# Leak Detection Research and Development

SOUTHWEST RESEARCH INSTITUTE®

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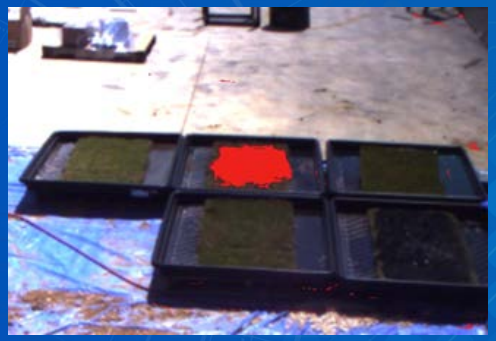
# Topics



Machine Learning
Applied to Leak Detection

Leak Detection
Sensor Testing

Gas Emissions
Monitoring

# Application of Machine Learning to Leak Detection

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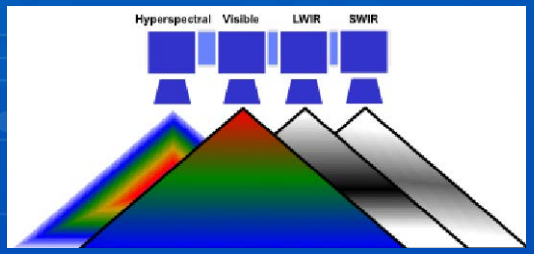
# So What Was SwRI's Research Goal?

- Develop a leak detection technology that is:
  - Platform Agnostic (Aerial, Ground, Stationary)
  - Low false alarm rates in a wide range of environmental and operational conditions
  - Non-intrusive, minimal to no retrofit to existing infrastructure
  - Autonomous
  - Real-time capable
  - Extensible
  - Able to detect any common pipeline fluid or gas without specific pipeline or operator-specific tuning

# Smart Leak Detection (SLED) System

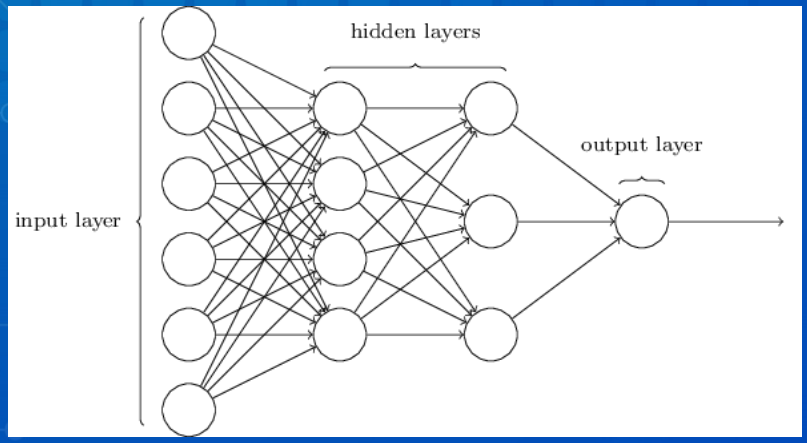
- A combination of optical sensor modalities
  - COTS components
  - Visible (0.4µm – 0.9µm)
  - Long-wave Infrared (7.5µm – 13µm)



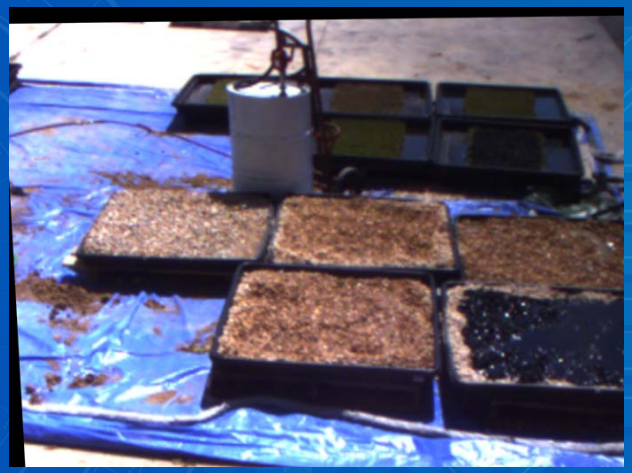

# Optical Sensing + Machine Learning

- Optical sensing already used in leak detection
- Addition of machine learning techniques for
  - Autonomy
  - High Reliability (low false alarm rates)
  - Machine Learning
    - Powerful techniques such as convolutional neural networks
    - Extensible and robust detection

