



Multi-Sensor Platform for Right of Way Defense

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Pipeline Safety R&D Forum 2023

Right of Way Monitoring Timeline

- Develop and Demonstrate a Remote Multi-Sensor Platform for ROW Defense
 - 2021 through 2023; Co-funded by DOT PHMSA and OTD
 - Agreement #693JK31910007POTA
- Pipeline ROW Monitoring and Notification System
 - 2015 through 2019; Co-funded by California Energy Commission, PHMSA, and OTD
- Detection of Unauthorized Equipment in the Pipeline ROW
 - 2003 through 2005; GTI early assessment of fiber optics; OTD funding
- Real-Time Acoustic Monitoring of Contact to Pipelines – Phase 4
 - 2003 through 2006; Battelle point acoustic sensors; GRI funding

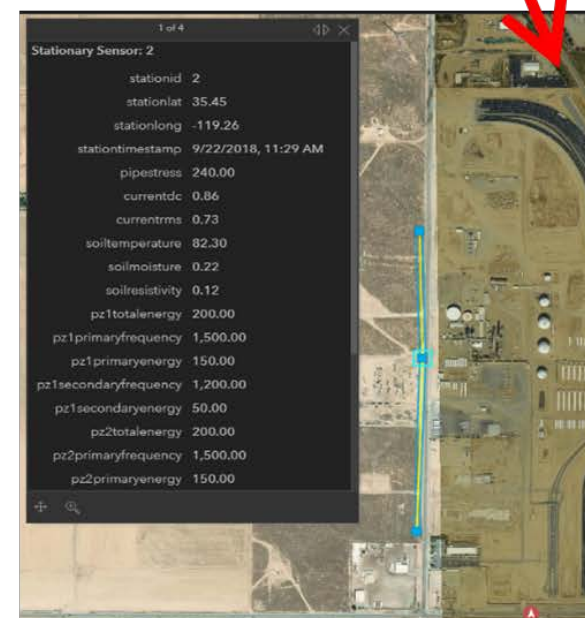
Right of Way Monitoring Timeline

- The technical progress has been driven by improvements in:
 - Sensing
 - Low-power electronics
 - Miniaturization
 - Wireless communication



Background

- Project with CEC/OTD deployed a system in the field.



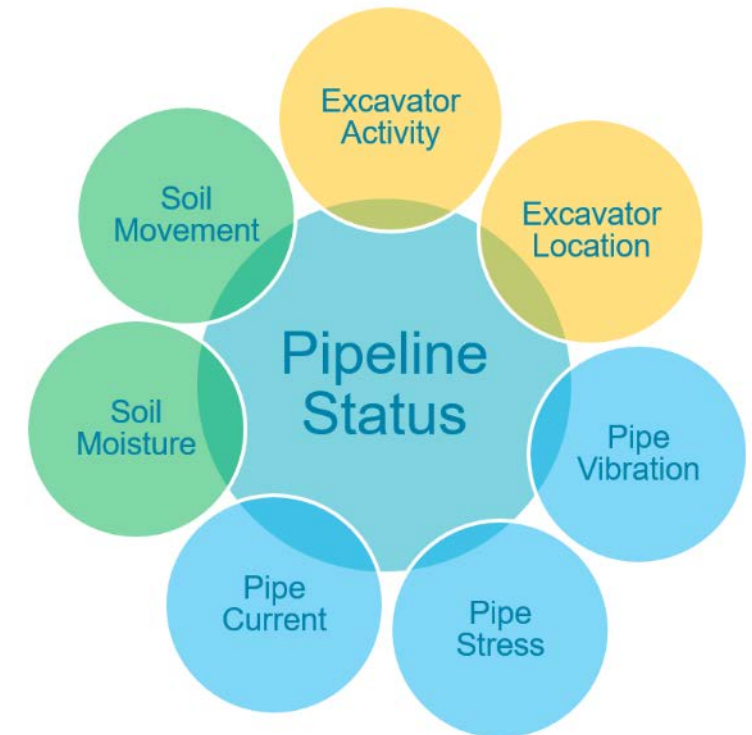
A sensor-based system that monitors for ROW activity

