

# Airborne Spectral Photometric Environmental Collection Technology

## ASPECT Texas Air Quality Survey Beaumont and Corpus Christi, TX 11 March 2021



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## **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).

Only one compound was detected on the morning mission Flight 20, 10 March 2021 over the Beaumont/Port Arthur areas and consisted of 1-butene (1.238 ppm). Flight conditions for an afternoon mission over the Houston area were marginal and forced the system to be operated at about 1200 ft AGL. No programmed compounds were detected but common air pollution compounds were observed in the FTIR system.

ASPECT did not detect any programmed compounds (those found in Appendix B, Table 1) as part of the mission over the Beaumont/Port Arthur areas on 11 March 2021. On Flight 23 ASPECT detected 1-butene (2.071 ppm) over a facility in the Point Comfort area and 1-butene (1.543 ppm) and 1,3-butadiene (0.696 ppm) over the Corpus Christi area.

# **ASPECT Texas Air Quality Survey Beaumont and Corpus Christi, TX 11 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, 3 and 4 show those areas corresponding to the Beaumont/Port Arthur, Houston, Corpus Christi and extended 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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Focus areas of monitoring for 9 March 2021 included 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).

Only one compound was detected on the mission (Flight 20) over the Beaumont/Port Arthur areas and consisted of 1-butene (1.238 ppm). Flight conditions for an afternoon mission over the Houston area were marginal and forced the system to be operated at about 1200 ft AGL. No programmed compounds were detected but common air pollution compounds were observed in the FTIR system.

The collection objectives for 11 March 2021 included a continuation of air monitoring collection activities at selected sites within the Beaumont/Port Arthur and Houston areas. Weather conditions for the Beaumont/Port Arthur collection area was forecast as marginal with the hope of favorable conditions once on station. Conditions over Houston were not favorable for data collection forcing the mission to be changed to the Corpus Christi area. This report summarizes the results of the mission.

