Field Report for Airborne Data Collected In Support of US EPA Region VI Intercontinental Terminals Company LLC Fire 19 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 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.

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.

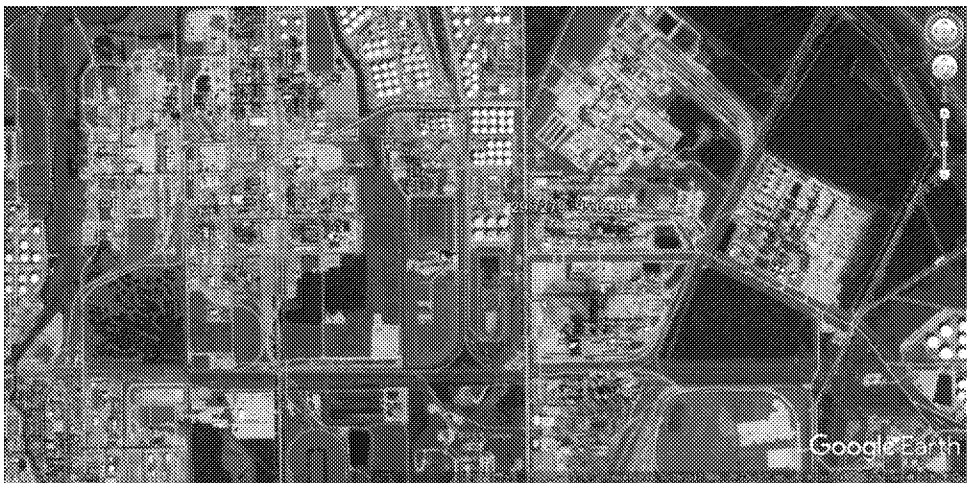

Figure 1: ITC, Deer Park, TX

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 3, 19 March 2019

Weather Conditions and Crew Report

Weather for the mission is given in table 1. The crew reported that winds at altitude (2800 ft) are at about 19 kts (7 m/s) from about 150 degrees. Smoke emitted from the fire was reported to be gray to black in color and was visible 50 miles from the facility. The plume was reported to still be rising but was lofting less than on 18 March 2019. Figure 2 shows a representative oblique image. Note that the plume is showing some vertical displacement indicating that upper air mixing is beginning to impact the dispersion of the plume. In general, the plume is occupying a region from 1500 feet AGL to about 5000 feet AGL. Plume motion was consistent with the reported winds at altitude or movement towards the northwest.

Table 1. ITC Fire Mission Weather 19 March 2019

Parameter	Surface (0900)	Surface (1000)
Wind direction	045 degrees	045 degrees
Wind speed	1.5 m/s	2.2 m/s
Temperature	14°C	16.5°C
Humidity	68%	60%
Dew Point	6°C	6°C
Pressure	1022 mb	1022 mb
Ceiling	Not Reported	Not Reported

As requested by Region 6, ASPECT estimated the perimeter location, floor and ceiling altitudes of the plume based on distance downwind from the fire. Figure 3 shows a generalized outline of the plume based on this measurement. Table 2 provides a summary of the plume geometry including centerline position, plume floor and ceiling altitudes and estimated cross plume distance in relationship to downwind distance.

