SAND2015-8405PE

Sandia National Laboratories

Computer Science and Engineering at Sandia Labs

Ross Hansen, R&D Computer Science
Data Analysis and Exploitation

8/7/2015

CS & Engineering Focus Areas

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- Systems Engineering
- Distributed system design
- Data exploitation/mining/fusion algorithms
- Digital signal processing
- Image processing
- User interfaces
- Scientific data visualization
- Numerical analysis
- Service-oriented architectures
- Relational/object/geographic database technologies

Work on a Variety of Projects

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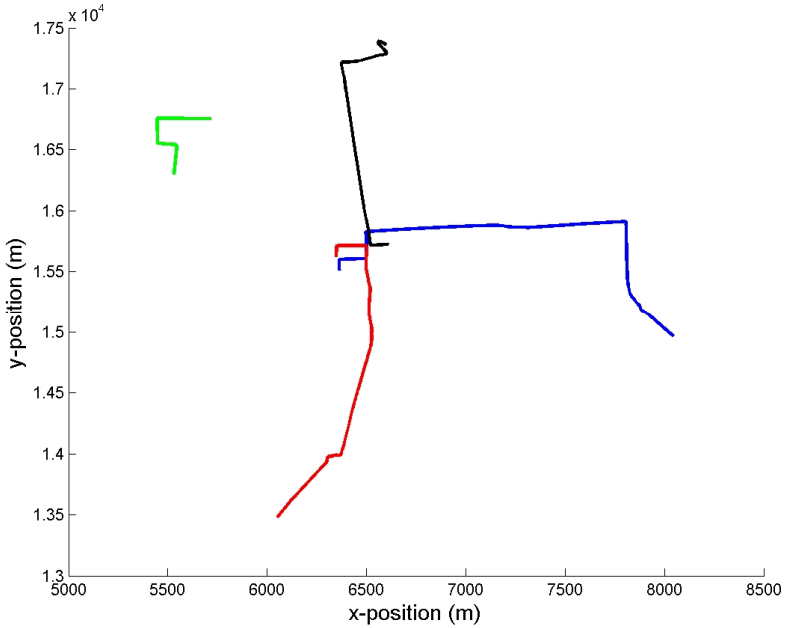
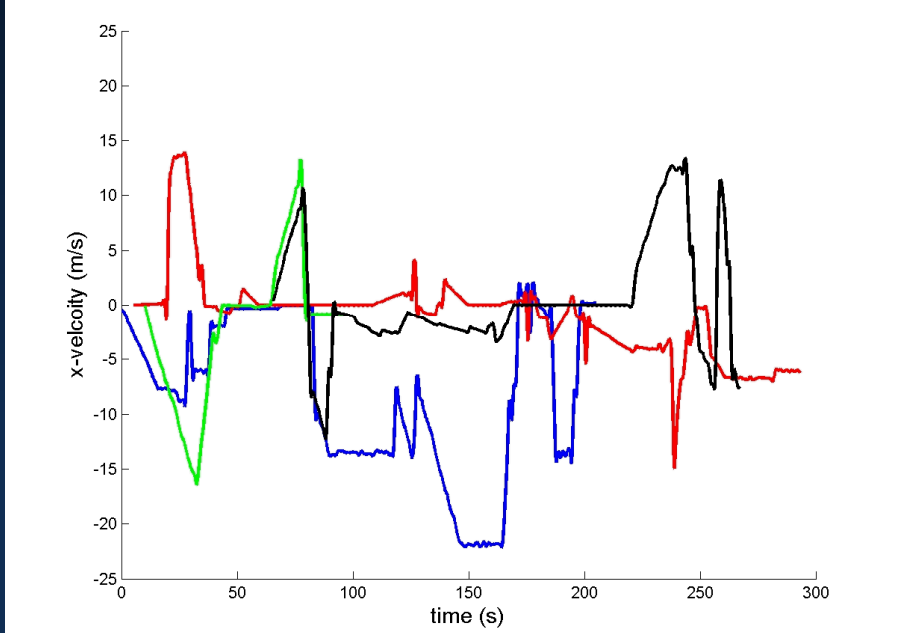
- Large Projects
  - Multi-year development cycles
  - Millions of lines of codes
  - Large teams/independent projects
  - S.E. design methodologies
  - Project/program management
- Small projects
  - Research and engineering
  - Rapid development cycles

Urban Vehicle Tracking

- Resolution of a few pixels per vehicle
- Occlusions, overlapping or unresolved vehicles
- Vehicle motion does not follow any constant velocity or constant acceleration model (see simulated tracks below)





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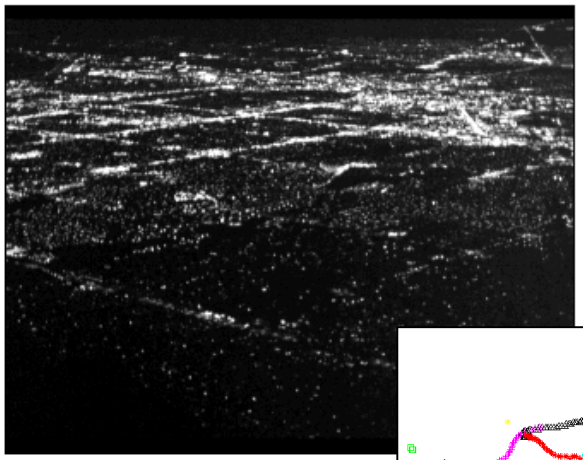
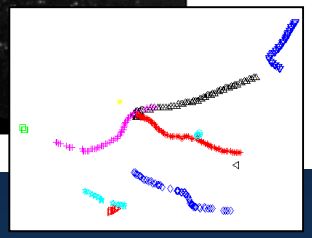
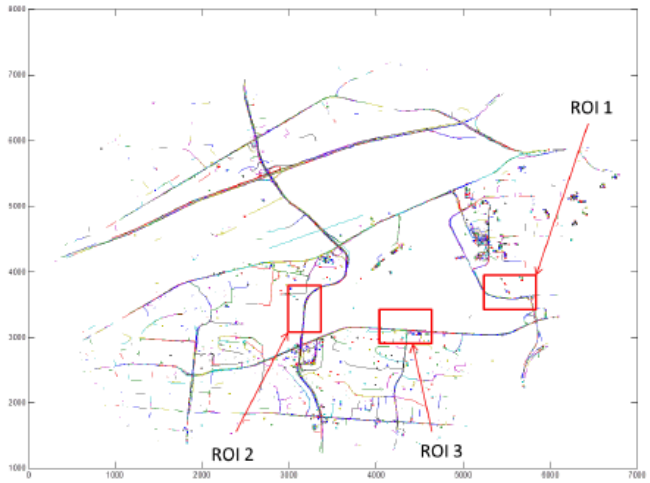
Urban Vehicle Tracking







