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Navigate Tomorrow Today

An Ocean Digital Twin for Maritime Supply Chain Resilience

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Digital Twin Conference

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About GSTS

- Global Maritime Intelligence company delivering solutions to enhance decision making in the maritime industry
- Proprietary AI-Powered SaaS Platform – OCIANA™ – designed to save lives, energy and the environment using innovative data collection and analysis techniques
- Validated intelligence for Commercial, Defence and Civil user groups based on vast amounts of advanced, agnostic, historical and real-time data (AIS, Optical, SAR, RF, Protected Species, Oceanographic and Environmental)

- Supported by Government of Canada Projects:
  - Canadian Space Agency
  - Innovation, Science and Economic Development Canada (ISED)
  - Transport Canada
  - Sustainable Development Technology Canada (SDTC)

The Challenge

An Increasingly Complex and Dynamic Maritime Sector

New Success Metrics

- Emissions
- Efficiency
- Economics

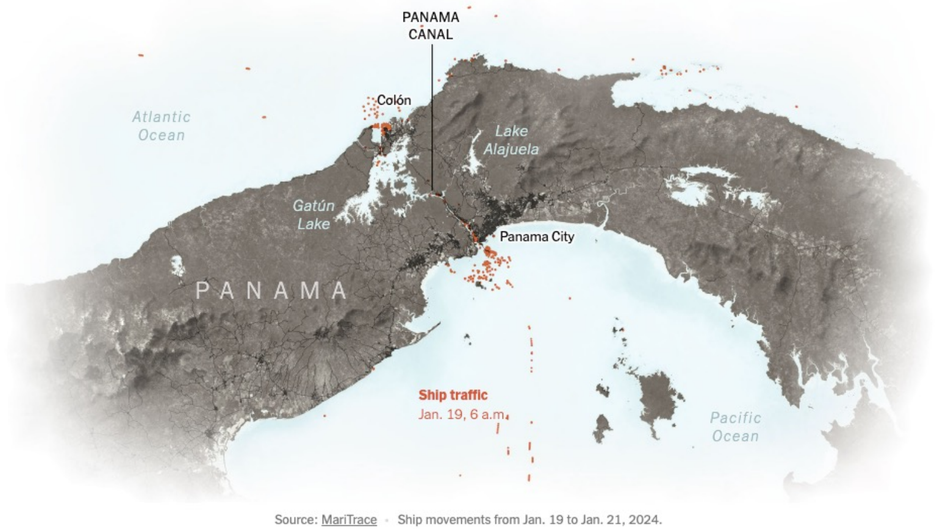
Increasing Threats to Global Shipping

Geopolitical Risk

Climate Change

The New York Times

Global Economy | U.S. Gas Exports | Attacks on Ships in Red Sea | A Global Soft Landing | Panama Canal Drought



Source: MariTrace · Ship movements from Jan. 19 to Jan. 21, 2024.

Panama Canal Drought Slows Cargo Traffic

By Mira Rojanasakul Jan. 26, 2024

The lake that allows the Panama Canal to function recorded the

Daily Mail + Follow

Building costs rise as Houthi attacks in the Red Sea push up s
prices amid fears disruption could delay stock and increase co
retailers and supermarkets

Story by Ed Holt • 1d

MARKETS TODAY ···

TSX ▲ +0.05% DJI ▲ +0.41% INX ▲ +0.82%

- **Firms have complained of higher costs for imported goods due to the attacks**

Houthi attacks in the Red Sea have led building costs to increase for the first time since last autumn

Houthis claim fresh attac
and US ships in Red Sea

**Two vessels not badly damaged but incident cast
success of UK-US strikes on Yemen missile sites**

Middle East crisis - live updates

Patrick Wintour
Diplomatic editor

Tue 6 Feb 2024 14.52 GMT

Supply Chain Resilience in Maritime Sector

Challenges in Supply Chain

Maritime supply chains face various challenges that require resilience and adaptability for effective operations.

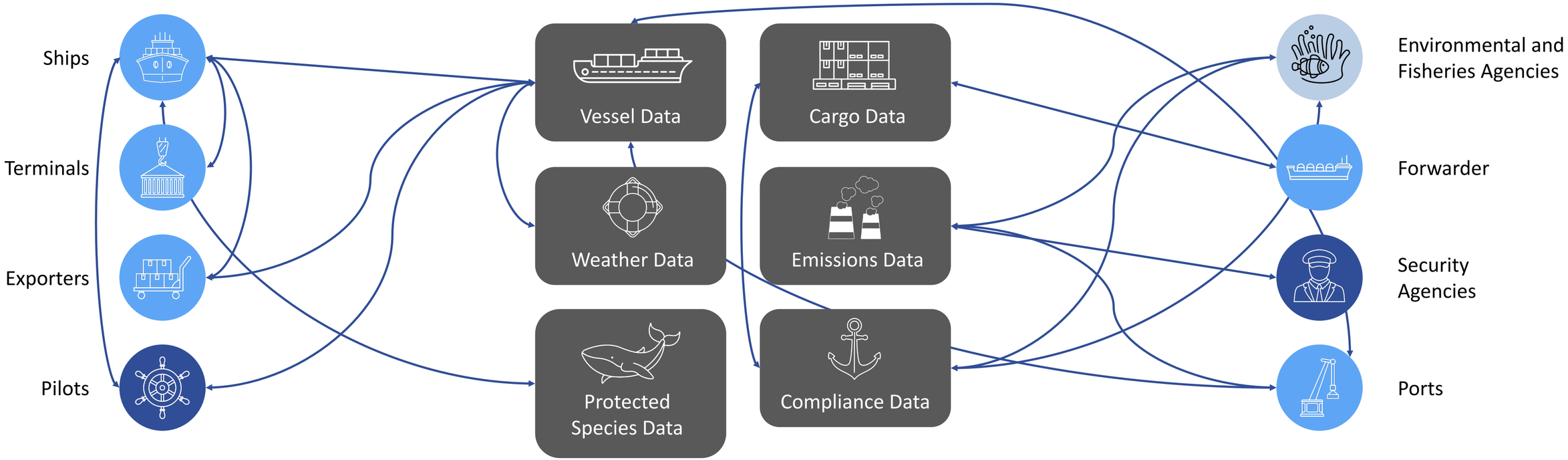
Technological Innovations

Digitalization initiatives across the maritime sector are bringing data and technology to reduce emissions and optimize supply chain

