Field Report for Airborne Data Collected In Support of US EPA Region 6 Intercontinental Terminals Company LLC Fire 23 March 2019

Background

On 17 March 2019 a large fire was reported at the Intercontinental Terminals Company LLC (ITC) 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 ITC 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 6 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.

ASPECT conducted a second flight over the facility on 18 March 2019. Analysis of IR data confirmed reports that the fire had expanded to multiple tanks. Specifically, the thermal signature of the fire and resulting heated air plume was measurably larger than that observed in the first flight. Crew reports indicated that the plume rise was still active with the lofted plume 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 with the highest values being just above 1 ppm.

ASPECT conducted a third flight over the ITC fire on 19 March 2019. Analysis of data indicated that the fire had grown as evident by the larger thermal signature and direct confirmation from aerial images. Plume geometry was assessed with the aircraft with findings showing the plume was about 47 miles in length, 17 miles wide at the largest extent and ranged in altitude from a floor of 1500 feet to a ceiling of 5000 feet. No chemical detections were reported on this flight.

ASPECT conducted a fourth flight over the ITC fire on 20 March 2019. Analysis of data indicated that the fire had been extinguished. Analysis of FTIR data showed detections of acetone and SO_2 to west of the farm and isobutylene and isoprene south of the farm. All concentrations were detected below 1 ppm.

Due to reports of vapors observed in the Deer Park vicinity ASPECT was requested to fly a fifth mission on 21 March 2019 near the impacted tank farm, and locations in Deer Park, La Porte, Galena Park and Jacinto City. Analysis of data showed normal temperatures within the farm and low levels of typical compounds within the urban atmosphere. Detected compounds included acetone and isobutylene at concentrations at or below 1 ppm.

ASPECT conducted a series of flight on 22 March 2019 with the focus being a possible breach of the tank farm secondary containment structure, discharge of foam and other material from the tank farm migrating into the ship channel and investigation of a re-ignition of a fire in the tank farm. IR results clearly showed the presence of material migrating into the ship channel and the presence of hot spots within the tank farm (corresponding to the fire). Detected compounds included acetone, 1, 3-butadiene, 1-butene, isobutylene and isoprene. Compounds detected in the general vacuity had concentrations less than 0.5 ppm while detections north of the tank farm during the fire showed levels less than 2 ppm.

ASPECT was dispatched on 23 March 2019 to fly a general data collection mission over the tank farm, at the confluence boom area on the ship channel and in a residential area northwest of the general area. This report summaries those measurements.

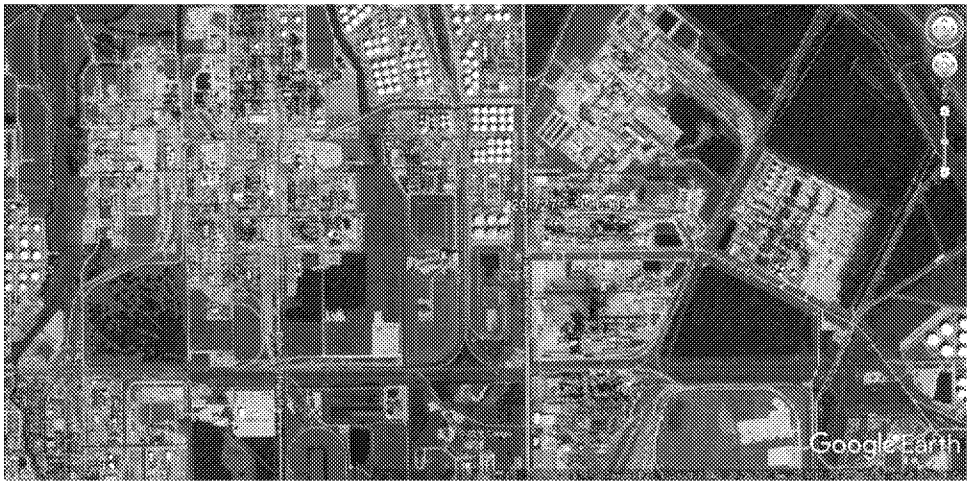

Figure 1: ITC, Deer Park, TX

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.

