Airborne
Spectral
Photometric
Environmental
Collection
Technology

ASPECT Hurricane Laura Assessment
Beaumont, Orange and Port Arthur, TX
28-30 August 2020

ASPECT TEAM

John Martin
  Project Officer/Planning Support
  Martin.John@EPA.gov
  214-789-1994

Jill Taylor
  Chemical/Photometric Lead
  Taylor.Jillianne@EPA.gov
  214-406-9896

Lyndsey Nguyen
  Radiation/Nuclear Lead
  Nguyen.Lyndsey@EPA.gov
  702-373-3756

ASPECT Mission Supporting:
Nicolas Brescia
Region 6 On-Scene Coordinator

Initial Mission Request
Bryant Smalley
Region 6 Section Chief
Readiness & Emergency Response Section

Table of Contents

Acronyms, Abbreviations, and Definitions

Alt	Altitude (in feet)
AGL	Above Ground Level
ASPECT	Airborne Spectral Photometric Environmental Collection Technology
cm	centimeter
CST	Central Standard Time
DEM	Digital Elevation Model
Digital	Digital photography file from the Nikon D2X camera
Flight #	Designates when a new flight has begun during the mission. Every time data is uploaded from the plane to the ground crew, a new flight number is given. This usually occurs at the end of the day—the next morning would have a new flight number—or mid-day when the plane is waiting for inclement weather to pass. The first numeral of the Flight number indicates the day of the response. The second numeral, a decimal place, indicates the Flight number for that day. For example, the second flight on the third day would be "Flight 3.2."
ft	feet
FTIR	Fourier Transform Infrared Spectrometer
FTP	File Transfer Protocol
igm	Spectral data format based on grams format
IR	Infrared
IRLS	Infrared Line Scanner
jpg	JPEG image format
kts	knots
Line #	Specific numbering system that corresponds to specific gps coordinates. Line numbers are assigned before the beginning of the first flight on the first day. Each line number can have multiple source names (e.g. facility names) within the line number—usually when facilities are close in a proximity to each other.
mph	miles per hour
Pass #	Corresponds to the number of "passes" over the designated line. Each line could have multiple passes in order to capture the data. Example of factors affecting data during a run where another pass is warranted include clouds appearing under the plane, turbulence, gust of wind, inclement weather, etc.
Run #	Numbering system for when the plane has flown over a line in chronological order for the day. For each flight, the run number starts over with number "1" for each day or when the plane lands. Run numbers can be test flights, the initial run (i.e. Pass #1), or a re-pass of a line (i.e. Pass #2, #3,…,etc.)
m/s	meters per second
MSIC	Digital photography file from the Imperx mapping camera
MSL	Mean Sea Level Altitude (in feet)
ppm	parts per million
UTC	Universal Time Coordinated

Executive Summary

Hurricane Laura made landfall near Cameron, LA on 27 August and moved north with the eye wall passing over Lake Charles. Damage to the area was extensive with peak wind gust reported as 132 mph. Due to the size of the cyclone, hurricane strength winds extended out from the eye over 50 miles which encompassed the areas of Port Arthur, Beaumont, and Orange. The ASPECT program was tasked by EPA Region 6 to conduct an assessment survey using the ASPECT airborne system over selected locations in these areas.

Flights were conducted on the 28th, 29th and 30th of August and encompassed a total of 52 data collection runs. Isoprene, a naturally occurring hydrocarbon, was detected on each flight. On the first flight conducted on 28 August (Flight #1.1), low levels of ammonia were detected in the Beaumont area at a concentration of 1.088 ppm. On the second flight of 28 August (Flight #1.2), 1-butene (1.406 ppm) and 1,3-butadiene (0.534 ppm) were detected in the Orange, TX area. A flight conducted on 29 August (Flight #2.1) focused on the Port Arthur area with isoprene being the only compound detected. The assessment was completed on August 30th (Flight #3.1) with the remaining locations in the Beaumont and Port Neches, TX area being surveyed. Two fugitive compounds were detected including 1-butene (maximum concentration of 1.250 ppm) and ethyl formate (maximum concentration of 1.690 ppm). IR imagery collected through the various flights did not show the presence of any chemical plumes. Photometric images for all runs were collected during the assessment of each site. All data from FTIR, IRLS, and photometric images is stored on the shared FTP site for the Region. Additional data products to meet Regional needs, including data products in different formats, can be requested at any time through any of the ASPECT Team members.

This report serves as the final complete mission report and should replace all previous draft versions.

ASPECT Hurricane Laura Assessment
Beaumont and Port Arthur, TX
30 August 2020

Background and Operational Overview

On 27 August 2020 Hurricane Laura made landfall near Cameron, LA and moved north with the eye wall passing over Lake Charles. Damage to the area was extensive with the peak wind gust reported as 132 mph. Due to the size of the cyclone, Hurricane strength winds extended from the eye out to over 50 miles encompassing the areas of Port Arthur, Beaumont, and Orange, TX. On the morning of 28 August, EPA Region 6 requested that ASPECT support an assessment mission to determine the character and nature of damage to facilities in the area. The assignment took 3 days to complete.

Table 1 outlines a complete list of runs for all three days. For a more detailed list of runs, number of passes for each line, and the corresponding line number for each source name (e.g. facility name), refer to Appendix D. For terms and descriptions used throughout the report, refer to Appendix E.

Table 1. Total Run Numbers for Each Flight by Date

Dates	Flight #	Total Number of Runs per Mission*
August 28, 2020	Flight 1.1	9
August 28, 2020	Flight 1.2	9
August 29, 2020	Flight 2.1	14
August 30, 2020	Flight 3.1	20

*Total number of runs per flight include test runs

General Mission Objectives

The following general mission objectives were employed in conducting emergency response data collection with ASPECT:

1. To capture an overall, situational awareness of the incident using aerial photography with:
    - Oblique camera—photos taken by hand from the view/position of the co-pilot, and
    - MSIC photos—advanced camera mounted underneath the plane for a top-down view of the designated sites.
2. To qualitatively locate and characterize any the visible and non-visible components of a plume, as well as any areas on fire:

- Using the Infrared Line Scanner (IRLS)
3. To screen for the presence and location of specific chemicals within ASPECT's automated chemical detection library:
    - Using the Fourier Transform Infrared (FTIR) Spectrometer

See Appendix C for a detailed description of ASPECT's instrumentation.

Flight Descriptions

28 August 2020. (Flights #1.1, 1.2) ASPECT conducted two assessment flights on 28 August for the purpose of collecting IR imagery, spectral, and photographic data to determine possible damage and releases from these areas. A total of 18 data collection runs were made over two flights primarily in the Orange, TX area with limited collection over locations in Beaumont. A map showing the sites surveyed in these two flights is given in Figure 1. Low levels of isoprene (0.79 ppm), ammonia (1.09 ppm), 1-butene (1.40 ppm) and 1,3-butadiene (0.53 ppm) were detected at various locations. IR imagery did not show the presence of any chemical plumes. Aerial photographic data did show storm damage to structures.
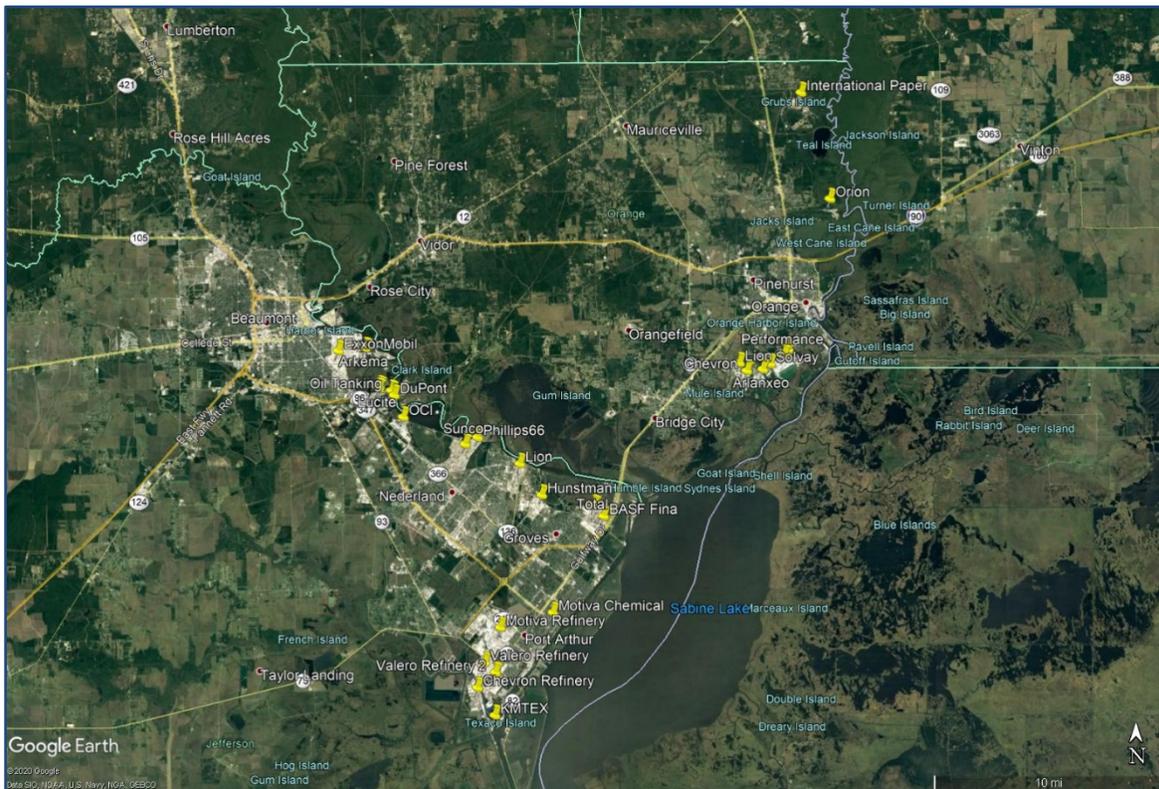

Figure 1: Facilities surveyed by ASPECT in the Port Arthur, Beaumont, and Orange, TX on 28 August 2020

