Quarterly Report No. 3

Slow Crack Growth Evaluation of Vintage Polyethylene Pipes

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Reporting Period: 3rd Quarterly Report

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1. Objectives

This collaborative program will provide an integrated set of quantitative tools that will provide a structured approach to reducing operational risk in vintage plastic distribution systems susceptible to Slow Crack Growth failures. A novel endoscopic structured light scanning tool will be developed and prototyped for internal inspection of small diameter plastic pipe. The data generated by the tool will be properly reduced to essential parameters to be synthesized with additional available system information including external conditions, inspection and leak records, historic data, and subject matter expertise into a fitness for service evaluation. This assessment will include a probabilistic estimate of the remaining effective lifetime of individual segments of vintage plastic pipe and a yes/no determination of whether a short-term pressure test is capable of validating the maximum defect size in the system. The Bayesian network methods employed are ideally suited to evaluating interacting threats, investigating root causes, and predicting the effect of mitigation strategies based on conditional probabilities calculated from available data.

2. Work Completed During Reporting Period

Work in this quarter included:

- Task 1: Probabilistic Decision Support System Design. We revised the Bayesian network structure and started working on models to generate its node probability distribution tables. The updated Bayesian network was deployed on the EDSS system and multiple types of testing were performed on the deployed system. Furthermore, we developed an ontology template to represent a Bayesian network so it can be stored in a graph database.
- Task 2: Probabilistic Decision Support System Development:
    - Continued developing underlying models. A large body of work was completed on RPM models, bi-directional shifting techniques, converting test results to probabilistic predictions for pipe segments and the use of non-linear FEM models for the estimation of stress intensification factors and damage propagation in pipes.
    - The stress rupture curves and FEM models needed to predict remaining lifetime of damaged pipe are complete.
    - We have a complete classification of typical stress risers in a piping system and have developed the methodology to apply these factors to lifetime prediction.
    - We have not completed guidelines for pressure testing of systems as we need to do more detailed analysis on the inherent conflict between the timescales of a pressure test and the

evolution of a creep failure or rupture in polyethylene. We will address this issue in the third quarter of 2016.

- We started building a framework for smart forms. We updated the JSON messaging structure for communication between user interface, ontology database, and model.

A detailed description of the work and results summarized above is provided in the body of the report.

- Task 3: Structured Light Scanning Method Development – Continued developing prototypes with all objectives being met per the milestone schedule. Detailed description of the work is provided below.
- Task 4: Bayesian Methods Development – Continued developing underlying models with all objectives being met per the milestone schedule. Detailed description of the work is provided below.

3. Payable Milestones and Planned Activity

Figure 1 shows the quarterly payable milestones to the end of the project.

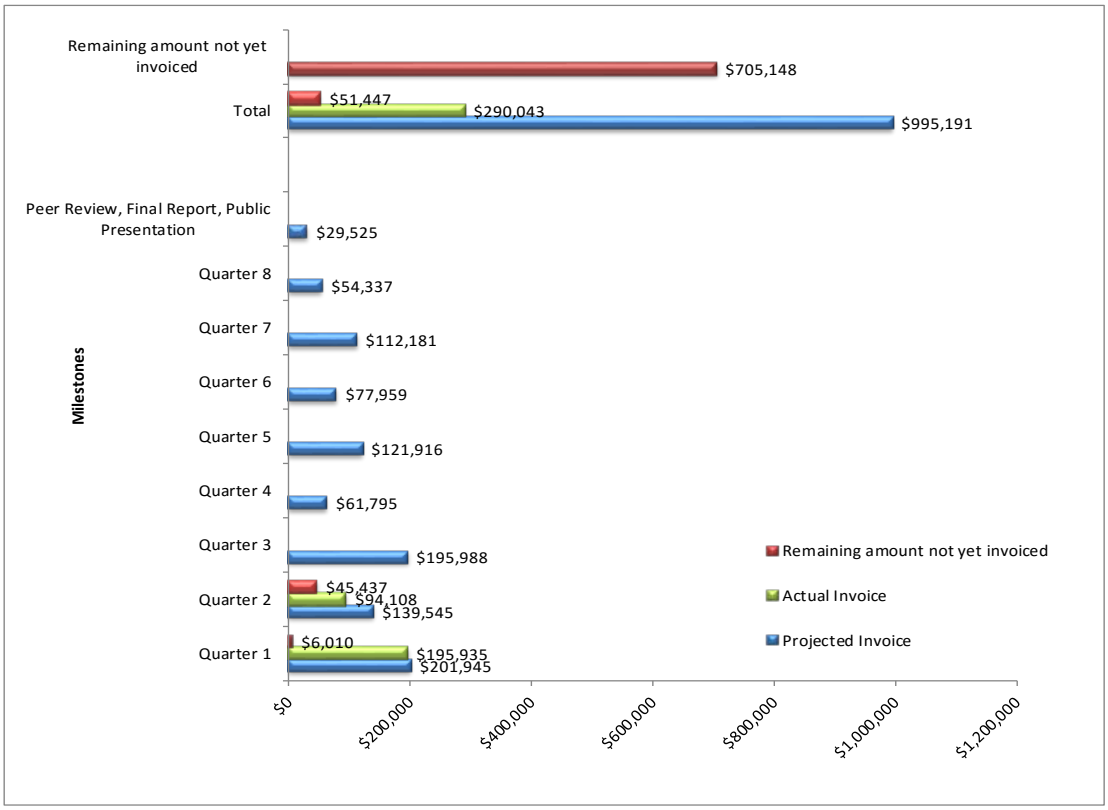

Figure 1. Quarterly payable milestones

Plans for Future Activity (Project Quarter #4)

- Task 1: Probabilistic Decision Support System Design –Continue developing system per the milestone schedule. No problems anticipated based on current progress.
- Task 2: Probabilistic Decision Support System Development – Continue developing models per the milestone schedule. Slight delay in smart form development, Pressure test guidelines and Inspection Reports Network, but no problems anticipated based on current progress. We have employed a graduate student from ASU who began work in June and is addressing this delay together with the rest of the GTI team.
- Task 3: Structured Light Scanning Method Development – Continue developing prototype per the milestone schedule. No problems anticipated based on current progress.
- Task 4: Bayesian Methods Development – Continue developing methods per the milestone schedule. No problems anticipated based on current progress.
- Task 6: Project Management Activities – Standard project management activities will be performed

End of Report