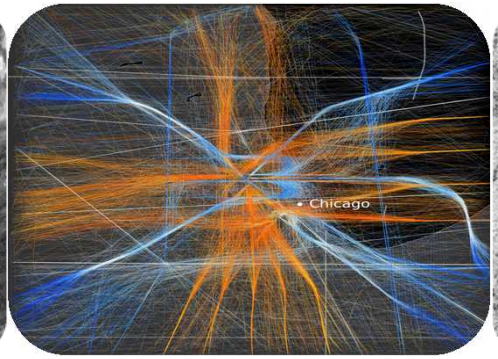
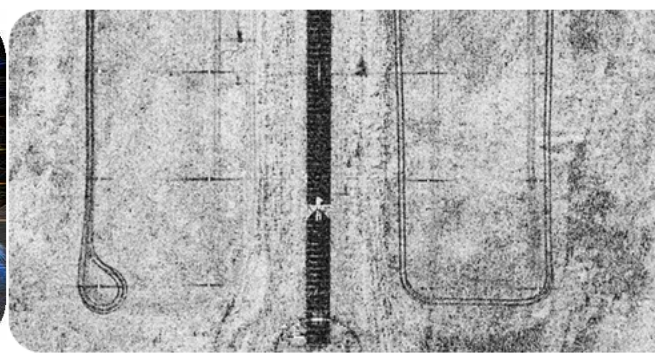
SAND2015-1596C

Exceptional service in the national interest

Sandia National Laboratories





Automated Advancements for Improved ISR

Sandia Airborne ISR: www.sandia.gov/radar/

Dr. James J. Hudgens, Deputy Director, Airborne ISR Systems,
Sandia National Laboratories
Unclass: jjhudge@sandia.gov

March 13th, 2015

U.S. DEPARTMENT OF ENERGY | NNSA

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Sandia National Laboratories

Sandia Corporation

- AT&T: 1949–1993
- Martin Marietta: 1993–1995
- Lockheed Martin: 1995–present

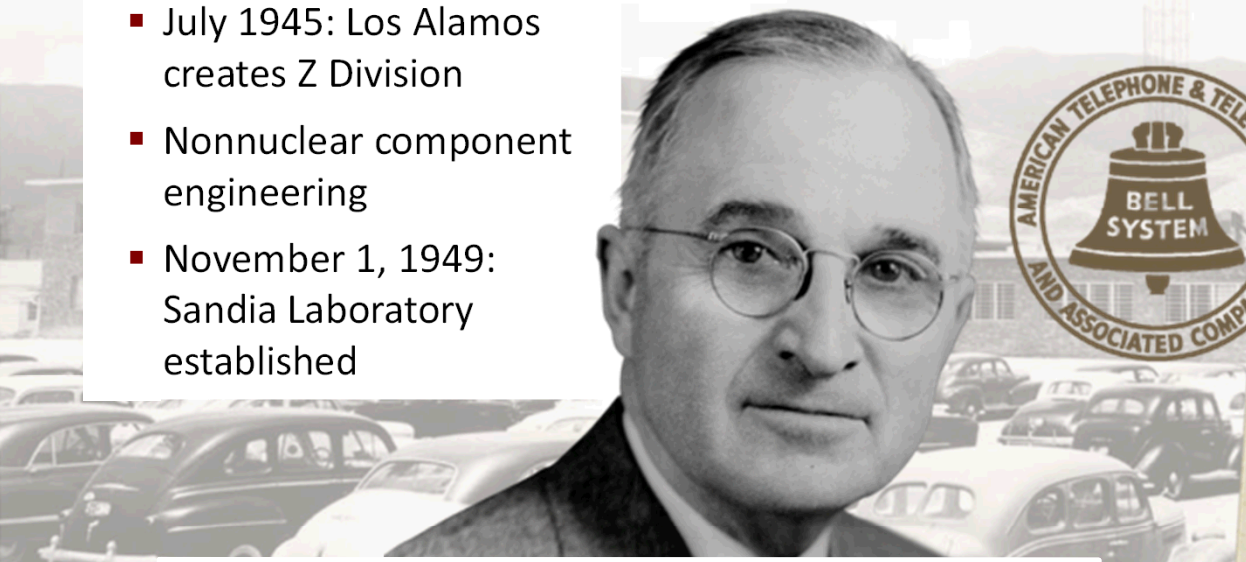
Government owned, contractor operated

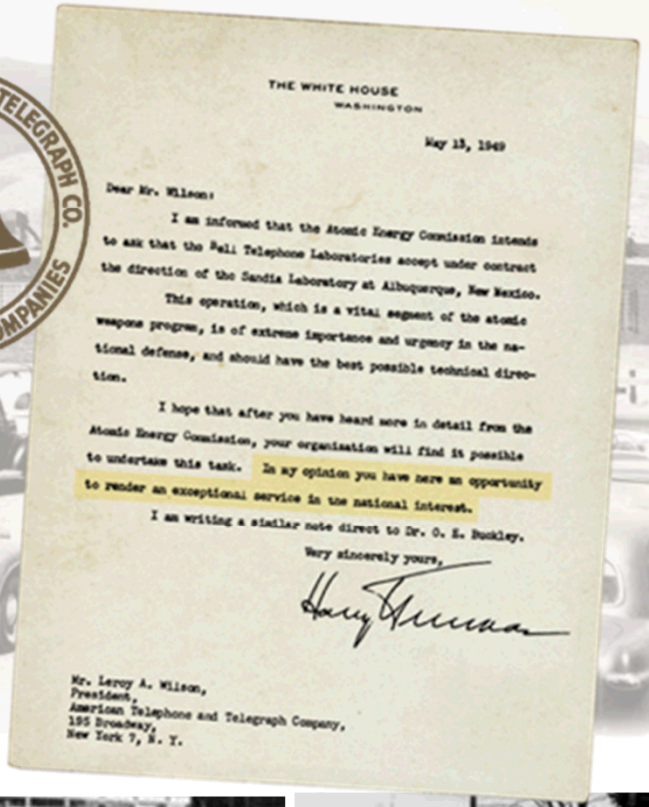
Federally funded research and development center

Sandia's History

Exceptional service in the national interest

- July 1945: Los Alamos creates Z Division
- Nonnuclear component engineering
- November 1, 1949: Sandia Laboratory established





THE WHITE HOUSE
WASHINGTON

May 13, 1949

Dear Mr. Wilson:

I am informed that the Atomic Energy Commission intends to ask that the Bell Telephone Laboratories accept under contract the direction of the Sandia Laboratory at Albuquerque, New Mexico.

This operation, which is a vital segment of the atomic weapons program, is of extreme importance and urgency in the national defense, and should have the best possible technical direction.

I hope that after you have heard more in detail from the Atomic Energy Commission, your organization will find it possible to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.

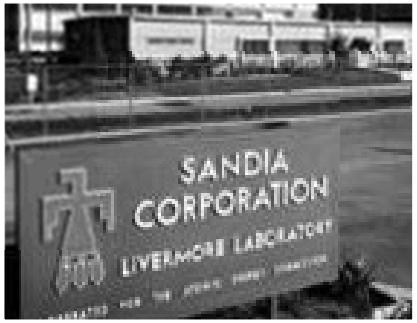
I am writing a similar note direct to Dr. O. E. Buckley.

Very sincerely yours,

Harry Truman

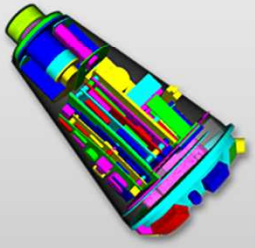
Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.

to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.