29 August 2020. (Flight #2.1) The flight conducted on 29 August was a continuation of the assessment collection process with a focus on the Port Arthur to Beaumont facility corridor. A total of 14 data collection runs were collected. The sites covered during this flight are shown in the map in Figure 2. Isoprene was the only compound detected on two data collection runs at a maximum concentration of 1.55 ppm. IR imagery did not show the presence of any chemical plumes.
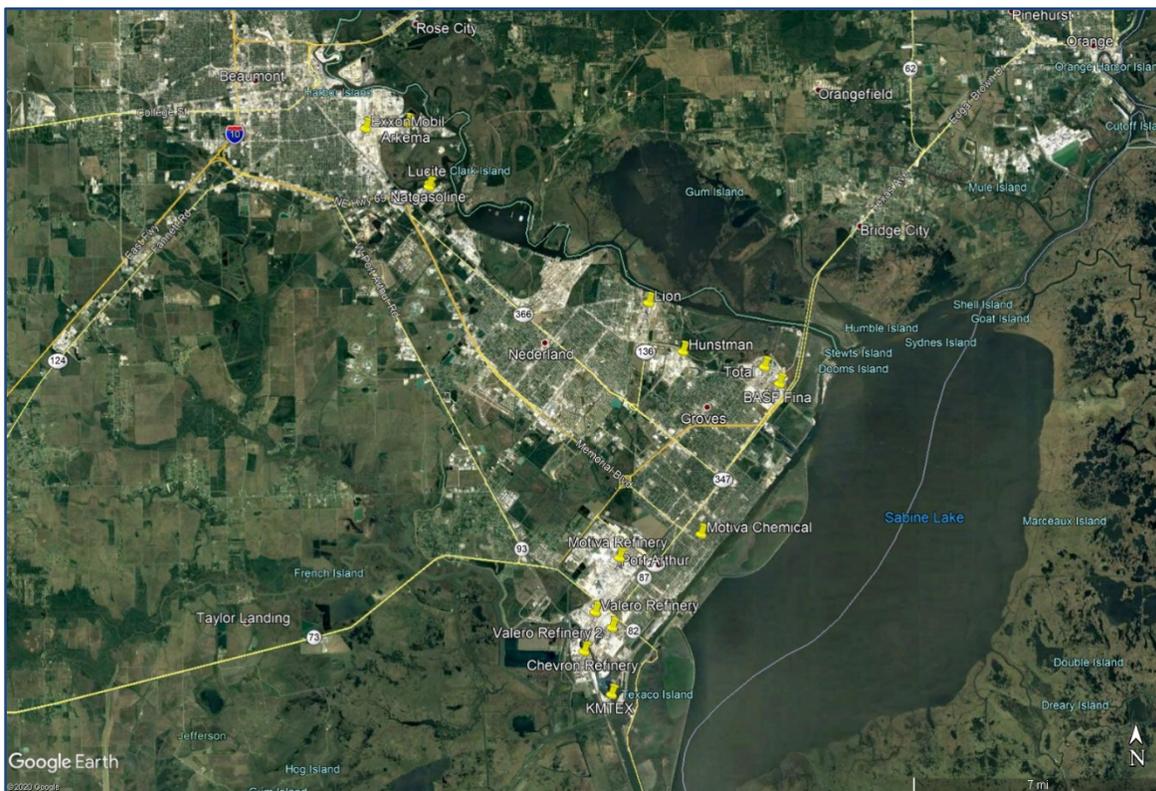
Figure 2: Facilities surveyed by ASPECT in Port Arthur, Beaumont, and Orange, TX on 29 August 2020

30 August 2020. (Flight #3.1) On 30 August, ASPECT was deployed to complete the assessment mission in the Beaumont and Port Neches area. A total of 20 data collection runs consisting of IR imagery, spectral and photographic data were made in the survey area. The map in Figure 3 shows the sites that were surveyed. During two data collection runs, isoprene was detected at a maximum concentration of 1.11 ppm. 1-butene and ethyl formate were detected on data collection run 20 at maximum concentrations of 1.25 ppm and 1.69 ppm, respectively. IR imagery did not show the presence of any chemical plumes.
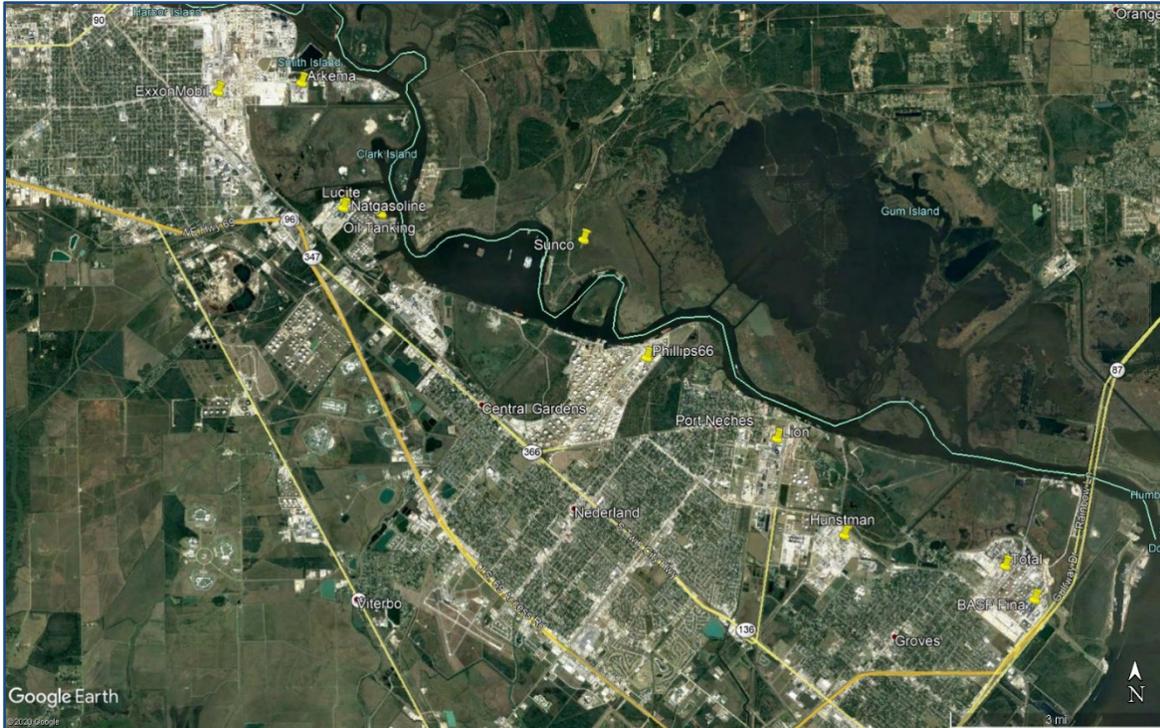
Figure 3: Facilities surveyed by ASPECT in Beaumont and Port Neches, TX on 30 August 2020

Flight Conditions and Status

<u>Weather</u>

Before each flight, updated status on the weather forecast, site conditions and any potential flight obstacles including radio towers were assessed for the health and safety of the crew. A summary of the weather conditions for each day is provided in Tables 2, 3, and 4.

Table 2. 28 August 2020 Ground Weather for Beaumont, TX

Location (time)	Ground (1100)	Ground (1200)	Ground (1300)	Ground (1400)	Ground (1500)	Ground (1600)
Wind direction	090 degrees (E)	225 (SW)	150 (SSE)	150 (SSE)	196 (SSW)	196 (SSW)
Wind speed	2.2 m/s (5 mph)	2.7 m/s (6 mph)	4.5 m/s (10 mph)	5.3 m/s (12 mph)	m/s (12 mph)	6.3 m/s (14 mph)
Temperature	25°C	28 °C	28 °C	26.5 °C	27 °C	26 °C
Humidity	94%	88%	85%	93%	94%	90%
Dew Point	24°C	26 °C	25 °C	24 °C	26 °C	24 °C
Pressure	1013 mb	1013 mb	1012 mb	1012 mb	1011 mb	1011 mb
Ceiling	2400	2200T	Clear	2500/T	2900/R	2400/R

Note: T = Thunderstorm, R = Rain

Table 3. 29 August 2020 Ground Weather for Beaumont, TX

Location (time)	Ground (0700)	Ground (0800)	Ground (0900)	Ground (1000)
Wind direction	000 degrees (000)	000 degrees (000)	202 (SSW)	150 (SSE)
Wind speed	0.0 m/s (0 mph)	0.0 m/s (0 mph)	2.2 m/s (5 mph)	5.3 m/s (12 mph)
Temperature	24°C	26°C	28°C	31°C
Humidity	100%	100%	85%	80%
Dew Point	24°C	26°C	27°C	27°C
Pressure	1012 mb	1012 mb	1012 mb	1013 mb
Ceiling	CLR F	CLR F	2200	1700

Note: F = Low level fog/mist

Table 4. 30 August 2020 Ground Weather for Beaumont, TX

Location (time)	Ground (0800)	Ground (0900)	Ground (1000)	Ground (1100)
Wind direction	000 degrees (000)	000 degrees (000)	220 (SW)	0 (000)
Wind speed	2.0 m/s (5 mph)	3.6 m/s (8 mph)	2.7 m/s (6 mph)	2.0 m/s (5 mph)
Temperature	27°C	28°C	27.5°C	31°C
Humidity	100%	94%	94%	80%
Dew Point	27°C	27°C	27°C	27°C
Pressure	1010 mb	1011 mb	1010 mb	1011 mb
Ceiling	CLR F	2000	3900 R	CLR

Note: F = Low level fog/mist, R = Rain

Site Conditions and Challenges

28 August 2020. After being activated by Region 6 and some delays due to air traffic and weather, the aircraft took off for the first flight at 1126 local (CST). Soon after takeoff, the crew reported numerous thunderstorms in the area. Winds at 2800 ft AGL were not specifically reported but based on relative plane motion are assumed to be from the SW at 18 m/s (35 kts). At 1310 local the aircraft diverted to Orange, TX due to a line of thunderstorms moving in from the southwest. Flight operations resumed at 1511 local after passage of storms. Reported weather aloft was light to moderate turbulence. A wind direction and speed at flight altitude was not given. The first flight started at 1126 local with a completion at 1304 local. The second flight was started at 1511 CST with completion at 1621 CST.

