

# Airborne Spectral Photometric Environmental Collection Technology

## ASPECT Texas Air Quality Survey Corpus Christi and Houston, TX 9 March 2021



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# Table of Contents

<b>Acronyms and Abbreviations.....</b>	<b>3</b>
<b>Background and Operational Overview .....</b>	<b>7</b>
<b>General Mission Objectives .....</b>	<b>13</b>
<b>Flight Conditions and Status .....</b>	<b>13</b>
Weather and Site Conditions .....	13
<b>Data Results .....</b>	<b>14</b>
Flight Paths .....	14
Line Scanner Data Results .....	16
FTIR Data Results .....	19
Aerial Photography Results .....	26
<b>Conclusion .....</b>	<b>29</b>
<b>Appendix A: File Names of Data Collected During Flight .....</b>	<b>30</b>
<b>Appendix B: ASPECT Systems .....</b>	<b>32</b>

## **Acronyms and Abbreviations**

Alt	Altitude (in feet)
AGL	Above Ground Level
cm	centimeter
CST	Central Standard Time
DEM	Digital Elevation Model
Digital	Digital photography file from the Nikon D2X camera
ft	feet
FTIR	Fourier Transform Infrared Spectrometer
igm	Spectral data format based on grams format
IR	Infrared
IRLS	Infrared Line Scanner
jpg	JPEG image format
kts	knots
mph	miles per hour
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

During the week of 15 February 2021, a strong Polar air mass extended over a large portion of the United States pushing temperatures into the negative digits. The State of Texas experienced frozen precipitation and low temperatures culminating in stress to the power grid resulting in brown and blackout conditions. Due to the widespread power loss within the State, most petrochemical and other Risk Management Plan facilities were forced to shut down. During the week of 22 February 2021 plans were made to restart many of these facilities with concern that the restarts may impact air quality. The U.S. Environmental Protection Agency Region 6 was requested by the State of Texas to deploy the ASPECT aircraft for the purpose of area-wide air monitoring over the Beaumont, Houston, and Corpus Christi regions commencing on 27 February 2021. This report provides a summary of the findings made during the survey.

ASPECT missions conducted on 27 Feb 2021 were hampered by poor weather and low cloud ceilings which prevented data collection in the Beaumont area. ASPECT was able to collect a limited set of data near Crosby, TX and 5 collection runs over the Corpus Christi area. No compounds were detected on these missions.

On 28 Feb 2021 ASPECT conducted an air monitoring mission for both the Corpus Christi and Houston areas with low levels of 1-butene, isoprene, 1,3-butadiene, acetone, and ammonia were detected at low levels in the collection areas. Visible and IR imagery both showed hot flare and steam vents suggesting that facilities are operational.

ASPECT conducted two flight missions (Flight 4 and 5) on 2 March 2021 including air monitoring survey collections over Corpus Christi, Freeport, Houston, Port Arthur, and Beaumont areas. Weather conditions for both flights was favorable with some elevated turbulence reported on the afternoon flight. Imagery (visible and IR) showed typical steam and cooling tower and flare signatures. Compounds detected in the Corpus Christi area consisted of acetone (1.536 ppm), isoprene (1.250 ppm) and 1-butene (1.391 ppm). Isobutylene was detected in the Beaumont area at a level of 1.577 ppm.

Two air quality surveys were collected on 3 March 2021 over Beaumont and Houston areas (Flight 6) and mission over the Corpus Christi areas (Flight 7). Weather conditions for both surveys was favorable for all types of data collection. Visible and IR imagery showed normal facility operations including elevated process unit piping and visible steam plumes. Compounds detected on the Beaumont and Houston flight showed detections of 1-butene (7.230 ppm), 2-butene (5.443 ppm), 1,3-butadiene (1.537 ppm), ethylene (2.075 ppm), isoprene (4.055 ppm) and isobutylene (5.267 ppm). On Flight 7 the following compounds were detected including sulfur dioxide (1.517 ppm), 1-butene (1.792 ppm), 1,3-butadiene (0.994 ppm), isoprene (1.232 ppm) and isobutylene (1.505 ppm).

The collection objectives for 4 March 2021 included a continuation of air monitoring collection activities at selected sites within the Beaumont, Houston, and Corpus Christi areas. Weather forecast in the collection areas were acceptable for all types of data collection. No chemical plumes were detected on any of the IR imagery. Compounds

detected on Flight 8 included acetone (0.793 ppm) and isobutylene (1.929 ppm) in the Corpus Christi area and ammonia (0.477 ppm), 1,3-butadiene (6.788 ppm), 1-butene (6.140 ppm), 2-butene (7.930 ppm), ethylene (0.845 ppm), isobutylene (3.299 ppm), isoprene (2.678 ppm) and sulfur dioxide (2.218 ppm) in the Freeport and Houston areas. Compounds detected on the second flight of the day over Beaumont showed 1-butene (1.766 ppm), 1,3-butadiene (0.983 ppm), and isobutylene (1.531 ppm).

ASPECT conducted two flight missions on 5 March 2021 including air monitoring survey collections over Houston (Flight 10) and Corpus Christi (Flight 11). Weather conditions were generally favorable with some clouds in the early portion of the Houston area. No chemical plumes were detected on IR imagery. IR imagery did indicate a possible sheen within a containment basin in the Houston area. Compounds detected as part of the Houston survey consisted of 1-butene (1.244 ppm), acetone (0.855 ppm) and isoprene (4.398 ppm). Compounds detected in the Corpus Christi area consisted of 1-butene (1.862 ppm), 2-butene (2.634 ppm), isobutylene (1.527 ppm) and isoprene (0.883 ppm). No chemical plumes were detected on any of the collection passes.

Flight objectives for 6 March 2021 included conducting air monitoring surveys over the Beaumont and Houston areas. Weather conditions were favorable for all types of data collection with exception of moderate to strong turbulence on the Houston data collection. Compounds detected in the Beaumont area (Flight 12) included 1-butene (1.656 ppm) and 1,3-butadiene (0.743 ppm). Flight 13 had an absence of targeted organics but the presence of peroxyacetyl nitrate (PAN) and ozone was frequently detected. Oblique imagery during the Houston flight indicated a haze of smog, consistent with the PAN observations.

Objectives for 7 March 2021 included surveys over the La Port and Corpus Christi areas (Flight 14) and a mission over Freeport (Flight 15). A single compound was detected in the La Porte area consisting of acetic acid (1.518 ppm) which was associated with a flare that appeared to be in the startup process. Compounds detected in the Corpus Christi area included acetone (0.984 ppm), 1-butene (1.912 ppm), 2-butene (2.198 ppm), isoprene (1.184 ppm) and isobutylene (1.736 ppm). Isobutylene (2.022 ppm) was the only compound that was detected in the Freeport area.

ASPECT conducted two flights on 8 March 2021 consisting of an air monitoring survey over the Houston area followed by an afternoon mission over the Beaumont/Port Arthur area. Compounds detected associated with the Houston mission (Flight 16) included acetone (0.642 ppm), 1-butene (1.283 ppm), and isoprene (1.846 ppm). Compounds detected on over the Beaumont/Port Arthur areas included 1-butene (1.711 ppm), isobutylene (1.703 ppm), isoprene (1.221 ppm) and SO<sub>2</sub> (1.612 ppm).

Flights on 9 March 2021 included missions over Houston, Corpus Christi and the extended Corpus Christi areas. Compounds detected on Flight 18 (Houston and Freeport areas) included acetone (0.655 ppm), ammonia (10.19 ppm), 1-butene (1.250 ppm), 2-butene (1.921 ppm), 1,3-butadiene (0.514 ppm), isobutylene (1.788 ppm) and isoprene (0.682 ppm). Compounds observed over the Corpus Christi and extended areas on Flight 19

consisted of acetone (0.611 ppm), 1-butene (2.352 ppm), 2-butene (2.242 ppm), isobutylene (1.531 ppm), isoprene (1.016 ppm) and n-butyl alcohol (1.327 ppm).

# **ASPECT Texas Air Quality Survey Corpus Christi and Houston, TX 9 March 2021**

## **Background and Operational Overview**

During the week of 15 February 2021, a strong Polar air mass extended over a large portion of the United States pushing temperatures into the negative digits. The State of Texas experienced snow, ice, and low temperatures. These conditions culminated in a stress to the power grid resulting in brown and blackout conditions in many parts of the State. Petrochemical facilities in many locations were forced to shut down. During the week of 22 February 2021 plans were made to restart many of these facilities with concern that the restarts may impact air quality. The U.S. Environmental Protection Agency Region 6 was requested by the State of Texas to deploy the ASPECT aircraft for the purpose of area-wide air monitoring over the Beaumont, Houston, and Corpus Christi regions commencing on 27 February 2021.

