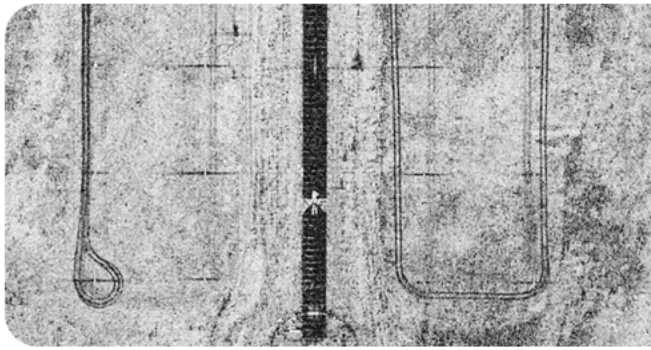
SAND2014-18747C

Exceptional service in the national interest

Sandia National Laboratories





Advancements in Synthetic Aperture Radar (SAR) for Improved ISR

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

Dr. James J. Hudgens, Deputy Director, Airborne ISR Systems
Sandia National Laboratories

October 24th, 2014

U.S. DEPARTMENT OF ENERGY | NNSA

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND NO. 2014-XXXXP

Sandia National Laboratories

Sandia Corporation

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

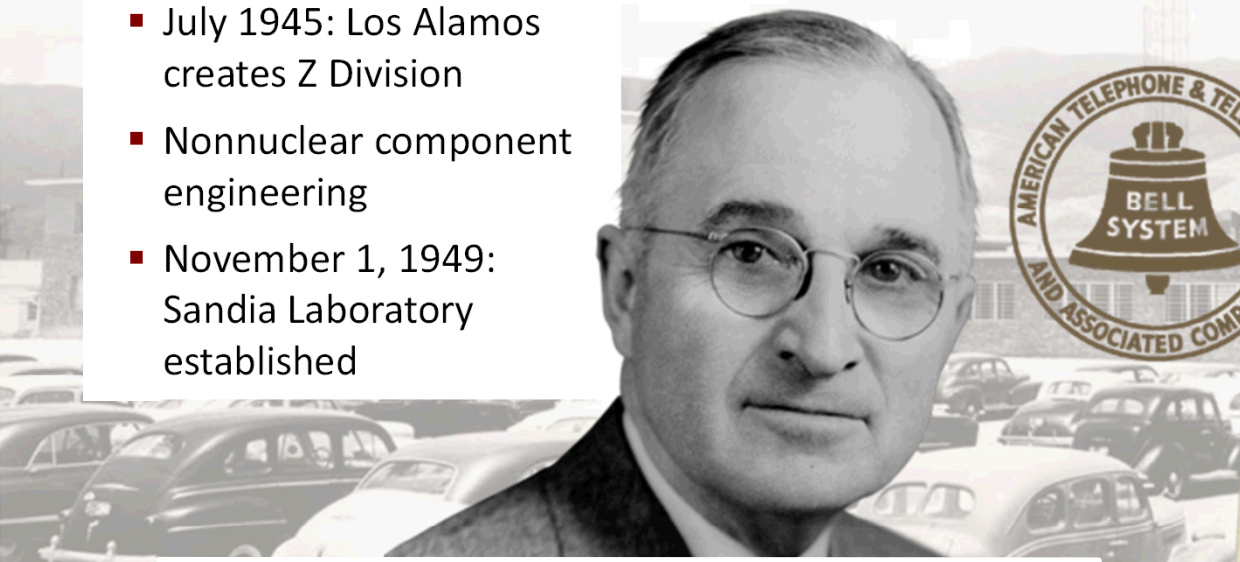
Government owned, contractor operated

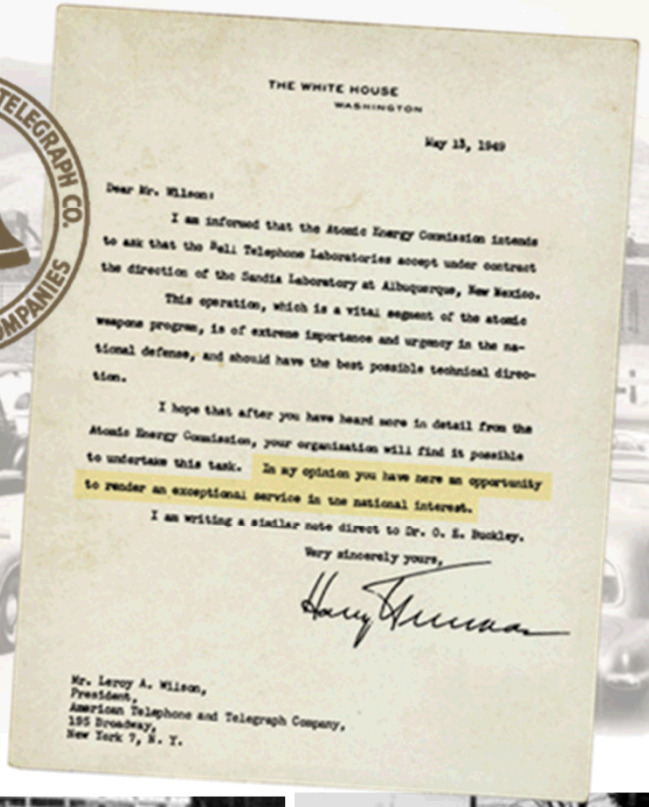
Federally funded research and development center

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.

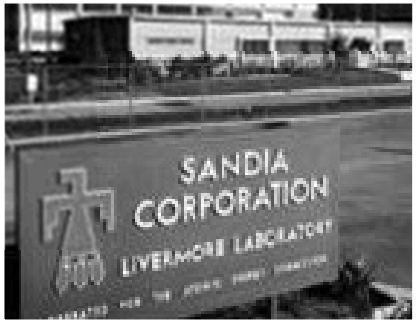
I am writing a similar note direct to Dr. O. E. Buckley.

Very sincerely yours,

Harry Truman

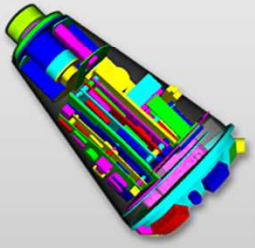
Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.

