Virtual System Engineering

Disprupting System Engineering with Model Based Approach

Capgemini

Virtual System Engineering as market stake enabler

Time to Market | **Performance cost & Quality** | **New technology integration to innovation** | **Collaborative & Global Environment** | **Digital Continuity to MES & Operation**

Benefits:

Efficient Management of Product Line roadmap by platforming and suggesting modular approach

Effective Decision Making by Modelling & simulating complex Behaviour

Fast Assessment of technical solution performance, innovation, cost and impact

Securing and verifying specification and interfaces prior to build

End-to-end view with advanced requirements management & simulation

Reducing inconsistencies by model sharing in global and collaborative environment

Optimise verification & validation (Virtual testing and V&V)

Anticipate issues (corner conditions, reproductivity)

Full ecosystem of partners, CESAMES, Dassault Systèmes, Spherea, Argosim/Stimulus, Capella/Arcadia, MIT…..

Virtual System Engineering & MBSE

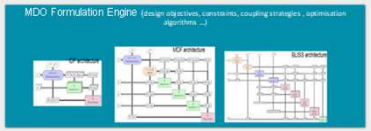
System Engineering tools are integrated with **CAD and PLM** environments, **project management** and **workflow tools** as part of a broader computer aided Engineering and Enterprise Management Environment to enable Digital Continuity from Design Offices to Manufacturing and Life time Operations.

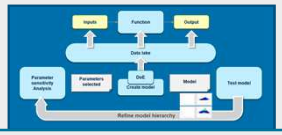
MBSE deliverables

views composed of System, behavioural and speciality models **managed in library mode for reuse and modular approach**

Stakes: Link MBSE system design to simulation capabilities

MBSE needs to address the model reuse and interoperability within different simulation environments





System

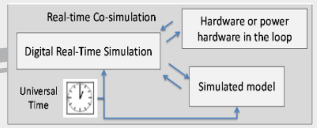
parametric

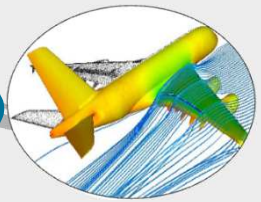
Surrogate

MDO

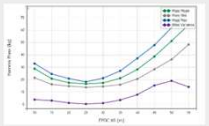
Data Analytics

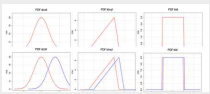
Simulate



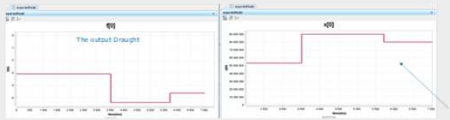


Analyze





Co-Simulation



Share

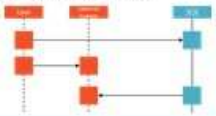
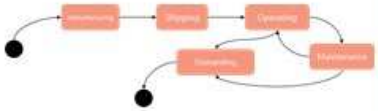
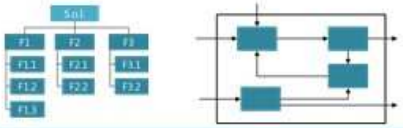
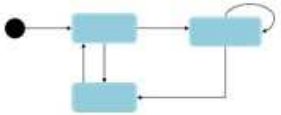
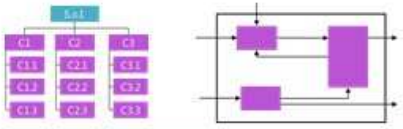
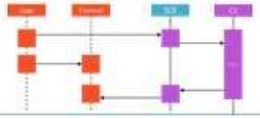
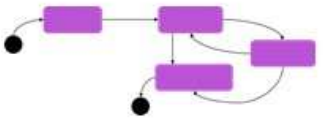
Collaborate

How to …?

