NUCLEAR ENERGY & GLOBAL SECURITY
TECHNOLOGIES

# Border Security

**March 2010**
**Dr. Dianna Blair**

# Sandia was created in 1948 to perform non-nuclear engineering, qualification, and test & evaluation for the U.S. nuclear weapons complex
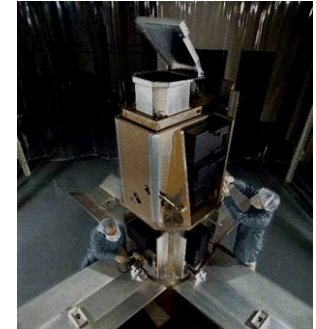
# Sandia National Laboratories Today

- **Six locations**
  - **New Mexico**
  - **California**
  - **Hawaii**
  - **Nevada**
  - **Texas**
  - **Washington, D.C.**

- **Workforce profile – 10,000 people**

  - **8600 permanent staff**
    - **65% Science and Engineering**
    - **50% PhDs/ Masters**

  - **1300 sabbaticals, post docs, students, interns**

  - **2200 contractors**

- **500+ university collaborations**

- **Annual budget (2006) $2.3B**


Nuclear Weapons


Defense Systems and Assessments
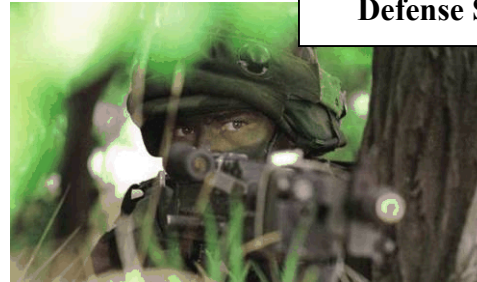

Energy and Nonproliferation
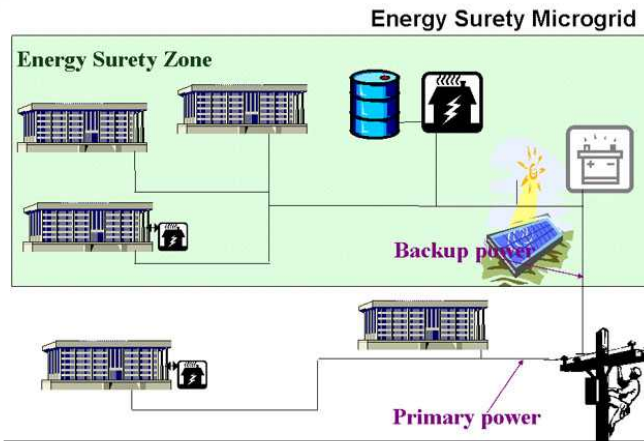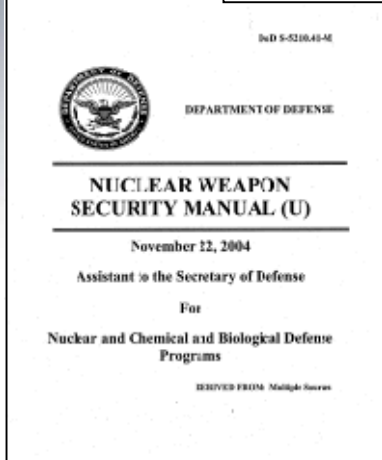

Homeland Security & Defense

**Supported by a science, technology, & engineering base.**

# Homeland Security & Defense Programs



**Physical Security**

**Chemical and Biological Defense**

**Energy Surety Microgrid**

**Energy Surety Zone**

**Backup power**

**Primary power**

**Base Infrastructure Protection**

**Force Protection**

**Borders Security**

**Radiological and Nuclear Defense**

Sandia National Laboratories
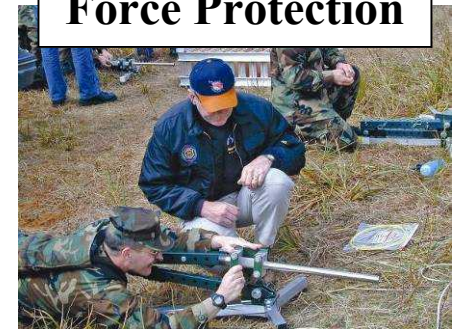
# Sandia National Laboratories
# Borders Security Capabilities & Expertise



## Field Testing
- **Outdoor Test Facility (OTF)**
- **Intrusion Detection Sensor Field**
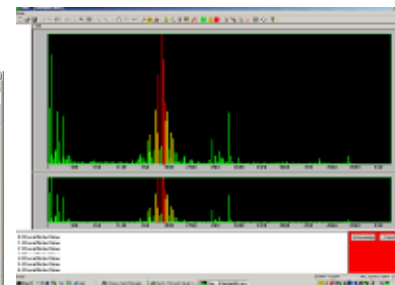- **TEAMS Site**



**Integrated Test Site**

## Specialized Facilities
- **Environmental Testing Complex**
- **Port of Albuquerque/Livermore Container Terminal**



## Relevant capabilities and expertise
- **Systems analysis**
- **Systems modeling**
- **Red teaming**
- **Tunnel detection**
- **Synthetic Aperture Radar**
- **UAVs**
- **Underwater monitoring**

Sandia National Laboratories

# Global Border Management Systems

*Strengthening global efforts to prevent and detect the proliferation of WMD-related materials, equipment, and technology*

- **Workshops and Training**
  - **Border Management Systems**
  - **Needs Assessment**
  - **Export Control**

- **Assessment and Analysis**
  - **Science & Technology Foundation**
  - **International Security Engagement**
  - **Visiting Scholars Program**

- **Technology Test and Evaluation**



**Indian and Pakistani Admirals Discuss Maritime Boundary Issues**

**Since the early 1990s, SNL has been involved in Global Border Security efforts in North America, Russia, FSU, Middle East, Asia, and Africa.**

