Field Report for Airborne Data Collected In Support of US EPA Region 6 Intercontinental Terminals Company LLC Fire 27 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. Data continued to show that tanks in the NW corner were 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 showed boomed oil products with some leakage occurring. No chemical detections were observed on the flight.

ASPECT conducted a short flight on 24 March 2019 but was forced to return to base due to weather. Note that this aborted mission was flight 11. ASPECT conducted flight 12 on 25 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery continued to show that tanks in the NW corner were warmer than others in the tank farm. IR images collected over the confluence into the ship channel continued to show boomed oil products with some leakage occurring with sheen being driven to the southwest due to winds. No significant chemical detections were observed on this flight.

ASPECT conducted flight 12 on 26 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected on this flight indicated that the NW tanks in the tank farm were cooler than on previous flights. IR data collected over the confluence into the ship channel continued to show sheen in the waterway. No significant chemical detections were observed on this flight.

ASPECT was requested to fly the tank farm, confluence and downwind areas on the morning of 27 March 2019. This report summarizes the findings of the mission.

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 14, 27 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 very light from the east. Speed is estimated at less than 10 kts (5 m/s). No turbulence was encountered. No significant ground activity was observed on flight 13.

Table 1. ITC Fire Mission Weather 27 March 2019

Parameter	Surface (0900)
Wind direction	090 degrees
Wind speed	2.5 m/s
Temperature	17C
Humidity	64%
Dew Point	9.4^{o}C
Pressure	1027 mb
Ceiling	Not Reported

The order to launch the aircraft was given at 0830 local on 27 March 2019 and the aircraft was airborne at 0835. The initial data collection run over the site was at 0854 (local) and the aircraft made a total of 7 data collection passes. Isobutylene was detected on pass 6. Flight information is summarized in Appendix A and Figure 2.

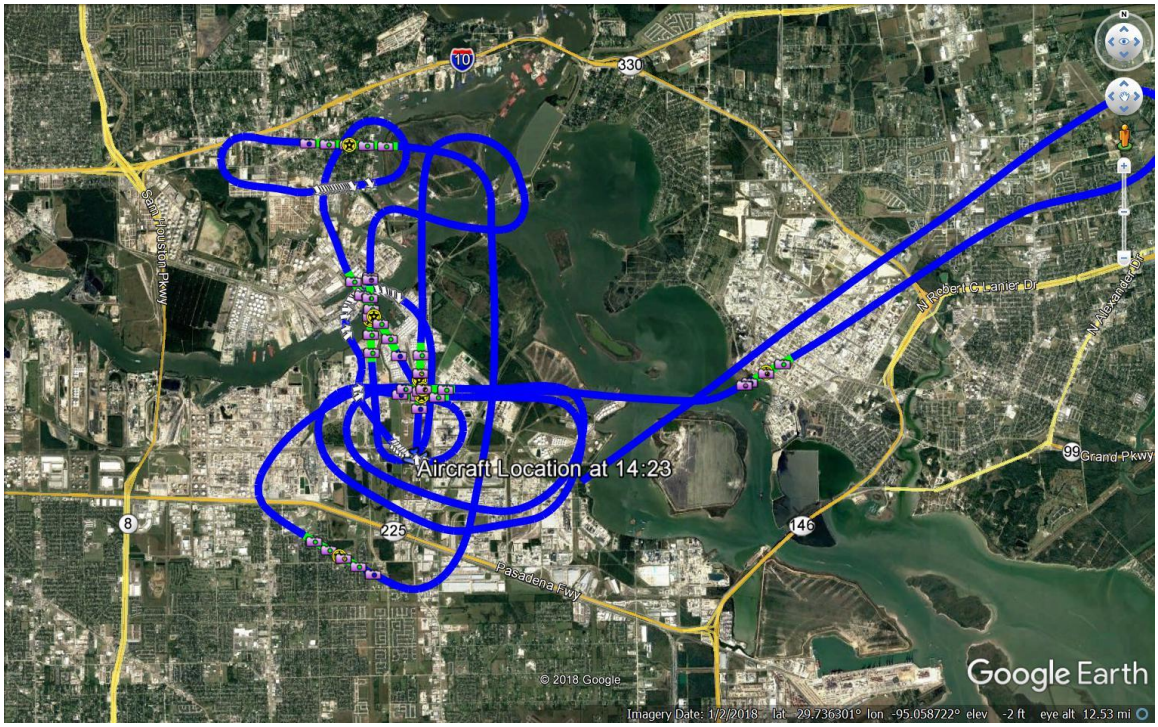

Figure 2: Flight line data for 27 March 2019, Flight 14. The blue lines represent the ASPECT flight path, green lines represent when the Infrared Line Scanner was actively collecting data, and the camera icons represent when a photo was taken.

