13:59 PM
Subject: RE: My edits on FAA's draft CO2 position paper
FAA-OST Breifing-ICAO CO2 Standard_2015-09-28_final review draft - epa comments+BM+CL.docx

Ex. 5 - Deliberative Process

From: Manning, Bryan
Sent: Tuesday, September 29, 2015 2:58 PM
To: Samulski, Michael <samulski.michael@epa.gov>
Cc: Leggett, Cullen <Leggett.Cullen@epa.gov>; Yen, David <Yen.David@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Mueller, John <mueller.john@epa.gov>
Subject: RE: My edits on FAA's draft CO2 position paper

Your suggested revisions look good, Mike. Attached please find a few additional edits and my responses to your questions in the comment boxes.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Samulski, Michael
Sent: Tuesday, September 29, 2015 1:11 PM
To: Manning, Bryan
Cc: Leggett, Cullen; Yen, David; Maeroff, Bruce; Mueller, John
Subject: My edits on FAA's draft CO2 position paper

Bryan,

Here's the edits we discussed. Please have a look. (Also I have a couple of questions in comment boxes for you).

Thanks,

Mike

****

Michael Samulski

U.S. Environmental Protection Agency

Office of Transportation and Air Quality

Director, Large Marine and Aircraft Center

1 (734) 214-4532

samulski.michael@epa.gov

****

To: Eric.Upton@gulfstream.com[Eric.Upton@gulfstream.com]
From: Leggett, Cullen
Sent: Thur 9/17/2015 8:47:57 PM
Subject: ICO2CDb updates for call 7
ICAO Aircraft CO2 Emissions Databank Introduction Text - v8 17 Sept2015.docx
CO2DB Options v1 - Sept 17.xlsx
CO2DB notes - Sept 1 2015.docx

Eric,

Ex. 5 - Deliberative Process

Cullen

To: Manning, Bryan[manning.bryan@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
Cc: Yen, David[Yen.David@epa.gov]
From: Leggett, Cullen
Sent: Mon 7/6/2015 8:24:01 PM
Subject: RE: Our comments on latest WH briefing
FAA-EPA CO2 Standard briefing_30 June 2015_EPA2 comments clean -FAAcomments.docx

Bryan, Lucie,

Here are my updates and changes.

From: Manning, Bryan
Sent: Monday, July 06, 2015 3:25 PM
To: Leggett, Cullen; Audette, Lucie
Cc: Yen, David
Subject: Our comments on latest WH briefing

Hello Cullen and Lucie,

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Audette, Lucie[audette.lucie@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]; Yen, David[Yen.David@epa.gov]
From: Leggett, Cullen
Sent: Thur 12/10/2015 4:07:58 PM
Subject: RE: Draft Press Releases (CO2 standard)
News Releases for CAEP 2016v 1 + CL3+BM.docx

Mike, Lucie,

Attached is the input/comments from Bryan, David, and myself on the press release.

From: Manning, Bryan
Sent: Thursday, December 10, 2015 10:17 AM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>; Yen, David <Yen.David@epa.gov>
Cc: Audette, Lucie <audette.lucie@epa.gov>
Subject: RE: Draft Press Releases (CO2 standard)

Ex. 5 - Deliberative Process

Thanks again,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Leggett, Cullen
Sent: Thursday, December 10, 2015 10:00 AM
To: Yen, David <Yen.David@epa.gov>
Cc: Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>
Subject: RE: Draft Press Releases (CO2 standard)

Updated doc with a few more minor text edits and corrected numbers.

From: Yen, David
Sent: Thursday, December 10, 2015 9:52 AM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>
Cc: Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>
Subject: RE: Draft Press Releases (CO2 standard)

Hi Cullen,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Best,

David

P.S., The file name (of the Excel spreadsheet) was given in my original email below.

From: Leggett, Cullen
Sent: Thursday, December 10, 2015 9:23 AM
To: Yen, David <Yen.David@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>
Subject: RE: Draft Press Releases (CO2 standard)

Thanks David.

Ex. 5 - Deliberative Process

From: Yen, David
Sent: Thursday, December 10, 2015 9:14 AM
To: Leggett, Cullen <Leggett.Cullen@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>
Subject: RE: Draft Press Releases (CO2 standard)

Hi all,

Ex. 5 - Deliberative Process

Best,

David

From: Leggett, Cullen
Sent: Wednesday, December 09, 2015 5:01 PM
To: Manning, Bryan <manning.bryan@epa.gov>; Yen, David <Yen.David@epa.gov>; Audette, Lucie <audette.lucie@epa.gov>
Subject: RE: Draft Press Releases (CO2 standard)

Ex. 5 - Deliberative Process

From: Manning, Bryan
Sent: Wednesday, December 09, 2015 2:52 PM
To: Yen, David <Yen.David@epa.gov>; Leggett, Cullen <Leggett.Cullen@epa.gov>
Subject: FW: Draft Press Releases (CO2 standard)

Hello Cullen and David,

Ex. 5 - Deliberative Process

From: Audette, Lucie
Sent: Tuesday, December 08, 2015 2:41 PM
To: Samulski, Michael <samulski.michael@epa.gov>; Manning, Bryan <manning.bryan@epa.gov>
Subject: Draft Press Releases

Ex. 5 - Deliberative Process

To: Manning, Bryan[manning.bryan@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Yen, David[Yen.David@epa.gov]
From: Leggett, Cullen
Sent: Tue 6/30/2015 8:16:44 PM
Subject: RE: For Review: Revised WH Briefing
FAA-EPA CO2 Standard briefing_ 24 June 2015_epa+BM2 +CL2+ lcacomments.docx

Here are a few additional comments. I have not updated any of the plots yet. I will get to that next, but it should be ok to send to Bill as is.

Ex. 5 - Deliberative Process

From: Manning, Bryan
Sent: Tuesday, June 30, 2015 3:39 PM
To: Audette, Lucie; Leggett, Cullen; Yen, David
Subject: RE: For Review: Revised WH Briefing

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Audette, Lucie
Sent: Tuesday, June 30, 2015 12:16 PM
To: Manning, Bryan; Leggett, Cullen; Yen, David
Subject: For Review: Revised WH Briefing

Ex. 5 - Deliberative Process

To: Manning, Bryan[manning.bryan@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Leggett, Cullen
Sent: Mon 6/29/2015 2:23:44 PM
Subject: RE: Materials for Monday (11:45) meeting with Janet on Aircraft
Janet McCabe Briefing ICAO CO2 Standard SG15 Mtg 6-29-15 v2.pptx

Ex. 5 - Deliberative Process

From: Manning, Bryan
Sent: Friday, June 26, 2015 1:19 PM
To: Sutton, Tia; Hengst, Benjamin
Cc: Iffland, JoNell; Leggett, Cullen; Yen, David; Mueller, John; OTAQ Materials; Charmley, William; Samulski, Michael; Audette, Lucie; Maeroff, Bruce
Subject: Materials for Monday (11:45) meeting with Janet on Aircraft

Hello,

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Audette, Lucie[audette.lucie@epa.gov]; Charmley, William[charmley.william@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
From: Leggett, Cullen
Sent: Fri 6/26/2015 2:23:45 PM
Subject: Charts for call with Lourdes (WH Brief)
CO2 plots - v1 - June 26.pptx

Bill,

Here are the charts that you requested for the WH brief. We thought it might be helpful for you call with Lourdes. We are still pulling together the US only data, so that is not included in this deck.

Let us know if you have any questions or comments.

Thanks

Cullen

To: Manning, Bryan[manning.bryan@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Leggett, Cullen
Sent: Thur 6/25/2015 6:36:51 PM
Subject: RE: Comments on FA's Draft briefing paper for Janet/Rich and WH
FAA-EPA CO2 Standard briefing_24 June 2015_epa+BM +CLcomments.docx

Here are a few more comments.

From: Manning, Bryan
Sent: Thursday, June 25, 2015 1:22 PM
To: Audette, Lucie
Cc: Leggett, Cullen
Subject: RE: Comments on FA's Draft briefing paper for Janet/Rich and WH

Nice job on the comments, Lucie. See my additional revisions and comment boxes. Let's talk soon.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Audette, Lucie
Sent: Thursday, June 25, 2015 11:18 AM
To: Manning, Bryan
Subject: Comments on FA's Draft briefing paper for Janet/Rich and WH

Bryan, I had a lot of comments… Sorry! See what you think and then let's discuss any concerns/questions you may have. A number of items need to

To: Manning, Bryan[manning.bryan@epa.gov]
Cc: Audette, Lucie[audette.lucie@epa.gov]
From: Leggett, Cullen
Sent: Mon 6/15/2015 5:54:37 PM
Subject: RE: Aircraft Package Federal Register Revisions
9924-06-OAR sm Edits lca +CL edits.docx

Here are the updated charts. Lucie was saying there was someone besides Pat we should send it to. Not sure who that person is.

From: Manning, Bryan
Sent: Monday, June 15, 2015 12:14 PM
To: Leggett, Cullen
Cc: Audette, Lucie
Subject: FW: Aircraft Package Federal Register Revisions

Hello Cullen,

Attached is the version of the aircraft GHG ending/ANPR to use for revising the figures. Thanks.

Bryan

From: Audette, Lucie
Sent: Friday, June 12, 2015 2:03 PM
To: Jantarasami, Lesley; Manning, Bryan
Subject: FW: Aircraft Package Federal Register Revisions

Ex. 5 - Deliberative Process

From: Audette, Lucie
Sent: Friday, June 12, 2015 1:48 PM
To: Scoville, Pat
Subject: Aircraft Package Federal Register Revisions

Thanks Pat, I left all her comment bubbles in and responded that I had addressed the issue she was pointing to.

To: Eric.Upton@gulfstream.com[Eric.Upton@gulfstream.com]
From: Leggett, Cullen
Sent: Fri 5/1/2015 9:28:23 AM
Subject: RE: Papers for Belfast
CAEP10_WG3_9_WPXX CO2DB group report rc1 + CL.docx
ICAO Aircraft CO2 Emissions Databank Introduction Text - v5+CL.docx

Eric,

Ex. 5 - Deliberative Process

Cullen

From: Eric.Upton@gulfstream.com [mailto:Eric.Upton@gulfstream.com]
Sent: Thursday, April 30, 2015 9:48 PM
To: Leggett, Cullen
Subject: Re: Papers for Belfast

Ex. 5 - Deliberative Process

Eric Upton, PhD
Environmental/Performance Specialist
Gulfstream Aerospace Corporation
Eric.Upton@gulfstream.com
ph: 912-395-8458
fax: 912-965-8850

This e-mail message, including all attachments, is for the sole use of the intended recipient(s) and may contain Personal Information under General Dynamics policy CP 07-105 and/or legally privileged and confidential information. Any Personal Information can be accessed only by authorized personnel of General Dynamics and its approved service providers and may be used only as permitted by General

Dynamics and its policies. Contractual restrictions apply to third parties. If you are not an intended recipient, you are hereby notified that you have either received this message in error or through interception, and that any review, use, distribution, copying or disclosure of this message or its attachments is strictly prohibited and is subject to criminal and civil penalties. All personal messages express solely the sender's views and not those of Gulfstream Aerospace Corporation.
If you received this message in error, please contact the sender by reply e-mail and destroy all copies of the original message.

To: Eric.Upton@gulfstream.com[Eric.Upton@gulfstream.com]
From: Leggett, Cullen
Sent: Thur 4/30/2015 6:57:19 PM
Subject: Papers for Belfast
ICAO Aircraft CO2 Emissions Databank Introduction Text - v4 redline.docx

Eric,

Ex. 5 - Deliberative Process

Cullen

To: Manning, Bryan[manning.bryan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Leggett, Cullen
Sent: Fri 4/17/2015 8:03:11 PM
Subject: FW: Final Paper to FESG/MDG from Communication of Effectivenes ad hoc group
CAEP10_MDG09_WP10_Report from ahg on Communication of Effectiveness_Draft9.docx

Final effectiveness paper.

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: Thursday, April 16, 2015 3:31 PM
To: chris@limitedskies.com; Dickson, Neil; Adam M; Olivier.husse@airbus.com; Anastasia Kharina; tpohle@airlines.org; Leggett, Cullen; Peterson B (rmpaero@frontier.com)
Subject: Final Paper to FESG/MDG from Communication of Effectivenes ad hoc group

Dear Communication of Effectiveness ad hoc group members,

Ex. 5 - Deliberative Process

This update includes the following changes:

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

The paper is provided in track changes.

Best regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Yen, David[Yen.David@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]
Cc: Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Leggett, Cullen
Sent: Mon 1/30/2017 5:03:52 PM
Subject: RE: Email from ICF -- Need some inputs from EPA

Ex. 5 - Deliberative Process

Best regards,

Cullen Leggett

+1 734-214-4514

From: Yen, David
Sent: Sunday, January 29, 2017 8:15 PM
To: Manning, Bryan <manning.bryan@epa.gov>
Cc: Leggett, Cullen <Leggett.Cullen@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>
Subject: Re: Email from ICF -- Need some inputs from EPA

Bryan, **Ex. 5 - Deliberative Process**

Sent from my iPhone

On Jan 28, 2017, at 12:12 AM, Manning, Bryan <manning.bryan@epa.gov> wrote:

Ex. 5 - Deliberative Process

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Manning, Bryan
Sent: Thursday, January 26, 2017 4:20 PM
To: 'Zimm, Peter' <Peter.Zimm@icf.com>
Cc: Joaquim R. R. A. Martins <jrram@umich.edu>; Harli, Kent <Kent.Harli@icf.com>; Leggett, Cullen <Leggett.Cullen@epa.gov>; Yen, David <Yen.David@epa.gov>; Maeroff, Bruce <Maeroff.Bruce@epa.gov>; Mueller, John <mueller.john@epa.gov>; Wolfe, Philip <wolfe.philip@epa.gov>
Subject: RE: Need some inputs from EPA

Thanks for the message, Peter. See my responses below in CAPs and red font. Let me know if you have any further questions.

Thanks again,

Bryan

From: Zimm, Peter [mailto:Peter.Zimm@icf.com]
Sent: Thursday, January 26, 2017 2:57 PM
To: Manning, Bryan <manning.bryan@epa.gov>
Cc: Joaquim R. R. A. Martins <jrram@umich.edu>; Harli, Kent <Kent.Harli@icf.com>
Subject: Need some inputs from EPA

Bryan,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks and best regards,

PETER C. ZIMM | Principal | +1.347.843.9746 mobile | peter.zimm@icf.com

ICF | 630 Third Avenue, 11th Floor, New York, NY 10017 USA | icf.com/aviation

Learn how ICF makes big things possible for its clients.

To: Samulski, Michael[samulski.michael@epa.gov]; Yen, David[Yen.David@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]
From: Leggett, Cullen
Sent: Fri 4/10/2015 8:18:22 PM
Subject: FW: CO2 Effectiveness Call 10 April 10:00 EDT
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft8_Clean.docx
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft8.docx

Ex. 5 - Deliberative Process

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: Thursday, April 09, 2015 10:07 PM
To: ADAM Michel; Anastasia Kharina; chris@limitedskies.com; Dickson, Neil; Peterson B (rmpaero@frontier.com); Olivier.husse@airbus.com; tpohle@airlines.org; Leggett, Cullen
Subject: CO2 Effectiveness Call 10 April 10:00 EDT

Hi Everyone,

Ex. 5 - Deliberative Process

Talk to you at 10:00.

Here are the Lync / call-in details:

Join Lync Meeting

Participant passcode: Ex. 6 - Personal Privacy

Ex. 6 - Personal Privacy

Ex. 6 - Personal Privacy

Best regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Manning, Bryan[manning.bryan@epa.gov]
From: Leggett, Cullen
Sent: Mon 1/12/2015 6:08:10 PM
Subject: RE: Section V - ANPR (Melina's comments)

Bryan

That sounds like a good response for that comment.

Were you ok w/ Leslie's comments that were in there?

How do we want to merge these comments in? We want to add them to the version in the subteam folder? I should be able to merge those documents pretty easily.