**Convolutional Neural Networks**

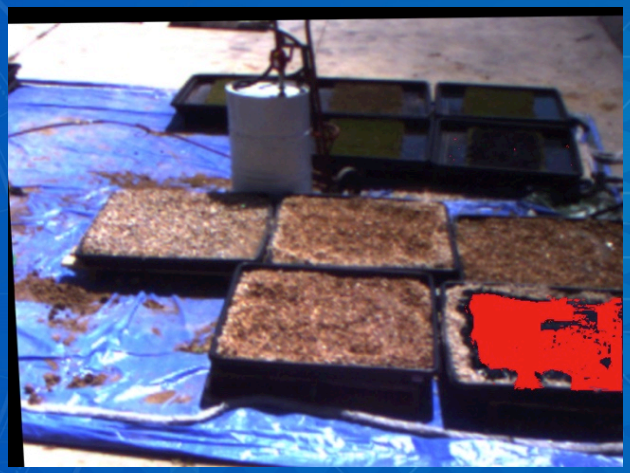


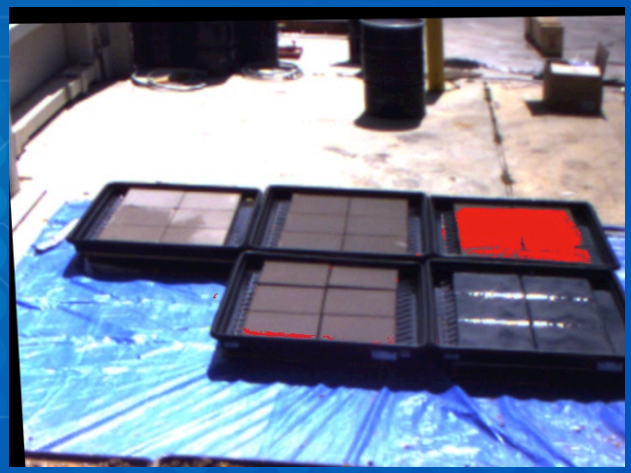
# Are There Hazardous Liquids In These Images?



