Field Report for Airborne Data Collected In Support of US EPA Region VI TPC Fire 27 November 2019

Background

On 27 November 2019 an explosion and subsequent fire was reported at the TPC Group facility located near Port Neches, TX. Local information indicated that at approximately 0100 (local) a large explosion rocked the area. The explosion subsequently caused a massive fire at the facility in a short amount of time. Local official ordered a 1-mile evacuation order which as of 0800 on 287 November 2019 was still in effect. 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 VI requested that the ASPECT system be deployed to provide monitoring support on 27 November 2019 and ASPECT completed the first of a 11 passes at 0750 local. Two subsequent missions were flown throughout the day and this report summarizes findings observed during the various missions.

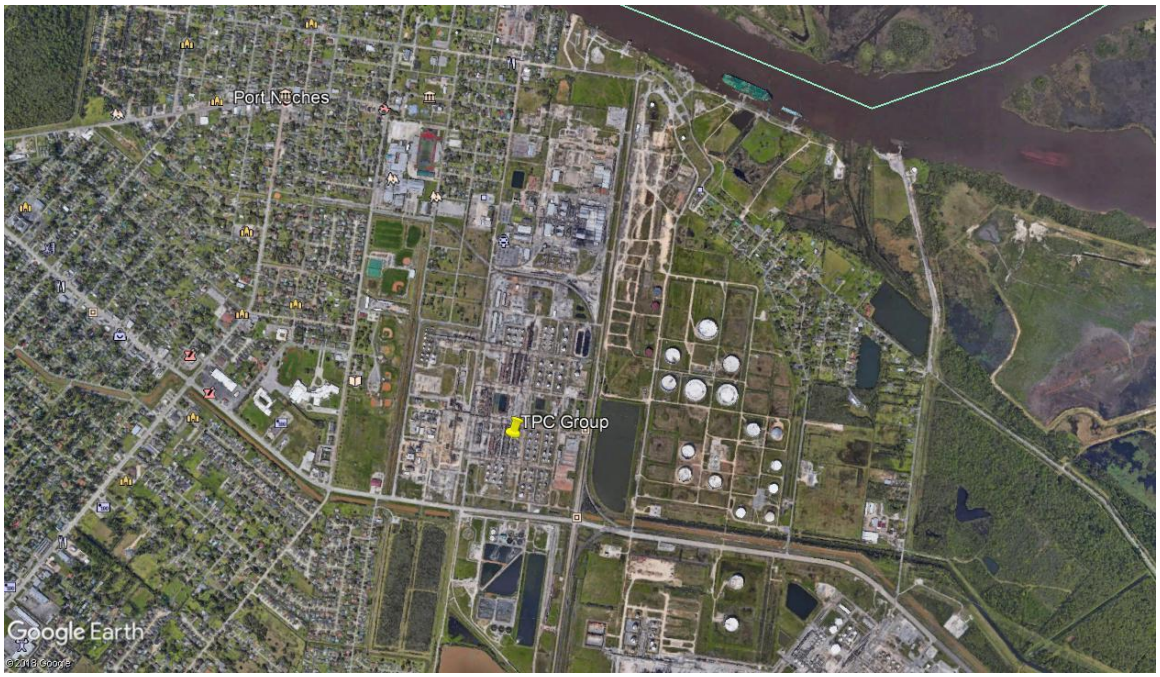

Figure 1: TPC Facility, Port Neches, TX

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

90126210

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 have the ability to 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 sufficient 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 at a later time.

All 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 1 -- 27 November 2019

Weather Conditions and Crew Report

Weather for the mission is given in table 1.

Table 1. TPC Group Mission Weather

Parameter	Surface (0700)	Surface (0800)	Surface (0900)	Surface (1000)
Wind direction	000 degrees	010 degrees	020 degrees	020 degrees
Wind speed	5.5 m/s (11 mph)	6.2 m/s (14 mph)	5.5 m/s (11 mph)	7 m/s (6 mph)
Temperature	18ºC	18ºC	17ºC	18ºC
Humidity	37%	35%	28%	28%
Dew Point	2.2ºC	2.2ºC	-1ºC	-1ºC
Pressure	1013 mb	1020	1020	1020
Ceiling	Clear	Clear	Clear	Clear

The crew reported that winds at altitude (2800 ft) were at about 17 kts (9 m/s) from the northeast. Smoke emitted from the fire was reported to be black in color and rose up to about 4000 ft with subsequent movement to the south.

Flight Status

The order to launch the aircraft was given at 0530 local on 27 November 2019 and the aircraft was airborne at 0635. The initial data collection run over the site was at 0750 (local) The aircraft made a total of 12 data collection passes; flight information is summarized in Appendix A 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.

