Field Report for Airborne Data Collected In Support of US EPA Region VI International Terminal Corporation Fire 18 March 2019

Background

On 17 April 2019 a large fire was reported at the International Terminal Corporation located in Deer Park, TX. Local reports indicate that the fire started at about 1030 local in an 80,000 barrel (capacity) tank storing naphtha. The International Terminal Corporation facility is located on the southern shore of the Houston ship channel in the City of Deer Park, TX. The geographical coordinates of the facility are 19.7322N, 95.1236W (figure 1).

The material reported in the fire is Naphtha. Naphtha is generally composed of either the first or second sequence of distillate obtained during primary distillation. Light naphtha is composed of light fraction straight chain and simple aromatics, typically less than 6 carbons while heavy naphtha consist of larger compounds (C6 plus) which normally is used as feed for catalytic cracking. Since the fraction of Naphtha is crude dependent, there is not a simple formula for the material.

The US EPA Region VI requested that the ASPECT system be deployed to provide monitoring support on 17 March 2019 and ASPECT completed a 7 pass mission at 1847 local. Acetone was detected on the first 2 passes (data collection 3 and 4) which were near the fire at a concentration estimated below 1 ppm (0.154 ppm and 0.357 ppm, respectively). No other compounds were detected.

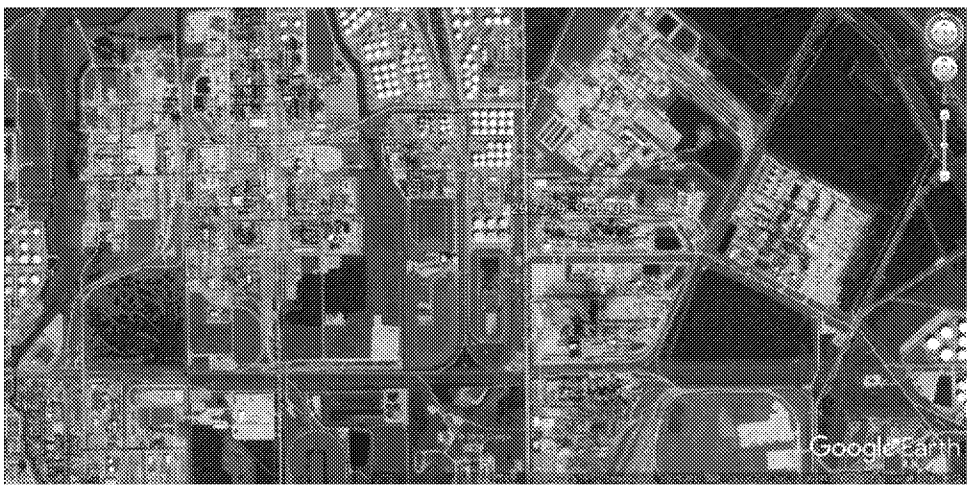

Figure 1: International Terminal Corporation, Deer Park, TX

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

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 reachback 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 reachback team for QA/QC analysis. Upon landing preliminary data results are examined and validated by the reachback team.

Weather Conditions and Crew Report

Weather for the mission is given in table 1.

Table 1. International Terminal Corporation Fire Mission Weather

Parameter	Surface (1400)
Wind direction	090 degrees
Wind speed	1 m/s (1.5 kts)
Temperature	21°C
Humidity	38%
Dew Point	3.3°C
Pressure	1022 mb
Ceiling	Not Reported

The crew reported that winds at altitude (2800 ft) are at about 15 kts (7 m/s) from the east. Smoke emitted from the fire was reported to be gray to black in color and was visible 30 miles from the facility. The plume was rising into a zone with the floor of the layer being about 2000 feet above ground and the plume top at 6500 feet above ground. Plume motion was to the west.

Flight Status

The order to launch the aircraft was given at 1000 local on 18 March 2019 and the aircraft was airborne at 1055. The initial data collection run over the site was at 1252 (local) The aircraft made a total of seven data collection passes; flight information is summarized in Appendix A and Figure 2.

Figure 2: Data collection passes, International Terminal Corporation Fire, Deer Park, TX. The blue lines represent the ASPECT flight path, green lines represent when the Infrared Line Scanner was actively collecting data, and the camera icons represent when a photo was taken.

