Field Report for Airborne Data Collected In Support of US EPA Region 6 South 4 Group Fire 06 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 mission flown on 06 December 2019.

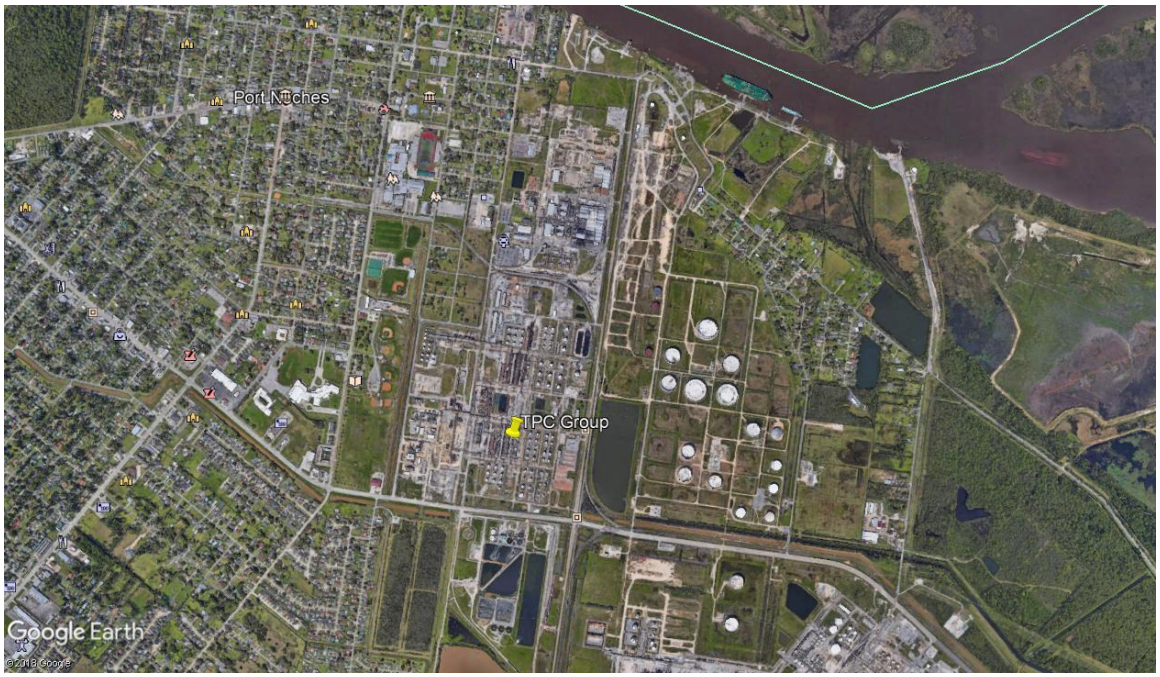

Figure 1: South 4 Group Facility, Port Neches, TX

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

9989550

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.

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. Analysis of IR imagery at the confluence of the drainage waterway and the Naches River showed no oil sheen signature. Data collected on the afternoon of 05 December 2019 showed no elevated temperature sources other than solar heating of tanks and metal surfaces. No chemical detections were made on the afternoon flight. Analysis of afternoon IR imagery at the confluence of the drainage waterway and the Naches River showed no oil sheen signature on either mission.

As part of the continuing South 4 Group fire response, ASPECT was requested by Region 6 to conduct a data collection flight downwind, upwind, up the wind axis in reference to the facility and over adjacent residential areas and the waterways leading to 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 18, 06 December 2019

Weather Conditions and Crew Report

Weather for the afternoon mission are given in table 1.

Table 1. South 4 Group Mission Weather

Parameter	Surface (1200)	Surface (1300)
Wind direction	270 degrees	290 degrees
Wind speed	3.1 m/s (7 mph)	4.5 m/s (10 mph)
Temperature	25.6ºC	26.7ºC
Humidity	56%	51%
Dew Point	16.1ºC	15.6ºC
Pressure	1018 mb	1017 mb
Ceiling	Few at 3000	Clear

The crew reported that winds at altitude (2800 ft) were at about 23 kts (11.8 m/s) from 240 degrees. There was no visible plume leaving the site and no water cannon was in use.

Flight Status

The order to launch flight 18 was given at 1200 central on 6 December 2019 with the aircraft reporting wheels up at 1215. The initial data collection run over the site was at 1241 (central) The aircraft made a total of 9 data collection passes; flight information is summarized in Appendix Flight #18 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.