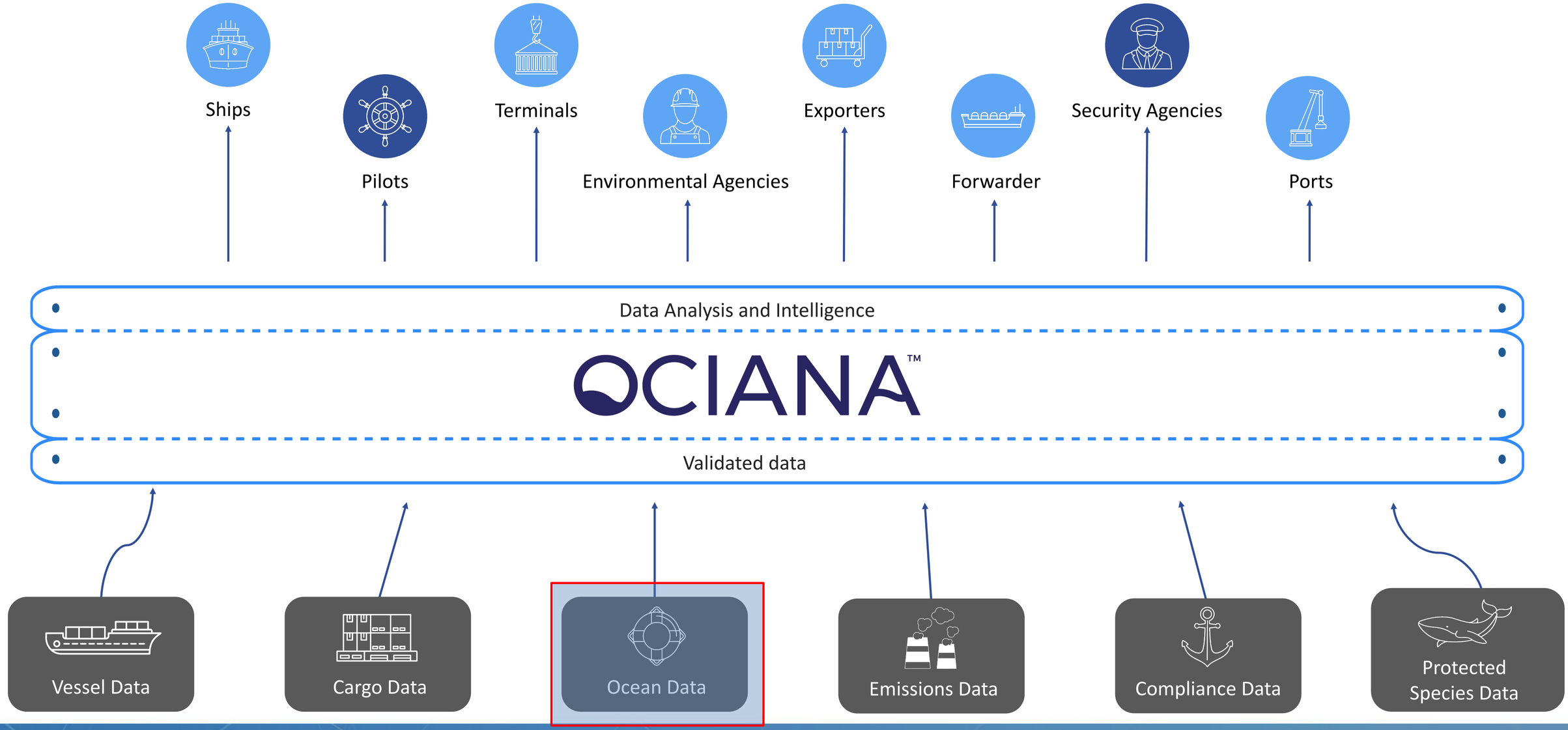
Risk Mitigation Strategies

Implementing robust risk mitigation strategies is crucial for ensuring smooth functioning of maritime supply chains.

Current Information Landscape



The Future


Ships
Pilots
Terminals
Environmental Agencies
Exporters
Forwarder
Security Agencies
Ports
Data Analysis and Intelligence
OCIANA™
Validated data
Vessel Data
Cargo Data
Ocean Data
Emissions Data
Compliance Data
Protected Species Data

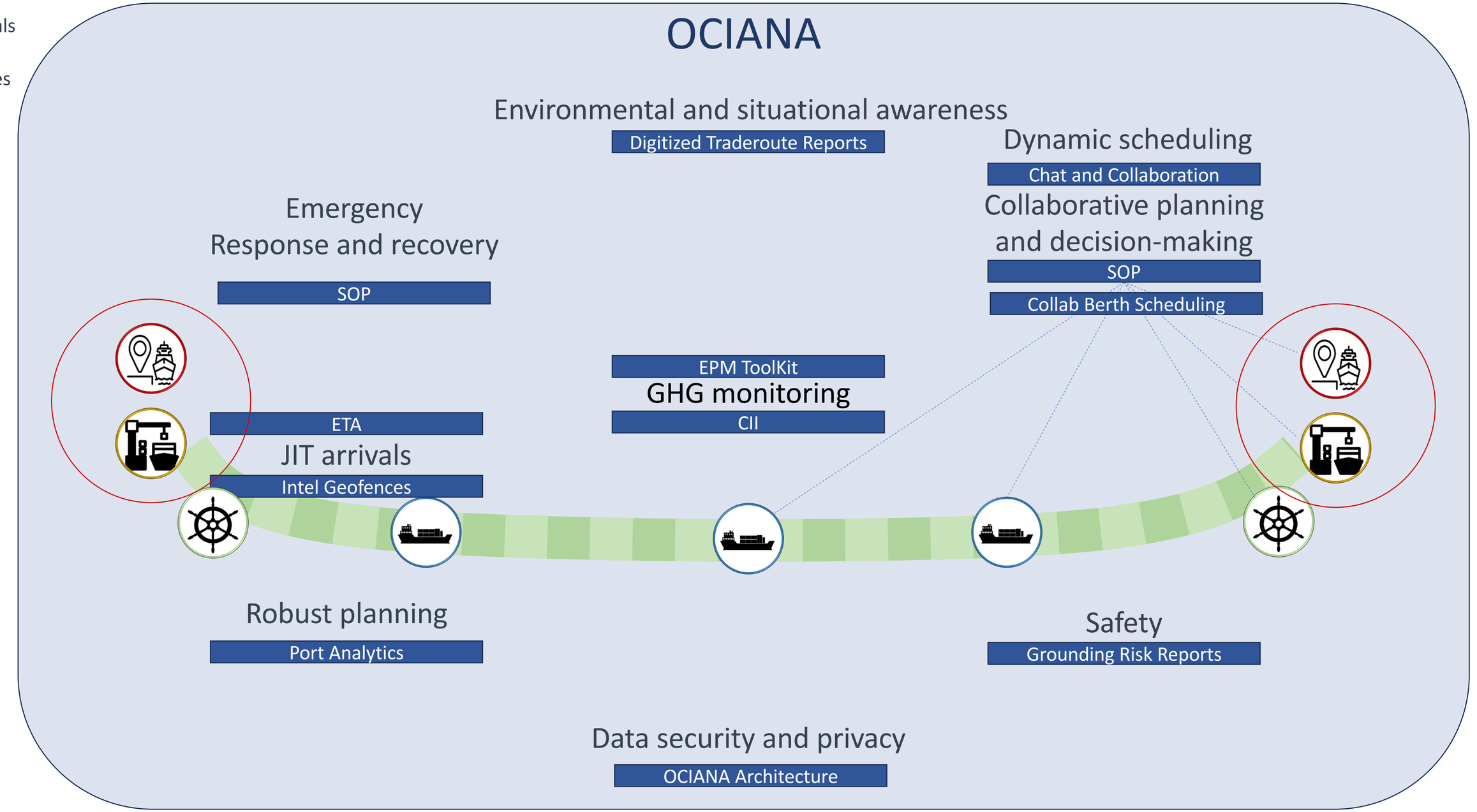
Digital Ocean Corridor Core Capabilities