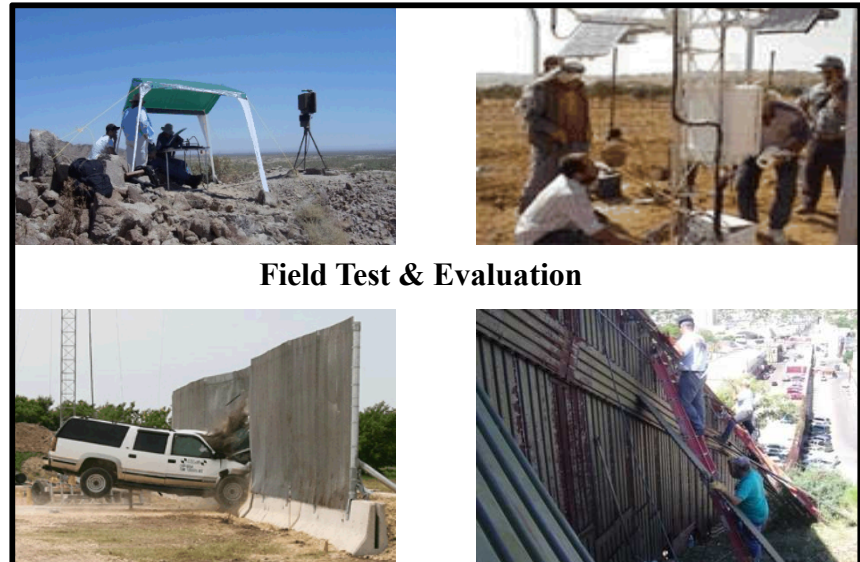# Global Border Management Systems


Contraband Detection in ME


Pakistani observation post along
the Pak-Afghan border


Highlighted areas indicate past and present
Global Security Engagements


Sensor, camera, and communications array at
the SNL Border Security System Test Facility


Field Test & Evaluation

# Border Security Mission

## Frontier Borders

Intercept unauthorized flows of people and goods through the frontier border
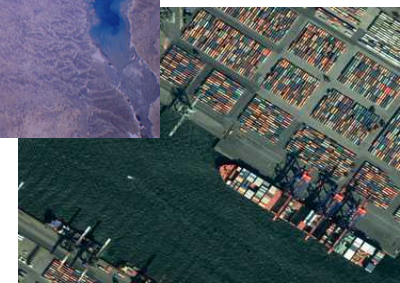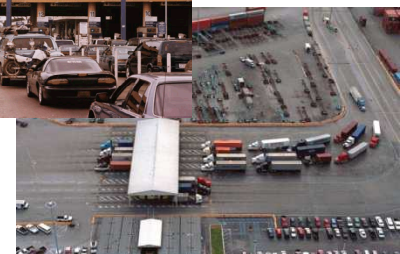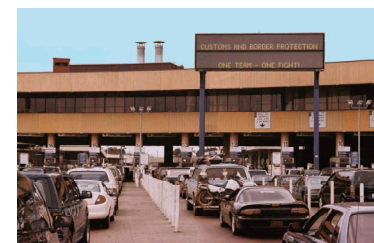
-----------------------

## Land Ports of Entry

Facilitate authorized flows of people and goods through the Ports of Entry, while intercepting illicit traffic and illegal immigration

-----------------------

## Maritime Domains

Operations oriented toward facilitating authorized flows of people and goods in territorial waters and maritime ports while intercepting illicit traffic and illegal immigration

# SNL Testing & Evaluation

## Honest Broker Mission

Provide an independent, unbiased evaluation of security systems and technologies

## Sandia experience

Over 30 years designing and testing security systems and technologies for the US Nuclear Weapons Complex

## Approach

Systems engineering, performance-based methodology derived from our nuclear weapons work

# Testing and Evaluation Overview

- **Scientific testing ensures that quality performance data exists to provide a basis for effective design and implementation of security systems and technologies**

- **Testing is based on standardized test procedures against an established design basis threat**

- **Testing: functional, performance, and vulnerability to defeat**
  - **OT&E**
  - **Probability of Detection (Pd)**
  - **False alarm/Nuisance alarm Rates (NAR/FAR)**
  - **Degradation factors**

# Sandia's Unique Facilities & Capabilities

- **Intrusion Detection Sensor Test Facility**
- **Border Sensor Test Range**
- **Technical Evaluation Assessment Monitor Site (TEAMS)**
- **Container Security Evaluation Facility**
- **Environmental Testing Facilities**
- **Delay Laboratory**
- **Video Assessment Laboratory**
- **Biometrics Laboratory**
- **Explosive Detection Laboratories**
- **Satellite Imagery and Analysis**
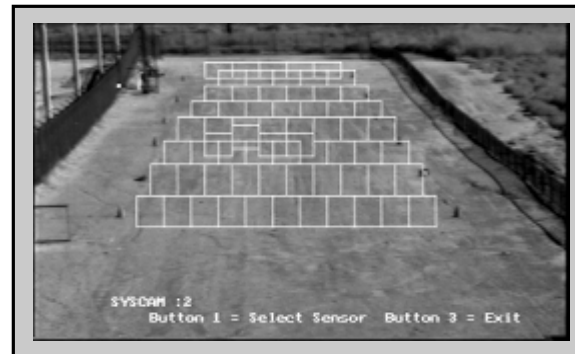- **Super Computing Facilities**
- **Vulnerability Assessment**
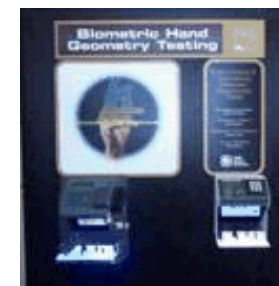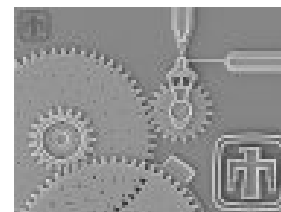
# Intrusion Detection Sensor Field

**IDSF is a multi-purpose area for testing performance and concepts applicable to physical security sensors**

- Exterior security sensors
- Interior security sensors
- Assessment capabilities



## Capabilities

Facility Characterization
On-site test beds
System Design
Installation Oversight
Alignment and Calibration
Acceptance Testing
Maintenance Training



**Intrusion Detection Sensor Field**

# Border Sensor Test Range

**Provides flexible operational test capabilities**
- Integrated Test Site
- Command Center
- Sensor testing
- Camera testing
- Radar testing
- Communications Systems Testing

**Integrated Test Site**

**Data Fusion & Communications System Testing**

**Sensor Testing**

**Camera Testing**

# SNL Border Security System Test Facility for Open Border Monitoring

## Objectives

– **Evaluate, deploy, test, and demonstrate border security technologies and systems in realistic outdoor environments.**

– **Large open area with mobile and fixed-site command center**

– **Enables the gathering of performance parameters from analysis**

– **Infrastructure for testing unattended ground sensors and cameras**

# Technical Evaluation Assessment Monitor Site (TEAMS)

**TEAMS provides a stable, flexible, multi-purpose area to test concepts applicable, but not limited to, radiation, biological, chemical, and explosive sensors**

- Cooperative SNL/DTRA facility
- CONOPs development
- Background measurements
- Performance measurements
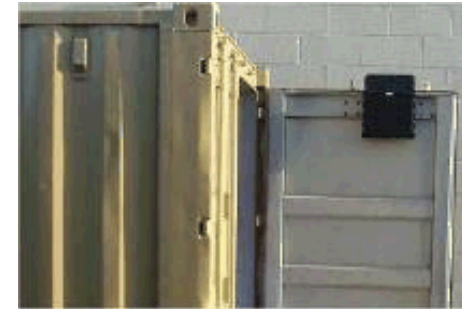- Calibration, testing
- Radiation sources



08/12/2004

Sandia National Laboratories

# Container Security Evaluation

## Port of Albuquerque

PoA provides a multi-purpose area to conduct functional, performance, and defeat testing for maritime security devices.