Figure 2: ITC Fire, 19 March 2019, Oblique Image

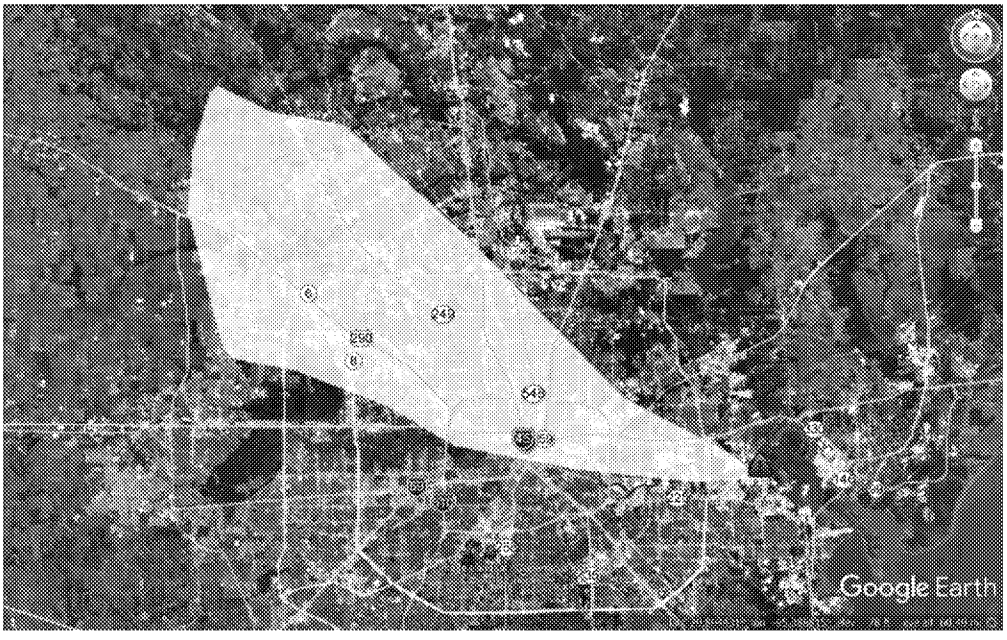

Figure 3: ITC Fire, Plume Outline 19 March 2019

Table 2: Plume Geometry for 19 March 2019

Observation	Downwind Distance at Centerline (Miles)	Latitude	Longitude	Plume Floor (Ft AGL)	Plume Ceiling (Ft AGL)	Plume Width (Miles)
1	5	29.7517	-95.1735	2500	5000	3.12
2	10	29.7641	-95.1335	2500	4500	5.15
3	15	29.8002	-95.3310	2500	4500	8.07
4	20	29.8388	-95.4090	1500	4500	11.4
5	25	29.8850	-95.4779	1500	4500	12.7
6	35	29.9646	-95.6120	2500	5000	17
7	47	30.1245	-95.7313	2500	5000	1

The order to launch the aircraft was given at 0700 local on 19 March 2019 and the aircraft was airborne at 0718. The initial data collection run over the site was at 0855 (local) The aircraft made a total of 12 data collection passes; flight information is summarized in Appendix A and Figure 4A and 4B.

Figure 4A: Flight lines in the immediate area downwind of the fire.

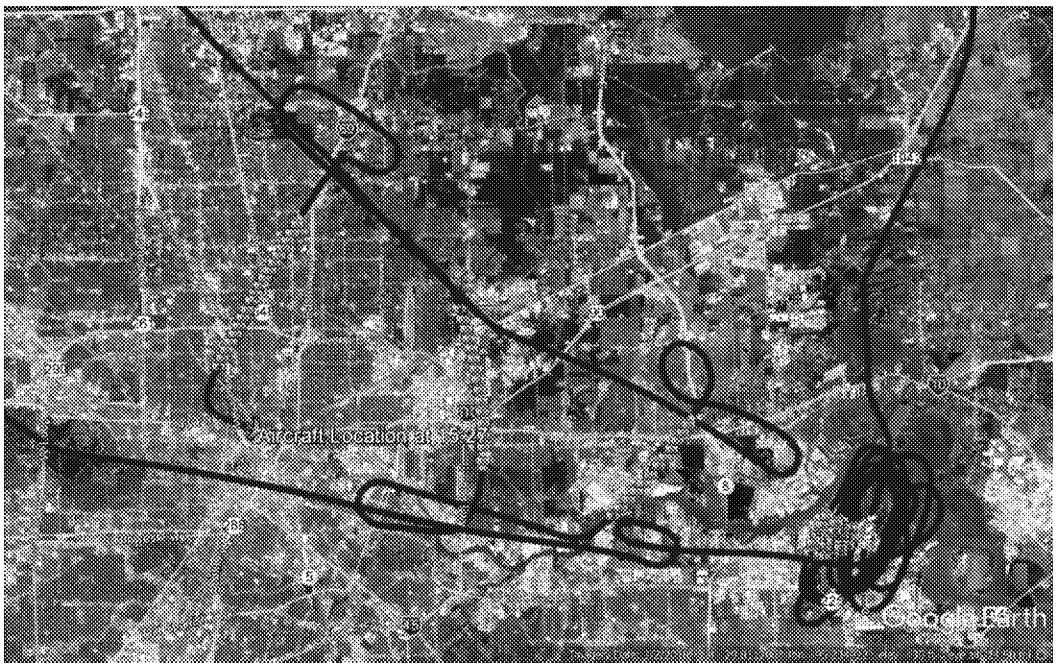

Figure 4B: Flight lines in the extended downwind area of the fire.

