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DP Conference, Houston October 17-18, 2000

Challenges related to propulsion equipment and their interface to the Dynamic Positioning System

By: Lars Kristian Moen, Kongsberg Simrad Inc.

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The Challenge

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Definition of a “DP System”

- DP Computers, interface electronics, cabling, monitors, panels and joystick
- DP software to provide functionality and user interface
- Sensors
- Position Reference Systems
- Power Systems
- Propulsion System to provide required forces and moments and the interface to this system
- The Operator
- The total system will not be better than the weakest link
- DP Systems are demanding to the actuator system due to its dynamic nature

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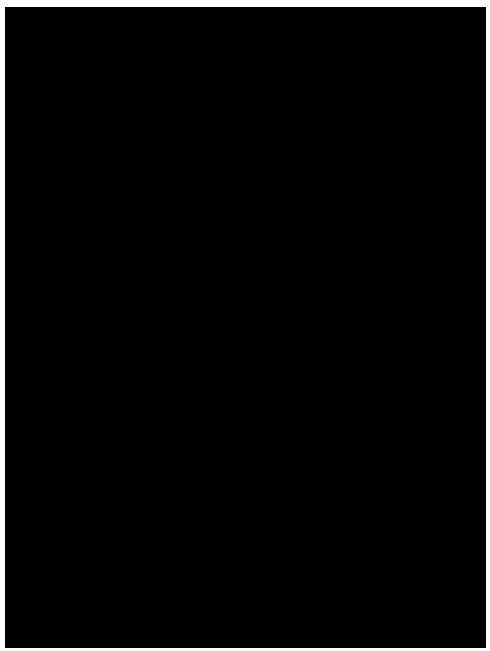
“Sub” Challenge

- Common understanding of the challenges among parties involved
- Overall performance requirements based upon knowledge and understanding
- Realize that selection is often a tradeoff between requirements that sometime are in different directions
- Propulsion systems (electrical, hydraulic, mechanical) that are designed and made for continuous DP control
- DP systems that to some degree can tolerate that the “real” propeller is not according to the “ideal” propeller
- DP systems and thruster control systems that provides fault diagnostics when something is not working as expected
- Platform Supply Vessels operating close (20-30ft) to rigs is often a critical application



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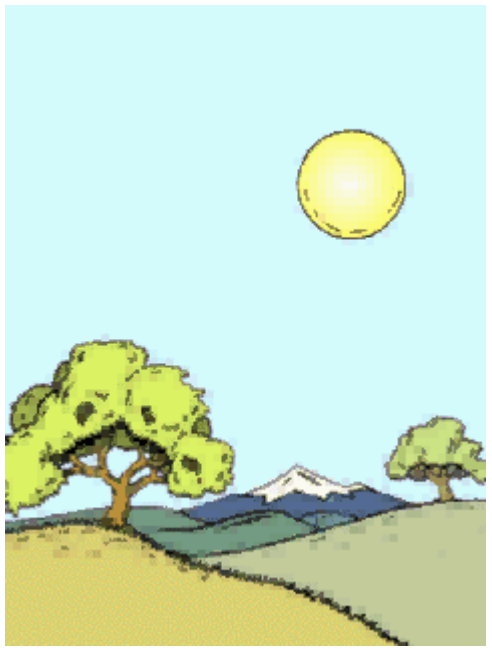
Experiences

- Thruster Control systems with no closed loop control
- Delays related to clutch operation
- No shaft brakes for main propulsion
- Lack of feedback sensors for pitch, RPM and azimuth
- Signal span is limited (setpoint and feedback)
- Questionable Fail to Safe logic especially for CPP units
- Tradeoff of accuracy can often be accepted, but what about safety ?
- Thruster control systems with pneumatic control involved often show less repeatability than electric
- Some systems with more wear and tear than expected for CPP main propulsion
- Operator related and reference system related….



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Power System for a DP vessel

- "Diesel mechanic" power
  - Mechanical and/or hydraulic transfer of power from diesel to propulsion forces
  - Alternators (AC generators) to produce electric power to other marine operations and hotel requirements
  - Mechanical power transferred to propulsion forces via gearbox, clutch and shaft. For hydraulic propulsion units hydraulic proportional or servo systems will be used.
  - If FPP, the RPM/Force of the propeller is controlled via the diesel governor
  - If CPP, the Pitch/Force of the propeller is controlled via a hydraulic pitch control system
- "Diesel electric" power
  - Diesel engines powering AC generators
  - Switchboards powering electric thruster/propeller motors/drives and other electric consumers via transformers
  - Different solutions of frequency conversions (cycloconverters) and Pulse Width Modulation (PWM) are used to obtain variable speed AC drives
  - Automated Power Management Systems handles the power plant

