Field Report for Airborne Data Collected In Support of US EPA Region 6 South 4 Group Fire 04 December 2019

Background

On 27 November 2019 an explosion and subsequent fire was reported at the South 4 Group facility located near Port Neches, TX. Local information indicated that at approximately 0100 (central) a large explosion rocked the area. The explosion subsequently caused a massive fire at the facility in a short amount of time. Local officials ordered an initial evacuation of 0.5 miles on 27 November 2019 which was extended to 4 miles around 1430 (central). The evacuation order was lifted at 1000 (central) on 29 November 2019. Reported onsite products include various olefins, butadiene, and isobutylene. The geographical coordinates of the facility are 29.9222N, 95.0547W (figure 1).

The US EPA Region 6 requested that the ASPECT system be deployed to provide monitoring support beginning on 27 November 2019. This report summarizes findings observed during the two missions flown on 04 December 2019.

Figure 1: South 4 Group Facility, Port Neches, TX

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

On 27 November 2019 ASPECT was dispatched to collect aerial remote sensing data over the South 4 Group facility located near Port Neches, TX and conducted three data collection missions. An explosion and fire involving a production unit and subsequent tank farms resulted in a black plume moving toward the south. Reports from the air crew indicated that significant lofting was occurring with smoke reaching 4000 feet above ground. Collected spectral data from both the IRLS and FTIR did not show any chemical detections. Data analysis from the second and third mission showed consistency to that of the first with the presence of a large thermal signature with the absence of detected compounds.

Due to poor weather and very low ceilings, ASPECT was only able to collect a few oblique images on 28 November 2019 and did not fly at all due to poor weather on 29 November 2019. On 30 November 2019 ASPECT collected aerial remote sensing data over the South 4 Group facility located near Port Neches, TX. Analysis of FTIR data did not show any chemical detections. IR image analysis showed the presence of elevated temperatures within the reactor complex, but the magnitude was substantially reduced from prior missions. Visible imagery showed only a light grey plume being generated at the facility with no active fires immediately visible. Damage to the facility and nearby spherical tanks was clear in the aerial and obliques images.

ASPECT conducted two flights on 01 December 2019. Analysis of IR imagery collected during the morning flight on 01 December 2019 indicated that isolated elevated thermal locations still exist within the production unit. Visible imagery confirmed that crew reports of light gray smoke was being emitted from the facility and was moving in an easterly direction. FTIR data collected in the vicinity of the facility showed one detection of isobutylene near the Orchard Ave bridge. The estimated concentration was about 1 ppm. Analysis of IR imagery of the junction of the waterway east of the facility which intersects with the Naches River showed no evidence of oil sheen. The afternoon showed a low thermal environment within the process unit and minimal smoke being emitted from the site. The analysis of imagery showed that four water cannons were being employed at the facility. IR imagery did not show any oil sheen presence on the Neches River. Analysis of FTIR data showed detections of isobutylene south of the facility near the wastewater treatment plant. These detections were approximately 1.7 ppm on two separate passes.

Analysis of IR imagery collected during the morning flight on 02 December 2019 indicated that very little thermal content was present in the process unit other than one fire on the north side of the unit. Visible imagery showed one water cannon in operation and light gray smoke being emitted from the facility due to the one fire. There were no chemical detections in the proximity of the facility. Analysis IR imagery of the junction of the waterway east of the facility which intersects with the Naches River showed no evidence of oil sheen. Flight 11 conducted on the afternoon of 02 December 2019 showed one fire on the northern edge of the process unit. A light gray smoke plume was still being emitted and at the time of the flight moving toward the southeast. Several of the reactor towers tended to show elevated temperatures as compared to the surrounding unit. IR imagery did not show any oil sheen presence on the Neches River but did

suggest that water flow is going into the river. Analysis of FTIR data showed detections of isobutylene south of the facility near the wastewater treatment plant. These detections were approximately 1.57 ppm on two separate passes.

Analysis of IR imagery collected during the morning flight on 03 December 2019 showed no high temperature locations suggesting that no fire was present in the process unit. Overhead visible imagery showed at the time of collection one cannon directed on the northern portion of the unit. Oblique imagery showed 5 cannons being used over a large portion of the facility. No smoke was observed by either the crew or analysis of imagery. There were no chemical detections in the proximity of the facility. Analysis IR imagery of the junction of the waterway east of the facility which intersects with the Naches River showed on evidence of oil sheen. Data collected on the afternoon flight did show the presence of 1,3-butadiene and aromatics 1300 meters west of the facility. Detected levels were approximately 0.93 ppm for 1,3-butadiene and less than 1 ppm for aromatics.

As part of the continuing South 4 Group fire response, ASPECT was requested by Region 6 to conduct a data collection flights downwind, upwind, up the wind axis in reference to the facility and over adjacent residential areas. An afternoon flight focused on collecting data up and downwind of the facility in addition to the waterway leading into the Naches River. This report details results and information from those missions.

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 can 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 enough 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 later.

All high resolution digital aerial photographic images collected by the ASPECT system are ortho-rectified and geospatially validated by the reach back 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 reach back team for QA/QC analysis. Upon landing preliminary data results are examined and validated by the reach back team.

Flight Results for Flight 12, 4 December 2019

Weather Conditions and Crew Report

Weather for the morning mission are given in table 1.

