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Content

- Introduction
 - Rolls-Royce Marine overview (Kongsberg from 1st April 2019)
 - Digitalization
 - Ship Intelligence
- Important steps towards Remote & Autonomous vessels
 - Base line
 - Digital infrastructure and Life Cycle Support
 - Intelligent Navigation System
 - Intelligent Machinery Systems
- Technology selection
- Summary



Our products and services

Ship design

More than 900 UT and NVC vessels are in operation all over the world – under the toughest conditions known to man. Our UT design is the benchmark of the offshore oil & gas industry.



System integration

From the fingertip controls of our advanced bridge systems, to the engine room, propulsion systems and ondeck equipment, we have unparalleled systems integration capability.

The widest range of products in the marine industry

Our technology can be found in ca 1 out of 4 vessels in the registered world fleet, delivering mission critical marine power and propulsion systems and deck machinery.





Through-life service and support

Global service network with more than 700 well-trained service engineers. Streamlined global spares distribution network and 24/7 technical support. Advanced customer training facilities in Norway, Singapore and Brazil.





Market Segments - EA&C

Fishery

Tugs & Workboats





Construction, Exploration & Production

































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Digitalization

- Shore Control Centre (SCC)
 - Fleet Management
 - Remote Control
 - Intelligent Machinery
 - Emergency Response
- Fleet Operation Centre
 - 24/7 support
 - Health and performance monitor
 - Condition based service
- Intelligent Analytic Centre
 - Advanced data analytics
 - Experts in the loop and advisory services
- Simulator centre
 - System verification and validation
 - Training and customer demonstrations
 - Optimization and prognostics
- Business sensitivity classification |© 2019 Rolls-Royce Platform

