



Develop and Deploy a Multi-Sensor Platform for Right of Way Defense

Agreement #693JK31910007POTA

Chris Ziolkowski

Debriefing Webinar - December 2023

Project Team

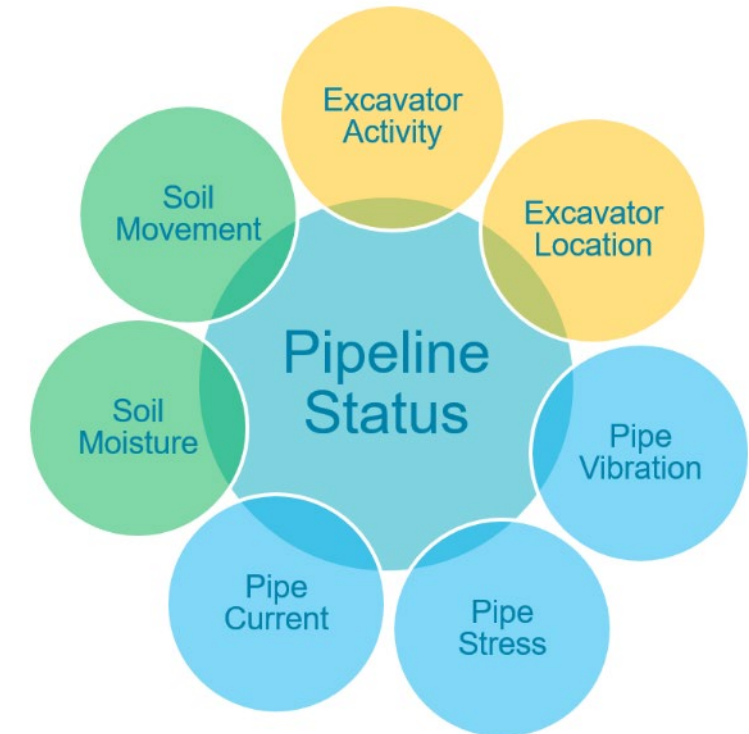
- DOT Pipeline and Hazardous Material Safety Administration (PHMSA); sponsor.
- Operations Technology Development LLC (OTD); sponsor.
- GTI Energy; lead technical contractor.
 - Nikolay Stepin, Ryan Feist, Jason Sphar, Brent Grossman
- SoCalGas Company; test site host.
 - Krikor Tasmajian, Hector Serrano, Kevin Chin
- Southwest Gas Company; test site host.
 - Pom Jintasawang, Andrew Miller, Brian Kalina

Right of Way Monitoring Challenge

- Utilities have extensive ROW (right of way) that contain pressurized pipelines.
- The ROW may be in remote areas that require significant travel time.
 - Risk: A breach, or other problem, may go undetected for significant time.
- The ROW may be in congested areas that complicates access.
 - Risk: Population may be exposed to hazards if response is not quick.
- The pipeline in any ROW location is exposed to general risks.
 - Third party excavation damage.
 - Geohazards from flooding, seismic, or other soil movement.
 - External forces such as lightning or forest fires.

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



Right of Way Monitoring Timeline

- Develop and Demonstrate a Remote Multi-Sensor Platform for ROW Defense
 - 2021 through 2023
- 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

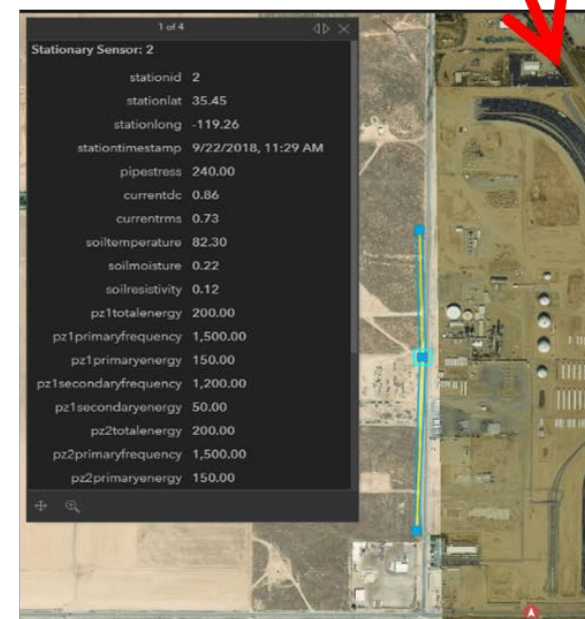
Right of Way Monitoring Timeline

- 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.

