

To the Edge with the Mayflower Autonomous Ship

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MARINE AI



Mayflower Autonomous Ship

- In 1620, the Mayflower sailed from Plymouth Sound to the New World.
- Idea conceived during a meeting to discuss how the city of Plymouth should commemorate the 400th anniversary in 2020.
- Since evolved as centerpiece of Plymouth's and wider UK's Mayflower 400 Commemorations



Mayflower Autonomous Ship



The power of AI/ML/DL is evidenced in how a total solution leverages data to not only steer the vessel but make decisions about navigation factors, maintenance and safety.

And in understanding the transferability of the Hybrid solution to other use cases.

IBM Visual Insights

IBM Edge

Red Hat

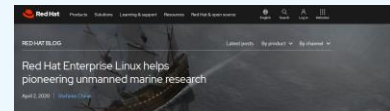
The Weather Company

IBM Power System AC922

IBM Watson Studio

IBM Operational Decision Manager

IBM CPLEX Optimizer



Ship

Sensing



Computer Vision
DL: Models on Jetson Edge Devices



Data Fusion
ML: Hazard Identification & Tracking



Voice Communications
NLP & Conversational AI

Computing



Mission Manager
Analytics and Cognitive Capabilities



Dynamic Path Planning
ODM: COLREGs compliance
CPO: Multi-ship interactions
“Common Sense” AI: Ship Intent



Safety Manager
Power and RHEL

Acting



Vehicle Control
ML: Vehicle Dynamics
ML: Power Management

Communications



Edge Agent



Kafka Brokers

Payloads

DL/ML: Acoustics

Neural Net Cost Maps

ML: Wave Energy
Estimation

ML: Side-by-side
comparisons with ML
Path Planning and
COLREGs modules

Shore

Deployment



CV Model Training
Maximo Visual Insights



Route Optimization
The Weather Company API
CPlex Optimizer



Model Deployment & Mgmt
Edge Application Manager

Monitoring



WebPortal
Watson Assistant Chatbot

Analysis



Sea Trial and Post Mission
Watson Studio

Agenda

- **Mission**
- Edge
- Hybrid AI
- Optimization
- Security
- The Plan Ahead





Design

- Trimaran configuration
 - Cruising Speed: 5 knots at 1.2kW
- Electric propulsion
 - Solar charging capacity
 - Backup generator

Dimensions

LOA = 15m

Draft = 0.5m

BOA = 6m

Displacement = 5000kg

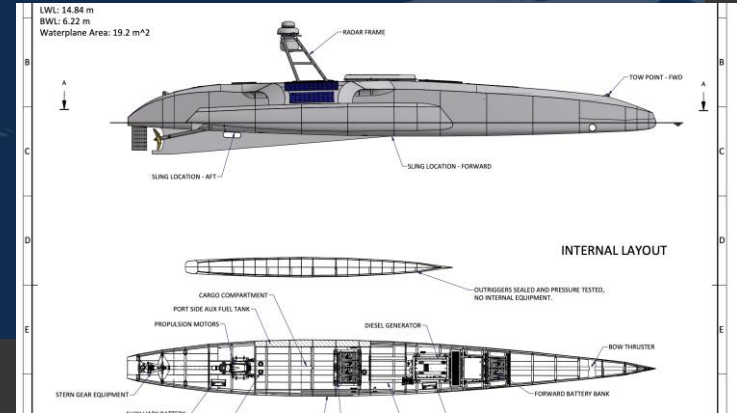
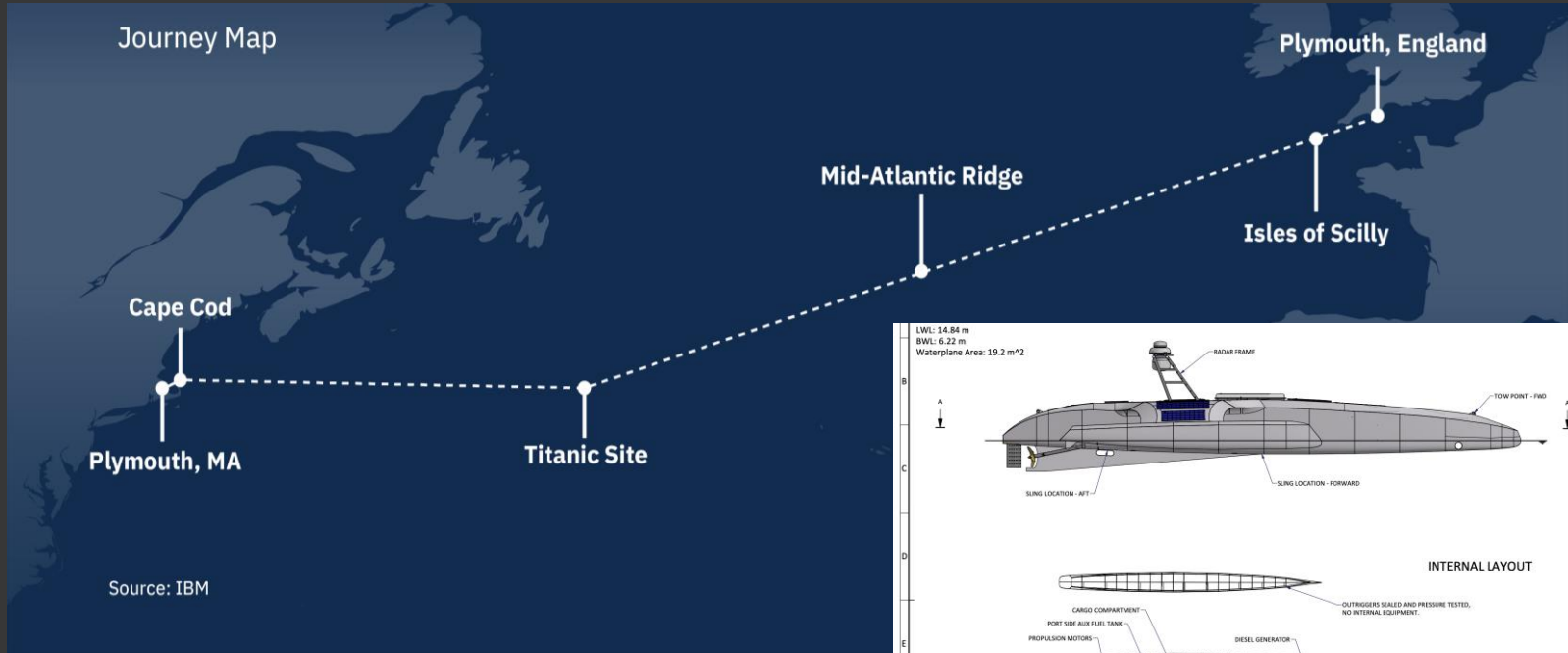
Capabilities

