External Quarterly Report

Date of Report: 1st Quarterly Report -December 30th, 2023

Contract Number: 693JK32310012POTA

Prepared for: DOT PHMSA

Project Title: A Framework for Improving Geohazard Monitoring, Data Integration, and Information Fusion at Scale

Prepared by: GTI Energy (Gas Technology Institute)

Contact Information: Ernest Lever, elever@gti.energy , 847-544-3415

For quarterly period ending: December 30th, 2023.

1: Items Completed During this Quarterly Period:

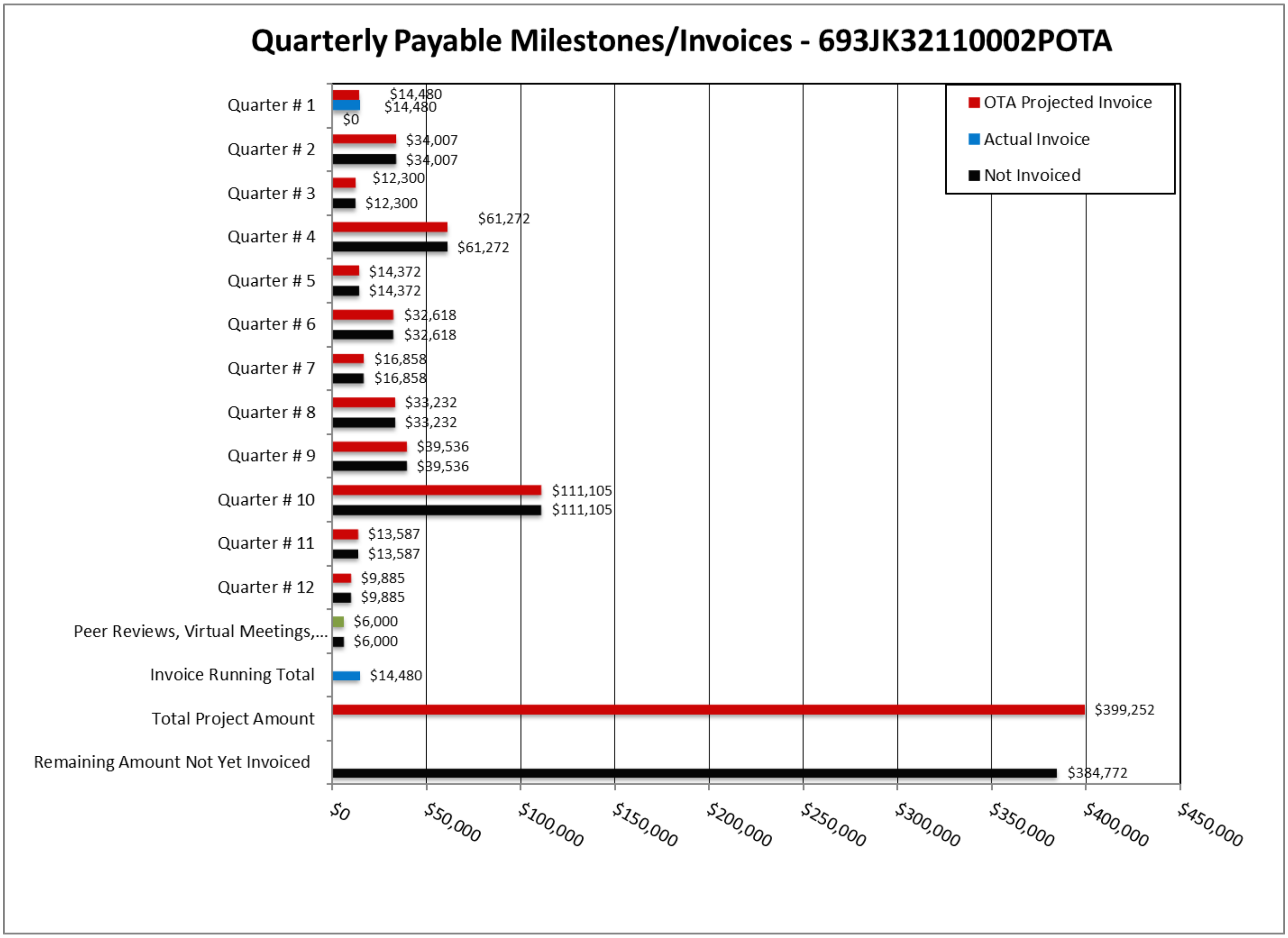
Item #	*Task #*	*Activity/Deliverable*	*Title*	*Federal Cost*	*Cost Share*
1	1	Project Kickoff, Stakeholder Identification, Requirements Development, and State-of-the-Art Documentation	Convene Technical Advisory Panel (TAP) and conduct kick-off Team meeting	$12,268	$6,222
2	11	1st Quarterly Status Report	Submit 1st quarterly report	$2,212	$3,572

1. Item #1 Convene Technical Advisory Panel (TAP) and conduct kick-off Team meeting .
2. Item #1: Submit 1st quarterly report

2: Items Not Completed During this Quarterly Period:

1. No outstanding Q1 deliverables.

3: Project Financial Tracking During this Quarterly Period:

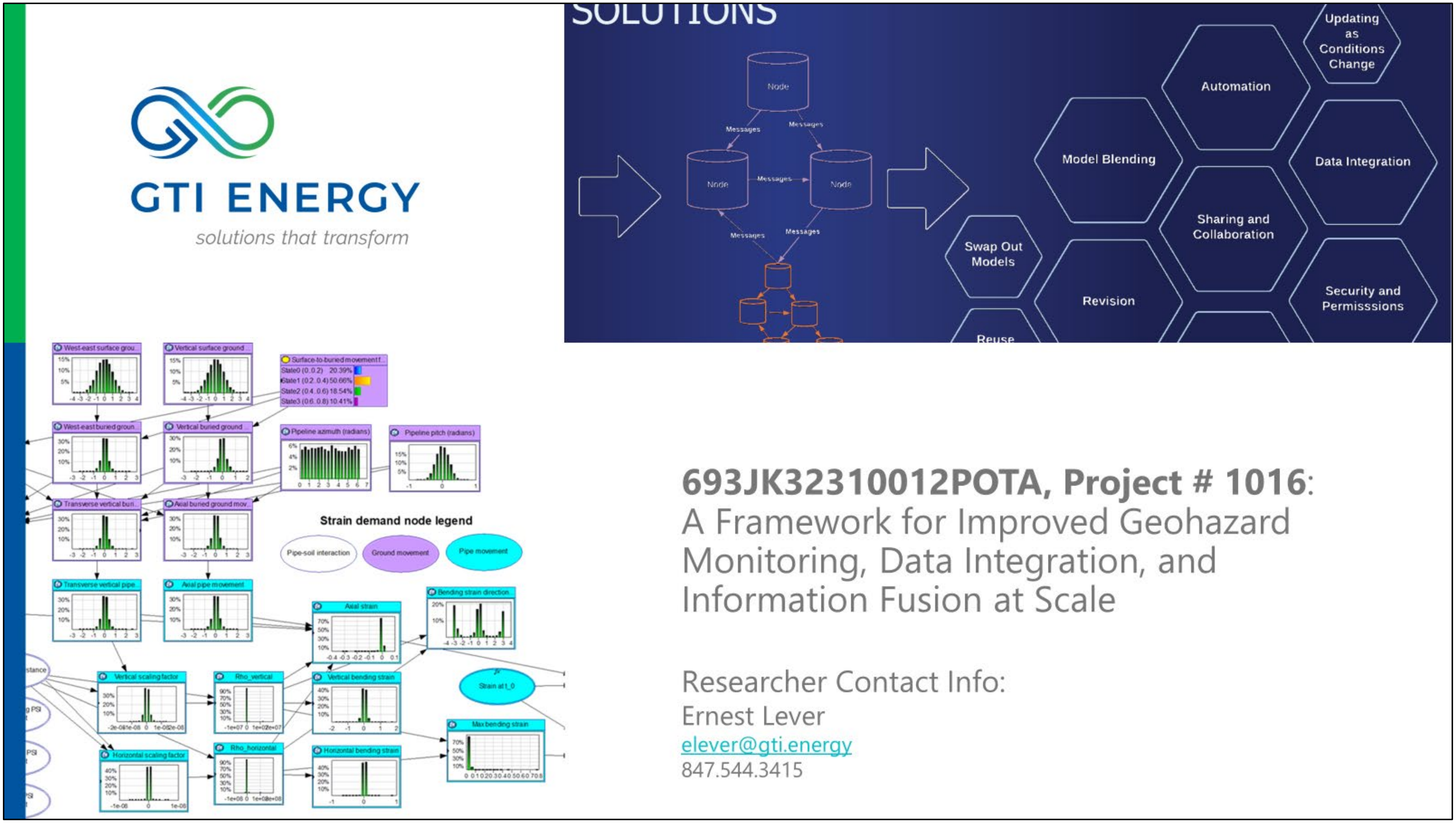


4: Project Technical Status

1. The technical advisory panel (TAP) for the project was convened and the project kickoff meeting was held virtually on December 14th, 2023.
2. The team members were introduced, the project objectives, deliverables, task work, budget, and timeline were outlined.
3. The project framework was discussed in detail:
    a. How the team members will coordinate amongst themselves, and how they will interact with the TAP,
    b. How outreach to industry organizations and standards committees will be managed,
    c. The methods that will be employed in developing the data, and information fusion framework were explained and discussed, and
    d. The use case for the workshop and interactive technology demonstration was presented and discussed.
4. There was vigorous discussion amongst all present about the various project elements with excellent feedback provided to the project team, even at this early stage of the project. We anticipate very healthy interaction with the extremely qualified and engaged TAP members going forward, in particular regarding collaboration and coordination with other institutions and projects that are addressing the same topic.
5. The slides presented at the kickoff meeting are provided in Appendix 1.

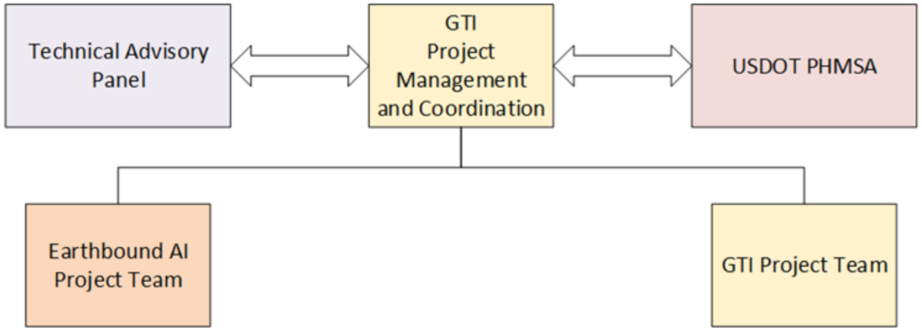
<u>End of section</u>

Appendix 1: Project Kickoff Meeting Slides



Project Team

- GTI
  - Ernest Lever
  - Dr. Keith Leewis
- Earthbound
  - Mollie Hector
  - Dr. Robert Berry
  - Susana Crespo
- TAP
  - Dr. Smitha Koduru, Enbridge
  - Sean Sullivan, TransMountain
  - Jonathan Bell, Williams
  - TBD, ONEOK
  - Peer Review TAP Members
    - Dr. Enrique Droguett, UCLA
    - Dr. Yong Yi Wang, CRES Americas



Project Objectives and Deliverables

GTI ENERGY

- Deliver well-documented data, information, and model fusion architectures that can be implemented on many commercially available platforms.
  - This project will define a new technology-architecture, and an approach to understand geohazard risk guided by thoughtful design principles that disrupt current approaches to geohazard monitoring and forecasting.
  - Central to this approach is the idea of making data analysis-ready, more addressable and accessible to networks of models to decision makers; this highly organized approach will unlock innovation.
  - This approach will extract more value from existing data and models and will lay the foundation for integrating real-time sensor feeds, pertinent information from any source, and fit-for-purpose models across a variety of information presentation formats, to facilitate agile, and effective decision making in the context of mitigating geohazard threats to pipelines.
- Demonstrate the framework via a workshop and publicly accessible use-case demonstration
- Outreach and coordination with standards organizations to lay the groundwork for an industry workgroup that can accept the project deliverables as initial input to develop a governing standard that covers data integration, information fusion, and model integration.

Project Objectives and Deliverables

GTI ENERGY

- Deliver well-documented data, information, and model fusion architectures that can be implemented on many commercially available platforms.
  - This project will define a new technology-architecture, and an approach to understand geohazard risk guided by thoughtful design principles that disrupt current approaches to geohazard monitoring and forecasting.
  - Central to this approach is the idea of making data analysis-ready, more addressable and accessible to networks of models to decision makers; this highly organized approach will unlock innovation.
  - This approach will extract more value from existing data and models and will lay the foundation for integrating real-time sensor feeds, pertinent information from any source, and fit-for-purpose models across a variety of information presentation formats, to facilitate agile, and effective decision making in the context of mitigating geohazard threats to pipelines.
- Demonstrate the framework via a workshop and publicly accessible use-case demonstration
- Outreach and coordination with standards organizations to lay the groundwork for an industry workgroup that can accept the project deliverables as initial input to develop a governing standard that covers data integration, information fusion, and model integration.

SOW and Project Tasks

- **Task 1**: A task to research the state-of-the-art and gather requirements,
- **Task 2**: A task to develop the framework covering both the generalized system and the selected use-case,
- **Task 3**: A task to cover standard organization outreach, and
- **Task 4**: A task to cover the demonstration workshop and final report deliverables.

