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Optimization of Power and Station Keeping Installations by a Total System Design Approach

Dynamic Positioning Conference
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Outline

- Introduction
- Integrated Systems
  - Total Integration
  - Total Simulation
- New Technologies for Functional Integration
  - Energy Management
  - Thrust Allocation
  - Weather Optimal Positioning
  - Passive Non-Linear Observer

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Total Integration

Power, Automation, and Positioning System

The exacting requirements as to vessel *performance*, *environmental aspects* and *overall safety* have resulted in an increased focus on the total vessel concept and the interactions between the different equipment and systems installed. Flexibility in operation has enabled electric power generation and distribution systems for propulsion, positioning, oil production, drilling, and loading, where all equipment and control systems are integrated into a common power plant network and automation network.

Positioning systems have been commercially available for marine vessels since the 1960s. However, it is only in the 1990s that fully integrated electric power, automation and positioning systems have become commercially available. In the international marine, oil and gas markets, there is a few vendors able to offer such solutions. ABB is unique as a total supplier with uniform in-house products, and this uniqueness is applied to create the optimum solution for the environment and customer with respect to vessel mission, energy consumption and safety.

However, there is still a potential for substantial cost savings and energy optimization for such vessels by applying new solutions based on so-called *in-between technology* within the fields of control, electric power and marine technology. ABB is addressing these issues with substantial R&D efforts. Some of the results will be presented.

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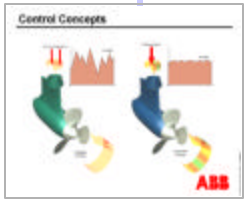
Sub Systems

OS

Controllers



Local Control I/O

Drilling

VMS

Positioning System

PMS

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Sub Sea Systems (continued)

- The power and automation installation for a vessel with station keeping capability is a complex system, and any engineering approach will start to split up in sub-systems for design, engineering, testing, etc.
- Simplified, the approaches are either, or in combination:
- Vertical:
- Positioning system, Vessel Management System, Power Management System, Drilling control systems, Cargo handling control system, etc.
- Horizontal:
- Operator station (MMI), Controllers, Local controllers (PLCs, motor controllers, governors, drilling controllers), etc.
- Regardless of how one select to split system, horizontally or vertically, or combination of these, one will always find that there is a large extent of interaction between the systems, influencing the total functionality of the installation.

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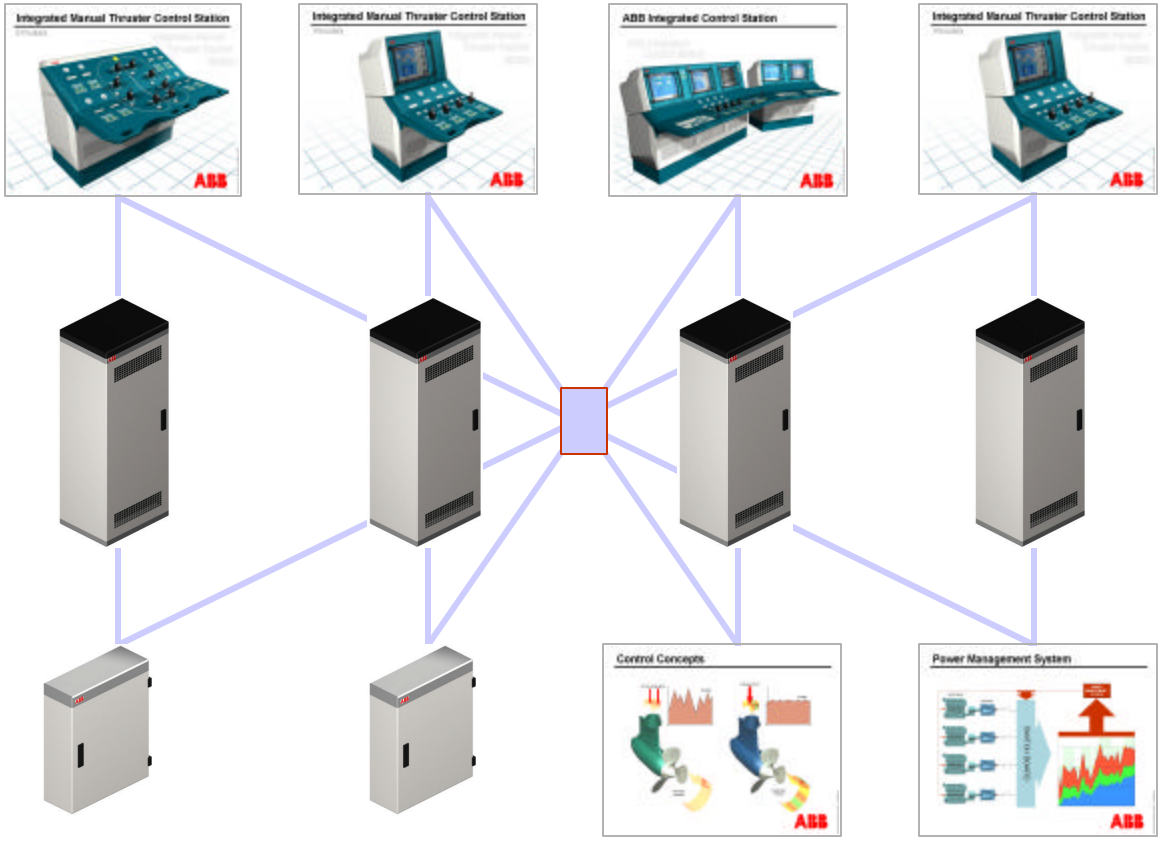
Real System



