

DOT PHMSA Internal Quarterly Report

Date of Report: 5th Quarterly Report - October 1 through December 31, 2020 – rev1

Contract Number: 693JK31910007

Prepared for: USDOT PHMSA and Operations Technology Develop LLC (OTD)

Project Title: Develop and Demonstrate a Remote Multi-Sensor Platform for Right-of-Way Defense

Prepared by: Gas Technology Institute

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For quarterly period ending: December 30, 2020

1: Items Completed During this Quarterly Period:

Table 1. Payable Milestones Completed this Quarter

Technical and Deliverable Milestone Schedule						
Item #	Task #	Title	Activity/Deliverable	Federal Cost	Cost Share	Total
12	2	Hardware Improvements	Procure equipment to facilitate hardware improvements and test improvements on pipe in GTI or utility test yard. Create a test report showing the performance of the equipment. Provided within a quarterly report	13,450	20,636	34,086
21	6		Submit 5 th Quarterly Report	3,392	4,086	7,478

Table 1 was populated with Items from Attachment #3, Technical and Deliverable Payable Milestone Schedule (in the contract) that were completed during this reporting period and are the corresponding Items included on our next invoice.

2: Items Not-Completed During this Quarterly Period:

The project is now roughly 2 quarters behind schedule as shown in Table 2. The OTD co-funding contract was finalized during December of 2019 whereas the PHMSA contract was finalized in September. In order to coordinate the PHMSA and OTD budgets, little effort was expended during the first project quarter. The pandemic has affected utility and equipment vendor schedules as well. GTI will be formally requesting a no cost time extension. The request will be submitted shortly after the next TAP meeting. At that time GTI should have an idea of the test sites.

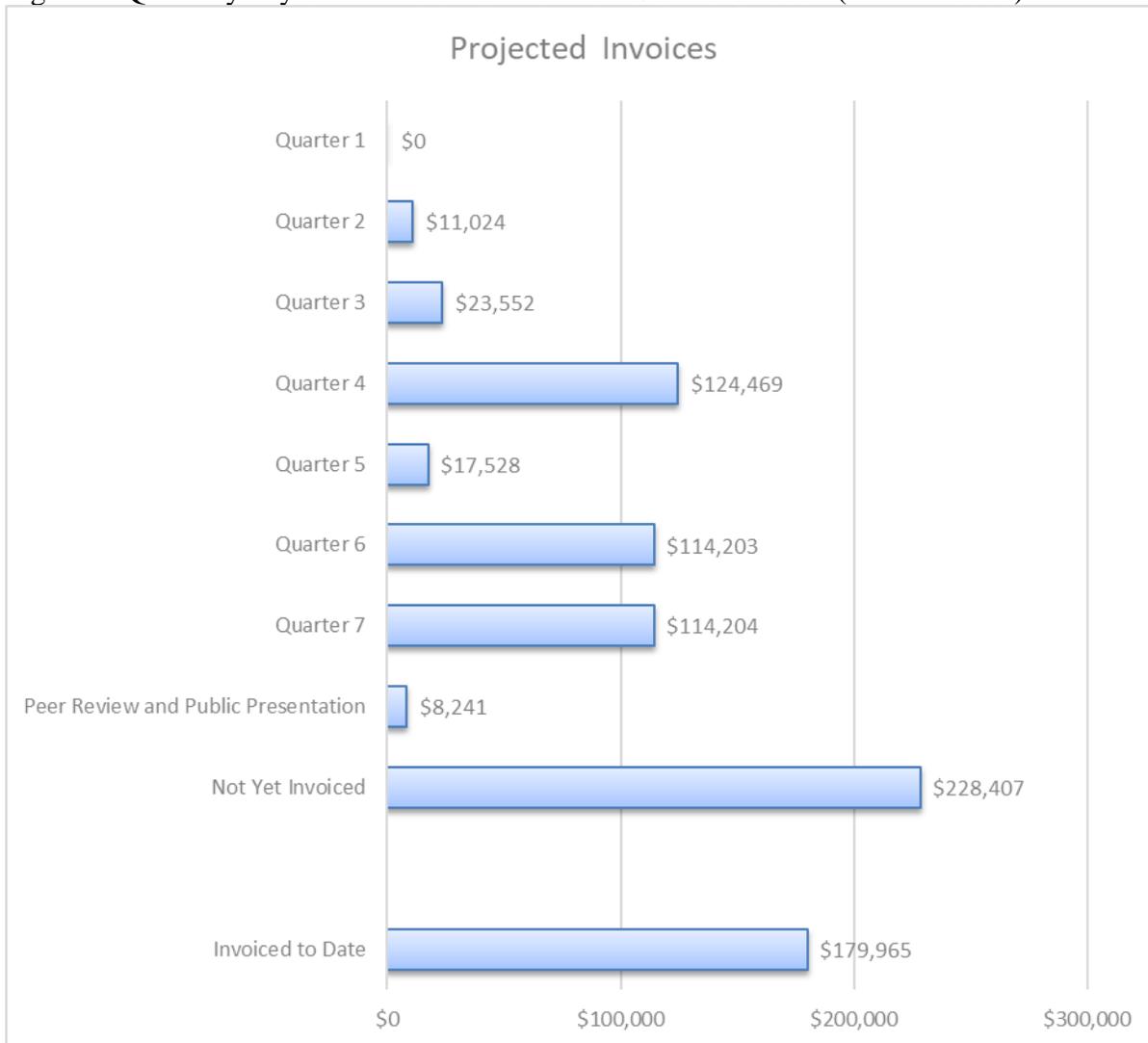
Table 2. Payable Milestones Not Completed this Quarter