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 7 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 2. IR imagery is now showing fine detail on the tank surfaces and there is effectively no detector saturation. Figure 4 is a thermal image and which confirms the finding of the line scanner and shows tank surface features of tanks at ambient temperature (some solar heating is occurring). As with other thermal images, note that the bottom right in the image is the NW due to the image being inverted.

IR Run 5 was conducted over the confluence of the drainage creek into the ship channel with results similar to the prior mission. Containment boom (white due to solar heating)

continues to trap material with leakage can be seen across the channel mouth and also upstream within the drainage channel. Sheen leakage can be seen in the southwest edge of the boom (Figure 5). Figure 6 is a thermal image of the boom area and clearly shows the some boom leakage.

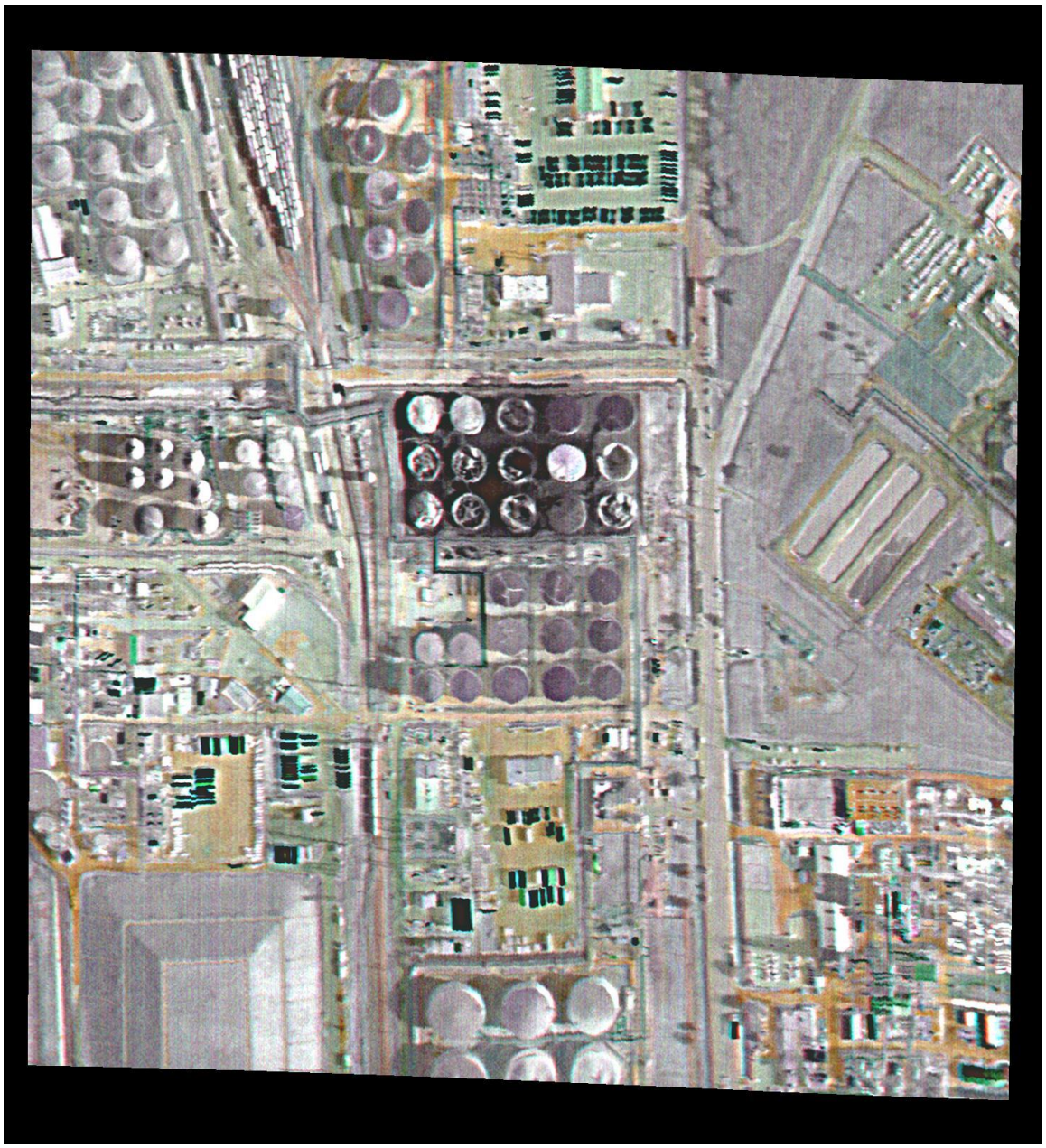

Figure 3: IR image of ITC data for 27 March 2019, Flight 14 Run 2

Figure 4: IR Thermal Analysis 27 March 2019, Flight 14, Run 8

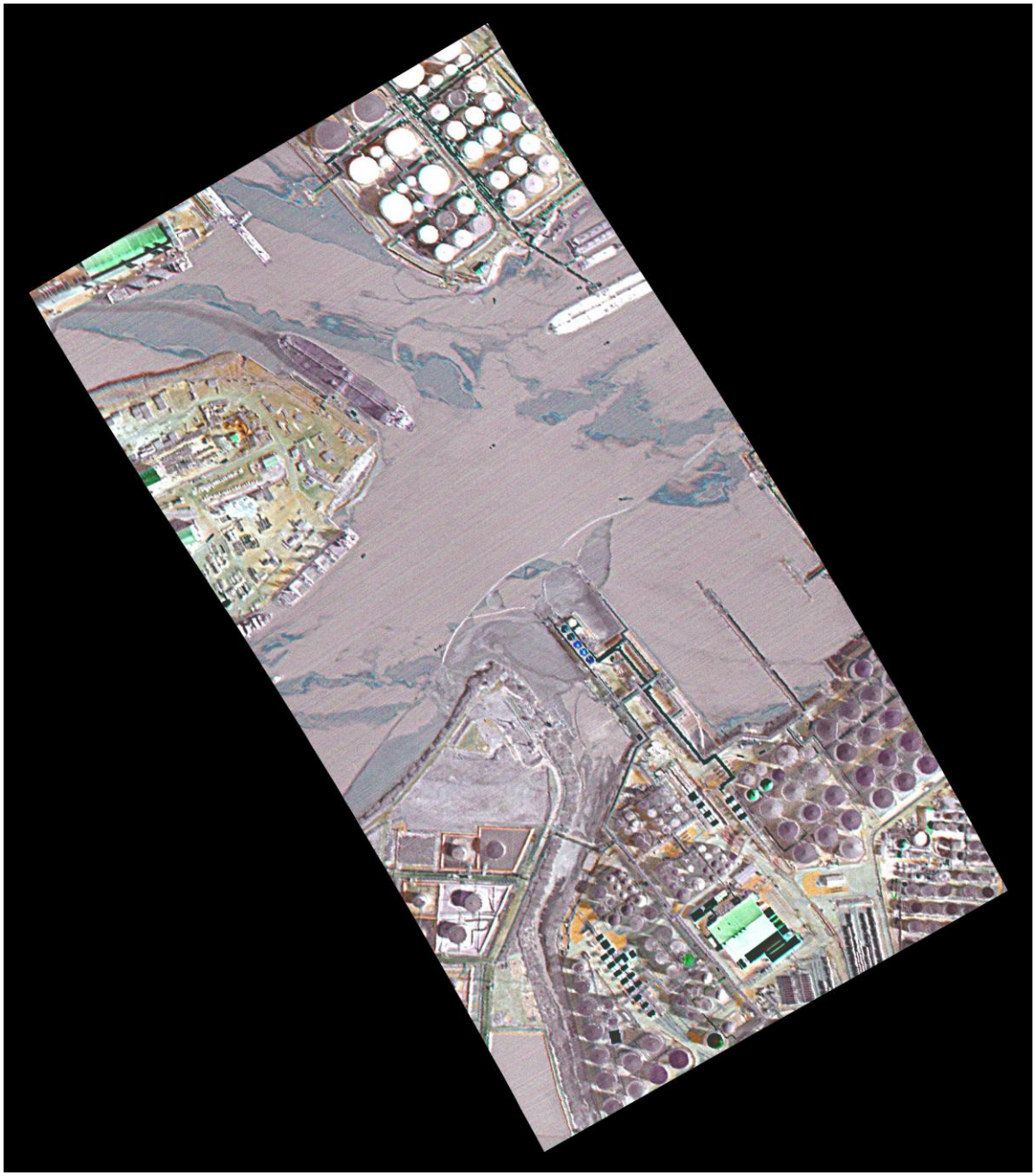

Figure 5: IR Image of Contained Oil 27 March 2019, Fight 14, Run 6

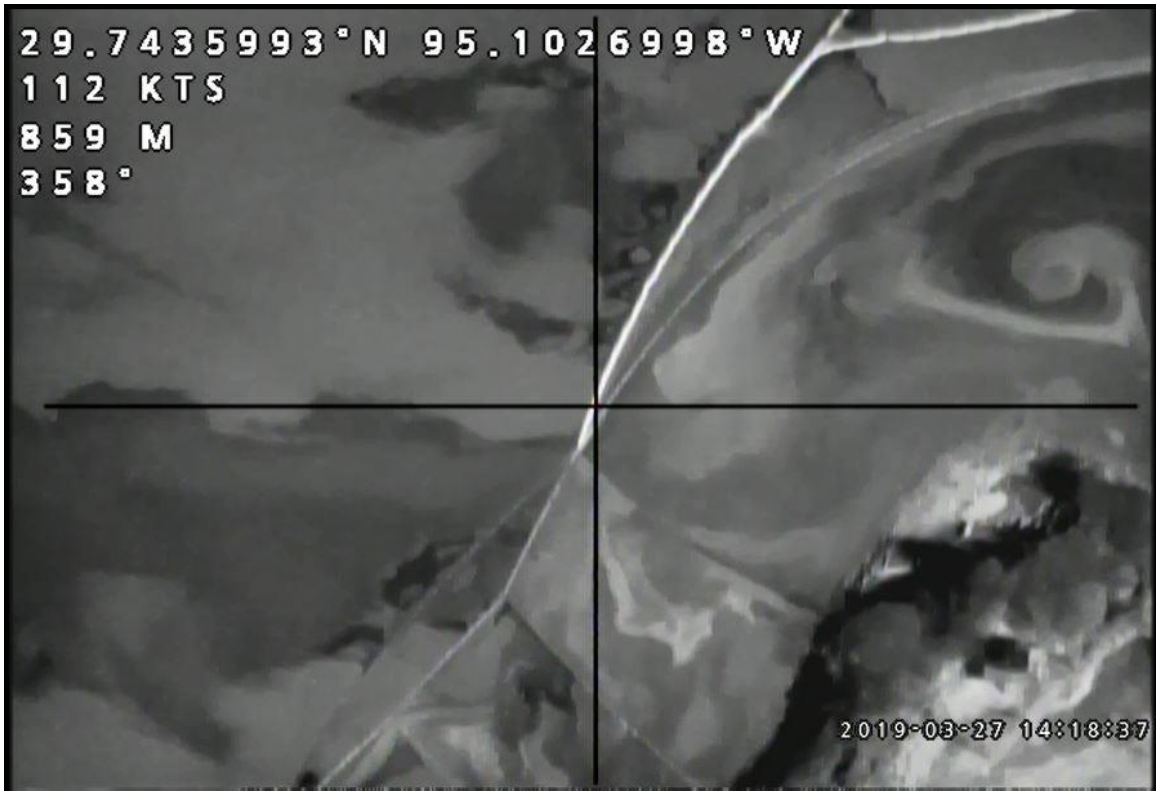

Figure 6: IR Image of Contained Oil 27 March 2019, Fight 14, Run 7

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 one group of isobutylene detections on a pass over the ship channel (Figure 6). Table 3. Provides details of the data collection.

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 13

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	27 March 2019	0854	Test	Test
2		0859	ND	None
3		0903	ND	None
4		0905	ND	None
5		0909	ND	None
6		0913	Isobutylene	1.60
7		0918	ND	None
8		0922	ND	None
ND – Non-detect				

Figure 7: Isobutylene Detection 27 March 2019, Fight 14, Run 6

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. There is effectively little new information that can be extracted for the tank farm. Figure 8 provides an overhead view of the confluence area. The amount of trapped product appears to be less than on prior missions. The image does not show boom leakage. The same area as viewed using the oblique camera downs more detail of the trapped product and does show some leakage from one boom layer to the next. Little leakage is evident from the main booms

