A Sensor Network System for Process Unit Emissions Monitoring

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Project Overview

- Flint Hills Resources (FHR), Molex LLC and EPA ORD initiated a cooperative research and development agreement (CRADA) in June 2017.

- The CRADA objective is to develop and validate innovative leak detection and repair (LDAR) approaches that can help find leaks soon after they occur.

- Cost effective next-gen LDAR approaches will:
  - Reduce emissions of air pollutants
  - Create safer working environments
  - Reduce resource waste through more efficient work practices and by minimizing product loss
  - Improve emissions inventory knowledge and communications with regulators & communities

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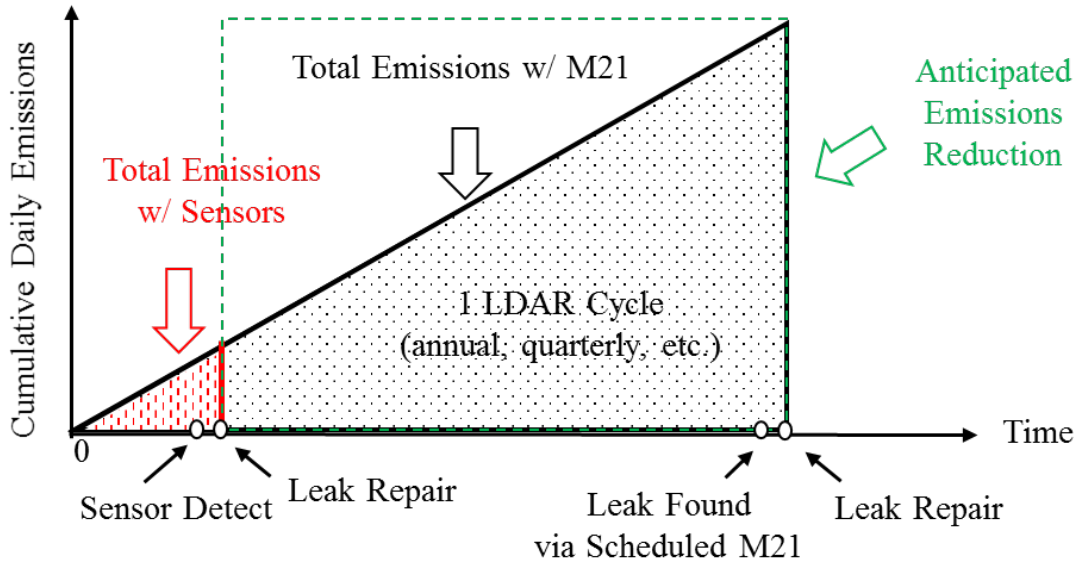
Paradigm Shift In Emissions Monitoring



Method 21 (M21) manual leak detection is labor intensive and executed infrequently so leaks can go undetected for an extended time

- Analyses by the American Petroleum Institute (API) have shown that over 90% of controllable fugitive emissions come from only approximately 0.13% of the piping components.[1]
- By detecting leaks including those from non-LDAR components earlier, repairs can be performed sooner thereby reducing total emissions.