Data Results Flight 2 18 March 2019

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 7 data passes were made in the proximity of the site and an infrared line scanner images were generated for each pass. Figure 3 shows a typical 3-band infrared image obtained from data collected for Run 5. The image clearly shows that the fire is very intensive and is not only generating a hot target (as white) but is also producing an extended plume of hot air as the plume moves to the west. An examination of the area to the west shows almost total obscuration most likely due to particulate loading of the plume and to a certain extent thermal masking of the surface signal.

Figure 4 shows a comparison of IR data collected on 17 March 2019 (left) and 18 March 2019 (right). The size of the saturated hot thermal area (as indicated as solid white) for the 18 March 2019 image is several times that of the 17 March 2019 data. This is

consistent with the fact that only 1 tank was burning on the 17th but six tanks appear to be burning during this mission.

Figure 3: – 3 band IR image, Run 5, International Terminal Corporation Fire, Flt 2

Figure 4: 3 band IR images, Comparison of 17 and 18 March Data. 17 March 2019 is on the left, 18 March 2019 is on the right.

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.

Spectral examination of the fire showed more detections than on the afternoon/evening of 17 March 2019. Figure 5 shows the where individual compounds were detected in relationship to the fire. Most of the compounds detected were made on the northern side of the fire. Compound detections east of the fire are most likely native compounds present in the urban air.

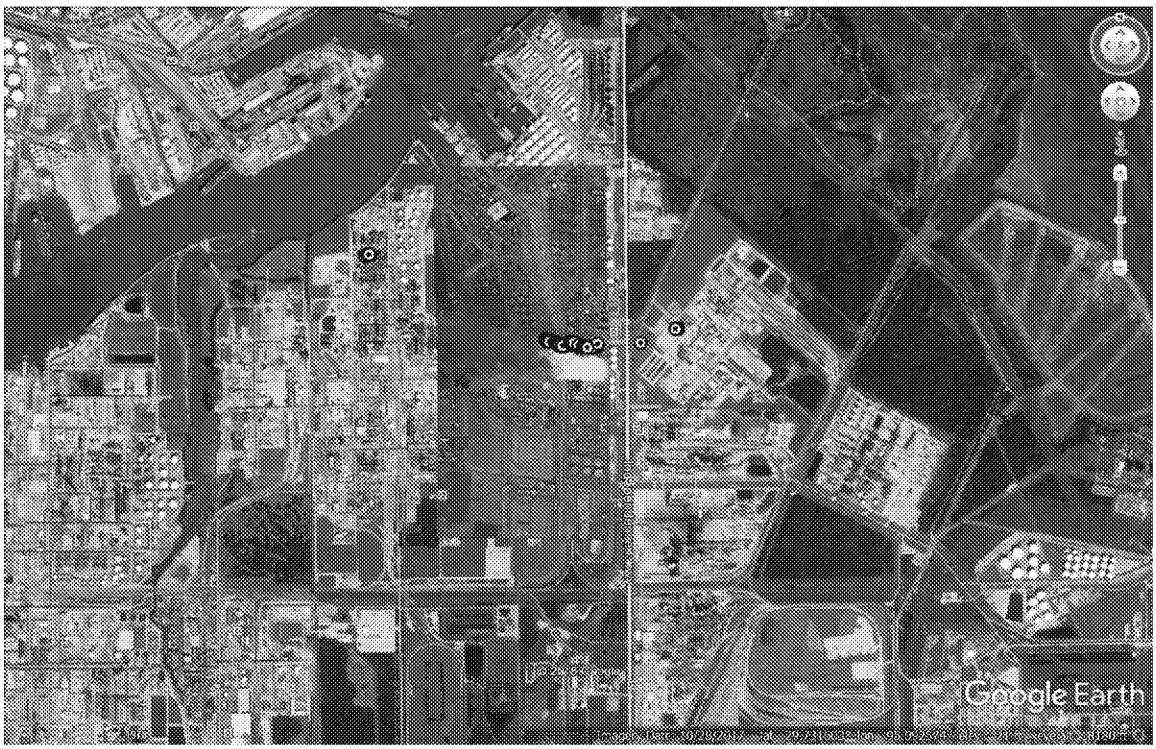

Figure 5: Chemical detections as denoted by dots on the image.

Table 3 list the compounds detected and the maximum concentration estimated from the FTIR data. These detections are very low with the highest being just above 1 ppm. It should be noted that based on the plume structure and height, it is probable that most/all of the detected compounds near and/or generated by the fire are several hundred meters in altitude.

