ALBERTA INNOVATES

CLEAN ENERGY

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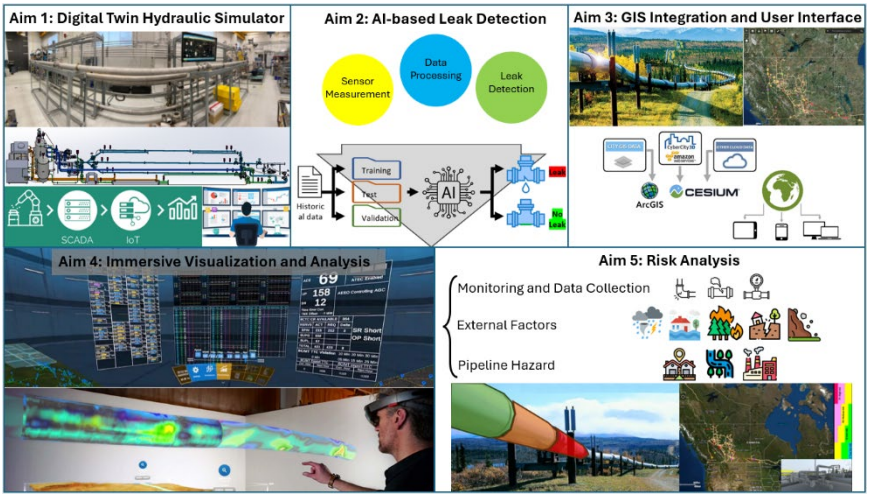
HYDROGEN CENTRE OF EXCELLENCE

Safe Hydrogen Agile Pipeline Engineering (SHAPE): Digital Transformation and Leak Detection Through Artificial Intelligence and Digital Twin

Global concerns regarding greenhouse gas emissions necessitate innovative approaches to hydrogen production, storage, and transportation to tackle safety and efficiency issues. Safely moving hydrogen from production sites to consumers presents a challenge. This project proposes an innovative pipeline health monitoring system using digital twin technology, integrating real-time data for risk assessment and improved hydrogen transportation safety and efficiency. Through virtual and mixed reality interfaces, the system offers spatial visualization for both a comprehensive understanding and informed decision-making. Combining information management with advanced detection methods, it serves as a comprehensive toolkit for accident detection, risk assessment, and structural health monitoring.



FUNDING DETAILS

RECIPIENT:
University of Calgary

PARTNERS:
Plains Midstream, ECC (formerly CEPA)

TOTAL BUDGET:
$1,252,000

AI HCOE FUNDING:
$610,000

PROJECT DATES:
APR 2024 – FEB 2026

PROJECT TRL:
Start: 4
End: 6

APPLICATION

Integrating hydrogen into Alberta's extensive natural gas pipeline network generates immediate, significant market demand, driving sectoral advancement. Enhanced safety and efficiency further bolster this demand. The project utilizes advanced digital twin technology and AI-driven leak detection systems to optimize hydrogen transportation, improving safety, efficiency, and cost-effectiveness. Leveraging abundant natural gas resources and strategic advantages, it promotes economic growth, job creation, and environmental stewardship, solidifying Alberta's position in the global hydrogen market while tackling critical pipeline integrity and monitoring challenges.

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PROJECT GOALS

The project aims to digitize a physical hydrogen pipeline flow facility using digital twin technology, empowered by SCADA interfaces, to enhance operational efficiency and safety. It focuses on immersive visualization and analytics using the digital twin, leveraging AR/VR interfaces for intuitive data interpretation. The system provides interactive visualization, enabling exploration of the pipeline infrastructure virtually. Additionally, it integrates GIS with AI onto the digital twin for environmental monitoring and risk assessment. Furthermore, the project aims to develop an AI-based leak detection system for hydrogen pipelines and conduct risk analysis using the E-RTTM method. Lastly, it assesses H2 risk through Bayesian theory and Monte Carlo simulation, ensuring safe transportation amidst environmental challenges.

BENEFITS TO ALBERTA

The project aligns with Alberta's strategic objectives, providing a pathway for tapping into the North American hydrogen market. By leveraging abundant natural gas resources, clean hydrogen production can be facilitated, promoting economic growth, and diversifying the energy sector. Transitioning to hydrogen reduces greenhouse gas emissions, leading to improved public health outcomes. Integration of hydrogen into existing pipelines creates market demand and export opportunities, positioning Alberta as a leader in sustainable energy innovation. Implementation of digital twin technology enhances safety, operational efficiency, and intuitive data interpretation, while reducing downtime due to false alarms. These advancements boost Alberta's reputation globally, attracting collaborations with international partners and advancing the province's clean energy agenda.

5 Publications

6 Students Trained

1 Patent

1-5 Project Jobs

10-100 Future Jobs

2 New Products/Services

1 Spinoff Company

10-100 kt/yr Project GHGs Reduced

100-1000 kt/yr Future GHGs

CURRENT STATUS

APR 2025

The University of Calgary team has developed a prototype digital twin of a mini flow loop, incorporating virtual reality modeling and a leak detection system. Preliminary GIS analysis was also performed for risk assessment and will be further developed in the second year. Hardware and software updates were made to the Advanced Pipeline Research and Innovation Laboratory (APRIL) flow facility, preparing it for the integration and testing of the developed technology in a more realistic system in the coming year.