Ports

Terminals

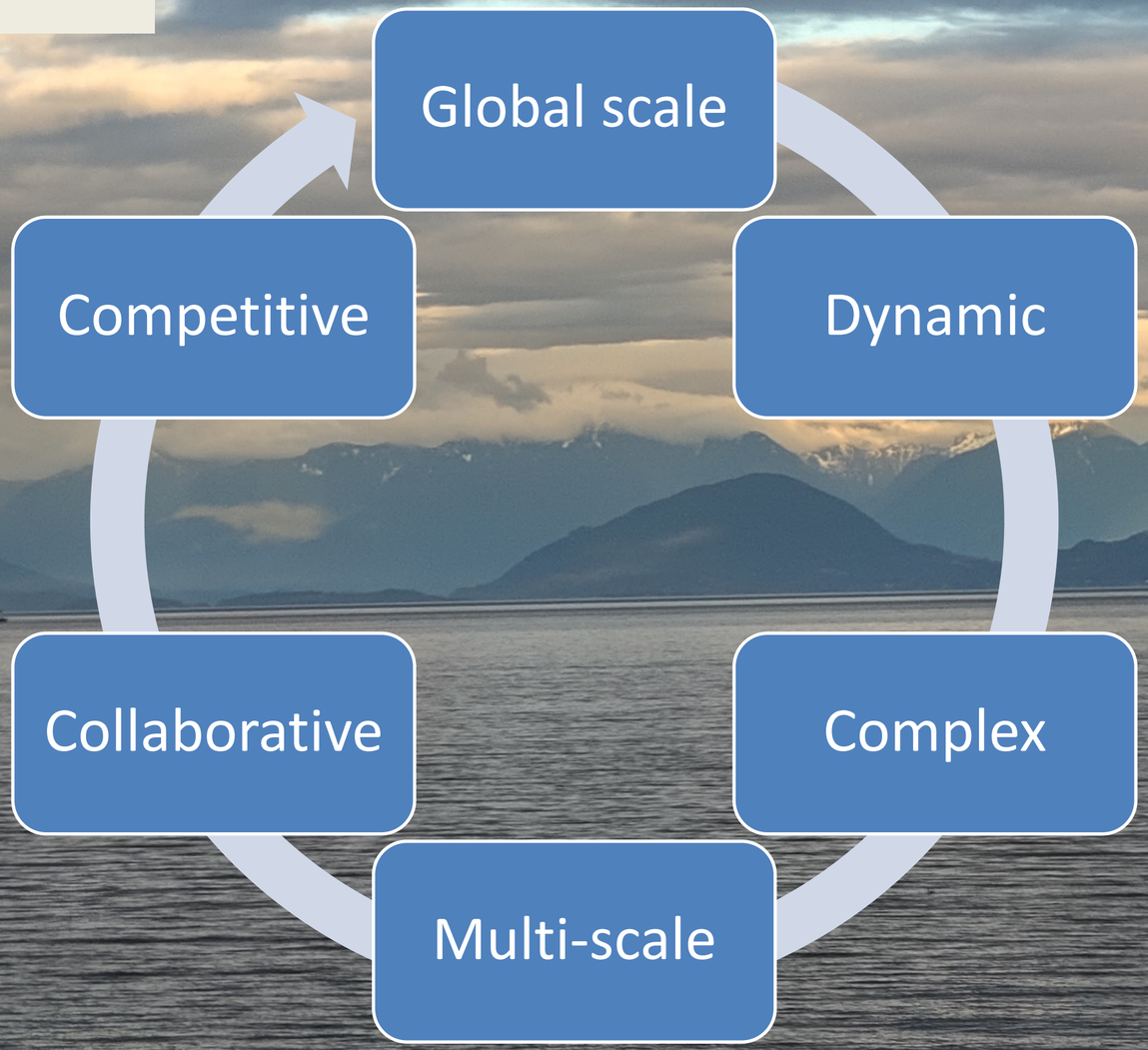
Pilotages

Vessels



MARITIME ECOSYSTEM

Maritime Supply Chain Characteristics



Digital Twins in the Maritime Sector

Predictive Maintenance

Digital twin representations enable predictive maintenance, reducing downtime and optimizing asset performance.

Environmental Impact Assessment

Digital twins support evaluations of the environmental impact of maritime activities, aiding in sustainability efforts.

Port Optimization

Through simulation modeling and analysis, digital twins help optimize the performance of port operations wrt stressors and shocks

Earth System Digital Twins

- Earth system processes increasingly monitored via regular earth observation technologies
- Geospatial Data Integration critical to realizing benefits of integrated ML/AI across specific domains
- Representation and integration across scales of measurement remain challenging (climate model → localized turbidity)

"Digital replica of an Earth system component, structure, process, or phenomenon obtained by merging digital modelling (notably, learning based models) and real-world observational continuity, that is, natural and societal sensing data streams. A Digital Twin of the Earth continuously learns and updates itself and must be seen as a living digital simulation model that modifies and changes itself as its physical counterpart changes"

Nativi et al. 2021

Design Goals for Ocean Digital Twin to Support Maritime Supply Chain Resilience

Develop a common data representation and data model that can integrate data from all relevant sources and provide a common framework for modelling and analysis

Employ open standards for data documentation and processing to enhance interoperability and transparency of the application