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

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

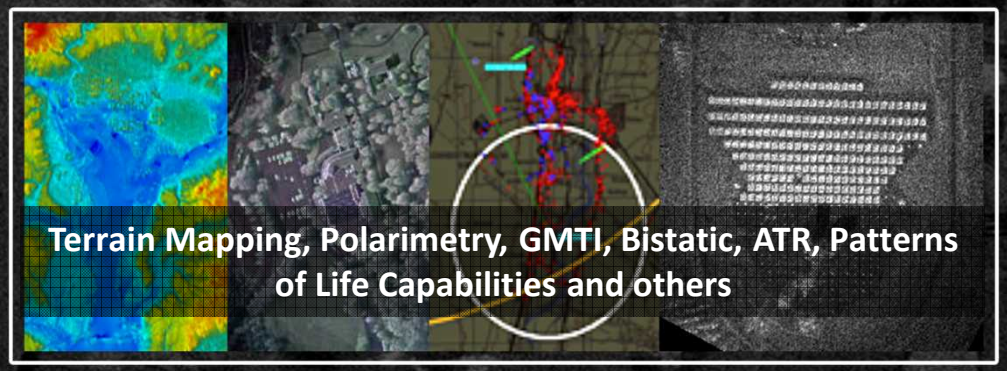
Advanced radar fuzing technology

Synthetic Aperture Radar

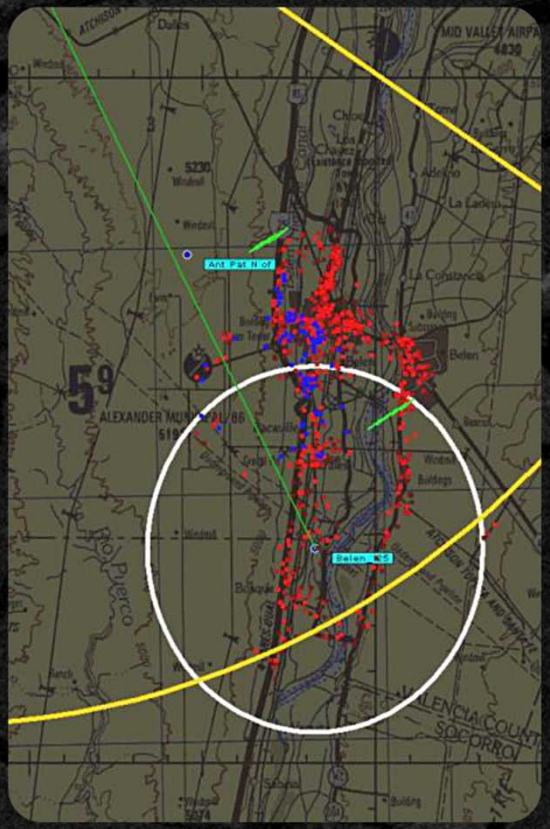
Pathfinder Airborne ISR Solutions

Synthetic Aperture Radar (SAR)

- All Weather, Day or Night
- High Resolution, Optical-like
- Persistent
- On-board and Real-time Processing
- Flexible platform and TPED configuration



SAR/GMTI Overview

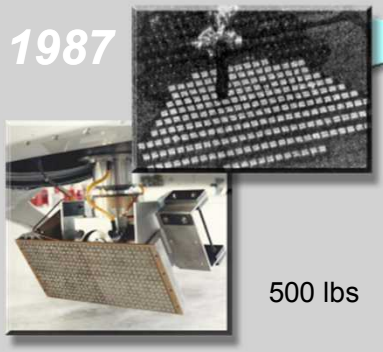


- SAR forms images all weather, day/night
- GMTI provides range and velocity for moving objects
- SAR are designed differently than GMTI radars (Antenna)

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

Sandia SAR Evolution

1987



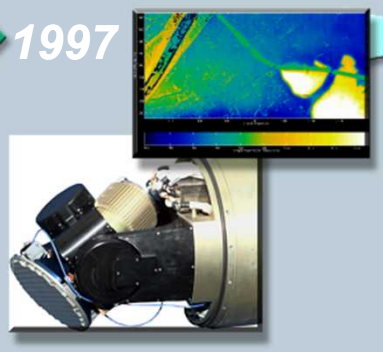
500 lbs

SAR Target Recognition & Location systems (STARLOS)

1991

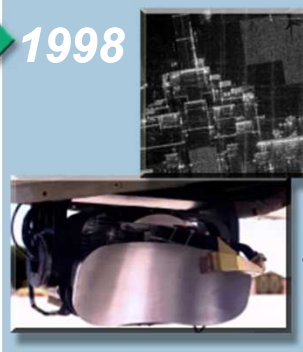
Terminal Fix System (TFS) SAR

1997



Inertial Terrain Aided Guidance (ITAG)

1998

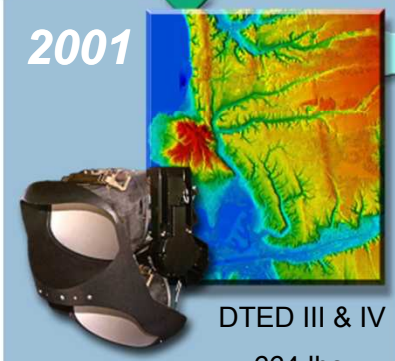


120 lbs

Lynx Multi-Mode Radar

CCD & GMTI

2001

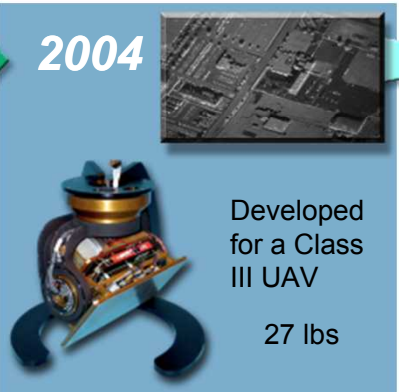


DTED III & IV

664 lbs

Rapid Terrain Visualization (RTV)