Table 1. South 4 Group Mission Weather

Parameter	Surface (0900)	Surface (1000)	Surface (1100)
Wind direction	000 degrees	000 degrees	000 degrees
Wind speed	3.2 m/s (7 mph)	4.0 m/s (9 mph)	2.7 m/s (6 mph)
Temperature	14.4°C	17°C	19.4°C
Humidity	81%	63%	52%
Dew Point	11.1°C	10°C	9.4°C
Pressure	1019 mb	1019 mb	1019
Ceiling	Clear	Clear	Clear

The crew reported that winds at altitude (2800 ft) were at about 9 kts (4.6 m/s) from 340 degrees. There was no visible plume leaving the site. The crew reported that one cannon was being to cool a spherical tank south of the process unit.

Flight Status

The order to launch flight 14 was given at 0900 central on 4 December 2019 with the aircraft reporting wheels up at 0920. The initial data collection run over the site was at

0944 (central) The aircraft made a total of 9 data collection passes; flight information is summarized in Appendix Flight #14 and Figure 2.

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.

Figure 2: Data collection passes, Flight 14, South 4 Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

Line Scanner Data Results

A total of 1 test and 8 data collection passes were made in the proximity of the fire and an infrared line scanner image was generated for each pass. Figure 3 shows a typical 3-band infrared image obtained from data collected for Run 2. The thermal environment of the unit continues to be low. At the time of the IR collection, a water cannon was

being used to spray a spherical tank south of the production unit, but no water was being applied to the unit proper. No emissions were detected in the IR imagery. Figure 4 shows a close-up thermal analysis of the production facility. Solar heating of tanks and metal surfaces is evident in the image. A cool spray of water can be seen being directed to a spherical tank south of the unit with that tank much cooler than the neighboring vessels. No significantly elevated temperature sources are present in the image.

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 is 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.

There were no chemical detections on the morning mission. A summary of data of the data collection is given in table 3.