Data Results Flight 10, 23 March 2019

Weather Conditions and Crew Report

Weather for the mission is given in table 1. The crew reported that winds at flight level (2800 ft) were generally from the southeast about 12 kts (6 m/s). Turbulence was moderate. No significant ground activity was observed on flight 10.

Table 1. ITC Fire Mission Weather 23 March 2019

Parameter	Surface (1500)	Surface (1630)
Wind direction	180 degrees	180 degrees
Wind speed	2.2 m/s	2 m/s
Temperature	22.6°C	22°C
Humidity	61%	63%
Dew Point	15°C	15°C
Pressure	1022 mb	1021 mb
Ceiling	Not Reported	Not Reported

The order to launch the aircraft was given at 1440 local on 23 March 2019 and the aircraft was airborne at 1500. The initial data collection run over the site was at 1510 (local) and the aircraft made a total of 8 data collection passes. No detections were observed on any passes. Flight information is summarized in Appendix A and Figure 2.

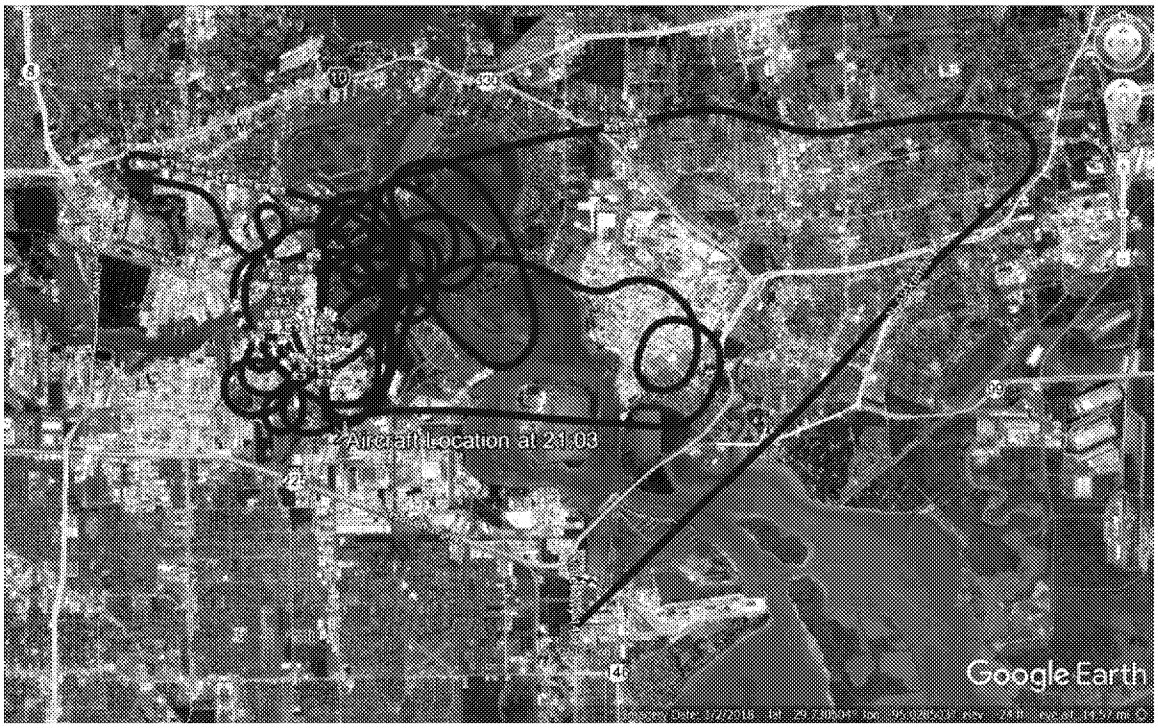

Figure 2: Flight line data for 23 March 2019, Flight 10. The blue lines represent the ASPECT flight path, green lines represent when the Infrared Line Scanner was actively collecting data, and the camera icons represent when a photo was taken.

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 8 data passes were made in the proximity of the impacted tank farm and also in extended areas surrounding the site and infrared line scanner images were generated for each pass. Figure 3 shows a typical 3-band infrared image obtained from data collected for Run 3. The image continues to show the tank farm with a black color within the secondary containment (oil/petroleum). As with the last flight, tanks in the northeast corner and center have the appearance of showing elevated temperature their white color. A thermal analysis using the RS00 line scanner was conducted on a same image (Figure 4) and tends to support this finding however the estimated temperatures are only a few degrees warmer than the surround tanks. In general, the warmer tanks are 30°C to 40°C. This was further confirmed by collecting an image with the night vision camera which again showed that these two tanks are the warmest (figure 5).