Sample UAV Dataset

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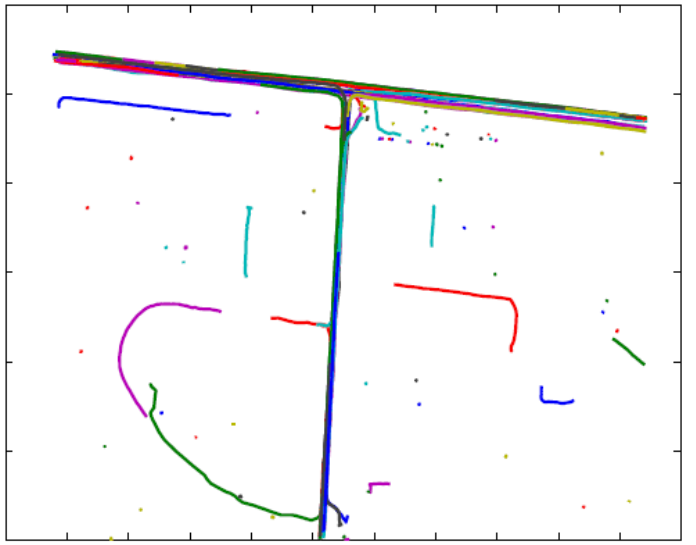