Drilling **VMS** **Positioning System** **PMS**

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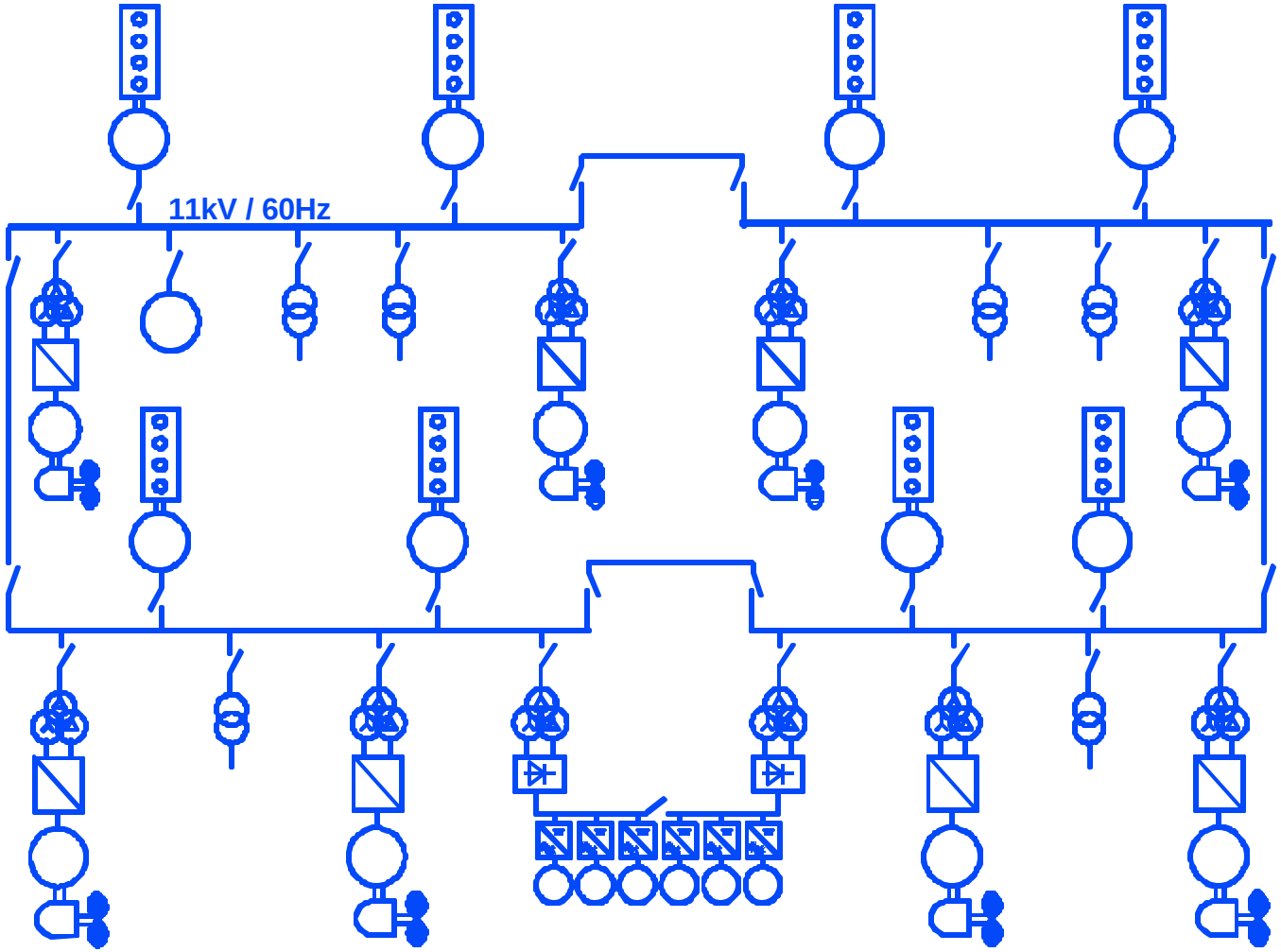

