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WORLD CLASS — through people, technology and dedication



A network of ideas



Technology — inspired by nature



Kongsberg — at your command



DP Design Studies

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'Design' in this context

- Thruster configurations
 - Types, sizes, locations
 - Dynamic capabilities
- Power system configurations
 - Generator sizes and dynamic capabilities
 - Switchboard layout
- Sensor specifications
 - Accuracy
 - Update rate
- DP control system and thrust allocation strategies



DP Design Studies

- DP Capability Analyses
- Performance simulations
- Drift-off and drive-off simulations



DP Capability analyses

- Purpose
 - Establish the limiting weather conditions
 - Determine thrust utilisation for a 'design sea state'

- Basic procedure
 - For a given weather condition calculate thruster forces needed
 - Increase the wind/waves/current until thrusters are fully utilised
 - Repeat for all wind angles-of-attack



DP Capability analyses

- Configuration
 - Main particulars
 - Load coefficients
 - Thruster and rudder types, sizes, locations

- Setup per case
 - Wind/wave/current relationships
 - Wind and wave spectra
 - 'Spare' thrust required
 - Thrusters and rudders to use



DP Capability analyses

- Characteristics:
 - + Fairly easy configuration
 - + Uses thruster allocation algorithm from DP control system
 - + Frequency domain (wind/wave forces)
 - + Low turn-around time

 - Power limitations are not taken into account



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DP Capability Plot

EXAMPLE

Case number : 1
 Case description : DP Design 1
 Thrusters active : T1-T4
 Rudders active :

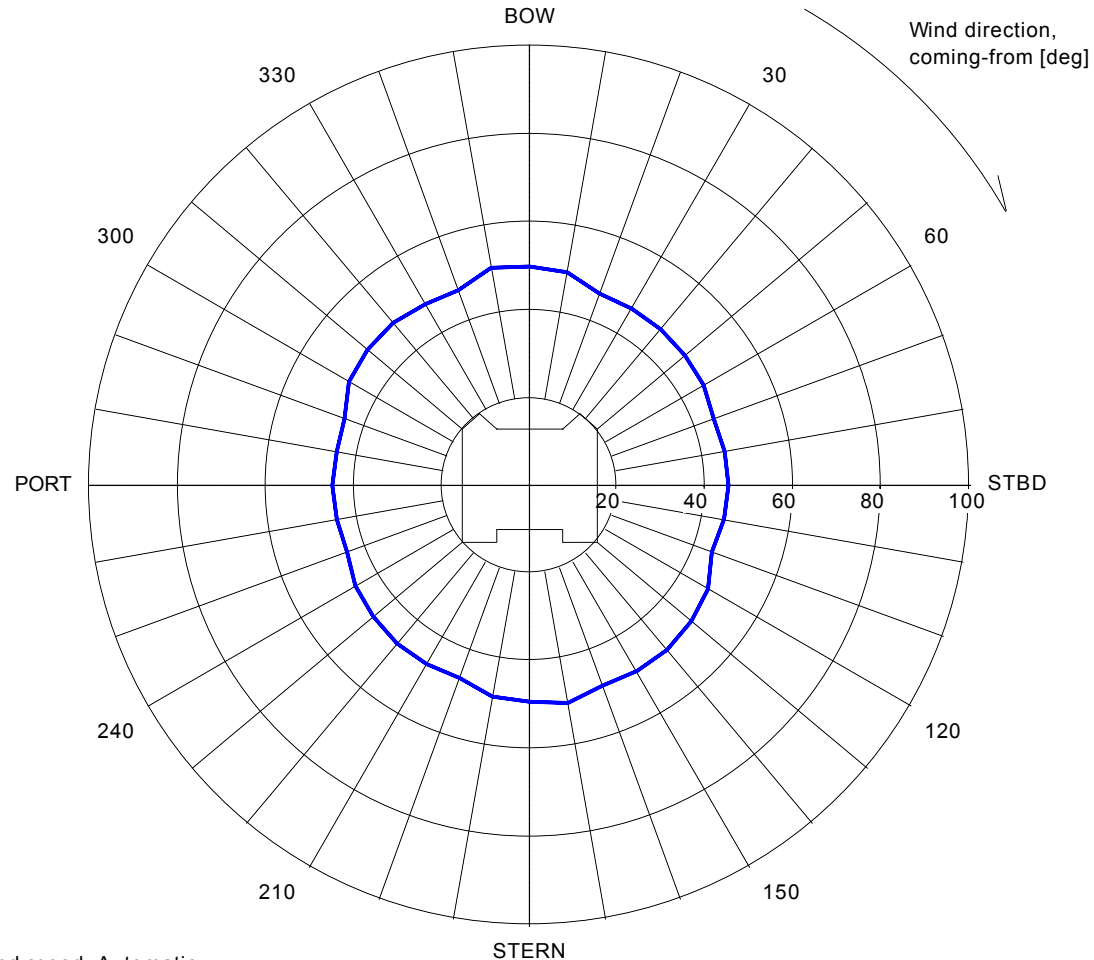
Input file reference : Example.scp
 Last modified : 2002-08-09 13.57 (v. 1.3.0)

