Field Report for Airborne Data Collected In Support of US EPA Region 6 South 4 Group Fire 05 December 2019

Background

On 27 November 2019 an explosion and subsequent fire was reported at the South 4 Group facility located near Port Neches, TX. Local information indicated that at approximately 0100 (central) a large explosion rocked the area. The explosion subsequently caused a massive fire at the facility in a short amount of time. Local officials ordered an initial evacuation of 0.5 miles on 27 November 2019 which was extended to 4 miles around 1430 (central). The evacuation order was lifted at 1000 (central) on 29 November 2019. Reported onsite products include various olefins, butadiene, and isobutylene. The geographical coordinates of the facility are 29.9222N, 95.0547W (figure 1).

The US EPA Region 6 requested that the ASPECT system be deployed to provide monitoring support beginning on 27 November 2019. This report summarizes findings observed during the two missions flown on 04 December 2019.

Figure 1: South 4 Group Facility, Port Neches, TX

ASPECT response to this Mission/Incident was in support of:
US EPA Region 6. OSC: Adam Adams

On 27 November 2019 ASPECT was dispatched to collect aerial remote sensing data over the South 4 Group facility located near Port Neches, TX and conducted three data collection missions. An explosion and fire involving a production unit and subsequent tank farms resulted in a black plume moving toward the south. Reports from the air crew indicated that significant lofting was occurring with smoke reaching 4000 feet above ground. Collected spectral data from both the IRLS and FTIR did not show any chemical detections. Data analysis from the second and third mission showed consistency to that of the first with the presence of a large thermal signature with the absence of detected compounds.

Due to poor weather and very low ceilings, ASPECT was only able to collect a few oblique images on 28 November 2019 and did not fly at all due to poor weather on 29 November 2019. On 30 November 2019 ASPECT collected aerial remote sensing data over the South 4 Group facility located near Port Neches, TX. Analysis of FTIR data did not show any chemical detections. IR image analysis showed the presence of elevated temperatures within the reactor complex, but the magnitude was substantially reduced from prior missions. Visible imagery showed only a light grey plume being generated at the facility with no active fires immediately visible. Damage to the facility and nearby spherical tanks was clear in the aerial and obliques images.

ASPECT conducted two flights on 01 December 2019. Analysis of IR imagery collected during the morning flight on 01 December 2019 indicated that isolated elevated thermal locations still exist within the production unit. Visible imagery confirmed that crew reports of light gray smoke was being emitted from the facility and was moving in an easterly direction. FTIR data collected in the vicinity of the facility showed one detection of isobutylene near the Orchard Ave bridge. The estimated concentration was about 1 ppm. Analysis of IR imagery of the junction of the waterway east of the facility which intersects with the Naches River showed no evidence of oil sheen. The afternoon showed a low thermal environment within the process unit and minimal smoke being emitted from the site. The analysis of imagery showed that four water cannons were being employed at the facility. IR imagery did not show any oil sheen presence on the Neches River. Analysis of FTIR data showed detections of isobutylene south of the facility near the wastewater treatment plant. These detections were approximately 1.7 ppm on two separate passes.

Analysis of IR imagery collected during the morning flight on 02 December 2019 indicated that very little thermal content was present in the process unit other than one fire on the north side of the unit. Visible imagery showed one water cannon in operation and light gray smoke being emitted from the facility due to the one fire. There were no chemical detections in the proximity of the facility. Analysis IR imagery of the junction of the waterway east of the facility which intersects with the Naches River showed no evidence of oil sheen. Flight 11 conducted on the afternoon of 02 December 2019 showed one fire on the northern edge of the process unit. A light gray smoke plume was still being emitted and at the time of the flight moving toward the southeast. Several of the reactor towers tended to show elevated temperatures as compared to the surrounding unit. IR imagery did not show any oil sheen presence on the Neches River but did

suggest that water flow is going into the river. Analysis of FTIR data showed detections of isobutylene south of the facility near the wastewater treatment plant. These detections were approximately 1.57 ppm on two separate passes.

Analysis of IR imagery collected during the morning flight on 03 December 2019 showed no high temperature locations suggesting that no fire was present in the process unit. Overhead visible imagery showed at the time of collection one cannon directed on the northern portion of the unit. Oblique imagery showed 5 cannons being used over a large portion of the facility. No smoke was observed by either the crew or analysis of imagery. There were no chemical detections in the proximity of the facility. Analysis IR imagery of the junction of the waterway east of the facility which intersects with the Naches River showed on evidence of oil sheen. Data collected on the afternoon flight did show the presence of 1,3-butadiene and aromatics 1300 meters west of the facility. Detected levels were approximately 0.93 ppm for 1,3-butadiene and less than 1 ppm for aromatics.

Analysis of IR imagery collected during the morning flight on 04 December 2019 showed no elevated temperature sources other than local solar heating of metal surfaces. Analysis of imagery showed no indication of an active fire. Aerial imagery showed one cannon being employed to spray a spherical tank south of the production unit. No smoke or emissions were detected in any imagery. Analysis of FTIR data showed no detections over and in the vicinity of the facility. Data collected on the afternoon 04 December 2019 indicated what appears to be solar heating of metal surfaces in the process unit and no signature of smoke or chemical emissions being generated by the process unit. Water cannons were observed on both flights with a spray being directed to a spherical tank south of the facility. Analysis of IR imagery collected at the confluence of the waterway and the Naches River showed no sheen signature.

As part of the continuing South 4 Group fire response, ASPECT was requested by Region 6 to conduct a data collection flights downwind, upwind, up the wind axis in reference to the facility and over adjacent residential areas and the waterway leading to the Neches River. An afternoon flight focused on collecting data up and downwind of the facility and community in addition to the waterway leading into the Neches River. This report details results and information from those missions.

ASPECT System

The US EPA ASPECT system collects airborne infrared (IR) images and chemical screening data from a safe distance over the site (about 3,000 ft AGL). The system consists of an airborne high-speed Fourier transform infrared spectrometer (FTIR) coupled with a wide-area IR line scanner (IRLS). The ASPECT IR systems can detect compounds in both the 8 to 12-micron (800 to 1200 cm-1) and 3 to 5 micron (2000 to 3200 cm-1) regions. The 8 to 12-micron region is typically known as the atmospheric window region since the band is reasonably void of water and carbon dioxide influence.