From: Manning, Bryan
Sent: Monday, January 12, 2015 12:38 PM
To: Leggett, Cullen
Subject: Section V - ANPR (Melina's comments)

Hello Cullen,

I agree with you that Melina's comments are fine. There is only one of her comments that I question.

Ex. 5 - Deliberative Process

What do you think about my response to Melina?

Let me know how you want to coordinate or divide up responding to Melina's other comments.

Thank you,

Bryan

P.S. I hope you feel better.

To: Chris Eyers[chris@limitedskies.com]; Thrasher, Theodore[TThrasher@icao.int]
Cc: ADAM Michel[adamm@iata.org]; Anastasia Kharina[karin@theicct.org]; Dickson, Neil[NDickson@icao.int]; Peterson B (rmpaero@frontier.com)[rmpaero@frontier.com]; Olivier.husse@airbus.com[Olivier.husse@airbus.com]; tpohle@airlines.org[tpohle@airlines.org]
From: Leggett, Cullen
Sent: Fri 4/10/2015 4:46:16 PM
Subject: RE: CO2 Effectiveness Call 10 April 10:00 EDT
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft8_Clean+CL.docx

Ted,

Attached are my comments on section 4.3, along with some minor edits to 3.1 and 3.2

From: Chris Eyers [mailto:chris@limitedskies.com]
Sent: Friday, April 10, 2015 11:21 AM
To: Thrasher, Theodore
Cc: ADAM Michel; Anastasia Kharina; Dickson, Neil; Peterson B (rmpaero@frontier.com); Olivier.husse@airbus.com; tpohle@airlines.org; Leggett, Cullen
Subject: RE: CO2 Effectiveness Call 10 April 10:00 EDT

Ted

Here are my proposed edits for section2 as mentioned in the call

Chris

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: 10 April 2015 16:04
To: ADAM Michel; Anastasia Kharina; Chris Eyers; Dickson, Neil; Peterson B (rmpaero@frontier.com); Olivier.husse@airbus.com; tpohle@airlines.org; Leggett (leggett.cullen@epa.gov)
Subject: RE: CO2 Effectiveness Call 10 April 10:00 EDT

With track changes

From: Thrasher, Theodore
Sent: 9-Apr-15 10:07 PM

To: 'ADAM Michel'; 'Anastasia Kharina'; 'chris@limitedskies.com'; Dickson, Neil; 'Peterson B (rmpaero@frontier.com)'; 'Olivier.husse@airbus.com'; 'tpohle@airlines.org'; 'Leggett (leggett.cullen@epa.gov)'
Subject: CO2 Effectiveness Call 10 April 10:00 EDT

Hi Everyone,

It's been a very busy couple of days on the communication of effectiveness task. Attached is the consolidated, completely revised WP that will be discussed during the call at 10:00 EDT on 10 April. As the track changes were so messy, we will base the discussion on the "clean" version of the paper. We have tried to address the issues raised during the last call.

The intent of this call is to decide whether the paper is ready to go to the FESG/MDG meeting or if additional discussion within the ad hoc group would be beneficial. As a reminder, the deadline for papers to the Cologne meeting is 17 April.

Talk to you at 10:00.

Here are the Lync / call-in details:

Join Lync Meeting

Participant passcode: Ex. 6 - Personal Privacy

Canada (Montreal

US (Colorado) +1

Belgium, Brussels

France, Paris +33

Ex. 6 - Personal Privacy

Germany 0180

Germany , Fran

Germany Muni

Hungary, Buda

Ireland, Dublin

Israel, Tel Aviv

Italy, Milan +3

Italy, Rome +3

Portugal, Lisbo

Singapore +65

Spain, Barcelo

Spain, Madrid

UK, Belfast +4

UK, Edinburgh

UK, London +4

UK, Reading +

Ex. 6 - Personal Privacy

Best regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Samulski, Michael[samulski.michael@epa.gov]
Cc: Manning, Bryan[manning.bryan@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Leggett, Cullen
Sent: Thur 1/8/2015 8:42:56 PM
Subject: EPA comments back to FAA
Sec V_ANPRM- to FAA 12-29-2014_FAAcomments + EPA revisions.docx

Mike, here is the latest version with your comments integrated in.

To: Manning, Bryan[manning.bryan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]
Cc: Audette, Lucie[audette.lucie@epa.gov]
From: Leggett, Cullen
Sent: Mon 12/15/2014 9:08:17 PM
Subject: RE: Latest ANPR section
Sec V ANPRM- to FAA 12-15-2014.docx

Here is the clean version.

Cullen Leggett

734-214-4514

From: Manning, Bryan
Sent: Monday, December 15, 2014 3:41 PM
To: Samulski, Michael
Cc: Leggett, Cullen; Audette, Lucie
Subject: Latest ANPR section

Hello Mike,

Attached is the latest draft ANPR section in redline/strikeout.

Thanks,

Bryan

To: Thrasher, Theodore[TThrasher@icao.int]
Cc: Chris Eyers[chris@limitedskies.com]
From: Leggett, Cullen
Sent: Mon 3/30/2015 5:35:26 PM
Subject: RE: Communication of CO2 Effectiveness Next Steps
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft6redline.docx

Ted,

Attached is an updated version of the document from Chris and I. The goal lines in Figure 1 and 2 are provisional right now. We're working on finalizing them at the moment but wanted to get this over to you for your review.

Cullen

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: Thursday, March 26, 2015 3:00 PM
To: chris@limitedskies.com; Dickson, Neil; Peterson B (rmpaero@frontier.com); Adam M; Olivier.husse@airbus.com; Anastasia Kharina; tpohle@airlines.org; Leggett, Cullen
Subject: Communication of CO2 Effectiveness Next Steps

Dear Communication of CO2 Standard Effectiveness ad hoc group members,

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thank you all for your inputs on this important element of the CO2 Standard work.

Kind regards,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Manning, Bryan[manning.bryan@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Yen, David[Yen.David@epa.gov]
From: Leggett, Cullen
Sent: Fri 3/27/2015 7:59:16 PM
Subject: FW: Effectiveness - next steps?
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft5+cjeV2.docx

FYI: Latest version of the document, and some emails below of Chris's summary of the situation w/in the group.

From: Chris Eyers [mailto:chris@limitedskies.com]
Sent: Friday, March 27, 2015 8:35 AM
To: Chris Eyers; Leggett, Cullen
Subject: RE: Effectiveness - next steps?

Easier than I thought, I've added the advanced line to Fig 3. Please use this cjeV2 version

Thanks

Chris

From: Chris Eyers
Sent: 27 March 2015 13:19
To: 'Leggett (leggett.cullen@epa.gov)'
Subject: RE: Effectiveness - next steps?
Importance: High

Cullen,

Here is my attempt at the more "hard line" version for your additional input. It is "hard line" only in the sense of still including all the goals lines and all three figures. Otherwise, I have tried to include everything Ted asked for and everything I heard on the telecon yesterday (about 50% of the call I think!).

For your info, I have added blue shading where there is still input needed from you or me – although your thoughts on the whole thing are welcome of course. Also please forward this to Karin if you are OK with it and think it would be helpful.

Having done this "hard line" version, it has clarified my thoughts on what a compromise version might be. My negotiating redline is just Fig 3 with a 0.5% trend line (as per my original proposal, in fact). This would be the compromise version of the paper for me. We need to discuss whether either or both of Figs 1 and 2 are essential in your and Karin's view.

I think I'm done for today but will be available over the weekend to pick up anything you send. Also please call my mobile if anything needs discussing.

Thanks

Chris

Ex. 6 - Personal Privacy

From: Chris Eyers
Sent: 27 March 2015 10:50
To: Leggett (leggett.cullen@epa.gov)
Subject: Effectiveness - next steps?
Importance: High

Morning Cullen,

After yesterday's call, I'm wondering how we can get the outcome we want/need on communicating effectiveness to CAEP Members, using Ted's latest instructions. This email is to help get my thoughts together and to ask your view. Here are my musings:

Ex. 5 - Deliberative Process

Grateful for any thoughts. Meantime, as soon as I have some proposed edits to the "hard line" version, I'll get them to you.

Note , all the above is just about the internal communication to CAEP Members. The external comms also needs addressing, but that's a separate topic.

Best regs

Chris

Chris Eyers

Mobile: +44 7771 965638

To: Manning, Bryan[manning.bryan@epa.gov]; Yen, David[Yen.David@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Leggett, Cullen
Sent: Wed 3/25/2015 9:15:06 PM
Subject: FW: Draft Report of CO2 Effectiveness Comms ad hoc group
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft3 +CJE.docx

Current rough draft of the effectiveness work. We're going to have a discussion again tomorrow to work on this a bit more. Let me know if you have any thoughts/comments. This is not being finalized tomorrow.

From: Chris Eyers [mailto:chris@limitedskies.com]
Sent: Wednesday, March 25, 2015 12:16 PM
To: Thrasher, Theodore; Leggett, Cullen
Subject: RE: Draft Report of CO2 Effectiveness Comms ad hoc group

Ted, Cullen,

Thanks for the opportunity to comment – much appreciated. I've added some suggestions in the attachment, including my attempt to explain Figure 2 (Cullen's graph). Cullen – please check this. I'm not sure it's right. As a combined document it reads very well.

Chris

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: 25 March 2015 15:48
To: Leggett (leggett.cullen@epa.gov); Chris Eyers
Subject: Draft Report of CO2 Effectiveness Comms ad hoc group

Cullen and Chris,

I have attached a draft of the paper that I plan to distribute to the comms ad hoc group this afternoon as the basis for our call tomorrow. Before I send it out, I wanted to give you the opportunity to review the part of the write-up related to your inputs.

Please let me know if you have any comments by 4:00 PM EDT today (otherwise we can discuss any changes with the broader group).

Thanks,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Chris Eyers[chris@limitedskies.com]; Thrasher, Theodore[TThrasher@icao.int]
From: Leggett, Cullen
Sent: Wed 3/25/2015 9:13:10 PM
Subject: RE: Draft Report of CO2 Effectiveness Comms ad hoc group
CAEP10_MDG09_WPxx_Communication of Effectiveness_Draft3 +CJE+CL.docx

Chris, Ted,

Thanks for putting this together. I've gone through and made a few updates and changes to this. Chris – That is a good summary of fig. 2. I made a small change to correct the percentages, and to remove the linear fit from the 2010-2022 data.

Talk to you guys tomorrow.

From: Chris Eyers [mailto:chris@limitedskies.com]
Sent: Wednesday, March 25, 2015 12:16 PM
To: Thrasher, Theodore; Leggett, Cullen
Subject: RE: Draft Report of CO2 Effectiveness Comms ad hoc group

Ted, Cullen,

Thanks for the opportunity to comment – much appreciated. I've added some suggestions in the attachment, including my attempt to explain Figure 2 (Cullen's graph). Cullen – please check this. I'm not sure it's right. As a combined document it reads very well.

Chris

From: Thrasher, Theodore [mailto:TThrasher@icao.int]
Sent: 25 March 2015 15:48
To: Leggett (leggett.cullen@epa.gov); Chris Eyers
Subject: Draft Report of CO2 Effectiveness Comms ad hoc group

Cullen and Chris,

I have attached a draft of the paper that I plan to distribute to the comms ad hoc group this afternoon as the basis for our call tomorrow. Before I send it out, I wanted to give you the opportunity to review the part of the write-up related to your inputs.

Please let me know if you have any comments by 4:00 PM EDT today (otherwise we can discuss any changes with the broader group).

Thanks,

Ted

Chief, Environmental Standards Section

ICAO Air Transport Bureau

+1-514-954-8219, x 6721 phone

+1-514-954-6744 fax

Consider the environment before printing this e-mail

To: Eric.Upton@gulfstream.com[Eric.Upton@gulfstream.com]
From: Leggett, Cullen
Sent: Mon 3/23/2015 7:22:18 PM
Subject: RE: CO2Db Call 4 - Draft Agenda
ICAO Aircraft CO2 Emissions Databank Introduction Text - v2 - clean.docx
ICAO Aircraft CO2 Emissions Databank Introduction Text - v2.docx

Eric,

Here is an updated intro in redline and clean. I've left some comments in the clean as discussion points with the wider group.

Do we need anything else for the call tomorrow?

Cullen

From: Eric.Upton@gulfstream.com [mailto:Eric.Upton@gulfstream.com]
Sent: Wednesday, March 18, 2015 2:59 PM
To: Leggett, Cullen
Subject: RE: CO2Db Call 4 - Draft Agenda

OK, so the call will have to wait. I'm running behind again...

In the meantime, though, here are some edits and comments on the introduction...

Thanks for the good start :-)

Eric Upton, PhD
Environmental/Performance Specialist
Gulfstream Aerospace Corporation
Eric.Upton@gulfstream.com
ph: 912-395-8458
fax: 912-965-8850

This e-mail message, including all attachments, is for the sole use of the intended recipient(s) and may contain Personal Information under General Dynamics policy CP 07-105 and/or legally privileged and confidential information. Any Personal Information can be accessed only by authorized personnel of General Dynamics and its approved service providers and may be used only as permitted by General Dynamics and its policies. Contractual restrictions apply to third parties. If you are not an intended recipient, you are hereby notified that you have either received this message in error or through interception, and that any review, use, distribution, copying or disclosure of this message or its attachments is strictly prohibited and is subject to criminal and civil penalties. All personal messages express solely the sender's views and not those of Gulfstream Aerospace Corporation.
If you received this message in error, please contact the sender by reply e-mail and destroy all copies of the original message.

From: "Leggett, Cullen" <Leggett.Cullen@epa.gov>
To: "Eric.Upton@gulfstream.com" <Eric.Upton@gulfstream.com>,
Date: 03/18/2015 09:01 AM
Subject: RE: CO2Db Call 4 - Draft Agenda

I have a meeting from 130-230. Other than that I'll be around. Give me a call whenever.

From: Eric.Upton@gulfstream.com [mailto:Eric.Upton@gulfstream.com]
Sent: Tuesday, March 17, 2015 4:59 PM
To: Leggett, Cullen
Subject: Re: CO2Db Call 4 - Draft Agenda

Hi Cullen,

I think the agenda is in the right order, so no worries there. The EPA/ICSA material is pretty independent of the format of the DB...
I think we also need to approve the call 2 notes... unless we consider that closed due to lack of feedback from anyone after call 3...

I'll take a crack at the explanatory text tonight...

Will you be around tomorrow afternoon?

Eric Upton, PhD
Environmental/Performance Specialist
Gulfstream Aerospace Corporation
Eric.Upton@gulfstream.com
ph: 912-395-8458
fax: 912-965-8850

This e-mail message, including all attachments, is for the sole use of the intended recipient(s) and may contain Personal Information under General Dynamics policy CP 07-105 and/or legally privileged and confidential information. Any Personal Information can be accessed only by authorized personnel of General Dynamics and its approved service providers and may be used only as permitted by General Dynamics and its policies. Contractual restrictions apply to third parties. If you are not an intended recipient, you are hereby notified that you have either received this message in error or through interception, and that any review, use, distribution, copying or disclosure of this message or its attachments is strictly prohibited and is subject to criminal and civil penalties. All personal messages express solely the sender's views and not those of Gulfstream Aerospace Corporation.
If you received this message in error, please contact the sender by reply e-mail and destroy all copies of the original message.

From: "Leggett, Cullen" <Leggett.Cullen@epa.gov>
To: Eric Upton <eric.upton@gulfstream.com>,
Date: 03/17/2015 02:28 PM
Subject: CO2Db Call 4 - Draft Agenda

Eric,

Here is a draft agenda. What do you think? Should we go through the DB then into the EPA/ICSA input or the other way around. I'm thinking second so that we can the move right into the parameter discussion.