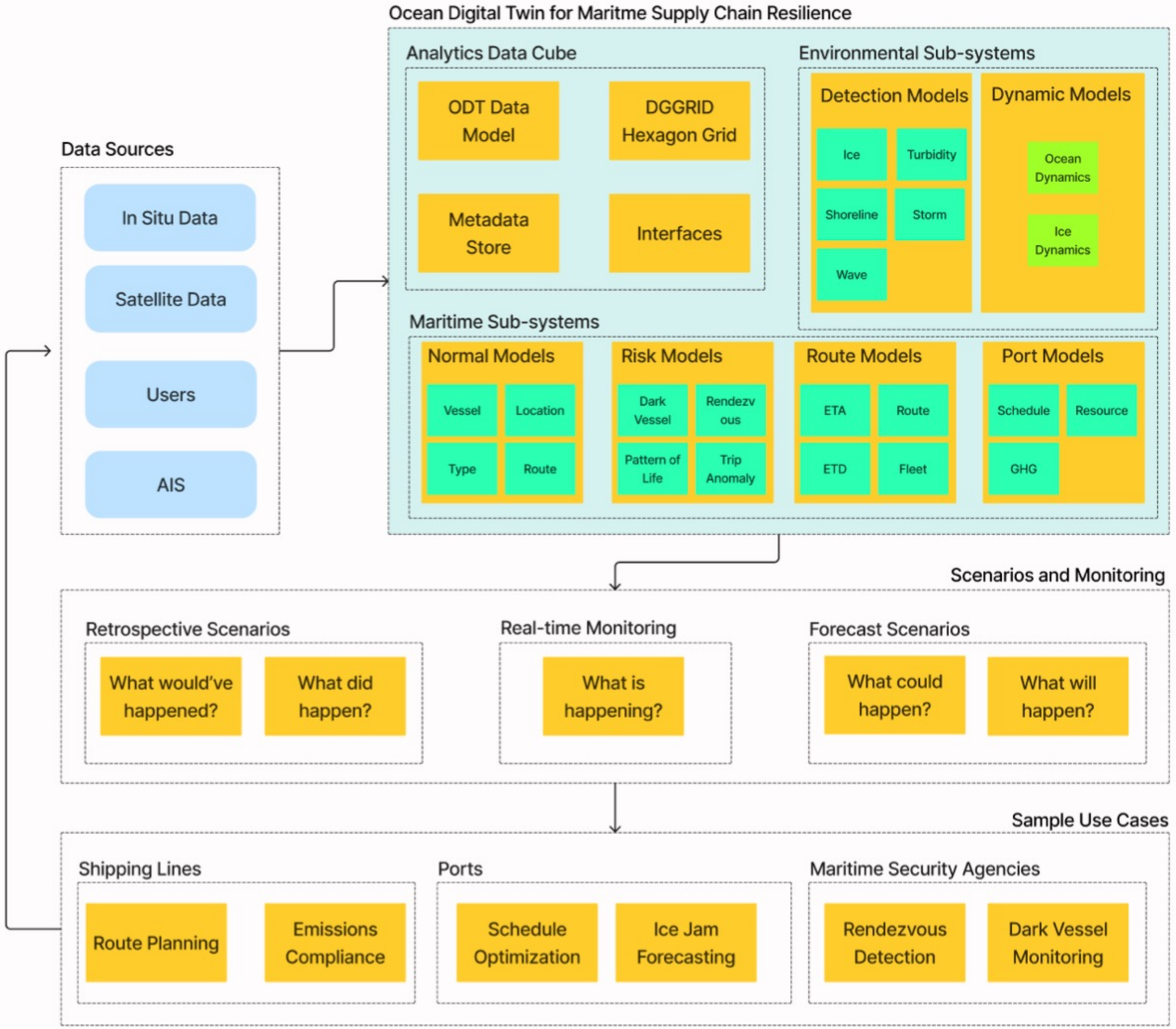
Develop state-of-the-art EO models for measuring identified ocean variables, employing both statistical and machine-learning approaches

Implement numerical models to represent key physical processes (e.g., parameterized by EO data)

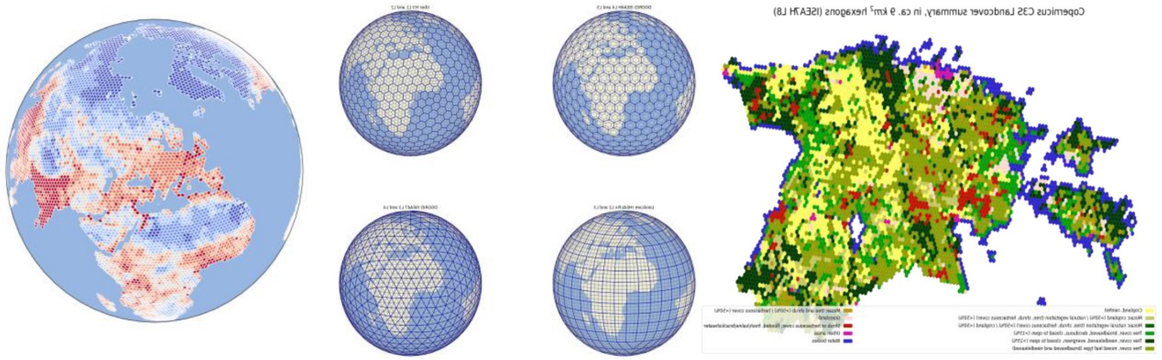
Enable real-time situational awareness of key ocean variables for shipping and maritime traffic

Enable retrospective analysis of changes in ocean environment variables, and **prospective scenario modelling** of changes in environment and maritime variables

