Aerial Radiological Search Operations

Outline

Aerial Measuring System

Spectral Advanced Radiological Computer System (SPARCS)

**Case Study:
U.S. Aerial Measuring System Response to the Fukushima Accident**

Aerial Measuring System (AMS)

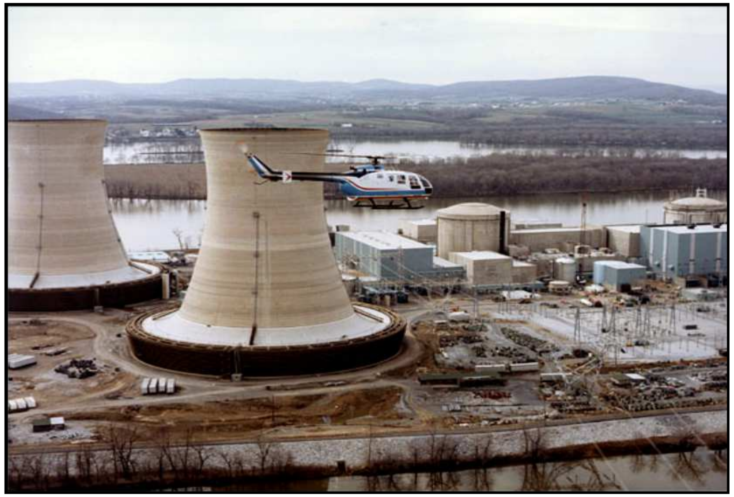
An Aerial Measuring System (AMS) is a capability for emergency response to search, locate, identify, quantify and map radiological incidents and accidents.

For large scale incidents or accidents, the AMS can provide rapid assessment of ground contamination and aid in developing protective action recommendations for the public.

AMS is a critical capability for rapidly locating radiation sources or dispersed radiation contamination, but equally as important, for confirming the absence of radiation.

AMS Missions

- Emergency Response
  - Lost or Stolen Radiation Source
  - Radiation Dispersal Incident
  - Nuclear Power Plant Accident
- Baseline Surveys
  - Nuclear Facilities
  - Major Public Events
  - City Surveys
- Environmental Monitoring
  - Nuclear Facilities
  - Contaminated Site Restoration



AMS Aircraft

Incidence Response

Airplane or Helicopter

- Rapid response
- Altitude 1000-2000 ft (~300-600 m)
- Line spacing 2000-4000 ft (~600-1200 m)
- Speed 70-140 kts (~50-95 km/h)
- 3-6 hour flight time
- Large area survey, low resolution
- Lower sensitivity (1 large detector)

Consequence Management

Helicopter

- Deliberate response
- Altitude 150-300 ft (~45-90 m)
- Line spacing 300-500 ft (~90-150 m)
- Speed 70 kts (~50 km/h)
- 3 hour flight time
- Detailed survey, high resolution
- High-sensitivity (multiple large detectors)

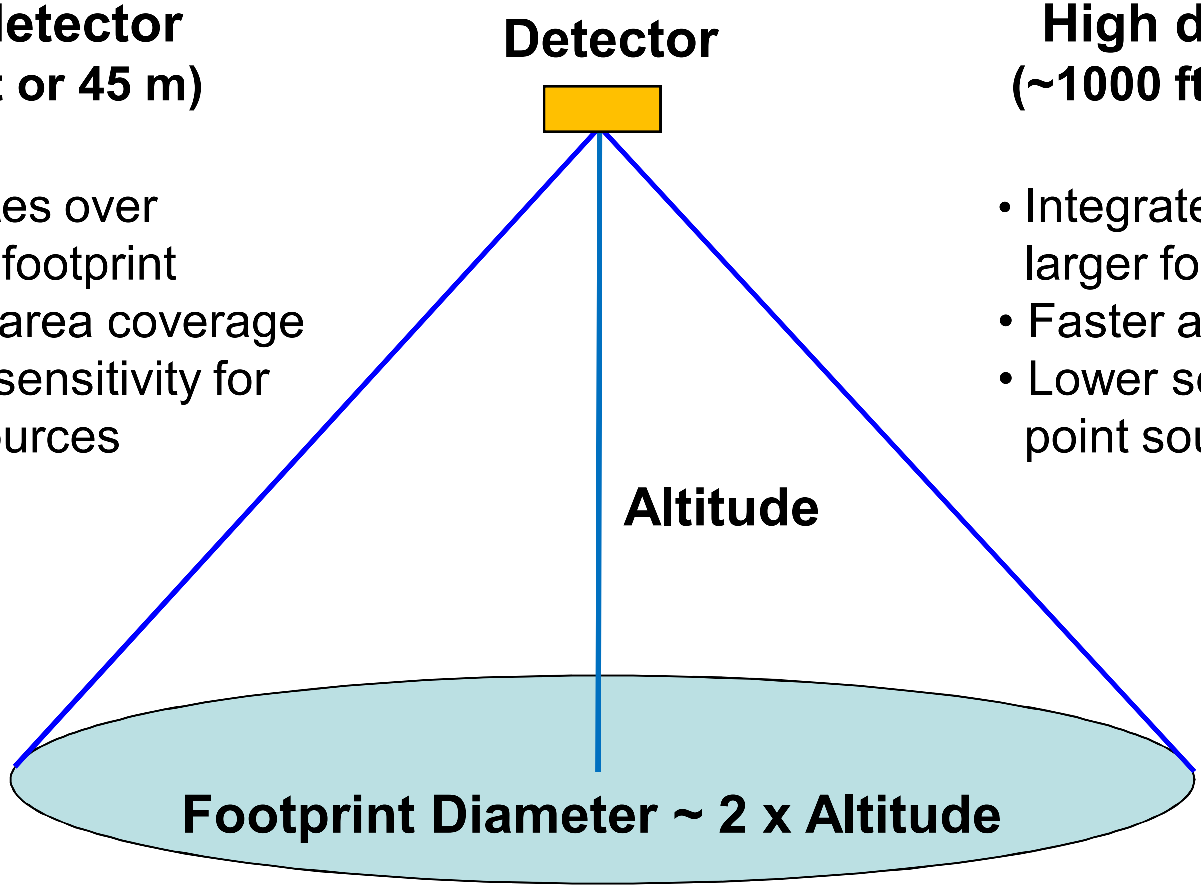
Aircraft Altitude Considerations

Low detector (~150 ft or 45 m)

- Integrates over smaller footprint
- Slower area coverage
- Higher sensitivity for point sources

High detector (~1000 ft or 300 m)

- Integrates over larger footprint
- Faster area coverage
- Lower sensitivity for point sources



Detection Sensitivity

To determine if an aerial search is applicable, one must first calculate the Minimum Detectable Activity (MDA)

$$\text{Detection sensitivity} \sim \frac{C \times S \times B \times A \times E \times e^{-(\mu \times \rho \times D)}}{4\pi \times D^2}$$

where:

C	1 disintegration/second/Bq
S	radiation source activity (Bq)
B	gamma-ray decay branching ratio
A	detector geometric cross section (cm^2)
E	detector total intrinsic efficiency
D	aircraft altitude (cm)
μ	air mass attenuation coefficient (cm^2/g)
ρ	air density (g/cm^3)