Background

- PHMSA/OTD - Develop and Demonstrate a Multi-Sensor Platform for ROW Defense.
 - Suitable for deployment in small excavation and retrofit applications.
- Addressed issues discovered during the earlier CEC/OTD work.
 - Stationary sensors for vibration were not satisfactory
 - Machine learning hosted on a cloud platform not adequately tested
 - The general sensor installation procedures need to be simplified
 - Methods for installation on live pipe are needed
- The improved methods and equipment were demonstrated.
- PHMSA agreement ended in August of 2023; GTI continues to monitor sites.

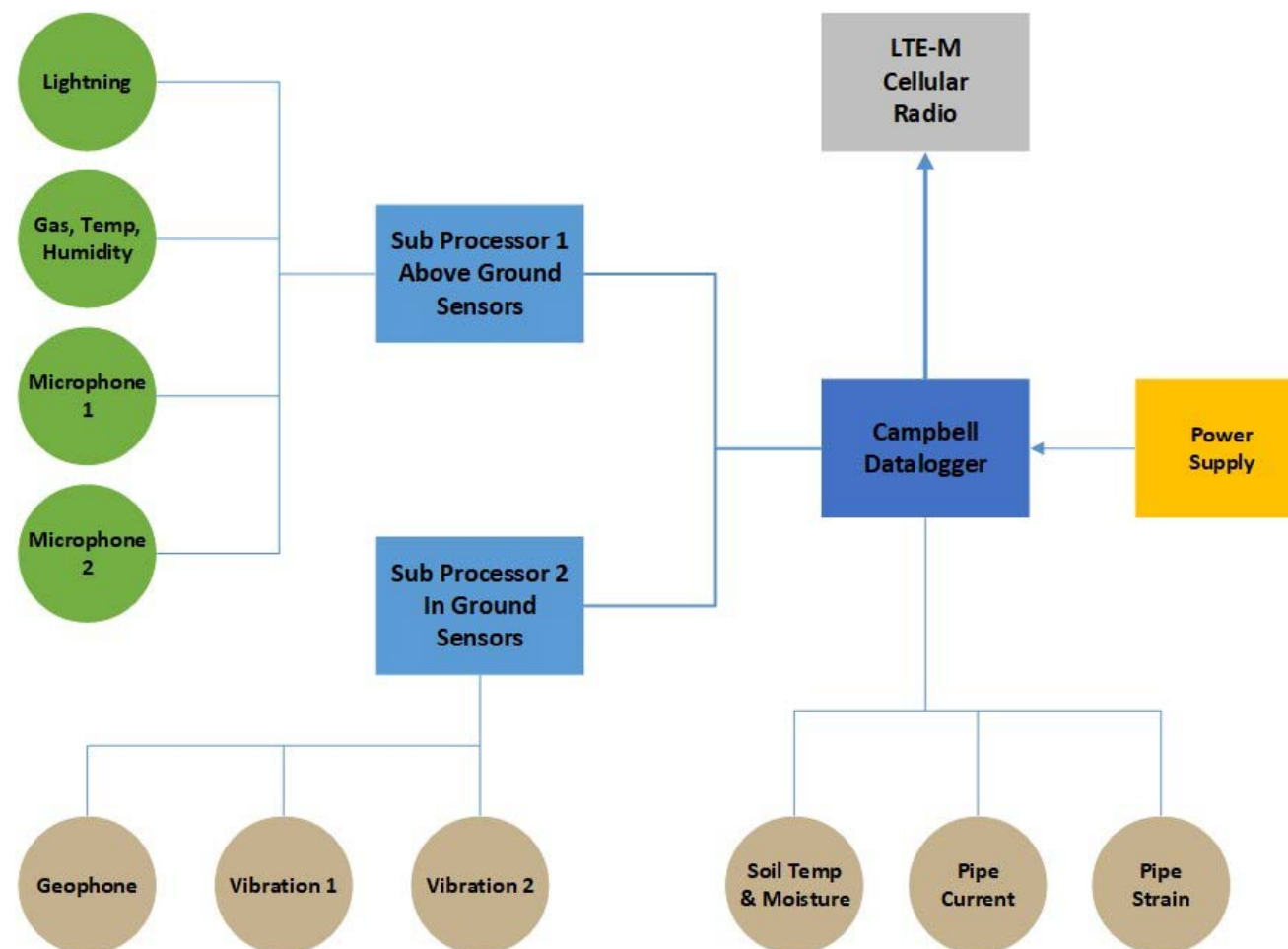
Objective(s)