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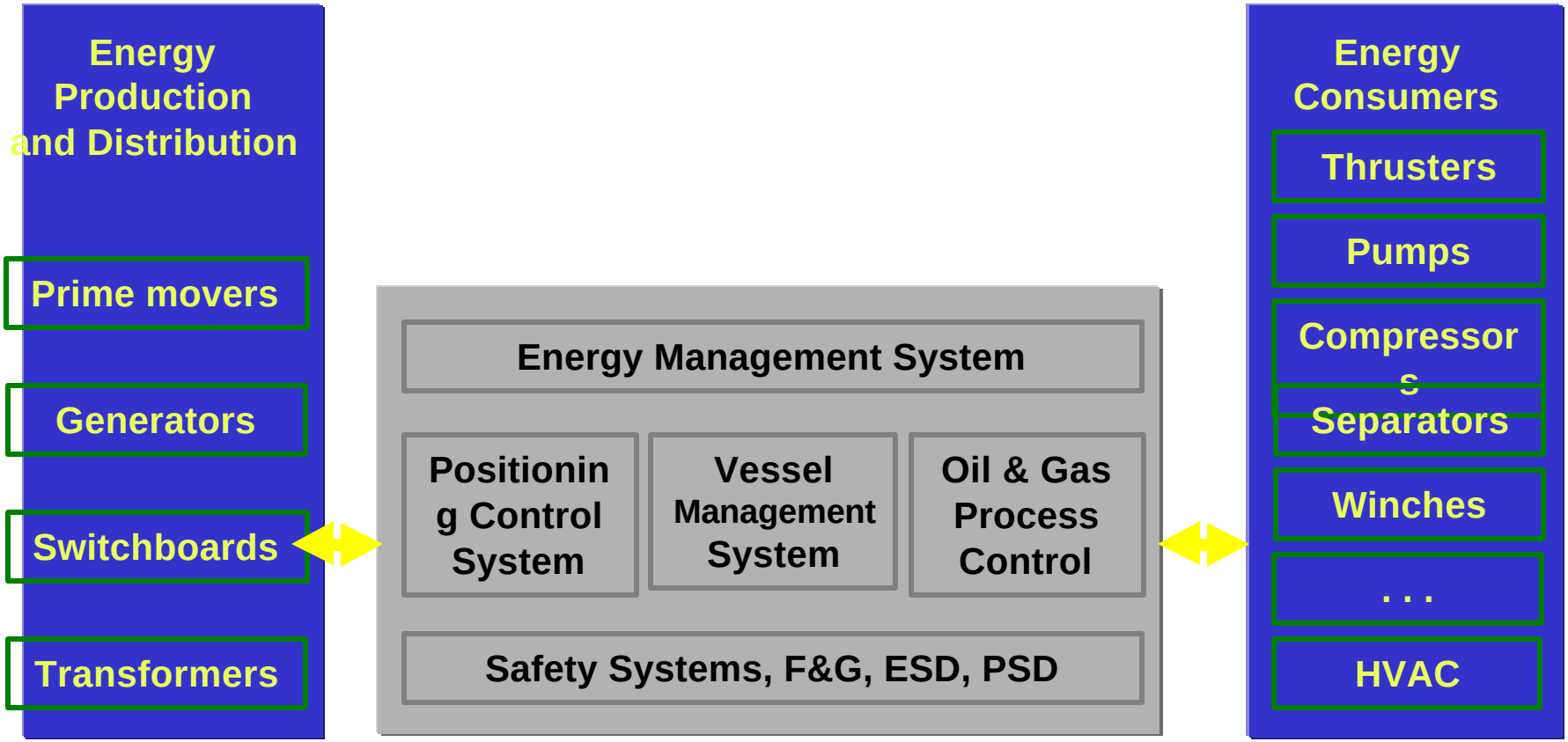
Energy Management System



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Sub Systems

Characteristics

- Separate:
  - Purchasing
  - Specification
  - Design and Simulation
  - Engineering
  - Testing
  - Commissioning
  - Operation, Maintenance
- Interfaces
  - Hardwired
  - Bus / Serial

Typical problems

- Interfaces
  - Scaling and interpretation
  - Communication protocols
  - Control and sequences
- Functionality
  - Power Management
  - Load reduction/shedding
  - Integrity
- Testing, Commissioning
- Maintenance, Upgrading

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Integration - and Functional Physical

- Reduced risk for yard and shipowner
- Simplified engineering and installation
- Fieldbus with single point of process signal I/F
- Reduced spare and maintenance costs
- System integrity
- Safe and ergonomic operation with unified Man-Machine Interface
- Uniform training and documentation
- Financing
- Better overall performance and system stability
- Intelligent and predictive blackout prevention
- Auto / remote control of motor starters
- Sleeping mode
- Optimal Energy Management
- Condition monitoring

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The Total Integrated Automation System

- Information Management
- Simulation
- Remote Diagnostics

Plant Network

- Integrated Monitoring & Control
  - Integrated Alarm System
- Integrated Thruster Control
  - Dynamic Positioning
  - Positioning/Mooring
  - Autosail
- Thruster Control
- Integrated Operator Workplace

Control Network

- Cargo Control
- Drilling Control
- Safety Systems
  - Process Shut Down
  - Emergency Shut Down
  - Fire & Gas
- Energy Management
- Power Management

Fieldbus Network

- Distributed Control
  - Local Engine Control and Safety
  - Drives
  - Power Generation & Distribution
  - Thrusters
  - Propulsion