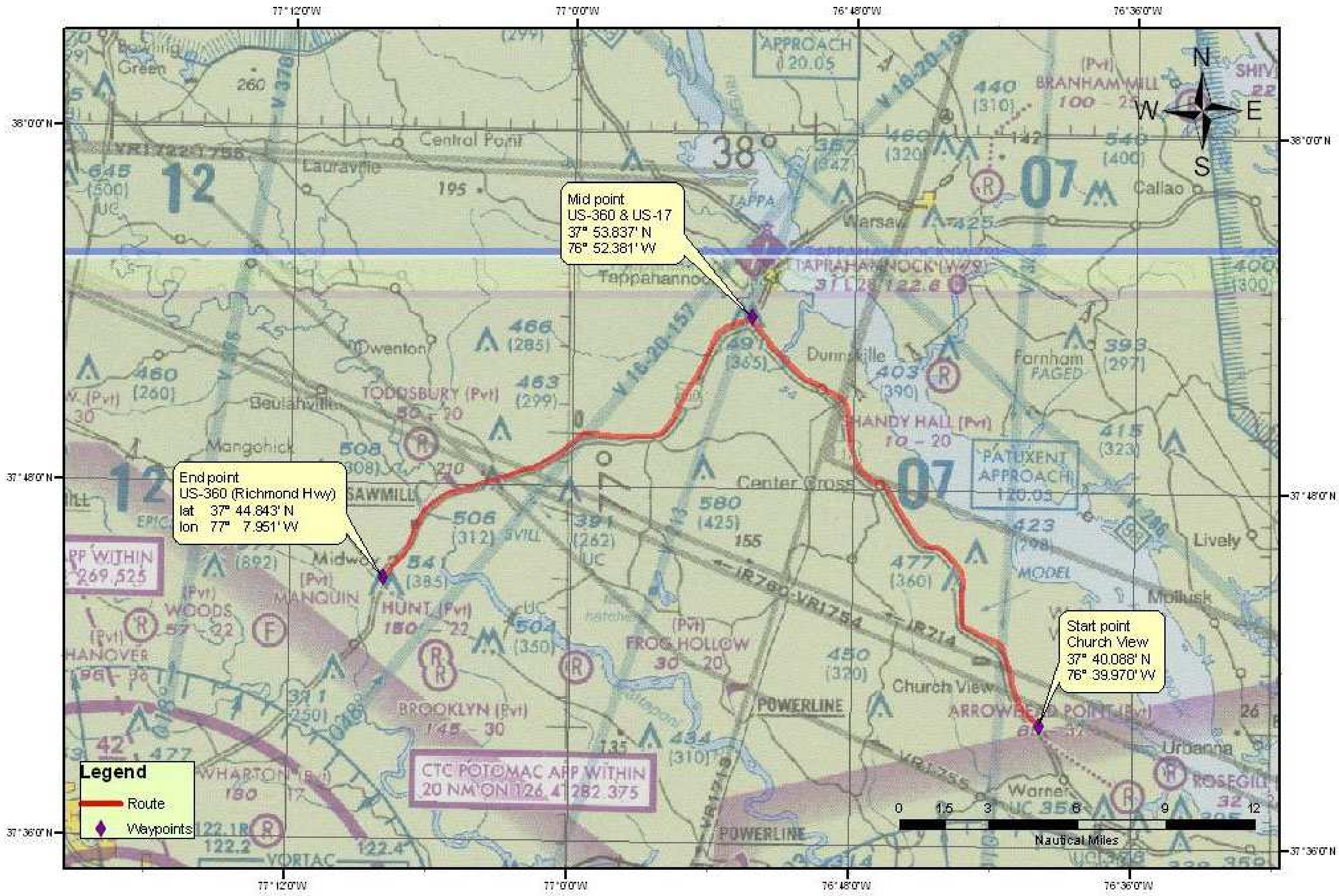
Increase detection sensitivity by increasing detector size and reducing the aircraft speed and altitude

Aerial Radiological Search for a Lost or Stolen Radiation Source

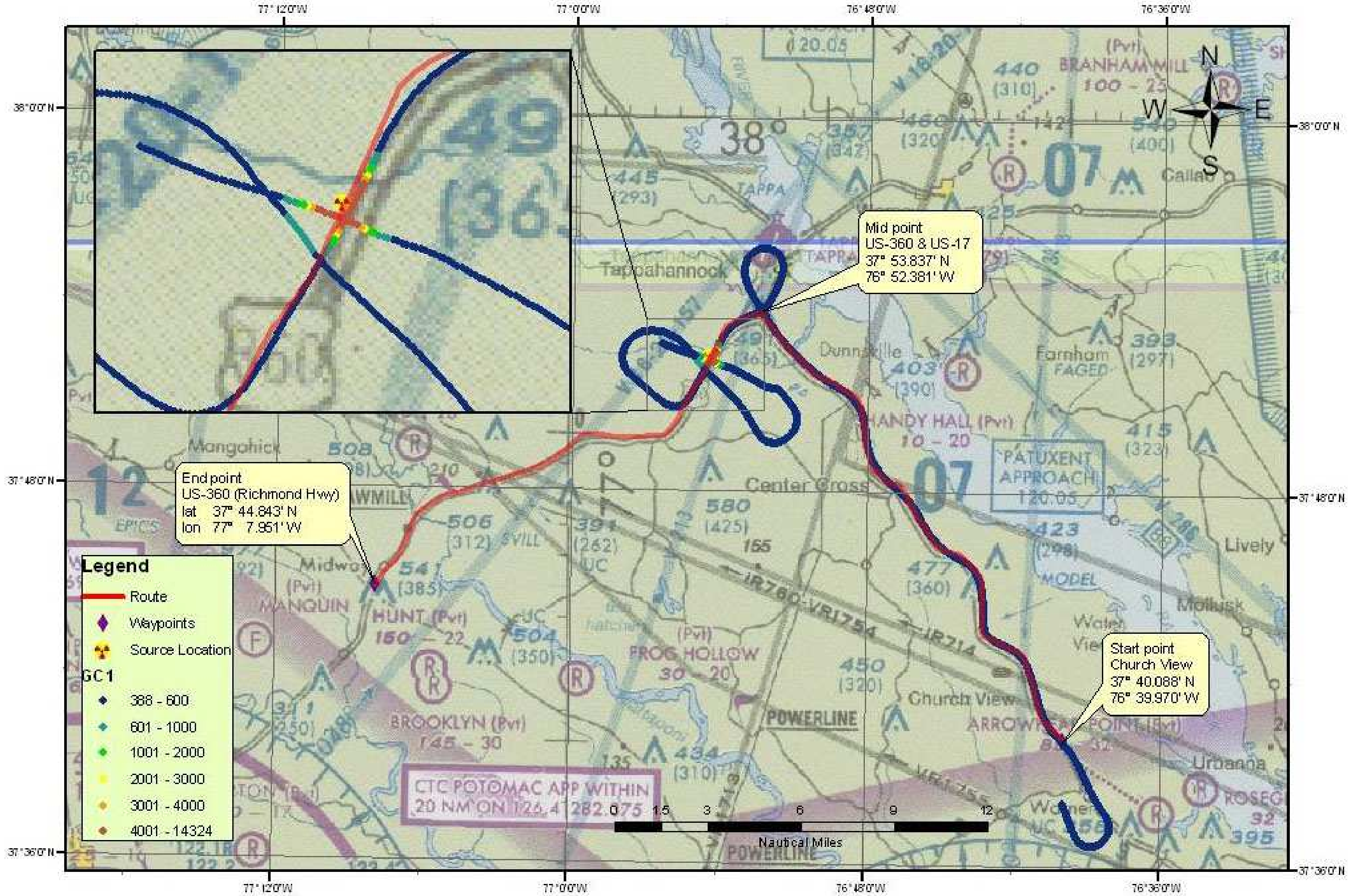
Lost Source – Road Search

- Obtain best estimates of lost or stolen source radioisotope and activity
- Determine the optimal altitude and speed to maximize detection probability
- Assume source may be shielded
- Determine GPS coordinates for start point and endpoint
- Develop the flight plan and brief team
- Monitor detector count rate and inform pilot of any radiation hotspots
- Perform bow-ties over hotspots to localize position
- Radio GPS position of hotspots to ground team for response

