Right of Way Automated Monitoring

"RAM"

MACHINERY THREATS

PHMSA Research & Development Forum

June 24-25, 2009

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Shell Pipeline Company LP

RAM Project Team

- TransCanada
- Williams
- El Paso
- Enbridge
- AOPL
- PG&E
- Chevron
- EPCO
- Shell
- ConocoPhillips
- Buckeye
- Gassco
- Colonial
- PHMSA
- ExxonMobil
- National Grid
- SoCal Gas
- Marathon
- BP
- GE
- Total
- Petrobras
- TransGas
- CenterPoint
- Explorer
- NASA Ames Research Center

So… what's the problem?

Cost-effective monitoring of machinery threats

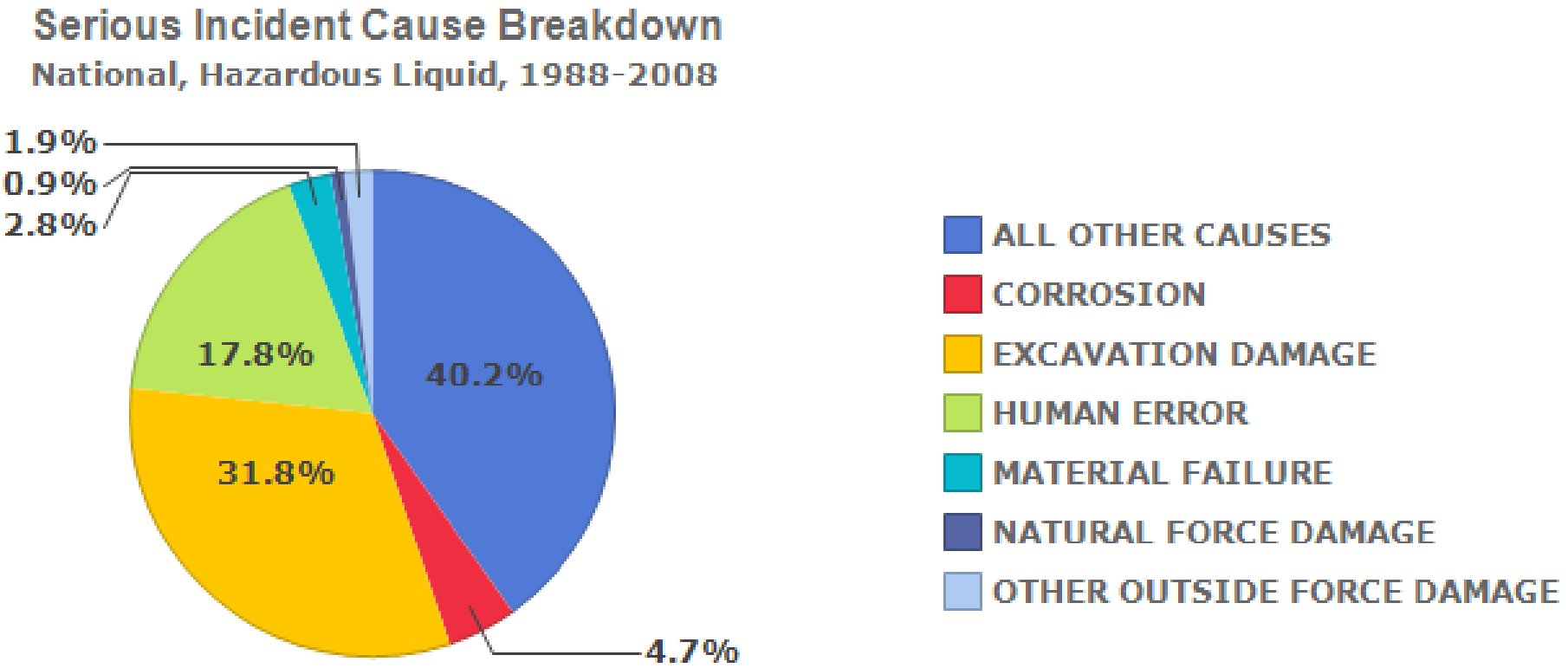
170,000 miles of hazardous liquid lines,

295,000 miles of gas transmission lines, and

1,900,000 miles of natural gas distribution lines

No single, automated system, service or suite of technologies has been developed to apply over the entire pipeline system network to address machinery threats.