29 August 2020. The aircraft was airborne at 0716 local (CST). Winds at 2800 ft AGL were not specifically reported but based on relative plane motion are assumed to be from the SW at 5 m/s (10 kts). Reports from the crew while transitioning to the survey area indicated some low-level fog. Turbulence levels were indicated as mild. As the flight progressed, the crew reported that clouds at or below flight level were moving into the area prompting a termination of the flight at 0940 CST. After a review of the forecast and taking into consideration a flight restriction in the area due

to the impending arrival of Air Force One, it was determined that another flight would not be attempted for the remainder of the day.

30 August 2020. The aircraft was airborne at 0727 local (CST). Winds at 2800 ft AGL were estimated to be from the south at 5 m/s (10 kts). Turbulence levels were indicated as mild to heavy due to convective activity in the area. Low scattered clouds complicated the flight with delays due to the passage of storm cells. The final data collection run was conducted at 1112 CST.

Data Results

The following data is provided as a summary analysis. All data products are available for the Region to access on a shared FTP site. For a complete list of available products, see Appendix B. The data collected during this mission included a flight path summary, IRLS images, FTIR chemical identification and quantification, high resolution MSIC photos, and oblique photos.

Flight Paths

Wide, slow turns are required to be made in between runs in order to keep the instruments stable. Figures 4a, 4b, 5, and 6 show the path of each completed flight. The blue lines indicate the flight path while the green lines indicate the specific sections of the flight where chemical data was collected and processed.
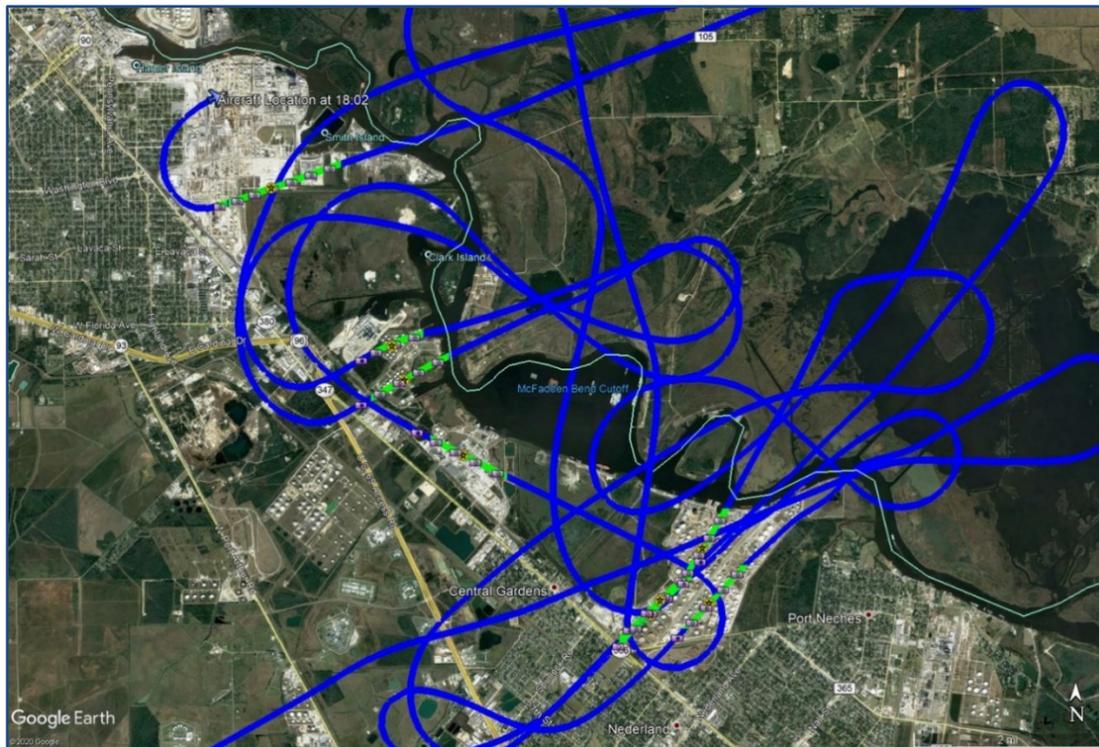
Figure 4a. 28 August 2020, Flight 1.1, data collection runs in Port Arthur, Beaumont, and Orange, TX
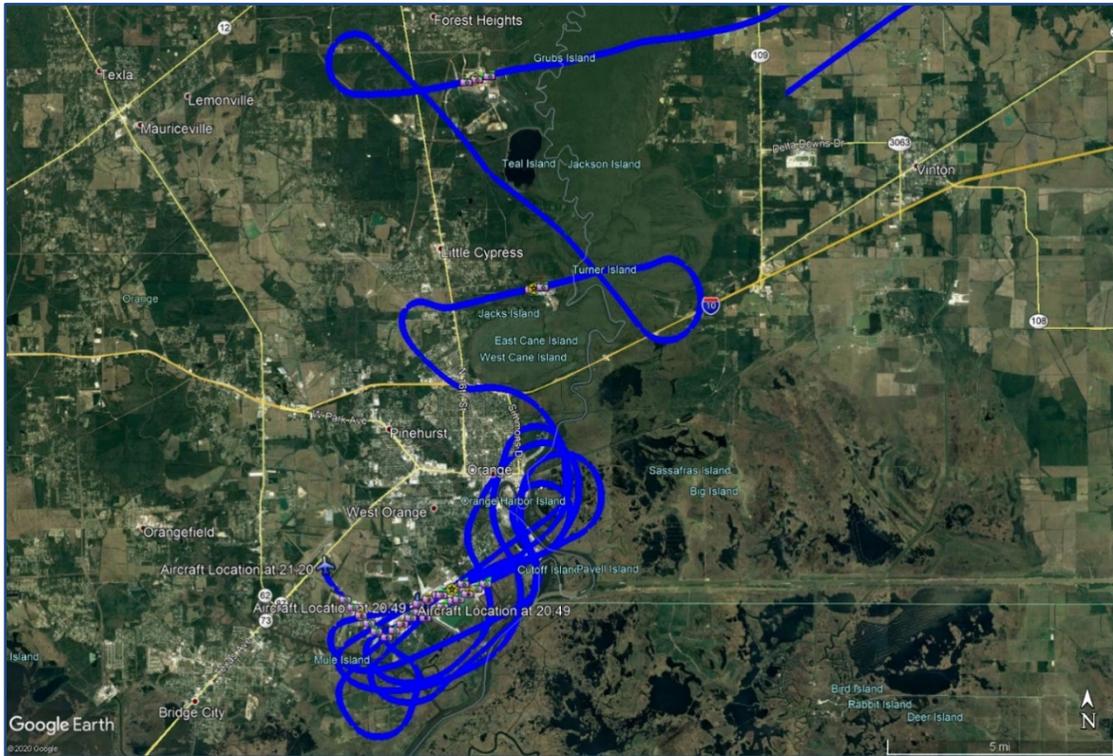
Figure 4b. 28 August 2020, Flight 1.2, data collection runs in Port Arthur, Beaumont, and Orange, TX

Figure 5. 29 August 2020, Flight 2.1, data collection runs in Port Arthur, Beaumont, and Orange, TX
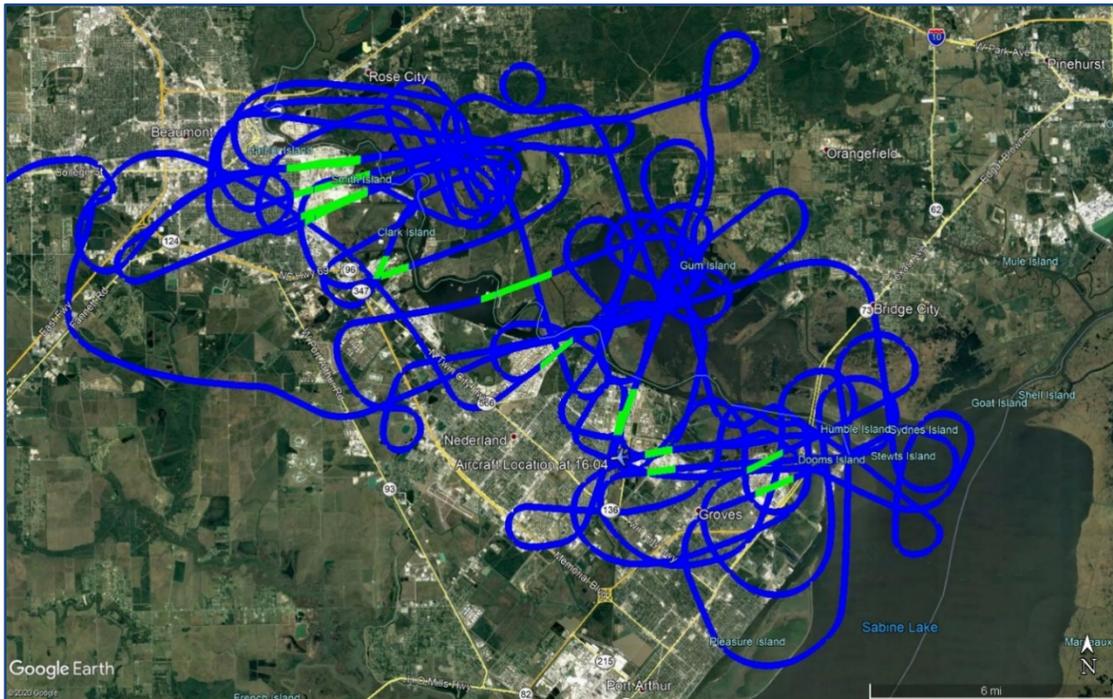
Figure 6. 30 August 2020, Flight 3.1, data collection runs in Beaumont and Port Neches, TX