Line Scanner Data Results

A total of 1 test and 9 data collection passes were made in the proximity of the facility 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 7. Analysis of the image shows a flat thermal environment for the process unit other than isolated locations heated by solar radiation. No plume is present in the image. To assess possible oil sheen presence on the Naches River and a nearby drainage channel, ASPECT collected IR data along the drainage waterways; no oil sheen signatures were detected (figures 4 and 5).

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.

There were no chemical detections observed on the mission. A summary of data of the data collection is given in table 3.

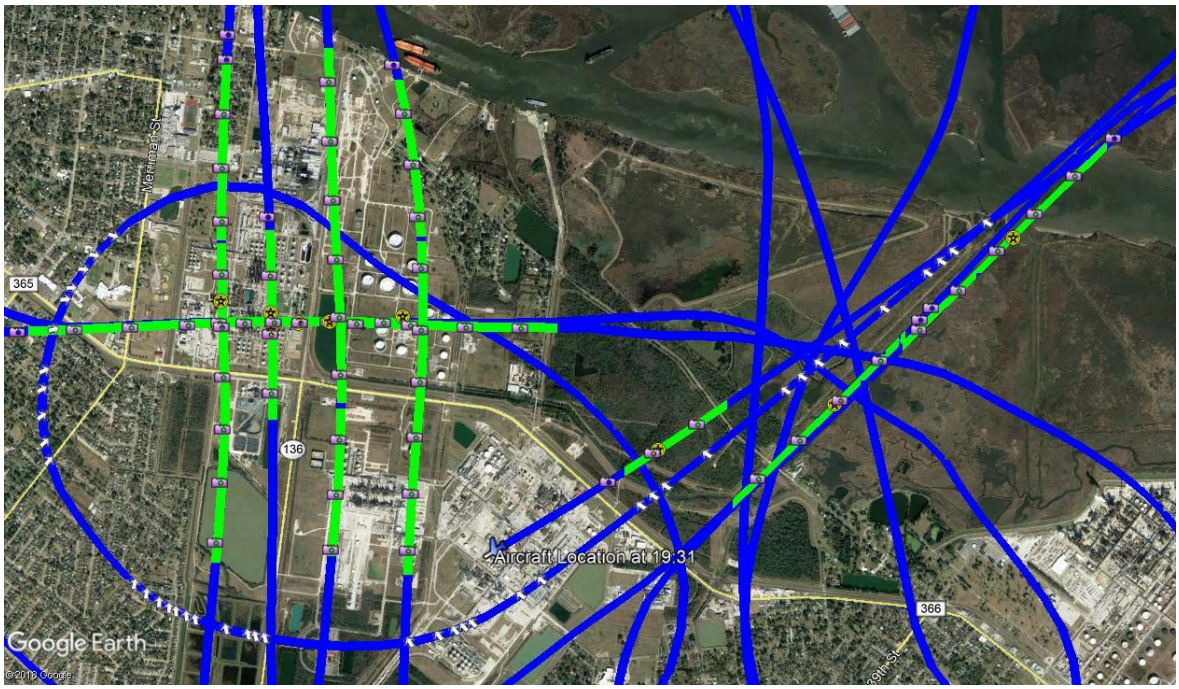

Figure 2: Data collection passes, Flight 18, South 4 Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

Figure 3: – 3 band IR image, Flight 18, Run 7, South 4 Group Fire

Figure 4: -- 3 band IR Image, Flight 18, Run 9, South 4 Group Naches River Confluence

Figure 5: -- 3 band IR Image, Flight 18, Run 10, 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	06 Dec 2019	1829	Test	Test
2		1841	ND	None
3		1846	ND	None
4		1851	ND	None
5		1858	ND	None
6		1904	ND	None
7		1911	ND	None
8		1918	ND	None
9		1924	ND	None
10		1930	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 6 and 7 show representative views of the process unit. No emissions are visible in these images. In addition, the images and crew reports indicated that no water cannon was in use.

Conclusions – Flight 18

Analysis of IR imagery collected during the afternoon flight on 06 December 2019 showed no elevated temperature sources within the process unit and the absence of water cannon. No emissions were observed in any data and no chemical detections were noted on any of the data collection passes. Analysis of IR imagery at the confluence of the drainage waterway and the Naches River and a smaller waterway showed no oil sheen signatures.

