Pipeline Research Council International, Inc.

PHMSA Meeting – 3/27/2012
Improving Leak Detection System Effectiveness

PRCI HL Leak Detection Research Activities
Past, Present, Future

David Bolan
Enterprise Products Partners
PRCI Research Activities - Past

- **Small Leak Detection in Liquid Pipelines – External Leak Detection Evaluation and Development**
  
  - **Research objective**
    - *Push the state of the art in the ability to detect small leaks in hazardous liquids pipelines*
  
  - **Schedule of projects**

  ![Timeline Diagram]

  - 4/15 - 2/1 Field Test Scope Defn
  - 2/1 - 12/31 Field Testing

  - 1/1/2006 - 12/31/2012
Field testing of Acoustic/Negative Pressure Wave Leak Detection Technologies

- Research objective:
  - Conduct a full-scale field test of several acoustic systems on a production pipeline to determine if they can detect such leaks while minimizing non-leak alarms.

- Key deliverables:
  - A report of the testing results will be generated. Evaluation criteria:

<table>
<thead>
<tr>
<th>Leak location</th>
<th>Non-leak alarm rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smallest detectable leak</td>
<td>Response time</td>
</tr>
<tr>
<td>Tools/information provided to user</td>
<td>Perform under various pipeline conditions</td>
</tr>
<tr>
<td>Installation/configuration time</td>
<td>--</td>
</tr>
</tbody>
</table>

- Benefits:
  - Provide guidance to liquid pipeline operators on complimentary technology for detecting leaks that are smaller than those currently detectable with existing systems.
A New Look at the Pipeline Variable Uncertainties and Their Effects on Leak Detection Performance

Research objective:

- This research will focus on finding efficient algorithms for pre-determining the leak detection sensitivity performance for a given pipeline configuration, pipeline operation and known instrumentation characteristics.

Key deliverables:

- A report documenting and quantifying the effects of pertinent variables on the operation of specific CPM algorithms during steady state and transient operations (which encompasses not only Crude, Refined Product fluids, but HVL fluids as well)
  - Variables: fluid properties, instrumentation quality, time steps, update rate, loss of data, LDS presentation
- An off-line software tool which can be used by operators to conduct leak detection performance capability studies

Benefits:

- Research will allow operators to determine upfront the expected leak detection sensitivity performance before committing to improvements
Alternatives for small seeper leak detection during hydrostatic testing

- Research objective:
  - Alternatives to SF6 need to be determined as to their hydrostatic testing leak detection effectiveness and limitations including any possible environmental effects.

- Key deliverables:
  - The deliverable will be a report on various methods of locating leaks during hydrostatic tests with the relative benefits and limitations of each technique including cost per mile and current or potential environmental limitations.

- Benefits:
  - The benefits and limitations of various leak detection techniques needs to be determined to ensure hydrostatic testing continues to remain a viable integrity management technique into the future.
PRCI Research Activities-Future

- **PRCI Leak Detection Roadmap**
  - A work in progress – under development since early 2011
  - Being circulated for review and input by stakeholders
  - Will continue to evolve as research takes place and industry advances
  - Addresses both gas and liquids pipeline operations
  - Five major strategic objectives presented in following slides
Leak Detection Roadmap Overview

Projects

A) Field test results (knowledge)  
B) Retrofit on fiber-based LDS (knowledge)  
C) Field test environment (tool)

Research Objectives

Detect leak (1% flow) with 95% certainty in < 5 minutes, under all operating conditions

#2 Continue R&D on Small Leak Size Detection

A) Best practices document (knowledge)  
B) Risk analysis in support of leak detection (knowledge)

Strategies

Detect large leak (>50% breach) with 99.99% certainty in < 5 minutes, under all operating conditions

#1 - Highly reliable rupture detection systems

Business Driver: Reduce detection time, overall response time, and spill volumes associated with pipeline integrity breaches.

#5 - LD Program Effectiveness Survey

Means to measure whether LD programs are actually meeting the business drivers.

