ASPECT Operations Plan for the Deployment to the 2013 Boy Scouts of America Jamboree 14 – 24 July 2013

Participating Organizations:
West Virginia 35th Civil Support Team
U.S. EPA Region 3
U.S. EPA CBRN CMAT ASPECT

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Situation. The US Environmental Protection Agency (EPA) CBRN Consequence Management Advisory Team (CMAT) Airborne Spectral Photometric Environmental Collection Technology (ASPECT) Program has been requested to support The 35th West Virginia Civil Support Team (CST) and EPA Region 3 for activities associated with the 2013 Boy Scout of America Jamboree located near Mt Hope, West Virginia. The deployment will be from 14 July 2013 through 24 July 2013. This Operations Plan details the components of the ASPECT Program and defines the roles and responsibilities of the participants involved in the deployment.

ASPECT System Description. The ASPECT components are installed and operated from an airplane capable of providing 24/7 chemical and radiological detection and visible and infrared imagery and can be forward deployed or respond to any location in the U.S (Figure 1). The system uses two chemical sensors and up to three radiological detector systems to detect and map chemical plumes and radiological sources and deposition. The ASPECT chemical sensors include a high resolution (0.5 meter pixels) multi-spectral infrared line scanner that produces a two dimensional image and a point detection Fourier Transform Infrared Spectrometer (FTIR) that can be used to obtain detailed chemical information of any point in the plume. Radiological gamma detection systems include (1) multi-crystal sodium iodide detectors, (2) multi-crystal lanthanum bromide (LaBr) detectors and (3) four helium-3 tubes for neutron detection. All sensors are fully integrated using full geospatial registration. The neutron and LaBr detectors are installed for specific missions. The NaI detectors are a permanent fixture.

Figure 1 -- ASPECT

ASPECT provides a preliminary indication of the chemical composition of a release and elevated radiation levels within 3 minutes with independent confirmation in 15 minutes. The results are communicated directly to the OSC for further analysis. Additional information on the ASPECT System and the aircraft are listed in Appendix B.

General Concept. The deployment time-line is shown in Appendix A. The aircraft will arrive in West Virginia on 13 July 2013. The aircraft will be operated out of KCRW Yeager Airport, Charleston, WV. All data processing will be located at the airport Fixed Base of Operation (FBO). ASPECT aircraft operations will be associated with the following FBO facility:

Executive Air
Yeager Airport
300 Eagle Mountain Road
Charleston, WV 25311
304-343-8818

The ASPECT deployment is in support of the 35th CST and EPA Region 3 and all data will be routed according to Region 3 procedures. The following data products will be generated by the aircraft including chemical IR spectra, IR imagery, visible imagery and radiological spectra. Chemical and radiological data will be processed while the aircraft is in flight status using both onboard automated software and ground-based software tools. All data will be retrieved by the ground team using a satellite data system and will be examined for Quality Assurance prior to release. The EPA Regional EOC will have complete access to all data (tentative and final). Once data has been QA checked by the ASPECT reach back team, all data will be made ready for immediate release to the OSC.

Communications and Contact Information. Logistical communication procedures, conference bridge information and ground to air frequencies are detailed in Appendix D. Appendix E contains detailed information for contacting key individuals during the deployment. Digital sensor data will be available at the FTP site per Appendix C.

<u>Appendixes:</u>

A - Proposed ASPECT Flight Plans and Profiles
B - Detailed ASPECT Technical Data
C – ASPECT Data Routing, Storage, and Viewing
D - Communications
E – Contact Information

Appendix A
Proposed ASPECT Flight Plans and Profiles

Background Data Collection

A number of scheduled flights are scheduled to support the BSA Jamboree and the proposed time line is contained in Table 1. A baseline flight is planned to provide background data to support the overall event. On the morning of 14 July 2013, ASPECT is scheduled to fly a chemical and radiological background survey over the main camp ground areas. (Figure 1 and 2). It is expected that this flight will be initiated at about 1000 and will last about 2 hours. The radiological background survey will be conducted at an altitude of 500 feet above ground (AGL). A line spacing of 500 feet will be used. In addition to the radiological survey, a chemical and photographic survey will also be collected over the campground areas. Chemical and photographic data will be collected at an altitude of 2800 feet AGL with an overall line spacing of 1800 Ft. Collection profiles are given in Table 2.

Starting 15 July 2013 and continuing through 24 July 2013, ASPECT will fly a number of surveillance missions over the campground areas and the surrounding 9 county area (Figure 3). For missions associated with the campground areas and stadium events, lines developed for the background surveys will be utilized for data collection. For missions associated with the Day of Service (17 – 19 July 2013 and 22 – 23 July 2013), the mission profile will consist of collecting limited background data over the major clusters of activity. This will include background collections over Beckley, Bluefield, Lewisburg, Oak Hill, Pineville, Sophia, Summersville, and Union (Figure 4). Once the backgrounds have been completed, ASPECT will be placed on a heightened state of readiness for response. In the event that a specific mission is called for in one of the 9 county areas, ASPECT will response using a standard emergency response flight profile or a profile suitable for the situation.

All data collected in support of the BSA Jamboree will be processed by the reach back team and uploaded to the EPA data servers.

Table 1 – Data Collection Profile

Date	Time Block	Mission	Comments
13 July 2013		Airborne Team Arrives in Charleston, WV. Data processing center established. Communications and Data Processing Test/Dry Runs.	Team meeting with OSC and 35th CST
14 July 2013	1000 – 1200[1]	Background chemical and Radiological data collection, Jamboree Campground Area	Background Data Collection
15 July 2013	1000 -- 1100 1400 -- 1500	Chemical and Radiological Collection	Campground Area
16 July 2013	0900 – 1000 1400 – 1500	Chemical and Radiological Collection	Campground Area
17 July 2013	1000 -- 1200	Airborne Holding Pattern, Mission on Demand	Day of Service
18 July 2013	1000 – 1200	Airborne Holding Pattern, Mission on Demand	Day of Service
19 July 2013	1000 – 1200	Airborne Holding Pattern, Mission on Demand	Day of Service
20 July 2013	1600 – 2000	Chemical and Radiological Collection	Stadium Area
21 July 2013	1100 – 1300 1500 – 1700	Chemical and Radiological Collection, Extended Data collection	Stadium Areas
22 July 2013	1000 – 1100	Airborne Holding Pattern, Mission on Demand	Day of Service
23 July 2013	1000 -- 1200	Airborne Holding Pattern, Mission on Demand	Day of Service
24 July 2013	0600 – 0800 1200	Chemical and Radiological Collection Aircraft transitions back to Texas	Campground Area

