Architecture and modularity enabling a stepping-stones approach to intelligent shipping

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Azipod® podded and advanced propulsion

Efficient, flexible, **energy-conserving**, more sustainable (**silent**) electrical propulsion actuators – Azipod® technology.

Best-in-class **manoeuvrability**, DP capability, **servo-control** and **thrust allocation** capabilities.

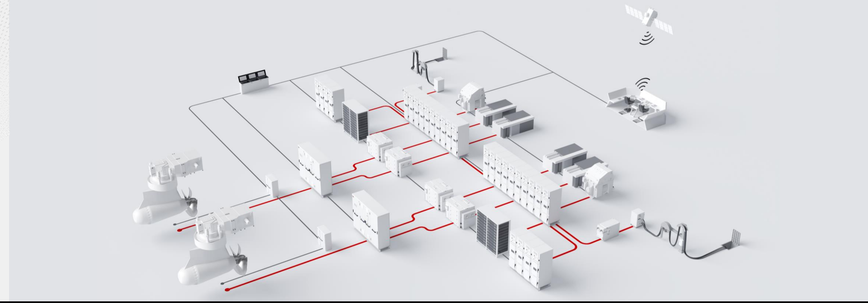
DynaFin™ innovative propulsion concept

Radical efficiency improvement (85%)

Unprecedented **manoeuvrability** due to instantaneous thrust vectoring.

Lack of complex mechanical and electrical assemblies contributing to **ease of maintenance and high MTBF.**

Exciting and **precise control and thruster allocation** capabilities allowing novel operational profiles.



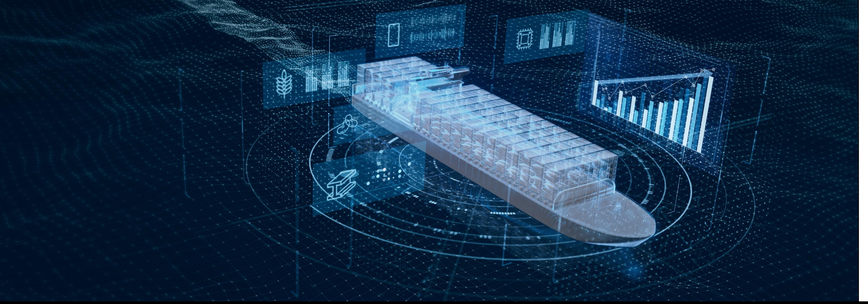
Zero-emissions electrical propulsion

Hybrid and zero-emissions MV (AC) and LV (AC, DC) power-plants.

Prime motive power-agnostic (work with fuel cells, batteries, ICEs running on MDO, ammonia, hydrogen, bioethanol).

Fuel cell and reformer integration.

Advanced dynamic **power and energy management** and online **optimization.**



Step-wise Autonomous Shipping

Scalable, "dial up and down" amount of **human integration** into vessel navigation, ending with highly abstract supervision tasks based on **hybrid AI-human collaborative decision-making.**

Situational awareness resilient to weather and sea conditions.

On-board, on-shore, and hybrid operation concepts including ROC.

Human factors and UX in novel maritime career profiles.

Autonomy Architecture for C&C, Human-Machine Collaboration, Safety and Security

Modular, scalable, **operationally and cyber-secure** architecture.

Quality of service contracts of individual functional modules, curated and governed information models and interfaces.

HW agnosticism, platformization, containerization and transversal and longitudinal state and data consistency.