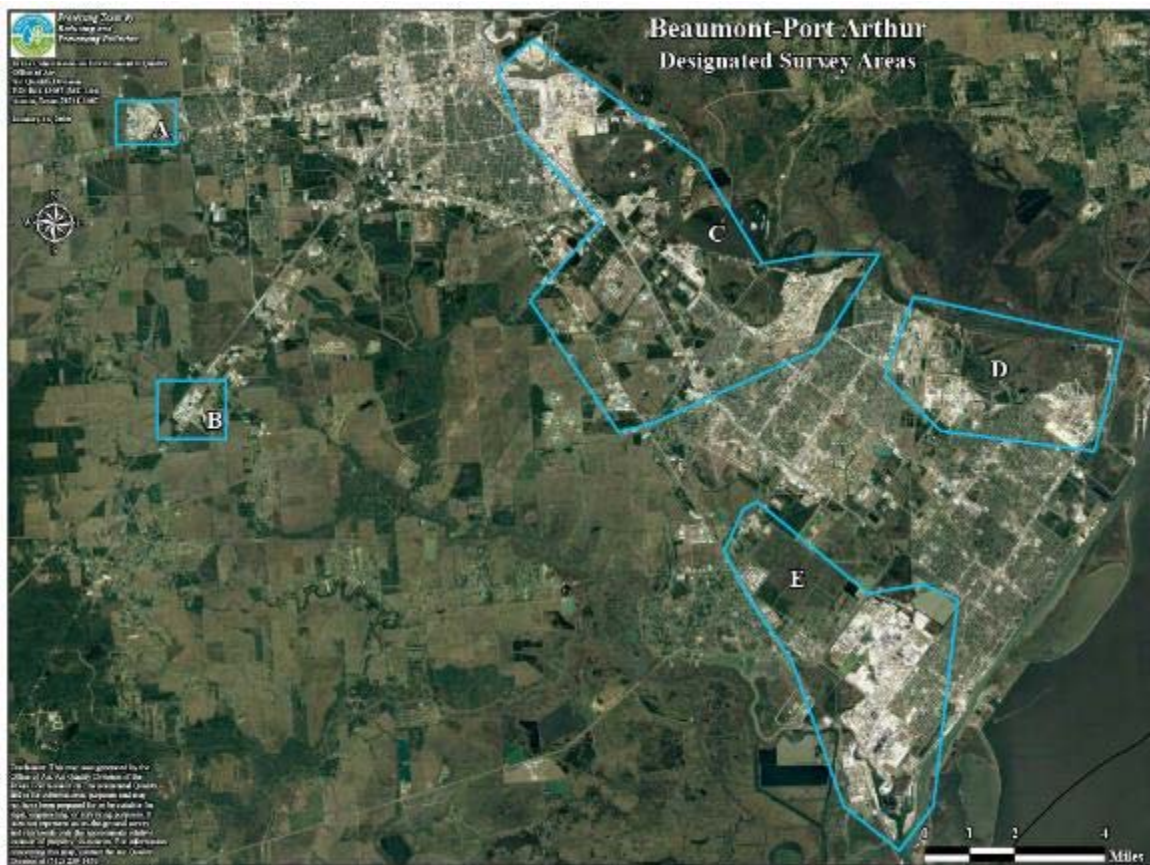
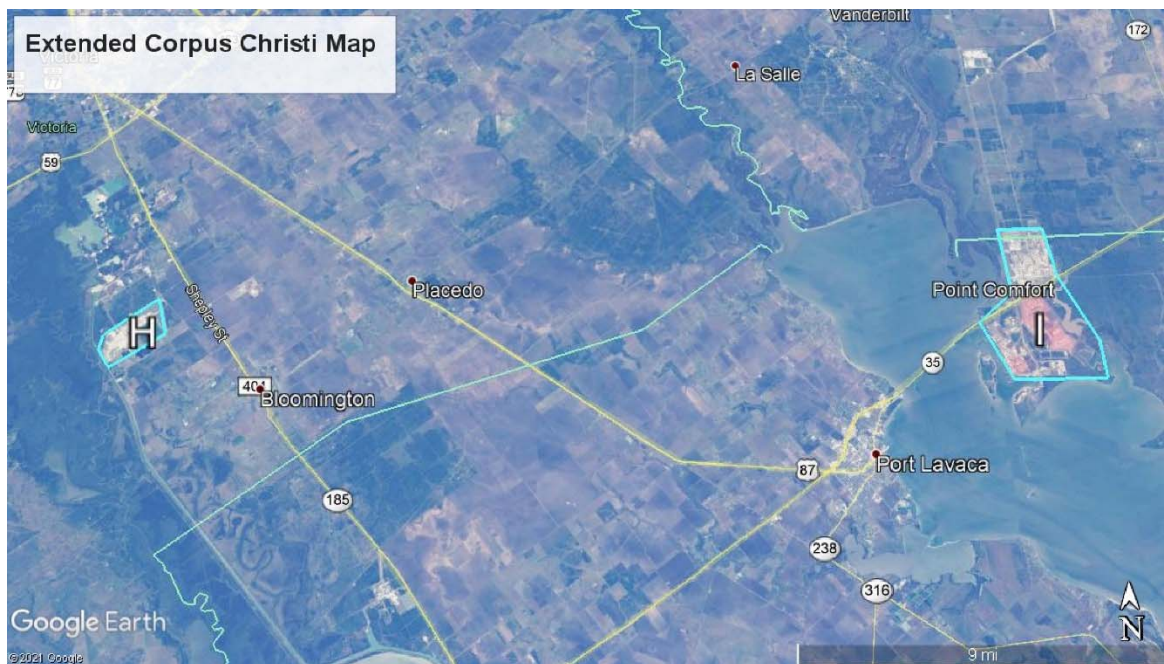
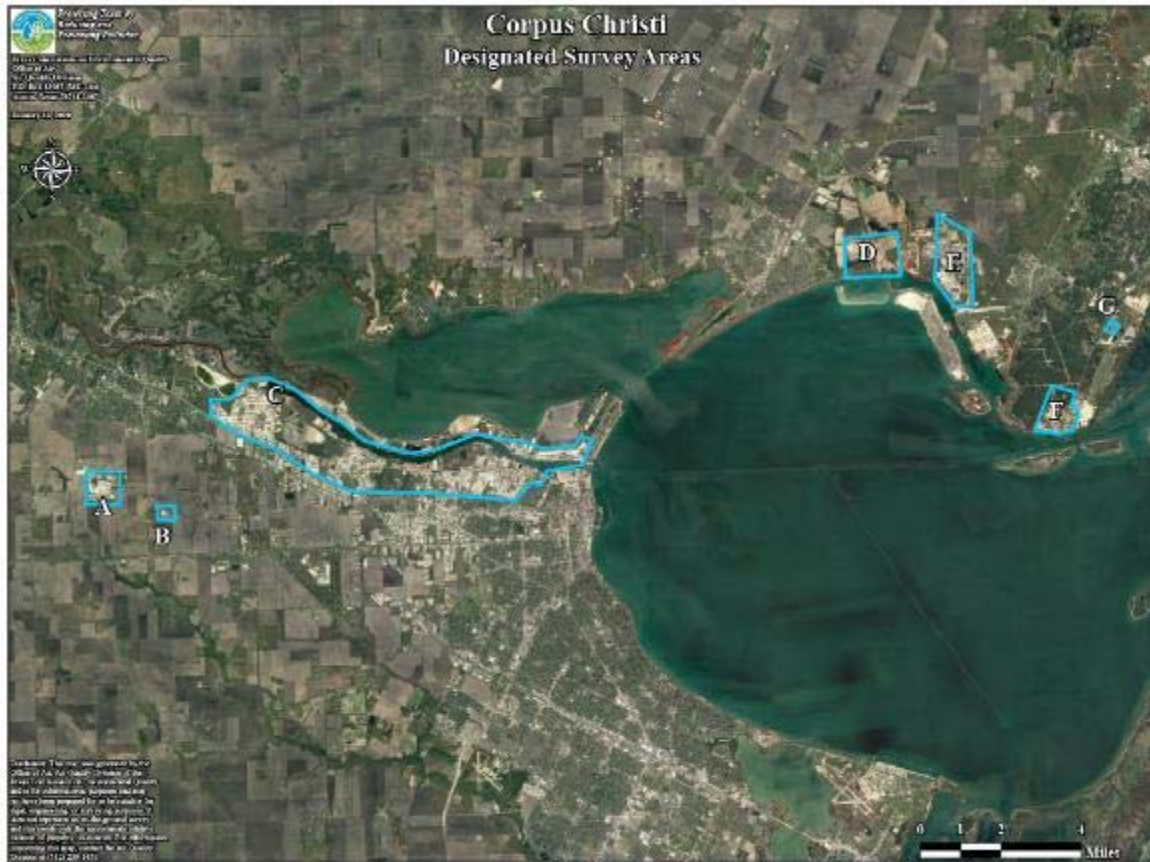


