Pipeline Research Council International, Inc.

Managing Pipeline Leak Detection Through R&D Programs

Overview of Current PRCI Work

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LEADING PIPELINE RESEARCH

Presentation Topics

- **Current and recently completed efforts**
  - PL-1 Program: Continuous and real-time leak detection monitoring
  - ROW-3 Program: Right-of-Way Automated Monitoring [Threat & Leak Detection]
  - Compressor & Pump Station Projects

PRCI Current Project Profile

PL Pipeline Leak Detection (continuous monitoring)

Completed	Current					
PL-1-1 (Liquids)	PL-1-3 (Liquids & Gas)	PL-1-2 (Liquids & Gas)	PL-1G (Liquids)	PL-1H (Liquids)	PL-1J (Liquids)	PL-1K (Liquids)

ROW Right-of-Way Monitoring

Completed		Current				
ROW-3 (PoC Flight Tests)	ROW-3B& ROW-3C (Phase 1)	ROW-A: Gen 1 Package	ROW-3B & ROW-3C: Software	ROW-3E: Liquid Vapor Plume	ROW-H: Remote Methane	ROW-J: Long range UAV

PL: Pipeline Leak Detection: Completed

- **PL-1-1: External Leak Detection Evaluation and Development -Distributed Acoustic Sensing Technology Evaluation**
  - *2012/2013: Blind Field testing of 3 DAS Commercial "off-the-shelf" products on batched liquid transmission line [pig separation]*
  - ***Results:** Performance was mixed based on the complexity of the line. Team and vendors would like to look at performance on a more simplistic line*

- **PL-1-3: Alternatives for SF6 Tracer Gas in Small Seeper Leak Detection During In-service Hydrotesting**
  - *Identify possible alternatives to SF6 tracer gas after hydrostatic testing and identify tradeoffs.*
  - ***Results:** Several alternatives were identified and evaluated for cost benefit; however, tracer alternative fluorocarbons were identified as the best alternative to utilized existing operational techniques*

PL Pipeline Leak Detection Current Work

- **PL-1-2: A New Look at the Pipeline Variable Uncertainties and Their Effects on Leak Detection Sensitivity**
  - *A new comprehensive revision, technical report of API's 1149 publication to address a number of gaps, shortcomings, and recent technological developments, engineering uncertainty factors, and operational requirements*
  - ***Projected Completion Date: 2nd Quarter 2015***
- **PL-1G: External LD on Existing Liquid Pipelines Evaluation and Development**
  - *Major impediment to deployment of cable LD is the lack of experience in retrofitting cables alongside existing production pipeline systems*
  - ***Projected Completion: 2nd Quarter 2015***
- **PL-1H: Petroleum Polymer Absorption Sensors LD Cable**
  - *PoC to provide liquid pipelines with system capable of the simultaneous real-time LD of small leaks and earth/equipment disturbances.*
  - ***Projected Completion: 1st Quarter 2015***

Pipeline Leak Detection Projected 2015

- **PL-1J: Evaluating Pipeline Integrity and Leak Detection using Smart Ball Technology**
  - *Study and quantify the effects of wall loss over time and to quantify leak detection / location performance (minimum leak size, location accuracy, operational robustness, and false alarm rate) through Operator field tests on crude, refined products, and High-Volatile-Liquid (HVL) fluid type pipeline operations.*
  - ***Projected Completion: 4th Quarter 2016***

- **PL-1K: Numerical Modeling and Laboratory Validation of Fluid Migration from Small Subsurface Pipeline Leaks**
  - *Study to predict and characterize the behavior of dense non-aqueous phase fluid (i.e. dilbit and gasoline) leaking from pipelines into surrounding geological porous media (i.e. sand and gravel). Project would integrate laboratory leakage simulations and modeling efforts.*
  - ***Projected Completion: 4th Quarter 2015***

