22nd. National & International Conference: Applied Systemic Management in the AI Era
Hellenic Society for Systemic Studies (HSSS)
University of Ioannina, Department of Accounting and Finance,
7th.-10th. October 2026
Preveza, Greece



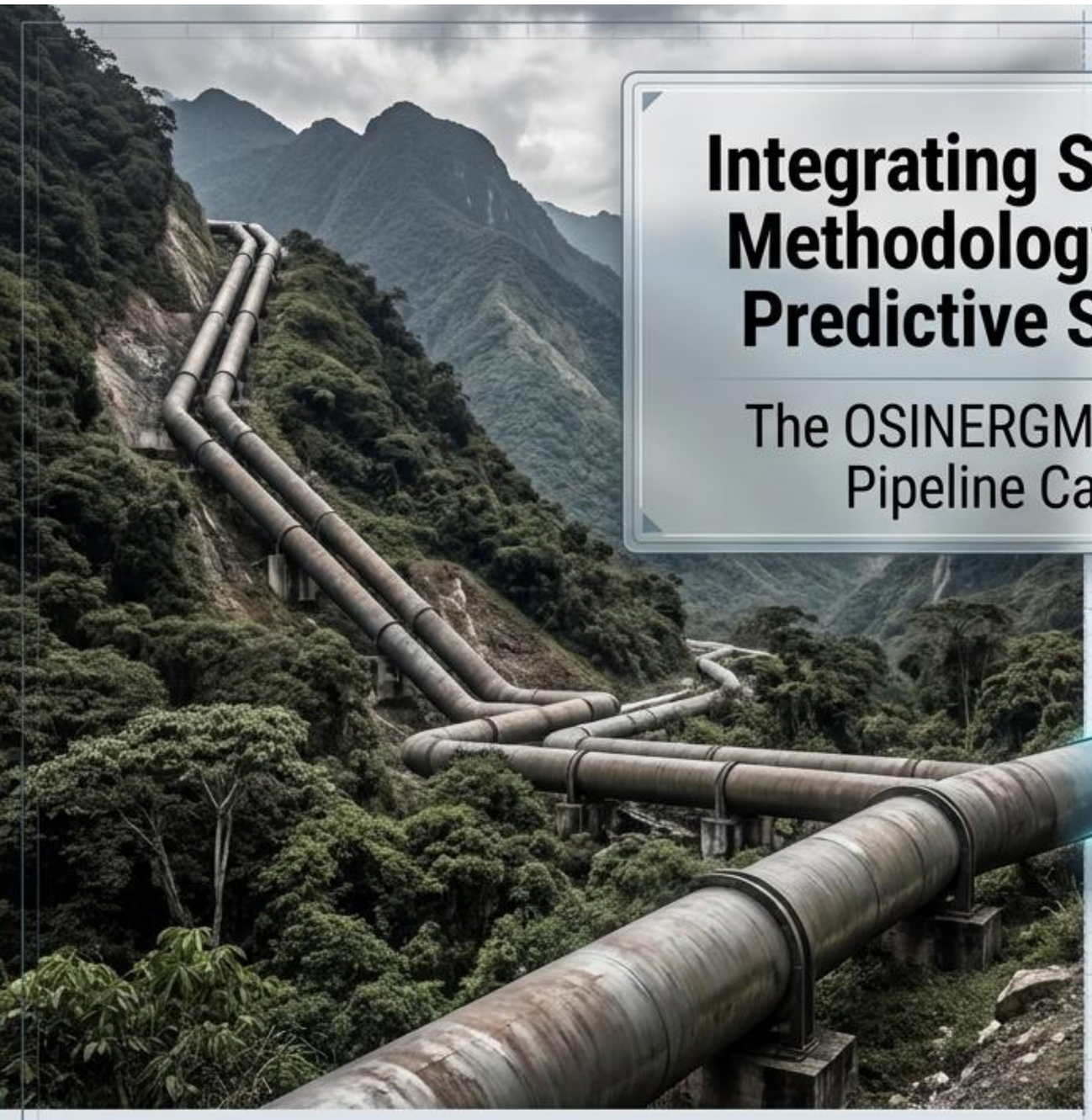
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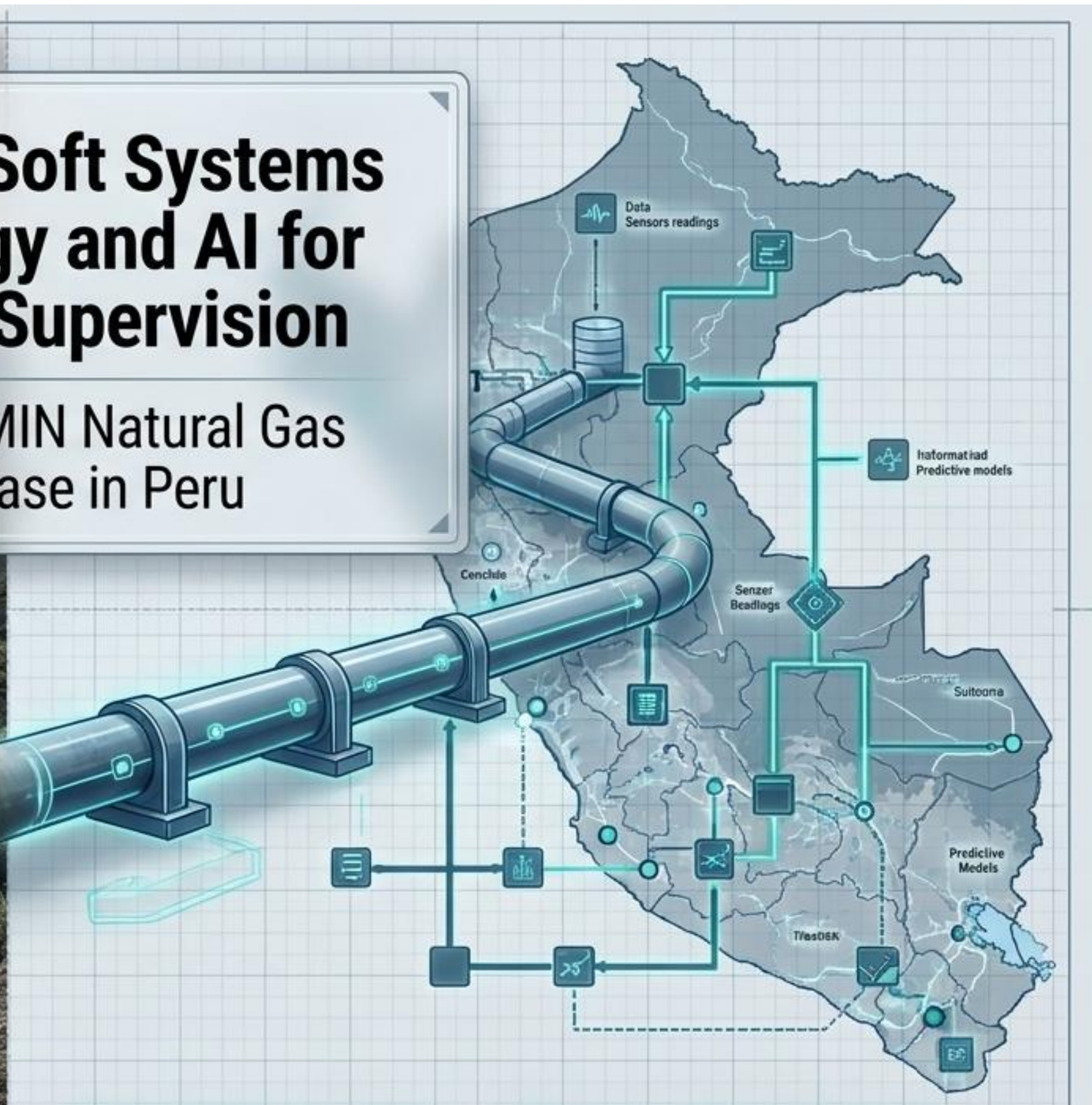
Integrating Soft Systems Methodology and AI-Based Multi-Criteria Decision Making for Predictive Supervision: A DEXi-Based Application in Peru's Natural Gas Transportation System

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Professor at National University of Engineering – UNI, Peru