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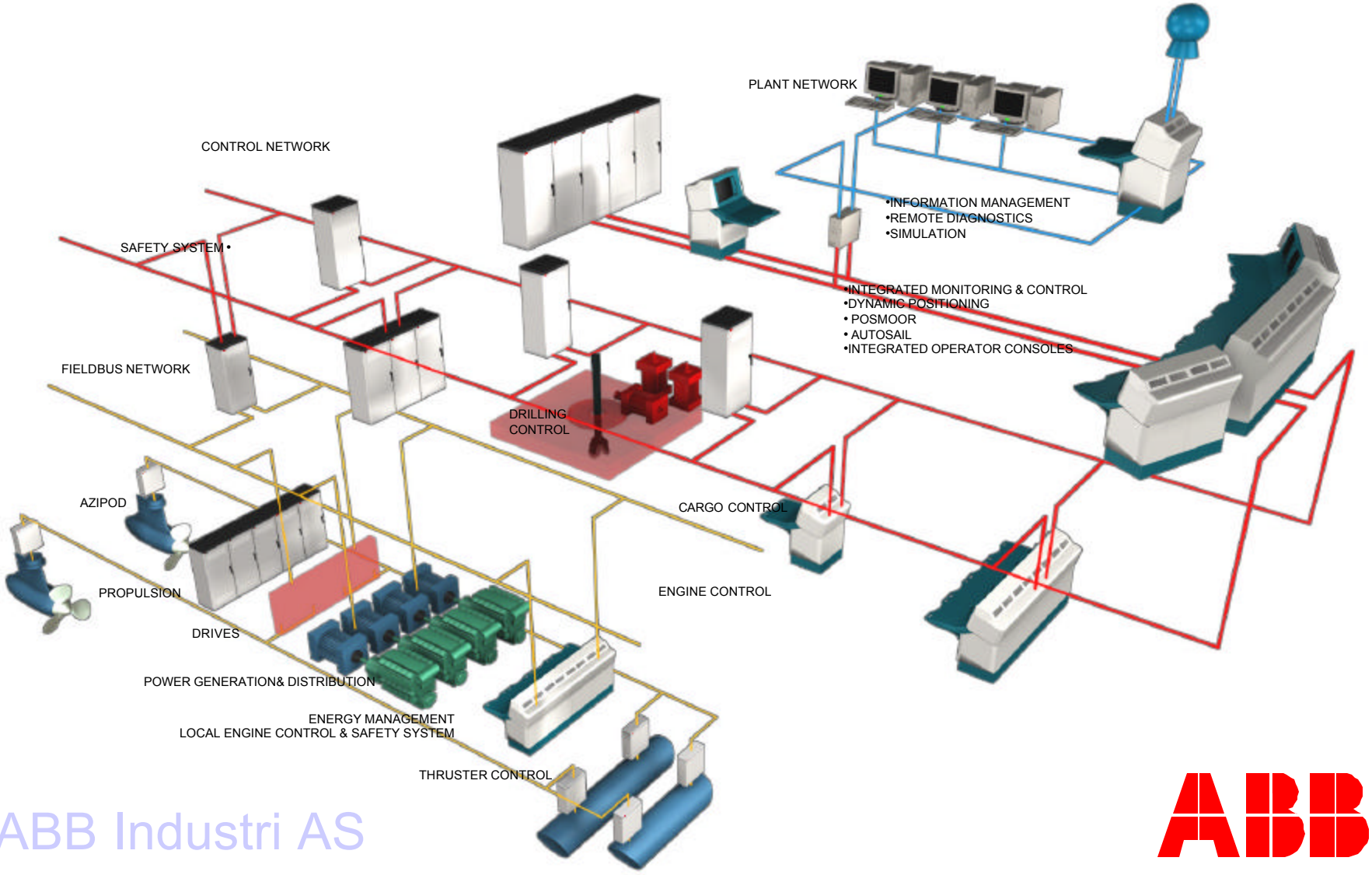
The Total Integrated System for Marine