Sandia SAR Evolved from NW Mission

NW Radar Fuze Tech Base



Radar tech base originated with Nuclear Weapons

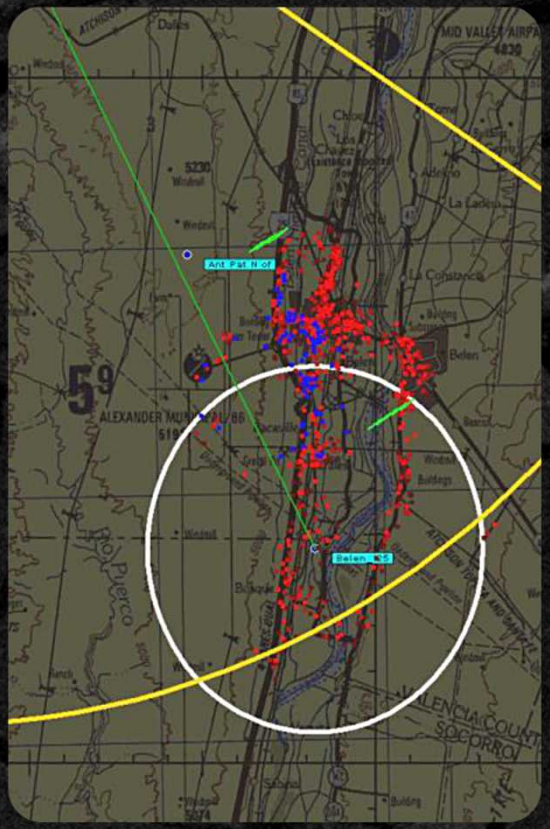
Strengthened through SAR development

Synthetic Aperture Radar

Applied advanced technology to NW systems (B-61 and W-76)

Advanced radar fuzing technology

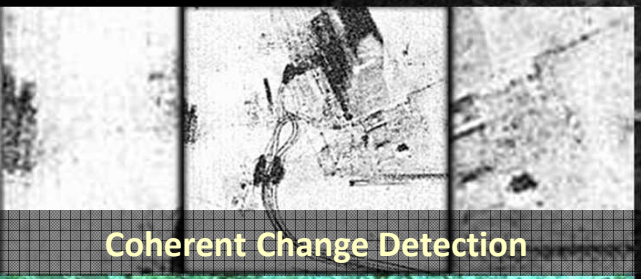
SAR/GMTI Overview

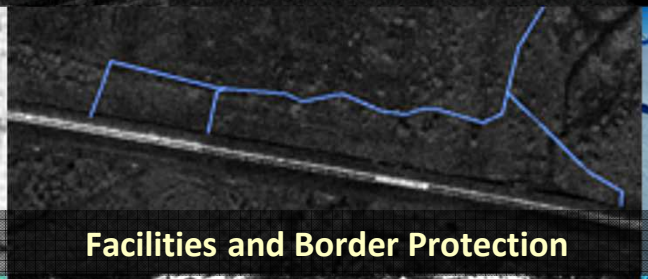


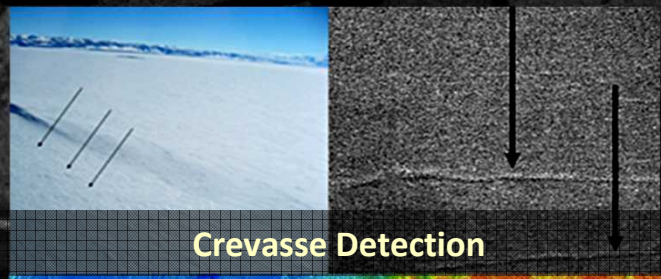
- SAR forms images all weather, day/night
- GMTI provides range and velocity for moving objects
- SAR are designed differently than GMTI radars (Antenna)

Sandia specializes in high resolution, on-board, real-time processed SAR for manned/unmanned UASs