2004



Developed for a Class III UAV

27 lbs

MiniSAR

2008

IED Detection

65 lbs

Copperhead

2010

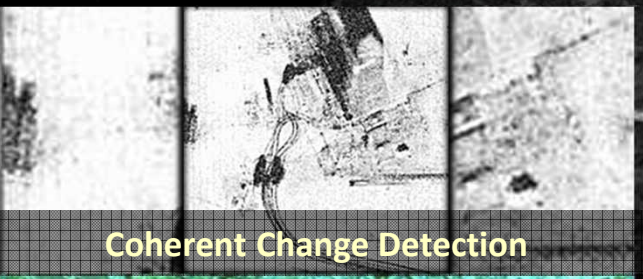
FARAD

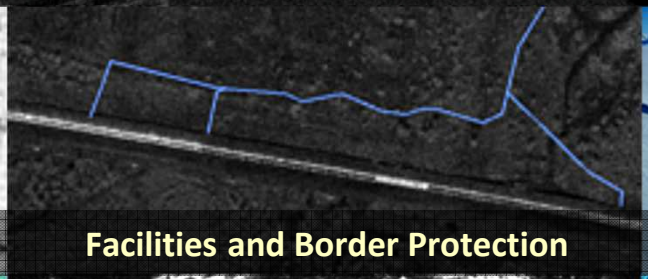
Multi-mode

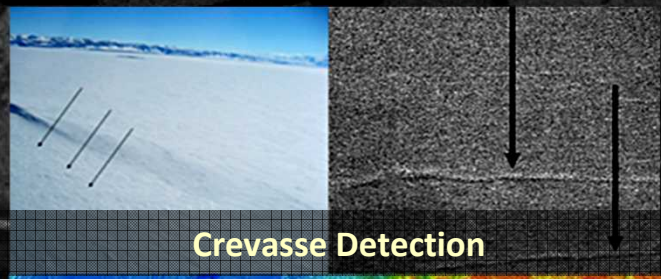
Variable Resolution & SWAP

Improving radar performance & reducing SWAP for over two decades

Real World Applications

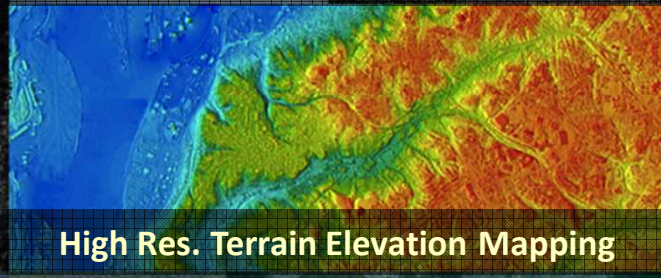

Coherent Change Detection


Facilities and Border Protection


Crevasse Detection

Environmental Monitoring


Space Missions

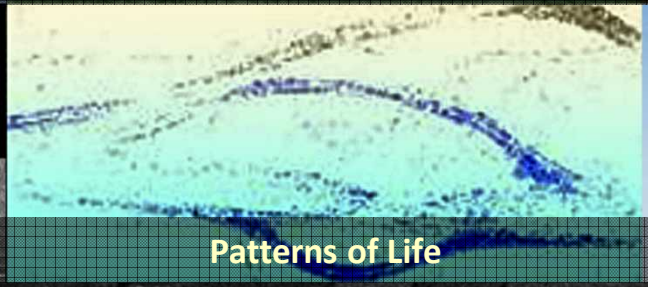

High Res. Terrain Elevation Mapping


Maritime & Littoral


Vehicle and Dismount Tracking


S&R and Targeting

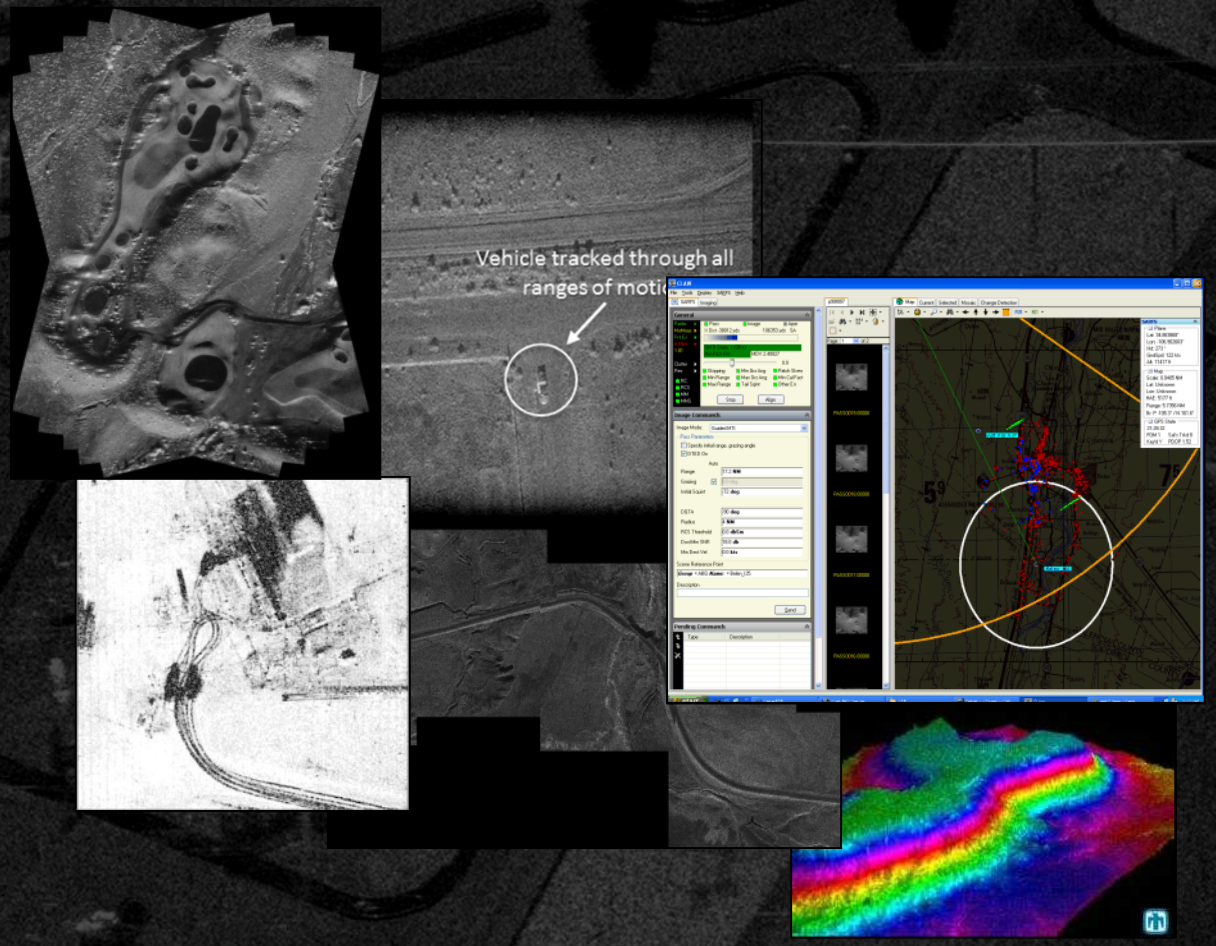

C-IED & Route Reconnaissance


Patterns of Life


Precision Guidance

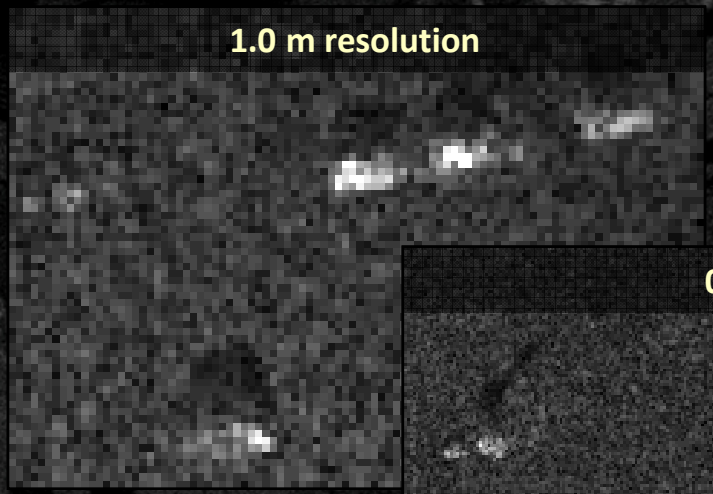
Multi-Mode Functionality

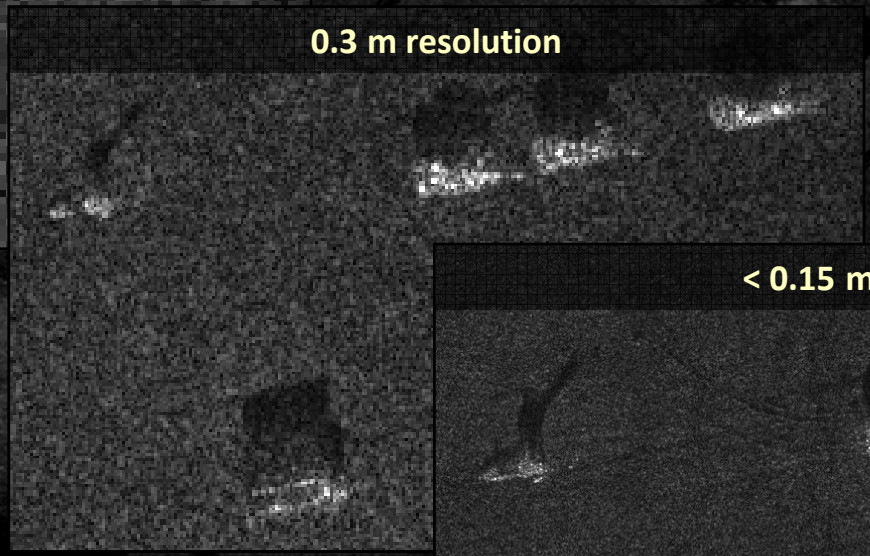
- Spotlight
- SpotDwell
- Circle
- Stripmap
- Arbitrary Stripmap
- CCD/NCP
- IFSAR