Right of Way Monitoring Tasks

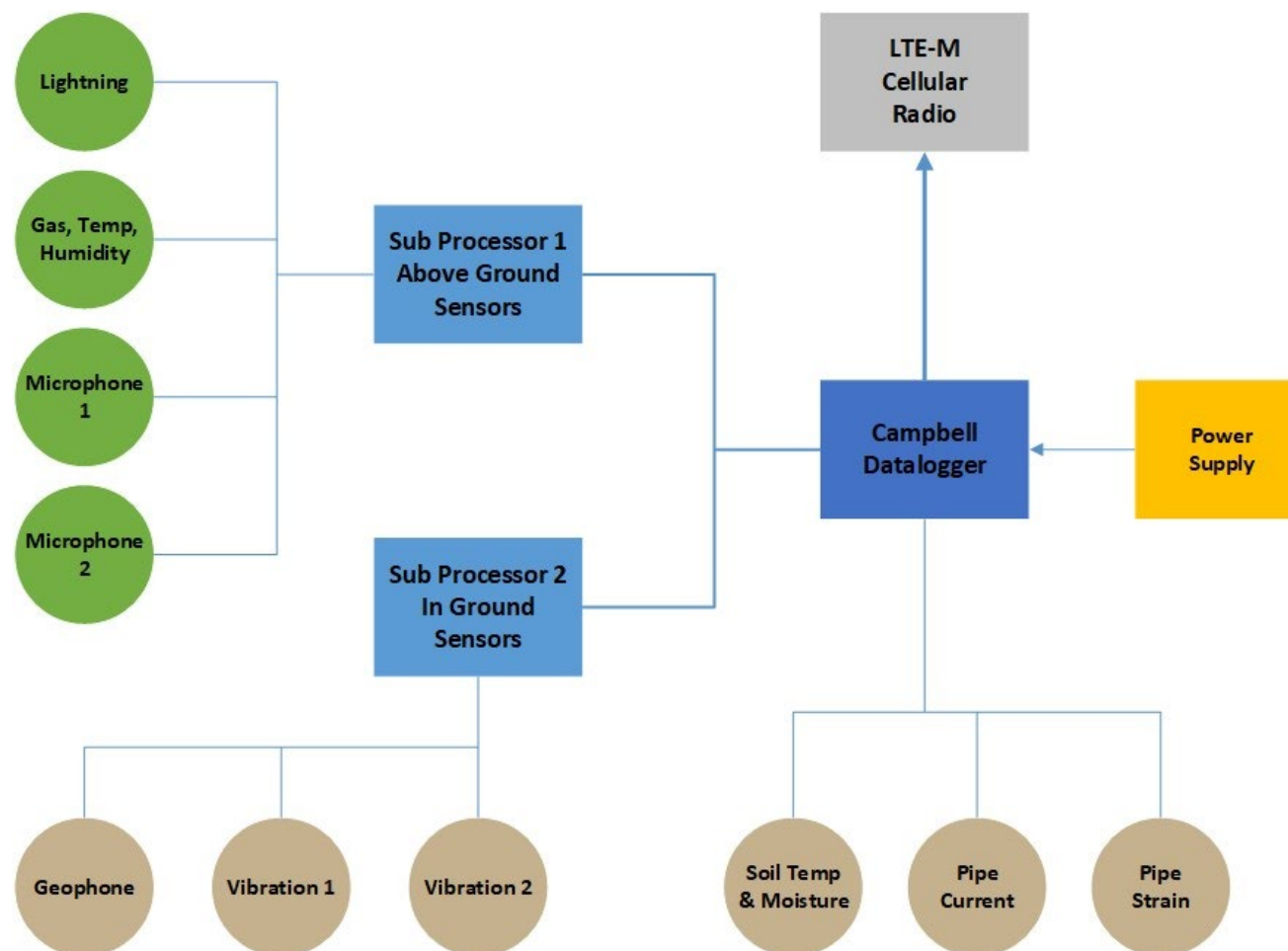
1.	Technology Review	PHMSA \$11,851	OTD \$11,024
2.	Improvements to the Hardware	PHMSA \$59,471	OTD \$90,871
3.	Data Management and Analytics	PHMSA \$266,425	OTD \$126,638
4.	Improvements to User Interface	PHMSA \$41,990	OTD \$50,838
5.	Deployment & Testing of Improved System	PHMSA \$91,271	OTD \$194,007
6.	Project Management	PHMSA \$43,751	OTD \$41,622
	Totals	PHMSA \$514,759	OTD \$515,000