1 Times are Eastern Time

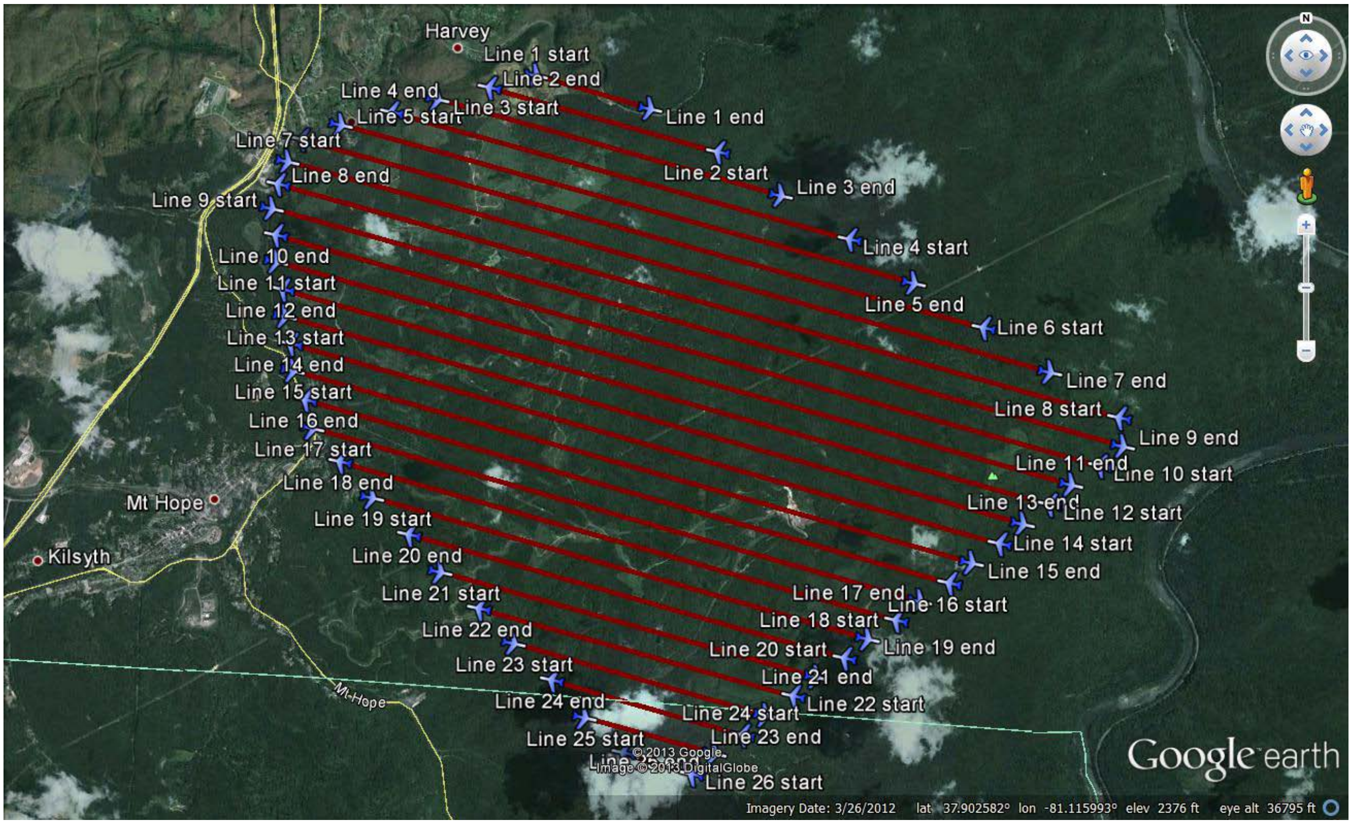

Figure 1. Proposed Radiological Collection Flight Lines

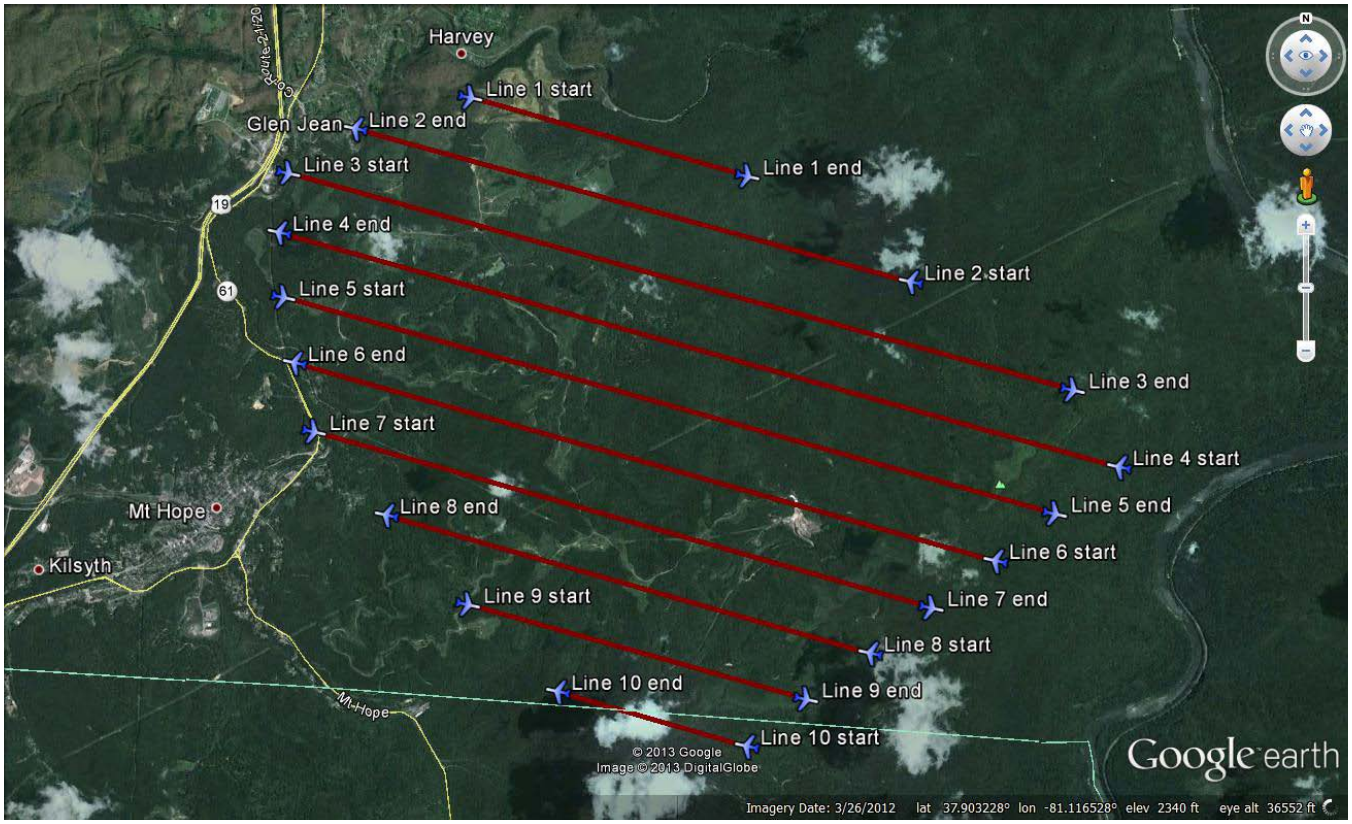

Figure 2. Proposed Chemical/Photographic Collection Flight Lines

Table 2 – Chemical and Radiological Collection Profile (Generic)

Mission	**Altitude (Ft AGL)**	**Line Spacing (Ft)**	**Speed (Kts)**	**Products**
Chemical	2800	1800	110	Position KML Chem Table IR Imagery NADAR Photos Oblique Photos
Radiological	500	750	110	Rad Sigma Rad Contour

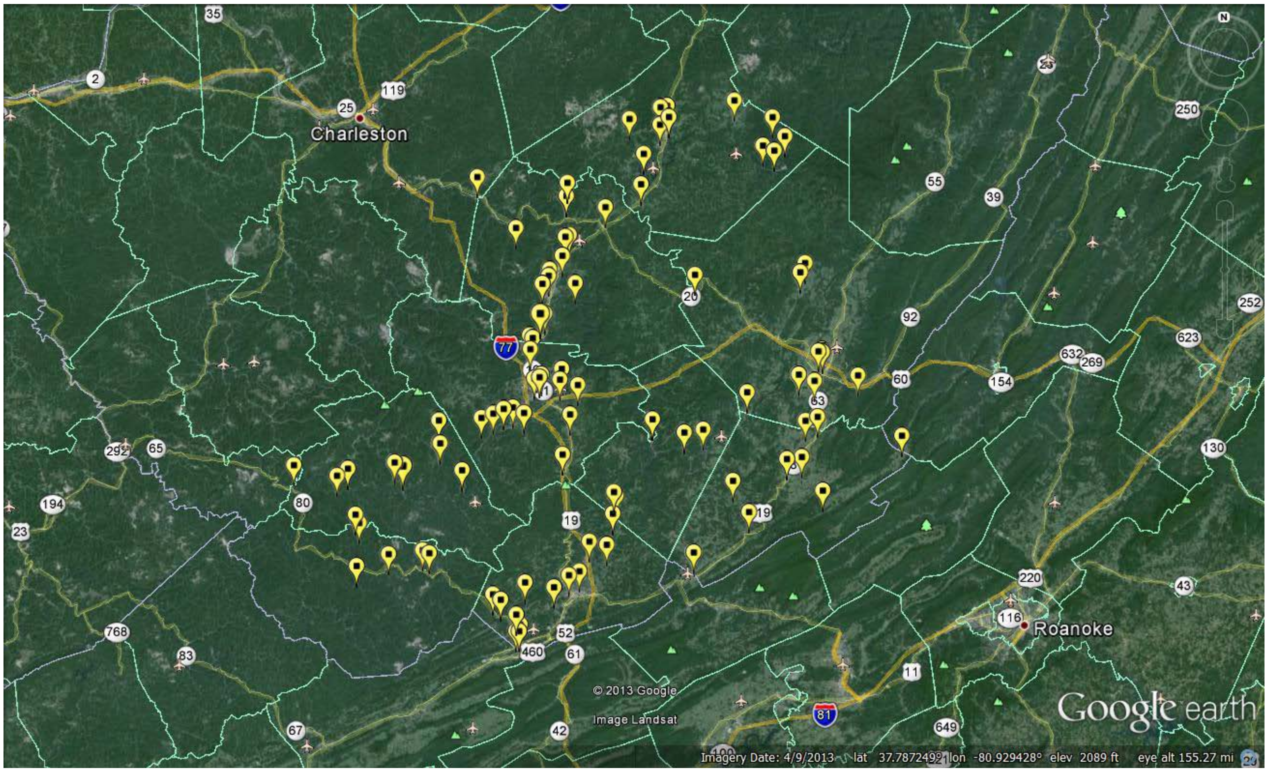

Figure 3. Day of Service Locations

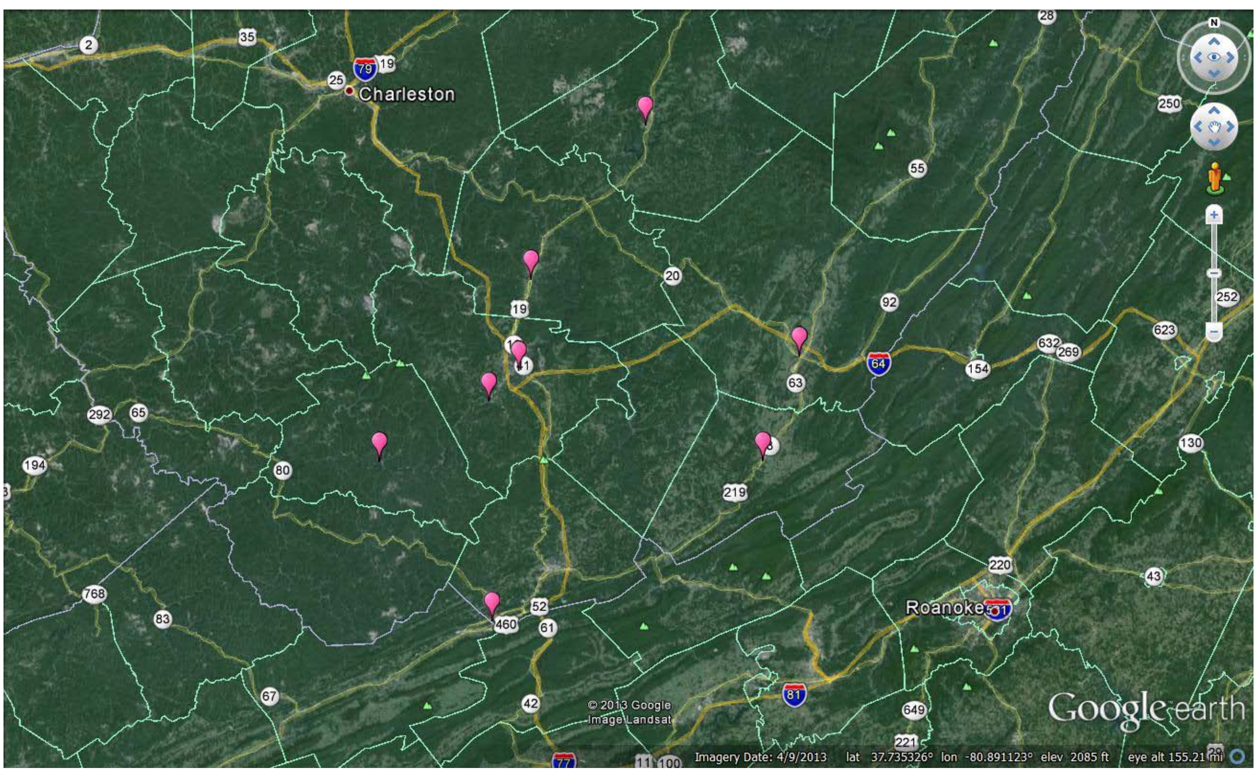

Figure 4. Day of Service Background Locations

Appendix B
Detailed ASPECT Technical Data

The ASPECT sensor suite (Figure 1) is mounted in a fixed wing aircraft and uses the principles of remote hazard detection to image, map, identify, and quantify chemical vapors and deposited radioisotopes. Chemical plume measurements are made at a rate of about two square miles per minute. The system normally operates at an altitude of 2800 feet above ground level (AGL) and results in a high IR spatial resolution of 0.3 meters. A simplified system diagram is provided in Figure 2. The radiological data is collected between 300 and 500 feet AGL with a collection time of once per second and a field of view about 600-1000 feet.

