Right of Way Automated Monitoring

“RAM” MACHINERY THREATS

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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
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.

So… what’s the problem?
Excavation Damage caused 32% of Significant Incidents between 1988-2008

Serious Incident Cause Breakdown
National, Hazardous Liquid, 1988-2008

- ALL OTHER CAUSES: 40.2%
- CORROSION: 17.8%
- EXCAVATION DAMAGE: 31.8%
- HUMAN ERROR: 2.8%
- MATERIAL FAILURE: 0.9%
- NATURAL FORCE DAMAGE: 1.9%
- OTHER OUTSIDE FORCE DAMAGE: 4.7%

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

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**

**Program Path**

**Goal:** Continuous Real-time Detection and Reporting

**Design Drivers Set by End-State Goal:**
- **persistence:** 24 x 7 x 365
  - Currently drives solution to satellite(s) and/or large fleet of aircraft
- **resolution:** <1 m (?) from orbit
- **reporting:** <1 min (?) drives solution to on-board processing or fat comm pipe

**Phase 1** (Design)
- **Instruments**
- **Algorithms**
- **Ground-based processing**
  - ~24 hrs
  - COTS
  - <1m @ 400 ft

**Phase 2** (Validation)
- **Data processing**
- **GeoCam**
- **On-board processing**
  - ~1 hr
  - <1m @ 5,000 ft

**Phase 3** (Commercialization)
- **Architecture**
- **On-board processing**
  - ~5 min
  - <1m @ 20,000 ft

**Courtesy of NASA Ames Research Center**
RAM Concept Overview

Detection
- Threats
  - Encroachments
  - Intrusions
  - Leaks
    - Hydrocarbons
    - Gas & Liquid
  - Change
    - Ground disturbances & movements

Processing
- Common Architecture
- Data capture process delivery

Distribution
- Archiving
- Pipeline Control Center
- Field Personnel
- Action as required
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

1000’ Detection using Array Camera

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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