Figure 1: Beaumont/Port Arthur, TX Survey Area



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 Beaumont, TX**

Time	853	950	1053	1153
Wind direction	157.5 degrees SSE	157.5 degrees SSE	157.5 degrees SSE	157.5 degrees SSE
Wind speed	7.6 m/s (17.0 mph)	7.6 m/s (17.0 mph)	8.9 m/s (20.0 mph)	10.3 m/s (23.0 mph)
Temperature	21.7 C	22.8 C	23.9 C	24.4 C
Relative humidity	87%	78%	74%	71%
Dew point	19.4 C	18.9 C	18.9 C	18.9 C
Pressure	30.19 mb	30.2 mb	30.2 mb	30.19 mb
Ceiling	Clear	Broken 1600 Ft	Broken 1900 Ft	Broken 2300 Ft

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

Time	1351	1451	1551	1651	1751
Wind direction	157.5 degrees SSE	157.5 degrees SSE	157.5 degrees SSE	135 degrees SE	135 degrees SE
Wind speed	10.7 m/s (24.0 mph)	12.5 m/s (28.0 mph)	11.6 m/s (26.0 mph)	11.2 m/s (25.0 mph)	10.7 m/s (24.0 mph)
Temperature	27.2 C	27.8 C	27.2 C	25.6 C	23.9 C
Relative humidity	58%	56%	58%	64%	71%
Dew point	18.3 C	18.3 C	18.3 C	18.3 C	18.3 C
Pressure	1017 mb	1016.5 mb	1015.8 mb	1015.7 mb	1015.9 mb
Ceiling	Scattered 3000 Ft	Few 2600 Ft	Few 2600 Ft	Few 2300 Ft	Few 2100 Ft

The aircraft departed Houston, TX at approximately 0904 CST after a delay waiting for acceptable weather in the Beaumont area. Winds at 2800 ft AGL were reported from 167° at 10 kts. Cloud cover was highly variable with some locations permitting 2800 ft and others much lower. As the mission progressed, low level ceiling moved into the area from the south and forced collections to move over the Nederland area. Turbulence was reported as minimal.

ASPECT was airborne at 1332 on the afternoon of 11 March with an air monitoring mission in the Point Comfort and Corpus Christi areas. Conditions in Point Comfort were less than optimal forcing the aircraft to collect data at 1500 ft AGL. The crew reported winds at 177° at 26 kts. Conditions in the Corpus Christi area were favorable with the aircraft operating at 2800 ft AGL. Wind and turbulence reports were not given for this area.

## **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. On Flight 22 the Port Arthur area was surveyed, and the flight path is shown in Figure 5. Flight 23 was conducted on the afternoon of 11 March 2021 and consisted of a mission over the Point Comfort and Corpus Christi areas as shown in Figure 6 and Figure 7, respectively.





Figure 5. Data Collection Flight Path over the Beaumont/Port Arthur, Flight 22, 11 March 2021