System Architecture for Ocean Digital Twin

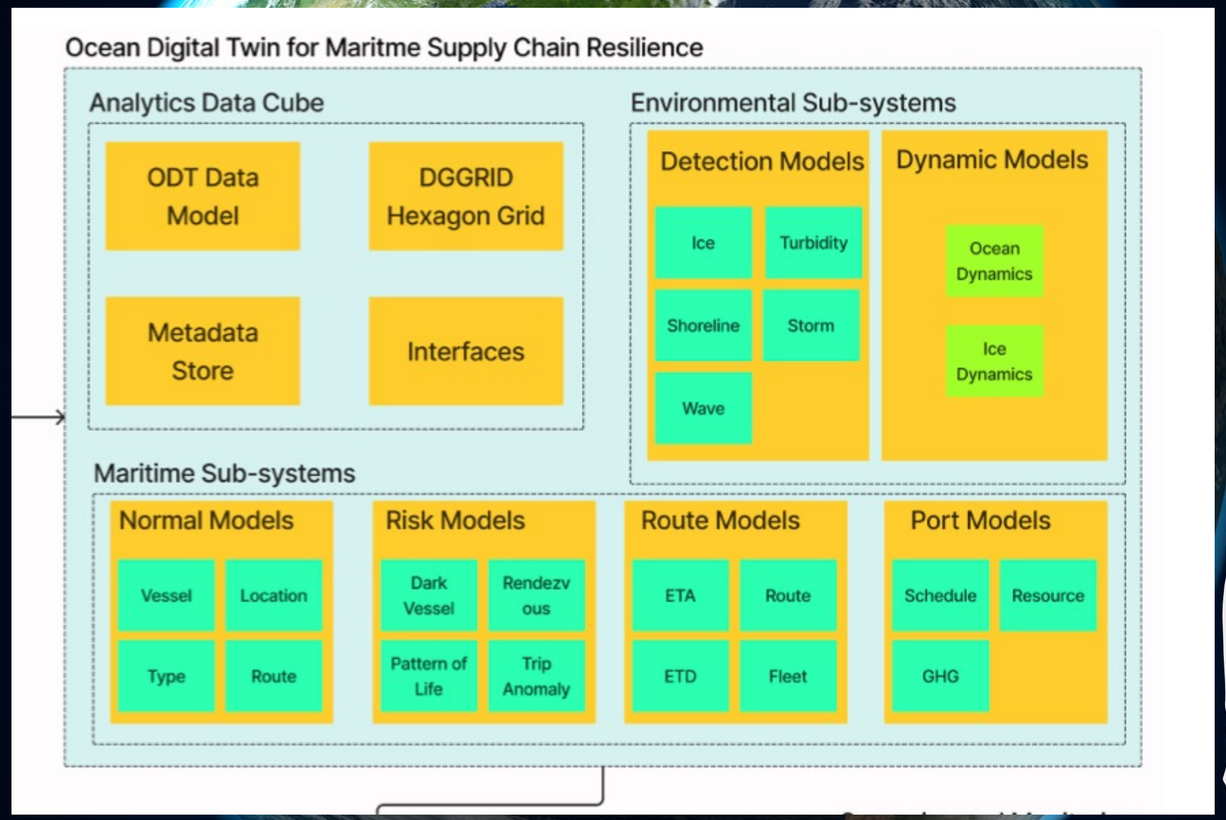


Analytics Data Cube



- Discrete Global Grid System (DGGS) as a technology facilitating geospatial data integration.
- Multi-resolution partitioning of Earth into discrete equal-area tiles.
- OGC standards
- A comprehensive spatial-temporal representation (cell time)
- IDEAS data model for ODT (Integrated Discrete Environmental Analytics System)
  - Spatial, temporal, attribute, metadata
- System interfaces (APIs, LLMs, Dashboards)

Domain System Components



Detection Models

Unlocking possibilities through synergies between EO and ML technologies.

Enhanced Insights with ML Integration (satellite, aerial, and ground- based sensors)

Computational Power and Resolution Diversity = promising results for the automated identification of patterns or anomalies

Ocean Sensing Advancements (sea ice, sea surface temperature, surface height anomalies, and wind speed)

Dynamic Models

Capable of simulating and predicting the ocean's behavior

Understanding Critical Ocean Variables for the shipping industry

Safe Navigation Insights - Ocean state forecasts

Regional Ocean Dynamic Models Enhance Predictions

Maritime Subsystems

Specific Models for maritime Trade and Security

Model Categorization and Commonalities

Defining Normality with Statistical Approaches (from thresholds to NN)

Diverse Evaluation Temporal Resolutions and common Reference System for Digital Twin

Scenarios and Monitoring

Retrospective

What would emissions at Port be if used optimized schedule?

What would have happened to average anchorage use last year if three had been removed due to environmental concerns?

What was total CO2 emissions for Vancouver to Singapore route last year?

Real-time Monitoring

What vessels are currenty inbound to Canadian ports?

Are there any current whale detections in shipping lanes?

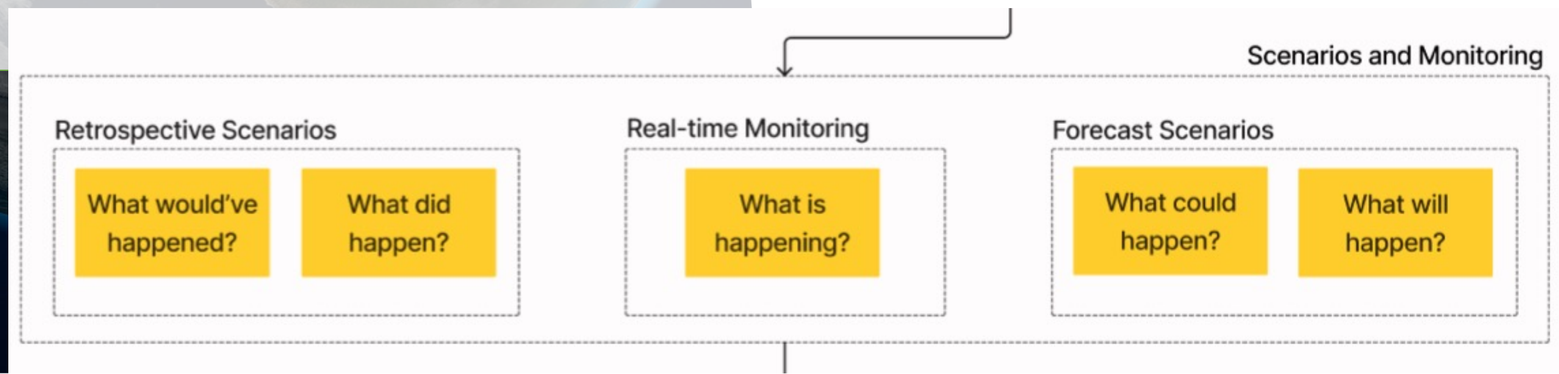
What vessels are currently operating with AIS off?

Forecast Scenarios

What is the likelihood of ice jams on the St. Lawrence River given the long range forecast?

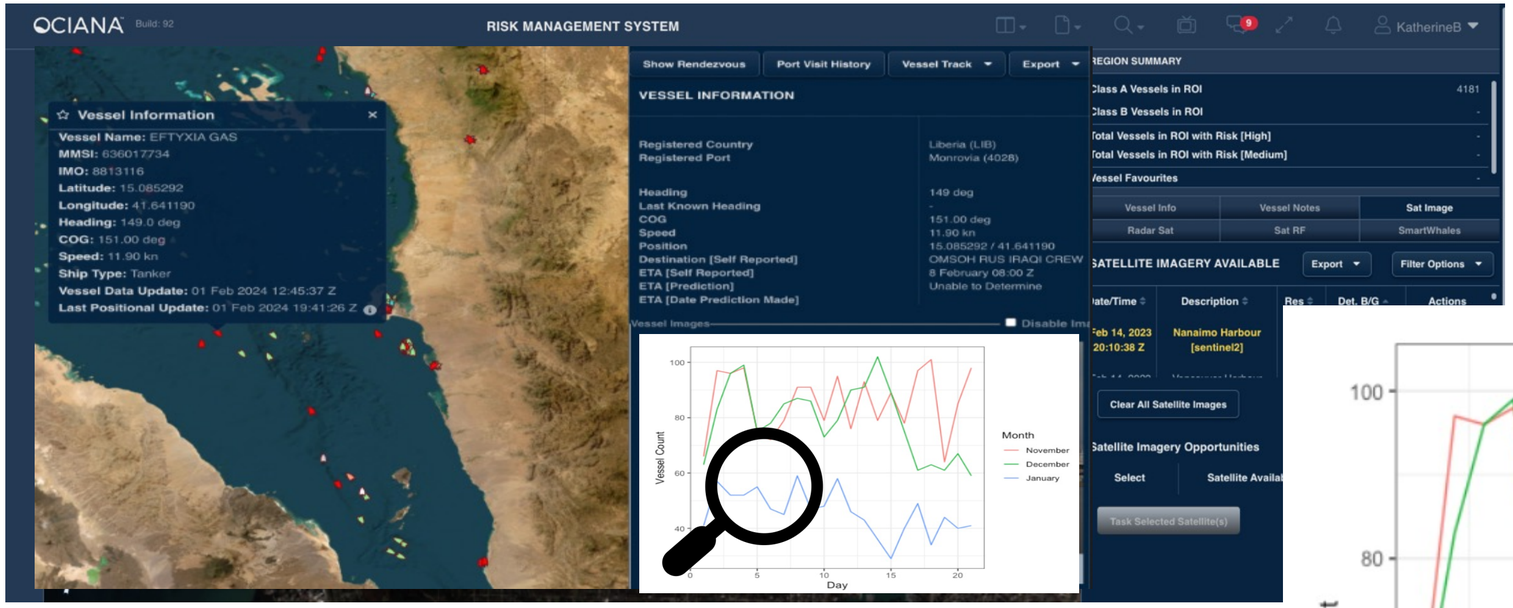
What would the impact of 20% of fleet moving to Green Ammonia be on annual emissions?