1. Analysis of Refinery Screening Data; API Publication No. 310; American Petroleum Institute: Washington, DC, 1997.

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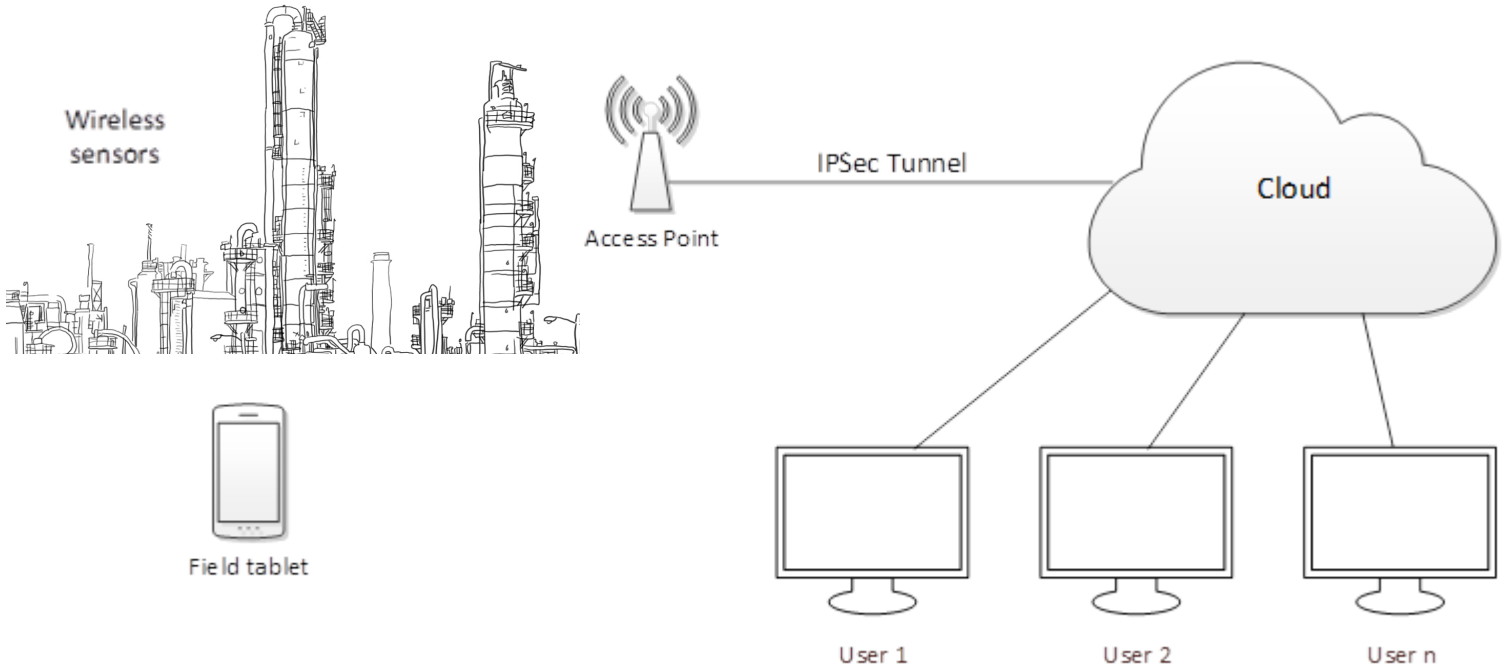
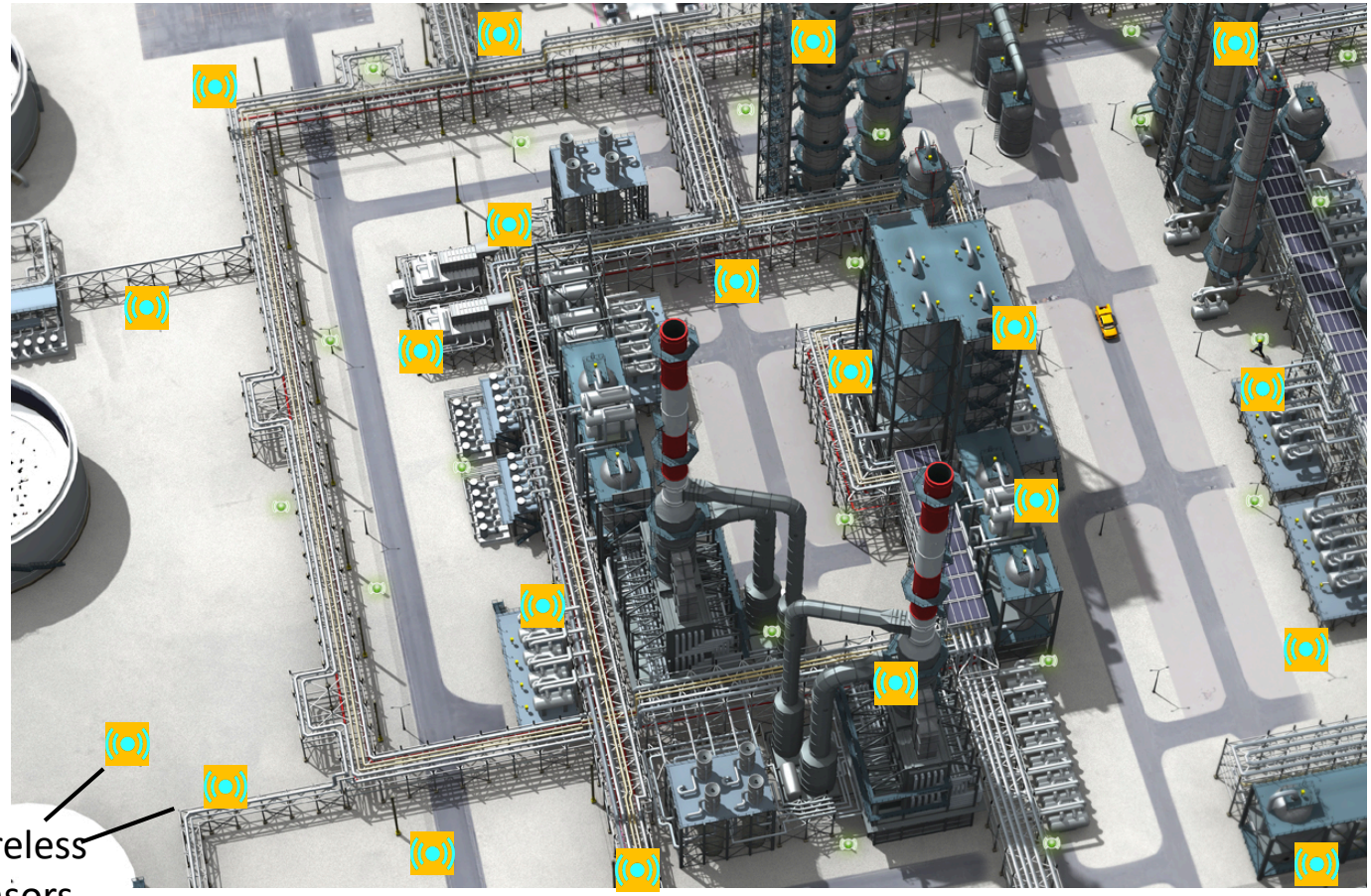
The Sensor-Based System Approach



