CAAP Quarterly Report

January 4th, 2024

Project Name: Development of a Framework for Assessing Cathodic Protection (CP) Effectiveness in Pipelines Based on Artificial Intelligence (AI)

Contract Number: 693JK32350005CAAP

Prime University: ***Texas A&M Engineering Experiment Station***

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Reporting Period: October 1st – December 30th, 2023

Project Activities for Reporting Period:

Task 1. Designing and building the physical prototypes in laboratory conditions and deterministic modeling.

In this task, the development of Deterministic Modeling started with the Transmission Line approach. The theoretical foundation from our previous 1D model will be considered for this modeling. The 2D modeling will include all parameters influencing the CP and the validation with experimental conditions. Technical description can be found in the Appendix. We designed different scales and configurations for the experimental setup to characterize and quantify the critical and useful parameters for deterministic and probabilistic modeling.

Task 2. Integrating field inspection, theoretical with experimental data by applying pattern recognition techniques relating the pipeline-coating-soil system with CP

In this task, we discussed different RoW (Pipeline sections) with the technical team members (UDayton and TAMU) regarding the required parameters for the soil/coating/soil system and data availability (data sources from both private and public databases). The conditions should include CP and direct and indirect technologies characterizing the RoW selected. This task will integrate the modeling, experimental setup, and field data.

Project Financial Activities Incurred during the Reporting Period:

- We finalized the contract to sub-award with UDayton for the project as part of the team.
- The personnel from TAMU includes one PhD student starting in December and two Master's degree students starting in January 2024.
- The Udayton team has one member, Sreelakshmi Sreeharan, as a newly graduated Ph.D. (passed her defense in Dec. 2023) in machine learning and uncertainty quantification, will shift from a Graduate Assistant to a PostDoc researcher in this project and continue her efforts in Task 2.
- No financial activities related to conferences or related activities.

- Laboratory has not stared yet; only design

Project Activities with Cost Share Partners:

During the first quarter of this project, we met twice with the co-sharing partners; the following outcomes from the meeting were:

- Meetings for updates on the project and future technical discussions. Meetings will be held twice a month.
- NDA should be in place for the database to be used for the RoW and any technology
- Workshops for technical discussions.

Project Activities with External Partners:

During our kick-off meeting for the project, there was a suggestion to have pipeline operators. We invited experts from the operator side, such as PRCI, Exxon, and BP. We await a response to ask them to join some of our meetings.

We will include several pipeline sectors for our project (such as service, operator, and academic), and we will organize workshops or video remote meetings.

Potential Project Risks:

For this first quarter, we identified some delays with the sub-award contract with our strategic partners. Also, the NDAs consider some delays for open discussions with our industrial co-share partners. However, this latter is not critical for the project's performance. We believe there is no impact during the second or third quarter. No further risks have been identified yet.

Future Project Work:

We anticipate following the proposed timeline with no current changes during the next months. We will follow the Gantt chart to mark any progress and plans.

During the next 30,60 and 90 days, we will perform task 1 activities. Also, we will start to develop some of Task 2's activities.

Theoretical work, laboratory work, and database analysis will be considered for the next quarter.

The timeline and schedule for the project are in the Gantt chart.

Task/Subtask	Fiscal Year											
	2023	2024				2025			2025	2026	2026	2026
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Task 1: Designing and building the physical prototypes in laboratory conditions and deterministic modeling												
Task 2: Integrating field inspection, theoretical with experimental data by applying pattern recognition techniques relating the pipeline-coating-soil system with CP												
Task 3: Validation of the *a priori* framework with experimental and field conditions for characterization/modeling and Evaluate/Validate												
Task 4: Development and validation of the methodology for ECDA based on CP levels												

Deliverable Milestones are indicated in black*

Potential Impacts to Pipeline Safety:

Laboratory simulations in task 1 will involve pipelines whose RoW reflects different soil conditions to cover a diverse range of typical U.S. soil properties. The laboratory simulations will also incorporate different operation conditions of steel pipe and coating conditions to soil exposure as consistency for coating anomalies characterization under different CP conditions.

Appendix

Transmission Line Model Approach as deterministic modeling

The transmission line model (TLM) consists of discrete, evenly distributed impedance elements that can be used to model the local processes along the surface. Figure 1 depicts a generalized 1D double-channel transmission line.

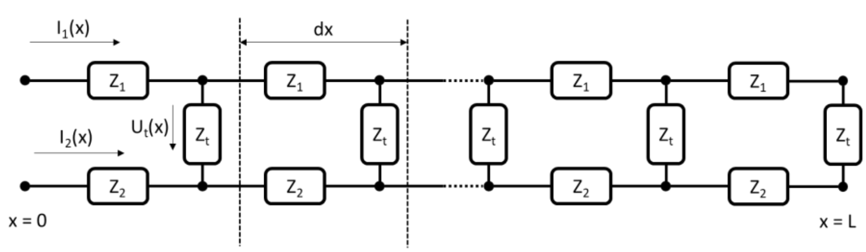

Figure 1: One Dimensional Generalized TLM

The 1D homogenous TLM has been heavily studied and applied to various systems, most commonly for porous electrodes, reinforced concrete, and substrate/polymeric coatings. Extension of the generalized 1D TLM to 2D would allow a more accurate description of the corrosion process across the surface at different interface conditions, including CP. The schematic of the 2D generalized TLM is shown in Figure 2.

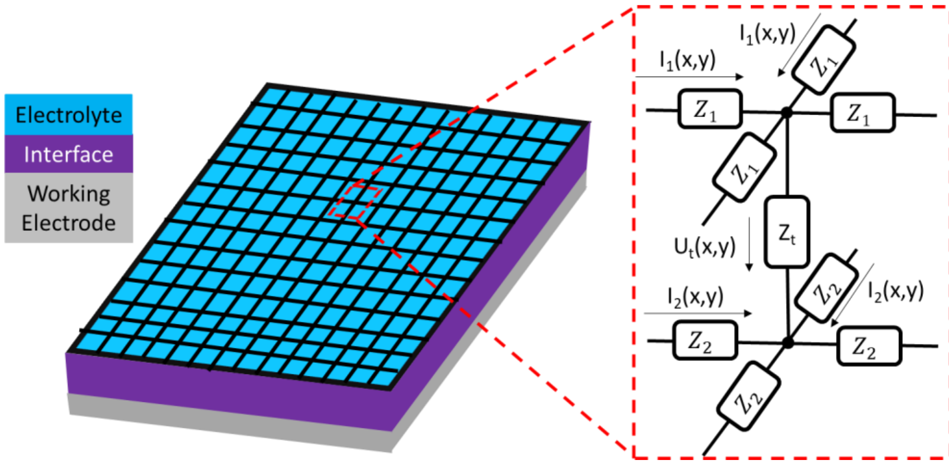

Figure 2: Extension of 1D generalized TLM model to 2D

We are working on a 2D heterogenous TLM for the soil/coating/pipeline system under different CP conditions.