UDT
Undersea Defence Technology
13-15 May 2019
Stockholmsmässan, Sweden

Innovative methods and tools for complex system design

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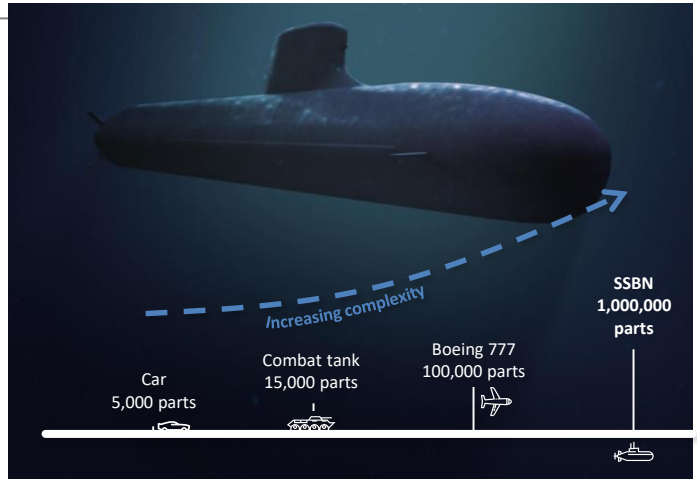
Complex system at early design stage : Challenges

Challenges :

- Multi-mission systems inter-operating (SoS)
- Numerous requirements depending on life cyle phase and operations
- Large amount of multi-physical subsystems interconnected
- Iterative design (design loop) involving heterogeneous technical domains
- High performances in a harsh environment



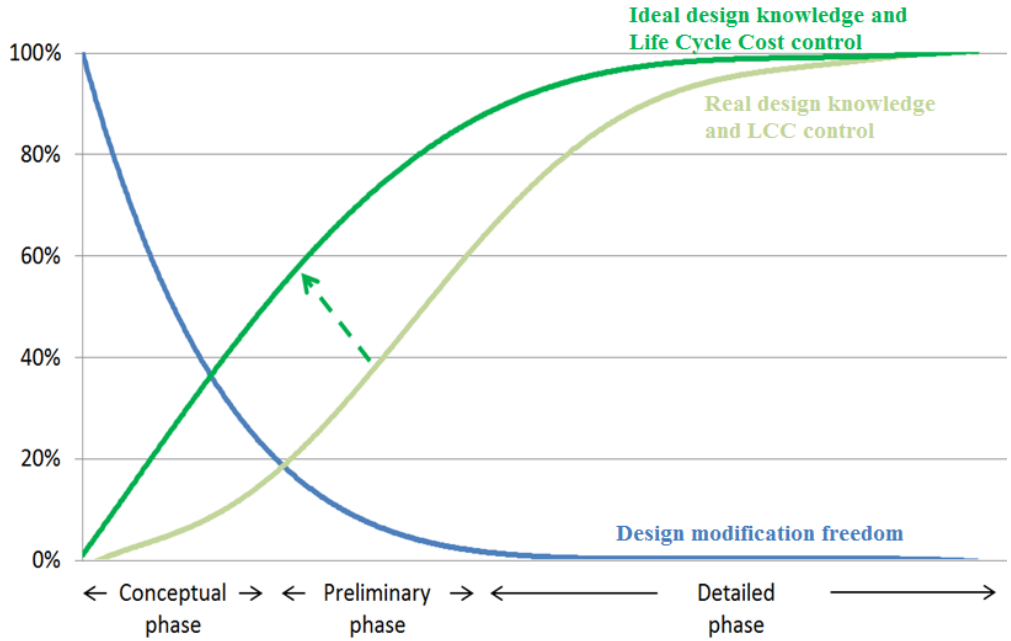
DESIGN & PREPARE | PRODUCE & INTEGRATE | TRAIN & SUPPORT | MAINTAIN & MODERNIZE | DISMANTLE & DECONSTRUCT

A town of 3 000 people living in complete autonomy for several months
On the surface of two football playgrounds

Complex system design at early design stage : Objectives

Objectives :