Project Schedule and Budget

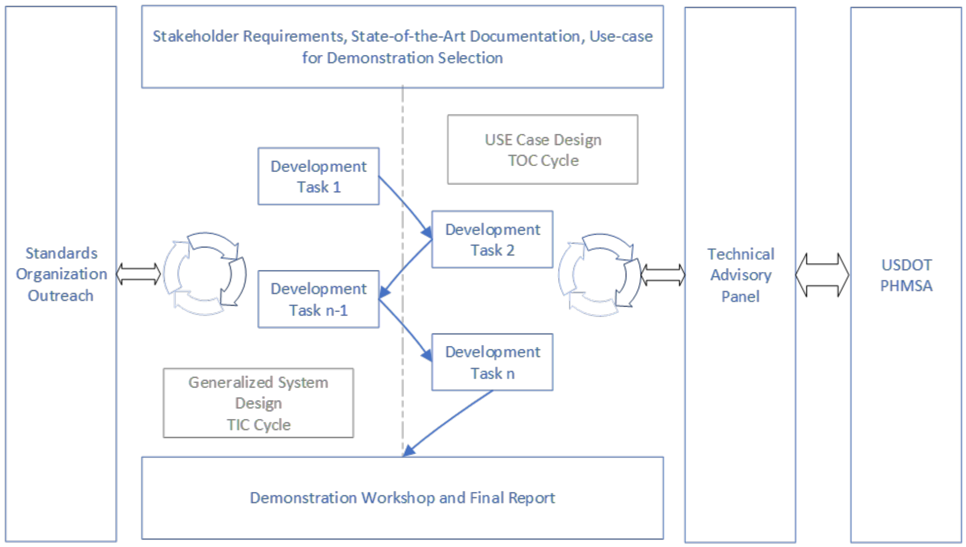
		2023	2024				2025				2026			Projected Cost		
		Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Federal	Cost Share	Total
Task 1	Kickoff, Stakeholder Identification, Requirements Development, and State-of-the-Art Documentation													$ 44,536	$ 32,444	**$ 76,980**
Task 2	Generalized Framework and Use-case Development													$ 116,151	$ 142,256	**$ 258,407**
Task 3	Use-case Demonstration Workshop and Final Report													$ 114,271	$ 144,120	**$ 258,391**
Task 4	Standards Organization Outreach													$ 96,125	$ 63,840	**$ 159,965**
Task 5	Reporting and Project Management													$ 28,169	$ 17,340	**$ 45,509**
													Total	**$ 399,252**	**$ 400,000**	**$ 799,252**

Overview of Standards Organization Outreach

Keith Leewis

Project Structure

- The framework development task will be structured in a tic/toc cycle where the generalized framework elements will be developed first, followed by
  - The implementation of those framework elements in the use-case demonstration.
- There will be two directions of oversight and feedback solicitation:
  - The tic cycle is more relevant to the standardization efforts, and
  - The toc cycle is more relevant to the industry subject matter experts sitting on the TAP



Standards Organization Outreach: Developing Code Activities

- API Geotechnical code Liaison into outcomes from
  - ***Development and Validation of a Probabilistic Method for Estimating Accumulated Strain and Assessing Strain Demand and Capacity on Existing Pipelines*** - Contract No 693JK32110002POTA, WP# 944-
- Expected ASME B31.8 for 2026
  - Convert above ***Strain Demand Capacity*** into B31.8 and B31.8S
  - Update Table 7.1-1 Acceptable Threat Prevention & Repair Methods
- Add Drone, Aircraft, & Satellite Patrols, ILI for pipe strains & record validation, steel, steel coil, & composite repair sleeves, consider weld undermatching (see 693JK32210007POTA),

Standards Organization Outreach: Current B31.8 & B31.8S Ballot Activities

GTI ENERGY

ASME Ballot #s trying for 2024 Publication

- 23-1940 & 23-1941 Adding CO2 Transmission Language into B31.8 and B31.8S
  - Based on PR000-22605-R01 Pipeline Transport of CO2 (PRCI Alt -1 -6) (PRCI Publication)
- 22-178 Addressing Leak/Rupture Analysis– improve consequence estimates
  - Review the Intent and Safety Impact of Hoop Stress and Percentage of Specified Minimum Yield Stress Boundaries on Natural Gas Transmission and Distribution Pipelines DOT/PHMSA CONTRACT NUMBER: 693JK31910001POTA -DOT WP#785 -
  - Will become new Appendix B in B31.8S - BR (Basic leak/Rupture) framework to improve the likelihood of failure consequence
- 15-450 Records to Retain for Lifetime – remove ambiguity, improve QC
  - Initiated from IPC2012-90406 and PHMSA FAQs
  - adding ASME QPS – 2021 Quality Program for Suppliers General Industry

Overview of Framework Elements

Earthbound ai Team

Geohazards are are complex

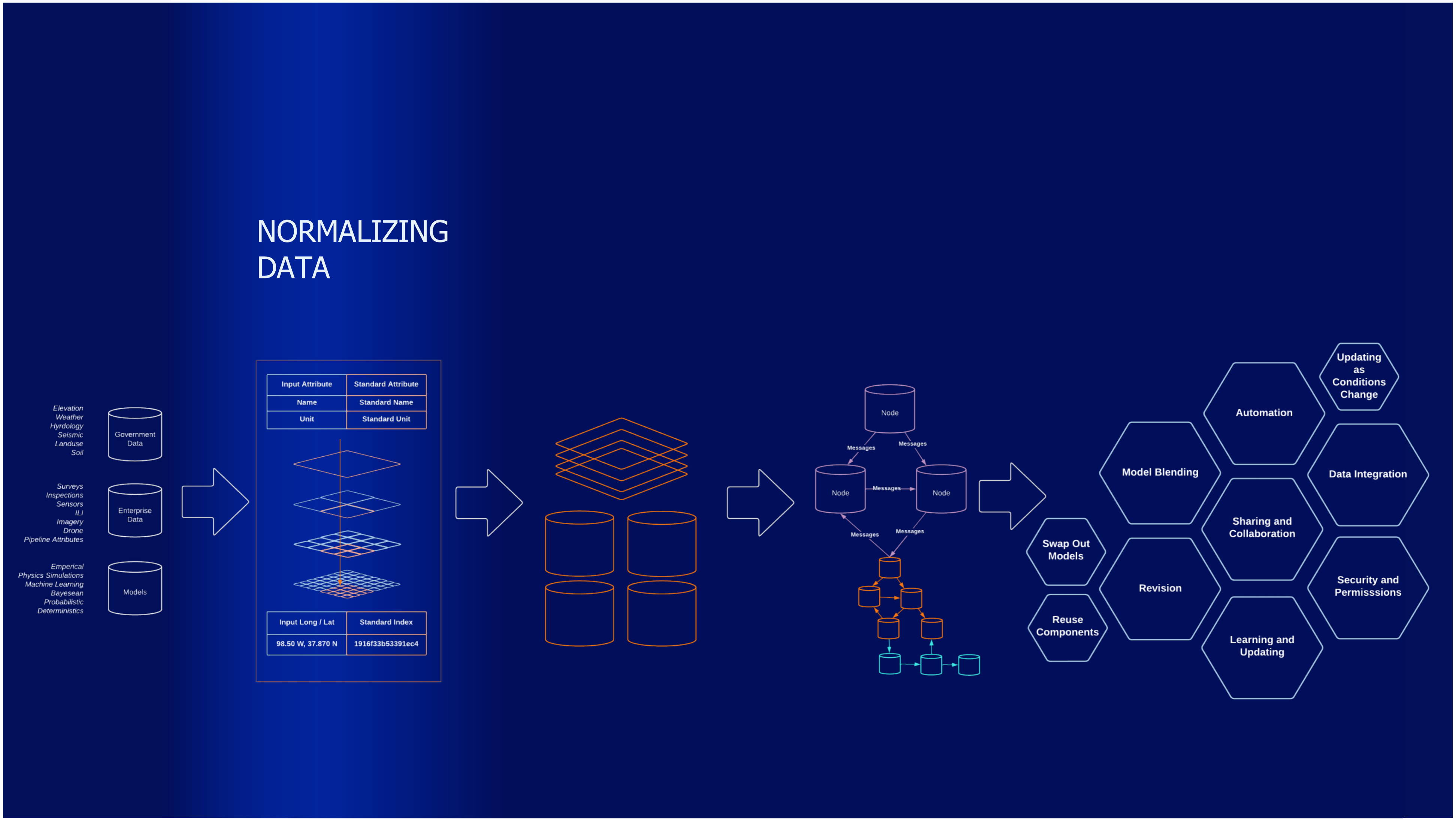
- They vary over space and time,
- They have high dimensionality,
- They draw from disparate data,
- They are event-driven.

