Field Report for Airborne Data Collected In Support of US EPA Region 6 Intercontinental Terminals Company LLC Fire 9 April 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 30ºC to 40ºC 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 conducted a 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 indicated that the NW tanks in the tank farm were 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 showed a reduction in the amount of trapped product. Leakage was still present but in less amounts as on prior flights.

ASPECT conducted flight 15 on 28 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. The flight was impacted by isolated low level clouds. Imagery collected on this flight indicated that the NW tanks in the tank farm were at ambient temperature. IR and photographic data collected over the confluence area indicated that product was captured by the upstream boom and no significant boom leakage was present.

ASPECT conducted flight 16 on 31 March 2019. Imagery collected over the tank farms showed that six of the tanks in the farm are in the process of being removed. All structures were found to be at ambient temperature. IR and photographic data collected over the confluence area indicated that product continues to be present in the boom network with some leakage observed pushed against the ship channel boom. No compound detections were observed on this mission.

ASPECT conducted flight 17 on 1 April 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected over the tank farms showed a similar state as on the prior flight, namely that six of the tanks in the farm are in the process of being removed or collapsed. IR and photographic data collected over the confluence area indicated that product continues to be present in the boom network with some leakage. No compound detections were observed on the mission.

The tank farm, confluence and downwind areas were flown on the morning of 2 April 2019 as part of flight 18. Imagery collected over the tank farms showed a similar state as on the prior flights with no change in the character of the site or tanks. IR and photographic data collected over the confluence area indicated that product continues to be present in the boom network with some sheen leakage in the northeast most structure. No compound detections were observed on this mission.

ASPECT conducted flight 20 on 3 April 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected over the tank farms showed no significant change from the mission on 2 April 2019. IR and photographic data collected over the confluence area indicated that product continues to be present in the boom network with minor sheen leakage in the northeast most boom structure. No compound detections were observed on the mission.

On 8 April 2019 ASPECT conducted flight 21with the goal to conduct a general survey at the tank farm and downwind of the site. Low levels of isoprene (0.76 ppm), 1-butene (1.55 ppm) and 1, 3-butadiene (0.70 ppm) were detected upwind of the site. No

detections were observed on top or downwind of the tank farm. Imagery of the tank farm area indicated no significant change from the mission on 3 April 2019. IR and photographic data collected over the confluence area indicated that the amount of trapped product appears to be greatly reduced from the previous flight. Some material was present on the outside of the boom structure and may be channel debris. No sheen was observed in the imagery.

ASPECT was dispatched on 9 April 2019 to fly the tank farm, confluence and downwind areas. 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 22, 9 April 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 from 270 degrees at 5 kts (2.5 m/s). Minimal turbulence was encountered with no significant ground activity observed on the ground.

Table 1. ITC Fire Mission Weather 9 April 2019

Parameter	Surface (0930)
Wind direction	270 degrees
Wind speed	2.7 m/s
Temperature	23.3ºC
Humidity	66%
Dew Point	16.7ºC
Pressure	1016 mb
Ceiling	Unlimited

The time for lift-off was given as 0845. The aircraft was over the site at 0915 and collected a total of 5 data collection passes over the ITC site. Flight information is summarized in Appendix A and Figure 2.