Spectrally, this region is used to detect carbon - non-carbon bonded compounds. The 3 to 5-micron region is also free of water and carbon dioxide but typically does not have enough energy for use. This band does show use in high-energy environments such as fires. The carbon - hydrogen stretch is very common in this region.

A digital Nikon DX2 camera (12.4 mega pixel CMOS 3:5 aspect ratio, 28 mm wide-angle lens) collects visible aerial imagery as part of the core data product package. The camera timing system is connected to the primary IR sensors and provides concurrent image collection when other sensors are triggered. All imagery is geo-rectified using both aircraft attitude correction (pitch, yaw, and roll) and GPS positional information. Imagery can be processed while in flight or approximately 600 frames per hour can be processed once the data are downloaded from the aircraft.

An Imperx mapping camera (29 mega pixels; mapping focal plane array) provides a similar aspect ratio and aerial coverage. Like the Nikon DX2, it is connected to the primary IR sensors and provides concurrent image collection when other sensors are triggered. These images are often digitally processed in lower resolution, so they can be transmitted via satellite communication. The high-resolution images (>20 MB each) are pulled from the ASPECT after the sortie and are available later.

All high resolution digital aerial photographic images collected by the ASPECT system are ortho-rectified and geospatially validated by the reach back team. In general, this consists of conducting geo-registration using a Digital Elevation Model (DEM) which promotes superior pixel computation and lessens topographic distortion. The image is then check by a team member (using a Google Earth base map) for proper location and rotation

Data is processed using automated algorithms onboard the aircraft with preliminary results being sent using a satellite system to the ASPECT reach back team for QA/QC analysis. Upon landing preliminary data results are examined and validated by the reach back team.

Flight Results for Flight 16, 05 December 2019

Weather Conditions and Crew Report

Weather for the morning mission are given in table 1.

Table 1. South 4 Group Mission Weather

Parameter	Surface (0800)	Surface (0900)
Wind direction	090 degrees	115 degrees
Wind speed	2.7 m/s (6 mph)	4.0 m/s (9 mph)
Temperature	13.9°C	17.2°C
Humidity	81%	70%
Dew Point	10.6°C	11.7°C

Pressure	1019 mb	1019 mb
Ceiling	Clear	Clear

The crew reported that winds at altitude (2800 ft) were at about 11 kts (4.9 m/s) from 248 degrees. There was no visible plume leaving the site. The crew reported that 5 water cannons were being used at the site.

Flight Status

The order to launch flight 16 was given at 0750 central on 5 December 2019 with the aircraft reporting wheels up at 0920. The initial data collection run over the site was at 0944 (central) The aircraft made a total of 9 data collection passes; flight information is summarized in Appendix Flight #16 and Figure 2.

Data Results

General Data Quality Objective

The following general data quality objectives are employed in conducting emergency response data collection with ASPECT:

1. To support overall situational analysis of the incident including aerial photography and IR imagery
2. To screen the incident for the presence of selected chemicals
3. To estimate the location and concentration of plumes being generated by the incident.

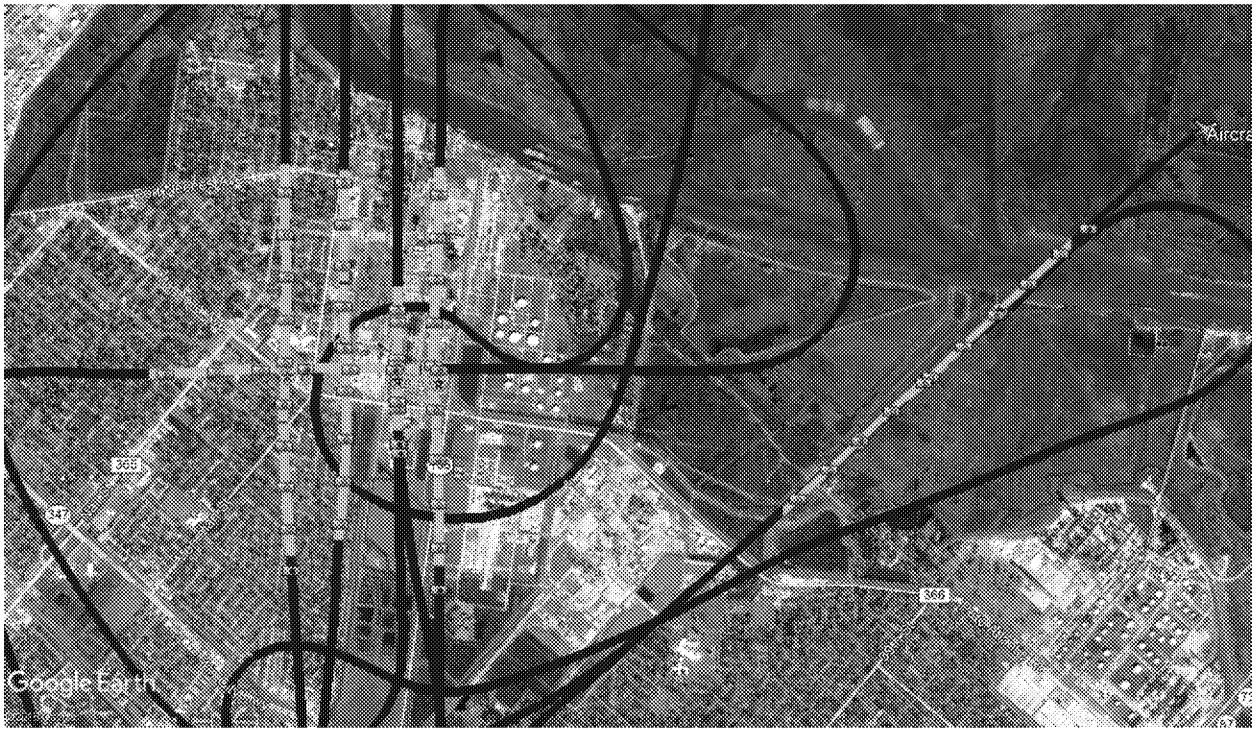

Figure 2: Data collection passes, Flight 16, South 4 Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