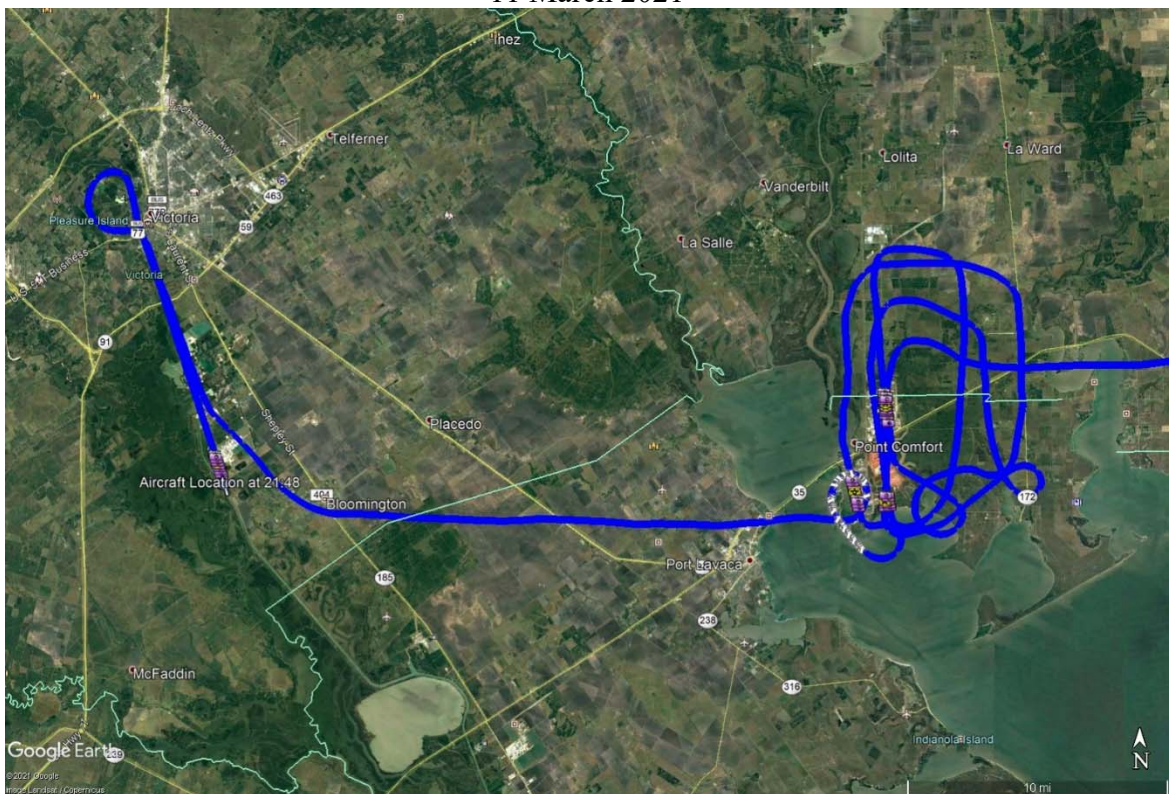


Figure 6. Data Collection Flight Path for the Point Comfort Area, Flight 23, 11 March 2021



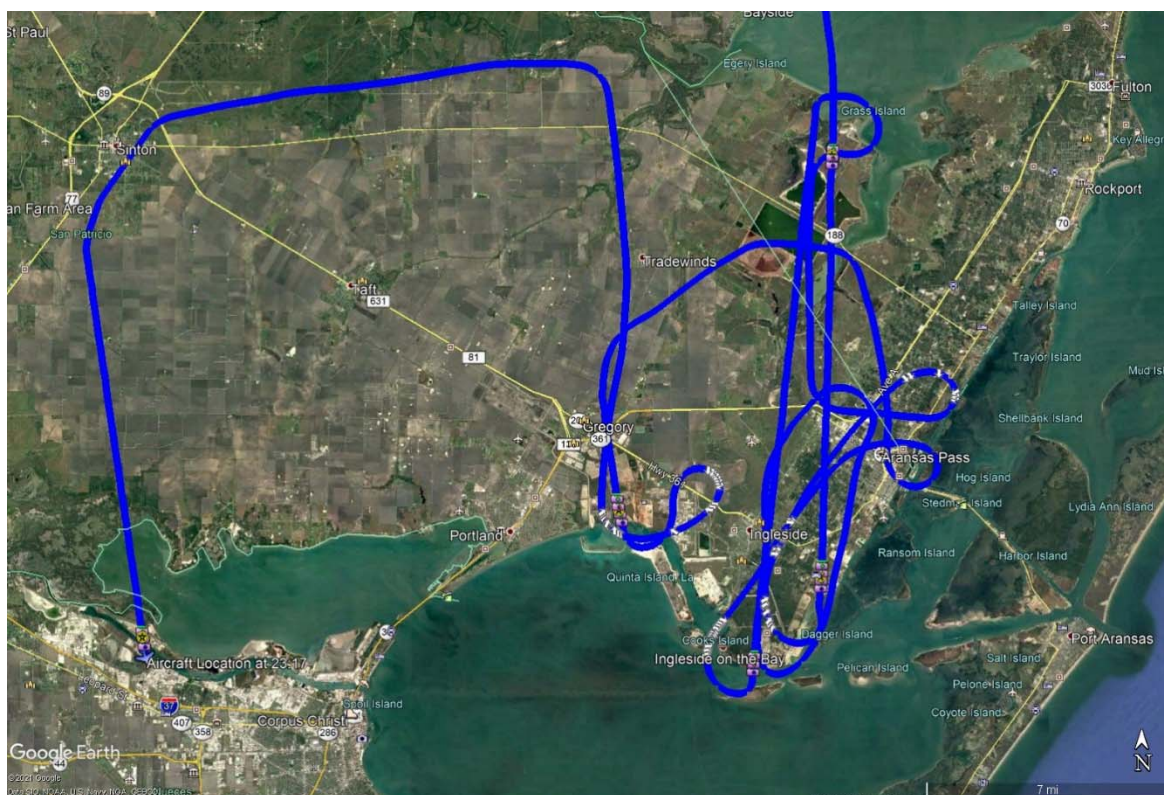


Figure 7. Data Collection Flight Path for the Corpus Christi Area, Flight 23, 11 March 2021

### Line Scanner Data Results

A total of 11 data collection runs were made over the Port Arthur and Beaumont area and during each collection run an infrared line scanner image was generated. Figure 8 shows a 3-band infrared image collected over the Port Arthur area. Examination of the image shows two small flares and hot process/piping throughout the upper portion of the image. Also, the dark feature in the upper right of the image is a cloud. No chemical plumes can be observed being emitted from the facility.

On the afternoon of 11 March 2021, ASPECT collected 12 IR images over selected sites over the Point Comfort and Corpus Christi areas. Figure 9 shows an image collected in the Corpus Christi areas showing a hot flare and several hot process units. No chemical plumes can be seen being emitted from the facility.