Supporting data includes high-resolution aerial digital photography and digital video that are concurrently collected with chemical and radiological data and forms the basis for a geographical information system data cube with several layered data products (Figure 3). Efficient mission execution requires that data is processed on-board the aircraft for transmission or hand-off to the first responder. To facilitate data transmission while in flight status, the aircraft is equipped with a broadband high-speed satellite data communications system. With a combination of onboard data processing and the satellite communication system, selected airborne situational data sets are ready for dissemination to the incident command team in less than 5 minutes after collection.

FIGURE 1 – Sensor Suite

NOTE: Images of the neutron detector and LaBr detectors are not shown. The aircraft is equipped with two RSX-4 units, only one is shown in this figure.

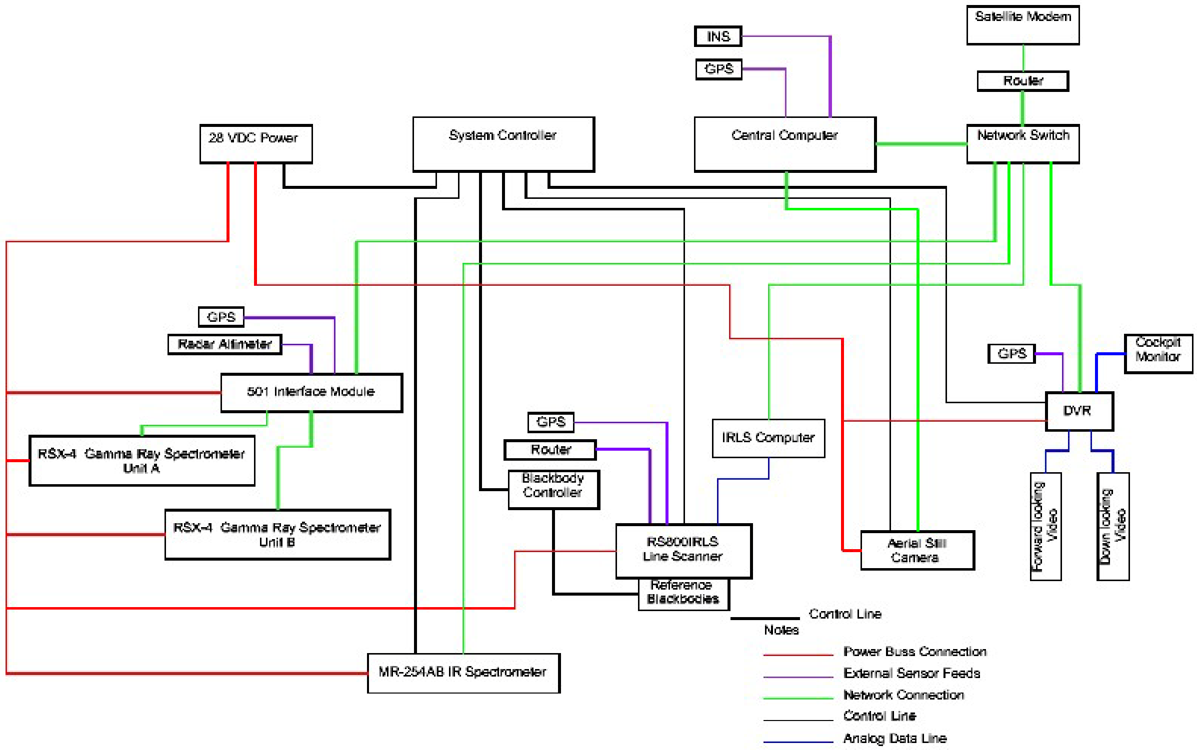

FIGURE 2 - Simplified ASPECT System Diagram

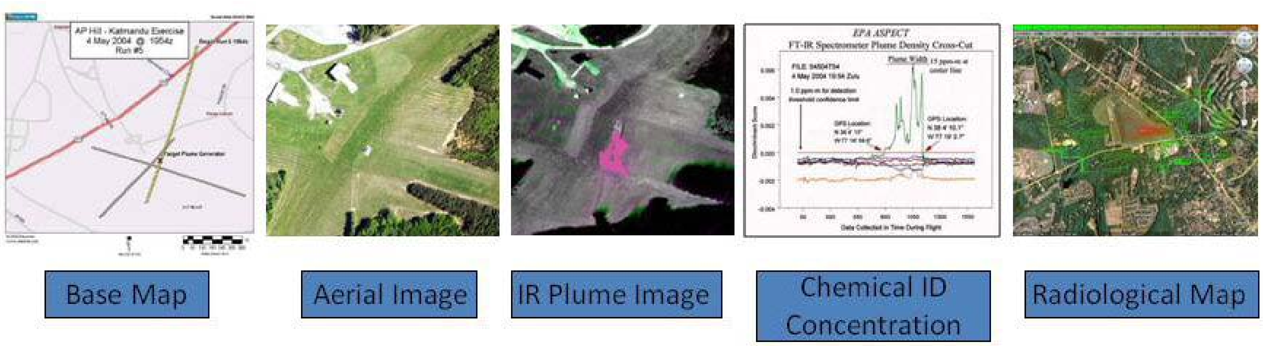

FIGURE 3 – Data Products

1. Airframe

The ASPECT sensor suite is operated from a twin engine AeroCommander 680FL aircraft (Figure 4). The aircraft and crew are certified for full instrument flight rules (IFR) flight operations. This aircraft is equipped with two 21-inch belly holes with retractable bay doors. All sensor systems are mounted on two vibrational isolated base plates positioned over the belly holes. The aircraft can operate from any airport having a 3000 ft runway and can stay aloft for 5 hours. Technical specifications for the program airframe are contained in Table 1.

FIGURE 4 – ASPECT Aircraft, N742W

TABLE 1 - N742W Technical Specifications

Tail:	N742W
System:	Twin Engine (Reciprocating) Propeller Driven Aircraft
Make:	Rockwell AeroCommander 680 F/L, Part 91 Certification
Power Plants:	Lycoming TGSIO-540-B1, 350 HP each side
Empty Weight:	6585 lbs
Useful Weight:	1915 lbs
Maximum Take-off Weight:	8500 lbs
Typical Cruise Speed:	180 Kts
Typical Flight Duration:	3.75 Hours (65% Power) Plus 45 Minute Reserve
Service and Ceiling:	Low Altitude Waiver, 24000 Ft (MSL) max altitude
Cabin:	Un-pressurized, Crew Oxygen
Portals:	Two 21 inch STC Camera holes with Remote Doors
Avionics	GPS IFR Package Terrain/Obstacle Avoidance Equipped Radar Altimeter Equipped Live Weather Feed Dual VOR Equipped Dual Comms Equipped Dual Transponders
Electrical Buss:	28 vdc @ 200 amps full load
Data Communication:	Phased Array Satellite System, 40-60 KB/sec Data Rate Satellite Telephone, 32kps Data Rate
Readiness Status:	24/7/365

2. Chemical Detection Capabilities

The principle of remote detection, identification, and quantification of a chemical vapor species is accomplished using passive infrared spectroscopy. Most vapor compounds have unique absorption spectral bands at specific frequencies in the infrared spectral region. An asymmetric stretching between two atoms in a molecule results in a fundamental frequency of vibration. Passive infrared measurements of a vapor species are possible due to small thermal radiance differences between the temperature of the chemical plume and a particular infrared scene background (Figure 5). Both the cloud and the atmosphere contribute to the total emitted radiance measured by an infrared sensor. Careful monitoring of the change in total infrared radiance levels leads to concentration estimations for a particular vapor species. Concentration times path length estimations are obtained based on the molar absorptivity for each vapor species.

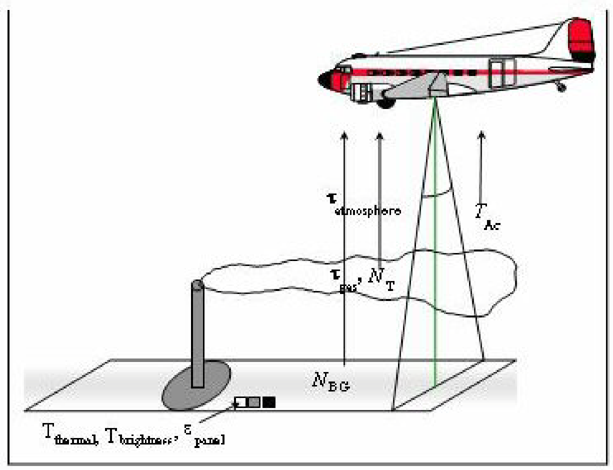

FIGURE 5 - Principles of Remote Infrared Detection

a. Equipment - RS800IRLS Infrared Imager

The ASPECT Program uses a modified Raytheon RS800 infrared line scanner to generate wide area chemical imagery (Figure 6). This system incorporates a unique detector assembly consisting of 16 cryogenically cooled optical band pass filters affixed to a focal plan array. Scanning is accomplished with an integrated rotating prism controlled by a feedback motor scan controller. Each rotation of the prism sweeps an angular field of view of 60 degrees resulting in 1500 data points. When the scan rate is coupled to the normal 110-knot ground speed of the aircraft, a scan swath of 0.5 meters is collected. This collection geometry outputs a square data pixel 0.5 X 0.5 meters square. Radiometric calibration is performed during each prism rotation by viewing two reference blackbodies mounted on either side of the unit. Image registration is accomplished during post processing by incorporating pitch and roll data collected from an integrated gyroscope mounted on the scanner body. An integrated GPS receiver is used in the processing step providing geo-registration of each pixel in the finished image product. Detailed specifications of the RS800IRLS are contained in Table 2.