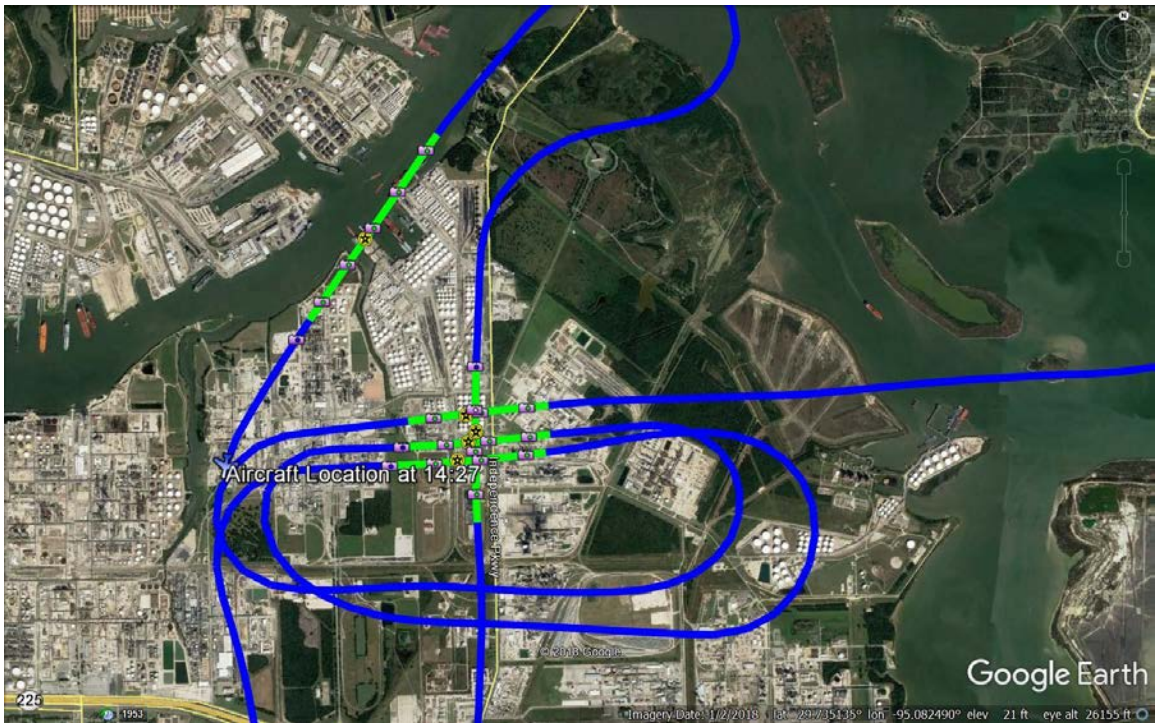

Figure 2: Flight line data for 9 April 2019, Flight 22. The blue lines represent the ASPECT flight path, green lines represent when the Infrared Line Scanner was actively collecting data, and the camera icons represent when a photo was taken.

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 5 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. It should be noted that due to a GPS constellation change (weeks since start), the flight log shows no IRLS collected. Data was collected and a software fix is being generated at this time. This change to the constellation only impacts the data header. Figure 3 shows a typical 3-band infrared image obtained from data collected for Run 5. Analysis of IR imagery of the tank farm shows no difference from data collected on 8 April 2019.

Figure 4 provides an IR image of the confluence area. Some product can be observed within the boom structure namely product pushed to south of each boom pocket. No change in the quantity of product from the flight on 8 April 2019 is evident. There does appear to be wide-spread sheen in the ship channel. The source is unclear since there appears to be no significant leakage from the booms suggesting that this may be native to the channel.