Lost Source – Road Search



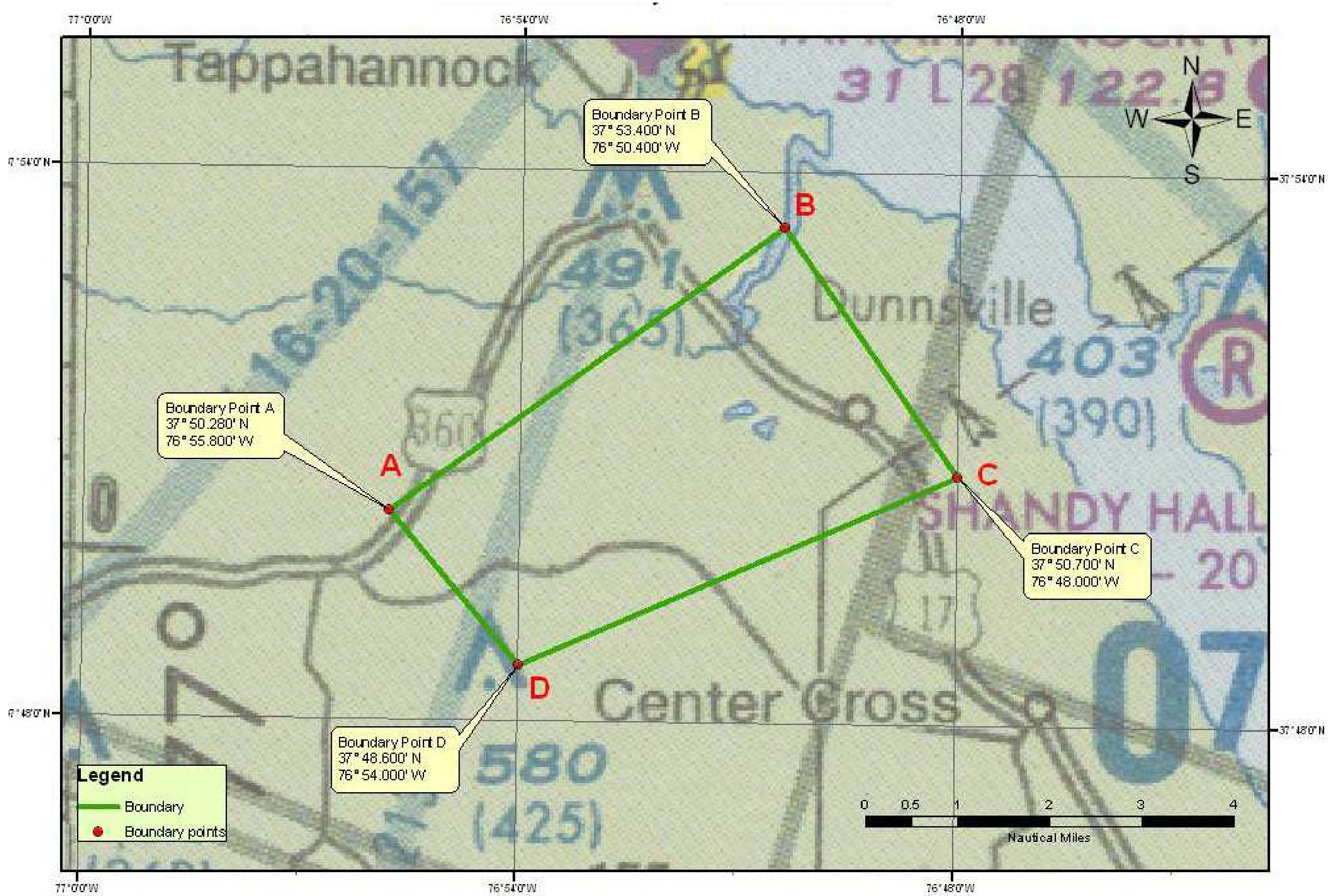
Lost Source – Road Search



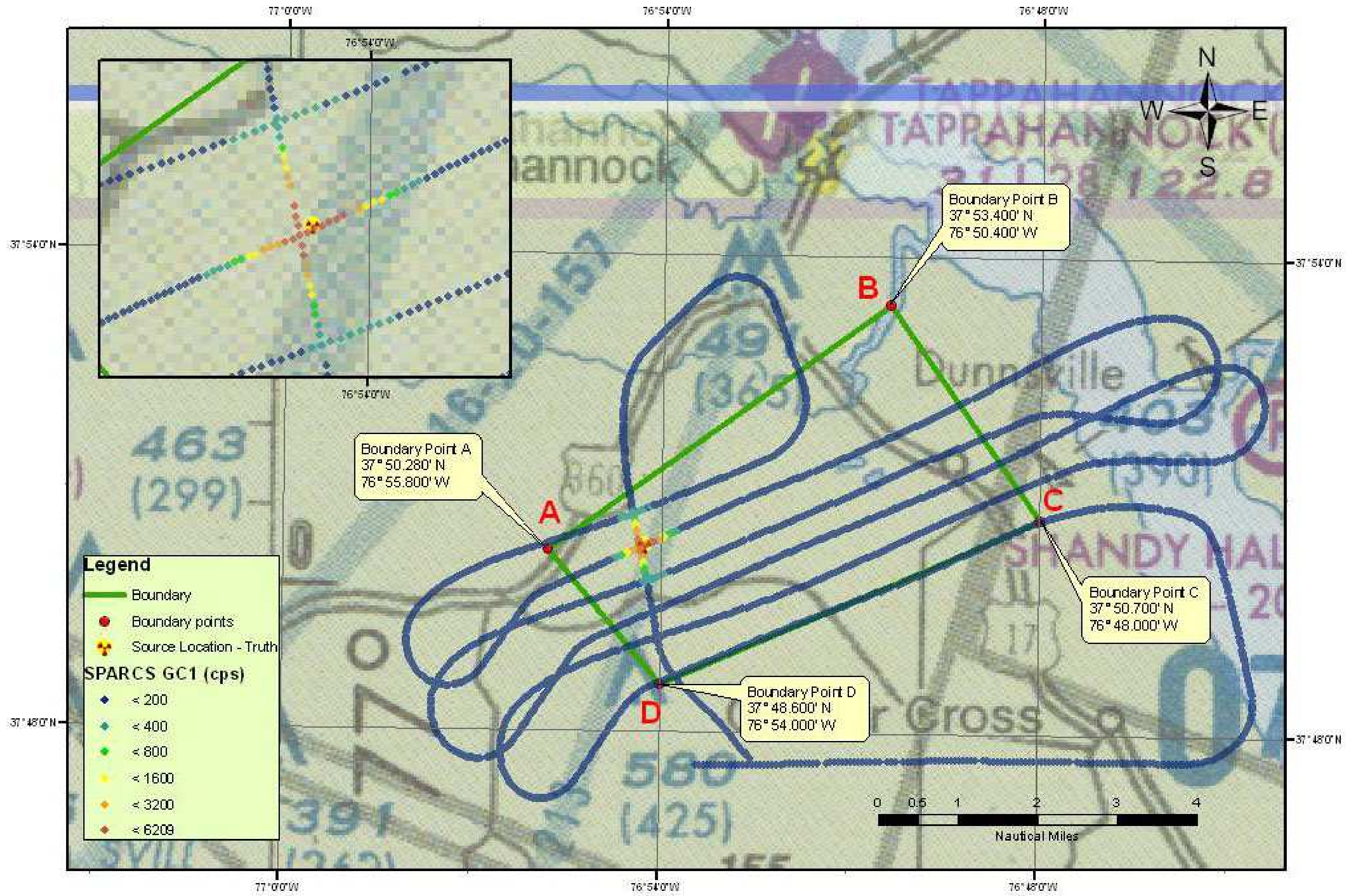
Lost Source – Grid Search

- Obtain best estimates of lost or stolen source radioisotope and activity
- Determine the optimal altitude, speed and parallel line spacing to maximize detection probability
- Assume source may be shielded
- Determine GPS coordinates for search grid area
- Develop the flight plan and brief team
- Monitor detector count rate and inform pilot of any radiation hotspots
- Perform bow-ties over hotspots to localize position
- Radio GPS position of hotspots to ground team for response

Lost Source – Grid Search



Lost Source – Grid Search



Aerial Radiological Mapping of a Dispersed Radioactive Material

Radiation Dispersal Device Incident
Nuclear Power Plant Accident

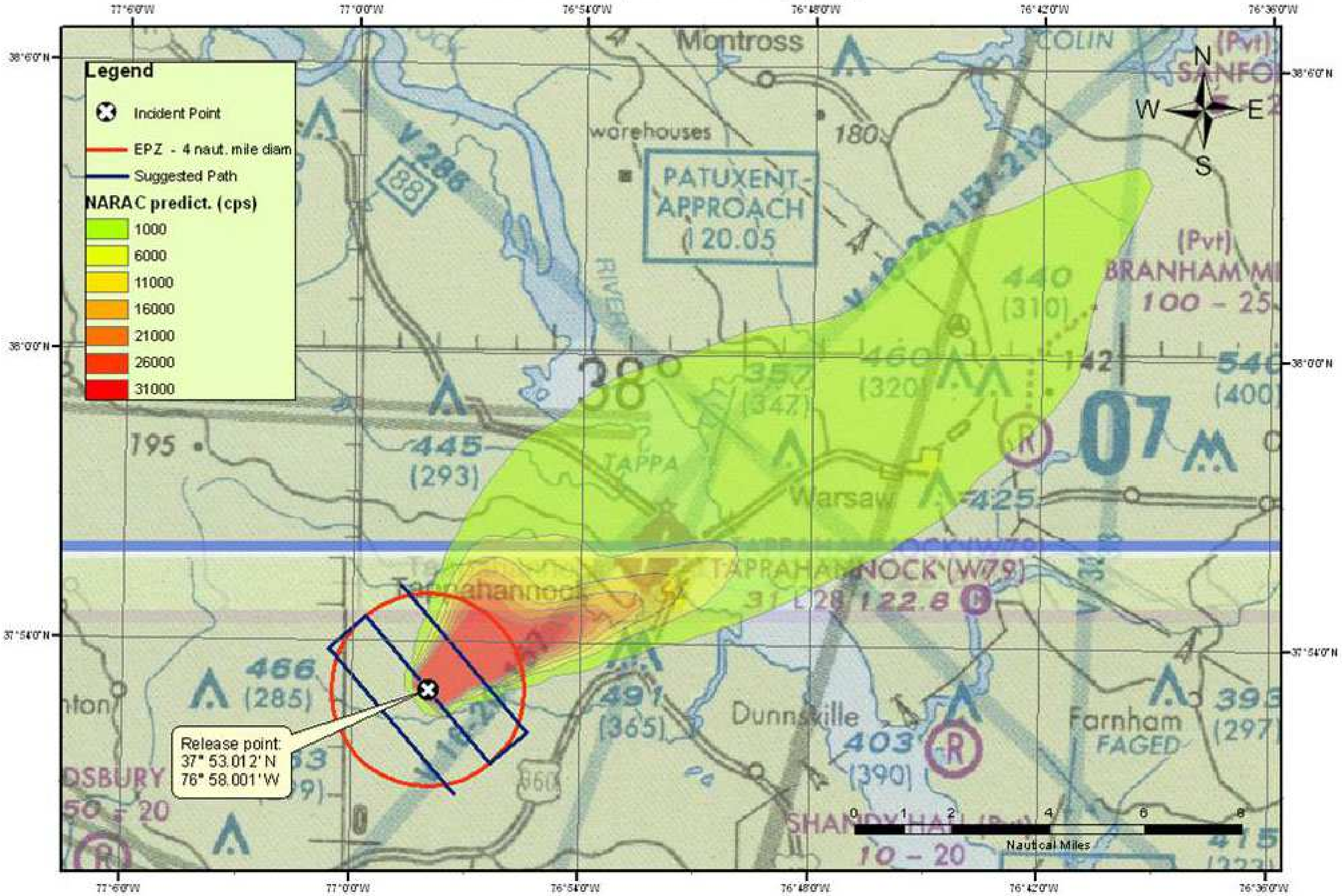
Ground Deposition Survey

- **Based on the source term estimate and plume modeling projection, determine the ground deposition area**
- **Determine altitude, speed and line spacing distance to survey the ground deposition in one flight**