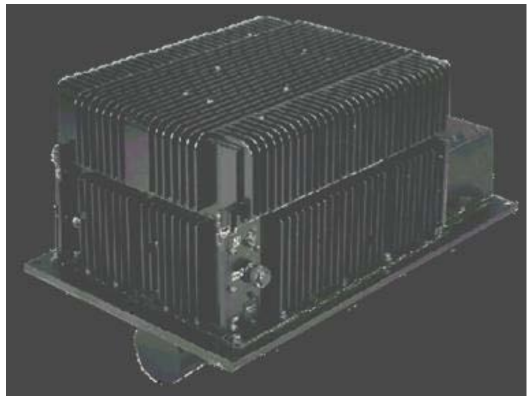

FIGURE 6 - RS800IRLS Line Scanner

TABLE 2 - RS800IRLS Technical Specifications

System:	TI Systems/Raytheon RS800 MSIRLS
Detector:	Cryogenically cooled focal plane array with integrated cold optical filters
Spectral Coverage:	3 – 5 micrometer (mid-wave) and 8 – 12 micrometer (long-wave)
Number of Spectral Channels:	16 total, 8 mid-wave and 8 long-wave
Spectral Resolution:	5 to 20 wave numbers, channel dependent
Spatial Resolution:	Better than 1.0 mill radian
Scan Rate:	60 Hz
Radiometric Calibration:	Two flanking blackbody units
Field of View (FOV):	60 Degrees
Thermal Resolution	0.05 Degree C.
Linear Range	0 to 200 Degree C
Pixel Resolution (IFOV):	0.5 meters @ 850 meter collection altitude (AGL)
Cross Field Scan Coverage:	980 meters @ 850 meter collection altitude (AGL)
Attitude Stabilization:	25 Hz pitch and roll providing stabilized video
Power:	28 vdc @ 10 amps full load
Weight:	27 Kg (60 lbs)
Spin-up Time:	Less than 12 minutes (including cyro-system)
Standard Outputs:	2 Channels of stabilized RS-170 video, 16 channels of digitized (16 bit) spectral data, 1 channel of GPS (2 Hz)
Data Processing	1 step full radiometric image generation using an onboard algorithm. Approximately 1 minute processing time.

b. IRLS - Chemical Image Processing

Processing of chemical data is divided into two broad categories including image processing and spectral processing. Infrared chemical signatures present a challenge in data processing due to the small signal to noise ratio (SNR) of the chemical vapor between the sensor and the surface. It is not uncommon to have a SNR of less than four in a typical vapor cloud. In order to image such a weak signal, the collection system and detector must be optimized for high collection efficiency and a small instantaneous field of view. The ASPECT RS800IRLS meets both of these requirements by using an F 1 high-speed optical train coupled to a 16-channel cold optical filter focal plane array. This configuration provides very high signal throughput while maintaining a 1.0 mill radian spatial resolution. The use of cold optical band pass filters directly mounted on the face of the focal plane array eliminates a large portion of the self-radiance (noise) while minimizing the attenuation of wanted signal content. Raw data is fully radiometrically calibrated using a set of flanking blackbodies providing radiance-adjusted imagery. Jitter removal and band registration are accomplished using an automated algorithm using an integrated 2 dimensional gyro and GPS feed. Final data is generated using an automated geo-registration algorithm in either a geo-Tiff or a geo-Jpeg format. Processing can be accomplished while in flight and requires about 30 seconds to 1 minute per image depending on size. The completed imagery is compressed and made available to ground user through the aircraft satellite link.

The vapor cloud, shown in Figure 7, is an infrared image collected by the RS800SIRLS multispectral sensor at an industrial site in the Midwest. The detection limit of the vapor concentration (shown in red) was determined to be less than 20 ppm/m while the center cloud concentration was greater than 250 ppm-m. This image has been cropped with only 1/3 of the actual sensor field-of-view being displayed. The original image width of the image was approximately 1200 meters wide. For the ASPECT application, the RS800IRLS system provides a qualitative indication of the presence or absence of a particular chemical species. The detection limit provided by the sensors is applicable to both chemical emergency response and crisis mitigation following a terrorism event.

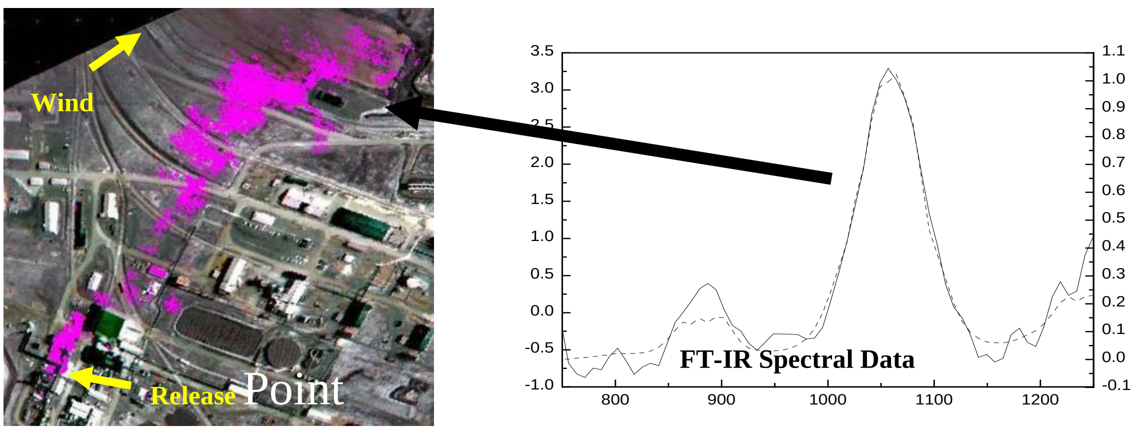

Figure 7 - RS800IRLS Data Product

c. Equipment - MR254AB Spectrometer

Chemical vapor detection and quantification is accomplished using a modified Bomen MR254AB spectrometer (Figure 8). This custom designed spectrometer utilizes a double wishbone pendulum interferometer providing both high signal throughput and vibrational noise immunity. Two cryogenically cooled detectors provide both mid and long wave operation. Spectral resolution is selectable and ranges from 1 to 128 wave number with 16-wave number normally used for automated compound detection. When operated at 16 wave number resolution, the unit scans at 70 Hz providing a spatial sampling interval every 0.75 meters along the ground track of the aircraft. The program uses an automated compound detection algorithm based on digital filtering and pattern recognition. Geo-registration of each Fourier Transform Spectrometer (FTS) scan is accomplished using a concurrent GPS input from the ASPECT main GPS receiver. Technical specifications of the FTS system are contained in Table 3.

FIGURE 8 - MR254AB FTS Spectrometer

TABLE 3 - FTS Technical Specifications

System:	Modified Bomem MR-200 Series (MR-254AB)
Detectors:	Cryogenically cooled Single Pixel Design
Spectral Coverage:	InSb Detector for 3 – 5 micrometer (mid-wave) MCT Detector for 8 – 12 micrometer (long-wave)
Noise Figure	Mid-wave $6x10^{-9}$ W/cm^2-$srcm^{-1}$, Long-wave $1.8x10^{-8}$ W/cm^2-$srcm^{-1}$
Spectral Resolution:	1 to 128 wave numbers, User selectable
Spatial Resolution:	5 milli-radian (0.2^o) thru 25.4 cm (10 inch) Primary Telescope, 0.75 meter interval at 110 kts collection velocity
Scan Rate:	70 Hz @ 16 wave number resolution
Field of View (FOV):	3 meters @ 850 meter collection altitude (AGL)
Radiometric Reference	Integrated cold source (77^o K)
Targeting	Calibrated bore camera (Nadir)
Power:	28 vdc @ 8 amps full load
Weight:	40 Kg (90 lbs)
Spin-up Time:	Less than 4 minutes (including cyro-system)
Standard Outputs:	2 Channels of Grams format spectral data (16 bit), 1 channel of RS-170 video.
Data Processing:	1 Step pattern recognition compound detection using onboard algorithms, approx 30 – 60 seconds processing time after data collection.

d. Spectral Processing

Spectral data processing (signal processing) from the ASPECT MR-254AB spectrometer is processed using background suppression, pattern recognition algorithm. Processing spectral data from a moving airborne platform requires unique methods to balance weak signal detection sensitivity, false alarm minimization, and processing speed. The background suppression, pattern recognition methods associated with the ASPECT Program have been documented in over 100 open literature publications.

One of the principle weaknesses of airborne FTS data is the ability to reference each collected spectra to a suitable background for subsequent spectra subtraction. While methods have been devised to accomplish this procedure, typical airborne spectra show changes between successive scan of several orders of magnitude due to changing radiometric scene conditions. These scan-to-scan changes render traditional background subtraction methods unusable for weak signal detection. The background suppression method used by ASPECT circumvents this problem by using a digital filtering process to remove the background component from the raw interferometer data. This approach is analogous to using the tuning section of a radio receiver to preselect the portion of the signal for subsequent processing. The resulting filtered intermediate data maintains the weak signal components necessary for subsequent analysis.

An additional weakness of traditional FTS processing involves the need to provide a resolution high enough to permit compounds exhibiting narrow spectra features to be matched with published library spectra. This method is initiated using the Fast Fourier Transform (FFT). While the FFT algorithm is very robust, mathematically certain data collection requirements must be met to permit the transform to be valid. In order to provide high spectral resolution spectra, the length of the interferogram must be matched to the desired resolution for the transform to work properly. This requirement forces a long collection period for each interferogram and since the aircraft is moving, it is probable that the radiometric scene being viewed by the spectrometer will change during the collection of the interferogram. The changing scene causes the FFT to generate spectral artifacts in the resulting spectral information. These artifacts are phantom signals that confuse and complicate subsequent compound identification.