ROW-3: Right-of-Way Automated Monitoring

- **ROW-3A**: Supplemental Testing of Full System Technology Packages for Automated Monitoring of Machinery Threats
- **ROW-3B & ROW-3C**: Algorithm Development for Machinery Threat Detection
- **ROW-3E:** Hydrocarbon Plume Vapor Modeling/Analysis
- **ROW-3H**: Fast, Accurate, Automated System to Find and Quantify Natural Gas Leaks
- **ROW-3J:** Ground Based Radar Monitoring of Slope Stability and Subsidence along Pipeline Right of Ways **[DOT OST-R]**
- **ROW-3K:** Demonstration of the Use of Long Endurance Unmanned Aircraft System (UAS) to Conduct Machinery Threat Detection and Oil Spill Detection on a Pipeline Corridor in the National Airspace System

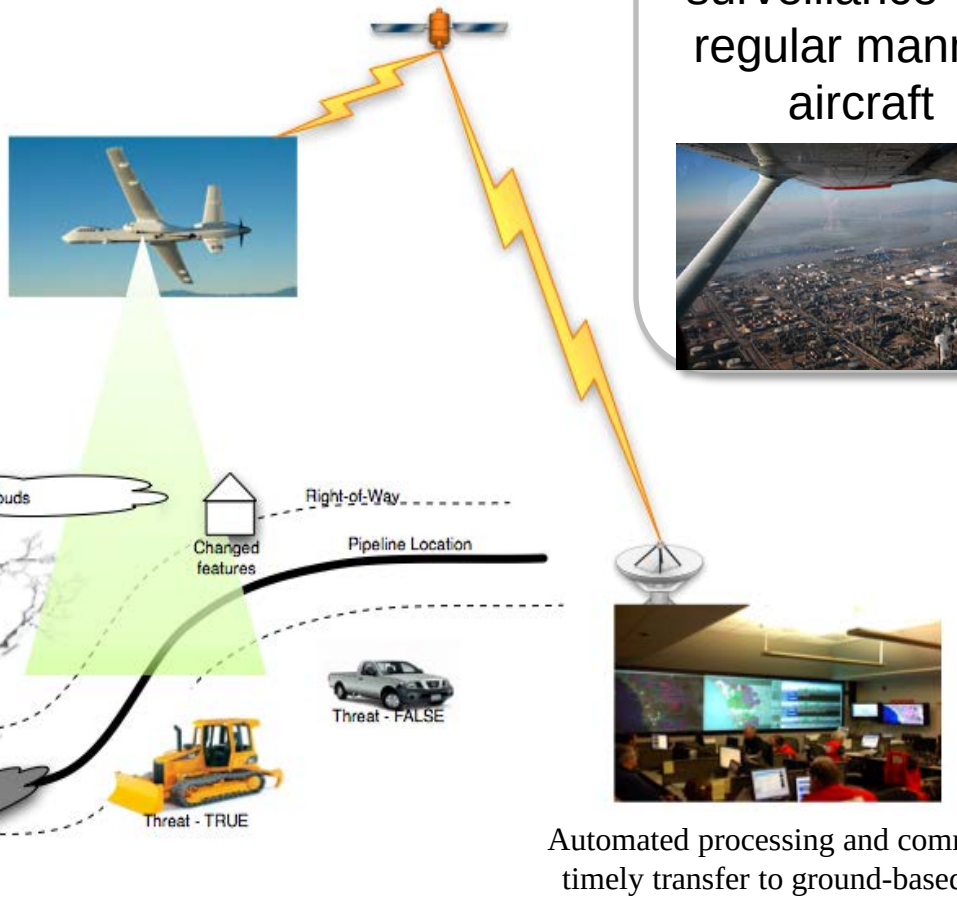
Threat Prevention from the Air
RAM Program Concept of Operations

No single, cost-effective system, service or suite of technologies has been developed to apply over the entire pipeline system network to address the three primary threats:

- **Machinery threats (3rd party damage)**
- **Leaks**
- Geologic activity/natural forces

Automating ROW Monitoring:
Detect – sensing & imagery collection
Process - data analysis via algorithms
Distribute – communication
Archive – improved data management processes and predictive modeling

LEAK DETECTION
Gas + Liquids
(Working Group #2)