Our goal: building capabilities to

- Predict the state of assets
- At any location,
- In real time,
- At scale,
- Accounting for the distinct environmental variables that change along the way.

Improving geohazard monitoring requires specific technical capabilities

1. Normalizing Data
2. Organizing Data and Models into Modular Components
3. Networking Modular Components Into Solutions


NORMALIZING DATA
Elevation
Weather
Hyrdology
Seismic
Landuse
Soil
Government Data
Surveys
Inspections
Sensors
ILI
Imagery
Drone
Pipeline Attributes
Enterprise Data
Emperical
Physics Simulations
Machine Learning
Bayesean
Probabilistic
Deterministics
Models
Input Attribute
Standard Attribute
Name
Standard Name
Unit
Standard Unit
Input Long / Lat
Standard Index
98.50 W, 37.870 N
1916f33b53391ec4
Node
Messages
Messages
Node
Messages
Node
Messages
Messages
Updating as Conditions Change
Automation
Model Blending
Data Integration
Sharing and Collaboration
Swap Out Models
Revision
Security and Permisssions
Reuse Components
Learning and Updating

NORMALIZING DATA

Lack of analysis-ready, spatially indexed data makes it difficult to address geohazard problems:

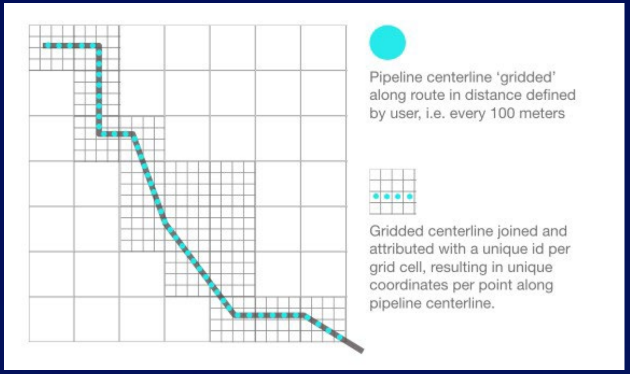
- At scale
- At specificity
- Over time as conditions change

Current approaches are:

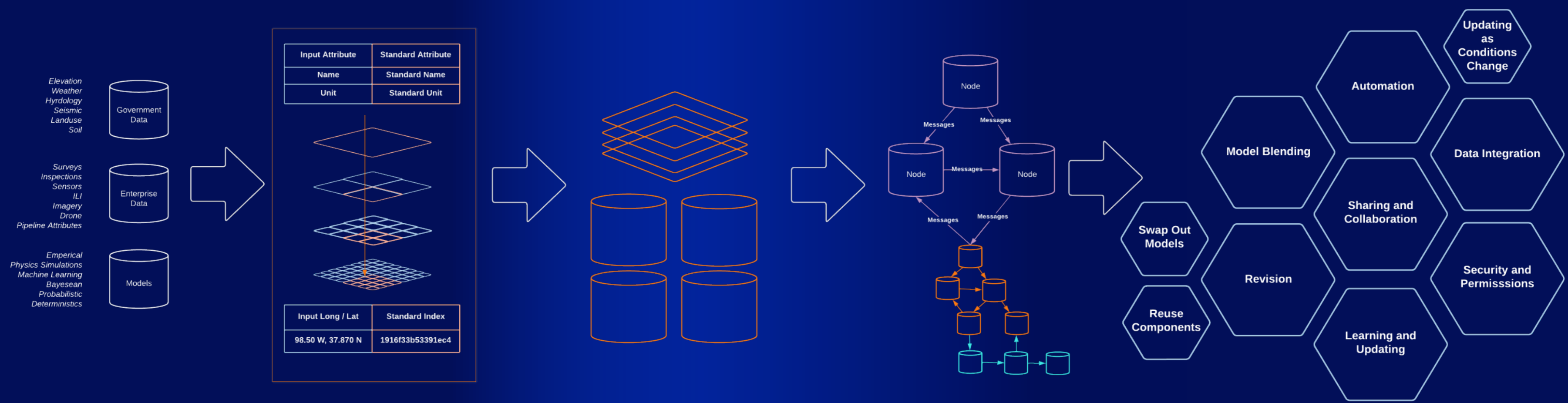
- Computationally expensive
- One-off, not reusable
- Not interoperable
- Slow

GRID DATA TO MAKE IT ANALYSIS READY

- Nested, grid-based coordinate system -- "geohashing" -- lays the foundation for automating analysis at scale.