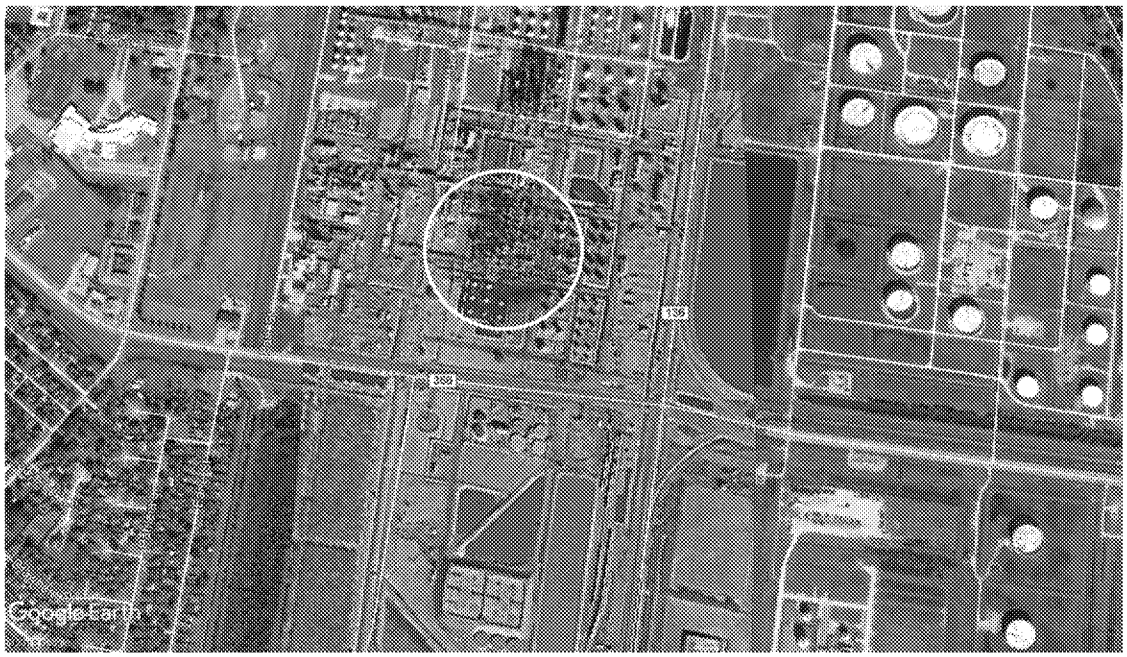

Figure 3: – 3 band IR image, Flight 14, Run 8, South 4 Group Fire

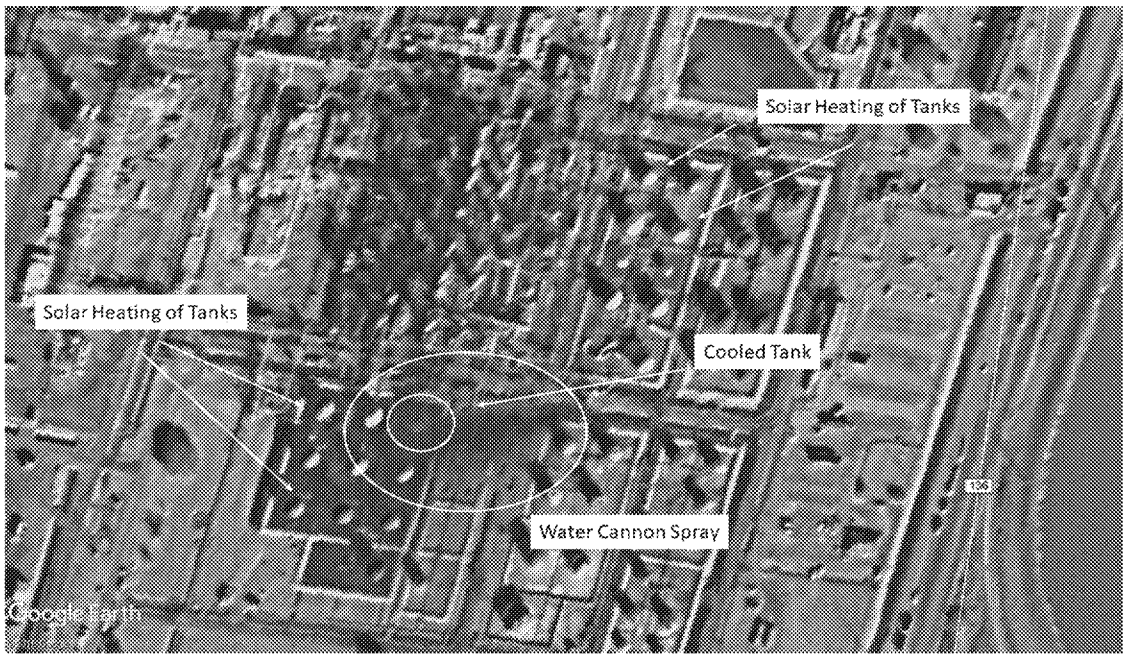

Figure 4: -- 3 band IR Image, Flight 14, Run 7, South 4 Group Thermal Image

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	4 Dec 2019	1533	Test	Test
2		1544	ND	None
3		1548	ND	None
4		1554	ND	None
5		1559	ND	None
6		1604	ND	None
7		1609	ND	None
8		1614	ND	None
9		1619	ND	None
Note: ND = No Detections				

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 5 shows a representative image collected as part of each pass. Smoke is not evident in the image and only one water cannon can be observed being directed on the spherical tank south of the unit. The oblique image in Figure 6 shows a detail of the cannon use on the spherical tank.

Conclusions – Flight 14

Analysis of IR imagery collected during the morning flight on 4 December 2019 no elevated temperature sources other than local solar heating of metal surfaces. Analysis of imagery showed no indication of an active fire. Aerial imagery showed one cannon being employed to spray a spherical tank south of the production unit. No smoke or emissions were detected in any imagery. Analysis of FTIR data showed no detections over and in the vicinity of the facility.

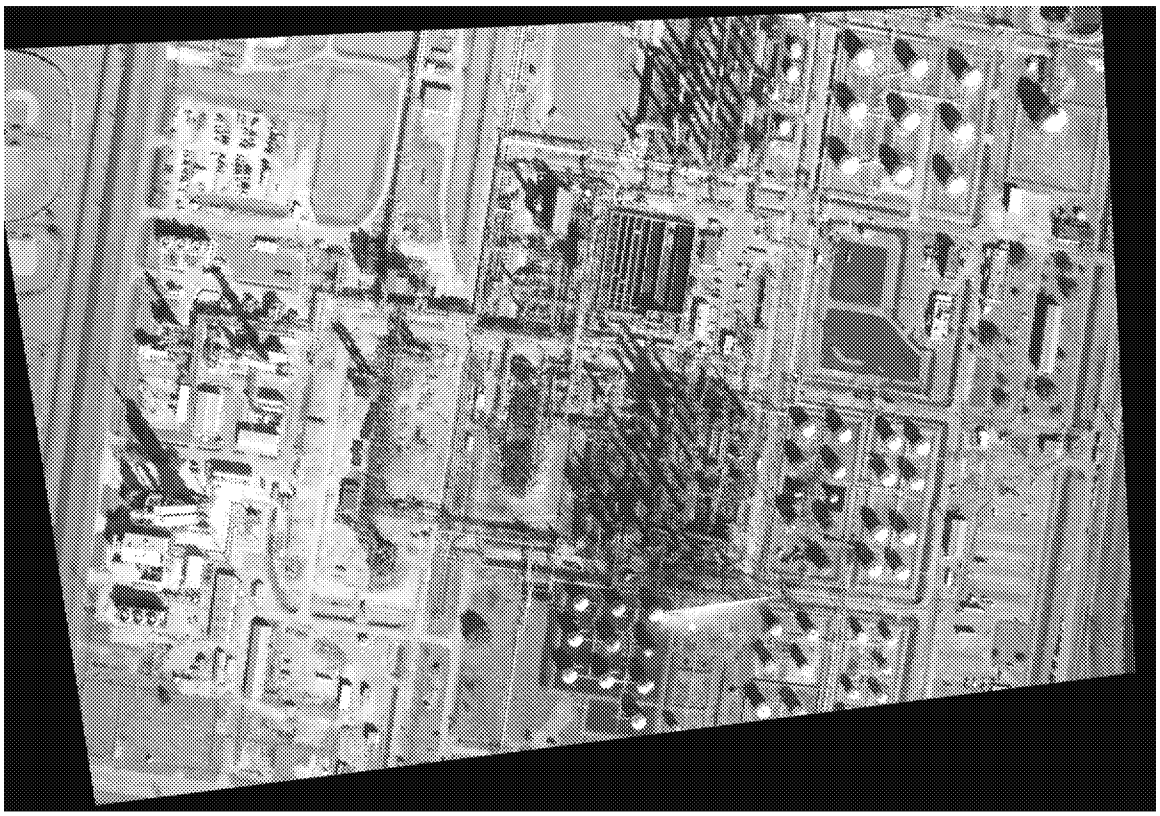

Figure 5: Aerial Image, Flight 14, Run 6, South 4 Group Fire.

