In-Situ Pipeline Coatings for Methane Emissions Mitigation and Quantification from Natural Gas Pipelines

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Oil & Natural Gas

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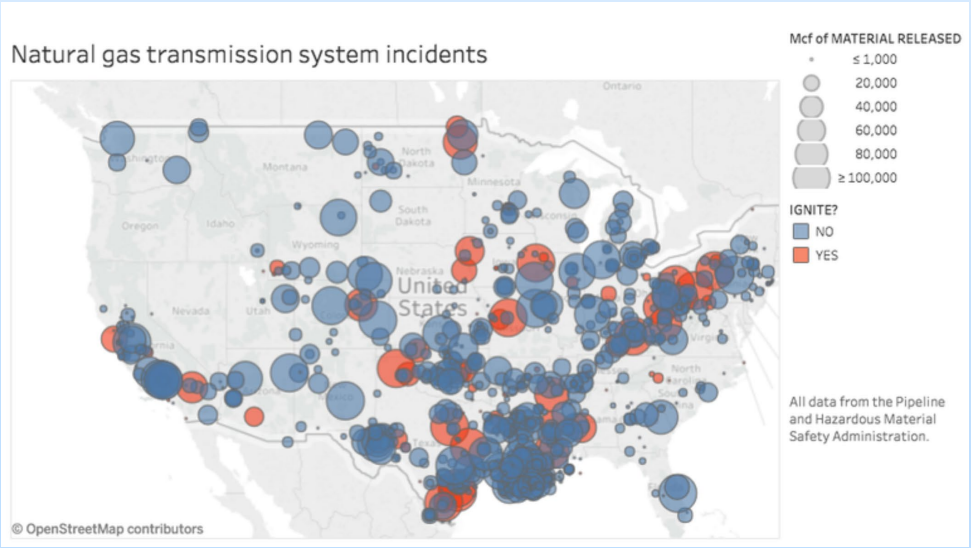
Program Overview

- The research effort is focused on developing a cost-effective method of reducing methane emissions from transport pipelines. The DragX treatment solution can do so in 3 key ways:
  - **Reductions in Maintenance** through protecting the internal pipeline surface.
  - **Reductions in Cost** through improved throughput and reduced frictional drag.
  - **Reductions in Emissions** through less invasive refurbishment of existing pipelines.
- 1 October 2016 – 31 August 2021

Technology Background

- The demand for natural gas in the US is increasing year over year.
- Existing pipeline infrastructure is aging, and prone to leaks.
- Estimated that ~2% of total NG production is lost due to leakage.
- Corrosion and deposits in lines result in lost production, reduced throughput and increased wear on pumps.
- Full replacement of lines is extremely costly due to retrenching and downtime.
- Catastrophic events such as Aliso Canyon/Prudhoe Bay can cost billions.



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Technology Background

- DragX is an **omniphobic** (water- and oil-repellent) **surface treatment** which chemically binds and infiltrates into pipeline surface.
- Extremely thin application (< 2mil) versus traditional flow coating materials.
- Imparts **low surface energy** (prevents deposition) and **low surface roughness** (prevents frictional drag losses).
- **Water-based**, thermally curable in wide range of ambient temperatures, **no VOC or hazardous materials**.