Excavation Damage caused 32% of Significant Incidents between 1988-2008



Source: PHMSA Significant Incidents Files April 15, 2009

Pipeline Operator Objectives

- Enhance public and environmental safety
- Automate detection and improve threat identification reliability
- Automate notification process for near real-time delivery
- Automate distribution of geo-referenced data to designated operations centers (Control Center, One Call Center, etc.)
- Customize suite of sensors to fit geographical or operational need
- Enable operators to receive better data for better decisions in the deployment of response resources more effectively
- Enhance record keeping and archiving of data
- Enhance cost effectiveness of right-of-way monitoring

Program Vision

Program Vision

Realize enhanced aerial surveillance of the ROW through a suite of cost effective advanced technology to prevent infrastructure damage.

Program Objective

Identify, validate and advance the next generation technology. Implement solutions near-term on manned aircraft with a long term view to satellite & unmanned surveillance.

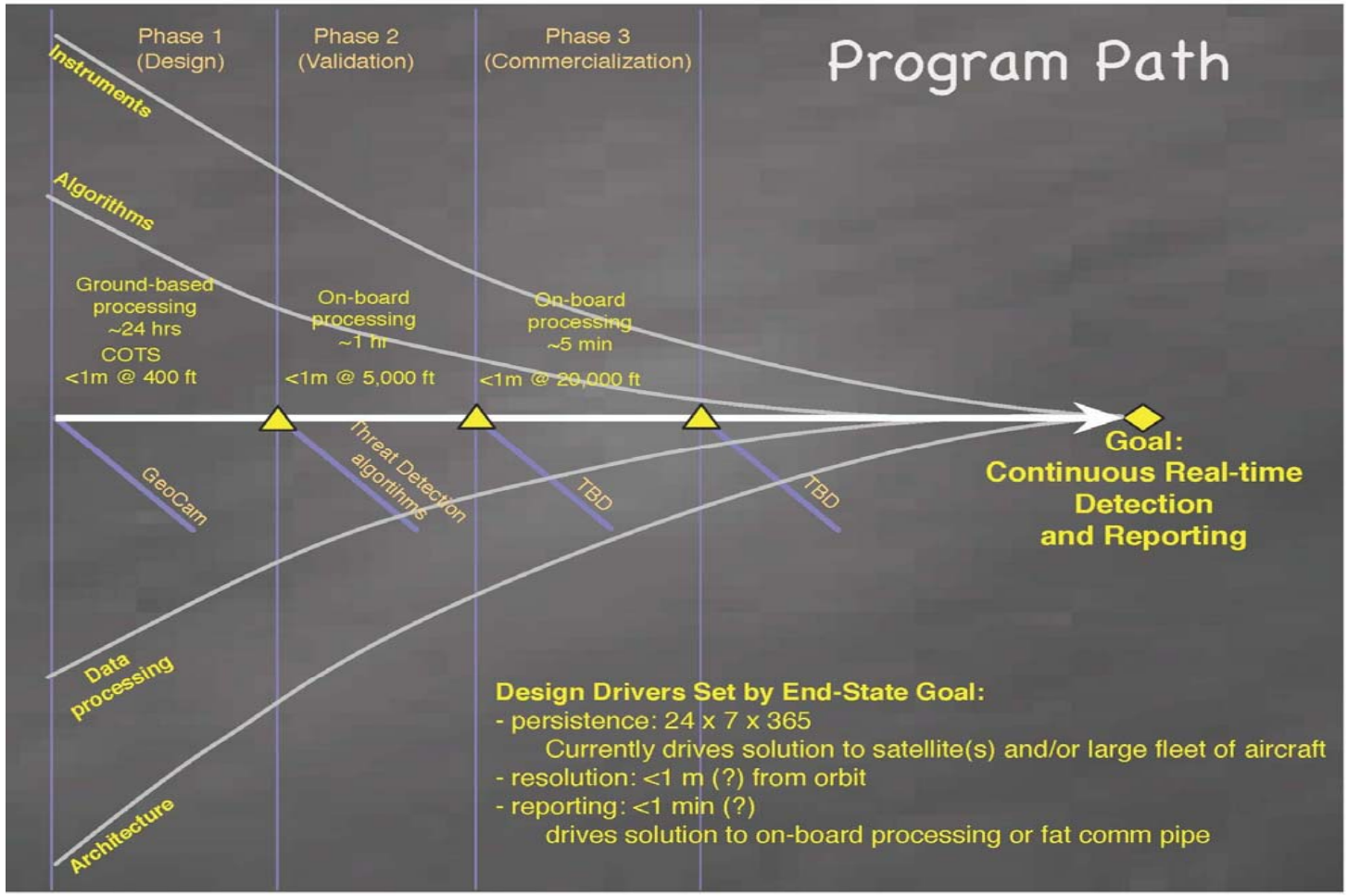
Scope – Automated Detection

- ROW Encroachments/intrusions
- Machinery/spills underneath tree canopy
- Ground disturbances, erosion, etc
- ROW Leak Detection – Gaseous and Liquid Hydrocarbons

Integration of sensors to:

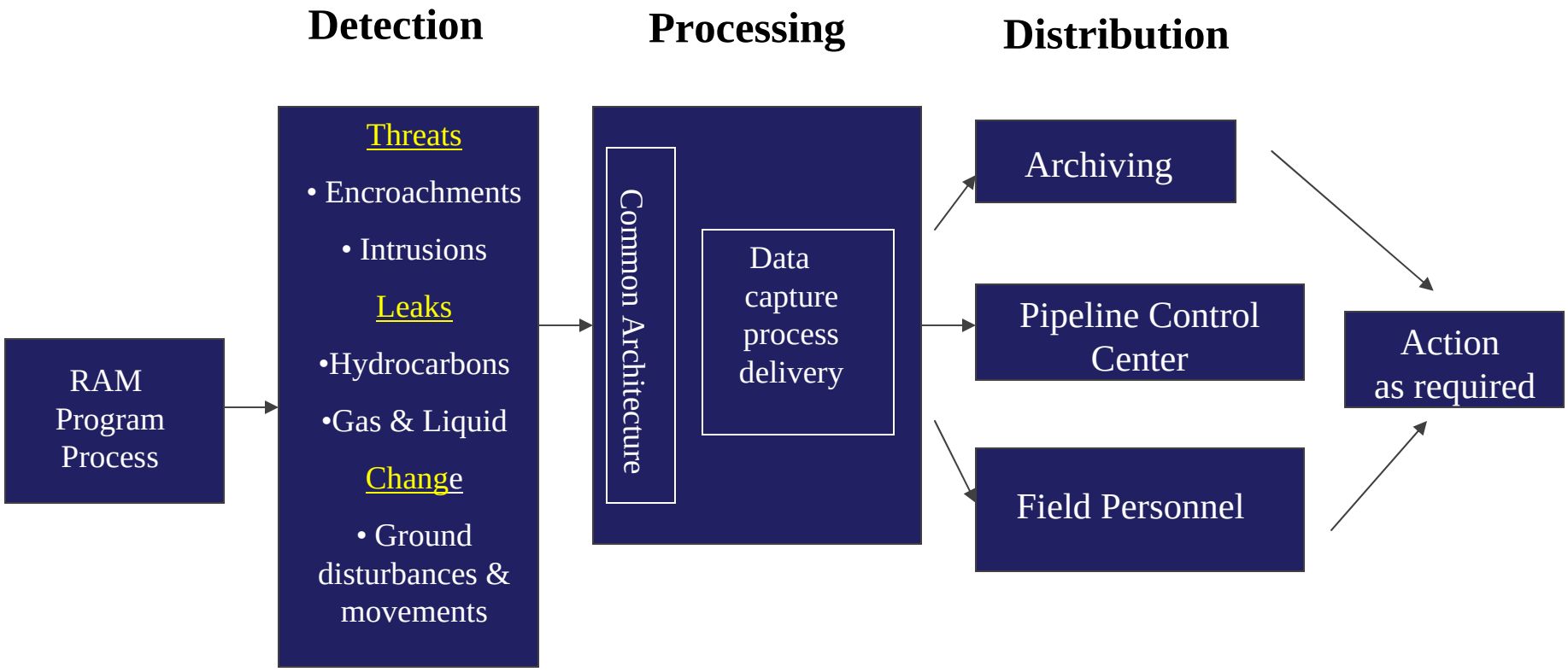
- ✓Airborne Threat detection systems
- ✓Near real-time detection & reporting
- ✓Long range communications
- ✓Multiple data systems
- ✓Image management systems
- ✓Predictive Modeling