ORGANIZING DATA AND MODELS INTO MODULAR COMPONENTS



spool

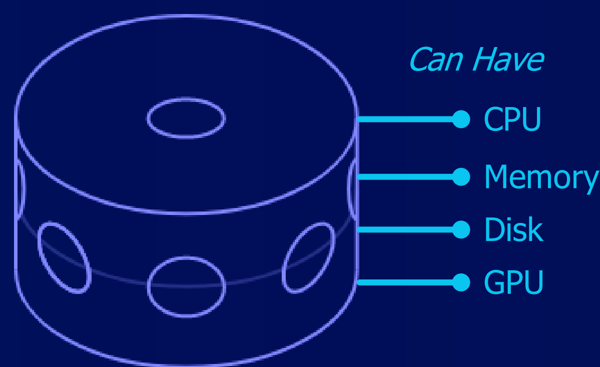
/sp o̅ol /

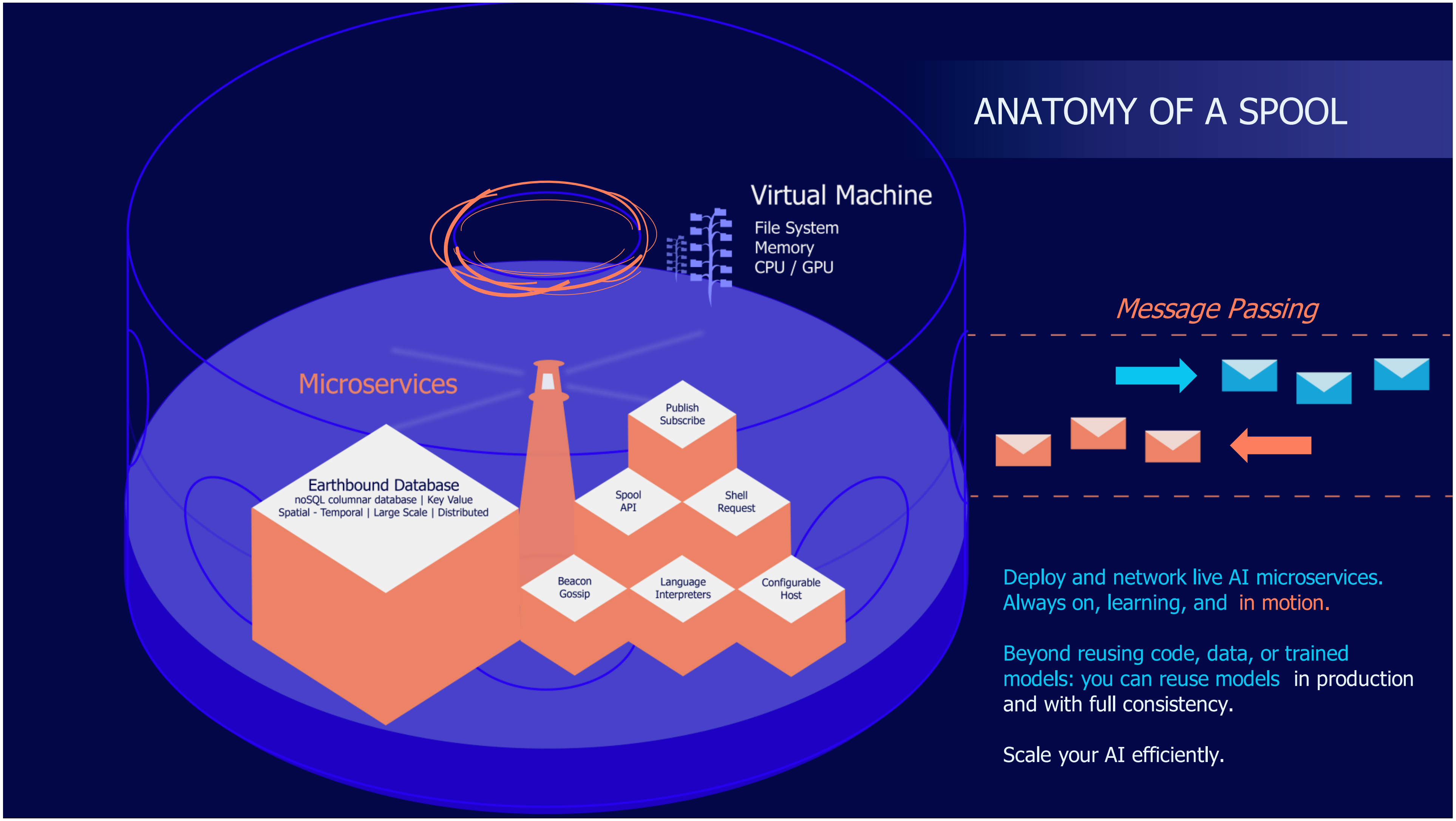
noun

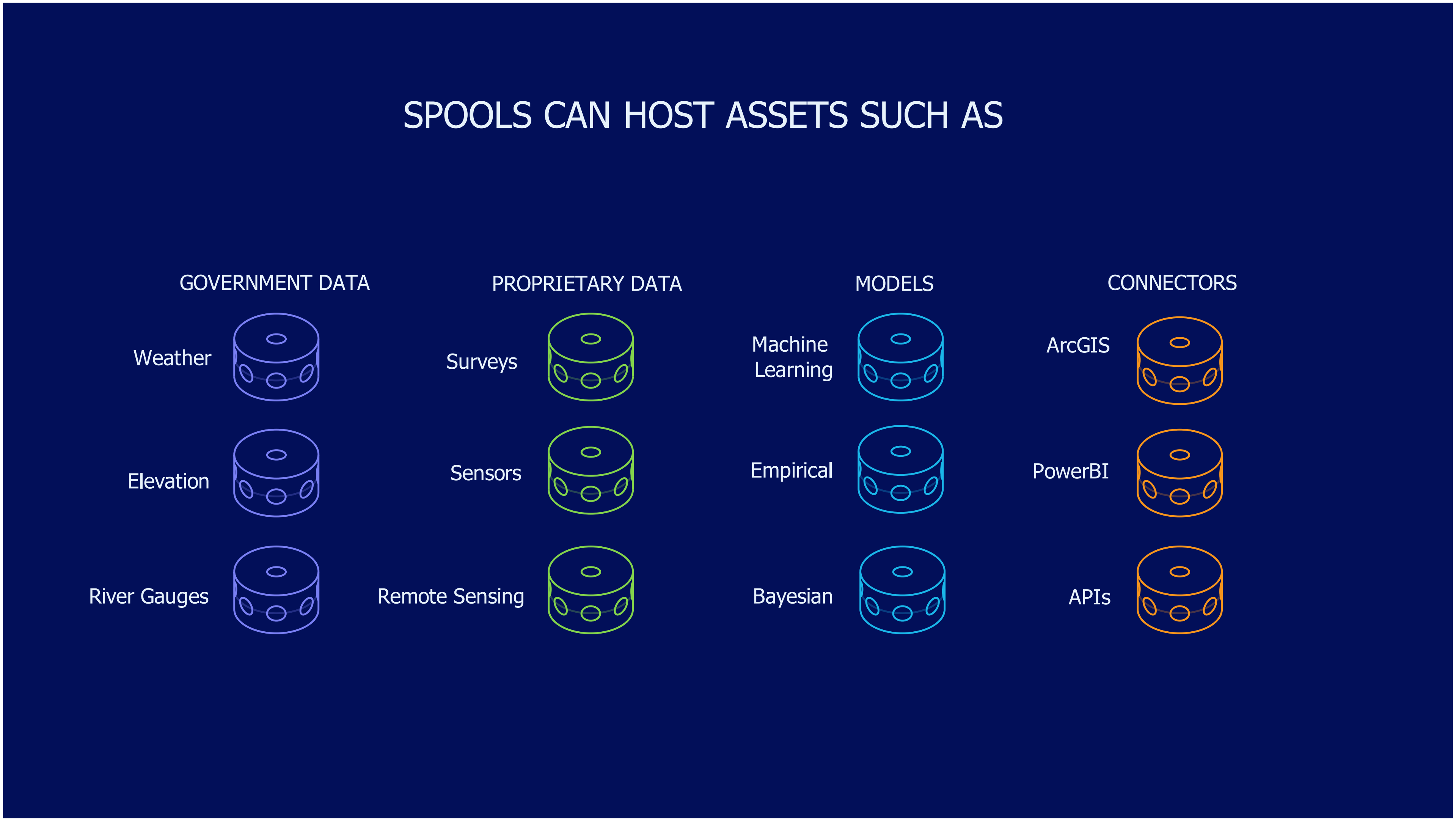
: Agent -Based Module – an isolated virtual machine with a computational kernel that can host spatial -temporal data, models and functions.

: Spools enable easy deployment of models into production.