Pipe Before Application

DragX Application

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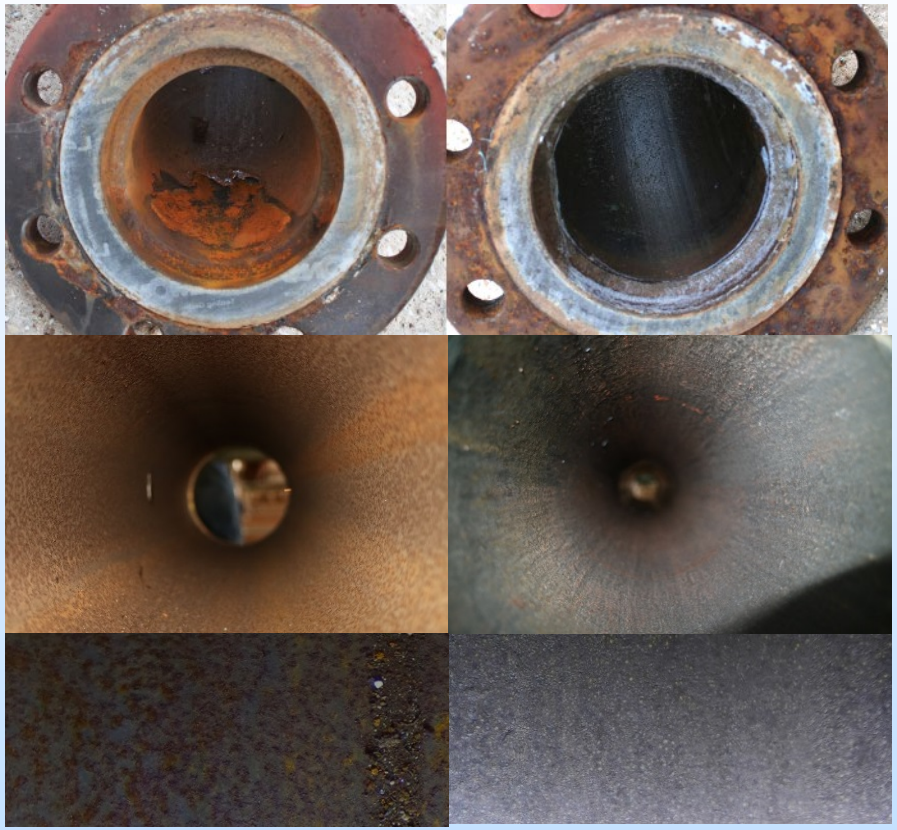
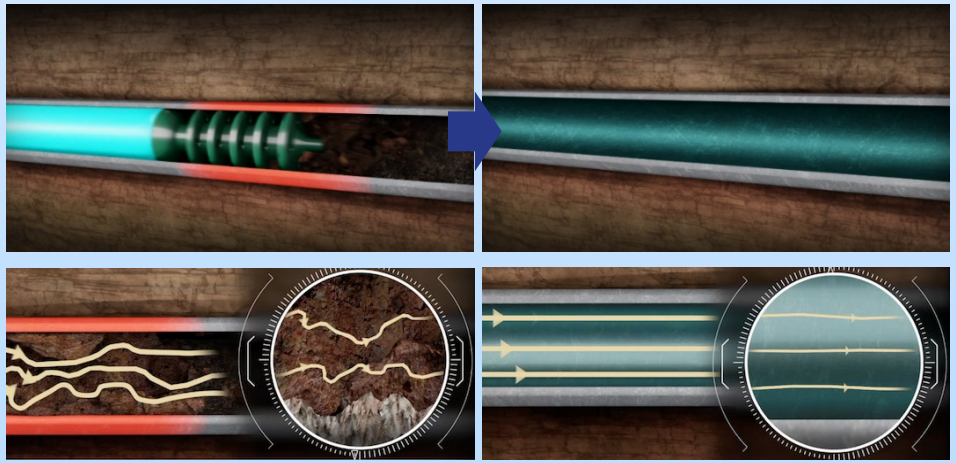
Technology Background

- In-situ treatment via pigging process is minimally invasive
- Scalable to full length of a pipeline (10+ miles), and multiple diameters (4 – 36 inches).
- Capable of protection on complex geometry (90° bends), weld seams, and flanges.



Untreated **DragX**



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Key Benefits of DragX

Public Benefits	Capital Expense Savings	Operational Expense Savings
Reduction in CO_2 and methane emissions due to maintenance-related pipeline opening/venting.	Enhanced pipeline lifetime, allowing avoidance of replacement and trenching activities.	10-15% improved throughput for pipelines due to reduced internal surface roughness.
Reduction in risk for CO_2 and methane emissions due to slow leaks caused by internal pipeline corrosion and pinhole leak formation.	Improved compressor pump lifetime due to increased efficiency.	Improved operational efficiency allows for reduced schedule of cleaning (fewer pigging runs, reduced usage of chemicals, less downtime).
Reduction in fuel and chemical usage in transport and cleaning activities.	Protection of pipeline after treatment allows for smaller corrosion allowance during the installation of new line (wall thickness, pipe material, continuous chemical treatment)	Enhanced flow properties can allow for reduced reliance on chemical flow assurance treatments (e.g. DRAs).