The standard matched filter compound discrimination method likewise exhibits weak signal performance and often generating false alarms due to common atmospheric interference. ASPECT solves these problems by using a combination of digital band pass filtering followed by a multi-dimensional pattern recognition algorithm. The digital filters and pattern recognition coefficients are developed using a combination of laboratory, field, and library data and folded into a training set that is run against unknown data. Digital filters can be readily constructed which take into account both spectrometer line shapes and adjacent interferents greatly improving the weak signal system gain. The pattern recognition algorithm processes the filter output in a multi-space fashion and enhances the selectivity of the detection. These methods are very similar to a superheterodyne receiver that uses band pass adjustable intermediate filters followed by a DSP detector/discriminator such as in a modern radar system. Since the methods use relatively simple computational operations, signal processing can be accomplished in a few seconds. Finally, as data is processed, the position of the detection is referenced to onboard GPS data providing a GIS ready data output. Table 4 lists the compounds that are currently installed in the airborne library using the digital filtering/pattern recognition method.

TABLE 4 - Chemicals Included in the ASPECT Auto-Processing Library

Acetic Acid	Cumene	Isoprene	Propylene
Acetone	Diborane	Isopropanol	Propylene Oxide
Acrolein	1,1-Dichloroethene	Isopropyl Acetate	Silicon Tetrafluoride
Acrylonitrile	Dichloromethane	MAPP	Sulfur Dioxide
Acrylic Acid	Dichlorodifluoromethane	Methyl Acetate	Sulfur Hexafluoride
Allyl Alcohol	Difluoroethane	Methyl Ethyl Ketone	Sulfur Mustard
Ammonia	Difluoromethane	Methanol	Nitrogen Mustard
Arsine	Ethanol	Methylbromide	Phosgene
Bis-Chloroethyl Ether	Ethyl Acetate	Methylene Chloride	Phosphine
Boron Tribromide	Ethyl Formate	Methyl Methacrylate	Tetrachloroethylene
Boron Triflouride	Ethylene	MTEB	1,1,1-Trichloroethane
1,3-Butadiene	Formic Acid	Naphthalene	Trichloroethylene
1-Butene	Freon 134a	n-Butyl Acetate	Trichloromethane
2-Butene	GA (Tabun)	n-Butyl Alcohol	Triethylamine
Carbon Tetrachloride	GB (Sarin)	Nitric Acid	Triethylphosphate
Carbonyl Chloride	Germane	Nitrogen Trifluoride	Trimethylamine
Carbon Tetraflouride	Hexafluoroacetone	Phosphorus Oxychloride	Trimethyl Phosphite
Chlorodifluoromethane	Isobutylene	Propyl Acetate	Vinyl Acetate

A unique feature of the ASPECT System includes the ability to process spectral data automatically in the aircraft with a full reach back link to the program QA/QC program. As data is generated in the aircraft using the pattern recognition software, a support data package is extracted by the reach back team and independently reviewed as a confirmation to data generated by the aircraft.

Figure 12 shows airborne absorbance spectra of ammonia vapor collected from an ammonium nitrate fire using the MR-254AB spectrometer. This spectrum was generated by carefully selecting a suitable background spectra and conducting a traditional background subtraction, a time consuming operation. Figure 13 shows the same data processed using the automated background suppression/pattern recognition method. Ammonia detection is clearly demonstrated. Figure 14 shows how these detections are referenced to a real-world geographical map. Individual detection locations corresponding to FTS scans are mated with latitude and longitude coordinate values.

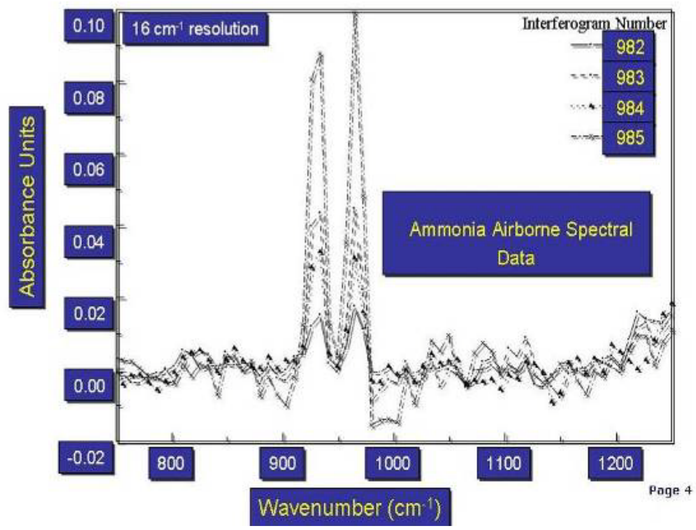

FIGURE 12 - Ammonia Spectra

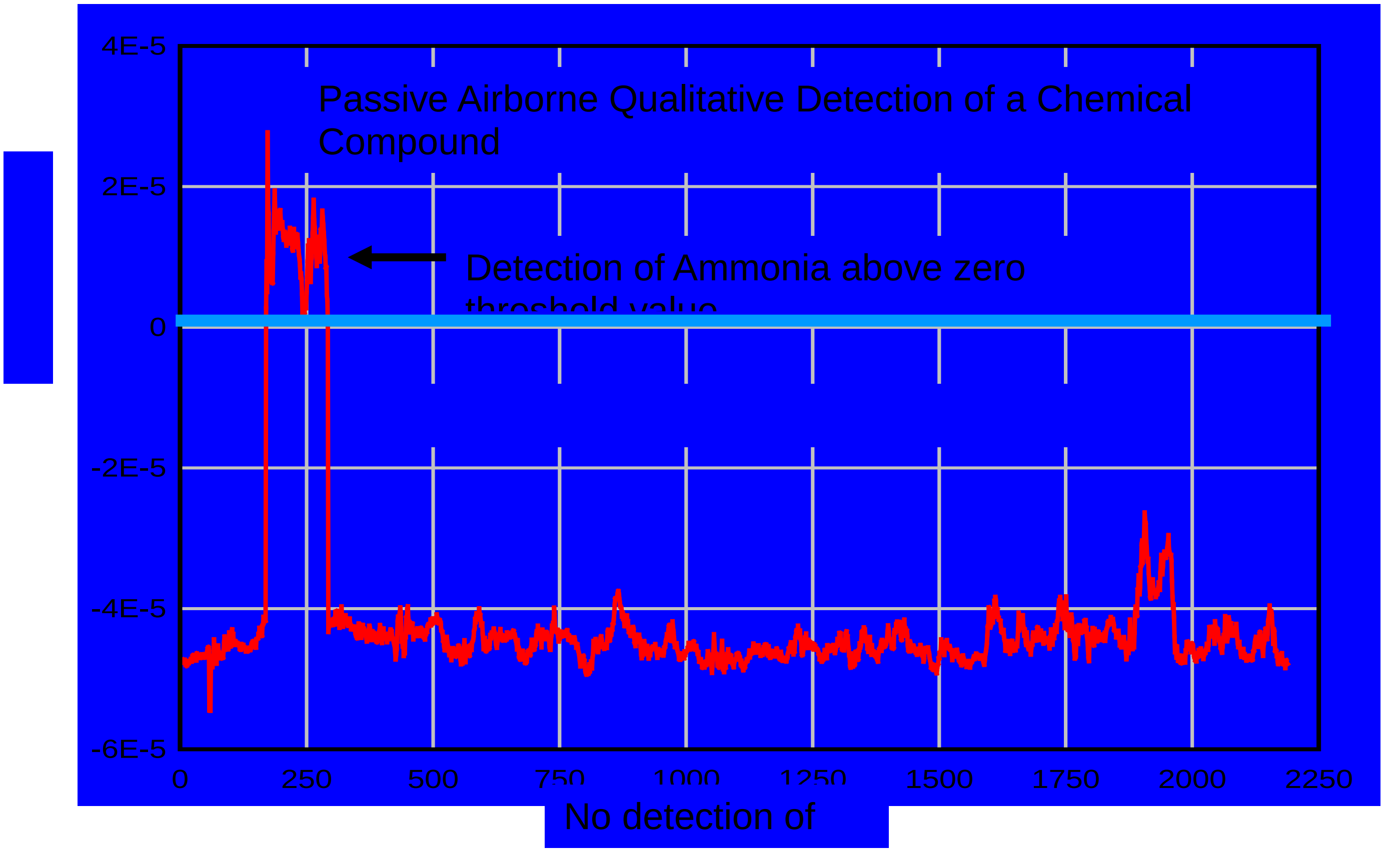

FIGURE 13 - Ammonia Detected with Pattern Recognition

FIGURE 14 - Locations of Ammonia Detection

Quantitative compound specific information is also generated using the MR-254AB spectrometer. This application uses a multi-dimensional model generated using radiometric, thermal, and concentration calibrated laboratory data for each compound in the airborne library. As with compound detection methods, multiple publications have documented the feasibility of using this approach to remotely quantify chemical vapors. The first open literature scientific peer reviewed paper was completed using the ASPECT method.

Figure 15 shows the estimated concentration measured by ground sensors and compared with the remotely collected FT-IR data. The data shows a standard error of prediction of 18 ppm-m for a range of concentration between 20 to 400 ppm-m. This range of concentrations is consistent with both hazardous vapor releases and terrorist concerns.