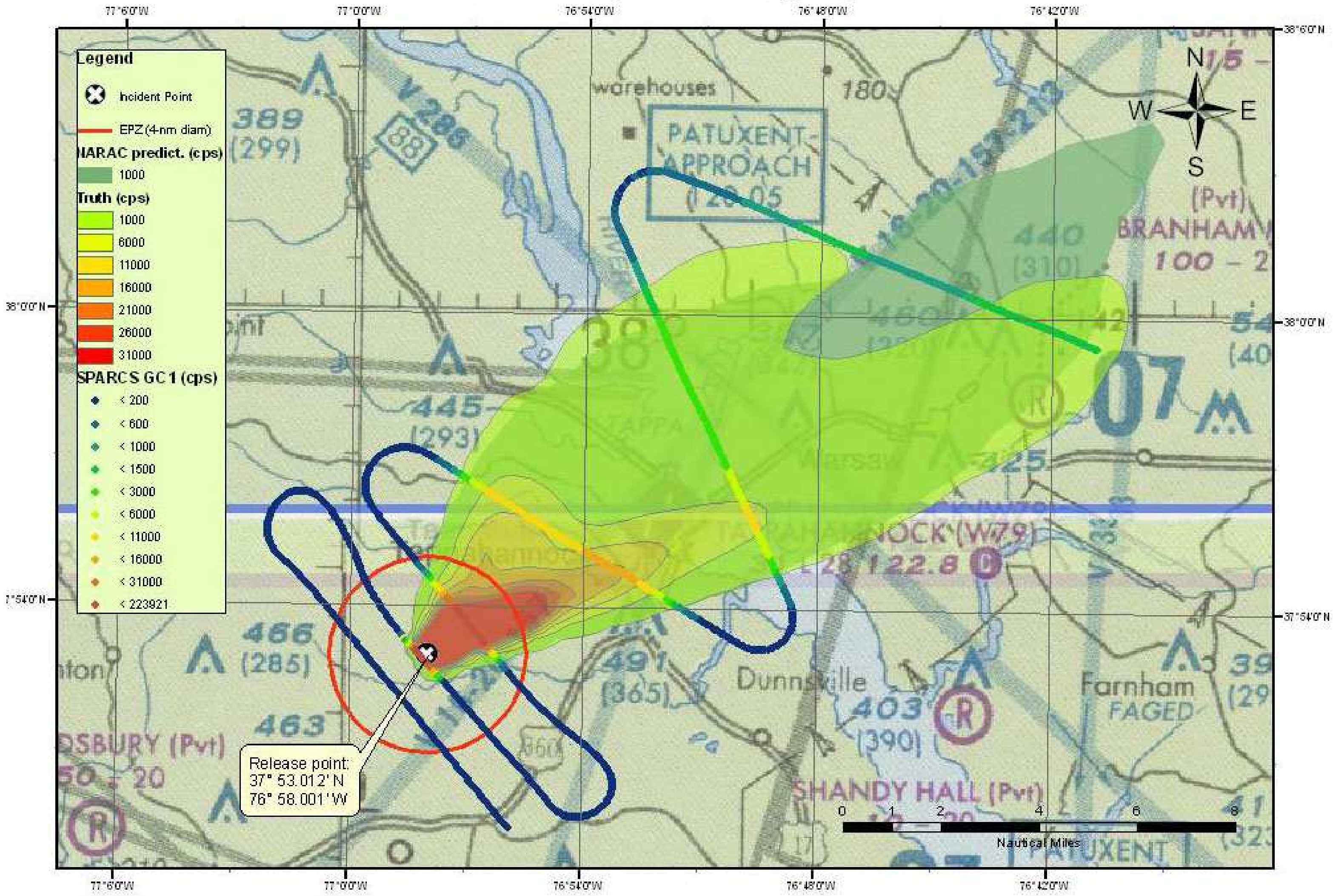
"bound the problem"

- **Determine upwind GPS entry point**
- **Fly parallel or zig-zag lines over the deposition area**
- **Verify that the radioactive material release has stopped**
- **Develop the flight plan and brief team**
- **Monitor detector count rate and inform pilot when entering and exiting deposition regions for turns**

Ground Deposition Survey



Ground Deposition Survey



Reactor Accident Scenario

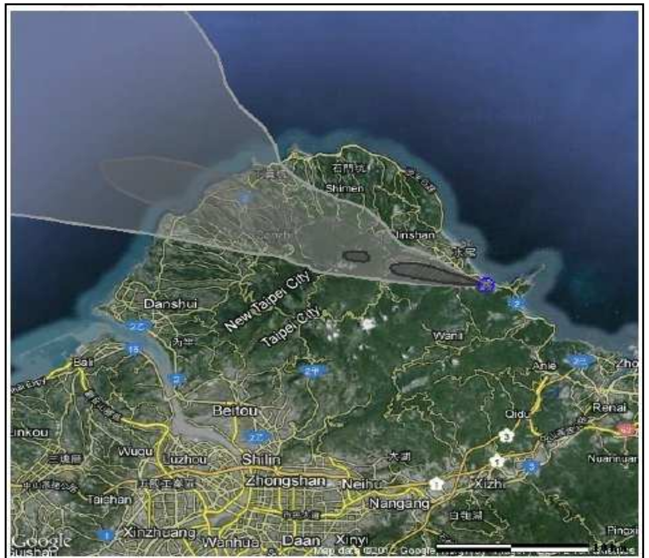
In a Nuclear Power Plant (NPP) accident, large quantities of radioactive material can be released into the atmosphere and deposited downwind from the plant. The radioactive contamination is a health risk to anyone in the path of the plume. The goal of the AMS is to rapidly conduct measurements to determine the area which has been contaminated in order to minimize the public exposure.

Emergency managers will use the AMS data to develop protective action guidance for the general public to include shelter in place and evacuation.

Radioactive Plume Modeling

A plume model prediction is prepared to aid the emergency managers in developing protective action guidance and for planning the aerial and ground monitoring response for consequence management.

An aerial mission will be conducted to rapidly map the ground contamination deposited downwind of the nuclear reactor site ***in an initial single flight***. The goal is to determine the extent (width) of the ground contamination and the center line (trajectory). The IXP plume model predictions will be used to estimate the survey area and optimize the flight parameters.



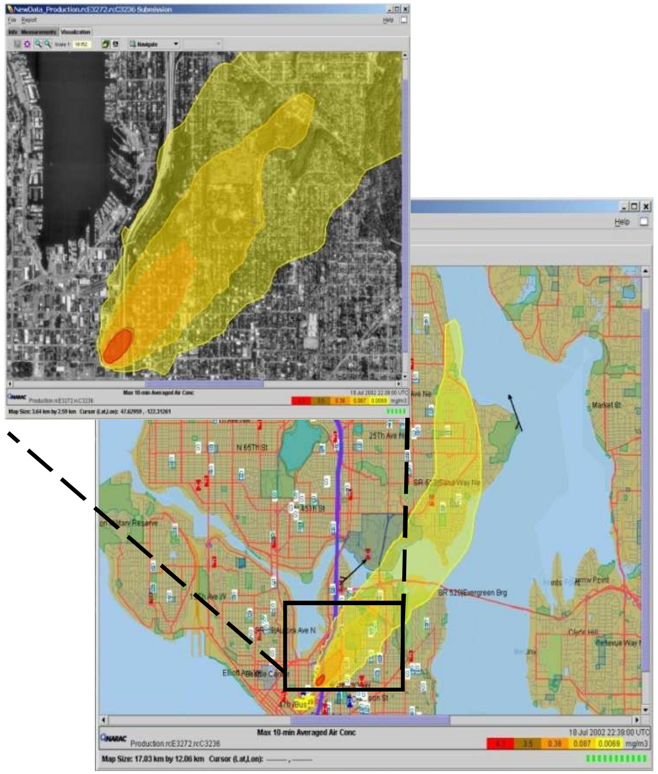
Map Size: 41.5 km by 41.5 km **Id:** IXP.rcE8838.rcC1

(MBq/m2) Extent Area	Population
>0.10 9.7 km 5.8 km2	200
>0.01 27.1 km 67.3 km2	4,620
>0.0010 67.4 km 1,201 km2	11,900

International Exchange Program (IXP)
DOE Reach Back Capability

Real-time computer predictions for atmospheric transport of radioactivity from a nuclear accident or incident

- **Contact**
  - Call DOE 24/7 at +1-202-586-8100
  - Request IXP assistance
  - Or request access via the IAEA
  - Or submit request via IXP web site at https://ixp.llnl.gov, results in 10 minutes
- **Map Products**
  - Exposure rates
  - Plume deposition
  - Ground contamination
  - Protective action recommendations