The overall objective of this survey was to examine the air quality of areas populated with Risk Management Plan (RMP) sites and petrochemical facilities using the ASPECT system. No specific sites were specified other than generic survey areas. Figures 1, 2, and 3 show those areas corresponding to the Beaumont/Port Arthur, Houston, and Corpus Christi survey locations. Within these areas, a series of guidance flight lines were developed to assist the flight crew in data collection using the ASPECT system. The ASPECT system has a set of automated compounds that can be automatically detected and if any of these compounds were detected, the location and approximate quality of the compound would be reported to EPA Region 6.

An ASPECT series of missions were flown on 27 Feb 2021 as part of a request from EPA Region 6 to support air monitoring within the Beaumont, Houston, and Corpus Christi areas. The ASPECT aircraft attempted to collect data at each of the general areas and was only able to obtain 1 collection pass near Crosby, TX and 5 collection runs over the Corpus Christi area. Poor weather hampered all collection activities due to low cloud levels and dark conditions. The limited FTIR data that was collected and analyzed showed no detections on any collection passes.

ASPECT conducted a mission on 28 Feb 2021 consisting of an air monitoring survey over selected areas of the Corpus Christi and Houston collection areas. Weather conditions in both locations were marginal due to low ceilings but a set of data was collected for both locations. Imagery collected showed that facilities appear to be operational with both

steam and active flares. Compounds including 1-butene (2.665 ppm), isoprene (3.065), 1,3-butadiene (2.56 ppm), acetone (0.688 ppm), and ammonia (0.440 ppm) were detected at low levels in the Houston area and 1-butene (1.219 ppm) and isoprene (1.012 ppm) were detected in the Corpus Christi area.

ASPECT conducted two flight missions on 2 March 2021 including air monitoring survey collections over Corpus Christi, Freeport, Houston, Port Arthur, and Beaumont areas. Weather conditions for both surveys was generally favorable with some elevated turbulence reported on the afternoon flight. Visible imagery collected showed what appears to be normal steam and cooling tower emissions. Examination of IR imagery showed numerous flares and hot process piping and units. Compounds detected on the flight over Corpus Christi included acetone (1.536 ppm), isoprene (1.250 ppm) and 1-butene (1.391 ppm) all associated with one facility. The flight over the Freeport and Houston locations showed no detections. Isobutylene was detected in the Beaumont area at a level of 1.577 ppm.

On 3 March 2021 air monitoring surveys were collected over the Beaumont and Houston areas (Flight 6) and a mission over the Corpus Christi areas (Flight 7). Weather conditions for both surveys was favorable for all types of data collection. Visible and IR imagery showed normal facility operations including elevated process unit piping and visible steam plumes. Compounds detected on the Beaumont and Houston flight showed detections of 1-butene (7.230 ppm), 2-butene (5.443 ppm), 1,3-butadiene (1.537 ppm), ethylene (2.075 ppm), isoprene (4.055 ppm) and isobutylene (5.267 ppm). On Flight 7 the following compounds were detected including sulfur dioxide (1.517 ppm), 1-butene (1.792 ppm), 1,3-butadiene (0.994 ppm), isoprene (1.232 ppm) and isobutylene (1.505 ppm).

ASPECT conducted two flight missions on 4 March 2021 including air monitoring survey collections over Corpus Christi and Houston areas (Flight 8) and a mission over the Beaumont/Port Arthur (Flight 9). Weather conditions were favorable for all types of data collection. No chemical plumes were detected on IR imagery. Compounds detected on flight 8 included acetone (0.793 ppm) and isobutylene (1.929 ppm) in the Corpus Christi area and ammonia (0.477 ppm), 1,3-butadiene (6.788 ppm), 1-butene (6.140 ppm), 2-butene (7.930 ppm), ethylene (0.845 ppm), isobutylene (3.299 ppm) isoprene (2.678 ppm) and sulfur dioxide (2.218 ppm) in the Freeport and Houston area. Flight 9 over the Beaumont area showed 1-butene (1.766 ppm), 1,3-butadiene (0.983 ppm), and isobutylene (1.531 ppm). As with flight 8, visible and IR imagery indicated that facilities are showing normal thermal signatures.

The ASPECT objectives on 5 March 2021 included two flight missions over Houston (Flight 10) and Corpus Christi (Flight 11). Weather conditions were generally favorable with some clouds in the early portion of the Houston area. No chemical plumes were detected on IR imagery. IR imagery did indicate a possible plume within a containment basin in the Houston area. Compounds detected as part of the Houston survey consisted of acetone (0.855 ppm) and isoprene (4.398 ppm). Compound detected in the Corpus Christi



area consisted of 1-butene (1.862 ppm), 2-butene (2.634 ppm), isobutylene (1.527 ppm) and isoprene (0.883 ppm). No chemical plumes were detected on any of the collection passes.

Flight objectives for 6 March 2021 included conducting air monitoring surveys over the Beaumont and Houston areas. Weather conditions were favorable for all types of data collection with exception of moderate to strong turbulence on the Houston data collection. Compounds detected in the Beaumont area (Flight 12) included 1-butene (1.656 ppm) and 1,3-butadiene (0.743 ppm). Flight 13 had an absence of targeted organics but the presence of peroxyacetyl nitrate (PAN) and ozone was frequently detected. Oblique imagery during the Houston flight indicated a haze of smog, consistent with the PAN observations.

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The collection objectives for 9 March 2021 included a continuation of air monitoring collection activities at selected sites within the Houston and Corpus Christi areas. Weather conditions for the collection areas were forecast as favorable for all types of data collection. A second air monitoring mission was done over the extended Corpus Christi area. Weather in the area was reported with low ceiling forcing mission planning to reduce the collection altitude to 2000 ft AGL. This report summarizes the results of the mission.