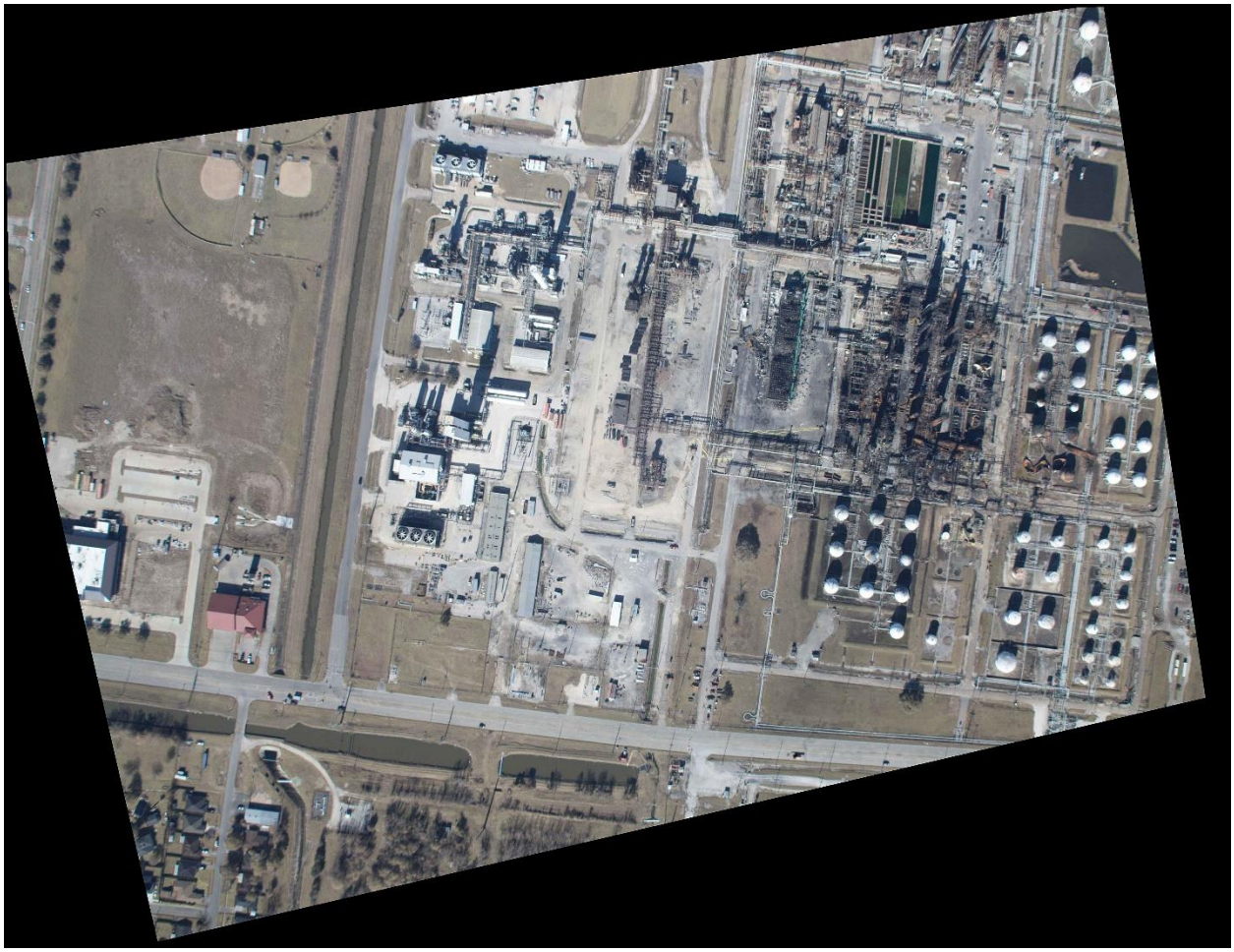

Figure 6: Aerial Image, Flight 18 South 4 Group Fire.