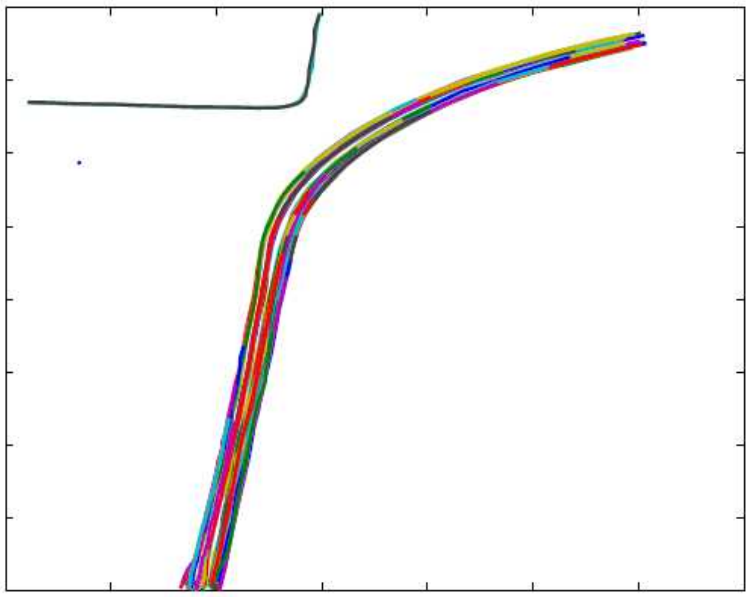
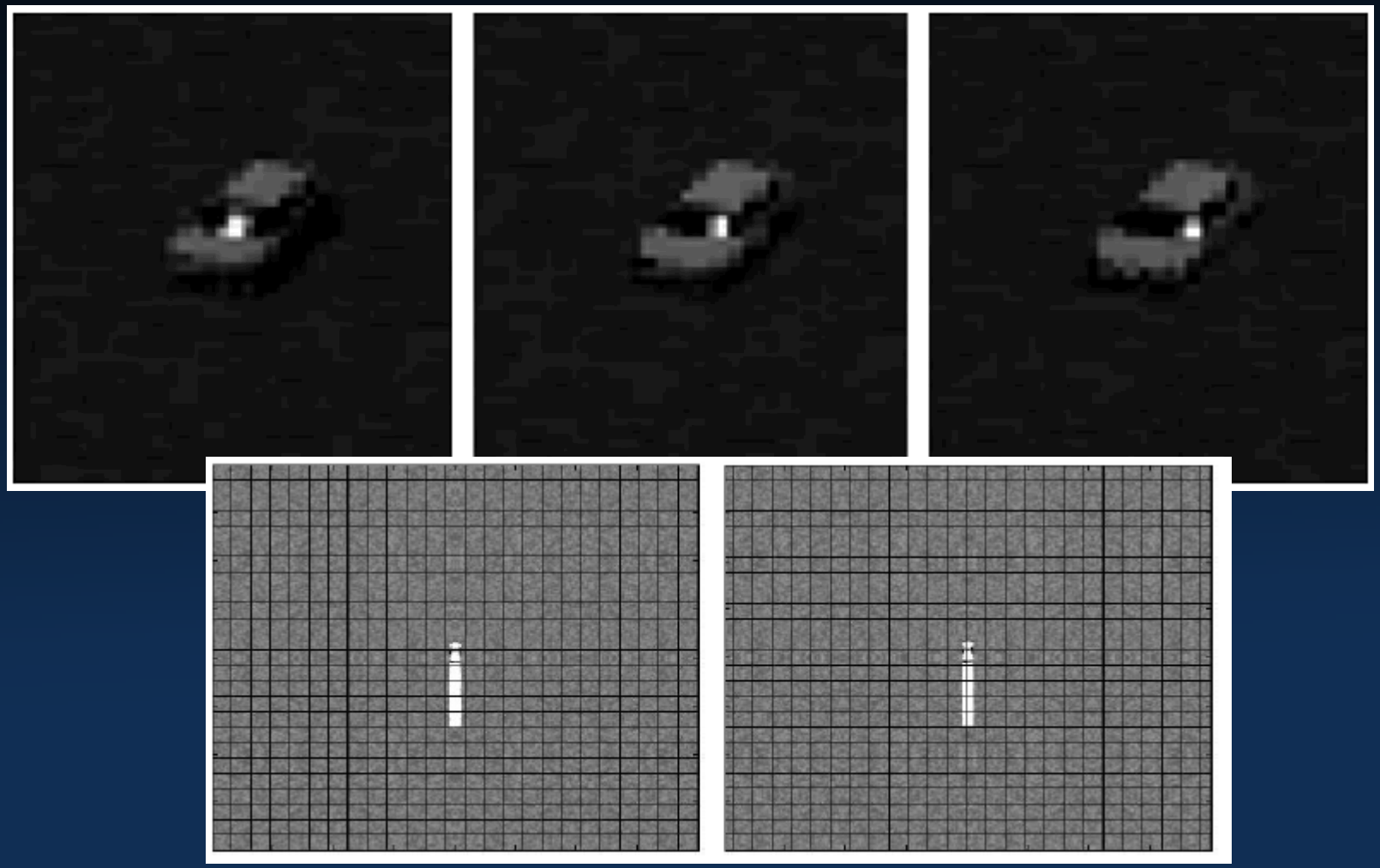
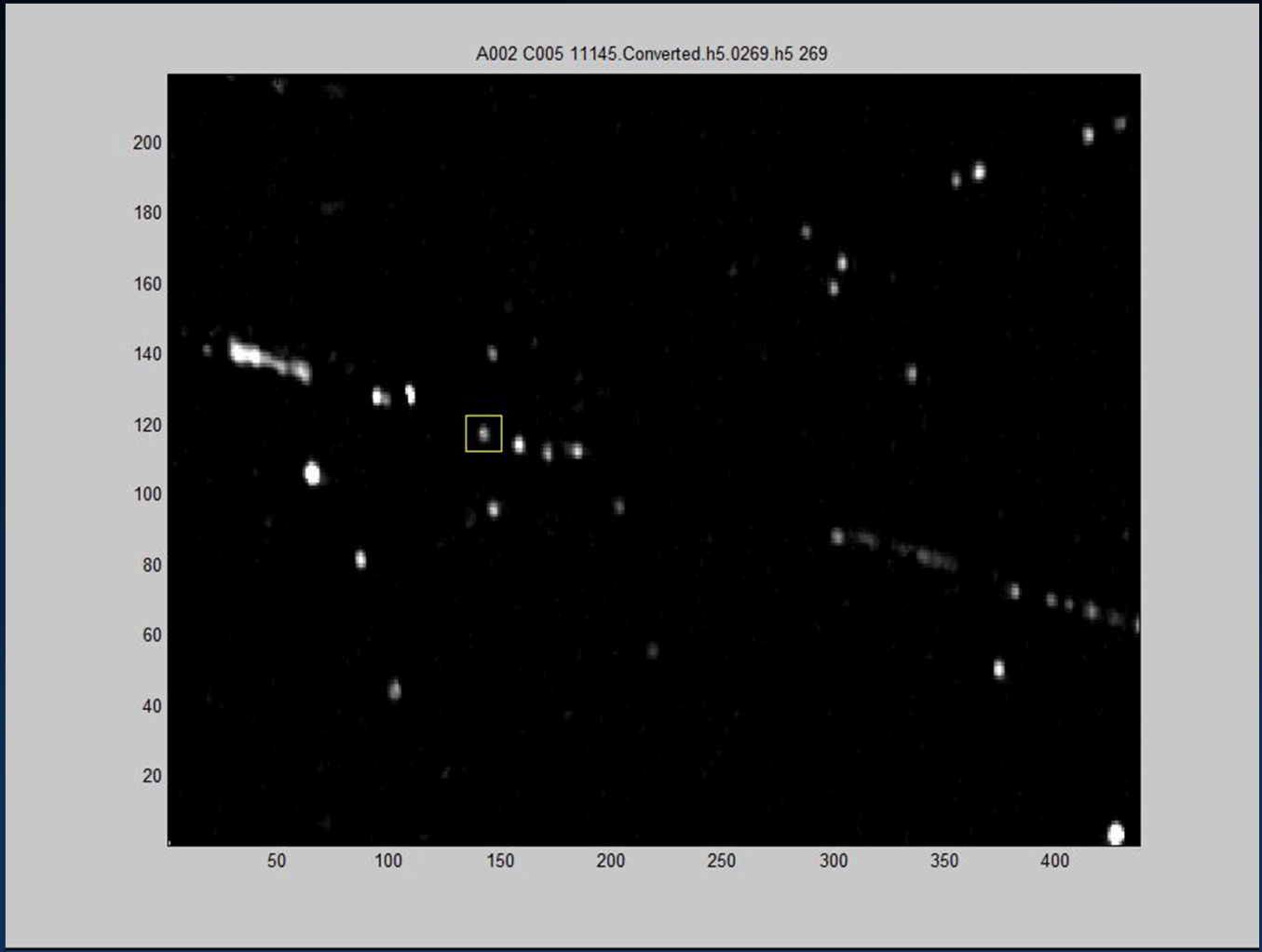