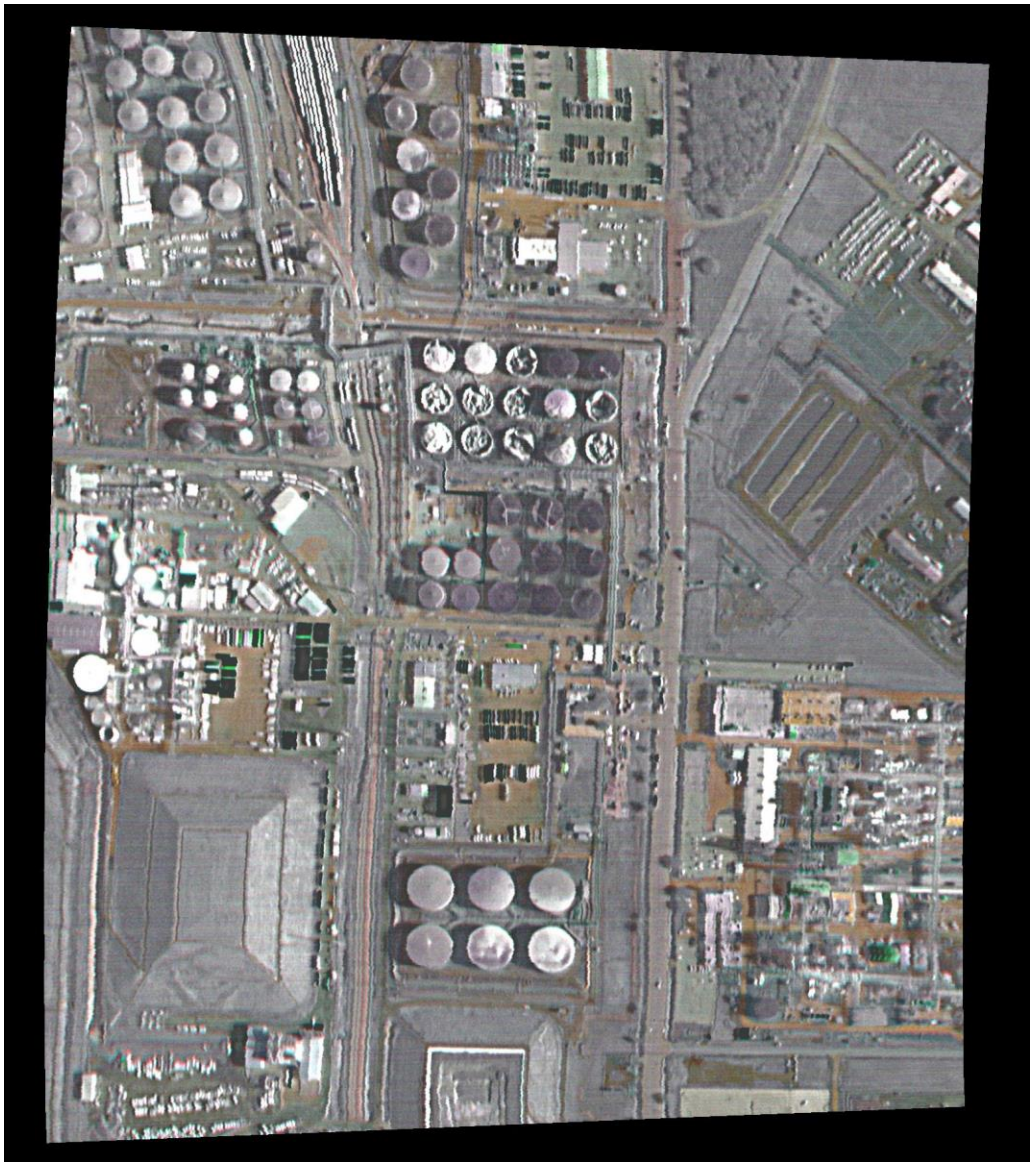

Figure 3: IR image of ITC data for 9 April 2019, Flight 22, Run 5

Figure 4: IR Image of Contained Oil 9 April 2019, Fight 22, Run 6

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.

No detections were observed during the mission. Details of the detection locations and data collection are given in Figure 5 and Table 3, respectively.

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 22

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	9 April 2019	0910	Test	Test
2		0915	ND	None
3		0918	ND	None
4		0921	ND	None
5		0923	ND	None
6		0926	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 5 and 6 show representative overhead images collected as part of each pass over the tank farm. As with the flight on 8 April 2019, the scene in both the aerial and oblique shows no significant change from prior flights.

The confluence area aerial image is given in figure 7. The image confirms a small amout of product in the boom structure. The oblique image (Figure 8) provides more detail and confirms the presence of dark product in both the drainage channel and the ship channel booms. No sheen is present in the image suggesting that the sheen observed in the IR is very light.