Project Scope and Technical Approach

Laboratory Development

Key Milestones

- Validation of treatment efficacy at benchtop level.
- Compatibility study of material in simulated conditions.
- Application method refinement.

Industry Subscale Pilot Demonstration

Key Milestones

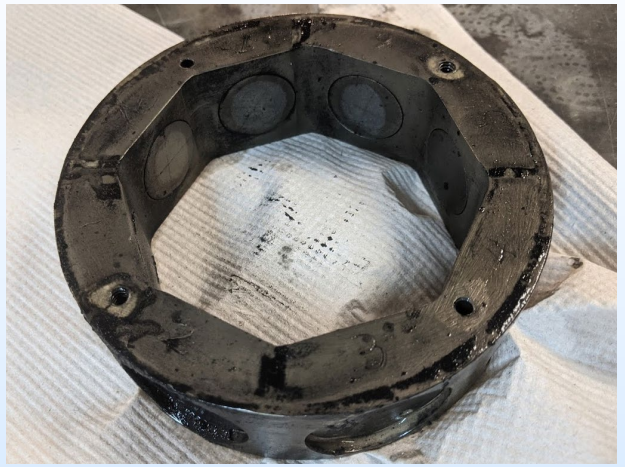
- Field application on non-operational pipelines.
- Performance validation for in-situ applied treatment.
- Develop inspection criteria and QC processes for in-field deployment.
- Go/No-Go economic viability studies in conjunction with industry partners

Full Deployment & Commercialization

Key Milestones

- Low-risk proof of viability on industry partner operational pipelines.
- In-field performance validation.
- Shipping and application logistics.
- Long-term commercial agreement for deployment and refurbishment.

Technical Status – MIC Protection (Laboratory Study)



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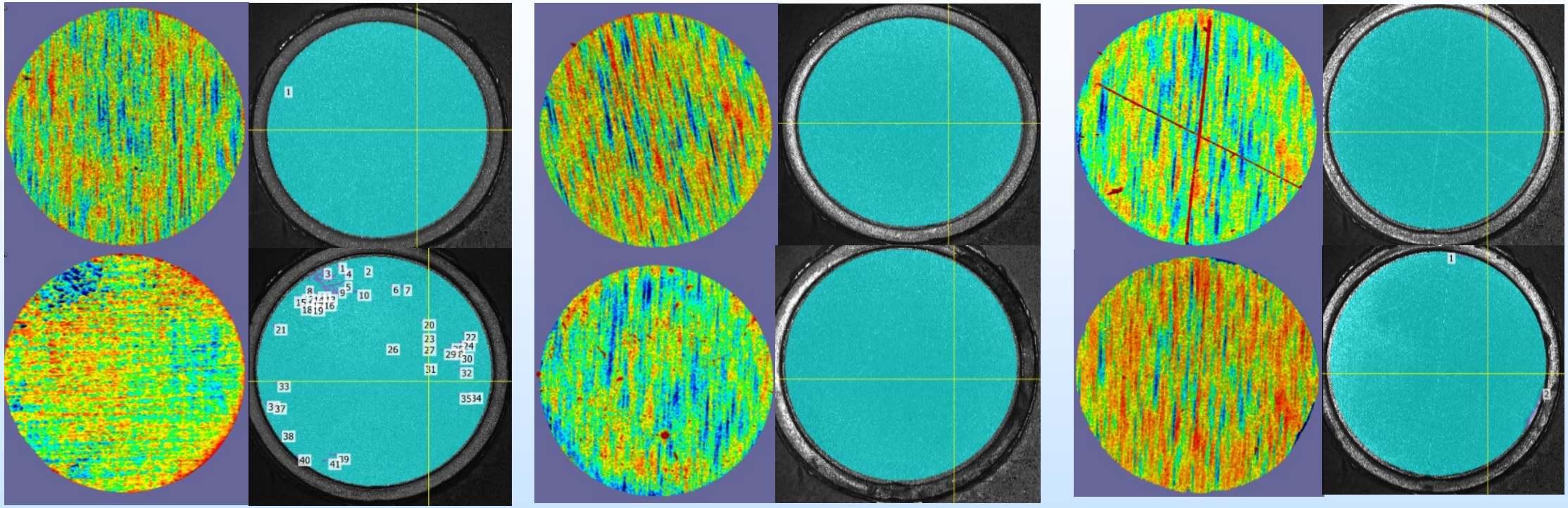
Technical Status – MIC Protection (Laboratory Study)