Length overall : 100.0 m
 Length between perpendiculars : 100.0 m
 Breadth : 100.0 m
 Draught : 20.0 m
 Displacement : 50000.0 t
 Longitudinal radius of inertia : 25.0 m (= 0.25 * Lpp)
 Pos. of origo ahead of Lpp/2 (Xo) : 0.0 m
 Wind load coefficients : From file (Scaled by Area)
 Current load coefficients : From file (Scaled by Displacement)
 Wave drift load coefficients : From file (Scaled by Displacement)

Tidal current direction offset : 0.0 deg
 Wave direction offset : 0.0 deg
 Wave spectrum type : Pierson-Moskowitz
 Wind spectrum type : NPD
 Current-wave drift interaction : OFF
 Load dynamics allowance : 1.0 * STD of thrust demand
 Additional surge force : 0.0 tf
 Additional sway force : 0.0 tf
 Additional yawing moment : 0.0 tf.m
 Additional force direction : Fixed
 Density of salt water : 1026.0 kg/m³
 Density of air : 1.23 kg/m³

#	Thruster	X [m]	Y [m]	F+ [tf]	F- [tf]	Max [%]	Pe [kW]	Rudder
1	AZIMUTH	45.0	-45.0	50.0	-29.1	100	3000	
2	AZIMUTH	45.0	45.0	50.0	-29.1	100	3000	
3	AZIMUTH	-45.0	-45.0	50.0	-29.1	100	3000	
4	AZIMUTH	-45.0	45.0	50.0	-29.1	100	3000	

Limiting 1 minute mean wind speed in knots
 at 10 m above sea level



Wind speed: Automatic
 Significant wave height: IMCA (North Sea)
 Mean zero up-crossing period: IMCA (North Sea)

Rotating tidal current: 1.5 knots
 Rotating wind induced current: 0.000*Uwi knots



Performance simulations

- Purpose:
 - Assess station keeping accuracy and power consumption for given sea state when the vessel is controlled by a DP system
 - Comparing different control and thruster allocation strategies
 - Comparing different thruster and power configurations

- Basic procedure
 - Specify setup
 - Record vessel states
 - thruster response
 - power consumption
 - position and heading (combined LF+WF motions)
 - Post-process recorded signals to obtain statistical results



Performance simulations

- Configuration
 - As for DP Capability analysis
 - Response Amplitude Operators (RAOs)
 - Thruster dynamic characteristics
 - Thruster open water diagrams
 - Power system configuration and dynamic characteristics

- Setup per simulation case
 - Sea state (fixed or changing with time)
 - DP Control system
 - Sensors
 - Thrusters, generators, bus ties
 - Operating modes
 - Sensor/actuator noise