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	18April 2019	1752	Test	Test
2		1816	None	None
3		1821	None	None
4		1826	1-Butene 1-Butene Acetone Isoprene	0.428 0.625 0.1 2.96
5		1831	None	None
6		1835	None	None
7		1839	Acetone	0.133
8		1849	None	None
9		1851	1-Butene 2-Butene Acetone Isoprene	0.377 0.828 0.643 1.04
9A		1851A	1-Butene Isoprene	0.402 0.080

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 6 shows a representative image collected as part of each pass. As discussed in the IRLS Figure 7 shows a representative oblique collected from the copilot station. This image clearly shows the presence of fire in the center tank with additional fire surrounding the tank. The fire is generating a large amount of smoke which is rising nearly vertical. The low light conditions of the image are a result of the plume shading the area as the aircraft passed over the site.

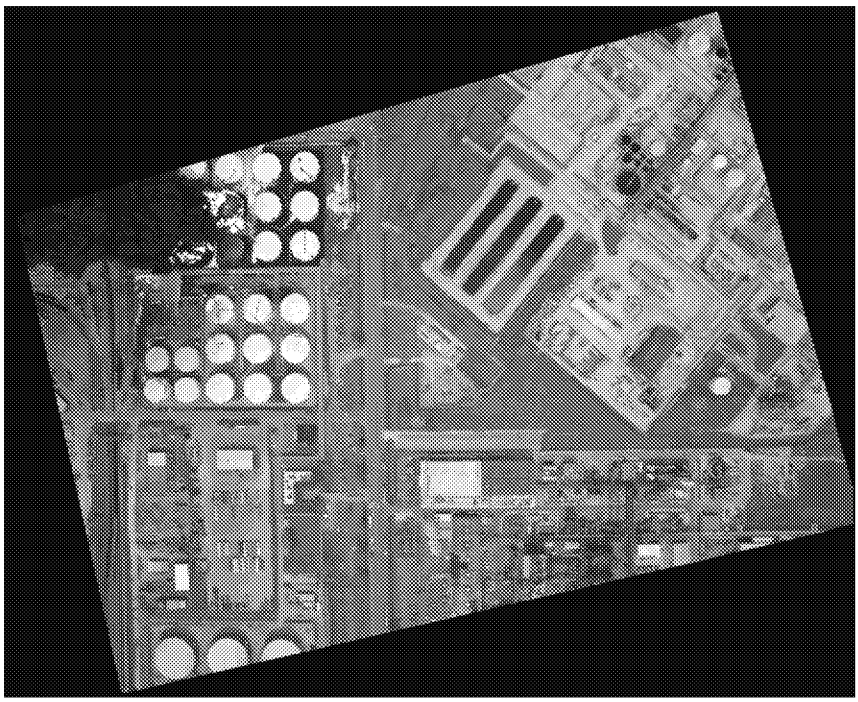

Figure 6: Aerial Image of the International Terminal Corporation Fire, Flt 2

Figure 7: Oblique Image of the International Terminal Corporation Fire, Flt 2

Conclusions

ASPECT conducted a second flight over the International Terminal Corporation fire on 18 March 2019. Analysis of IR data confirms that multiple tanks are currently

involved in the fire. The thermal signature of the fire and resulting heated air plume is much larger in area. Crew reports indicated that the plume continues to rise to several thousand feet occupying a region between 2000 and 6500 feet above ground with movement to the west. Spectral analysis of FTIR data indicated that compounds including 1-butene, 2-butene, isoprene, and acetone were detected primarily in a downwind portion of the plume. Some isolated detection was made upwind of the fire suggesting that some of these compounds exist in the urban air of the region. Estimated concentrations of these compounds tend to be low with the highest values being just above 1 ppm.

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: 2019-03-18 Houston Refinery Fire