- Welcome
- Approve call 3 notes
- Feedback from EPA
- Feedback from ICSA
- Review reorganization of the CO2 DB
- Review and discuss open parameters
- Introduction of explanatory text for CO2Db
- Way Forward
  - Co-leads to draft paper for Belfast meeting
  - Review explanatory text for CO2Db and provide text edits
- AOB?
- Next meeting April 20 at 10:00 EST
-

I've also attached a first draft of some introduction text for the CO2Db. I've built extensively off of the formatting of the EDb on the EASA website. Let me know what you think. I've included it in the agenda, if you think it is in reasonable enough shape to be sent out to the wolves to chew on. I'm thinking if we keep it in the agenda, we'll just say that we've drafted text and please provide comments.

http://easa.europa.eu/document-library/icao-aircraft-engine-emissions-databank#7

Cullen

[attachment "ICAO Aircraft CO2 Emissions Database Introduction Text - v1.docx" deleted by Eric Upton/SAV/GAC]

To: Audette, Lucie[audette.lucie@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]
From: Leggett, Cullen
Sent: Tue 10/21/2014 9:55:54 PM
Subject: RE: For Review: Briefings "Recommended Next Steps"
McCabe Update on ICAO progress Grundler Prebrief October 21 + CL.docx

I've added Lucie's edits to the briefing from earlier and updated the plot of the SOs.

From: Audette, Lucie
Sent: Tuesday, October 21, 2014 5:53 PM
To: Samulski, Michael; Manning, Bryan; Leggett, Cullen
Subject: For Review: Briefings "Recommended Next Steps"

I've tried to rework this section to take in Chris/Bill's comments. See what you think. LUcie

To: Audette, Lucie[audette.lucie@epa.gov]
Cc: Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]
From: Manning, Bryan
Sent: Fri 6/3/2016 6:08:55 PM
Subject: Summary of Communications Roll Out Call earlier today (aircraft GHG endang FRM)

Hello Lucie,

I just wanted to take a moment to let you know how the communications roll out call went earlier this afternoon. The participants were as follows: Lesley, Isabel DeLuca, Erin Birgfeld, John Millet, Chris Mylan, Bruce, and myself (note, I believe Chris Mylan was on the call, but I joined a bit late so I am not certain).

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Thanks,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

To: Jantarasami, Lesley[Jantarasami.Lesley@epa.gov]; Birnbaum, Rona[Birnbaum.Rona@epa.gov]; Samulski, Michael[samulski.michael@epa.gov]; Manning, Bryan[manning.bryan@epa.gov]; DeAngelo, Ben[DeAngelo.Ben@epa.gov]; Thrift, Mike[thrift.mike@epa.gov]; Schillo, Bruce[Schillo.Bruce@epa.gov]; Benner, Tim[Benner.Tim@epa.gov]; Bowen, Jennifer[Bowen.Jennifer@epa.gov]; Dutton, Steven[Dutton.Steven@epa.gov]; McDow, Stephen[McDow.Stephen@epa.gov]; Sarofim, Marcus[Sarofim.Marcus@epa.gov]; Hockstad, Leif[Hockstad.Leif@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]; Gordon, Jessica M[Gordon.Jessica@epa.gov]; Williams, Melina[Williams.Melina@epa.gov]; Ayres, Sara[Ayres.Sara@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]
From: Audette, Lucie
Sent: Wed 11/19/2014 7:58:37 PM
Subject: Aircraft Workgroup Meeting Reminder - **Ex. 6 - Personal Privacy**
Ex. 6 - Personal Privacy
Options Selection_Aircraft for Janet McCabe_11-12-14_Final.pptx
Aircraft Key Milestone dates (2).xlsx

Hello Workgroup Members,

We will have a meeting tomorrow, November 20, beginning at 9:15 am. Proposed Agenda Items include:

Ex. 5 - Deliberative Process

Lucie and Lesley

Environmental Technical Manual

DRAFT

Volume III
Procedures for the CO_2 Emissions Certification of Aeroplanes

International Civil Aviation Organization
Committee on Aviation Environmental Protection

DRAFT

FOREWORD

ICAO Doc 9501, Volume III, First Edition, includes material which has been approved by the ICAO Committee on Aviation Environmental Protection (CAEP) Steering Group during their tenth meeting (CAEP/10) in February 2016. This manual is to be periodically revised under the supervision of the CAEP Steering Group and is intended to make the most recent information available to certificating authorities, aeroplane certification applicants and other interested parties in a timely manner, aiming at achieving the highest degree of harmonisation possible. The technical procedures and equivalent procedures described in this approved revision of the ETM Volume III are consistent with currently accepted techniques and modern instrumentation. This revision and subsequent revisions that may be approved by the CAEP Steering Group will be posted on the ICAO website (http://www.icao.int/) under "publications" until the latest approved revision is submitted to CAEP for formal endorsement and subsequent publication by ICAO.

Comments on this manual, particularly with respect to its application and usefulness, would be appreciated from all States. These comments will be taken into account in the preparation of subsequent editions. Comments concerning this manual should be addressed to:

The Secretary General
International Civil Aviation Organization
999 Robert-Bourassa Boulevard
Montréal, Quebec H3C 5H7
Canada

EPA-HQ-2018-004348

TABLE OF CONTENTS

FOREWORD I

TABLE OF CONTENTS II

ACRONYMS AND ABBREVIATIONS III

CHAPTER 1 – INTRODUCTION 1
- ***1.1 PURPOSE*** *1*
- ***1.2 DOCUMENT STRUCTURE*** *1*
- ***1.3 TECHNICAL PROCEDURES*** *1*
- ***1.4 EQUIVALENT PROCEDURES*** *1*
- ***1.5 EXPLANATORY INFORMATION*** *2*
- ***1.6 CONVERSION OF UNITS*** *2*
- ***1.7 REFERENCES*** *2*

CHAPTER 2 - GENERAL GUIDELINES 3
- ***2.1 APPLICABILITY OF ANNEX 16, VOLUME III*** *3*
  - 2.1.4 Type design configurations which shall be certified 3
  - 2.1.5 Appropriate margin to regulatory level 4
- ***2.2 CHANGES TO CO2 APPROVED AEROPLANE TYPE DESIGNS*** *4*
- ***2.3 CO_2 EMISSIONS EVALUATION METRIC COMPLIANCE DEMONSTRATION PLANS*** *5*
- ***2.4 ENGINE INTERMIX*** *5*

CHAPTER 3 - SAR DETERMINATION PROCEDURES 7
- ***3.1 SAR MEASUREMENT PROCEDURES*** *7*
  - 3.1.1 FLIGHT TEST PROCEDURES 7
- ***3.2 SAR DATA ANALYSIS*** *9*
  - 3.2.1 DATA SELECTION 9
  - 3.2.2 CORRECTIONS TO REFERENCE CONDITIONS 11
  - 3.2.3 DATA EXTRAPOLATION 19
- ***3.3 VALIDITY OF RESULTS - CONFIDENCE INTERVAL*** *20*
  - 3.3.1 INTRODUCTION 20
  - 3.3.2 DIRECT FLIGHT TESTING 20
  - 3.3.3 REGRESSION MODEL 20
  - 3.3.4 WORKED EXAMPLE OF THE DETERMINATION OF 90 PER CENT CONFIDENCE INTERVALS 23
- *3.4* ***EQUIVALENT PROCEDURES*** *27*
  - 3.4.1 APPROVAL BASED ON EXISTING DATA 27
  - 3.4.2 APPROVAL BASED ON BACK-TO-BACK TESTING 27
  - 3.4.3 APPROVAL OF CHANGES BASED ON ANALYSIS 28

APPENDIX 1 - REFERENCES ..... A

APPENDIX 2 - BIBLIOGRAPHY ..... B

DRAFT

ED_001734_00021756-00004

ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Meaning	Unit
A	Area	m^2
A16V3	Annex 16 Volume III	-
AMC	Acceptable means of compliance	-
C_D	Drag coefficient	-
C_L	Lift coefficient	-
CG	Centre of gravity	-
CI	Confidence interval	-
CO_2	Carbon dioxide	-
ETMV3	Environmental technical manual volume III	-
g	Gravitational acceleration	m/s^2
GM	Guidance material	-
h	Altitude	m
InP	In-production	-
FLHV	Fuel lower heating value	MJ/kg
M	Mach number	-
MAC	Mean aerodynamic chord	cm
MTOM	Maximum take-off mass	kg
OML	Outer mould line	-
r	Radius	m
RE	Reynolds number	-
RGF	Reference geometric factor	-
RSS	Residual sum of squares	-
SAR	Specific air range	km/kg
T	Temperature	K
TAS	True air speed	km/h
TOM	Take-off mass	kg
V	Speed	m/s
W_f	Total aeroplane fuel flow	kg/h
W	Weight	N
WV	Weight variant	-
ρ	Density	kg/m^3

Chapter 1 – INTRODUCTION

1.1 PURPOSE

1.1.1 The aim of this manual is to promote uniformity of implementation of the technical procedures of Annex 16 — Environmental Protection, Volume III — Aeroplane CO_2 Emissions by providing: (1) guidance to certificating authorities, applicants and other interested parties regarding the intended meaning of the Standards in the current edition of the Annex; (2) guidance on specific methods that are deemed acceptable in demonstrating compliance with those Standards; and (3) equivalent procedures resulting in effectively the same CO_2 emissions evaluation metric that may be used in lieu of the procedures specified in the Appendices of Annex 16 Volume III.

1.2 DOCUMENT STRUCTURE

1.2.1 Chapter 1 provides general information regarding the use of this Environmental Technical Manual Volume III. Chapter 2 provides general guidelines on the interpretation of Annex 16 Volume III. Chapter 3 brings technical guidelines for the certification of aeroplanes against Annex 16 Volume III, including equivalent procedures.

1.2.2 Guidance is provided in the form of explanatory information, acceptable methods for showing compliance, equivalent procedures, and technical procedures.

1.3 TECHNICAL PROCEDURES

1.3.1 A technical procedure is a test or analysis procedure not defined in detail in the Annex but which certificating authorities have approved as being acceptable for compliance with the general provisions of the Annex.

1.3.2 The procedures described in the Annex shall be used unless an equivalent procedure is approved by the certificating authority. Equivalent procedures should not be considered as limited only to those described herein, as this manual will be expanded as new equivalent procedures are developed. Also, their presentation does not infer limitation of their application or commitment by certificating authorities to their further use.

1.4 EQUIVALENT PROCEDURES

1.4.1 An equivalent procedure is a test or analysis procedure which, while differing from the one specified in Annex 16, Volume III, in the technical judgement of the certificating authority, yields effectively the same CO_2 emission levels as the specified procedure.

1.4.2 The use of equivalent procedures may be requested by applicants for many reasons, including:

1) to make use of previously acquired or existing data for the aeroplane; and

2) to minimize the costs of demonstrating compliance with the requirements of Annex 16,

Volume III, by keeping aeroplane test time and equipment and personnel costs to a minimum.

1.5 EXPLANATORY INFORMATION

1.5.1 Explanatory information has the following purpose:

a) explains the intent of the Annex 16 Volume III Standards;

b) states current policies of certificating authorities regarding compliance with the Annex; and

c) provides information on critical issues concerning approval of applicants' compliance methodology proposals.

1.6 CONVERSION OF UNITS

1.6.1 Conversions of some non-critical numerical values between U.S. Customary (English) and SI units are shown in the context of acceptable approximations.

1.7 REFERENCES

DRAFT

1.7.1 Unless otherwise specified, references throughout this document to "the Annex" relate to Annex 16 to the Convention on International Civil Aviation (Environmental Protection), Volume III (Aeroplane CO_2 Emissions), First Edition.

1.7.2 References to sections of this manual are defined only by the section number to which they refer. References to documents other than the Annex are numbered sequentially (e.g., Reference 1, Reference 2, etc.). A list of these documents is provided in Appendix 1 of this manual, and a bibliography can be found in Appendix 2.

Chapter 2 - GENERAL GUIDELINES

2.1 APPLICABILITY OF ANNEX 16, VOLUME III

2.1.1 The Chicago Convention Article 3 specifically states that it is not applicable to state aircraft and provides some examples (see below), but this can also include specific flights carrying official government representatives:

" a) This Convention shall be applicable only to civil aircraft, and shall not be applicable to state aircraft.

b) Aircraft used in military, customs and police services shall be deemed to be state aircraft."

2.1.2 In addition, Annex 16 Vol. III, Part II, Chapter 2, para. 2.1 excepts amphibious aeroplanes; aeroplanes initially designed or modified for specialized operational requirements and used as such; aeroplanes designed with zero RGF; and those aeroplanes specifically designed or modified and used for fire-fighting purposes. These are typically special categories of aeroplanes which are limited in numbers and have specific technical characteristics resulting in very different CO2 metric values compared to all other aeroplane types in the proposed applicability scope.

2.1.3 Examples of specialized operational requirements include:

DRAFT

a) aeroplanes that are initially certified as civil aeroplanes during the production process but immediately converted to military aeroplanes;
b) a required capacity to carry cargo that is not possible by using less-specialised aeroplanes;
c) a required capacity for very short or vertical take-offs and landings;
d) a required capacity to conduct scientific, research, or humanitarian missions exclusive of commercial service; or
e) similar factors.

2.1.4 Type design configurations which shall be certified

2.1.4.1 Annex 16 Volume III defines in Part I, Chapter 1 the *"Maximum take-off mass" (MTOM)* as being *"the highest of all take-off masses for the type design configuration".* Part II, Chapter 2, section 2.3 defines the three reference masses at which the 1/SAR value shall be established, and these masses are calculated based on the MTOM.

2.1.4.2 Applicants may develop multiple TOM variants of a specific type design configuration (i.e., combination of airframe/engine) for operational purposes. As stated above, only the highest Maximum Take-off Mass of a specific airframe/engine combination is required to be certified against Annex 16 Volume III. As stated in Note 2 in Part II, Chapter II, section 2.3, certification at MTOM also certifies all TOM variants. These TOM variants would have the same CO_2 emissions evaluation metric value as the MTOM.

2.1.4.3 However Note 2 in Part II, Chapter II, section 2.3, states that *"The applicant may also apply for the approval of CO_2 metric values at take-off masses lower than the highest of all maximum take-*

off masses". The purpose of this note is to allow the applicant to apply for approval of a separate CO_2 emissions evaluation metric value for a TOM lower than the MTOM. In that case, the reference aeroplane masses, and the maximum permitted CO_2 emissions evaluation metric value, would be based on the TOM instead of the MTOM. The CO_2 emissions evaluation metric value for this TOM could then also be used for any TOM variant of even lower mass. The applicant can apply for approval for separate CO_2 emissions evaluation metric values for as many or as few TOM variants as they desire.

2.1.4.4 Example of type design configurations to be certified.

Assuming an Applicant applies for the approval of the following type design configurations:

a) Two fuselage lengths: Model A and Model B;
b) Two engine options: Engine X and Engine Y;
c) Two weight variants (WV) for each fuselage length: WV01 and WV02 for Model A and WV11 and WV12 for Model B.

The possible combinations are summarised in Table 01 below:

Model A	Engine X	WV01
		WV02
	Engine Y	WV01
		WV02
Model B	Engine X	WV11
		WV12
	Engine Y	WV11
		WV12

Table 01 - Type Design Configuration combinations

The Type Design Configurations that must be certified against Annex 16 Volume III are the ones that have the highest MTOM. Assuming WV01 and WV11 have higher Maximum Take-off Masses than WV02 and WV12, the following combinations must be certified:

a) Model A – Engine X – WV01;
b) Model A – Engine Y – WV01;
c) Model B – Engine X – WV11;
d) Model B – Engine Y – WV11.

The combinations with WV02 and WV12 would be assigned the same CO_2 emissions evaluation metric value as the combinations with WV01 and WV11, respectively. At the applicant's option, the combinations with WV02 and/or WV12 could also be certified to obtain a different CO_2 emissions evaluation metric value for those combinations.

2.1.5 Appropriate margin to regulatory level

2.1.5.1 If an applicant chooses to separately certify a lower TOM variant, as discussed in paragraph 2.1.4 above, it should be kept in mind that an underlying principle in applying the CO_2 standard is that the highest weight variant (MTOM) has the lowest margin to the regulatory limit level. The 1/SAR value used in the CO_2 metric system is calculated as an average of three reference masses (high, medium, and low).

2.1.5.2 In establishing the reference conditions for SAR determination, it is expected that the

highest SAR value will be sought at the maximum range cruise condition at the optimum altitude (Annex 16, Volume III, Chapter 2, Paragraph 2.5). It is noted that a greater non-linearity in the 1/SAR vs. mass relationship could be introduced by a constraint unrelated to the aerodynamic and propulsive efficiency of the aeroplane (e.g., an altitude pressurisation limitation). In this instance, particular care should be taken that the principle of the highest weight variant having the lowest margin to the regulatory limit level continues to hold.