Notes for Figure 4A and 4B: 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 2 test and 8 data passes were made in the proximity of the site and an infrared line scanner images were generated for each pass. Figure 5 shows a typical 3-band infrared image obtained from data collected for Run 6. The overall thermal signature of the fire is very large. A qualitative analysis of the image indicates that the region of total saturation of the detector (white) is roughly 280 meters across (north to south) and about 600 meters in length. As with prior flights almost total obscuration of the ground signal is being masked by heat and/or particulates. Figure 6 shows a comparison of IR data collected on 18 March 2019 (left) and 19 March 2019 (right). The images are roughly scaled to the same size. It is evident that the magnitude of the fire on 19 March 2019 is measurably larger than on previous flights.

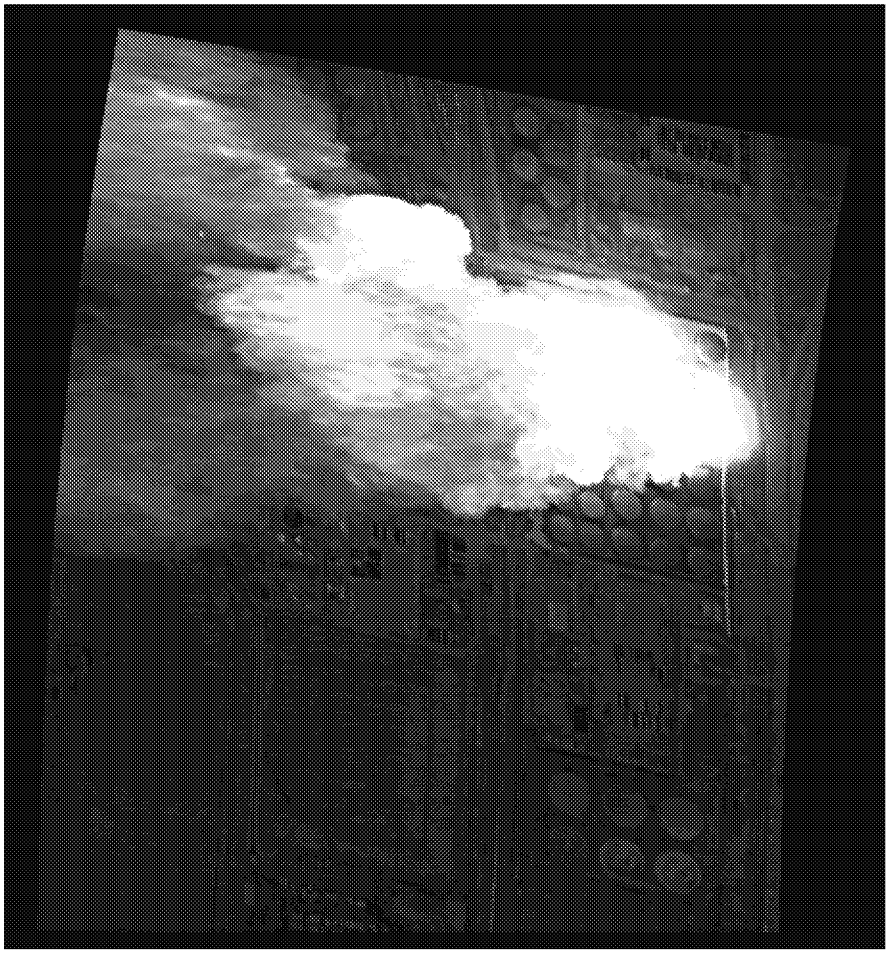

Figure 5: IR image ITC, 19 March 2019, Run 6

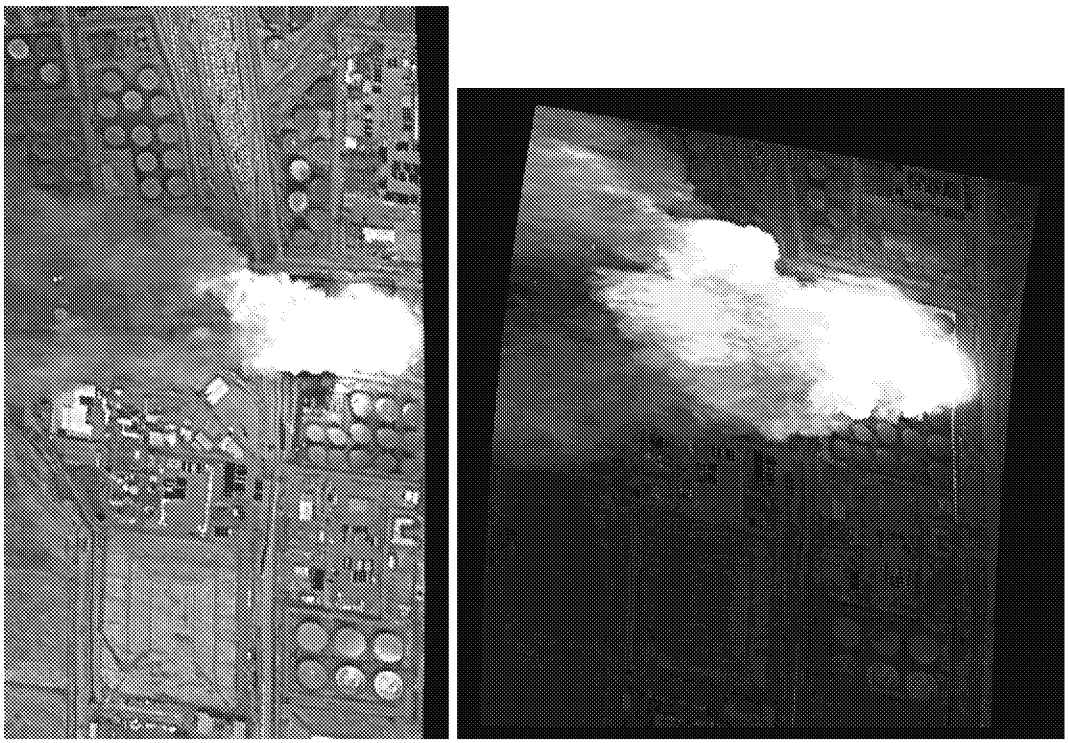

Figure 6: – Image comparison between 18 and 19 March 2019, ITC Fire

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. An examination of FTIR data collected on this mission showed no significant detections. For reference purposes, a summary table is provided in table 4.

Table 3. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	19 March 2019	0830	Test	Test
2		0834	Test	Test
3		0855	ND	None
4		0900	ND	None
5		0904	ND	None
6		0907	ND	None
7		0911	ND	None
8		0914	ND	None

9		0818	ND	None
10		0911	ND	None
11		0916	ND	None
12		0924	ND	None
ND – Non-detect				

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 7 shows a representative overhead image collected as part of each pass. Figure 8 illustrates a typical oblique image. Both images confirm the finding that the fire is much more involved than on prior days with most of the tanks in the tank farm on fire.