Figure 8. Three band IR image, Port Arthur Area, Run 6, Flight 22, 11 March 2021

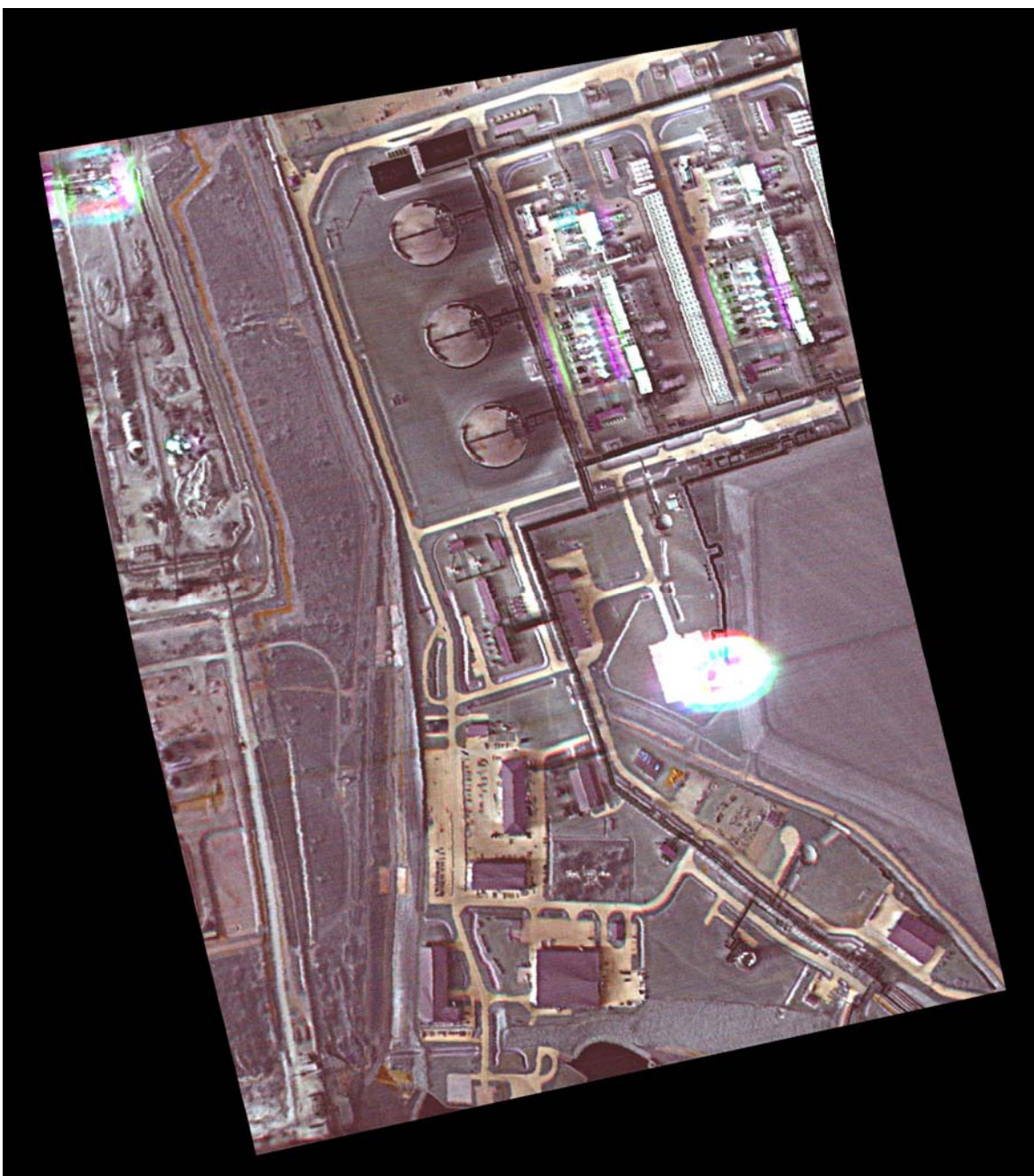


Figure 9. Three band IR image, Corpus Christi Area, Run 11, Flight 23, 11 March 2021

### 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.

ASPECT did not detect any programmed compounds (those found in Appendix B, Table 1) as part of the mission over the Beaumont/Port Arthur areas on 11 March 2021. Details of the monitoring results can be found in Table 3.

On Flight 23 ASPECT detected 1-butene (2.071 ppm) over a facility in the Point Comfort area. The location for this detection is given in Figure 10. Compounds detected over the Corpus Christi area included 1-butene (1.543 ppm) and 1,3-butadiene (0.696 ppm). Figures 11A and 11B show the respective locations for these detections. Figure 12 shows a representative spectrum of 1,3-butadiene. Detection details for the entire mission can be found in Table 4.