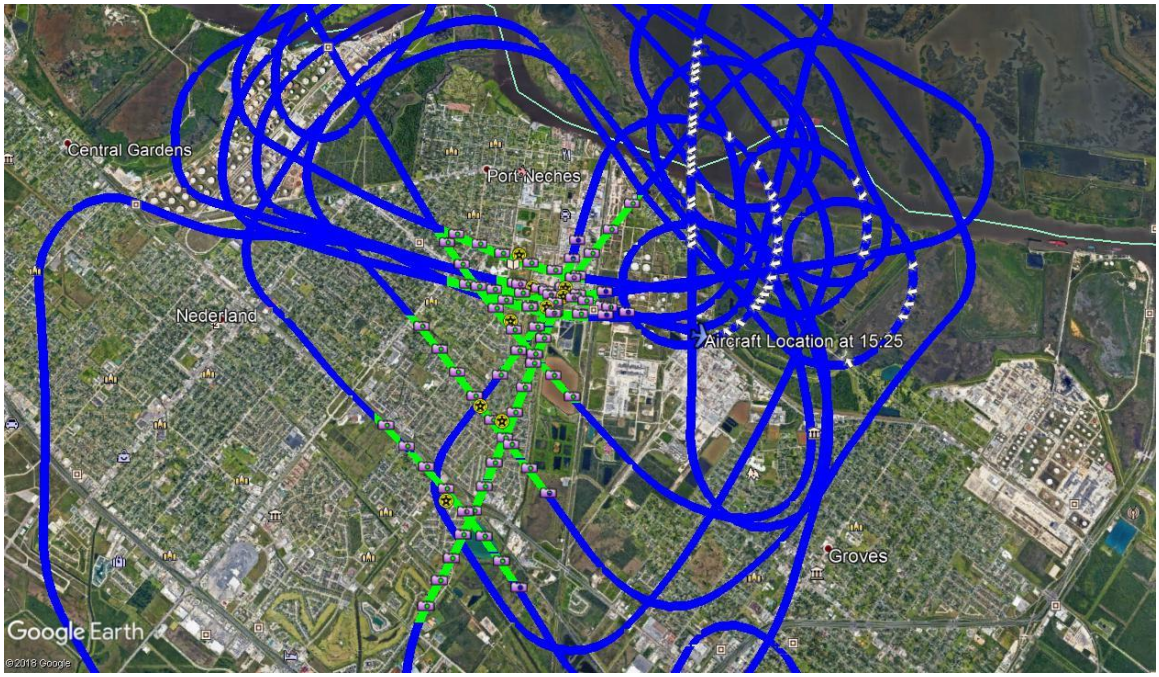

Figure 2: Data collection passes, TPC Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

Line Scanner Data Results

A total of 1 test and 11 data 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 2. This image was generated by flying approximately 100 meters downwind of the facility. The white area within the image is the hot signature of the fire. A thermal plume can be seen being emitted from the active fire location within the facility perimeter with no evidence of a chemical plume being generated by the fire.

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 and associated detection limits are 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.