Unprotected

Pits after testing = 41

DragX Treated

Pits after testing = 0

DragX Treated with Crosscut

Pits after testing = 2

- Identification of Pits (> 10µm in depth)
- Measurements taken with coating removed (looking only at substrate)

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Technical Status – MIC Protection (Laboratory Study)

	Unprotected	DragX Treated	DragX Treated with X-Cut
Number of Pits Found	41	0	2
% Increase in Surface Roughness	134%	5%	5.4%
Generalized Corrosion Rate (mpy)	23.39	0.65	2.18

- DragX reduced effective corrosion rate by 97%.
- Physical piercing of the material did not cause delamination or underfilm corrosion.
- Surface roughness of unprotected coupons increases by over 100% even after recleaning, while protected coupons show no significant changes.

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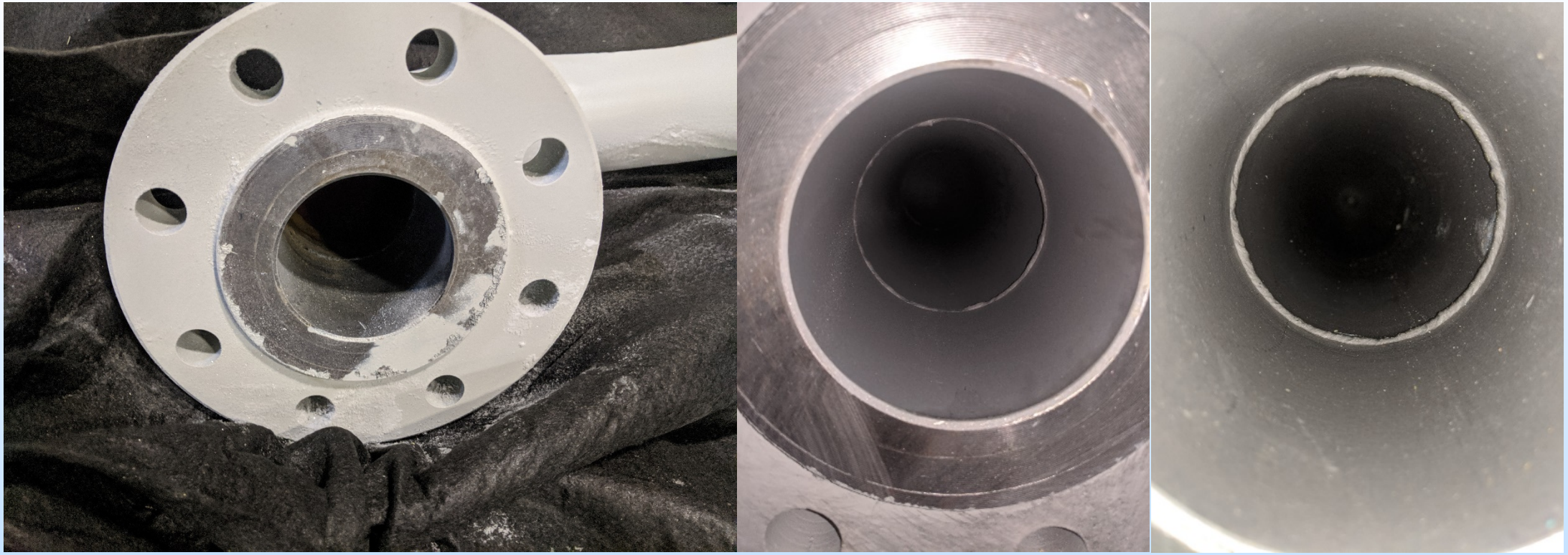
Technical Status – MIC Protection (Field Deployment)