# Hazardous Liquids Detection and Classification by SLED

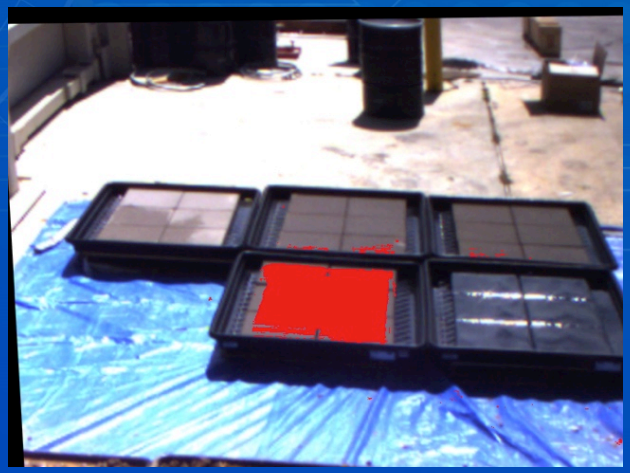
Crude Oil

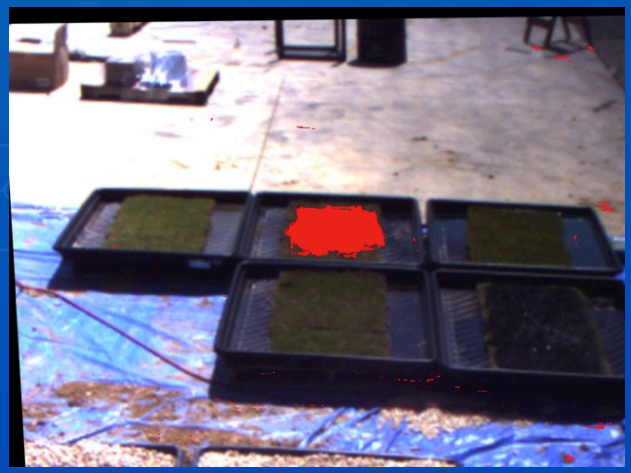




Diesel

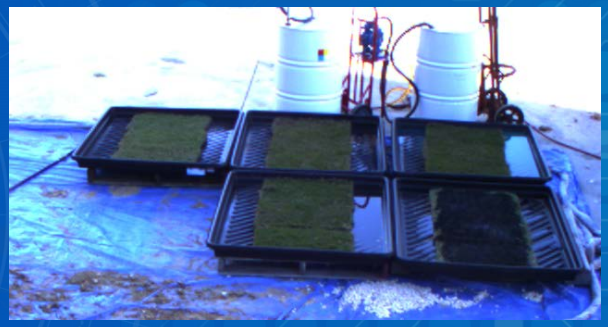
Mineral Oil

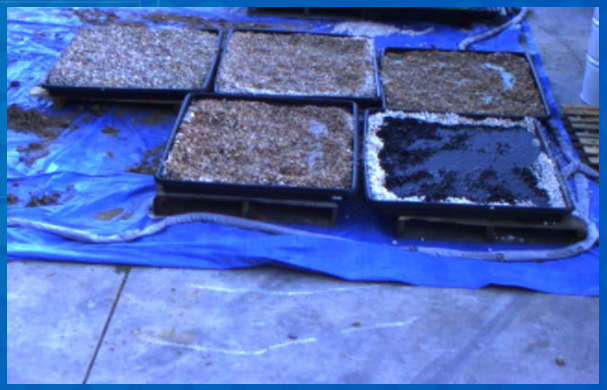




Gasoline

# Are There Hazardous Liquids In These Images?





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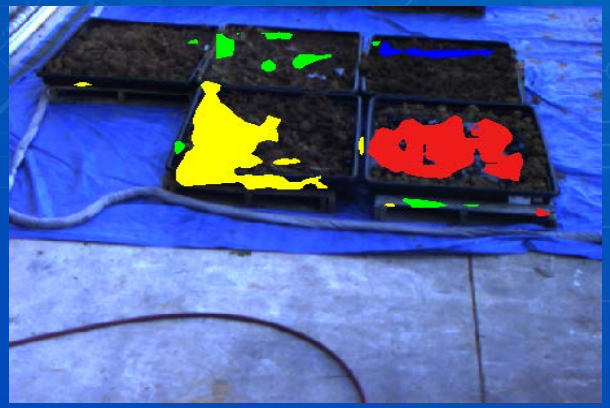
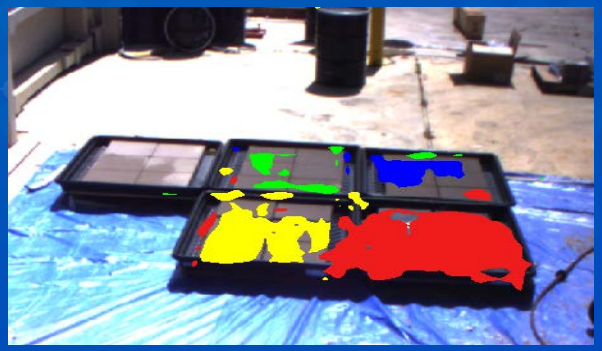




# SLED - Leak Detection Video

# SLED is Extensible and can be used for…

- Different target substances
  - Gases – methane, ethylene, nitrogen
- Different sensors inputs and combinations
  - Optical sensors
  - Analog sensors
  - Fiber optics
  - Acoustic sensors
  - Etc.

# SLED for Methane

- Based on SLED work and results
  - We were recently awarded a project by the DOE to develop a similar technology to detect methane leak/emissions at compressor stations and similar-type facilities
  - 18 month project started in October 2016

# Next Steps for SLED

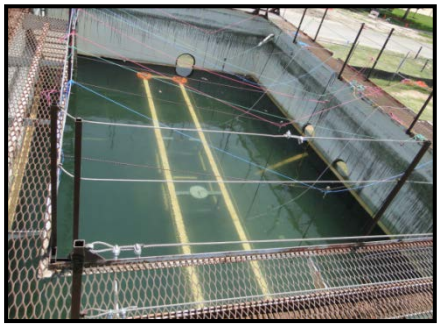
- We want to demonstrate and quantify system performance in a realistic scenario
  - Pipelines
  - Facilities