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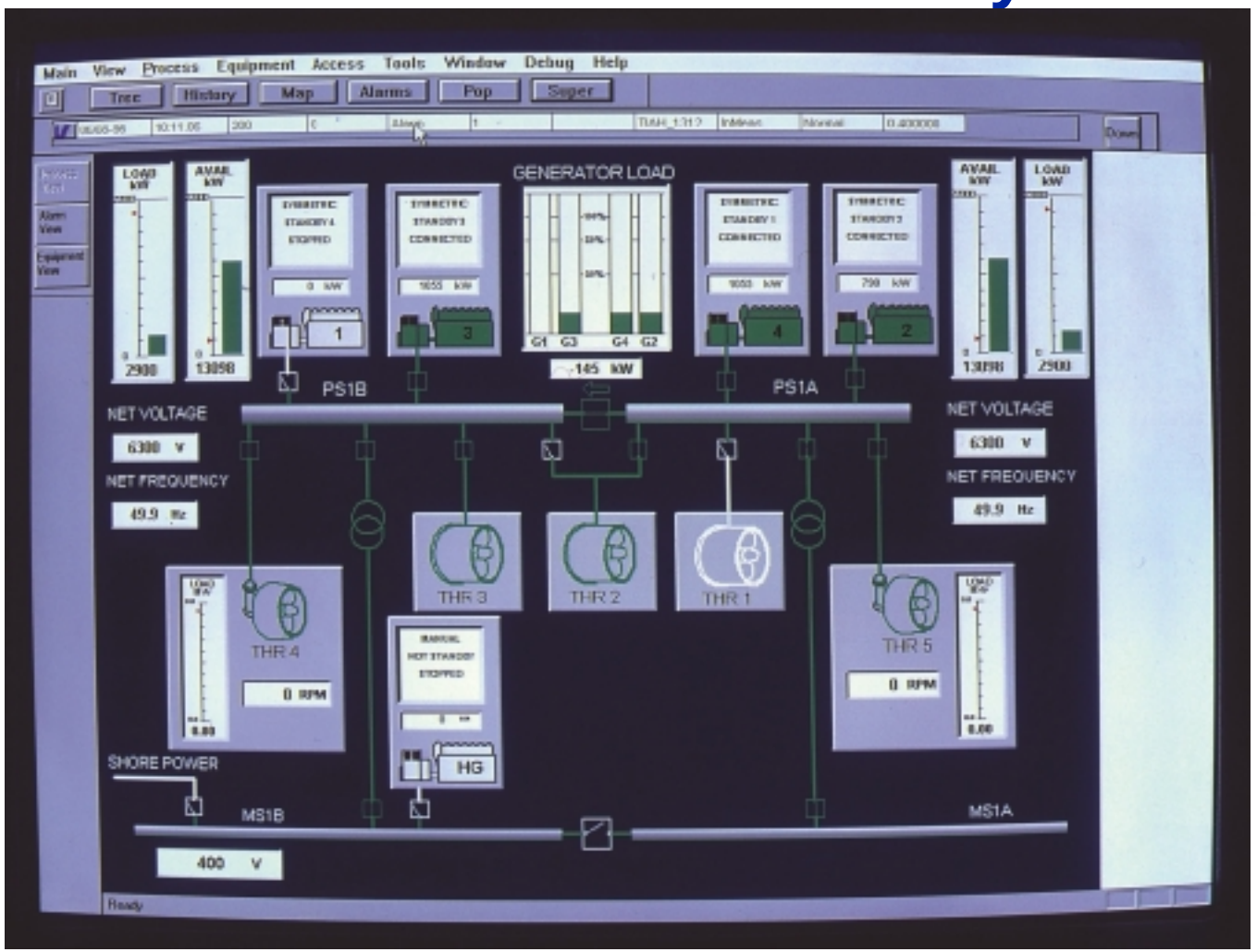
Diesel Electric Power System



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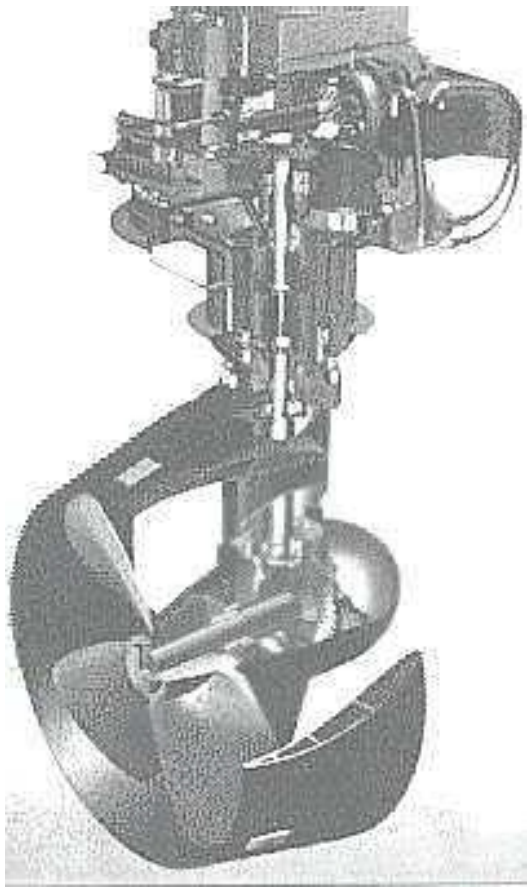
Propulsion Units for a DP Vessel