Technical and Deliverable Milestone Schedule						
Item #	Task #	Title	Activity/Deliverable	Federal Cost	Cost Share	Total
13	3	Data Management and Analytics	Investigate machine learning (ML) tools available for the selected GIS environment. Provide an assessment of their applicability to the expected test site data. Provided within a quarterly report	36,013	18,536	54,549
14	4	User Interface Improvements	Provide test data verifying that improved hardware can connect to GIS and to dashboard. Provided within a quarterly report.	9,999	11,737	21,736
15	5	Deploy System	Complete procedures and equipment list required to deploy the ROW Defense System on a test site. Finalized location of utility test sites. Schedule for deployment of equipment on test sites. Provided within a quarterly report	2,177	13,854	16,031
17	2	Hardware Improvements	Provide final test reports or needed clarifications showing the performance of the equipment as deployed. Provided within a quarterly report.	12,948.00	20,169.00	33,117.00
18	3	Data Management and Analytics	Summarize the performance and costs of maintaining GIS environment. Provided within a quarterly report	72,667.00	32,132.00	104,799.00
19	4	User Interface Improvements	Provide second and final demonstration of improved dashboard to TAP	8,922.00	11,738.00	20,660.00
20	5	Deploy System	Narrative describing the deployment of equipment on the utility test sites. The narrative will cover the installation process and any issues encountered. Provided within a quarterly report.	6,930.00	31,696.00	38,626.00

3: Project Financial Tracking During this Quarterly Period:

The nature of the contract for this research effort is fixed price, with clearly defined milestone/deliverable payments. **Figure 2** below outlines projected invoicing, as well the invoice submitted upon delivery of the Third Payable Milestone.

Figure 1. Quarterly Payable Milestones/Invoices - 693JK31910007 (Federal Costs)



4: Project Technical Status

ACTIVITY: TECHNOLOGY REVIEW AND TECHNICAL ADVISORY PANEL (TAP)

Item Title: Notes of Kickoff Meeting Detailing any Project Scope Changes

Item Number: 1

Task Number: 1

This item is complete.

ACTIVITY: SUBMIT 1ST QUARTERLY STATUS REPORT

Item Title: 1st Quarterly Report

Item Number: 2

Task Number: 6

This item was completed on December 31, 2019.