Line Scanner Data Results

A total of 20 data collection runs were made in the proximity of the survey area and an infrared line scanner image was generated for each run. Figure 7 shows a typical 3-band infrared image obtained from data collected for the flight on August 30th, Run 13. This image was generated by flying from east to west over Arkema and ExxonMobil facilities in Beaumont, TX. Objects that are white are hotter than those that are black. Three hot flare are present (indicated by white with a rainbow signature) as is a hot process unit in the lower left-hand portion of the image.   No chemical plumes were observed in any of the images collected during any of the flights.
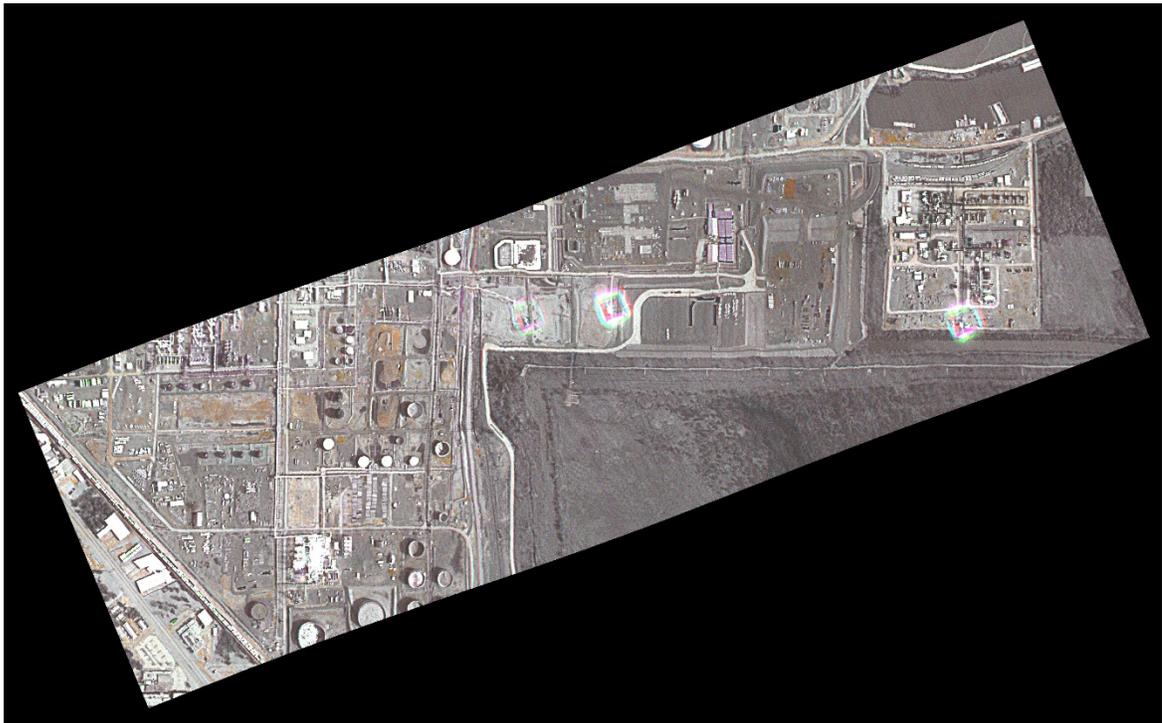
Figure 7. Three band IR image, Run 13, 30 August 2020

FTIR Data Results

FTIR spectral data at a resolution of 16 wavenumbers was collected for each run. ASPECT uses an automated detection algorithm to permit compounds to be automatically analyzed while the aircraft is in flight. Seventy-six chemical compounds are included in the airborne algorithm library (the list is provided in Appendix C, Table 1). In addition, collected data was also manually quality checked against a collection of published library spectra for each chemical detected. See Appendix A for a complete list of chemicals detected for the entire mission and their approximate concentrations.

28 August 2020. Ammonia was observed during the first flight (CAS 7664-41-7) on runs 7 and 8 at maximum concentrations of 1.08 and 0.69 ppm, respectively. The location of these detections are shown in Figure 8.

Three compounds were detected on the second flight including 1-butene, 1,3-butadiene and isoprene at maximum concentrations of 1.41 ppm, 0.53 ppm, and 0.79 ppm respectively (see Appendix A). Figure 10a illustrates a low concentration 1,3-butadiene spectrum with Figure 10b showing an associated library spectrum. Locations of detections made during Flight #1.2 are shown in Figure 9. Of note is the peak located near 910 cm^{-1}. In addition to the listed compounds, ozone was detected in most collected data with a representative spectrum given in Figure 11 as evident by the large broad peak centered on 1050 cm^{-1}.

Figure 8. 28 August 2020 Ammonia detection location, Flight 1.1
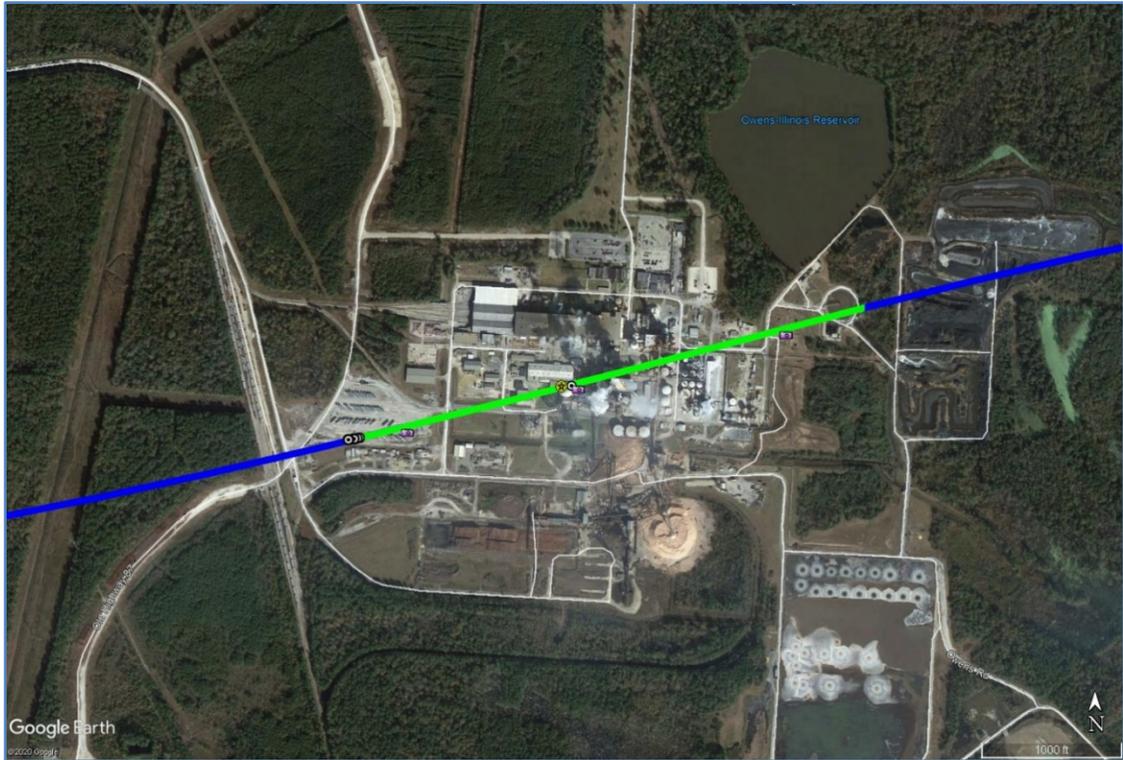
Figure 9. 28 August 2020 1-Butene, 1,3-Butadiene and Isoprene detection locations, Flight 1.2
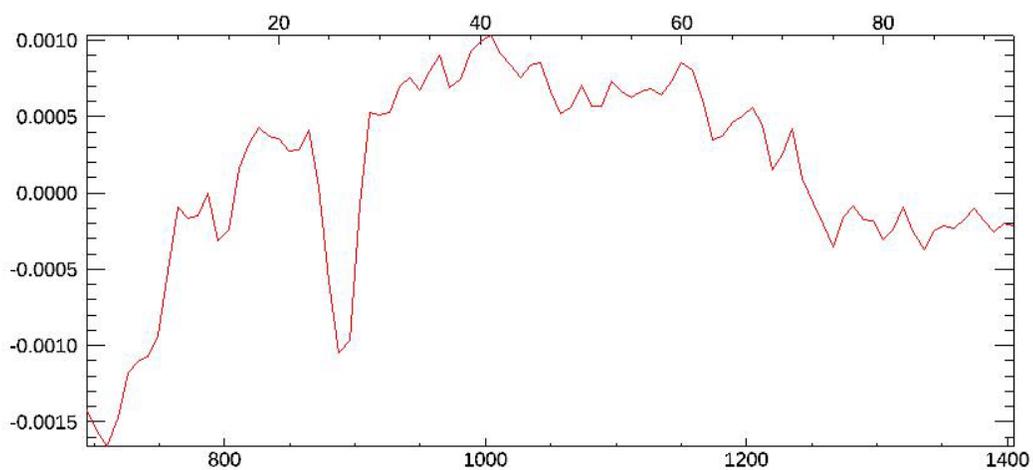
Figure 10a. 28 August 2020 field spectrum at 16 cm-1 resolution, 1,3-butadiene peak at 910cm^{-1}
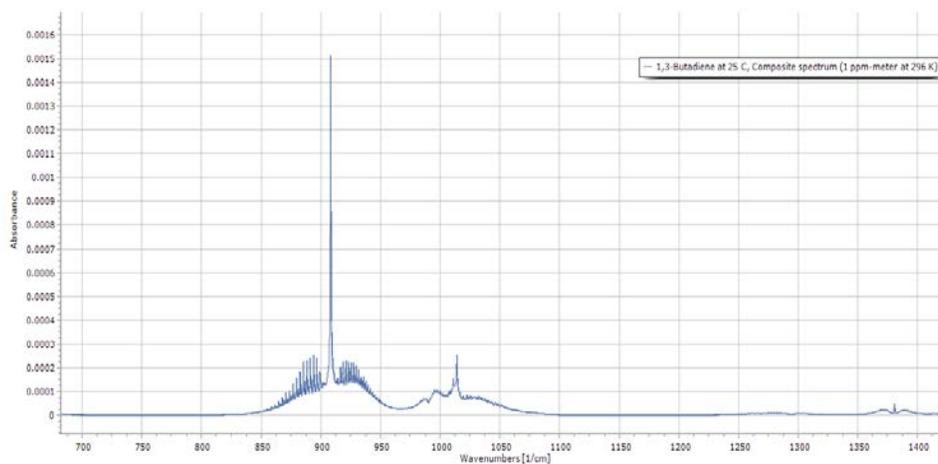
Figure 10b. Library spectrum, 1,3-butadiene
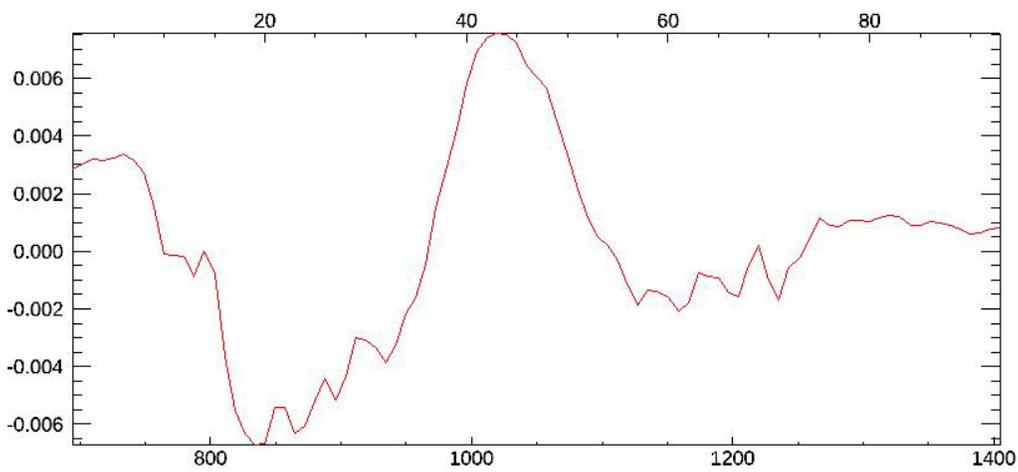
Figure 11. 28 August 2020 field spectrum at 16 cm-1 resolution, ozone