Aerial Planning – Initial Flight

Modeling predicted survey area

6-12 miles (10-20 km) wide
15 miles (24 km) downwind
15 lines, 1 mile (1.6 km) spacing
Line length 8 miles (13 km)
120 miles (190 km) of lines
14 turns at 1 minute/turn
Time: 90 minutes

Aircraft altitude

1000 feet (300 m) AGL

Aircraft speed

100 miles/hour (90 knots)

Water line

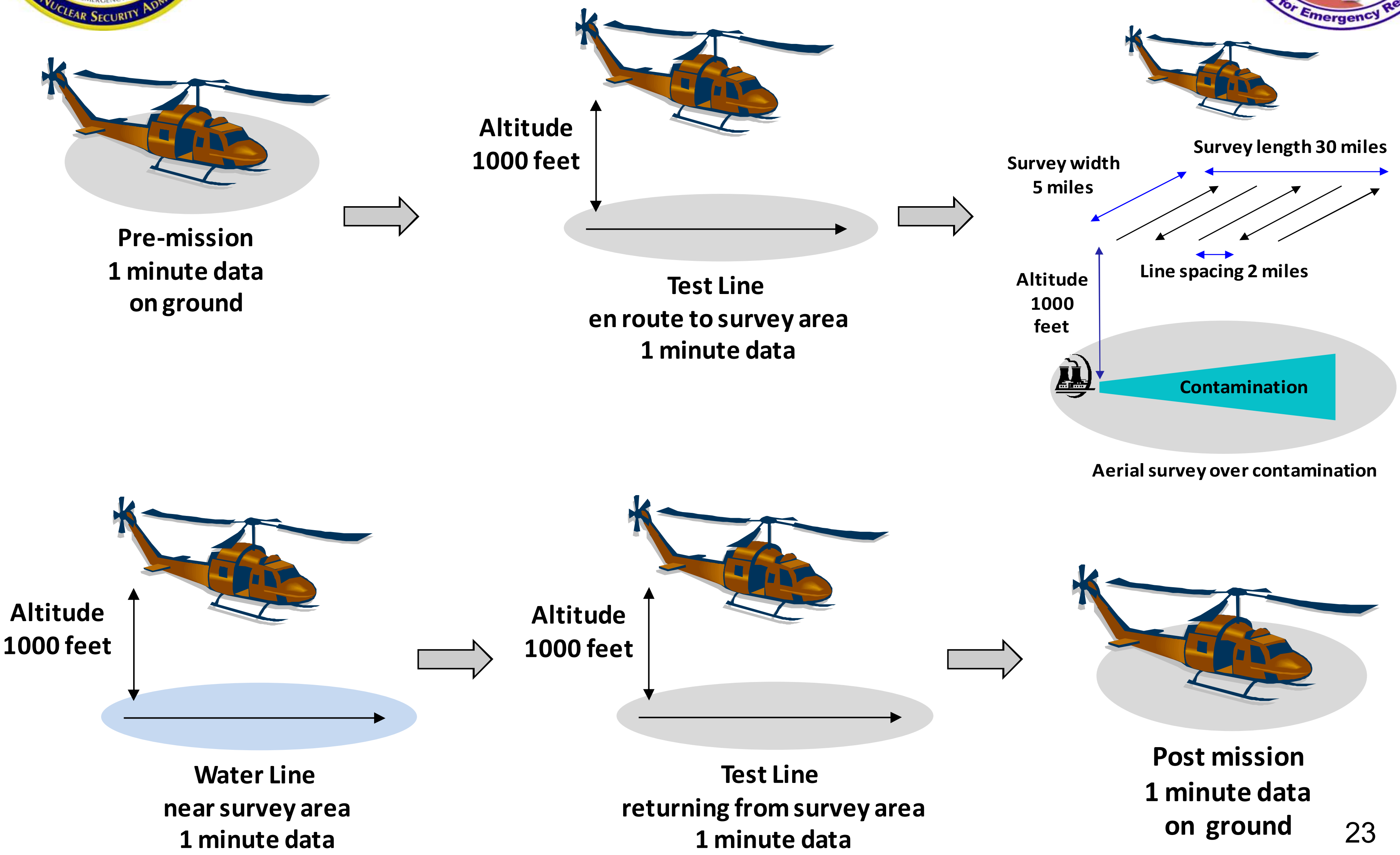
Time: 30 minutes

Roundtrip transit from airport to survey site
Time: 60 minutes
(15 minutes in/45 out)

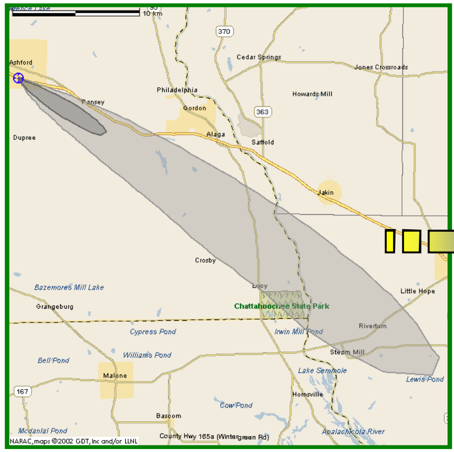
Total flight time

Time: 180 minutes (3 hours)

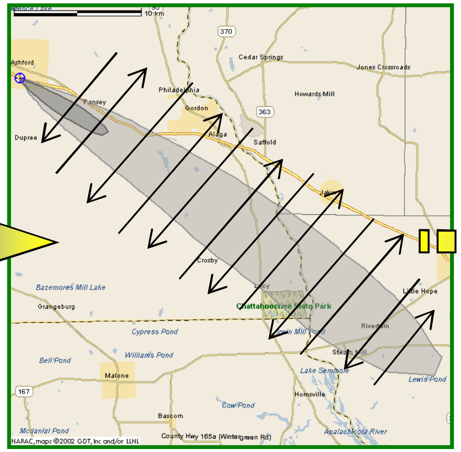
Aerial Flight Profile for a NPP Accident



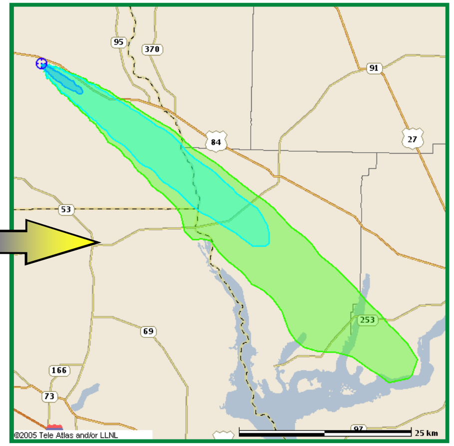
Ground Deposition Characterization Process



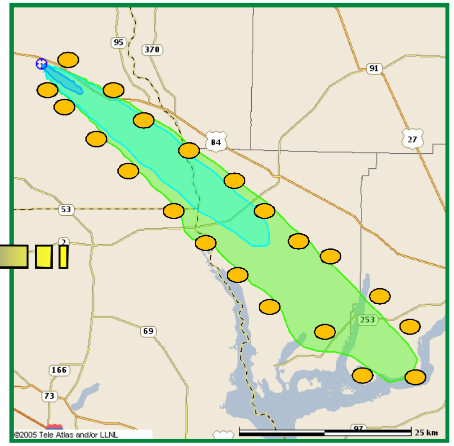
Smoke plot generated showing wind direction



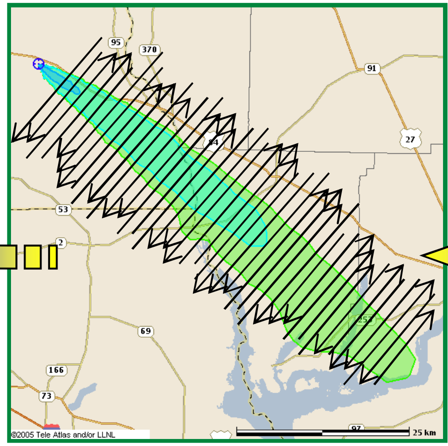
Airplane data used to bound ground deposition



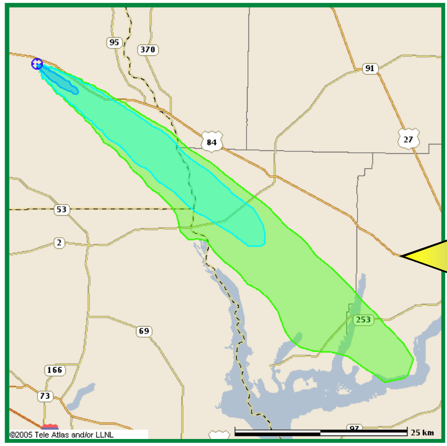
Plume model normalized to initial aerial data