ACTIVITY: TECHNOLOGY REVIEW TAP FEEDBACK

Item Title: Capture TAP Feedback

Item Number: 3

Task Number: 1

This item was completed June 30, 2020.

ACTIVITY: HARDWARE IMPROVEMENTS

Item Title: Develop Hardware Requirements

Item Number: 4

Task Number: 2

This item was completed June 30, 2020.

ACTIVITY: DATA MANAGEMENT AND ANALYTICS

Item Title: Review of GIS Standards and Tools

Item Number: 5

Task Number: 3

This item was completed August 30, 2020.

ACTIVITY: USER INTERFACE REQUIREMENTS

Item Title: Capture TAP feedback

Item Number: 6

Task Number: 4

This item was completed August 30, 2020.

ACTIVITY: SUBMIT 2ND QUARTERLY STATUS REPORT

Item Title: 2nd Quarterly Report

Item Number: 7

Task Number: 6

This item was completed on March 31, 2020.

ACTIVITY: HARDWARE IMPROVEMENTS

Item Title: Identify Alternative Hardware Products

Item Number: 8

Task Number: 2

This item was completed June 30, 2020.

ACTIVITY: DATA MANAGEMENT AND ANALYTICS

Item Title: Set up and Maintain a GIS Environment

Item Number: 9

Task Number: 3

This item was completed August 30, 2020.

ACTIVITY: USER INTERFACE REQUIREMENTS

Item Title: Provide a Demonstration of User Interfaces Capabilities

Item Number: 10

Task Number: 4

This item was completed August 30, 2020.

ACTIVITY: SUBMIT 3RD QUARTERLY STATUS REPORT

Item Title: 3rd Quarterly Report

Item Number: 11

Task Number: 6

This item was completed on June 30, 2020.

ACTIVITY: HARDWARE IMPROVEMENTS

Item Title: Procure equipment to facilitate hardware improvements and test on GTI pipe or utility yard.

Item Number: 12

Task Number: 2

This item is complete. The major equipment items are in hand and testing has begun. There is development work to be done but the major hardware decisions are complete. Based on the experience with the first ROW Monitor site, a Campbell datalogger (Figure 2) will be used as the central data aggregator for field sensor locations. An upgraded model, the CR6, will be used as it provides more flexible sensor interfaces and communication options. GTI acquired one such device for testing and placed an order for an additional five devices based on testing results.

Figure 2. Campbell Scientific CR6 Datalogger



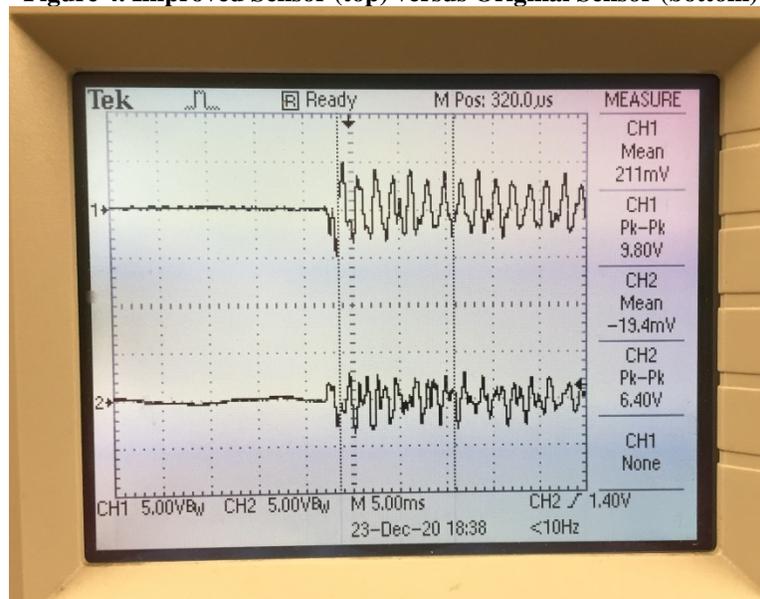
The other area identified for improvement was vibration sensors and their installation on pipelines. An accelerometer (TE4030) with more robust packaging and an integral cable was selected for further testing. One of the issues with the original sensor was that there was substantial in-field work required to install and seal it. A side-by-side comparison (Figure 3) of the two sensors was performed on a pipe cut-out section. The new sensor was installed on a mounting plate that is secured with brazed-on threaded pins. The original sensor is adhesive bonded as it is in the field.