29 August 2020. Isoprene (CAS 78-79-5) was the only compound detected on this mission. Maximum concentrations of 1.55 and 0.75 ppm were made on runs 11 and 12, respectively. The locations of these detections are shown in Figure 12.

Figure 12. 29 August 2020 isoprene detection locations, Runs 11 and 12

30 August 2020. Three compounds were detected on this flight including isoprene (CAS 78-79-5), 1-butene (CAS 106-98-9), and ethyl formate (CAS 109-94-4). The location of the isoprene detections is given in Figure 13a. Isoprene was observed on data collection runs 12 and 13 and was detected at a maximum concentration of 1.11 ppm with the presence most likely due to natural occurrence (trees). 1-butene was detected on data collection run 20 at a maximum concentration of 1.25 ppm (Figure 13b). In addition to 1-butene, ethyl formate was also detected on run 20 at a maximum concentration of 1.69 ppm (Figure 13c). Both compounds appear to be fugitive in nature.

Figure 13a. 30 August 2020 Isoprene detection locations, Runs 12 and 13
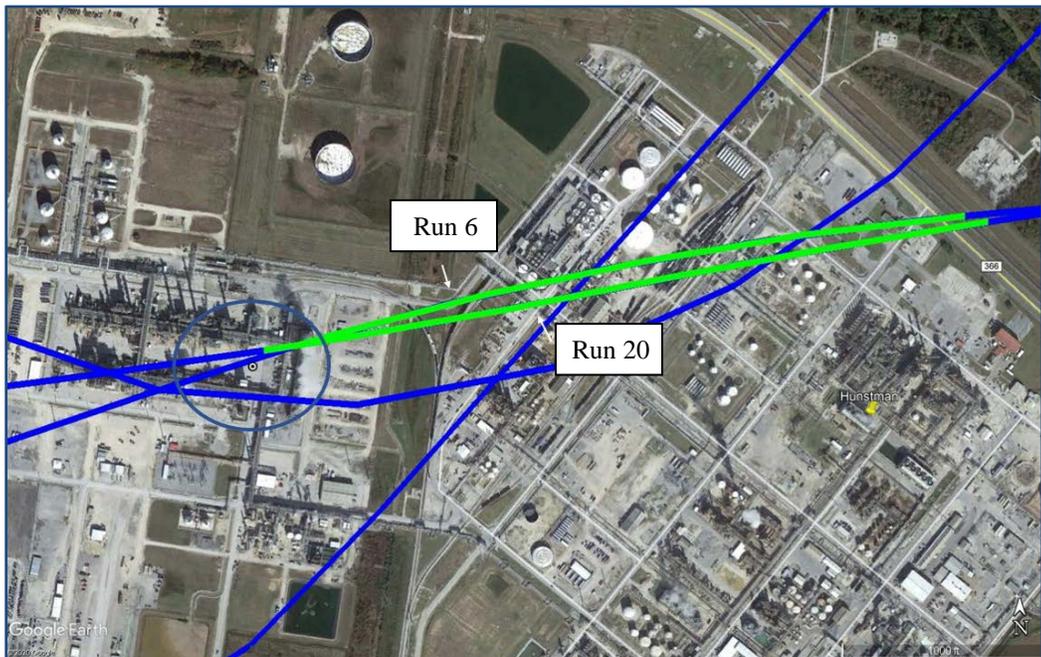
Figure 13b. 30 August 2020 1-butene detection locations on Run 20 near the
intersection with Run 6

Figure 13c. 30 August 2020 Ethyl Formate detection locations on Run 20
in reference to Run 6

Aerial Photography Results

A full set of high-resolution aerial digital photographs were collected as part of each flight. Figure 14 shows a representative image collected using the MSIC camera on 30 August 2020. Analysis of the image shows that a sizable amount of standing water is present at this particular site. Figure 15 shows an oblique image of a facility in the survey area taken on 28 August 2020 with visible storm damage.

Figure 14. MSIC Aerial Image, Run 8

Figure 15. Oblique image of a facility in the survey area with visible storm damage

Summary

The Hurricane Laura damage assessment requested by Region 6 was completed by the ASPECT program on 30 August 2020. Across the 3 days and 4 flights, 52 data collection runs were completed, each of which included a full set of IR imagery, IR spectrometer and photographic data. Five compounds were detected including isoprene (maximum concentration of 1.55 ppm), 1-butene (maximum concentration of 1.25 ppm), ammonia (maximum concentration of 1.09 ppm), 1,3-butadiene (maximum concentration of 0.53 ppm) and ethyl formate (maximum concentration of 1.69 ppm). IR imagery did not show the presence of any chemical plumes on any of the runs collected.

Appendix A: Complete Mission Chemical Detection Summary

Table 1. Chemical Results Summary

Run #	Date	Time (UTC)	Chemical	Max Concentration (ppm)
			28 August 2020, Flight 1	
1		16:48:17	Test	Test
2		17:09:36	ND	ND
3		17:13:04	ND	ND
4	28 Aug 2020	17:23:44	ND	ND
5		17:30:36	ND	ND
6		17:40:09	ND	ND
7		17:45:48	Ammonia	1.09
8		17:51:22	Ammonia	0.69
9		18:00:46	ND	ND
			28 August 2020, Flight 2	
1		20:25:18	Test	Test
2		20:35:02	1-Butene	1.41
			1,3-Butadiene	0.53
3		20:43:08	ND	ND
4	28 Aug 2020	20:48:44	ND	ND
5		20:55:16	ND	ND
6		21:02:31	ND	ND
7		21:08:60	ND	ND
8		21:16:22	ND	ND
9		21:19:25	Isoprene	0.79
			29 August 2020, Flight 1	
1		12:32:56	Test	Test
2		12:39:05	Test	ND
3		12:49:45	ND	ND
4		12:55:57	ND	ND
5		13:01:45	ND	ND
6		13:06:43	ND	ND
7	29 Aug 2020	13:12:04	ND	ND
8		13:19:12	ND	ND
9		13:26:36	ND	ND
10		13:35:45	ND	ND
11		13:42:54	Isoprene	1.55
12		13:49:23	Isoprene	0.75
13		13:58:02	ND	ND
14		14:05:50	ND	ND
			30 August 2020, Flight 1	
1		12:50:07	Test	Test
2		12:53:08	Test	ND

3	30 Aug 2020	13:14:52	ND	ND
4		13:23:51	ND	ND
5		13:31:53	ND	ND
6		13:39:08	ND	ND
7		13:50:03	ND	ND
8		14:06:53	ND	ND
9		14:12:15	ND	ND
10		14:20:50	ND	ND
11		14:26:18	ND	ND
12		14:34:02	Isoprene	0.68
13		14:40:47	Isoprene	1.11
14		14:58:00	ND	ND
15		15:11:45	ND	ND
16		15:11:45	ND	ND
17		15:27:54	ND	ND
18		15:51:34	ND	ND
19		15:58:01	ND	ND
20		16:03:32	1-Butene	1.25
			Ethyl Formate	1.69

ND = No Detection

Appendix B: File Names of Data Collected During Flight

28 August 2020 Data Files

Run #	Time (UTC)	Altitude (ft MSL)	Velocity (knots)	MSIC Data Files	FTIR Data Files	IRLS Data Files	Gamma Files
FLIGHT 1							
Run 1	16:48:17	3005	132	20200828164822700.jpg 20200828164829954.jpg 20200828164836313.jpg	20200828_164820_A.igm	2020_08_28_16_48_21_R_01 TA=25.1;TB=44.8;Gain=3	None
Run 2	17:09:36	3160	109	20200828170941914.jpg 20200828170948256.jpg 20200828170955519.jpg 20200828171001884.jpg 20200828171008237.jpg	20200828_170939_A.igm	2020_08_28_17_09_41_R_02 TA=26.1;TB=45.9;Gain=3	
Run 3	17:13:04	2997	125	20200828171309812.jpg 20200828171316161.jpg 20200828171322522.jpg 20200828171328871.jpg 20200828171336147.jpg	20200828_171307_A.igm	2020_08_28_17_13_09_R_03 TA=24.2;TB=44.2;Gain=3	
Run 4	17:23:44	3119	113	20200828172350783.jpg 20200828172357148.jpg 20200828172403491.jpg 20200828172409856.jpg 20200828172417125.jpg	20200828_172348_A.igm	2020_08_28_17_23_50_R_04 TA=24.5;TB=44.3;Gain=3	
Run 5	17:30:36	3100	106	20200828173042974.jpg 20200828173049323.jpg 20200828173055672.jpg 20200828173102037.jpg	20200828_173040_A.igm	2020_08_28_17_30_41_R_05 TA=23.8;TB=43.7;Gain=3	
Run 6	17:40:09	3086	114	20200828174014945.jpg 20200828174022214.jpg 20200828174028564.jpg 20200828174034922.jpg 20200828174041272.jpg	20200828_174012_A.igm	2020_08_28_17_40_14_R_06 TA=26.0;TB=46.0;Gain=3	