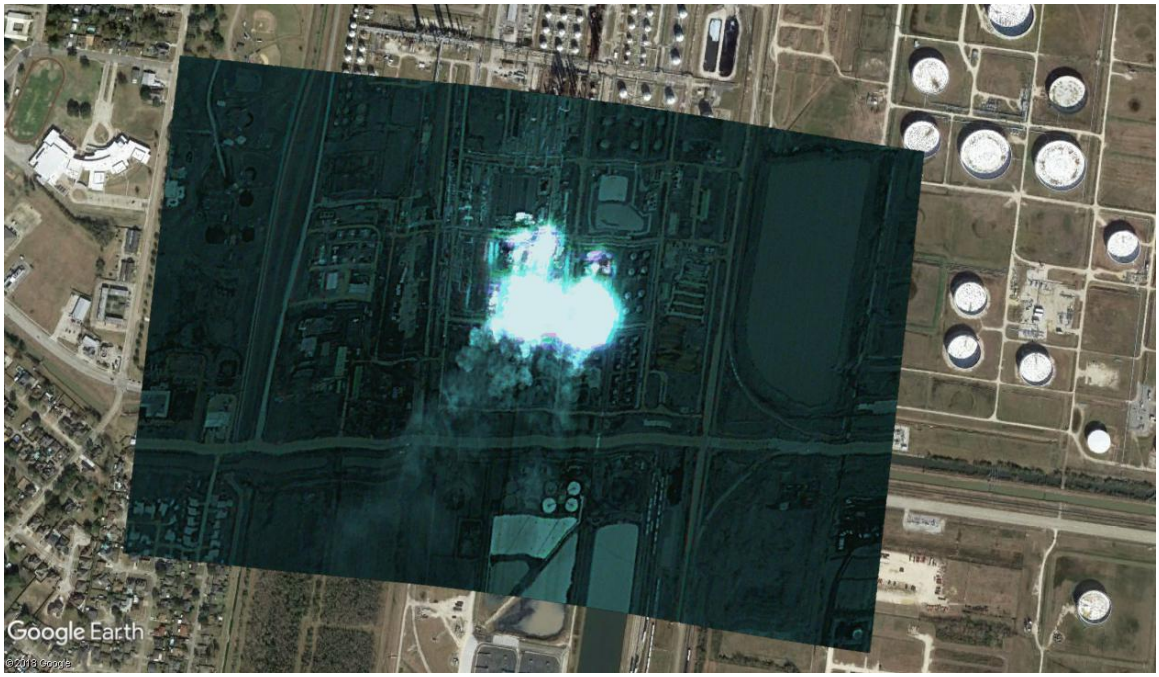

Figure 3: – 3 band IR image, Run 5, KMCO Fire, Pass 2

As illustrated in figure 2, ASPECT flew several passes over and downwind of the site. Analysis of both automated and manual analysis of the data showed no significant detections. A complication which may have influenced this was that the FTIR telescope was slightly ajar in the sensor mount. After flight was completed (during a fuel stop) the telescope was checked, and the mounts tightened.

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	27 Nov 2019	1347	Test	Test
2		1350	ND	None
3		1407	ND	None
4		1414	ND	None
5		1426	ND	None
6		1429	ND	None
7		1441	ND	None
8		1449	ND	None
9		1500	ND	None
10		1511	ND	None
11		1515	ND	None
12		1524	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 4 shows a representative image collected as part of each pass. The image illustrates that several fires are present in the field of view and the plume generated by the fire was moving to the south. Figure 5 shows a representative oblique collected from the copilot station. As with the aerial image, the frame shows multiple fires contributing to the generation of the smoke plume.

Conclusions – Flight 1

On 27 November 2019 ASPECT was dispatched to collect aerial remotes sensing data over the TCP Group facility located near Port Neches, TX. An explosion and fire involving a production unit and subsequent tank farms resulted in a black plume moving toward the south. Reports from the crew indicated that significant lofting was occurring with smoke reaching 4000 feet above ground. Collected spectral data did not show any chemical detections.

Figure 4: Aerial Image of the TCP Group Fire

Figure 5: Oblique Image of the TCP Group Fire

Flight 2 -- 27 November 2019

Weather Conditions and Crew Report

Weather for the mission is given in table 4.

Table 4. TPC Group Mission Weather – Flight 2

Parameter	Surface (1200)	Surface (1300)	Surface (1400)	
Wind direction	020 degrees	045 degrees	020 degrees	
Wind speed	5 m/s (11 mph)	6.2 m/s (14 mph)	6.2 m/s (14 mph)	
Temperature	19.5ºC	22ºC	22ºC	
Humidity	21%	24%	25%	
Dew Point	-1ºC	-1ºC	-1ºC	
Pressure	1020 mb	1020	1020	
Ceiling	Clear	Clear	Clear	

The crew reported that winds at altitude (2800 ft) were at about 23 kts (10 m/s) from the northeast. Smoke emitted from the fire was reported to be gray and less dense than on flight 1.

Flight Status

A second flight was conducted with the aircraft reporting wheels up at approximately 1145 local with the first data collected at 1209. The aircraft made two passes with flight information is summarized in Appendix A and Figure 6.

Data Results

Line Scanner Data Results

A total of 2 test and 2 data passes were made in the proximity of the fire and an infrared line scanner image was generated for each pass. In a similar fashion to data collected on flight 1, line scanner data continues to show a very hot environment due to the fires in the facility. An image is currently being uploaded and will be included in a revised report on the morning of 28 November 2019.