Figure 3. Sensor Comparison Testing



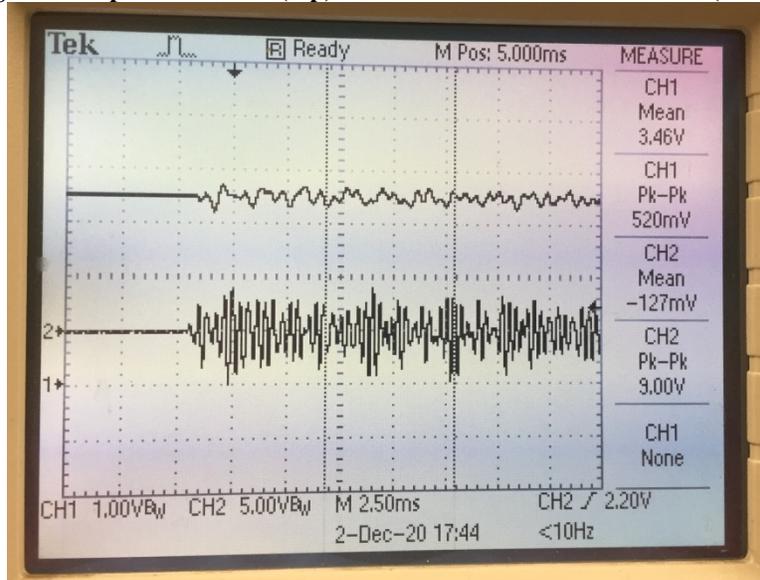
The two sensors are conditioned with the same amplifier modules (DataForth 8B40 series) as will be installed in new field installations. The new TE4030 has some internal amplification of the vibration signal prior to injecting in the cable. The original sensor is piezoelectric element bonded directly to the pipe with no amplification prior to the cable. The choice of an amplified sensor was intentional for noise management; it will be more resistant to induced interference in long cables. Additional amplification was added prior to capturing the signals: a gain of 50 for the new sensor and a gain of 250 for the original. The plate rested on a foam slab for damping; excitation is created by tapping the plate lightly with a small tip screwdriver. It can be seen (Figure 4) on an oscilloscope that the performance of the improved sensor is equivalent or slightly better than the original. The ease of installation and noise management will also be better under field conditions.

Figure 4. Improved Sensor (top) versus Original Sensor (bottom)



The TE4030 was also tested versus an off-the-shelf reference accelerometer: Wilcoxon Research 935M. This was done to verify performance specifications: the WR935M is a laboratory grade accelerometer with 10 Volt/g sensitivity and 7000 Hz of bandwidth. The TE4030 is an industrial accelerometer with 1 Volt/g sensitivity and 1000 Hz bandwidth at a reasonable cost. Both were mounted on a pipe cut-out section for testing. The oscilloscope (Figure 5) shows the difference in performance as expected: the WR part has higher output by roughly 10 with greater bandwidth.

Figure 5. Improved Sensor (top) versus Reference Accelerometer (bottom)



The industrial specification TE4030 is completely appropriate for this application. The bandwidth of sensors for buried applications is generally low; the blanket of soil attenuates high frequencies drastically. In the existing ROW Monitor test site, impacts generated almost no data above 100 Hz.

The other sensor types for soil parameters, seismic activity, and pipeline current density remain the same as in the original application. These are not in need of substantial modification or improvement.

ACTIVITY: DATA MANAGEMENT AND ANALYTICS

Item Title: Investigate machine learning (ML) tools available for the selected GIS environment.