- Cargo Containers
  - 20-ft, 40-ft, 40-ft Hi-Cube,
  - Steel & Aluminum
- Infrastructure
  - Communication
  - Lighting



| TECHNICAL OBJECTIVES | | |
|---|---|---|
| Objective | Goal | Threshold |
| Detect a hole in the container | | |
| Time to detect hole in the container | | |
| Time to detect door open status | | |
| Linear distance to detect door open | | |
| Time to detect person(s) [> 50lbs/110 lbs] | | |
| Probability of Detection (Pd) of an alarm event | | |
| Probability of False Alarm (Pfa) | | |
| False Alarm Rate (Rfa) | | |
| Operational Availability (Ao) | | |
| Power Source Duration | | |
| Cost/Trip | | |

## Livermore Container Terminal

OT&E of Container Security Devices

Advanced Container Security Device R&D

Partnership with Port of Oakland

- Deploying systems

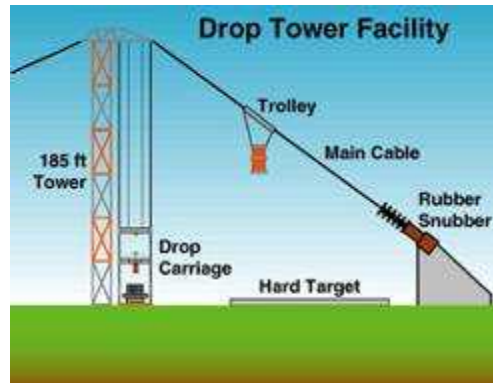- Est. baseline conditions & OT&E in CA- HI trade lanes

Sandia National Laboratories

# Environmental Testing Facilities

Shake Table

**Environmental testing of component-level assets to full systems**

- **Mechanical shock**
- **Temperature testing**
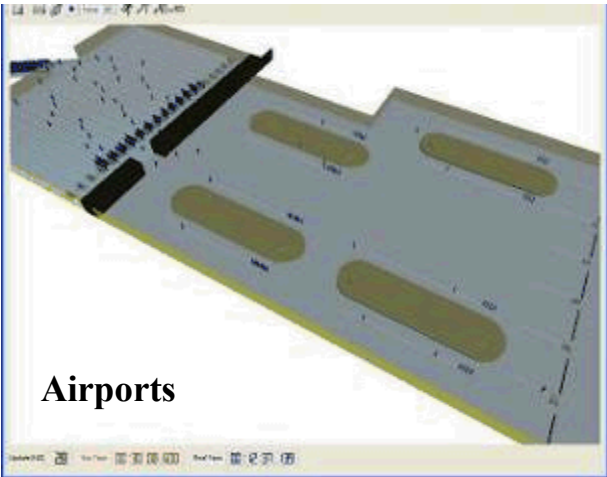- **Vibration testing**
- **Radiation testing**
- **Salt fog**

Drop Tower Facility

185 ft Tower

Trolley

Main Cable

Rubber Snubber

Drop Carriage

Hard Target

**Facilities in NM, CA, NV, and HI**

Sandia National Laboratories

# Modeling and simulation tools provide systems analysis of security and operations at US borders
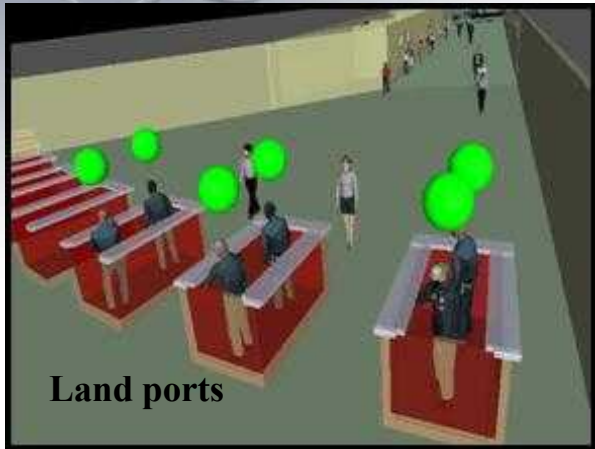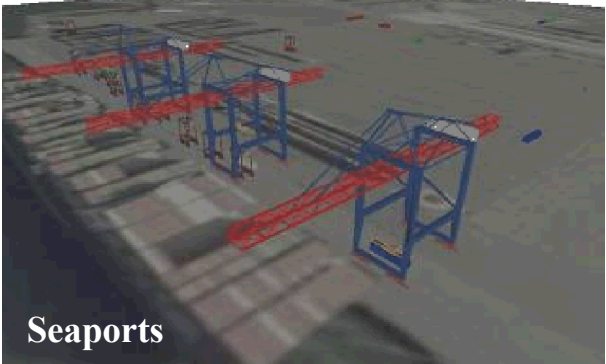

