NGA/IBE/Support to the

Airborne Spectral Photometric Environmental Collection Technology (ASPECT) Program

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ASPECT Program Description:

- Operational Model
  - Current Technology and planned technology upgrades
  - R&D Focus
- Emergency Response
  - Activities and Examples
- Disaster Response
  - Activities and Examples
- Evolution of Airborne Water Quality Assessment (WQA)
- Evolution of Emergency response data analysis, products, and formats
- Program Status and Challenges as of December 2008

ASPECT Operational Model

Scope:

Unclassified Interagency collaboration to sustain, evolve, integrate and transition airborne remote sensing technology and data analysis applications to the civil sector for emergency response and homeland security applications

Customers:

NGA/PMH/PMHR/NST

Department of Homeland Security

US-EPA regional offices

State and local emergency response offices

Participating agencies:

Department of Homeland Security/ Infrastructure Protection

United States Environmental Protection Agency/ National Decontamination Team

Los Alamos National Laboratories/Bioscience Division and Spectroscopy Group

NGA/IID/IBE

Technical approach:

Conduct engineering and field studies to evolve and Integrate COTS technology and hardware to meet documented airborne emergency response specifications

Build, upgrade & integrate COTS sensor systems

Develop and implement mission related data analysis and emergency response product generation and dissemination software

Conduct field experiments and exercises with the emergency response, industrial and DHS communities

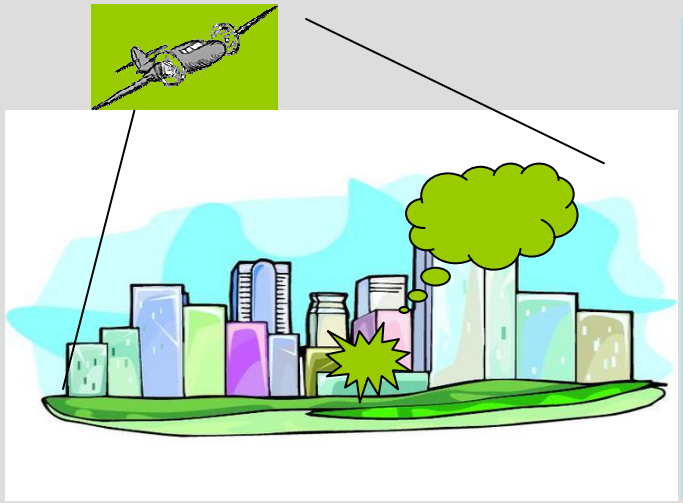
Publish R&D, data analysis results, utility assessments and developed capabilities in journals and conference proceedings to facilitate peer review

Implement airborne emergency response capability by regional priority based on industrial proximity and threat potential

Airborne Spectral Photometric Environmental Collection Technology (ASPECT)

•EPA ASPECT is the nation's only 24/7 chemical wide-area detection and imaging capability supporting local first responders

- The U.S. EPA provides low altitude, high-spatial / spectral resolution data on emergency responses to state and local first responders
- A single aircraft exists currently located Texas



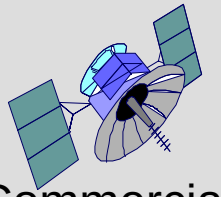
DHS ←→EPA Cooperation:

•Utilize ASPECT for NSSE, SEAR level 1& 2 events

•Multi-Organizational collaborative R&D program to comprehensively evolve airborne infrared spectrometry and transition it for use by the CIVIL sector

Operational Integration of Aircraft Platform to First Responders and Joint Operation Centers

Emergency Operations



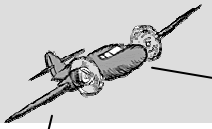
Commercial Voice & Data

Emergency Response Location

Immediate Results

External Peer Review

Technical Reachback

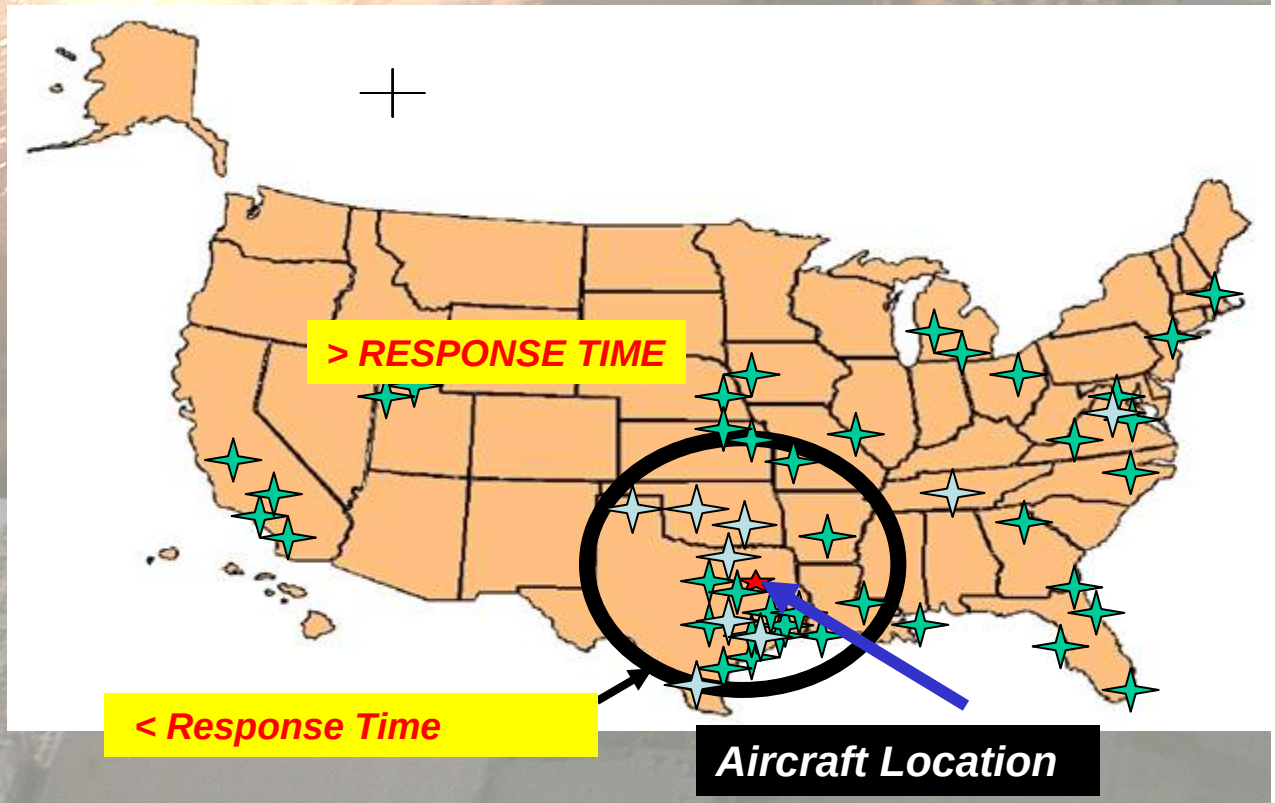


EPA Dispatch Aircraft

AeroCommander 680 Twin Engine

- **ASPECT has been deployed over 97 times since 2001**
- **Natural and Technological Disasters**
- **ASPECT has directly supported numerous NSSE, SEAR level 1 & 2 as well as special events and training exercises**