Run 7	17:45:48	3080	113	20200828174554498.jpg 20200828174600847.jpg 20200828174607212.jpg 20200828174613561.jpg 20200828174619926.jpg	20200828_174551_A.igm	2020_08_28_17_45_53_R_07 TA=24.0;TB=44.2;Gain=3	
Run 8	17:51:22	3096	105	20200828175127695.jpg 20200828175134060.jpg 20200828175140409.jpg 20200828175145853.jpg	20200828_175125_A.igm	2020_08_28_17_51_27_R_08 TA=23.8;TB=42.8;Gain=3	
Run 9	18:00:46	3115	102	20200828180053313.jpg 20200828180059678.jpg 20200828180106027.jpg 20200828180112391.jpg 20200828180118741.jpg 20200828180125090.jpg 20200828180131455.jpg	20200828_180050_A.igm 20200828_180129_A.igm	2020_08_28_18_00_52_R_09 TA=23.9;TB=43.8;Gain=3	
FLIGHT 2							
Run 1	20:25:18	2932	119	20200828202524722.jpg 20200828202531071.jpg 20200828202537436.jpg 20200828202539245.jpg	20200828_202522_A.igm	2020_08_28_20_25_23_R_01 TA=25.9;TB=46.8;Gain=3	
Run 2	20:35:02	3127	119	20200828203508488.jpg 20200828203515751.jpg 20200828203522100.jpg	20200828_203506_A.igm	2020_08_28_20_35_07_R_02 TA=24.7;TB=44.9;Gain=3	
Run 3	20:43:08	3094	114	20200828204314201.jpg 20200828204321471.jpg	20200828_204312_A.igm	2020_08_28_20_43_13_R_03 TA=23.0;TB=43.1;Gain=3	
Run 4	20:48:44	3101	121	20200828204850115.jpg 20200828204856479.jpg 20200828204903733.jpg	20200828_204848_A.igm	2020_08_28_20_48_49_R_04 TA=21.1;TB=41.2;Gain=3	

Run 5	20:55:16	3075	113	20200828205523237.jpg 20200828205529588.jpg 20200828205535953.jpg 20200828205538661.jpg	20200828_205521_A.igm	2020_08_28_20_55_22_R_05 TA=21.2;TB=41.3;Gain=3	
Run 6	21:02:31	3154	112	20200828210236294.jpg 20200828210243564.jpg 20200828210249913.jpg 20200828210256262.jpg	20200828_210234_A.igm	2020_08_28_21_02_36_R_06 TA=23.3;TB=43.3;Gain=3	
Run 7	21:08:60	3119	111	20200828210905778.jpg 20200828210912128.jpg 20200828210918492.jpg 20200828210924849.jpg	20200828_210903_A.igm	2020_08_28_21_09_04_R_07 TA=21.5;TB=41.3;Gain=3	
Run 8	21:16:22	3132	110	20200828211627917.jpg 20200828211634281.jpg 20200828211640631.jpg 20200828211646995.jpg 20200828211653344.jpg	20200828_211625_A.igm	2020_08_28_21_16_27_R_08 TA=21.1;TB=41.2;Gain=3	
Run 9	21:19:25	3053	119	20200828211931316.jpg 20200828211937665.jpg 20200828211944020.jpg 20200828211950384.jpg 20200828211956734.jpg	20200828_211928_A.igm	2020_08_28_21_19_30_R_09 TA=20.6;TB=40.6;Gain=3	

29 August 2020 Data Files

Run #	Time (UTC)	Altitude (ft MSL)	Velocity (knots)	MSIC Data Files	FTIR Data Files	IRLS Data Files	Gamma Files
FLIGHT 1							
Run 1	12:32:56	3180	142	20200829123302589.jpg 20200829123308931.jpg 20200829123315291.jpg	20200829_123300_A.igm	2020_08_29_12_33_01_R_01 TA=23.9;TB=44.8;Gain=3	None
Run 2	12:39:05	3183	149	20200829123912102.jpg 20200829123918467.jpg 20200829123924815.jpg	20200829_123909_A.igm	2020_08_29_12_39_11_R_02 TA=18.8;TB=39.4;Gain=3	
Run 3	12:49:45	3072	115	20200829124952178.jpg 20200829124958527.jpg 20200829125004892.jpg 20200829125011241.jpg 20200829125017606.jpg	20200829_124949_A.igm	2020_08_29_12_49_50_R_03 TA=17.9;TB=38.1;Gain=3	
Run 4	12:55:57	3076	110	20200829125602596.jpg 20200829125608961.jpg	20200829_125600_A.igm	2020_08_29_12_56_01_R_04 TA=20.6;TB=40.7;Gain=3	
Run 5	13:01:45	3064	111	20200829130152142.jpg 20200829130158507.jpg	20200829_130149_A.igm	2020_08_29_13_01_50_R_05 TA=20.4;TB=40.2;Gain=3	
Run 6	13:06:43	3061	117	20200829130649946.jpg 20200829130656295.jpg 20200829130702644.jpg 20200829130707193.jpg	20200829_130647_A.igm	2020_08_29_13_06_48_R_06 TA=20.5;TB=40.7;Gain=3	
Run 7	13:12:04	3042	108	20200829131210436.jpg 20200829131216785.jpg 20200829131223132.jpg	20200829_131208_A.igm	2020_08_29_13_12_09_R_07 TA=20.6;TB=40.7;Gain=3	
Run 8	3077	3077	109	20200829131918057.jpg 20200829131924406.jpg 20200829131930755.jpg 20200829131937120.jpg 20200829131944374.jpg	20200829_131914_A.igm	2020_08_29_13_19_17_R_08 TA=20.9;TB=41.0;Gain=3	

Run 9	13:26:36	3096	111	20200829132642013.jpg 20200829132648377.jpg 20200829132654732.jpg 20200829132701986.jpg 20200829132708350.jpg	20200829_132640_A.igm	2020_08_29_13_26_41_R_09 TA=21.1;TB=41.1;Gain=3	
Run 10	13:35:45	3077	114	20200829133551294.jpg 20200829133554929.jpg 20200829133601291.jpg 20200829133608545.jpg 20200829133614910.jpg 20200829133621259.jpg 20200829133627609.jpg 20200829133633973.jpg 20200829133640322.jpg	20200829_133552_A.igm 20200829_133631_A.igm	2020_08_29_13_35_50_R_10 TA=21.0;TB=41.2;Gain=3 2020_08_29_13_35_54_R_11 TA=21.1;TB=41.3;Gain=3	
Run 11	13:42:54	3096	115	20200829134300735.jpg 20200829134307090.jpg 20200829134313448.jpg 20200829134319798.jpg 20200829134326158.jpg 20200829134332522.jpg 20200829134338871.jpg 20200829134345220.jpg	20200829_134258_A.igm 20200829_134336_A.igm	2020_08_29_13_42_59_R_12 TA=21.8;TB=42.0;Gain=3	
Run 12	13:49:23	3091	108	20200829134929313.jpg 20200829134935678.jpg 20200829134942027.jpg 20200829134948392.jpg 20200829134954741.jpg 20200829135002011.jpg 20200829135008349.jpg 20200829135014709.jpg 20200829135021074.jpg 20200829135027424.jpg	20200829_134927_A.igm 20200829_135006_A.igm	2020_08_29_13_49_28_R_13 TA=22.1;TB=42.0;Gain=3	
Run 13	13:58:02	3055	110	20200829135808648.jpg 20200829135815003.jpg 20200829135821351.jpg 20200829135827716.jpg	20200829_135806_A.igm	2020_08_29_13_58_07_R_14 TA=22.3;TB=42.3;Gain=3	

Run #	Time (UTC)	Altitude (ft MSL)	Velocity (knots)	MSIC Data Files	FTIR Data Files	IRLS Data Files	Gamma Files
				20200829135834065.jpg 20200829135840415.jpg			
Run 14	14:05:50	3102	119	20200829140557124.jpg 20200829140603473.jpg 20200829140609838.jpg	20200829_140553_A.igm	2020_08_29_14_05_55_R_15 TA=23.3;TB=43.2;Gain=3	

30 August 2020 Data Files

Run #	Time (UTC)	Altitude (ft MSL)	Velocity (knots)	MSIC Data Files	FTIR Data Files	IRLS Data Files	Gamma Files
FLIGHT 1							
Run 1	12:50:07	2778	137	20200830125013420.jpg 20200830125020675.jpg 20200830125027033.jpg	20200830_125010_A.igm	2020_08_30_12_50_12_R_01 TA=24.8;TB=45.7;Gain=3	None
Run 2	12:53:08	2776	128	20200830125314079.jpg 20200830125320444.jpg 20200830125326793.jpg	20200830_125311_A.igm	2020_08_30_12_53_13_R_02 TA=17.9;TB=38.6;Gain=3	
Run 3	13:14:52	2786	112	20200830131457821.jpg 20200830131504170.jpg 20200830131510534.jpg 20200830131516884.jpg 20200830131523248.jpg	20200830_131455_A.igm	2020_08_30_13_14_56_R_03 TA=17.9;TB=37.9;Gain=3	
Run 4	13:23:51	2788	112	20200830132358026.jpg 20200830132404376.jpg 20200830132410725.jpg 20200830132417090.jpg 20200830132423439.jpg	20200830_132355_A.igm	2020_08_30_13_23_56_R_04 TA=19.6;TB=39.6;Gain=3	
Run 5	13:31:53	2807	115	20200830133200121.jpg 20200830133206470.jpg 20200830133212820.jpg	20200830_133157_A.igm	2020_08_30_13_31_58_R_05 TA=19.7;TB=39.9;Gain=3	
Run 6	13:39:08	2728	117	20200830133914096.jpg 20200830133920445.jpg 20200830133926794.jpg	20200830_133911_A.igm	2020_08_30_13_39_13_R_06 TA=19.8;TB=39.8;Gain=3	