IR Run 5 was conducted over the confluence of the drainage creek into the ship channel. Containment boom has been fitted across the mouth of the creek and the white (warmer) oil can be seen behind the boom. A small amount of leakage can be seen breaking through the boom.

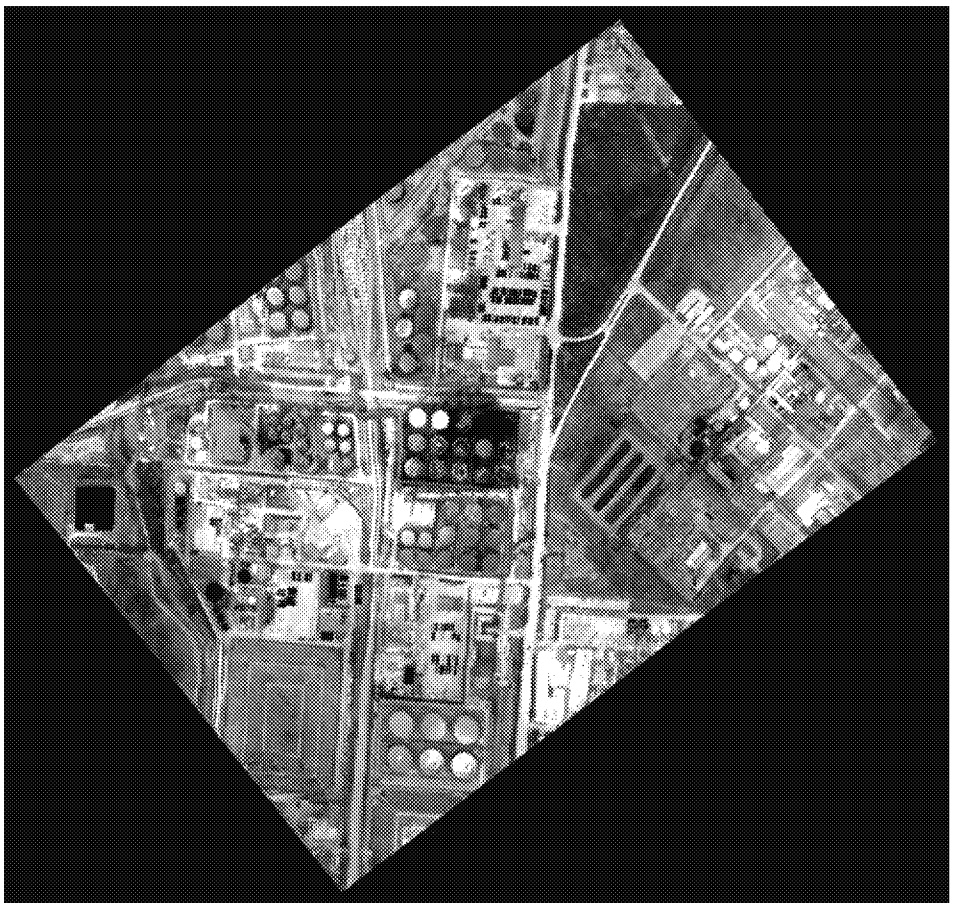

Figure 3: IR image of ITC data for 23 March 2019, Flight 10 Run 3

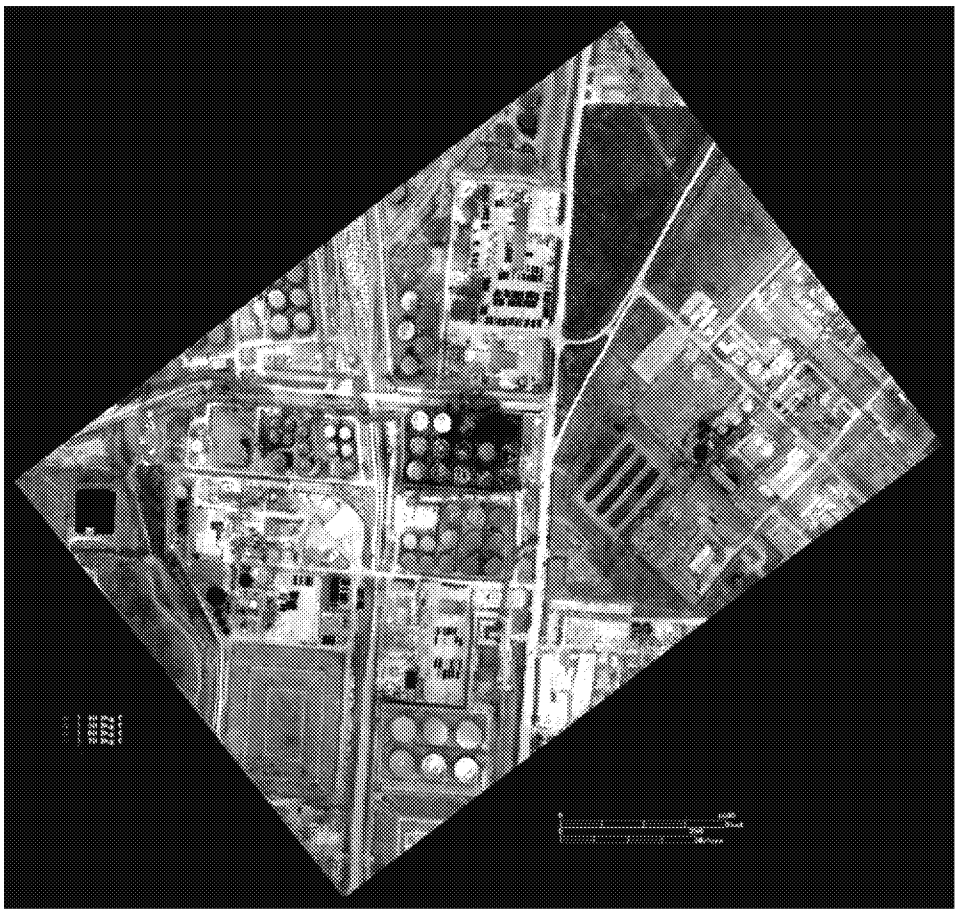

Figure 4: IR Thermal Analysis 23 March 2019, Flight 10, Run 3

Figure 5: IR Image 22 March 2019, Flight 8, Run 5

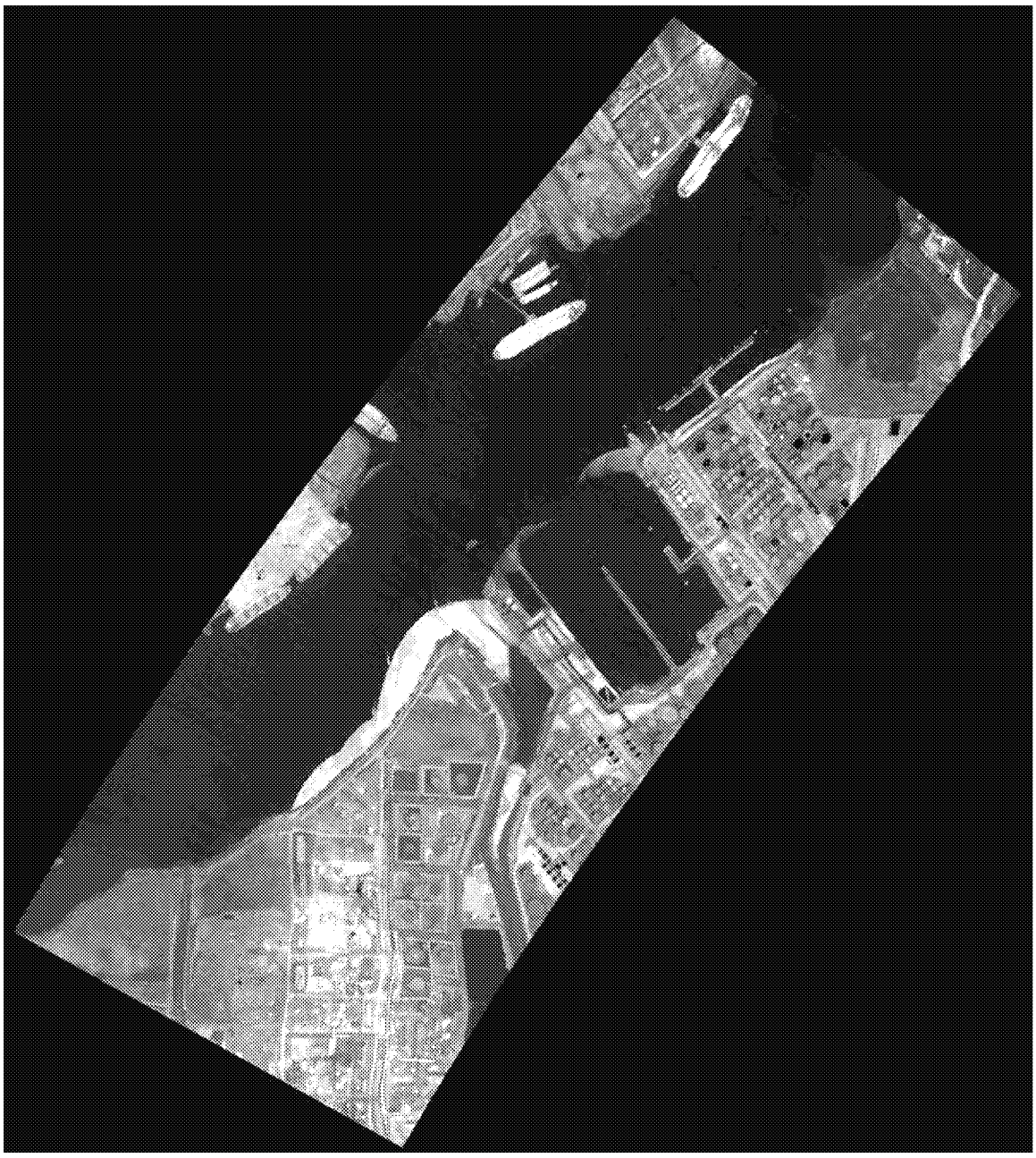

Figure 6: IR Image of Contained Oil 23 March 2019, Fight 10, Run 5

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 and associated detection limits are given in Tables 2. In addition, collected data are also manually analyzed by comparing any detected spectral signatures to a collection of published library spectra.

An examination of FTIR data collected on this mission showed no significant detection on only of the lines flown. For reference purposes, a table showing collection data is given in table 3.

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, Flight 10

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	23 March 2019	1510	Test	Test
2		1515	ND	None
3		1523	ND	None
4		1530	ND	None
5		1534	ND	None
6		1545	ND	None
7		1554	ND	None
8		1558	ND	None
9		1602	ND	None
ND – Non-detect				

Aerial Photography Results

A full set of high resolution aerial digital photography was collected as part of the flight. Figure 7 shows a representative overhead image collected as part of each pass over the tank farm. Captured oil behind the boom is evident as is light sheen leakage moving into the channel. The same features can be seen in an oblique collected at about the same time (Figure 8)