# Leak Detection Sensor Testing

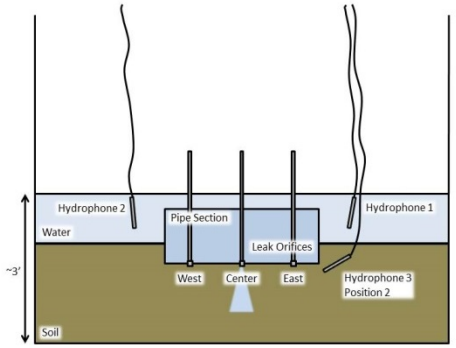
# Technology Validation

- Areas of evaluation
  - Evaluation of performance
  - Non-leak alarm discrimination
  - Ease of implementation
  - Robustness
- Methods
  - Laboratory testing
  - Field testing

## Sensitivity Tests



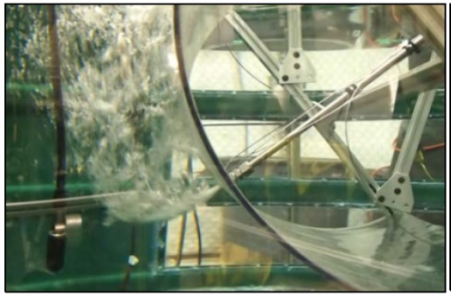
## Leak Characterization

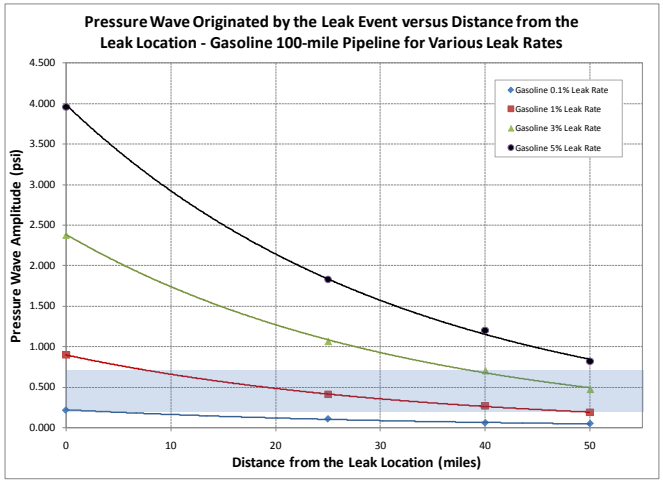