Business proprietary classification **Export Control classification**

Enabling Remote & Autonomous

Move operators to shore Remote control and watch keeping Condition monitoring

Vessel design

System integration

Cyber-physical products

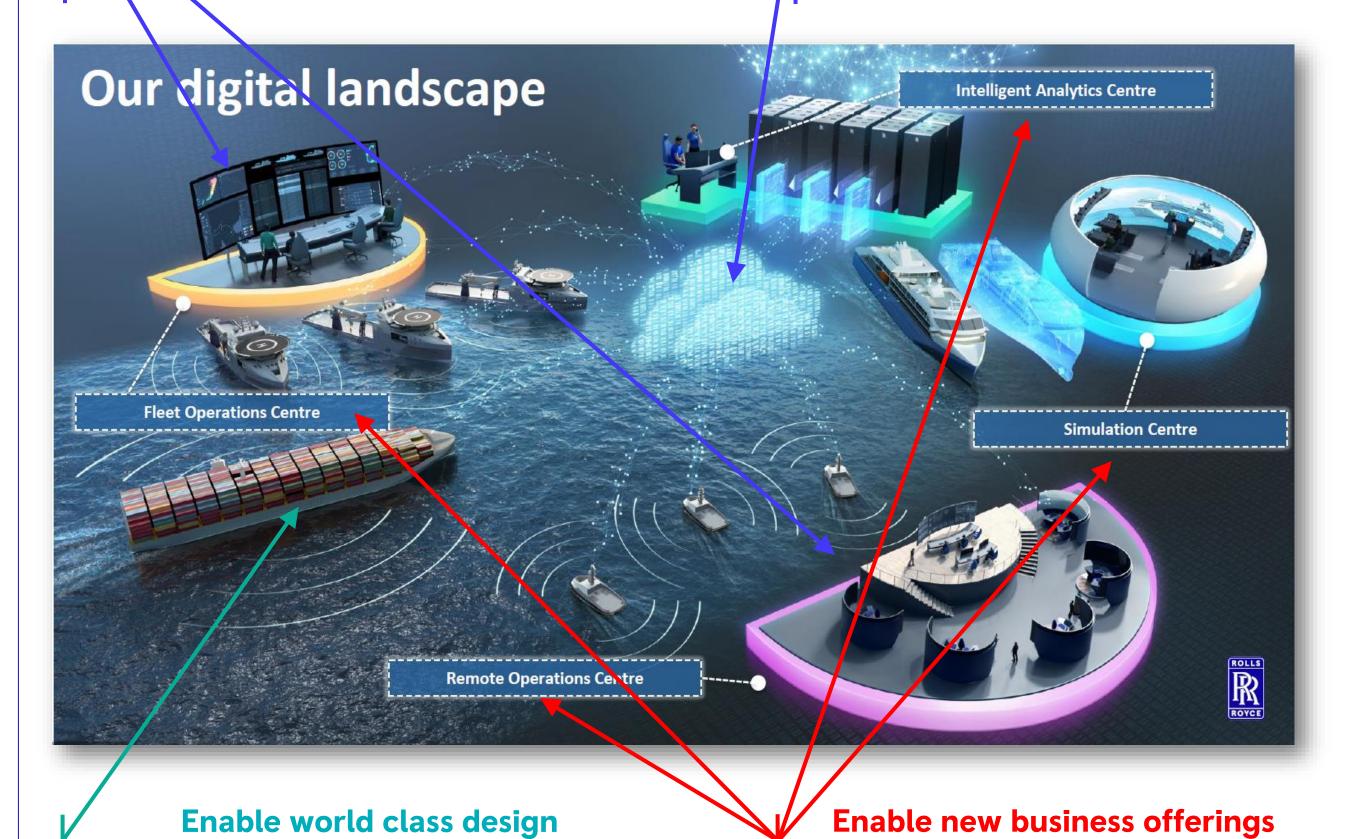
Digital Infrastructure

Connectivity and cyber security Cloud solution Storage, data management, Tools

Life cycle support

Power by the hour

Future extended services







Ship Intelligence



Intelligent Asset Management



Remote & Autonomous Operations



Energy Management



Health





Data Management



Fleet Management



Intelligent Awareness



Remote
Operations Centre

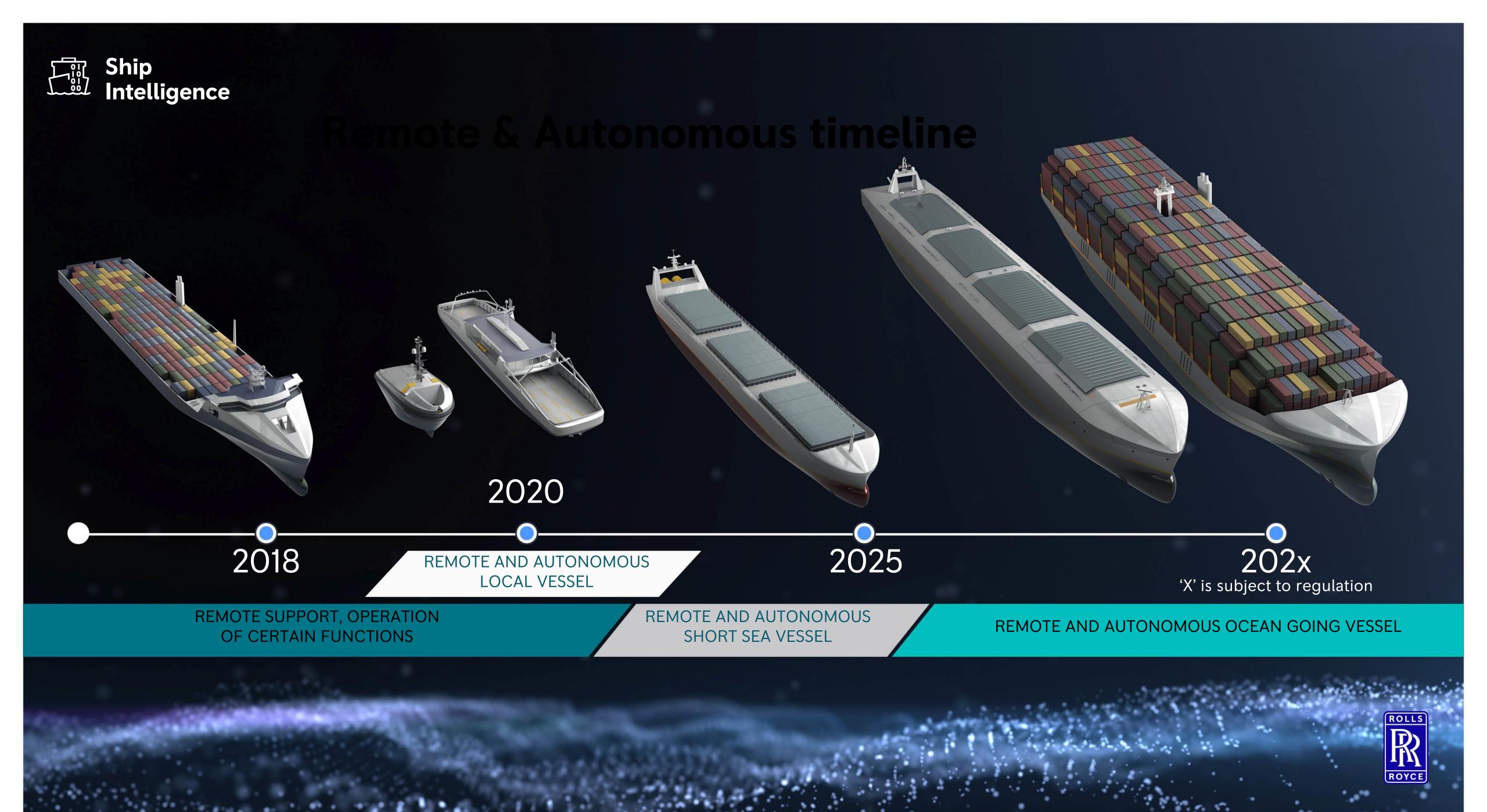


Autonomous Navigation System



Vessel Connection







Automation & Control Product Lines

Positioning & Manoeuvring

Ship Automation



Bridge Solutions



- Dynamic Positioning
 - Joystick Systems
- Autocrossing System
 - Track Pilot *
- Propulsion & Thruster Control
 - Steering Gear Control

- Automation & Alarm Systems
- Emergency Shutdown Systems
 - LNG Control & Monitoring
- Power Management System
- Digital Automation Platform *

- Integrated Bridge System
- [Integrated Navigation System]
 - Bridge Alarm System
 - Bridge Equipment Control
- Multi-function monitoring, video-wall *
 - Operator Chairs



Mcon - Manoeuvering Control

Integrated System for Propulsion, Thruster and Steering Gear Control















Segment

Product





























New Solutions

All-speed DP

Positioning and track-keeping from zero to transit speed



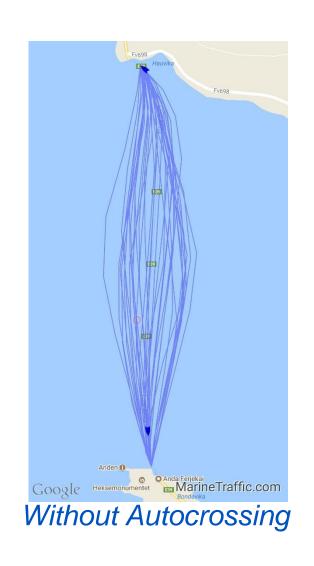
Tested on harbour tug in Copenhagen

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Autocrossing



Automatic crossing and docking of ferries, by combining propulsion & DP controls





Windfarm DP



Automated operation between wind turbine landing points, integration with gangways