2.2 CHANGES TO CO2 APPROVED AEROPLANE TYPE DESIGNS

2.2.1 Part I, Chapter I includes the following definition:

> ***"Derived version of a CO_2-certified aeroplane.*** *An aeroplane which incorporates changes in type design that increase its CO_2 emissions evaluation metric value by more than xx."*

2.2.2 Consequently any change to an aeroplane type design which increases its certified CO_2 emission evaluation metric value by more than xx shall be considered a derived version, and the applicant must demonstrate compliance with Annex 16 Volume III.

2.2.3 Changes to a CO_2-certified aeroplane which do not increase its CO_2 emissions evaluation metric by more than xx are considered no-CO_2 changes, and the CO_2 emissions evaluation metric evaluation value of the derived version shall be considered the same as the parent type design.

2.2.4 The evaluation of some changes can be done by simpler equivalent procedures, as detailed in 3.4.2 – Approval based on back-to-back testing or 3.4.3 – Approval of changes based on analysis.

DRAFT

2.3 CO_2 EMISSIONS EVALUATION METRIC COMPLIANCE DEMONSTRATION PLANS

2.3.1 Prior to undertaking a CO_2 certification demonstration, the applicant should submit to the certificating authority a CO_2 compliance demonstration plan. This plan contains a complete description of the methodology and procedures by which an applicant proposes to demonstrate compliance with the CO_2 certification Standards specified in Annex 16 Volume III. Approval of the plan and the proposed use of any equivalent procedures or technical procedures not included in the Annex remains with the certificating authority. CO_2 compliance demonstration plans should include the following types of information:

a) *Introduction.* A description of the aeroplane CO_2 certification basis.

b) *Aeroplane description.* Type, model number and the specific configuration to be certificated.

Note.— The certificating authority should require that the applicant demonstrate and document the conformity of the test aeroplane, particularly with regard to those parts which might affect its CO_2 emissions evaluation metric.

c) *Aeroplane CO_2 certification methodology.* Means of compliance, equivalent procedures from this ETM and technical procedures from Annex 16 Volume III.

d) *Plans for tests.* The plans for test should include:

1) *Test description.* Test methods to comply with the test environment and

flight path conditions of the Annex, as appropriate.

e) Deliverables. List the documents that should show compliance with Annex 16 Volume III (test and analysis reports, including RGF determination).

Note— Plans for tests shall either be integrated into the basic CO_2 compliance demonstration plan or submitted separately and referenced in the basic plan.

2.4 ENGINE INTERMIX

2.4.1 Applicants will typically demonstrate compliance with the Standard of Chapter 2 of Annex 16 Volume III for an aeroplane type configuration where all engines are of the same design. However an applicant may wish to demonstrate compliance of an aeroplane type configuration where not all the engines are of the same design. Such a configuration is commonly referred to as an "engine intermix" configuration.

2.4.2 In such a case the applicant may, subject to the approval of the certificating authority, demonstrate compliance in one of three ways:

a) In accordance with the test procedures defined in paragraph 2.6 of Chapter 2 of the Annex and for which the test aeroplane shall be representative of the intermix configuration for which certification is requested; or

b) In cases where the CO_2 metric value has been established for aeroplanes on which each of the intermix engine models has been exclusively installed, compliance can be demonstrated on the basis of either:

1) the average of the CO_2 emissions evaluation metrics for aeroplanes on which each of the intermix engine models has been exclusively installed; or

2) the highest CO_2 emissions evaluation metric of the aeroplanes on which each of the intermix engine models has been exclusively installed.

Note.– Paragraph 2.1.2 of Chapter 2 of Annex 16, Volume III, states that in the case of time-limited engine changes Contracting States may not require a demonstration of compliance with the Standards of Annex 16, Volume III.

DRAFT

EPA-HQ-2018-004348

Chapter 3 - SAR DETERMINATION PROCEDURES

3.1 SAR MEASUREMENT PROCEDURES

3.1.1 FLIGHT TEST PROCEDURES

Placeholder for any needed explanations.

3.1.1.1 Data Acquisition

Recommended flight-test techniques for gathering SAR measurement data as applicable to each of the agreed to methods (i.e., duration, stability, etc.).

3.1.1.2 Measurement accuracy

Include an explanation about instrumentation for data acquisition on SAR determining flight tests, including acceptability of aeroplane standard instruments.

DRAFT

3.1.1.3 Fuel properties

3.1.1.3.1 One of the important factors when determining the CO_2 emissions of an aeroplane according to Annex 16 Volume III is the fuel used in the flight tests.

3.1.1.3.2 Section *2.6.3* of the Annex states:

> *"Note. — The fuel used for each flight test shall meet the specification defined in either ASTM D1655, DEF STAN 91-91 or equivalent."*

Equivalent fuel specifications accepted for the purposes of CO_2 emissions certification are the following:

a) Brazil: CNP-08, QAV-1;

b) China: GB6537 Number 3 Jet Fuel;

c) France: DCSEA 134;

d) Russia: GOST 10227-86 or 52050-2006, RT;

e) USA: ASTM D1655[1] "Standard Specification for Aviation Turbine Fuels", Jet-A1;

f) UK: DEF STAN 91-91[2] "Turbine Fuel, Kerosene Type, Jet A-1";

g) Similar specifications from other member states, subject to the approval of the certificating authority.

3.1.1.3.3 Section 2.5.1 of the Annex specifies the reference conditions to which the test conditions shall be corrected. The reference fuel lower heating value is specified as 43.217 MJ/kg

ED_001734_00021756-00012

(18 580 BTU/lb). Recommendation 1 to paragraph 3.2.1c) of Appendix 1 of the Annex states that the fuel lower heating value should be determined in accordance with methods that are at least as stringent as ASTM D4809-09A[3], "Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)." This method is estimated to have an accuracy level on the order of 0.23%.

3.1.1.3.4 Paragraph 3.2.1d) of Appendix 1 of the Annex states that a sample of fuel shall be taken for each flight test to determine its specific gravity and viscosity when volumetric fuel-flow meters are used. The fuel's specific gravity and viscosity need not be determined if volumetric fuel-flow meters are not used.

Examples of acceptable methods to determine the fuel's specific gravity and viscosity are ASTM D4052[4], entitled "Standard Test Method for Density and Relative Density of Liquids by Digital Density Meter" and ASTM D445[5], entitled "Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)". Other methods may be used, subject to the approval of the certificating authority.

DRAFT

SAR DATA ANALYSIS

3.1.2 DATA SELECTION

Selection of data used to show compliance to the standard encompasses both the selection of flight test data gathered during each test condition used to obtain an individual SAR point, as well as the distribution of the resulting corrected SAR points in relation to the three reference masses and the reference conditions.

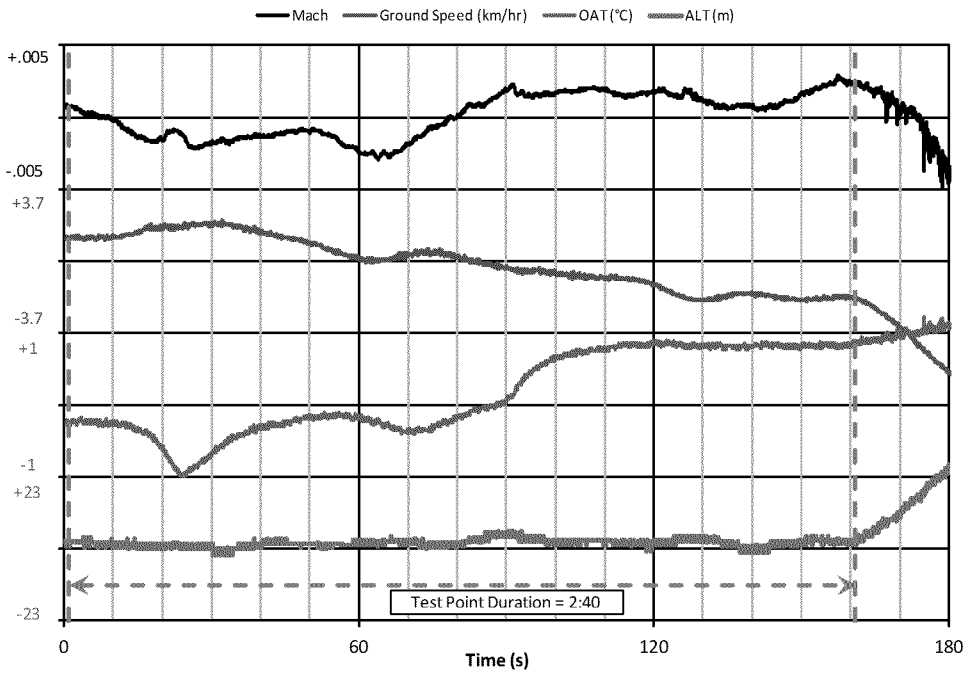
3.1.2.1 Selection of Flight Test Data

3.2.1.1.1 There are multiple methods employed by aeroplane manufacturers in selecting flight test data for analysis, reflecting a variety of tools and practices. Whichever method is chosen, the flight test data encompassed within the selected range of time is expected to meet the stability criteria detailed in Annex 16 Volume III, Appendix 1, paragraph 3.2.3.1, or alternative stability criteria approved by the certificating authority under paragraph 3.2.3.2 of that Annex 16 Volume III appendix. Test data that do not meet these stability criteria should normally be discarded. However, if such test data appears to be valid when compared with data that meet the stability criteria, and the overall stability of the conditions is reasonably bounded, these data can be retained, subject to approval of the certificating authority.

3.2.1.1.2 One acceptable method is to employ an algorithm that automatically selects the data that meets all the stability criteria, and discards data that does not. This method could be used to select the longest possible duration SAR point that meets the required stability criteria, or could be used to select multiple SAR points of the minimum requirement duration (one minute) providing these points are separated by a minimum of two minutes or by an exceedance of the stability criteria as specified in paragraph 3.2.2.2 of Annex 16 Volume III, Appendix 1. Using a defined algorithm to select data in an automated process allows repeatable and consistent application to other SAR points. This method may also yield a greater number of SAR points to be used in defining the CO_2 metric value and should represent a good statistical distribution. However, because the amount of test data included in each SAR point is maximized, the resulting SAR points could exhibit more scatter than if additional selection criteria are used.

3.2.1.1.3 Another method is to more closely examine the collected flight test data and select the timeframe to be used to define the SAR point, by choosing the best or most stable data available and ignoring less stable data that technically still meets the stability criteria. An example of this is presented in Figure XX.

DRAFT



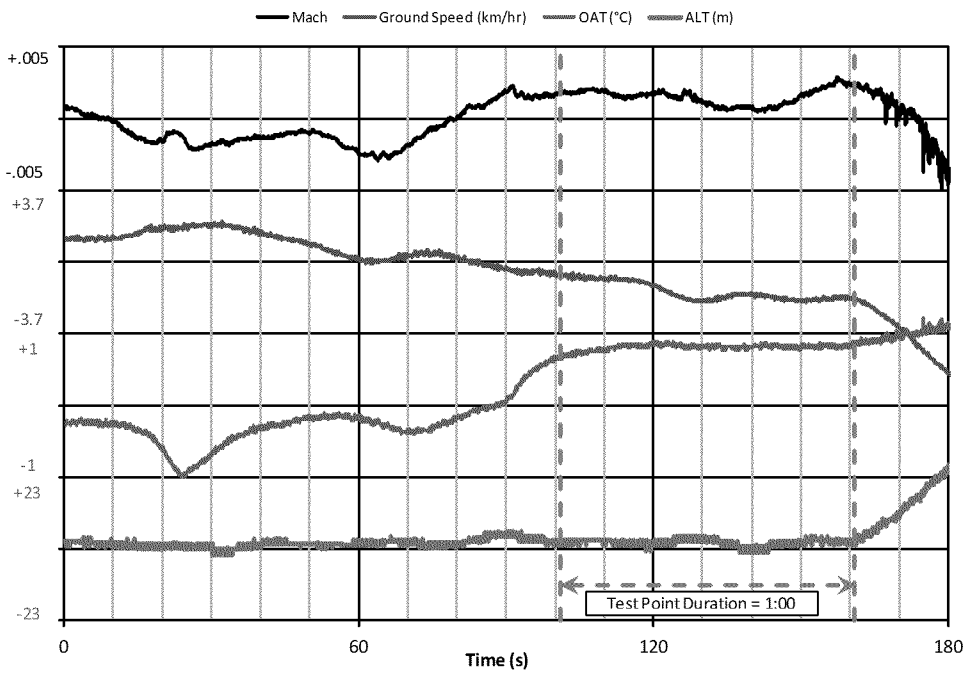


FIGURE XX

3.2.1.1.4 The first graph shows that the plotted parameters stay within the tolerances allowed by the stability criteria for the duration of the test condition. (The changing altitude after the end of the condition reflects pilot input to leave steady flight and transition to the next test condition.) While all parameters are within the required tolerances, fluctuations in ambient temperature and Mach are evident. The second graph shows the same data, but with a manually selected range of shorter duration where the parameters are more stable.

3.2.1.1.5 Selecting data that meets more demanding stability criteria, instead of using all data that meets the Annex 16 Volume III stability criteria, may allow the applicant to filter out observed instabilities caused by air quality, changing environmental conditions, flight control inputs, and aeroplane system dynamics. This could result in a SAR point that is actually more

representative of actual aeroplane performance.

3.2.1.1.6 Whichever approach is taken to select data to define SAR points, it is important the methodology be applied as consistently as possible, to minimize potential unseen bias in the resulting distribution of SAR points.

3.2.1.1.7 Another important aspect to consider when selecting data is to ensure that the time interval chosen is representative of the aircraft's performance, and not indicative of a larger trend. For example, the first plot in Figure YY shows a trend line drawn through ground speed data over a 60 second time interval. This ground speed data meets the stability criteria, and taken alone would indicate the need for an energy correction. However, if the ground speed data trace was continued over a longer time interval, it becomes apparent that it exhibits cyclic behaviour. Cyclic data need not be discarded necessarily, but the applicant should ensure that an appropriate time interval is selected such that the arithmetic average is representative. In the example shown, an energy correction would be inappropriate.

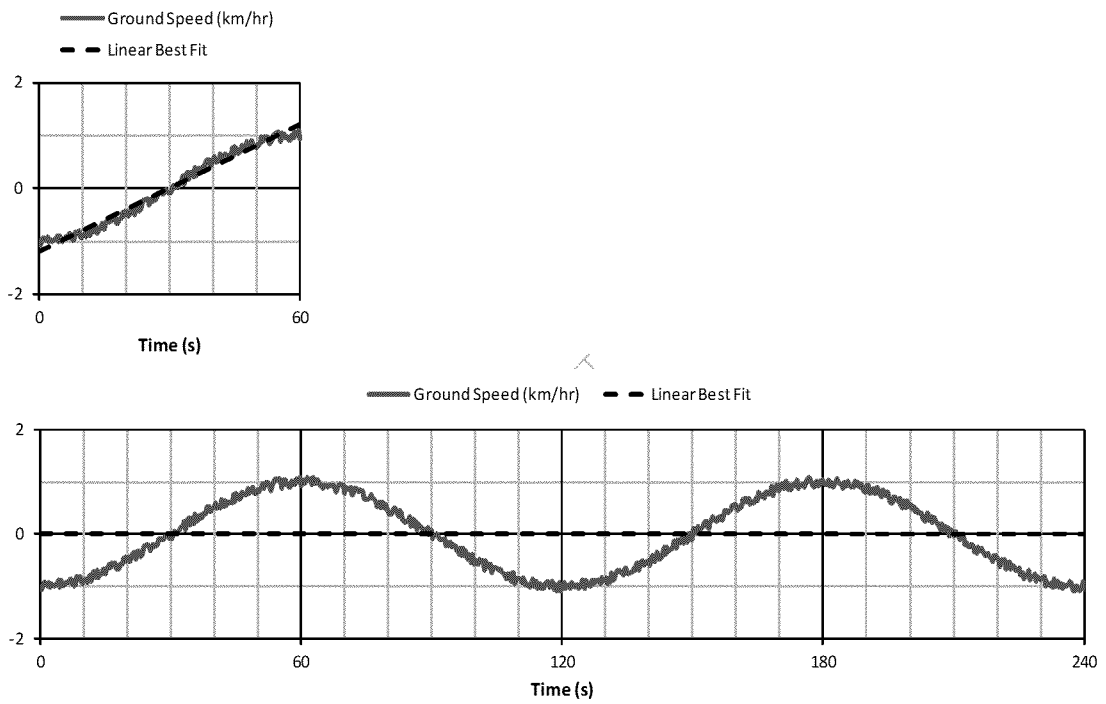


FIGURE YY

3.1.2.2 Distribution of Resulting SAR points

3.2.1.2.1 Once the individual SAR points have been selected and corrected to reference conditions, they should be examined to ensure they present an accurate representation of aeroplane performance.