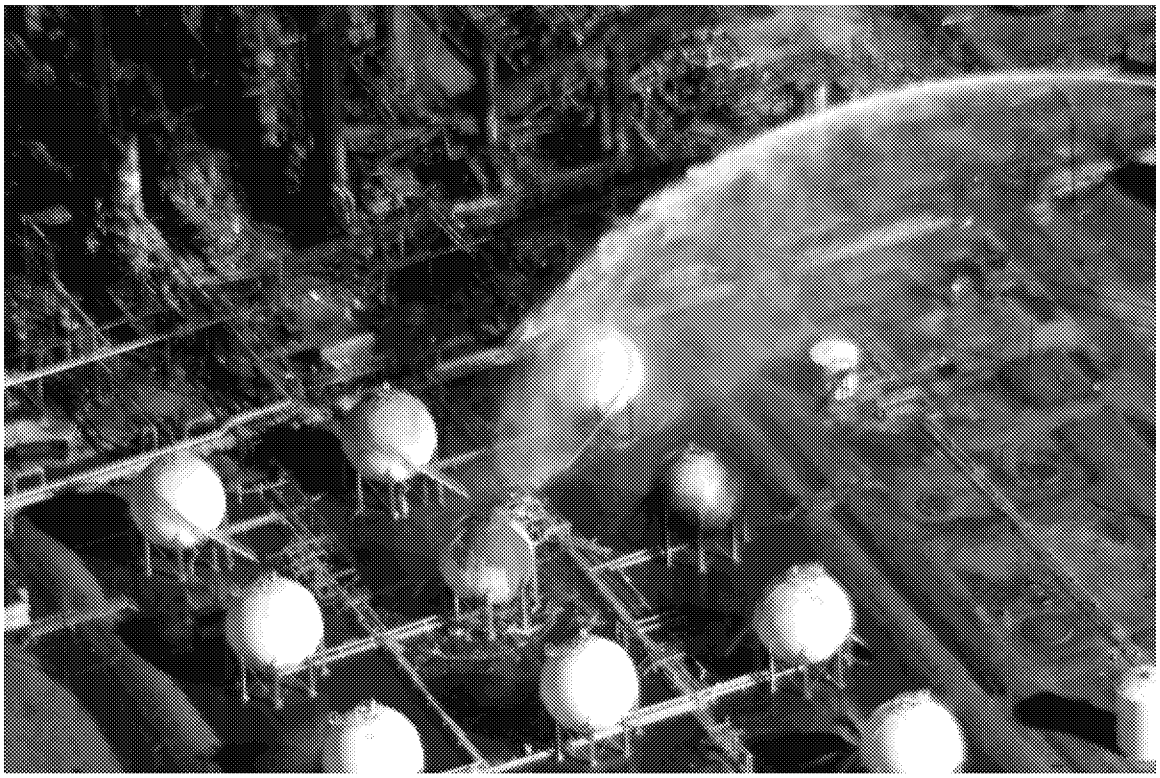

Figure 6: Oblique Image of the South 4 Group Fire

Appendix Flight #14

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:   2019-12-04 South 4 Group Fire

Date:      12/4/2019
Time UTC: 15:27

Aircraft Number: N9738B
Pilot: Todd Seale
Copilot: James Glaviano
Operator: James Crisp
Aft Operator: Gerry Broyles
Ground Controller: Ahmed Hafez

DEM: Using elevation from DEM Database
-------------------------------------------------------------------

Run: 1 Time: 15:33:47 UTC
        Alt: 2777 ft MSL  Elev: -1 ft  Elevation from DEM Database
        Vel: 130 knots  Heading: 287

Digitals:  None
MSIC: 3
        20191204153353814.jpg
        20191204153400163.jpg
        20191204153406528.jpg
FTIR: 1
        20191204_153351_A.igm
IRLS: 1
        2019_12_04_15_33_51_R_01 TA=10.9;TB=30.8;Gain=3
```

Gamma Runs: None

Run: 2 Time: 15:44:25 UTC
Alt: 2725 ft MSL Elev: 8 ft Elevation from DEM Database
Vel: 103 knots Heading: 80

Digitals: None
MSIC: 4
20191204154431162.jpg
20191204154438416.jpg
20191204154444781.jpg
20191204154451130.jpg
FTIR: 1
20191204_154430_A.igm
IRLS: 1
2019_12_04_15_44_29_R_02 TA=9.0;TB=29.0;Gain=3
Gamma Runs: None

Run: 3 Time: 15:48:18 UTC
Alt: 2690 ft MSL Elev: 7 ft Elevation from DEM Database
Vel: 104 knots Heading: 277

Digitals: None
MSIC: 8
20191204154824491.jpg
20191204154830840.jpg
20191204154837205.jpg
20191204154843554.jpg
20191204154849919.jpg
20191204154856268.jpg
20191204154902617.jpg
20191204154907157.jpg
FTIR: 2
20191204_154820_A.igm
20191204_154859_A.igm
IRLS: 1
2019_12_04_15_48_22_R_03 TA=8.6;TB=28.6;Gain=3
Gamma Runs: None

Run: 4 Time: 15:54:23 UTC
Alt: 2768 ft MSL Elev: 8 ft Elevation from DEM Database
Vel: 103 knots Heading: 80

Digitals: None
MSIC: 4
20191204155429469.jpg
20191204155435818.jpg
20191204155442183.jpg