Automation & DP - Power Generation & Distribution - Propulsion & Drives



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Integrated System on FPSO

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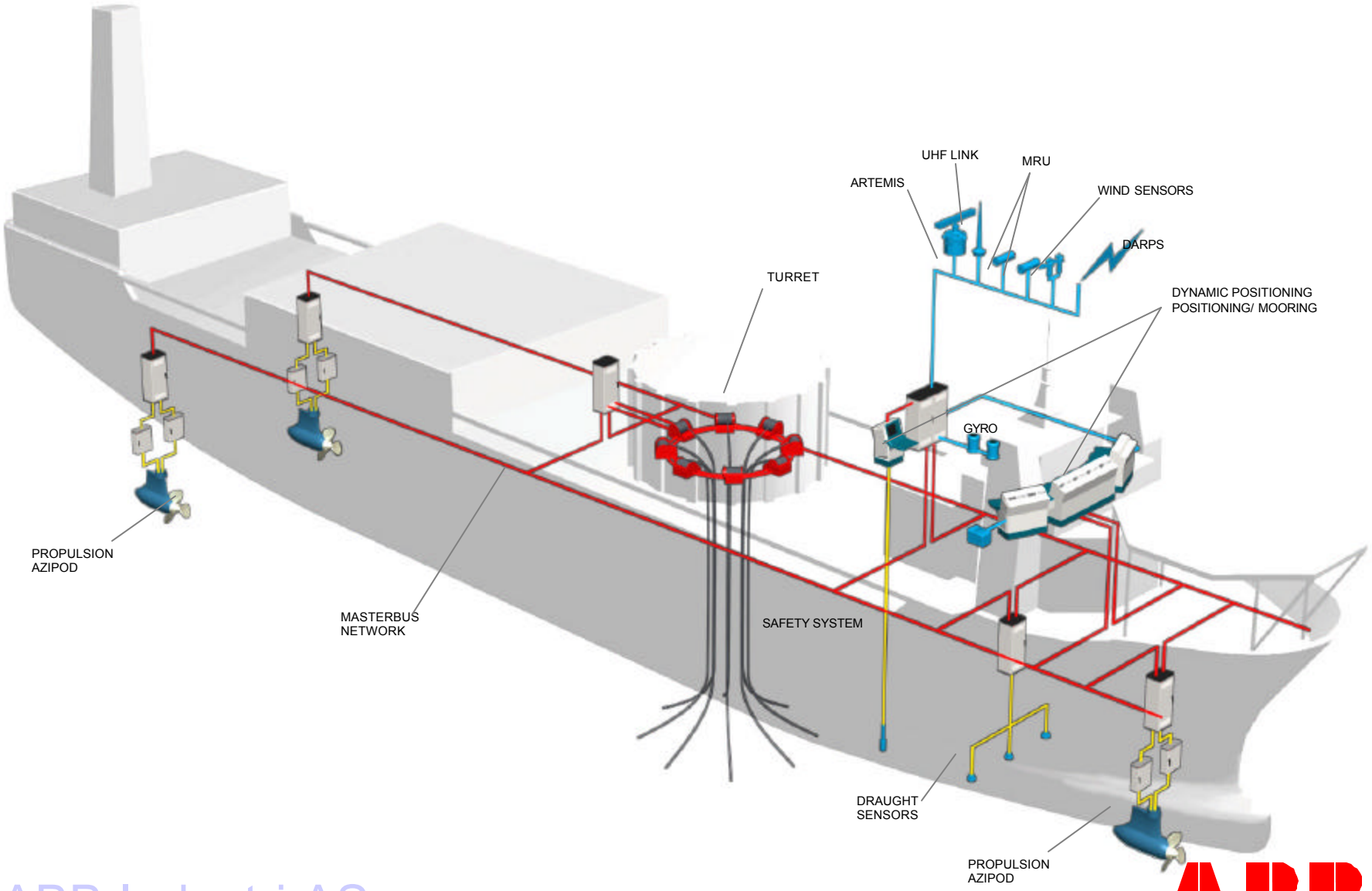

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Applications - Posmoor FPSO

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Applications - DP 3 Drilling

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Total Simulation
Simulation of Complete Vessel, Power, Automation, and Positioning System

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Simulator Characteristics

- Dynamic Vessel Model
  - 6 DOF model
  - Thruster / propeller model with dynamic losses
- Dynamic Power Model
  - Generators
  - Distribution
  - Thrusters and propulsion
  - Drilling, etc..

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Total Simulation
Simulation of Complete Vessel, Power, Automation, and Positioning System

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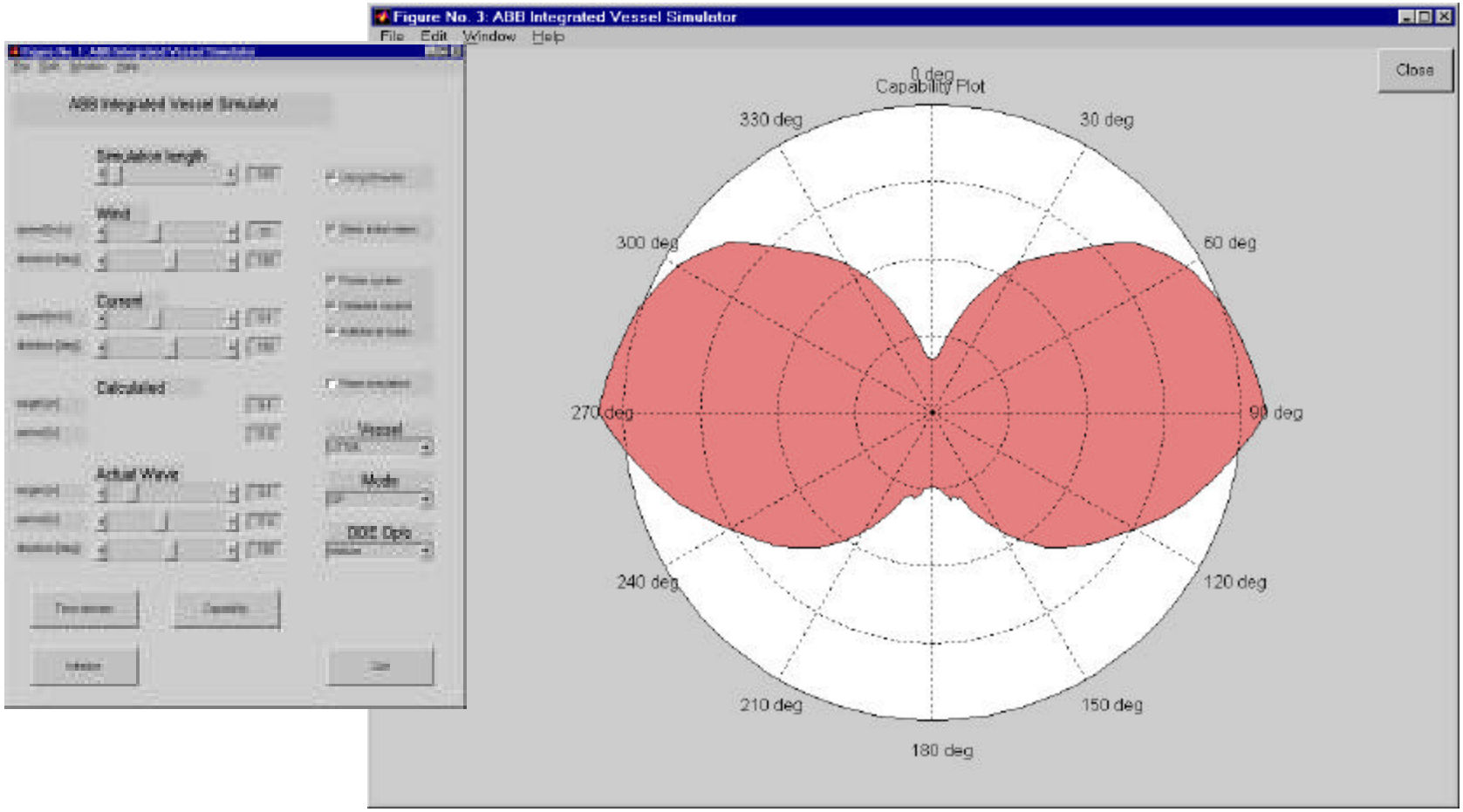
Capability Plots