- VideoSAR/VICTR
- GMTI/DMTI
- Wide Area Search
- High Range Resolution



As new radar modes are developed they can be integrated into existing Sandia radars during product improvement phases without redeveloping the entire system

Resolution Matters

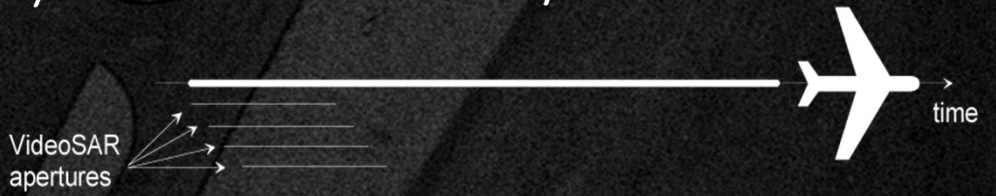




Advanced RADAR Mode: Video SAR

- **Traditional SAR**
  - phase histories are only collected during real-time apertures
  - time between images = time to collect real-time aperture + time to process image (many tens of seconds at long ranges)
  - Moving targets disappear or smear, difficult to locate/track

- **VideoSAR**
  - phase histories are collected continuously
  - images are formed from overlapping sets of phase histories
  - time between images is user selectable and is independent of aperture length (0.1 to 0.3 seconds seems best)
  - slow moving targets (< 15 mph) can often be observed/tracked
  - Latency < 8 sec.

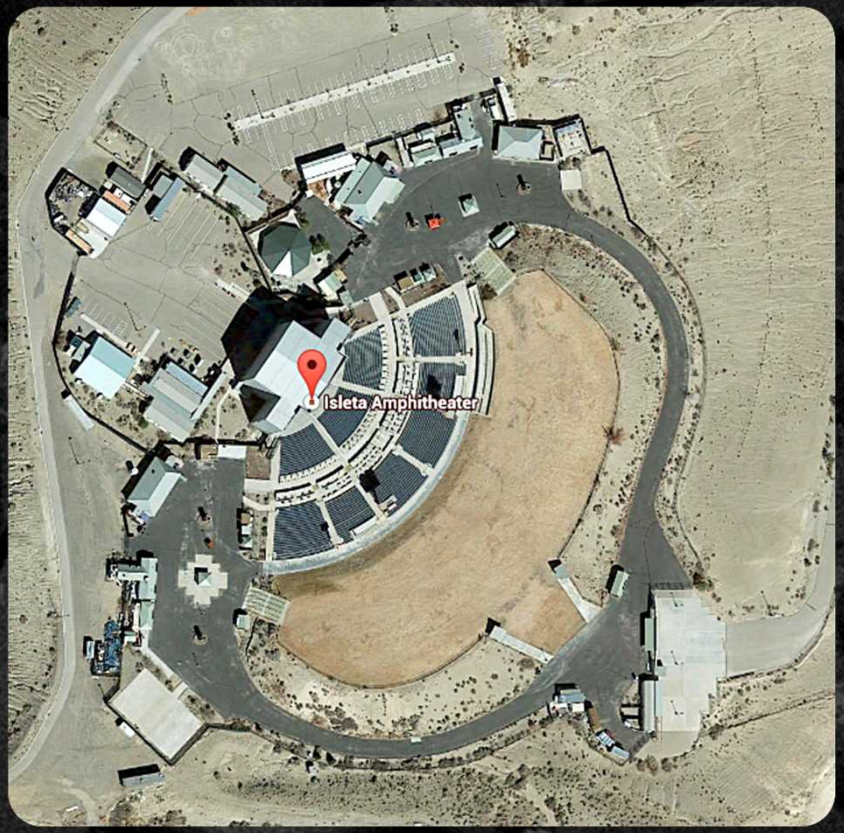


Why VideoSAR?