State-of-the-art:

- Autonomous control systems & navigation
- Sonar and collision avoidance
- Solar panel and power technology
- Communications
- Weather prediction and avoidance



Mission 1: North Atlantic / Science



Mission 2: Proof of Technology



Who are the Makers ?



20+ years
designing
submarines with
autonomous
functions

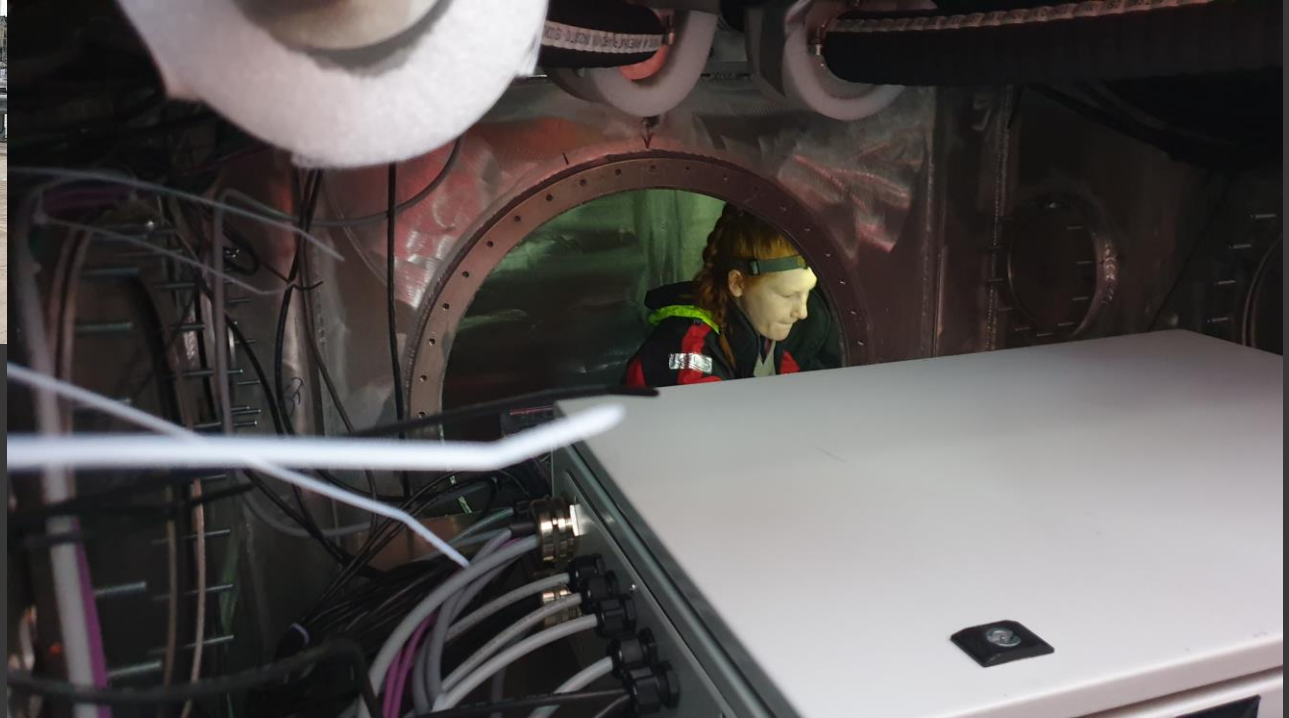
Maritime tradition



Who are the Makers ?



Who are the Makers ?



Challenges?

Yes.

Many.

Regulatory

Who will flag and class the MAS?

- Lloyds Registry
- DNV GL

Are the International Maritime Organisation and UK's Maritime & Coastguard Agency 'ready' for her?