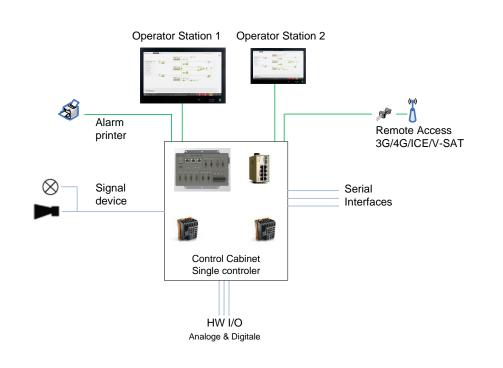


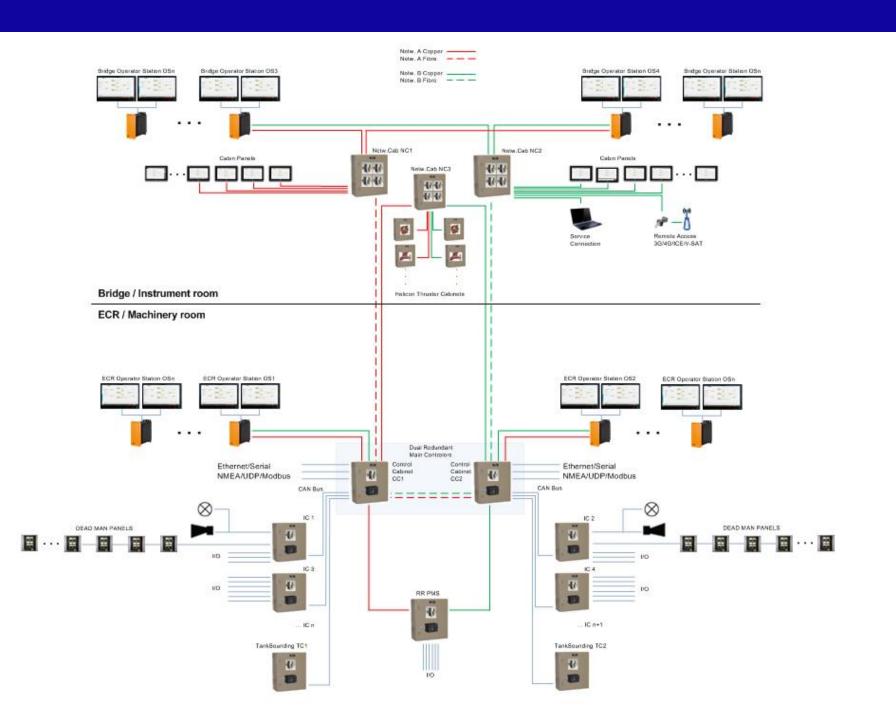
Automation Product Variants

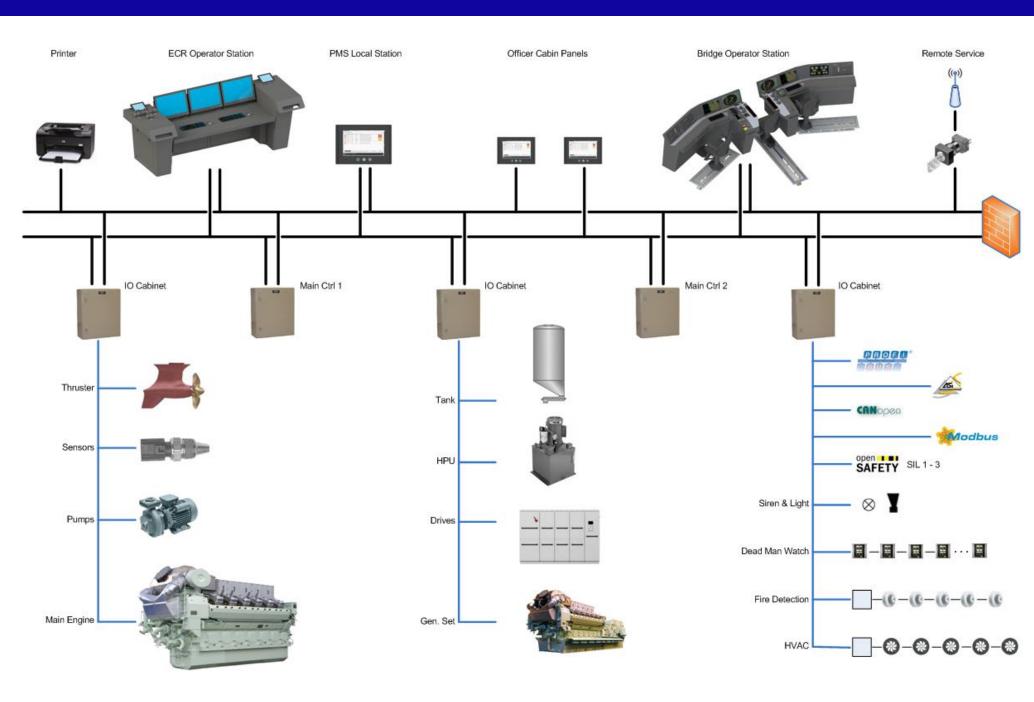
Compact

Medium

Complex













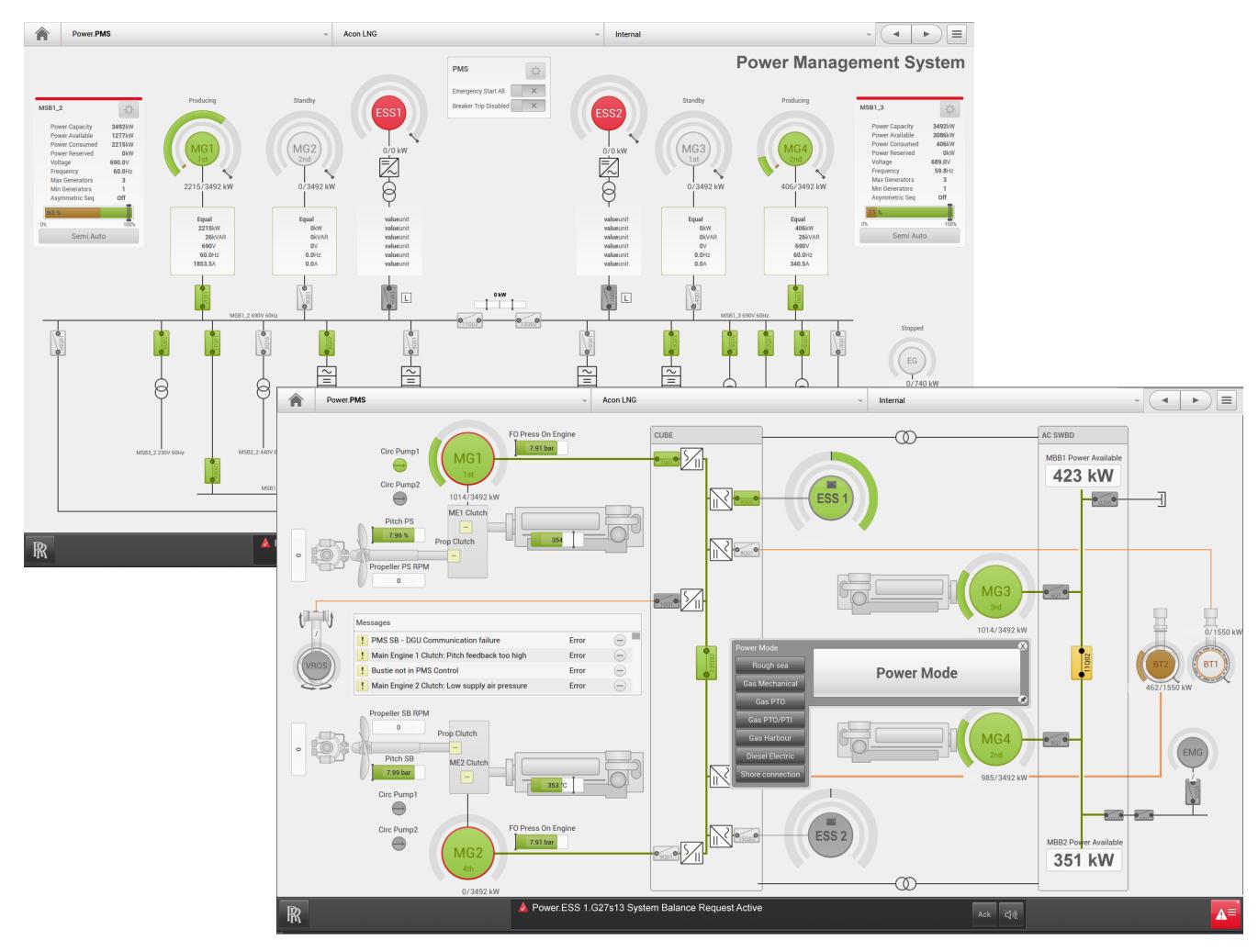




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Power Management System





Power management system integrated in SAVe CUBE solutions for efficient power and propulsion concepts, including energy storage solutions. Easy setup for different power modes through mode selection functionality.