VideoSAR bridges the gap between SAR and GMTI for slow moving targets. In addition, VideoSAR has the following advantages over traditional MTI:

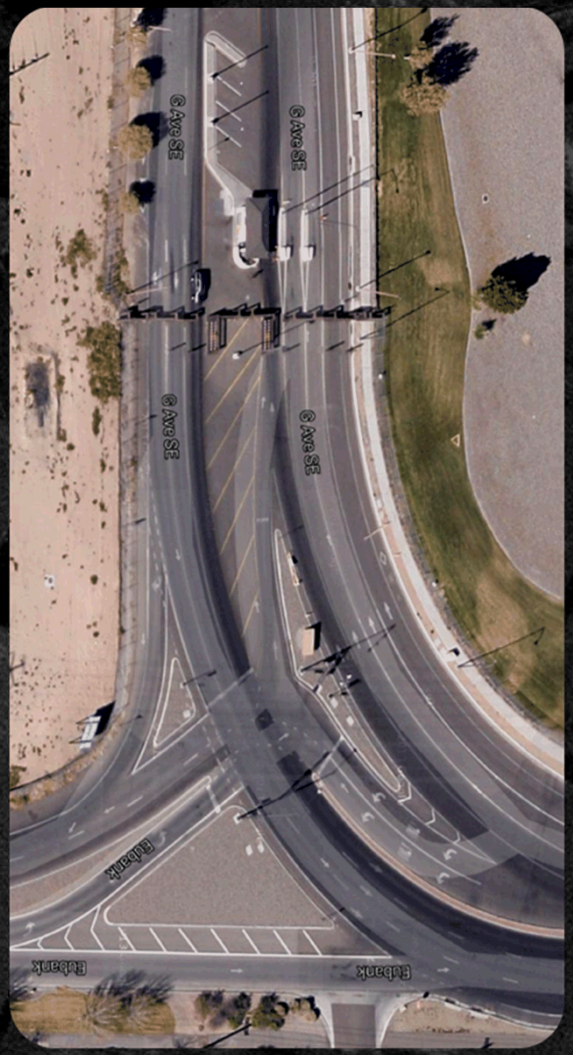
- Minimum detectable velocities down to 0: targets are visible when they are stationary or mobile
- Minimum detectable RCS << 10 dBsm: VideoSAR relies on the shadow of moving vehicles for detection.
- Azimuth resolution < 1 m: vehicle location is know to within the geographic precision of the SAR image
- Moving targets shown in relation to stationary clutter: much more situational awareness than from traditional MTI

VideoSAR



Journal Pavilion Amphitheater
Albuquerque, NM

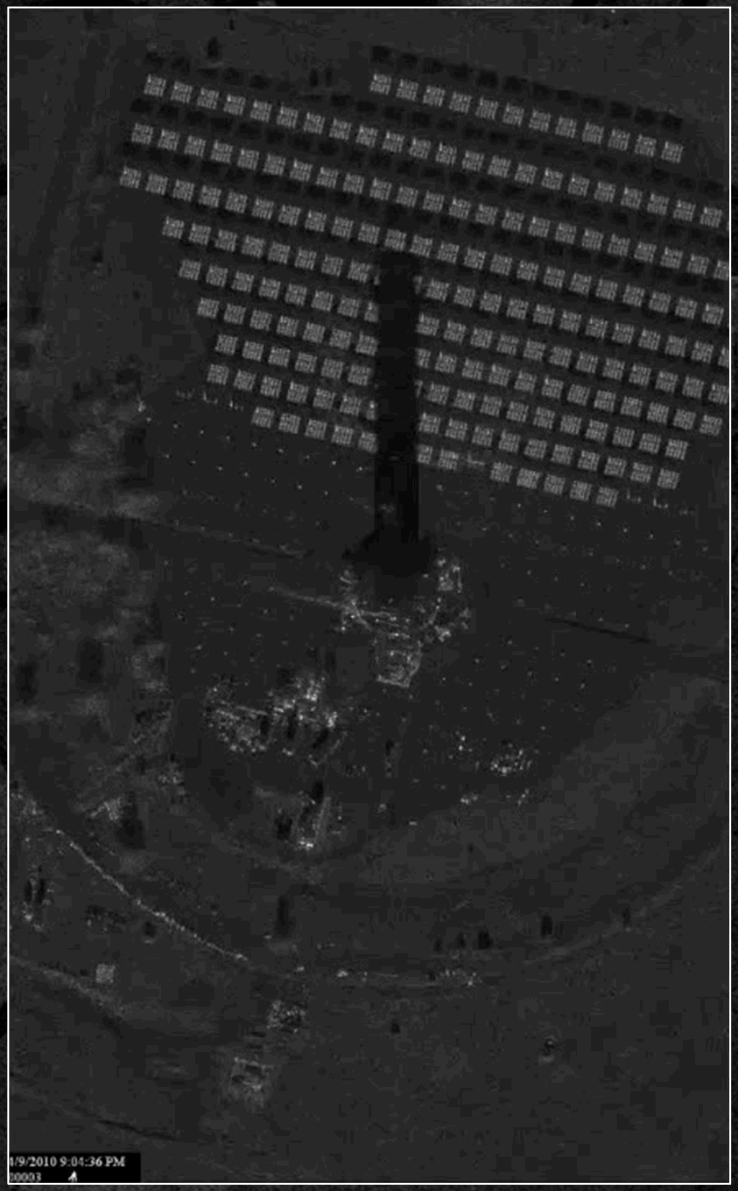
Sample SAR Videos



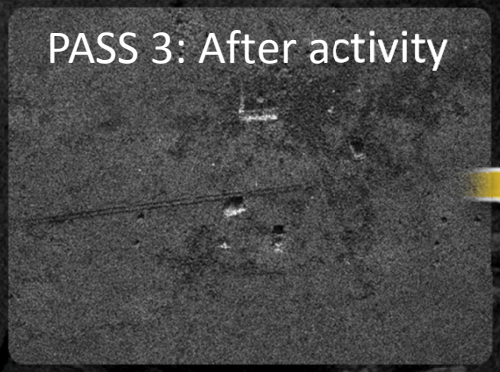
Kirtland AFB Gate
Albuquerque, NM

VideoSAR

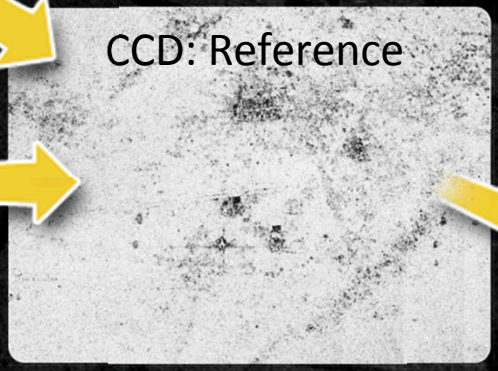
Sandia Solar Tower
Albuquerque, NM



Normalized Coherent Product (NCP)