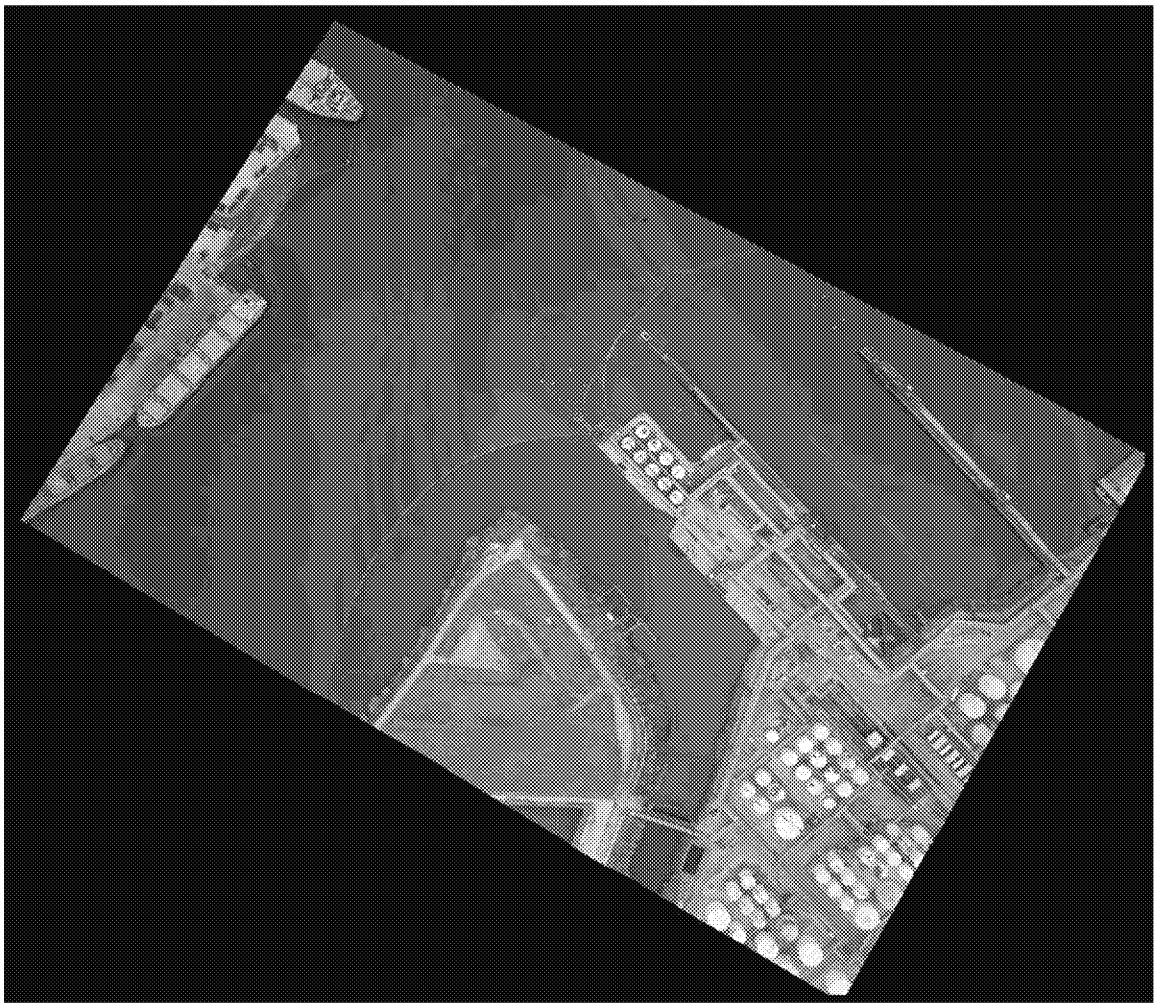

Figure 7: Aerial Image of the Ship Channel Boom Area, 23 March 2019, Flight 10

Figure 9: Oblique Image of the Ship Channel Boom Area, 23 March 2019, Flight 10

Conclusions

ASPECT conducted flight 10 23 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Data continues to show that tanks in the NW corner are warmer than others in the tank farm with estimated temperatures being in the 30°C to 40°C range. IR images collected over the confluence into the ship channel continues to show boomed oil products with some leakage occurring. No chemical detections were observed on this flight.

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

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Mission:   2019-03-23 Houston Refinery Fire

Date:      3/23/2019
Time UTC: 20:02

Aircraft Number: N9738B
Pilot: Beorn Ledger
Copilot: Todd Seale
Operator: Steven Brister
Aft Operator: Gerry Broyles
Ground Controller: Mark Thomas

DEM: Using elevation from DEM Database
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Run: 1 Time: 20:10:48 UTC
        Alt: 2998 ft MSL  Elev: 20 ft  Elevation from DEM Database
        Vel: 107 knots  Heading: 248

Digitals:  None
MSIC: 3
        20190323201054336.jpg
        20190323201100688.jpg
        20190323201107054.jpg
FTIR: 1
        20190323_201052_A.igm
IRLS: 1
        2019_03_23_20_10_52_R_01 TA=14.0;TB=33.9;Gain=3
Gamma Runs:  None

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Run: 2 Time: 20:15:07 UTC
        Alt: 2947 ft MSL  Elev: 17 ft  Elevation from DEM Database
        Vel: 96 knots  Heading: 204

Digitals:  None
MSIC: 5
        20190323201514042.jpg
        20190323201520405.jpg
        20190323201526755.jpg
        20190323201533121.jpg
        20190323201539472.jpg
FTIR: 1
        20190323_201512_A.igm
IRLS: 1
        2019_03_23_20_15_12_R_02 TA=14.0;TB=34.0;Gain=3
Gamma Runs:  None