RAM Program Overview

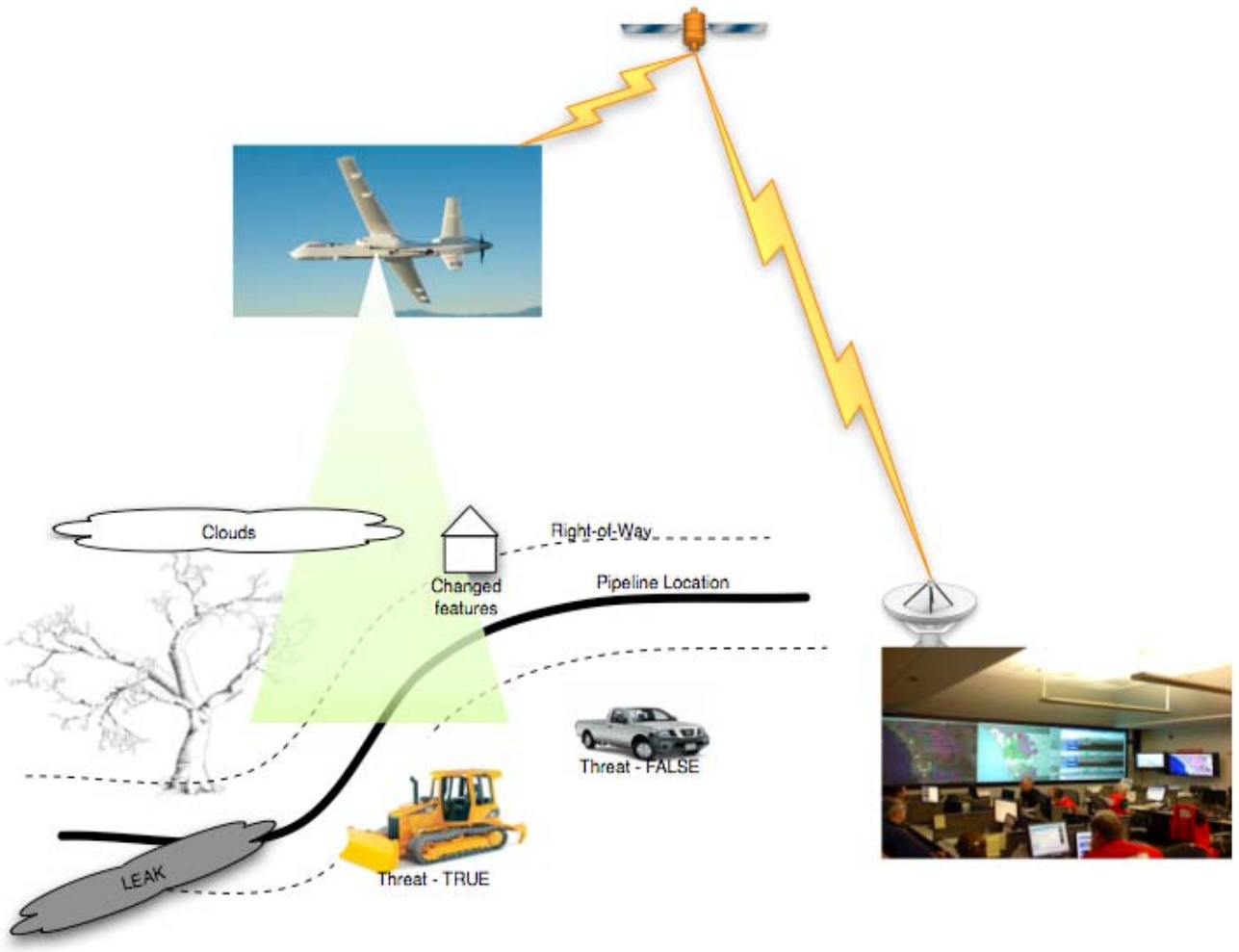


Courtesy of NASA Ames Research Center

RAM Concept Overview



Concept of Operation



Courtesy of NASA Ames Research Center

RAM – Concept of Operations

- Suite of sensors mounted on various aerial platforms to detect machinery threats (as well as other threats such as leaks and ROW changes)
- Automated recognition and identification of threats and process data on board aerial platform
- Via communication link (wireless, radio) notify operations center and/or designated field locations of threat with appropriate alarm indicating severity
- Download and archive data

Machinery Threat

- **Objectives**
  - Develop technology to enhance detection encroachment or intrusion along ROW of machinery threats
  - Bulldozers, backhoes, drill/augers, and scrapers
  - Improve efficiency, coverage and cost-effectiveness of patrol

- **Approach**
  - Automate documentation and detection tools
  - Enhance current practice (manned patrols)
  - Develop algorithms and prototypes for future flight systems

- **Schedule**
  - Phase 1: Collect data, evaluate sensors, develop algorithms & concept of operations
  - Phase 2: Validate algorithms, prototype and test system in field
  - Phase 3: Refine, produce, and test flight system