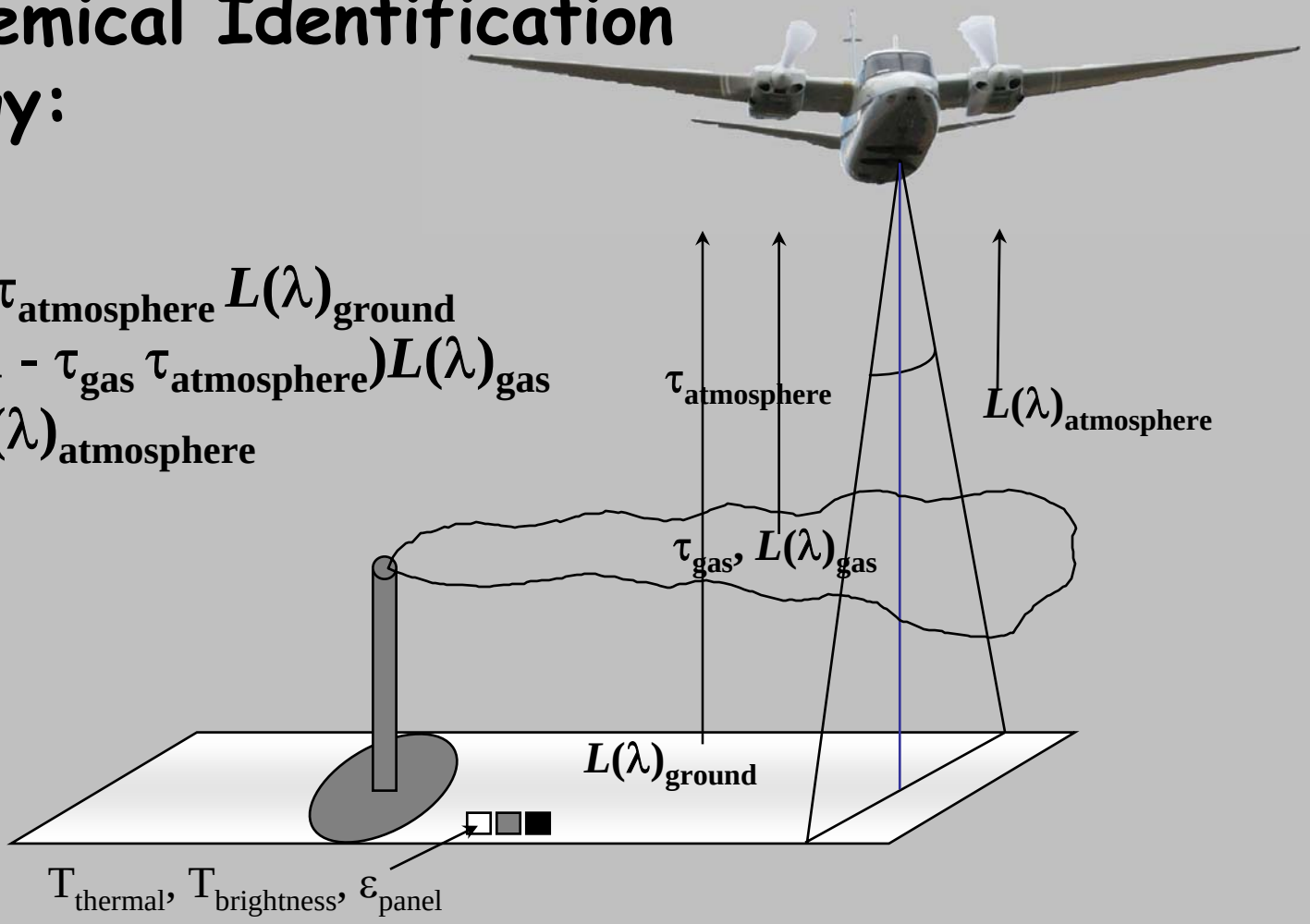
- AeroCommander Platform
  - Base of Operation: *Waxahachie, Texas*
  - IFR/GPS equipped
  - Satellite Com. equipped
  - High Quality Filtered Power
  - STC Camera Holes in the floor
- Crew: Two Pilots, One Operator, All Commercial/ATP Rated
- Speeds:
  - Data Collection at 100 kts
  - Cruise at 180 – 200 kts
- Range/Aloft Time:
  - Range 1100 NM
  - Aloft Time 4 – 6 hours
- Service Altitude:
  - Data Collection at 2200 Ft AGL
  - Cruise at 20000 Ft (with Supplemental Oxygen)



Current Technology

Published, Peer Reviewed & Validated Remote Chemical Identification Methodology:

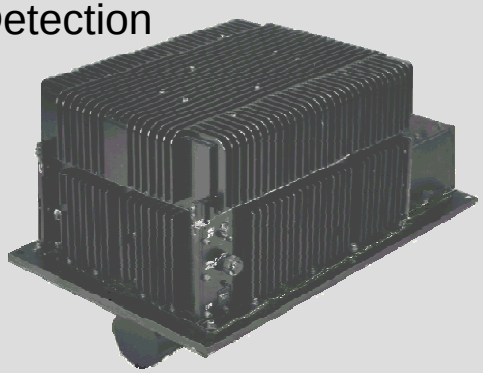
$$L(\lambda)_s = \tau_{gas}\,\tau_{atmosphere}\,L(\lambda)_{ground} + (1 - \tau_{gas}\,\tau_{atmosphere})L(\lambda)_{gas} + L(\lambda)_{atmosphere}$$



Current ASPECT sensor suite major components

Three Primary State-of-the-Art Sensors:

- Infrared Line Scanner to image the plume
- High Speed Infrared Spectrometer to identify and quantify the composition of the plume
- Gamma-Ray Spectrometer for Radiological Detection



Multi-Spectral IR Imager

Fourier Transform IR Spectrometer

Gamma-Ray Spectrometer

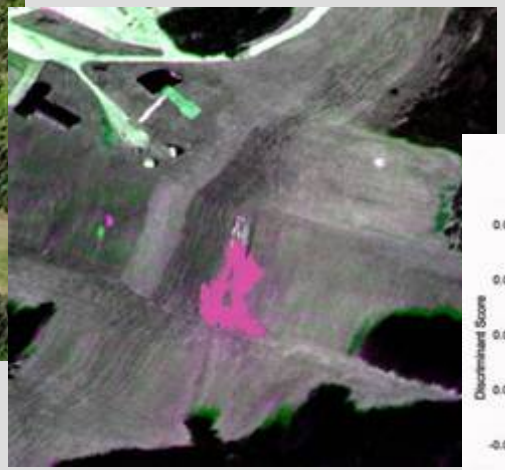
A single aircraft pass over produces a data set that permits informational mapping using aerial photography, infrared imaging & chemical identification, and gamma ray spectrometry.

Priority products can be generated and sent directly via commercial satellite from the on-scene aircraft or via the commercial internet using the ASPECT Pioneered Google Earth Situational Awareness Tool (SAT)

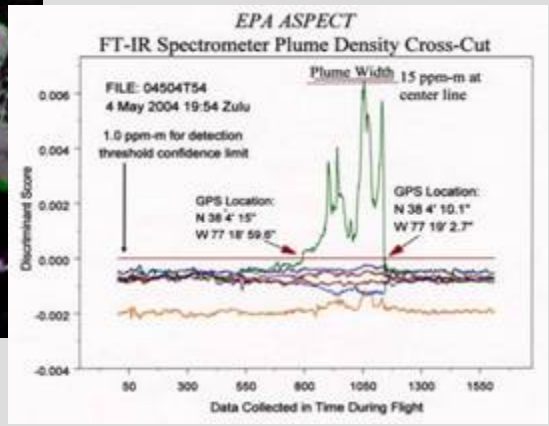
Standardized Data Products

Base Map

Aerial Image

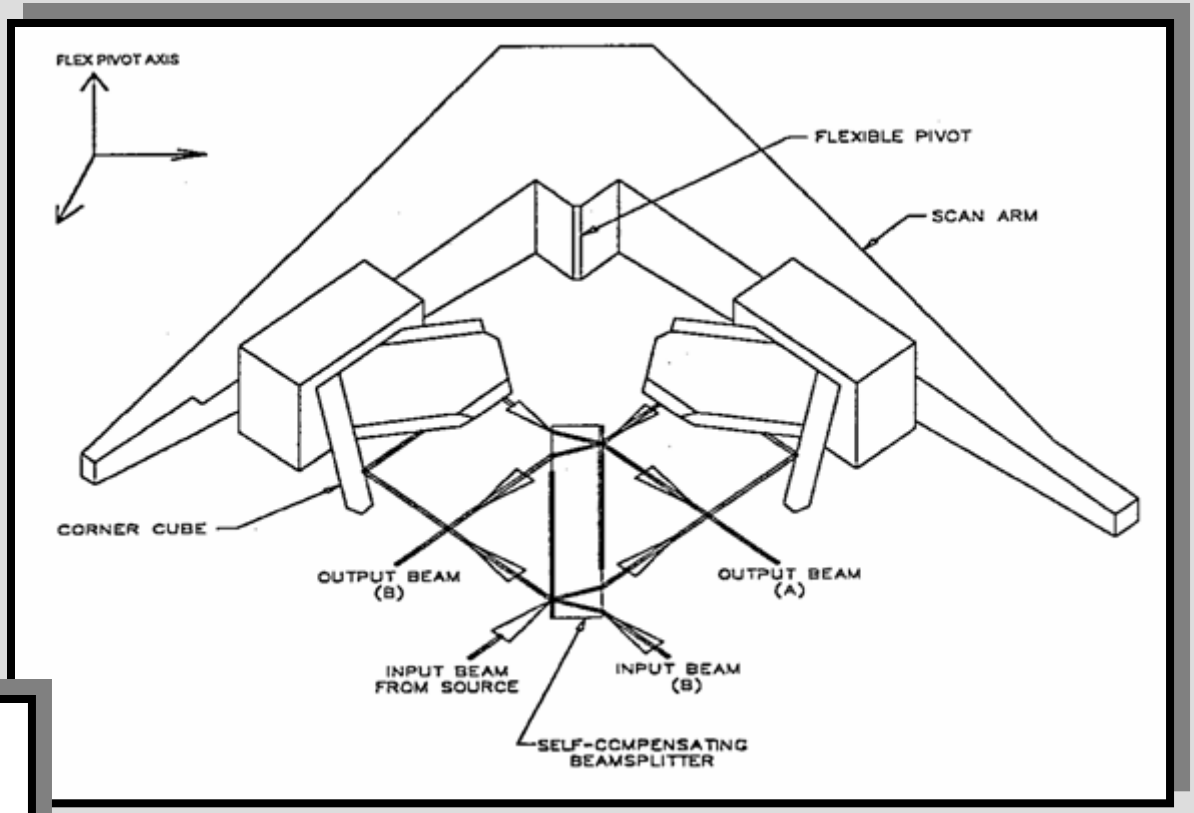


IR Plume Image



Chemical ID Information

Chemical identification:



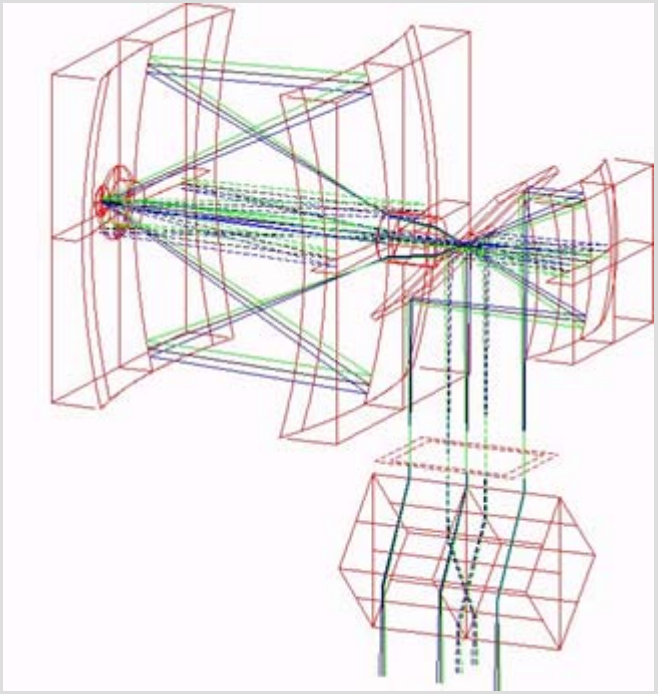
INTERFEROMETER DESIGN

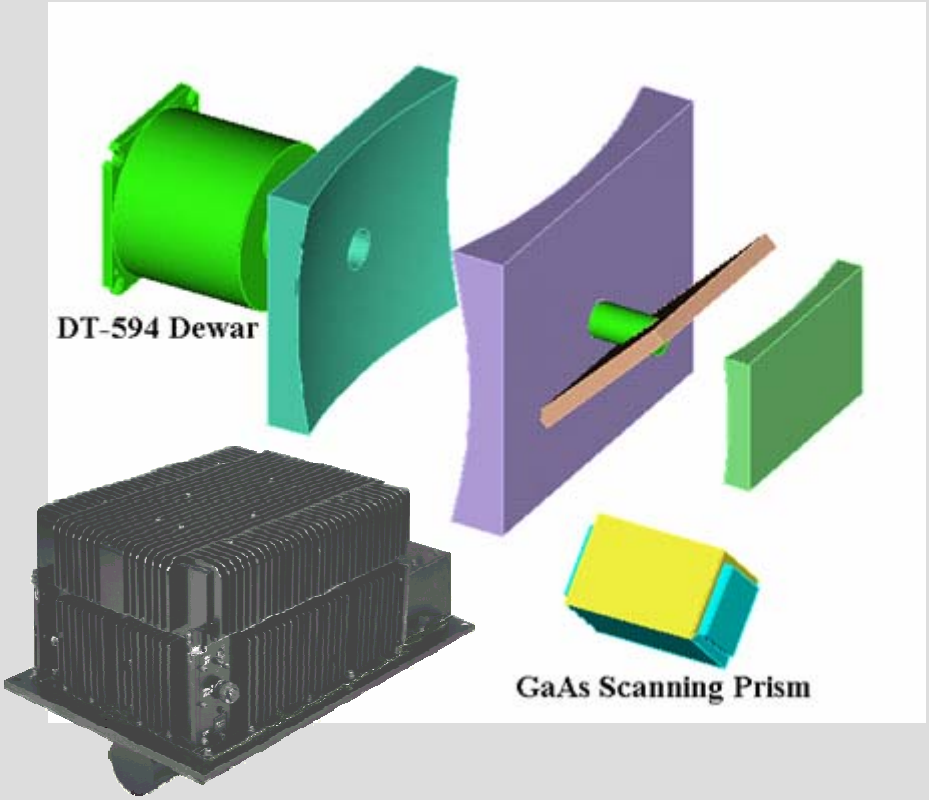
- **Throughput - 0.1 cm^2*sr**
- **Scan Speed - 87 scans/sec**
- **Telescope - 10” (0.2° FOV)**
- **Dual Scan Direction**
- **Thermal Stabilization**
- **Controlled Blackbody**
- **0.5 to 32 cm^{-1} resolution**

- **Channel 1 - 3 - 5 microns $6*10^{-9}$ W/cm^2srcm^{-1}**
- **Channel 2 - 8-12 microns $1.8*10^{-8}W/cm^2srcm^{-1}$**
- **Channel 3 - RS-170 Video**

Chemical Mapping:

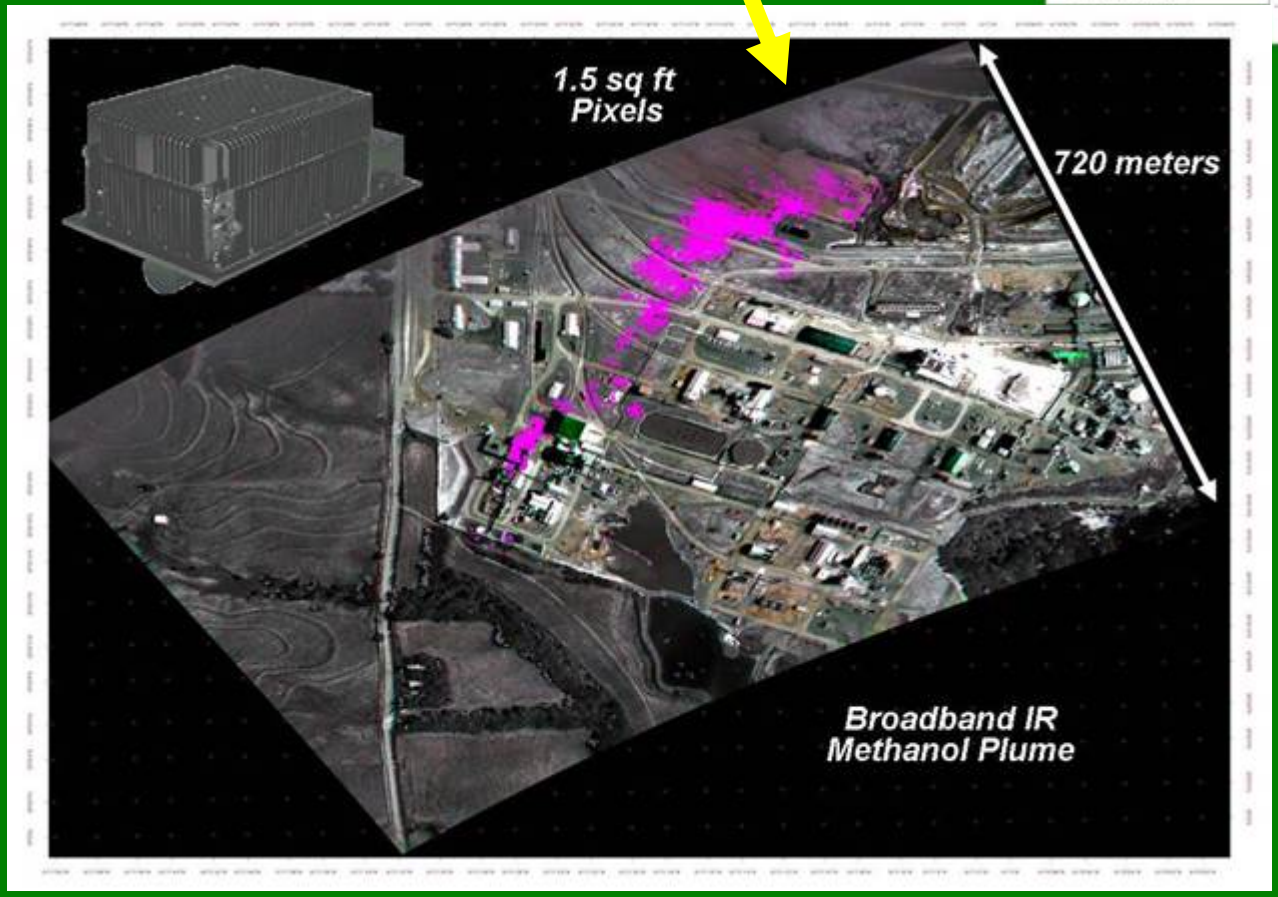
RS-800 SENSOR OPTICS





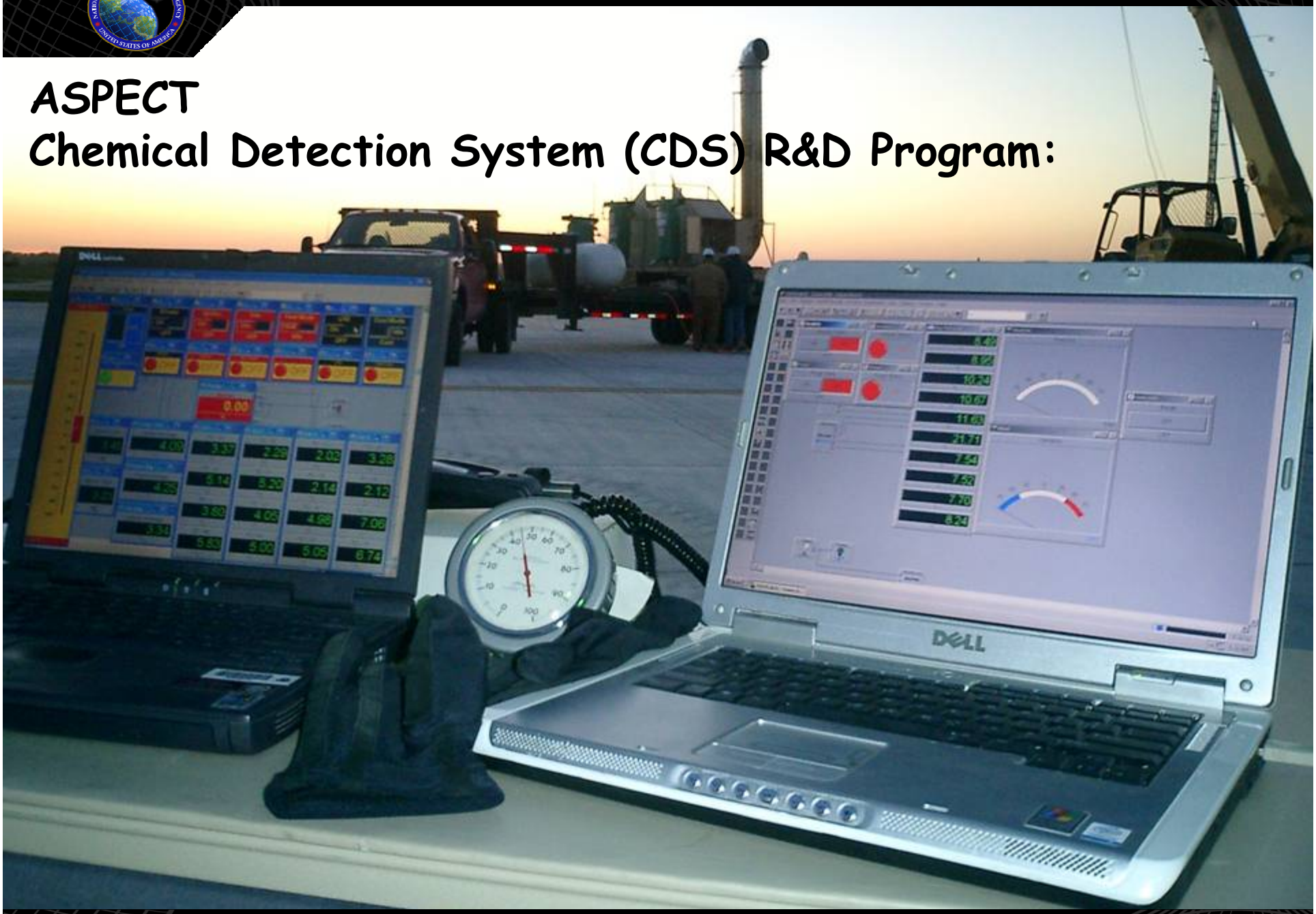
- Focal Length: 2.00 inches
- F/ Number: 1.18 Effective
- IFOV: 1.00 mrad
- Optical Transmission: 0.80

IRLS Sensor Field-of-View Operational Altitude



Field-of-View (Degrees)	60 degrees
Number of Pixels Across Image	1500 pixels
Spectral Range	MWIR & LWIR
Pixel Size (FOV)	0.45 meter
Effective FOV Width (meters)	710 meters

ASPECT
Chemical Detection System (CDS) R&D Program:



CDS-R&D Program

Objective:

Five year comprehensive scientific evolution of airborne infrared spectrometry and its emergency response and homeland security applications

Technical approach:

Conduct engineering, laboratory and field studies to evolve and integrate COTS technology and hardware to meet our Program specifications

Conduct field experiments and exercises with the emergency response, industrial and DHS communities

Publish R&D, data analysis results, utility assessments and developed capabilities in journals and conference proceedings to facilitate continuous peer review

R&D-CDS Program Areas of Research:

Conduct high probability incident research:

- Remote sensing of chlorine and other large scale industrial chemicals
- Assess and evaluate suitable remote sensing technologies for a broader range of incident responses

Assess, build, upgrade & integrate COTS sensor systems

- Insure current successful sensor suite remains state of the art
- Incorporate new remote sensing technologies as needed based on internal R&D and changing mission requirements

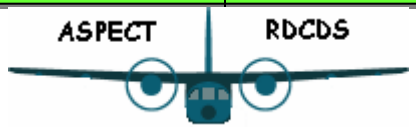
Develop and implement sensor suite laboratory & field quality control and calibration methodologies

- Sensor performance monitoring capabilities
- Data calibration capabilities for quantitative measurements

Maintain and upgrade as needed

- Situational Awareness Tool (SAT) for connectivity to JOC's
- Satellite based internet connectivity to aircraft

Five YR. Supporting R&D Tasks and Schedule

09	10	11	12	13
High probability incident research				
Chlorine sensing → Determine if an airborne approach is feasible				
Assess and incorporate new remote sensing technologies (mission requirements driven)				
Sensor suite instrumentation upgrades, performance monitoring, laboratory and field testing & calibration				
Coefficient Generation and Quant Development – 50 Vapor Species → Ongoing				
Data analysis and product generation software development (automated vapor species analysis)				
Maintenance and evolution of SAT to accommodate communication and reporting req'ts to NOC				
Satellite internet	 Equip and certify second aircraft			

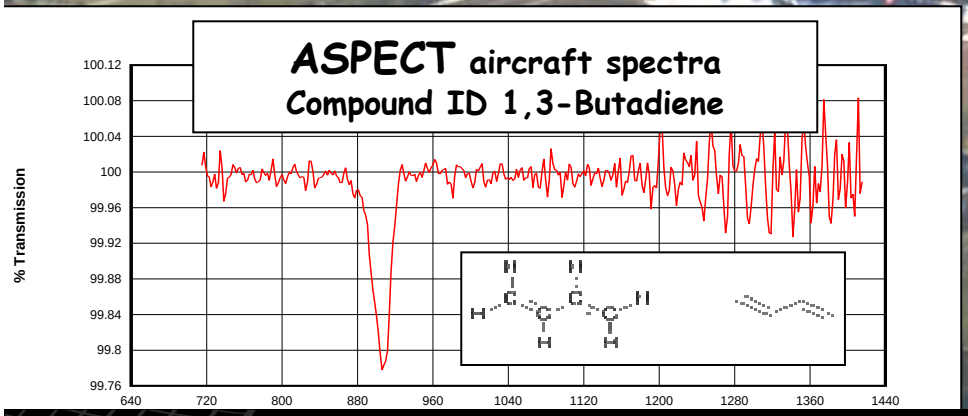
Subset of over 97 Emergency & Disaster Response