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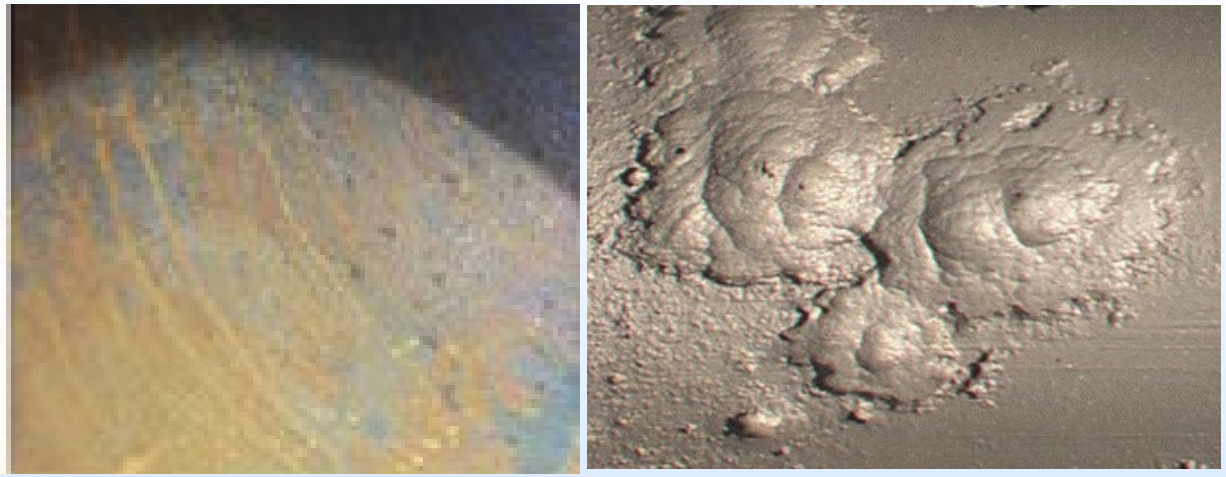
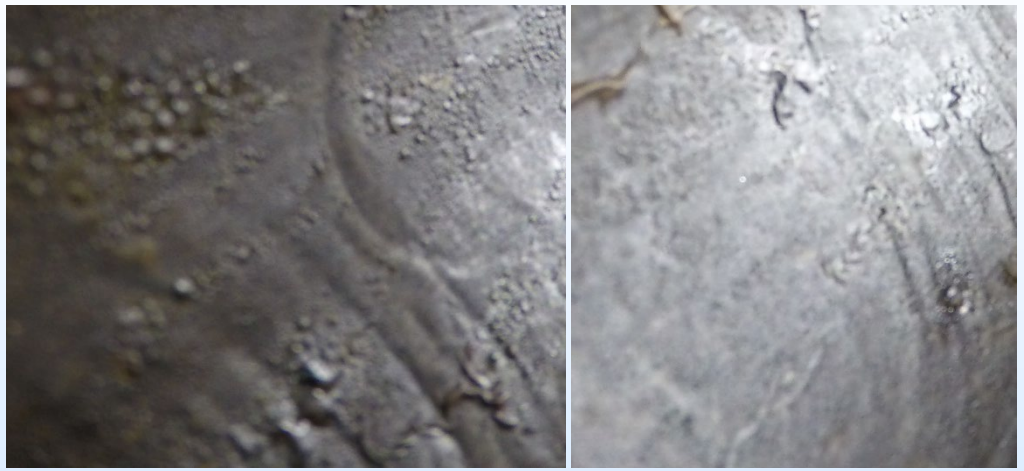
Technical Status – MIC Protection (Field Deployment)



Typical MIC Pitting



With DragX treatment

- No pitting and no signs of corrosion after 6 months of typical operational use.
- No signs of wall loss (**pre-treatment had up to 85% in deepest pits**)
- Passed existing UT inspection acceptance criteria for operation.