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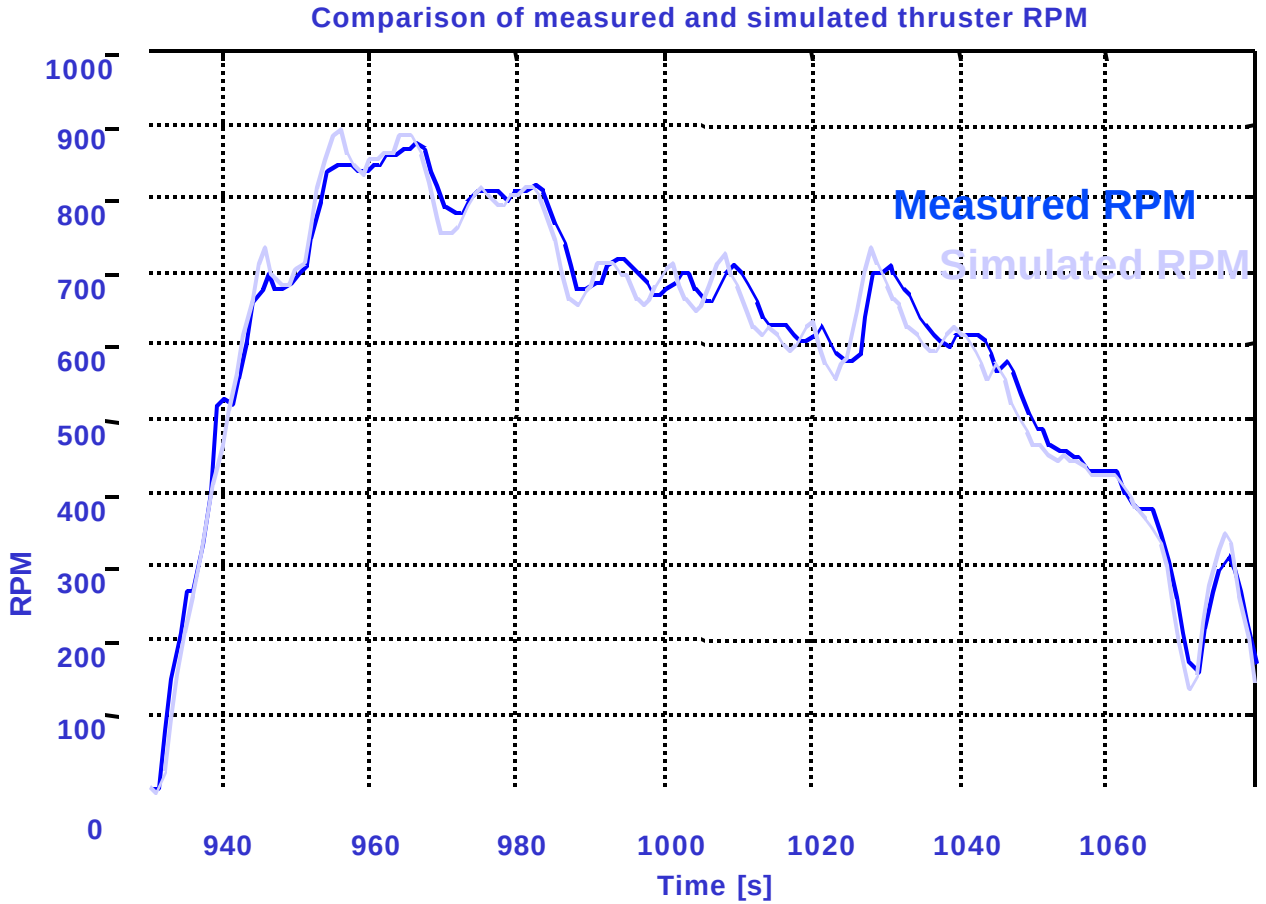
Thruster Dynamic Model Verification