When will vessel X depart from berth?

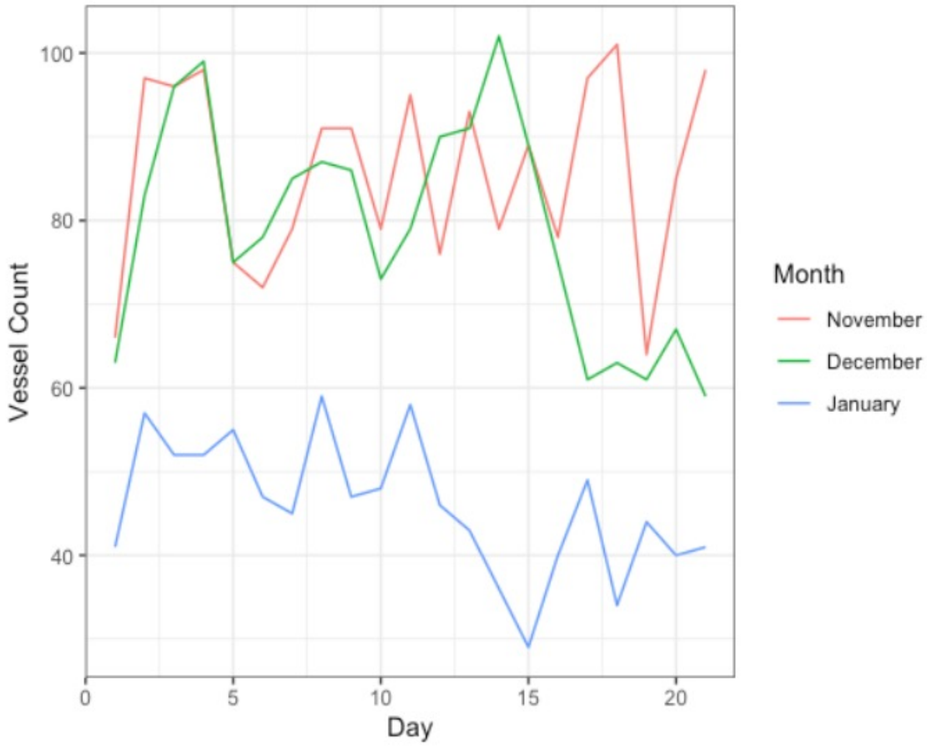


Sample Usecase: Red Sea Traffic Scenario Modelling

Geopolitical tensions – Middle East

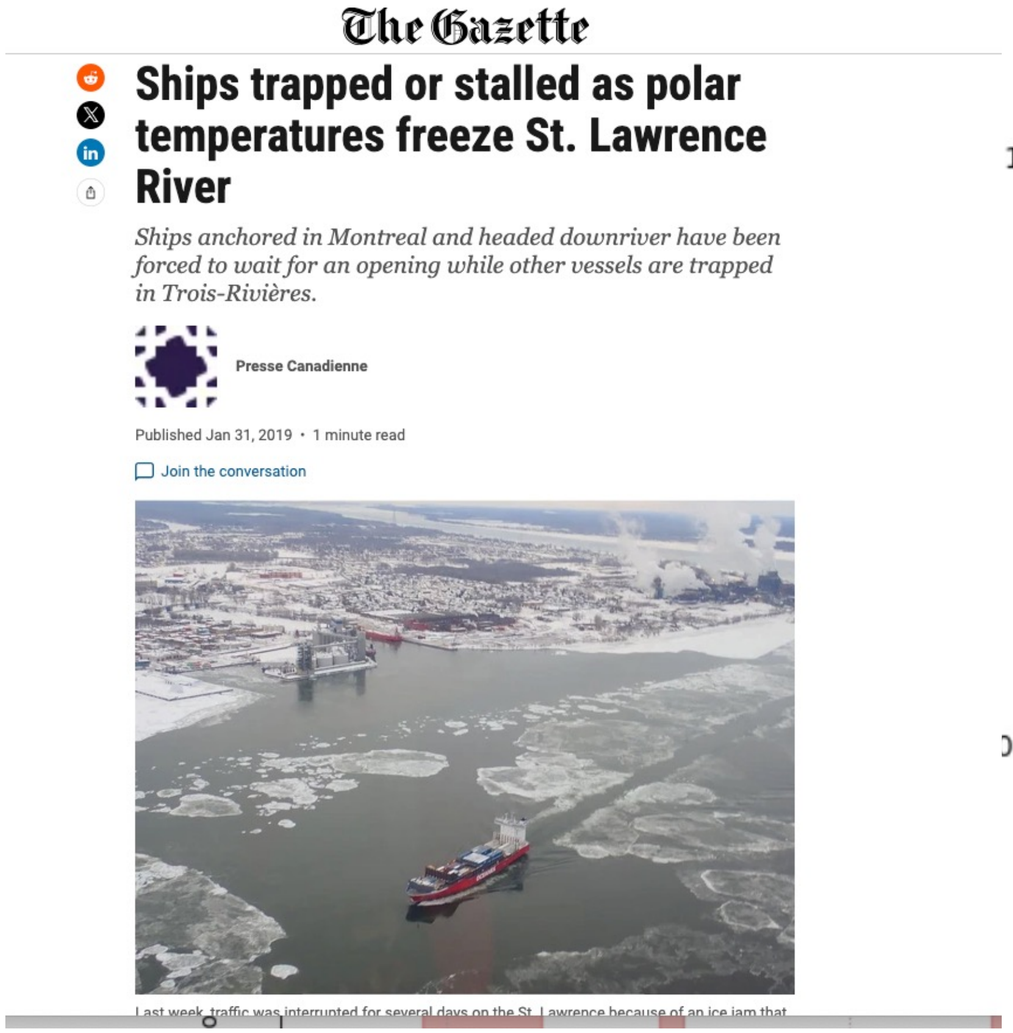


Modeling Down-chain impacts



- Unique vessels transiting the entrance to the Red Sea through Bab al-Mandab Strait
- Vessel traffic reduced ~ 50%
- Potential Scenarios
  - Impacts on ETA → Model + barriers in the cells
  - Impacts of 20% reroute, 40% reroute, 80% reroute etc.