Right of Way Monitoring Tasks 1 & 2

- Task 1. Technology Review
 - The previous work was presented to the PHMSA and OTD sponsors in a series of TAP meetings.
 - The positive and negative aspects of the prior work were presented to collect feedback on implementations that would be acceptable to utility operators.
- Task 2. Improvements to the Hardware
 - Known issues with the prior hardware were addressed and new solutions tested.
 - A modified hardware architecture was developed for the sensors.
 - Installation methods were modified.

Implementation Architecture – Task 2

- 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 – Task 2

- 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.

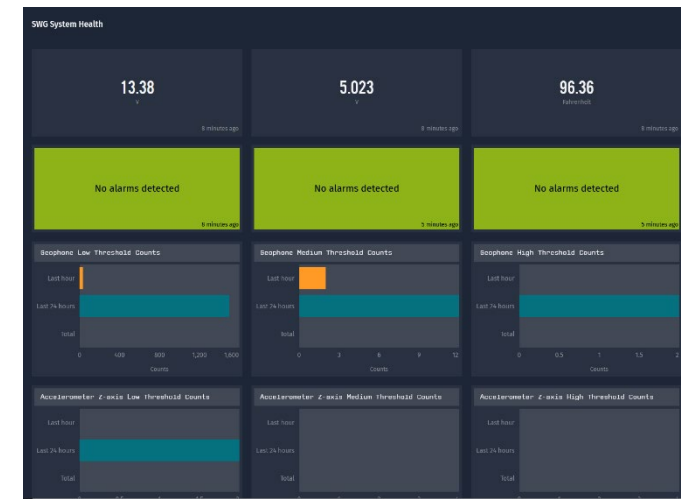
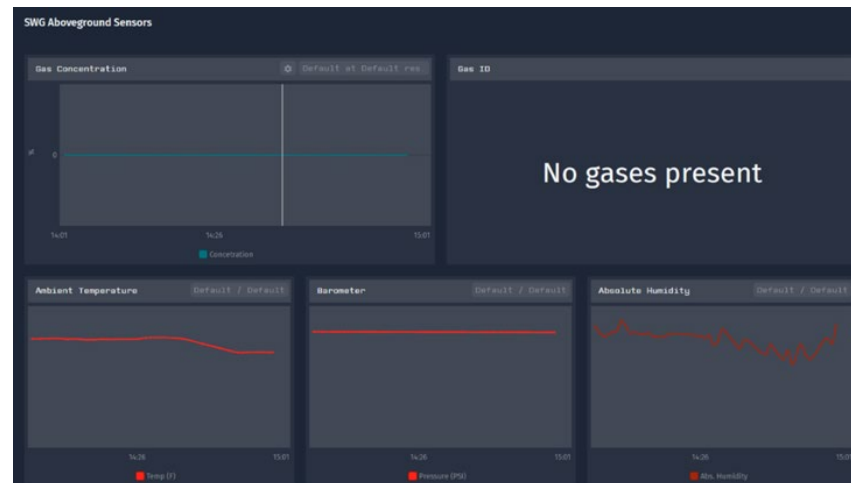
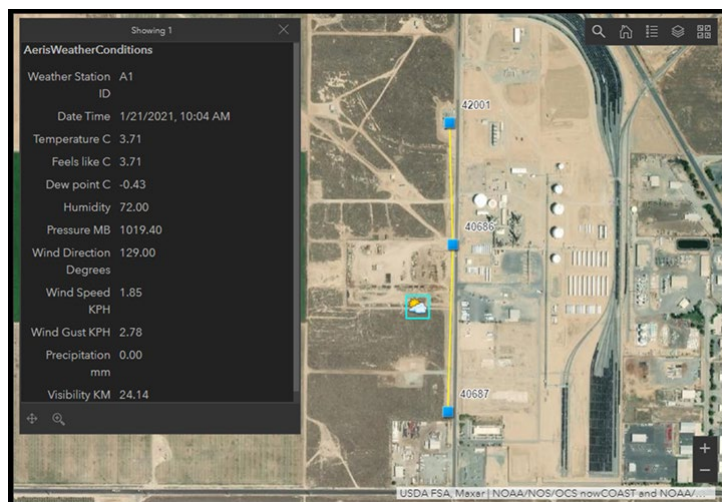