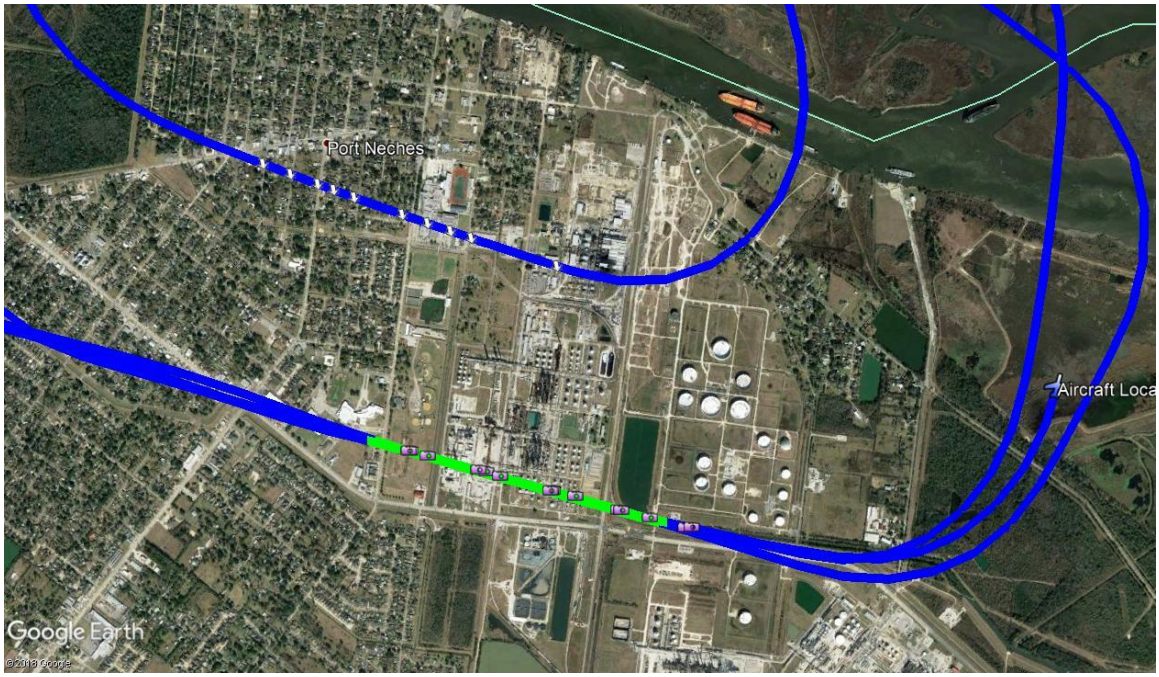

Figure 6: Data collection passes, TPC Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

IR Image in the process of being uploaded.

Figure 7: – 3 band IR image TPC Group Fire, Flight 2

FTIR Data Results

No chemical detections were made on flight 2. A summary of the data collection is given in table 5.

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 8 shows a representative image collected as part of each pass. The image illustrates that several fires continue to burn in the area, but the intensity of the smoke appears to be somewhat diminished. Figure 9 shows confirms that several fires are present with some indication that the number of individual fires has expanded.

Table 5. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	27 Nov 2019	1741	Test	Test
2		1751	ND	None
3		1804	ND	None
4		1825	ND	None
Note: ND = No Detections				

Figure 8: Aerial Image of the TCP Group Fire, Flight 2

Figure 9: Oblique Image of the TCP Group Fire, Flight 2

Conclusions for Flight 2

Data collected on flight two of the TCP Group fire continued to show a very hot fire with significant black emissions being liberated from the site. Analysis of both IR imagery and Spectral data did not show the presence of chemical leaving the facility.

Flight 3 -- 27 November 2019

Weather Conditions and Crew Report

Weather for the mission is given in table 6.

Table 6. TPC Group Mission Weather – Flight 3

Parameter	Surface (1600)	Surface (1700)		
Wind direction	000 degrees	045 degrees		
Wind speed	5.8 m/s (13 mph)	5 m/s (11 mph)		
Temperature	22.5ºC	22ºC		
Humidity	30%	32%		
Dew Point	2.7ºC	2.7ºC		
Pressure	1020 mb	1020		
Ceiling	Overcast	Overcast		

The crew reported that winds at altitude (2800 ft) were at about 25 kts (10 m/s) from the northeast. Smoke emitted from the fire was reported to be gray, less dense than flight 2 and was staying closer to the ground.

Flight Status

The third flight conducted on 27 November 2019 initiated at 1417 with the first of three data passes conducted over the facility. Flight information is summarized in Appendix A and Figure 10.