Real World Applications

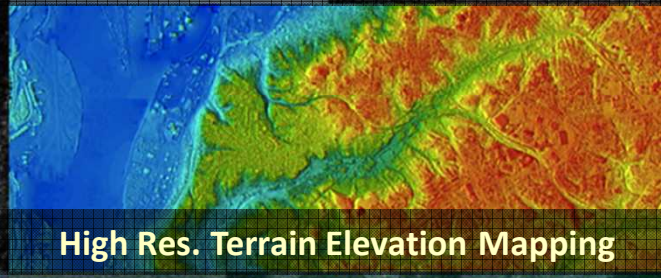

Coherent Change Detection


Facilities and Border Protection


Crevasse Detection

Environmental Monitoring


Space Missions

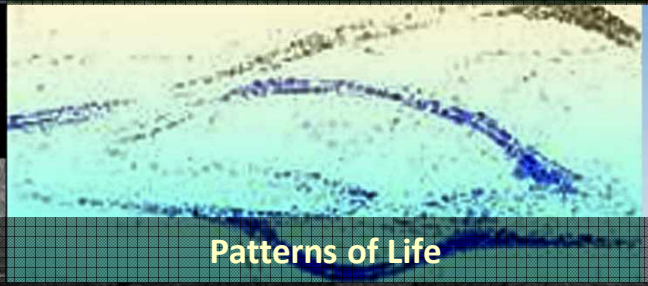

High Res. Terrain Elevation Mapping


Maritime & Littoral


Vehicle and Dismount Tracking


S&R and Targeting


C-IED & Route Reconnaissance

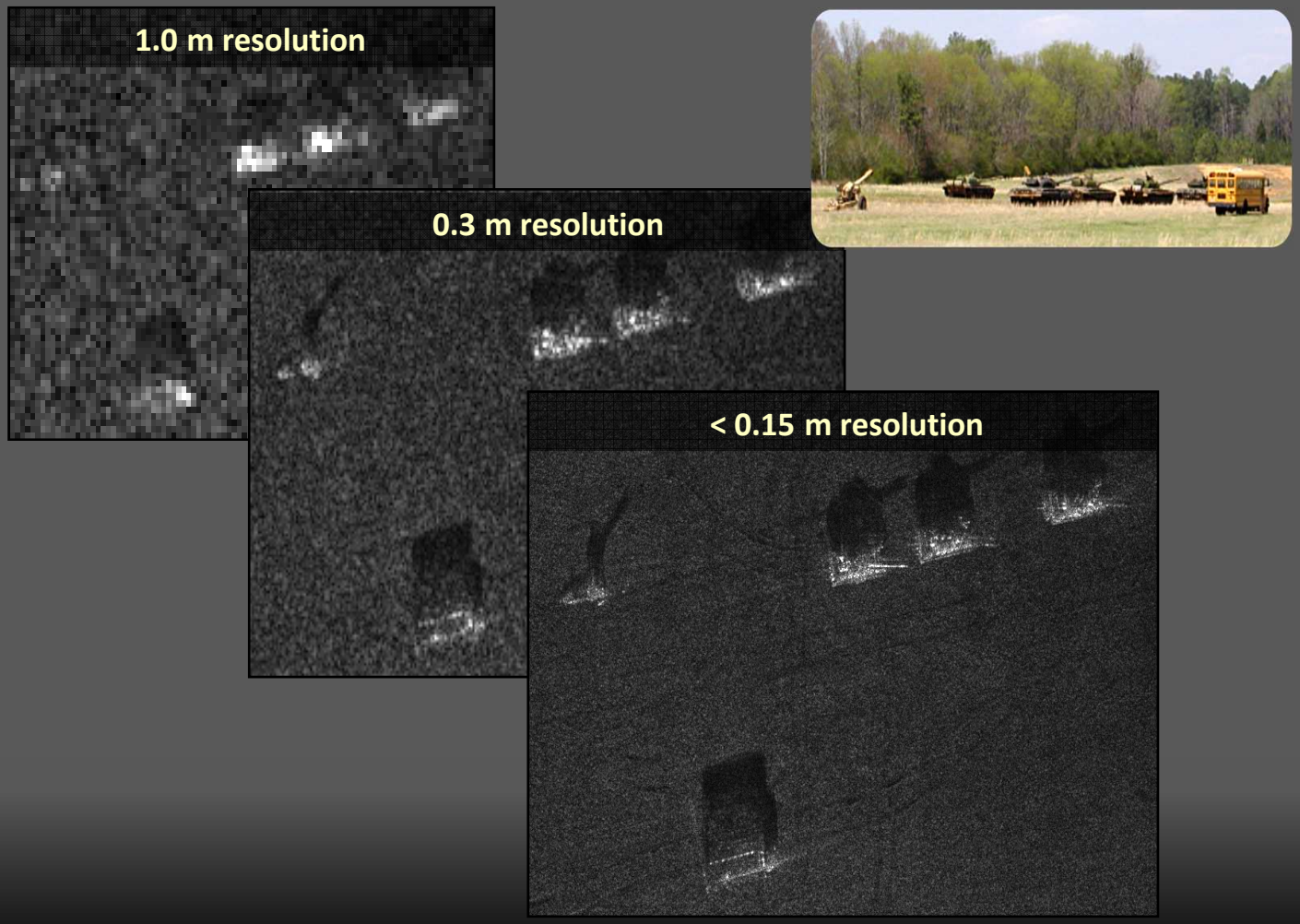

Patterns of Life


Precision Guidance

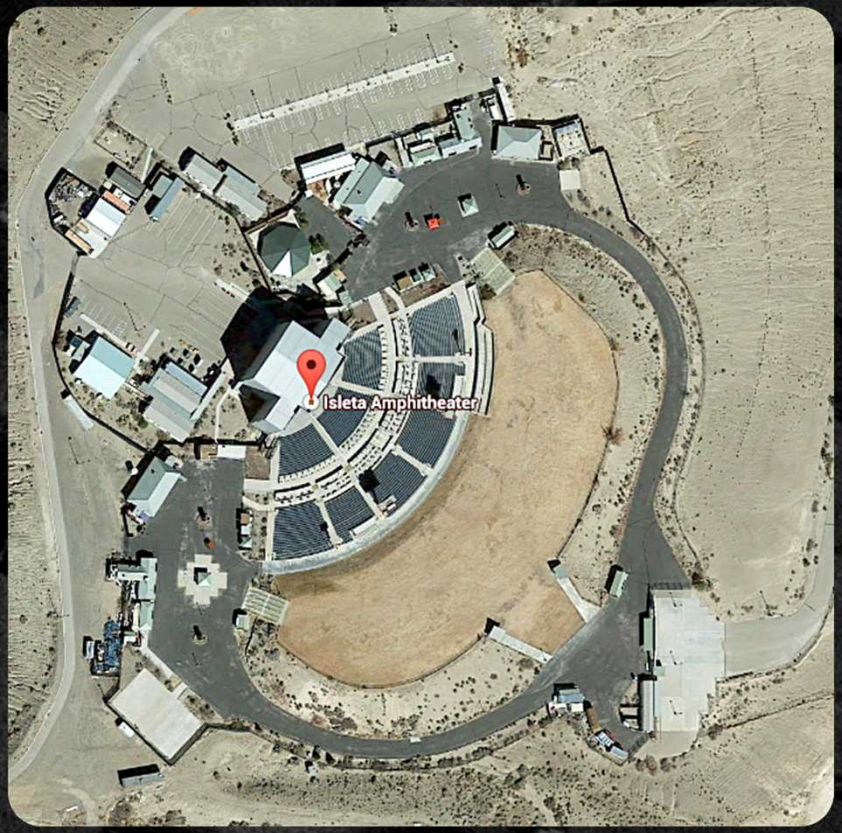
Resolution Matters

Modes:

- Spotlight
- SpotDwell
- Circle
- Stripmap
- Arbitrary
- Stripmap,
- CCD/NCP
- IFSAR
- VideoSAR/VICTR
- GMTI/DMTI
- Wide Area Search
- High Range Resolution



VideoSAR



Journal Pavilion Amphitheater
Albuquerque, NM

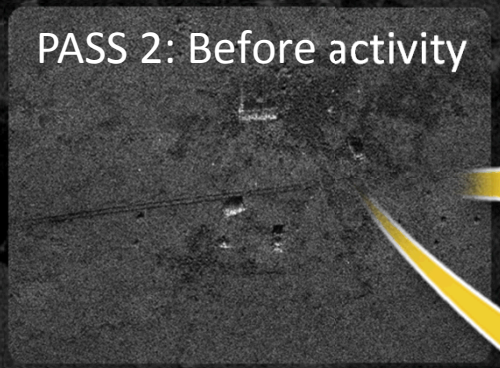
VideoSAR

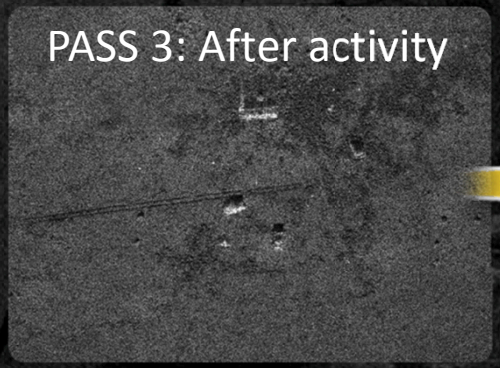
Kirtland AFB Gate
Albuquerque, NM

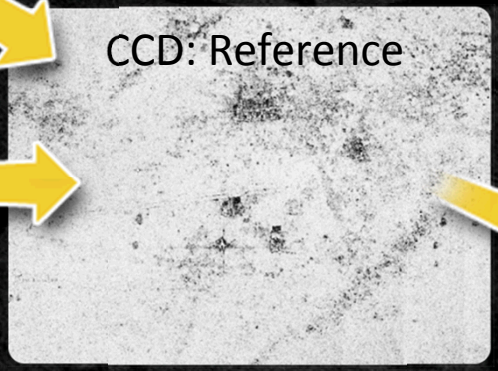
Coherent Change Detection (CCD)

Normalized Coherent Product (NCP)

- Foot paths
- Tire tracks
- Bicycle tracks
- Ground disturbances
- **Often the changes cannot be seen at visible wavelengths**