- Main Propellers
  - Mechanical via diesel engines, gearbox, clutch, shaft and usually a hydraulic pitch control system
  - Electrical via AC drives and gearbox
  - w/w.o. rudders
  - Independent or linked rudders
- Azimuth / Z-Drives
  - RPM controlled via mechanical dedicated diesel engine
  - RPM controlled via AC drive
- Tunnel thruster
  - RPM controlled
  - Pitch controlled



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Propulsion units as seen from the DP

- Thruster Models
  - Max/Min forces
  - Force to pitch/RPM curves
  - Power to pitch/RPM curves
  - Moments arms,
  - Response time, rise and fall times
  - Dead Band
  - Hysteresis
  - Thruster Hull Interaction
  - Thruster Thruster Interaction
  - Forbidden (dead) zones
  - Fixed angles or variable angles
  - Clutch delay logic (Idle Speed to engage clutch)
  - Idle Speed logic, thruster bias
  - Non reversible FPP (usually azimuth/z-drive)
  - Thruster configuration flexibility (type and geometry)

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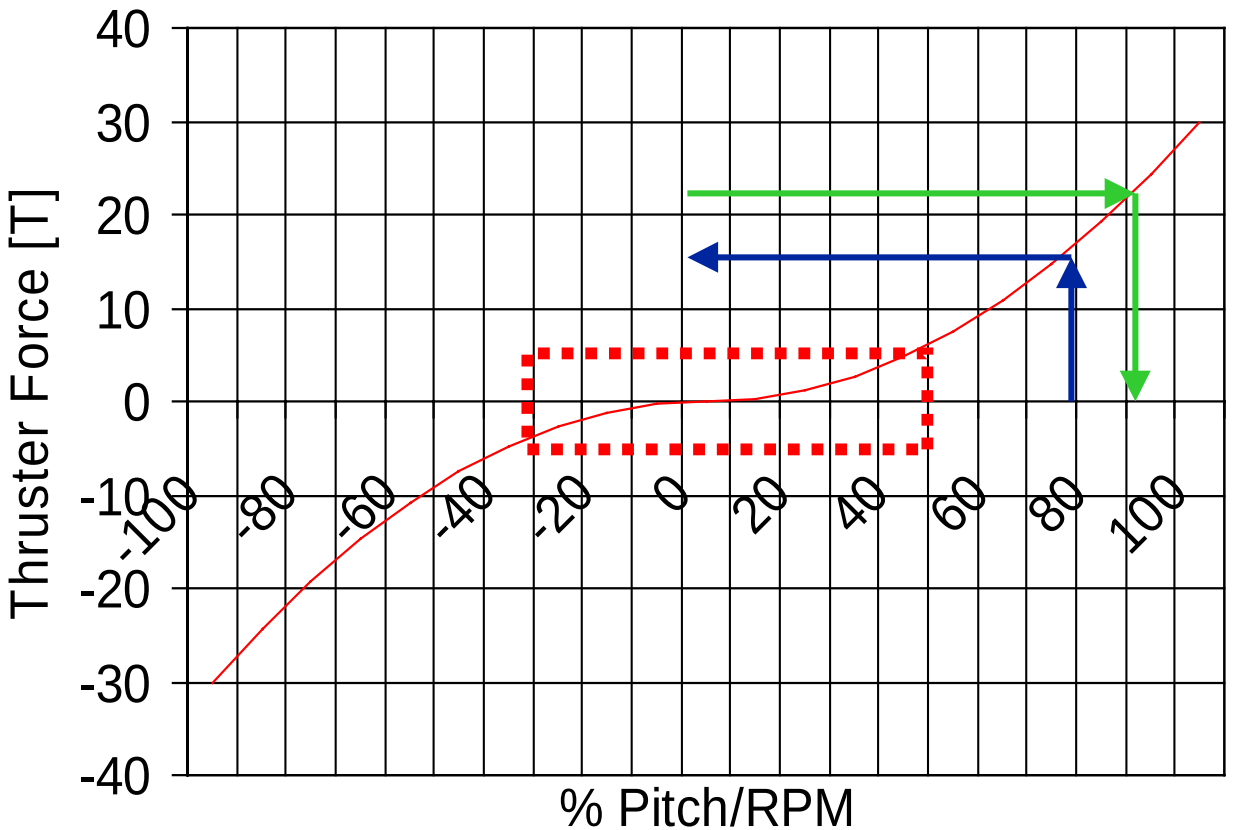
Thruster Models, Force-Pitch/RPM