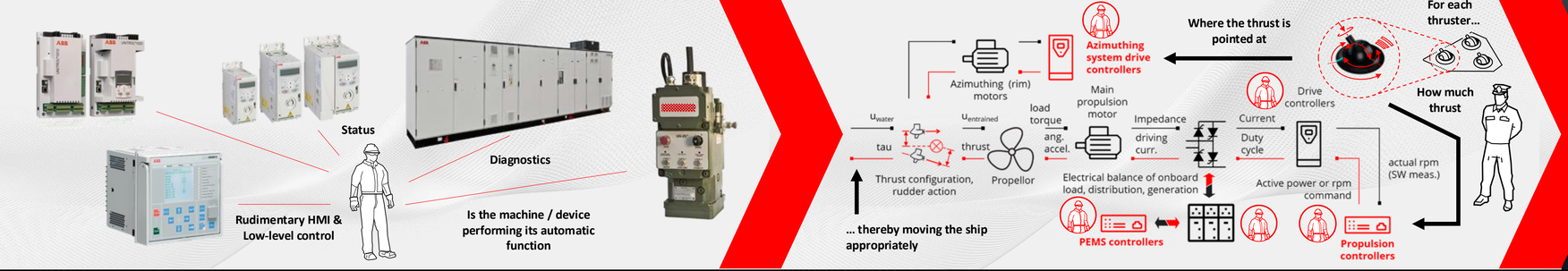
Centrally Supported Fleet Operations, Planning, and Execution

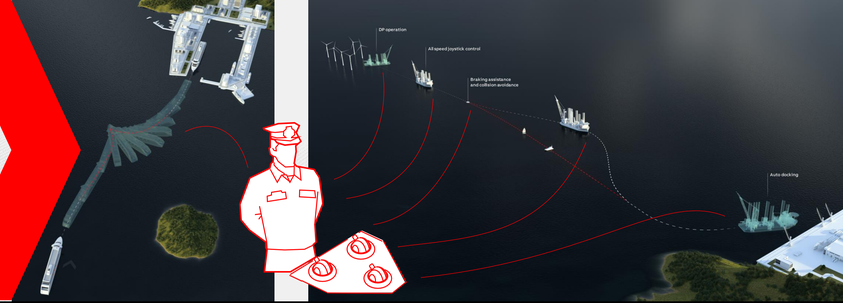
Diagnostics, condition-based, and predictive maintenance.

Resource control and allocation for lifecycle management.

Route optimization & weather routing.

Ecological / sustianability KPIs review and compliance (EEXI, CII, etc.).





Machinery control

Automates the function of each machine which contributes to ship motion

- AVRs (Automatic voltage regulators)
- Governors / ECU (Engine control units)
- BMS (Battery management system)
- FCMS (Fuel cell management system / balance of plant system)
- Drive (rectifier and inverter) control, e.g. ABB® DTU®
- Isolation and safety algorithms on IDEs (Relion®)

Process control

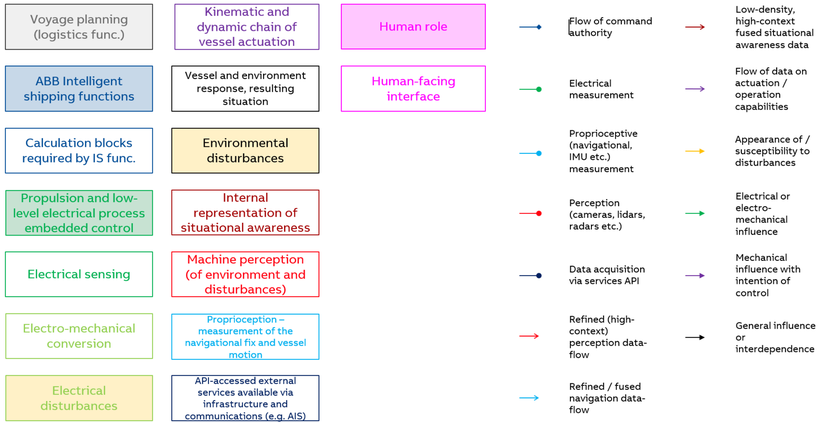
Automates the physical process required to exert control authority on the vessel (thrust, rudder, thrust direction, bow and stern tunnel thrusters)

- Azimuth slew / toe angle (azimuth degree of freedom)
- Propulsion control (PAS)
- Power and energy management (PEMS)
- Remote operation of multiple propulsion units / line-ups (RCS)