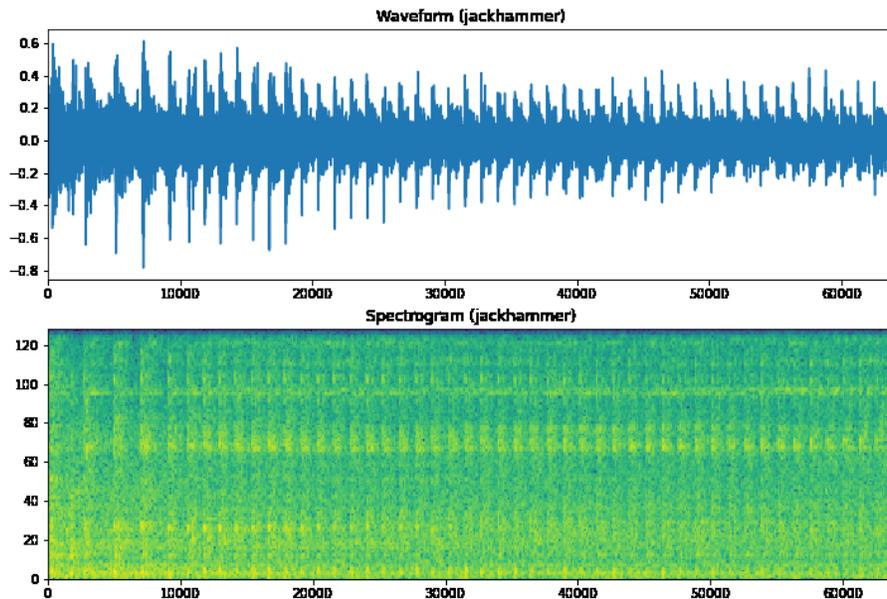
Item Number: 13

Task Number: 3

This item is partially complete: it will continue next quarter. At this time, effort is focused on enabling ML models that run directly on the sensor hardware in the field. The target hardware for the vibration sensor processing is the STM32L4 processor family. This hardware can support ML models developed in TensorFlow Lite, Keras, or other frameworks. The goal is for remote field hardware to be able to identify events of interest (Figure 4) from raw sensor data and transmit alerts when appropriate.

An additional layer of ML will need to be hosted in the cloud. This higher ML layer is needed to geospatially associate data from scattered field sensor hardware and general data such as weather or seismic activity. This layer would be used to categorize events of interest by locality: is the event specific to a sensor location or of greater extent? Work on the higher-level ML has not yet started.

Figure 6. Jackhammer time waveform with spectrogram



ACTIVITY: USER INTERFACE REQUIREMENTS

Item Title: Provide test data verifying that improved hardware can connect to GIS and to dashboard.

Item Number: 14

Task Number: 4

This item is partially complete: it is expected to complete next quarter. It was necessary to set up a service contract with Trilliant to support the RPMA wireless network. This step was accomplished in December after some negotiation. The next step will be to mount the RPMA access point on a structure roof on the GTI campus. This will enable local testing of improved hardware.

ACTIVITY: DEPLOY SYSTEM

Item Title: Complete procedures and equipment list required to deploy the ROW Defense System on a test site.

Item Number: 15

Task Number: 5

This item is not complete: it is expected to be complete next quarter. The procedures for attaching sensors to the pipe are being tested and have been reviewed by the TAP. GTI is awaiting comments on the procedure. Pin brazing (Figure 7) was chosen based on experience from the prior work. It is a form of resistance welding that uses a silver-based solder to attach threaded pins to the pipe surface. The pins are bonded to the steel at a much lower temperature than conventional welding or brass compound brazing. Coating must be removed, and a small amount of grinding performed at the attachment point.

It is important to have an attachment method that is acceptable to the utilities for use on live pipe. Bond temperature is critical to not hardening or otherwise compromising the existing pipe material. The method must also be reasonable to apply under varying field condition. The packaging of the sensors must lend itself to prefabricating the assemblies as much as possible. All these considerations will lend themselves to end user adoption of the technologies.