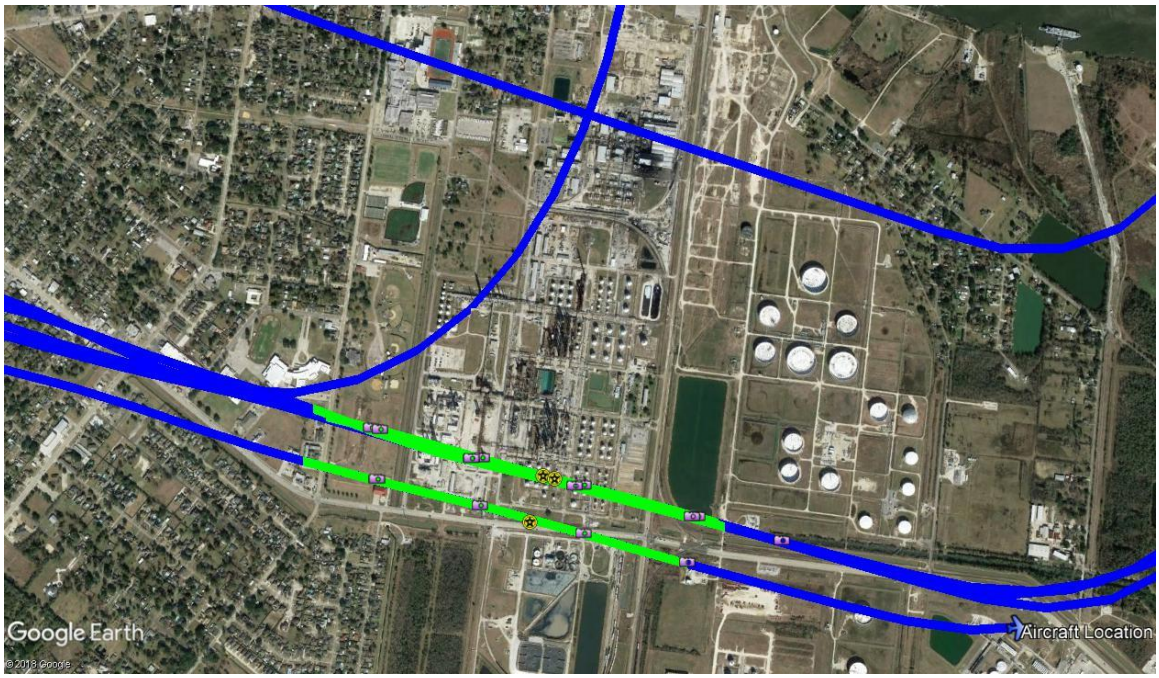

Figure 10: Data collection passes, TPC Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was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

Data Results

Line Scanner Data Results

A total of 4 test and 3 data passes were made in the proximity of the fire and an infrared line scanner image was generated for each pass. Analysis of IR imagery generally shows consistency from early flights namely very intense heat within the field of view (figure 11).

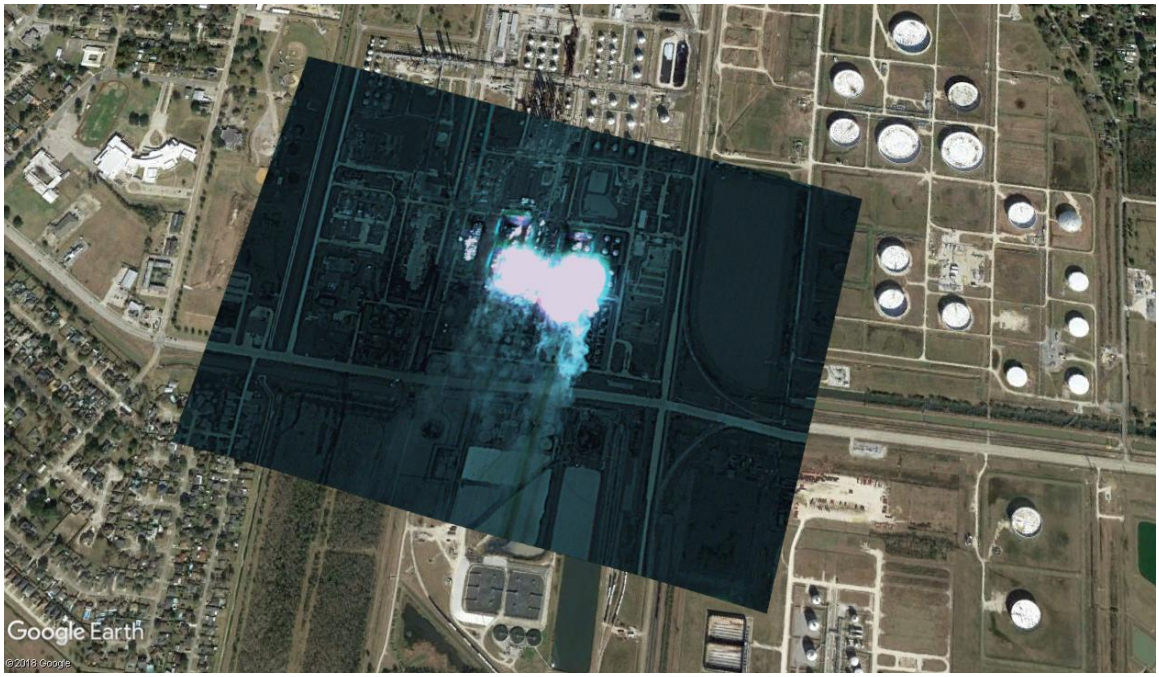

Figure 11: – 3 band IR image, TPC Group fire, Flight 3, Run 6

FTIR Data Results

Prior to the launch of flight 3, an adjustment was made to the FTIR to maximize the amount of radiant energy admitted to the system. Even after this adjustment, no significant chemical detections were made on any of the data collection passes. A summary the data collection is given in table 7.