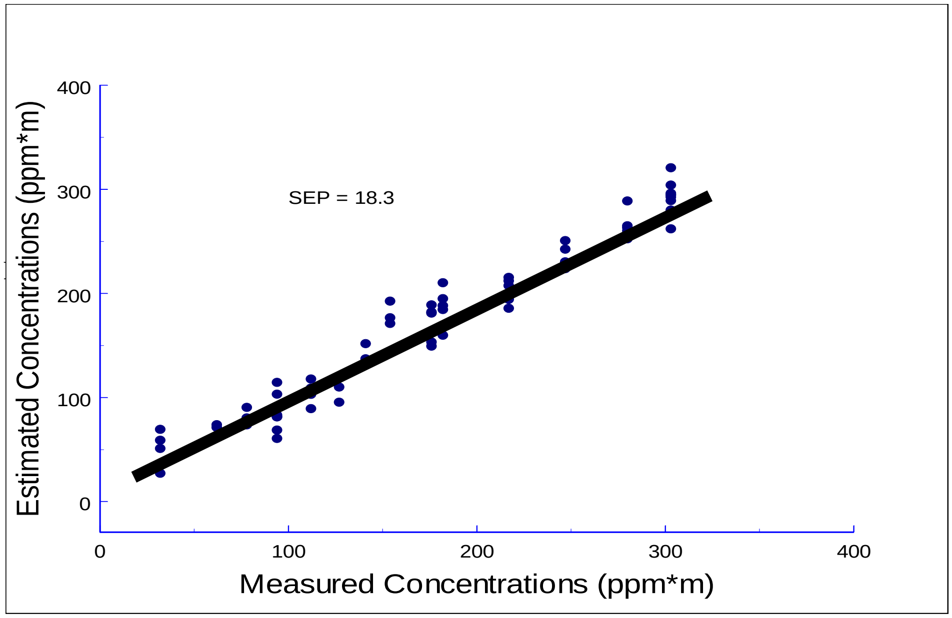

Figure 15 - Quantitative Methanol Results

3. Radiological Detection Capabilities

Airborne radiological measurements are conducted using two fully integrated multi-crystal sodium iodide (NaI) RX4 gamma ray spectrometers (Figure 16). Each RX4 spectrometer contains four 4"x2"x16" doped NaI crystals each having an independent photomultiplier/ spectrometer assembly. Count and energy data from each crystal is combined using a self-calibrating signal processor to generate a virtual detector output. Both spectrometer "packs" are further combined using a signal console controlled by the on-board computer in the aircraft. Due to the advanced signal processing techniques unique to the RX4 units, very high (approximately 1 million counts per second) can be discriminated and processed.

Additional detection systems include up to three 3" x 3" LaBrA crystals and a four-tube helium-3 neutron detector. These additional systems provide improved spectral information for radioisotope identification and if neutron emitters are present.

FIGURE 16 - RX4 Gamma Ray Spectrometer

Radiological spectral data, GPS position, and radar altitude are collected at a one-second interval at all times during a survey. In order to provide optimal collection geometry, flight line data is loaded into the aircraft flight computer prior to conducting the survey. Typical airborne surveys are flown at 300 to 500 feet AGL.

Proper spectrometer operation and data quality assurance is maintained using both internal and external calibration algorithms. A self-contained internal calibration algorithm acts as a watchdog and continuously monitors the spectrometer systems for proper system operation and data output. If any errors are encountered with a specific crystal and/or spectrometer pack during the collection process an error message is generated and the data associated with that crystal are removed from further analyses. External calibration procedures are routinely executed and consist of both designed data collection over characterized areas and pad calibrations over known quantities of radiologically doped concrete. Technical specifications for the RX4 gamma ray spectrometers are contained in Table 5.

TABLE 5 - RX4 Technical Specifications

System:	RSI RSX4 Gamma Ray Spectrometer
Detector:	4 Doped NaI Detectors per pack, 2 Packs, 2x4x16 inch crystals.
Energy Coverage:	0 – 3000 KeV
Number of Channels:	1024
Energy Resolution:	Approx 3 KeV per Channel
Scan Rate:	1 Hz
Internal Calibration:	Automatic based on Natural K, U, and T
Field of View (FOV):	45 Degrees
Cross Field Scan Coverage:	700 meters @ 850 meter collection altitude (AGL)
Altitude Determination:	2.4 GHz Radar Altimeter, 10 Meter DEM Database
Power:	28 vdc @ 3 amps full load (2 Packs)
Weight:	90 Kg (200 lbs)
Spin-up Time:	Less than 3 minutes
Standard Outputs:	1024 Gamma Ray Spectra, GPS (2 Hz)
Data Processing	1 Step Full Processing of Total Count, Sigma, and Exposure, Approximately 1 minute Processing Time After Data Collection.

a. Radiological Data Processing

All radiological data is processed automatically using airborne algorithms. Normally, a specifically designed survey flight path is flow by the aircraft and once complete, a spectrum of radiological products is generated from the collected data. Since radiological sources are universally present from the earth and from cosmic sources, all radiological data must be corrected to establish a baseline measurement. Cosmic estimates are established by flying the aircraft 3000 feet AGL while collecting gamma spectral data. At altitudes of 3000 feet and greater all radiological inputs are either from the cosmic sources or the aircraft (which is a constant). Quantified cosmic contributions are stripped out from all subsequent data. Depending on the length of the radiological survey, cosmic backgrounds may be collected at the beginning and end of the survey. In a fashion similar to the cosmic correction, the natural radiological background for the survey area is also established. This process normally calls for collecting a limited amount of data (a test line) at the survey altitude (300 – 500 ft AGL) in an area of similar geology/land use but outside of the region of survey interest. By subtracting the test line data from the survey data, a corrected radiation map for the survey area is generated.

Several data products are generated automatically by the system including total counts, a sigma map, and an exposure map. The total count product is generated by mapping the corrected total count data (approximately 30 – 3000 KeV) from the spectrometers using the integrated GPS data as the geographic datum. Maps are normally contoured at regular intervals in micro-Roentgens (µR). Figure 17 illustrates a typical survey total count plot.

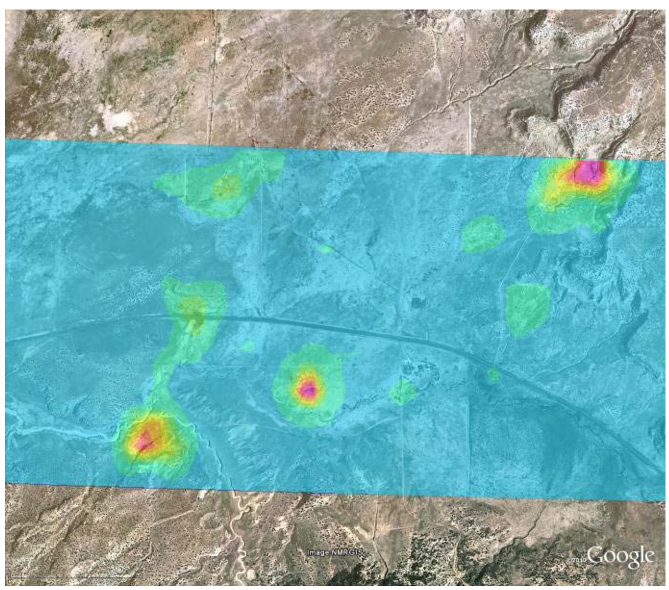

FIGURE 17 - Total Count Plot

A second radiological product includes an array of isotope specific sigma plots or maps. These plots are very useful to the first responder since they help highlight specific data points that may require detailed ground investigation. This procedure consist of a two-step method with the first being a windowing for selected isotope energies followed by a statistical treatment of the data. Isotope specific data is generated by windowing the gamma spectrum at energy levels corresponding to the isotopes of interest. As part of this analysis, higher energy contributions from uranium and thorium are removed using a stripping coefficient. A statistical average and standard deviation is next computed for the entire survey area using the isotope windowed data. Since the standard deviation provides a measure of the variance of the data set, data values showing several standard deviations (sigma) indicate that these values are statistically different from the majority of the population. ASPECT uses a graded scale in which 0 to 4 sigma are considered normal and greater than 4 sigma highlights data very different from the population. Greater than 6 sigma indicates that the data is extremely different and warrants additional investigation. By using different isotope windows, a number of sigma maps can be generated for a given survey (Figure 18).

The final set of products generated by the gamma ray spectrometers consist of an exposure plot or map. This procedure consist of extrapolating the measured total count data collected at the flight altitude down to the total count that would be measured 1 meter above the surface. This method utilizes a weighting algorithm that provides more focus on the high energy counts since these represent the most energetic and penetrating gamma rays. The extrapolation process is accomplished using the calibration coefficients developed as part of the exterior calibration process. The resulting data is plotted in μR/hr and provides the first responder with a health-based estimate of radiological dosage at the ground surface (Figure 19).

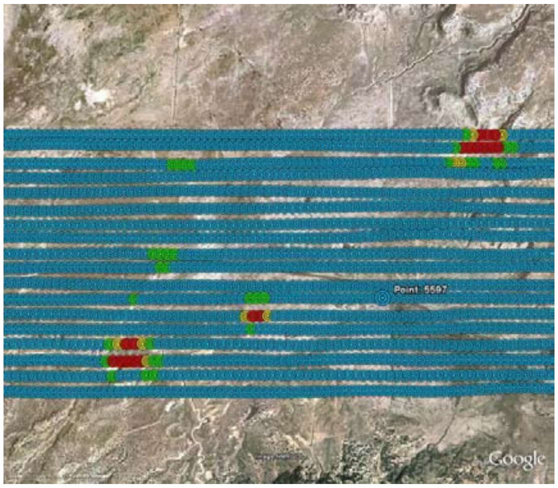

FIGURE 18 - Sigma Plot

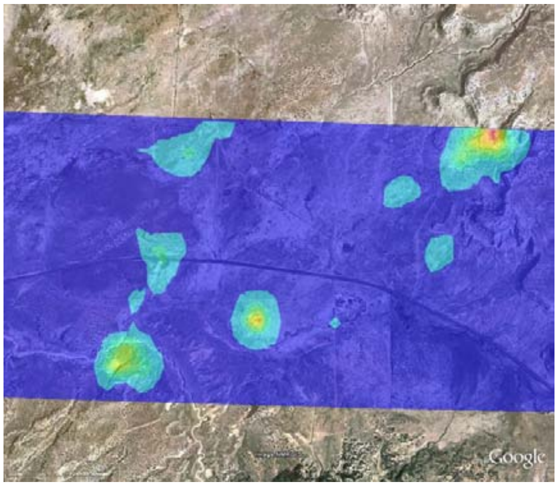

FIGURE 19 - Exposure Plot

4. Visible Imaging Technology

ASPECT utilizes a still digital Nikon DX2 camera to collect and provide visible aerial imagery as part of the core data product package (Figure 20). The DX2 consist of a 12.4 mega pixel CMOS camera supporting a 3:5 aspect ratio frame. The system uses a 28 mm wide-angle lens to provide an image of similar size to the RS800 IRLS generated image. The digital camera is slaved to the primary IR sensors and provides concurrent image collection when the other sensors are triggered for operation. All imagery is geo-rectified using both aircraft attitude correction (pitch, yaw, and roll) and GPS positional information. Imagery can be processed while the aircraft is in flight status or approximately 600 frames per hour can be automatically batch processed once the data is downloaded from the aircraft. Technical specification for the DX2 camera is provided in Table 6.