Figure 7. Pin Brazing Equipment under Test



ACTIVITY: SUBMIT 4TH QUARTERLY STATUS REPORT

Item Title: 4th Quarterly Report

Item Number: 16

Task Number: 6

This item was completed August 30, 2020.

ACTIVITY: HARDWARE IMPROVEMENTS

Item Title: Provide documentation of new equipment performance as deployed for testing.

Item Number: 17

Task Number: 2

This item is not complete.

ACTIVITY: DATA MANAGEMENT AND ANALYTICS

Item Title: Report on performance and cost of maintaining the GIS environment.

Item Number: 18

Task Number: 3

This item is not complete.

ACTIVITY: USER INTERFACE REQUIREMENTS

Item Title: Provide a demonstration of the improved GIS dashboard to the TAP.

Item Number: 19

Task Number: 4

This item is not complete.

ACTIVITY: DEPLOY SYSTEM

Item Title: Describe and document deployment of a ROW Defense System on a test site.

Item Number: 20

Task Number: 5

This item is not complete: it is expected to commence next quarter.

ACTIVITY: SUBMIT 5TH QUARTERLY STATUS REPORT

Item Title: 5th Quarterly Report

Item Number: 21

Task Number: 6

This document is the 5th Quarterly Status Report.

ACTIVITY: PROJECT MANAGEMENT

Item Title: N/A

Item Number: N/A

Task Number: 6

During this quarter, GTI conducted project scheduling, budgeting, task/activity sequencing, preparation of reports, and coordination, organization, and facilitation of required meetings.

5: Project Schedule

The project schedule through December 31, 2020 (ending September 30, 2021) is shown below. The project is 6 months behind schedule. A formal no cost time extension will be requested after reviewing potential test sites with the TAP members. Progress on payable milestones (delineated by Item and Task number) are linked to the schedule and are also shown below for completeness.

Figure 8. Project Schedule

Task	Item	Title	% Complete	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
1	1	Technology Review TAP	100%	■								
1	3	Technology Review Reported	100%		■							
2	4	Hardware Improvements Requirements	100%		■							
2	8	Hardware Improvements Identify Products	100%			■						
2	12	Hardware Improvements Testing	100%				■					
2	17	Hardware Improvements Procurement	75%					■				
3	5	Data Management & Analytics Review	100%		■							
3	9	Data Management Set Up GIS	100%			■						
3	13	Data Management Machine Learning	50%				■					
3	18	Data Management Initial Performance	0%					■				
3	24	Data Management Final Performance	0%							■		
4	6	User Interface Improvements Requirements	100%		■							
4	10	User Interface Initial Demonstration	100%			■						
4	14	User Interface Verify GIS Connection	60%				■					
4	19	User Interface Final Demonstration	0%					■				
5	15	Deployment Confirm Test Sites	15%				■					
5	20	Deployment Installation Reported	0%					■				
5	22	Deployment 2nd Operation Report	0%						■			
5	25	Deployment 1st Operation Report	0%							■		
6		Project Management	50%	■	■	■	■	■	■	■	■	
				2019	2020				2021			