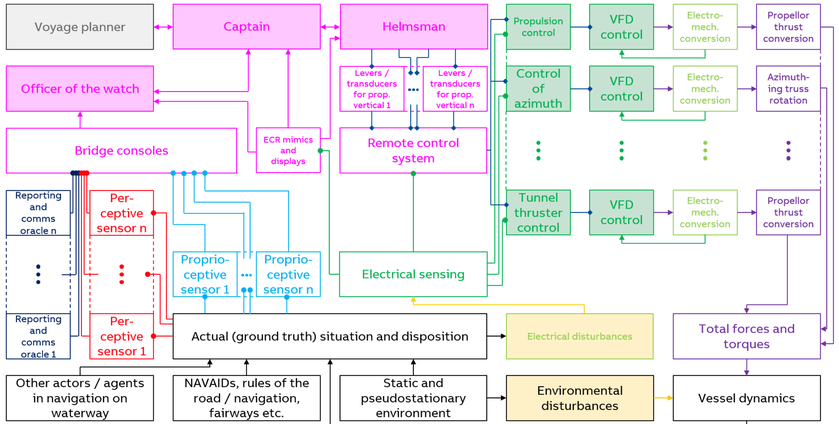
Vessel control

Abstracts the entire vessel as an actuated moving object / robot under automatic control authority

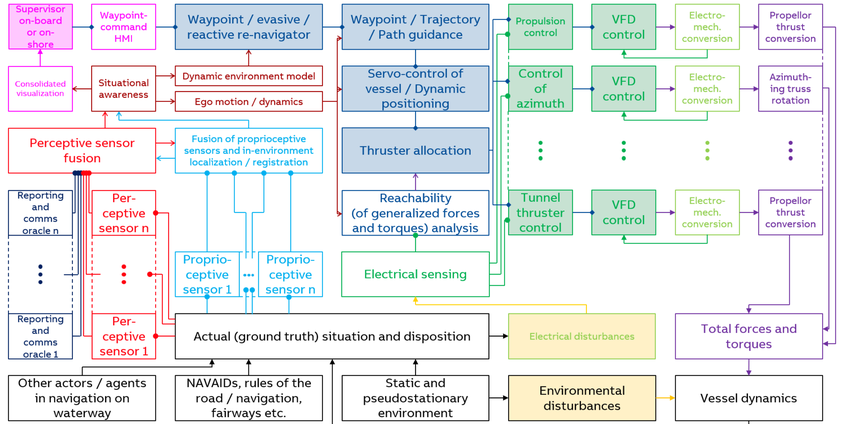
Autopilot / DP functions || Servo-control of the vessel (voyage execution) || Low-speed and special manoeuvres (DP, auto-docking, auto-anchor-weighing/unmooring) || Collision avoidance || Situational awareness || Situation-adaptive navigation (decision-making) || **Human on-the-loop supervision**



Legend

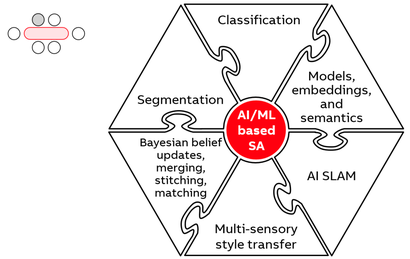


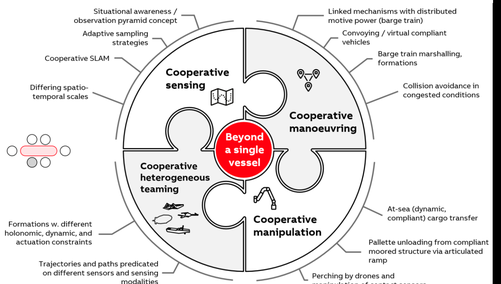
Modern manually operated vessel



Human-on-the-loop supervised vessel

With smart / autonomy / driver assistance functions e.g. collision avoidance, predicated on holistic, synesthetic and integrated situational awareness