Line Scanner Data Results

A total of 2 test and 8 data collection passes were made in the proximity of the fire and an infrared line scanner image was generated for each pass. Figure 3 shows a typical 3-band infrared image obtained from data collected for Run 5. Analysis of the image shows a flat thermal environment for the process unit other than isolated spots heated by solar radiation. As reported by the crew, IR imagery showed no evidence of a plume being emitted from the site. The thermal environment of the unit continues to be low. Figure 4 shows a thermal close-up of the process unit with the only noteworthy content being the low thermal levels generated by 5 water cannons being to flood the process unit and nearby tanks. To asses possible oil sheen presence on the Naches River, ASPECT collected IR data along the drainage waterway leading into the river (figure 5). No oil sheen signatures were detected.

FTIR Data Results

FTIR Spectral data at a resolution of 16 wavenumbers was collected for each pass. ASPECT uses an automated detection algorithm to permit compounds to be analyzed while the aircraft is in flight. 72 compounds are included in this algorithm and the list is given

in Table 2. In addition, collected data are also manually analyzed by comparing any detected spectral signatures to a collection of published library spectra.

Low level detections of ethylene were made near the school northwest of the facility. Figure 6 shows the locations of the detections. Detected concentrations were just above the detection limit of the system with a maximum reading of 0.522 ppm. Figure 7 shows a confirmation spectrum with the characteristic ethylene peak at 950 wave numbers. A summary of data of the data collection is given in table 3.