Date: 3/18/2019

Time UTC: 17:42

Aircraft Number: N9738B

Pilot: James Glaviano

Copilot: Beorn Ledger

Operator: James Crisp

Aft Operator: Steve Brister

Ground Controller: Tim Curry

DEM: Using elevation from DEM Database

Run: 1 Time: 17:52:30 UTC

Alt: 2958 ft MSL Elev: 361 ft Elevation from DEM Database

Vel: 149 knots Heading: 131

Digitals: None

MSIC: 3

20190318175236660.jpg

20190318175243009.jpg

20190318175249373.jpg

FTIR: 1

20190318_175233_A.igm

IRLS: 1

2019_03_18_17_52_34_R_01 TA=13.0;TB=33.0;Gain=3

Gamma Runs: None

Run: 2 Time: 18:16:56 UTC

Alt: 2880 ft MSL Elev: 15 ft Elevation from DEM Database

Vel: 130 knots Heading: 175

Digitals: None

MSIC: 6

20190318181702875.jpg

20190318181709224.jpg

20190318181715588.jpg

20190318181721937.jpg

20190318181728286.jpg

20190318181730112.jpg

FTIR: 1

20190318_181659_A.igm

IRLS: 1

2019_03_18_18_17_00_R_02 TA=13.0;TB=33.0;Gain=3

Gamma Runs: None

Run: 3 Time: 18:21:35 UTC

Alt: 2811 ft MSL Elev: 15 ft Elevation from DEM Database

Vel: 109 knots Heading: 176

Digitals: None

MSIC: 5

20190318182141592.jpg

20190318182147941.jpg

20190318182154306.jpg

20190318182200655.jpg

20190318182207019.jpg

FTIR: 1

20190318_182138_A.igm

IRLS: 1

2019_03_18_18_21_39_R_03 TA=13.3;TB=33.3;Gain=3

Gamma Runs: None

Run: 4 Time: 18:26:40 UTC

Alt: 3267 ft MSL Elev: 11 ft Elevation from DEM Database

Vel: 117 knots Heading: 178

Digitals: None

MSIC: 6

20190318182645737.jpg

20190318182652992.jpg

20190318182659357.jpg

20190318182705706.jpg

20190318182712055.jpg

20190318182718420.jpg

FTIR: 1

20190318_182643_A.igm

IRLS: 1

2019_03_18_18_26_44_R_04 TA=11.1;TB=31.1;Gain=3

Gamma Runs: None

Run: 5 Time: 18:31:09 UTC

Alt: 2861 ft MSL Elev: 21 ft Elevation from DEM Database

Vel: 130 knots Heading: 170

Digitals: None

MSIC: 6

20190318183115378.jpg

20190318183121727.jpg

20190318183128091.jpg

20190318183134440.jpg

20190318183140789.jpg

20190318183147154.jpg

FTIR: 1

20190318_183113_A.igm

IRLS: 1

2019_03_18_18_31_13_R_05 TA=11.1;TB=31.1;Gain=3

Gamma Runs: None

Run: 6 Time: 18:35:12 UTC

Alt: 2772 ft MSL Elev: 19 ft Elevation from DEM Database

Vel: 116 knots Heading: 167

Digitals: None

MSIC: 5

20190318183517780.jpg

20190318183524129.jpg

20190318183531398.jpg

20190318183537747.jpg

20190318183542287.jpg

FTIR: 1

20190318_183515_A.igm

IRLS: 1

2019_03_18_18_35_16_R_06 TA=16.7;TB=36.7;Gain=3

Gamma Runs: None

Run: 7 Time: 18:39:30 UTC

Alt: 2917 ft MSL Elev: 18 ft Elevation from DEM Database

Vel: 109 knots Heading: 168

Digitals: None

MSIC: 4

20190318183936532.jpg

20190318183942881.jpg

20190318183949230.jpg

20190318183955594.jpg

FTIR: 1

20190318_183933_A.igm

IRLS: 1

2019_03_18_18_39_35_R_07 TA=16.6;TB=36.6;Gain=3

Gamma Runs: None

Run: 8 Time: 18:49:11 UTC

Alt: 6493 ft MSL Elev: 7 ft Elevation from DEM Database

Vel: 110 knots Heading: 90

Digitals: None

MSIC: 27

20190318184917574.jpg

20190318184923923.jpg

20190318184930287.jpg

20190318184936636.jpg

20190318184943001.jpg

20190318184949350.jpg

20190318184955699.jpg

20190318185002064.jpg

20190318185008413.jpg

20190318185014778.jpg

20190318185022032.jpg

20190318185028396.jpg

20190318185034745.jpg

20190318185041094.jpg

20190318185047459.jpg

20190318185053808.jpg

20190318185100157.jpg

20190318185106522.jpg

20190318185112871.jpg

20190318185119236.jpg

20190318185125585.jpg

20190318185131949.jpg

20190318185138299.jpg

20190318185144648.jpg

20190318185151917.jpg

20190318185158266.jpg

20190318185204631.jpg

FTIR: 5

20190318_184914_A.igm

20190318_184953_A.igm

20190318_185032_A.igm

20190318_185112_A.igm

20190318_185152_A.igm

IRLS: 1

2019_03_18_18_49_15_R_08 TA=16.6;TB=36.6;Gain=3

Gamma Runs: None

Mission Complete: 19:27 (UTC)