Kystverket's "Bøkfjord" in DP operation on hybrid power system



Intelligent Asset Management



Solutions overview







On shore





Health Management







Expert in the loop





Health Management

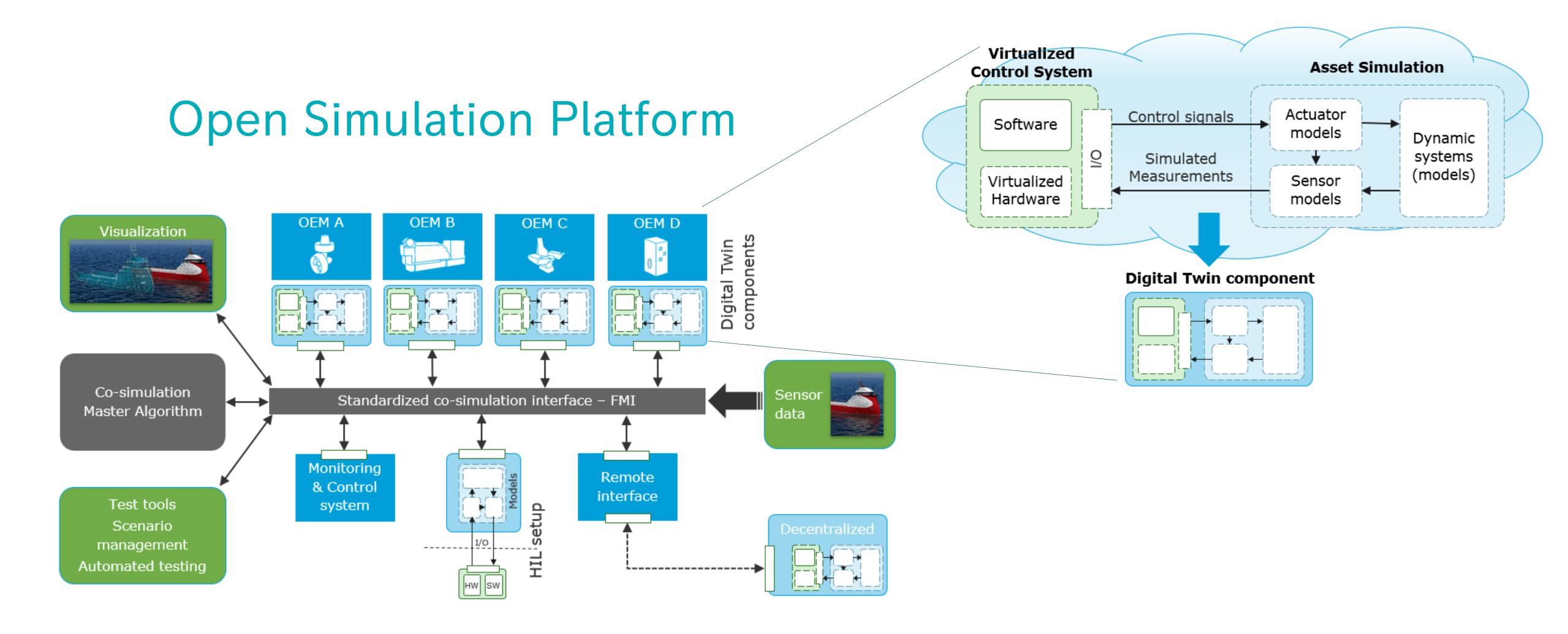




Simulering and Digital Twin



Digital Twin components

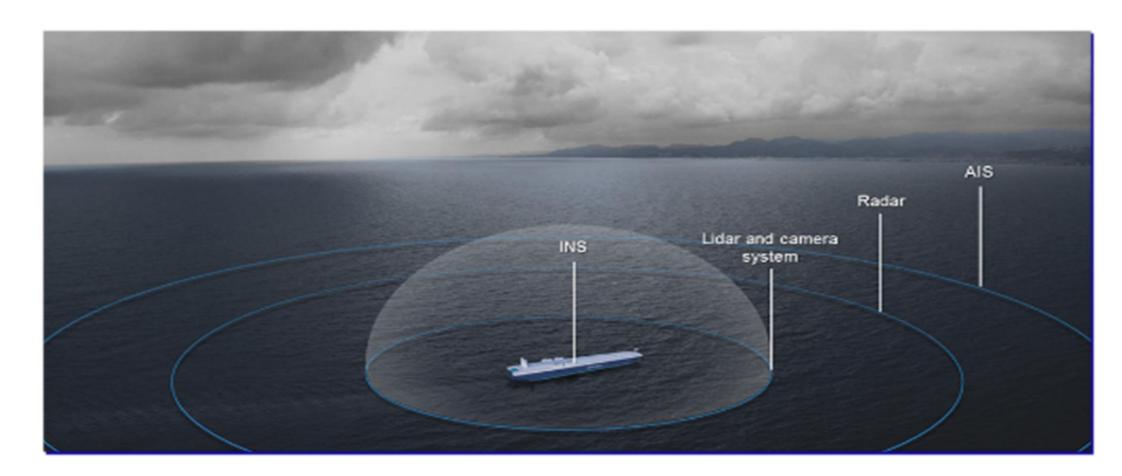




Intelligent Awareness systems (IA)

- Intelligent awareness (IA) system provides overall picture of dynamic and static objects around the vessel.
- System uses sensors and systems already known in marine industry as well as new technologies
- Sensor fusion combines all the aspects of the object detection, ranging and tracking sensors in the system in order to provide reliable, accurate and real time situational awareness information to the Autonomous Navigation System and Shore Control Station.







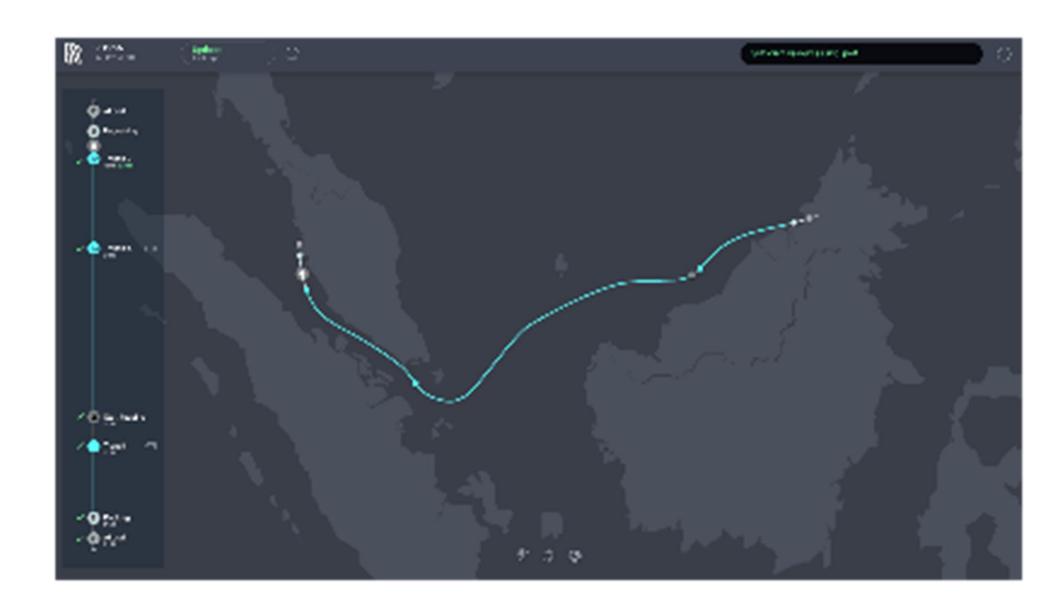
Autonomous Navigation System (ANS)

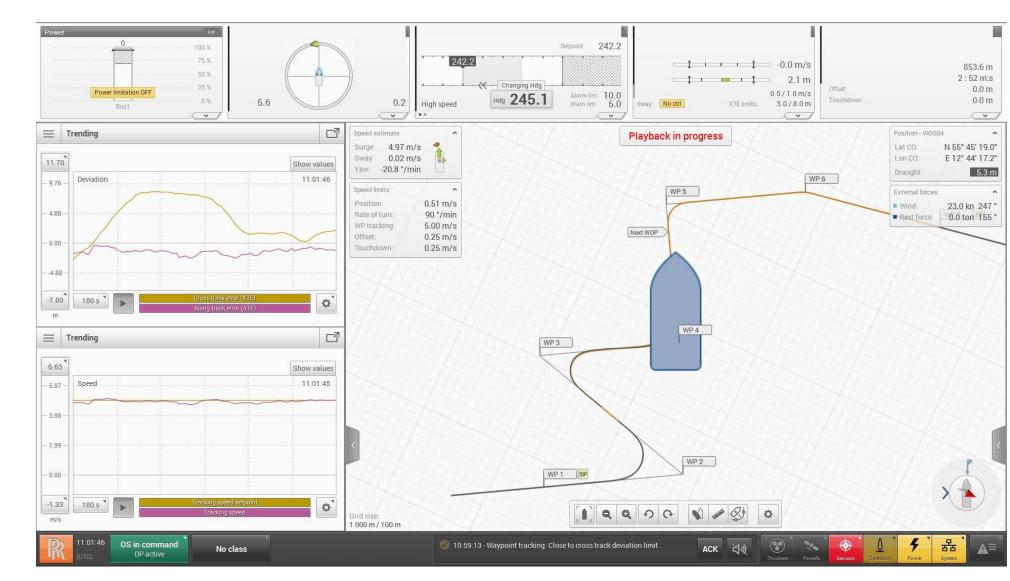
The Rolls-Royce Autonomous Navigation System (ANS) is responsible for