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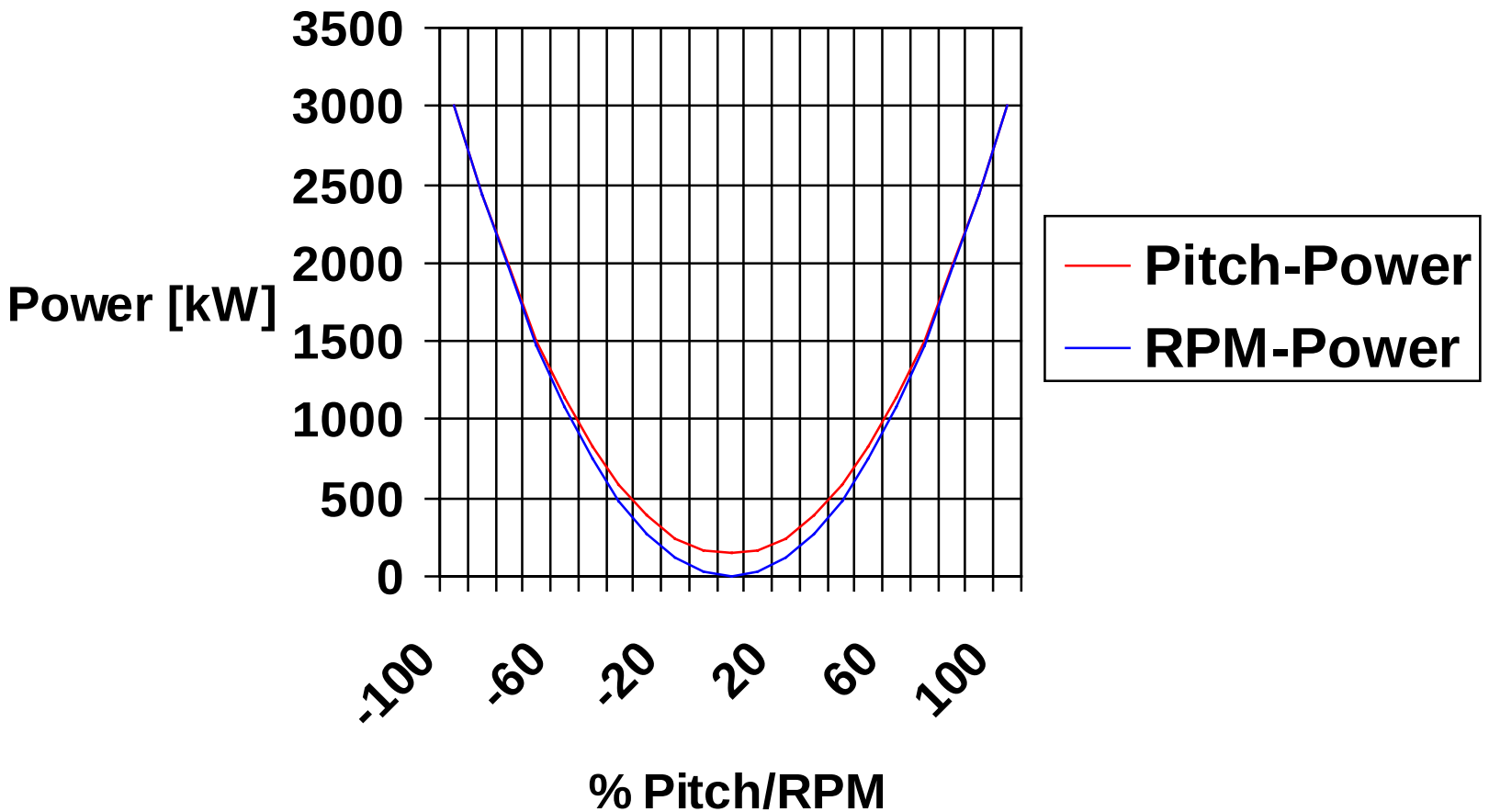
Thruster Models, Pitch/RPM-Power