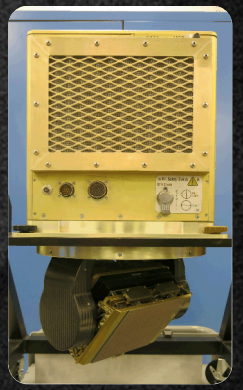


MISSION EXAMPLES

Counter IED -- Copperhead

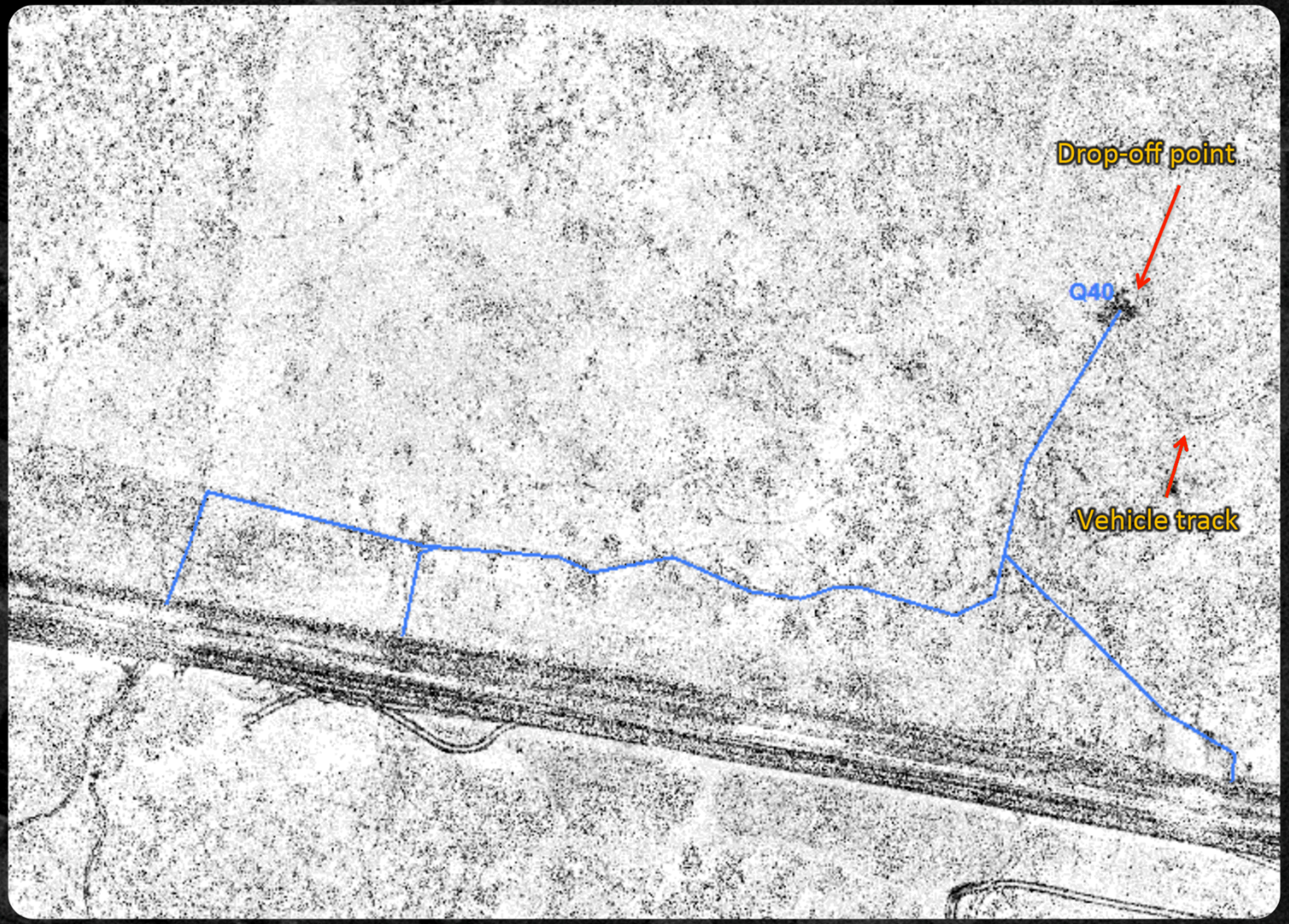
- **Mission**
  - Counter - IED ISR (C-IED ISR) - Monitors one or more routes and provides MGRS coordinates of suspected enemy activity for Route Clearance Teams to investigate

- **Copperhead Provides:**
  - Change Detection - capable of detecting very small surface disturbances
  - Modes: Route Following Strip-map, Circle (Spotlight) images
  - Onboard Processing and compression
  - Images meeting quality specifications in high-relief terrain
  - Automatically-created flight plans for route following and disturbance verification missions



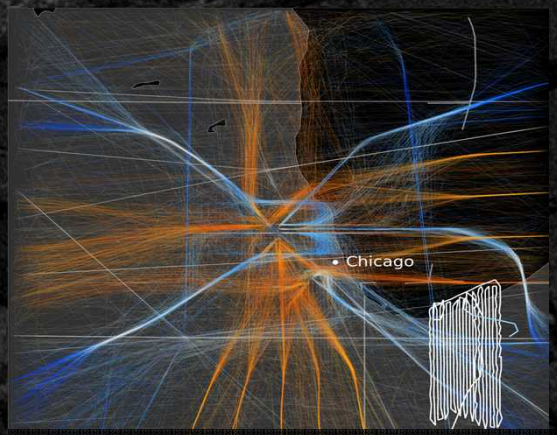
Size	Volume: 1.53Ft^3 (REA inside UAS), 0.83Ft^3 for the radome
Weight	< 65lbs
Power	< 650W peak
Frequency Band	Ku-Band
Platform	Hunter UAS

Border Security

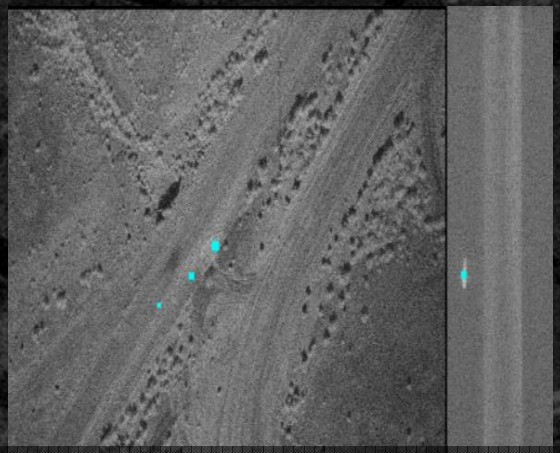


Statistically Normalized Coherence

Where are we headed?



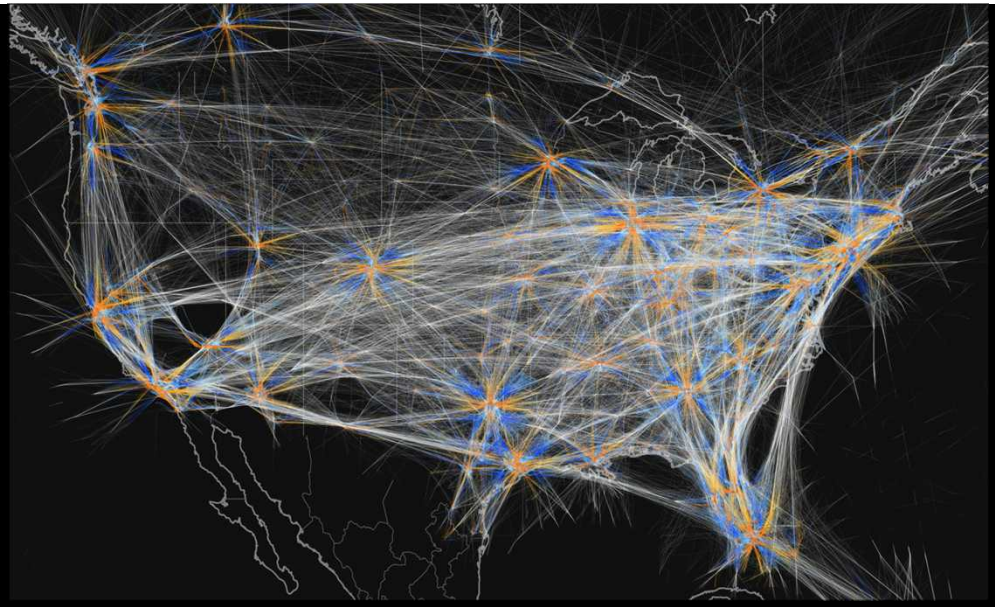
Rethinking Search



Simultaneous VideoSAR/GMTI with automated tracking of movers (VICTR)