```
        20191204155448532.jpg
FTIR: 1
        20191204_155427_A.igm
IRLS: 1
        2019_12_04_15_54_27_R_04 TA=8.7;TB=28.7;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 5 Time: 15:59:03 UTC
        Alt: 2765 ft MSL  Elev: 4 ft  Elevation from DEM Database
        Vel: 102 knots  Heading: 80

Digitals:  None
MSIC: 4
        20191204155909100.jpg
        20191204155915464.jpg
        20191204155922718.jpg
        20191204155929083.jpg
FTIR: 1
        20191204_155906_A.igm
IRLS: 1
        2019_12_04_15_59_07_R_05 TA=8.8;TB=28.8;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 6 Time: 16:04:37 UTC
        Alt: 2717 ft MSL  Elev: 7 ft  Elevation from DEM Database
        Vel: 100 knots  Heading: 79

Digitals:  None
MSIC: 4
        20191204160443220.jpg
        20191204160449570.jpg
        20191204160456824.jpg
        20191204160503188.jpg
FTIR: 1
        20191204_160441_A.igm
IRLS: 1
        2019_12_04_16_04_41_R_06 TA=8.3;TB=28.3;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 7 Time: 16:09:15 UTC
        Alt: 2783 ft MSL  Elev: 6 ft  Elevation from DEM Database
        Vel: 103 knots  Heading: -2

Digitals:  None
MSIC: 5
        20191204160921026.jpg
        20191204160928296.jpg
        20191204160934645.jpg
```

```
        20191204160941010.jpg
        20191204160945549.jpg
FTIR: 1
        20191204_160919_A.igm
IRLS: 1
        2019_12_04_16_09_20_R_07 TA=8.9;TB=28.9;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 8 Time: 16:14:15 UTC
        Alt: 2839 ft MSL  Elev: 5 ft  Elevation from DEM Database
        Vel: 106 knots  Heading: 82

Digitals:  None
MSIC: 8
        20191204161420640.jpg
        20191204161427909.jpg
        20191204161434259.jpg
        20191204161440608.jpg
        20191204161446973.jpg
        20191204161453322.jpg
        20191204161459687.jpg
        20191204161505131.jpg
FTIR: 2
        20191204_161419_A.igm
        20191204_161457_A.igm
IRLS: 1
        2019_12_04_16_14_19_R_08 TA=9.9;TB=29.9;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 9 Time: 16:19:37 UTC
        Alt: 2793 ft MSL  Elev: 9 ft  Elevation from DEM Database
        Vel: 109 knots  Heading: 82

