**CAAP Quarterly Report**

**9/1/2025**

*Project Name: Pipeline Risk Management Using Artificial Intelligence-Enabled Modeling and Decision Making*

*Contract Number: 693JK32150001CAAP*

*Prime University: Rutgers University*

*Prepared by: Bingyan Cui (PhD student), Xingsen Yang (PhD student), Alireza Khatami (PhD student), Dr. Hao Wang (PI), Dr, Qindan Huang (Co-PI)*

*Reporting Period: 4/1/2025 – 6/30/2025*

**Project Activities for Reporting Period:**

*Task 1 Literature Review (Completed)*

*Task 2 Data Collection from Industry Partners (Completed)*

*Task 3 Data-Driven Probabilistic Modeling of Pipeline Defects (Completed)*

*Task 4 Quantification of Probability of Failure (Completed)*

*Task 5 Decision Making of Inspection and Repair Strategy using Reinforcement Learning*

***Decision Making with AI techniques***

The reinforcement learning model is refined to optimize inspection and repair strategies for whole pipeline with multiple soil zones to have the minimum life-cycle cost while satisfying the safety threshold. The model outputs are the specific pipe segments to be inspected and repaired at the specific year determined by the reinspection schedule. The growth of external corrosion defects is predicted by the Bayesian Neural Network (BNN) considering variation of soil properties at each zone along the pipeline.

***LCCA with Analytical Solution Methods***

Different from AI-based optimization, LCCA was conducted using analytical solution methods. Life-cycle cost management of pipelines with multiple segments was studied and efforts were made on reducing computational effort. The current framework to consider multiple segments is extended based on an analytical solution for the life-cycle cost of pipelines with a single segment developed in the previous PHMSA project (Kere and Huang 2024). In particular, the possibility of different numbers of failures in different segments are considered. For instance, in the proposed framework, when considering the expected cost associated with a single failure, the failure event can occur in either segment; when considering the expected cost associated with two failures, failures may occur within the same segment or in any two segments in a pipeline system.

The draft of final report has been submitted for review.

**Financial Activities with Cost Share:**

The graduate student salary, fringe, and university overhead are charged for two PhD students at Rutgers University and One PhD student at Marquette University.

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| **Budget Item** | **Expenses (1/1/2025 – 6/30/2025)** |
| Graduate Research Assistant - Salary | $31,727.03 |
| Graduate Research Assistant - Fees | $1,485.75 |
| Tuition | $5,154.00 |
| Fringe | $7,084.70 |
| Computer Supplies | $1,952.22 |
| Travel | $101.36 |
| Subcontract (Marquette University) | $19,388.03 |
| F&A 57% (exclude tuition and subcontract after first $25k) | $24,140.10 |
| **Total** | **$91,033.19** |

Cost share is provided by Rutgers University and Marquette University during this quarterly period as budgeted in the proposal. The cost share requirement has been met by 9/30/2024.

**Project Activities with External Partners:**

N/A

**Potential Project Risks:**

N/A

**Future Project Work:**

Work will be continued on Task 5 on decision making of inspection timing and repair strategy and Task 6 on draft final report.

**Potential Impacts to Pipeline Safety:**

The AI-enabled modeling and analysis of pipeline inspection data will be used to develop probabilistic growth models of corrosion defects and make cost-effective repair or replacement decisions to minimize pipeline failure risk.