Table 7. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	27 Nov 2019	2226	Test	Test
2		2227	Test	Test
3		2231	Test	Test
4		2232	Test	Test
5		2239	ND	None
6		2249	ND	None
7		2306	ND	None
Note: ND = No Detections				

Aerial Photography Results

A partial set of high resolution aerial digital photography were collected on the last flight of the day with a representative image given in figure 12. It should be noted that the image is slightly blurring due to the long exposure time needed to collect the image under low light conditions. The image shows that fires continue to burn with no apparent spreading in structures or tanks. Due to the time of day and lack of enough light, oblique images were not collected on this flight.

Figure 12: Aerial Image of the TCP Group Fire, Flight 3

Conclusions for Flight 3

Data collected on the final flight of the day showed no significant change from flight 2. IR imagery continued to show the presence of a large intense region with spectral analysis showing no chemical detections.

Appendix A

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: 2019-11-27 Port Neches

Date: 11/27/2019

Time UTC: 13:18

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: 13:47:33 UTC

Alt: 2944 ft MSL Elev: 135 ft Elevation from DEM Database

Vel: 119 knots Heading: 134

Digitals: None

MSIC: 3

20191127134739480.jpg

20191127134745828.jpg

20191127134752193.jpg

FTIR: 1

20191127_134736_A.igm

IRLS: 1

2019_11_27_13_47_38_R_01 TA=15.0;TB=35.0;Gain=3

Gamma Runs: None

Run: 2 Time: 13:50:49 UTC

Alt: 2858 ft MSL Elev: 100 ft Elevation from DEM Database

Vel: 119 knots Heading: 129

Digitals: None

MSIC: 3

20191127135055580.jpg

20191127135101929.jpg

20191127135108293.jpg

FTIR: 1

20191127_135052_A.igm

IRLS: 1

2019_11_27_13_50_54_R_02 TA=8.1;TB=23.4;Gain=3

Gamma Runs: None

Run: 3 Time: 14:07:03 UTC

Alt: 2819 ft MSL Elev: 7 ft Elevation from DEM Database

Vel: 107 knots Heading: 131

Digitals: None

MSIC: 8

20191127140709741.jpg

20191127140716090.jpg

20191127140722439.jpg

20191127140728804.jpg

20191127140735153.jpg

20191127140742422.jpg

20191127140748771.jpg

20191127140755121.jpg

FTIR: 2

20191127_140707_A.igm

20191127_140746_A.igm

IRLS: 1

2019_11_27_14_07_08_R_03 TA=3.1;TB=21.5;Gain=3

Gamma Runs: None

Run: 4 Time: 14:14:47 UTC

Alt: 2825 ft MSL Elev: 4 ft Elevation from DEM Database

Vel: 112 knots Heading: 132

Digitals: None

MSIC: 8

20191127141454577.jpg

20191127141500926.jpg

20191127141507275.jpg

20191127141513640.jpg

20191127141519989.jpg

20191127141526354.jpg

20191127141532703.jpg

20191127141539052.jpg

FTIR: 2

20191127_141452_A.igm

20191127_141531_A.igm

IRLS: 1

2019_11_27_14_14_53_R_04 TA=6.8;TB=26.9;Gain=3

Gamma Runs: None

Run: 5 Time: 14:23:36 UTC

Alt: 2824 ft MSL Elev: 2 ft Elevation from DEM Database

Vel: 109 knots Heading: 130

Digitals: None

MSIC: 8

20191127142342954.jpg

20191127142349319.jpg

20191127142355668.jpg

20191127142402033.jpg

20191127142408382.jpg

20191127142414731.jpg

20191127142421096.jpg

20191127142427445.jpg

FTIR: 2

20191127_142339_A.igm

20191127_142419_A.igm

IRLS: 1

2019_11_27_14_23_41_R_05 TA=6.0;TB=26.0;Gain=3

Gamma Runs: None

Run: 6 Time: 14:29:09 UTC

Alt: 2908 ft MSL Elev: 2 ft Elevation from DEM Database

Vel: 96 knots Heading: 23

Digitals: None

MSIC: 16

20191127142915244.jpg

20191127142922513.jpg

20191127142928863.jpg

20191127142935227.jpg

20191127142941576.jpg

20191127142947925.jpg

20191127142954290.jpg

20191127143000639.jpg