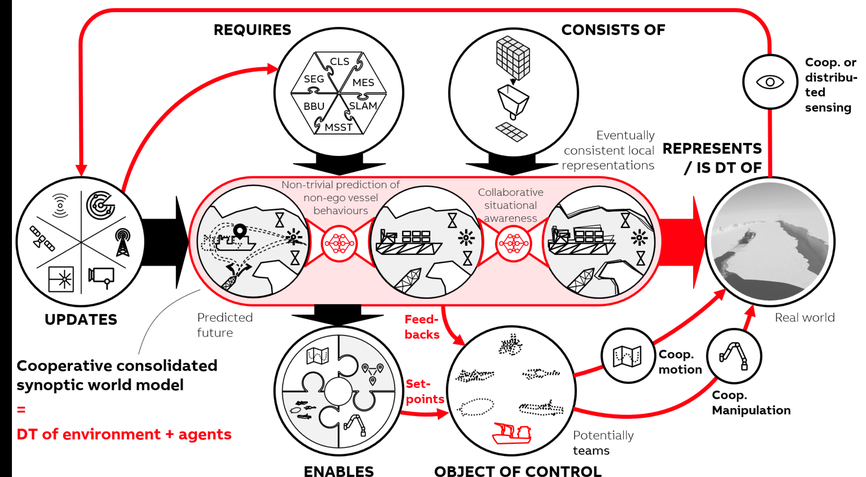


Federation of upstream (sensing and sense-making) capabilities

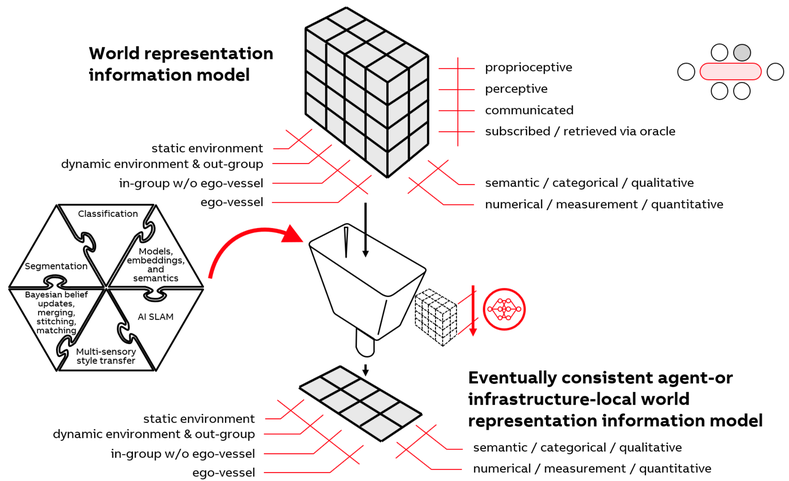
Contribution to content or structure (network/graph) of situational awareness world model.

Federation of downstream (action and intervention) capabilities

Spatial and actionable intelligence and flexibility – collaboration, cooperation, resilience, flexibility, efficiency, sustainability.

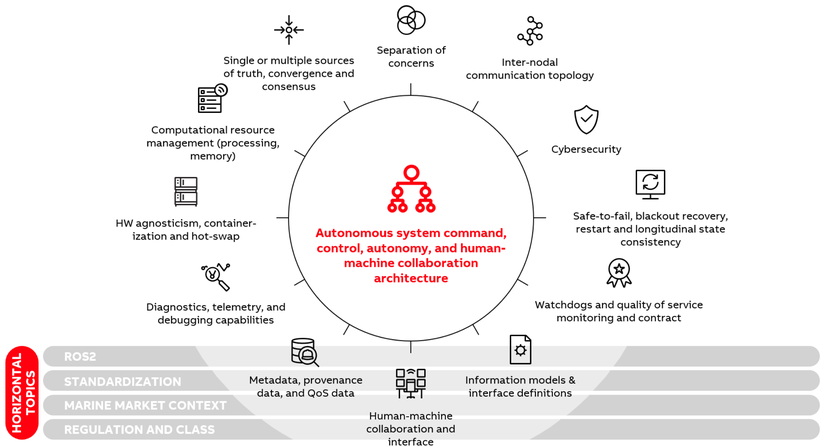


How true machine situational awareness arises through following a stepping-stones approach



Nexus of situational awareness

An integratory world model that is knowledge-dense but data-sparse (abstract, actionable information structured according to information models and knowledge graphs)



Necessary system qualities of mission-critical systems such as MASS – a tall order!