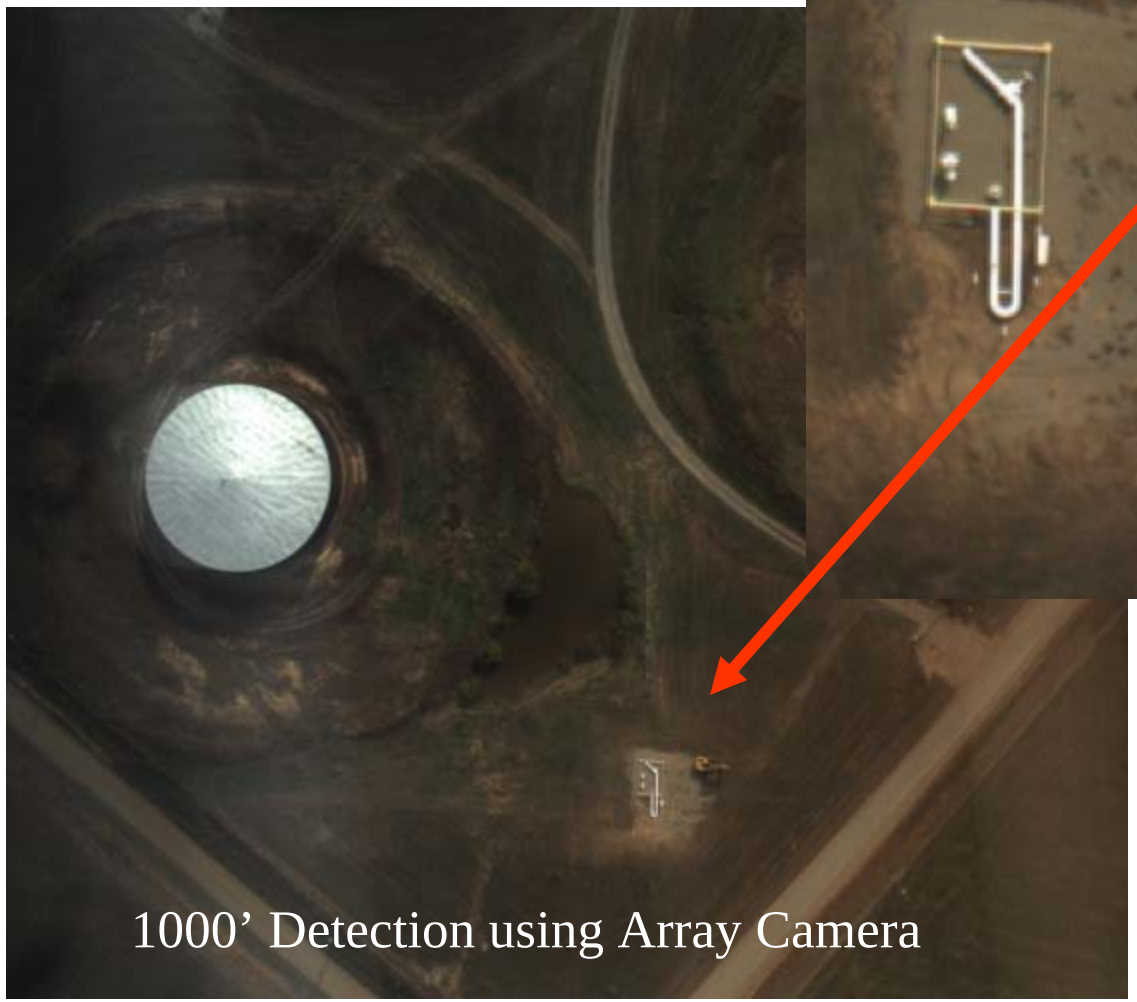
Photos courtesy of NASA Ames Research Center

Example of Camera with Improved Spatial Resolution & Detection

Pilot at higher safer altitude 1000’ rather than 400’.

Detected threat can be clearly identified by dispatcher.

Location can be geo-referenced



Aircraft flown At 1000’

Photos courtesy of BP Pipeline and NASA Ames Research Center

Current RAM Program Focus

- **Algorithms for Machinery Threats**
- **PHMSA and NASA working together on Gap Assessment and Request For Information (FedBizOps RFI #DTPH56-09-1000001)**
  - **Industry**
  - **National Labs**
  - **Academia**
  - **Commercial**
- **System Level Design Requirements**
- **Collection of ROW threat imagery for testing sensor package**
  - Airborne flight data & digital photography of excavation equipment
  - Simulations being conducted – scaled versions in NASA lab