: Spools serve analysis -ready data

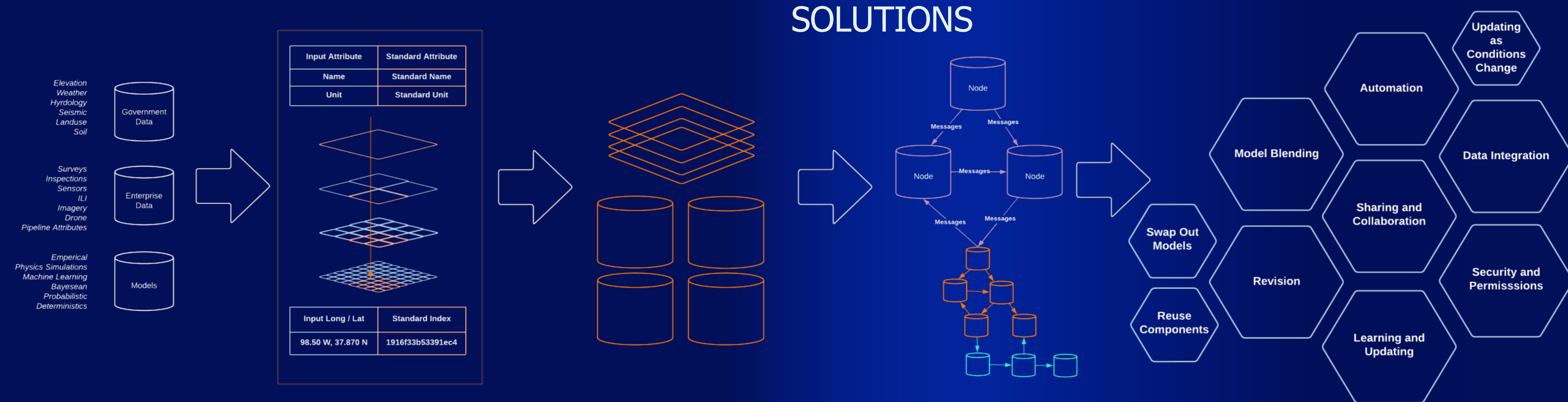



ANATOMY OF A SPOOL
Virtual Machine
File System
Memory
CPU / GPU
Message Passing
Microservices
Earthbound Database
noSQL columnar database | Key Value
Spatial - Temporal | Large Scale | Distributed
Publish Subscribe
Spool API
Shell Request
Beacon Gossip
Language Interpreters
Configurable Host
Deploy and network live AI microservices.
Always on, learning, and in motion.
Beyond reusing code, data, or trained models: you can reuse models in production and with full consistency.
Scale your AI efficiently.



SPOOLS CAN HOST ASSETS SUCH AS
GOVERNMENT DATA
Weather
Elevation
River Gauges
PROPRIETARY DATA
Surveys
Sensors
Remote Sensing
MODELS
Machine Learning
Empirical
Bayesian
CONNECTORS
ArcGIS
PowerBI
APIs

NETWORKING MODULAR COMPONENTS INTO SOLUTIONS

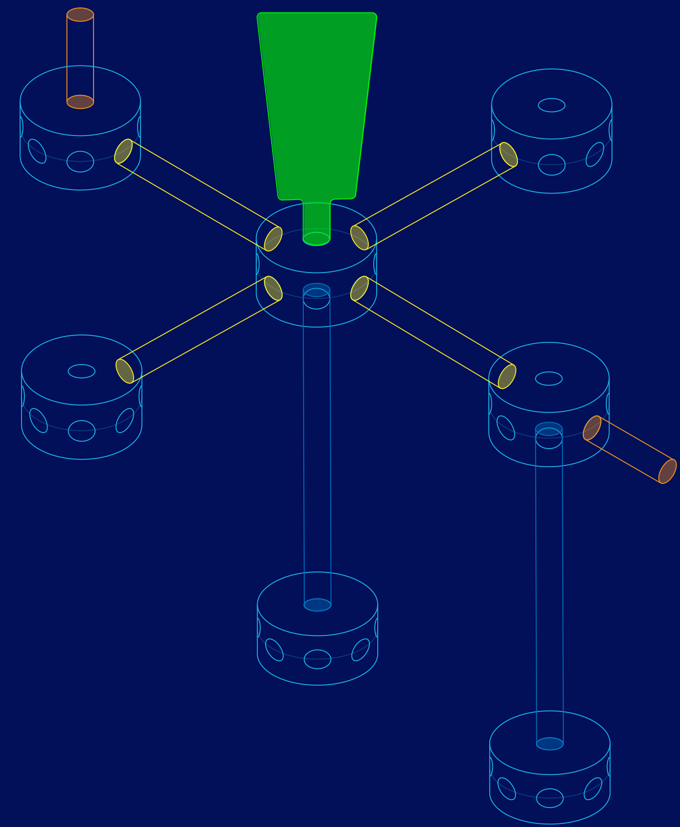


TINKER TOYS FOR AI

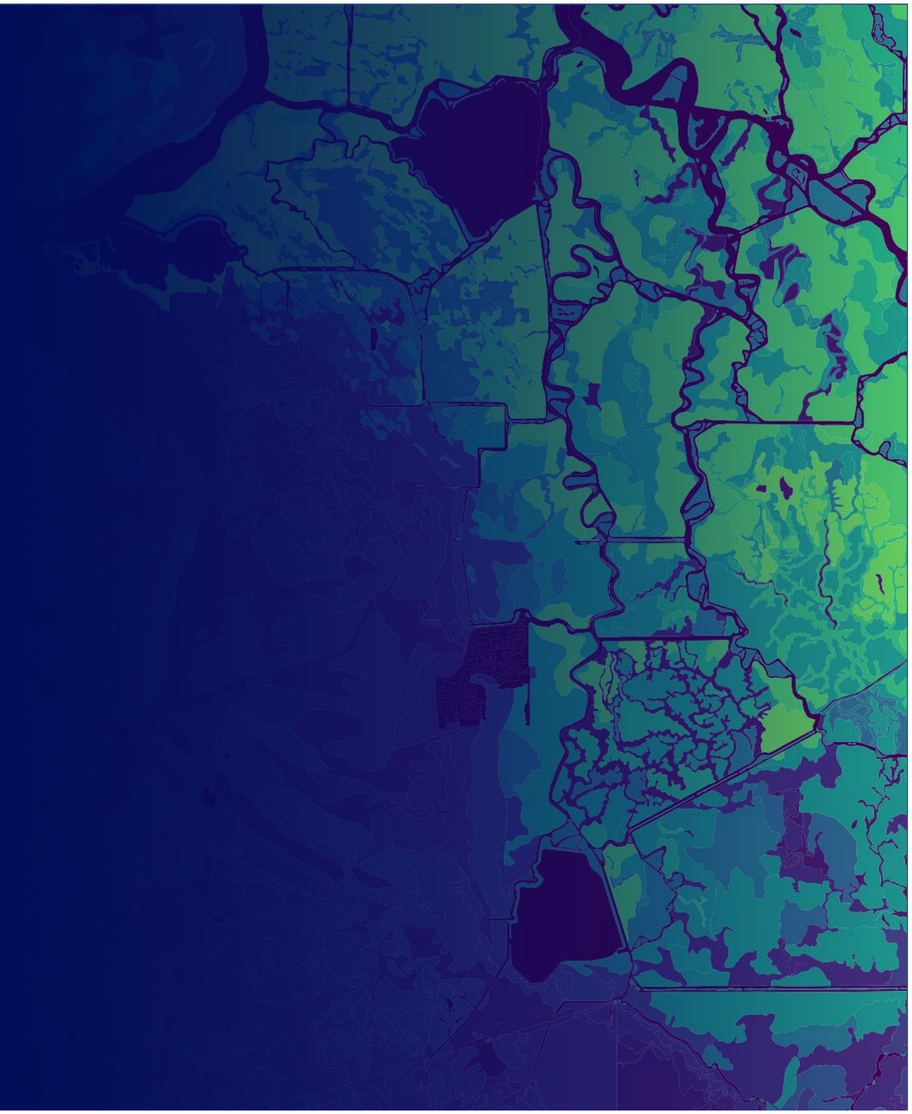
When Spools are networked together,
they pass messages to one another.