Figure 7: Aerial Image of the ITC Fire, Flight 3

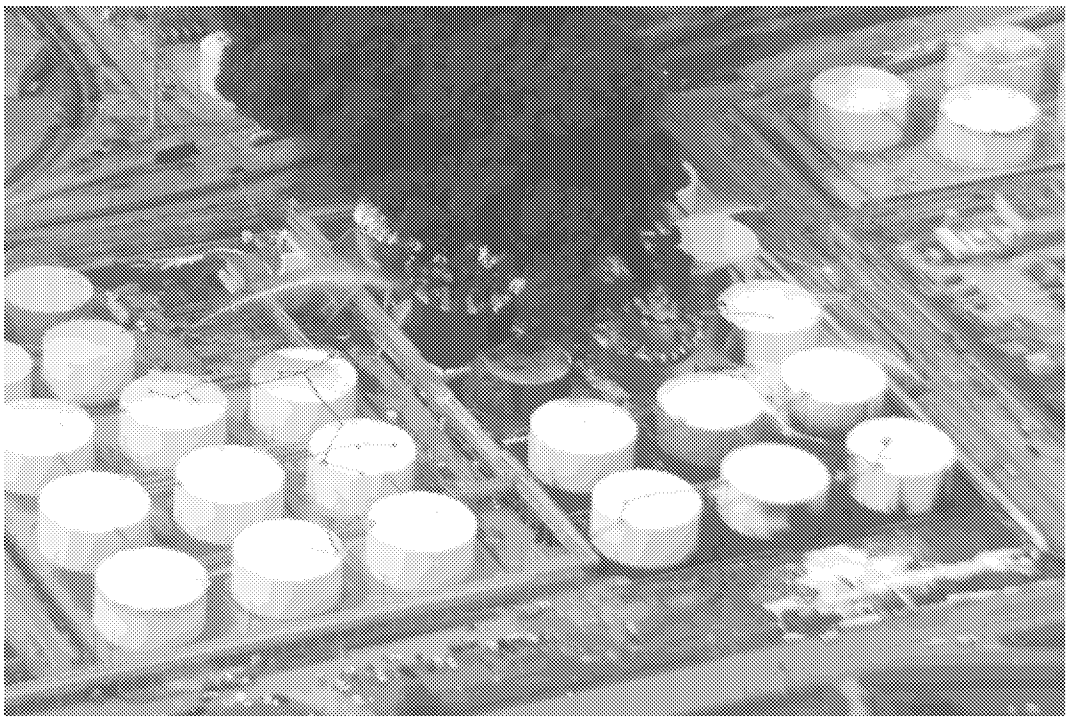

Figure 8: Oblique Image of the ITC Fire, Flight 3

Conclusions

ASPECT conducted a third flight over the ITC fire on 19 March 2019. Analysis of data indicated that the fire has grown as evident 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.