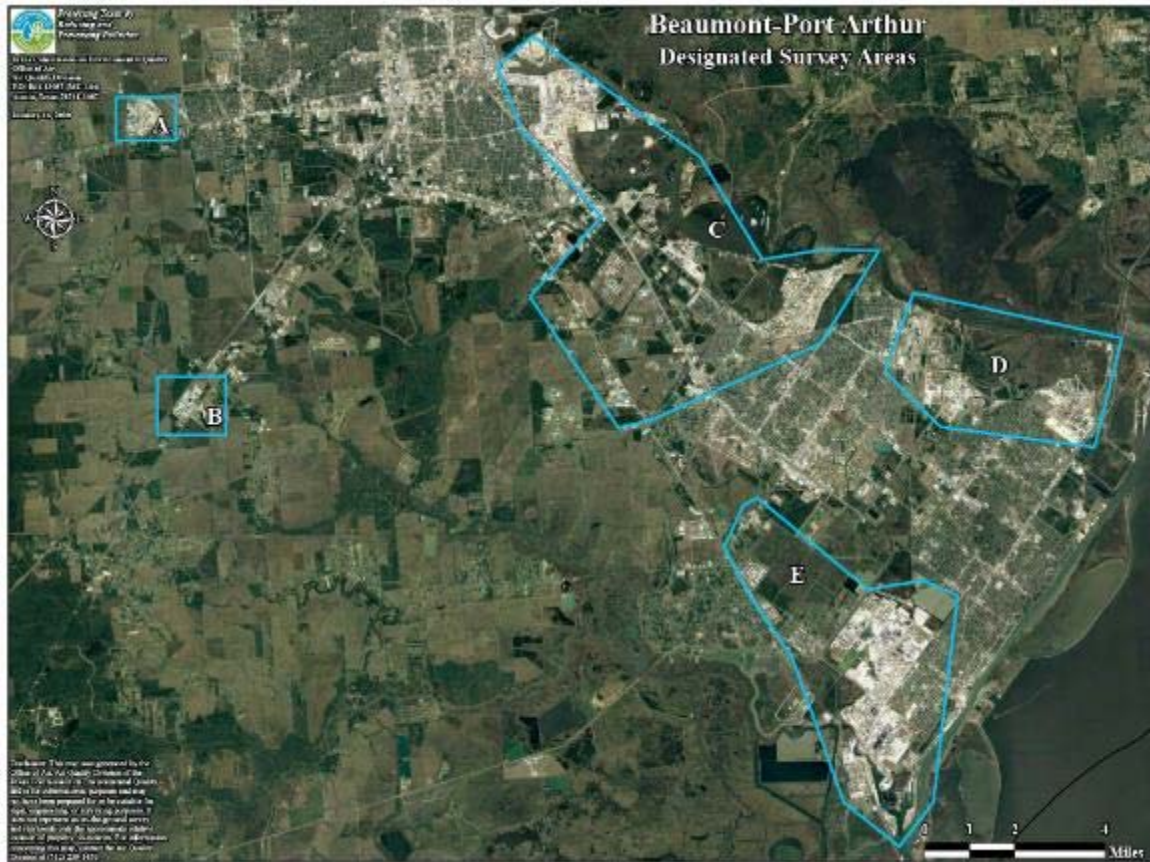
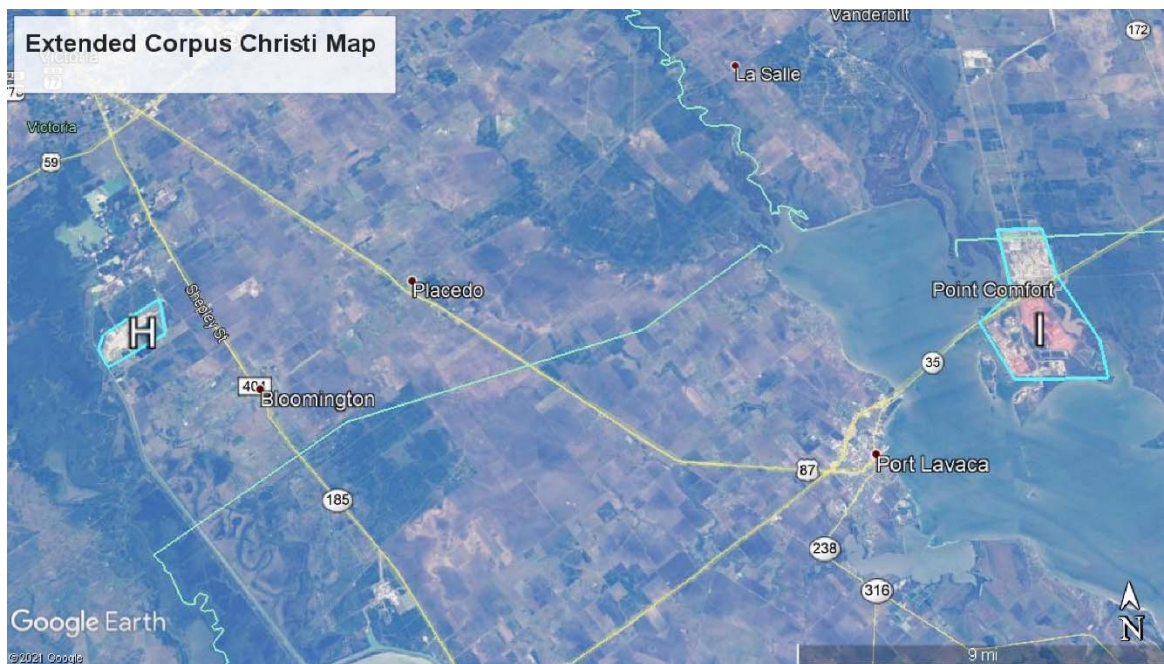
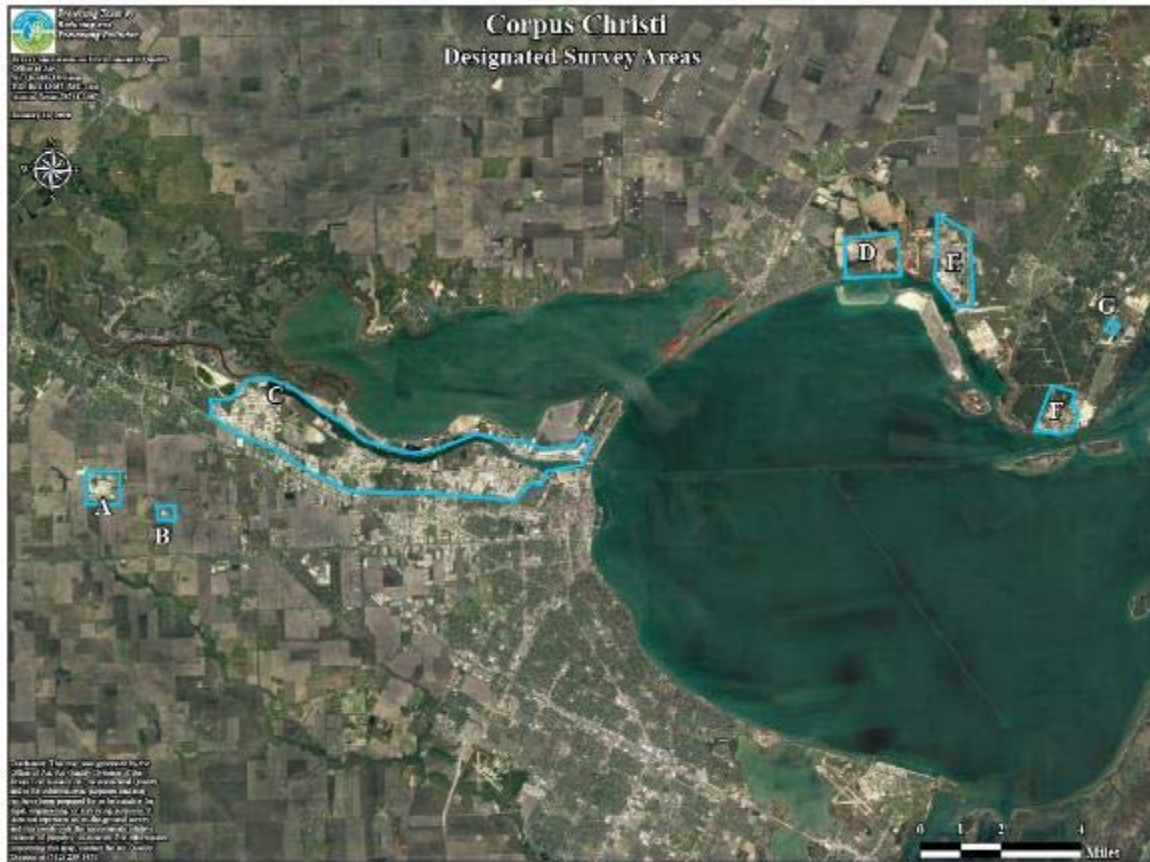


Figure 1: Beaumont/Port Arthur, TX Survey Area



Figure 2. Houston, TX Survey Area





## General Mission Objectives

Once granted access to fly over the sites, 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

## Flight Conditions and Status

### Weather and Site Conditions

Prior to each flight, an updated status of the current and forecasted weather, site conditions and any potential flight obstacles including radio towers impacting safety is assessed by the crew. A complete timeline of the ground weather conditions during the two missions can be found in Tables 1 and 2.

**Table 1. Ground Weather for Houston, TX**

Time	750	850	950	1050
Wind direction	112.5 degrees ESE	135 degrees SE	135 degrees SE	112.5 degrees ESE
Wind speed	3.1 m/s (7.0 mph)	5.4 m/s (12.0 mph)	6.7 m/s (15.0 mph)	8.0 m/s (18.0 mph)
Temperature	17.2 C	20.0 C	22.2 C	22.2 C
Relative humidity	94%	78%	61%	61%
Dew point	16.1 C	16.1 C	13.9 C	13.9 C
Pressure	1027.1 mb	1027.8 mb	1027.7 mb	1027.7 mb
Ceiling	Few 5000 Ft	Few 5000 Ft	Scattered 3000 Ft	Broken 3400 Ft

**Table 2. Ground Weather for Corpus Christi, TX**

Time	1151	1251	1351	1451	1551	1651
Wind direction	157.5 degrees SSE	157.5 degrees SSE	157.5 degrees SSE	135 degrees SE	157.5 degrees SSE	135 degrees SE
Wind speed	10.7 m/s (24.0 mph)	11.2 m/s (25.0 mph)	11.2 m/s (25.0 mph)	12.5 m/s (28.0 mph)	13.4 m/s (30.0 mph)	11.6 m/s (26.0 mph)
Temperature	26.1 C	26.1 C	26.7 C	26.1 C	25.0 C	22.8 C
Relative humidity	49%	49%	47%	49%	54%	66%
Dew point	14.4 C	14.4 C	14.4 C	14.4 C	15.0 C	16.1 C
Pressure	1024.9 mb	1024.3 mb	1022.7 mb	1021.1 mb	1020.4 mb	1020.9 mb
Ceiling	Few 2900 Ft	Few 3400 Ft	Few 2800 Ft	Few 3300 Ft	Few 3300 Ft	Few 2500 Ft

The aircraft departed Houston, TX at approximately 0740 CST (estimated) and was on station in the Houston area at 0819 CST. Winds were reported as 175° at 23 kts. Sky conditions showed some clouds higher than the ASPECT flight level.

At 1246 ASPECT was airborne to conduct air monitoring activities over the Corpus Christi and extended area. The crew reported on station at 1400 and reported flight level winds from 1600 at 25 kts. Clouds were reported at the normal collection level of 2800 ft AGL resulting in the collection altitude being lowered to 2000 ft AGL. Turbulence was reported as moderate.

### **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 A. The data collected during these missions 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 to keep the instruments stable. 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. Areas surveyed on Flight 18 included facilities near Houston and Freeport, TX (Figure 5). On the afternoon of 9 March 2021 ASPECT conducted a mission over the Corpus Christi and extended areas (Figure 6).