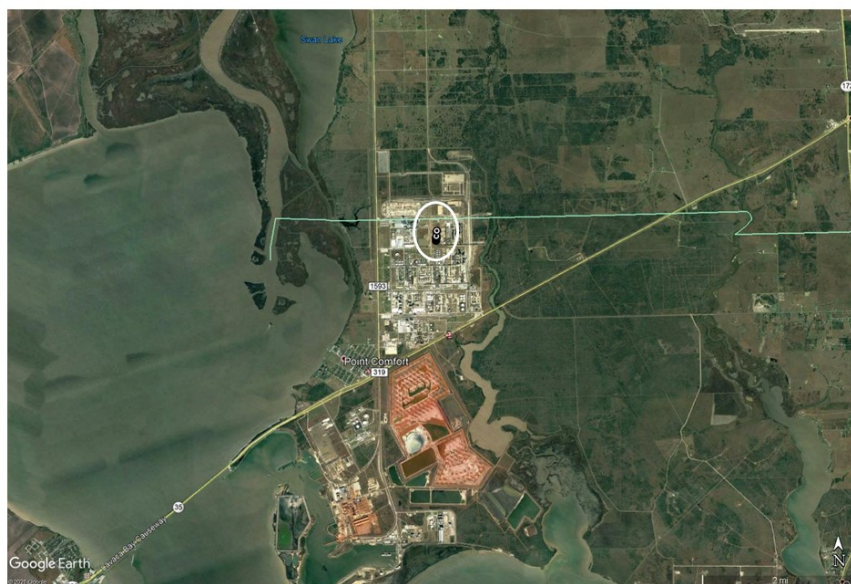


Figure 10. 1-Butene Detection Location, Point Comfort area, Flight 23, 11 March 2021



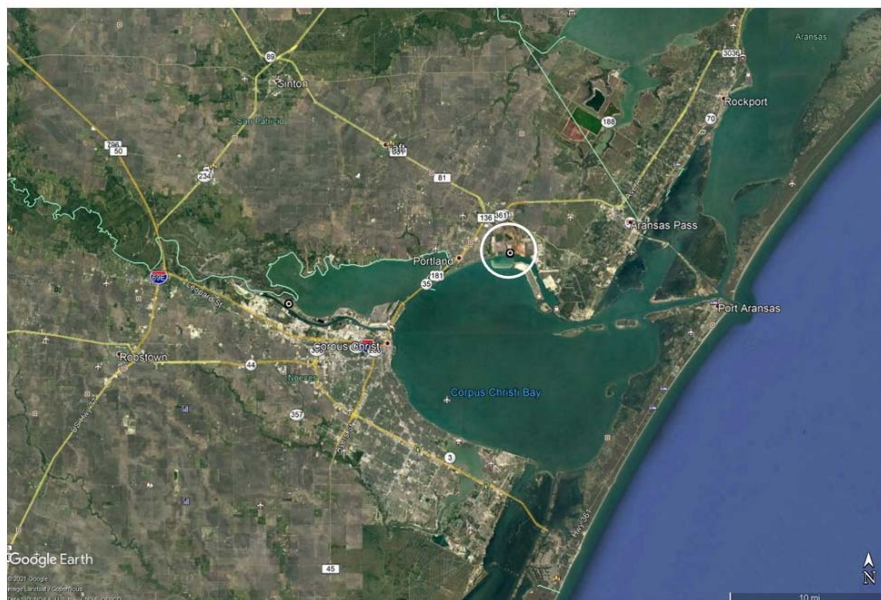


Figure 11A. 1-Butene Detection Locations, Corpus Christi, Flight 23, 11 March 2021

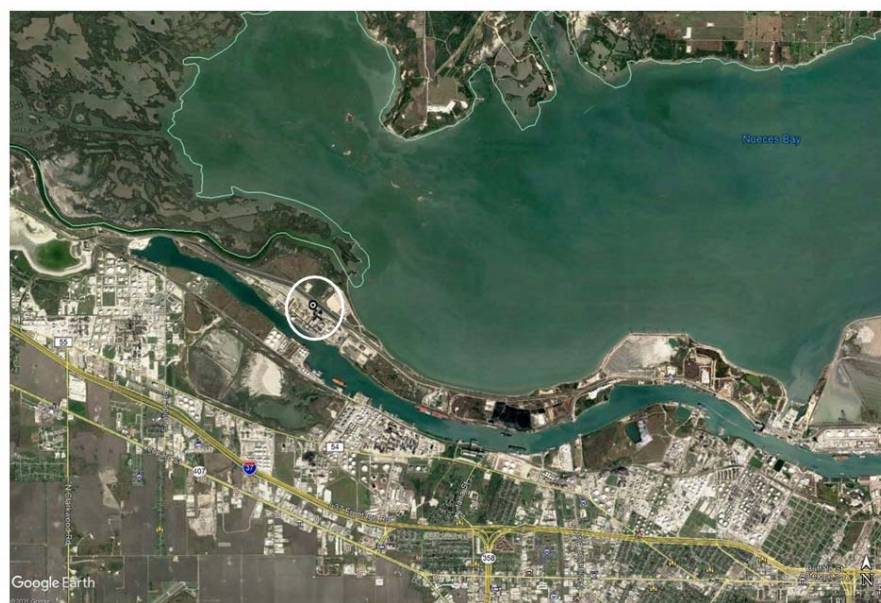


Figure 11B. 1,3-Butadiene Detection Location, Corpus Christi, Flight 23, 11 March 2021