Ground measurements refine local deposition



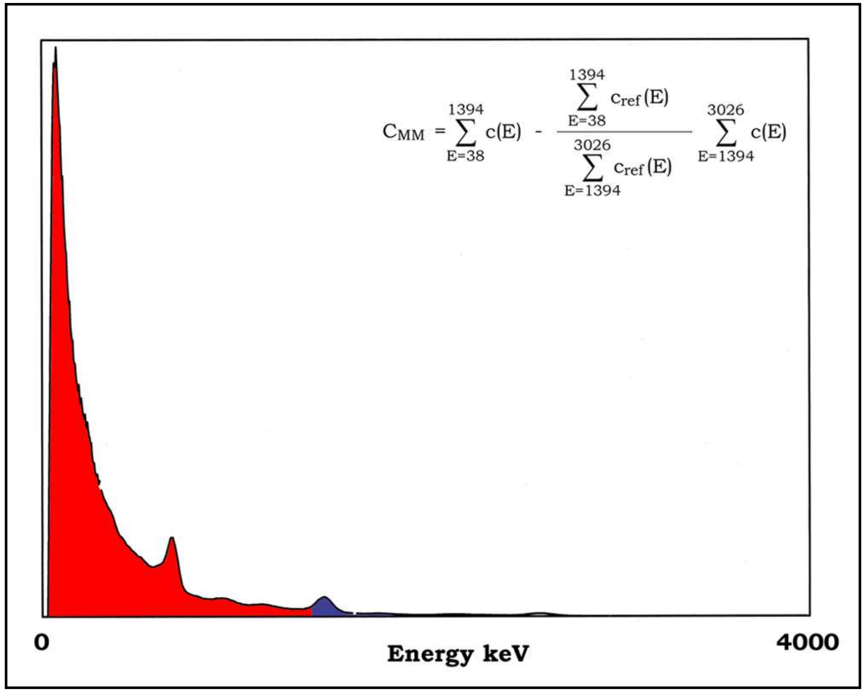
Helo data provides high resolution ground deposition



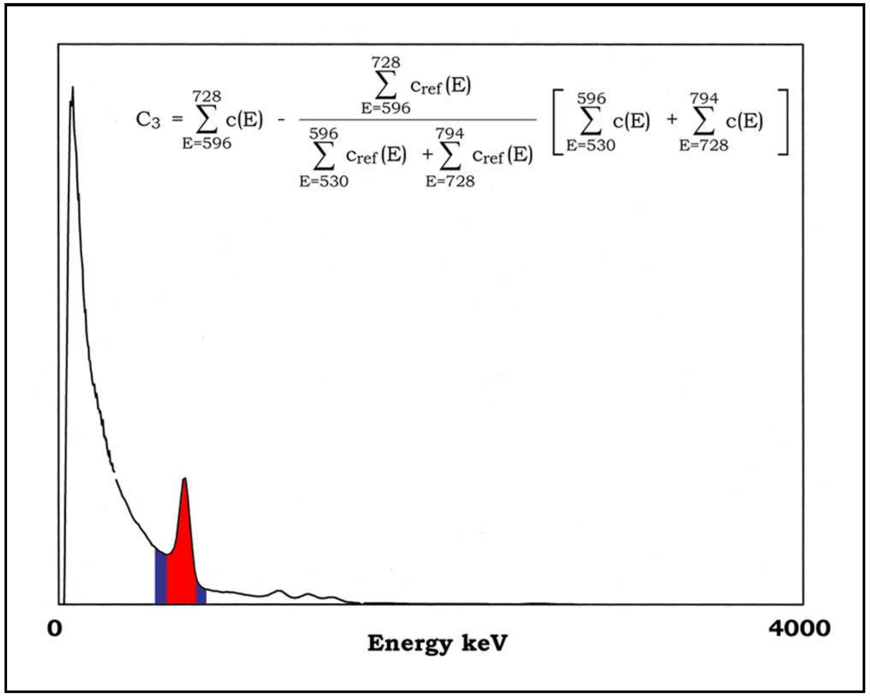
Long term characterization of ground deposition

Data Analysis

The gamma-ray spectral window stripping process can be used to extract radioisotope information from aerial data



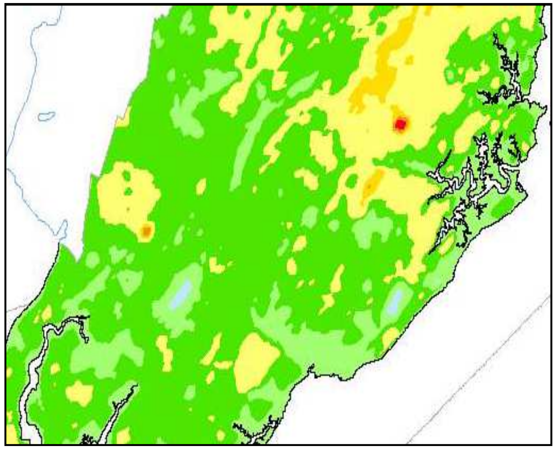
Man-Made Gross Count



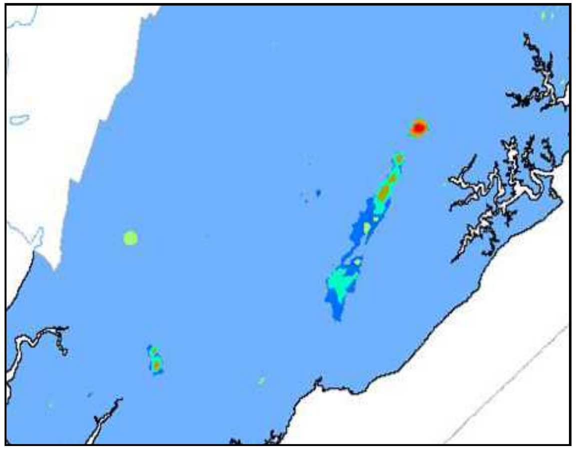
Photopeak Net Count

AMS Survey Data Products

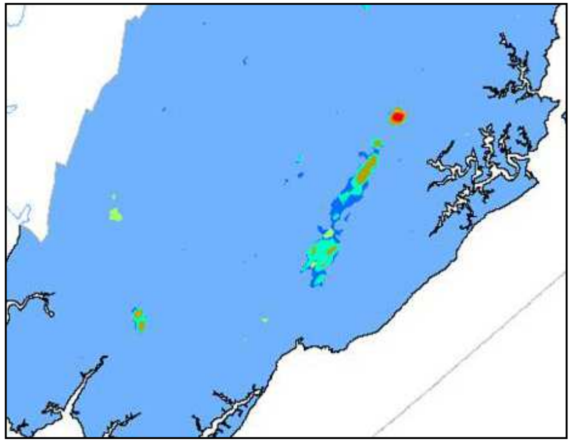
Detailed high resolution radiation contour plots can be obtained in the post-processing of aerial radiological data



Gamma Gross Count
40-3000 keV



Man-Made Gross Count
Ratio high E to low E



Isotope Net Count
Photopeak only

Spectral Advanced Radiological Computer System (SPARCS) for Aerial Radiological Response

What is SPARCS?

SPARCS is a radiological data acquisition and analysis system designed for the nuclear or radiological emergency response mission. It has been used by DOE for over 20 years.

- Modular system that records the gamma radiation levels, spectral data and GPS coordinates

- Operator display with key data and position tracking on a map

- Portable, relatively light, and durable enough that it can be readily mounted in almost any vehicle, boat or aircraft

- Wide array of applications to include search, portal monitoring, pre-event baseline surveys, aerial measurements and emergency response

- Easy to install and operate

Multi-Platform Compatible

SPARCS Basic Components

Laptop Display (rugged notebook computer)

Acquisition and Telemetry Unit (ATU)

Detector Pod

SPARCS Detector Pod

Detector Pod:

- Gamma-ray Detectors
  - Sodium iodide
- Support Electronics:
  - HV power supplies
  - Preamplifiers
  - Multi-channel analyzers
- Size:
  - 16.5”W x 32.5”D x 10”H
  - (42 cm x 82 cm x 25 cm)
- Weight:
  - 68 lbs (31 kg)

Acquisition and Telemetry Unit (ATU)

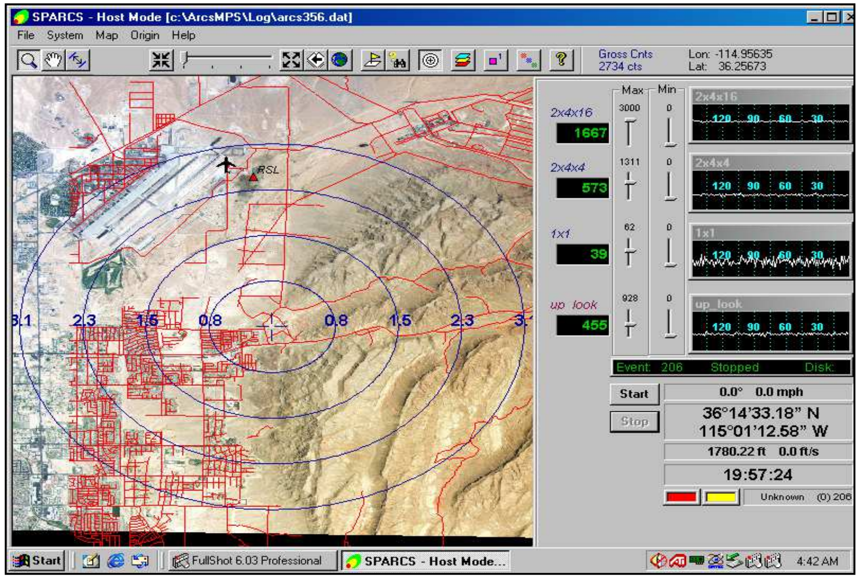
ATU:

- Records detector data
- Records GPS coordinates
- Stores data on Compact Flash card
- Provides data for laptop display
- Provides DC power for detector pod
- Size: 7.3"W x 11.5"D x 6.2"H
  (18 cm x 30 cm x 16 cm)
- Weight: 10.5 lbs (4.8 kg)

Laptop Display

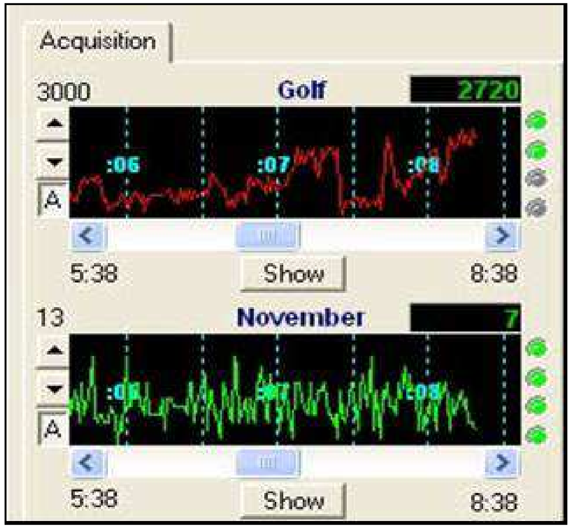
Laptop Display:

- Rugged laptop computer with touch screen
- Acquisition and calibration software
- Displays gross count data with colored points, or “bread crumbs,” on a moving geo-referenced map