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



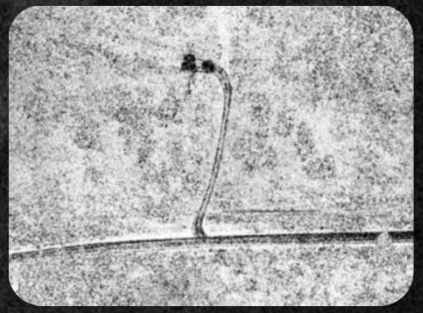
MISSION EXAMPLES

Copperhead

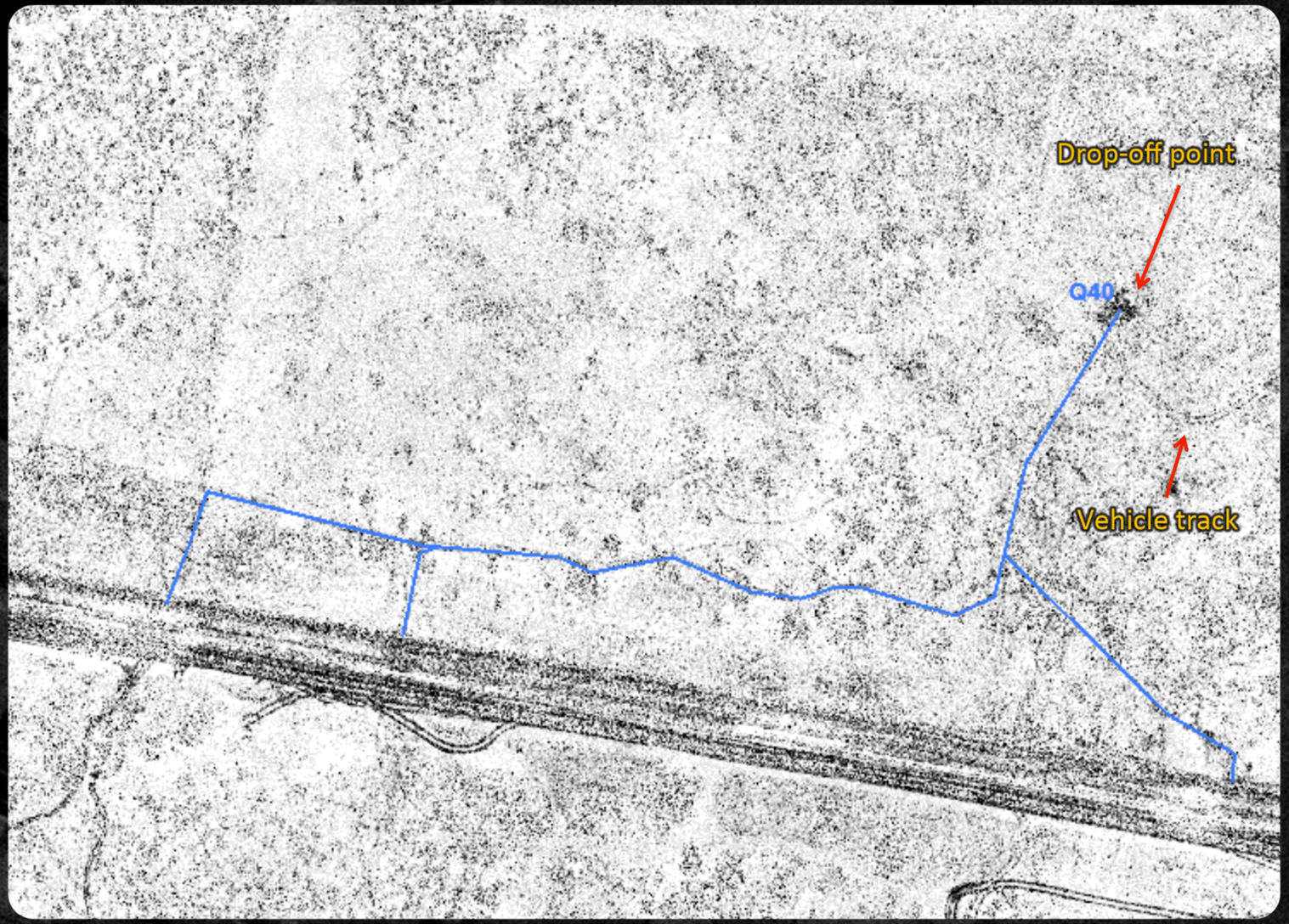
- **Mission**
  - Counter - IED ISR (C-IED ISR) - Monitors one or more routes and provides MGRS coordinates of suspected enemy activity for Route Clearance Teams to investigate

- **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	NAVAIR Extended Tigershark transferring to Hunter

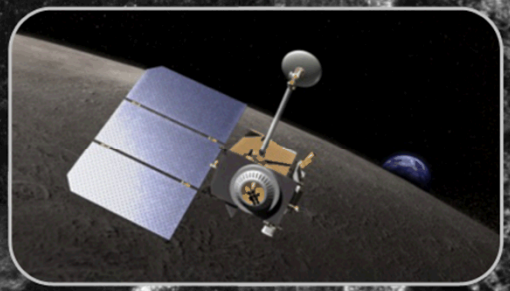


Border Security



Statistically Normalized Coherence

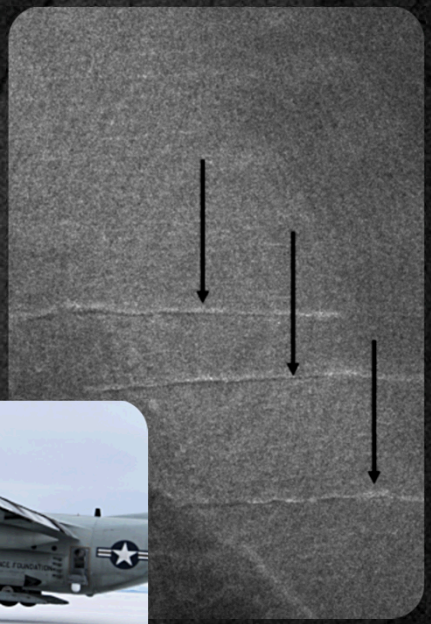
Lunar Reconnaissance Orbiter (LRO)
NASA Program



- Sandia and partners developed the high-resolution bistatic imaging system Mini-RF SAR on board the LRO and helped map 98% of both polar regions of the moon.
- The system identified subsurface water-ice deposits and mapped previously shadowed regions of the moon.