Digitals:  None
MSIC: 7
        20191204161943857.jpg
        20191204161950206.jpg
        20191204161956571.jpg
        20191204162002920.jpg
        20191204162009285.jpg
        20191204162015634.jpg
        20191204162021984.jpg
FTIR: 2
        20191204_161940_A.igm
        20191204_162019_A.igm
IRLS: 1
        2019_12_04_16_19_41_R_09 TA=10.1;TB=30.1;Gain=3
Gamma Runs:  None
```

Flight Results for Flight 15, 4 December 2019

Weather Conditions and Crew Report

Weather for the mission is given in table 4.

Table 4. South 4 Group Mission Weather

Parameter	Surface (1400)	Surface (1500)
Wind direction	000 degrees	000 degrees
Wind speed	6.1 m/s (6 mph)	6.1 m/s (6 mph)
Temperature	23.3°C	23.3°C
Humidity	33%	31%
Dew Point	6.1°C	5°C
Pressure	1017 mb	1017
Ceiling	Clear	Clear

The crew reported that winds at altitude (2500 ft) were at about 8 kts (4 m/s) from the 350 degrees. Light to moderate turbulence was reported. No smoke was reported being generated by the site with a total of five water cannons in use.

Flight Status

The aircraft was airborne at 1415 (central) was over the site at 1433 (central). A total of 1 test and 9 data collection passes were completed. Flight information is summarized in Appendix Flight #14 and Figure 7.

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.

Figure 7: Data collection passes, Flight 15 South 4 Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

Line Scanner Data Results

A total of 1 test and 8 data collection passes were made in the proximity of the fire and an infrared line scanner image was generated for each pass. Figure 8 shows a 3-band infrared image obtained from data collected for Run 2. Examination of the image shows no significant elevated thermal locations on this collection pass. The white signatures seen on the tanks and metal structures are due to solar heating. No chemical plume was observed in the frame. Figure 9 shows a close-up of the process unit collected on Run 5. The most significant signature is that of the water spray and the cooling effect for the entire process unit. It should be noted that the water spray on the spherical tank has cooled to the tank to the same approximate temperature as the water. To check for possible oil sheen presence on the Naches River, ASPECT was flown along the waterway leading into the river. Figure 10 shows an IR image of the waterway/river confluence with no signature of oil sheen.

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 is given in Table 5. In addition, collected data are also manually analyzed by comparing any detected spectral signatures to a collection of published library spectra.

There were no chemical detections on the morning mission. A summary of data of the data collection is given in table 6.

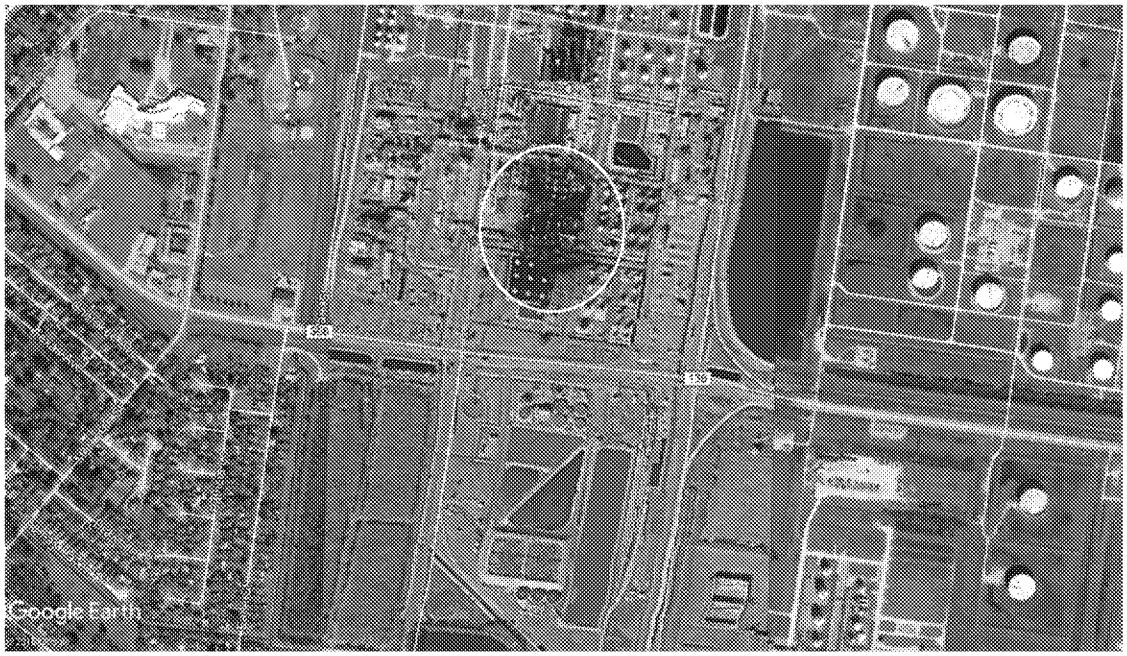

Figure 8: – 3 band IR image, Flight 15, Run 2, South 4 Group Fire

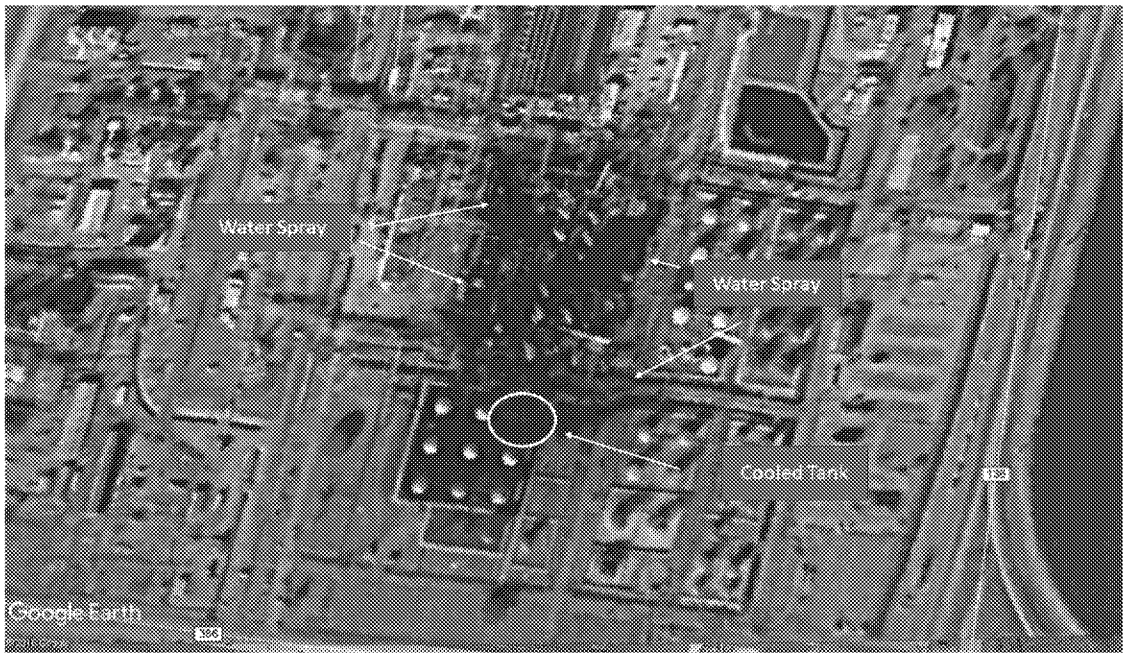

Figure 9: -- 3 band IR image, Flight 15, Run 5, South 4 Group Fire

Figure 10: -- 3 band IR image, Flight 15, Run 7, South 4 Group Fire