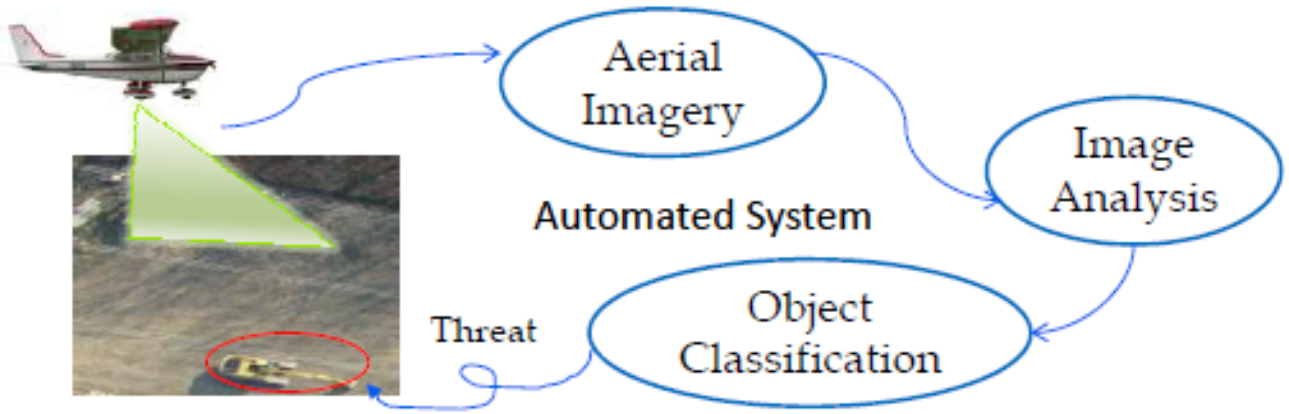


Standard aerial surveillance with regular manned aircraft

Automated processing and communication – timely transfer to ground-based operations personnel to address the identified threat Management

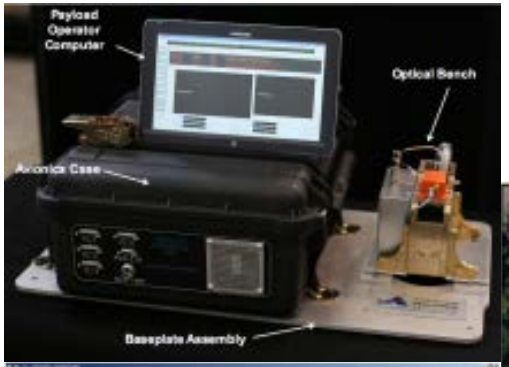
ROW: Right-of-Way Automated Monitoring

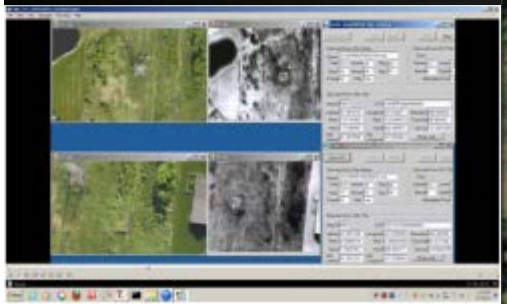
- **ROW-3A, 3B & 3C: Supplemental Testing of Full System Technology Packages for Automated Monitoring of Machinery Threats**
  - *Prototype Package (Integrated Hardware & Software Package) threat detection validation flights underway* ***[Univ. of Dayton & AAAI]***
  - ***Leak Detection (hyperspectral/IR) sensors to be integrated for validation 2015***
  - ***Leak Detection sensor selection building upon Vapor Plume Modeling (ROW-3E) work from 2013/2014***
  - ***Current fixed wing package also suitable for long-range UAV platform***