Phenomenology Studies



Difficulties in Target Tracking



Paths of Continental US Flights

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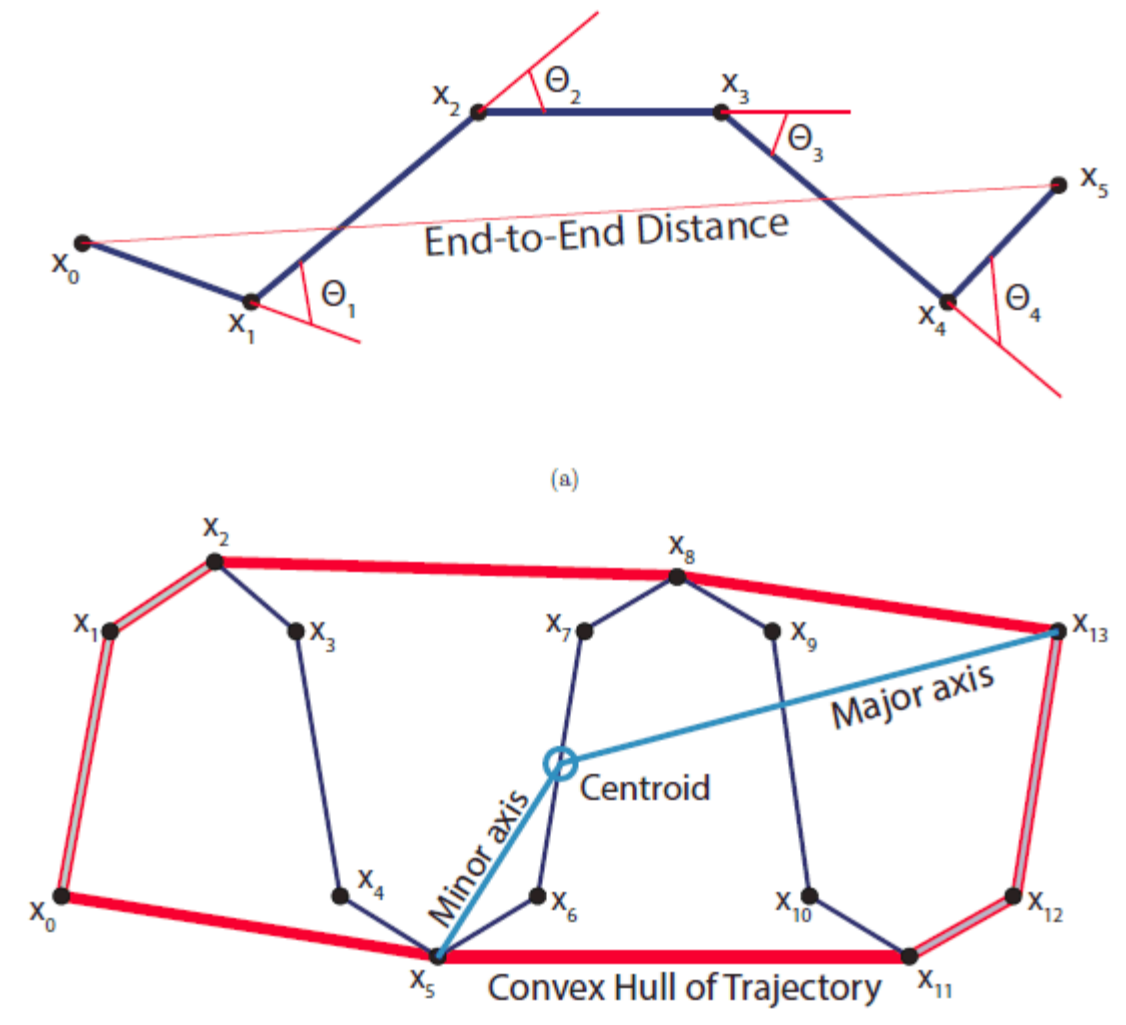
How Do You Represent a Trajectory?