20191127143007004.jpg

20191127143013353.jpg

20191127143019702.jpg

20191127143026067.jpg

20191127143032416.jpg

20191127143038780.jpg

20191127143046034.jpg

20191127143050574.jpg

FTIR: 3

20191127_142912_A.igm

20191127_142951_A.igm

20191127_143029_A.igm

IRLS: 1

2019_11_27_14_29_14_R_06 TA=6.7;TB=26.6;Gain=3

Gamma Runs: None

Run: 7 Time: 14:41:02 UTC

Alt: 2787 ft MSL Elev: 7 ft Elevation from DEM Database

Vel: 97 knots Heading: 87

Digitals: None

MSIC: 5

20191127144107937.jpg

20191127144114301.jpg

20191127144120650.jpg

20191127144127000.jpg

20191127144133364.jpg

FTIR: 1

20191127_144104_A.igm

IRLS: 1

2019_11_27_14_41_07_R_07 TA=6.7;TB=26.7;Gain=3

Gamma Runs: None

Run: 8 Time: 14:49:08 UTC

Alt: 2808 ft MSL Elev: 9 ft Elevation from DEM Database

Vel: 95 knots Heading: 96

Digitals: None

MSIC: 6

20191127144914578.jpg

20191127144920927.jpg

20191127144927276.jpg

20191127144934546.jpg

20191127144940895.jpg

20191127144947259.jpg

FTIR: 1

20191127_144912_A.igm

IRLS: 1

2019_11_27_14_49_13_R_08 TA=7.0;TB=27.0;Gain=3

Gamma Runs: None

Run: 9 Time: 15:00:18 UTC

Alt: 2860 ft MSL Elev: 8 ft Elevation from DEM Database

Vel: 93 knots Heading: 95

Digitals: None

MSIC: 6

20191127150024589.jpg

20191127150030954.jpg

20191127150037303.jpg

20191127150043668.jpg

20191127150050017.jpg

20191127150054556.jpg

FTIR: 1

20191127_150021_A.igm

IRLS: 1

2019_11_27_15_00_23_R_09 TA=7.9;TB=27.9;Gain=3

Gamma Runs: None

Run: 10 Time: 15:11:59 UTC

Alt: 2838 ft MSL Elev: 8 ft Elevation from DEM Database

Vel: 104 knots Heading: 82

Digitals: None

MSIC: 6

20191127151205490.jpg

20191127151211855.jpg

20191127151218204.jpg

20191127151224553.jpg

20191127151230918.jpg

20191127151237267.jpg

FTIR: 1

20191127_151201_A.igm

IRLS: 1

2019_11_27_15_12_04_R_10 TA=7.7;TB=27.7;Gain=3

Gamma Runs: None

Run: 11 Time: 15:15:55 UTC

Alt: 2866 ft MSL Elev: 6 ft Elevation from DEM Database

Vel: 116 knots Heading: 215

Digitals: None

MSIC: 8

20191127151600643.jpg

20191127151607897.jpg

20191127151614262.jpg

20191127151620611.jpg

20191127151626960.jpg

20191127151633325.jpg

20191127151639674.jpg

20191127151646039.jpg

FTIR: 2

20191127_151559_A.igm

20191127_151638_A.igm

IRLS: 1

2019_11_27_15_16_00_R_11 TA=8.9;TB=28.9;Gain=3

Gamma Runs: None

Run: 12 Time: 15:24:38 UTC

Alt: 2837 ft MSL Elev: 8 ft Elevation from DEM Database

Vel: 102 knots Heading: 95

Digitals: None

MSIC: 4

20191127152444489.jpg

20191127152450854.jpg

20191127152457203.jpg

20191127152504472.jpg

FTIR: 1

20191127_152440_A.igm

IRLS: 1

2019_11_27_15_24_44_R_12 TA=8.7;TB=28.7;Gain=3

Gamma Runs: None

Mission Complete: 15:37 (UTC)

****

Flight 2

Mission: 2019-11-27 Port Neches 2

Date: 11/27/2019
Time UTC: 17:33

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: 17:41:45 UTC
    Alt: 2792 ft MSL Elev: 21 ft Elevation from DEM Database
    Vel: 110 knots Heading: 182

Digitals: None
MSIC: 3
    20191127174151801.jpg
    20191127174158153.jpg
    20191127174205425.jpg
FTIR: 1
    20191127_174153_A.igm
IRLS: 1
    2019_11_27_17_41_50_R_01 TA=16.0;TB=36.0;Gain=3
Gamma Runs: None

Run: 2 Time: 17:51:34 UTC
    Alt: 2823 ft MSL Elev: 8 ft Elevation from DEM Database
    Vel: 112 knots Heading: 99

Digitals: None
MSIC: 5
    20191127175141214.jpg
    20191127175147566.jpg
    20191127175153932.jpg
    20191127175200285.jpg
    20191127175204826.jpg
FTIR: 1
    20191127_175139_A.igm
IRLS: 1
    2019_11_27_17_51_39_R_02 TA=11.2;TB=31.2;Gain=3
Gamma Runs: None