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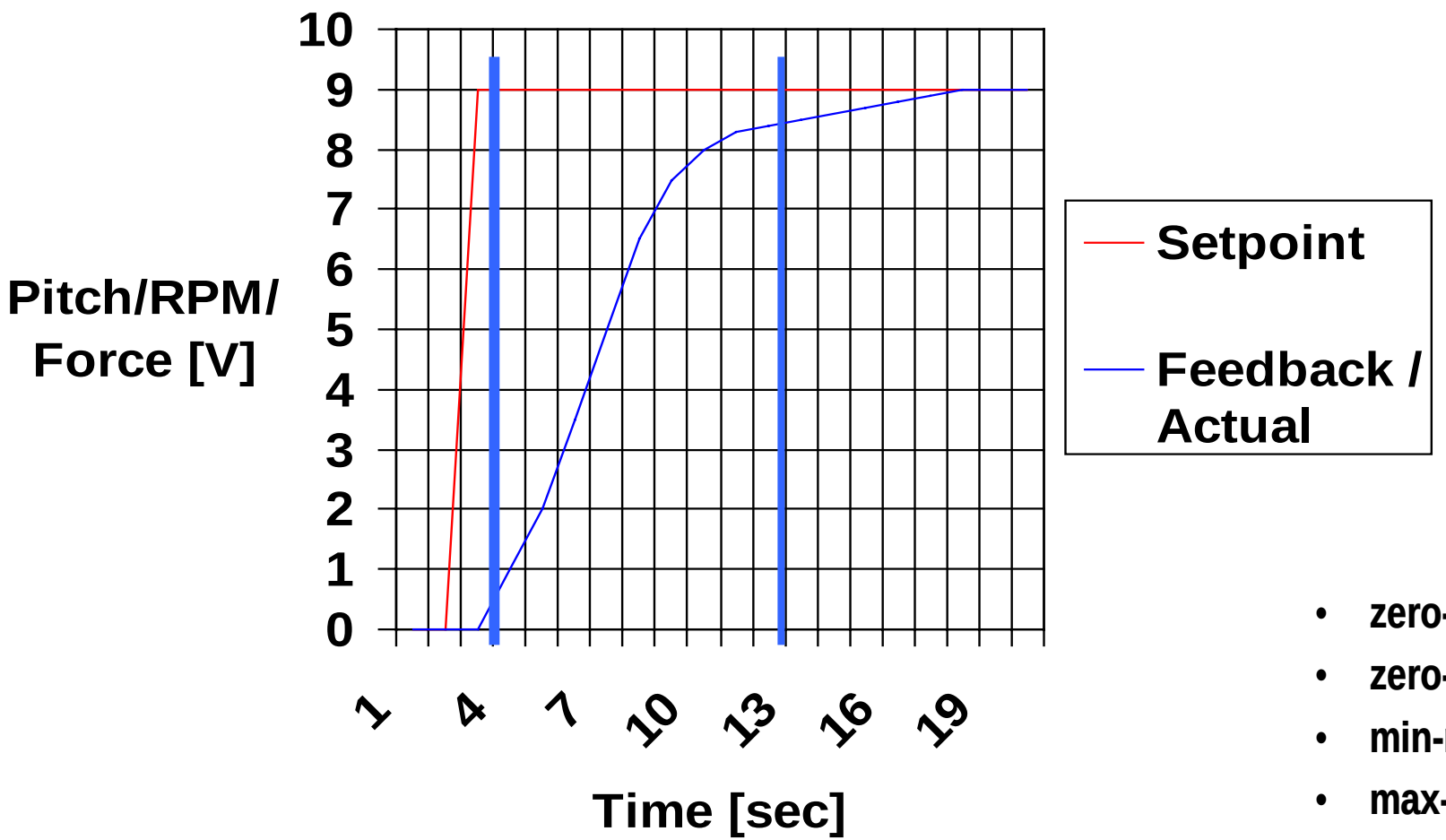
Thruster Response Time



- zero-max
- zero-min
- min-max
- max-min

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Guide for Requirements

- Station Keeping Accuracy
  - Depends on the DP Application/Operation
- Power and Force/Moment
  - Required Environmental Operational Envelope
  - Power/Propulsion efficiency
- System Availability Considerations
  - DP Application
  - Duration of Station Keeping (intermittent duty, continuous duty)
  - Client, Flag State, Classification Society, Vessel Owner policy/requirements
  - Operational Safety/Risk considerations
  - Failure Mode Effect (Consequence) Analysis (FMEA/FMECA) studies (Fail to Safe)
  - ABS: DPS-1, 2, 3

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Tradeoffs in selecting equipment and solutions

- Vessel Speed performance for transit
- Vessel maneuverability
- Vessel Station Keeping performance
- Investment costs
- Owner supply or yard supply
- Where is the operation ?
- Maintenance schedule accepted for the vessel and its equipment
- Power consumption for operation
- DP system software can adapt to limitations in propulsion equipment, but not without consequences
- Station Keeping accuracy can be downgraded due to physical limitations of actuators, but this is sometimes a sign of mismatch between expectations and implementations

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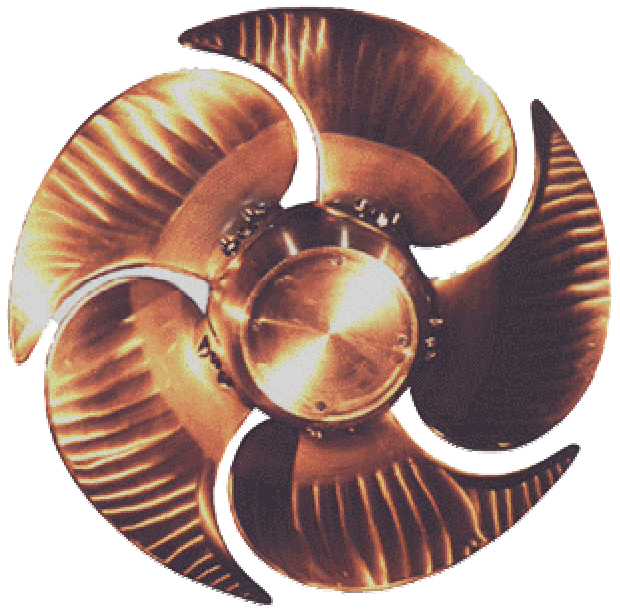
DP Propulsion Setpoint

- Internally the DP calculates individual setpoints for thruster forces and directions
- At each cycle (e.g. 1 Hz) the DP system generates a new setpoint for each propulsion unit.
- The individual forces are transferred to pitch and/or RPM setpoints
- The RPM and pitch setpoints are sent to the thruster control units as voltages (+/-10V) or currents (0-20 mA)
- The DP system “expects” the thruster control units to accept the setpoints and make sure the pitch and RPM always become the same as tested and verified during seatrials
- For the thruster control system to be able to do this for hours, days, weeks and months, a “closed loop control” system is necessary.