“Avoid” Patterns

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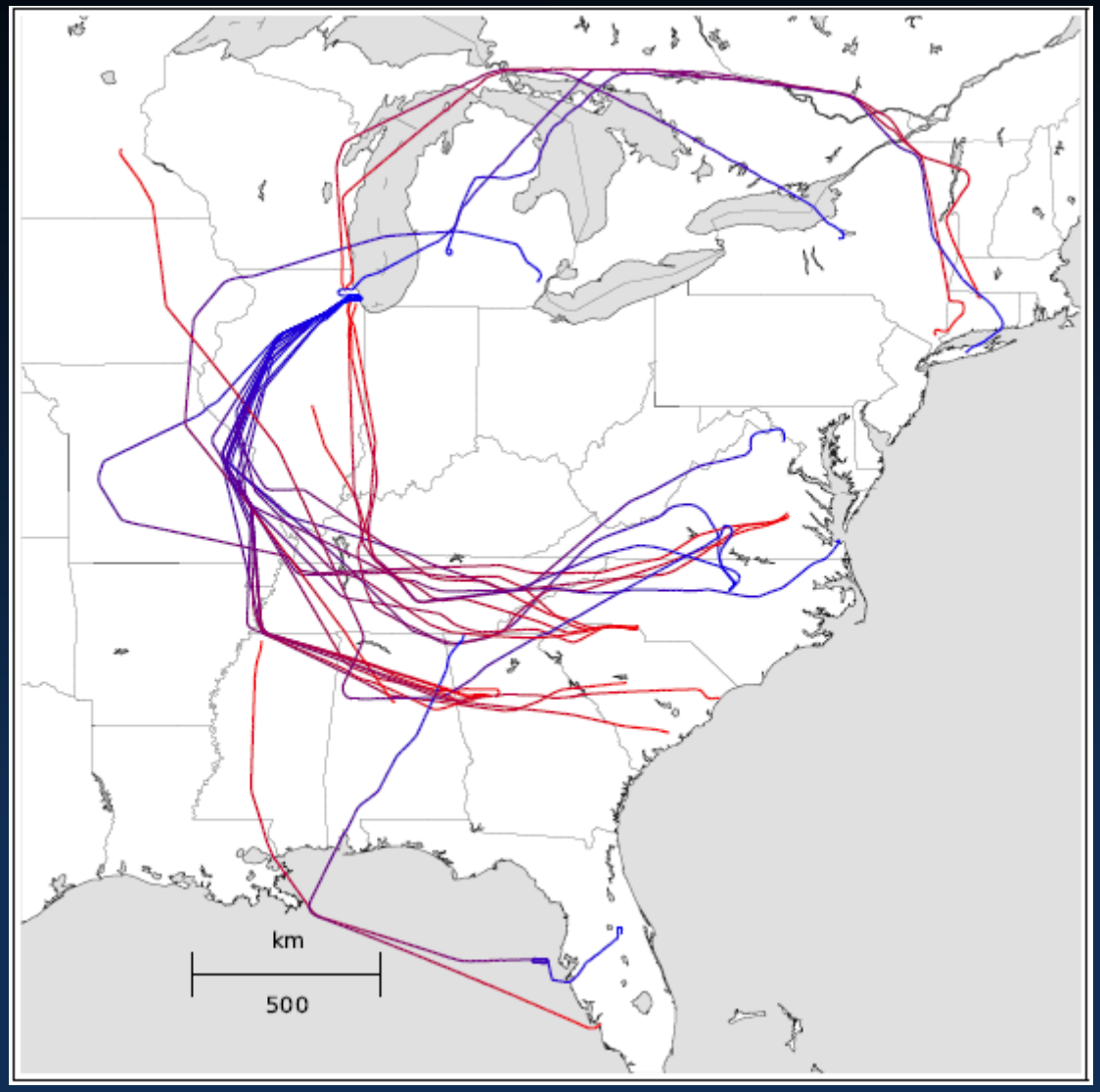
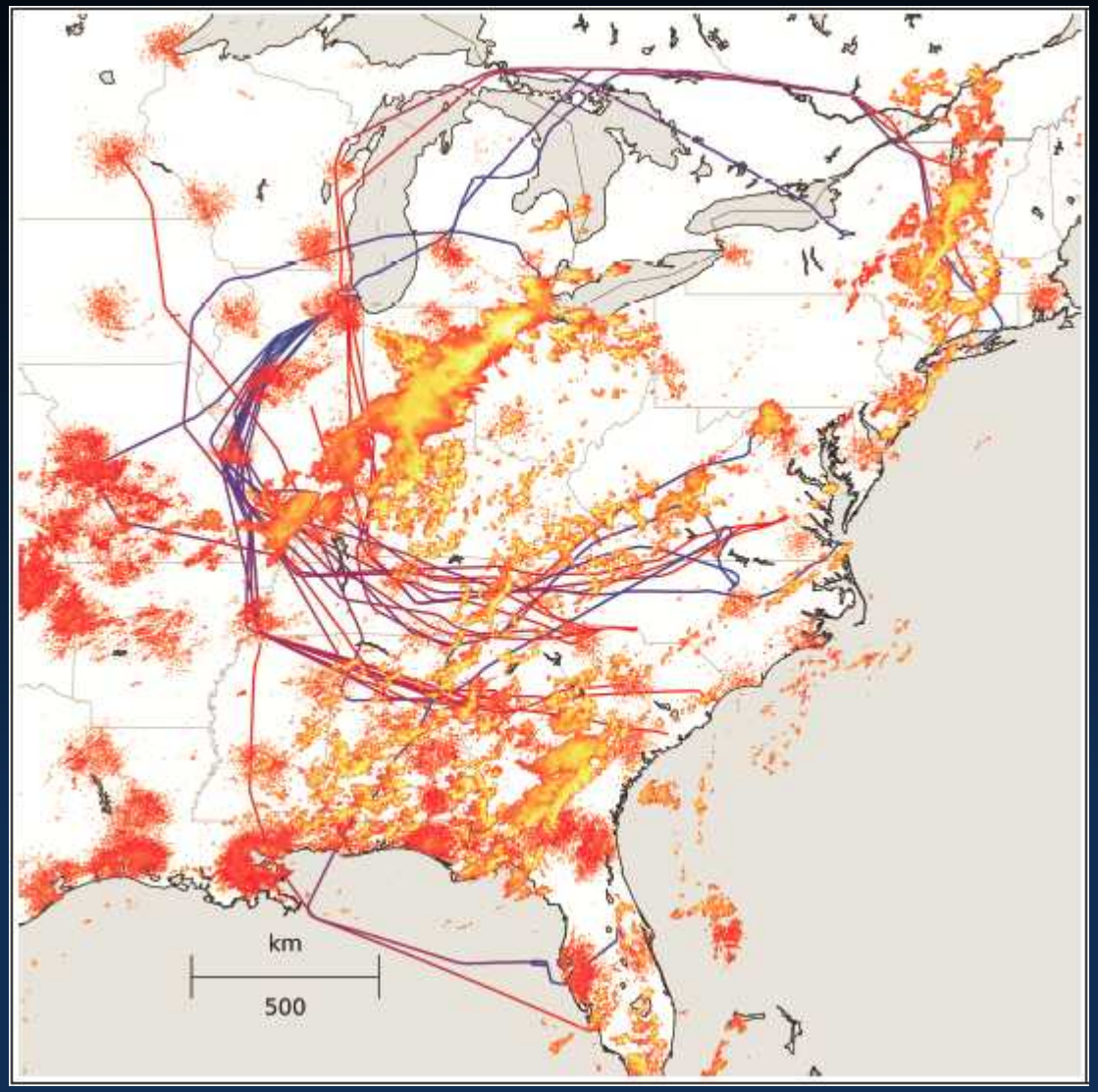


What Were They Avoiding?