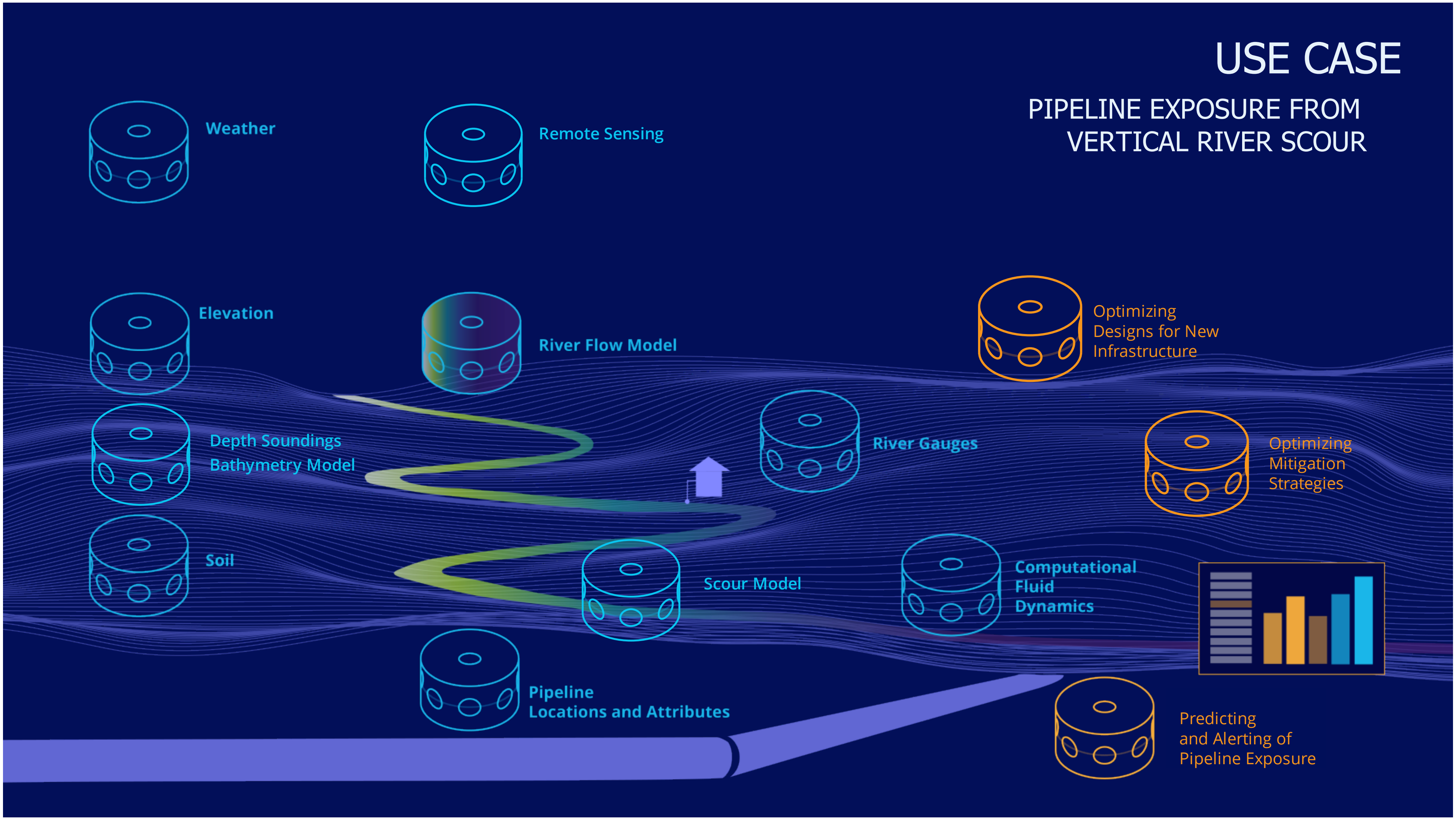
As a result, they respond to inputs from sensor data and human observations to offer continuous and updating insights.

Spools can also be reused, rearranged and interchanged without disrupting a project.



EARTH MOVEMENT WITHIN AND AROUND RIVERS

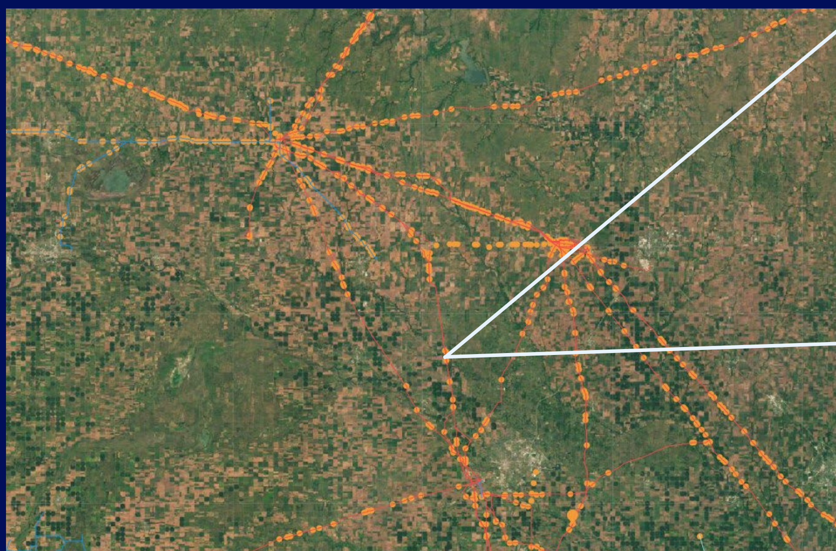



USE CASE
PIPELINE EXPOSURE FROM VERTICAL RIVER SCOUR
Weather
Remote Sensing
Elevation
River Flow Model
Optimizing Designs for New Infrastructure
Depth Soundings Bathymetry Model
River Gauges
Optimizing Mitigation Strategies
Soil
Scour Model
Computational Fluid Dynamics
Pipeline Locations and Attributes
Predicting and Alerting of Pipeline Exposure

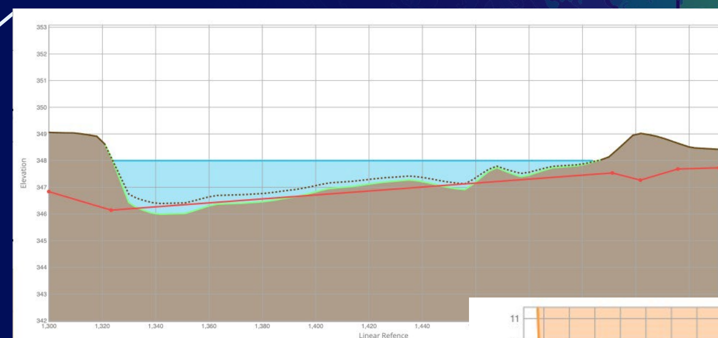
NETWORKS OF MICROSERVICES ENABLE SCALE AND SPECIFICITY