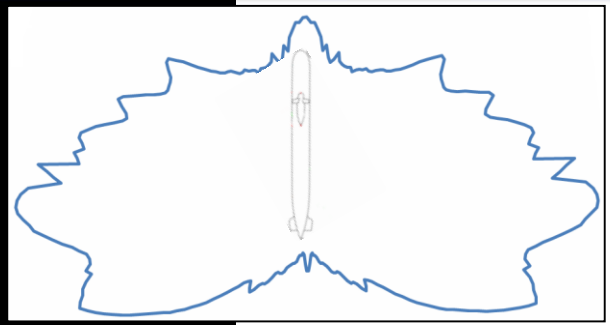
Reach a high level of definition and performance assessment early in order to reduce the life cycle cost and project risks.



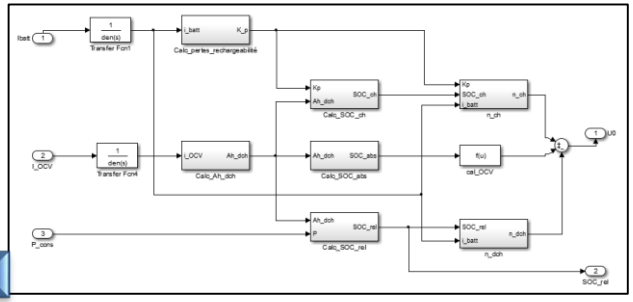
Focus on complex system architecture modelling : architecting = modelling + simulating

Operational Performances & Life cycle cost management

Simulation driven design



Model based system engineering



Focus on system engineering modelling : Objectives at early design stage

- Offer relevant views of system architecture to handle complexity.
- Explore numerous possibilities of systems architecture solutions.
- Organize the collaborative workflow.
- Ensure that system definition meet stakeholders needs.
- Identify emerging behaviours as opportunities or failures.

Focus on complex system architecture modelling : System architecture and requirement management tool

System architecture tool	+	Scenarios and requirement tool management
▪ Map and navigate among system components and physical interactions. ▪ Document all components and interface properties. ▪ Identify functional chains and networks. ▪ Perform global qualitative analysis such as dysfunctional analysis.		▪ Describe stake-holders requirements for the whole Life Cycle. ▪ Contextualize requirements within operational scenarios to ease discussion and trade off. ▪ Link between requirements and performance are performed directly via users responsible of systems and/or operational scenarios.

Configuration management tests of system architecture
& needs analysis with tools inspired from software development

Focus on complex system architecture modelling : System architecture and requirement management tool

Operational scenarios example for surface vessel : *"TRA2018 Compliance matric model based on shipowners operational needs" A.Guegan et. al*

The ship is on standby in the harbour and receives a pollution alert. Hydrocarbons are being released by a damaged cargo ship drifting on the ocean at 100 nm from the harbour – 30nm from the coast.
The ship is assigned a two-fold emergency mission by the pollution-fighting coordination centre: 1/ preliminary cleaning of the area, 2/ early-stage investigation to find the source of the pollution.
The ship embarks the modular ROV equipment and leaves the harbour in dense traffic at the highest possible speed (10knots) then follows the route given by the coordination centre at full speed to reach the area of the spill(20 knots STW at MCR 85%). Sea state is at level 2.
Upon reaching the operation area, the crew deploys anti-pollution equipment at reduced speed (4 knots STW). Dispersant nozzles are deployed and the vessel sails into the oil slick for anti-pollution operation. The ship spreads 80m^3 of dispersant product onto the polluted surface. Sea state degrades to SS3.
Once all the dispersant has been released, the investigation operation starts. In order to perform ROV operation, the ship is kept at a controlled 300 meters from the damaged vessel, using its bow thrusters and Dynamic Positioning System.
The ROV is immersed with the crane and controlled from a dedicated container on the aft deck. Videos of the situation are recorded by the ROV, transmitted in real time to the ROV control container and **copied to a screen on the bridge**.
The leak has been fully documented after 40 minutes of ROV operation. The ROV is recovered and secured on the aft deck. The cleaning of the ROV starts immediately.
The ship patrols at 6 knots for half an hour until a special de-pollution ship arrives on site for a full cleaning operation.