- The new approach is a multilayered system approach that includes sensors, software, data and procedures.

Leak Detection Area Sensors (LDAS)



Wireless Sensors

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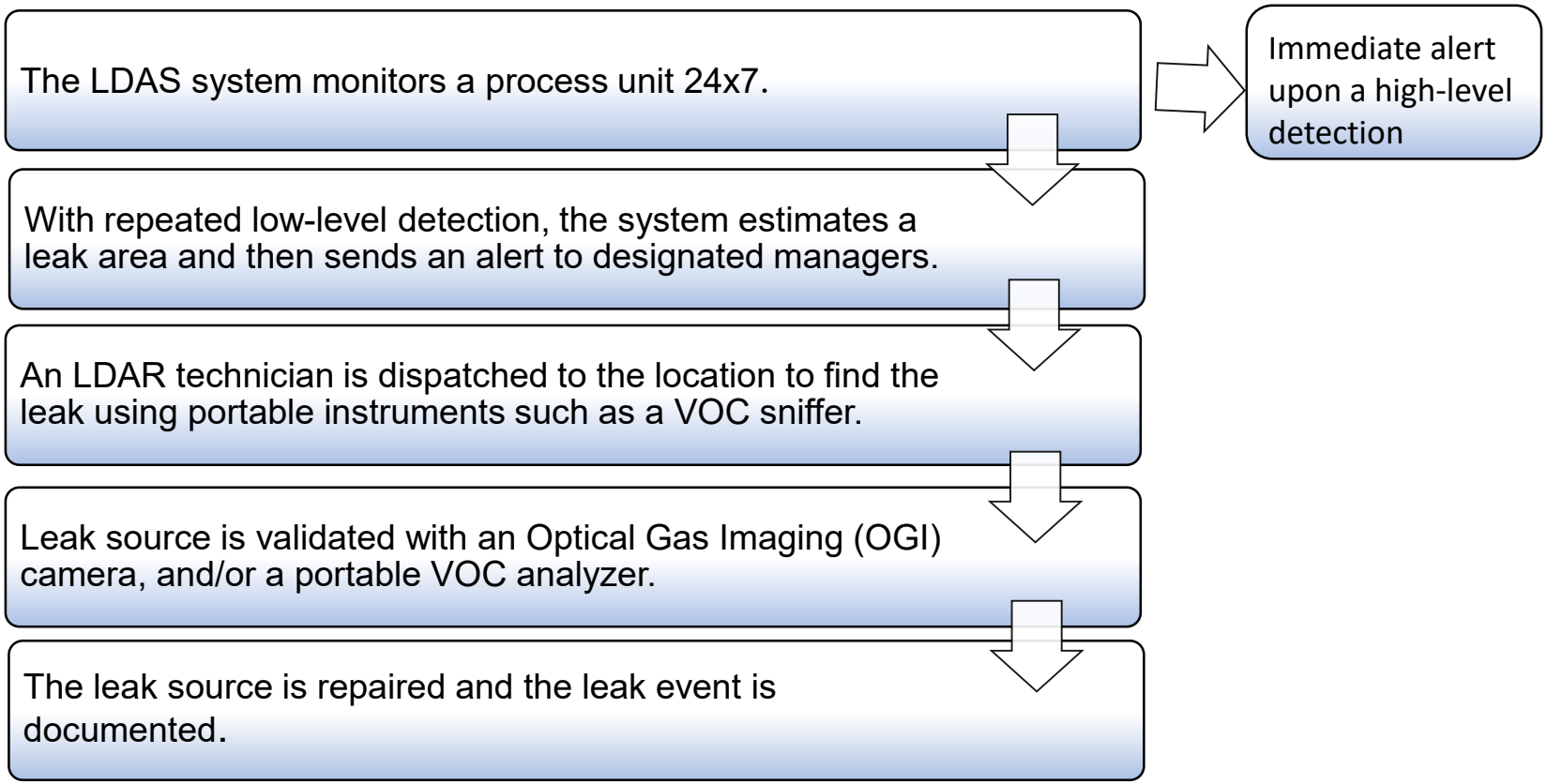
Detection Response Framework (DRF)