Deployments since 2001

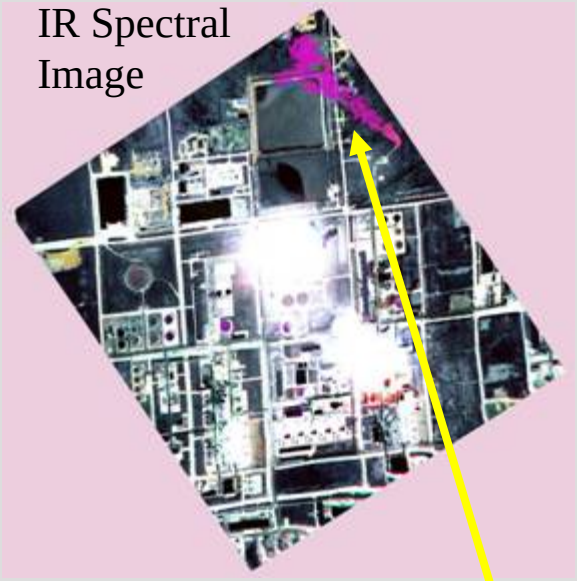
Floods Houston TX FEMA 6/2001	Presidential Inauguration Feb 2005
Derailment Jacksonville TX 9/2001	Oil Refinery Explosion Texas City TX March 2005
Superbowl Pre-deployment LA 1/2002	Gas Bottling Plant Explosion St. Louis MO 6/24/2005
Olympics Pre-deployment UT 2/2002	Valley Solvents Plant Explosion Ft. Worth TX 7/25/2005
Tire Fire Roanoke VA 3/2002	Solvent Recovery Plant Explosion Romulus, MI 8/11/05
Refinery Tank Fire Houston 4/2002	Hurricane Katrina Chemical, Radiological and Damage Assessment mapping response Aug/Sep 2005
Plant Fire Friendswood TX 5/2002	Hurricane Rita Chemical, Radiological and Damage Assessment mapping response Sep 2005
Plant Explosion Freeport TX 9/2002	Point Comfort, TX Plastics plant explosion Oct 2005
Landfill Fire Meosho MO 10.2002	Allstar Baseball Game Pittsburg, PA 2006
Derailment Amite LA 10/2002	Chemical Fire Apex, NC Oct 2006
Refinery Study Port Arthur TX 1/2003	Research&Development Collections Ottawa, KS Oct 2006
Shuttle Columbia Response 2/2003	Research&Development Collections Ottawa, KS Nov 2006
Swamp Gases Toledo Bend TX 3/2003	Chem Central Fire, Kansas City KS Feb 2007
Radar Tests Canadian River OK 4/2003	Rosebowl Pasadena, CA Jan 2007
Plant fire Bay City MI 7/2003	Train Derailment Sheperdsville, KY Jan 2007
Landfill Fire Warren OH 7/2003	Train Derailment Sugarland, TX Jan 2007
Wildfires CA FEMA Response 11/2003	Dead Birds, DHS response, Austin, TX 2007
Magnesium Plant Fire OH 12/2003	Tornado FEMA Region 7, Greensburg, KS May 2007
State of the Union Washington DC 1/20/04	Flooding Coffeyville, KS July 2007
Pesticide Fire Atlanta GA 1/22/04	Rosebowl Pasadena, CA Jan 2008
Chemical Plant Pool Fire Conyers GA 5/29/04	Super Bowl Phoenix, AZ Feb 2008
G8 Summit Pre-Deployment 6/8/04	Refinery Explosion Big Springs, TX 2008
	National East Coast 4th July coverage Philadelphia, PA 2008
	DNC, Denver, CO Aug, 2008
	Hurricane Gustav, LA, September 2008
	Hurricane Ike, TX, September 2008

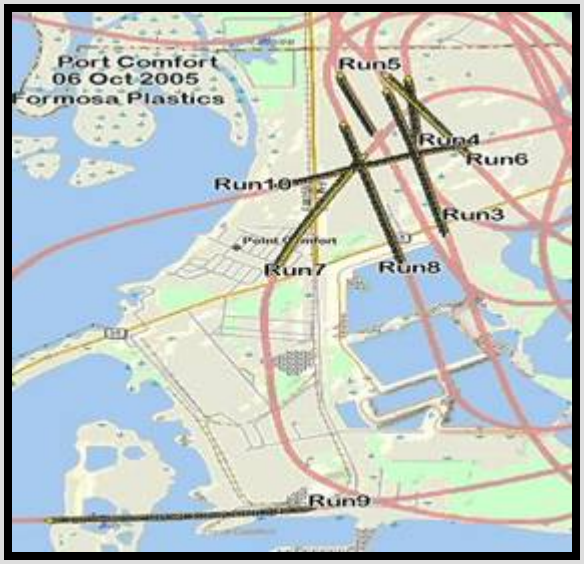
CSX Train Derailment 01/17/2007
Brooks, Kentucky

ASPECT/RDCDS
Comprehensive Evolution of Infrared Spectroscopy for Emergency Response & Home Land Security Applications

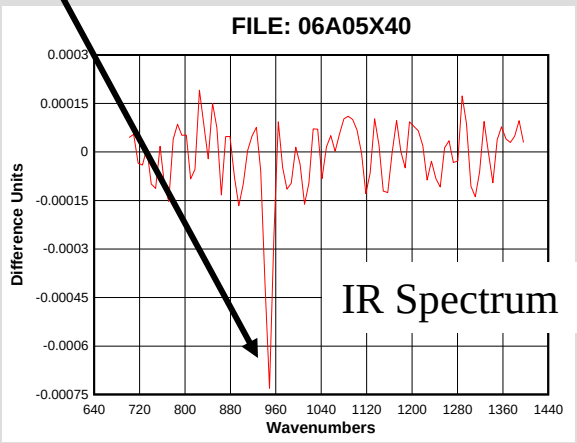


EPA ASPECT – Formosa Plastics Fire 10/06/05

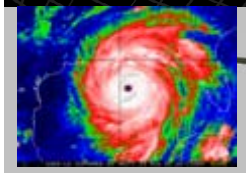




Ethylene Detection



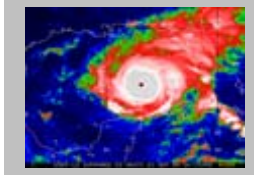
ASPECT Hurricanes Katrina & Rita
EPA/FEMA Regions 4&6
Rapid Needs Assessment (RNA)



ASPECT collects RNA data for 9 consecutive days resulting in 15 sorties (64 Flight Hours)

AUG 29 | AUG 30 | AUG 31 | SEP 1 | SEP 2 | SEP 3 | SEP 4 | SEP 5 | SEP 6 | SEP 7 | SEP 8 | SEP 9

- Concurrently, ASPECT conducts 5 emergency response actions ranging from fires to chemical releases
- The ASPECT Aircraft and team were the first reconnaissance aircraft on-scene in support of EPA & FEMA Regions 4 & 6



ASPECT pre-positioned in San Antonio, TX begins RNA data collection 24 Sept. 60kt winds as level II thunderstorms move out of the area. Collects for 4 consecutive days

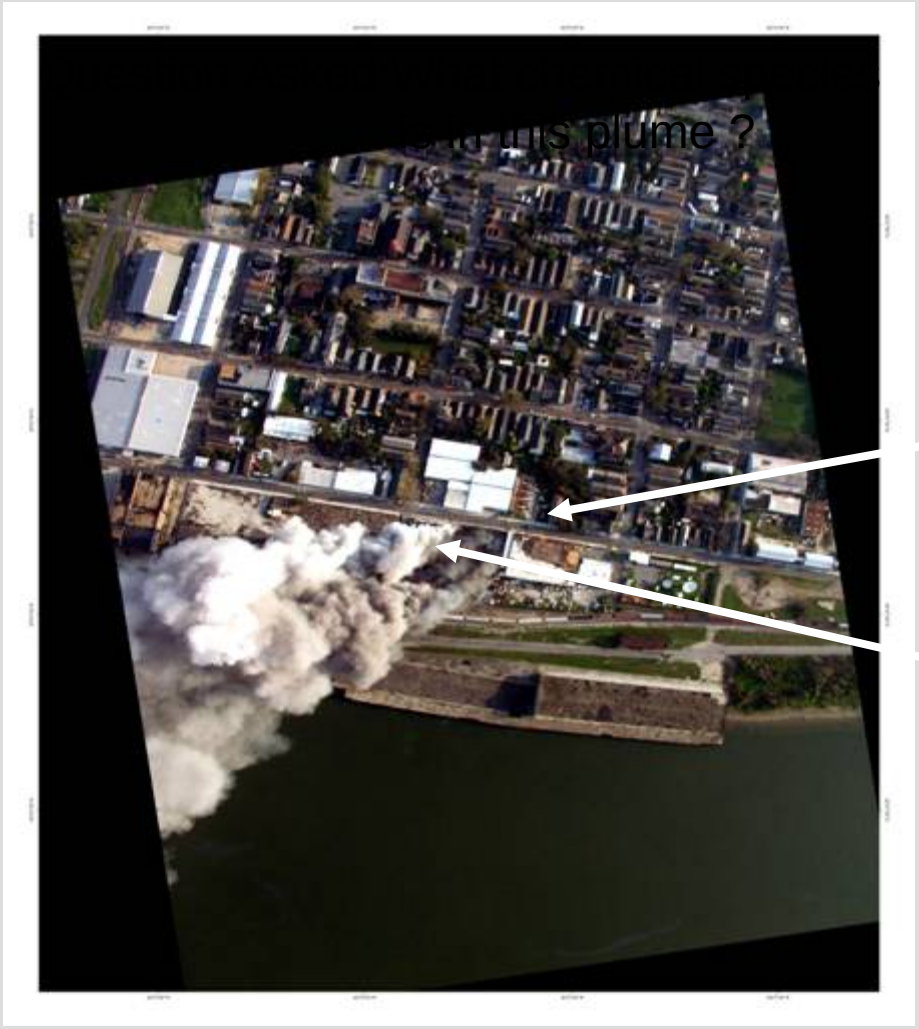
SEP 23 | SEP 24 | SEP 25 | SEP 26 | SEP 27

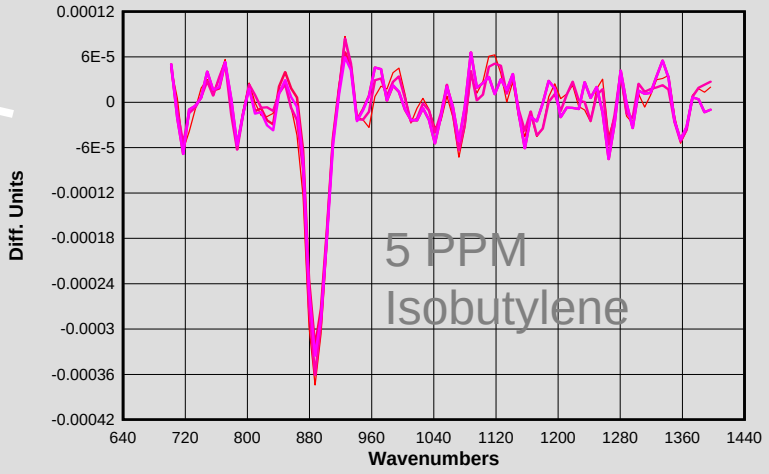
- 250 Gb RNA Data collected Over:
- Port Arthur,TX, Beaumont, TX, Freeport, TX,
- Orange, TX Lake Charles, LA.