#4 - More rapid implementation

Reduce CPM implementation time to days vs. months

#3 - Metrics to measure LDS performance

Consistent means to define/relate: Leak size, detection time, confidence factor

A) Update API 1149 (knowledge/tool)  
B) CPM Performance Measurement Std (standard)  
C) LD Testing methodologies (knowledge)

A) Research to ID roadblocks and overcome them (knowledge)  
B) Research to ID what data should be collected over time by operators to demonstrate system effectiveness.
Leak Detection Roadmap - 1

- **Highly reliable pipeline rupture detection – liquids & gas pipelines**
  - **Objective:** Develop a means to consistently and reliably recognize large leaks in either liquids or gas pipelines.
    - *The end point to this objective is to have an automated shut-in system on the identified pipeline segment when a rupture is detected.*
    - *A proposed research objective is: Detect a large leak (>50% leak rate) with 99.99% certainty in less than 5 minutes, under all operating conditions.*
  - **Required Research Outcome or Needs:**
    - *Best practices document (knowledge)*
    - *Risk Analysis in Support of Leak Detection (knowledge)*
Leak Detection Roadmap - 2

- Continuing R&D on small leak size detection on liquids pipelines.
  - **Objective:** Develop a means to confidently identify smaller leaks in a shorter amount of time than is currently commonly achieved by industry today.
    - A proposed research objective is: Detect 1% leak of current flow rate in less than 5 minutes, with 95% confidence level, under all operating conditions.
  - **Required Research Outcome or Needs:**
    - Field test results from promising technologies (PL-1-1 - Field testing on Acoustic/Negative Wave Leak Detection technologies. (knowledge)
    - Retrofit Techniques for Fiber Optic-based Leak Detection Systems (knowledge)
    - Field test environment (tool)
Leak Detection Roadmap - 3

- **Metrics to measure leak detection performance – liquids & gas pipelines**
  - **Objective**: Develop a means to consistently measure leak detection system performance by addressing: percent of flow that can be identified, in what timeframe, and with what confidence level.
    - *The methodology must include all aspects of a leak detection program including: the CPM system, layers of defense, SCADA system performance, and the human factor performance of the controller.*
  - **Required Research Outcome or Needs:**
    - *Updated API 1149 document and tool set. (knowledge & tool)*
    - *CPM Performance Measurement Standard (standard)*
    - *Leak Detection Testing Methodologies (knowledge)*
Facilitate more rapid implementation of CPM systems – liquids & gas pipelines

Objective: Develop a means to be able to more rapidly implement CPM systems on new pipeline systems.

- Current systems can take on the order of months to implement (for a complex pipeline).
- The research objective should be days versus months.

Required Research Outcome or Needs:
- Research to identify roadblocks and methods to overcome them (knowledge)
Leak Detection Roadmap - 5

- Leak detection program effectiveness survey -- liquids & gas pipelines

  **Objective:** A leak detection program is comprised of many interrelated parts (SCADA, CPM, field instrument maintenance, controller training, etc). It will be beneficial to industry to have a means to measure whether leak detection programs are actually reducing the detection, response times, and spill volumes associated with product releases over a given period of time.

  **Required Research Outcome or Needs:**

  - Research to identify data that should be collected over time by operators to demonstrate that their leak detection program is appropriate given the risk level of their pipelines (knowledge)
Questions / Discussion
Pipeline Research Council International, Inc.

Leak Detection R&D
Natural Gas Transmission Pipelines

Game Changers & Changing the Game

PHMSA Leak Detection Workshop
Rockville, MD
March 27, 2012

Mark Piazza
PRCI
Presentation Topics

• PRCI – who we are and what we do
• Current R&D Focus – RAM Program
  • Aerial Platforms
  • Ground-based systems
• Changing the Game
PRCI Membership

- **37 Energy Pipeline Operating Companies**
  - 23 Natural Gas Transmission; 9 Liquid
  - 5 Liquid/Natural Gas

- **4 Pipeline Industry Organization (PIO) Members**
  - Association of Oil Pipe Lines (AOPL) /API
  - Operations Technology Development (OTD)
  - Australian Pipeline Industry Association (APIA)
  - Electric Power Research Institute (EPRI)

- **25 Associate Members & Technical Program Associate Members**
  - Australia, Canada, China, Europe, Japan, Mexico, U.S.