- The objective is to provide operators with timely situational awareness of threats to pipeline integrity.
 - There are multiple threats on the pipeline right of way (ROW)
 - Third party damage is the most visible threat
 - There are also slower acting, cumulative risks to consider
 - Extreme weather and geohazards must also be considered
 - Multiple sensing technologies are needed



Implementation Architecture

- A suite of sensors is needed to detect ROW threats.
 - Attached to the pipe
 - Vibration, Stress, Current Density
 - In the adjacent soil
 - Moisture, Temperature, Motion
 - Above ground
 - Gas presence, Sound dB, Air temperature, Humidity



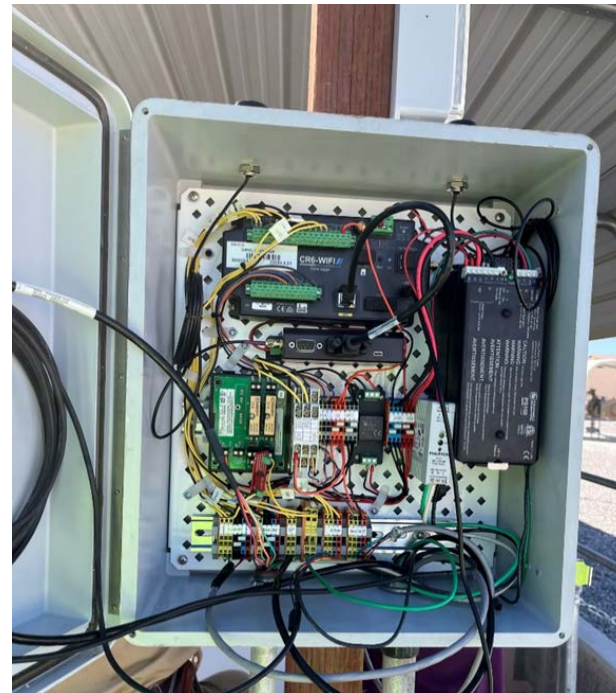
Sensor Installation Improvements

- An improved method for pipe sensor attachment, pin brazing, was successfully tested.
- Operators generally allow pin-brazing on live pipelines.
- The original adhesive bonding method was impractical under most field conditions.



