Public Quarterly Report

Date of Report: 10th Quarterly Report-Jamuary 31, 2021
Contract Number: 693JK31810001
Prepared for: DOT
Project Title: Improvements to Pipeline Assessment Methods and Models to Reduce Variance
Prepared by: GTI
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For quarterly period ending: January 31st, 2021

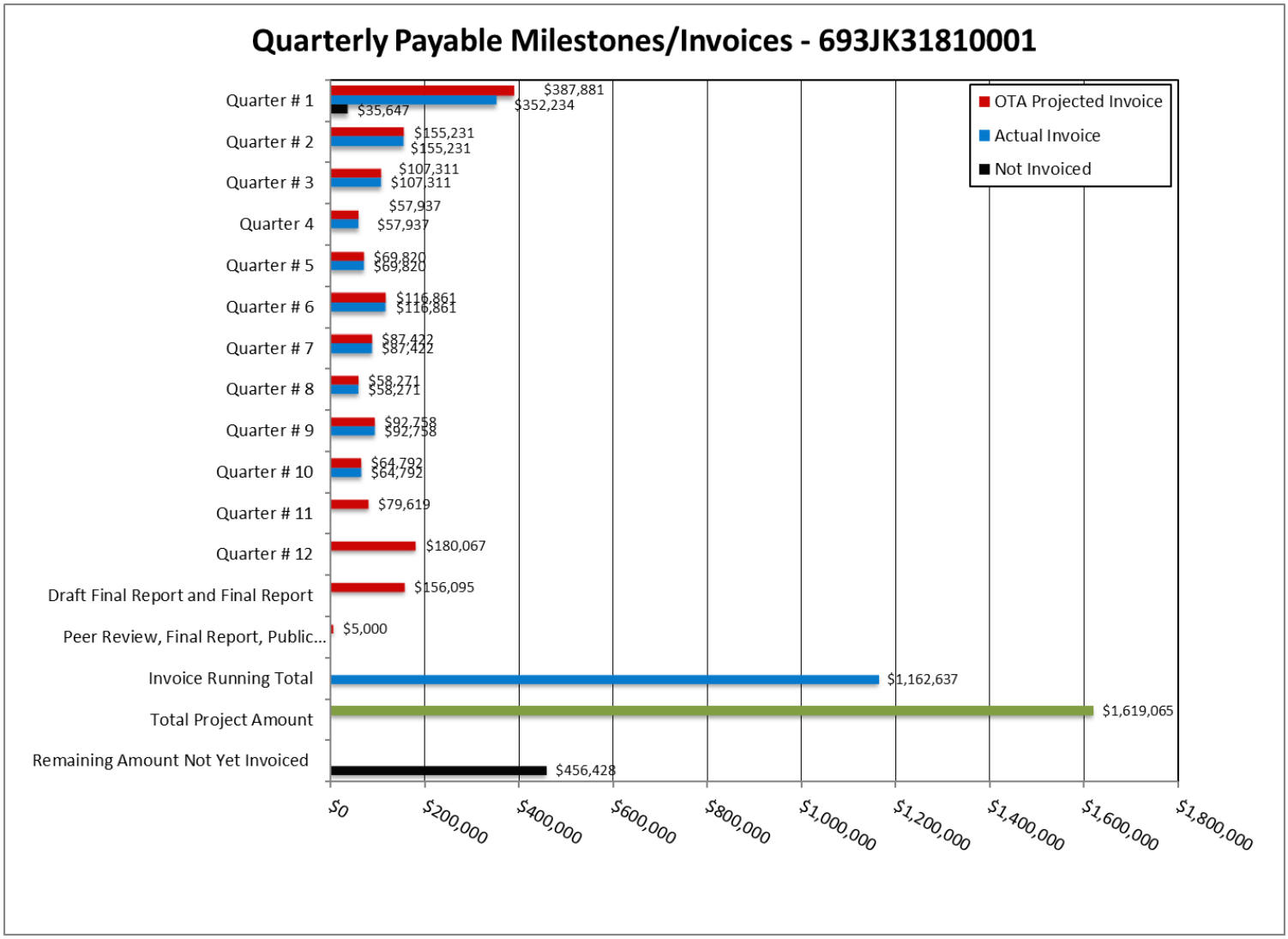
1: Items Completed During this Quarterly Period:

Item #	*Task #*	*Activity/Deliverable*	*Title*	*Federal Cost*	*Cost Share*
65	3.3.2.2	Uncertainty Reduction	Integrated Variance Reduction and Bayesian Updating Phase 4 Report	24,825.00	
66	4.3.2	Structural FEM Study	FEM DoE Phase 8 Report	15,505.00	
67	5.3.2.2	FEM Simulation of NDE Signal Responses	Learning and Data Fusion Phase 4 Report	20,501.00	
68	9.3.2	Project Management	10th Quarterly Report	3,961.00	

2: Items Not Completed During this Quarterly Period:

Item #	*Task #*	*Activity/Deliverable*	*Title*	*Federal Cost*	*Cost Share*
NA	NA	NA	NA	NA	NA

3: Project Financial Tracking During this Quarterly Period:



The invoice that will be submitted will include the following line items:

Item #	*Task #*	*Activity/Deliverable*	*Title*	*Federal Cost*	*Cost Share*
65	3.3.2.2	Uncertainty Reduction	Integrated Variance Reduction and Bayesian	$ 24,825	$ -
66	4.3.2	Structural FEM Study	FEM DoE Phase 8 Report	$ 15,505	$ -
67	5.3.2.2	FEM Simulation of NDE	Learning and Data Fusion Phase 4 Report	$ 20,501	$ -
68	9.3.2	Project Management	10th Quarterly Report	$ 3,961	$ -
			Total	**$ 64,792**	$ -

4: Project Technical Status

Item # 65, Task # 3.3.2.2 Integrated Variance Reduction and Bayesian Updating Phase 4 Report
This report summarizes the work done by ASU during the 10th quarter period, which is mainly focusing on the risk assessment integrated with uncertainty reduction using the Bayesian entropy method. The deliverable for Task 3.3.2.2 Uncertainty Reduction: Integrated Variance Reduction and Bayesian Updating Phase 4 Report is completed.
Advances in detection and sensor techniques achieve an explosion of the data available from experiments. Hundreds or thousands mechanical or chemical measurements can be obtained from a single experiment. Therefore the statistical methods face challenging tasks when dealing with such high-dimensional data. However, much of the data is highly redundant and can be reduced to a much smaller number of variables without a significant loss of information by dimension reduction techniques. The reduced relevant features can benefit the probabilistic analysis. Observed data (or information) from experiments can also be used to reduce the uncertainty in engineering models and optimize the management of systems by the Bayesian updating technique, in which prior probabilistic models are updated with data and observations. The Bayesian framework enables the combination of uncertain and incomplete information with models from different sources and provides probabilistic information on the accuracy of the updated model. The updated information can then affect the probabilistic risk analysis results. The probabilistic fracture assessment in the project mainly contains three parts: 1). Dimension reduction; 2). Bayesian updating for uncertainty reduction; 3). Efficient risk assessment. The dimension reduction is performed using the Bayesian model averaging (BMA). The uncertainty reduction is realized by the Bayesian Entropy Network (BEN). BEN is a generalized information fusion tool that can combine additional information such as statistical moments (mean or variance, etc.) and range information to reduce the overall variance. As for the risk assessment, the direct sampling methods are used due to the numerical efficient active learning kriging model. The time consuming fully developed finite element model can be avoided so that computational efforts can be reduced. A demonstrated example of risk assessment integrated with Bayesian uncertainty reduction and dimension reduction due to the existence of random corrosion surface (loss of materials) and material uncertainties was presented to show the feasibility of the framework.

Item # 66, Task # 4.3.2, Structural FEM Study, FEM DoE Phase 8 Report

In the 10th quarter, GTI focused on final refinement in implementation of the steel material model into the latest version (v5.6) of COMSOL Multiphysics® and preparation of the 3D model of a pipe with an axial crack and wall loss from corrosion.
The inclusion of elastic damage in the steel material model was also thoroughly investigated. Inclusion of elastic damage provided good behavior in cases without high stress concentrations, however, in cases of with high stress concentrations, such as thin cracks, the elastic damage was found to be too sensitive and resulted in significantly more conservative predictions versus closed-form FFS-1 Level 2 assessments. Going forward in this project, only plastic damage will be included in the steel material model used in simulations.

In the 11th and final quarter of this project, GTI will run large simulation designs of experiment (DoEs) to obtain response surfaces of the pressure at which damage begins to propagate. These response surfaces are intended to provide insight into the performance envelope of pipes of different materials and defect interaction.In the next quarter, GTI will focus on producing various FEA-based response

surfaces for 3D models of pipes with internal, longitudinal, semi-elliptical surface cracks and external corrosion and a wide variety of steel properties.

Item # 67, Task # 5.3.2.2, FEM Simulation of NDE Signal Responses, Learning and Data Fusion Phase 4 Report

In this report we have addressed the section 5.3.2.2 of project deliverable. Here defect propagation has been investigated for failure evaluation. The FEM simulation of fatigue growth is studied via solid mechanics and fatigue module in COMSOL in the last report. To complete the work of learning and thereby performing the risk assessment, first, we need to identify threats specific to the system regarding the geometrical information such as length width and depth. In the next part, we will link NDE measurements from FEM simulation with the evaluation. In this quarter metal loss corrosion and its propagation has been studied. A mathematical model has been developed for analysis of depth propagation as defect depth needs significant attention. Predicted depth of different defects over a time span matches well with the ILI data taken from literature thus consolidating the efficacy of the model. However as stated in literature [10] that due to measurement error in the ILI tools, majority of the defects decreased from 2004 to 2007. Thus, the ILI tool needs proper calibration. Hence it will be good for us if we can get some ILI inspection data from GTI for our model based study in next quarter.

Item # 8 Task # 9.3.2, Project Management, 10th Quarterly Report

All project management reporting requirements have been met.

5: Project Schedule –

All deliverables scheduled for completion in the tenth quarter were completed as scheduled.

End Project Status Update