Field Report for Airborne Data Collected In Support of US EPA Region VI International Terminal Corporation Fire 17 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. Local authorities have ordered a 5 mile radius evacuation. The City of Deer Park has issued a shelter in place.

The US EPA Region VI requested that the ASPECT system be deployed to provide monitoring support at approximately 1545 on 17 March 2019. ASPECT was airborne at 1635. Travel time to the facility from the Addison base was estimated to be about 90 minutes.

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. 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.

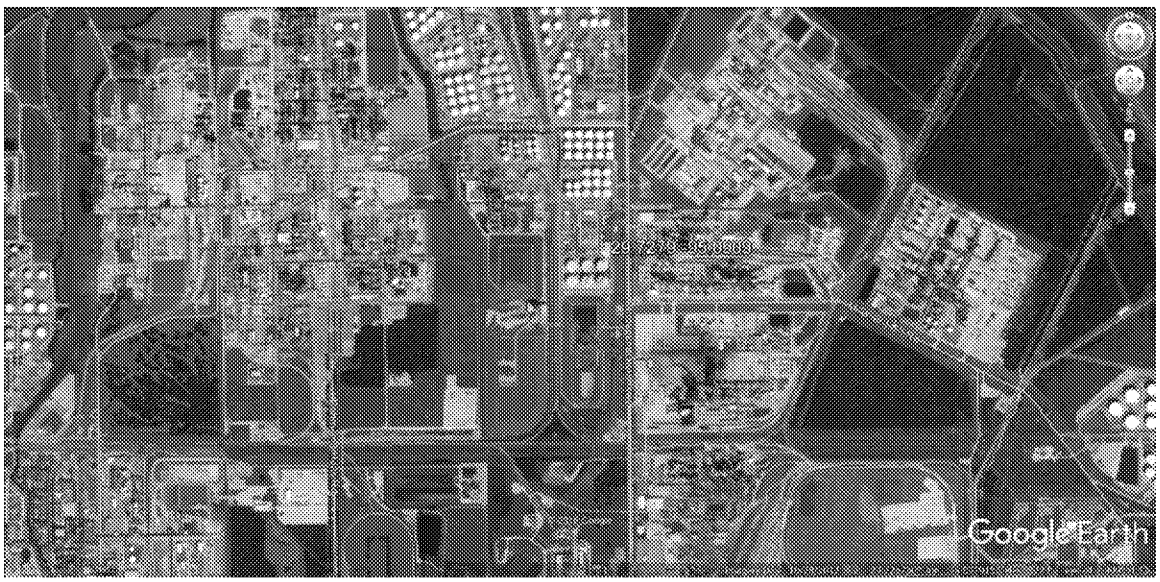

Figure 1: International Terminal Corporation, Deer Park, TX

ASPECT response to this Mission/Incident was in support of:
US EPA Region 6. OSC: Adam Adams and Pratisha 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 (1700)	Surface (1800)
Wind direction	090 degrees	Calm
Wind speed	1 m/s (1.5 kts)	Calm
Temperature	17°C	17°C
Humidity	28%	34%
Dew Point	2°C	2°C
Pressure	1022 mb	1022 mb
Ceiling	Not Reported	Unlimited

The crew reported that winds at altitude (2800 ft) are light and from the east. . Smoke emitted from the fire was reported to be gray in color and was visible 40 miles from the facility. It was reported that the plume was rising near vertical up to 4000 feet and then moving toward the west (figure 2). In general, the smoke was being pushed into a layer with the floor at 3500 and the top at about 4000 which appears to be a fairly strong thermal inversion.

Figure 2 : ITC Fire Plume, Approximately 40 miles away. Note vertical lofting of the plume.

Flight Status

The order to launch the aircraft was given 1545 local on 17 March 2019 and the aircraft was airborne at 1635. The initial data collection run over the site was at 1757 (local) The aircraft made a total of seven data collection passes; flight information is summarized in Appendix A and Figure 3.