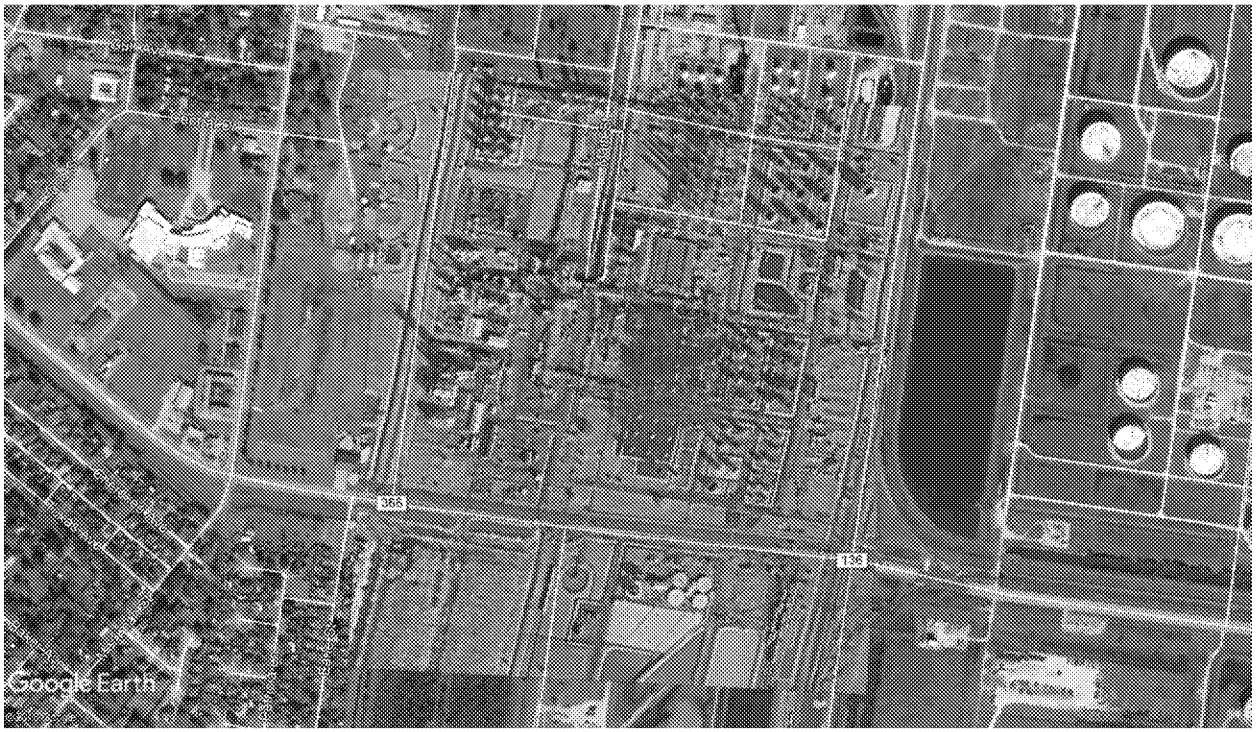

Figure 3: – 3 band IR image, Flight 16, Run 5, South 4 Group Fire

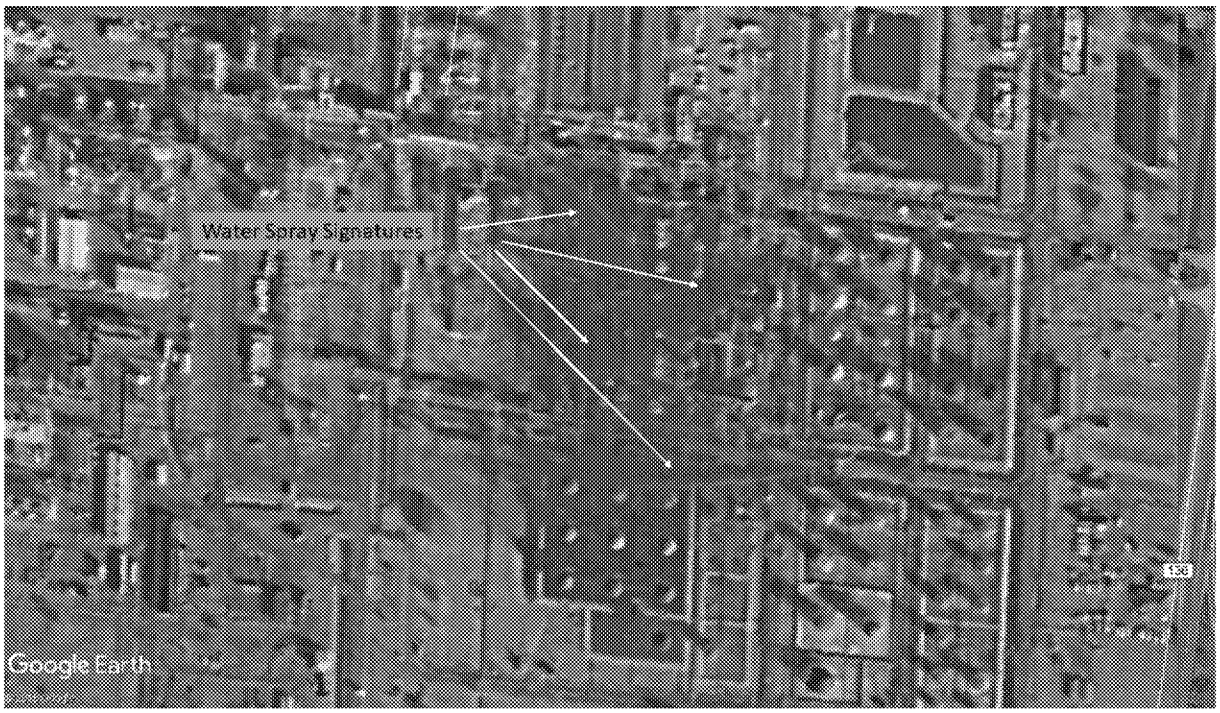

Figure 4: -- 3 band IR Image, Flight 16, Run 7, South 4 Group Thermal Image

Figure 5: -- 3 band IR Image, Flight 16, Run 10, South 4 Group Waterway Image

Figure 6: -- Ethylene Detection, Flight 16, South 4 Group Waterway Image

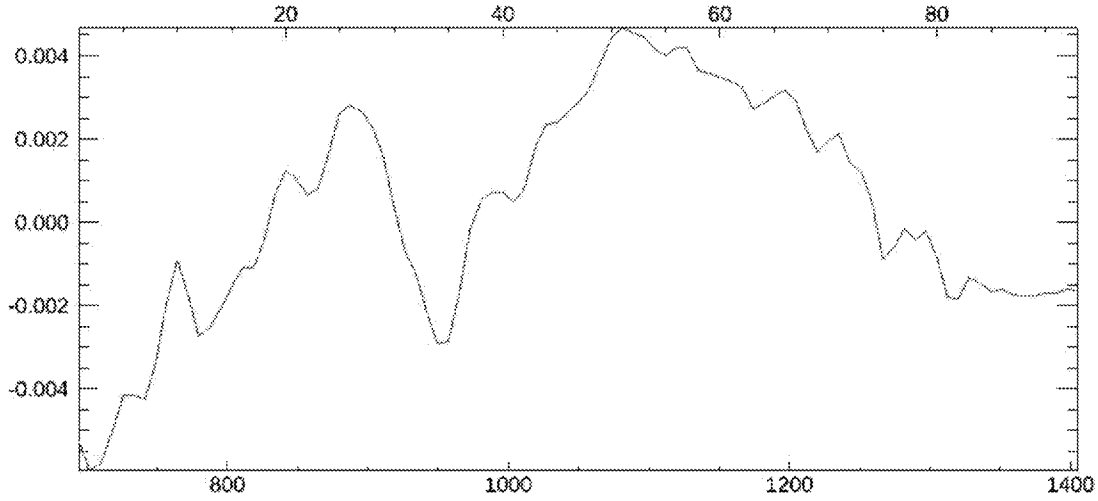

Figure 7: -- Ethylene Detection Spectrum, Flight 16, South 4 Group Waterway Image

TABLE 2 - Chemicals Included in the ASPECT Auto-Processing Library

Acetic Acid	Cumene	Isoprene	Propylene
Acetone	Diborane	Isopropanol	Propylene Oxide
Acrolein	1,1-Dichloroethene	Isopropyl Acetate	Silicon Tetrafluoride
Acrylonitrile	Dichloromethane	MAPP	Sulfur Dioxide
Acrylic Acid	Dichlorodifluoromethane	Methyl Acetate	Sulfur Hexafluoride
Allyl Alcohol	Difluoroethane	Methyl Ethyl Ketone	Sulfur Mustard
Ammonia	Difluoromethane	Methanol	Nitrogen Mustard
Arsine	Ethanol	Methylbromide	Phosgene
Bis-Chloroethyl Ether	Ethyl Acetate	Methylene Chloride	Phosphine
Boron Tribromide	Ethyl Formate	Methyl Methacrylate	Tetrachloroethylene
Boron Triflouride	Ethylene	MTEB	1,1,1-Trichloroethane
1,3-Butadiene	Formic Acid	Naphthalene	Trichloroethylene
1-Butene	Freon 134a	n-Butyl Acetate	Trichloromethane
2-Butene	GA (Tabun)	n-Butyl Alcohol	Triethylamine
Carbon Tetrachloride	GB (Sarin)	Nitric Acid	Triethylphosphate
Carbonyl Chloride	Germane	Nitrogen Trifluoride	Trimethylamine
Carbon Tetraflouride	Hexafluoroacetone	Phosphorus Oxychloride	Trimethyl Phosphite
Chlorodifluoromethane	Isobutylene	Propyl Acetate	Vinyl Acetate

Table 3. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	05 Dec 2019	1416	Test	Test
2		1417	Test	Test
3		1430	ND	None
4		1434	Ethylene	0.522
5		1442	ND	None
6		1449	ND	None
7		1456	ND	None
8		1502	ND	None
9		1506	ND	None
10		1513	ND	None
Note: ND = No Detections				

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 8 and 9 show representative views of the process unit with a 5 cannon flood. No emissions are visible in these images.