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VOC Sensor Technologies

- Many sensors can be used for detecting volatile organic compounds
  - Infrared (NDIR)
  - Flame ionization detector (FID)
  - Photoionization detector (PID)
  - Metal oxide semiconductor (MOS)
  - Ion mobility
  - Electrochemical
  - Pellistors
  - Colorimetric
  - Surface acoustic wave (SAW)
  - UV-DOAS, FT-IR, TDLAS, CRDS, DIAL, SOF, LIDAR, GC, …

- Each sensor has pros and cons, and is only suitable for a subset of VOC compounds.
- One particular point sensor technology was used for the LDAS prototype testing.

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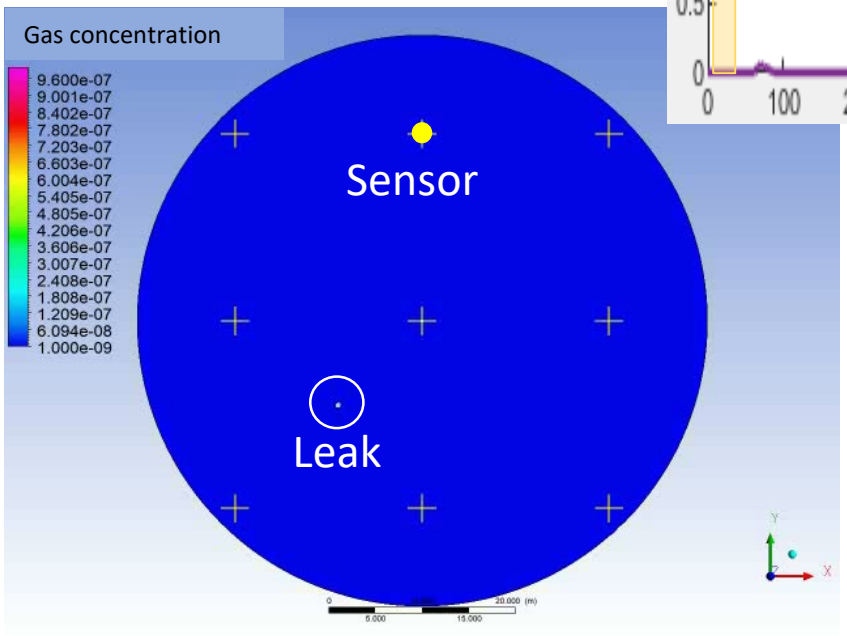
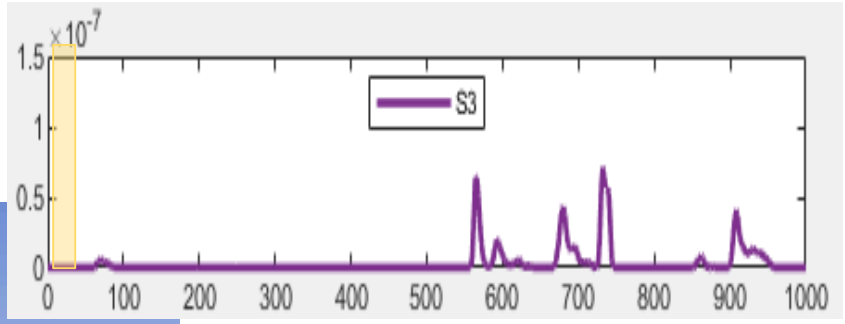
Gas Detection Simulation & Preliminary Evaluation





Over first year, the CRADA team performed simulations and extensive controlled release testing at EPA and an FHR facility.