- Route creation
- Route monitoring
- Collision avoidance
- Fail safe state control
- Mission management and scheduling

All-speed track pilot system

- Track pilot over full speed range
- Position keeping
- Auto docking







Remote Control Station

- Remote Control
- Supervised Navigation
- Autonomous Navigation



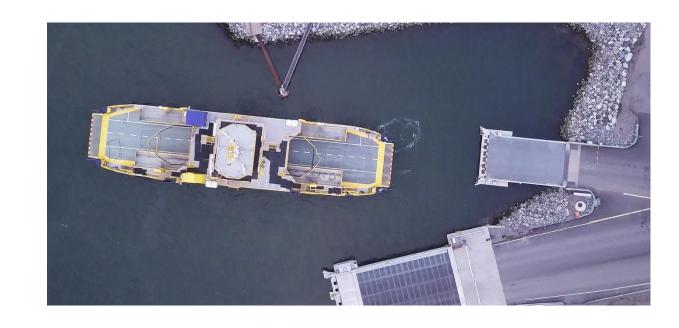


Demonstration of R&A Ferry – December 2018

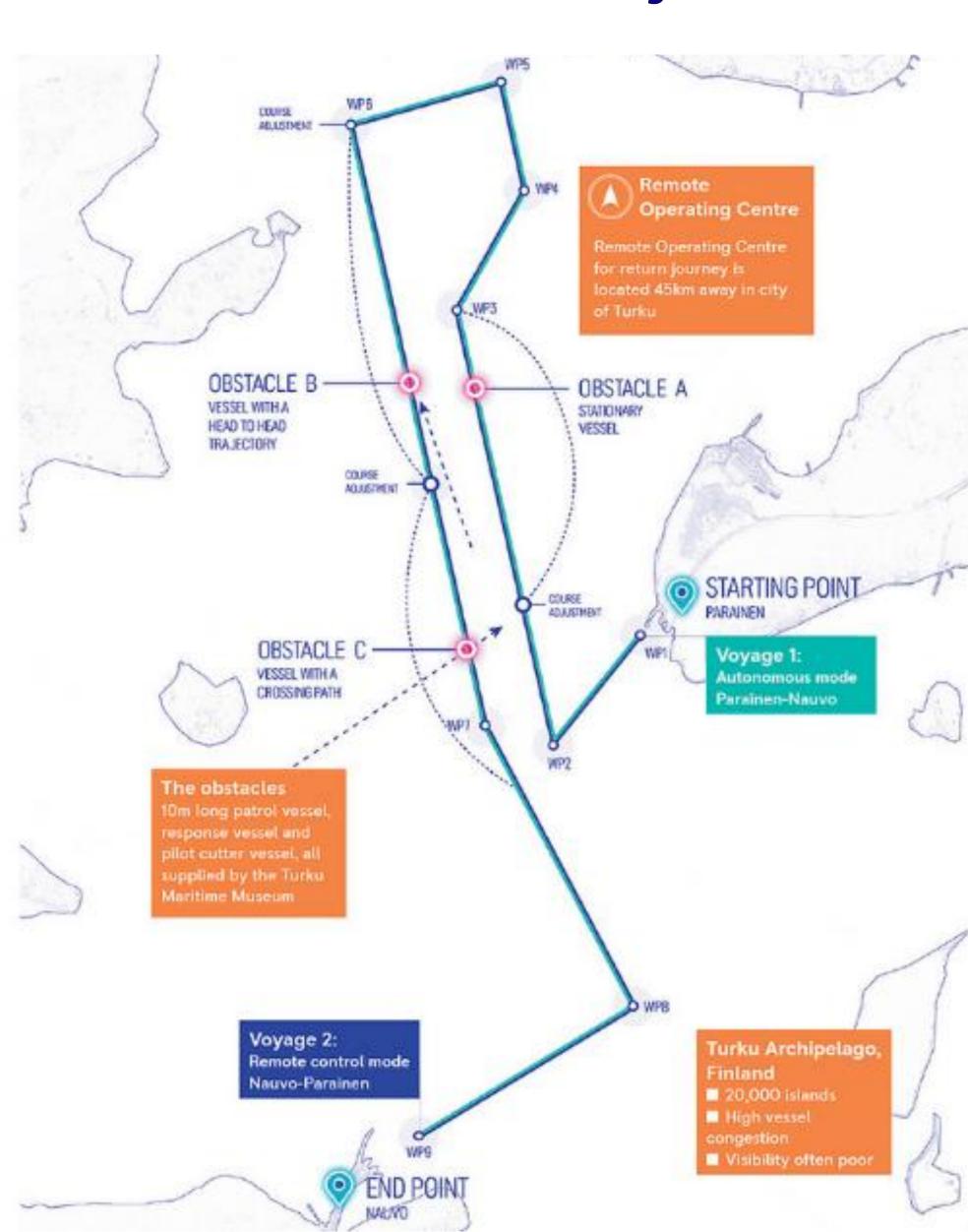
Remote Control



Auto docking



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Autonomous Navigation

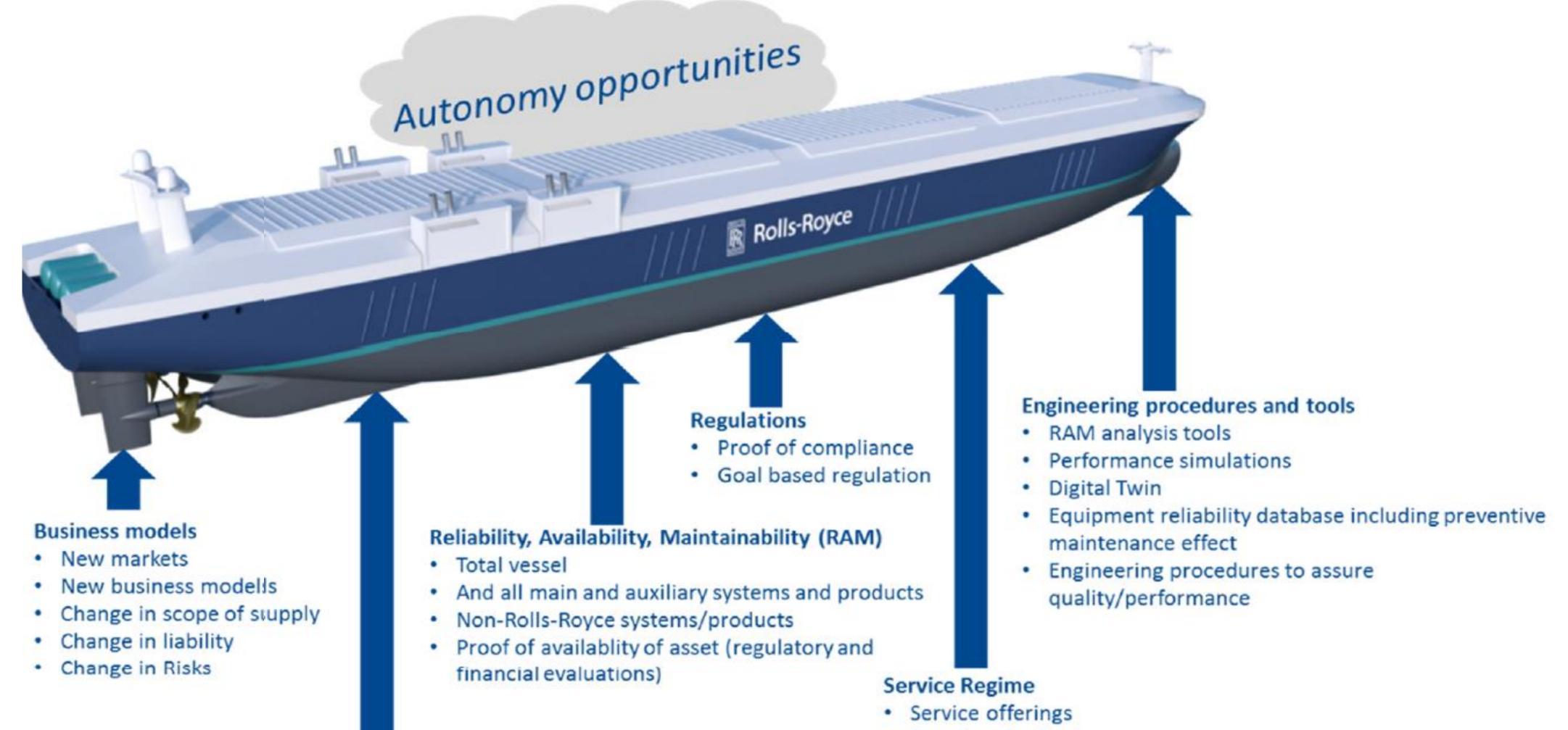


Collision Avoidance





Fundamentals from a ship designers perspective



Ship and Equipment Design

- Robust system design is key (not only redundancy)
- Modularization and Standardization required
- Cost reduction

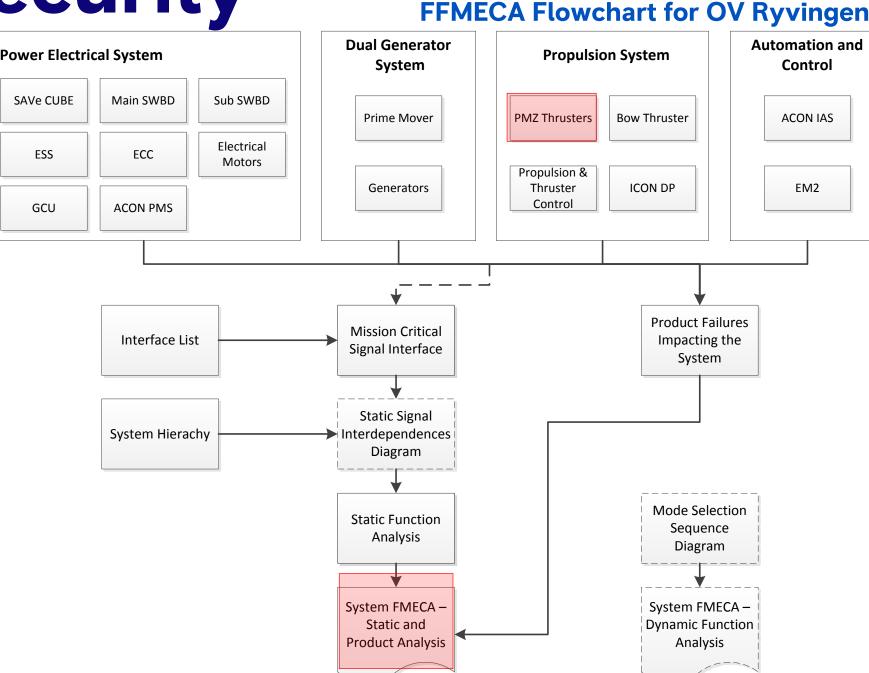