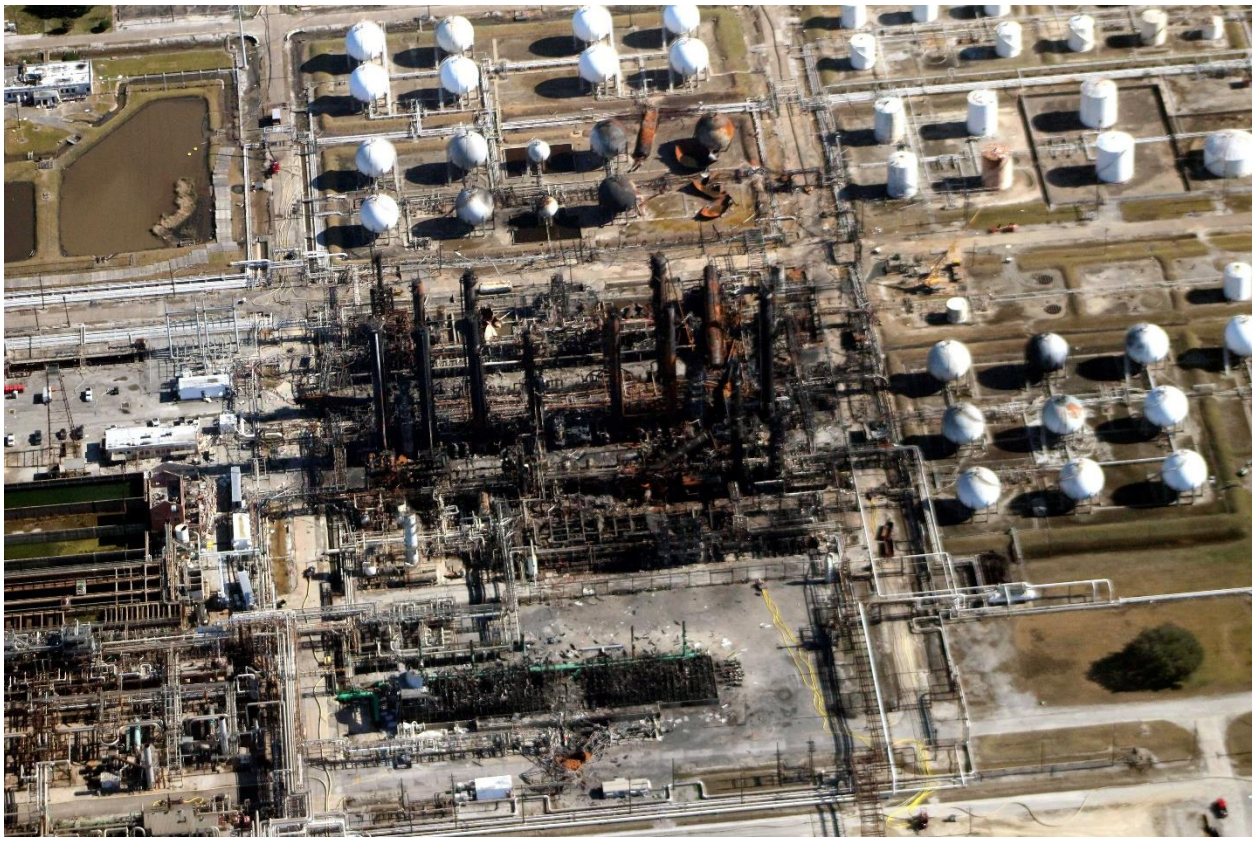

Figure 7: Oblique Image, Flight 18 South 4 Group Fire

Appendix Flight #18

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: 2019-12-06 South 4 Group Fire

Date: 12/6/2019

Time UTC: 18:21

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: 18:29:04 UTC
Alt: 2890 ft MSL Elev: 6 ft Elevation from DEM Database
Vel: 108 knots Heading: 269

Digitals: None
MSIC: 3
20191206182909864.jpg
20191206182916218.jpg
20191206182922576.jpg
FTIR: 1
20191206_182909_A.igm
IRLS: 1
2019_12_06_18_29_08_R_01 TA=22.0;TB=42.0;Gain=3
Gamma Runs: None

Run: 2 Time: 18:41:30 UTC
Alt: 2857 ft MSL Elev: 7 ft Elevation from DEM Database
Vel: 109 knots Heading: 348

Digitals: None
MSIC: 4
20191206184137075.jpg
20191206184143417.jpg
20191206184149773.jpg
20191206184156138.jpg
FTIR: 1
20191206_184135_A.igm
IRLS: 1
2019_12_06_18_41_35_R_02 TA=21.5;TB=41.5;Gain=3
Gamma Runs: None

Run: 3 Time: 18:46:09 UTC
Alt: 2777 ft MSL Elev: 7 ft Elevation from DEM Database
Vel: 107 knots Heading: 190

Digitals: None
MSIC: 9
20191206184614889.jpg

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        20191206184621246.jpg
        20191206184627605.jpg
        20191206184633958.jpg
        20191206184640307.jpg
        20191206184646656.jpg
        20191206184653926.jpg
        20191206184700291.jpg
        20191206184706643.jpg
FTIR: 2
        20191206_184612_A.igm
        20191206_184651_A.igm
IRLS: 1
        2019_12_06_18_46_13_R_03 TA=22.4;TB=42.4;Gain=3
Gamma Runs:  None