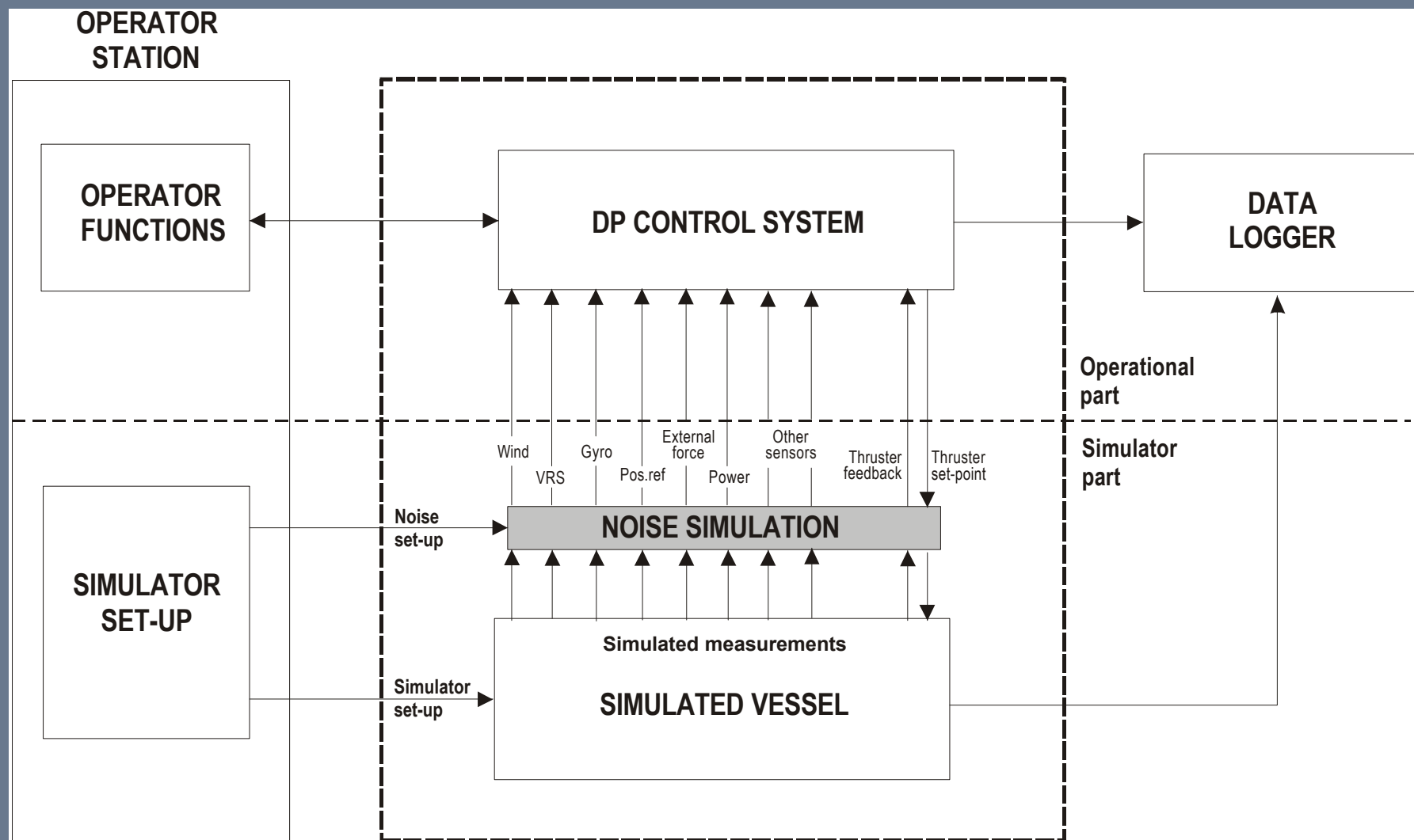
Performance simulations

- Characteristics
 - + Time domain
 - + Simulates vessel response to wind, waves and current
 - + Simulates thruster response to DP system orders
 - + Simulates power consumed by the thrusters
 - + DP Control system in the loop including thrust allocation algorithm
 - + Power limitations are taken into account
 - + Output is time-series for statistical analysis
 - + Non-linearities may be modelled