“Mapping” or “Searching” Pattern

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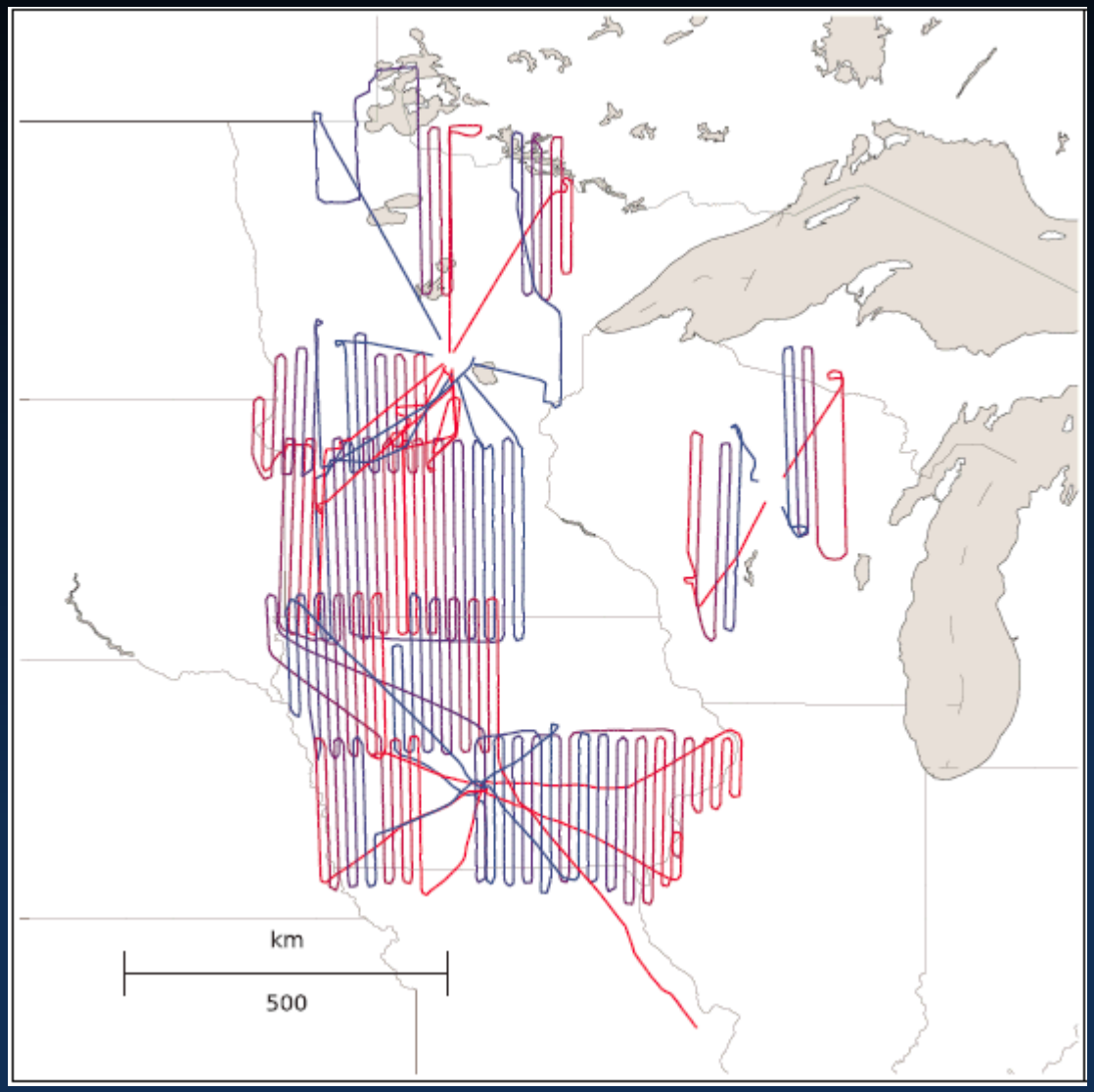