- ASPECT analysis teams discover several active chemical releases
  Data is rapidly forwarded to EPA Region 6 and Company Personnel.
  All releases are secured by Company Response Teams.
- The ASPECT Aircraft and team were the first reconnaissance aircraft on-scene in support of EPA & FEMA Regions 4 & 6

ASPECT – Katrina Hurricane Response

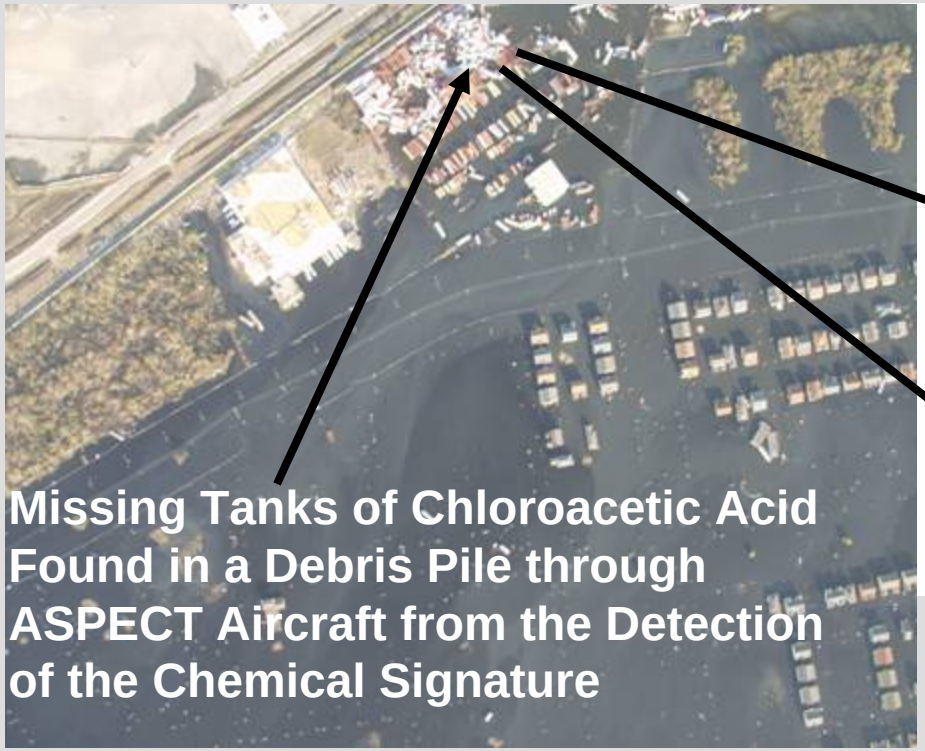
New Orleans Waterfront Fire on 2 September 2005

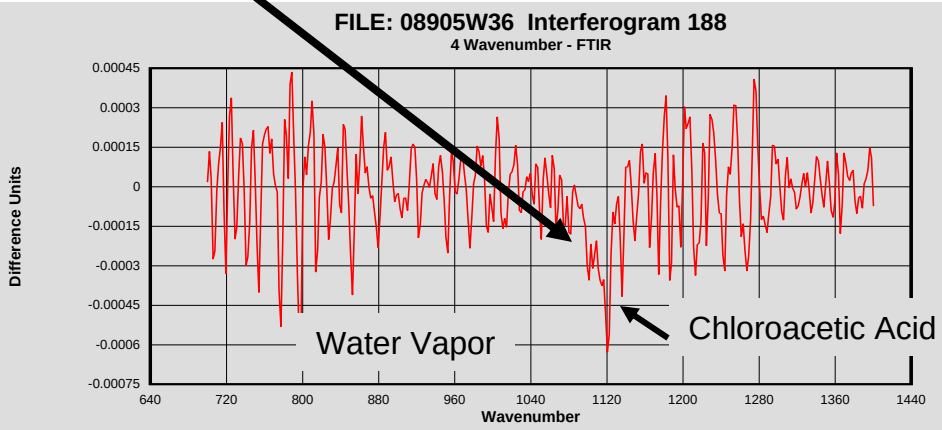




ASPECT – Katrina Hurricane Response

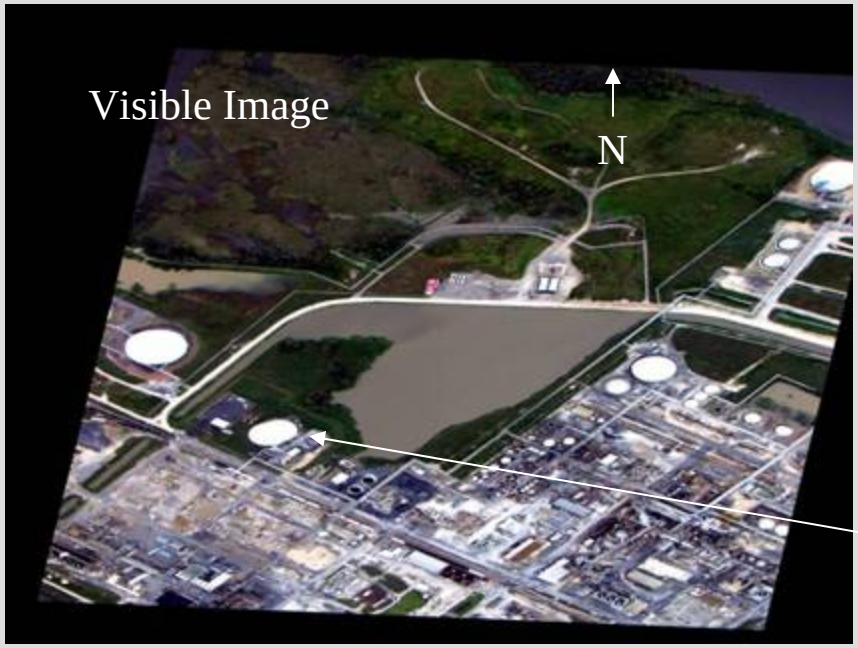
Locate Missing Tanks of Chloroacetic Acid - 5 September 2005

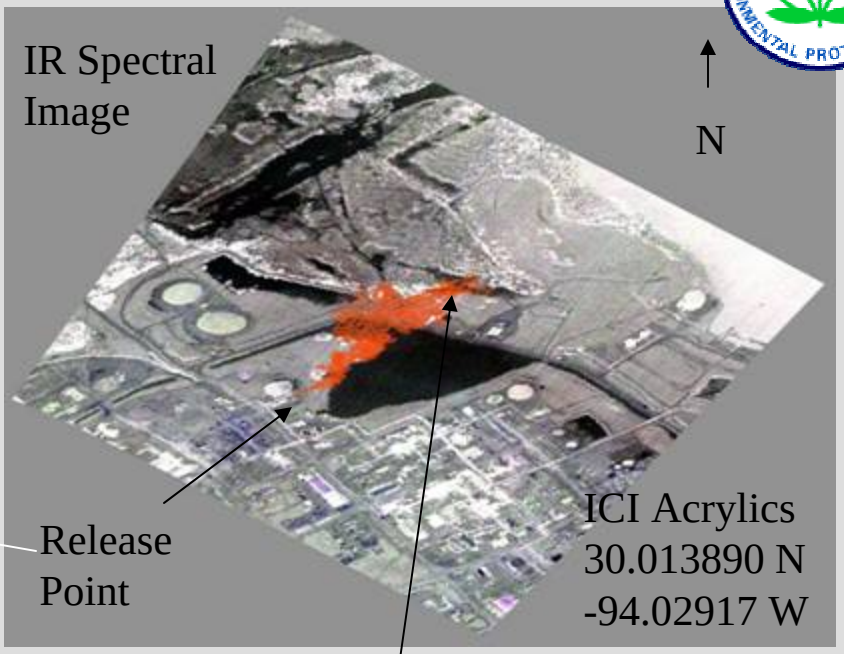




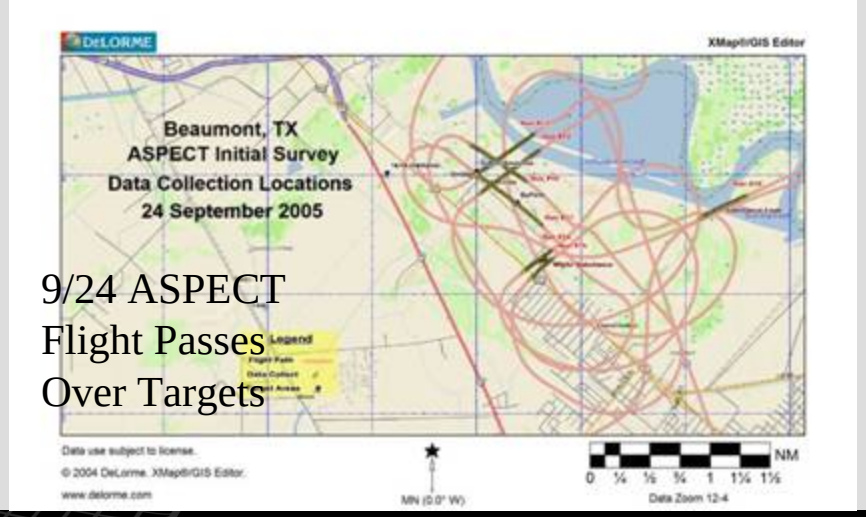
- ASPECT aircraft found tanks Leaking 1.2 mi from initial location
- EPA HAZMAT Team on ground immediately notified for cleanup and disposal