3.2.1.2.2 For example, if direct flight test is being used to collect 6 SAR points targeting one reference mass, those 6 points when corrected to reference conditions should result in a reasonable grouping. If 5 of the points form a reasonable grouping and one point is a clear outlier, the offending point may require closer scrutiny to ensure it is actually representative. In such a situation, collection of additional data may be warranted, or, if appropriate, and subject to approval by the certificating authority, the offending data point could be discarded.

3.2.1.2.3 If the applicant conducts tests across a range of weights to build a regression line of SAR versus weight, the collected SAR points should be reasonably distributed across the weight range. If a large portion of the regression line is unsupported by data, or is anchored by a single SAR point, then the SAR determined for one of the reference masses may be suspect. This is an important aspect to consider during the development of the certification plan and flight test programme. As with the direct test method, if a single SAR point appears to be an outlier compared to the rest of the data points, it should be examined more closely and could potentially be discarded.

3.2.1.2.4 The applicant should investigate the collection of SAR points for potential sources of unintended bias, for example if all of the data points collected were during periods where groundspeed was increasing. If all of the test points require a large energy correction in one direction, resulting in all SAR point being significantly increased (or decreased), further scrutiny may be required to ensure a bias is not introduced, depending on the test data and correction techniques being used.

3.1.3 CORRECTIONS TO REFERENCE CONDITIONS

3.1.3.1 General. The guidance provided here represents one set of methods, but not the only acceptable methods, for correcting the specific air range test data to the reference conditions specified in paragraph 2.5 of Annex 16 Volume III Part II.

3.1.3.1.1 Care needs to be taken not to inadvertently account for a correction twice when making any of the corrections below. For example, when adjusting to the reference Mass/δ from the test Mass/δ, a drag correction is introduced to account for the change in lift coefficient (C_L). This change in C_L, at a constant Mach number, also changes the reference Reynolds number and the reference mass. However, these additional changes may already be accounted for in the drag adjustments for off-nominal Reynolds number and aeroelastics depending on the correction methods used.

3.1.3.1.2 The corrections identified in paragraphs 3.2.2.2 through 3.2.2.12 cover corrections that should be made to the tested values of aeroplane mass, drag, and fuel flow. These corrected values of aeroplane mass, drag, and fuel flow should then be used to determine SAR for the reference conditions in the following manner:

3.1.3.1.2.1 Determine the aeroplane mass corrected to reference conditions per paragraph 3.2.2.2. Use this mass as the reference mass in paragraphs 3.2.2.3.2, 3.2.2.4.1, and 3.2.2.7.1, and as the mass for determining the aeroplane drag in paragraph 3.2.2.1.2.2.

3.1.3.1.2.2 Determine the aeroplane drag for the test condition using the mass corrected for gravitational acceleration. Determine all of the drag corrections per paragraphs 3.2.2.3, 3.2.2.4, 3.2.2.5, 3.2.2.6, and 3.2.2.7. Sum these drag corrections and add to the aeroplane drag for the test condition to obtain the aeroplane drag corrected to the reference conditions.

3.1.3.1.2.3 Use the drag level corrected to reference conditions from paragraph 3.2.2.1.2.2 as a thrust level (thrust = drag) to determine the total engine fuel flow for these conditions from an engine performance model. Correct this engine fuel flow to reference conditions per paragraphs 3.2.2.8, 3.2.2.9, 3.2.2.10, 3.2.2.11, and 3.2.2.12.

3.1.3.1.2.4 The SAR value corrected to reference conditions is given by the following relationship:

Where SAR_{ref} is the specific air range for the reference conditions in kilometers/kilogram,

TAS is the aeroplane true airspeed for the test condition in kilometers/hour, and

Fuel $Flow_{ref}$ is the engine fuel flow for the reference conditions (from paragraph 3.2.2.1.2.3) in kilograms/hour.

3.1.3.2 Apparent gravity. Acceleration, caused by the local effect of gravity, and inertia affects the test weight of the aeroplane. The apparent gravity varies with latitude, altitude, and direction of motion relative to the Earth's axis. The reference gravitational acceleration is based on the reference altitude, geodetic latitude of 45 degrees, and the aeroplane travelling in the direction of true north.

3.1.3.2.1 Since the mass of the aeroplane during each test condition cannot be directly measured, it is determined from the test weight that has been corrected for gravitational acceleration. The test mass corrected for gravitational acceleration, which is to be used in paragraphs 3.2.2.3.2, 3.2.2.4.1, and 3.2.2.7.1, should be determined from the following equation:

$Mass_{grav}$ is the average mass of the aeroplane during the test condition corrected for gravitational acceleration in kilograms,

W_t is the average weight of the aeroplane during the test condition in newtons, and

g_0 is the standard gravitational acceleration = 9.80665 meters/second^2.

3.1.3.2.2 The following corrections are based on the World Geodetic System 84 Ellipsoidal Gravity definition. Other formulations and simplifications may provide essentially equivalent results.

DRAFT

3.1.3.2.3 The correction to the test weight for the effect of the variation in gravitational acceleration from the reference gravitational acceleration, can be determined from the following equation:

Where ΔW_{grav} is the weight correction in newtons for being off the reference gravitational acceleration,

W_t is the average weight of the aeroplane during the test condition in newtons,

$g_{\varphi,alt}$ is the gravitational acceleration at the test altitude and latitude in meters/second^2,

Δg_{cent} is the change in the gravitational acceleration due to centrifugal effect in meters/second^2,

$\Delta g_{Coriolis}$ is the change in the gravitational acceleration due to Coriolis effect in meters/second^2, and

g_{ref} is the reference gravitational acceleration in meters/second^2.

3.1.3.2.4 The gravitational acceleration for the test altitude and latitude, $g_{\varphi,alt}$, is determined as follows:

a. First determine the gravitational effect of latitude at sea level from the following equation:

Where Φ is the test latitude in degrees.

b. The gravitational acceleration for the test altitude and latitude is then determined from the following equation:

Where g_{φ} is the gravitational acceleration at the test latitude at sea level (from paragraph 3.2.2.2.4.a),

h is the test altitude in meters, and

r_e is the radius of the Earth at the test latitude, which is determined from the following equation:

DRAFT

Where a is the Earth's radius at the equator = 6378137 meters,

b is the Earth's radius at the pole = 6356752 meters, and

3.1.3.2.5 The change in the gravitational acceleration due to centrifugal effect, Δg_{cent}, is determined from the following equation:

Where V_g is the ground speed in meters/second,

r_e is the radius of the Earth in meters at the test latitude, which is determined from the following equation:

, and

h is the test altitude in meters.

3.1.3.2.6 The change in the gravitational acceleration due to Coriolis effect, $g_{Coriolis}$, can be found from the following equation:

Where ω_E is the Earth's rotation rate = 7.29212 x 10^{-5} radians/second,

V_G is the aeroplane's ground speed in meters/second,

Φ is the test latitude in degrees, and

σ is the ground track angle of the aeroplane in degrees.

3.1.3.2.7 The reference gravitational acceleration, g_{ref}, is the gravitational acceleration at the reference altitude and at 45 degrees north latitude. It can be determined using the process defined in paragraph 3.2.2.2.4, using the reference altitude and 45 degrees latitude as the test altitude and latitude, respectively.

DRAFT

3.1.3.3 ***Mass/δ:.*** The lift coefficient of the aeroplane is a function of mass/δ and Mach number, where δ is the ratio of the atmospheric pressure at a given altitude to the atmospheric pressure at sea level. The lift coefficient for the test condition affects the drag of the aeroplane. The reference mass/δ is derived from the combination of the reference mass, reference altitude, and atmospheric pressures determined from the ICAO standard atmosphere.

3.1.3.3.1 The effect on drag of the test condition mass/δ being different than the reference mass/δ can be determined from the drag equation:

Where $\Delta D_{Mass/\delta}$ is the drag correction in newtons due to the test mass/δ being different than the reference mass/δ,

ρ is the density of air at the test altitude and test temperature in kilograms/meter^3,

V is the aeroplane's average true airspeed during the test condition in meters/second,

A is the aeroplane's reference wing area in meters^2,

$C_{D\ Ref\ Mass/\delta}$ is the drag coefficient from the aeroplane's drag model at the reference mass/δ, and

$C_{D\ Test\ Mass/\delta}$ is the drag coefficient from the aeroplane's drag model at the test mass/δ.

3.1.3.3.2 The aeroplane's drag coefficient in the aeroplane's drag model is a function of the lift coefficient. Given the lift coefficient, the drag coefficient can be determined. The lift coefficients at the reference mass/δ and test mass/δ can be determined from the lift equation:

Where C_L is the lift coefficient,

Mass/δ is the mass/δ of the aeroplane in kilograms (either the test mass/δ after correcting the test mass for gravitational acceleration, or the reference mass/δ, depending on which C_L value is being determined. (Note: δ is the ratio of the ambient air pressure at a specified altitude (reference or test) to the ambient air pressure at sea level)),

M is the aeroplane's average Mach number during the test condition, and

A is the aeroplane's reference wing area in meters^2.

3.1.3.4 ***Acceleration/deceleration (energy).*** *D*rag determination is based on an assumption of steady, unaccelerated flight. Acceleration or deceleration occurring during a test condition affects the assessed drag level. The reference condition is steady, unaccelerated flight.

3.1.3.4.1 The correction for the change in drag force resulting from acceleration during the test condition can be determined from the following equation:

Where ΔD_{accel} is the drag correction in newtons due to acceleration occurring during the test condition,

M_{grav} is the average mass of the aeroplane during the test condition corrected for gravitational acceleration in kilograms, and

(dV_G/dT) is the change in ground speed over time during the test condition in meters/second^2.

3.1.3.5 ***Reynolds number.*** The Reynolds number affects aeroplane drag. For a given test condition the Reynolds number is a function of the density and viscosity of air at the test altitude and temperature. The reference Reynolds number is derived from the density and viscosity of air from the ICAO standard atmosphere at the reference altitude and temperature.

3.1.3.5.1 The value of the drag coefficient correction for being off the reference Reynolds number condition during the test can be expressed as:

Where $\Delta C_{D\ RE}$ is the change in drag coefficient due to being off the reference Reynolds number,

B is a value representing the variation of drag with Reynolds number for the specific aeroplane (see paragraph 3.2.2.5.2),

M is Mach number, and

RE is Reynolds number.

3.1.3.5.2 One method to obtain B is to use a drag model to obtain the incremental drag variation in response to changing Mach and altitude from a reference cruise condition. The value for B is the value of a single representative slope of a plot of the drag variation, ΔDrag versus Log_{10}.

3.1.3.5.3 The term *is the term determined at the temperature and altitude for the test condition divided by the same term determined at the standard day temperature and the reference altitude for the test mass/*δ using the following equation:

DRAFT

Where RE/meter is Reynolds number per meter,

P_S is static pressure in pascals, and

T_S is static termperature in Kelvin.

3.1.3.5.4 The effect on aeroplane drag can then be determined from $\Delta C_{D\ RE}$ and the aeroplane drag equation as follows:

Where ΔD_{RE} is the aeroplane drag correction in newtons due to the test Reynolds number being different than the reference Reynolds number,

ρ is the density of air at the test altitude and test temperature in kilograms/meter^3,

V is the aeroplane's average true airspeed during the test condition in meters/second,

A is the aeroplane's reference wing area in meters^2, and

$\Delta C_{D\ RE}$ is the change in drag coefficient due to being off the reference Reynolds number from paragraph 3.2.2.5.1.

3.1.3.6 ***CG position.*** The position of the aeroplane centre of gravity affects the drag due to longitudinal trim.

3.1.3.6.1 The drag correction for being off the reference CG position during the test is the difference between the drag at the reference CG position and the drag at the test CG position. This drag correction can be determined by: (1) determining the lift coefficient at the reference and test CG positions; (2) using the aeroplane's drag model with the lift coefficients for the test and reference CG positions to determine the respective drag coefficients; and (3) using the drag equation with the test and reference CG drag coefficients to determine difference in aeroplane drag between the reference and test CG positions.

DRAFT

3.1.3.6.2 The lift coefficient at the test CG position can be determined by using the lift equation in paragraph 3.2.2.3.2. The lift coefficient at the reference CG position can be determined from the following equation:

$$C_{L\ Ref\ CG} = C_{L\ Test}\ [1 + (MAC/L_t)\ (CG_{Ref} - CG_{Test})]$$

Where MAC is the length of the wing mean aerodynamic chord in centimeters,

L_t is the length of the horizontal stabilizer arm (normally measured between the wing 25 percent MAC and the stabilizer 25 percent MAC) in centimeters,

CG_{Ref} is the reference CG position in percent MAC/100, and

CG_{Test} is the CG position in percent MAC/100 during the test condition.

3.1.3.6.3 Once the drag coefficients are determined from the aeroplane drag model using the lift coefficients above, the aeroplane drag for the reference and test CG positions can be determined from the drag equation:

Where ΔD_{CG} is the aeroplane drag correction in newtons due to the test CG being different than the reference CG,

ρ is the density of air at the test altitude and test temperature kilograms/meter^3,

V is the aeroplane's average true airspeed during the test condition in meters/second,

A is the aeroplane's reference wing area in meters^2, and

$C_{D\ Test\ CG}$ and $C_{D\ Ref\ CG}$ are the drag coefficient from the aeroplane's drag model at the test condition CG and reference CG positions, respectively.

3.1.3.7 ***Aeroelastics.*** Wing aeroelastics may cause a variation in drag as a function of aeroplane wing mass distribution. Aeroplane wing mass distribution will be affected by the fuel load distribution in the wings and the presence of any external stores.

3.1.3.7.1 There are no simple analytical means to correct for different wing structural loading conditions. If necessary, corrections to the reference condition should be developed by flight test or another suitable analysis process.

3.1.3.7.2 The reference condition for the wing structural loading is to be selected by the applicant based on the amount of fuel and/or removable external stores to be carried by the wing based on the aeroplane's payload/range capability and the manufacturer's recommended procedures. The reference to the aeroplane's payload/range capability is to provide a link between the expected amount of fuel to be loaded and a particular flight length, while the reference to the manufacturer's recommended procedures is to cover the distribution of that fuel and how that distribution changes as fuel is burned.

DRAFT

3.1.3.7.3 As an example, the reference condition for the wing structural loading reference condition of a large commercial passenger aeroplanes may be defined with a typical passenger load in a multi-class interior arrangement assuming a fixed baggage allowance. When the zero-fuel-mass of the airplane is defined by this payload assumption, standard fuel management practices will determine the amount of fuel present in each fuel tank for a given gross mass. For large commercial aeroplanes, an example of standard fuel management practice is to load the main (wing) fuel tanks before loading the center (body) fuel tanks and to first burn any fuel in the center tanks before burning the fuel in the main tanks. This helps keep the cg aft, and reduces trim drag. With these assumptions, the fuel loading for SAR testing at each of the three reference masses defined in 2.3 of Chapter 2, Part II of Annex 16 Volume III, can be determined.