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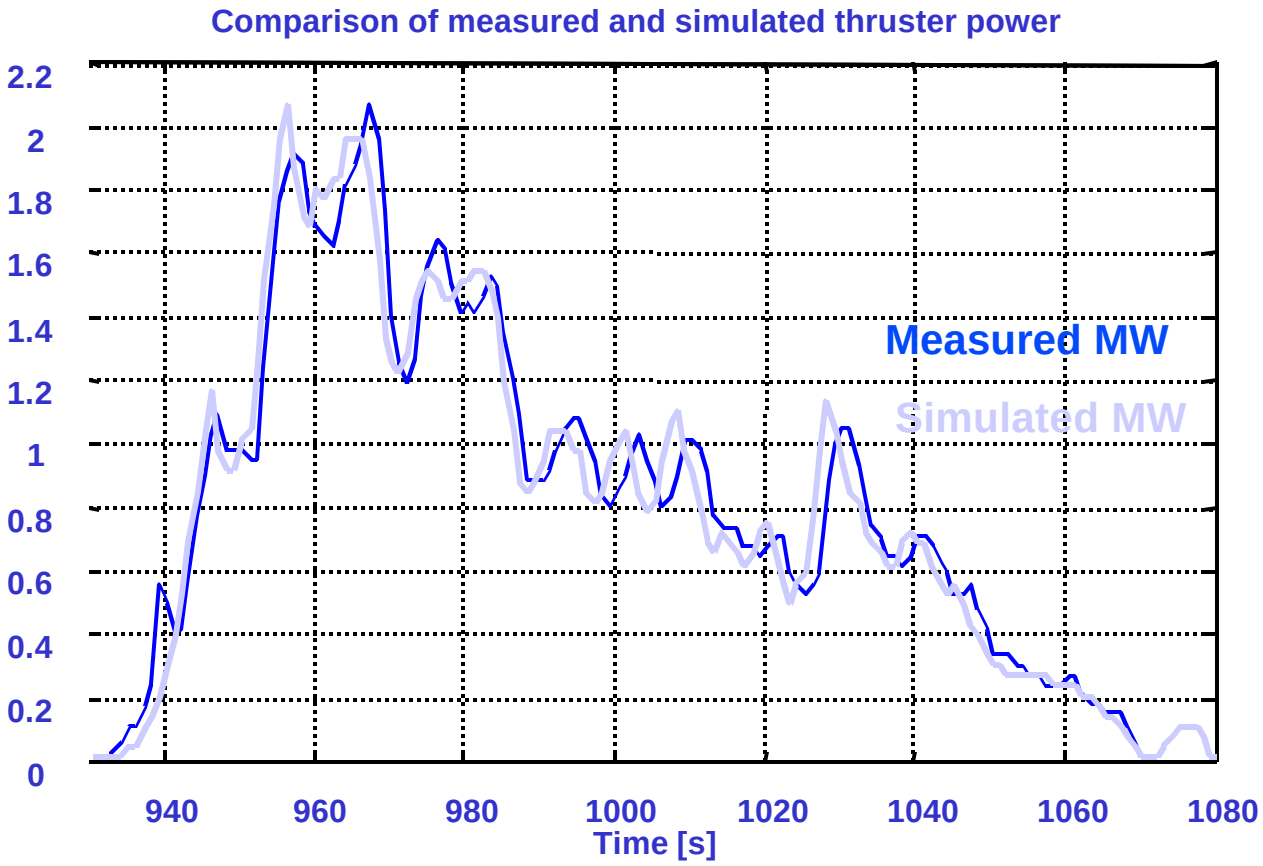
Thruster Power Model Verification



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Why Total Simulation?

- Design
  - Test new concepts, simple and unrestricted
  - Constraints in thruster and power system
- Engineering and Commissioning
  - Static analysis - Dynamic verification
  - Pre-tuned by simulation, extreme conditions
- Sea Trial
  - Reduced time for tuning
- Training

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Applied State-of-the-art Control Theory

Using state-of-the-art non-linear theories and methods for control and estimation, optimal solutions have replaced ad-hoc solutions

Examples:

- Thrust Allocation
- Weather Optimal Positioning
- Passive non-linear Observer

True optimal, generic and configurable control algorithms, more robust and simpler to tune

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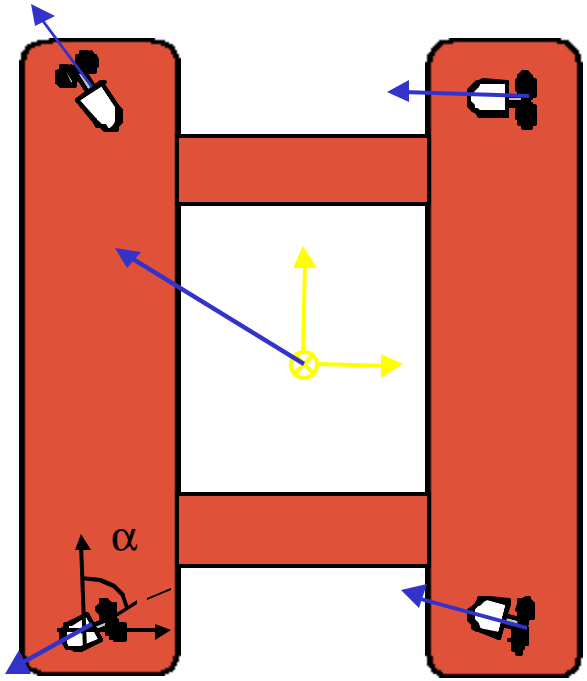
Thrust Allocation