Land ports


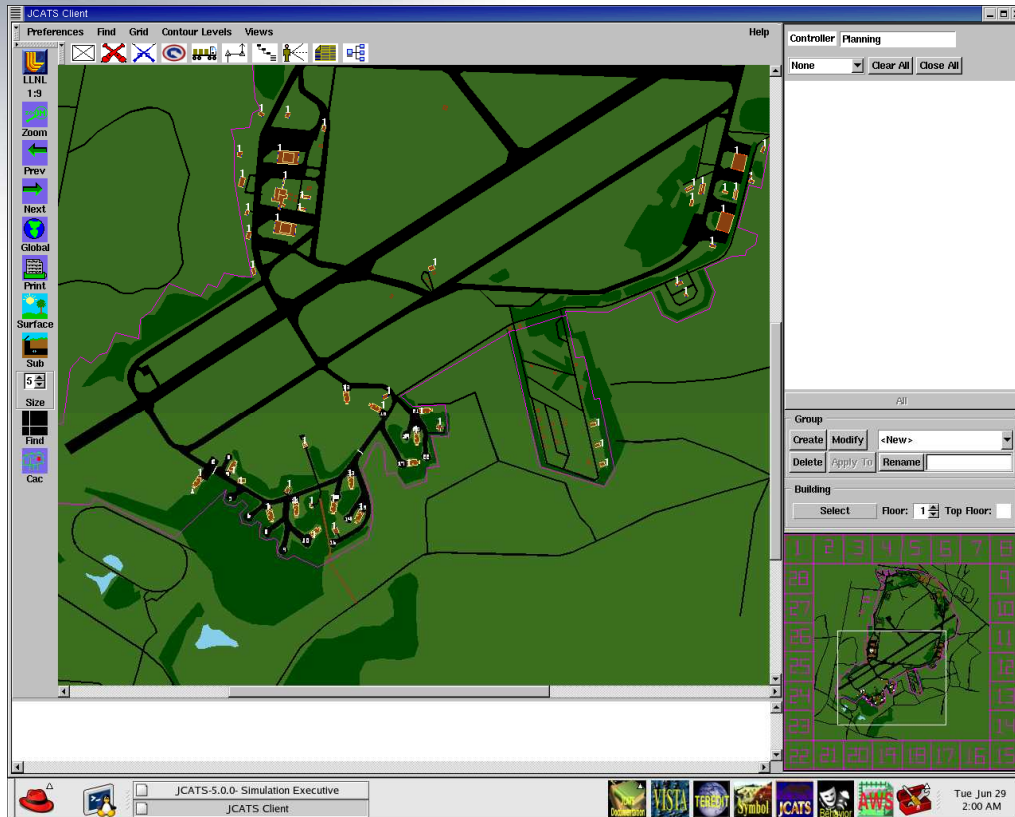

Airports

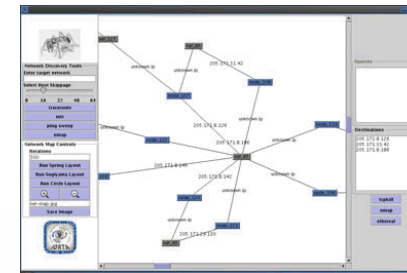# Integrated SoS Models and Analysis


Seaports





Economics

# Sandia has capabilities to assess effectiveness of protection systems and perform red team assessments



**Joint Conflict and Tactical Simulation (JCATS)**
- **Large-scale, theater-level simulations**
- **Smaller force-on-force interactions**

## Red Teaming
- **Flexible tool for current or dynamic threats**
- **Measurable, reproducible, and actionable results**

# Sandia has efforts assessing current methods for tunnel detection and developing new techniques

- **Current technology assessments**
  - Seismic and acoustic sensors for detecting people
  - Active geophysical techniques such as gravity gradiometry, EM resistivity and gradiometry, seismic reflection
  - Experience in underground characterization from Otay/Mesa/Calexico with NORTHCOM, DOE waste remediation and energy exploration, and DoD hard target defeat

- **Development of advanced systems**
  - Systems analysis of tunnel construction to identify high-risk sections of border
  - Tunnel finding/monitoring system such as instrument intelligent passive seismic, acoustic and EM sensor systems
  - Monitor for specific tunnel detection
    - Use complete signatures of tunnel construction activity
  - Use background noise to create subsurface images
    - Direct tunnel imaging
    - Change detection
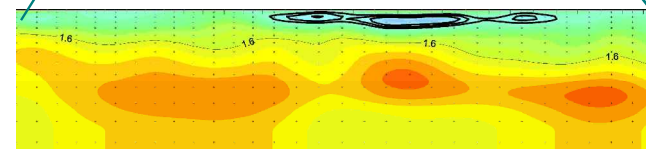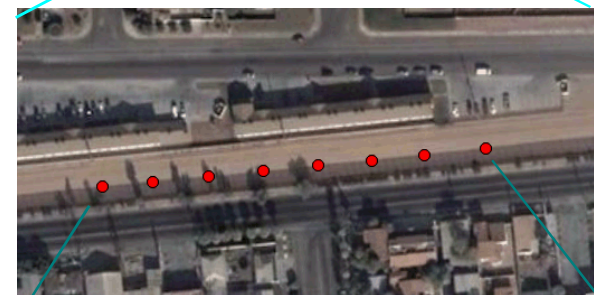
# Sandia's capabilities allowed us to quickly develop and execute a T&E program for underwater detection

- **Multi-vendor, multi-customer tests**
  - **NOAA Facility, Lake Washington, WA**
- **Demonstrate performance in detecting & identifying humans**
- **Evaluate heuristic deployment, automated alarming**
- **Range of real-world operations & conditions**
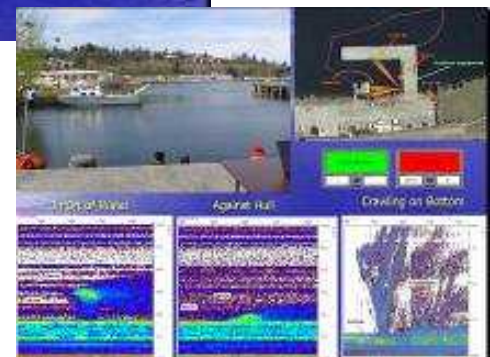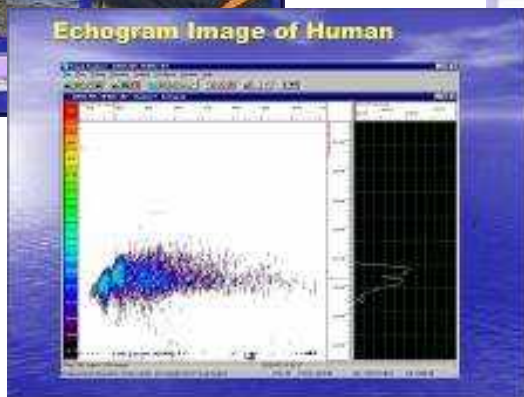
# Sandia Synthetic Aperture Radar Systems

**Novel Real-time SAR and Interferometric SAR**

- **Two decades experience**
- **Multiple frequency bands (VHF, UHF, L, S, X, Ku, Ka)**
- **Ultra-fine resolution (4")**
- **Real-time Exploitation (Coherent Change Detection, Aided Target Recogntion, Ground Moving Target Inidcation)**
- **Full system development**
- **Miniaturized systems**
- **Fielded operational systems**