Automated localized awareness across miles and miles of pipeline

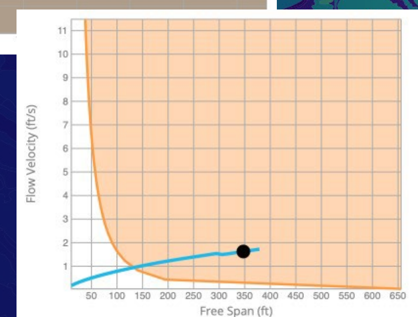
30,000 RIVER CROSSINGS

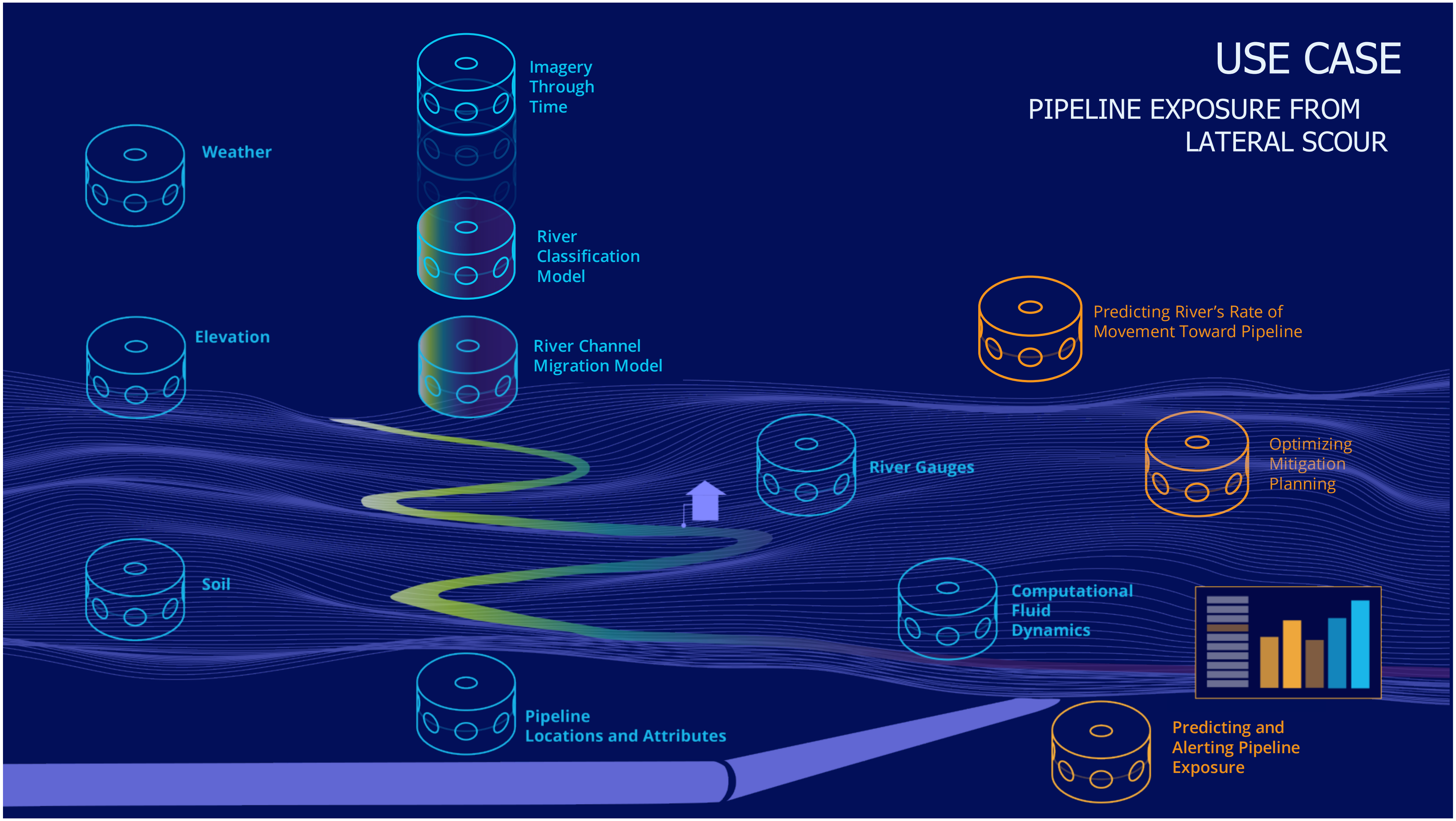


LOCALIZED PREDICTIONS + REALTIME RISK



- River Flow
- Cross-Sectional Area
- Weather
- Soil Type
- Depth of Cover
- Scouring

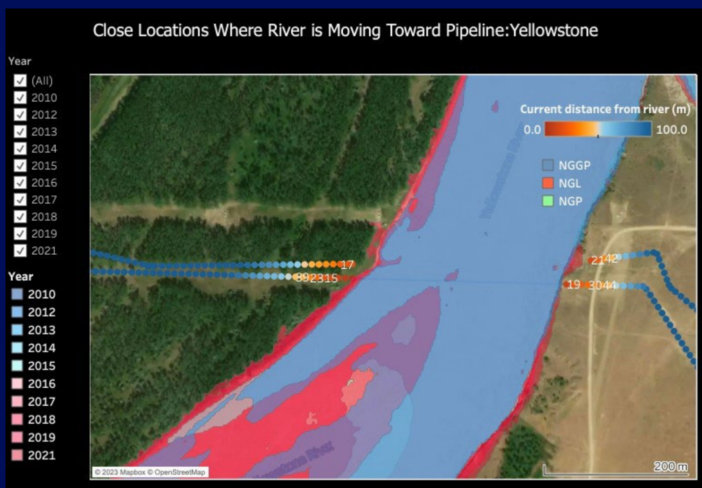




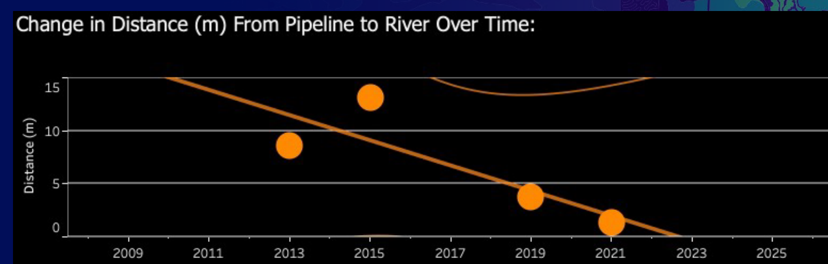
USE CASE
PIPELINE EXPOSURE FROM LATERAL SCOUR
Weather
Imagery Through Time
River Classification Model
Elevation
River Channel Migration Model
Soil
Pipeline Locations and Attributes
River Gauges
Computational Fluid Dynamics
Predicting River's Rate of Movement Toward Pipeline
Optimizing Mitigation Planning
Predicting and Alerting Pipeline Exposure

NETWORKS OF MICROSERVICES ENABLE TIME SERIES MODELING AT SCALE

RIVER CHANNEL MIGRATION THROUGH TIME



LOCALIZED PREDICTIONS OF WHEN RIVER WILL REACH PIPELINE



Questions

End of report