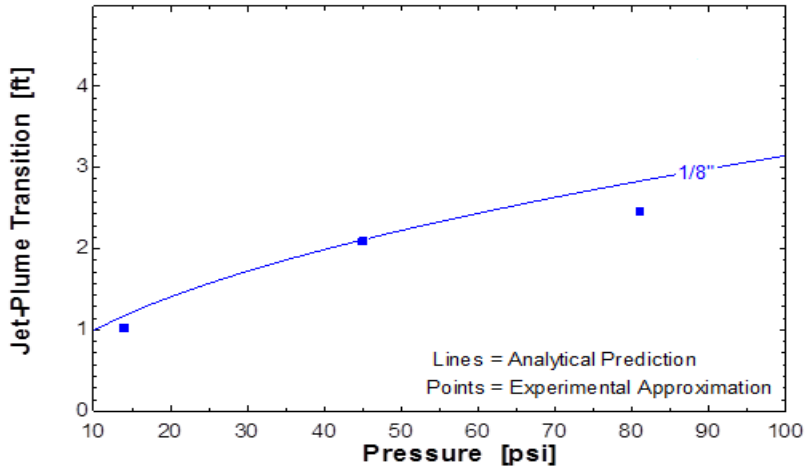

## Large-Scale Testing

# Leak Characterization

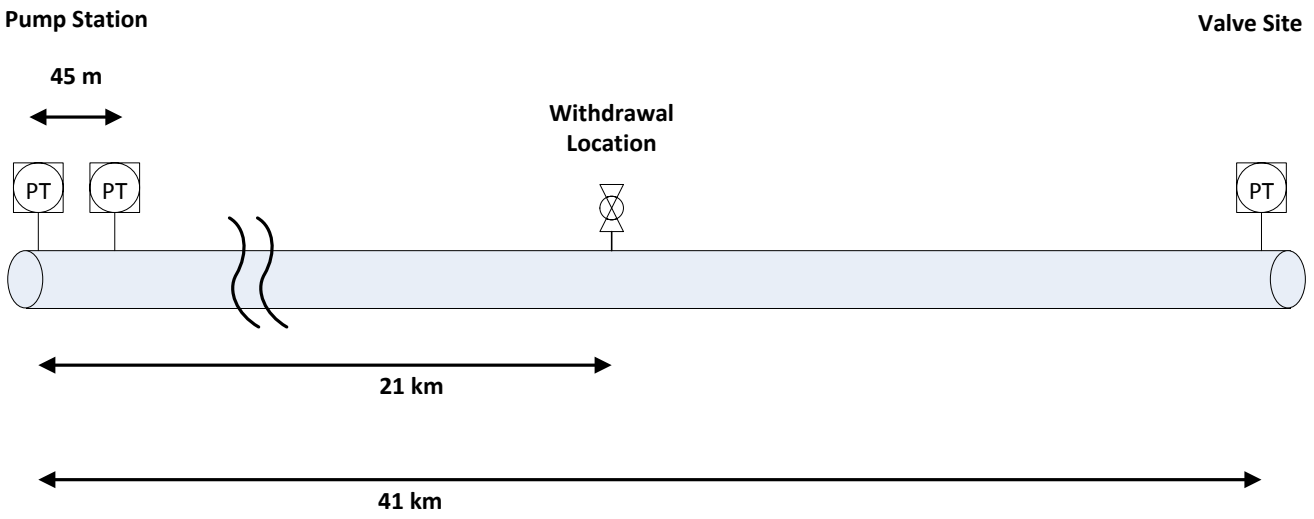
- Discharged fluid propagation
- Thermal profiles
- Plume migration
- Acoustic fields

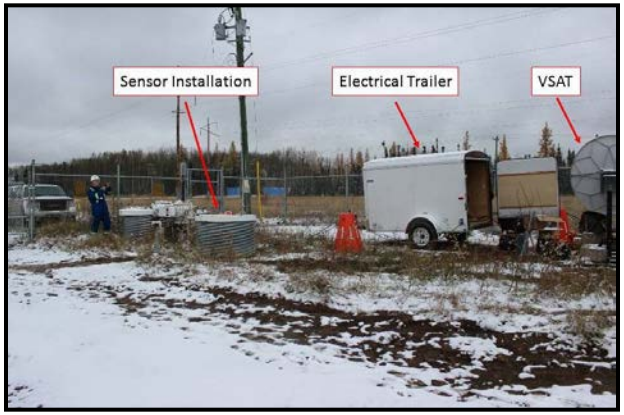




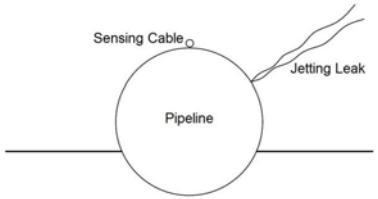
# Field Testing of Negative-Wave Systems