HRTI 4 Real-time Topographic Mapping



Coherent Change Detection
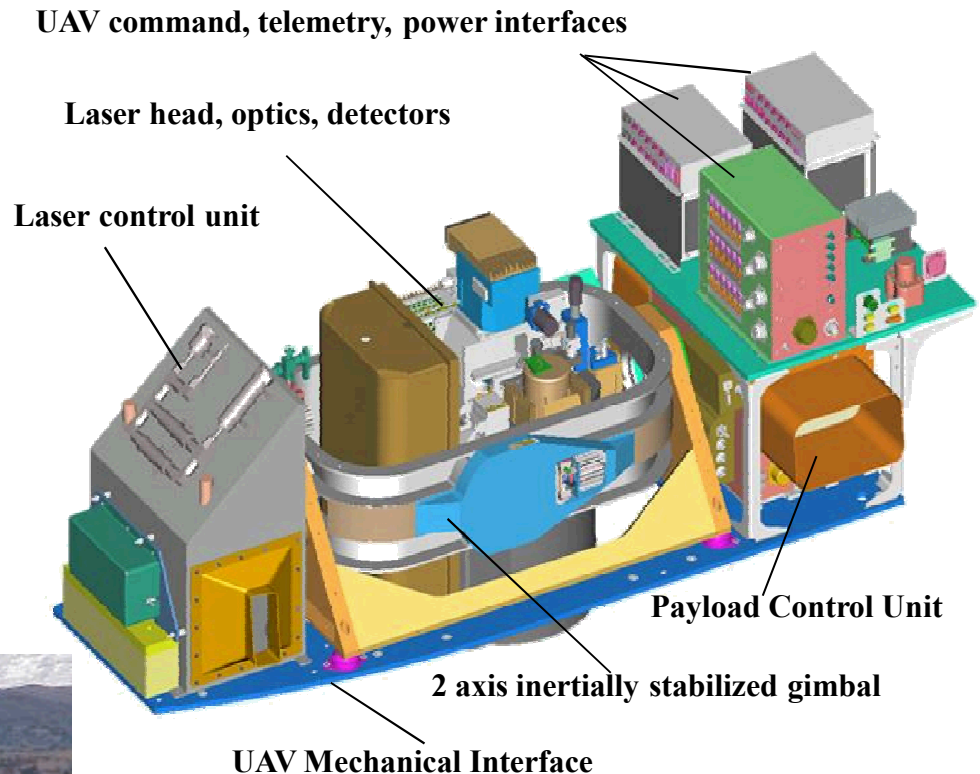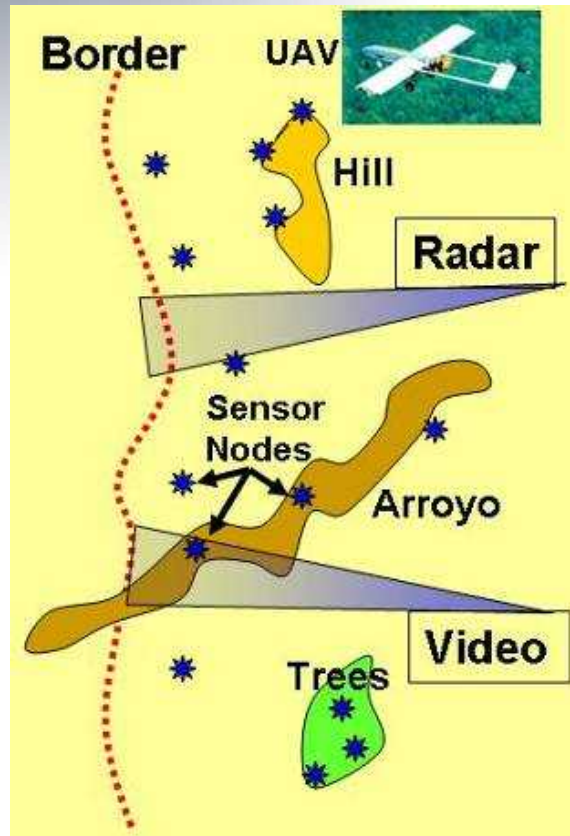
Expanded View of a 2.5 Ton Truck
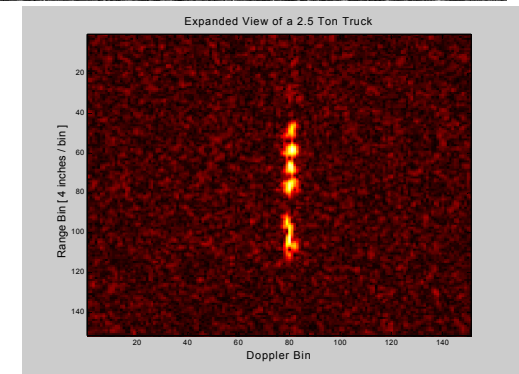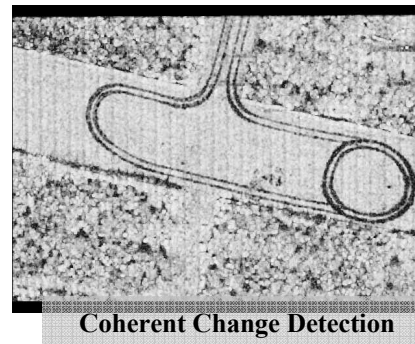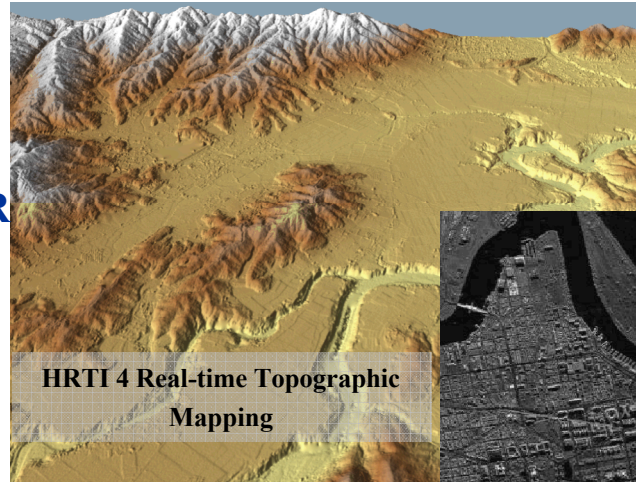
# Sandia has developed UAV-based instrumentation payloads and T&E of UAV systems and operations