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LDAS Prototype Testing at FHR Sour Lake Olefins Facility (SLOF)

- Controlled release of simulated leaks with M21 and OGI (relatively open setting)
- Discovered emission source from a fin fan bank that was not detectable by OGI
- Discovered an LDAR program leak between M21 inspections
- Studied detection sensitivity and interferences

Fin fan

Sensor detections were investigated

M21 and Optical Gas Imaging (OGI) was performed

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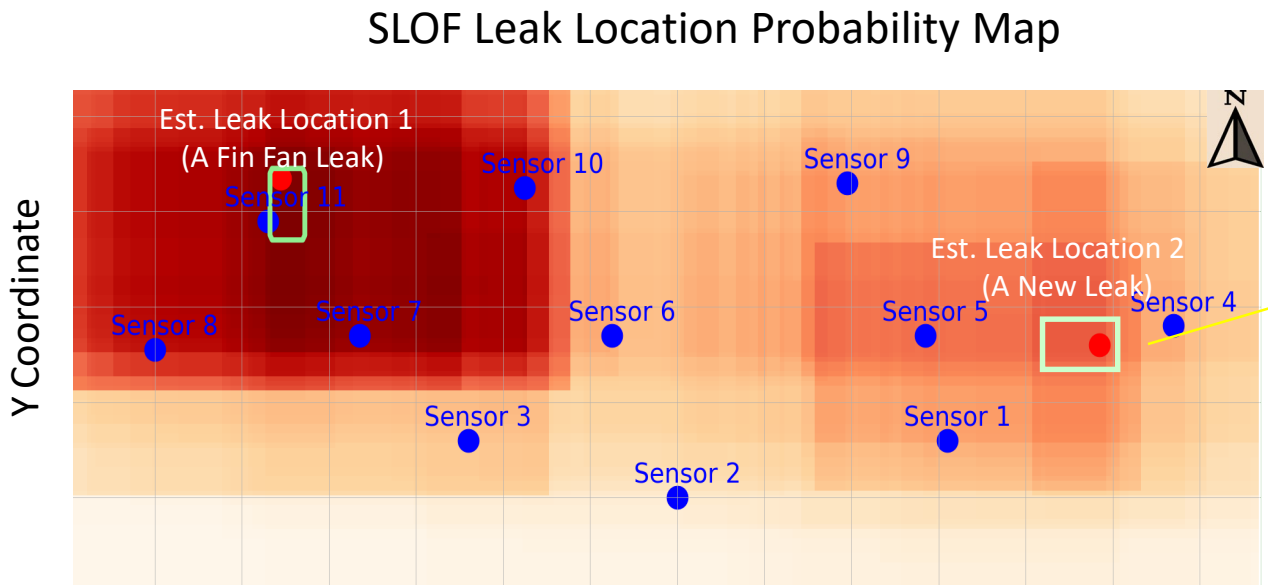
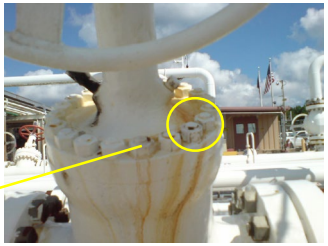
More Results from LDAS in SLOF Testing

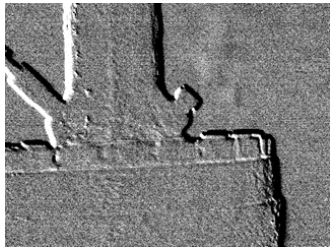
- Detection of new leaks on top of an interfering background



A valve leak was found



OGI Video



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What We Know So Far About LDAS

- A 24x7 LDAS network is a great partner with “on demand” OGIl
- Sensors can detect leaks that are well below what OGI can routinely see but are not as sensitive as M21 (as one would expect) l
- It’s all about required sensor node density…..Is it cost effective?
- Small leaks as low as 1.5 g/hr can be detected in relatively open settings from significant distances.
- What happens in a complex process unit where wind flow is obstructed and more interferences exist? Can realistic node densities still be achieved?
- Initial results indicate that the key to high detection performance is in next gen data analytics that can perform collaborative detection schemes.

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