- IMO's Maritime Safety Committee (MSC) debating
- UK's MAS WRG defining the UK's position

Resistance

In Maritime Industry

- Bureaucracy
- Decision Makers are 'greybeards' in a very traditional industry
- Who Owns the Risk?
- Why Take a Risk?
- Perceived threat to traditional employment

Technical

Timing and the desire to remain on the crest of the autonomy wave

Developing technology to allow autonomous control of:

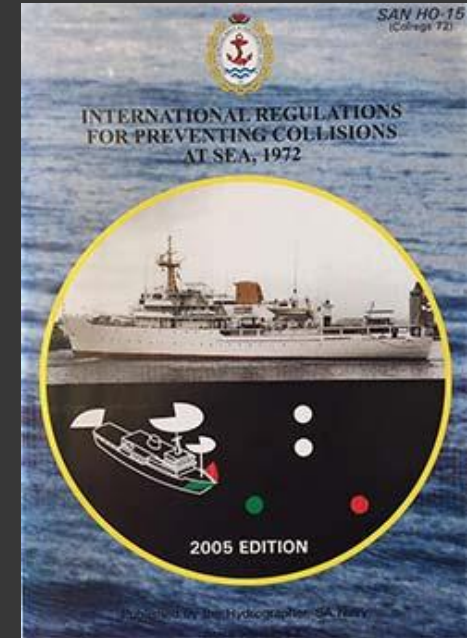
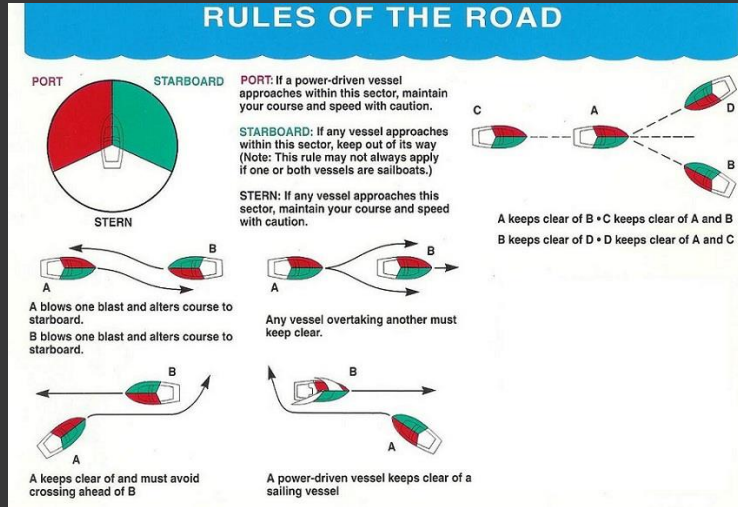
- Hybrid Propulsion System
- Battery Energy Management System and

Integrating a 'System of Systems'

- Mini drones and UAVs
- Environmental sensors

What are the navigation challenges ?

- Regulations : IMO/COLREGS/SOLAS



Ultimate Rule: do not hit anything !

- Explain decisions taken (no man on loop)
- Security
- Management with minimal or no connectivity

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An Autonomous vessel capable to operate remotely in all corners of the globe with 'no man on loop'

Ship Management Capabilities:

- Mission
- Cognitive and Analytics Capabilities
- Vehicle Control
- Autonomy
- Battery
- Electrical Distribution
- Sensors (AIS, Radar, Weather, Sonar..)
- Secure Payloads
- ...



Ship DL: NavHazard Detection

- Inference / Video
- Upload data
- Retrain models
- Download models
- Test models in parallel

On board ML & Control

- Navigation (Charts, Weather)
- COLREGs / Rules runtime
- SOLAS / Decisions
- Optimization
- Vehicle Control