Integrating Soft Systems Methodology and AI for Predictive Supervision

The OSINERGMIN Natural Gas Pipeline Case in Peru



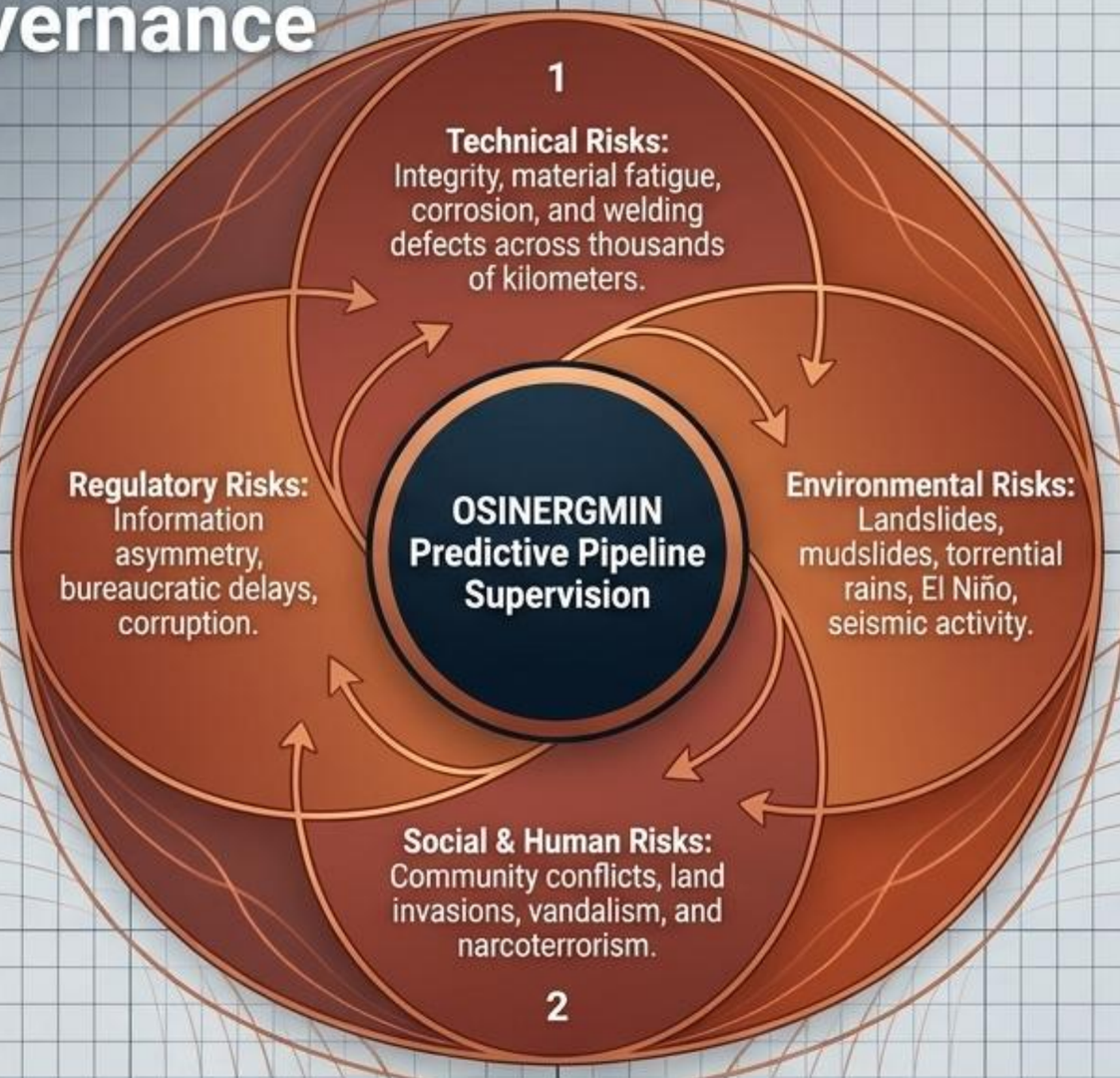


Ricardo A. Rodríguez-Ulloa, Instituto Andino de Sistemas (IAS)

Systemic Inquiry → Explainable Decisions.