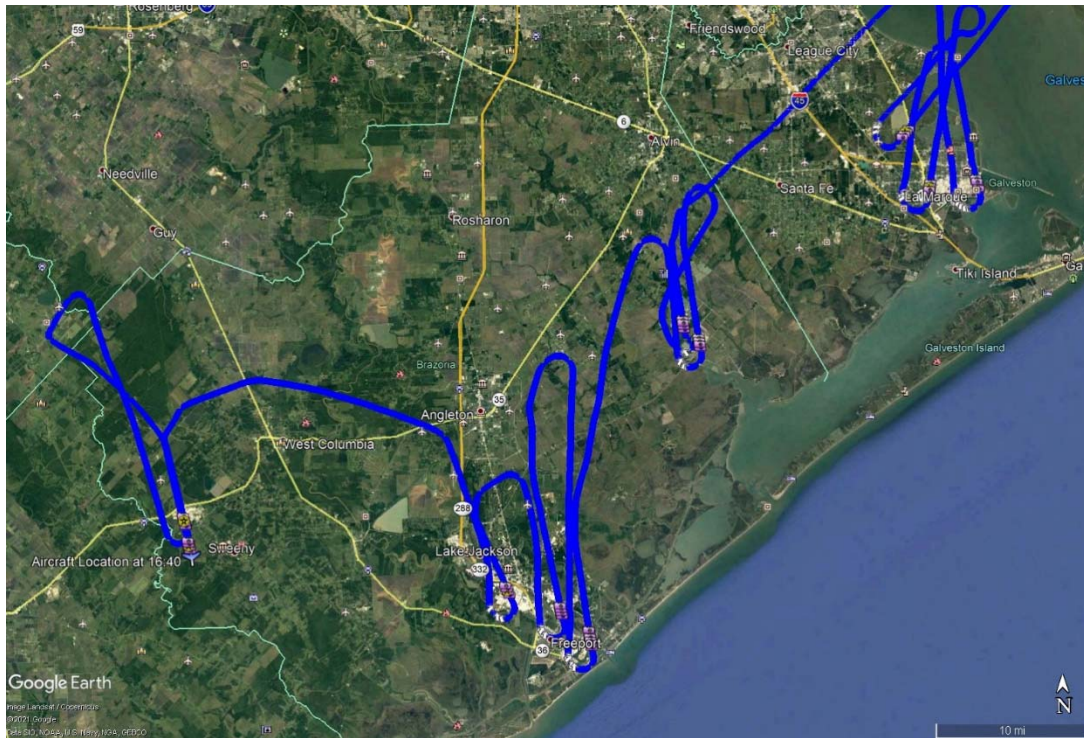


Figure 5. Data Collection Flight Path over the Houston/Freeport Areas, Flight 18, 9 March 2021

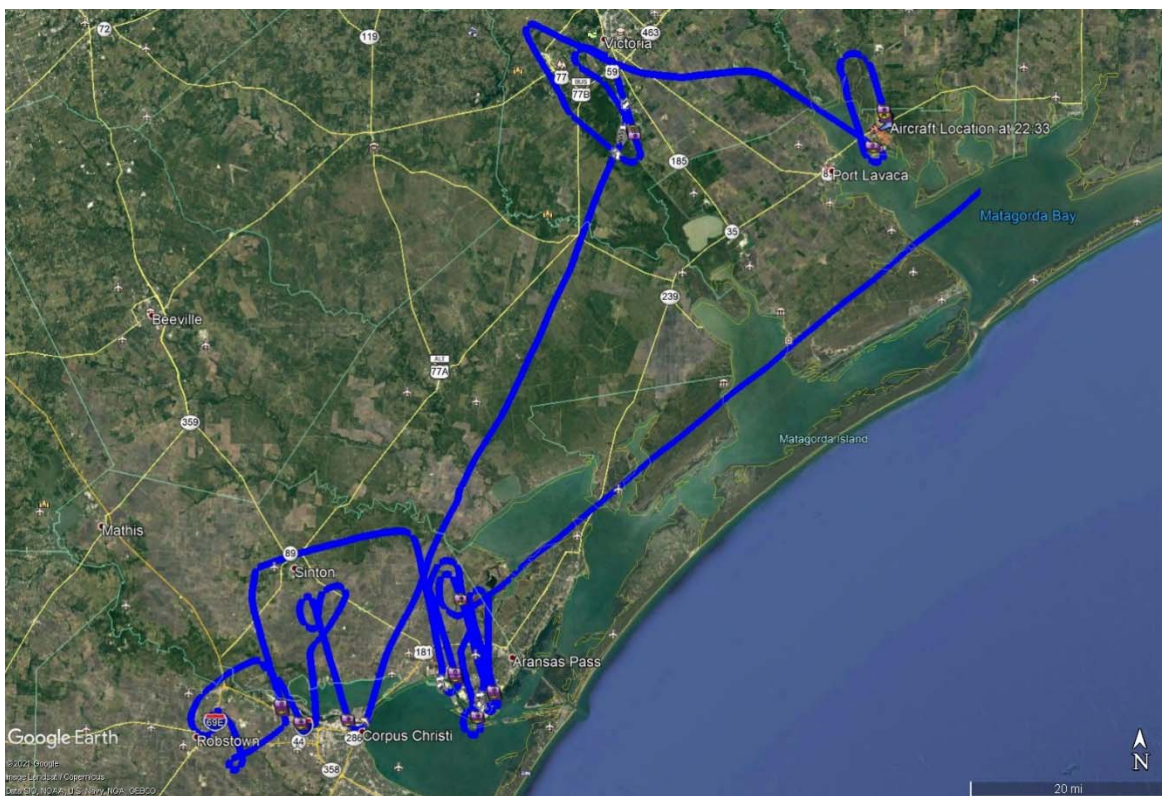


Figure 6. Data Collection Flight Path for the Corpus Christi and Extension Areas, Flight 19, 9 March 2021

### Line Scanner Data Results

A total of 10 data collection runs were made over the Houston/Freeport area and during each collection run an infrared line scanner image was generated. Figure 7 shows a 3-band infrared image collected over the Freeport area. A large area of elevated temperature is evident in the lower left portion of the image, most likely a flare. Other signatures include hot process units and piping. No chemical plumes can be observed being emitted from the facility.

As part of the second flight on 9 March 2021, ASPECT collected 10 IR images over selected sites with a representative image over the Victoria, TX area given in Figure 8. This facility appears to be active as evident by hot piping and process units and a hot flare. No chemical plumes can be seen being emitted from the facility. Other images in the areas showed similar results.



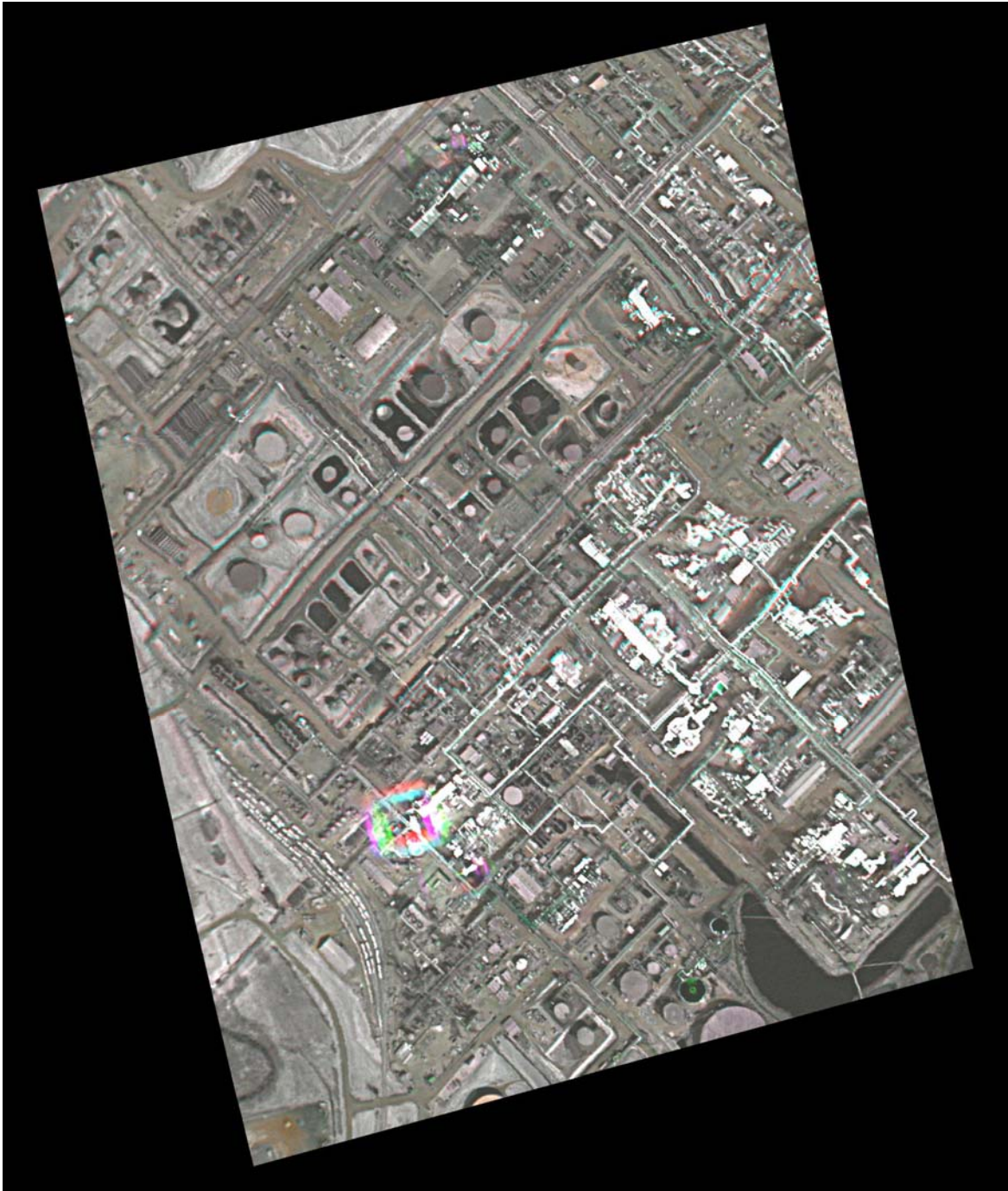


Figure 7. Three band IR image, Freeport Area, Run 10, Flight 18, 9 March 2021



Figure 8. Three band IR image, Victoria Area, Run 8, Flight 19, 9 March 2021



## 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 B, Table 1). In addition, collected data was also manually quality checked against a collection of published library spectra for each chemical detected.