Crevasse Detection

- Developed for the New York Air National Guard (NYANG) and National Science Foundation (NSF)
- The radar provides real-time imaging of large areas at one foot resolution. This allows navigators to make quick decisions about potential landing areas
- The system is used for remote surveying of landing sites for crevasses hidden by snow bridges in all weather conditions

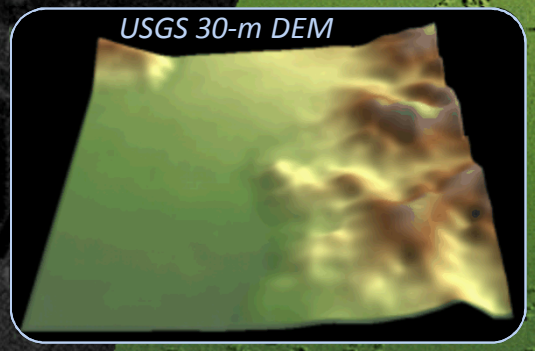


Frequency Band	X-Band (converted from Ku band)
Platform	LC-130
Resolution	0.2,0.3, 1m

Terrain Mapping

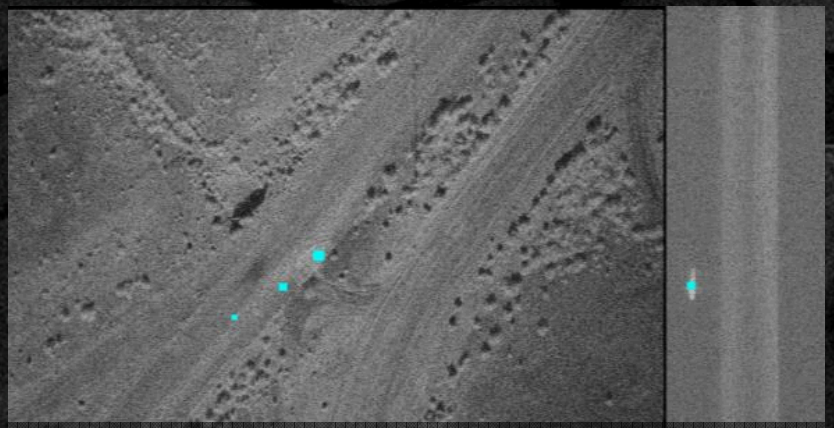
Secret Service and FEMA for Olympic Security

RTV IFSAR -- 3 Meter Terrain – Park City, Utah



Where are we headed?

Fully Polarimetric VideoSAR/CCD

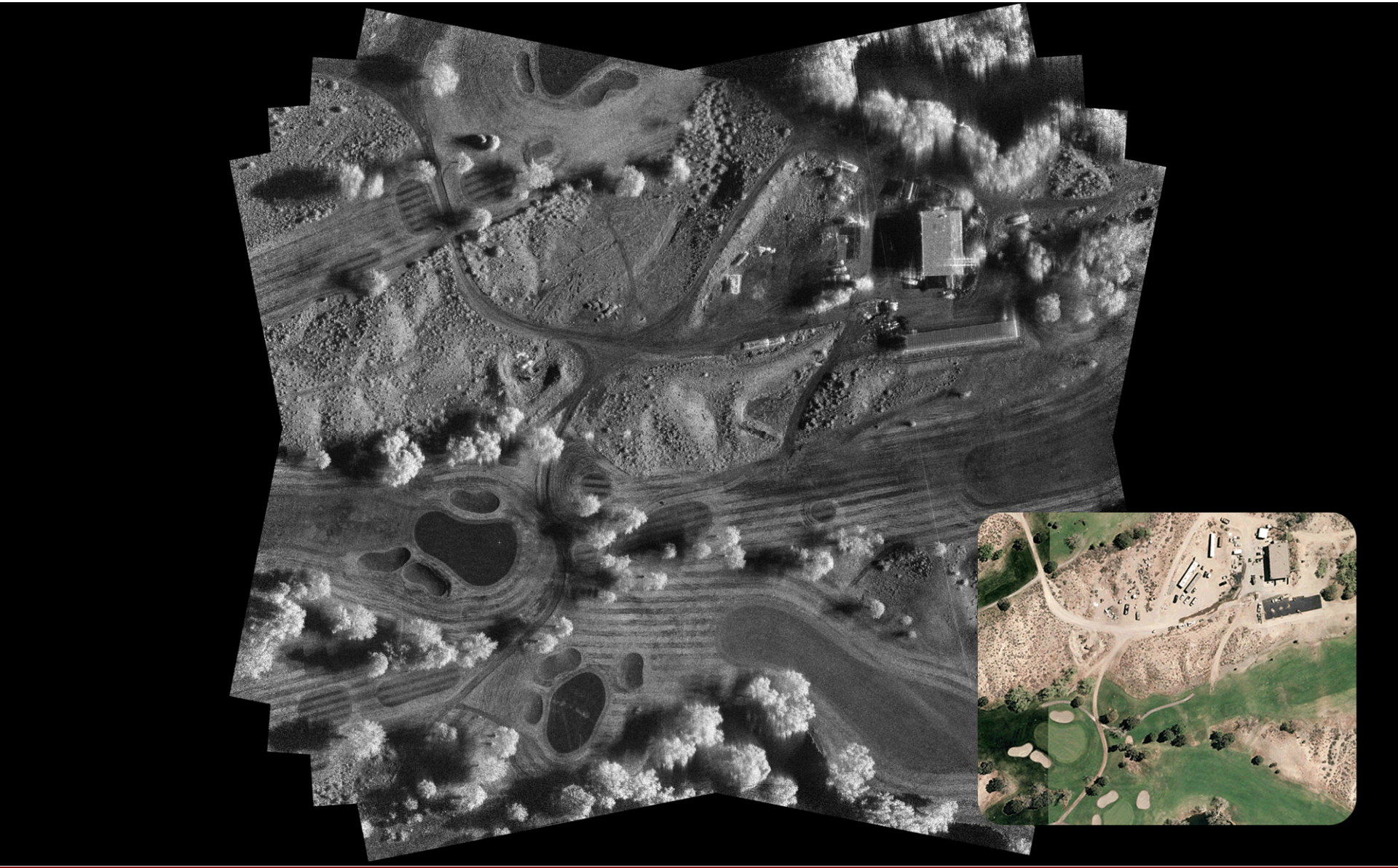


Simultaneous VideoSAR/GMTI with automated tracking of movers including repointing the antenna (VICTR)