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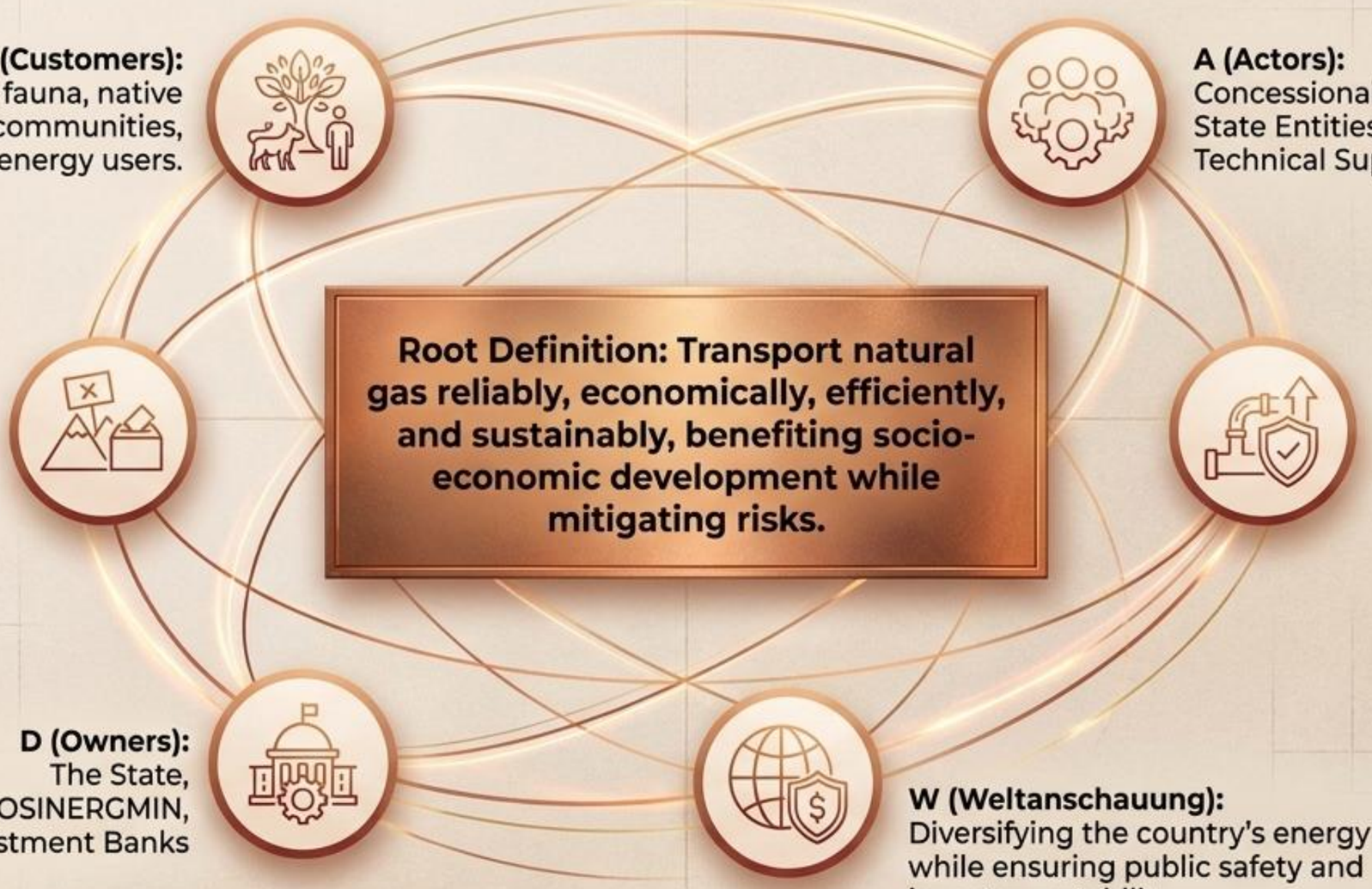
The Non-Linear Reality of Infrastructure Governance



Supervising Peru's natural gas transportation is a multi-variable governance challenge. Linear algorithms are insufficient—systemic framing must precede the AI model.