- Store and access Models in common repository
- Interface multiple level of model fidelity
- Real time simulation, co-simulation

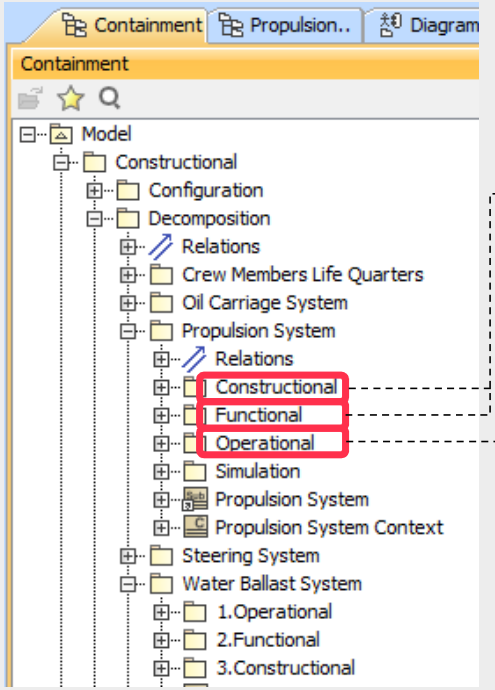
- share model and simulation for co-design
- analyze, correlate simulation results
- ease data interoperability and workflow between simulation tools

System architecture & modeling

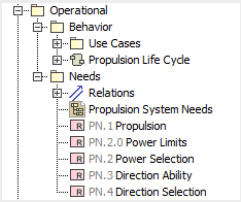
	Requirements	Static view	Dynamic view	States
Operational Vision ***Why?***	▪ Stakeholders needs: *« The **production manager** shall be able to get hourly production data »*	▪ Use cases & Stakeholders analysis ▪ Environment diagram 	Operational scenarios focused on external interactions 	Lifecycle 
Functional Vision ***What?***	▪ Functional requirements: *« The **flowline** shall monitor production quality for each part »*	▪ Functional Breakdown Structure ▪ Functional interactions diagram 	Functional scenarios focused on functions interactions 	Functional modes 
Constructional Vision ***How?***	▪ Component requirements: *« The **flowline communication component** shall interface with plant MES network »*	▪ Product Breakdown Structure ▪ Components interactions diagram 	Constructional scenarios focused on interaction between components 	Technical configurations 

Main MBSE deliverables are views composed of a number of SysML models (global and/or specialty) intertwined with simulations

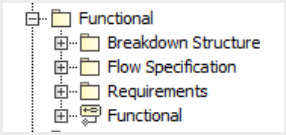
CESAM Methodology for Tanker



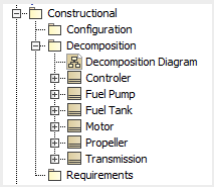
- Operation Requirements
- Operational Behavior in terms of Use Cases



- Functional Requirements
- Functional Breakdown Structure
- Functional Specifications



- Constructional Requirements
- Constructional Decomposition
- Configuration Management