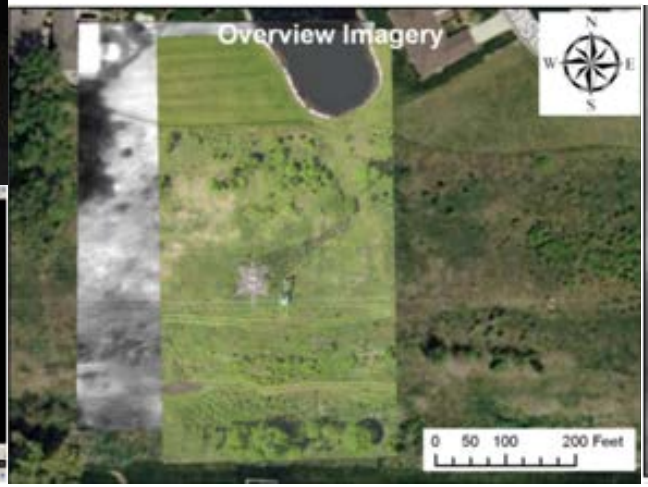


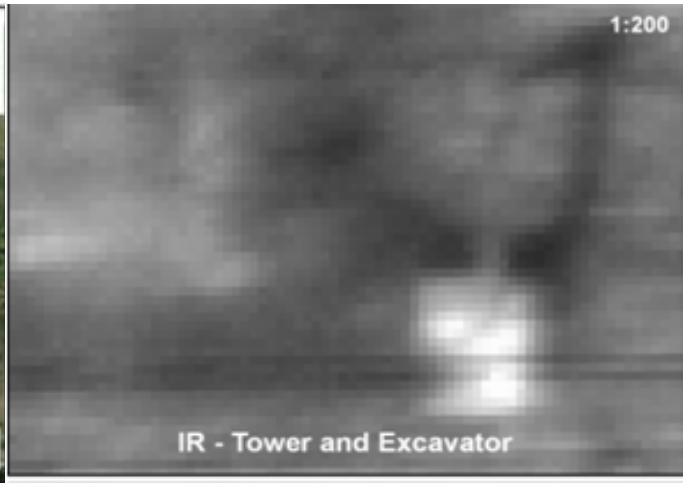
RAM Technology Package

- PoC of integrated algorithm & package along 10 mile ROW in 2013
- 2014 campaign: validation in additional ROW terrain in member aircraft
- 2014 ROW-3K: payload/algorithm in UAV









ROW-3H: Fast, Accurate, Automated System to Find and Quantify Natural Gas Leaks

- **Objective**: Key deliverables are increasing the robustness of miniature sensor to operate in all-weather conditions and development of the leak location and flux quantification strategy for use by foot leak surveyors and UAVs.
  - *The project will also include ground and aerial tests in controlled and real environments including rural, residential, and commercial areas. JPL will transfer technology to outside companies for industrialization and commercialization.*