- Repair vs Replace
- Service access
- Achieved availability/operational availability
- · Preventive maintenance
- On-board corrective maintenance

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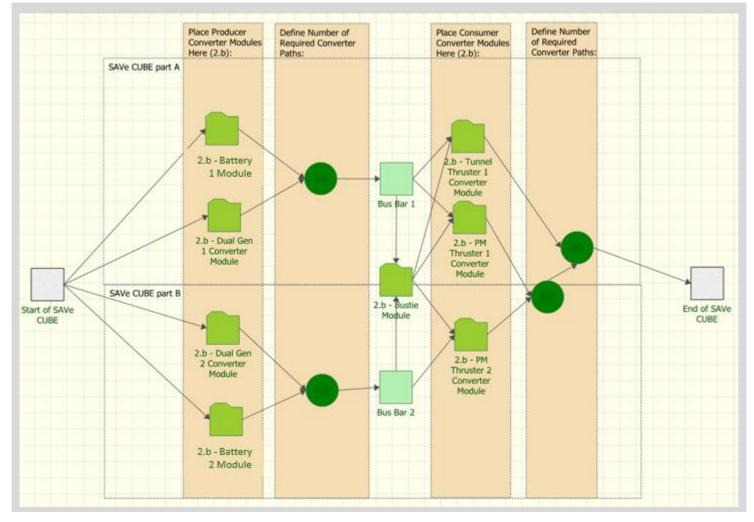


Methods for safety, reliability and security

- Modularization
- Product analysis
 - FMECA
- System analysis
 - System FMECA
 - RAMS model MTTF/MTTR- Quantification of Availability
 - Link RAMS model to System FMECA
 - STPA
- Collection of metric lifetime date
 - Failure data, downtime data, etc. (MTTF, MTTR)
- Static model
 - System design and analysis
 - Update model parameters based on operational data
- Future dynamic models for and simulation and control
 - Dynamic operational profile, mode, system configuration
 - Online Risk Control for Autonomous Ships (ORCAS)