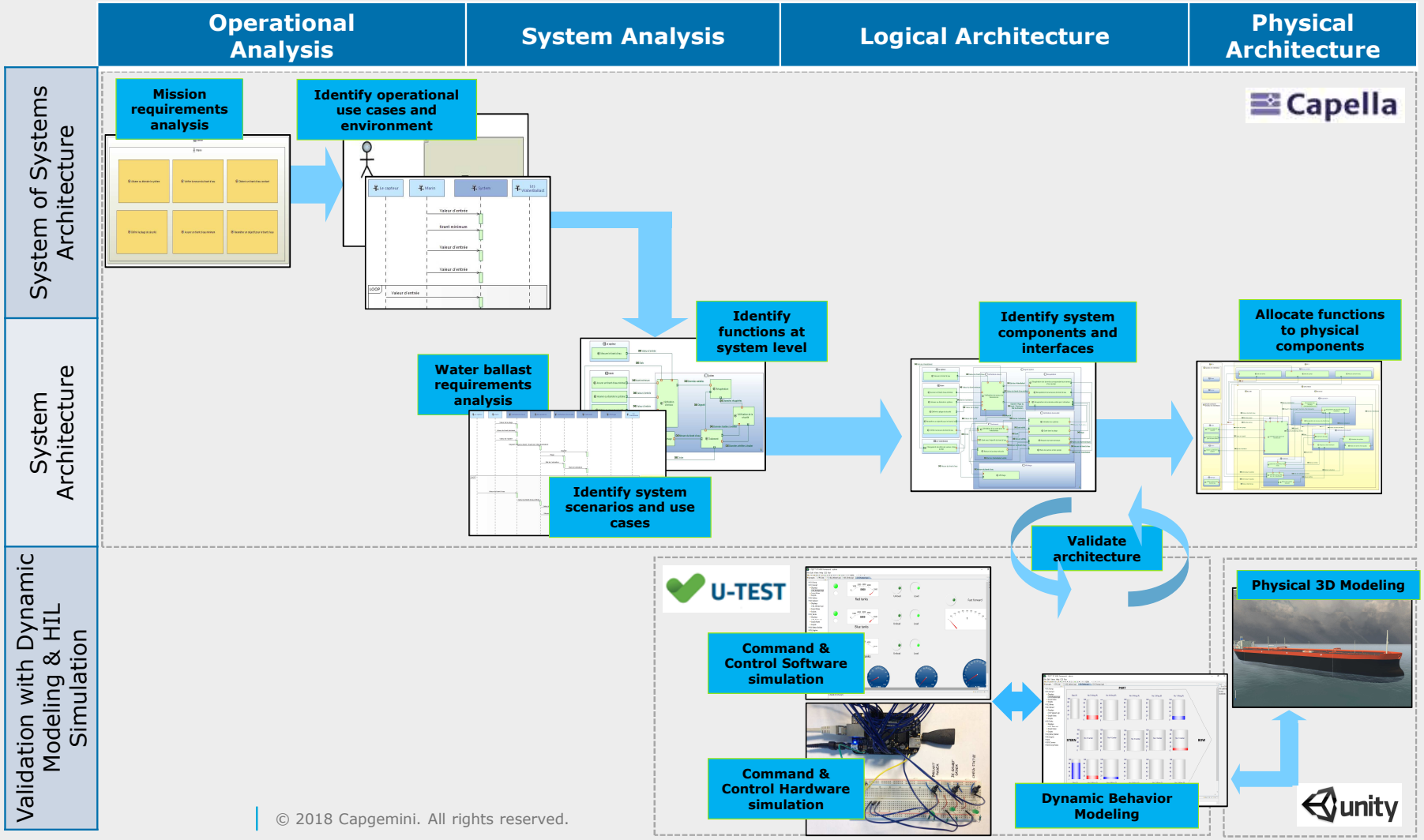
A Comprehensive System Engineering Approach for system modeling & architecture.

Once the modeling choices are well designed, the SysML language allows to model systems using tool approach:

- ARCADIA/Capella
- Cameo/No Magic
- RFLP/3DX

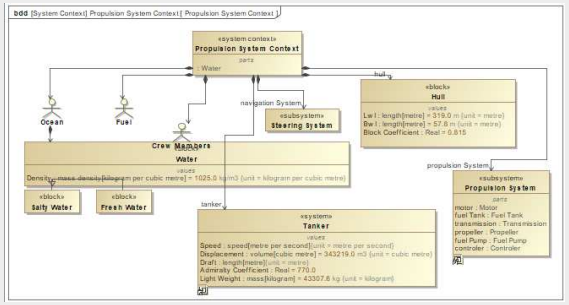
MBSE Engineering process: Tanker

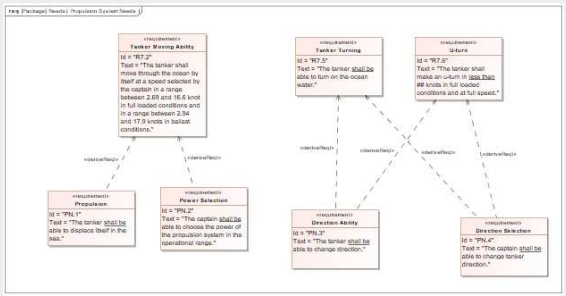
Capella/U_Test

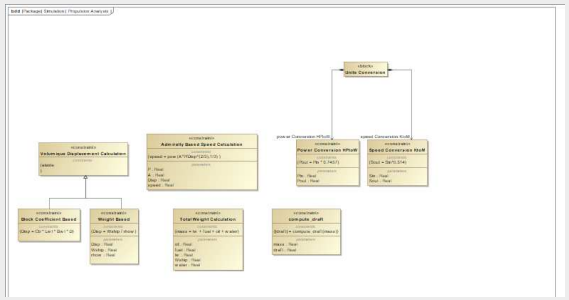


MBSE Engineering process: Tanker

Cameo/No Magic

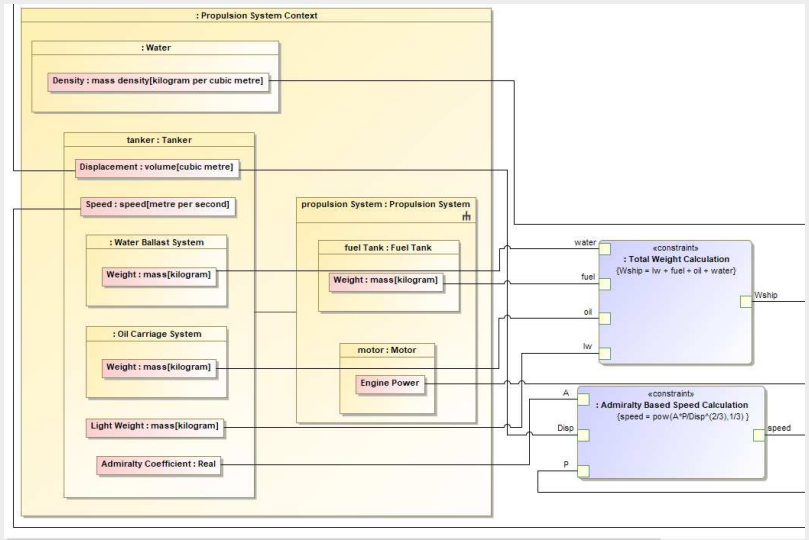