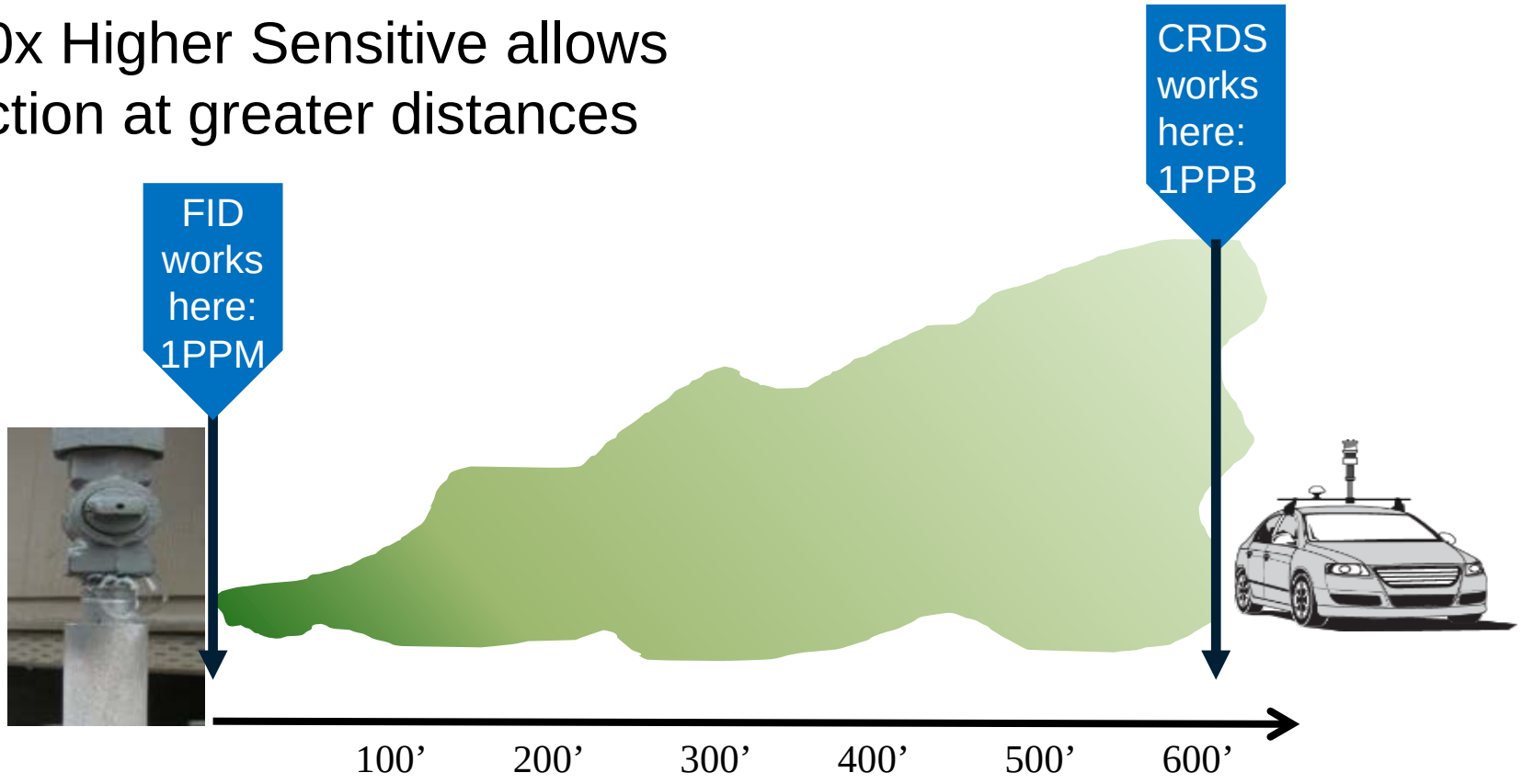
- Builds upon previous Piccaro (CRDS validation work- ground and areal trials from 2012/2013)

- **Current Status:** Initial prototype testing completed July 2014
  - *Handheld completion 2014*
  - *UAV completion 2015*
- Contractor: NASA JPL