Figure 9. Item Progress

Technical and Deliverable Milestone Schedule					
Task No. (per proposal)	Activity/Deliverable	Quarter No.	Expected	Payable Milestone	Item Progress
			Completion Date/Mos		
ACTIVITY/DELIVERABLE				TITLE	
1	Technology Review	1	3 months	List of members for a technical advisory panel (TAP) consisting of utilities and technology providers.	Complete
	1st Quarterly Status Report	1	3 months	Submit 1st quarterly report	Complete
First Payable Milestone		1	3 months	SUBTOTAL	Complete
1	Technology Review	2	6 months	Provide a final list of features of and improvements to the ROW Defense technology that will be adhered to for the balance of the project. Provide a list of potential utility test sites. Provided within a quarterly report.	Complete
2	Hardware Improvements	2	6 months	A set of hardware requirements that incorporate the TAP feedback captured during Task 1. Provided within a quarterly report.	Complete
3	Data Management & Analytics	2	6 months	Review Open Geospatial Consortium (OGC) standards for representing sensor data, review current state of available Geographic Information System (GIS) tools, and create a list of the specific tools to be used in this project. Provided within a quarterly report.	Complete
4	User Interface Improvements	2	6 months	A set of user interface requirements that incorporate the TAP feedback captured during Task 1. Provided within a quarterly report.	Complete
6	2nd Quarterly Status Report	2	6 months	Submit 2nd quarterly report	Complete
Second Payable Milestone		2	6 months	SUBTOTAL	Complete
2	Hardware Improvements	3	9 months	Identify alternative hardware products that can reduce the size and power consumption of the ROW Defense System. Provide a list of the selected devices. Verify costs and delivery times. Provided	Complete
3	Data Management & Analytics	3	9 months	Set up and maintain for the duration of the project a GIS environment to capture and visualize data collected from the various test sites. Provide the test site hosts and other stakeholders login	Complete
4	User Interface Improvements	3	9 months	Provide a demonstration of improved ability of the dashboard to drill down to details and to present warnings and alerts.	Complete
6	3rd Quarterly Status Report	3	9 months	Submit 3rd quarterly report	Complete
Third Payable Milestone		3	9 months	SUBTOTAL	Complete
2	Hardware Improvements	4	12 months	Procure equipment to facilitate hardware improvements and test improvements on pipe in GTI or utility test yard. Create a test report showing the performance of the equipment. Provided within a quarterly report	Complete
3	Data Management & Analytics	4	12 months	Investigate machine learning (ML) tools available for the selected GIS environment. Provide an assessment of their applicability to the expected test site data. Provided within a quarterly report	In Progress
4	User Interface Improvements	4	12 months	Provide test data verifying that improved hardware can connect to GIS and to dashboard. Provided within a quarterly report.	In Progress
5	Deploy System	4	12 months	Complete procedures and equipment list required to deploy the ROW Defense System on a test site. Finalized location of utility test sites. Schedule for deployment of equipment on test sites. Provided within a quarterly report	In Progress
6	4th Quarterly Status Report	4	12 months	Submit 4th quarterly report	Complete
Fourth Payable Milestone		4	12 months	SUBTOTAL	Not Complete
2	Hardware Improvements	5	15 months	Provide final test reports or needed clarifications showing the performance of the equipment as deployed. Provided within a quarterly report.	Not Complete
3	Data Management & Analytics	5	15 months	Summarize the performance and costs of maintaining GIS environment. Provided within a quarterly report	Not Complete
4	User Interface Improvements	5	15 months	Provide second and final demonstration of improved dashboard to TAP	Not Complete
5	Deploy System	5	15 months	Narrative describing the deployment of equipment on the utility test sites. The narrative will cover the installation process and any issues encountered. Provided within a quarterly report.	Not Complete
6	5th Quarterly Status Report	5	15 months	Submit 5th quarterly report	Complete
Fifth Payable Milestone		5	15 months	SUBTOTAL	Not Complete
5	Deploy System	6	17 months	Narrative describing the operation of equipment on the utility test sites. The narrative will cover events observed or recorded on the test sites during the reporting period. Provided within a quarterly report	On Schedule
6	6th Quarterly Status Report	6	18 months	Submit 6th quarterly report	On Schedule
Sixth Payable Milestone		6	18 months	SUBTOTAL	On Schedule
3	Data Management & Analytics	7	21 months	Final summary of the performance of GIS ML tools on data from the utility test sites. Provided within a quarterly report.	On Schedule
5	Deploy System	7	21 months	Narrative describing the operation of equipment on the utility test sites. The narrative will cover events observed or recorded on the test sites during the reporting period. Provided within a quarterly report	On Schedule
6	7th Quarterly Status Report	7	21 months	Submit 7th quarterly report	On Schedule
Seventh Payable Milestone		7	21 months	SUBTOTAL	On Schedule
	8th Quarterly Status Report	10	28 months	Submit draft final report with quarterly	On Schedule