- **Worldwide Research Organization**
  - 38 U.S. Companies
  - 23 Non-U.S. (Australia, Brazil, Canada, China, Europe, Japan, Mexico, Saudi Arabia)
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 these various threats.

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

LEAK DETECTION
Gas + Liquids

Automated processing and communication – benefits to Damage Prevention, Emergency Response & Crisis Management

Courtesy of NASA Ames Research Center
**RAM Technology Roadmap**

**Progressive Development Path**

Gen 1 is current target - fixed wing with vision to future platforms

**RAM Success**

Hyperspectral sensing confirmation for Natural Gas Leaks

Diagram prepared by NASA Ames Research Center
Detecting Leaks from Aerial Platforms

500 feet AGL

Real-time weather data to optimize sensor placement

Turbulent Mixing

Wind

Turbulence acts to disperse the plume both laterally and vertically while the mean wind simply moves the plume downwind of the release.
Aerial Platforms for CRDS - Sensitivity

- **Cavity Ring-Down Spectroscopy (CRDS)**
  - Laser based, tunable technology – ppb levels, very sensitive
  - Isotopes of carbon for differentiation of sources – C12/C13 ratios
  - Developed initially for atmospheric monitoring – GHG focus - methane, CO, moisture, etc. – cross-over technology

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**Modeling a Leak**

Leak Rate: 0.44 cfh
Wind Speed: 2 mph

750 scf/hr = 43 ppb at 500 ft
Field demos – 250 scf/hr at 500 ft + CH4 spikes at 1000 ft

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1 PPM

0.01 PPM

100’  200’  300’  400’  500’  600’ (distance downwind from source)
Aerial Platforms for CRDS – Sensitivity (cont)

- Cavity Ring-Down Spectroscopy (CRDS) – successful testing in 2011 & 2012
  - NASA Unmanned Aerial System testing
  - Field Proof of Concept (ground-based as well)
  - A number of controlled release test flights (3 total)
- Calibration of instruments – isotopes and methane; use NIST standards to confirm sensitivity, drift
- Develop pilot interface & algorithms – optimize flight path for leak detection
- Full-scale pipeline ROW test – planned June 2012

Cockpit Display (shown in C172)
Ground-based Gas Leak Detection - CRDS

Picarro CONOPS
Synergy with RAM Program

Fully integrated system
Real-time data
Concentration maps
User Flexibility

Up to 45 mph

Little “r” & Big “D”
Ground-based Gas Leak Detection - CRDS
Ground-based Gas Leak Detection - CRDS
Ground Based Gas Leak Detection - CRDS

- Recognition that many transmission line ROWs are in urban and suburban areas – aircraft challenges
- Link to distribution assets of PRCI members

2011 & 2012 Testing Program

- 2 controlled release tests – leak indications and locating
- Full complement of high precision weather data and continuous monitoring of conditions
- Data drives work to further develop/improve algorithms and software systems for data processing and management
Ground Based Gas Leak Detection - CRDS

20 controlled leaks – all detected (85% locating accuracy)

Leak Types: Service connections, under road, underground, in buildings, etc.

- Leak rates: 0.44 to 3.7 scf/hr
- Measured two small plumes from 0.44 scf/hr leaks at 300 ft from source
- Found leaks in test site piping
Ground Based Gas Leak Detection - CRDS

Leak Indications and targeted search area

# = region identification
Ground Based Gas Leak Detection - CRDS

Next Steps

- Side by side testing – ongoing
- Possibly link with aerial study in June 2012
- Testing in field – volunteers welcome
Changing the Game – Some Things to Consider

**Engineer the Environment**
- Bugs – CO₂, Temperature/Thermal
- Plants
- Other?

DRA-like substances

**Unmanned Systems**

**Satellites**
- Move to automation - iPad Generation
- Current capabilities vs future
- How does pipeline industry help define next generation?
- Of, by, and for the people? Government role

Expand our view of the world

Closing Thoughts

PRCI R&D Roadmap – Leak Detection is a top priority

Leak Detection for Facilities

The first adopter – drives innovation

Seize opportunities

Developing the Program for 2013; 5 target areas for Roadmap + RAM Program

Collaboration
Questions?

Any follow up to:

Mark Piazza, PRCI
mpiabella@prci.org
678 339 3645
678 763 5911