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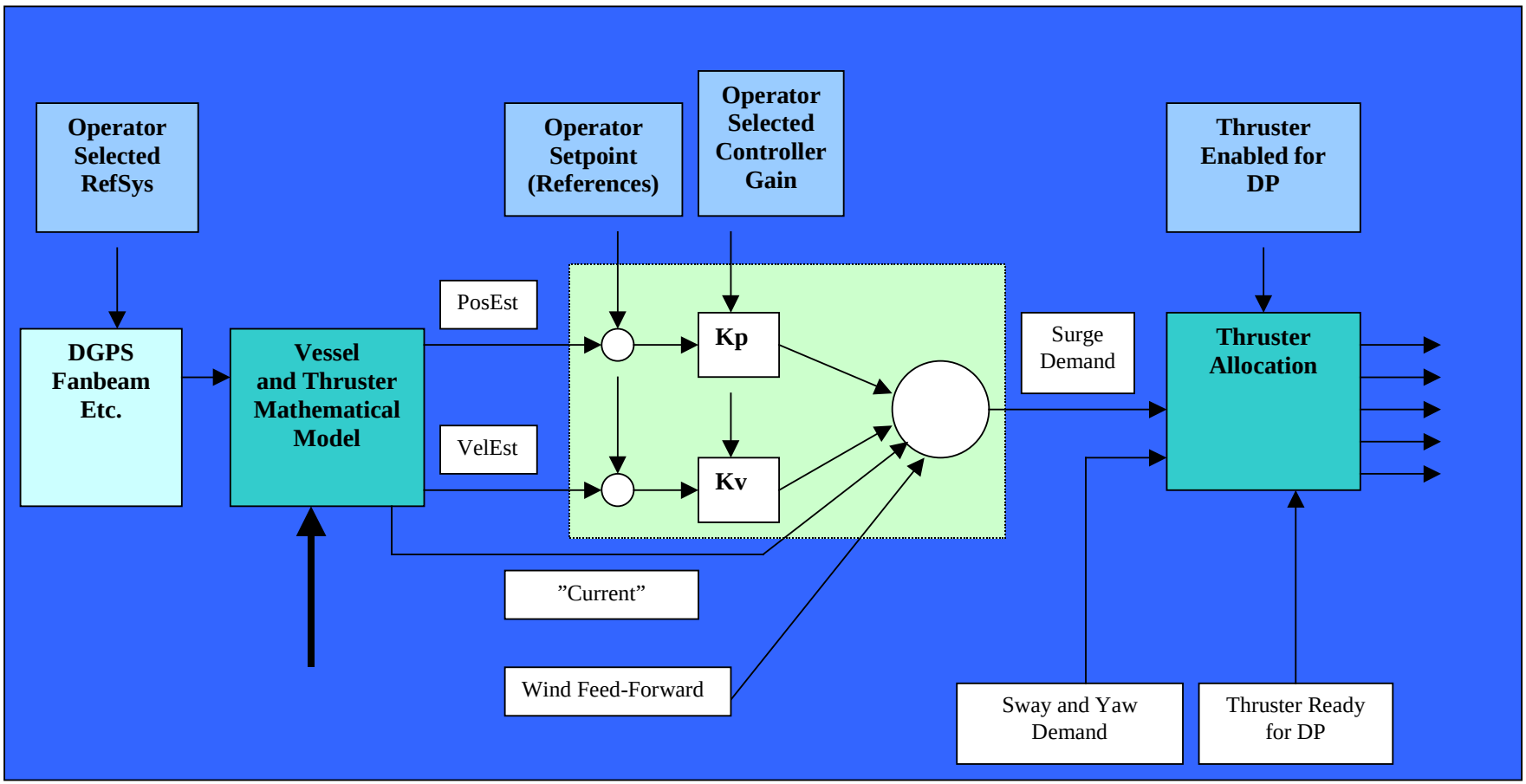
Calculation of DP Setpoints