Conclusions – Flight 16

Analysis of IR imagery collected during the morning flight on 05 December 2019 showed no elevated temperature sources within the process unit. 5 water cannons were visible in all imagery. On data collection line 4, very low levels of ethylene (0.522 ppm) were detected in two spectra. No other chemical detections were made during the mission. Finally, analysis of IR imagery at the confluence of the drainage waterway and the Naches River showed no oil sheen signature.

Figure 8: Aerial Image, Flight 16 South 4 Group Fire.

Figure 9: Oblique Image of the South 4 Group Fire

Appendix Flight #16

Abbreviations:

DEM – Digital elevation model
Alt – Altitude (in feet)
MSL – Mean sea level altitude (in feet)
Digital – Digital photography file from the Nikon D2X camera
MSIC – Digital photography file from the Imperx mapping camera
FTIR – Spectral IR data collected with a Fourier Transform Infrared Spectrometer
IRLS – Infrared Line Scanner
Jpg – JPEG image format
UTC – Universal Time Coordinated
img – Spectral data format based on Grams format

Mission: 2019-12-05 South 4 Group Fire

Date: 12/5/2019

Time UTC: 14:10

Aircraft Number: N9738B

Pilot: Todd Seale

Copilot: James Glaviano

Operator: James Crisp

Aft Operator: Gerry Broyles

Ground Controller: Ahmed Hafez

DEM: Using elevation from DEM Database

Run: 1 Time: 14:16:07 UTC

Alt: 2688 ft MSL Elev: 13 ft Elevation from DEM Database

Vel: 150 knots Heading: 251

Digitals: None

MSIC: 3

20191205141613396.jpg

20191205141619760.jpg

20191205141626110.jpg

FTIR: 1

20191205_141612_A.igm

IRLS: 1

2019_12_05_14_16_12_R_01 TA=9.1;TB=29.1;Gain=3

Gamma Runs: None

Run: 2 Time: 14:17:50 UTC

Alt: 2792 ft MSL Elev: 10 ft Elevation from DEM Database

Vel: 122 knots Heading: 233

Digitals: None

MSIC: 3

20191205141755991.jpg

20191205141802355.jpg

20191205141808705.jpg

FTIR: 1

20191205_141753_A.igm

IRLS: 1

2019_12_05_14_17_54_R_02 TA=6.4;TB=25.4;Gain=3

Gamma Runs: None

Run: 3 Time: 14:30:13 UTC

Alt: 2874 ft MSL Elev: 7 ft Elevation from DEM Database

Vel: 105 knots Heading: 179

Digitals: None

MSIC: 4

20191205143018672.jpg

20191205143025021.jpg

20191205143031370.jpg

20191205143037735.jpg

FTIR: 1

20191205_143016_A.igm

IRLS: 1

2019_12_05_14_30_17_R_03 TA=5.3;TB=25.3;Gain=3

Gamma Runs: None

Run: 4 Time: 14:34:35 UTC

Alt: 2766 ft MSL Elev: 8 ft Elevation from DEM Database

Vel: 101 knots Heading: -3

Digitals: None

MSIC: 9

20191205143441050.jpg

20191205143447415.jpg

20191205143453764.jpg

20191205143501033.jpg

20191205143507383.jpg

20191205143513732.jpg

20191205143520097.jpg

20191205143526446.jpg

20191205143532795.jpg

FTIR: 2

20191205_143439_A.igm

20191205_143518_A.igm

IRLS: 1

2019_12_05_14_34_40_R_04 TA=6.1;TB=26.1;Gain=3

Gamma Runs: None

Run: 5 Time: 14:42:44 UTC

Alt: 2776 ft MSL Elev: 7 ft Elevation from DEM Database

Vel: 102 knots Heading: 181

Digitals: None

MSIC: 4

20191205144250416.jpg

20191205144257670.jpg

20191205144304035.jpg

20191205144310384.jpg

FTIR: 1

20191205_144247_A.igm

IRLS: 1

2019_12_05_14_42_49_R_05 TA=6.4;TB=26.4;Gain=3

Gamma Runs: None

Run: 6 Time: 14:49:46 UTC

Alt: 2841 ft MSL Elev: 9 ft Elevation from DEM Database

Vel: 101 knots Heading: 180

Digitals: None

MSIC: 10

20191205144952593.jpg

20191205144958942.jpg

20191205145005307.jpg

20191205145011656.jpg

20191205145018005.jpg

20191205145024370.jpg

20191205145030719.jpg

20191205145037084.jpg

20191205145043433.jpg

20191205145049782.jpg

FTIR: 2

20191205_144949_A.igm

20191205_145029_A.igm

IRLS: 1

2019_12_05_14_49_51_R_06 TA=6.4;TB=26.4;Gain=3

Gamma Runs: None

Run: 7 Time: 14:56:25 UTC

Alt: 2871 ft MSL Elev: 9 ft Elevation from DEM Database

Vel: 108 knots Heading: 94

Digitals: None

MSIC: 7

20191205145631157.jpg

20191205145638427.jpg

20191205145644776.jpg

20191205145651141.jpg

20191205145657490.jpg

20191205145703839.jpg