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Phase 1: Structuring the Systemic Mission (SSM)



C (Customers):
Flora, fauna, native communities, national energy users.

A (Actors):
Concessionaires (TGP), State Entities, Technical Supervisors.

E (Environment):
Extreme geography, social conflicts, shifting national politics.

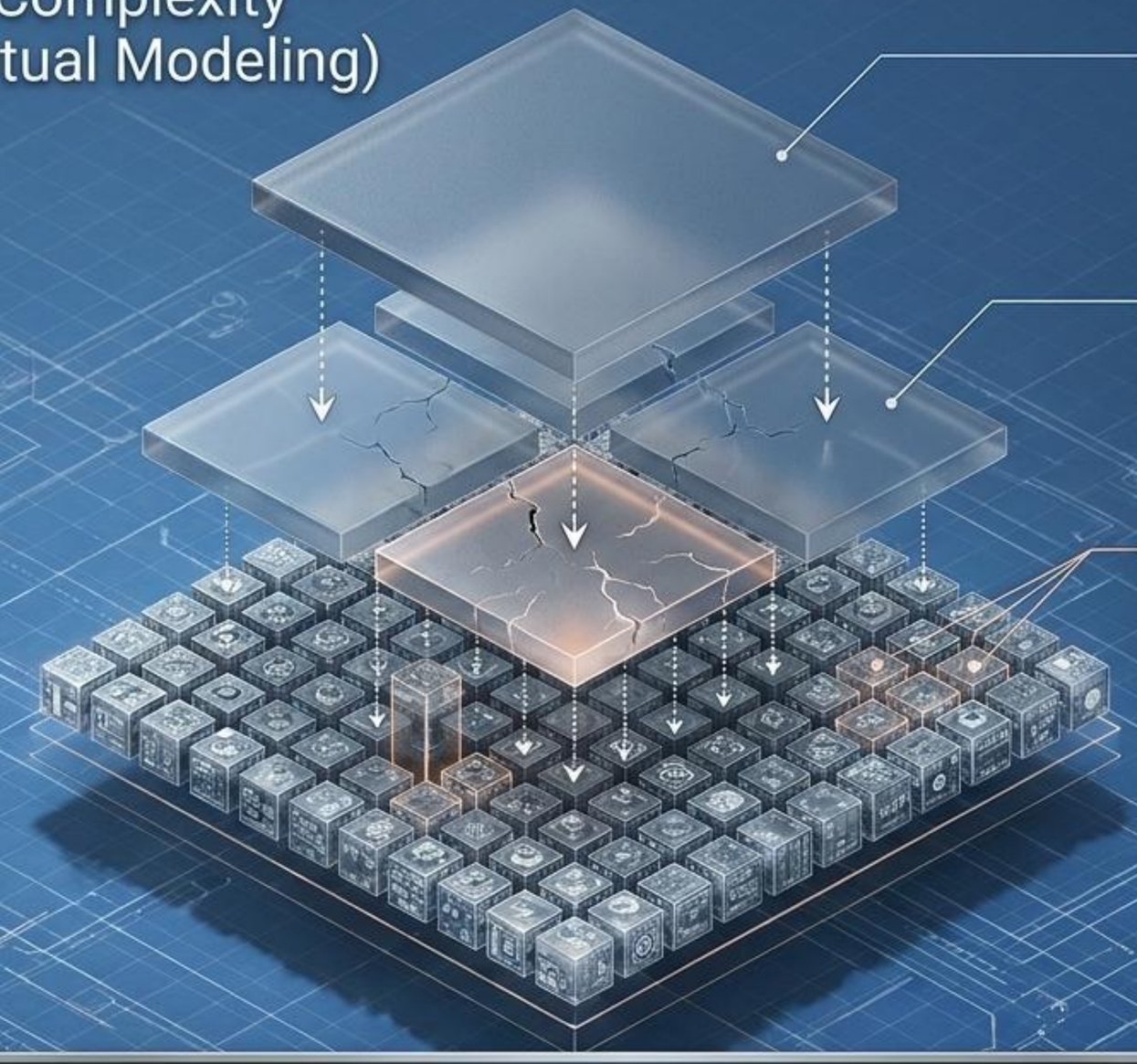
T (Transformation):
From unsupervised, reactive pipelines to sustainably supervised operations.