Figure 5: Aerial Image of the Tank Farm, 9 April 2019, Flight 22

Figure 6: Oblique Image of the Tank Farm (looking south), 9 April 2019 Flight 22

Figure 7: Aerial Image of the Ship Channel Boom Area, 9 April 2019, Flight 22

Figure 8: Oblique Image of the Ship Channel Boom Area, 9 April 2019, Flight 22

Conclusions

Findings from the ASPECT mission conducted on 9 April 2019 showed consistency with the flight conducted on 8 April 2019. As with prior flight the goals of the mission included conducting a general survey at the tank farm, downwind areas and the confluence area. No detections were noted on the mission. Imagery of the tank farm area indicated no significant change from the mission on 8 April 2019. IR data did show light sheen in the channel but the source of the sheen is unclear. No evidence of sheen was observed in the visible data.

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:   2019-04-09 Houston Refinery Fire

Date:      4/9/2019
Time UTC: 14:02

Aircraft Number: N9738B
Pilot: Beorn Ledger
Copilot: Todd Seale
Operator: James Crisp
Aft Operator: Steve Brister
Ground Controller: Tim Curry

DEM: Using elevation from DEM Database
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Run: 1 Time: 14:10:56 UTC
        Alt: 3021 ft MSL  Elev: 12 ft  Elevation from DEM Database
        Vel: 115 knots  Heading: 260

Digitals:  None
MSIC: 3
        20190409141103032.jpg
        20190409141109381.jpg
        20190409141115746.jpg
FTIR: 1
        20190409_141100_A.igm
IRLS:  None
Gamma Runs:  None

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Run: 2 Time: 14:15:31 UTC
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        Alt: 2944 ft MSL  Elev: 16 ft  Elevation from DEM Database
        Vel: 113 knots  Heading: 266

Digitals:  None
MSIC: 3
        20190409141537214.jpg
        20190409141543579.jpg
        20190409141549928.jpg
FTIR: 1
        20190409_141535_A.igm
IRLS:  None
Gamma Runs:  None

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Run: 3 Time: 14:18:23 UTC
        Alt: 2860 ft MSL  Elev: 19 ft  Elevation from DEM Database
        Vel: 103 knots  Heading: 270

Digitals:  None
MSIC: 4
        20190409141829716.jpg
        20190409141836066.jpg
        20190409141842430.jpg
        20190409141848779.jpg
FTIR: 1
        20190409_141827_A.igm
IRLS:  None
Gamma Runs:  None

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

Run: 4 Time: 14:21:18 UTC
        Alt: 2954 ft MSL  Elev: 22 ft  Elevation from DEM Database
        Vel: 112 knots  Heading: 269

Digitals:  None
MSIC: 4
        20190409142124029.jpg
        20190409142130394.jpg
        20190409142136743.jpg
        20190409142143092.jpg
FTIR: 1
        20190409_142121_A.igm
IRLS:  None
Gamma Runs:  None

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Run: 5 Time: 14:23:51 UTC
        Alt: 2986 ft MSL  Elev: 20 ft  Elevation from DEM Database
        Vel: 103 knots  Heading: 356

Digitals:  None
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```
MSIC: 4
        20190409142358374.jpg
        20190409142404724.jpg
        20190409142411088.jpg
        20190409142417438.jpg
FTIR: 1
        20190409_142354_A.igm
IRLS:  None
Gamma Runs:  None

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Run: 6 Time: 14:26:19 UTC
        Alt: 2731 ft MSL  Elev: 1 ft  Elevation from DEM Database
        Vel: 108 knots  Heading: 218

Digitals:  None
MSIC: 6
        20190409142625450.jpg
        20190409142632720.jpg
        20190409142639069.jpg
        20190409142645434.jpg
        20190409142651783.jpg
        20190409142658132.jpg
FTIR: 1
        20190409_142623_A.igm
IRLS:  None
Gamma Runs:  None
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