Sample Usecase: Ice Jam Risk Forecast Model



The Gazette

Ships trapped or stalled as polar temperatures freeze St. Lawrence River

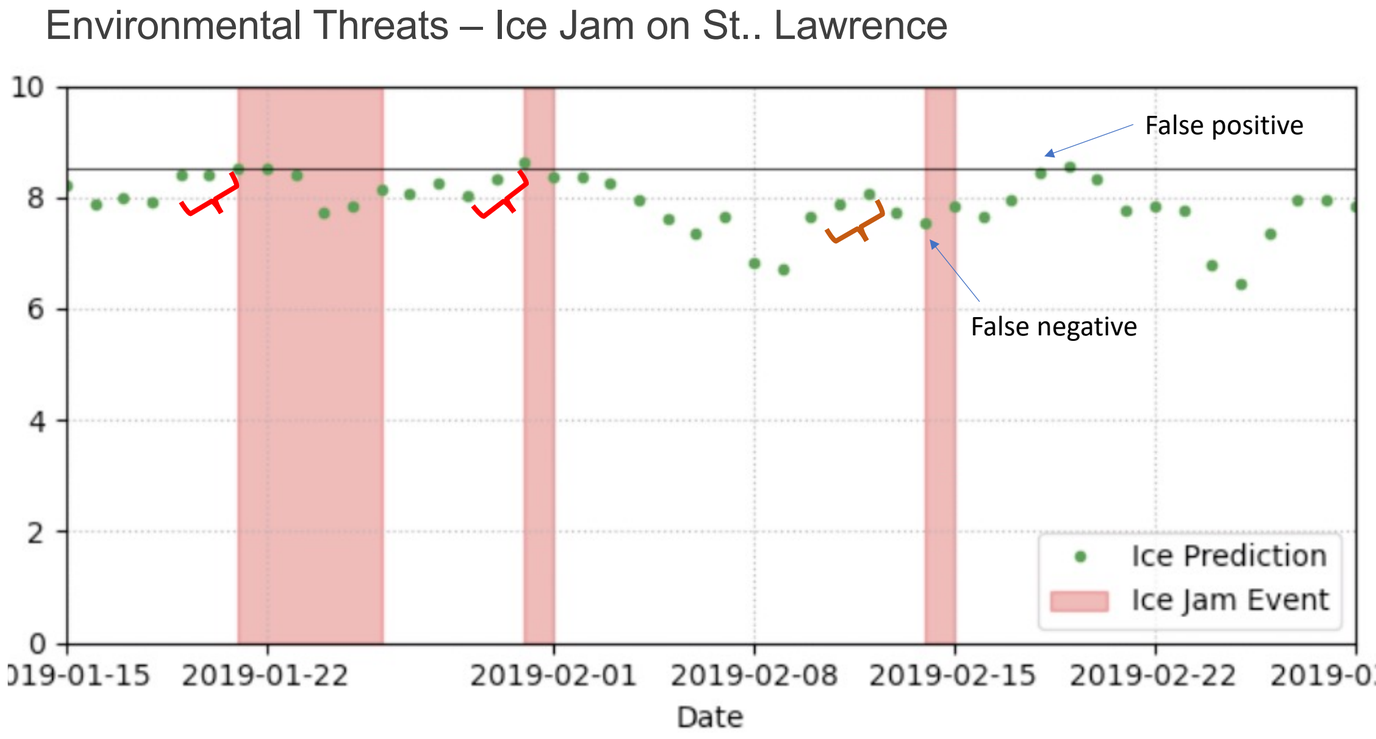
Ships anchored in Montreal and headed downriver have been forced to wait for an opening while other vessels are trapped in Trois-Rivières.