Compounds detected on the mission over the Houston and Freeport areas included acetone (0.655 ppm), ammonia (10.19 ppm), 1-butene (1.250 ppm), 2-butene (1.921 ppm), 1,3-butadiene (0.514 ppm), isobutylene (1.788 ppm) and isoprene (0.682 ppm). The locations of these detections are given in Figures 9A through 9G. A representative spectrum of ammonia is given in Figure 10. Details of these detections can be found in Table 4.

The air monitoring mission conducted over the Corpus Christi and extended areas resulted in compounds including acetone (0.611 ppm), 1-butene (2.352 ppm), 2-butene (2.242 ppm), isobutylene (1.531 ppm), isoprene (1.016 ppm) and n-butyl alcohol (1.327 ppm). Details of these detections can be found in Table 5. The locations of the Flight 19 detections are shown in Figures 11A through 11F.

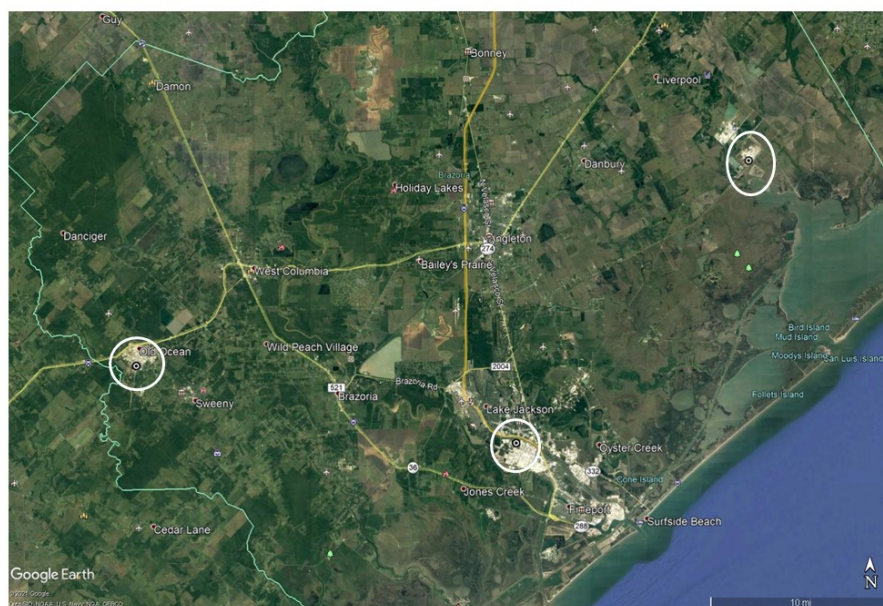


Figure 9A. Acetone Detection Location, Houston/Freeport Areas, TX, Flight 18, 9 March 2021



Figure 9B. Ammonia Detection Locations, Houston/Freeport Areas, TX, Flight 18, 9 March 2021

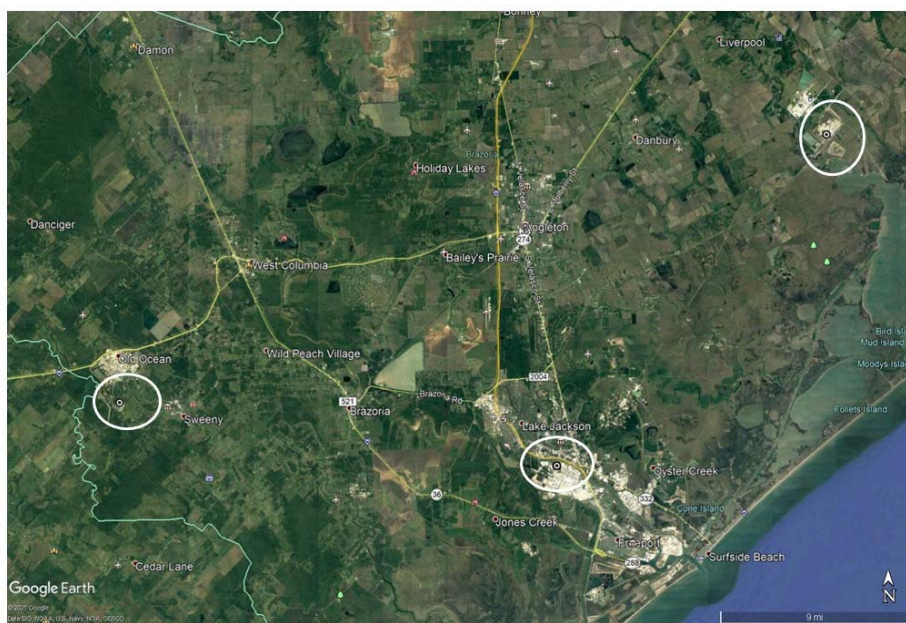


Figure 9C. 1-Butene Detection Locations, Houston Freeport Areas, Flight 18, 9 March 2021



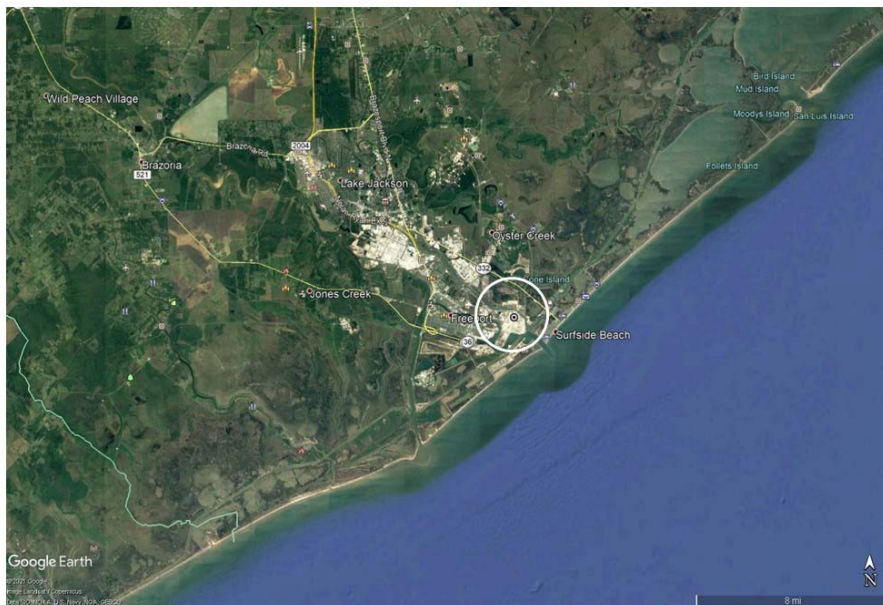


Figure 9D. 2-Butene Detection Location, Houston Freeport Areas, Flight 18, 9 March 2021

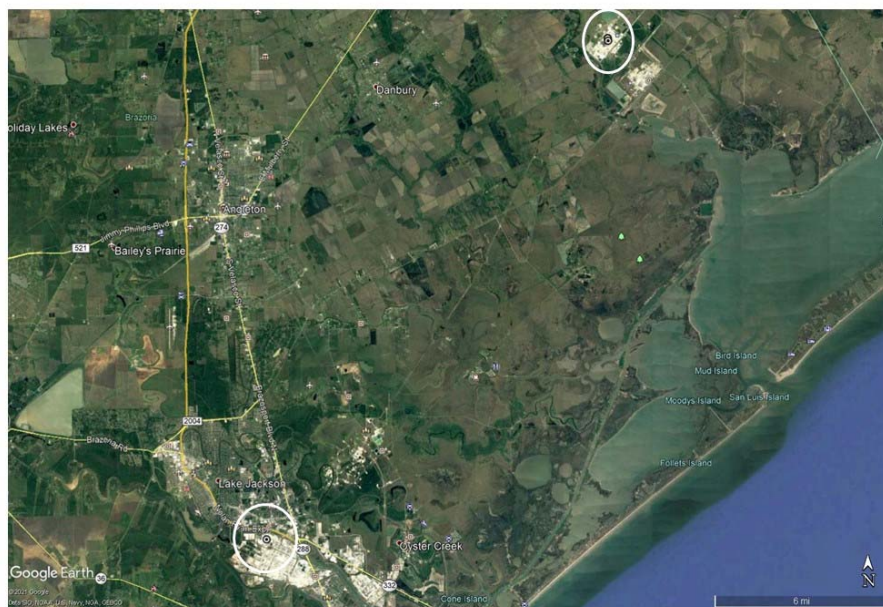


Figure 9E. 1,3-Butadiene Detection Location, Houston Freeport Areas, Flight 18, 9 March 2021