20191205145710204.jpg

FTIR: 2

20191205_145629_A.igm

20191205_145708_A.igm

IRLS: 1

2019_12_05_14_56_30_R_07 TA=6.7;TB=26.7;Gain=3

Gamma Runs: None

Run: 8 Time: 15:02:21 UTC

Alt: 2860 ft MSL Elev: 7 ft Elevation from DEM Database

Vel: 104 knots Heading: 181

Digitals: None

MSIC: 10

20191205150227968.jpg

20191205150234317.jpg

20191205150240682.jpg

20191205150247031.jpg

20191205150253396.jpg

20191205150259745.jpg

20191205150307015.jpg

20191205150313364.jpg

20191205150319713.jpg

20191205150326078.jpg

FTIR: 2

20191205_150224_A.igm

20191205_150304_A.igm

IRLS: 1

2019_12_05_15_02_27_R_08 TA=6.9;TB=26.9;Gain=3

Gamma Runs: None

Run: 9 Time: 15:06:56 UTC

Alt: 2751 ft MSL Elev: 2 ft Elevation from DEM Database

Vel: 103 knots Heading: 51

Digitals: None

MSIC: 5

20191205150702158.jpg

20191205150708507.jpg

20191205150714872.jpg

20191205150721221.jpg

20191205150727570.jpg

FTIR: 1

20191205_150659_A.igm

IRLS: 1

2019_12_05_15_07_01_R_09 TA=7.1;TB=27.1;Gain=3

Gamma Runs: None

Run: 10 Time: 15:13:14 UTC

Alt: 2794 ft MSL Elev: 0 ft Elevation from DEM Database

Vel: 108 knots Heading: 49

Digitals: None

MSIC: 6

20191205151320750.jpg

20191205151327099.jpg

20191205151333464.jpg

20191205151339813.jpg

20191205151346178.jpg

20191205151351622.jpg

FTIR: 1

20191205_151316_A.igm

IRLS: 1

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2019_12_05_15_13_19_R_10 TA=6.9;TB=26.9;Gain=3

Gamma Runs:  None



Mission Complete: 15:40 (UTC)
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Flight Results for Flight 17, 05 December 2019

Weather Conditions and Crew Report

Weather for the afternoon mission are given in table 4.

Table 4. South 4 Group Mission Weather

Parameter	Surface (1500)	Surface (1600)
Wind direction	150 degrees	150 degrees
Wind speed	4.9 m/s (11 mph)	5.8 m/s (13 mph)
Temperature	21.7°C	20.6°C
Humidity	63%	65%
Dew Point	14.4°C	14.4°C
Pressure	1017 mb	1017 mb
Ceiling	Clear	Clear

The crew reported that winds at altitude (2800 ft) were at about 15 kts (7.7 m/s) from 220 degrees. There was no visible plume leaving the site. The crew reported that 1 water cannon was being used during a portion of the mission.

Flight Status

The order to launch flight 17 was given at 1445 central on 5 December 2019 with the aircraft reporting wheels up at 1457. The initial data collection run over the site was at 1526 (central) The aircraft made a total of 7 data collection passes; flight information is summarized in Appendix Flight #17 and Figure 10.

Data Results

General Data Quality Objective

The following general data quality objectives are employed in conducting emergency response data collection with ASPECT:

4. To support overall situational analysis of the incident including aerial photography and IR imagery
5. To screen the incident for the presence of selected chemicals

6. To estimate the location and concentration of plumes being generated by the incident.

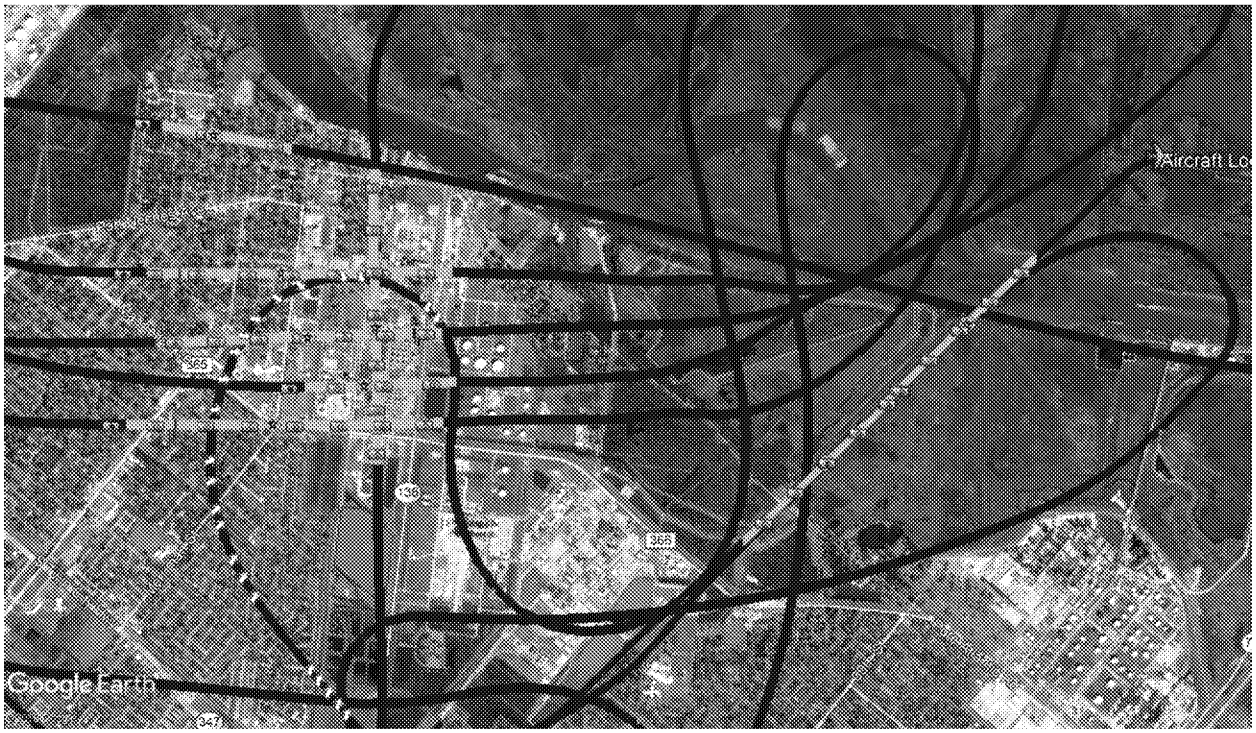

Figure 10: Data collection passes, Flight 17, South 4 Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

Line Scanner Data Results

A total of 1 test and 7 data collection passes were made in the proximity of the facility and an infrared line scanner image was generated for each pass. Figure 11 shows a typical 3-band infrared image obtained from data collected for Run 2. Analysis of the image shows a flat thermal environment for the process unit other than solar heating of tanks and metal surfaces. Smoke or other emissions are absent in the imagery. A closeup thermal image (figure 12) shows only solar heating. At the time of the IR collection, the signatures of water cannon are not present. A collection pass over the confluence of the drainage waterway and Naches River shows tidal effects pulling water out of the channel but no oil sheen signatures were detected (figure 13).