Multi-look SAR

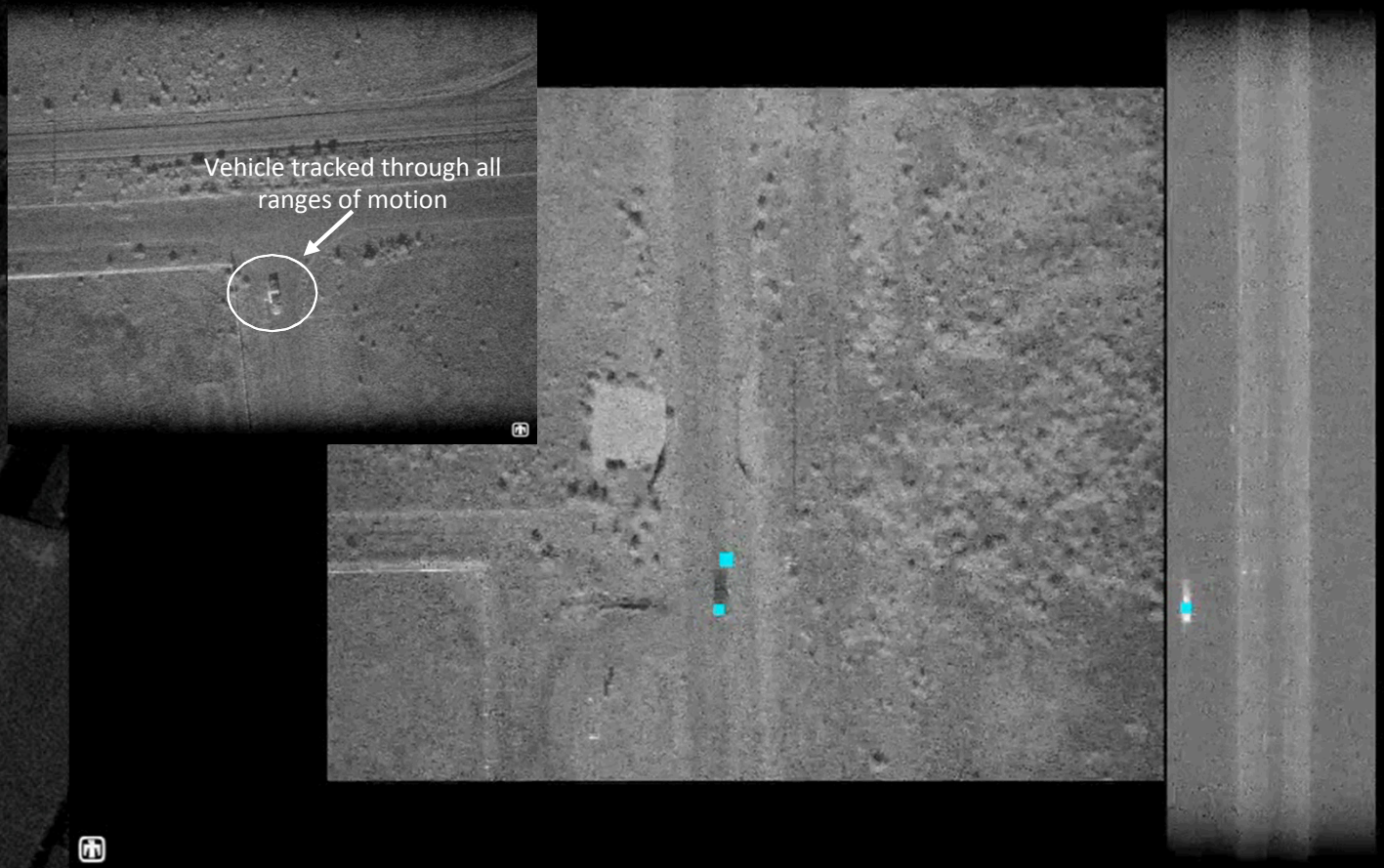
FARAD Radar: In-house multi-mode, high-performance research radar

Multilook SAR



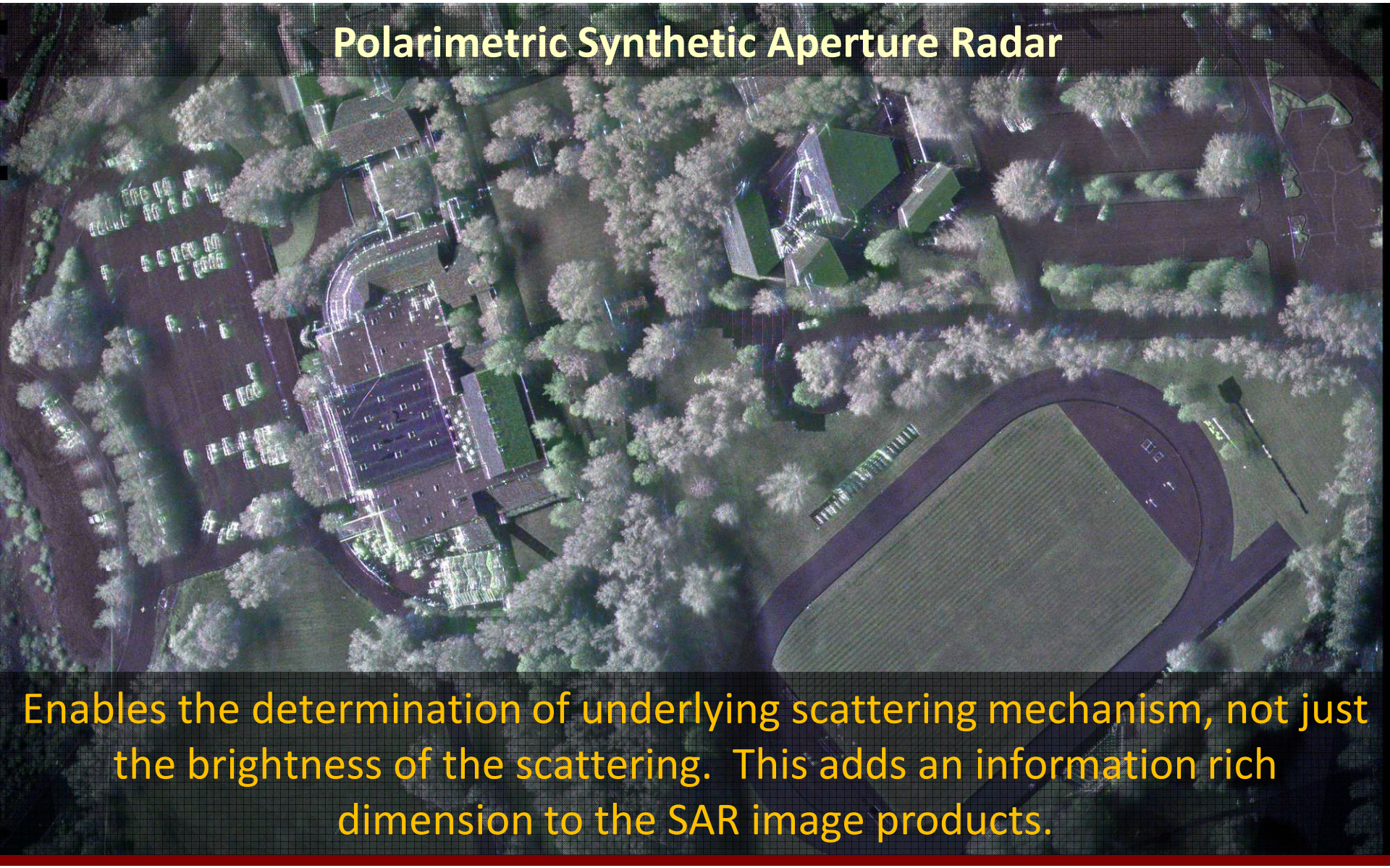
Continuous Tracking

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
Sandia Airborne ISR
www.sandia.gov/radar/