ROW-3H: Addressing Gaps

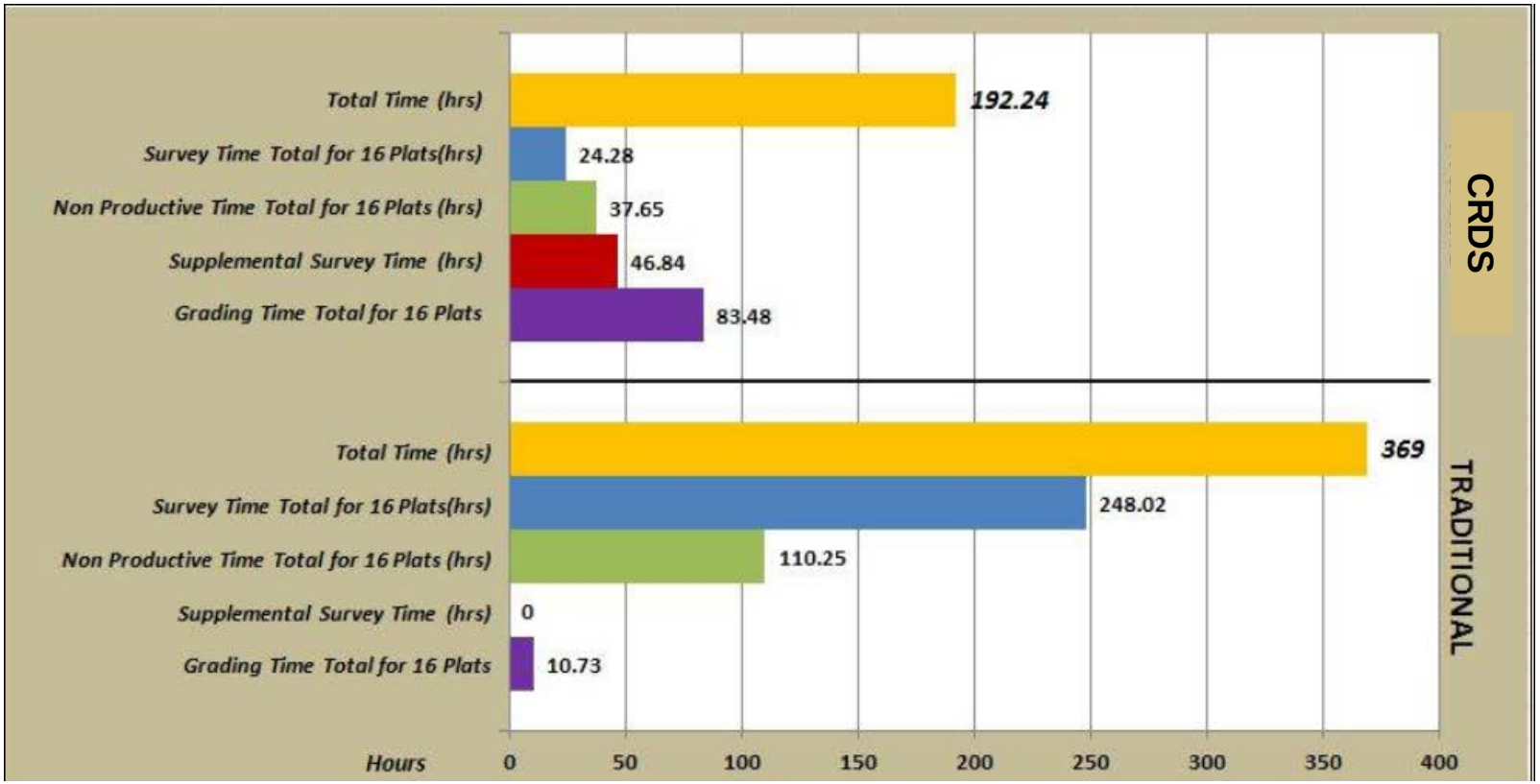
Gap between CRDS and traditional tools

1,000x Higher Sensitive allows detection at greater distances



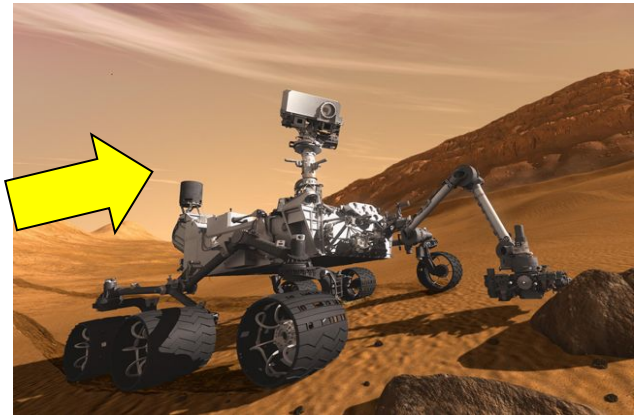
ROW-3H: Addressing Gaps

- **Need for more rapid methane leak indications: With vehicle based methane detector, the most time consuming step is locating leaks from an indication**



ROW-3H: Technology Development

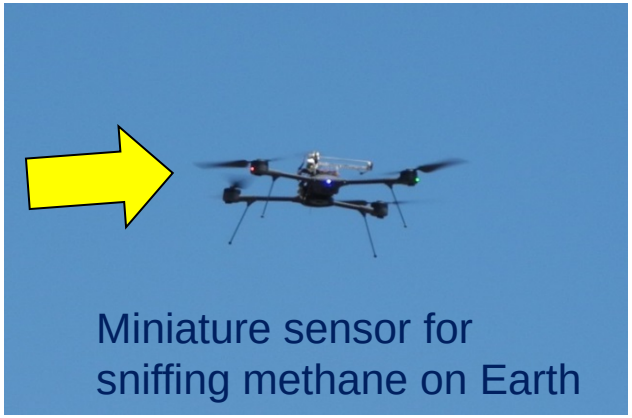
NASA JPL Methane Detector Technology



Miniature sensor for sniffing methane on Mars

Mars version is more sensitive:

- 1 ppb in 1 sec
- Isotopes in methane



Specifications (Earth version)

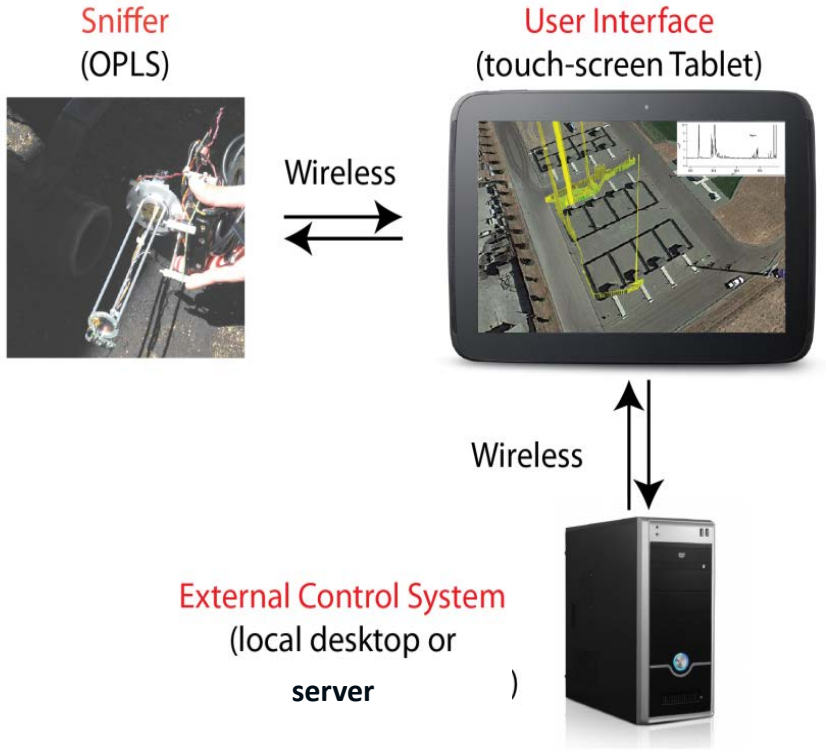
- 250 g (hand carried)
- 20 ppb 1 sec
- Measures CH_4 + water
- Open-path (quick response)

ROW-3H: Miniature Methane Detection

Open-path Laser Spectrometer (OPLS)

Current validation for Hand-carry device to locate/verify methane hot spots.

- Operational Prototype ready for industrialization by the end of 2014



2015 Validation using UAV Platform

Mounted on quadrotor

ROW-3K: Long Range UAS on a Pipeline Corridor in the National Airspace System

Objectives:

1) Demonstrate operation of a long range/endurance UAS carrying the RAM Technology Package (ROW-3A/B/C) on a pipeline corridor in civilian airspace – safely, effectively and in full compliance with all FAA and FCC regulations
2) Evaluate the performance differences between manned & unmanned aircraft
3) Establish a test range for continuing research

Benefits:

- Increased safety (eliminate risk to pilots)
- Far greater endurance
- Higher precision flight profiles
- Smaller signature
- Emergency Response

AMERICAN AEROSPACE
Airborne Systems Group
Flight Services • Mission Systems

Parameter	Units	Cessna 172	RS-16 UAS
Endurance	Hours	4	12 to 16
Range	Miles	400	600+
Fuel	Gallons	52	1.5
Pilots	No.	1	0.33