Fully Polarimetric VideoSAR/CCD

Rethinking Search

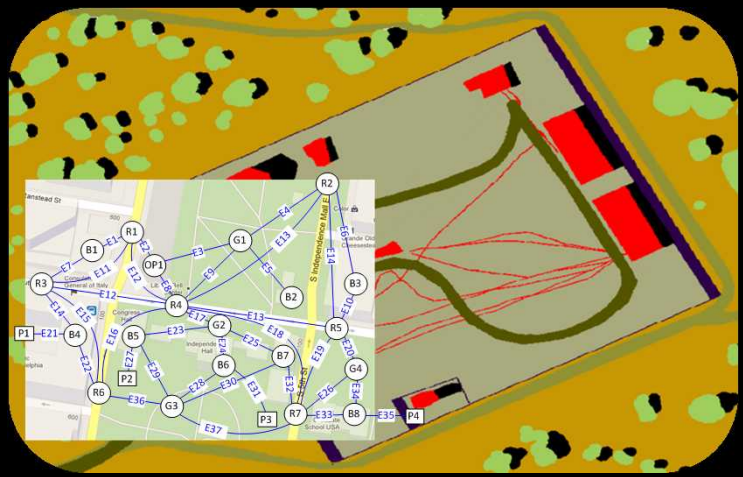


Rethinking traditional GIS and geospatial search.

- Compact, efficient representations of features extracted from sensor data.
- Sensor agnostic capability for multi-INT feature relationships in time and space.
- Predictive and forensic analysis.

Rethinking patterns in motion.

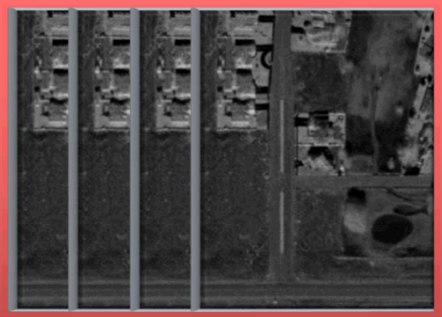
- Geometric and temporal trajectory analyses – changing dots to tracks to *trajectories*.
- Geospatial-temporal relationships – i.e., identifying things like co-travelers.

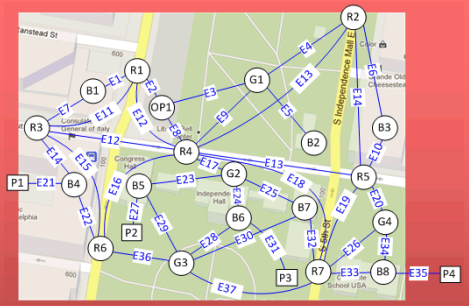


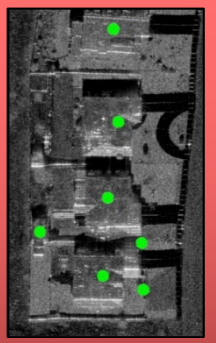
Analysts care about "what", "where", and "when".
Where is it going? Where has it been? What's the relationship? What's changed?

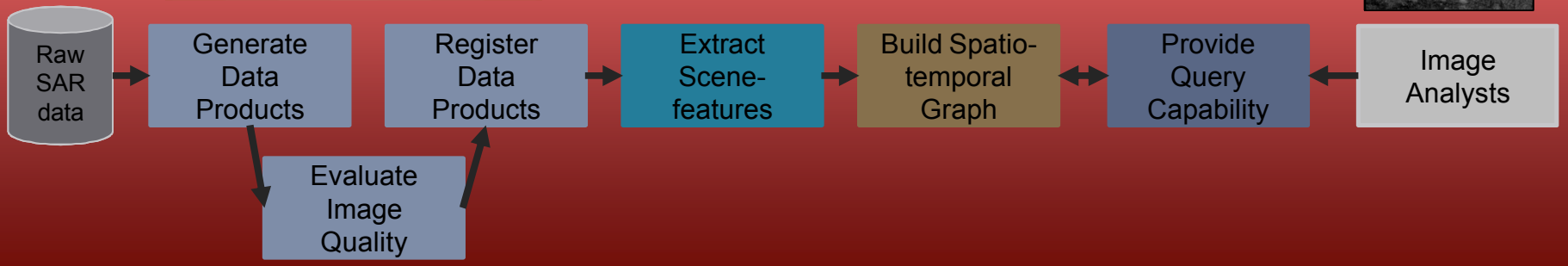
Automatic SAR Feature Extraction

- Aiding analysis in exploiting massive amounts of SAR image data.
- Moving from pixels to analysis:
  - Augment analyst capabilities through automated query and search of SAR data products.
  - Represent spatial and temporal relationships of scene features in searchable graph.
  - Automate classification of static structures and terrains.
  - Automate detection of ephemeral tracks, disturbances, and vehicle movement.



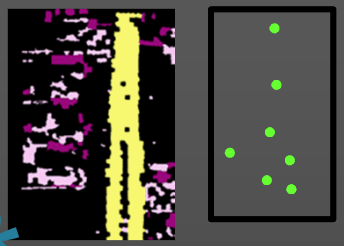




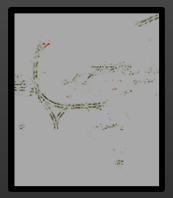


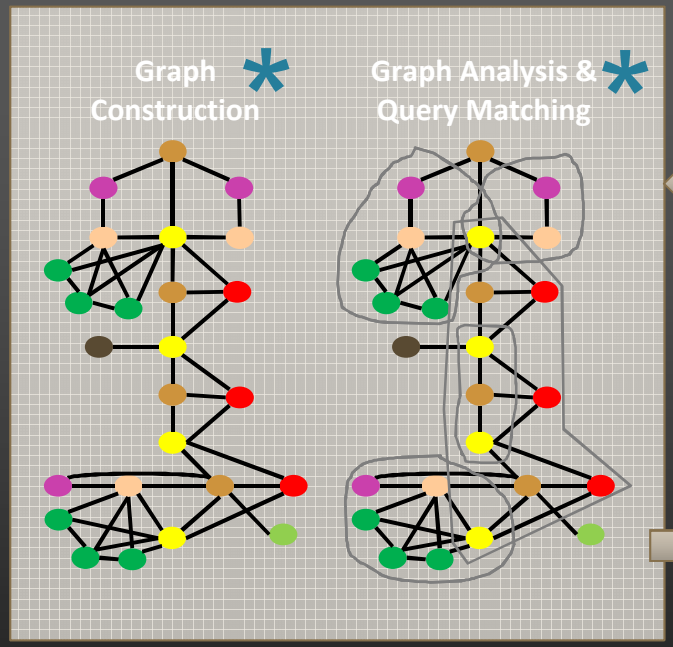
Moving Away From Pixels
Graph Construction and Analysis

Static Features



Ephemeral Features





Analyst constructs search queries and visualizes results

Query Pattern

Search Results

* Points at which big sensor data becomes more manageable

Moving Away from Pixels

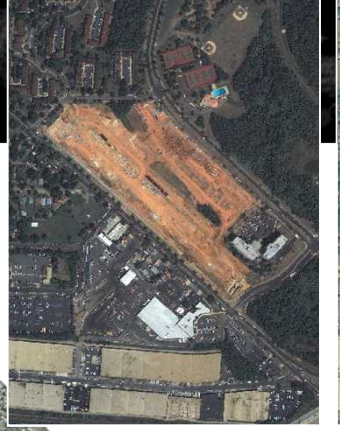
Example: Seek complexes of new buildings, across an entire city:

≤ 40 m
$A_{relative} \leq 1.5x$
$Eccentricity_{relative} \leq 1.5x$

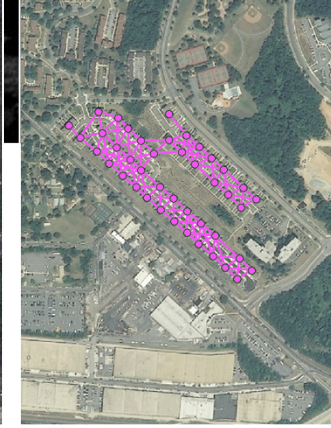
Constructed
Data: Building
Exists now
$A \geq 100\ m^2$
New, Extended, Changed
$n \in [5, \infty]$

2006*

2011



2006*

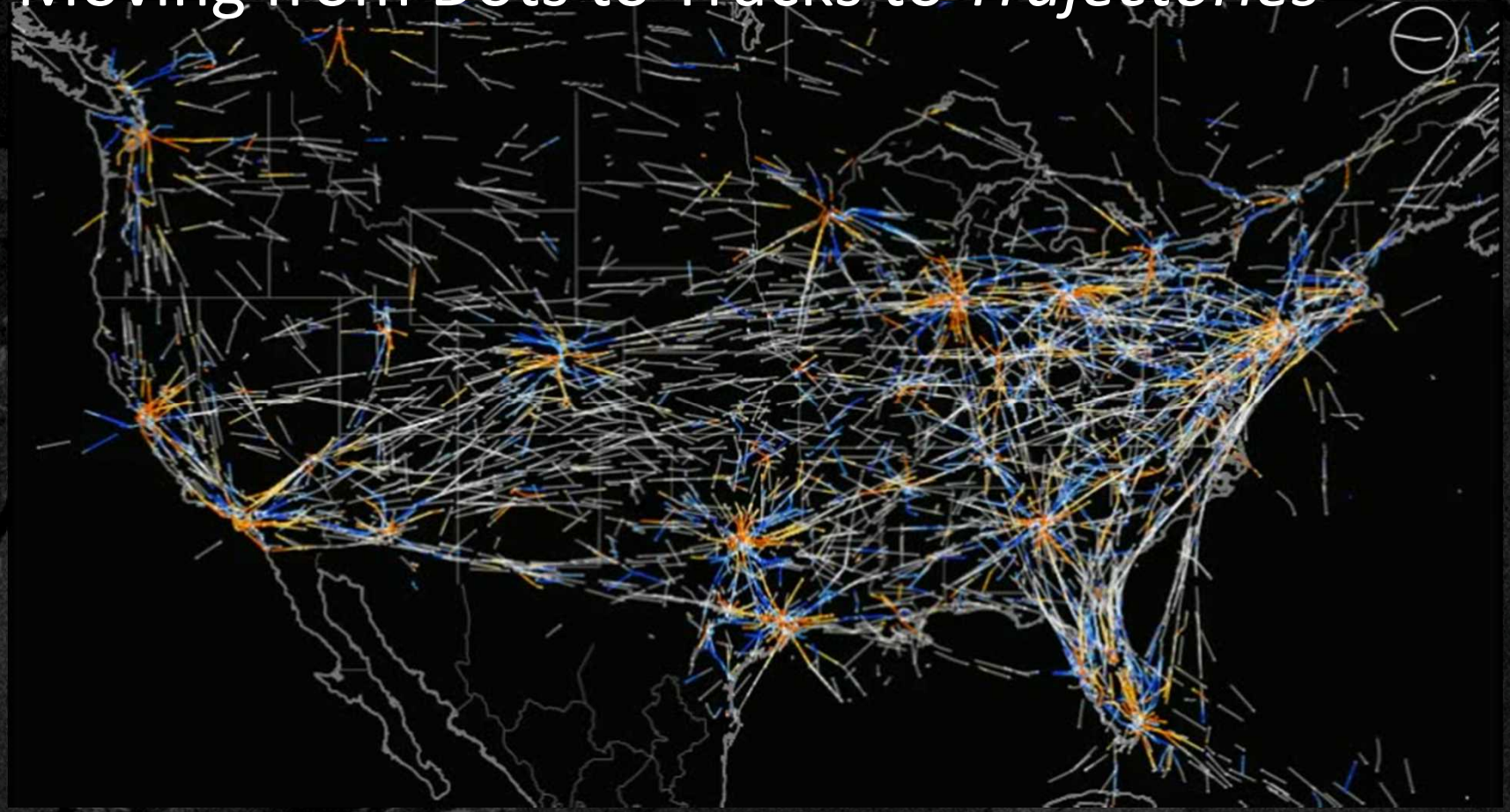


2011

* Image from DigitalGlobe.
Other Image data provided by University of Vermont.

Trajectory Analysis

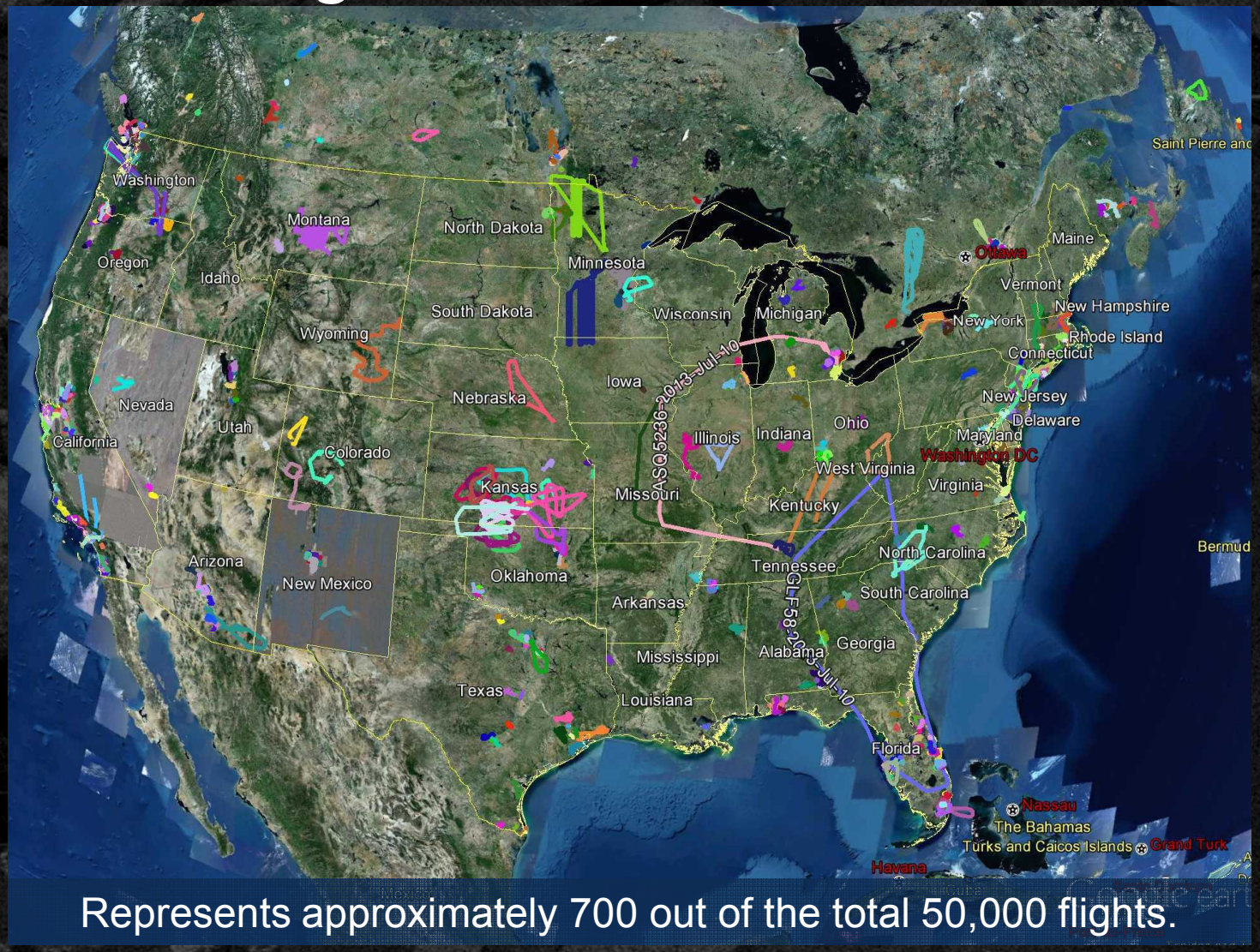
Moving from Dots to Tracks to *Trajectories*