D (Owners):
The State, MINEM, OSINERGMIN, Investment Banks

W (Weltanschauung):
Diversifying the country's energy matrix while ensuring public safety and investor rentability.

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Phase 2: Resolving Complexity (Multi-Level Conceptual Modeling)



Level 1 (Macro):
Execute intelligent, risk-based supervision of the Natural Gas Pipeline System.

Level 2 (The 4 Lifecycle Phases):
Design (4.2), Construction (4.3), Operation & Maintenance (4.4/4.5), Abandonment (4.6).

Levels 3-6 (Micro Processes):
Shattering down into targeted Human Activity Systems (HAS) such as “Supervise pre-commissioning” and "Supervise welding defect mitigation".

The intervention mapped Human Activity Systems down to the 6th level of resolution, systematically framing **59,049** potential sub-processes before writing a single line of code.

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Phase 3: Defining the Parameters of Intelligence



Effectiveness (Eficacia) - Doing the right things

Process 3 (Infrastructure):
Km operational / Total Km target to 2025

Process 4 (Transport):
Number of failures / 1000 Kms per year

Process 4.3 (Construction):
Compliance with safety and technical obligations



Efficiency (Eficiencia) - Doing things right

Process 3 (Infrastructure):
Cost per Km in operation

Process 4 (Transport):
Transport cost (US$) / Volume transported (m3)

Process 4.3 (Construction):
Time and cost of executing the supervision cycle

These indicators derived directly from the conceptual models define the exact parameters the intelligence engine must evaluate to predict risk.

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THE BRIDGE: From Systemic Inquiry to Explainable AI