Figure 3: 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

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 3 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 4 shows a typical 3-

band infrared image obtained from data collected for Run 4. The white area within the image overlay is the thermal plume of the fire. Immediately south of the fire, a region of elevated temperature can be seen. This is most likely air being heated by the fire. Approximately 300 meters further south an area of obscuration of the surface (ground) thermal signature is present. This is likely the impact of volume and geometry of the plume block transmission due to the particulate load of the fire. It should be noted that no evidence of a chemical plume being generated by the fire was observed. A similar image generated on run 5 clearly shows an elevated temperature plume being generated by the fire (Figure 5).

Figure 4: – 3 band IR image, Run 4, International Terminal Corporation Fire

Figure 5: 3 band IR image, Run 5, International Terminal Corporation 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.

Spectral examination of the fire indicated that this particular fire did not generated many detectable compounds. It should be stressed that while ASPECT can detect many compounds, normal and aromatic hydrocarbons are very difficult to detect passively due to the presence of CO_2 and water vapor. Figure 6 does show the present of very low levels of acetone which was observed the passes nearest the fire. The two peaks located at approximately 1250 and 1350 are the two primary peaks of acetone in the atmospheric window. The greatly elevated spectra is indicative of a hot radiometric environment. Consequently, the relatively low signal to noise ratio of the acetone detections indicate very low concentrations (less than 1 ppm). It is possible that this compound may be a feature of the urban air and not necessarily generated by the fire.

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

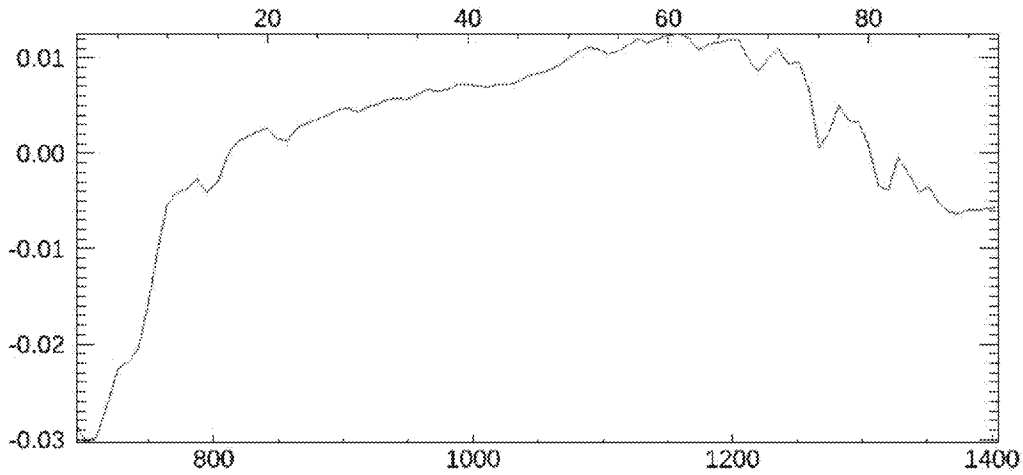

Figure 6: Acetone Spectra, Run 4, International Terminal Corporation Fire

Table 3. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	17April 2019	2220	Test	Test
2		2227	Test	Test
3		2236	Test	Test
4		2257	Acetone	0.154
5		2302	Acetone	0.357
6		2308	Acetone	None

7		2319	Acetone	None
8		2334	Acetone	None
9		2340	None	None
10		2347	None	None

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 7 shows a representative image collected as part of each pass. 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 actually a result of the plume shading the area as the aircraft passed over the site.