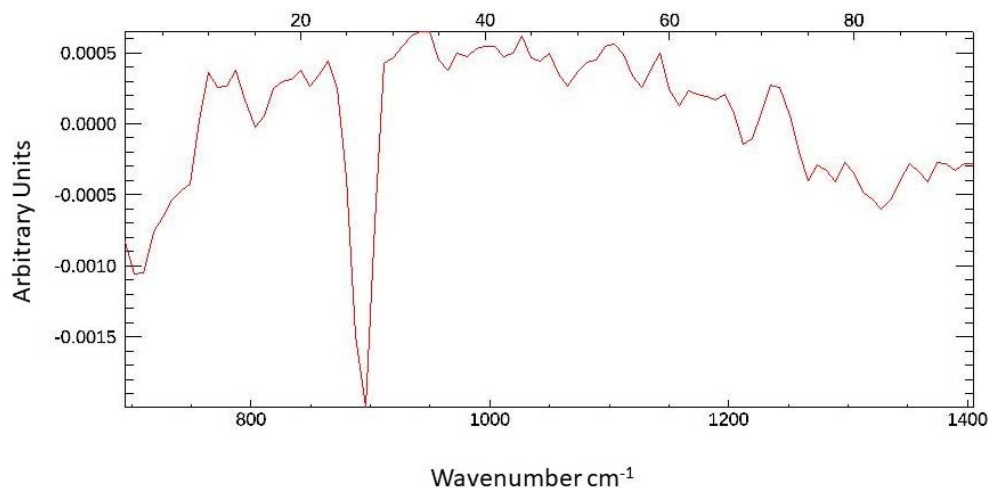


Figure 12. 1,3-Butadiene Spectrum, Corpus Christi Area, Flight 23,  
11 March 2021

**Table 3. Chemical Results Summary**  
**Beaumont/Port Arthur Collection Area, Flight 22**

Pass	Date	Time (UTC)	Chemical	Max Concentration (ppm)
1	2021-03-11	15:24:38	ND	ND
2		15:41:41	ND	ND
3		15:52:34	ND	ND
4		16:01:46	ND	ND
5		16:13:07	ND	ND
6		16:23:20	ND	ND
7		16:37:07	ND	ND
8		16:52:04	ND	ND
9		17:03:07	ND	ND
10		17:10:42	ND	ND
11		17:18:23	ND	ND
ND = No Detection				

**Table 4. Chemical Results Summary  
Point Comfort/Corpus Christi Areas, Flight 23**

Pass	Date	Time (UTC)	Chemical	Max Concentration (ppm)
1	2021-03-11	20:44:31	ND	ND
2	2021-03-11	20:51:16	1-butene	2.071
3	2021-03-11	20:53:03	ND	ND
4	2021-03-11	21:04:01	ND	ND
5	2021-03-11	21:12:17	ND	ND
6	2021-03-11	21:26:10	ND	ND
7	2021-03-11	21:48:11	ND	ND
8	2021-03-11	22:12:55	ND	ND
9	2021-03-11	22:18:38	ND	ND
10	2021-03-11	22:44:39	ND	ND
11	2021-03-11	22:57:14	1-butene	1.543
12	2021-03-11	23:17:13	butadiene	0.696
ND = No Detection				

*\* 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 Beaumont/Port Arthur areas was poor to marginal and resulted in several photos with cloud content. Figure 13 shows an example of light cloud content in the frame. In addition to cloud content there appears to be some emissions from the process unit, but differentiation is difficult due to the similar texture and color as low level clouds.



Figure 13. MSIC Aerial Image, Port Arthur Area, Flight 22

## Conclusion

ASPECT did not detect any programmed compounds (those found in Appendix B, Table 1) as part of the mission over the Beaumont/Port Arthur areas on 11 March 2021. On Flight 23 ASPECT detected 1-butene (2.071 ppm) over a facility in the Point Comfort area and 1-butene (1.543 ppm) and 1,3-butadiene (0.696 ppm) over the Corpus Christi area.

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

### Beaumont/Port Arthur Collection Areas, Flight 22, 11 March 2021

Run#	Time (UTC)	Altitude (MSL)	Velocity (knots)	MSIC Data Files	FTIR Data Files	IRLS Data Files	Gamma Files
1	15:24:38	2912	110	20210311152444644.jpg 20210311152451913.jpg 20210311152458263.jpg	20210311_152442_A.igm	2021_03_11_15_24_43_R_01 TA=19.9;TB=40.6;Gain=3	
2	15:41:41	2923	107	20210311154147845.jpg 20210311154154194.jpg 20210311154200559.jpg 20210311154206908.jpg	20210311_154145_A.igm	2021_03_11_15_41_46_R_02 TA=14.6;TB=34.8;Gain=3	
3	15:52:34	2818	107	20210311155240618.jpg 20210311155246983.jpg 20210311155253332.jpg	20210311_155238_A.igm	2021_03_11_15_52_39_R_03 TA=9.5;TB=29.5;Gain=3	
4	16:01:46	2792	107	20210311160152622.jpg 20210311160158971.jpg 20210311160205336.jpg 20210311160211685.jpg	20210311_160150_A.igm	2021_03_11_16_01_51_R_04 TA=9.4;TB=29.3;Gain=3	
5	16:13:07	2790	107	20210311161313542.jpg 20210311161319906.jpg 20210311161326256.jpg 20210311161332620.jpg	20210311_161310_A.igm	2021_03_11_16_13_11_R_05 TA=9.6;TB=29.5;Gain=3	
6	16:23:20	2790	108	20210311162326386.jpg 20210311162332735.jpg 20210311162340004.jpg 20210311162346353.jpg	20210311_162323_A.igm	2021_03_11_16_23_25_R_06 TA=20.5;TB=40.6;Gain=3	
7	16:37:07	2816	107	20210311163712572.jpg 20210311163718922.jpg 20210311163726191.jpg 20210311163732540.jpg	20210311_163711_A.igm	2021_03_11_16_37_11_R_07 TA=22.3;TB=42.3;Gain=3	
8	16:52:04	2813	109	20210311165210477.jpg 20210311165216842.jpg 20210311165223191.jpg 20210311165229556.jpg 20210311165235905.jpg	20210311_165207_A.igm	2021_03_11_16_52_08_R_08 TA=20.2;TB=40.0;Gain=3	
9	17:03:07	2838	102	20210311170314164.jpg 20210311170320513.jpg 20210311170326878.jpg	20210311_170311_A.igm	2021_03_11_17_03_12_R_09 TA=12.2;TB=32.2;Gain=3	
10	17:10:42	2821	107	20210311171049014.jpg 20210311171055379.jpg 20210311171101728.jpg	20210311_171046_A.igm	2021_03_11_17_10_47_R_10 TA=22.6;TB=42.6;Gain=3	
11	17:18:23	2789	108	20210311171829324.jpg 20210311171835689.jpg 20210311171842038.jpg 20210311171849308.jpg	20210311_171826_A.igm	2021_03_11_17_18_28_R_11 TA=10.4;TB=30.6;Gain=3	