Run 7	13:50:03	2582	111	20200830135009599.jpg 20200830135015948.jpg 20200830135022297.jpg 20200830135025938.jpg	20200830_135006_A.igm	2020_08_30_13_50_08_R_07 TA=20.9;TB=41.2;Gain=3	
Run 8	14:06:53	2534	115	20200830140700088.jpg 20200830140706438.jpg 20200830140712802.jpg	20200830_140656_A.igm	2020_08_30_14_06_59_R_08 TA=21.7;TB=41.8;Gain=3	
Run 9	14:12:15	2594	110	20200830141221481.jpg 20200830141227834.jpg 20200830141234199.jpg 20200830141241453.jpg 20200830141247812.jpg	20200830_141219_A.igm	2020_08_30_14_12_20_R_09 TA=22.4;TB=42.1;Gain=3	
Run 10	14:20:50	2593	113	20200830142056262.jpg 20200830142103532.jpg 20200830142109881.jpg 20200830142116246.jpg	20200830_142054_A.igm	2020_08_30_14_20_56_R_10 TA=21.1;TB=41.2;Gain=3	
Run 11	14:26:18	2584	112	20200830142624023.jpg 20200830142630372.jpg 20200830142637642.jpg	20200830_142621_A.igm	2020_08_30_14_26_23_R_11 TA=22.9;TB=43.0;Gain=3	
Run 12	14:34:02	2799	111	20200830143408863.jpg 20200830143415228.jpg 20200830143421577.jpg 20200830143427927.jpg 20200830143434292.jpg 20200830143440650.jpg 20200830143447904.jpg 20200830143454269.jpg	20200830_143406_A.igm 20200830_143446_A.igm	2020_08_30_14_34_08_R_12 TA=24.0;TB=43.9;Gain=3	
Run 13	14:40:47	2765	113	20200830144052883.jpg 20200830144059248.jpg 20200830144105597.jpg 20200830144112851.jpg 20200830144119216.jpg 20200830144125565.jpg 20200830144131930.jpg 20200830144138279.jpg	20200830_144050_A.igm 20200830_144129_A.igm	2020_08_30_14_40_52_R_13 TA=23.1;TB=43.3;Gain=3	

Run 14	14:58:00	2781	115	20200830145806983.jpg 20200830145813347.jpg 20200830145819697.jpg 20200830145826061.jpg 20200830145832411.jpg 20200830145838760.jpg 20200830145845125.jpg 20200830145851474.jpg	20200830_145804_A.igm 20200830_145843_A.igm	2020_08_30_14_58_06_R_15 TA=25.5;TB=45.5;Gain=3	
Run 15	15:11:45	2809	115	20200830151151368.jpg 20200830151157717.jpg 20200830151204082.jpg 20200830151210431.jpg 20200830151216781.jpg 20200830151223145.jpg 20200830151229495.jpg 20200830151235859.jpg	20200830_151148_A.igm 20200830_151228_A.igm	2020_08_30_15_11_50_R_16 TA=16.1;TB=36.3;Gain=3	
Run 16	15:11:45	2809	115	20200830151151368.jpg 20200830151157717.jpg 20200830151204082.jpg 20200830151210431.jpg 20200830151216781.jpg 20200830151223145.jpg 20200830151229495.jpg 20200830151235859.jpg	20200830_151148_A.igm 20200830_151228_A.igm	2020_08_30_15_11_50_R_16 TA=16.1;TB=36.3;Gain=3	
Run 17	15:27:54	2857	116	20200830152800100.jpg 20200830152806449.jpg 20200830152812814.jpg 20200830152820083.jpg 20200830152826433.jpg 20200830152832782.jpg 20200830152839147.jpg 20200830152845496.jpg	20200830_152757_A.igm 20200830_152836_A.igm	2020_08_30_15_27_59_R_17 TA=24.2;TB=44.2;Gain=3	
Run 18	15:51:34	2813	117	20200830155140067.jpg 20200830155146416.jpg 20200830155152781.jpg	20200830_155136_A.igm	2020_08_30_15_51_40_R_18 TA=16.8;TB=36.0;Gain=3	

Run 19	15:58:01	2827	116	20200830155807742.jpg 20200830155814091.jpg 20200830155820456.jpg	20200830_155804_A.igm	2020_08_30_15_58_07_R_19 TA=26.9;TB=46.9;Gain=3	
Run 20	16:03:32	2800	118	20200830160338212.jpg 20200830160344577.jpg 20200830160350926.jpg	20200830_160335_A.igm	2020_08_30_16_03_38_R_20 TA=25.9;TB=45.8;Gain=3	

Appendix C: ASPECT Systems

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 Infra-Red (FTIR) spectrometer coupled with a wide-area IR Line Scanner (IRLS). The ASPECT IR systems can detect chemical compounds in both the 8 to 12 micron (800 to 1200 cm-1) and 3 to 5 micron (2000 to 3200 cm-1) regions. List of chemicals and detection limits are listed in Table 1. 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.

An Imperx mapping camera (29 mega pixels; mapping focal plane array) is concurrently operated as part of all chemical collections. These images are often digitally processed in lower resolution, so they can be transmitted via satellite communication. 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. 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 scientific reach back team. In general, this consists of conducting geo-registration using a USGS Digital Elevation Model (DEM) which promotes superior pixel computation and lessens topographic distortion. The image is check by the team (using a Google Earth base map) for proper location and rotation.

Airborne radiological measurements are conducted using three fully integrated multi-crystal sodium iodide (NaI) RSX4 gamma ray spectrometers. Each RSX4 spectrometer contains four 4"x2"x16" doped NaI crystals each having an independent photomultiplier/spectrometer assembly. One RSX unit is configured with an additional upward NaI crystal utilized to provide real-time cosmic ray correction. Count and energy data from each crystal and pack is combined using a self-calibrating signal processor to generate a virtual detector output. All radiological spectrometer "packs" are further combined using a signal console controlled by the on-board central computer in the aircraft. Altitude correction data is provided by a radar altimeter with internal GPS systems within the packs serving as a backup. It should be noted that no radiological measurements were conducted on this mission.

Data is processed using automated algorithms onboard the aircraft with preliminary results being sent using a satellite system to the ASPECT scientific reach back team for QA/QC analysis. Upon landing, preliminary data results are examined and validated by the scientific reach back team.

Table 1. ASPECT Automated Compounds

This table contains ASPECT's library of automated compounds.
Detection limits are for each chemical is found in parenthesis in units of parts per million (ppm)

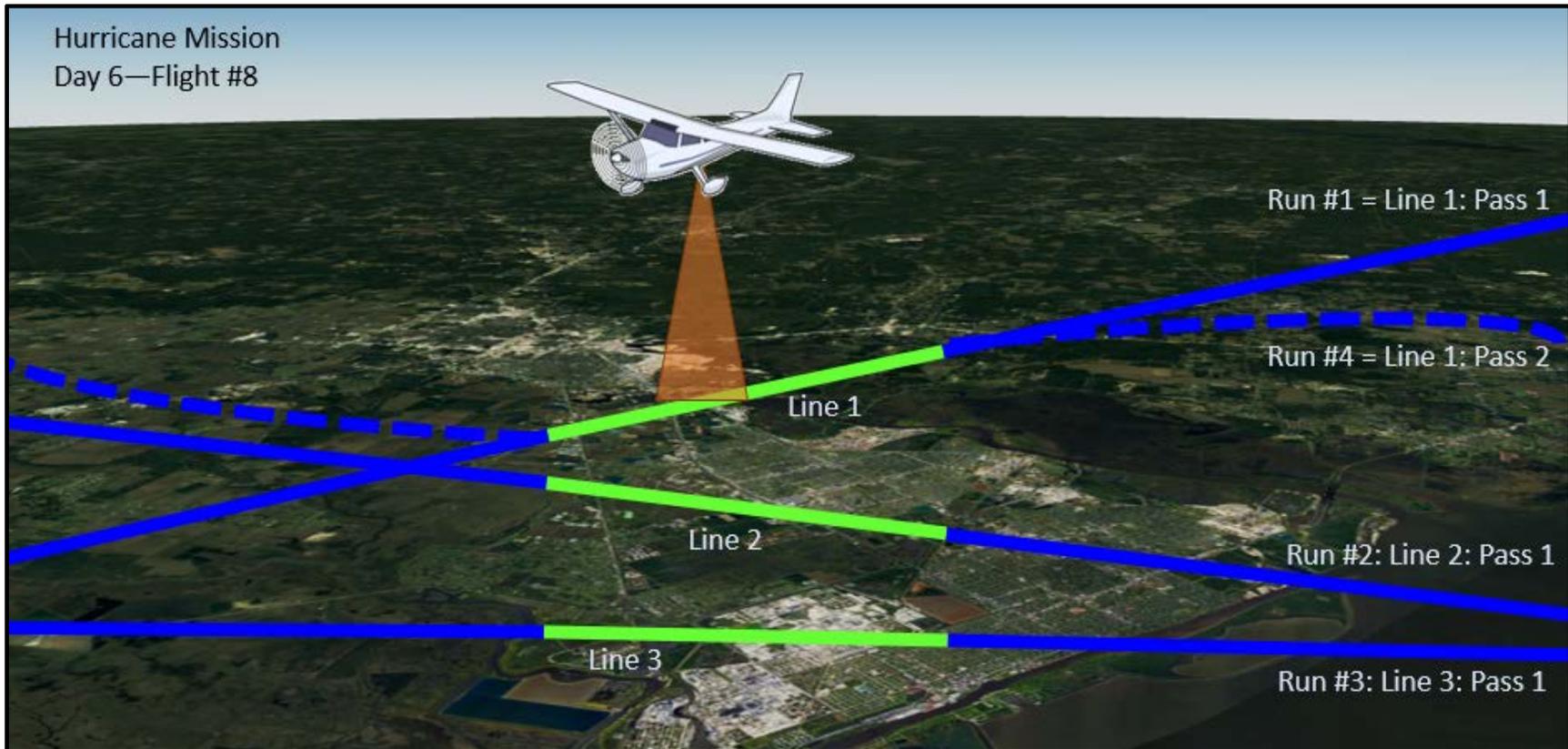|			
Acetic Acid (2.0)	Cumene (23.1)	Isoprene (6.5)	Phosphine (8.3)
Acetone (5.6)	Diborane (5.0)	Isopropanol (8.5)	Phosphorus Oxychloride (2.0)
Acrolein (8.8)	1,1-Dichloroethene (3.7)	Isopropyl Acetate (0.7)	Propyl Acetate (0.7)
Acrylonitrile (12.5)	Dichloromethane (6.0)	MAPP (3.7)	Propylene (3.7)
Acrylic Acid (3.3)	Dichlorodifluoromethane (0.7)	Methyl Acetate (1.0)	Propylene Oxide (6.8)
Allyl Alcohol (5.3)	1,1-Difluoroethane (0.8)	Methyl Acrylate (1.0)	Silicon Tetrafluoride (0.2)
Ammonia (2.0)	Difluoromethane (0.8)	Methyl Ethyl Ketone (7.5)	Sulfur Dioxide (15)
Arsine (18.7)	Ethanol (6.3)	Methanol (5.4)	Sulfur Hexafluoride (0.07)
Bis-Chloroethyl Ether (1.7)	Ethyl Acetate (0.8)	Methylbromide (60)	Sulfur Mustard (6.0)
Boron Tribromide (0.2)	Ethyl Acrylate (0.8)	Methylene Chloride (1.1)	Sulfuryl Fluoride (1.5)
Boron Triflouride (5.6)	Ethyl Formate (1.0)	Methyl Methacrylate (3.0)	Tetrachloroethylene (10)
1,3-Butadiene (5.0)	Ethylene (5.0)	MTEB (3.8)	1,1,1-Trichloroethane (1.9)
1-Butene (12.0)	Formic Acid (5.0)	Naphthalene (3.8)	Trichloroethylene (2.7)
2-Butene (18.8)	Freon 134a (0.8)	n-Butyl Acetate (3.8)	Trichloromethane (0.7)
Carbon Tetrachloride (0.2)	GA (Tabun) (0.7)	n-Butyl Alcohol (7.9)	Triethylamine (6.2)
Carbonyl Fluoride (0.8)	GB (Sarin) (0.5)	Nitric Acid (5.0)	Triethylphosphate (0.3)
Carbon Tetraflouride (0.1)	Germane (1.5)	Nitrogen Mustard (2.5)	Trimethylamine (9.3)
Chlorodifluoromethane (0.6)	Hexafluoroacetone (0.4)	Nitrogen Trifluoride (0.7)	Trimethyl Phosphite (0.4)
Chloromethane (12)	Isobutylene (15)	Phosgene (0.5)	Vinyl Acetate (0.6)