- **Over 20 yrs experience**
- **Data collection in more than 460 operational flight hours**
- **WMD proliferation missions**
  - **Chem/bio stand-off detection**
- **Climate prediction and climate change assesments**
- **Working relationship with UAV manufacturers**

**UAV command, telemetry, power interfaces**

**Laser head, optics, detectors**

**Laser control unit**

**Payload Control Unit**

**2 axis inertially stabilized gimbal**

**UAV Mechanical Interface**

Sandia National Laboratories

- **Sandia is performing OT&E and Field Development Evaluations for VPEDs components, and subsystems for DOE and DoD programs.**
  - **Radar systems**
  - **Thermal imaging**
  - **IP video**
  - **Wireless communications**
  - **Ground sensors**
  - **Algorithms for data processing**
  - **VPS architecture and systems**
- **Networked systems solutions**

**21st Century Border Solutions require 21st Century Technology and Systems**
**• Networked Sensors, Data Fusion, Decision Support**

# Sandia is Involved in Remote Field Testing and Cooperative T&E Efforts at the Borders
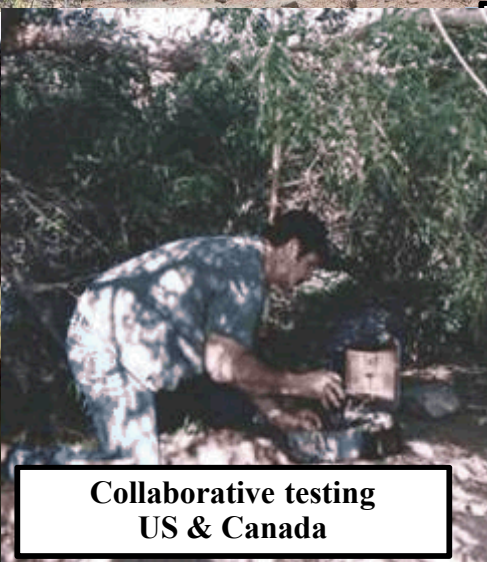


Border Patrol Agent Installing Sensor

National Guard Installing Seismic Sensors

Ground-Based Radar Technology

Fiber Optic Fence Sensor Installation

Collaborative testing US & Canada
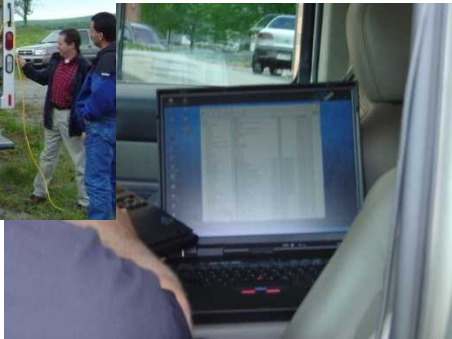
Fiber optic protective measures test at SNL

# Collaborative US Border Patrol / Canada's Integrated Border Enforcement Teams (IBET)

**Long Range Video**

**US Border Patrol Agent**
**Royal Canadian Mounted Police Agent**

**Ground Sensors**

**Maritime Radar Testing**

# Long Range Sensors
## (Acoustic Fiber Optics)



Fiber Optic

Sandia National Laboratories
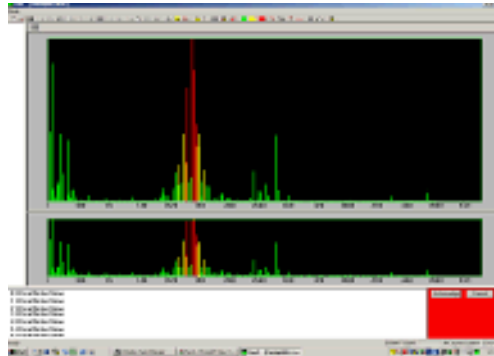
# Ground Surveillance Radar Testing by Border Agents







**Mohawk Valley, 65km southeast of Yuma, AZ**

# Performance Sensor System Testing

- **Probability of Detection**
- **NAR / FAR**
- **Vulnerability Assessment**



**Night Testing of Passive Infrared**



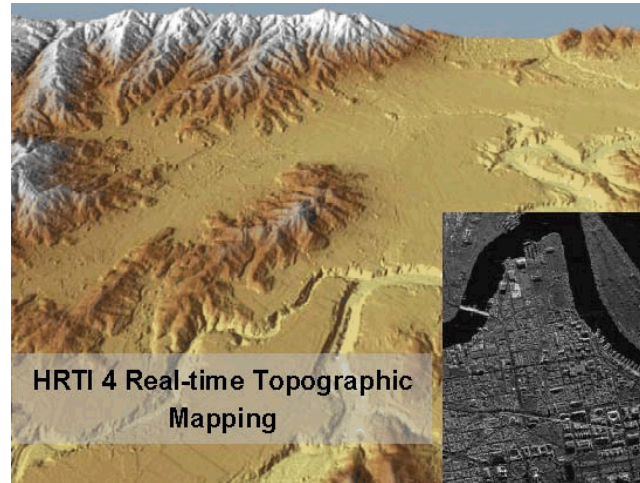**Testing BA-5590 Batteries**



**Seismic -- human walking versus distance**







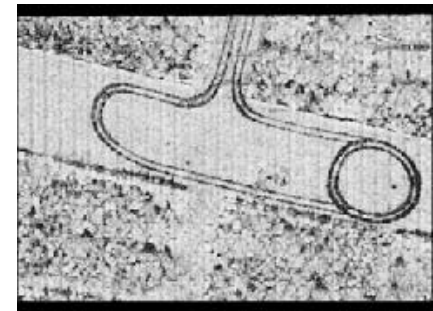**Testing Against Various Threat Types --**