Find optimal thruster angle and thruster force equal to commanded forces (surge and sway) and moment (yaw)

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Thrust Allocation

Method:

- Non-linear optimization with constraints

Features:

- True optimal with respect to,
  - Fuel - Tear and Wear - Position
- Generic, any vessel type configurable
  - Azimuth, Azipod, Tunnel, Propeller+rudder, ..
  - Forbidden / Restricted zones and speeds, ..
  - No of thruster running, Priority

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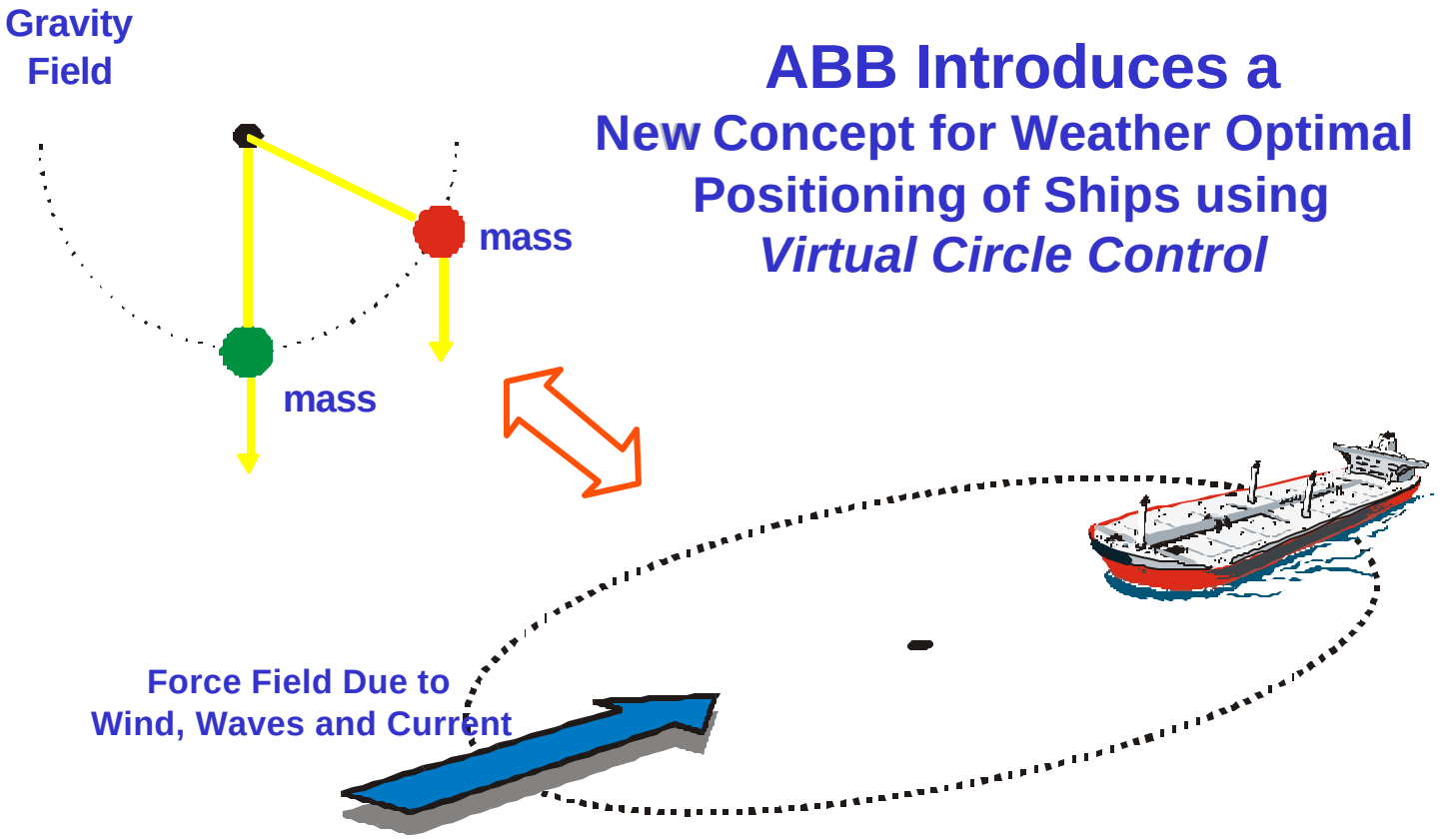

ABB Introduces a New Concept for Weather Optimal Positioning of Ships using *Virtual Circle Control*

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Passive Non-Linear Observer

Method:

- Passive non-linear control theories

Features:

- Robust
- Continuous, without gain scheduling
- Based on physical models
- Quick adaption
- Replaces Kalman Filter

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Summary

- Aspects of Total Integration
  - Physical Integration
  - Functional Integration
- Functional Integration
  - Total System Simulation
  - Optimized Design and Control
- Total System Simulation
  - Verification
  - Pre-Tuning