24 hours in the US: Average of 50,000 flights
5 million data points / 1GB of data

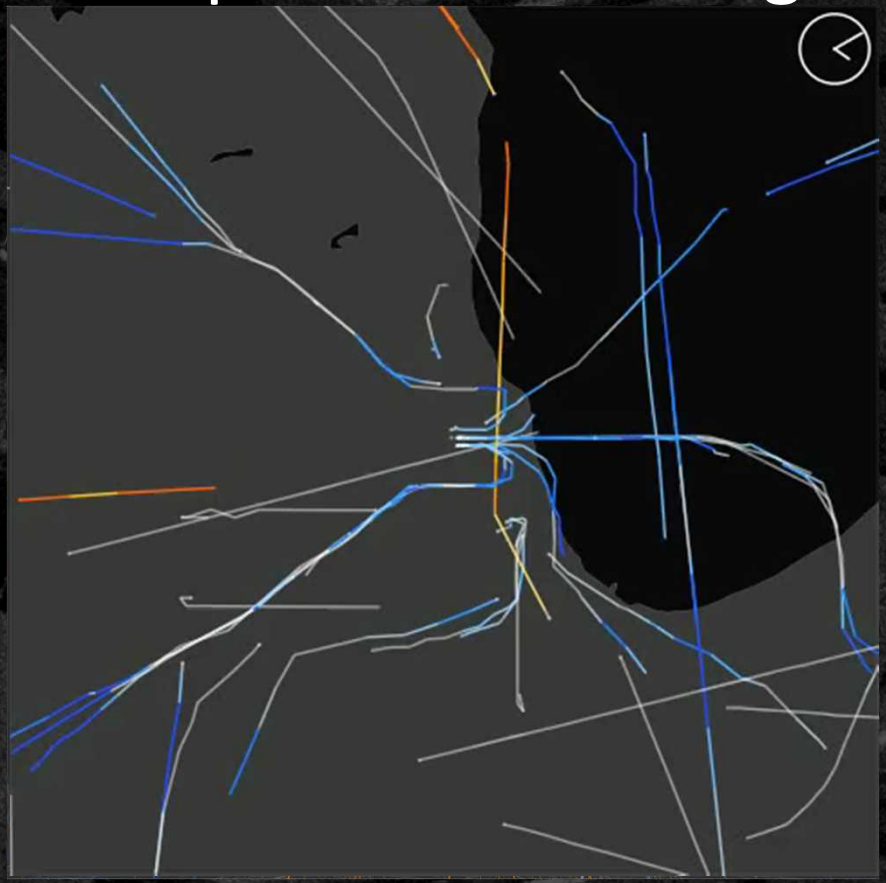
Discovery of Odd flights
Unsupervised learning

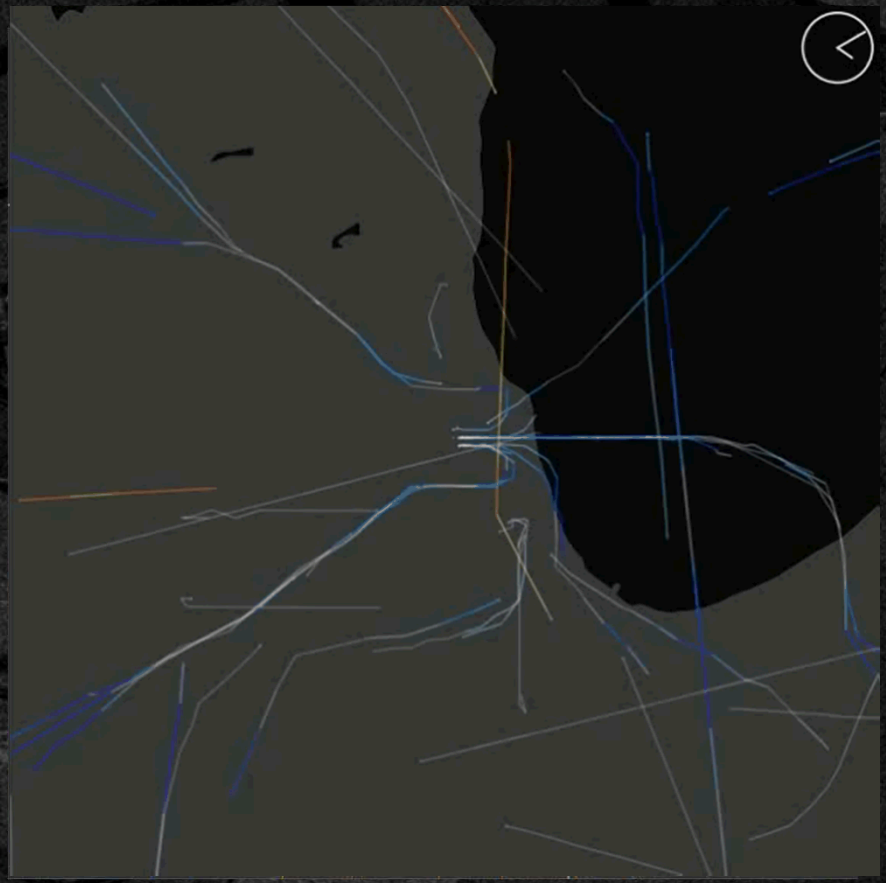
Clustering done based on geometric features.

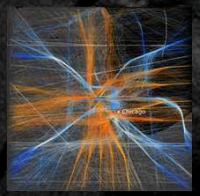


Represents approximately 700 out of the total 50,000 flights.