Integrates engineering analysis model & Design model

Use constraints and equations for parameters influence analysis



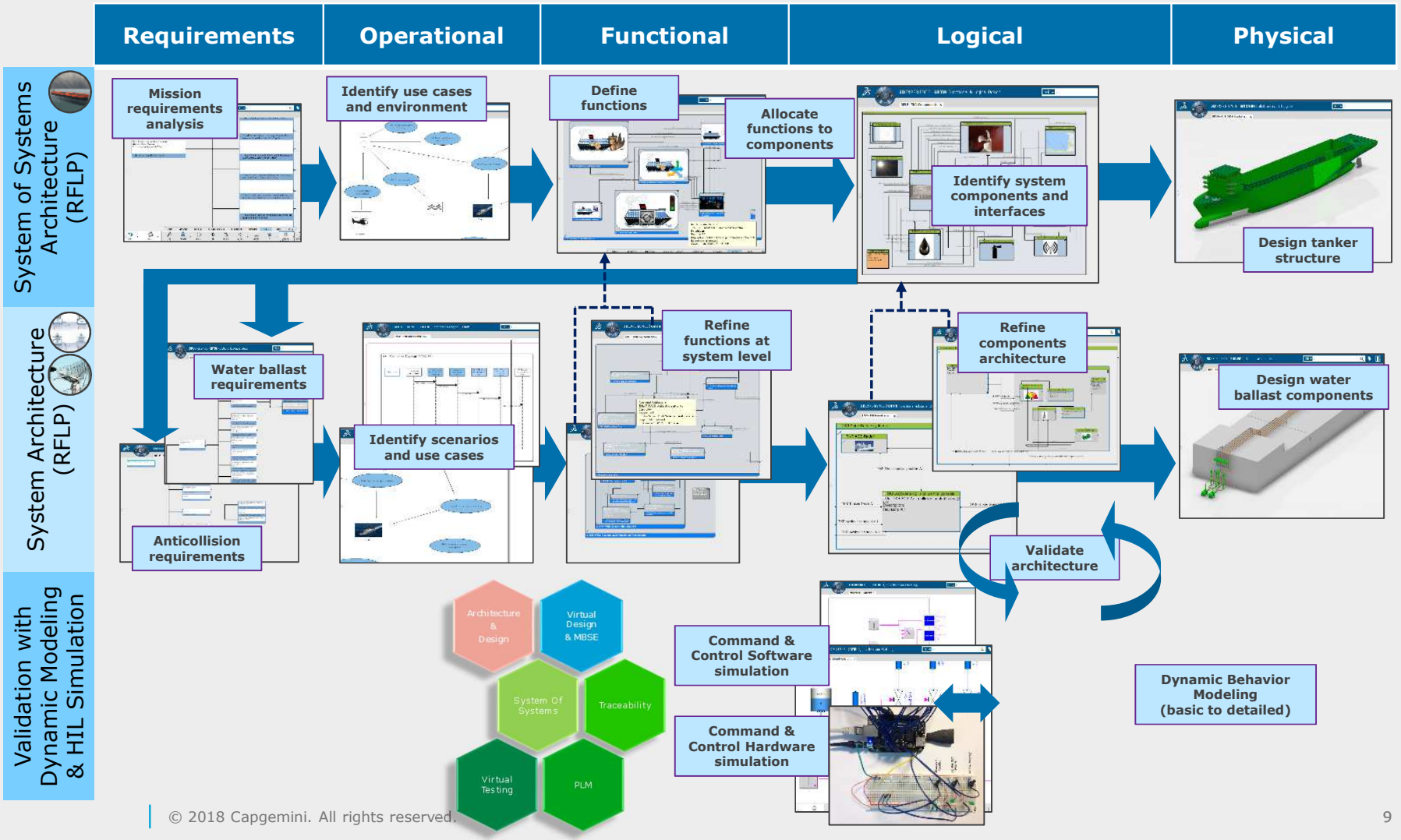
Block + Requirements + Constraints

Validate high level requirements

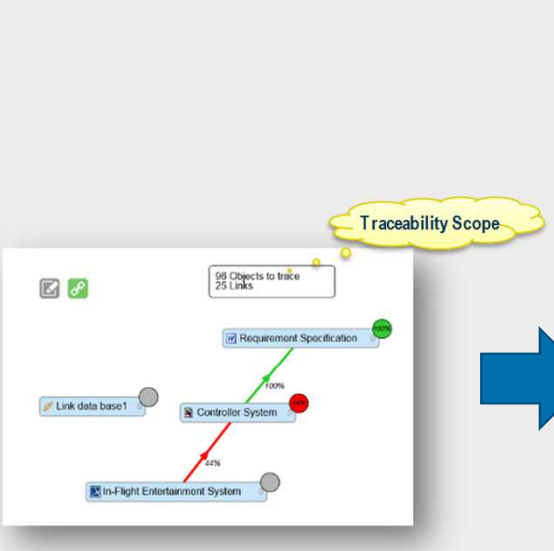
Evaluating critical parameters & Optimizing the system within the basis of Cost-Quality-Time