3.1.3.7.4 Commercial freighters may be designed from scratch, but more often are derivatives or converted from passenger models. While there is no way to predict how a freighter may be operated relative to a passenger model, it is reasonable to assume that the reference loading would be the same as the passenger model. If there is no parent passenger model, the reference zero-fuel-mass can for a freighter can be based on the maximum structural payload mass, often used to define the mission capability for marketing purposes.

3.1.3.7.5 Using a reference payload significantly lower the passenger interior limits or structural limited payload could potentially provide a more beneficial aeroelastic effect. An applicant would need to justify the reference payload assumptions in the context of the capability of the aeroplane and what could be considered typical for the configuration.

3.1.3.8 ***Fuel lower heating value.*** The fuel lower heating value defines the energy content of the fuel. The lower heating value directly affects the fuel flow at a given test condition.

The fuel flow measured during the flight test is corrected to the fuel flow for the reference lower heating value as follows:

Where Fuel Flow$_{Cor\ r\ LHV}$ is the fuel flow in kilograms/hour corrected for the reference fuel lower heating value,

Fuel Flow$_{test\ LHV}$ is the measured fuel flow in kilograms/hour during the test (at the test fuel lower heating value,

LHV$_{test}$ is the fuel lower heating value of the fuel used for the test in MJ/kg, and

LHV$_{Ref}$ is the reference fuel lower hearing value = 43.217 MJ/kg.

3.1.3.9 ***Altitude.*** The altitude at which the aeroplane is flown affects the fuel flow.

DRAFT

3.1.3.9.1 The engine model should be used to determine the difference between the fuel flow at the test altitude and the fuel flow at the reference altitude. The fuel flow at the test altitude should be corrected by this value so that it represents the fuel flow that would have been obtained at the reference altitude.

3.1.3.10 ***Temperature.*** The ambient temperature affects the fuel flow. The reference temperature is the standard day temperature from the ICAO standard atmosphere at the reference altitude.

3.1.3.10.1The engine model should be used to determine the difference between the fuel flow at the test temperature and the fuel flow at the reference temperature. The fuel flow at the test temperature should be corrected by this value so that it represents the fuel flow that would have been obtained at the reference temperature.

3.1.3.11 ***Engine deterioration level.*** *When first used,* engines undergo a rapid, initial deterioration in fuel efficiency. Thereafter, the rate of deterioration significantly decreases. Engines with less than the reference deterioration level may be used, subject to the approval of the certification authority. In such a case, the fuel flow shall be corrected to the reference engine deterioration level, using an approved method. Engines with more deterioration than the reference engine deterioration level may be used. In this case a correction to the reference condition shall not be permitted.

3.1.3.11.1As stated above, a correction should not generally be made for engine deterioration level. If an applicant proposes to use an engine or engines with less than the reference deterioration level for testing, it may be possible to establish a conservative correction level to apply to the test fuel flow to represent engines at the reference deterioration level. Such a correction should be

substantiated by engine fuel flow deterioration data from the same engine type or family.

3.1.3.12 ***Electrical and mechanical power extraction and bleed flow.*** Electrical and mechanical power extraction and bleed flow affects the fuel flow.

3.1.3.12.1 The engine model should be used to determine the difference between the fuel flow at the test power extraction and bleed flow and the fuel flow at the reference power extraction and bleed flow. The fuel flow at the test power extraction and bleed flow should be corrected by this value so that it represents the fuel flow that would have been obtained at the reference power extraction and bleed flow.

3.1.4 DATA EXTRAPOLATION

DRAFT

3.2 VALIDITY OF RESULTS - CONFIDENCE INTERVAL

3.2.1 INTRODUCTION

3.2.1.1 Sections 3.3.2 to 3.3.4 provide an insight into the theory of confidence interval evaluation. Application of this theory and some worked examples are provided in 3.3.4. A suggested bibliography is provided in Appendix 2 to this manual for those wishing to gain a greater understanding.

3.2.2 DIRECT FLIGHT TESTING

3.3.2.1 If *n* measurements of SAR $y_1, y_2, \ldots, y_n$ are obtained under approximately the same conditions and it can be assumed that they constitute a random sample from a normal population with true population mean, μ, and true standard deviation, σ, then the following statistics can be derived:

DRAFT

From these and the Student's t-distribution, the confidence interval, CI, for the estimate of the mean,

can be determined as:

$$\mathrm{CI} = \bar{y} \pm t_{\left(1-\frac{\alpha}{2},\zeta\right)} \frac{s}{\sqrt{n}}$$

Where *denotes the percentile* of the single-sided Student's t-test with degrees freedom (for a

clustered data set) and where α is defined such that *per cent is the desired confidence level for the*

confidence interval. In other words it denotes the probability with which the interval will contain

the unknown mean, μ. For CO2 certification purposes, 90 per cent confidence intervals are generally

desired and thus *is used.* See Table 3-1 for a listing of values of for different values of .

3.2.3 REGRESSION MODEL

3.3.3.1 If *n* measurements of SAR ($y_1, y_2, ..., y_n$) are obtained under significantly varying values of mass ($x_1, x_2, ..., x_n$) respectively, then a polynomial can be fitted to the data by the method of least squares. For determining the mean SAR, *m* , the following polynomial regression model is assumed to apply:

$$\mu = B_0 + B_1 x + B_2 x^2 + ... + B_k x^k \ .$$

The estimate of the mean line through the data of the SAR is given by:

DRAFT

$$y = b_0 + b_1 x + b_2 x^2 + ... + b_k x^k \ .$$

Each regression coefficient (B_i) is estimated by b_i from the sample data using the method of least squares in a process summarized as follows.

Each observation (x_i, y_i) satisfies the equations:

$$\begin{aligned} y_i &= B_0 + B_1 x_i + B_2 x_i^2 + . \quad . + B_k x_i^k . + \varepsilon_i \\ &= b_0 + b_1 x_i + b_2 x_i^2 + ... + b_k x_i^k + e_i \ , \end{aligned}$$

where ε_i and e_i are, respectively, the random error and residual associated with the SAR. The random error ε_i is assumed to be a random sample from a normal population with mean zero and standard deviation *s* . The residual (e_i) is the difference between the measured value and the estimate of the value using the estimates of the regression coefficients and x_i . Its root mean square value (*s*) is the sample estimate for *s* . These equations are often referred to as the normal equations.

Table 3-1. Student's t-distribution (for 90 per cent confidence) for various degrees of freedom

Degrees of freedom (z)	$t_{.95,\zeta}$
1	6.314
2	2.920
3	2.353
4	2.132
5	2.015
6	1.943
7	1.895
8	1.860
9	1.833
10	1.812
12	1.782
14	1.761
16	1.746
18	1.734
20	1.725
24	1.711
30	1.697
60	1.671
>60	1.645

DRAFT

The *n* data points of measurements (x_i, y_i) are processed as follows:

Each elemental vector $(\underline{x}_i)$ and its transpose $(\underline{x}'_i)$ are formed such that:

$\underline{x}_i = \begin{pmatrix} 1 & x_i & x_i^2 & . & . & x_i^k \end{pmatrix}$, a row vector; and

$$\underline{x}'_i = \begin{pmatrix} 1 \\ x_i \\ x_i^2 \\ . \\ . \\ x_i^k \end{pmatrix}$$, a column vector.

A matrix $\underline{X}$ is formed from all the elemental vectors $\underline{x}_i$ for i = 1, ..., n. $\underline{X}'$ is the transpose of $\underline{X}$. A matrix $\underline{A}$ is defined such that $\underline{A} = X'\underline{X}$ and a matrix $\underline{A}^{-1}$ is the inverse of $\underline{A}$. In addition, $\underline{y} = (y_1\ y_2 \ldots y_n)$, and $\underline{b} = (b_0\ b_1 \ldots b_2)$, with $\underline{b}$ determined as the solution of the normal equations:

$$\underline{y} = \underline{X}\underline{b} \text{ and } \underline{X}'\underline{y} = \underline{X}'\underline{X}\underline{b} = \underline{A}\underline{b},$$

to give

$$\underline{b} = \underline{A}^{-1}\underline{X}'\underline{y}.$$

The 90 per cent confidence interval CI_{90} for the mean value of the SAR estimated with the associated value of the mass x_0 is then defined as:

$$\mathrm{CI}_{90} = \bar{y}(x_0) \pm t_{.95,\zeta}\ s\ v(x_0),$$

where $v(x_0) = \sqrt{\underline{x}_0 \underline{A}^{-1} \underline{x}'_0}$.

Thus $\mathrm{CI}_{90} = \bar{y}(x_0) \pm t_{.95,\zeta}\ s\ \sqrt{\underline{x}_0 \underline{A}^{-1} \underline{x}'_0}$,

where:

- $\underline{x}_0 = \left(1\ x_0\ x_0^2 \ldots\ x_0^k\right)$;
- $\underline{x}'_0$ is the transpose of $\underline{x}_0$;
- $\bar{y}(x_0)$ is the estimate of the mean value of the SAR at the associated value of the engine-related parameter;

DRAFT

— $t_{.95,\zeta}$ is obtained for ζ degrees of freedom. For the general case of a multiple regression analysis involving K independent variables (i.e. $K+1$ coefficients) ζ is defined as $\zeta = n - K - 1$ (for the specific case of a polynomial regression analysis, for which k is the order of curve fit, there are k variables independent of the dependent variable, and so $\zeta = n - k -$); and

— $s = \sqrt{\frac{\sum_{i=1}^{i=n} (y_i - \bar{y}(x_i))^2}{n - K - 1}}$, the estimate of σ, the true standard deviation.

3.2.4 WORKED EXAMPLE OF THE DETERMINATION OF 90 PER CENT CONFIDENCE INTERVALS

3.2.4.1 Direct Flight Testing

3.3.4.1.1 Example 1: the confidence Interval is less than the confidence interval limit

DRAFT

Let's consider the following set of 6 independent measurements of SAR obtained by flight test around one of the reference masses of the CO2 emissions evaluation metric. After correction to reference conditions, the following clustered data set of SAR values is obtained:

Measurement number	*Corrected SAR (km/kg)*
1	0.38152
2	0.38656
3	0.37988
4	0.38011
5	0.38567
6	0.37820

The number of data points (n) = 6

The degrees of freedom (n-1) = 5

The Student's t-distribution for 90 per cent confidence and 5 degrees of freedom $() = 2.015$ (see

Table 3-1)

Estimate of the mean SAR ( ) for the clustered data set

Estimate of the standard deviation (s) of the mean

Confidence Interval determination

The confidence interval (CI) is calculated as follows (see §3.4.2):

DRAFT

Check of confidence interval limits

The confidence interval extends to ±0.00258 km/kg around the mean SAR value of the clustered data set (0.38282 km/kg). This represents ±0.67 per cent of the mean SAR value, which is below the confidence interval limit of 1.5 per cent defined in Annex 16 Volume 3 Appendix 1 §6.4.

As a result, the SAR value of 0.38282 km/kg associated to one of the reference masses of the CO2 emissions evaluation metric can be used for the metric determination.

3.3.4.1.2 Example 2: the confidence Interval exceeds the confidence interval limit

Let's consider the following set of 6 independent measurements of SAR obtained by flight test around one of the three masses of the CO2 emissions evaluation metric. After correction to reference conditions, the following clustered data set of SAR values is obtained:

Measurement number	*Corrected SAR (km/kg)*
1	0.15208
2	0.15795
3	0.15114
4	0.15225
5	0.15697
6	0.15834

The number of data points (n) = 6

The degrees of freedom (n-1) = 5

The Student's t-distribution for 90 per cent confidence and 5 degrees of freedom $() = 2.015$ (see

Table 3-1)

DRAFT

Estimate of the mean SAR ( ) *for the clustered data set*

Estimate of the standard deviation (s) of the mean

Confidence Interval determination

The confidence interval (CI) is calculated as follows (see §3.4.2):

Check of confidence interval limits

The confidence interval extends to ±0.00248 km/kg around the mean SAR value of the clustered data set (0.15479 km/kg). This represents ±1.60 per cent of the mean SAR value, which is above the confidence interval limit of 1.5 per cent defined in Annex 16 Volume 3 Appendix 1 §6.4.

In such a case, a penalty equal to the amount that the 90 per cent confidence interval exceeds ±1.5 per cent shall be applied to the mean SAR value, i.e. (1.60-1.50)=0.1 per cent. The mean SAR value shall therefore be penalized by an amount of 0.1 per cent as follows:

As a result, the SAR value of 0.15463 km/kg associated to one of the reference masses of the CO2 emissions evaluation metric can be used for the metric determination.

3.3.4.2 Regression model

DRAFT

3.3.4.3 First Principle Model

3.3 EQUIVALENT PROCEDURES

3.3.1 APPROVAL BASED ON EXISTING DATA

3.4.1.1 The use of existing data as an equivalent procedure may be requested by applicants, and it can be utilized in the below approaches of equivalent procedures or other approaches approved by the certificating authority according to their technical judgement.

a) Develop a regression curve approach for SAR values across the gross weight (MTOM) range using existing data.

b) ..... [INSERT other approaches for using existing data]

3.4.1.2 The information typically needed to use existing data for demonstrating compliance as an equivalent procedure is as follows:

a) The existing model based on data that does cover the Mach-C_L range needed to interpolate for SAR, but may not cover the full mass range defined in the standard.
b) The existing model used company test data that was not witnessed by an authority and/or the aeroplane configuration was not conformed by an authority, but the data obtained is deemed acceptable by the certificating authority.
c) The accuracy of the instrumentation and the data reduction processes may not have been documented to the quality standard desired for certification, or the original documentation may not have been retained, but the data available is deemed acceptable by the certificating authority.
d) ..... [INSERT additional criteria]

DRAFT

Matt M: The issues here may include

- Having an existing model that is based on data which does not cover the full mass range defined in the standard, but does cover the Mach-C_L range needed to interpolate for SAR.
- A model that uses company testing that would not have been witnessed by an authority nor would the configuration be conformed by an authority.
- The accuracy of the instrumentation and the data reduction processes may not have documentation of the quality desired for certification, or the documentation may not have been retained.

3.3.2 APPROVAL BASED ON BACK-TO-BACK TESTING

3.4.2.1 The use of back-to-back test data may be requested by applicants as an equivalent procedure for determining the CO_2 metric value for relatively small configuration changes that can be made based on test data obtained on the same aeroplane with the same engines (e.g. antenna installations or other simple drag changes). This approach will typically not be appropriate for engine changes where the SFC of the engine may change due to internal changes. This compliance approach will likely be especially useful for STC modifiers who do not have access to the original flight test data from the aeroplane manufacturer.

a) Back-to-back testing should be accomplished on the same aeroplane and engines with

the modification installed and not installed.

b) Instrumentation adequate to provide data meeting the accuracy requirements of the standard is installed in the test aeroplane.
c) The data reduction and comparison processes are acceptable to the certificating authority.
d) ..... [INSERT additional criteria]

DS: Don't know if this a good name for it, but this is supposed to refer to a potential means for determining the CO2 MV from back-to-back testing. This would be especially useful for STC holders who do not have the original flight test data

Matt M: Back-to-back testing may be useful for relatively easy configuration changes that can be made on the same aeroplane with the same engines (e.g. an antenna or some kind of drag improvement installation). It may not be practical for changes that affect the SFC of the engines (either improve or degrade) since these changes may be internal and not easily removed or installed.

3.3.3 APPROVAL OF CHANGES BASED ON ANALYSIS

3.4.3.1 The use of analytical processes to establish compliance with the CO_2 metric value criteria for changes to the SAR metric value of a previously approved aeroplane configuration may be requested by applicants, provided those processes are approved by the certificating authority according to their technical judgement. This equivalent procedure may be acceptable for SAR metric value changes of xx or less.

DRAFT

a) The data on which the analysis is based was derived from flight test data.
b) Use of CFD and wind tunnel analyses may be acceptable if agreed to by the certificating authority.
c) The analytical results must include a xx increment of conservatism in the determined SAR metric value of the modified configuration.
d) ..... [INSERT additional items]

The following analytical processes are considered acceptable in using analysis as a means of compliance for changes to approved aeroplanes instead of conducting flight tests:

a) ..... [INSERT acceptable analytical processes]

Matt M: This topic should include a discussion of the extent of the analysis and guidelines for conservatism. Do the MOC need to be derived from flight test data? Are CFD and wind tunnel analyses acceptable?