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: 2019-03-19 ITC Fire

Date: 3/19/2019

Time UTC: 13:15

Aircraft Number: N9738B

Pilot: Todd Seale

Copilot: Beorn Ledger

Operator: Steven Brister

Aft Operator: Jimmy Crisp

Ground Controller: Mark Thomas

DEM: Using elevation from DEM Database

Run: 1 Time: 13:30:06 UTC

Alt: 2953 ft MSL Elev: 258 ft Elevation from DEM Database

Vel: 145 knots Heading: 127

Digitals: None

MSIC: 4

20190319133012530.jpg

20190319133018894.jpg

20190319133025242.jpg

20190319133027051.jpg

FTIR: 1

20190319_133009_A.igm

IRLS: 1

2019_03_19_13_30_10_R_01 TA=5.0;TB=25.0;Gain=3

Gamma Runs: None

Run: 2 Time: 13:34:59 UTC

Alt: 3008 ft MSL Elev: 234 ft Elevation from DEM Database

Vel: 141 knots Heading: 116

Digitals: None

MSIC: 4

20190319133505736.jpg

20190319133512100.jpg

20190319133518448.jpg

20190319133525717.jpg

FTIR: 1

20190319_133503_A.igm

IRLS: 1

2019_03_19_13_35_04_R_02 TA=-1.0;TB=18.9;Gain=3

Gamma Runs: None

Run: 3 Time: 13:55:42 UTC

Alt: 2723 ft MSL Elev: 16 ft Elevation from DEM Database

Vel: 121 knots Heading: 199

Digitals: None

MSIC: 5

20190319135548523.jpg

20190319135554872.jpg

20190319135601236.jpg

20190319135607584.jpg

20190319135613044.jpg

FTIR: 1

20190319_135545_A.igm

IRLS: 1

2019_03_19_13_55_46_R_03 TA=-1.7;TB=18.3;Gain=3

Gamma Runs: None

Run: 4 Time: 14:00:17 UTC

Alt: 2803 ft MSL Elev: 14 ft Elevation from DEM Database

Vel: 128 knots Heading: 200

Digitals: None

MSIC: 6

20190319140023588.jpg

20190319140029952.jpg

20190319140036301.jpg

20190319140042665.jpg

20190319140049918.jpg

20190319140051728.jpg

FTIR: 1

20190319_140021_A.igm

IRLS: 1

2019_03_19_14_00_22_R_04 TA=5.5;TB=25.4;Gain=3

Gamma Runs: None

Run: 5 Time: 14:04:09 UTC

Alt: 2992 ft MSL Elev: 16 ft Elevation from DEM Database

Vel: 108 knots Heading: 177

Digitals: None

MSIC: 5

20190319140415990.jpg

20190319140422354.jpg

20190319140428703.jpg

20190319140435067.jpg

20190319140441416.jpg

FTIR: 1

20190319_140412_A.igm

IRLS: 1

2019_03_19_14_04_14_R_05 TA=5.0;TB=25.1;Gain=3

Gamma Runs: None

Run: 6 Time: 14:07:53 UTC

Alt: 2678 ft MSL Elev: 26 ft Elevation from DEM Database

Vel: 114 knots Heading: 169

Digitals: None

MSIC: 3

20190319140759315.jpg

20190319140805679.jpg

20190319140812028.jpg

FTIR: 1

20190319_140755_A.igm

IRLS: 1

2019_03_19_14_07_57_R_06 TA=5.6;TB=25.5;Gain=3

Gamma Runs: None

Run: 7 Time: 14:11:09 UTC

Alt: 2876 ft MSL Elev: 25 ft Elevation from DEM Database

Vel: 112 knots Heading: 174

Digitals: None

MSIC: 4

20190319141115405.jpg

20190319141121769.jpg

20190319141128118.jpg

20190319141134467.jpg

FTIR: 1

20190319_141112_A.igm

IRLS: 1