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Run: 4 Time: 18:51:51 UTC
        Alt: 2852 ft MSL  Elev: 6 ft  Elevation from DEM Database
        Vel: 100 knots  Heading: 347

Digitals:  None
MSIC: 10
        20191206185158080.jpg
        20191206185204438.jpg
        20191206185210787.jpg
        20191206185217136.jpg
        20191206185223490.jpg
        20191206185230761.jpg
        20191206185237110.jpg
        20191206185243475.jpg
        20191206185249824.jpg
        20191206185256173.jpg
FTIR: 2
        20191206_185156_A.igm
        20191206_185234_A.igm
IRLS: 1
        2019_12_06_18_51_56_R_04 TA=22.6;TB=42.6;Gain=3
Gamma Runs:  None

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

Run: 5 Time: 18:58:04 UTC
        Alt: 2872 ft MSL  Elev: 9 ft  Elevation from DEM Database
        Vel: 105 knots  Heading: 270

Digitals:  None
MSIC: 10
        20191206185811225.jpg
        20191206185817574.jpg
        20191206185823939.jpg
        20191206185830288.jpg
        20191206185836653.jpg
        20191206185843002.jpg
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        20191206185849351.jpg
        20191206185855716.jpg
        20191206185902065.jpg
        20191206185908414.jpg
FTIR: 2
        20191206_185807_A.igm
        20191206_185847_A.igm
IRLS: 1
        2019_12_06_18_58_09_R_05 TA=22.1;TB=42.1;Gain=3
Gamma Runs:  None

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

Run: 6 Time: 19:04:52 UTC
        Alt: 2887 ft MSL  Elev: 7 ft  Elevation from DEM Database
        Vel: 100 knots  Heading: 354

Digitals:  None
MSIC: 11
        20191206190457966.jpg
        20191206190505229.jpg
        20191206190511578.jpg
        20191206190517943.jpg
        20191206190524292.jpg
        20191206190530657.jpg
        20191206190537006.jpg
        20191206190543355.jpg
        20191206190549720.jpg
        20191206190556075.jpg
        20191206190558790.jpg
FTIR: 2
        20191206_190456_A.igm
        20191206_190535_A.igm
IRLS: 1
        2019_12_06_19_04_56_R_06 TA=22.2;TB=42.2;Gain=3
Gamma Runs:  None

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Run: 7 Time: 19:11:28 UTC
        Alt: 2842 ft MSL  Elev: 8 ft  Elevation from DEM Database
        Vel: 103 knots  Heading: 271

Digitals:  None
MSIC: 4
        20191206191134718.jpg
        20191206191141083.jpg
        20191206191147432.jpg
        20191206191153781.jpg
FTIR: 1
        20191206_191131_A.igm
IRLS: 1
        2019_12_06_19_11_33_R_07 TA=22.2;TB=42.2;Gain=3
Gamma Runs:  None
```

Run: 8 Time: 19:18:37 UTC
Alt: 2840 ft MSL Elev: 2 ft Elevation from DEM Database
Vel: 106 knots Heading: 41

Digitals: None
MSIC: 6
20191206191843255.jpg
20191206191849604.jpg
20191206191855969.jpg
20191206191902318.jpg
20191206191908667.jpg
20191206191910492.jpg
FTIR: 1
20191206_191840_A.igm
IRLS: 1
2019_12_06_19_18_41_R_08 TA=22.5;TB=42.5;Gain=3
Gamma Runs: None

Run: 9 Time: 19:24:55 UTC
Alt: 2780 ft MSL Elev: 0 ft Elevation from DEM Database
Vel: 102 knots Heading: 39

Digitals: None
MSIC: 6
20191206192501850.jpg
20191206192508199.jpg
20191206192514564.jpg
20191206192520913.jpg
20191206192527262.jpg
20191206192533627.jpg
FTIR: 1
20191206_192459_A.igm
IRLS: 1
2019_12_06_19_25_00_R_09 TA=19.3;TB=39.3;Gain=3
Gamma Runs: None

Run: 10 Time: 19:30:24 UTC
Alt: 2887 ft MSL Elev: 7 ft Elevation from DEM Database
Vel: 99 knots Heading: 243

Digitals: None
MSIC: 3
20191206193031420.jpg
20191206193037769.jpg
20191206193044134.jpg
FTIR: 1
20191206_193027_A.igm

IRLS: 1
2019_12_06_19_30_29_R_10 TA=9.6;TB=31.0;Gain=3
Gamma Runs: None