Modelling and governing the syntax

Data that the system operates on

Provenance data, metadata, quality assurance data

Modelling and governing the semantics

Relationships of data the system operates on to one another and to the properties, qualities, parameters, or configuration of the system

Modelling and governing interfaces

How new data can be introduced

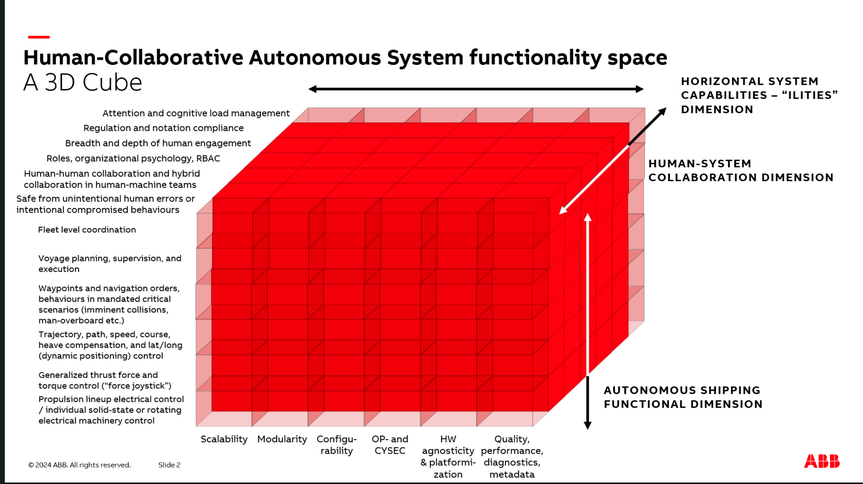
How new semantics can be introduced

Metamorphic interfaces and **meta-interfaces** (how new ways in which data or semantics can be introduced can themselves be introduced at run-time)

Assurance criteria

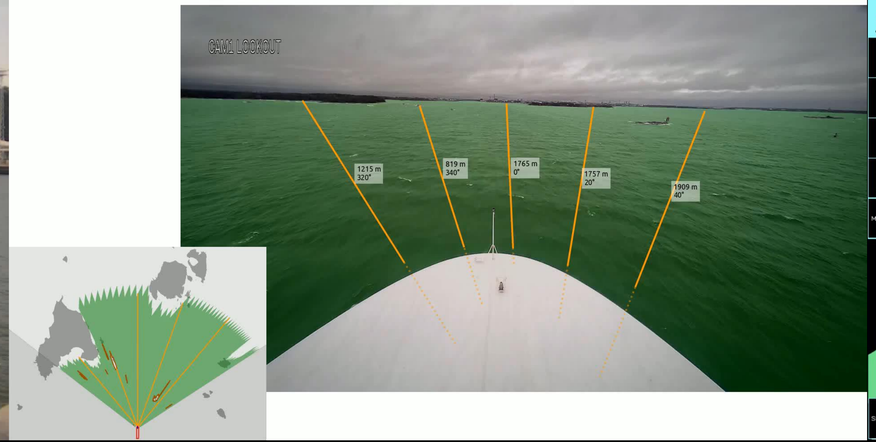
What is the contract with the users of the systems (other humans or other systems of systems wherein the system is a citizen / component of) about the system's behaviours, performance, quality, efficiency, resilience, sustainability, fitness for purpose

Clarity of purpose | Design statement | Definition and description | Change management | Quality assurance | Standardization



Bringing human behaviour into the picture – a tall order!

Non-ego vessels' courses and speeds from monocular camera (structure from motion)



Navigable water detection from monocular camera (structure from motion)

Autonomous collision avoidance of erratically manoeuvring non-ego vessel

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SCAN ME

Inkeri Huttu

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EU HORIZON EUROPE | EU INNOV. FUND | EDF | EU S&CF, ERRF | EU INTERREG | EU MARTERA | NATO SPS | Nat. prg. | IN, SG, US

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