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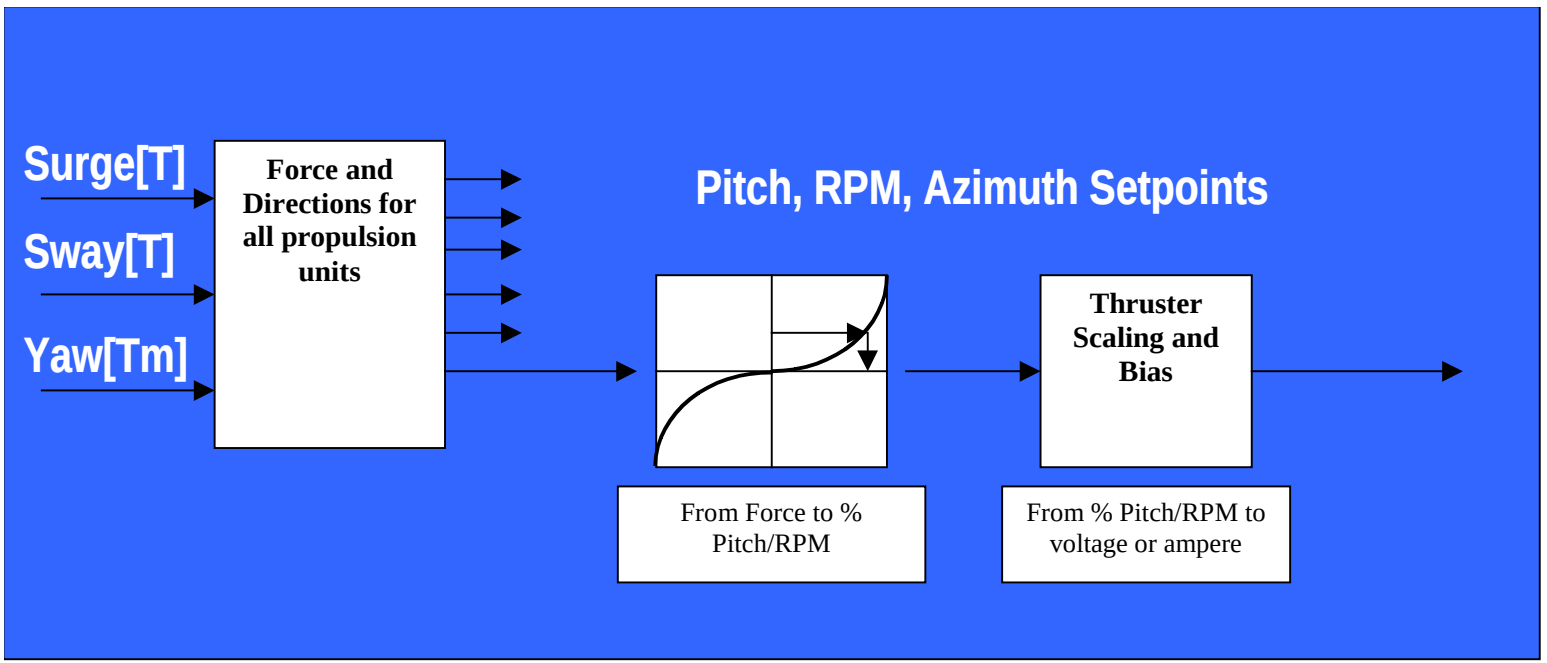
Allocating a Demand to Individual Setpoints



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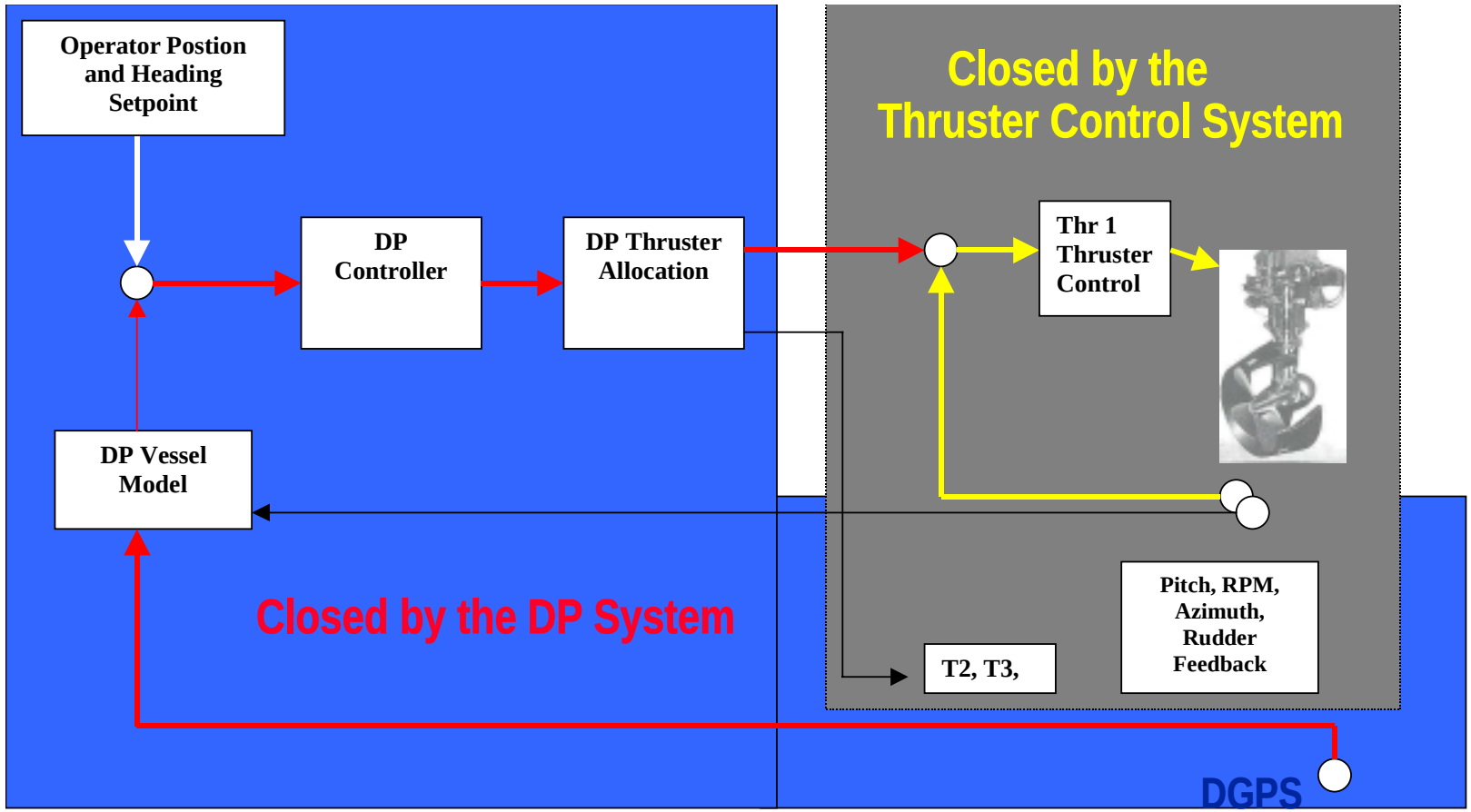