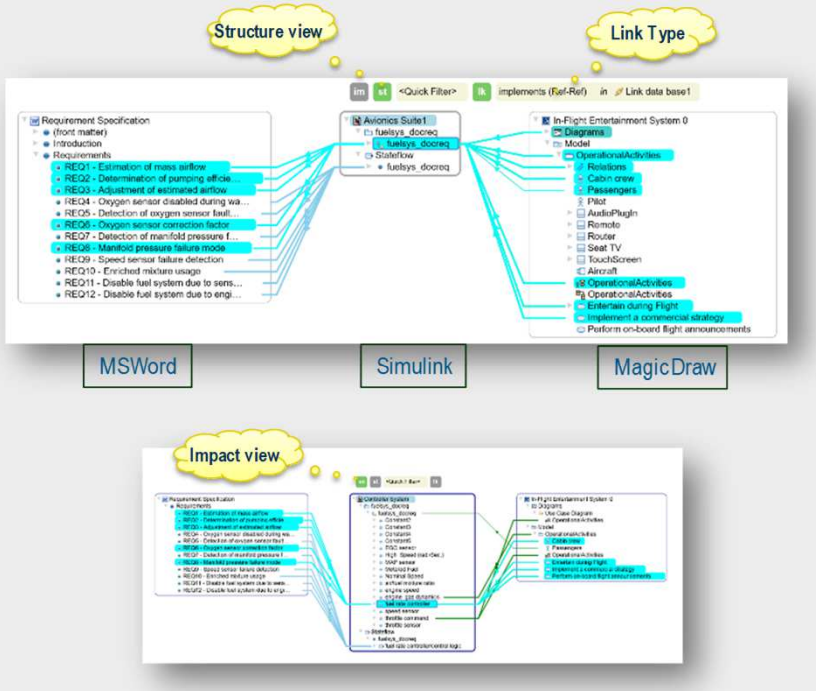
MBSE Engineering process: Tanker

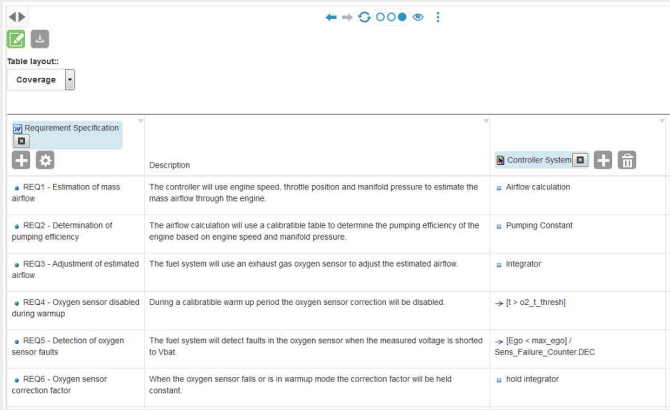
3DExperience



Requirements: New Interactive web base Traceability & System Analysis







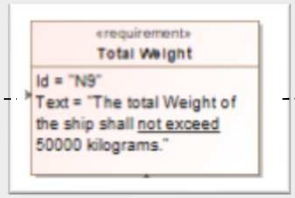
Enhanced traceability from heteregenous sources
Model annotation & discussion threads

- Graphical, tabular views based on scopes & traceability
- Interactive traceability based navigation
- Patterns editor
- Semantic Analyzer

TRADE-OFF ANALYSIS

Formal System Block

« satisfy »

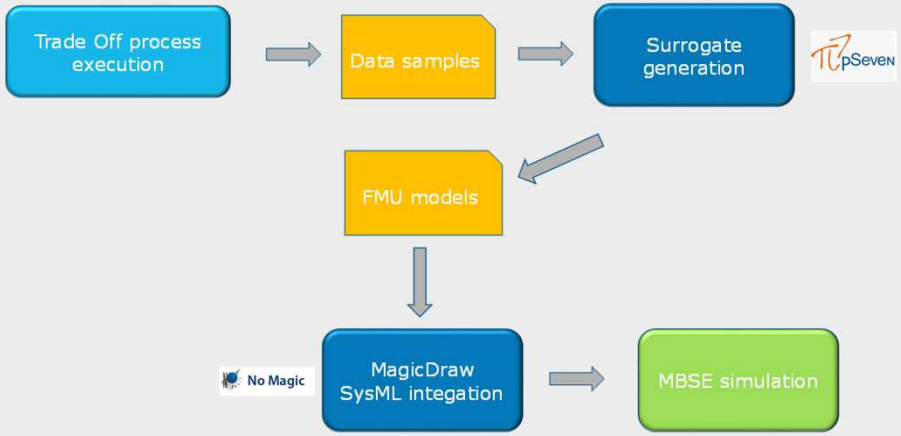


Formal Requirement Block

« refine »

Formal Constraint Block

Trade analysis to support decisions throughout the systems engineering process from Requirement till solution level.