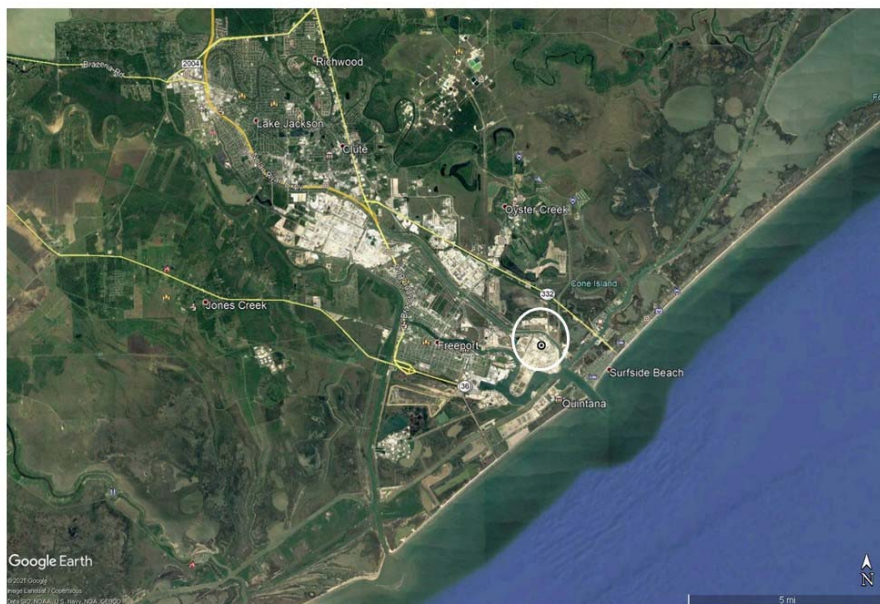


Figure 9F. Isobutylene Detection Location, Houston Freeport Areas, Flight 18, 9 March 2021

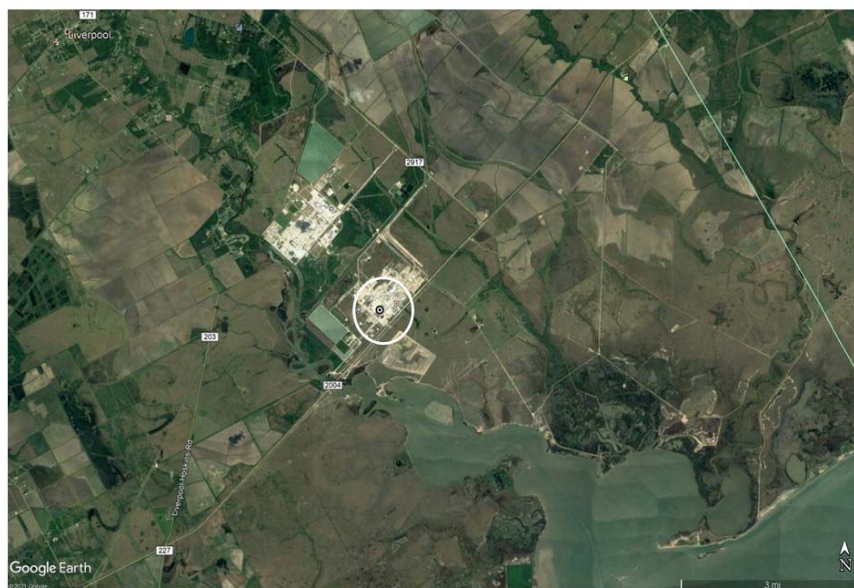


Figure 9G. Isoprene Detection Locations, Houston/Freeport Areas, Flight 18, 9 March 2021



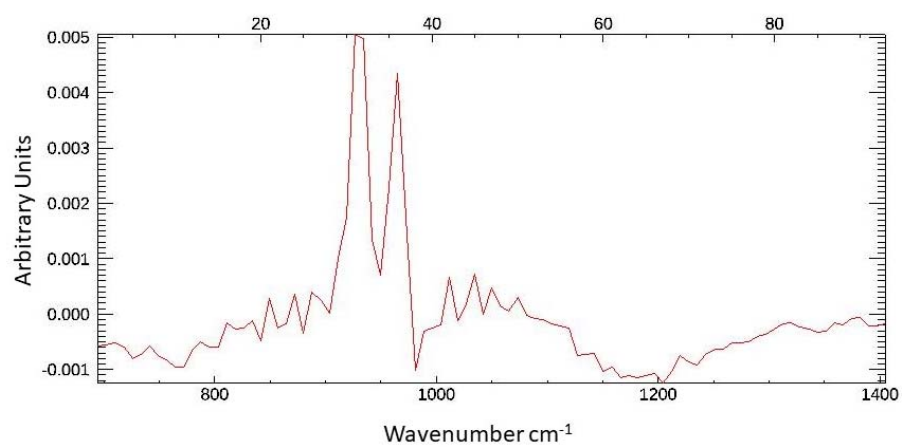


Figure 10. Ammonia Spectrum, Houston/Freeport Areas, Flight 18,  
9 March 2021

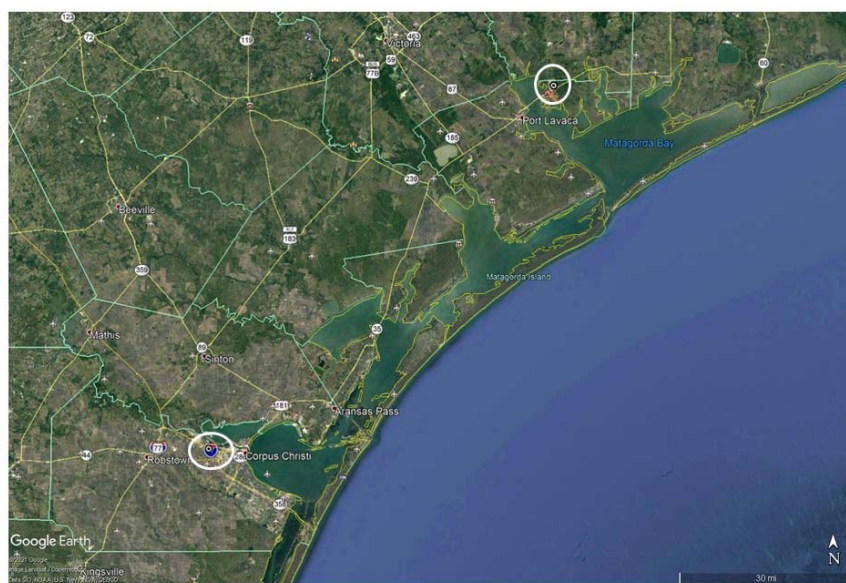


Figure 11A. Acetone Detection Locations, Corpus Christi and Extended Areas, TX area, Flight 19, 9 March 2021

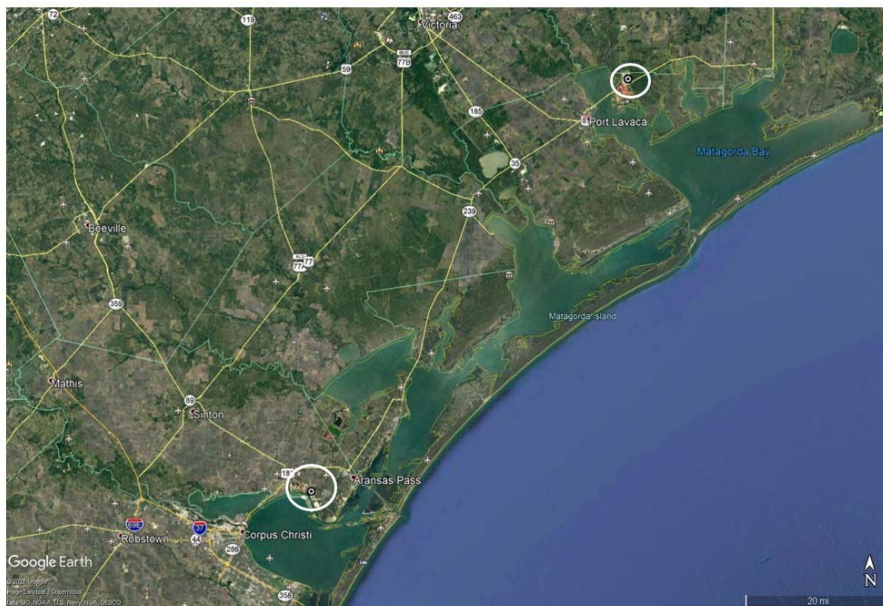


Figure 11B. 1-Butene Detection Locations, Corpus Christi and Extended Areas, TX area, Flight 19, 9 March 2021