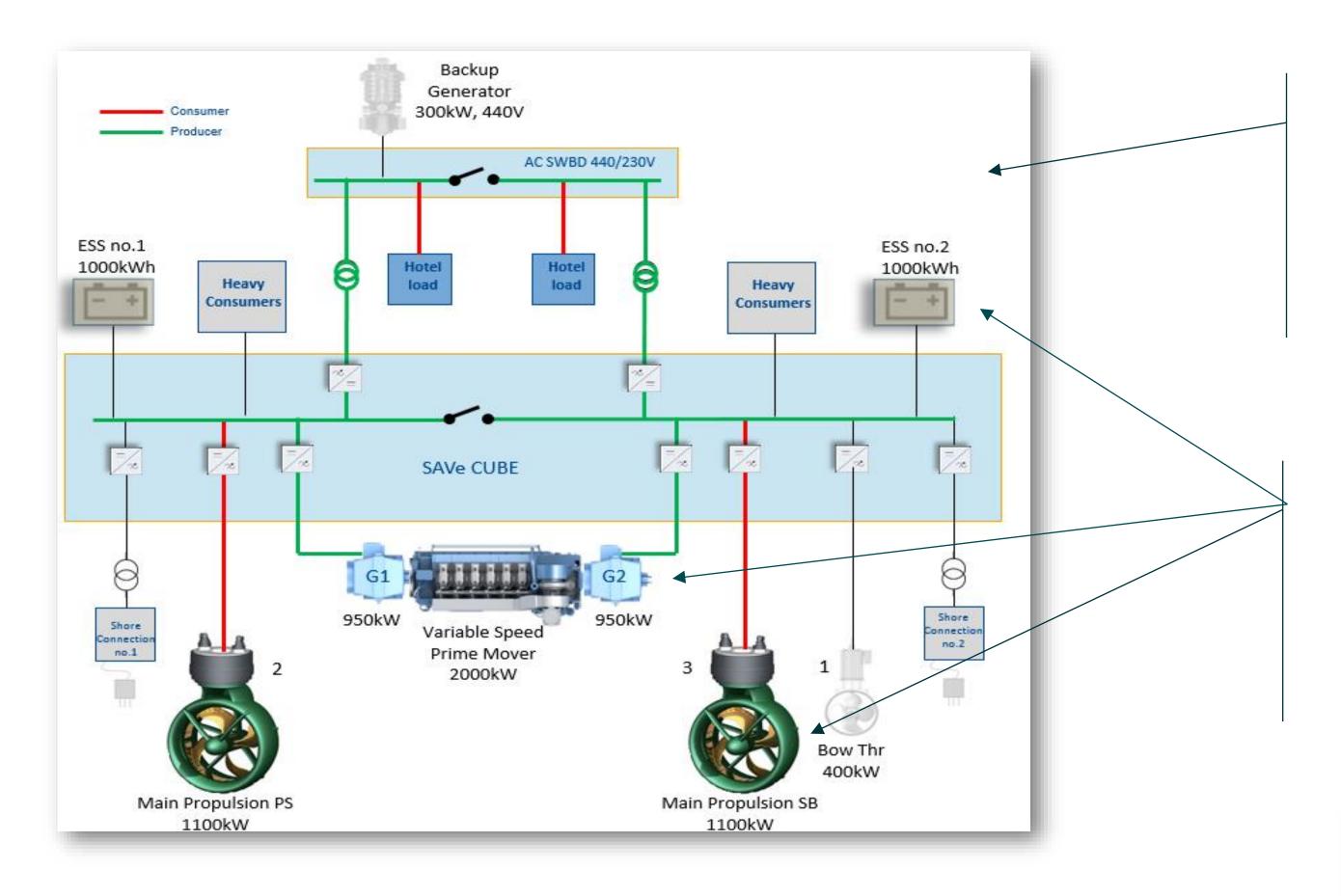


Example of RAM module





Machinery Systems features for Remote & Autonomous Vessels



High availability systems

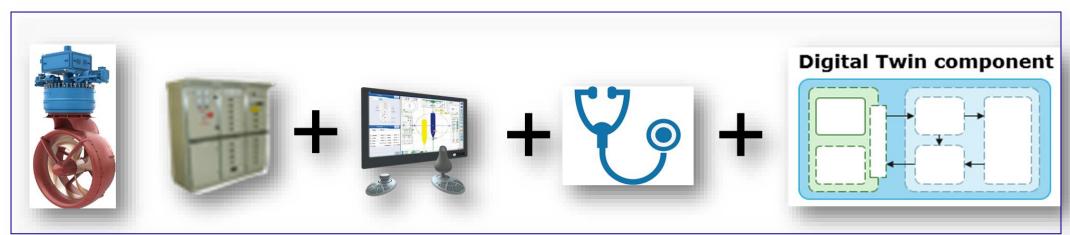
Availability of main functions Fault tolerant design Modularized design

...made up of...

Cyber-physical products

Product reliability
Maintainability
Standardization
Self contained / Distributed intelligence

HW + Control + Health & Performance + Digital Twin





External and Internal Situational Awareness

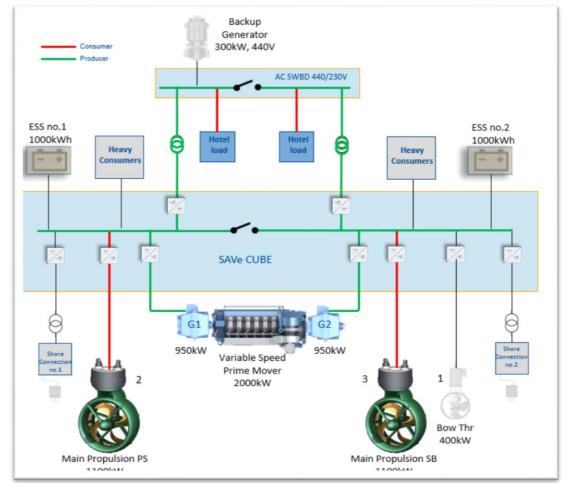


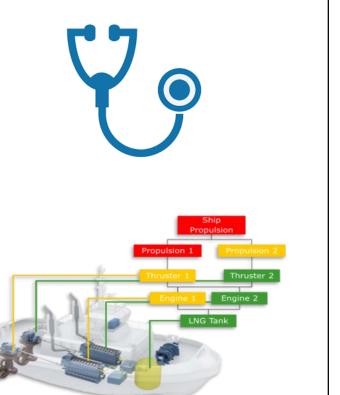
- Information about external context
 - Static and dynamic objects
 - Environmental conditions
 - Criticality level
- Decision support
- Remote and Autonomous operations





- Information about internal state
 - Health and Performance
 - Availability of functional modes
 - Robustness level
- Decision support
- Remote and Autonomous operations







Key control system functions for Autonomous Machinery Systems

ARMS ACON Resource Management System

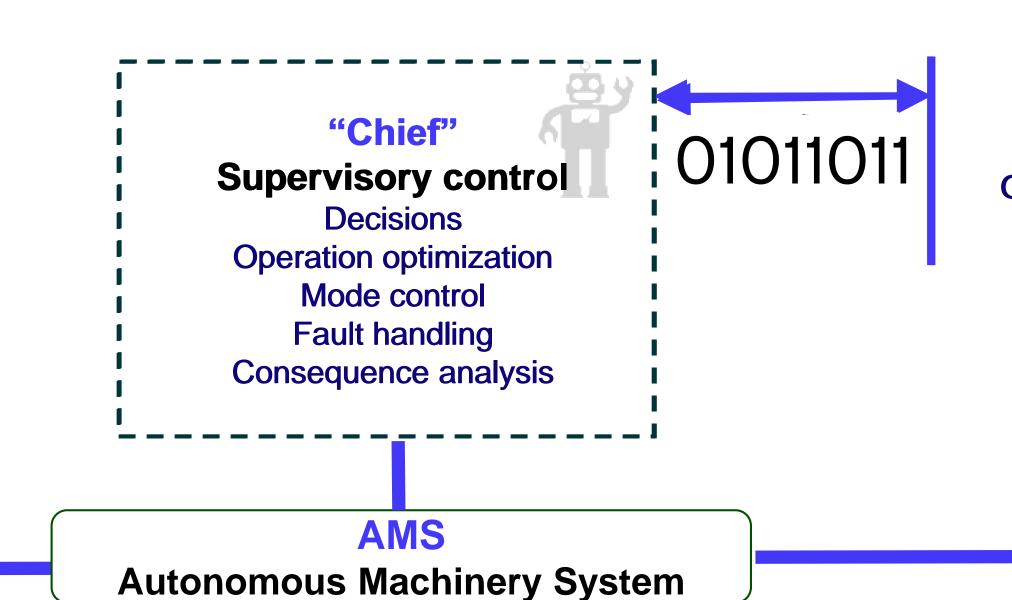
Assess availability of functional i

Estimate system robustness level

State and dependencies of resources

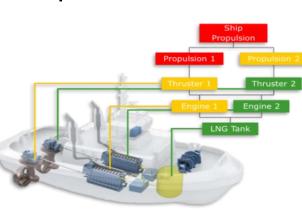
Alarm tree and risk model

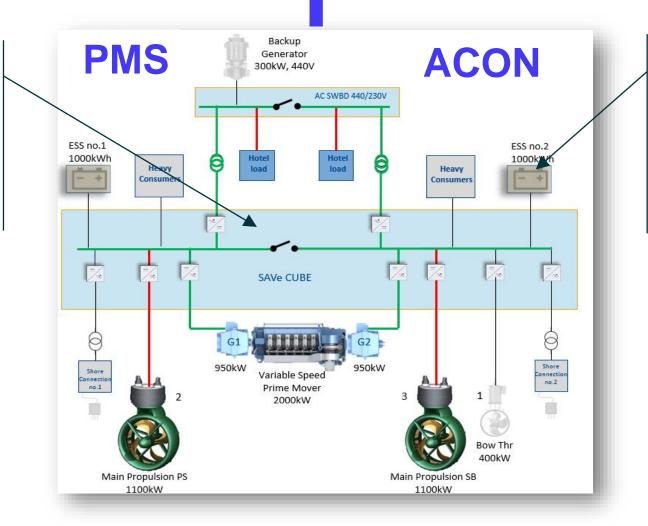
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High availability systems