Discovery of Odd flights
Unsupervised learning







Chicago Air Traffic

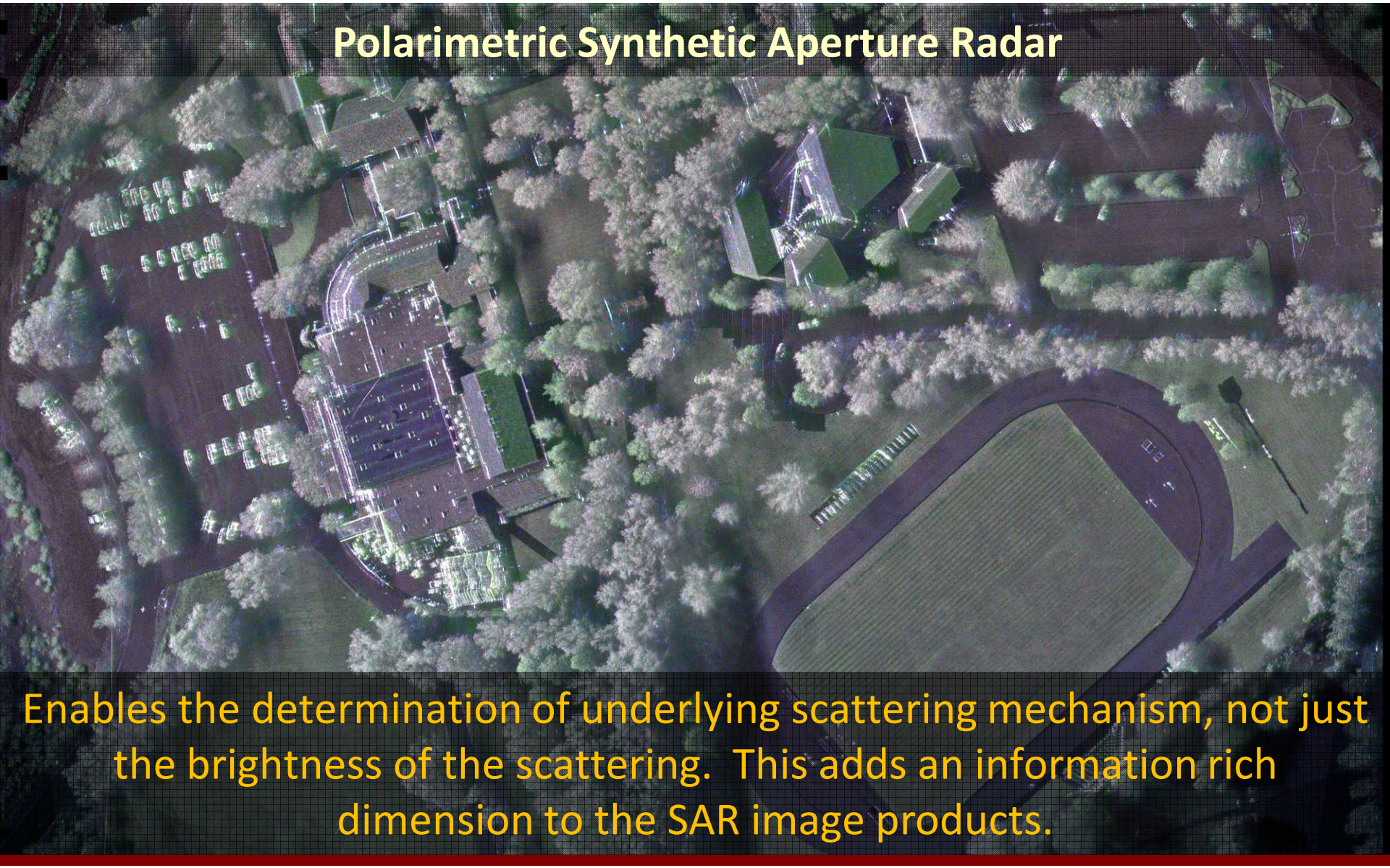
80,456 points
3,986 flights
~15MB of data

Continuous Tracking

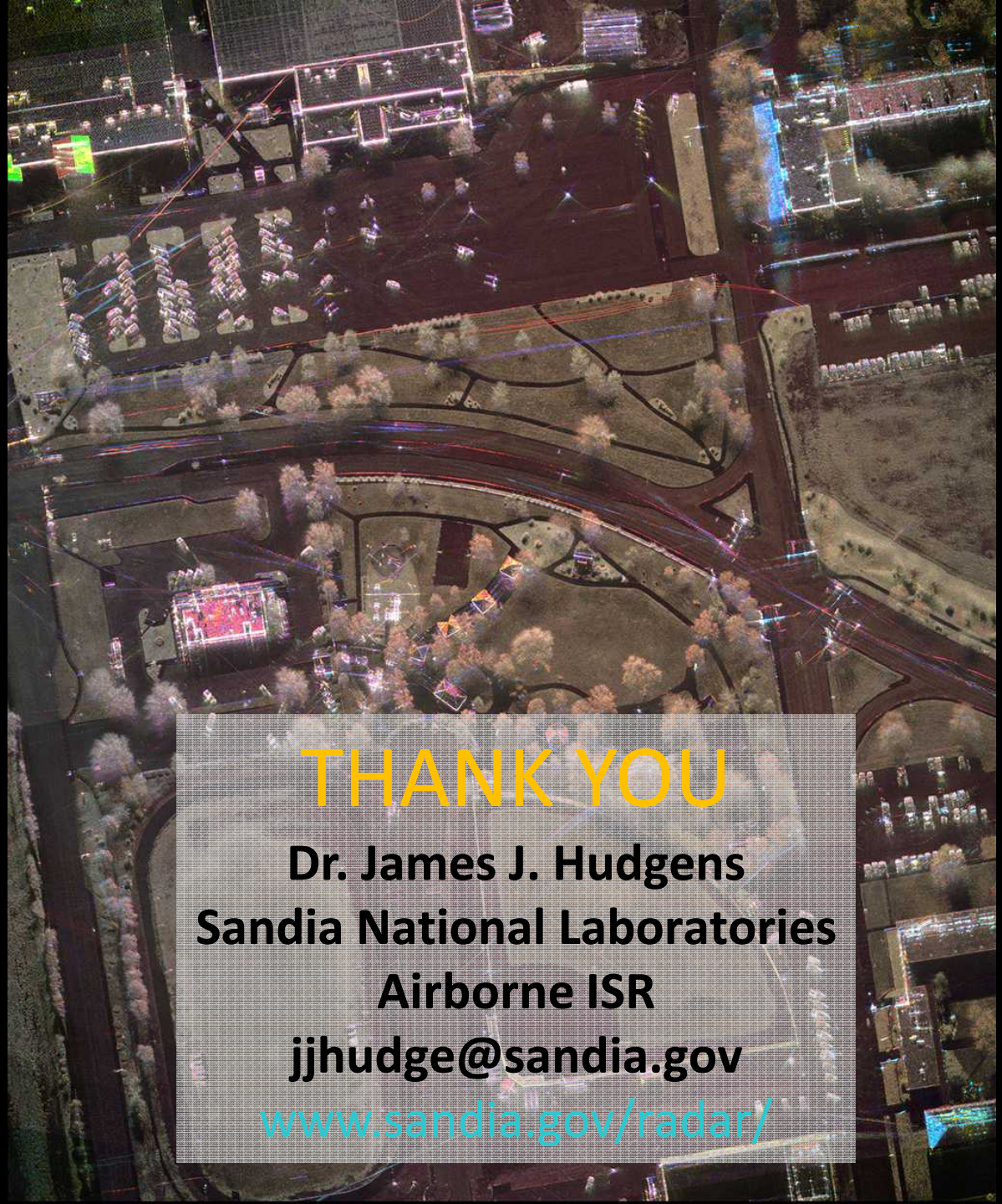
Velocity Independent Continuous Tracking Radar (VICTR)

Simultaneous VideoSAR/GMTI with automated tracking of movers including repointing the antenna

Polarimetric SAR



Enables the determination of underlying scattering mechanism, not just the brightness of the scattering. This adds an information rich dimension to the SAR image products.



THANK YOU

Dr. James J. Hudgens
Sandia National Laboratories
Airborne ISR
jjhudge@sandia.gov
www.sandia.gov/radar/