Interesting Findings

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More Interesting Findings

Backup

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RANSAC

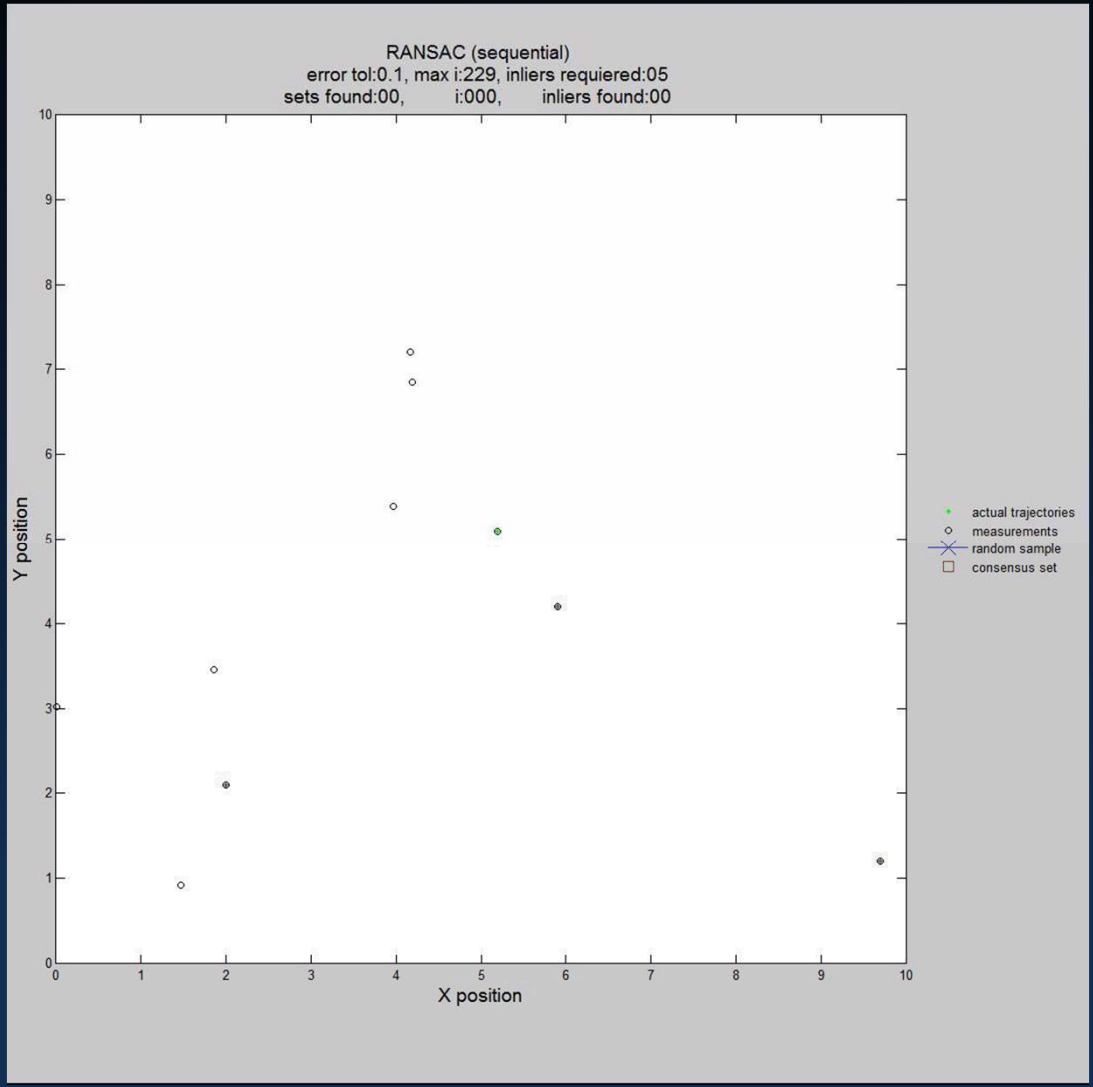
- Motion model based

$$\begin{aligned} x(t) &= x_1 + v_x(t - t_1) \\ y(t) &= y_1 + v_y(t - t_1) \end{aligned}$$

- Steps
  1. Randomly sample n measurements to minimally fit the model
  2. Fit the n measurements to the model's free parameters
  3. Calculate how many measurements are inliers of the model
  4. If a sufficient number of inliers, remove all inliers in the consensus set (sequential RANSAC)
  5. Repeat steps 1-4 a set number of iterations

M. A. Fischler and R. C. Bolles, "Random sample consensus: A paradigm for model fitting with applications to image analysis and automated cartography," *Commun. ACM*, vol. 24, pp. 381-395, June 1981.

RANSAC


RANSAC (sequential)
error tol:0.1, max i:229, inliers requiered:05
sets found:00, i:000, inliers found:00
Y position
X position
actual trajectories
measurements
random sample
consensus set

Markov Chain Monte Carlo

- Estimates association posterior $\mathrm{P}(\omega \mid Y)$ using MCMC

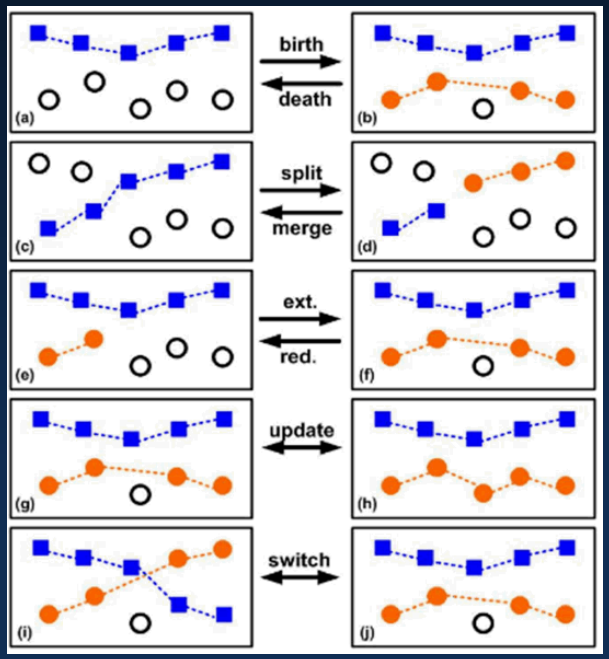
$$\mathrm{P}(\omega \mid Y) \propto P(Y \mid \omega)\, P(\omega)$$

Track associations — Observations

- Generate samples from posterior by random track moves, get MAP estimate

- Can be seen as simulated annealing at constant temperature

Random track moves



S. Oh, S. Russell, S. Sastry, "Markov Chain Monte Carlo Data Association for Multi-Target Tracking", *IEEEE Transactions on Automatic Control*, March 2009

Markov Chain Monte Carlo

- Estimates association posterior $\mathrm{P}(\omega \mid Y)$ using MCMC

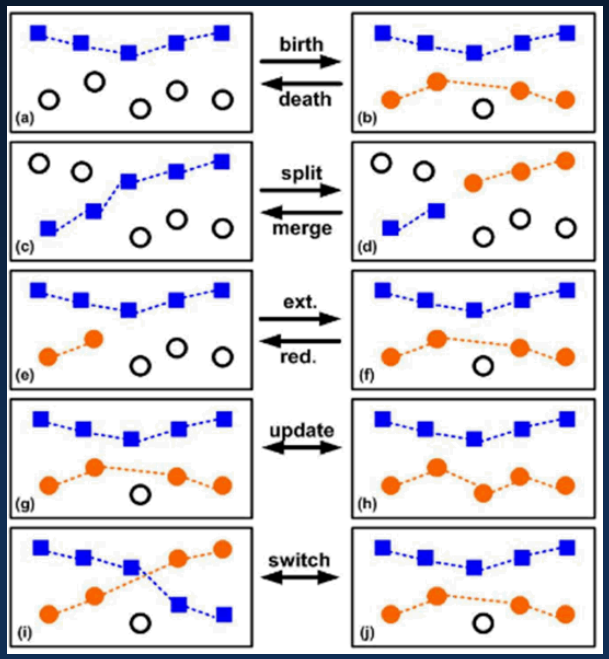
$$\mathrm{P}(\omega \mid Y) \propto P(Y \mid \omega)\, P(\omega)$$