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Run: 3 Time: 20:23:44 UTC
        Alt: 2941 ft MSL  Elev: 18 ft  Elevation from DEM Database
        Vel: 110 knots  Heading: 224

Digitals:  None
MSIC: 4
        20190323202350746.jpg
        20190323202357096.jpg
        20190323202403462.jpg
        20190323202409813.jpg
FTIR: 1
        20190323_202348_A.igm
IRLS: 1
        2019_03_23_20_23_48_R_03 TA=15.1;TB=35.1;Gain=3
Gamma Runs:  None

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Run: 4 Time: 20:30:36 UTC
        Alt: 2893 ft MSL  Elev: 6 ft  Elevation from DEM Database
        Vel: 91 knots  Heading: 163

Digitals:  None
MSIC: 6
        20190323203042093.jpg
        20190323203048447.jpg
        20190323203054811.jpg
        20190323203101171.jpg
        20190323203107515.jpg
        20190323203114780.jpg
FTIR: 1
        20190323_203040_A.igm
IRLS: 1
        2019_03_23_20_30_39_R_04 TA=15.3;TB=35.3;Gain=3
```

Gamma Runs: None

Run: 5 Time: 20:34:15 UTC
Alt: 2937 ft MSL Elev: 1 ft Elevation from DEM Database
Vel: 99 knots Heading: 208

Digitals: None
MSIC: 8
20190323203421848.jpg
20190323203428198.jpg
20190323203434564.jpg
20190323203440914.jpg
20190323203447280.jpg
20190323203453630.jpg
20190323203459990.jpg
20190323203506340.jpg
FTIR: 2
20190323_203420_A.igm
20190323_203458_A.igm
IRLS: 1
2019_03_23_20_34_19_R_05 TA=9.5;TB=26.8;Gain=3
Gamma Runs: None

Run: 6 Time: 20:45:49 UTC
Alt: 2888 ft MSL Elev: 12 ft Elevation from DEM Database
Vel: 116 knots Heading: 273

Digitals: None
MSIC: 8
20190323204556494.jpg
20190323204602844.jpg
20190323204609210.jpg
20190323204615560.jpg
20190323204621910.jpg
20190323204628276.jpg
20190323204634626.jpg
20190323204640992.jpg
FTIR: 2
20190323_204554_A.igm
20190323_204633_A.igm
IRLS: 1
2019_03_23_20_45_53_R_06 TA=8.2;TB=28.2;Gain=3
Gamma Runs: None

Run: 7 Time: 20:54:53 UTC
Alt: 2988 ft MSL Elev: 18 ft Elevation from DEM Database
Vel: 89 knots Heading: 176

```
Digitals:  None
MSIC: 4
        20190323205459493.jpg
        20190323205506764.jpg
        20190323205513114.jpg
        20190323205519464.jpg
FTIR: 1
        20190323_205458_A.igm
IRLS: 1
        2019_03_23_20_54_58_R_07 TA=13.9;TB=33.9;Gain=3
Gamma Runs:  None

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Run: 8 Time: 20:58:22 UTC
        Alt: 2935 ft MSL  Elev: 18 ft  Elevation from DEM Database
        Vel: 99 knots  Heading: 181

Digitals:  None
MSIC: 5
        20190323205828340.jpg
        20190323205834690.jpg
        20190323205841040.jpg
        20190323205847405.jpg
        20190323205853755.jpg
FTIR: 1
        20190323_205826_A.igm
IRLS: 1
        2019_03_23_20_58_26_R_08 TA=14.0;TB=34.0;Gain=3
Gamma Runs:  None

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Run: 9 Time: 21:02:02 UTC
        Alt: 3027 ft MSL  Elev: 18 ft  Elevation from DEM Database
        Vel: 96 knots  Heading: 178

Digitals:  None
MSIC: 5
        20190323210208068.jpg
        20190323210214434.jpg
        20190323210220784.jpg
        20190323210227133.jpg
        20190323210233499.jpg
FTIR: 1
        20190323_210205_A.igm
IRLS: 1
        2019_03_23_21_02_06_R_09 TA=13.9;TB=33.9;Gain=3
Gamma Runs:  None
```