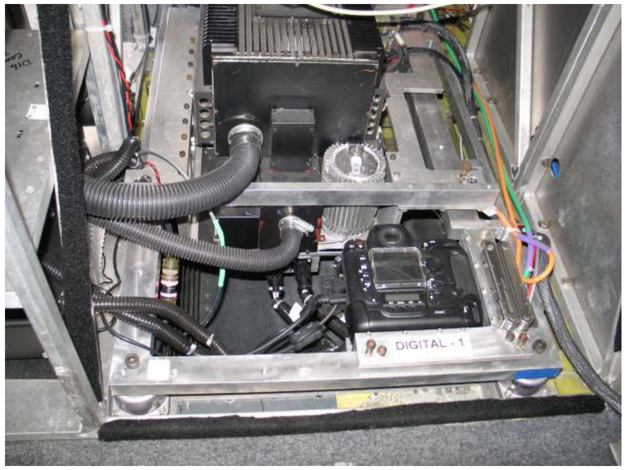

FIGURE 20 - DX2 Aerial Digital Camera

TABLE 6 - DX2 Aerial Digital Camera Technical Specifications

System:	Nikon DX2 Camera Body
Detectors:	12.4-megapixel digital CMOS sensor
Aspect Ratio:	3:5
Lens:	28 mm Digital Compatible
Field of View (FOV):	824 meters Cross flight and 548 meters Direction of Flight @ 850 meter collection altitude (AGL)
Pixel Resolution (IFOV):	19.2 cm @ 850 meter collection altitude (AGL)
Frame Timing and Collection Rate:	Operator Selectable, 3 to 8 seconds, Approximately 600 frames per hour
Trigger Control:	Automatic, Manual, and Slave
Power:	12 vdc @ 1 amp full load
Spin-up Time:	Less than 2 minutes from System Start
Standard Outputs:	JPEG, Tiff
Data Processing:	Full INS/GPS Geospatial Rectification

In order to provide situational information from the perspective of the flight crew, ASPECT also supports an oblique camera system that is operated from the right side of the aircraft. This camera consists of a Canon EOS Rebel digital SLR camera body with a 30 – 120 mm variable zoom lens (Figure 21). Frames are collected at an approximate the 2 o'clock position relative to the aircraft with the target approximately 1000 meters from the aircraft. Table 7 provides technical specification of the oblique camera system.

FIGURE 21 - EOS Oblique Camera

TABLE 7 - Canon EOS Aerial Oblique Digital Camera Technical Specifications

System:	Canon EOS Camera Body
Detectors:	6.3-megapixel digital CMOS sensor
Aspect Ratio:	3:5
Lens:	30-120 mm zoom, Digital Compatible
Trigger Control:	Manual
Power:	Internal Battery
Standard Outputs:	JPEG, Tiff
Data Processing:	Spatial Geo-reference

a. Visible Imagery Data Processing

Visible imagery collected with the ASPECT System is ultimately processed into a geo-registered jpeg or tiff format image. Image processing is composed of two primary steps including image enhancement and geo-registration. Both of these processing steps can be processed while the aircraft is in flight status but typically, imagery is processed once the aircraft lands due to the large quantity of data involved with aerial photography. A standard flight mission often generates 600 aerial images.

The ASPECT aerial camera consists of a still frame 3x4 ratio digital camera. A wide field of view lens is utilized to match the ground width coverage of the line scanner system. Due to the speed of the aircraft and the fact that ASPECT may fly in low light conditions, the camera uses a fixed focus and shutter speed configuration. Raw imagery is subsequently processed to balance contrast and saturation of each image. In addition, since a wide-angle lens is uses, edge distortion is corrected using a custom-built camera model. Both of these overall algorithms are executed automatically in a batch processing system.

The ASPECT camera is fix-mounted to the primary optical base plate. The camera axis is bore sighted to within 0.5 degrees to the axis centers of the other optical systems. While images are being collected, a concurrent system collects both GPS data and inertial data to provide a high-resolution pitch, roll, and yaw correction dataset. An automatic software package merges these data set and geo-corrects each image using a triangular correction mode. The resulting images statistically show less than 11 meters of center frame positional error and less than 1 degree of rotational error. As with the frame enhancement processing, geo-registration is accomplished in a batch mode at a rate of approximately 800 images per hour. Following registration, images can be directly used by the responder or further corrected with minor positional and rotation corrections (Figure 22).

If requested by the data user, aerial photography (and IR imagery) can be stitched into a wide area mosaic. While this process does take some time, a 4 square kilometer mosaic image (approximately 8 frames) can be assembled in about 2 hours (Figure 23).

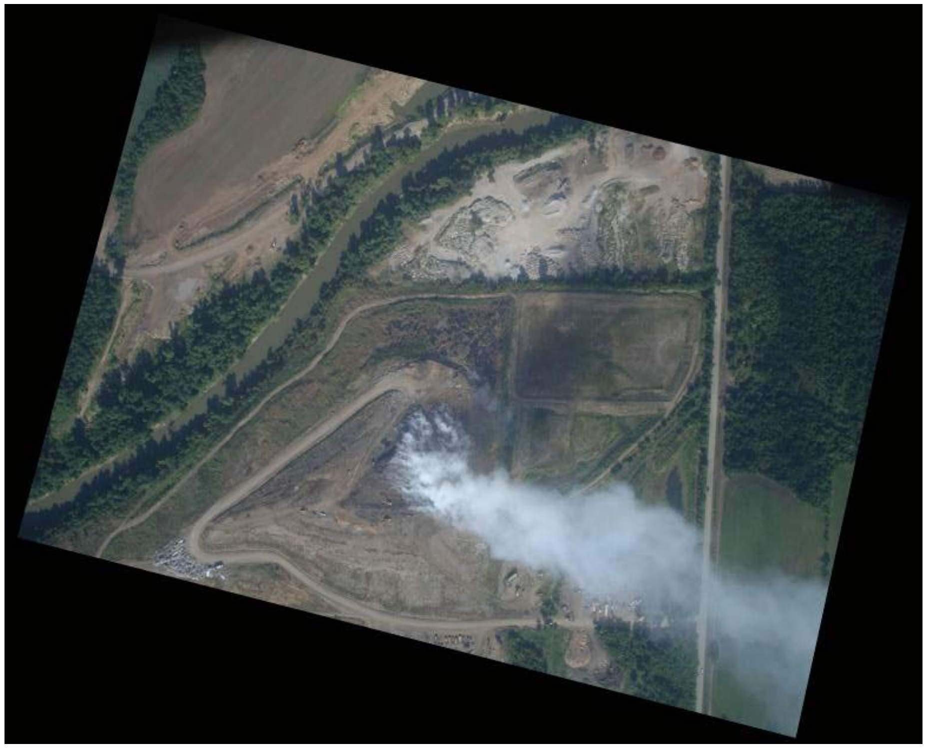

FIGURE 22 - Digital Aerial Visible Imagery

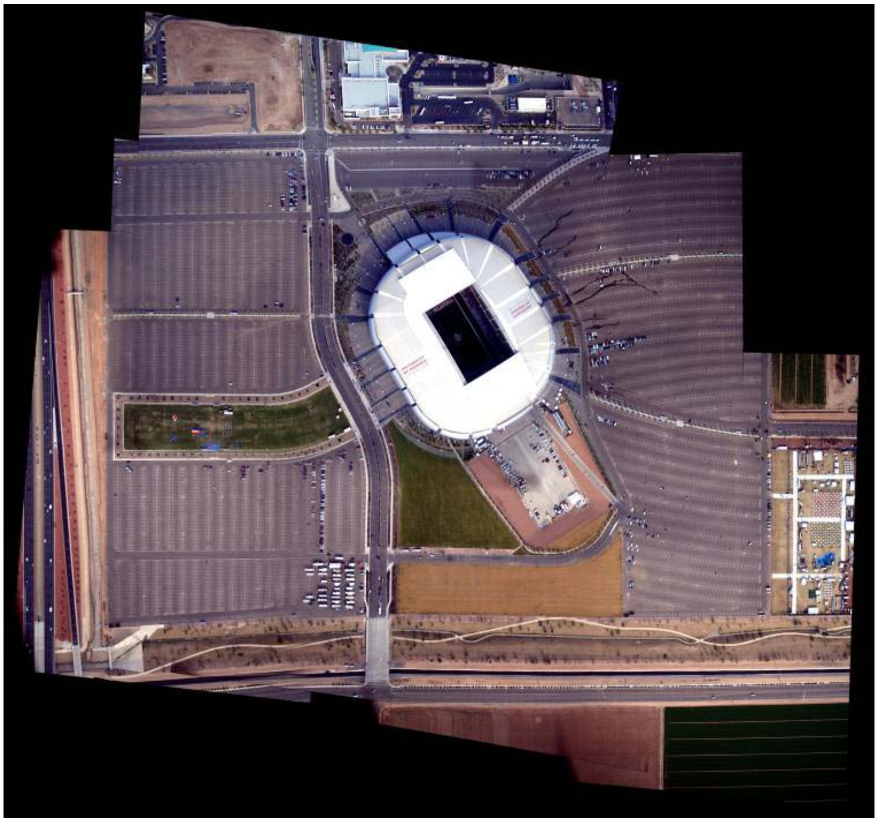

FIGURE 23 - Mosaic Imagery Product

Oblique digital photography is processed to capture the situational environment from the perspective of the flight crew. All frames are collected from the right side of the aircraft at approximately 45 degrees from the nose of the aircraft. During automated processing, GPS data is used to provide the position that the frame was collected and the direction that the frame was collected is determined from the track of the aircraft and the relative direction that the camera was operated from within the aircraft. Figure 24 illustrates an example of an oblique image.