Right of Way Monitoring Tasks 3 & 4

- Task 3. Data Management and Analytics
 - The communication system for the sensors was a major hurdle.
 - The RPMA radio system that was used in the earlier system, after substantial effort, was ultimately abandoned.
 - A cellular solution was used to enable the testing to go forward.
- Task 4. Improvements to User Interface
 - The original geospatial based system for aggregating and visualizing the data proved unwieldy.
 - A single source “IoT Dashboard” system was used for the demonstration user interface.

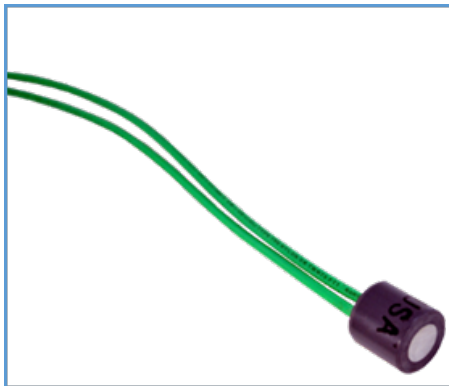
Visualization Improvements – Task 4

- 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.



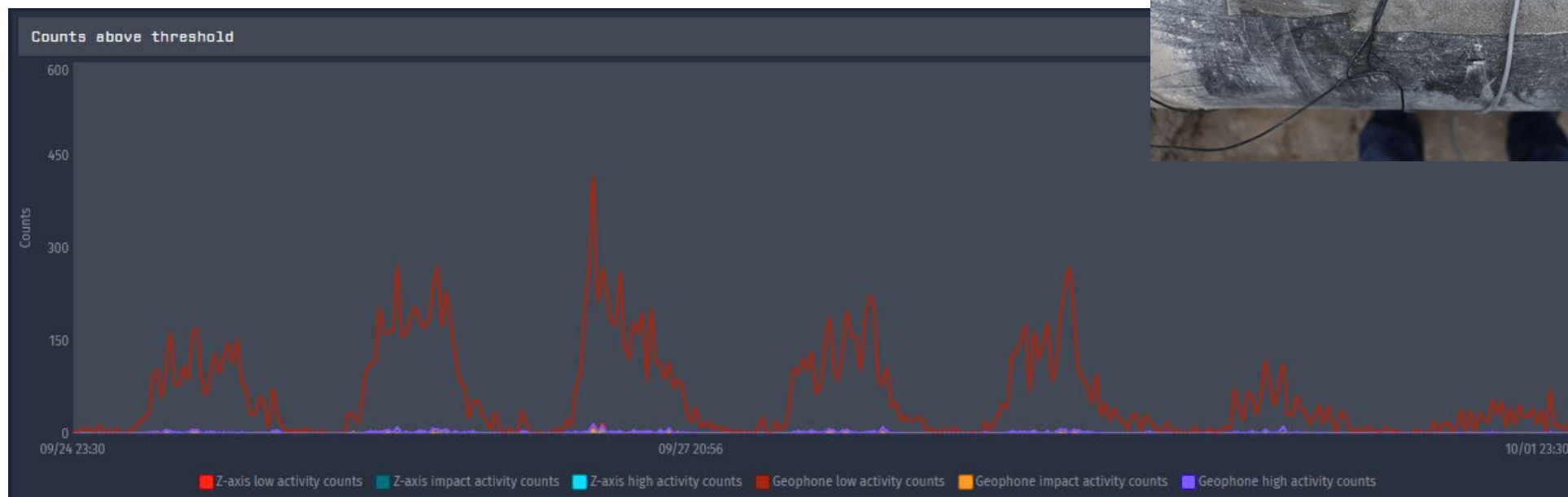
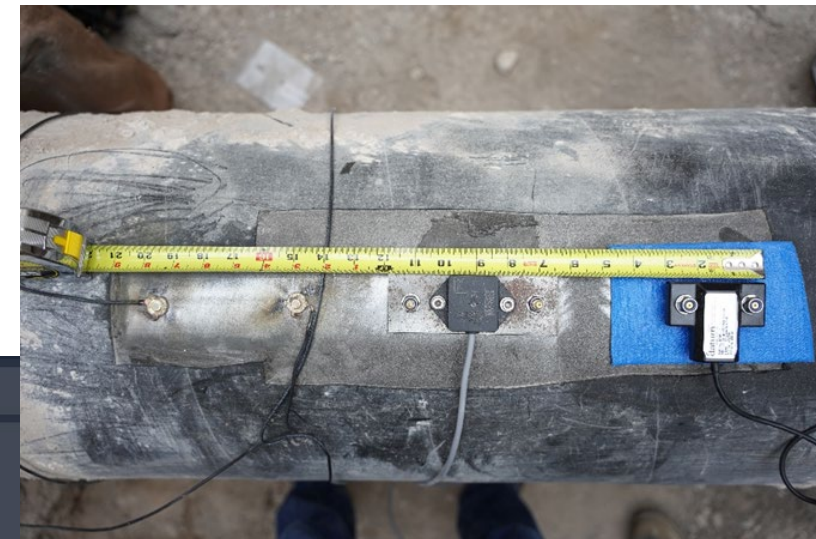
Visualization Example – Task 4