FTIR Data Results

FTIR Spectral data at a resolution of 16 wavenumbers was collected for each pass. ASPECT uses an automated detection algorithm to permit compounds to be analyzed while the aircraft is in flight. 72 compounds are included in this algorithm and the list is given in Table 5. In addition, collected data are also manually analyzed by comparing any detected spectral signatures to a collection of published library spectra.

Flight 17 did not generate any chemical detections. A summary of data of the data collection is given in table 6.

Figure 11: – 3 band IR image, Flight 17, Run 1, South 4 Group Fire

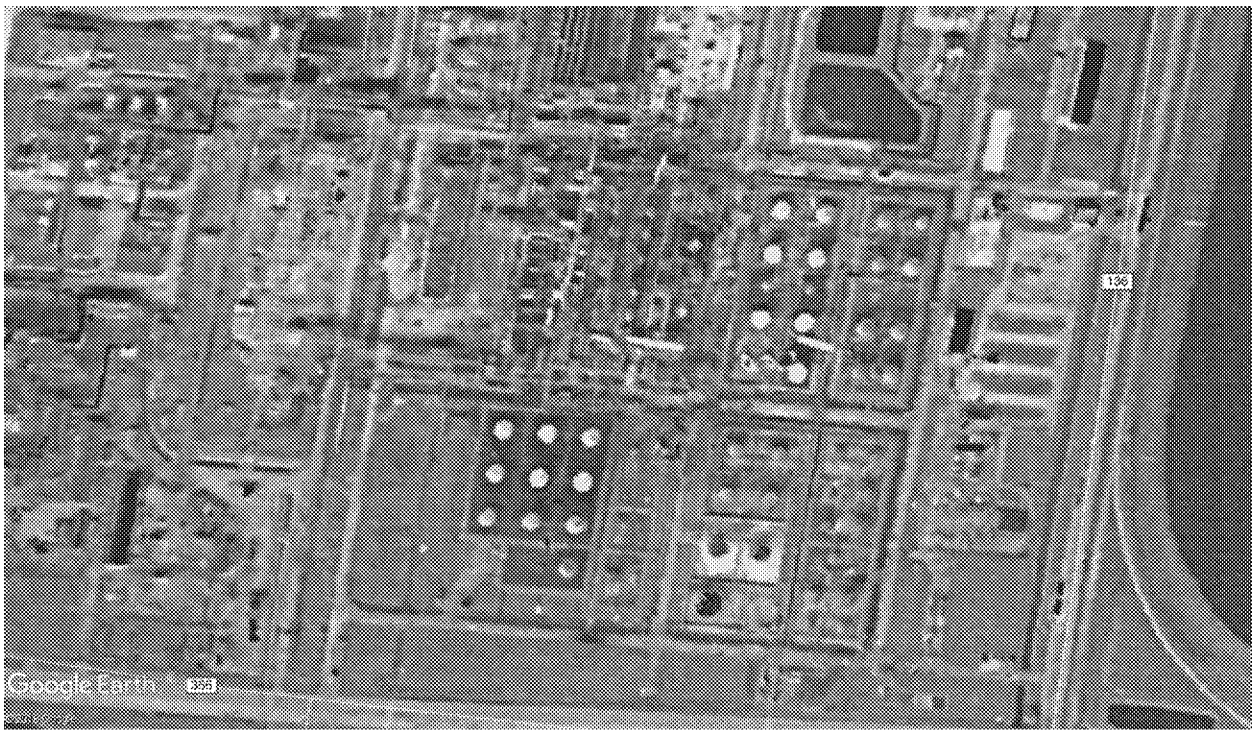

Figure 12: -- 3 band IR Image, Flight 17, Run 5, South 4 Group Thermal Image

Figure 13: -- 3 band IR Image, Flight 17, Run 8, South 4 Group Waterway Image

TABLE 5 - Chemicals Included in the ASPECT Auto-Processing Library

Acetic Acid	Cumene	Isoprene	Propylene
Acetone	Diborane	Isopropanol	Propylene Oxide
Acrolein	1,1-Dichloroethene	Isopropyl Acetate	Silicon Tetrafluoride
Acrylonitrile	Dichloromethane	MAPP	Sulfur Dioxide
Acrylic Acid	Dichlorodifluoromethane	Methyl Acetate	Sulfur Hexafluoride
Allyl Alcohol	Difluoroethane	Methyl Ethyl Ketone	Sulfur Mustard
Ammonia	Difluoromethane	Methanol	Nitrogen Mustard
Arsine	Ethanol	Methylbromide	Phosgene
Bis-Chloroethyl Ether	Ethyl Acetate	Methylene Chloride	Phosphine
Boron Tribromide	Ethyl Formate	Methyl Methacrylate	Tetrachloroethylene
Boron Triflouride	Ethylene	MTEB	1,1,1-Trichloroethane
1,3-Butadiene	Formic Acid	Naphthalene	Trichloroethylene
1-Butene	Freon 134a	n-Butyl Acetate	Trichloromethane
2-Butene	GA (Tabun)	n-Butyl Alcohol	Triethylamine
Carbon Tetrachloride	GB (Sarin)	Nitric Acid	Triethylphosphate
Carbonyl Chloride	Germane	Nitrogen Trifluoride	Trimethylamine
Carbon Tetraflouride	Hexafluoroacetone	Phosphorus Oxychloride	Trimethyl Phosphite
Chlorodifluoromethane	Isobutylene	Propyl Acetate	Vinyl Acetate

Table 6. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	05 Dec 2019	2116	Test	Test
2		2126	ND	None
3		2130	ND	None
4		2135	ND	None
5		2141	ND	None
6		2147	ND	None
7		2153	ND	None
8		2159	ND	None
Note: ND = No Detections				

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 14 and 15 show representative views of the process unit and tank farm. No emissions are visible in these images.