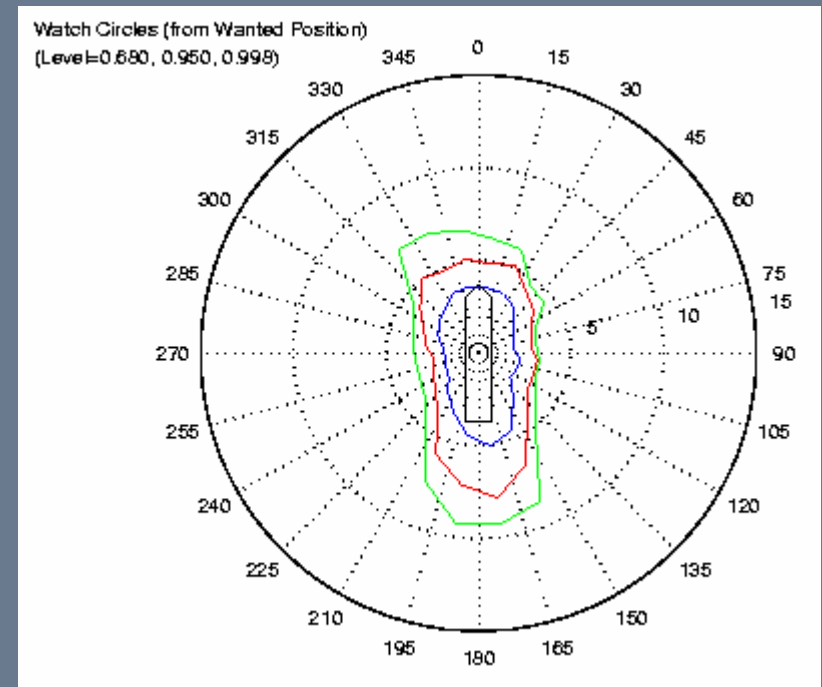
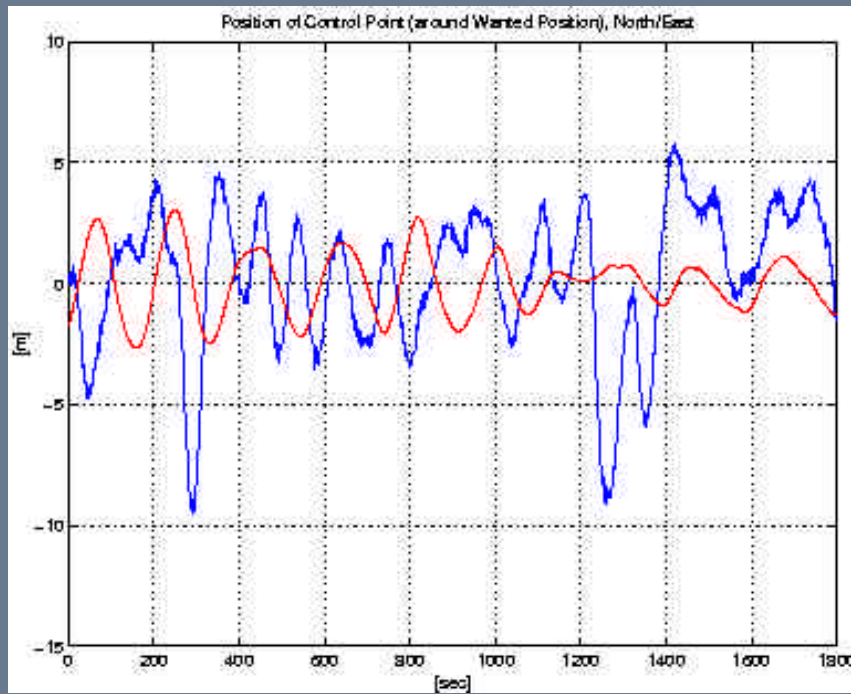
 - More complex configuration, more input data required
 - Longer turn-around time



Performance simulations



Performance simulations





Drift-off and drive-off simulations

- Purpose:
 - Assess Time-to-go after failure
- Basic procedure
 - Vessel is on station in a given sea state
 - Introduce failure in
 - thrusters (setpoint/feedback, local thruster control, trip)
 - generators (trip)
 - power system (bus failure, switch opens/closes)
 - position reference systems (freeze, drift, sudden jump)
 - other sensors (increased noise, general failure)
 - Measure time until limits are exceeded



Drift-off and drive-off simulations

Problem:

- Environmental dynamics will cause different results for different time-of-failure

Qualitative procedure to find span in results:

- Determine statistics of environment and positioning
- Using average environmental loads and position, introduce failure(s)
- Using high env. loads and down-weather position, introduce same failure(s)
- Using low env. loads and up-weather position, introduce same failure(s)

		Start position		
		Watch circle 0.950 up weather	Average	Watch circle 0.950 down weather
Environmental forces	Average – two standard deviations	Longest		
	Average		Average	
	Average + two standard deviations			Shortest