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Technical Status – MIC Protection (Commercial Deployment)

- Based on DragX field trial success, now to apply on 2 – 10 miles of future pipe/tubing Q3 – Q4 2021.
- Passed all internal metrics for deployment/compatibility/efficacy.
- Established new metrics and procedures for large scale production, handling, storage of materials.
- Establishing internal procedures for pipe handling and logistics.

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Accomplishments of the Project

- 10% or better reduction in compressor fuel use compared to bare steel pipe (based on INGAA reference studies on internal coatings)
- 16-25% transmission increase due to reduction in friction coefficient (expected 50% reduction)
- Significant reduction in surface roughness (from typical in-service pipeline roughness of 4000 μin to below 100 μin)
- Substantial reduction in CAPEX and OPEX for gas transmission pipelines
- 97% reduction in weight loss under microbially-induced corrosion (MIC) conditions.
- 90%+ reduction in adhered bacteria concentration.
- Applicable in extreme weather conditions; in-field demonstrations at installation sites completed in temperatures between 40 - 110°F.

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Lessons Learned

- **The key driver of technology adoption is not preventative protection against corrosion but improved economic performance first.**
- Need to get commercial partner buy-in early, otherwise there is no "industry pull" to allow for testing opportunities.
- Flexibility in application by pursuing opportunities in adjacent fields still allows for operational and logistical experience to be gained.
- Pipeline technologies that can aid with energy transition are in great demand.

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Synergy Opportunities

- **DragX is positioned well as a key complementary technology to the energy transition initiatives of the US.**
- Energy Transition Opportunities
  - Hydrogen Transport
  - CO_2 Transport and Storage
  - Geothermal Applications
- Fuel Efficiency (Eliminating the energy penalty)

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Project Summary

- Key Accomplishments
  - Multiple industry aligned field demonstrations completed to show DragX corrosion protection and improved throughput.
  - Demonstration of economic value as a direct consequence of these trials.
- Next Steps
  - Long term evaluation and recommendations for refurbishment of treatment after use.
  - Full scale commercial deployment on actual in-service lines.
- **Take-Away Message**
  - **With the aid of DOE and NETL, DragX has been fully developed from a benchtop technology into a commercial product that has been derisked and is ready for adoption by multiple pipeline operators.**

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Appendix

Benefit to the Program

With the rapid growth in natural gas utilization comes an increased risk of increased emissions of greenhouse gases. Methane (CH4), is an efficient, potent greenhouse gas up to 25 times more powerful than carbon dioxide (CO2) at trapping heat within the atmosphere over a 100-year period. Methane comprises over 75% of natural gas, and studies from the Environmental Defense Fund (EDF) estimate approximately 2% total loss rate across all-natural gas operations.

The research effort developed a low-surface energy treatment capable of application to existing methane pipelines to reduce overall carbon emissions. The technology supports multiple key objectives of NETL:

- Speeding the decarbonization transition of the fossil fuel industry.
- Improving public safety through reduced risk of both blowouts and slow leaks of methane/Natural Gas product.
- Enhancing good operational practice through improved maintenance and monitoring of pipelines.