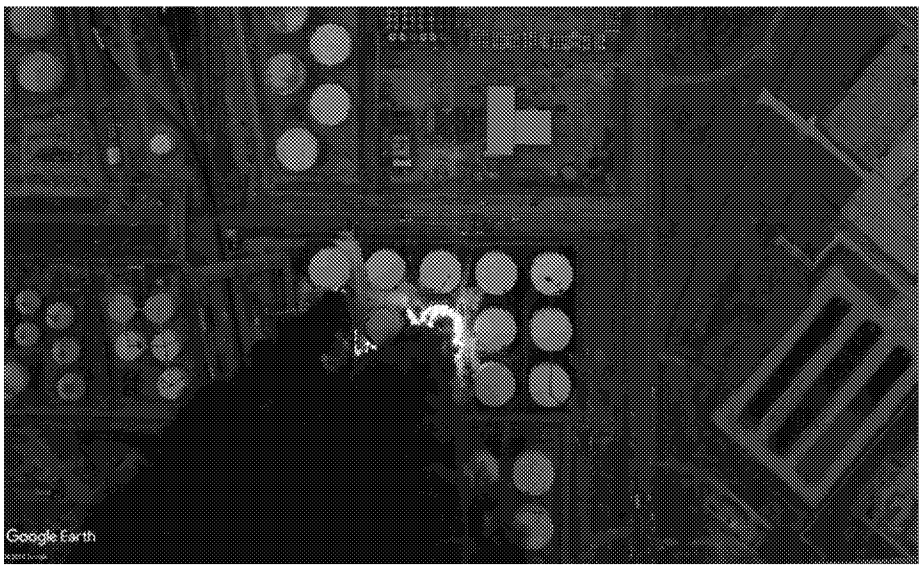

Figure 7: Aerial Image of the International Terminal Corporation Fire.

Conclusions

ASPECT was dispatched at the request of the EPA Region VI emergency response program to provide air monitoring of the International Terminal Corporation fire. ASPECT arrived on-site at 1757 (local) and began the first of 7 data collection passes. Acetone was detected the first 5 passes which were near the fire at a concentration estimated below 1 ppm. Passes 6 and 7 which were several hundred meters downwind did not show any detections. Manual analysis of spectra did not show any addition compounds. This result is not unanticipated with a feed stock of this type. Naphtha is essentially the first cut from thermal distillation of crude and contains varying amounts of normal and aromatic hydrocarbons. These compound tend to be difficult to detection passively with IR due to the band locations either being obscured by water and CO_2 or in the case of the straight chain compounds, being located in the mid IR region.

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: 2019-03-17 International Terminal Corporation Fire

Date: 3/17/2019
Time UTC: 22:20

Aircraft Number: N9738B
Pilot: Todd Seale
Copilot: Beorn Ledger
Operator: Bob Kirby
Aft Operator: Bob Kirby
Ground Controller: Mark Thomas

DEM: Using elevation from DEM Database

Run: 1 Time: 22:27:10 UTC
Alt: 3389 ft MSL Elev: 242 ft Elevation from DEM Database
Vel: 157 knots Heading: 152

Digitals: None
MSIC: 3
20190317222715532.jpg
20190317222722801.jpg
20190317222729150.jpg
FTIR: 1
20190317_222712_A.igm
IRLS: 1

2019_03_17_22_27_14_R_01 TA=7.1;TB=26.9;Gain=3
Gamma Runs: None

Run: 2 Time: 22:36:23 UTC
Alt: 2900 ft MSL Elev: 285 ft Elevation from DEM Database
Vel: 160 knots Heading: 130

Digitals: None
MSIC: 3
20190317223629329.jpg
20190317223635677.jpg
20190317223642026.jpg
FTIR: 1
20190317_223626_A.igm
IRLS: 1
2019_03_17_22_36_27_R_02 TA=6.0;TB=26.0;Gain=3
Gamma Runs: None

Run: 3 Time: 22:57:58 UTC
Alt: 3098 ft MSL Elev: 19 ft Elevation from DEM Database
Vel: 131 knots Heading: 173

Digitals: None
MSIC: 5
20190317225804831.jpg
20190317225811196.jpg
20190317225817544.jpg
20190317225823893.jpg
20190317225828433.jpg
FTIR: 1
20190317_225802_A.igm
IRLS: 1
2019_03_17_22_58_03_R_03 TA=8.4;TB=28.4;Gain=3
Gamma Runs: None