Figure 6: Aerial Image of the Tank Farm, 27 March 2019, Flight 14

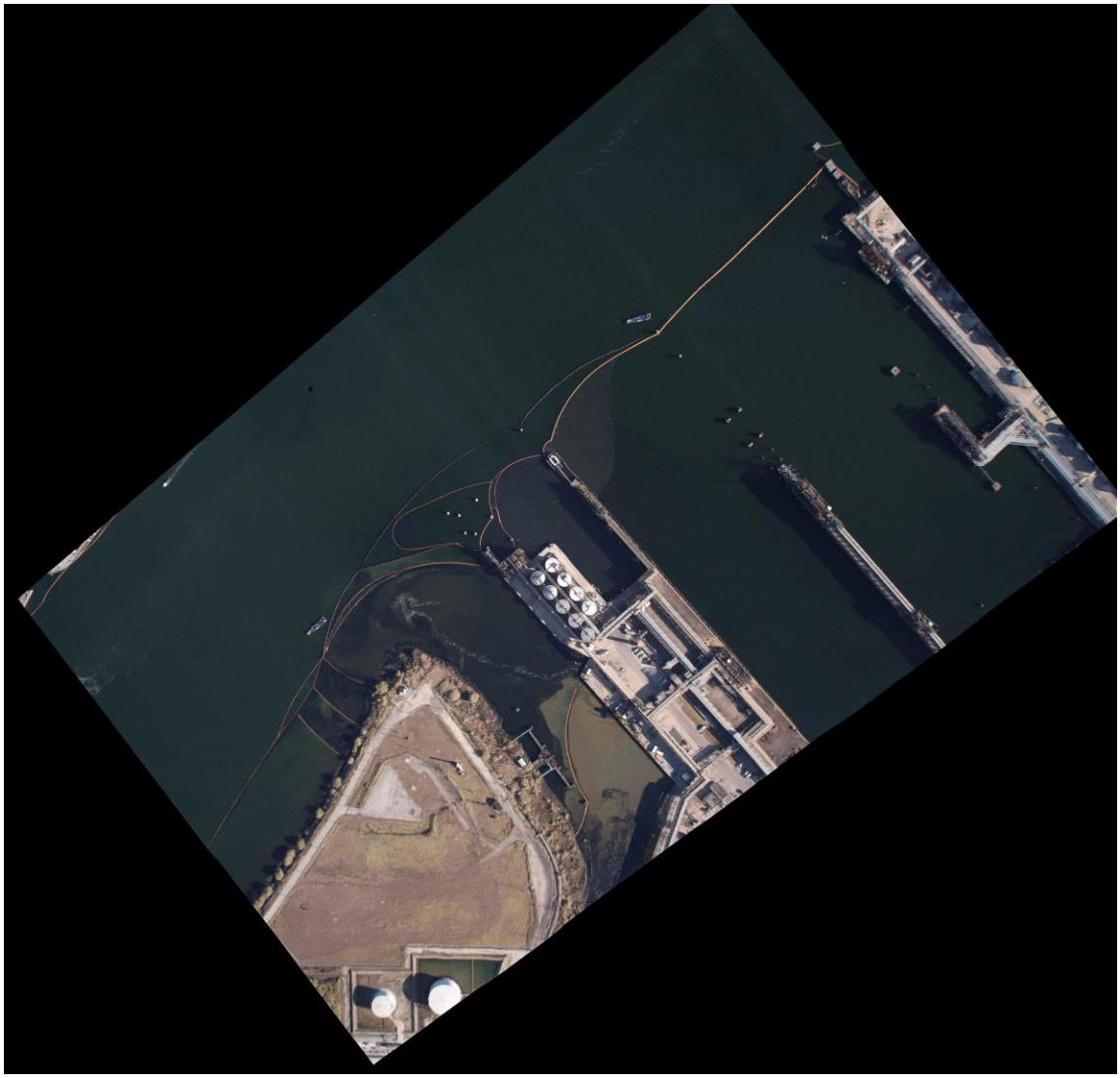

Figure 7: Aerial Image of the Ship Channel Boom Area, 27 March 2019, Flight 14

Figure 8: Oblique Image of the Ship Channel Boom Area, 27 March 2019, Flight 14

Conclusions

ASPECT conducted flight 14 on 27 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected on this flight indicates that the NW tanks in the tank farm are at essentially at ambient temperature. Analysis of FTIR data showed one cluster of isobutylene north of the site at maximum levels of 1.60 ppm. IR and photographic data collected over the confluence area tends to show a reduction in the amount of trapped product. Leakage is still present but in less amounts as on prior flights.