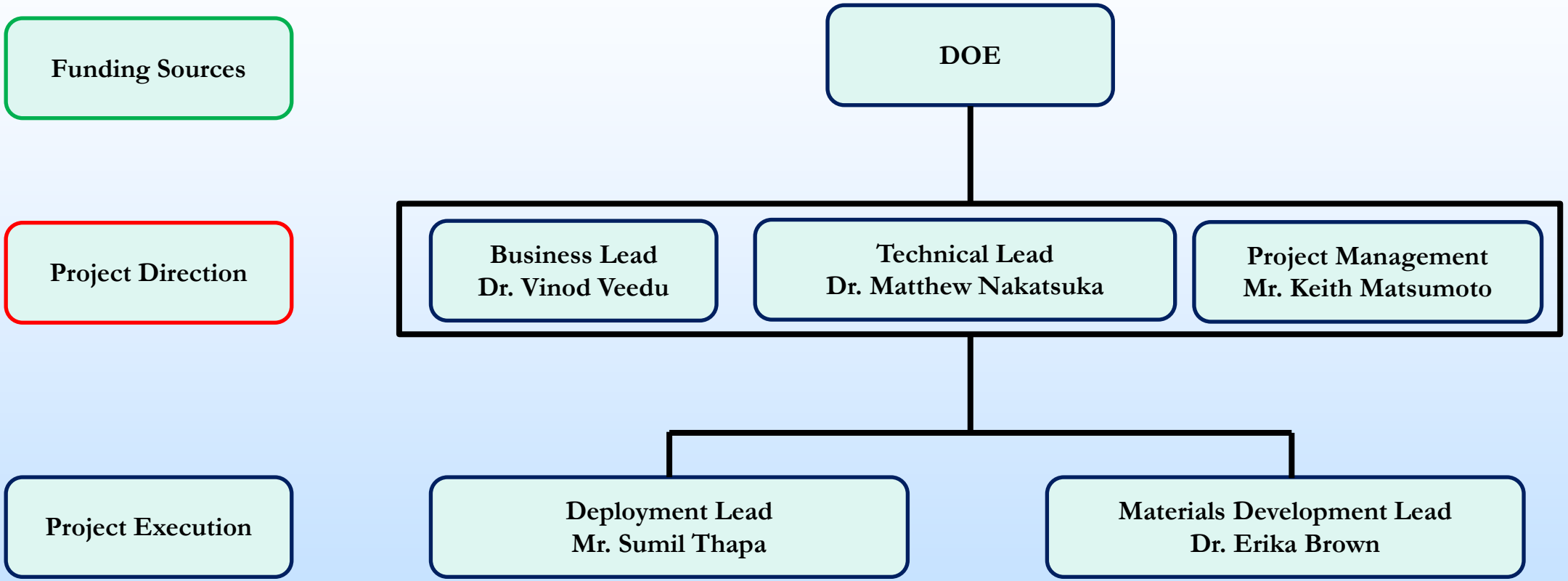
The key benefit to this project is that it provides **economic value for pipeline operators** at the same time. This has resulted in buy-in from these companies who have been willing to put in financial investments and access to assets as part of their evaluation process.