TABLE 5 - 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 6. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	04 Dec 2019	2025	Test	Test
2		2033	ND	None
3		2037	ND	None
4		2043	ND	None
5		2047	ND	None
6		2053	ND	None
7		2059	ND	None
8		2105	ND	None
9		2115	ND	None
Note: ND = No Detections				

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 11 shows a representative image collected as part of each pass. Visible data mirrors that of the IR in that no smoke can be seen being emitted from the facility. At the time of the visible collection, in a similar fashion as the morning flight no smoke was observed being emitted from the site. Oblique imagery does show that water cannons continue to be used to flood the process unit (figure 12).

Conclusions – Flight 15

Data collected on the afternoon 15 December 2019 indicated what appears to be solar heating of metal surfaces in the process unit and no signature of smoke or chemical emissions being generated by the process unit. Water cannons were observed on both flights with a spray being directed to a spherical tank south of the facility. Analysis of IR imagery collected at the confluence of the waterway and the Naches River showed no sheen signature.

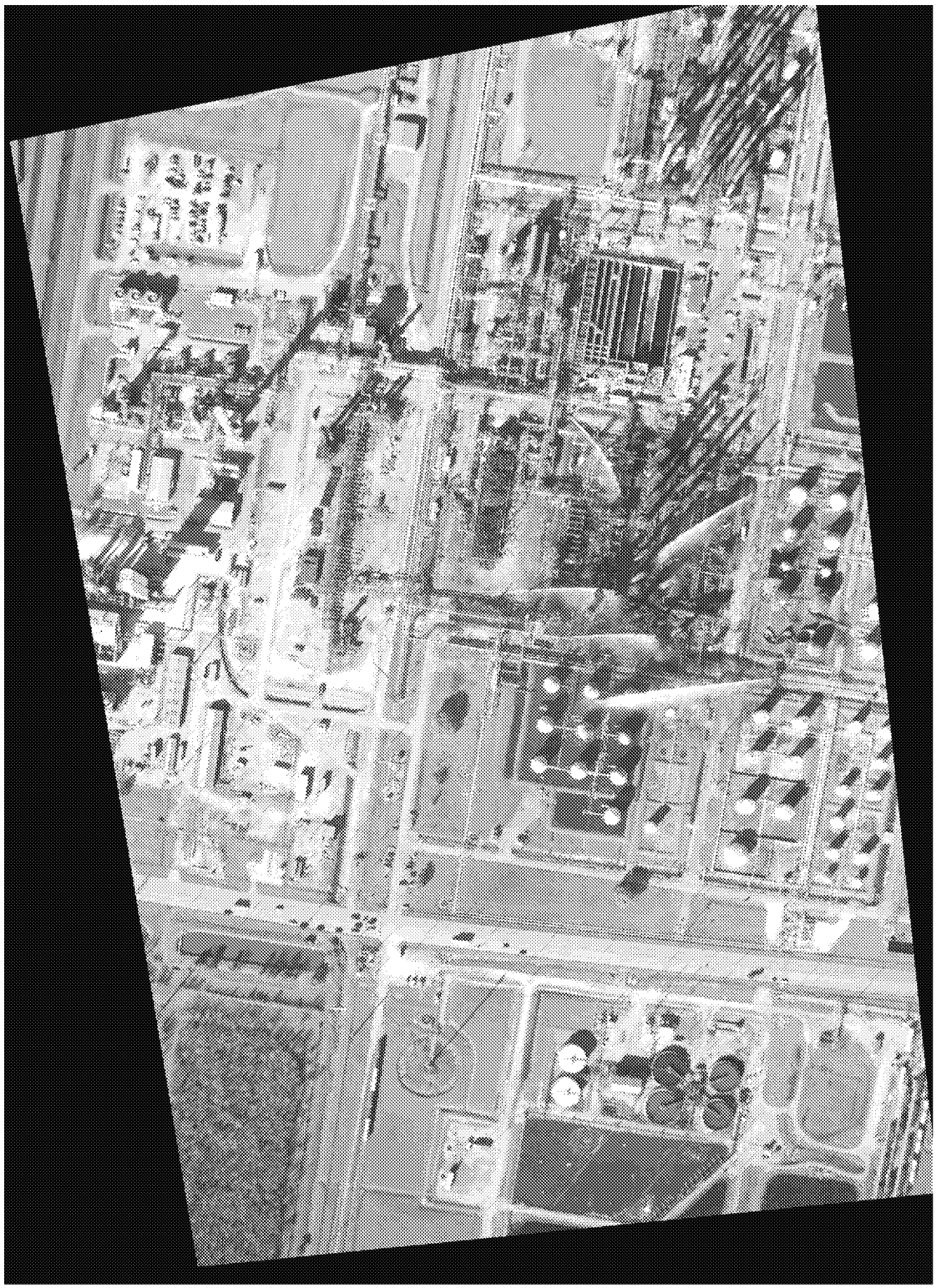

Figure 11: Aerial Image of the South 4Group Fire, Flight 15

Figure 12: Oblique Image of the South 4Group Fire, Flight 15

Appendix Flight #15

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:   2019-12-04 South 4 Group Fire

Date:      12/4/2019
Time UTC: 20:15

Aircraft Number: N9738B
Pilot: Todd Seale
Copilot: James Glaviano
Operator: James Crisp
Aft Operator: Gerry Broyles
Ground Controller: Ahmed Hafez

DEM: Using elevation from DEM Database
-------------------------------------------------------------------

Run: 1 Time: 20:25:33 UTC
        Alt: 2801 ft MSL  Elev: 4 ft  Elevation from DEM Database
        Vel: 137 knots  Heading: 318

Digitals:  None
MSIC: 3
        20191204202539996.jpg
        20191204202546360.jpg
        20191204202552709.jpg
FTIR: 1
        20191204_202539_A.igm
IRLS: 1
        2019_12_04_20_25_38_R_01 TA=19.0;TB=39.0;Gain=3
Gamma Runs:  None

-------------------------------------------------------------------

Run: 2 Time: 20:33:31 UTC
```

```
        Alt: 2811 ft MSL  Elev: 8 ft  Elevation from DEM Database
        Vel: 104 knots  Heading: 82

Digitals:  None
MSIC: 4
        20191204203337535.jpg
        20191204203343883.jpg
        20191204203351153.jpg
        20191204203357502.jpg
FTIR: 1
        20191204_203334_A.igm
IRLS: 1
        2019_12_04_20_33_36_R_02 TA=16.7;TB=36.7;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 3 Time: 20:37:23 UTC
        Alt: 2726 ft MSL  Elev: 7 ft  Elevation from DEM Database
        Vel: 103 knots  Heading: 272

Digitals:  None
MSIC: 8
        20191204203729950.jpg
        20191204203736299.jpg
        20191204203742663.jpg
        20191204203749012.jpg
        20191204203755361.jpg
        20191204203801726.jpg
        20191204203808980.jpg
        20191204203815344.jpg
FTIR: 2
        20191204_203728_A.igm
        20191204_203806_A.igm
IRLS: 1