# Sandia Synthetic Aperture Radar Systems


HRTI 4 Real-time Topographic Mapping

**Novel Real-time SAR and Interferometric SAR**

- Two decades experience
- Multiple frequency bands (VHF, UHF, L, S, X, Ku, Ka)
- Ultra-fine resolution (4")
- Real-time Exploitation (Coherent Change Detection, Aided Target Recognition, Ground Moving Target Inidcation)
- Full system development
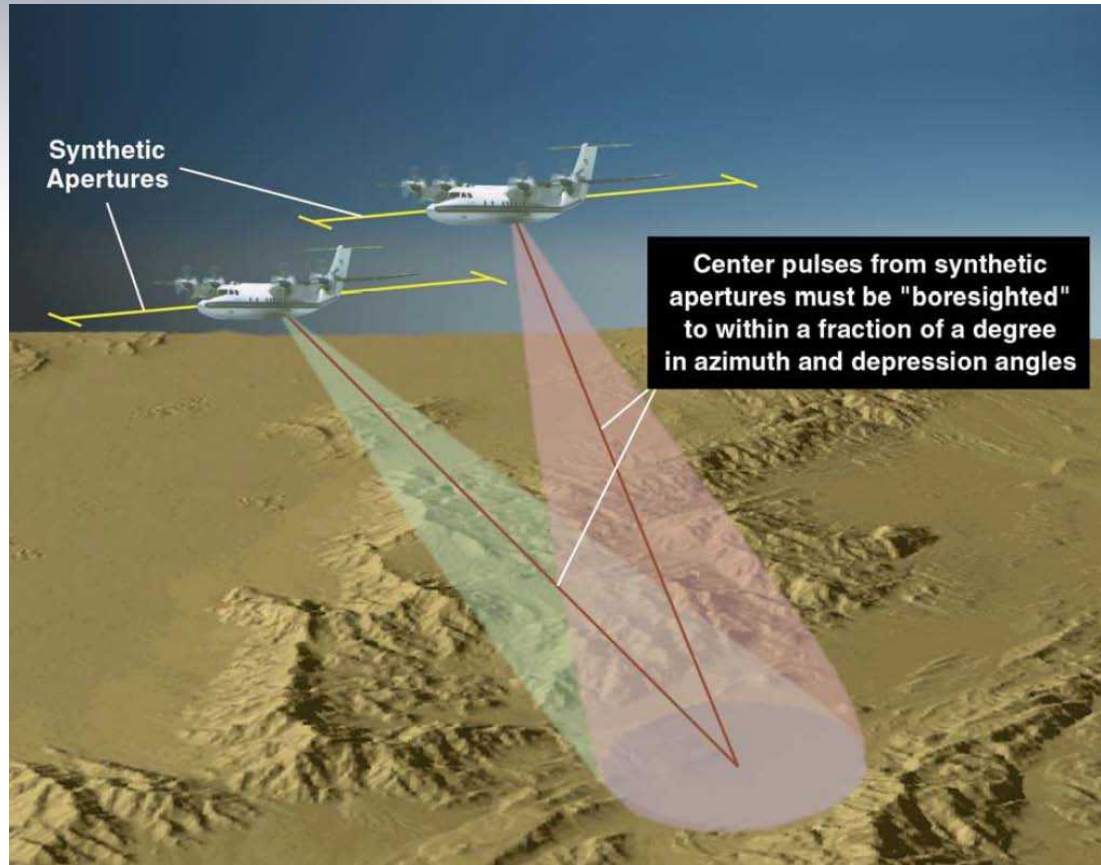- Miniaturized systems
- Fielded operational systems


Coherent Change Detection

Sandia National Laboratories

# Coherent Change Detection (CCD)



Synthetic Apertures

Center pulses from synthetic apertures must be "boresighted" to within a fraction of a degree in azimuth and depression angles

- **Two SAR passes**

- **Similar imaging geometries**

- **Accurate motion compensation**

- **Accurate image registration**

- **Availability of complex image data**

- **Low-loss image compression and transfer**

# Baseline CCD map example



SAR magnitude image



CCD map

Mower activity

Human footprints
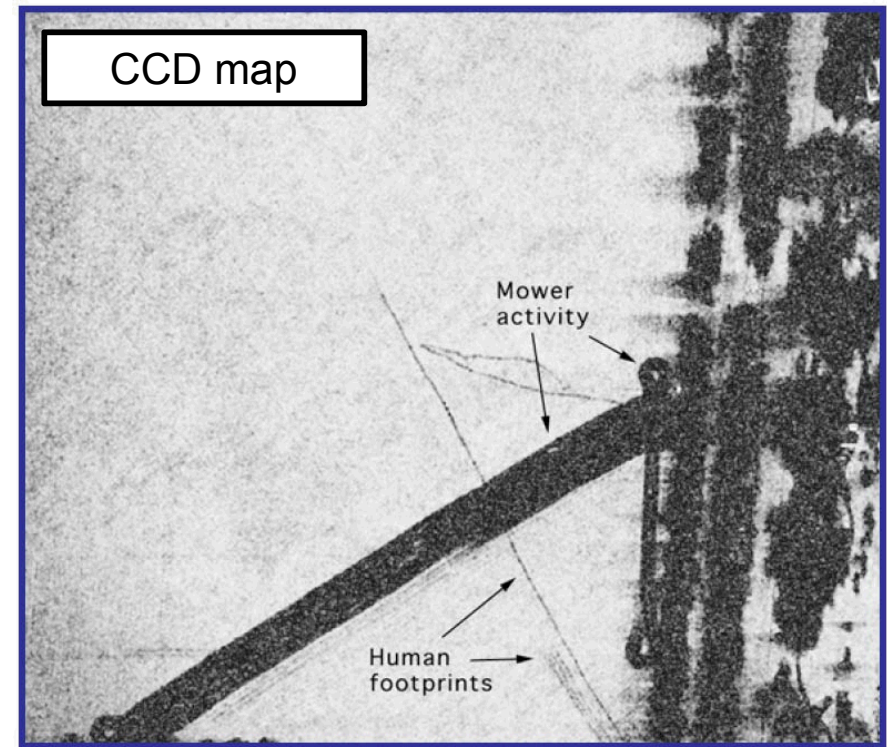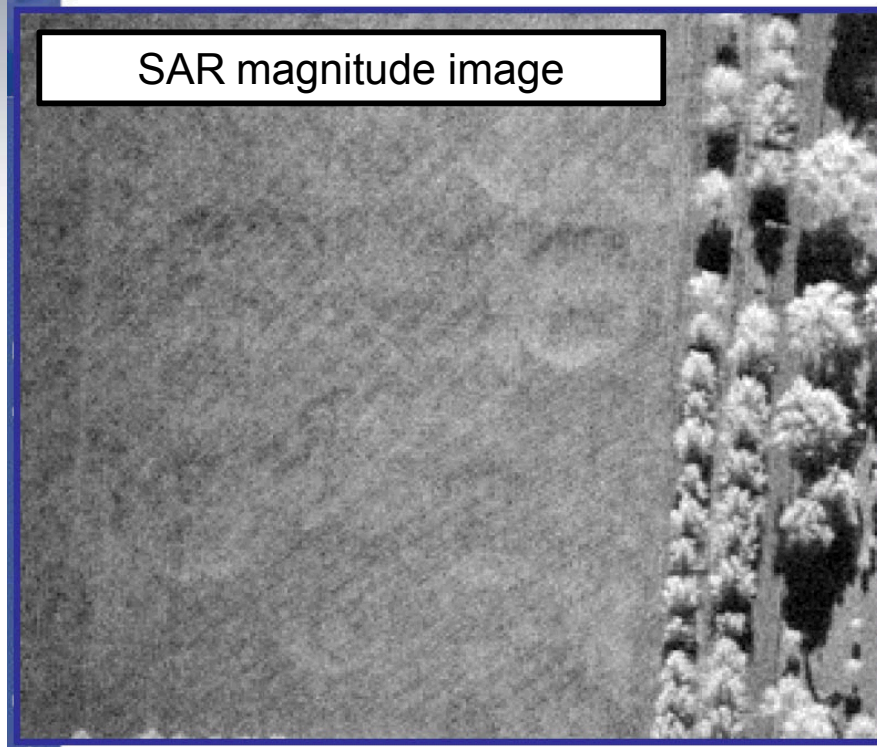
- **CCD map depicts of regions of de-correlation (dark pixels) indicating change**
- **Baseline CCD map indicates all regions of de-correlation**
- **Some of these regions are non-informative false-alarms**
- **CCD map exploitation could be improved by development of enhanced map generation**