Upload collected data,
Download models,
Trigger actions



Web Portal



- Follow the mission
- Explore scientific data collected

Development onprem/offprem



Weather

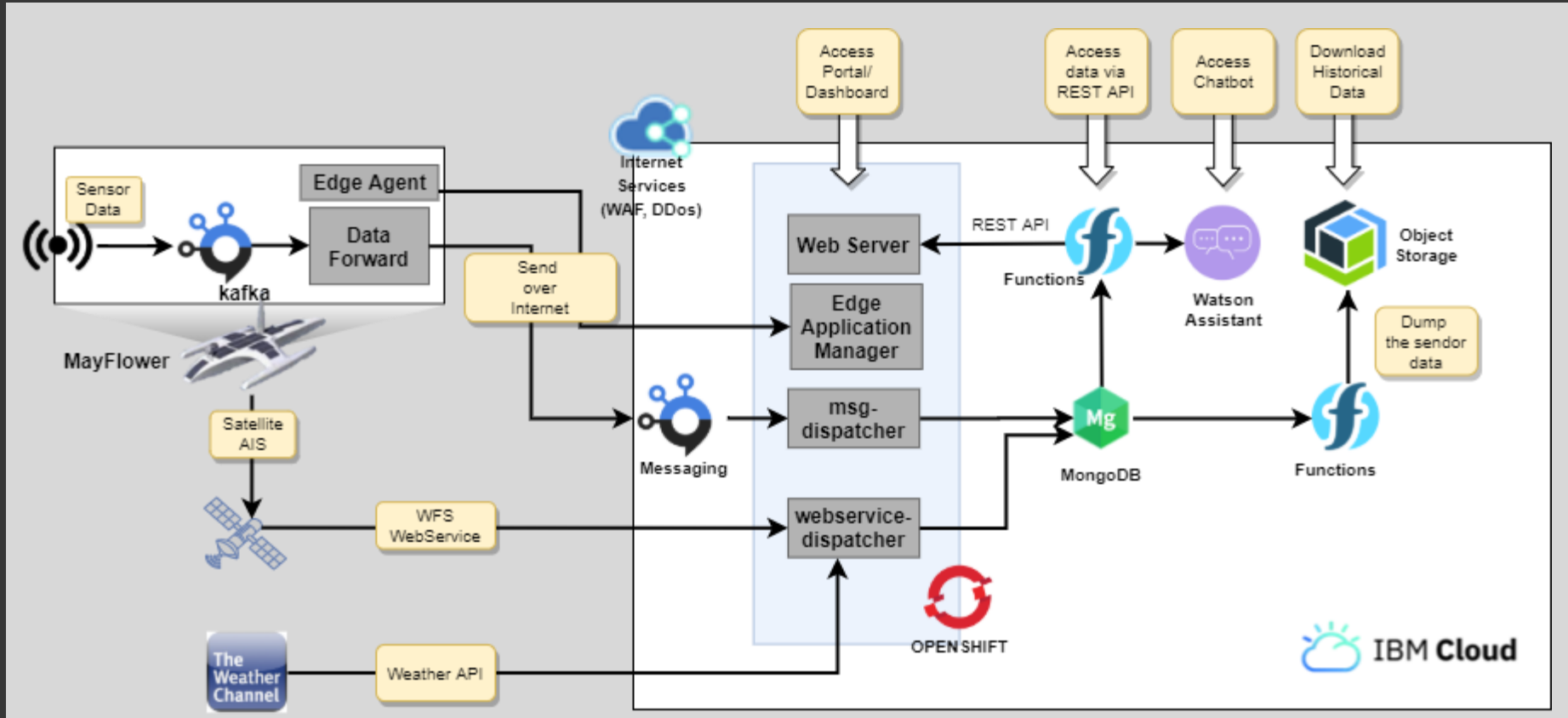


Mission Control



Models/Rules creation

Solution Architecture Details

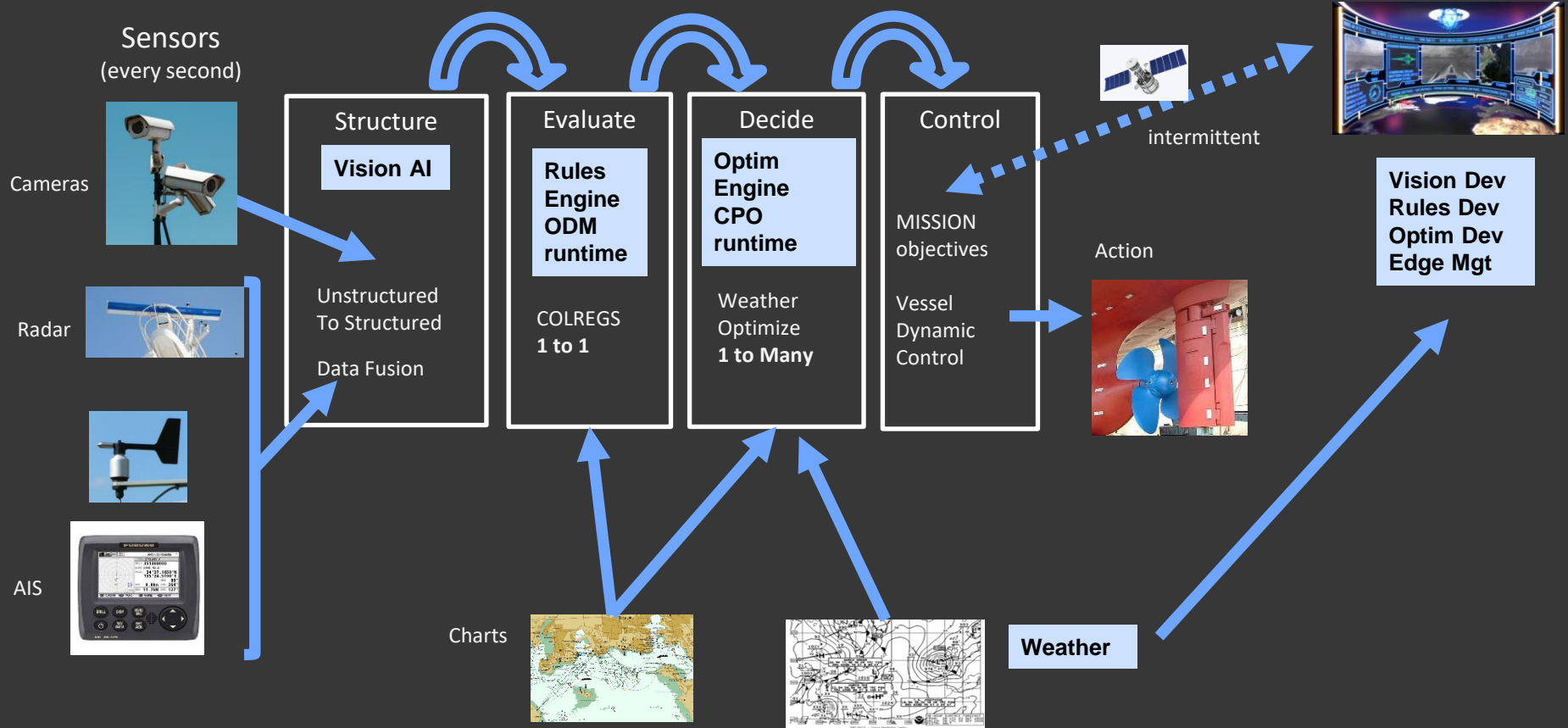


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Hybrid AI Solution