Appendix 1 - REFERENCES

[1] ASTM D1655-12 entitled "Standard Specification for Aviation Turbine Fuels". This ASTM publication may be obtained from the American National Standards Institute, 25 W 43rd Street, 4th Floor, New York, NY, USA.

[2] Defence Standard 91-91, Issue 7, Amendment 1, entitled "Turbine Fuel, Kerosene Type, Jet A-1". This Ministry of Defence Standard may be obtained from Defence Equipment and Support, UK Defence Standardization, Kentigern House, 65 Brown Street, Glasgow G2 8EX, UK.

[3] ASTM D4809-09A entitled "Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)". This ASTM publication may be obtained from the American National Standards Institute, 25 W 43rd Street, 4th Floor, New York, NY, USA.

[4] ASTM D4052-11 entitled "Standard Test Method for Density and Relative Density of Liquids by Digital Density Meter". This ASTM publication may be obtained from the American National Standards Institute, 25 W 43rd Street, 4th Floor, New York, NY, USA.

[5] ASTM D445-12 entitled "Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)" This ASTM publication may be obtained from the American National Standards Institute, 25 W 43rd Street, 4th Floor, New York, NY, USA.

EPA-HQ-2018-004348

Appendix 2 - BIBLIOGRAPHY

1. Kendall, M.G. and A. Stuart. *The Advanced Theory of Statistics.* Volumes 1, 2 and 3. New York: Hafner, 1971.

2. Kendall, M.G. and G.U. Yule. *An Introduction to the Theory of Statistics.* 14th ed. New York: Griffin, 1950.

3. Snedecor, G.W. and W.G. Cochran. *Statistical Methods.* 6th ed. Arnes, Iowa: The Iowa State University Press, 1968.

4. Walpole, R.E. and R.H. Myers. *Probability and Statistics for Engineers and Scientists.* New York: MacMillan, 1972.

5. Wonnacott, T.H. and R.J. Wonnacott. *Introductory Statistics,* 5th ed. N.p.: John Wiley & Sons, 1990.

DRAFT

ED_001734_00021756-00038

To: Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Manning, Bryan
Sent: Thur 1/23/2014 3:54:03 PM
Subject: Updated ICF SH&E presentation (PLEASE REVIEW)
2014-01-21 CO2TG Briefing v3.6.pptx

See below/attached. Let me know if you have any comments on the updated/revised ICF SH&E presentation for tomorrow. Thanks. Bryan

-----Original Message-----
From: Zimm, Peter [mailto:Peter.Zimm@icfi.com]
Sent: Thursday, January 23, 2014 10:46 AM
To: Manning, Bryan
Cc: McDonald, Glenn
Subject: RE: Update (thoughts from Steve Arrowsmith)

Bryan,

Please see attached proposed final deck for tomorrow's call. Note new slides added or changes to existing slides:
- 23 - Added in production tech insertion examples
- 37 - Updated metric formula
- 42-43 - Added assessment of NRC function
- 46-49 - Added appendix info, especially Embraer changes to E-Jet production standard

Ex. 4 - CBI

LMK if you want to get on the phone to discuss.

Peter

-----Original Message-----
From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Thursday, January 23, 2014 9:47 AM
To: Zimm, Peter
Cc: McDonald, Glenn
Subject: RE: Update (thoughts from Steve Arrowsmith)

Okay, Peter. Many thanks for the update. Sounds fine.

I talked to Steve Arrowsmith (CO2TG co-lead) yesterday about your presentation. He said that he is hearing from some folks that they perceive your analysis as something that could help CAEP to determine whether the eventual CO2 standard will meet the purpose of the standard: "to achieve reductions beyond what would be achieved in the absence of a standard; analyzed using ICAO criteria of technical feasibility, environmental benefit, cost effectiveness, and impacts of interdependencies." The CAEP Task Groups, MDG and FESG, will be working on this assessment, instead of the CO2TG. My reply to Steve is that I had not thought of that specifically, but if ICF SH&E's work can be helpful for the purpose of the standard, the group is welcome to use it. Of course, we would need to be careful if we use any of your time or effort

for that.

In any event, because of the feedback Steve is hearing, he recommended that we specifically clarify that ultimately your analysis aims to provide tech response and cost information at the aircraft level (tech response and costs for individual aircraft being developed). I realize that you say that on slides 33 and 37, but we should verbalize this upfront to make sure folks understand the main objective of your work. This is an introductory presentation that provides information at the aircraft category level, but your objective is to develop tech response and cost results at the individual aircraft level.

You were probably planning to state this verbally upfront, but I just wanted to make sure you received the recommendation from Steve (which I agree with). Okay?

Thanks again,

Bryan

Bryan Manning
U.S. EPA Office of Transportation and Air Quality Large Marine and Aviation Center
2000 Traverwood Drive
Ann Arbor, MI 48105
(ph) 734-214-4832 (fax) 734-214-4816
manning.bryan@epa.gov

-----Original Message-----
From: Zimm, Peter [mailto:Peter.Zimm@icfi.com]
Sent: Thursday, January 23, 2014 8:45 AM
To: Manning, Bryan
Subject: Update

Bryan,

To update you, all the new slides are built. Glenn and I need to verify some content on two of the slides and we're done. We're going into meetings this am until 10:30 and will finalize and get over to you late this am.

Peter

To: Samulski, Michael[samulski.michael@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Yen, David[Yen.David@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Manning, Bryan
Sent: Fri 7/11/2014 3:00:11 PM
Subject: Ralph Rissmiller comments on WP15 (CO2TG)
CAEP10_WG3_CO2-6_WP15_Draft SG2014 CO2 InP Applicability Options_140711 rr cmts.docx

Hello,

Attached please Ralph Rissmiller's comments on WP15 (CO2TG). Thanks.

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Ralph Rissmiller [mailto:rrissmil@aol.com]
Sent: Friday, July 11, 2014 10:57 AM
To: Manning, Bryan
Cc: 'Zimm, Peter'
Subject: RE: CO2-6 Papers - 6th Batch

Attached are my comments to WP15. They are embedded as comments and/or changes in the Word document. Please call if you have any questions or desire further discussion.

Ralph Rissmiller

RR Aviation Services, LLC

19685 S 1475 Rd

Stockton, MO 65785-7430

Email: rrissmil@aol.com

Tel: 316-253-6182 (cell), Ex. 6 - Personal Privacy

Fax: 417-276-1314

From: Manning, Bryan [mailto:manning.bryan@epa.gov]
Sent: Friday, July 11, 2014 7:26 AM
To: Ralph Rissmiller
Cc: Zimm, Peter
Subject: FW: CO2-6 Papers - 6th Batch

Hello Ralph,

In case you did not see it, attached is the latest InP Applicability Options paper (for next week's meeting). I realize you have begun to comment on the earlier version with ICCAIA comments, but it would be very helpful to also have your comments on this latest version (from the co-leads) – as we discussed earlier. Let me know if you have any questions.

Thank you,

Bryan

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov

From: Arrowsmith Stephen [mailto:Stephen.Arrowsmith@easa.europa.eu]
Sent: Friday, July 11, 2014 5:44 AM
To: ACI HQ Montreal - Xavier Oh (xoh@aci.aero); ACI Zurich - Emanuel Fleuti (emanuel.fleuti@zurich-airport.com); ANAC - (alexandre.filizola@anac.gov.br); ANAC - (daniel.nicolato@anac.gov.br); ANAC Brazil - Ricardo Antonio Binotto Dupont; BAH - Philippe Bonnefoy (bonnefoy_philippe@bah.com); Bombardier - (david.lye@aero.bombardier.com); Bombardier - Florentina Viscotchi (florentina.viscotchi@aero.bombardier.com); Bombardier - mark.huising@aero.bombardier.com; Bombardier - Russell.Stratton@aero.bombardier.com; Bombardier - stephen.colavincenzo@aero.bombardier.com; CAA UK - Jonathan Ruff; Cessna - (tshriner@cessna.textron.com); Cessna - Bill Dolejsi (wcdolejsi@cessna.textron.com); Chris Eyers - (chris@LimitedSkies.com); COMAC - Cui Ning (cuining@comac.cc); COMAC - Cyrille Bread (cyrillebreard@comac.cc); DfT - (Roger.Worth@dft.gsi.gov.uk); DfT - Mark Thompson; DfT - Richard Clarkson (Richard.Clarkson@dft.gsi.gov.uk); DGAC-F - (jean-philippe.dufour@aviation-civile.gouv.fr); DGAC-F - bruno.hamon@aviation-civile.gouv.fr; DGAC-F - jean-luc.kittery@aviation-civile.gouv.fr; DGAC-F - Jean-Philippe Dufour (Home) (jean-philippe.dufour@laposte.net); DGAC-F - kevin.guittet@aviation-civile.gouv.fr; ENAC - Francesco SEPE (f.sepe@enac.gov.it); Leggett, Cullen; Passavant, Glenn; Yen, David; Maeroff, Bruce; Manning, Bryan; Samulski, Michael; EPA - rrissmil@aol.com; FAA - (carl.burleson@faa.gov); Carl.Ma@faa.gov; FAA - (Lourdes.Maurice@faa.gov); FAA - (warren.gillette@faa.gov); FAA - Chris Sequeira (christopher.sequeira@faa.gov); FAA - curtis.holsclaw@faa.gov; FAA - Julie Marks (Julie.Marks@faa.gov); FAA - kevin.welsh@faa.gov; FAA - Maddie Miguel (maddie.miguel@faa.gov); FAA - Mary Alice Locke; FAA - nicole.didyk@faa.gov; FAA - Pat.Moran@faa.gov; FAA - Ralph.Iovinelli@faa.gov; FOCA - Theo.Rindlisbacher@bazl.admin.ch; GE - (steve.csonka@ge.com); GE - Joe Zelina (GE Aviation, US); GE - Muni Majjigi (muni.majjigi@ge.com); GeorgiaTech - (dongwook.lim@asdl.gatech.edu); GerogiaTech - Michelle Kirby (michelle.kirby@ae.gatech.edu); Gulfstream - (eric.upton@gulfstream.com); Gulfstream - charles.etter@gulfaero.com; Gulfstream - Charlie Osonitsch (Charlie.Osonitsch@gulfstream.com); Gulfstream - Scott McCurdy (Scott.Mccurdy@gulfstream.com); Gulfstream - tom.lavrisa@gulfstream.com; Honeywell - rudolph.dudebout@honeywell.com; IATA / A4A - Nancy Young (nyoung@airlines.org); IATA / A4A - Tim Pohle (tpohle@airlines.org); IATA / AA - (tom.opderbeck@aa.com); IATA / Continental - (gary.leduc@coair.com); IATA / Delta - (david.anvid@delta.com); IATA / Emirates - Daniel Wong (daniel.wong@emirates.com); IATA / Emirates - Zainal Abidin; IATA / FedEx - dmjensen@fedex.com; IATA / IBAC - ecotti@nbaa.org; IATA / NACE - Bengt-Olov Näs; IATA / South Africa Aiways - (QuintinHolder@flysaa.com); IATA Geneva - HardemanA@iata.org; IATA Geneva - Thomas Roetger (roetgert@iata.org); ICAO CAEP - Tetsuya

Tanaka (TTanaka@icao.int); ICSA / Earth Justice - Sarah Burt (sburt@earthjustice.org); ICSA/ICCT - (dan@theicct.org); ICSA/ICCT - karin@theicct.org; ICSA/T&E - (paul.peeters1000@gmail.com); IFALPA - (rcbrons@planet.nl); MIT - (byutko@mit.edu); MMU - (B.Owen@mmu.ac.uk); MMU - D.S.Lee@mmu.ac.uk; Netherlands MINIENM - Michael Lunter (michael.lunter@minienm.nl); NLR - (middel@nlr.nl); P&W - (laurence.gray@pw.utc.com); P&W - Anuj.bhargava@pw.utc.com; P&W - domingo.sepulveda@pw.utc.com; P&WC - (kian.mccaldon@pwc.ca); T&E - Bill Hemmings (bill.hemmings@transportenvironment.org); UBA - Frank Wetzel (frank.wetzel@uba.de); University of Madrid - Arturo Benito (arturo.benito@upm.es); Williams - (jcondevaux@williams-int.com); AEA - Gareth Horton (gareth.horton@aeat.co.uk); Aerodyne - Rick Miake-Lye; AIA - Leslie Riegle (leslie.riegle@aia-aerospace.org); Airbus - Brian Kitson; Airbus - Dan Carnelly (Daniel.Carnelly@airbus.com); Airbus - Hans Smit; Airbus - Michaela Vanova (MICHAELA.VANOVA@airbus.com); Airbus - Olivier Husse (olivier.husse@airbus.com); Airbus - Olivier Husse Home (olivier.husse@gmail.com); Antonov - (V.Deniskov@antonov.kiev.ua); ATR - Giuseppe Romano; Avio - (fabio.turrini@aviogroup.com); BMVBS - Martin Schaefer (Martin.Schaefer@bmvbs.bund.de); Boeing - (douglas.p.dubois@boeing.com); Boeing - daniel.m.allyn@boeing.com; Boeing - Matt Muelhausen (matthew.r.muehlhausen@boeing.com); Boeing - Mike Garrison (mike.garrison@boeing.com); Boeing - robert.b.solaimani@boeing.com; CAAS Singapore - (vincent_ng@caas.gov.sg); CAAS Singapore - Chew Choong Cheng (chew_choong_Cheng@caas.gov.sg); CARC Jordan - Saleh Alamoush (dairstand@carc.gov.jo); CIAM - (Volkov@ciam.ru); Dassault - Christian Camihort (Christian.Camihort@dassault-aviation.com); Dassault - Gardette Benjamin; Dassault - Thierry Percheron (thierry.percheron@dassault-aviation.com); DfT Tunisia - (hatem.jameleddine@mt.gov.tn); DfT Ukraine - (grasko@avia.gov.ua); DfT Ukraine - Victoria Shtets (shtets@neia.gov.ua); DLR - (Martin.Plohr@dlr.de); Herms Erika; BILAS Illimar; DE LEPINAY Ivan; Bauer Kai; Roe Nick; FRANKEN Willem; Readman Guy; EASA - skillen@northcheriton.fsnet.co.uk; Hoermann Werner; Embraer - arnaud.bonnet@embraer.com.br; Embraer - gustavo.royo@embraer.com.br; Embraer - Krisha Nobega (krisha.nobrega@embraer.com.br); richard.holt@ec.gc.ca; Envisa - (nicolas@env-isa.com); Envisa - Ayce Celikel (ayce@env-isa.com); Goodrich - (jia.yu@goodrich.com); Hawker Beechcraft - Greg Worley (greg_worley@hawkerbeechcraft.com); ICAO - (CMustapha@icao.int); ICAO - Neil Dickson; ICF International - (Adam.Klauber@icfi.com); ICF International - Glenn McDonald (GMcDonald@icfi.com); ICF International - Kevin Michaels (KMichaels@icfi.com); ICF International - Peter Zimm (Peter.Zimm@icfi.com); Indonesia CAA - ajaria96@yahoo.co.id; Indonesia CAA - Mukhtaris; Japan IHI - (mitsuo_imamura@ihi.co.jp); Japan IHI - (tsutomu_ooishi@ihi.co.jp); Japan IHI - (y_nakamura@inc.ihi.co.jp); Japan JAXA - (fuji@chofu.jaxa.jp); Japan JAXA - (machida.shigeru@jaxa.jp); Japan MLIT - Katsutoshi Tsuboi (tsuboi-k2wc@mlit.go.jp); Japan SJAC - (iijima@sjac.or.jp); MHI - (yuji_yamamoto@mhi.co.jp); NASA - (gregory.j.follen@nasa.gov); NASA - (william.j.haller@nasa.gov); OBN - Hans Pulles (hans.pulles@obnconsultancy.nl); Progress - (progress@ivchenko-progress.com); Progress - (progress@zmkb.com); RR - (simon.smith@rolls-royce.com); RR - Jon Hart; RR - paul.madden@rolls-royce.com; RR Corp - nader.k.rizk@rolls-royce.com; Russia Aviadviagtel - Alexey Sipatov (sipatov@avid.ru); Russia CIAM - Artur Mirzoyan (mirzoyan@ciam.ru); Russia Ecoflight - yuriy.medved@gmail.com; Snecma - Dominique Collin; Snecma - LEENAERT Clement (SNECMA); Snecma - olivier.penanhoat@snecma.fr; Swedish Transport Agency - Magnus Molitur (Magnus.molitor@Transportstyrelsen.se); Transport Canada - (frank.viele@tc.gc.ca); Transport Canada - (sylvie.mallet@tc.gc.ca); University of Civil Aviation China - Yang Xiaojun; University of Florence - Antonio Andreini (andreini@brun.de.unifi.it); University of Kiev - Oleksander Zaporozhets (zap@nau.edu.ua); University of Kiev - Sergiy Boichenko; Volpe - David Pace (david.pace@dot.gov); Volpe - Gregg.Fleming@dot.gov; Volpe - S.Balasubramania.CTR@dot.gov
Cc: FAA - (Laszlo.Windhoffer@faa.gov); Transport Canada - (wendy.bailey@tc.gc.ca)
Subject: CO2-6 Papers - 6th Batch

Dear CO2TG,

Please find attached WP15 which is the latest iteration of a draft InP paper to SG2014 following the input and discussion during the Cahg telecon on Tuesday.