Track associations — Observations

$$\mathrm{P}(\omega|Y) \propto P(Y|\omega)\, P(\omega)$$
$$\propto P(Y|\omega)\, f(p_{det}, p_{death}, \lambda_{birth}, \lambda_{FA})$$

$P(Y|\omega)$ is calculated using constant-velocity Kalman filters for each track

Random track moves



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VELA-Hotel: The Origin of Satellite Remote Sensing at Sandia

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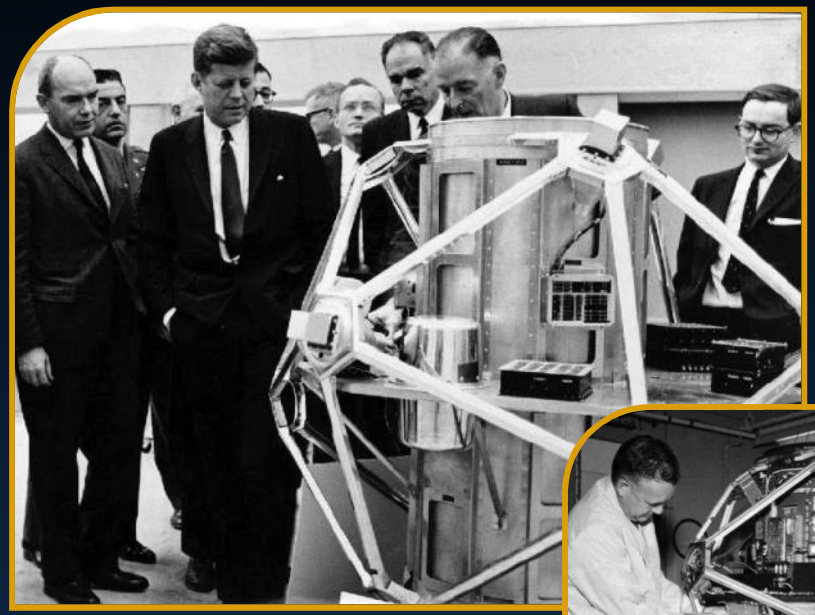

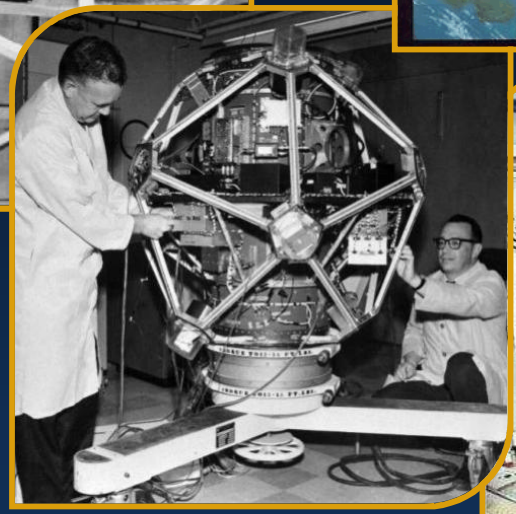

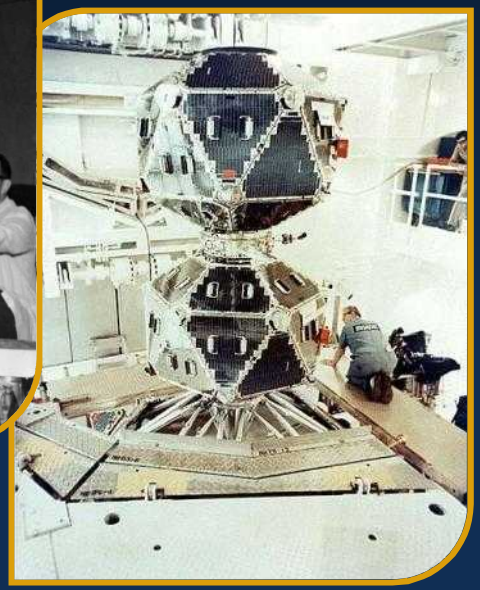

Mission: Nuclear Proliferation Monitoring

Combating Terrorism and Treaty Monitoring

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Proliferation Detection

Nuclear Detonation Detection

Space

Multispectral Thermal Imager

Global Burst Detection

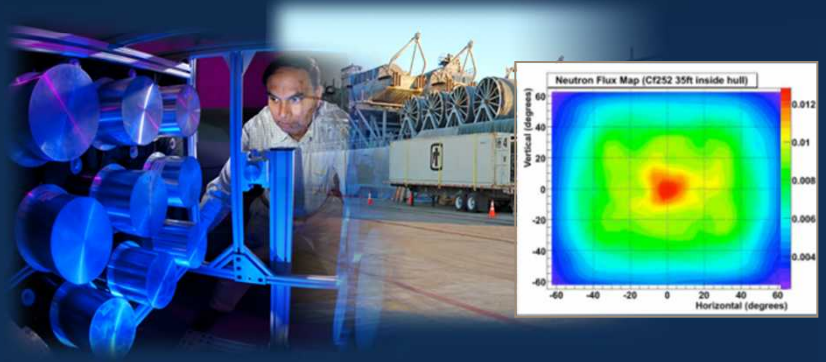
Air

Advanced Sandia LIDAR

Airborne Radiological Collection System

Ground

Nuclear Material Detection



Microsystems Seismometer