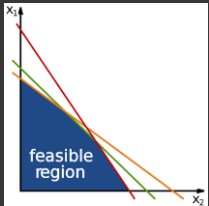
Making Decisions - AI Technologies



- **Deep-Learning**



- **Prescriptive Logic / Inference Rules**



- **Optimization / Linear Programming**

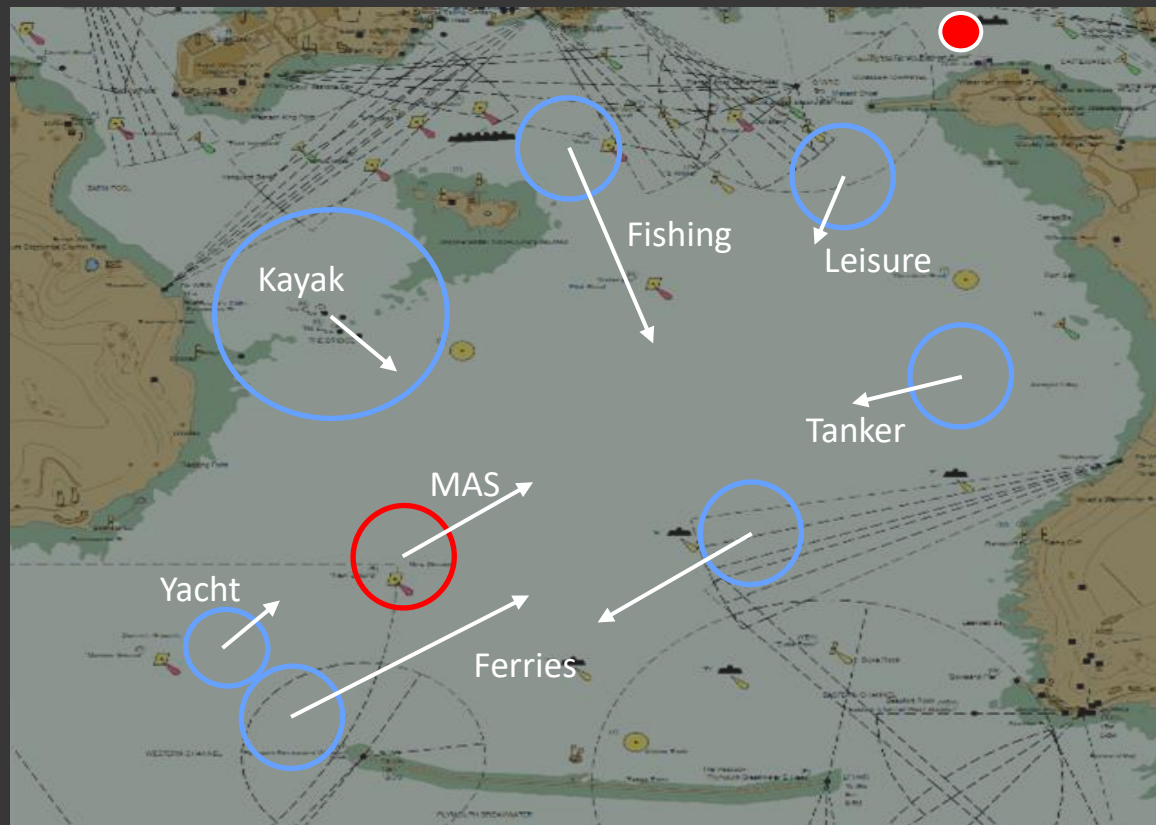
> Transparency and Auditability by rule/law

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The Ship 'situation room' : modelling 'contacts' problem



Sensors provide an estimation of contacts:

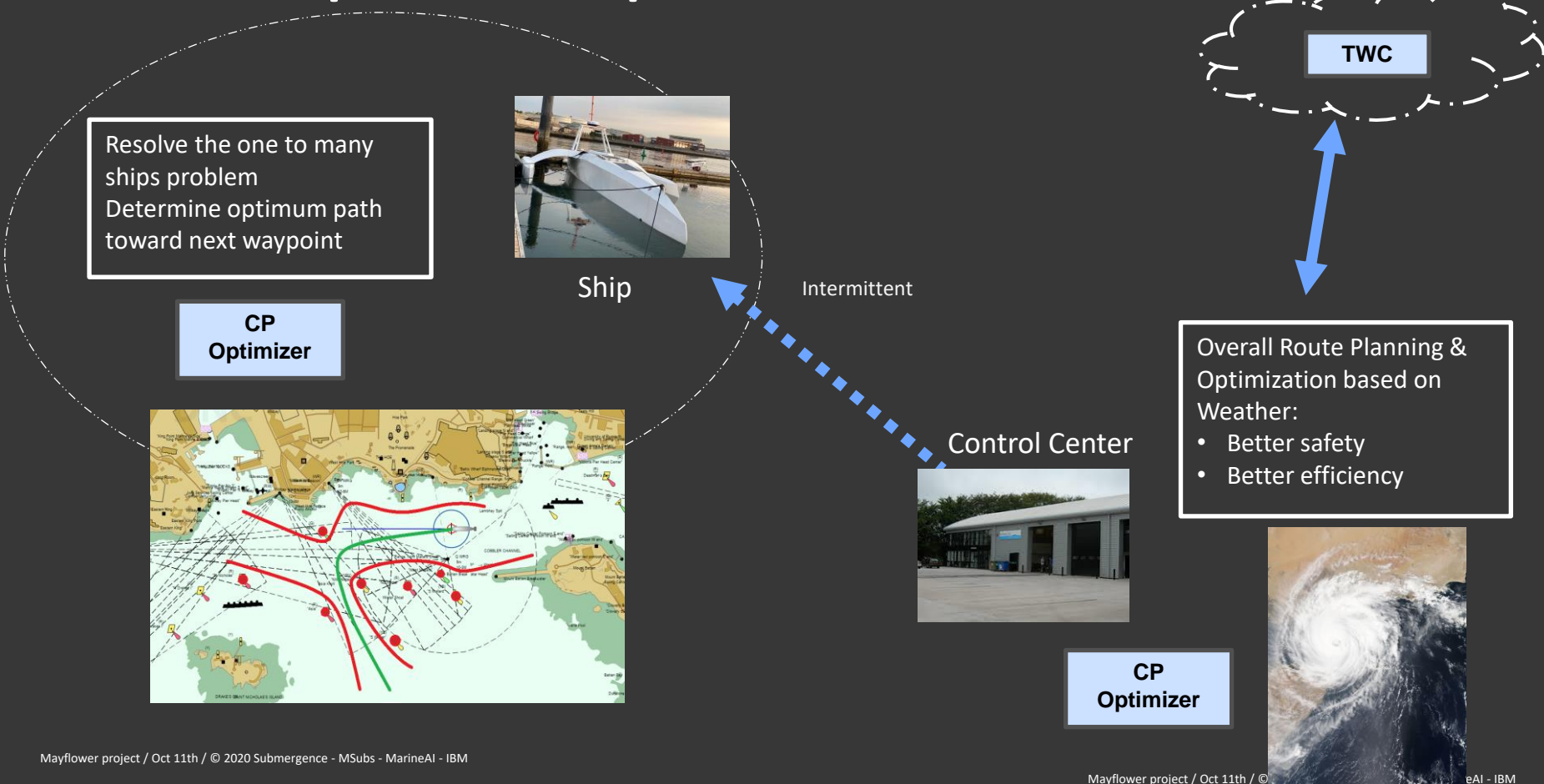
- types (behaviors)
- speed vectors

At each 'situation ' run, the decision variables are the contacts coordinates

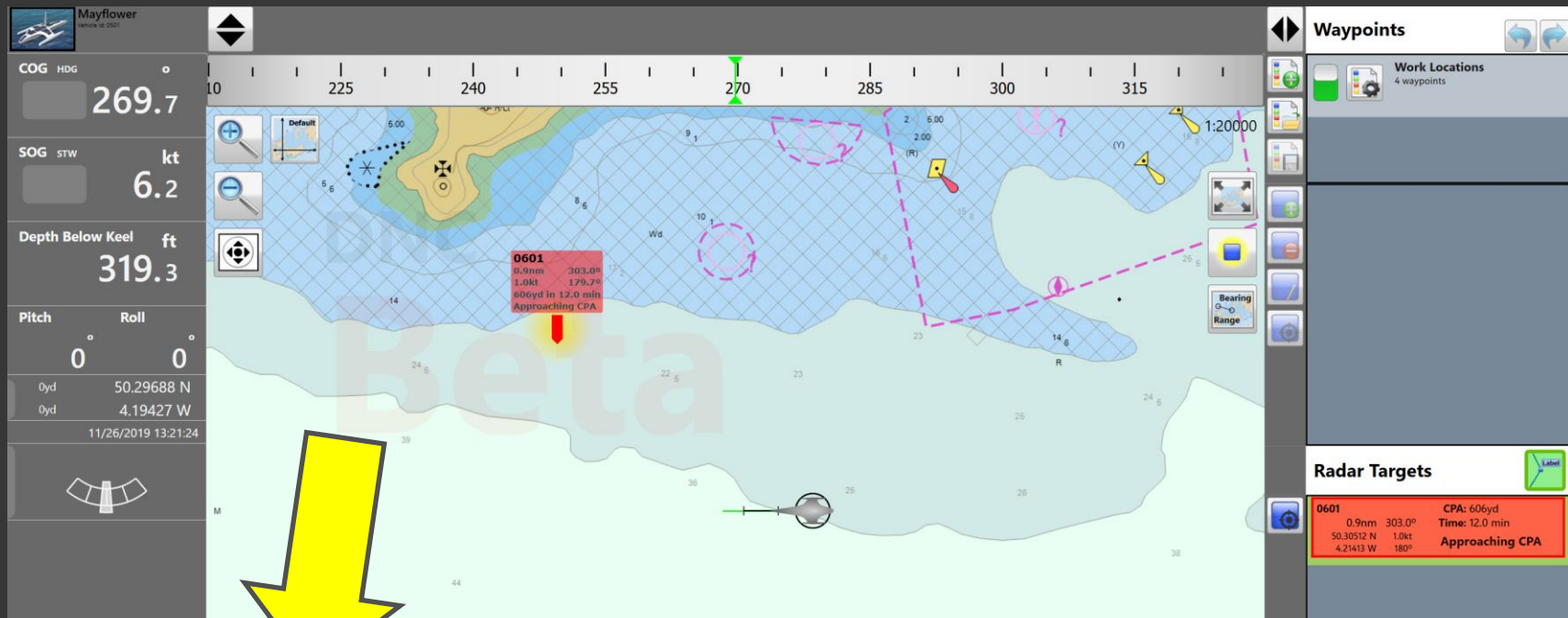
Find the 'optimal' vector for:

- Weather
- Safety
- Route
- Battery life
- ...

Where is Optimization performed?



Complex AI testing : Serious Game scenario



Turn Demand: **90° to Starboard**

Spd Demand: **4.0 kt**

Vessel State: **Crossing Turn**

The vessel has been recommended to slow down to 4 knots as to prevent collision with a crossing vessel; complying with rule 15 of COLREGs

The other vessel should follow her current course and speed



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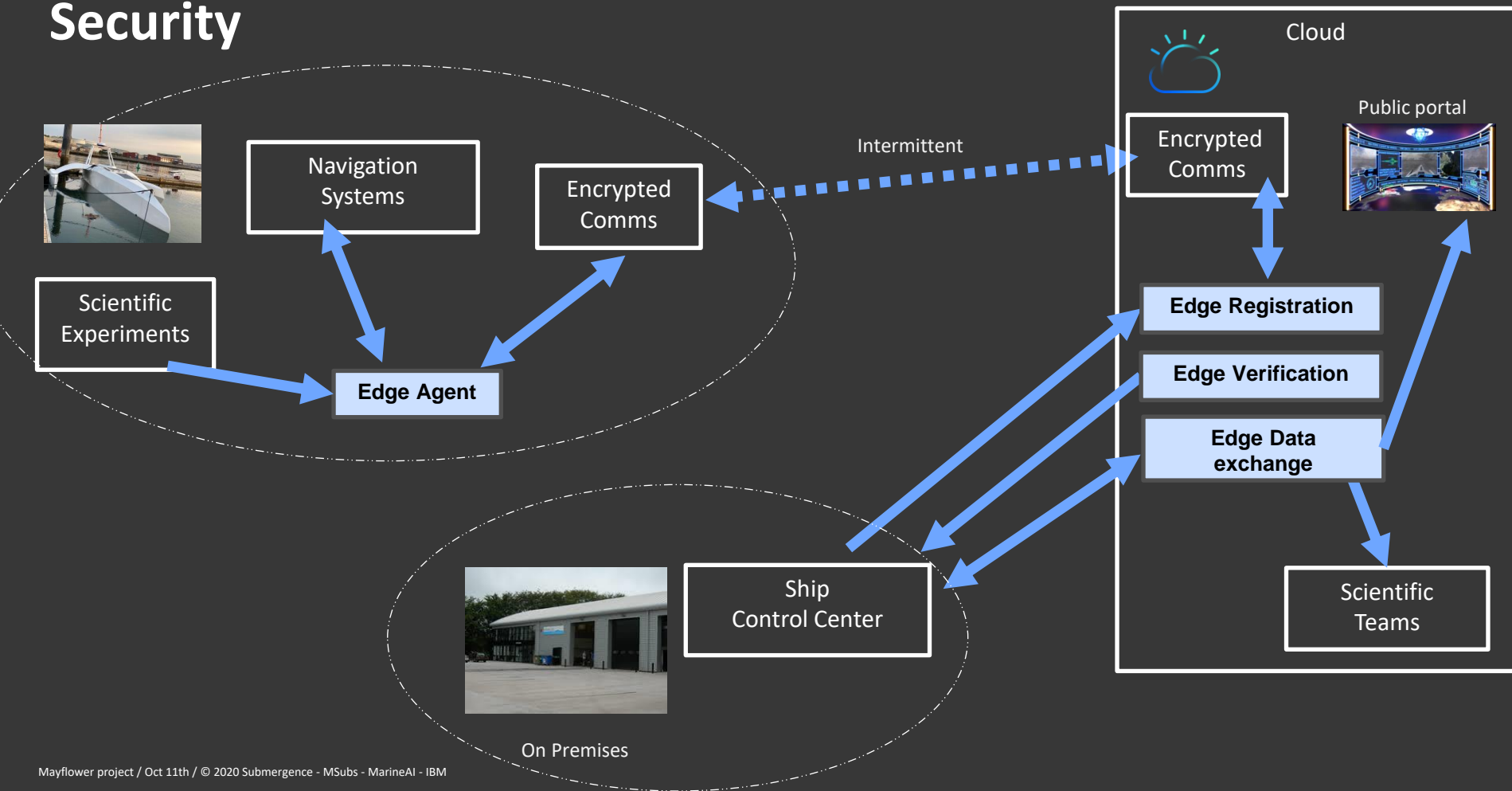