We look forward to further discussions in Cincinnati such that we can finalise it as WG3 input into SG2014.

Best Regards

Steve, Laszlo and Wendy

CO2 co-Leads / Cahg co-Leads

From: Arrowsmith Stephen
Sent: 07 July 2014 22:19
To: 'ACI HQ Montreal - Xavier Oh (xoh@aci.aero)'; 'ACI Zurich - Emanuel Fleuti (emanuel.fleuti@zurich-airport.com)'; 'ANAC - (alexandre.filizola@anac.gov.br)'; 'ANAC - (daniel.nicolato@anac.gov.br)'; 'ANAC Brazil - Ricardo Antonio Binotto Dupont'; 'BAH - Philippe Bonnefoy (bonnefoy_philippe@bah.com)'; 'Bombardier - (david.lye@aero.bombardier.com)'; 'Bombardier - Florentina Viscotchi (florentina.viscotchi@aero.bombardier.com)'; 'Bombardier - mark.huising@aero.bombardier.com'; 'Bombardier - Russell.Stratton@aero.bombardier.com'; 'Bombardier - stephen.colavincenzo@aero.bombardier.com'; 'CAA UK - Jonathan Ruff'; 'Cessna - (tshriner@cessna.textron.com)'; 'Cessna - Bill Dolejsi (wcdolejsi@cessna.textron.com)'; 'Chris Eyers - (chris@LimitedSkies.com)'; 'COMAC - Cui Ning (cuining@comac.cc)'; 'COMAC - Cyrille Bread (cyrillebreard@comac.cc)'; 'DfT - (Roger.Worth@dft.gsi.gov.uk)'; 'DfT - Mark Thompson'; 'DfT - Richard Clarkson (Richard.Clarkson@dft.gsi.gov.uk)'; 'DGAC-F - (jean-philippe.dufour@aviation-civile.gouv.fr)'; 'DGAC-F - bruno.hamon@aviation-civile.gouv.fr'; 'DGAC-F - jean-luc.kittery@aviation-civile.gouv.fr'; 'DGAC-F - Jean-Philippe Dufour (Home) (jean-philippe.dufour@laposte.net)'; 'DGAC-F - kevin.guittet@aviation-civile.gouv.fr'; 'ENAC - Francesco SEPE (f.sepe@enac.gov.it)'; 'EPA - (leggett.cullen@epa.gov)'; 'EPA - (Passavant.Glenn@epamail.epa.gov)'; 'EPA - (yen.david@epa.gov)'; 'EPA - Bruce Maeroff (Maeroff.Bruce@epamail.epa.gov)'; 'EPA - manning.bryan@epa.gov'; 'EPA - Michael Samulski (Samulski.Michael@epamail.epa.gov)'; 'EPA - rrissmil@aol.com'; 'FAA - (carl.burleson@faa.gov)'; 'FAA - (carl.ma@faa.gov)'; 'FAA - (Lourdes.Maurice@faa.gov)'; 'FAA - (warren.gillette@faa.gov)'; 'FAA - Chris Sequeira (christopher.sequeira@faa.gov)'; 'FAA - curtis.holsclaw@faa.gov'; 'FAA - Julie Marks (Julie.Marks@faa.gov)'; 'FAA - kevin.welsh@faa.gov'; 'FAA - Maddie Miguel (maddie.miguel@faa.gov)'; 'FAA - Mary Alice Locke'; 'FAA - nicole.didyk@faa.gov'; 'FAA - Pat.Moran@faa.gov'; 'FAA - Ralph.lovinelli@faa.gov'; 'FOCA - Theo.Rindlisbacher@bazl.admin.ch'; 'GE - (steve.csonka@ge.com)'; 'GE - Joe Zelina (GE Aviation, US)'; 'GE - Muni Majjigi (muni.majjigi@ge.com)'; 'GeorgiaTech - (dongwook.lim@asdl.gatech.edu)'; 'GerogiaTech - Michelle Kirby (michelle.kirby@ae.gatech.edu)'; 'Gulfstream - (eric.upton@gulfstream.com)'; 'Gulfstream - charles.etter@gulfaero.com'; 'Gulfstream - Charlie Osonitsch (Charlie.Osonitsch@gulfstream.com)'; 'Gulfstream - Scott McCurdy (Scott.Mccurdy@gulfstream.com)'; 'Gulfstream - tom.lavrisa@gulfstream.com'; 'Honeywell - rudolph.dudebout@honeywell.com'; 'IATA / A4A - Nancy Young (nyoung@airlines.org)'; 'IATA / A4A - Tim Pohle (tpohle@airlines.org)'; 'IATA / AA - (tom.opderbeck@aa.com)'; 'IATA / Continental - (gary.leduc@coair.com)'; 'IATA / Delta - (david.anvid@delta.com)'; 'IATA / Emirates - Daniel Wong (daniel.wong@emirates.com)'; 'IATA / Emirates - Zainal Abidin'; 'IATA / FedEx - dmjensen@fedex.com'; 'IATA / IBAC - ecotti@nbaa.org'; 'IATA / NACE - Bengt-Olov Näs'; 'IATA / South Africa Aiways - (QuintinHolder@flysaa.com)'; 'IATA Geneva - HardemanA@iata.org'; 'IATA Geneva - Thomas Roetger (roetgert@iata.org)'; 'ICAO CAEP - Tetsuya Tanaka (TTanaka@icao.int)'; 'ICSA / Earth Justice - Sarah Burt (sburt@earthjustice.org)'; 'ICSA/ICCT - (dan@theicct.org)'; 'ICSA/ICCT - karin@theicct.org'; 'ICSA/T&E - (paul.peeters1000@gmail.com)'; 'IFALPA - (rcbrons@planet.nl)'; 'MIT - (byutko@mit.edu)'; 'MMU - (B.Owen@mmu.ac.uk)'; 'MMU -

D.S.Lee@mmu.ac.uk'; 'Netherlands MINIENM - Michael Lunter (michael.lunter@minienm.nl)'; 'NLR - (middel@nlr.nl)'; 'P&W - (laurence.gray@pw.utc.com)'; 'P&W - Anuj.bhargava@pw.utc.com'; 'P&W - domingo.sepulveda@pw.utc.com'; 'P&WC - (kian.mccaldon@pwc.ca)'; 'T&E - Bill Hemmings (bill.hemmings@transportenvironment.org)'; 'UBA - Frank Wetzel (frank.wetzel@uba.de)'; 'University of Madrid - Arturo Benito (arturo.benito@upm.es)'; 'Williams - (jcondevaux@williams-int.com)'; 'AEA - Gareth Horton (gareth.horton@aeat.co.uk)'; 'Aerodyne - Rick Miake-Lye'; 'AIA - Leslie Riegle (leslie.riegle@aia-aerospace.org)'; 'Airbus - Brian Kitson'; 'Airbus - Dan Carnelly (Daniel.Carnelly@airbus.com)'; 'Airbus - Hans Smit'; 'Airbus - Michaela Vanova (MICHAELA.VANOVA@airbus.com)'; 'Airbus - Olivier Husse (olivier.husse@airbus.com)'; 'Airbus - Olivier Husse Home (olivier.husse@gmail.com)'; 'Antonov - (V.Deniskov@antonov.kiev.ua)'; 'ATR - Giuseppe Romano'; 'Avio - (fabio.turrini@aviogroup.com)'; 'BMVBS - Martin Schaefer (Martin.Schaefer@bmvbs.bund.de)'; 'Boeing - (douglas.p.dubois@boeing.com)'; 'Boeing - daniel.m.allyn@boeing.com'; 'Boeing - Matt Muelhausen (matthew.r.muehlhausen@boeing.com)'; 'Boeing - Mike Garrison (mike.garrison@boeing.com)'; 'Boeing - robert.b.solaimani@boeing.com'; 'CAAS Singapore - (vincent_ng@caas.gov.sg)'; 'CAAS Singapore - Chew Choong Cheng (chew_choong_Cheng@caas.gov.sg)'; 'CARC Jordan - Saleh Alamoush (dairstand@carc.gov.jo)'; 'CIAM - (Volkov@ciam.ru)'; 'Dassault - Christian Camihort (Christian.Camihort@dassault-aviation.com)'; 'Dassault - Gardette Benjamin'; 'Dassault - Thierry Percheron (thierry.percheron@dassault-aviation.com)'; 'DfT Tunisia - (hatem.jameleddine@mt.gov.tn)'; 'DfT Ukraine - (grasko@avia.gov.ua)'; 'DfT Ukraine - Victoria Shtets (shtets@neia.gov.ua)'; 'DLR - (Martin.Plohr@dlr.de)'; 'EASA - (erika.herms@easa.europa.eu)'; 'EASA - (illimar.bilas@easa.europa.eu)'; 'EASA - (ivan.de-lepinay@easa.europa.eu)'; 'EASA - (kai.bauer@easa.europa.eu)'; 'EASA - (Nick.Roe@easa.europa.eu)'; 'EASA - Franken Willem (willem.franken@easa.europa.eu)'; 'EASA - Readman Guy (guy.readman@easa.europa.eu)'; 'EASA - skillen@northcheriton.fsnet.co.uk'; 'EASA - Werner Hoermann (werner.hoermann@easa.europa.eu)'; 'Embraer - arnaud.bonnet@embraer.com.br'; 'Embraer - gustavo.royo@embraer.com.br'; 'Embraer - Krisha Nobega (krisha.nobrega@embraer.com.br)'; 'Env. Canada - (richard.holt@ec.gc.ca)'; 'Envisa - (nicolas@env-isa.com)'; 'Envisa - Ayce Celikel (ayce@env-isa.com)'; 'Goodrich - (jia.yu@goodrich.com)'; 'Hawker Beechcraft - Greg Worley (greg_worley@hawkerbeechcraft.com)'; 'ICAO - (CMustapha@icao.int)'; 'ICAO - Neil Dickson'; 'ICF International - (Adam.Klauber@icfi.com)'; 'ICF International - Glenn McDonald (GMcDonald@icfi.com)'; 'ICF International - Kevin Michaels (KMichaels@icfi.com)'; 'ICF International - Peter Zimm (Peter.Zimm@icfi.com)'; 'Indonesia CAA - ajaria96@yahoo.co.id'; 'Indonesia CAA - Mukhtaris'; 'Japan IHI - (mitsuo_imamura@ihi.co.jp)'; 'Japan IHI - (tsutomu_ooishi@ihi.co.jp)'; 'Japan IHI - (y_nakamura@inc.ihi.co.jp)'; 'Japan JAXA - (fuji@chofu.jaxa.jp)'; 'Japan JAXA - (machida.shigeru@jaxa.jp)'; 'Japan MLIT - Katsutoshi Tsuboi (tsuboi-k2wc@mlit.go.jp)'; 'Japan SJAC - (iijima@sjac.or.jp)'; 'MHI - (yuji_yamamoto@mhi.co.jp)'; 'NASA - (gregory.j.follen@nasa.gov)'; 'NASA - (william.j.haller@nasa.gov)'; 'OBN - Hans Pulles (hans.pulles@obnconsultancy.nl)'; 'Progress - (progress@ivchenko-progress.com)'; 'Progress - (progress@zmkb.com)'; 'RR - (simon.smith@rolls-royce.com)'; 'RR - Jon Hart'; 'RR - paul.madden@rolls-royce.com'; 'RR Corp - nader.k.rizk@rolls-royce.com'; 'Russia Aviadviagtel - Alexey Sipatov (sipatov@avid.ru)'; 'Russia CIAM - Artur Mirzoyan (mirzoyan@ciam.ru)'; 'Russia Ecoflight - yuriy.medved@gmail.com'; 'Snecma - Dominique Collin'; 'Snecma - LEENAERT Clement (SNECMA)'; 'Snecma - olivier.penanhoat@snecma.fr'; 'Swedish Transport Agency - Magnus Molitur (Magnus.molitor@Transportstyrelsen.se)'; 'Transport Canada - (frank.viele@tc.gc.ca)'; 'Transport Canada - (sylvie.mallet@tc.gc.ca)'; 'Transport Canada - (wendy.bailey@tc.gc.ca)'; 'University of Civil Aviation China - Yang Xiaojun'; 'University of Florence - Antonio Andreini (andreini@brun.de.unifi.it)'; 'University of Kiev - Oleksander Zaporozhets (zap@nau.edu.ua)'; 'University of Kiev - Sergiy Boichenko'; 'Volpe - David Pace (david.pace@dot.gov)'; 'Volpe - Gregg.Fleming@dot.gov'; 'Volpe - S.Balasubramania.CTR@dot.gov'
Cc: FAA - (Laszlo.Windhoffer@faa.gov)
Subject: CO2-6 Papers - 1st Batch

Dear CO2 Task Group,

Thanks very much for all your input into the CO2-6 meeting. We look forward to addressing the

remaining issues which will allow us to agree on critical path deliveries to SG2014 for the CO2 standard setting process. Attached is the first batch of papers which includes a current list of papers (IP01).

Please inform us if your paper is not currently listed, and send it to us as soon as possible in order for us to circulate it to the Task Group. A draft agenda is also attached and, as usual, this will need to be flexible to adapt to the meeting discussions.

We will be circulating the last few papers in the next day or two. Safe travels to Cincinnati.

Best Regards

Steve and Laszlo

CO2 co-Leads

Stephen Arrowsmith

Environmental Protection Officer

European Aviation Safety Agency

EASA

Tel.: +49 221 89990 5016

Postal: Postfach 10 12 53, 50452 Cologne, Germany

An agency of the European Union

This message is intended for the use of the addressee only and may contain information that is privileged and confidential. If you are not the intended recipient, your are notified that any dissemination of this communication is strictly prohibited. If you have received this communication in error, please notify us immediately by returning of this e-mail. Sender accepts no liability for damage of any kind resulting from the risks inherent in the electronic transmissions of messages. This communication does not constitute any formal commitment on behalf of the European Aviation Safety Agency.

To: Samulski, Michael[samulski.michael@epa.gov]; Yen, David[Yen.David@epa.gov]; Leggett, Cullen[Leggett.Cullen@epa.gov]; Audette, Lucie[audette.lucie@epa.gov]; Maeroff, Bruce[Maeroff.Bruce@epa.gov]
From: Manning, Bryan
Sent: Wed 1/6/2016 3:11:45 PM
Subject: Talk with Bill this morning: prep for Boeing meeting
Boeing Analysis of Production Impacts of USG ICAO Position dec212015.pdf

Hello,

Ex. 5 - Deliberative Process

Mike, we should discuss these Bill requests when you get into the office today. Thanks. Bryan

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Ex. 5 - Deliberative Process

Bryan Manning

U.S. EPA Office of Transportation and Air Quality

Large Marine and Aviation Center

2000 Traverwood Drive

Ann Arbor, MI 48105

(ph) 734-214-4832 (fax) 734-214-4816

manning.bryan@epa.gov