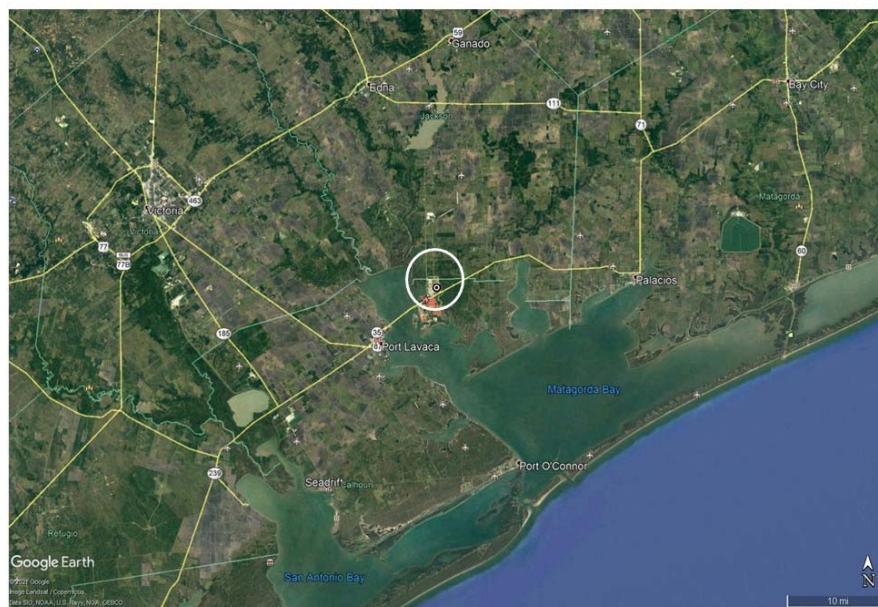


Figure 11C. 2-Butene Detection Location, Corpus Christi and Extended Areas, TX area, Flight 19, 9 March 2021



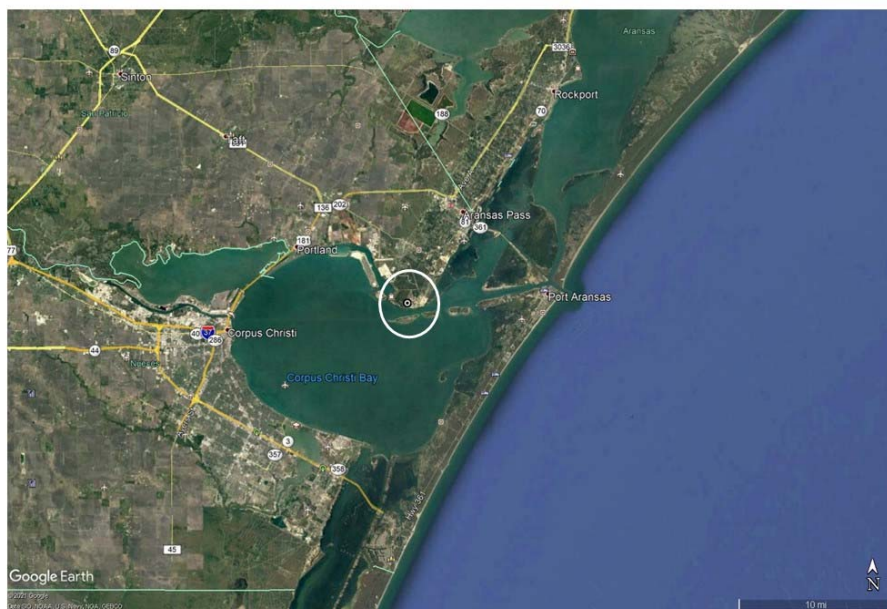


Figure 11D. Isobutylene Detection Location, Corpus Christi and Extended Areas, TX area, Flight 19, 9 March 2021

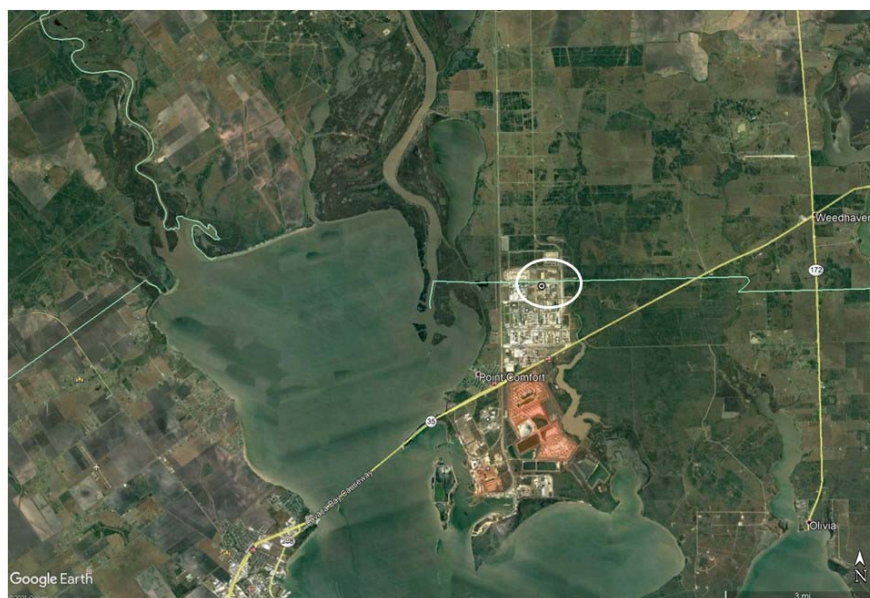


Figure 11E. Isoprene Detection Location, Corpus Christi and Extended Areas, TX area, Flight 19, 9 March 2021

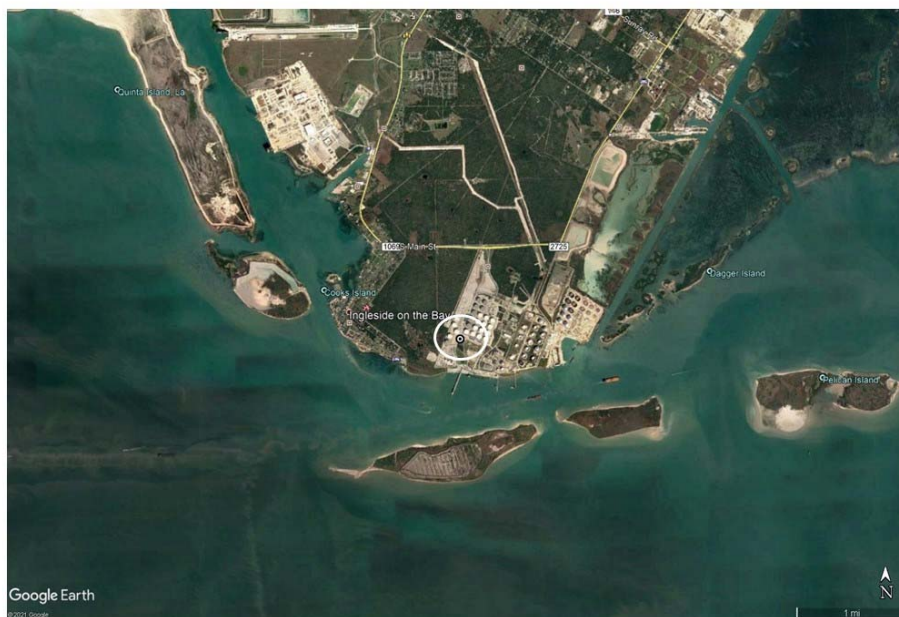


Figure 11F. n-Butyl Alcohol Detection Location, Corpus Christi and Extended Areas, TX area, Flight 19, 9 March 2021

**Table 4. Chemical Results Summary  
Houston/Freeport Collection Area, Flight 18**

Pass	Date	Time (UTC)	Chemical	Max Concentration (ppm)
1	2021-03-09	14:17:32	ND	ND
2		14:29:04	ND	ND
3		14:41:15	ND	ND
4		14:51:15	ND	ND
5		15:11:08	butadiene ammonia	0.592 10.19
6		15:21:51	isoprene acetone 1-butene	0.682 0.655 1.250
7		15:38:56	isobutylene 2-butene	1.788 1.921
8		15:56:00	ND	ND
9		16:05:26	acetone 1-butene butadiene	0.597 1.436 0.514
10		16:21:41	acetone	0.844
11		16:39:36	1-butene	1.211
ND = No Detections				