        2019_12_04_20_37_28_R_03 TA=17.5;TB=37.5;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 4 Time: 20:43:07 UTC
        Alt: 2874 ft MSL  Elev: 5 ft  Elevation from DEM Database
        Vel: 102 knots  Heading: 85

Digitals:  None
MSIC: 7
        20191204204313126.jpg
        20191204204319475.jpg
        20191204204325839.jpg
        20191204204332188.jpg
        20191204204338537.jpg
        20191204204344902.jpg
        20191204204351251.jpg
FTIR: 2
```

```
        20191204_204309_A.igm
        20191204_204348_A.igm
IRLS: 1
        2019_12_04_20_43_11_R_04 TA=16.6;TB=36.6;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 5 Time: 20:47:50 UTC
        Alt: 2898 ft MSL  Elev: 6 ft  Elevation from DEM Database
        Vel: 104 knots  Heading: 0

Digitals:  None
MSIC: 4
        20191204204757284.jpg
        20191204204803633.jpg
        20191204204809998.jpg
        20191204204816347.jpg
FTIR: 1
        20191204_204754_A.igm
IRLS: 1
        2019_12_04_20_47_55_R_05 TA=16.4;TB=36.4;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 6 Time: 20:53:51 UTC
        Alt: 2801 ft MSL  Elev: 9 ft  Elevation from DEM Database
        Vel: 106 knots  Heading: 81

Digitals:  None
MSIC: 8
        20191204205356805.jpg
        20191204205404059.jpg
        20191204205410423.jpg
        20191204205416772.jpg
        20191204205423137.jpg
        20191204205429486.jpg
        20191204205435835.jpg
        20191204205441295.jpg
FTIR: 2
        20191204_205354_A.igm
        20191204_205432_A.igm
IRLS: 1
        2019_12_04_20_53_56_R_06 TA=16.4;TB=36.4;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 7 Time: 20:59:43 UTC
        Alt: 2850 ft MSL  Elev: 2 ft  Elevation from DEM Database
        Vel: 107 knots  Heading: 43

Digitals:  None
```

```
MSIC: 5
        20191204205949058.jpg
        20191204205955423.jpg
        20191204210001772.jpg
        20191204210008121.jpg
        20191204210015390.jpg
FTIR: 1
        20191204_205947_A.igm
IRLS: 1
        2019_12_04_20_59_48_R_07 TA=16.8;TB=36.8;Gain=3
Gamma Runs:  None

-------------------------------------------------------------------

Run: 8 Time: 21:05:06 UTC
        Alt: 2879 ft MSL  Elev: 0 ft  Elevation from DEM Database
        Vel: 107 knots  Heading: 42

Digitals:  None
MSIC: 5
        20191204210512259.jpg
        20191204210519529.jpg
        20191204210525878.jpg
        20191204210532242.jpg
        20191204210538591.jpg
FTIR: 1
        20191204_210509_A.igm
IRLS: 1
        2019_12_04_21_05_11_R_08 TA=14.1;TB=34.1;Gain=3
Gamma Runs:  None

-------------------------------------------------------------------

Run: 9 Time: 21:15:40 UTC
        Alt: 2864 ft MSL  Elev: 7 ft  Elevation from DEM Database
        Vel: 107 knots  Heading: 13

Digitals:  None
MSIC: 9
        20191204211546872.jpg
        20191204211550507.jpg
        20191204211554142.jpg
        20191204211557761.jpg
        20191204211600491.jpg
        20191204211604125.jpg
        20191204211607744.jpg
        20191204211611379.jpg
        20191204211614109.jpg
FTIR: 1
        20191204_211543_A.igm
IRLS: 1
        2019_12_04_21_15_45_R_09 TA=9.0;TB=29.0;Gain=3
Gamma Runs:  None
```