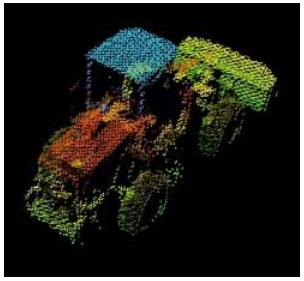
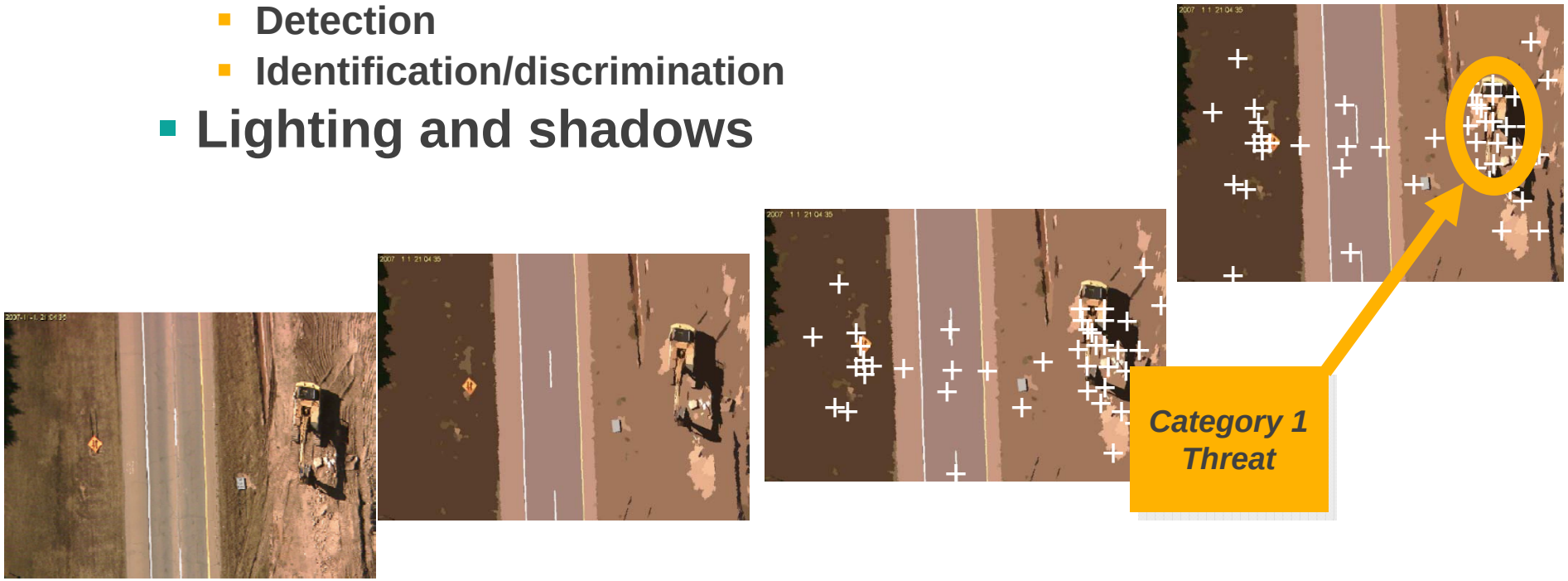


Photo courtesy of BP Pipeline

Challenges and Additional R&D Needs

Algorithms

- Development
- Speed (goal is real time)
- Accuracy and Reliability - “Friend vs Foe”
  - Detection
  - Identification/discrimination
- Lighting and shadows



Photos courtesy of NASA Ames Research Center

Challenges and Additional R&D Needs

Sensors

- What are the minimum requirements
  - Type
  - Resolution
  - Calibration & maintenance requirements
- Sensor and computer miniaturization
- Automated sensors and cameras that detect machinery in various environments, terrains, and background conditions
  - Snow, grass, dirt, sand
  - Mountain, swamp, forest and variable terrains
  - Under tree canopy

Challenges and Additional R&D Needs

Data Processing and Communications

- **Near-real time to real time**
  - Detection, analysis & processing
  - Dissemination and appropriate notification
- **Over the horizon, high band-width communications**
  - Systems architecture challenges
- **Full integration with aircraft and ground systems**
- **Data management and archiving challenges**
- **Human factors**

Aerial Platforms

- **Manned – near term focus**
- **Unmanned – mid to long term goal**
- **Satellite – long term goal**

Benefits of RAM and Related R&D

- Enhance community safety and environmental protection
- Increase pilot safety
- Increase pipeline integrity, security and reliability
- Significant improvement to efficiency and effectiveness of monitoring pipeline ROWs
- Augment ability to detect and respond to unauthorized excavations
- Reduce third party encroachments and incidents

RAM – Other Potential Benefits

- **Enhance localized aerial surveillance**
- **Focus surveillance during spill/event**
  - Marine oil spill, wildfires, hurricanes
- **Security surveillance**
  - Refinery, tank farm or marine terminals
- **Threat detection and security for other linear industries or critical infrastructure**
  - **Water, electric, highway, rail, communications**

For More Information

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