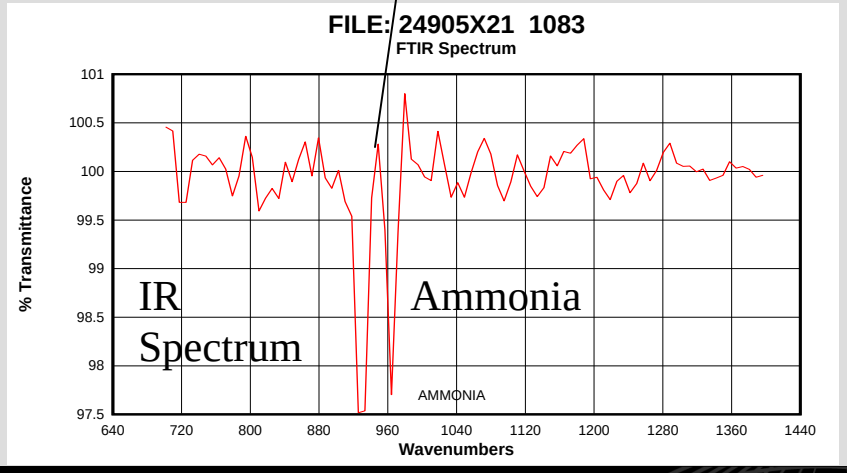
EPA ASPECT – Hurricane RITA Response 9/24/2005





Plume Identification and Classification





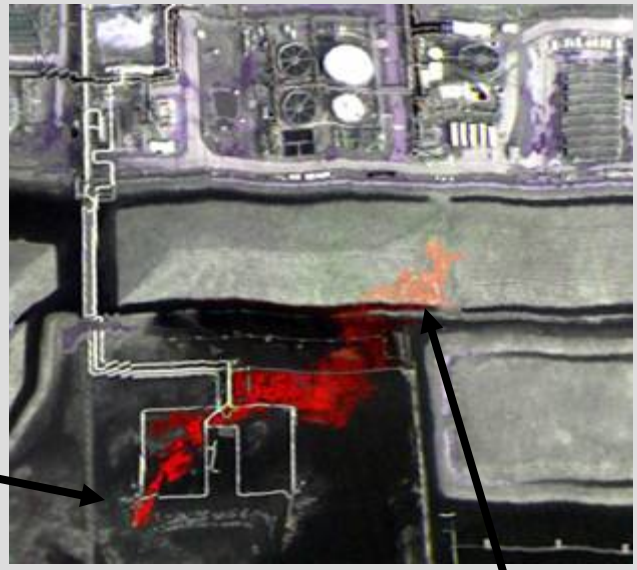
EPA ASPECT – Hurricane RITA Response 9/25/2005

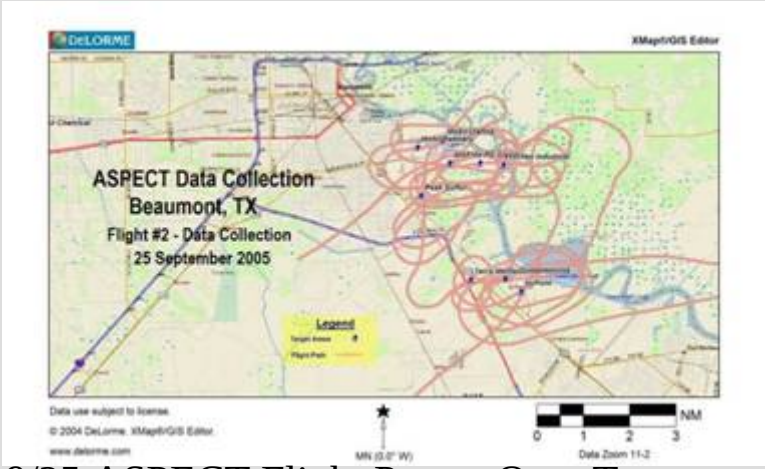
Beaumont, Texas

30.06537 N
-94.0633 W

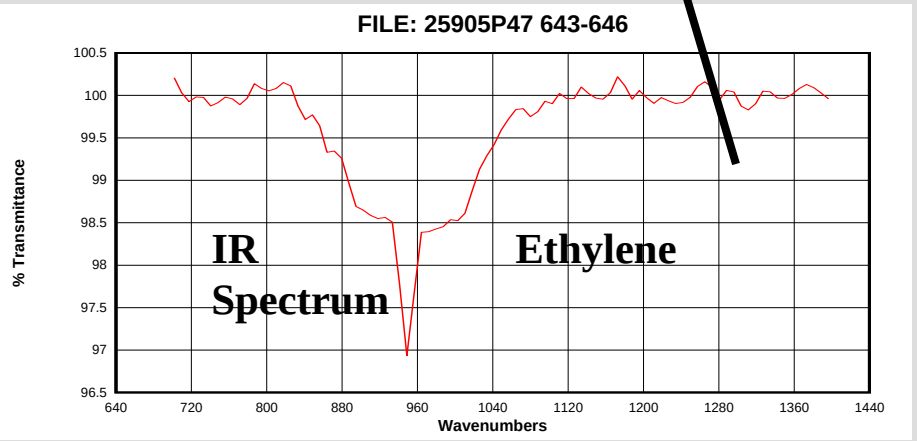
Release Point

IR Image



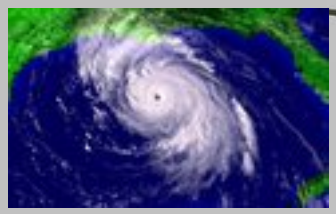


9/25 ASPECT Flight Passes Over Targets



Hurricanes Gustav & Ike September 2008 ASPECT Rapid Needs Assessment (RNA) and Petro-Chemical and infrastructure assessment missions

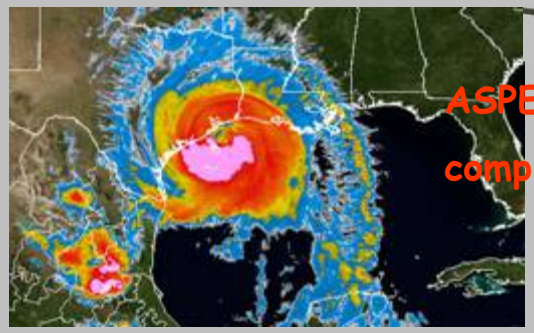
Hurricane Gustav



ASPECT collects RNA data for 4 consecutive days. Assigned missions complete Sept.5 2008

Sep 1 Sep 2 Sep 3 Sep 4 Sep 5

Hurricane Ike



ASPECT collects RNA data for 7 consecutive days. Assigned missions complete Sept.19 2008

Sep 13 Sep 14 Sep 15 Sep 15 Sep 17 Sep 18 Sep 19

- The ASPECT Aircraft and team were the first reconnaissance aircraft on-scene in support of EPA & FEMA Region 6, DHS/IP and DHS-NRCC
- Provided RNA, chemical assessment, air quality, pollution, and infrastructure situational awareness information on over 800 assigned targets
- ASPECT Pioneered SAT tool was praised for its ability to provide geo-spatially relevant information directly to first responders and local-state-federal joint operation centers

Evolution of Airborne Water Quality Assessment (WQA)