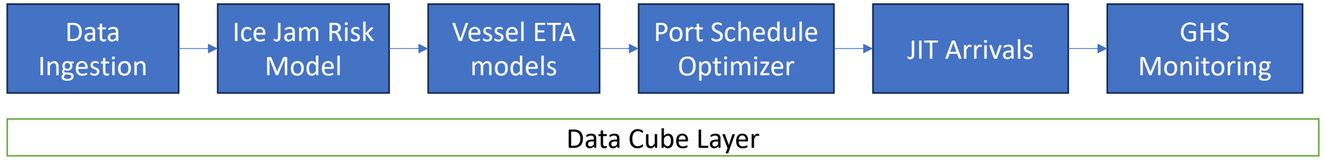
Presse Canadienne

Published Jan 31, 2019 • 1 minute read

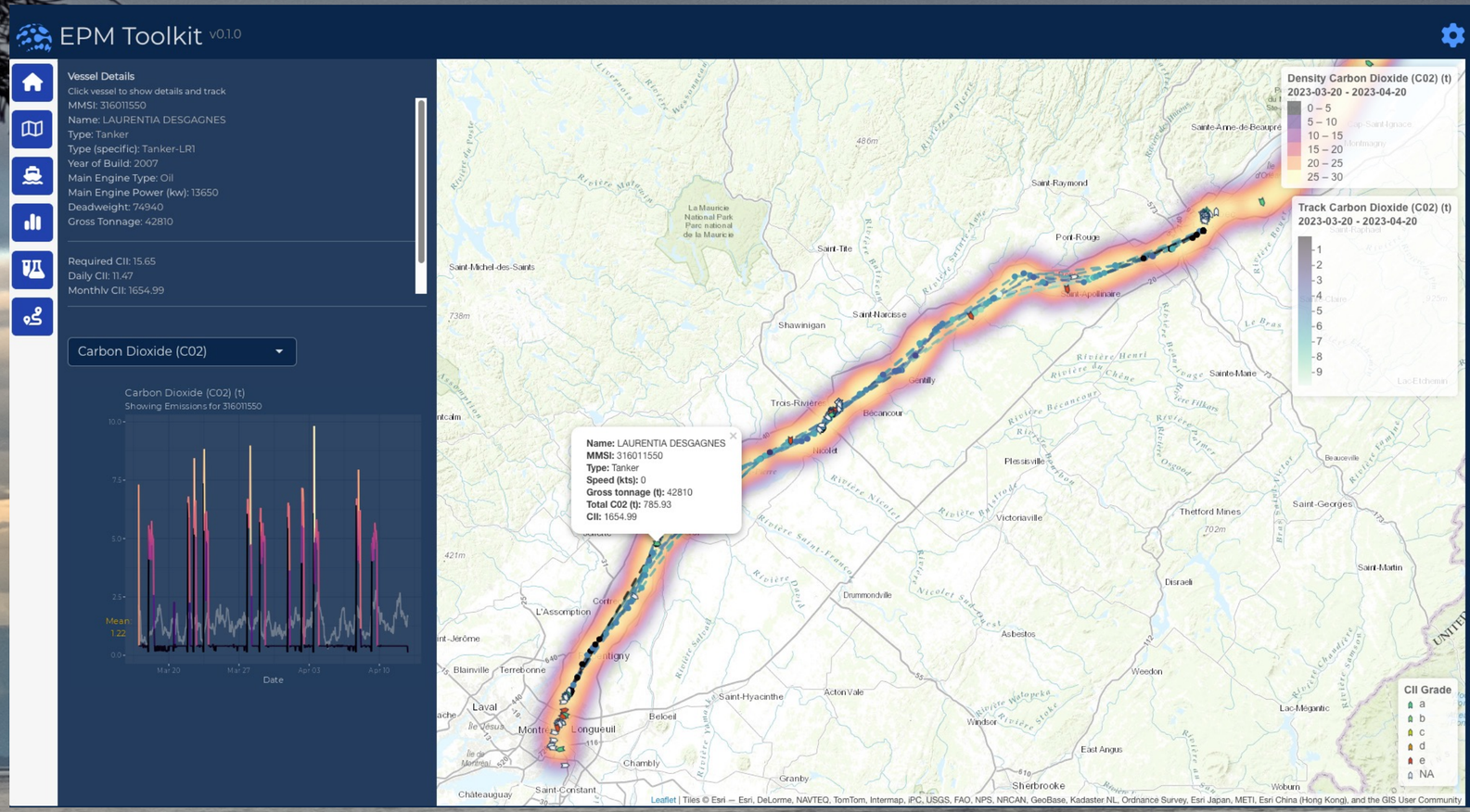
Join the conversation

Last week, traffic was interrupted for several days on the St. Lawrence because of an ice jam that





Green Corridors and Ocean Environment



Sustainable Shipping Practices

Digital twin applications contribute to the development of green corridors, promoting sustainable and environmentally friendly shipping practices.

Ecosystem Monitoring

Digital twins aid in monitoring and assessing the impact of maritime activities on the ocean environment, supporting conservation efforts.

Regulatory Initiatives

Supporting regulatory initiatives, digital twins help in implementing measures for minimizing environmental impact and ensuring ocean health (IMO mandatory reporting metrics EEXI and CII).

Integration of Supply Chain Processes

Interconnected Operations

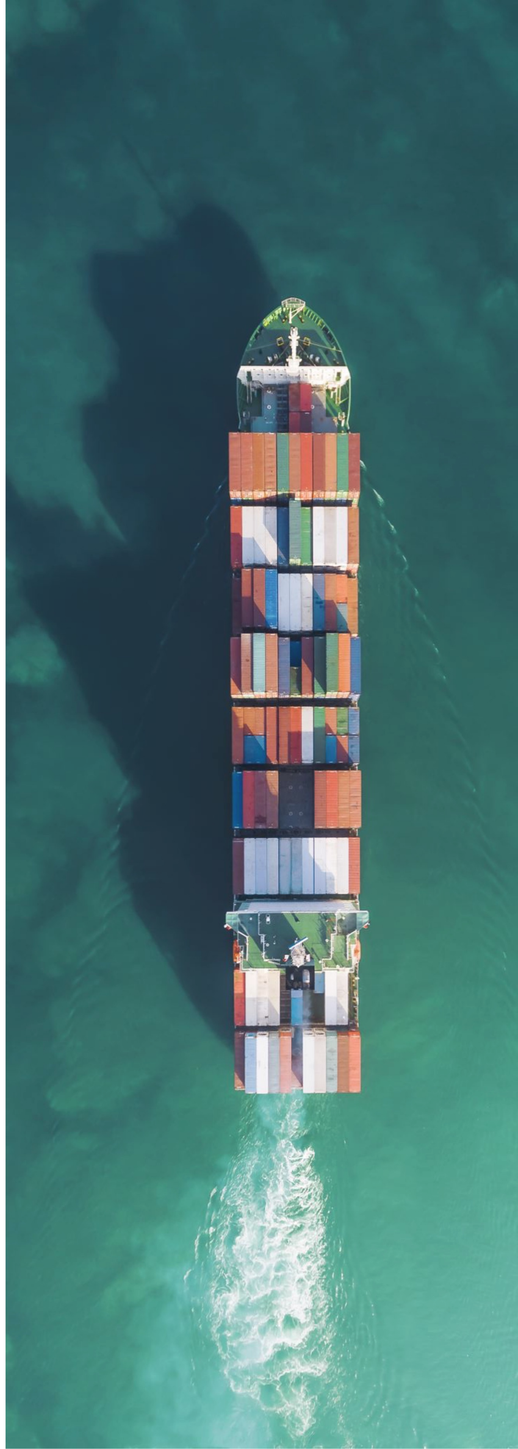
Seamless integration of supply chain processes across multiple stakeholders leads to enhanced operational efficiency and transparency → **Landside integrations**

Collaborative Decision-making

Integration facilitates collaborative decision-making, enabling faster responses to market dynamics and operational challenges → **System level optimizations**

Data Sharing and Visibility

Improved data sharing and visibility in integrated supply chain processes enhance coordination and responsiveness.



Challenges and Opportunities

Technical Hurdles

Data ingestion from different geospatial formats remains challenging. Benefits of integrated representation only seen after data onboarded into data cube. Different output represnetations needed for computation vs presentation.

Adoption Hurdles

Challenges in technology adoption, data quality, and change management pose hurdles in digital twin implementation – working with different levels of digitalization across maritime sector. Focus on applications that integrate data across jurisdictions and scales.

Regulatory Compliance

Navigating regulatory frameworks and ensuring compliance is essential for providing formal requirements to realize interoperable digital twins in the maritime industry. Key areas of focus include cargo, maritime single window, and emissions.

Technical Innovation

Sector-based ontology development backed by emerging IMO standards around e-navigation, emissions and other digital twin initiatives in Canada and internationally.

AI-based integration of models and data.

Acknowledgements

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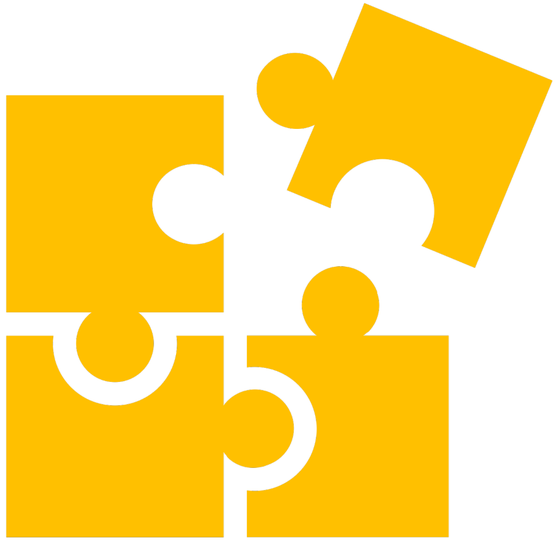
Harry Singh (former GSTS Senior Data Scientist)



GREAT LAKES ST. LAWRENCE SEAWAY SYSTEM

Port of New York & New Jersey

NRC·CNRC Canada

CENTRE POUR LE TRANSPORT MARITIME RESPONSABLE
ClearSeas
CENTRE FOR RESPONSIBLE MARINE SHIPPING

PORT MONTRÉAL

Canada Border Services Agency

CSA ASC

CANADIAN SPACE AGENCY
AGENCE SPATIALE CANADIENNE

PORT TROIS-RIVIÈRES

CSL

SALUTI PRIMUM AUXILIO SEMPER

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