Project Overview

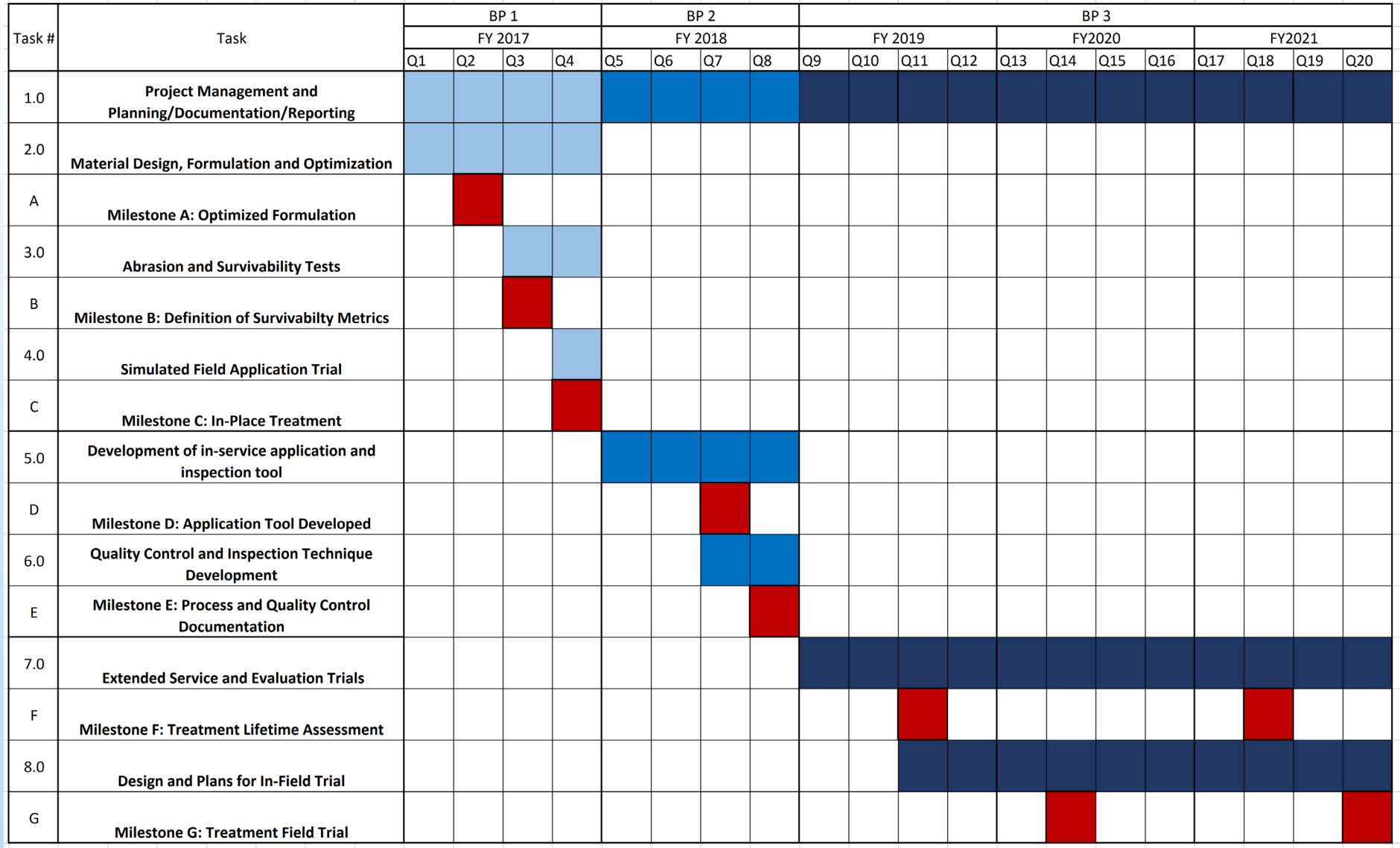
Goals and Objectives

- The objective of the proposed research is to demonstrate the capability of omniphobic, low-adhesion coatings applied in-situ on transmission and distribution pipelines to provide protection against corrosion, deposition, plugging and gas leaks.
- The work will result in improvements to physical infrastructure and institutional policies centered around natural gas transport. The work will also contribute to information resources on technical progress in materials that can provide corrosion protection, and in the applicability of cost-efficient, long ranging sensing technologies for more efficient utilization of existing pipeline networks.
- The project increases the knowledge and awareness in the workforce in a new, state-of-the-art technology area. This work will result in increased knowledge in corrosion prevention in the Oceanit workforce and in the workforce of future industry partners. The work will also result in the development of institutional knowledge around materials development and handling that will drive policies and procedures around the materials area.
- Success Criteria at budget period transition points include:
    - BPI to BPII – Develop material with mechanical and chemical durability to stand up to pipeline conditions.
    - BPII to BPIII – Pilot scale deployment and determination of economic value.
    - BPIII to Commercial Transition – Industry partner adoption & materials formulation scaleup.

Organization Chart



Gantt Chart


Task #
Task
BP 1
BP 2
BP 3
FY 2017
FY 2018
FY 2019
FY2020
FY2021
Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20
1.0 Project Management and Planning/Documentation/Reporting
2.0 Material Design, Formulation and Optimization
A Milestone A: Optimized Formulation
3.0 Abrasion and Survivability Tests
B Milestone B: Definition of Survivabilty Metrics
4.0 Simulated Field Application Trial
C Milestone C: In-Place Treatment
5.0 Development of in-service application and inspection tool
D Milestone D: Application Tool Developed
6.0 Quality Control and Inspection Technique Development
E Milestone E: Process and Quality Control Documentation
7.0 Extended Service and Evaluation Trials
F Milestone F: Treatment Lifetime Assessment
8.0 Design and Plans for In-Field Trial
G Milestone G: Treatment Field Trial

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