Sandia National Laboratories

# Automated CCD exploitation example



Red = foot traffic
Blue = vehicle traffic
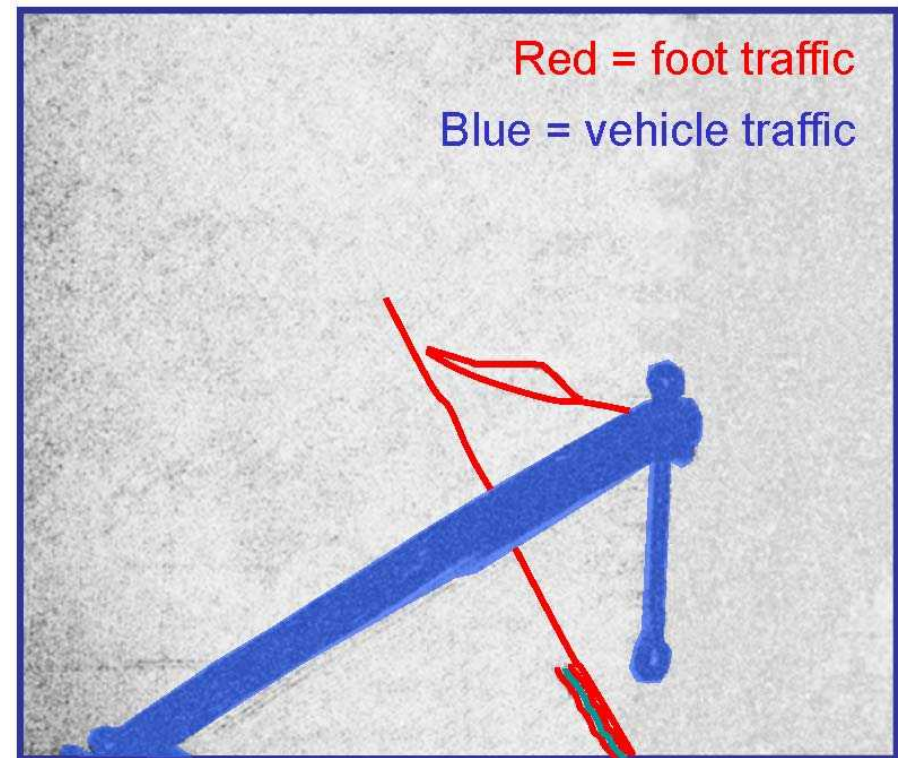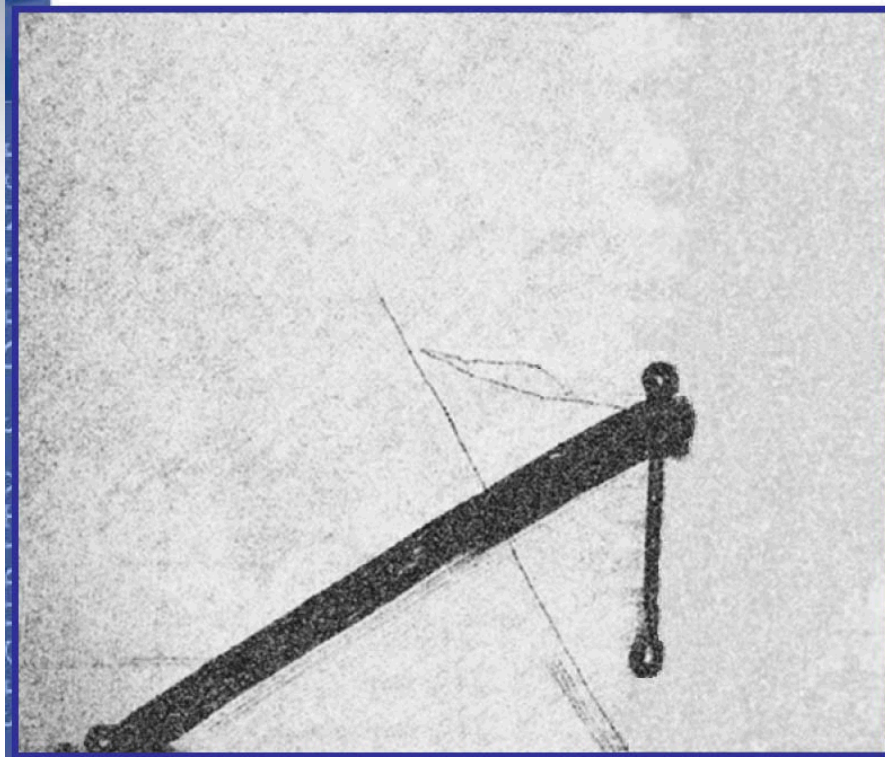
- **Left image: notional enhanced CCD map**
- **Right image: notional exploited CCD map with cues**
  - **User can toggle cues consistent with different types of change**
  - **Cues enable quick, targeted searching of specific types of interesting change in large volumes of CCD map imagery**

- **Has a long history of developing Systems to Solve challenging National Security Problems**

- **Builds solutions on strong analytical and technology foundations using a Systems engineering approach combined with field test and evaluation**

- **Looks for Opportunities to partner with other government agencies, industry and academia**