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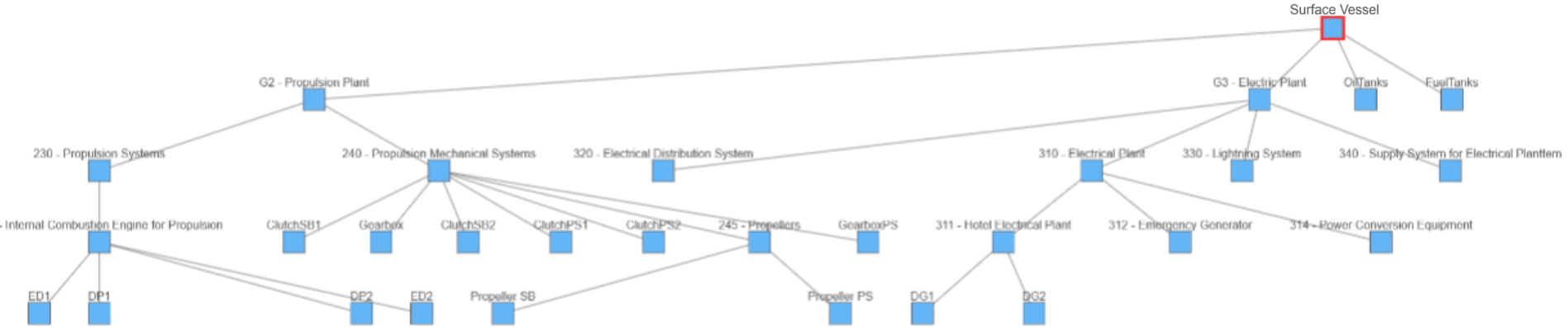
Focus on complex system architecture modelling : example

Example : surface vessel hybrid propulsion system model

Propulsion and machinery system PBS view



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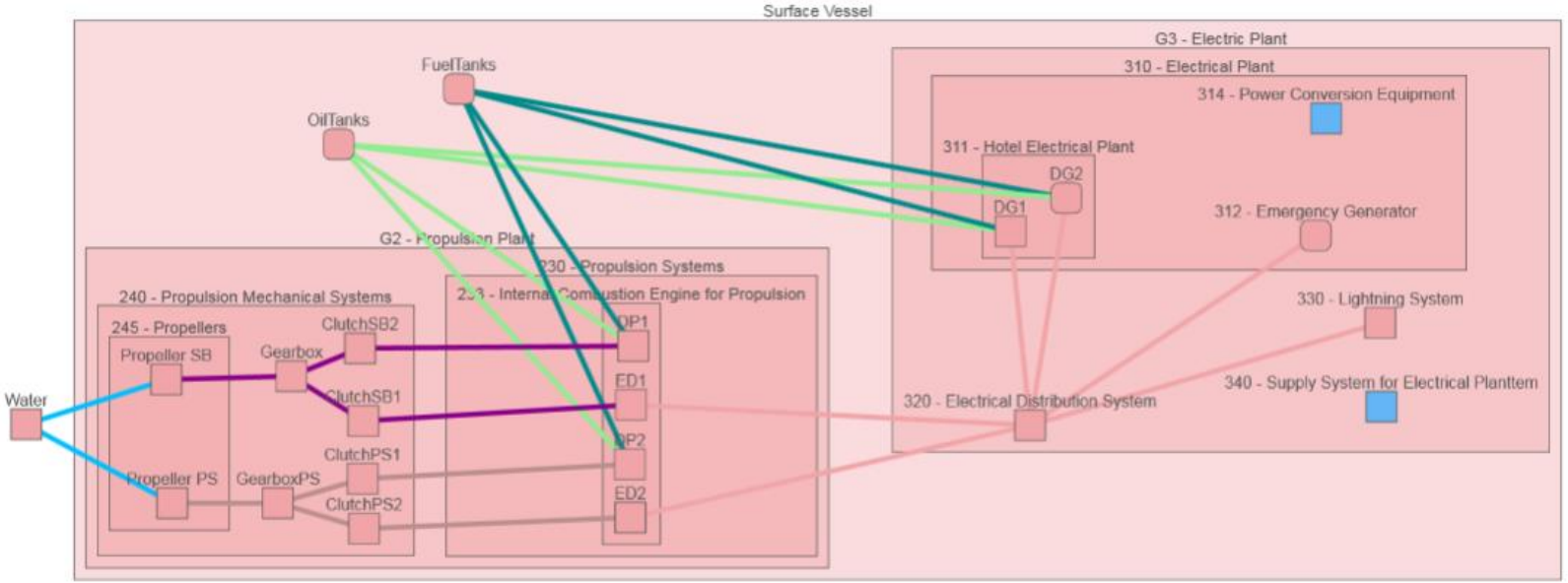
Focus on complex system architecture modelling : example