Closed Loops

Closed Loops

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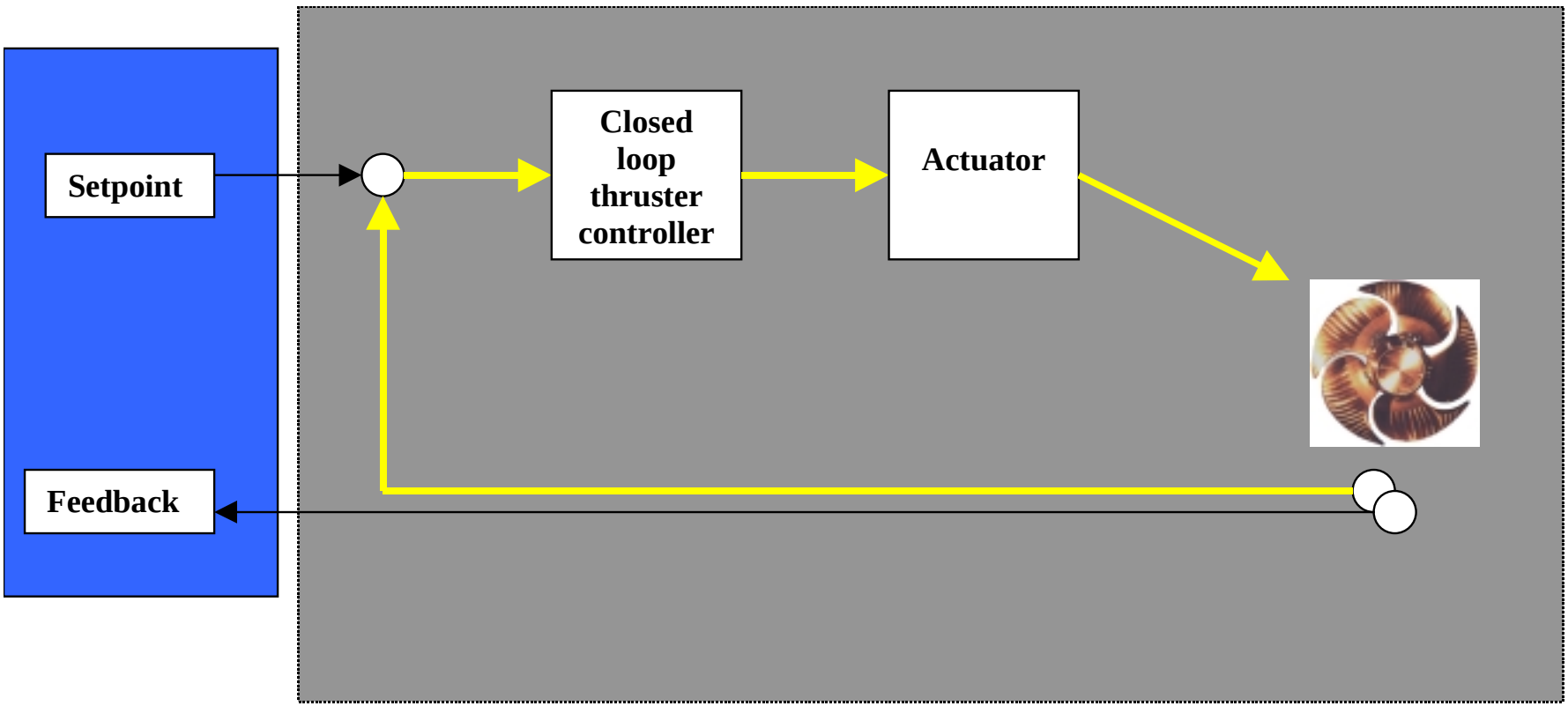
Closed Loop Thruster Control



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Way forward

- Open minded dialog on the subject between vessel owner, thruster manufacturer, classification society, oil companies, DP vendors and others
- Probably more requirements from oil companies (clients), flag state, and classification companies
- Sharing of information and ideas as the challenges are seen from different perspectives
- Improvements to the problem will be implemented in DP systems, power systems and thruster systems. This will be a combination of actual improvements and trouble shooting tools for the crew
- Early engineering in the design phase of new-buildings and retrofits to define requirements and tradeoffs
- Selection of power systems, thruster systems and DP system functionality based upon requirements and tradeoffs