FAA UAV/UAS Center of Excellence Test Sites

Virginia Tech team includes Virginia, Maryland and New Jersey

Alaska team includes Alaska, Oregon and Hawaii

Several other states are continuing UAS efforts, but they will not be able to approve commercial operations

http://www.faa.gov/about/initiatives/uas/infographic/

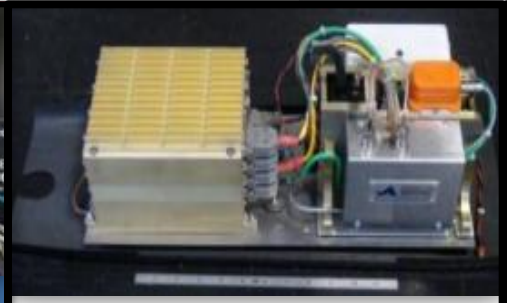
ROW-3K: Long Range UAS

- **2014 Timeline:**
- **COA Application submitted with Virginia Center of Excellence**
- **Projected Initial flights to begin October 2014**
- **2015 Analysis and Reporting**

RS-16 UAS™

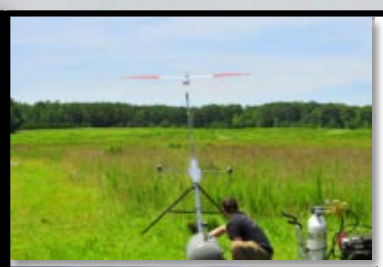
12’ Wingspan, 25 lb. payload capacity

Mobile Operations Centers



Multi-Mission Payload System

- Machinery Threat
- Gas Leak
- Liquid Leak
- Encroachment
- Emergency Mgmt.



Runway not required for launch or landing operations

Flies for 12+ hours on 1.5 gallons of gasoline

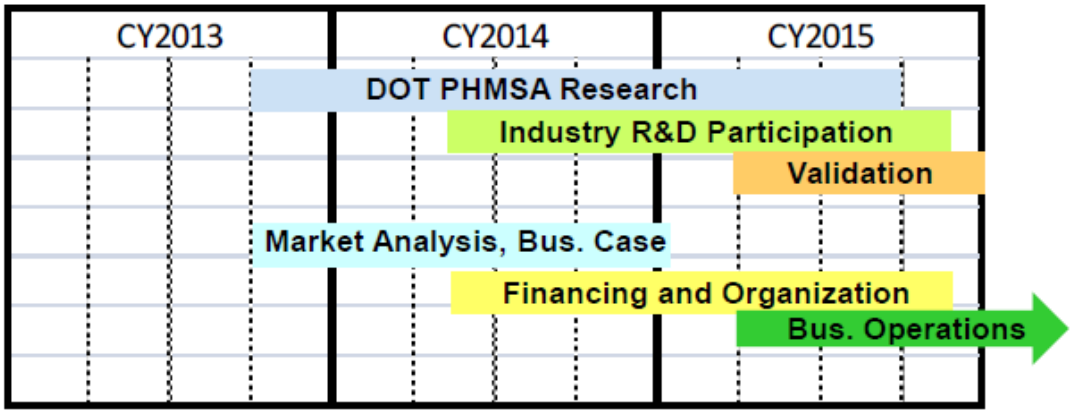
Compressor & Pump Station Projects- 2015

- **CPS-11-4: GHG Database to Support Emission Factor Improvement**
  - **Objective:** Continue to review and evaluate the greenhouse emissions information reported through the EPA e-GGRT database. The research will review the data for abnormalities and identify best practices for measuring and reporting greenhouse gas emission information.
  - **Projected Outcome**: Specific guidance on best practices to report greenhouse emission data (3rd year of effort to be competed 2015)

- **CPS-8-4: Catalytic Reduction of Methane from 2-Stroke LB NG Engines: Feasibility Assessment**
  - **Objective:** Evaluate the feasibility of applying current methane catalyst technology upstream of the turbocharger in 2-stroke lean burn natural gas engines to achieve significant alkane reduction.
  - **Projected Outcome:** The key deliverable will be a report containing test data, modeling results, and interpretation aimed at accomplishing the research objective.

Non-PRCI Collaborations

- **PHMSA /Ball Aerospace: LiDAR Liquids LD on Fixed Wing Platform**
  - **2014 PRCI Research Exchange Workshop**
  - Key interface and collaboration with operator stakeholders and industry SMEs



- **PRCI CPS Program/INGAA Methane Emissions**
  - Collaboration on Industry Roadmap for reduction of methane emissions at compressor stations

Questions?

Thank you for your attention

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