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: 2019-03-27 Houston Fire

Date: 3/27/2019

Time UTC: 13:46

Aircraft Number: N9738B

Pilot: Todd Seale

Copilot: Beorn Ledger

Operator: James Crisp

Aft Operator: Gerry Broyles

Ground Controller: Bob Kirby

DEM: Using elevation from DEM Database

Run: 1 Time: 13:54:07 UTC

Alt: 2918 ft MSL Elev: 7 ft Elevation from DEM Database

Vel: 116 knots Heading: 238

Digitals: None

MSIC: 4

20190327135413019.jpg

20190327135419368.jpg

20190327135425717.jpg

20190327135427542.jpg

FTIR: 1

20190327_135410_A.igm

IRLS: 1

2019_03_27_13_54_11_R_01 TA=8.0;TB=28.0;Gain=3

Gamma Runs: None

Run: 2 Time: 13:59:35 UTC

Alt: 2869 ft MSL Elev: 16 ft Elevation from DEM Database

Vel: 119 knots Heading: 270

Digitals: None

MSIC: 3

20190327135940744.jpg

20190327135948014.jpg

20190327135954363.jpg

FTIR: 1

20190327_135938_A.igm

IRLS: 1

2019_03_27_13_59_40_R_02 TA=9.4;TB=29.7;Gain=3

Gamma Runs: None

Run: 3 Time: 14:03:42 UTC

Alt: 2862 ft MSL Elev: 16 ft Elevation from DEM Database

Vel: 116 knots Heading: 272

Digitals: None

MSIC: 3

20190327140348602.jpg

20190327140354951.jpg

20190327140401300.jpg

FTIR: 1

20190327_140345_A.igm

IRLS: 1

2019_03_27_14_03_46_R_03 TA=8.0;TB=28.0;Gain=3

Gamma Runs: None

Run: 4 Time: 14:05:29 UTC

Alt: 2860 ft MSL Elev: 23 ft Elevation from DEM Database

Vel: 104 knots Heading: 115

Digitals: None

MSIC: 5

20190327140535723.jpg

20190327140542087.jpg

20190327140548436.jpg

20190327140554785.jpg

20190327140601150.jpg

FTIR: 1

20190327_140532_A.igm

IRLS: 1

2019_03_27_14_05_34_R_04 TA=8.4;TB=28.4;Gain=3

Gamma Runs: None

Run: 5 Time: 14:09:27 UTC

Alt: 2865 ft MSL Elev: 15 ft Elevation from DEM Database

Vel: 120 knots Heading: 271

Digitals: None

MSIC: 5

20190327140933582.jpg

20190327140939935.jpg

20190327140946299.jpg

20190327140952664.jpg

20190327140959013.jpg

FTIR: 1

20190327_140930_A.igm

IRLS: 1

2019_03_27_14_09_32_R_05 TA=7.8;TB=27.8;Gain=3

Gamma Runs: None

Run: 6 Time: 14:13:20 UTC

Alt: 2793 ft MSL Elev: 4 ft Elevation from DEM Database

Vel: 103 knots Heading: 142

Digitals: None

MSIC: 6

20190327141326000.jpg

20190327141332364.jpg

20190327141338713.jpg

20190327141345062.jpg

20190327141351427.jpg

20190327141358681.jpg

FTIR: 1

20190327_141323_A.igm

IRLS: 1

2019_03_27_14_13_25_R_06 TA=7.5;TB=27.5;Gain=3

Gamma Runs: None

Run: 7 Time: 14:18:22 UTC

Alt: 2714 ft MSL Elev: 6 ft Elevation from DEM Database

Vel: 110 knots Heading: 3

Digitals: None

MSIC: 6

20190327141828317.jpg

20190327141834682.jpg

20190327141841031.jpg

20190327141847395.jpg

20190327141853744.jpg

20190327141854649.jpg

FTIR: 1

20190327_141825_A.igm

IRLS: 1

2019_03_27_14_18_27_R_07 TA=8.5;TB=28.5;Gain=3

Gamma Runs: None

Run: 8 Time: 14:22:25 UTC

Alt: 2928 ft MSL Elev: 18 ft Elevation from DEM Database

Vel: 109 knots Heading: 175

Digitals: None

MSIC: 4

20190327142231627.jpg

20190327142237992.jpg

20190327142244341.jpg

20190327142250690.jpg

FTIR: 1

20190327_142228_A.igm

IRLS: 1

2019_03_27_14_22_30_R_08 TA=8.8;TB=28.8;Gain=3

Gamma Runs: None

Mission Complete: 15:01 (UTC)