**Table 5. Chemical Results Summary  
Corpus Christi and Extended Areas, Flight 19**

Pass	Date	Time (UTC)	Chemical	Max Concentration (ppm)
1	2021-03-09	19:59:54	ND	ND
2		20:06:13	Isobutylene n-butyl alcohol	1.531 1.327
3		20:19:03	ND	ND
4		20:31:53	1-butene	1.369
5		20:51:53	ND	ND
6		21:09:24	acetone	0.611
7		21:26:34	ND	ND
8		21:59:10	ND	ND
9		22:23:56	ND	ND
10		22:32:38	isoprene 2-butene 1-butene acetone	1.016 2.242 2.352 0.611
ND = No Detections				

*\* The ASPECT FTIR is a standoff detector – measurements are taken >1,000 ft above the ground, and assumptions are made about the path length of the plume to calculate a concentration estimate. For this reason, these measurements should not be considered equivalent to volumetric measurement, but instead serve as a reasonable estimate of the concentration within the plume. They are not necessarily representative of concentrations at the ground level. Any measurements that appear out of the norm should be confirmed with ground measurements.*

#### Aerial Photography Results

A full set of high-resolution aerial digital photography were collected as part of each data collection pass. Weather conditions over the Houston/Freeport areas allowed high quality aerial images to be collected. Figure 12 shows a representative frame of a facility collected in the Freeport area. Inspection of the frame shows steam emissions suggesting operation of the facility. Figure 13 shows an oblique image collected during the morning flight showing what appears to be normal plant operations.





Figure 12. MSIC Aerial Image, Freeport Area, Flight 18



Figure 13. Oblique Image, Freeport Area, Flight 18

## Conclusion

ASPECT conducted two data collection missions on 9 March 2021 including flights over Houston and the Corpus Christi and extended area. Compounds detected on Flight 18 (Houston and Freeport areas) included acetone (0.655 ppm), ammonia (10.19 ppm), 1-butene (1.250 ppm), 2-butene (1.921 ppm), 1,3-butadiene (0.514 ppm), isobutylene (1.788 ppm) and isoprene (0.682 ppm). Compounds observed over the Corpus Christi and extended areas consisted of acetone (0.611 ppm), 1-butene (2.352 ppm), 2-butene (2.242 ppm), isobutylene (1.531 ppm), isoprene (1.016 ppm) and n-butyl alcohol (1.327 ppm).

## Appendix A: File Names of Data Collected During Flight

### Houston/Freeport Collection Area, Flight 18, 9 March 2021

Run#	Time (UTC)	Altitude (MSL)	Velocity (knots)	MSIC Data Files	FTIR Data Files	IRLS Data Files	Gamma Files
1	14:17:32	2876	106	20210309141738284.jpg 20210309141745538.jpg 20210309141751902.jpg	20210309_141736_A.igm	2021_03_09_14_17_37_R_01 TA=18.0;TB=38.6;Gain=3	
2	14:29:04	2871	108	20210309142910065.jpg 20210309142916430.jpg 20210309142922779.jpg 20210309142929128.jpg	20210309_142908_A.igm	2021_03_09_14_29_08_R_02 TA=11.9;TB=32.3;Gain=3	
3	14:41:15	2866	104	20210309144121008.jpg 20210309144128168.jpg 20210309144134517.jpg 20210309144140881.jpg	20210309_144119_A.igm	2021_03_09_14_41_20_R_03 TA=11.1;TB=31.4;Gain=3	
4	14:51:15	2852	107	20210309145121008.jpg 20210309145127372.jpg 20210309145133721.jpg 20210309145140991.jpg	20210309_145118_A.igm	2021_03_09_14_51_19_R_04 TA=12.7;TB=32.7;Gain=3	
5	15:11:08	2869	106	20210309151114874.jpg 20210309151121223.jpg 20210309151127587.jpg 20210309151133936.jpg	20210309_151112_A.igm	2021_03_09_15_11_13_R_05 TA=9.6;TB=29.6;Gain=3	
6	15:21:51	2888	106	20210309152157650.jpg 20210309152204015.jpg 20210309152210364.jpg 20210309152216729.jpg	20210309_152154_A.igm	2021_03_09_15_21_56_R_06 TA=16.1;TB=36.0;Gain=3	
7	15:38:56	2906	106	20210309153902662.jpg 20210309153909011.jpg 20210309153916281.jpg 20210309153922630.jpg 20210309153928995.jpg 20210309153935344.jpg	20210309_153859_A.igm	2021_03_09_15_39_01_R_07 TA=16.1;TB=36.2;Gain=3	
8	15:56:00	2901	107	20210309155606773.jpg 20210309155613123.jpg 20210309155619472.jpg 20210309155625836.jpg	20210309_155603_A.igm	2021_03_09_15_56_05_R_08 TA=17.4;TB=37.3;Gain=3	
9	16:05:26	2884	108	20210309160532384.jpg 20210309160538733.jpg 20210309160545098.jpg 20210309160551447.jpg	20210309_160530_A.igm	2021_03_09_16_05_31_R_09 TA=14.4;TB=34.2;Gain=3	
10	16:21:41	2864	105	20210309162147472.jpg 20210309162153821.jpg 20210309162200186.jpg 20210309162206535.jpg	20210309_162144_A.igm	2021_03_09_16_21_46_R_10 TA=20.8;TB=40.7;Gain=3	
11	16:39:36	2869	103	20210309163942427.jpg 20210309163948776.jpg 20210309163955125.jpg 20210309164001490.jpg	20210309_163939_A.igm	2021_03_09_16_39_42_R_11 TA=23.7;TB=43.8;Gain=3	

### Corpus Christi and Extended Areas, Flight 19, 9 March 2021

Run#	Time (UTC)	Altitude (MSL)	Velocity (knots)	MSIC Data Files	FTIR Data Files	IRLS Data Files	Gamma Files
1	19:59:54	2079	97	20210309200001199.jpg 20210309200005738.jpg 20210309200010277.jpg	20210309_195958_A.igm	2021_03_09_19_59_59_R_01 TA=20.9;TB=41.1;Gain=3	
2	20:06:13	2066	105	20210309200618864.jpg 20210309200623403.jpg 20210309200627943.jpg 20210309200632482.jpg	20210309_200616_A.igm	2021_03_09_20_06_18_R_02 TA=30.3;TB=50.0;Gain=3	
3	20:19:03	2088	102	20210309201909632.jpg 20210309201914171.jpg	20210309_201906_A.igm	2021_03_09_20_19_08_R_03 TA=22.9;TB=43.0;Gain=3	

				20210309201918711.jpg 20210309201923250.jpg 20210309201926885.jpg 20210309201931424.jpg			
4	20:31:53	2073	102	20210309203159508.jpg 20210309203204047.jpg 20210309203208586.jpg 20210309203213126.jpg 20210309203217665.jpg 20210309203222205.jpg 20210309203225824.jpg	20210309_203157_A.igm	2021_03_09_20_31_59_R_04 TA=21.0;TB=41.1;Gain=3	
5	20:51:53	2016	95	20210309205158794.jpg 20210309205203334.jpg 20210309205207873.jpg 20210309205212413.jpg 20210309205216952.jpg 20210309205221491.jpg 20210309205226031.jpg 20210309205230570.jpg	20210309_205156_A.igm	2021_03_09_20_51_58_R_05 TA=30.1;TB=50.1;Gain=3	
6	21:09:24	2000	97	20210309210930132.jpg 20210309210934665.jpg 20210309210939205.jpg 20210309210943744.jpg 20210309210948284.jpg	20210309_210927_A.igm	2021_03_09_21_09_29_R_06 TA=30.7;TB=50.7;Gain=3	
7	21:26:34	2118	102	20210309212640578.jpg 20210309212645117.jpg 20210309212649657.jpg 20210309212654196.jpg	20210309_212637_A.igm	2021_03_09_21_26_40_R_07 TA=29.6;TB=49.6;Gain=3	
8	21:59:10	2031	107	20210309215917081.jpg 20210309215921620.jpg 20210309215926160.jpg 20210309215930699.jpg 20210309215934334.jpg 20210309215938874.jpg	20210309_215914_A.igm	2021_03_09_21_59_16_R_08 TA=21.4;TB=41.5;Gain=3	
9	22:23:56	2067	113	20210309222402405.jpg 20210309222406944.jpg 20210309222410579.jpg 20210309222415119.jpg 20210309222419658.jpg	20210309_222359_A.igm	2021_03_09_22_24_01_R_09 TA=20.3;TB=40.5;Gain=3	
10	22:32:38	2048	110	20210309223244440.jpg 20210309223248075.jpg 20210309223252614.jpg 20210309223257154.jpg 20210309223301693.jpg 20210309223306233.jpg 20210309223310772.jpg 20210309223315312.jpg	20210309_223241_A.igm	2021_03_09_22_32_43_R_10 TA=18.8;TB=39.0;Gain=3	

## **Appendix B: 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  $\text{cm}^{-1}$ ) and 3 to 5 micron (2000 to 3200  $\text{cm}^{-1}$ ) 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 checked 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 Trifluoride (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 Tetrafluoride (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)