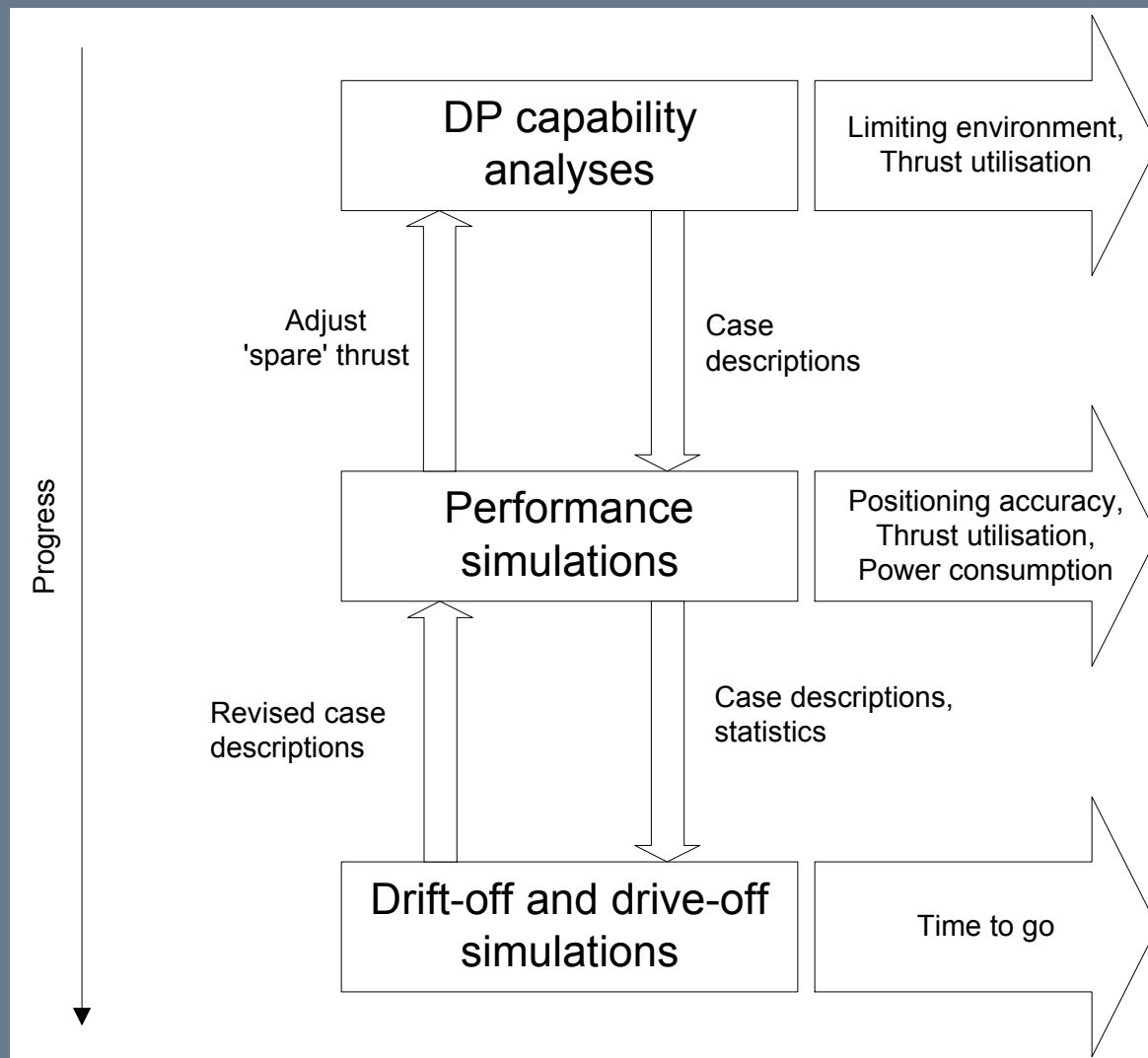


Drift-off and drive-off simulations

- Configuration
 - As for Performance simulations
- Setup per case
 - As for Performance simulations (sea state is fixed)
 - Failure(s)
- Characteristics
 - + Based on the performance simulator structure
 - + Qualitative approach to randomness
 - + Simulates single or multiple failure(s)
 - Does not provide significance levels of the results (no Monte-Carlo simulations)



Relationship between the simulation types





Concluding remarks

- Simulations
 - valuable for investigating and comparing different designs
 - complement to model tests or full-scale tests
 - theoretical exercises
 - relies on adequate mathematical modelling and input data
- Thorough hydrodynamic analysis will also be beneficial for installed DP system