Systemic Structuring (SSM) - What to evaluate & Why

Intelligent Evaluation (DEXi/MCDM) - How to evaluate via expert rules

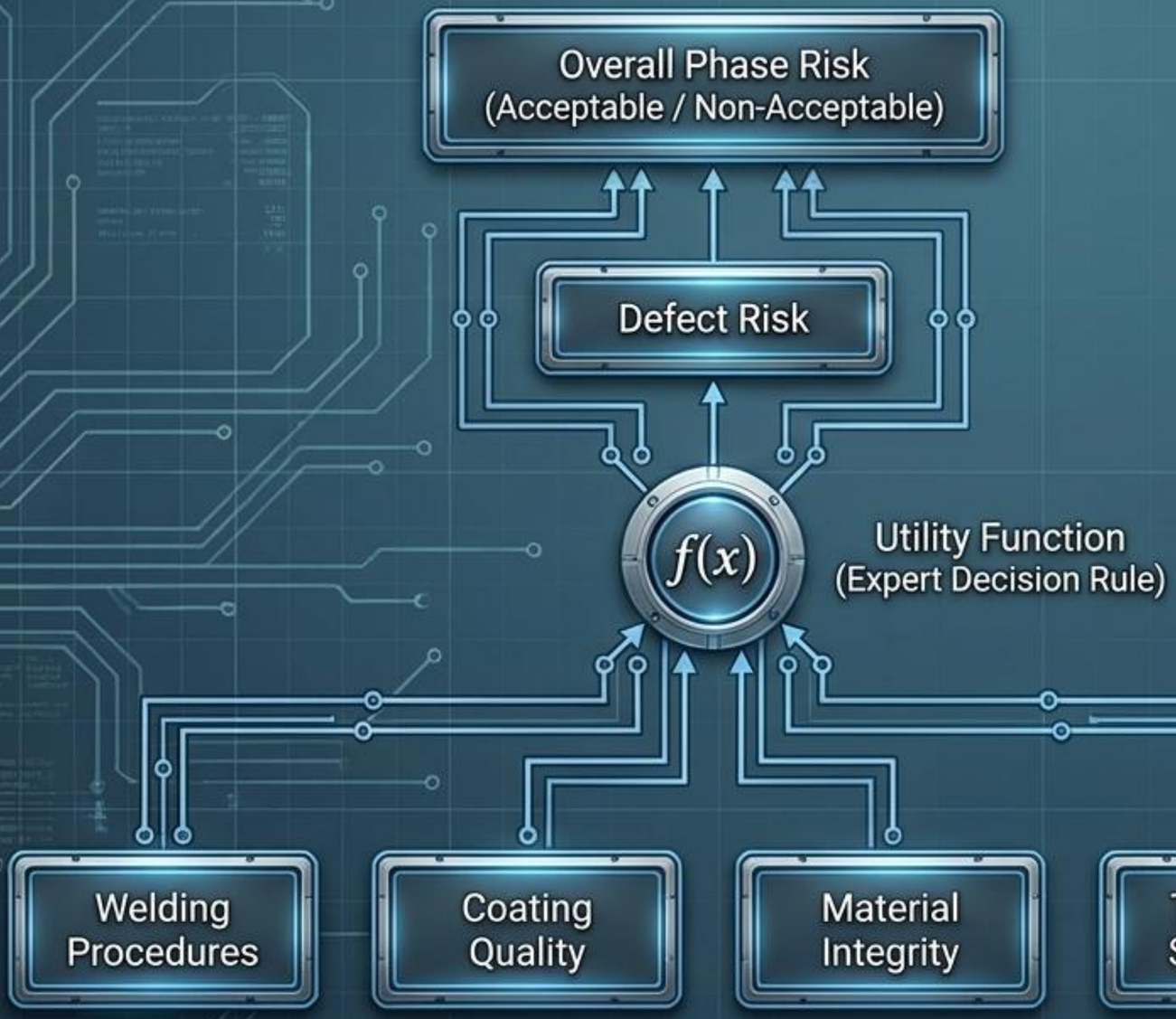
Translation Matrix

Conceptual Model (SSM)	Attribute Hierarchy (DEXi)
Activity: Evaluate external corrosion	→ **Leaf Attribute:** External Corrosion Measures (A1)
Activity: Check welding quality	→ **Leaf Attribute:** Welding Quality Control (A4)
Indicator: Effectiveness of infrastructure safety	→ **Utility Function:** Combines A1 + A4 to determine Technical Risk

Key Insight: AI is not layered on top of the problem. Human Activity Systems structurally engineer the Artificial Intelligence.

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DEXi: The Qualitative Multi-Criteria Decision Engine



IF lower-level attributes = {states}
THEN higher-level assessment = {risk class}

Unlike opaque deep learning models, DEXi utilizes explicit expert-defined utility functions, allowing 100% traceability for every supervisory decision backward to its root cause.

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Encoding Human Expertise: 1,047 Explicit Decision Rules



Design Phase:
93 Rules

Construction Phase:
216 Rules

Operation & Maintenance Phase:
438 Rules
(Highest logical density reflecting active, high-pressure infrastructure)

Abandonment Phase:
300 Rules

Expert Systems Rule Density

Iterative Calibration Process



Validated by:
OSINERGMIN Technical Work Committee (CTT), Division of Natural Gas Supervision, and top-tier industry experts.

The rules were not generated in a vacuum; they are the codified consensus of Peru's leading governance experts.

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Real-World Application & Regulatory Action

