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Adaptive Hybrid Welding and Digital Qualification for Hydrogen-Ready Line Pipes


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ORGANISATION PROFILE

Ion Industrial Metallurgy R&D Inc.

CORPORATE PROFILE

2019

Founded at METU Technopolis

OUR TEAM

6 people

PhD & MSc in metallurgical, materials, electronics, software chemical and welding (IIW & EWE) engineering.

R&D EXPERIENCE

SAAM Technique, KNIGHT Process Intelligence, SMART EUREKA DISTOPIA

CORE CAPABILITIES

Material Intelligence
Nadcap & ISO/IEC 17025 accredited testing, characterisation and structural integrity.

Advanced Manufacturing
Welding, DED, alloy engineering and prototype manufacturing.

Process Intelligence
Sensor integration, process monitoring and adaptive control.



PROPOSAL INTRODUCTION (I)

Optimized Resilient Industrial Operations for Next-generation Hydrogen Pipelines

VISION

Adaptive hybrid welding for hydrogen-ready line pipes.

To develop and validate an adaptive hybrid welding and digital qualification framework for hydrogen-ready HSLA line pipes.

MOTIVATION

Weld-zone heterogeneity challenges long-term hydrogen pipeline integrity.

Hydrogen transport increases the integrity demand on welded pipe seams, where weld metal and HAZ heterogeneity, residual stress and local brittle microstructures may govern fracture and hydrogen-assisted cracking risk. Previous Ion-led X70M studies showed that keyhole-based hybrid welding can reduce heat input and improve fracture toughness compared with conventional routes.

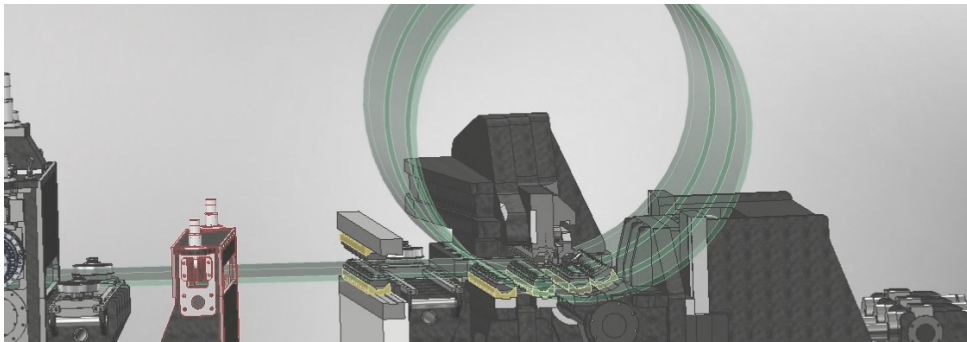
CONTENT

Adaptive Hybrid Welding Development
Develop and compare HLAW and narrow-gap welding routes, evaluating electromagnetic backing and tailored filler wires for HSLA pipes.

Hydrogen-Focused Metallurgical Validation
Assess weld microstructures through thermal-cycle modelling, characterisation, fracture testing and hydrogen-environment performance evaluation.

Real-Time Adaptive Process Control
Integrate KNIGHT sensor fusion for groove tracking, melt-pool monitoring and adaptive welding control, supported by an operator-facing XR interface.

Digital Traceability and Intelligence
Connect process, inspection and testing records through S'GMA and RETINA, enabling interoperable digital material passports and manufacturing intelligence.



PROPOSAL INTRODUCTION (II)

Optimized Resilient Industrial Operations for Next-generation Hydrogen Pipelines

EXPECTED OUTCOMES

Industrial Pipe Welding Demonstrator
Demonstrate a modular hybrid welding cell on representative HSLA pipe sections, comparing HLAW and narrow-gap process routes.

Validated Welding Process Windows
Establish reproducible process windows, groove tolerances and documented welding procedures, benchmarked against conventional submerged arc welding.

Adaptive Control Demonstrator
Integrate KNIGHT-based groove profiling and weld-pool observation with experimentally validated adaptive controls and an operator-oriented XR interface.

Hydrogen-Focused Integrity Validation & Digital Passport
Characterise weld and HAZ microstructures, residual stresses, fracture toughness and hydrogen-environment performance through representative qualification-oriented testing. Deliver traceable, pipe-specific manufacturing histories linking KNIGHT process records, inspection findings and mechanical test results through S'GMA.

EXPECTED MARKET IMPACTS

Hydrogen-Ready Structural Integrity
Improve weld and HAZ microstructural control to reduce hydrogen-assisted cracking susceptibility and strengthen long-term pipeline reliability.

Faster Qualification and Adoption
Link reproducible welding procedures with traceable inspection and H_2-environment test evidence, supporting more efficient industrial qualification and adoption.

Exportable Technology and Services
Open international markets for modular hybrid welding, KNIGHT-enabled control and S'GMA traceability through partnerships with pipe manufacturers.

SCHEDULE

30 - 36

months

YEAR 1	YEAR 2	YEAR 3
Procedure design & monitoring architecture	Adaptive control, metallurgical optimization	Qualification dossier, digital passport, exploit.