Example : surface vessel hybrid propulsion system model

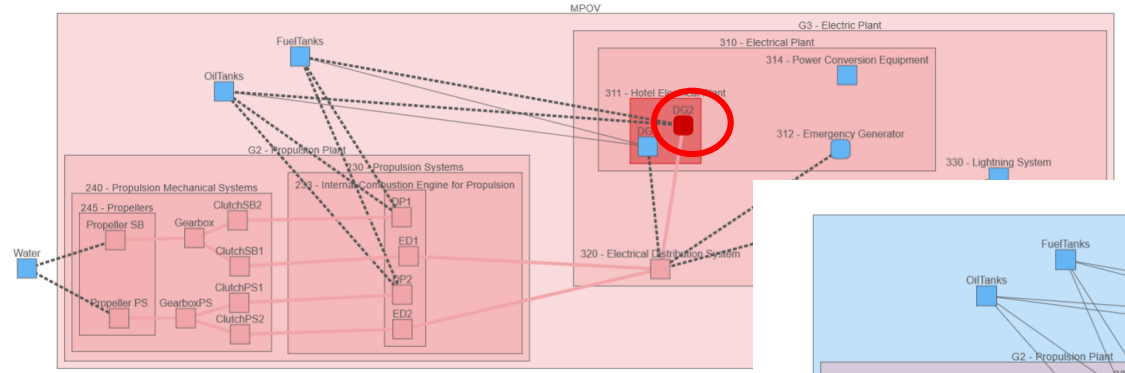
Propulsion and machinery system flat view including system interactions

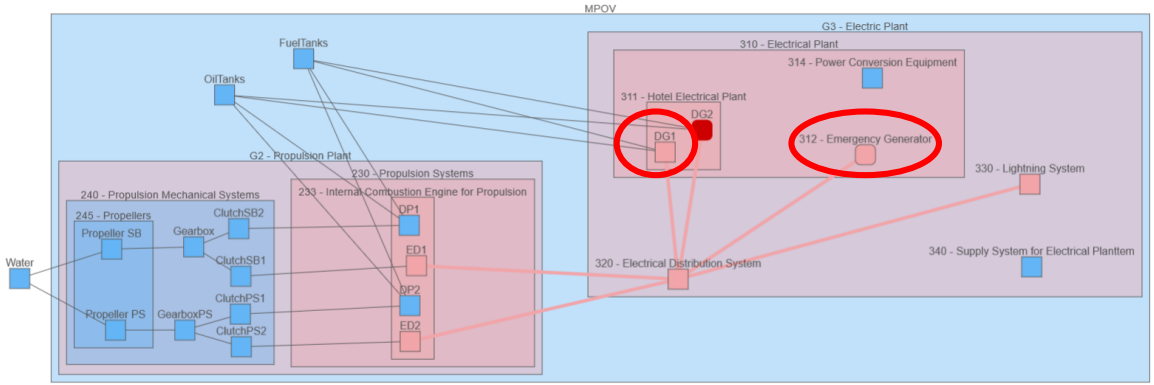


Focus on complex system architecture modelling : functional/dysfunctional example

Example : surface vessel hybrid propulsion system model and dysfunctional analysis