Monitoring of system availability, robustness and performance





Cyber-physical products

Monitoring of products health and performance



"Captain"

Supervisory control

Decisions

Gets machinery status information from "Chief" Controls vessel modes Inform "chief" about criticality level

Distributed Health and Performance monitoring system

Online monitoring for resource management and remote life cycle support

Anomaly detection Self diagnostics

Performance Monitoring

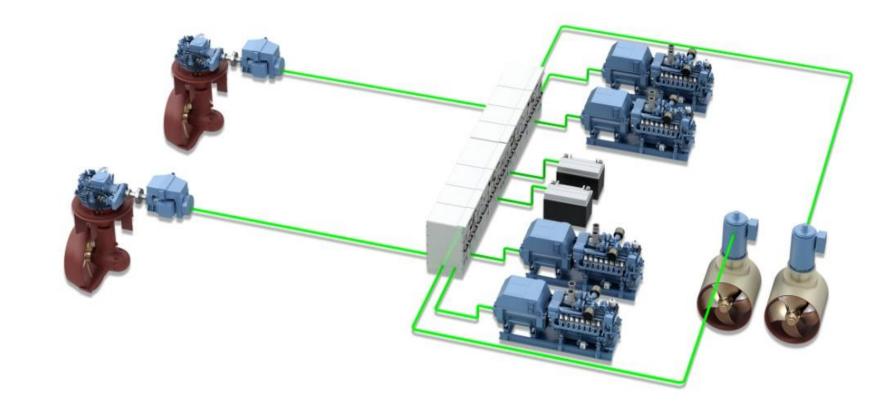
Prognostics
Service notifications



Technology selection

Conventional systems

- Consumption: Mechanical, electric or hydraulic
- Distribution: Shaft lines, diesel- electric, hydraulic systems
- Generation: HFO, MDO, LNG, Dual fuel/Multi fuel engines

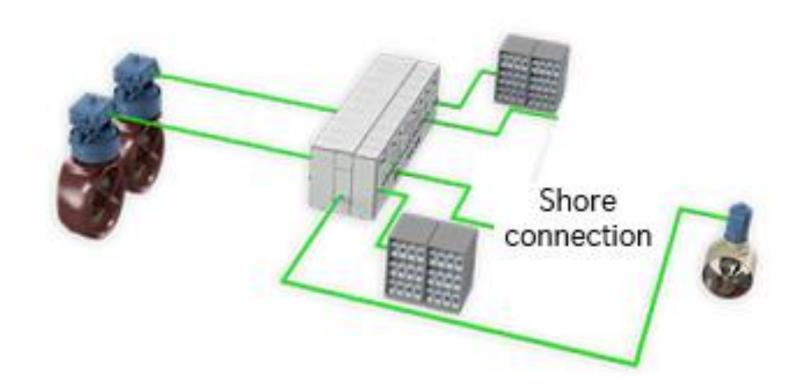


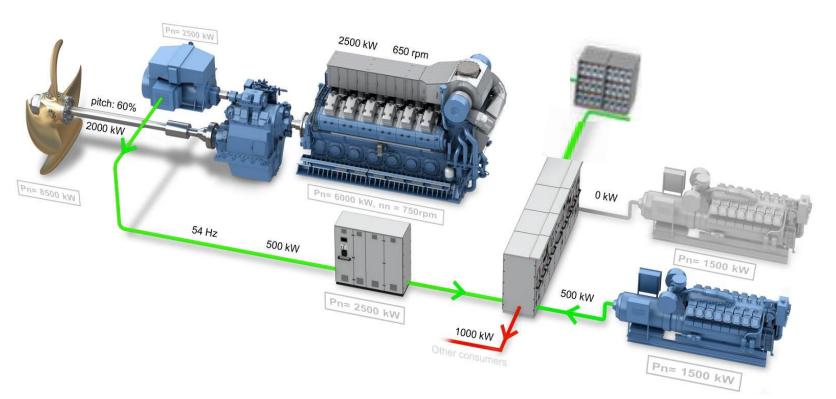
Electrical system

- Consumption: Electric
- Distribution: Frequency converters, Energy storage
- Generation: Batteries, Shore connection Fuel cells, solar, wind and waves

Hybrid systems

- Consumption: Mechanical and electrical
- Distribution: Mechanical and electrical (PTI/PTO)
- Generation: Engines, energy storage and shore connection





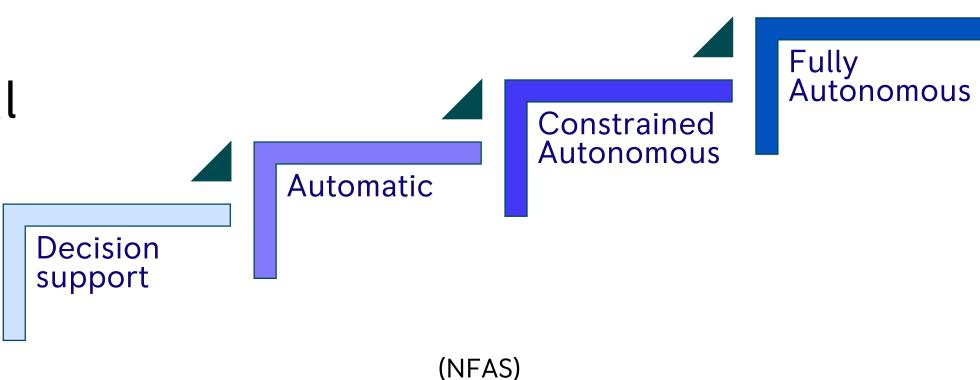


Technology selection

- Selection criteria
 - Mission requirements
 - Availability of technology
 - KPI
 - Constraints (rules and regulations)
- Some important factors
 - Level of autonomy and manning level
 - Optimum combination of conventional and electrical
 - Energy efficiency, fuel consumption, emission
 - Service and maintenance strategy
 - Rules and regulations
 - Logistics



(HOLISHIP – H2020)





Summary

- RRM deliver complete vessel solutions
 - Vessel Design and system integration
 - Propulsion and steering, deck machinery, power systems
 - Automation and control systems
- Digitalization is a key enabler for autonomous ships
 - Asset management new business models
 - Remote & Autonomous functions
- Basic Digital infrastructure has been established
 - Cloud solution
 - Connectivity and Cyber security solutions
 - Four centers are being established (Intelligent Analytic-, Fleet Operation-, Simulation- and Shore Control Centre
- First version of Intelligent Navigation Systems has been demonstrated
 - SISU and SVAN demonstrations in 2017-2018
- Intelligent Machinery Systems is being focused now
 - Autonomous Machinery Systems (enabling Remote and Autonomous operations)