PARTNERS

CURRENT CONSORTIUM

Ion Industrial Metallurgy R&D Inc. | Process Monitoring & Adaptive Control

Welding metallurgy, process optimisation, validation testing, microstructural examination, KNIGHT monitoring/adaptive control.

Retina Data Technology Inc. | Data & Engineering Intelligence

Industrial-scale data management, digital material passports and S'GMA integration, with potential LLM-based engineering applications.

PARTNER SEARCH

Industrial Pipe Manufacturer | Priority

HSAW/LSAW producer or hydrogen pipeline stakeholder. To define industrial requirements, provide a representative demonstrator and support manufacturability assessment and qualification.

EM-backing & System Integrator

European industrial partner with expertise in EM-backing, HLAW, NGW, welding head integration.

Flux-cored Wire Manufacturer

TMCP-compatible wire and flux-cored wire development.

Alloy Design and Modelling

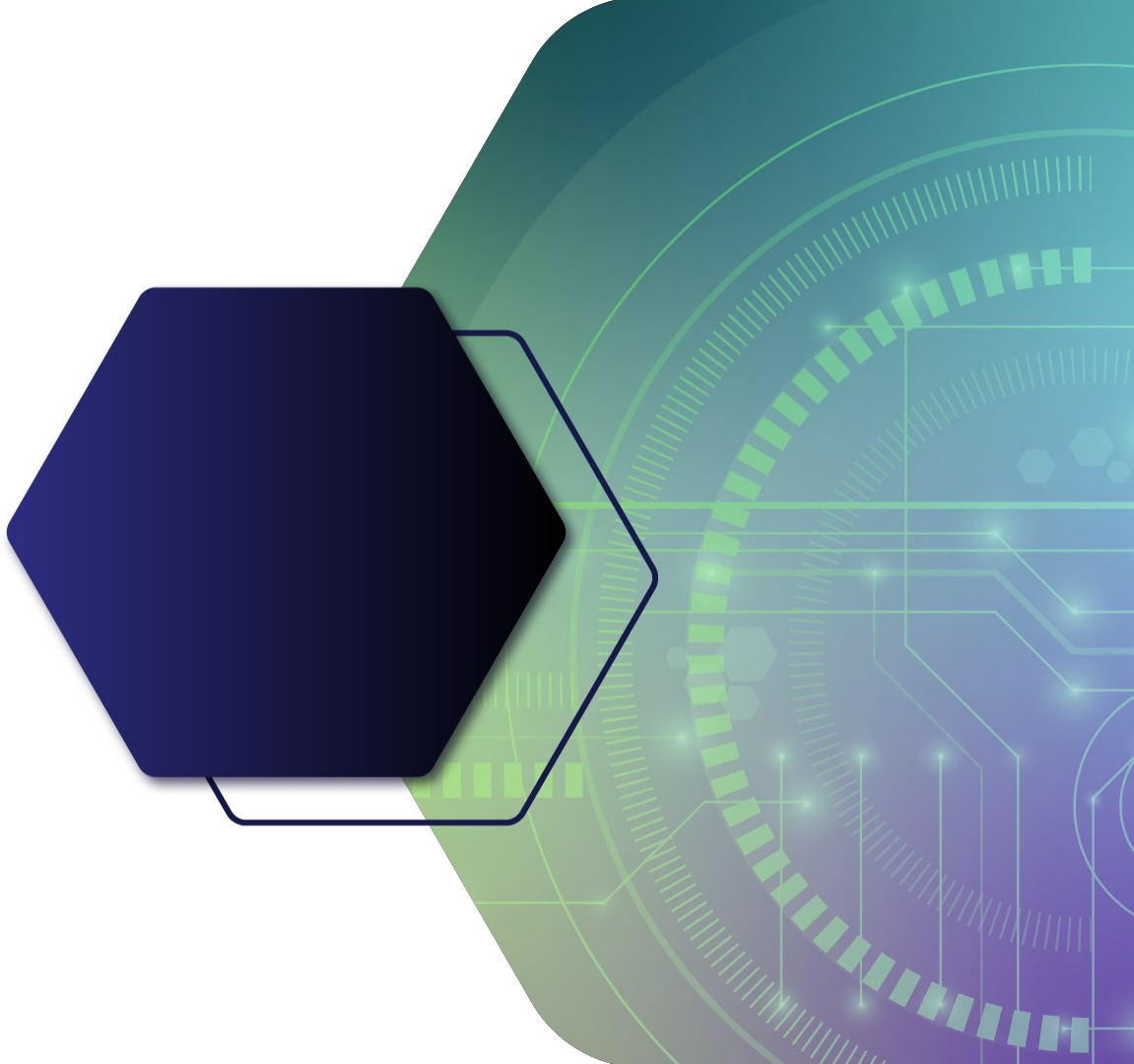
CALPHAD, HAZ simulation, hydrogen embrittlement, SEM/TEM/EBSD support.

CONTACT INFO

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