- Users identify for each physical network **producers and consumers** components for functional chains.
- Here for high speed functional chain the example is given with a DG **out of service**.
- **Impact and solution** can be developed using connectivity graphs

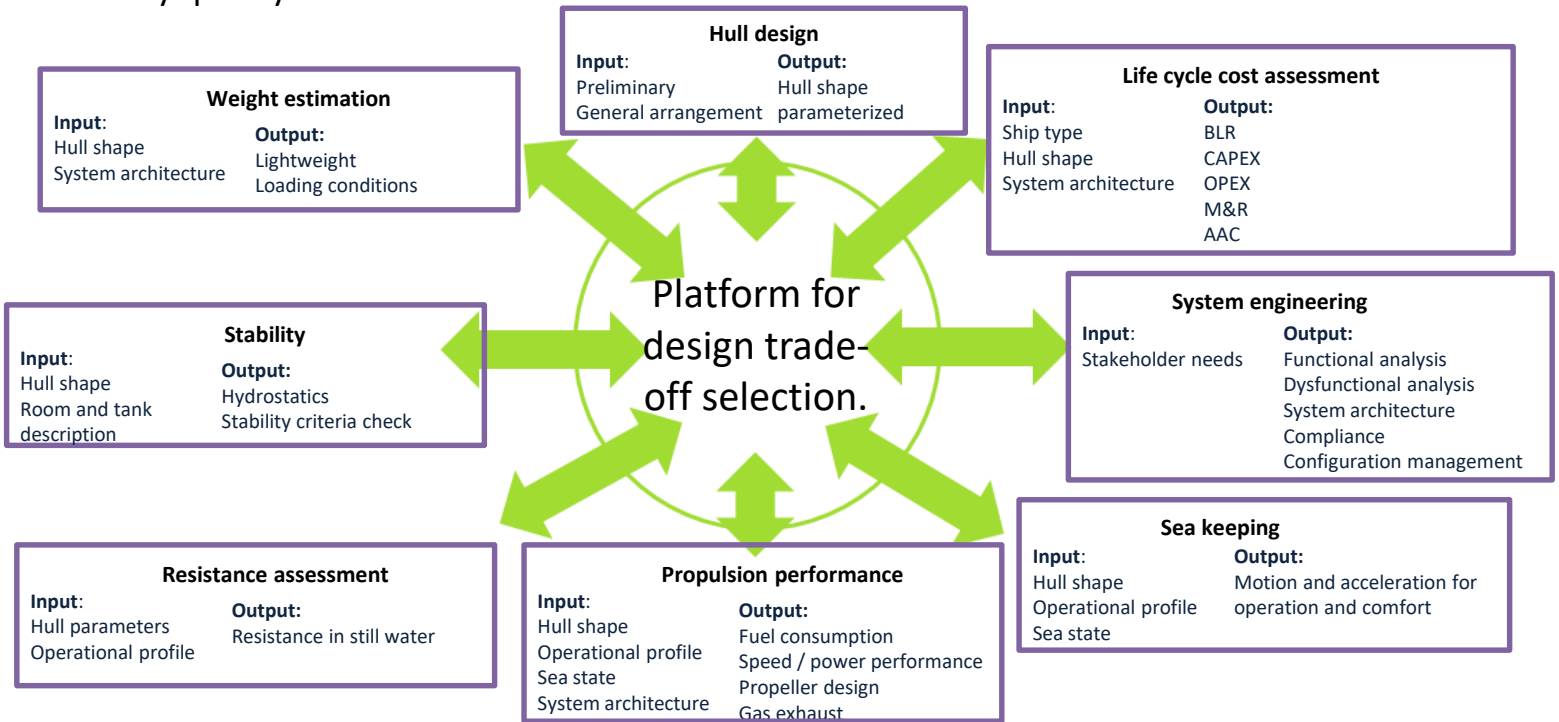




Complementary approach : simulation driven design : surface vessel example

Approach : launch batches of design simulations on a parametrized model to :

- Explore space of solution avoiding asynchronous iterations at early design stage
- Identify quickly unfeasible solutions and Pareto front for discussions.



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Thank you for your attention, any question ?

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