Run: 4 Time: 23:02:54 UTC
Alt: 3246 ft MSL Elev: 19 ft Elevation from DEM Database
Vel: 136 knots Heading: 176

Digitals: None

MSIC: 6
20190317230259894.jpg
20190317230306243.jpg
20190317230312607.jpg
20190317230319861.jpg
20190317230326225.jpg
20190317230332574.jpg
FTIR: 1
20190317_230256_A.igm
IRLS: 1
2019_03_17_23_02_58_R_04 TA=1.0;TB=21.9;Gain=3
Gamma Runs: None

Run: 5 Time: 23:08:09 UTC
Alt: 3172 ft MSL Elev: 19 ft Elevation from DEM Database
Vel: 140 knots Heading: 174

Digitals: None
MSIC: 5
20190317230815829.jpg
20190317230822194.jpg
20190317230828543.jpg
20190317230834892.jpg
20190317230841256.jpg
FTIR: 1
20190317_230813_A.igm
IRLS: 1
2019_03_17_23_08_15_R_05 TA=6.0;TB=26.2;Gain=3
Gamma Runs: None

Run: 6 Time: 23:19:02 UTC
Alt: 4429 ft MSL Elev: 20 ft Elevation from DEM Database
Vel: 153 knots Heading: 176

Digitals: None
MSIC: 8
20190317231908604.jpg
20190317231914938.jpg
20190317231921302.jpg
20190317231927651.jpg
20190317231934016.jpg
20190317231940365.jpg

20190317231946714.jpg
20190317231953078.jpg
FTIR: 2
20190317_231906_A.igm
20190317_231945_A.igm
IRLS: 1
2019_03_17_23_19_07_R_06 TA=7.2;TB=27.2;Gain=3
Gamma Runs: None

Run: 7 Time: 23:34:57 UTC
Alt: 4913 ft MSL Elev: 17 ft Elevation from DEM Database
Vel: 140 knots Heading: 167

Digitals: None
MSIC: 10
20190317233503686.jpg
20190317233510035.jpg
20190317233516384.jpg
20190317233522748.jpg
20190317233529097.jpg
20190317233535446.jpg
20190317233541811.jpg
20190317233548160.jpg
20190317233554525.jpg
20190317233600874.jpg
FTIR: 2
20190317_233500_A.igm
20190317_233539_A.igm
IRLS: 1
2019_03_17_23_35_02_R_07 TA=5.3;TB=25.3;Gain=3
Gamma Runs: None

Run: 8 Time: 23:40:42 UTC
Alt: 4972 ft MSL Elev: 14 ft Elevation from DEM Database
Vel: 139 knots Heading: 163

Digitals: None
MSIC: 12
20190317234048671.jpg
20190317234055035.jpg
20190317234101384.jpg
20190317234107733.jpg

20190317234114098.jpg
20190317234120447.jpg
20190317234126812.jpg
20190317234133161.jpg
20190317234139510.jpg
20190317234145874.jpg
20190317234152224.jpg
20190317234158588.jpg
FTIR: 2
20190317_234046_A.igm
20190317_234124_A.igm
IRLS: 1
2019_03_17_23_40_47_R_08 TA=2.7;TB=23.0;Gain=3
Gamma Runs: None

Run: 9 Time: 23:47:43 UTC
Alt: 4887 ft MSL Elev: 19 ft Elevation from DEM Database
Vel: 141 knots Heading: 170

Digitals: None
MSIC: 8
20190317234749018.jpg
20190317234755383.jpg
20190317234801732.jpg
20190317234809001.jpg
20190317234815350.jpg
20190317234821699.jpg
20190317234828064.jpg
20190317234834413.jpg
FTIR: 2
20190317_234746_A.igm
20190317_234825_A.igm
IRLS: 1
2019_03_17_23_47_48_R_09 TA=3.6;TB=23.6;Gain=3
Gamma Runs: None