- 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 – Task 4

- 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.

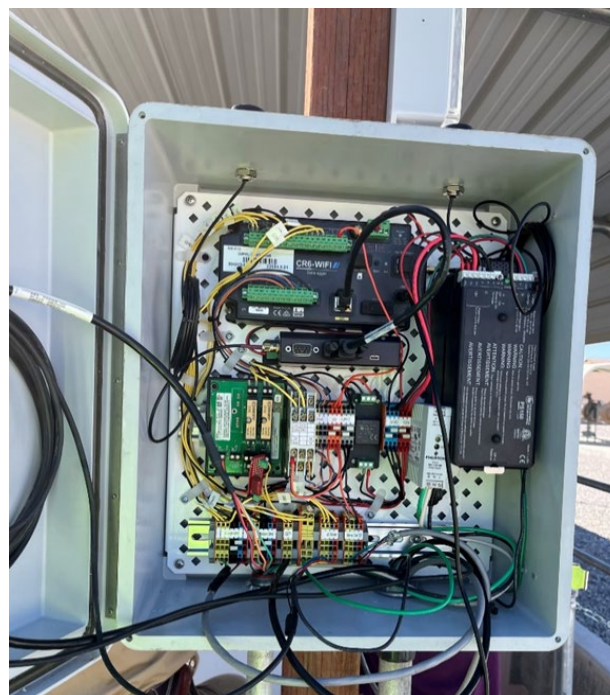


Right of Way Monitoring Tasks 5 & 6

- Task 5. Deployment & Testing of Improved System
 - Finding an appropriate test site was the largest source of project delays.
 - Siting and permitting was complicated by the need for an above ground installation.
 - An additional site for hardware deployment was only identified in early 2023.
 - A site from the earlier work was upgraded to the newer hardware.
 - Next version of hardware must be significantly smaller and less complex.
- Task 6. Project Management
 - Maintain scope, schedule, and budget through multiple amendments.

Deployed Improvements – Task 5

- 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.



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!

- **Questions?**
- Thank you for your time.
- Thank you to PHMSA and OTD for sponsoring this work.
- We appreciate any comments or feedback.
- cziolkowski@gti.energy