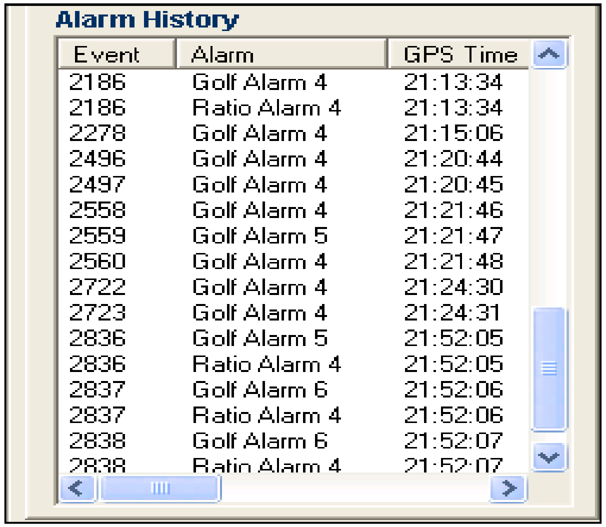


Operator Display Options

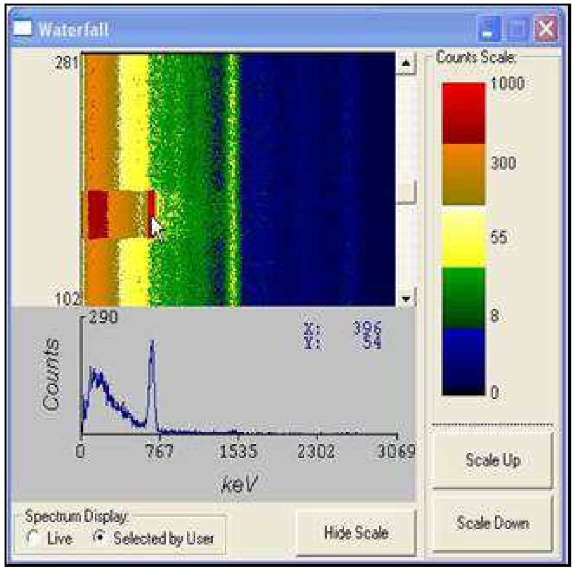
Strip Charts



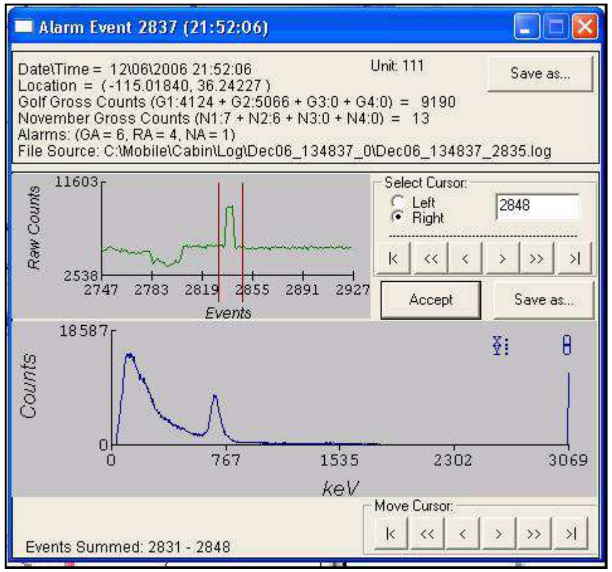
Alarm History



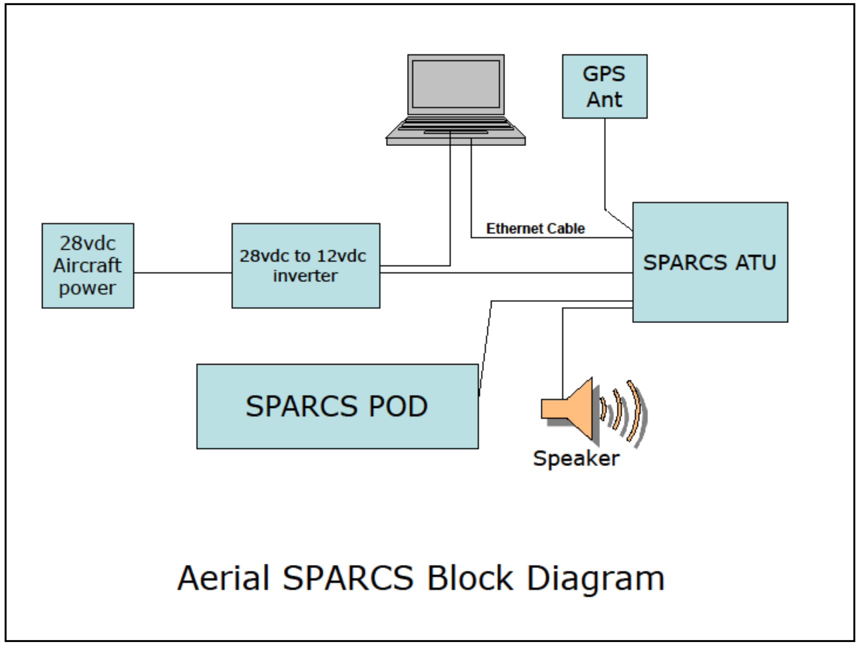
Waterfall Plots

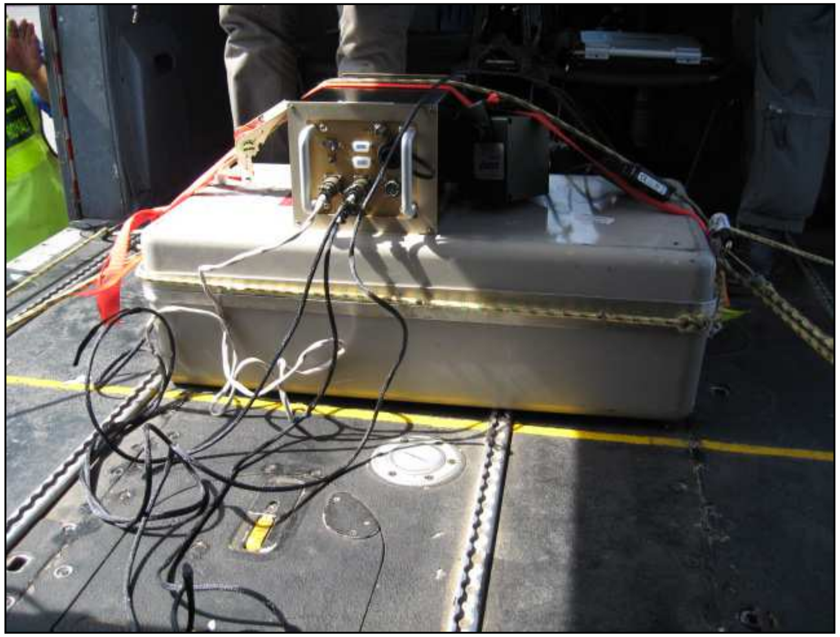


Alarm Events



SPARCS Aircraft Installation



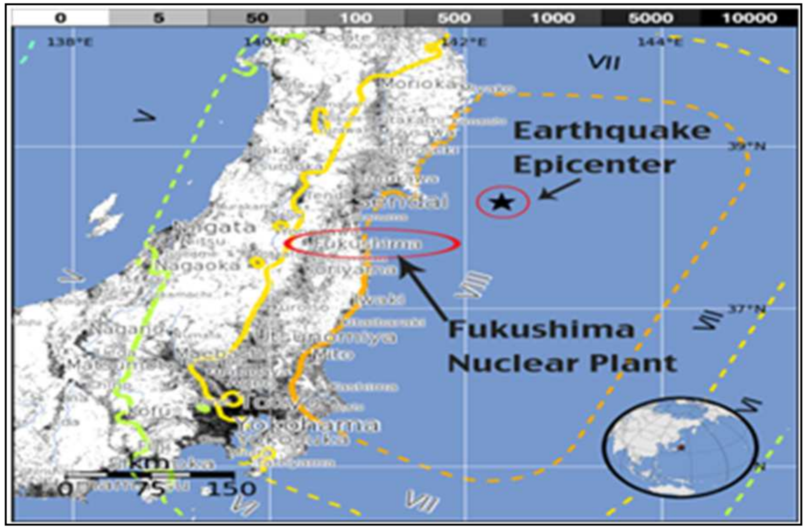


Rapid installation in any aircraft
Compatible with aircraft power (10-40 volt input)
Aircraft certified fiberglass detector pod
GPS magnetic mount antenna placed on dashboard
Monitored by technician with radio contact to pilot

U.S. DOE Aerial Measuring System Response to Fukushima Accident

U.S. DOE Response to Fukushima

On March 11, 2011 at 1446 an 8.9 magnitude earthquake occurred off the coast of Japan which triggered the Fukushima Dai-ichi reactors to scram. Within minutes, the reactor site was flooded by a 14 m tsunami which caused power loss to the reactor cooling systems. Japan established a 20 km mandatory evacuation zone affecting 110,000 residents. Seawater with boric acid was injected into the reactors to cool the cores. Within days, explosions occurred at all three reactors resulting in core breach and the release of radioactivity inland towards the Fukushima Prefecture.



DOE Response Timeline

March 11 DOE activates the Nuclear Incident Team (NIT) at DOE/HQ and the Consequence Management Home Team (CMHT). The NIT initiates deployment orders for a Consequence Management Response Team (CMRT) and AMS.

March 14 CMRT/AMS departs for Japan with 33 personnel and 17,000 lbs (7800 kg) of equipment on a US Air Force C-17 airplane.

March 16 CMRT/AMS arrives Yokota Air Base 0155 JST. Situation upon arrival includes radioactivity in the air at Yokota and the news reporting continued reactor releases. First AMS flight at 0805 JST over Yokota detects no ground deposition and near background dose rates.

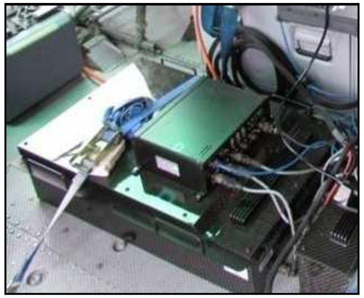
March 17 First AMS flights to conduct surveys over the Fukushima Prefecture exclusion zone

March 22 First AMS data from both helicopter and airplane flights published on DOE website

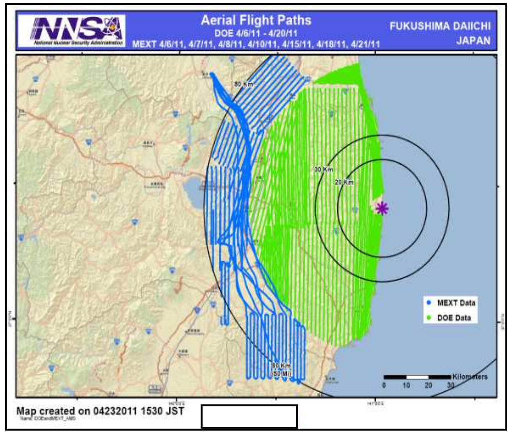
The DOE Team remained in Japan until May 28 working with Japan and providing daily multiple aircraft AMS surveys and supporting ground monitoring. The data was used to provide emergency and intermediate phase protective action guidance to protect the public.

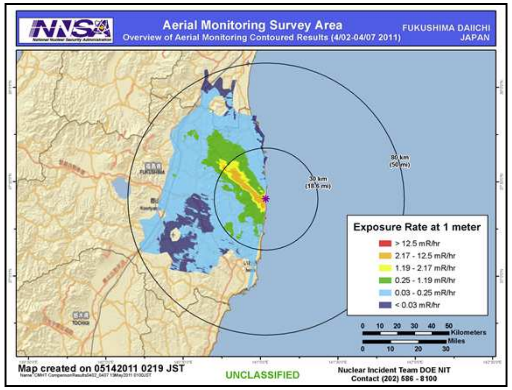
AMS Operations in Japan

Multiple Aircraft



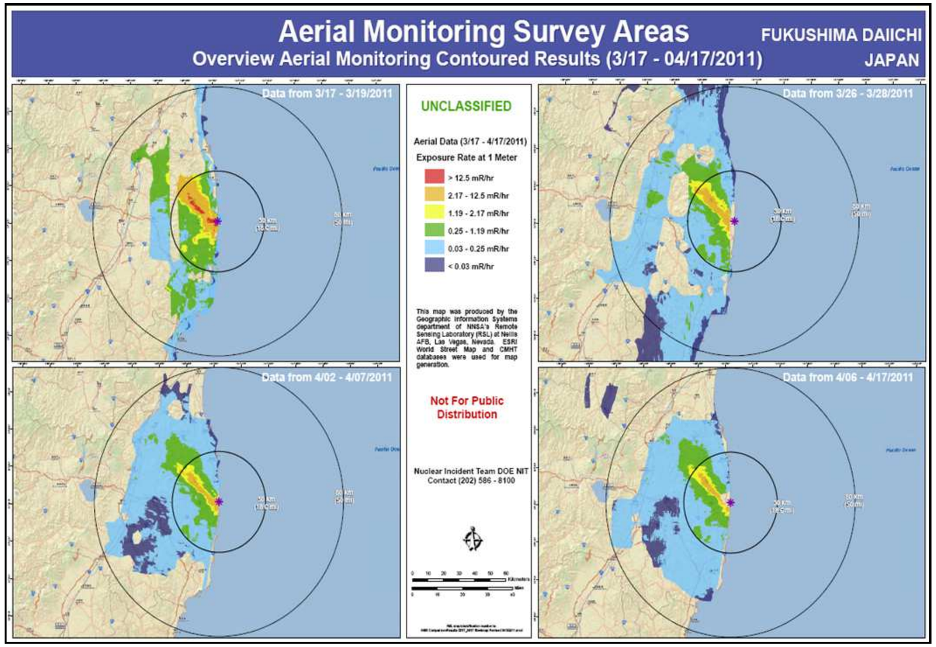
Detection Systems



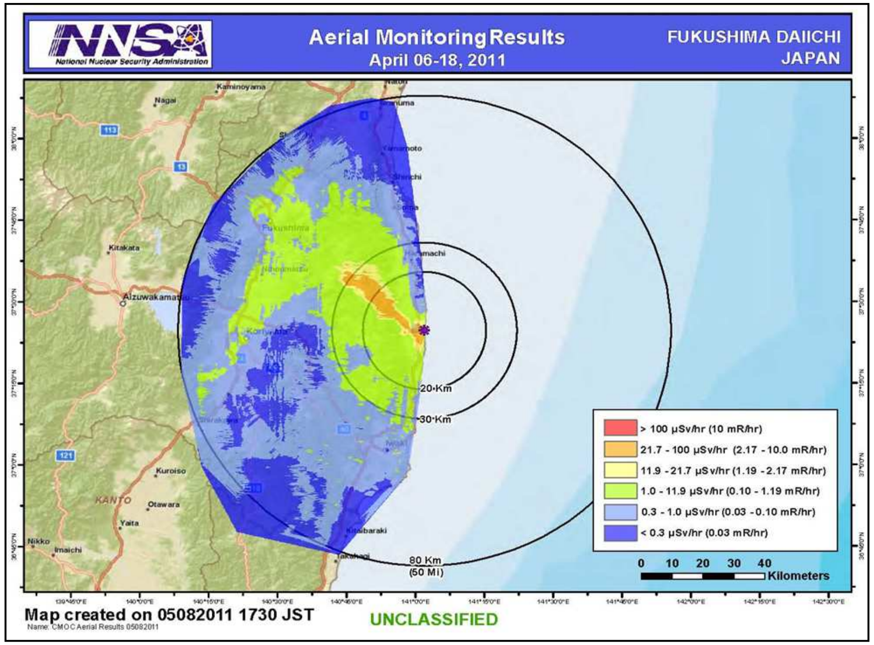


Integrated Data Products

AMS Monitoring Results



March 17 to April 17



April 6-18

From March 16 - May 28, DOE conducted over 100 AMS flights and 525 flight hours over an area of 25,000 km^2 out to 80 km from Fukushima

Aerial Radiological Search Operations

Questions?