Conclusions – Flight 17

Analysis of IR imagery collected during the both the morning and afternoon flights on 5 December 2019 showed no elevated temperature sources other than solar heating of tanks

and metal surfaces. During the morning flight, 5 water cannons were visible in imagery with none seen during the afternoon mission. Two ethylene detections were made on the morning flight northwest of the facility with a maximum concentration of 0.522 ppm recorded. No chemical detections were made on the afternoon flight. Finally, analysis of IR imagery at the confluence of the drainage waterway and the Naches River showed no oil sheen signature on either mission.

Figure 14: Aerial Image, Flight 16 South 4 Group Fire.

Figure 15: Oblique Image of the South 4 Group Fire

Appendix Flight #17

Abbreviations:

DEM – Digital elevation model
Alt – Altitude (in feet)
MSL – Mean sea level altitude (in feet)
Digital – Digital photography file from the Nikon D2X camera
MSIC – Digital photography file from the Imperx mapping camera
FTIR – Spectral IR data collected with a Fourier Transform Infrared Spectrometer
IRLS – Infrared Line Scanner
Jpg – JPEG image format
UTC – Universal Time Coordinated
img – Spectral data format based on Grams format

Mission: 2019-12-05 South 4 Group Fire

Date: 12/5/2019
Time UTC: 21:05

Aircraft Number: N9738B

Pilot: Todd Seale
Copilot: James Glaviano
Operator: James Crisp
Aft Operator: Gerry Broyles
Ground Controller: Ahmed Hafez

DEM: Using elevation from DEM Database

Run: 1 Time: 21:16:34 UTC
Alt: 2782 ft MSL Elev: 11 ft Elevation from DEM Database
Vel: 152 knots Heading: 276

Digitals: None
MSIC: 3
20191205211640165.jpg
20191205211647435.jpg
20191205211653785.jpg
FTIR: 1
20191205_211637_A.igm
IRLS: 1
2019_12_05_21_16_38_R_01 TA=19.0;TB=39.0;Gain=3
Gamma Runs: None

Run: 2 Time: 21:26:27 UTC
Alt: 2831 ft MSL Elev: 8 ft Elevation from DEM Database
Vel: 113 knots Heading: 263

Digitals: None
MSIC: 4
20191205212633063.jpg
20191205212639412.jpg
20191205212645777.jpg
20191205212652126.jpg
FTIR: 1
20191205_212630_A.igm
IRLS: 1
2019_12_05_21_26_31_R_02 TA=12.9;TB=32.9;Gain=3
Gamma Runs: None

Run: 3 Time: 21:30:22 UTC
Alt: 2805 ft MSL Elev: 10 ft Elevation from DEM Database
Vel: 102 knots Heading: 94

Digitals: None
MSIC: 7
20191205213029133.jpg
20191205213035476.jpg
20191205213041841.jpg
20191205213048190.jpg

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        20191205213054555.jpg
        20191205213100905.jpg
        20191205213107255.jpg
FTIR: 2
        20191205_213027_A.igm
        20191205_213106_A.igm
IRLS: 1
        2019_12_05_21_30_27_R_03 TA=12.5;TB=32.5;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 4 Time: 21:35:47 UTC
        Alt: 2844 ft MSL  Elev: 10 ft  Elevation from DEM Database
        Vel: 107 knots  Heading: 264

Digitals:  None
MSIC: 8
        20191205213553266.jpg
        20191205213559615.jpg
        20191205213605980.jpg
        20191205213612330.jpg
        20191205213618679.jpg
        20191205213625949.jpg
        20191205213632299.jpg
        20191205213636838.jpg
FTIR: 2
        20191205_213550_A.igm
        20191205_213629_A.igm
IRLS: 1
        2019_12_05_21_35_51_R_04 TA=11.8;TB=31.8;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 5 Time: 21:41:15 UTC
        Alt: 2935 ft MSL  Elev: 8 ft  Elevation from DEM Database
        Vel: 104 knots  Heading: 182

Digitals:  None
MSIC: 7
        20191205214121022.jpg
        20191205214127387.jpg
        20191205214133737.jpg
        20191205214140102.jpg
        20191205214147356.jpg
        20191205214153721.jpg
        20191205214200071.jpg
FTIR: 2
        20191205_214119_A.igm
        20191205_214158_A.igm
IRLS: 1
        2019_12_05_21_41_19_R_05 TA=11.4;TB=31.4;Gain=3
Gamma Runs:  None
```

Run: 6 Time: 21:47:34 UTC
Alt: 2851 ft MSL Elev: 8 ft Elevation from DEM Database
Vel: 105 knots Heading: 264

Digitals: None
MSIC: 8
20191205214740543.jpg
20191205214746907.jpg
20191205214753256.jpg
20191205214759621.jpg
20191205214805971.jpg
20191205214812320.jpg
20191205214819590.jpg
20191205214825940.jpg
FTIR: 2
20191205_214737_A.igm
20191205_214817_A.igm
IRLS: 1
2019_12_05_21_47_38_R_06 TA=11.4;TB=31.4;Gain=3
Gamma Runs: None

Run: 7 Time: 21:53:45 UTC
Alt: 2744 ft MSL Elev: 2 ft Elevation from DEM Database
Vel: 104 knots Heading: 50

Digitals: None
MSIC: 6
20191205215351904.jpg
20191205215358253.jpg
20191205215404603.jpg
20191205215410968.jpg
20191205215417317.jpg
20191205215420047.jpg
FTIR: 1
20191205_215348_A.igm
IRLS: 1
2019_12_05_21_53_49_R_07 TA=11.9;TB=31.9;Gain=3
Gamma Runs: None

Run: 8 Time: 21:59:45 UTC
Alt: 2809 ft MSL Elev: 0 ft Elevation from DEM Database
Vel: 102 knots Heading: 49

Digitals: None
MSIC: 5
20191205215951434.jpg
20191205215957799.jpg

```
        20191205220004148.jpg
        20191205220010498.jpg
        20191205220016863.jpg
FTIR: 1
        20191205_215949_A.igm
IRLS: 1
        2019_12_05_21_59_49_R_08 TA=10.5;TB=30.5;Gain=3
Gamma Runs:  None
```