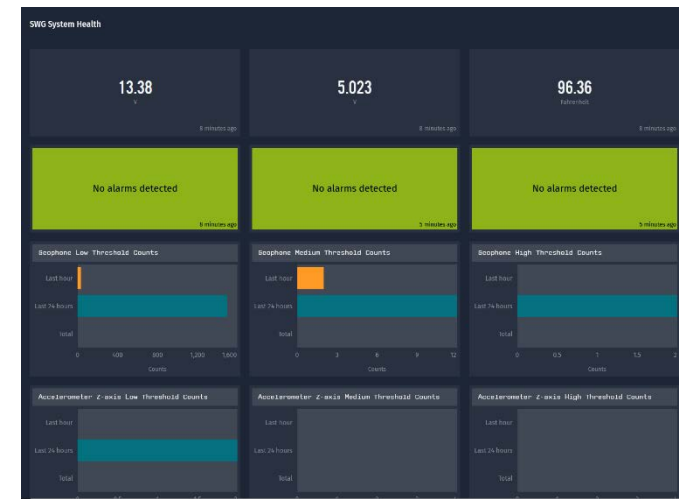
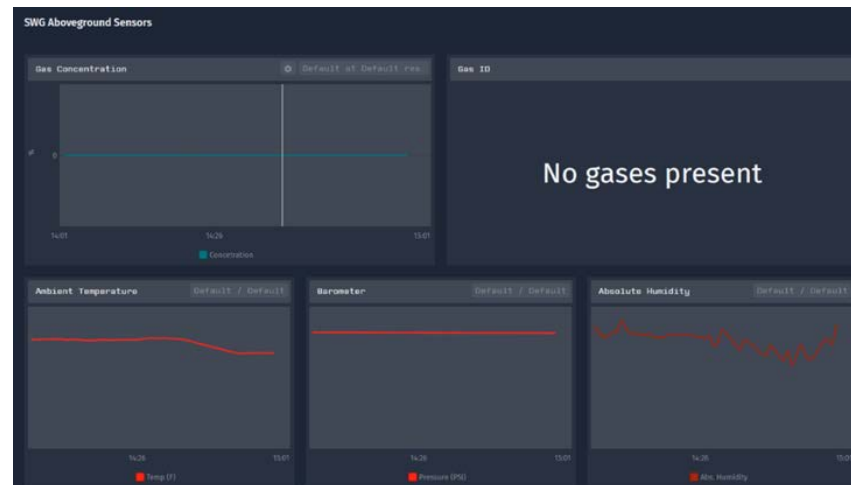
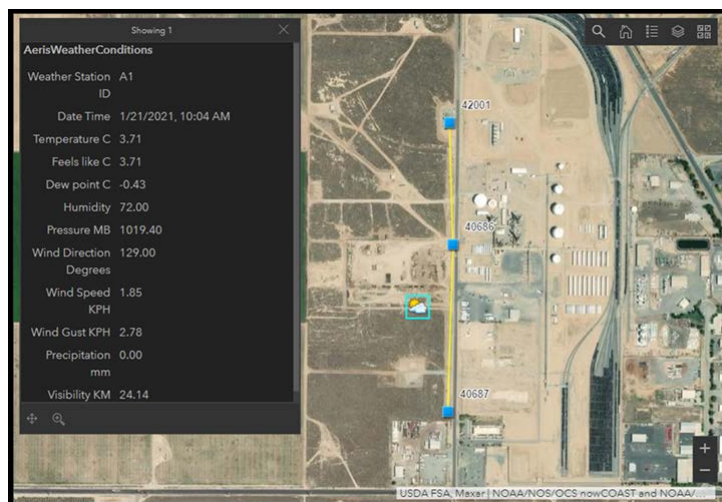
Instrumentation Improvements

- For the original system, the vibration sensors and supporting instrumentation were provided by a third party that was separately contracted by CEC.
- This part of the instrumentation did not perform well during the earlier field test.
- This sub-system was redesigned for the current project and is operating reliably.



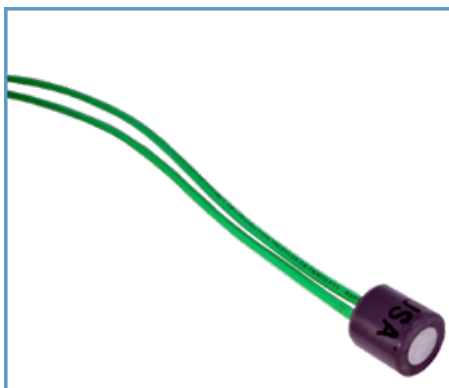
Visualization Improvements

- Data is flowing from test sites, through AWS, and into a visualization dashboard.
- The earlier dashboard version used multiple pieces of software to produce visualizations and alarms.
- The current version uses a single “IoT” software platform to perform all these functions.
- The single platform approach has improved availability/reliability of the dashboard.