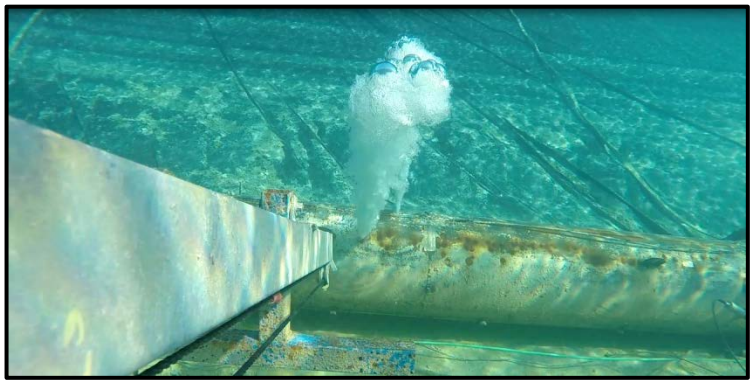


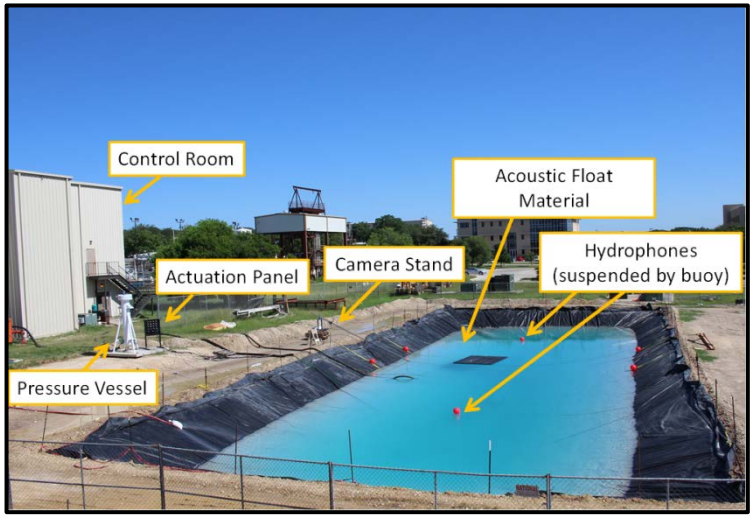




# Testing of DTS/DAS Systems - Large-Scale Testing

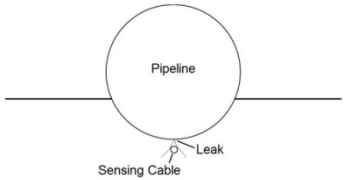
## Leak Into Water

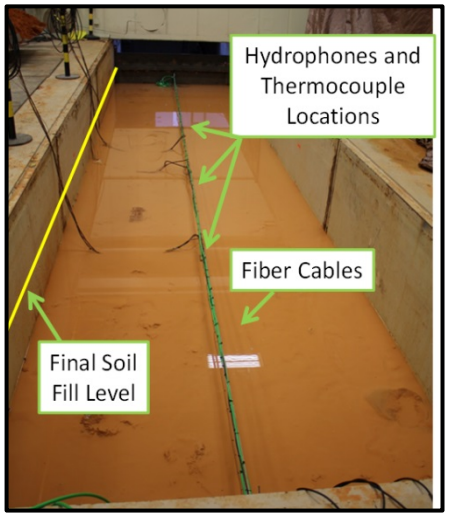





## Leak Into Soil




# Need for Facility Field Testing

- Facility leaks responsible for:
  - 52% of all leaks[1]
  - 60% of all leaks less than five (5) barrels[1]
- 76% of facility leaks are less than five (5) barrels[1]
- Often outside of monitored segments
- Lack of available performance data for aboveground leak detection at facilities
- Possible to accommodate many types of technologies in one test

# Gas Emissions Monitoring

# SwRI Emissions Monitoring

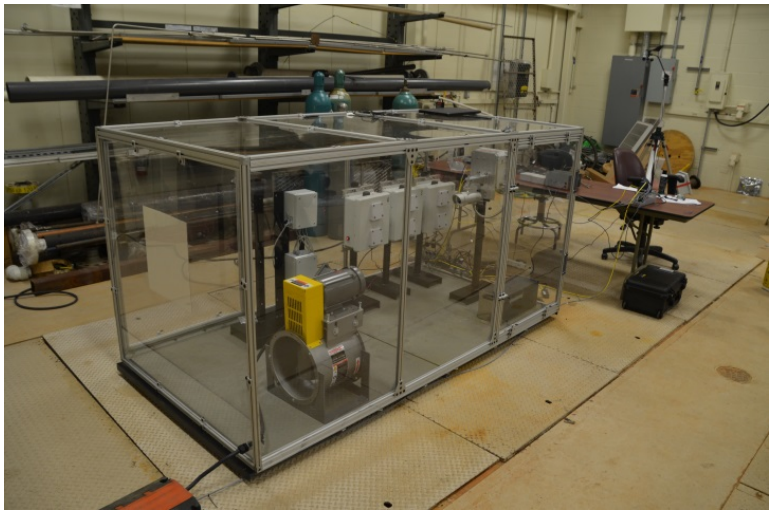
- SwRI has conducted tests on gas monitoring technologies in laboratories, field, and customer sites
- Experience with state-of-the-art instrumentation:
  - OGI
  - CRDS
  - TDLAS

# SwRI Emissions Technology Areas

- Instrumentation evaluation
- Fugitive emissions testing
- Leak quantification
- Leak modeling

# Methane Detectors Challenge

- Lead testing of novel low-cost sensors for continuous monitoring
- Partnership with the Environmental Defense Fund and collaboration with:
  - Eight gas companies
  - U.S. federal government
  - Three universities
  - Multiple technology companies

# Questions?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# References

[1] American Petroleum Institute, 2005, "PPTS Advisory2005-3 – Overview of Incidents Occurring on Facilities Piping and Equipment," http://www.api.org/~/media/Files/Oil-and-Natural- Gas/PPTS/Advisories- Archive/2005_3AdvisoryFacilitiesGenl.pdf?la=en