2019_03_19_14_11_14_R_07 TA=5.5;TB=25.5;Gain=3

Gamma Runs: None

Run: 8 Time: 14:14:44 UTC

Alt: 3254 ft MSL Elev: 14 ft Elevation from DEM Database

Vel: 134 knots Heading: 194

Digitals: None

MSIC: 5

20190319141450559.jpg

20190319141456924.jpg

20190319141503272.jpg

20190319141509637.jpg

20190319141515985.jpg

FTIR: 1

20190319_141446_A.igm

IRLS: 1

2019_03_19_14_14_49_R_08 TA=5.5;TB=25.5;Gain=3

Gamma Runs: None

Run: 9 Time: 14:18:23 UTC

Alt: 2689 ft MSL Elev: 18 ft Elevation from DEM Database

Vel: 120 knots Heading: 175

Digitals: None

MSIC: 3

20190319141829349.jpg

20190319141835713.jpg

20190319141842062.jpg

FTIR: 1

20190319_141826_A.igm

IRLS: 1

2019_03_19_14_18_28_R_09 TA=3.3;TB=23.5;Gain=3

Gamma Runs: None

Run: 10 Time: 15:11:10 UTC

Alt: 10029 ft MSL Elev: 14 ft Elevation from DEM Database

Vel: 141 knots Heading: 216

Digitals: None

MSIC: 12

20190319151115939.jpg

20190319151122304.jpg

20190319151128653.jpg

20190319151135018.jpg

20190319151141366.jpg

20190319151147715.jpg

20190319151154985.jpg

20190319151201334.jpg

20190319151207698.jpg

20190319151214047.jpg

20190319151220412.jpg

20190319151226761.jpg

FTIR: 2

20190319_151112_A.igm

20190319_151152_A.igm

IRLS: 1

2019_03_19_15_11_15_R_10 TA=3.8;TB=23.8;Gain=3

Gamma Runs: None

Run: 11 Time: 15:16:36 UTC

Alt: 10174 ft MSL Elev: 31 ft Elevation from DEM Database

Vel: 144 knots Heading: 42

Digitals: None

MSIC: 15

20190319151641874.jpg

20190319151649128.jpg

20190319151655493.jpg

20190319151701842.jpg

20190319151708206.jpg

20190319151714555.jpg

20190319151720904.jpg

20190319151727269.jpg

20190319151733618.jpg

20190319151739982.jpg

20190319151746331.jpg

20190319151752680.jpg

20190319151759045.jpg

20190319151805394.jpg

20190319151812663.jpg

FTIR: 3

20190319_151639_A.igm

20190319_151718_A.igm

20190319_151757_A.igm

IRLS: 1

2019_03_19_15_16_41_R_11 TA=3.7;TB=23.7;Gain=3

Gamma Runs: None

Run: 12 Time: 15:24:18 UTC

Alt: 10014 ft MSL Elev: 55 ft Elevation from DEM Database

Vel: 118 knots Heading: 207

Digitals: None

MSIC: 19

20190319152423978.jpg

20190319152431247.jpg

20190319152437596.jpg

20190319152443961.jpg

20190319152450310.jpg

20190319152456659.jpg

20190319152503023.jpg

20190319152509372.jpg

20190319152515721.jpg

20190319152522086.jpg

20190319152528435.jpg

20190319152535704.jpg

20190319152542053.jpg

20190319152548418.jpg

20190319152554767.jpg

20190319152601116.jpg

20190319152607480.jpg

20190319152613829.jpg

20190319152620194.jpg

FTIR: 4

20190319_152421_A.igm

20190319_152500_A.igm

20190319_152539_A.igm

20190319_152618_A.igm

IRLS: 1

2019_03_19_15_24_24_R_12 TA=2.2;TB=22.0;Gain=3

Gamma Runs: None

Mission Complete: 15:37 (UTC)