FIGURE 24 - Oblique Aerial Image

5. Data Communication Technology

The ability to rapidly transfer data from the ASPECT aircraft to the ultimate end user is mandatory if the system is to support emergency response functions. ASPECT uses a state of the art satellite-based communication system that provides broadband data through put while the aircraft is in flight status (Figure 25). The system consists of an electronically steered phase array satellite antenna coupled to a RF power amplifier/receiver supporting a wired onboard computer TCP/IP modem/network. All components of the system have been installed and certified as part of a formal FAA STC procedure. The system utilizes a geosynchronous satellite connection and permits full rate communication throughout the contiguous U.S. Table 8 contains the technical specifications for the satellite communications system.

FIGURE 25 - Satellite Communication System Phased Array Antenna

TABLE 8 - Satellite Communication Technical Specifications

System:	Chelton Broadband Satellite System
Antenna:	HGA-7000 Electronically Steered Phased Array Antenna.
Modem:	Integrated Airborne Modem/Router, 100 MB/s data rate
Power Amplifier:	HPA-7400 Bi-directional Power Amplifier/Pre-Amplifier Short Coupled to the Phased Array Antenna.
Data Rate:	Up to 332 kbs (Approximately 60 Kbs) Full Duplex
Constellation Type:	Fixed Geo-Synchronous
Coverage:	Continuous Coverage Over the Lower 48 States.
Certification:	FAA STC
Power:	28 vdc @ 10 amp full load
Spin-up Time:	Less than 2 minutes from System Start
Standards:	TCP/IP

6. Technical Coordination and Support

The ASPECT Data Team will be located at the Executive Air FBO will provide data analysis services and QC for the event. It is anticipated that the team will be active on 14 July 2013. This data analysis support will provide information in four formats to include: (1) digital data stored on an FTP site, (2) communication through conference lines, (3) hard copy displays, and (4) data presentation and display through Google Earth. Procedures to access this information are provided in Appendix D.

A secondary responsibility of the reach back team will be to provide hardware support to the aircraft sensors, including backup chemical, radiological, and camera systems. In the event that these systems show faults, the team will exchange the reserve sensors.

Appendix C
ASPECT Data Routing, Storage and Viewing

ASPECT data consists of several distinct file types. These data types include: (1) visible camera images, (2) visible images in a data format capable for import to GIS packages, (3) wide-area high spatial resolution infrared GIS maps, (4) processed infrared spectra showing vapor species identified, (5) maps showing the location of flight paths, (6) processed chemical data, (7) processed gamma ray data, (8) data logs containing information about each collected data file, and (9) data analysis reports (in Microsoft Word) and Excel format.

ASPECT uses onboard data processing to accelerate the delivery of data. Both chemical and radiological data are processed while in flight status and a data package is extracted from the aircraft using the satellite data system. All data is QA reviewed by the ASPECT team prior to delivery to the Region. Once data has been certified, it is immediately transferred to the Region for use.

Data Storage

The raw data collected as part of the Rose Bowl will be archived at the **URL Site: ftp.epaaspect2.net** with the **User ID: jamboree@epaaspect2.net** (password protected, contact ASPECT POCs for password**)**. The file structure in the archive will be the following for both the raw and processed data. The raw data will be under "raw" while the processed data will be under "processed". The standardized files structure used is contained in Table 1.

Table 1 - Data File Structure

Main subdirectory labeled with Date and Flight number		
File	**Contents**	
DIGITALS	Raw NADAR aerial digital photography data and event (shutter) times.	
FTIR	Raw FTIR spectral data	
GAMMA	Raw gamma spectral data	
GPS	Raw gps positional data and inertial navigation data	
IRLS	Raw line scanner data	
OBLIQUES	Raw oblique aerial digital photography data	
PROCESSED DATA	Processed data consisting of:	
	Processed Digitals	Georectified NADAR color photography
	Processed FTIR	Georectified chemical detections Text data package
	Processed GAMMA	Georectified Sigma Plot Georectified Exposure Contour Plot Text data package
	Processed IRLS	Georectified 3-band IR imagery
	MOSAIC	Georectified color photography mosaic
	Processed Obliques	Georeferenced color oblique photography
Reports	Completed mission reports and mission updates	
Run sheets	Scan copies of written in-flight collection logs Mission orders	

Data Distribution
Distribution of data will be under the control of EPA Region 3. To aid in this process a secure website has been developed and can be found at http://www.epaosc.org/nsj2013. Both Google Earth and ESRI (FlexViewer) data will be available.

To support State requirements, a Google Eearth component will be provided within this website to further aid in viewing the data. This website contains detailed information and links to all supporting ASPECT data. Direct access to all ASPECT products can be accomplished using a Google Earth Tool. An event specific and password protected KML file can be downloaded from the website and placed on any computer with a copy of Google Earth (free or pro). The KML link can also be distributed using email. User and password information will be distributed to parties authorized by the OSC. A brief instruction set on using the Google Earth tool is contained in the following section.

Google Earth Instructions
To expedite data delivery a simplified tool based on Google Earth can be used to disseminate and view geo-spatial data. Use of this tool requires that an up-to-date free version of Google Earth and a suitable web browser (Internet Explorer, Chrome or Firefox) be installed on the user's computer. Access to all data is facilitated through a small kml file. The following instructions detail how to use the tool:

1. Using your email server download the KML file to your desktop if you received it through email. If provided on a memory stick, simply copy the KML file to your desktop.

2. To open the kml, double click the file located on your desktop. This will automatically bring up your Google Earth Program, and the ASPECT airplane icon will appear and zoom to the geographic area of the mission.

3. The ASPECT airplane icon provides total access to all of the data available for the mission. Double Click the airplane and a balloon will expand listing all of the relevant information for this particular ASPECT mission. The relevant information available may vary from mission to mission. All of the sections depicted in blue are links to data on the ASPECT mission servers. The following is a brief description of each section:

Brief Mission Description
This section contains details of the overall mission and specific details of the current mission which will open up in a separate browser window. When completed with the section close the browser window to return to Google Earth.

Sensor suite capabilities
This browser window contains a description of the sensors used on ASPECT aircraft. When finished with this section close the browser window.

Color aerial photography

Clicking the color aerial photography section permits georectified NADAR images to be displayed and/or downloaded using the Google Earth. Once selected, available images from the last mission will be displayed as transparent outlines on the main screen.

> *Note: By default, only outlines from the last mission are displayed. Additional images collected on prior missions can be selected under the places menu on the left side of the Google Earth tool.*

To load the actual imagery into Google Earth, click on a camera icon in one of the polygons. A photo balloon will open and a thumb nail of the non-georectified photograph will be displayed. Two options are given at the bottom of the image:

> Download Image Overlay into Google Earth

> Download High Resolution Image into Web Browser

By clicking on the “Download Image Overlay into Google Earth” the image will be imported into the Google Earth imagery database and the georegistered image will be shown on the screen. Repeat this process for as many images as you are interested in. Note: each time you execute this procedure the referenced aerial photograph frame will appear in blue in you temporary places pane on the left hand side of the Google Earth window. Should you want to view a full resolution image of this frame, click on the option “Download High Resolution Image into Web Browser”. The full resolution image will be displayed in a separate browser window.

Mosaic Aerial Photography (By Date)

Selection of a color mosaic will load a georectified color mosaic into Google Earth. Selected of the appropriate image is referenced to the date of collection.   Due to the large size of these files, several minutes may be required to fully download the file.

Oblique Photography

Viewing of oblique color aerial photography is accomplished by selecting the oblique photography item. Once selected, available oblique images for the last flight will be displayed as a collection of arrows. These arrows represent the location that the aircraft was positioned and the direction the camera was pointed when the frame was collected out of the right side of the aircraft. As the curser is moved over the respective arrows, the frame number will be highlighted. If an arrow is double clicked a thumb nail of the image will be displayed. The user has the option of downloading the image in a browser.

Infrared Color Imagery

Multi-channel color infrared imagery is selected using this option. Once selected, transparent outlines of available images from the last flight will be displayed. Operation and manipulation of IR imagery is identical to procedures used to view color aerial photography.

FTS Confirmed Detection

This section contains the locations of confirmed remote sensed chemical detections for the last mission. Detections will be displayed as an icon. Each detected compound will be displayed as a unique icon. As with other data, data from prior missions can be selected under the places menu.

Chemical Report Retrieval

Chemical data associated with FTS confirmed detections is contained in this section. Each report shows a listing of compounds which are automatically scanned by ASPECT. The number of detections, maximum concentration, and the coordinates of the collection line are given in the report.

Aircraft Flight Tracks (By Date)

Flight track information for the last mission is available using this selection. Once selected, a color flight path will be displayed. Multiple tracks can be displayed by selecting additional paths from other missions.

New Data Additions

As new data is added to the mission website the provided Google Earth link will permit full access to the new data. You must periodically close the Google Earth program and re-open it again using the Google Earth icon on your desktop. When you exit the program, Google Earth will prompt whether to save your "temporary places". Select discard. Depending on the amount of data being collected and uploaded to the mission server, reloading the Google Earth program once each hour will permit access to the new data.

Trouble Shooting

If you are having problems with multiple ASPECT airplane icons appearing on the screen do the following:

1. Locate the Places Box on the upper left hand side of Google Earth.
2. Locate the line labeled as My Places.
3. Right click on My Places and select Delete Contents
4. Close Google Earth and reopen using the Google Earth Icon on your desktop

Appendix D
Communications

Phone Conference Call Bridge
The ASPECT program has a dedicated 24/7 phone bridge which be used to communicate with the reach back data analysis team.

Phone bridge # (toll Free): 1-866-299-3188
Code: 2025642415#

Direct Tracking of Aircraft from EOC
Due to the anticipated terrain and location, FAA will not provide public tracking of the aircraft during the event (Flight Following). The aircraft will be providing periodic Google Earth updates so the location of the aircraft will be known. This information will be made available as part of periodic status updates on the mission.

Google Earth Link for Data Display
The data analysis cell located at Executive Air will be processing data collected from the aircraft and processing it into a format that can be accessed through a Google Earth file or a FlexViewer Configuration File. This file will contain processed data providing situational awareness information. A Google script will be provided to the State event manager for distribution.

Direct Aircraft Communications
Direct radio communication (if necessary) with the aircraft will be conducted using 123.45 MHz (AM) during the event. Members of the ASPECT team will provide the necessary radio equipment.

Appendix E

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Stephanie Wenning, Region 3 OSC
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Region 3 24 Hour Regional Spill Line
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