First in the published literature

R. Kroutil, P. Lewis, M. Thomas, D. Miller, S. Shen, T. Curry

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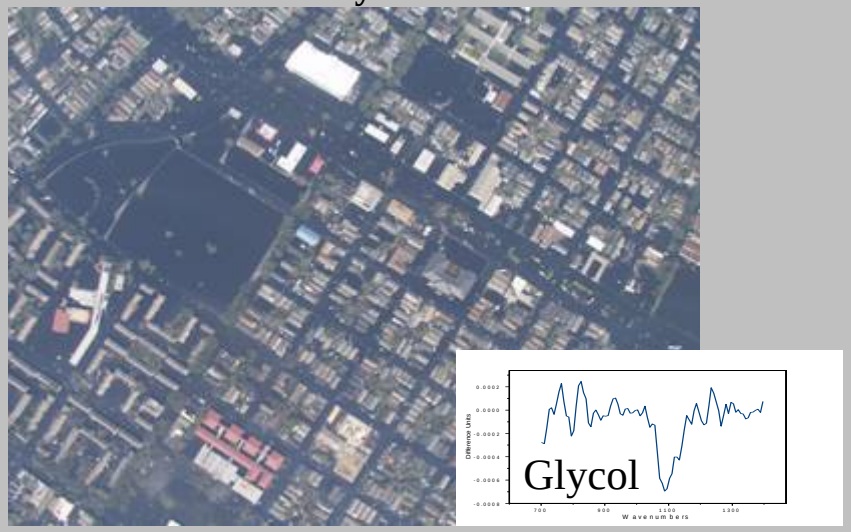
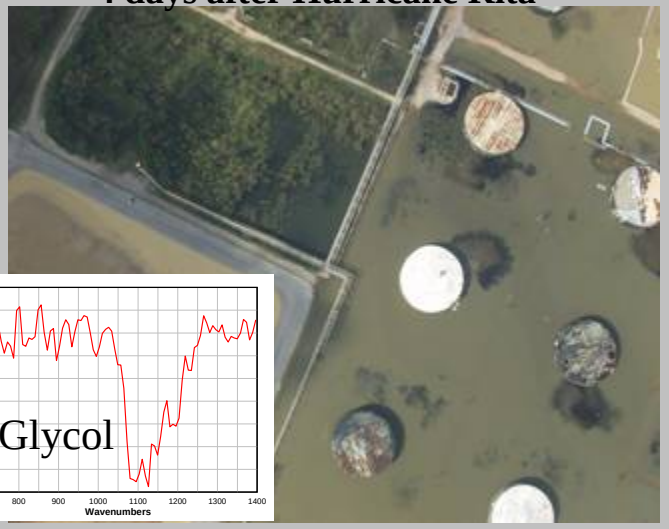
Evolution of Airborne Water Quality Assessment - First in the published literature

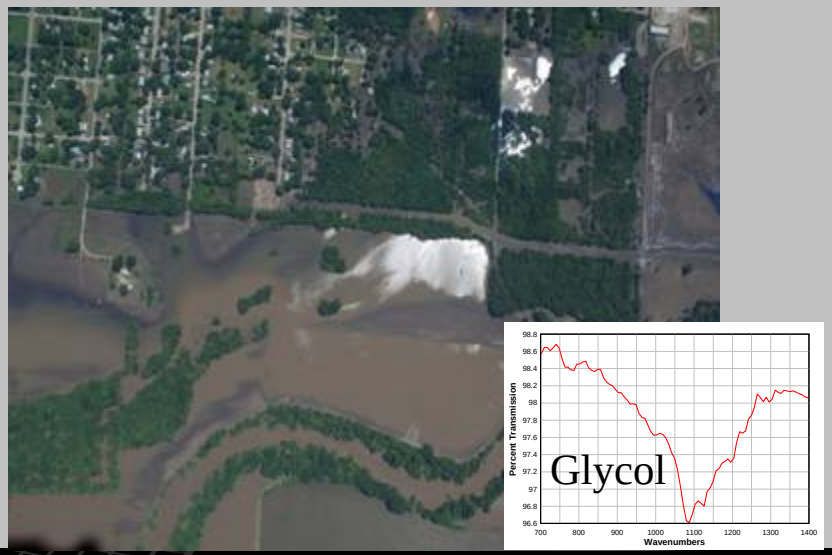
New Orleans Areas Under Water –
6 days after Hurricane Katrina



Near Beaumont, Texas
4 days after Hurricane Rita

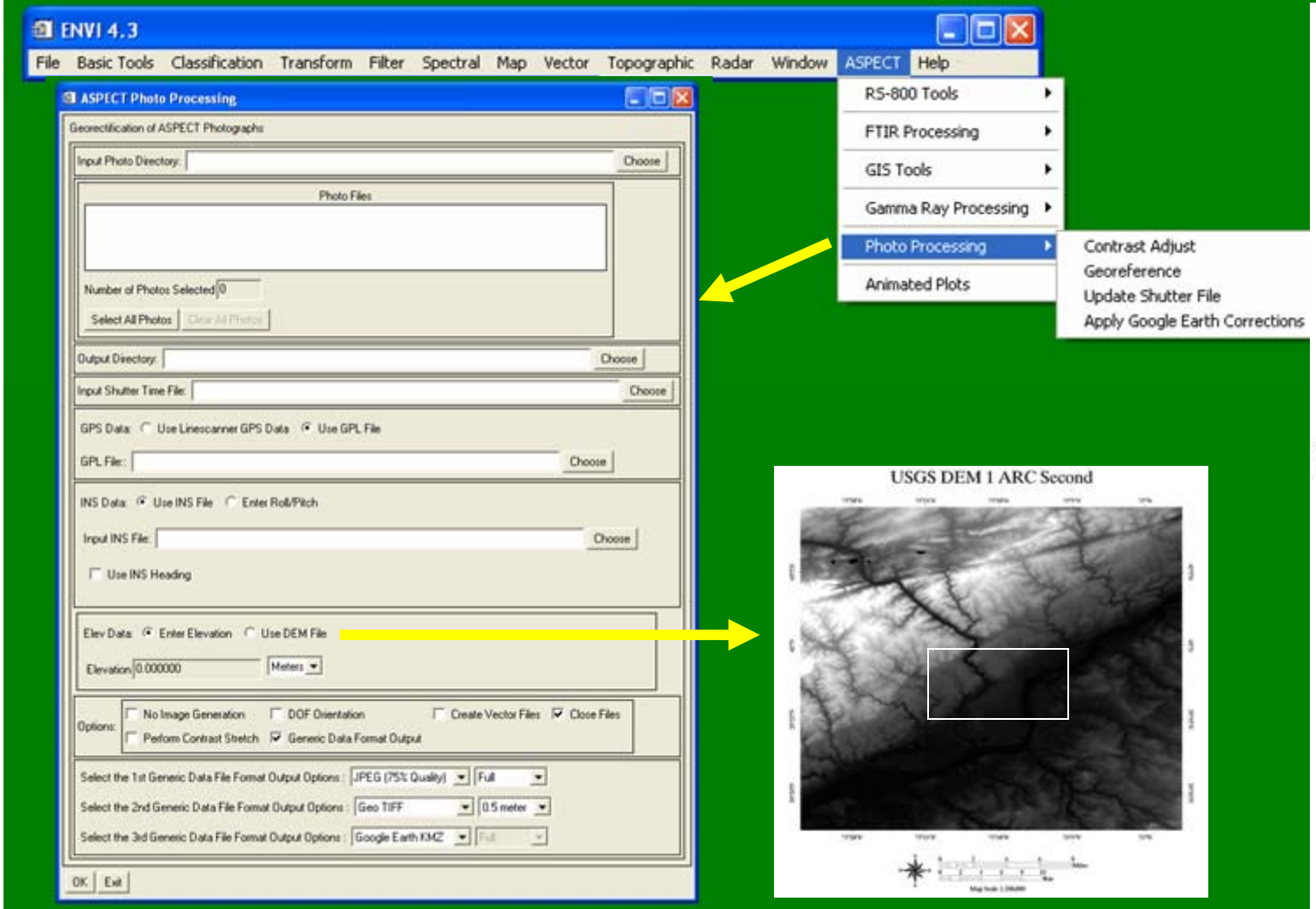


Coffeyville,Kansas Flooding – July 2007
4 days after flooding started



- The FTIR spectrum is a close match to either propylene glycol, 2,3-butylene glycol, or ethylene glycol
- Propylene glycol and 2,3-butylene glycol have extensive documentation as fermentation products in the open scientific literature.
- The glycol spectra are only seen above standing water after 4 to 5 days with associated high temperatures.
- Future investigations will focus on whether the glycol spectral signature is an indicator of high biological activity in flood waters.
- **These measurements may have utility for health resource deployment after large floods or hurricane events.**

ASPECT DATA Processing Tools



Rapid Response Map

ASPECT Pioneered Situational Awareness Tool (SAT)

ASPECT Program Status & Challenges

- Current ASPECT aircraft and sensor suite
  - Aircraft operational
    - crew trained and on call 24/7
  - Sensor suite operational
    - Sensors being maintained
    - Automated data analysis and dissemination software being maintained and evolved through current CDS R&D program
- Homeland security and disaster response demands warrant second operational aircraft and sensor suite
  - Current aircraft 40 years old
    - Newer aircraft required to cut operational maintenance costs
    - Train second operational crew
- Upgrade and evolve sensor suite (two operational units with backup)
  - Chemical Identification -- FTS electronics upgrade nearly complete
    - FTS focal plane replacement optical and engineering studies complete
      - Acquire, integrate and test new linear focal plane systems
  - Chemical Mapping – RS-800 optical and engineering studies nearly complete
    - Next generation – RS-800 chemical mapping system acquisition
- Organizational responsibilities, MOU's and cost sharing