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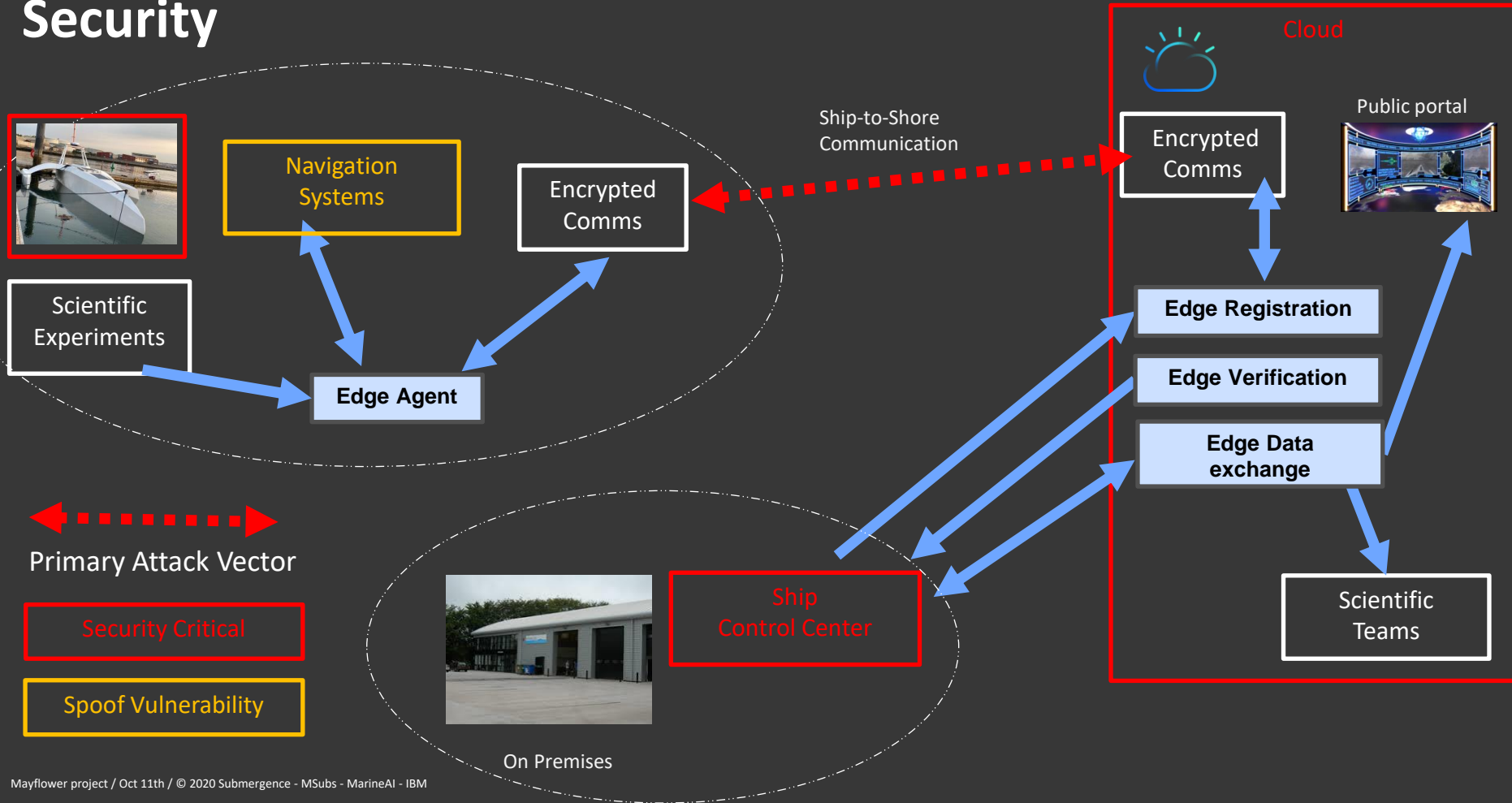
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Security



Security



Security



Primary Attack Vector

Security Critical

Spoof Vulnerability

**MAS Security Model follows CIA
to assess risk and establish security policies**

- **Confidentiality**
- **Integrity**
- **Availability**

To maintain critical Edge compute capabilities

- **Data Integrity**
- **High Availability**

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Mayflower project / Oct 11th / © 2020 Sul

Current Activities:

- Navigability Tests
 - Systems Integration
 - Autonomy Tests
 - Science Experiments
 - Integration
-
- Spring – Crossing
 - Summer – US/Canada
 - Fall – Return via HMS Challenger route



The Business Case for Marine Autonomy

- **\$134.90 billion by 2030 (Allied Market Research)**
- Huge market opportunity for IT (need for AI, IoT, connectivity, cameras, sensors, computer vision etc.)
- Asia-Pacific, Europe and North America are fastest growth regions for autonomous ships.
- Key players include ABB, Honeywell, Kongsberg Gruppen, Mitsubishi, Marine Technologies, Yara, Mitsui O.S.K. Lines, Northrop-Grumman, Rolls-Royce, Ulstein Group ASA, and Wartsila.

But remember:

- non-mature market (most vehicles are Remote Control)
- the cost of mariners is negligible compared to ship/goods
i.e this is not a plan to remove humans

QUESTIONS ?

MAS400.com