Run: 3 Time: 18:04:00 UTC
    Alt: 2768 ft MSL Elev: 8 ft Elevation from DEM Database
    Vel: 98 knots Heading: 100

Digitals: None
MSIC: 5
    20191127180405900.jpg
    20191127180412251.jpg
    20191127180418602.jpg
    20191127180424969.jpg
    20191127180431319.jpg
FTIR: 1
    20191127_180404_A.igm
IRLS: 1
    2019_11_27_18_04_04_R_03 TA=14.5;TB=34.5;Gain=3
Gamma Runs: None

Run: 4 Time: 18:25:49 UTC
    Alt: 2785 ft MSL Elev: 12 ft Elevation from DEM Database
    Vel: 89 knots Heading: 92

Digitals: None
MSIC: 3
    20191127182555390.jpg
    20191127182602646.jpg
    20191127182609012.jpg
FTIR: 1
    20191127_182553_A.igm

IRLS: 1
2019_11_27_18_25_53_R_04 TA=14.9;TB=34.9;Gain=3
Gamma Runs: None

****

Mission: 2019-11-27 Port Neches 3

Date: 11/27/2019
Time UTC: 22:17

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: 22:26:11 UTC
Alt: 2774 ft MSL Elev: 11 ft Elevation from DEM Database
Vel: 115 knots Heading: 240

Digitals: None
MSIC: 3
20191127222617147.jpg
20191127222624416.jpg
20191127222630765.jpg
FTIR: 1
20191127_222614_A.igm
IRLS: 1
2019_11_27_22_26_15_R_01 TA=17.0;TB=37.0;Gain=3
Gamma Runs: None

Run: 2 Time: 22:27:46 UTC
Alt: 2805 ft MSL Elev: 11 ft Elevation from DEM Database
Vel: 107 knots Heading: 225

Digitals: None
MSIC: 3
20191127222753383.jpg
20191127222759747.jpg

20191127222806096.jpg
FTIR: 1
20191127_222750_A.igm
IRLS: 1
2019_11_27_22_27_51_R_02 TA=14.9;TB=33.8;Gain=3
Gamma Runs: None

Run: 3 Time: 22:31:04 UTC
Alt: 2803 ft MSL Elev: 0 ft Elevation from DEM Database
Vel: 142 knots Heading: 221

Digitals: None
MSIC: 3
20191127223110394.jpg
20191127223116758.jpg
20191127223123108.jpg
FTIR: 1
20191127_223108_A.igm
IRLS: 1
2019_11_27_22_31_08_R_03 TA=10.1;TB=30.0;Gain=3
Gamma Runs: None

Run: 4 Time: 22:32:49 UTC
Alt: 2818 ft MSL Elev: 7 ft Elevation from DEM Database
Vel: 109 knots Heading: 123

Digitals: None
MSIC: 3
20191127223255709.jpg
20191127223302073.jpg
20191127223308423.jpg
FTIR: 1
20191127_223254_A.igm
IRLS: 1
2019_11_27_22_32_53_R_04 TA=8.9;TB=28.3;Gain=3
Gamma Runs: None

Run: 5 Time: 22:39:56 UTC
Alt: 2774 ft MSL Elev: 8 ft Elevation from DEM Database
Vel: 107 knots Heading: 101

Digitals: None
MSIC: 4
    20191127224002428.jpg
    20191127224008777.jpg
    20191127224015142.jpg
    20191127224022396.jpg
FTIR: 1
    20191127_223959_A.igm
IRLS: 1
    2019_11_27_22_40_00_R_05 TA=9.7;TB=29.7;Gain=3
Gamma Runs: None

Run: 6 Time: 22:49:13 UTC
    Alt: 2816 ft MSL Elev: 8 ft Elevation from DEM Database
    Vel: 106 knots Heading: 102

Digitals: None
MSIC: 5
    20191127224919878.jpg
    20191127224926237.jpg
    20191127224932586.jpg
    20191127224939855.jpg
    20191127224945300.jpg
FTIR: 1
    20191127_224917_A.igm
IRLS: 1
    2019_11_27_22_49_18_R_06 TA=9.4;TB=29.4;Gain=3
Gamma Runs: None

Run: 7 Time: 23:06:35 UTC
    Alt: 2800 ft MSL Elev: 8 ft Elevation from DEM Database
    Vel: 108 knots Heading: 102

Digitals: None
MSIC: 4
    20191127230642143.jpg
    20191127230648507.jpg
    20191127230654856.jpg
    20191127230701206.jpg
FTIR: 1
    20191127_230638_A.igm

IRLS: 1

2019_11_27_23_06_39_R_07 TA=9.4;TB=29.4;Gain=3

Gamma Runs: None