### Point Comfort and Corpus Christi Areas, Flight 23, 11 March 2021

Run#	Time (UTC)	Altitude (MSL)	Velocity (knots)	MSIC Data Files	FTIR Data Files	IRLS Data Files	Gamma Files
1	20:44:31	1982	117	20210311204437879.jpg 20210311204443323.jpg 20210311204448783.jpg	20210311_204435_A.igm	2021_03_11_20_44_36_R_01 TA=23.0;TB=42.8;Gain=3	
2	20:51:16	1597	115	20210311205122795.jpg 20210311205126430.jpg 20210311205130969.jpg 20210311205135509.jpg 20210311205140048.jpg	20210311_205120_A.igm	2021_03_11_20_51_21_R_02 TA=25.5;TB=45.4;Gain=3	
3	20:53:03	1457	111	20210311205309917.jpg 20210311205313551.jpg 20210311205317186.jpg 20210311205319916.jpg 20210311205323535.jpg	20210311_205307_A.igm	2021_03_11_20_53_08_R_03 TA=25.5;TB=45.2;Gain=3	



4	21:04:01	1508	108	20210311210407234.jpg 20210311210410853.jpg 20210311210414488.jpg 20210311210418123.jpg 20210311210420853.jpg	20210311_210404_A.igm	2021_03_11_21_04_06_R_04 TA=23.5;TB=43.6;Gain=3	
5	21:12:17	1517	108	20210311211223832.jpg 20210311211227467.jpg 20210311211231101.jpg 20210311211233831.jpg 20210311211237451.jpg 20210311211241085.jpg 20210311211244720.jpg 20210311211247450.jpg 20210311211251069.jpg 20210311211254704.jpg 20210311211258338.jpg	20210311_211221_A.igm	2021_03_11_21_12_22_R_05 TA=21.0;TB=41.1;Gain=3	
6	21:26:10	1503	113	20210311212616371.jpg 20210311212620005.jpg 20210311212623640.jpg 20210311212626354.jpg 20210311212629989.jpg 20210311212633624.jpg 20210311212637243.jpg 20210311212639973.jpg 20210311212643608.jpg 20210311212647242.jpg	20210311_212613_A.igm	2021_03_11_21_26_15_R_06 TA=22.0;TB=41.9;Gain=3	
7	21:48:11	1523	107	20210311214818258.jpg 20210311214820988.jpg 20210311214824607.jpg 20210311214828242.jpg 20210311214831877.jpg 20210311214834607.jpg 20210311214838226.jpg 20210311214841861.jpg	20210311_214814_A.igm	2021_03_11_21_48_16_R_07 TA=24.3;TB=44.2;Gain=3	
8	22:12:55	2933	107	20210311221300856.jpg 20210311221308127.jpg 20210311221314476.jpg	20210311_221258_A.igm	2021_03_11_22_13_00_R_08 TA=21.4;TB=41.3;Gain=3	
9	22:18:38	2901	106	20210311221844944.jpg 20210311221851309.jpg 20210311221857658.jpg 20210311221904023.jpg	20210311_221841_A.igm	2021_03_11_22_18_43_R_09 TA=20.5;TB=40.5;Gain=3	
10	22:44:39	2905	106	20210311224444723.jpg 20210311224451993.jpg 20210311224458342.jpg	20210311_224442_A.igm	2021_03_11_22_44_44_R_10 TA=20.9;TB=40.8;Gain=3	
11	22:57:14	2912	111	20210311225720105.jpg 20210311225726454.jpg 20210311225732804.jpg 20210311225739168.jpg	20210311_225717_A.igm	2021_03_11_22_57_19_R_11 TA=12.1;TB=32.2;Gain=3	
12	23:17:13	2956	108	20210311231719446.jpg 20210311231725795.jpg 20210311231732160.jpg	20210311_231716_A.igm	2021_03_11_23_17_18_R_12 TA=19.6;TB=39.5;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)