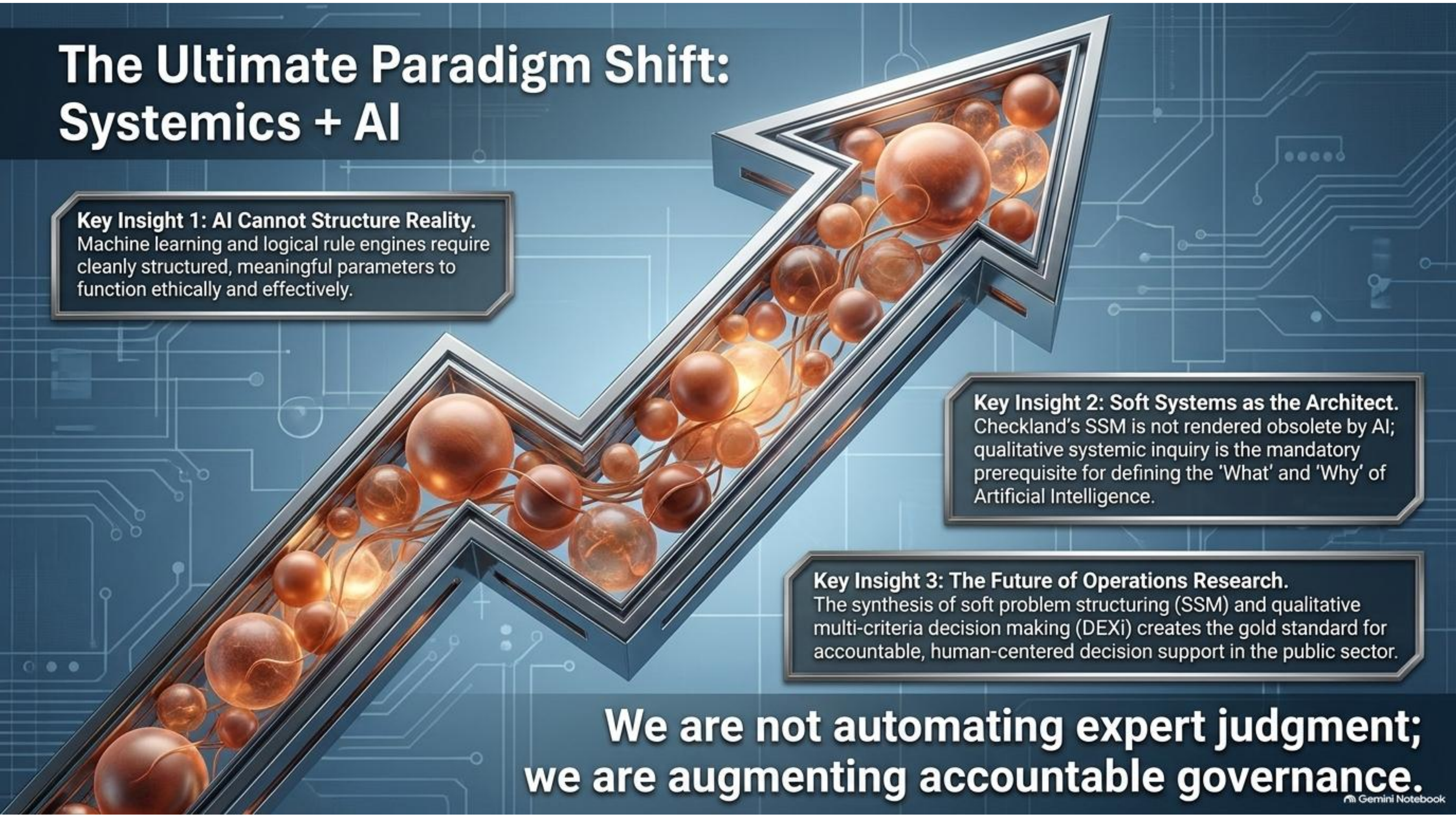
Evaluation Case	AI Risk Assessment	Recommended Action Plan
Case 1: TGP KP95 (Construction) - Route change in complex terrain.	⚠ Non-Acceptable Risk	Mandate geotechnical supervision 1x/month.
Case 2: Repsol Kinteroni-Sagari (Construction) - New pipeline construction.	⚠ Non-Acceptable Risk	Mandate welding supervision 2x/month.
Case 3: PeruLNG KP01 (Abandonment) - Decommissioning of proprietary duct.	✓ Acceptable Risk	Routine environmental supervision 1x/year.

The methodology translates complex multi-variable systemic analysis into explicit, targeted, and legally binding regulatory actions.

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The Ultimate Paradigm Shift: Systemics + AI

Key Insight 1: AI Cannot Structure Reality.
Machine learning and logical rule engines require cleanly structured, meaningful parameters to function ethically and effectively.



Key Insight 2: Soft Systems as the Architect.
Checkland's SSM is not rendered obsolete by AI; qualitative systemic inquiry is the mandatory prerequisite for defining the 'What' and 'Why' of Artificial Intelligence.

Key Insight 3: The Future of Operations Research.
The synthesis of soft problem structuring (SSM) and qualitative multi-criteria decision making (DEXi) creates the gold standard for accountable, human-centered decision support in the public sector.

We are not automating expert judgment; we are augmenting accountable governance.

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International Federation for Systems Research - IFSR

Thanks! / Ευχαριστώ!

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