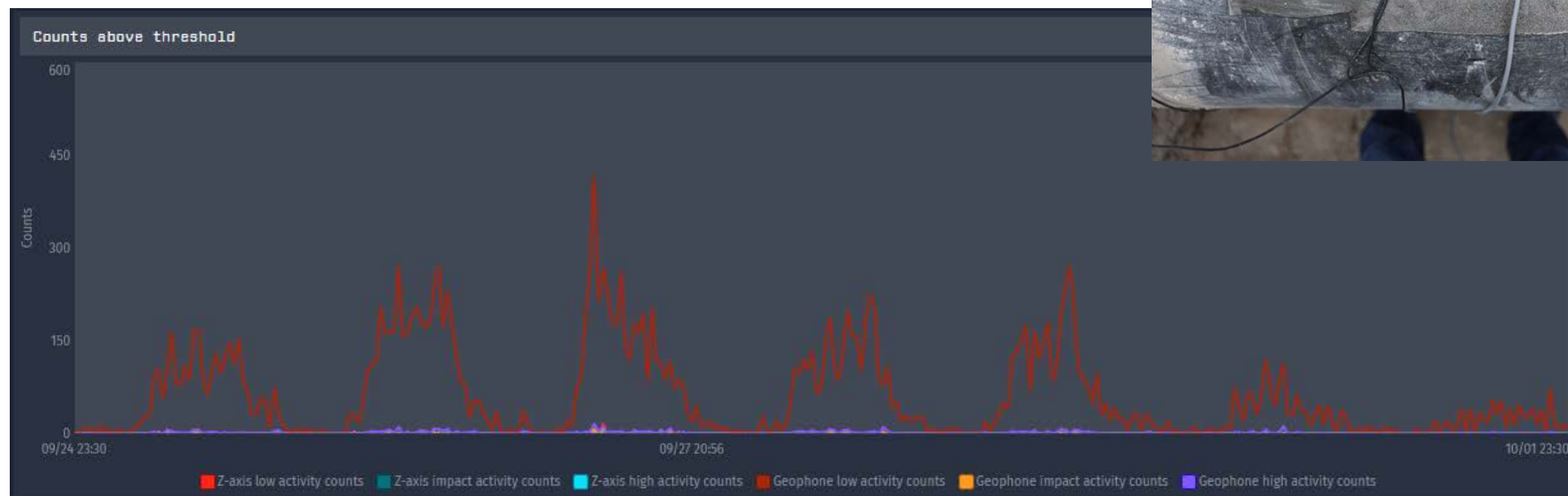
Visualization Example

- Seven days of data showing a discontinuity in the CP current through 1 cm² coupon.
- Soil temperature, moisture, and conductivity are relatively flat over this period.
- Utility verified that rectifiers were shut off for maintenance for several hours at a time.



Visualization Example

- Data shows accelerometer data over 7 days.
- Accelerometer is mounted on the upper surface of pipe.
- The activity appears to correspond with traffic through the facility and days of the week.



Improvements Still Needed

- The original RPMA radio system is not well supported.
 - For the near-term tests, cellular modems are being used.
 - LoRaWAN could be used on appropriate sites.
- Getting permits to install the equipment in the ROW is difficult.
 - Several promising sites were lost to permitting issues, driving schedule delays.
 - The newest test site is “inside the fence” and did not require permitting.
 - The older, upgraded site was already permitted and built.
- Future equipment must be made smaller and less expensive.
 - Fewer sensors per location may facilitate this.



Summary

- An improved prototype ROW Monitoring system was developed based on experience from earlier efforts.
- Deployment took place at two locations; one new, one an upgrade of earlier equipment.
- Data is currently being collected and archived in an AWS instance.
- Data visualization is also available in a user dashboard.
- GTI continues to monitor these sites going forward.

Thank You!

- Thank you for your time.
- Thank you to PHMSA and OTD for sponsoring this work.
- We appreciate any comments or feedback.
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