Appendix D: Summary of Flight Passes

The table below layouts the overall summary for each Flight Line number, the source names (e.g. facility names) assigned within the Flight Line number, the dates for when the first pass on the Line was conducted (i.e. Pass #1), and dates of redo passes for the specific Line Numbers. The information below does not include the Test Flights.

Flight Line #	Source Name encompassing the Flight #	Reference Number	Area	Latitude	Longitude	Run #1 Date	Run #1 Time	Run #2 Date	Run #2 Time	Run #3 Date	Run #3 Time
1	Golden Pass LNG Export Terminal	107053530	Sabine Pass	29.761268	-93.919938	8/29/2020	7:50:41 AM				
2	KMTEX	100640283	Port Arthur	29.829198	-93.963312	8/29/2020	7:56:31 AM				
3	KMTEX	100640283	Port Arthur	29.829198	-93.963312	8/29/2020	8:02:25 AM				
4	Chevron Phillips	100209857	Port Arthur	29.84658	-93.975953	8/29/2020	8:07:28 AM				
5	Chevron Phillips	100209857	Port Arthur	29.84658	-93.975953	8/29/2020	8:12:57 AM				
6	Valero Refinery	102584026	Port Arthur	29.856085	-93.962921	8/29/2020	8:20:12 AM				
7	Valero Refinery	102584026	Port Arthur	29.856085	-93.962921	8/29/2020	8:27:25 AM				
8	Valero Refinery	102584026	Port Arthur	29.862331	-93.970724	8/29/2020	8:36:58 AM				
9	Motiva Port Arthur Refinery	100209451	Port Arthur	29.884353	-93.95955	8/29/2020	8:45:40 AM				
10	Motiva Port Arthur Refinery	100209451	Port Arthur	29.884353	-93.95955	8/29/2020	8:51:12 AM				
11	Motiva Port Arthur Refinery	100209451	Port Arthur	29.884353	-93.95955	8/29/2020	8:58:53 AM				
12	Motiva Chemicals	100217389	Port Arthur	29.893459	-93.921548	8/29/2020	9:08:04 AM				
13	BASF FINA NAFTA	100216977	Port Arthur	29.953918	-93.884819	8/30/2020	8:15:38 AM				
14	TOTAL Petrochemicals	102457520	Port Arthur	29.960756	-93.891736	8/30/2020	8:24:29 AM				

#	Name	ID	City	Lat	Long	Date	Time	Date	Time	Date	Time
15	Huntsman	100219252	Port Neches	29.967062	-93.929532	8/30/2020	8:32:30 AM				
16	Huntsman	100219252	Port Neches	29.967062	-93.929532	8/30/2020	8:40:02 AM	8/30/2020	11:04:51 AM		
17	Lion Elastomers	100224799	Port Neches	29.986675	-93.945354	8/30/2020	8:50:37 AM	8/30/2020	10:58:49 AM		
18	Lion Elastomers	100224799	Port Neches	29.986675	-93.945354	8/30/2020	9:07:47 AM	8/30/2020	10:52:06 AM		
19	Phillips 66	102596210	Nederland	30.003154	-93.97599	8/30/2020	9:13:13 AM				
20	Phillips 66	102596210	Nederland	30.003154	-93.97599	8/28/2020	12:10:38 PM				
21	Phillips 66	102596210	Nederland	30.003154	-93.97599	8/28/2020	12:13:54 PM	8/28/2020	12:24:50 PM		
22	Phillips 66	102596210	Nederland	30.003154	-93.97599	8/28/2020	12:31:41 PM				
23	OCI Beaumont Plant	102559291	Nederland	30.015794	-94.029552	8/28/2020	12:41:17 PM				
24	Du Pont	100216035	Nederland	30.029444	-94.036111	8/28/2020	12:46:50 PM				
	Oil Tanking	101042885	Beaumont	30.032408	-94.038298						
25	Du Pont	100216035	Nederland	30.029444	-94.036111	8/28/2020	12:48:57 PM	8/30/2020	9:21:34 AM		
	Oil Tanking	101042885	Beaumont	30.032408	-94.038298						
26	Lucite Beaumont Plant	102736089	Nederland	30.03365	-94.047283	8/30/2020	9:26:51 AM				
	Natgasoline	106586795	Beaumont	30.035096	-94.046758						
	Oil Tanking	101042885	Beaumont	30.032408	-94.038298						
27	Arkema	100216373	Beaumont	30.059048	-94.057088	8/28/2020	1:02:14 PM	8/30/2020	9:35:00 AM	8/30/2020	9:42:05 AM
	ExxonMobil Beaumont Refinery	102450756	Beaumont	30.057188	-94.076696						
28	Arkema	100216373	Beaumont	30.059048	-94.057088	8/30/2020	9:51:39 AM				
	ExxonMobil Beaumont Refinery	102450756	Beaumont	30.057188	-94.076696						

29	ExxonMobil Beaumont Refinery	102450756	Beaumont	30.057188	-94.076696	8/30/2020	10:29:02 AM	8/30/2020	11:12:42 AM		
30	Chevron Phillips	100215615	Orange	30.044827	-93.781246	8/28/2020	4:20:14 PM				
	Lion Elastomers Orange	100224468	Orange	30.049755	-93.786642						
31	Arlanxeo	100825363	Orange	30.045728	-93.769804	8/28/2020	4:17:13 PM				
	Solvay	102305505	Orange	30.049027	-93.764477						
32	Performance Materials	100542711	Orange	30.05463	-93.754363	8/28/2020	4:10:21 PM				
33	Performance Materials	100542711	Orange	30.05463	-93.754363	8/28/2020	4:03:46 PM				
34	Invista SARL Orange Site	104392626	Orange	30.057868	-93.751196	8/28/2020	3:55:52 PM				
35	Invista SARL Orange Site	104392626	Orange	30.057868	-93.751196	8/28/2020	3:49:21 PM				
36	Orion Orange Carbon Black	100209386	Orange	30.152318	-93.720997	8/28/2020	3:43:45 PM				
37	International Paper	100214428	Orange	30.218793	-93.741834	8/28/2020	3:35:42 PM				
38	Sunoco	100214626	Nederland	30.02886	-93.98777	8/30/2020	10:12:52 AM				

Appendix E: Visual Description of Terms

Hurricane Mission
Day 6—Flight #8

Run #1 = Line 1: Pass 1

Run #4 = Line 1: Pass 2

Line 1

Line 2

Run #2: Line 2: Pass 1

Line 3

Run #3: Line 3: Pass 1

When a specific *mission* is given to ASPECT, designated *flight lines* are created to meet the specifics of the mission's data quality objectives. The flight line numbers never change. Missions begin with a designated *flight number* for the day. Anytime the data is uploaded to the server (typically when the plane is grounded), a new flight number is given for the following flight. For example, if the day began with flight #3 and bad weather hit, the plane would land at the nearest airport, data would be uploaded, and a new flight number (i.e. Flight 4) would begin once the weather clears. *Run numbers* are given after a line has been flown. Runs are in chronological order of the flight. Each time a line is flown, the number of *passes* for that specific line increases. For example, if you need to fly Line 10 four times, the run would be designated with a description of "Line 10: Pass 4."