Trade-Off Strategy

Define System functions

Define System Solutions

Define Assessment Criterias

Assign Weightage to Criterias

Establish MOEs

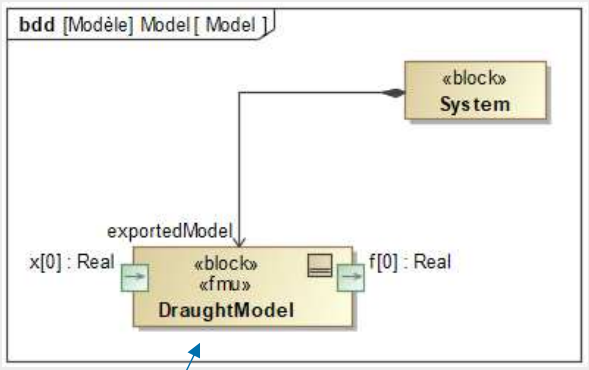
Determining better solutions

Solution Merge for System Architecture

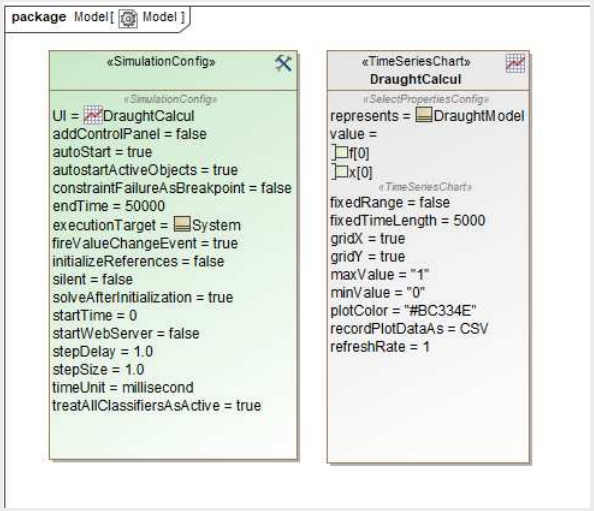
Co-Simulation with FMI

- Cameo Simulation Toolkit supports Functional Mockup Interface (FMI)
- FMI is a standard that supports model exchange and co-simulation of models
- Cameo Simulation Toolkit is able to read FMU files, integrate them into the model and launch their simulation

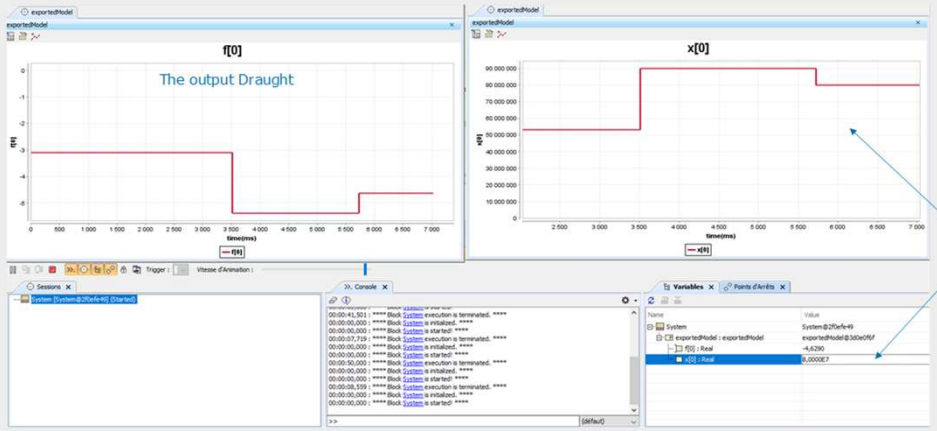
The draught example :



Drag and drop the FMU file



Configure simulation parameters

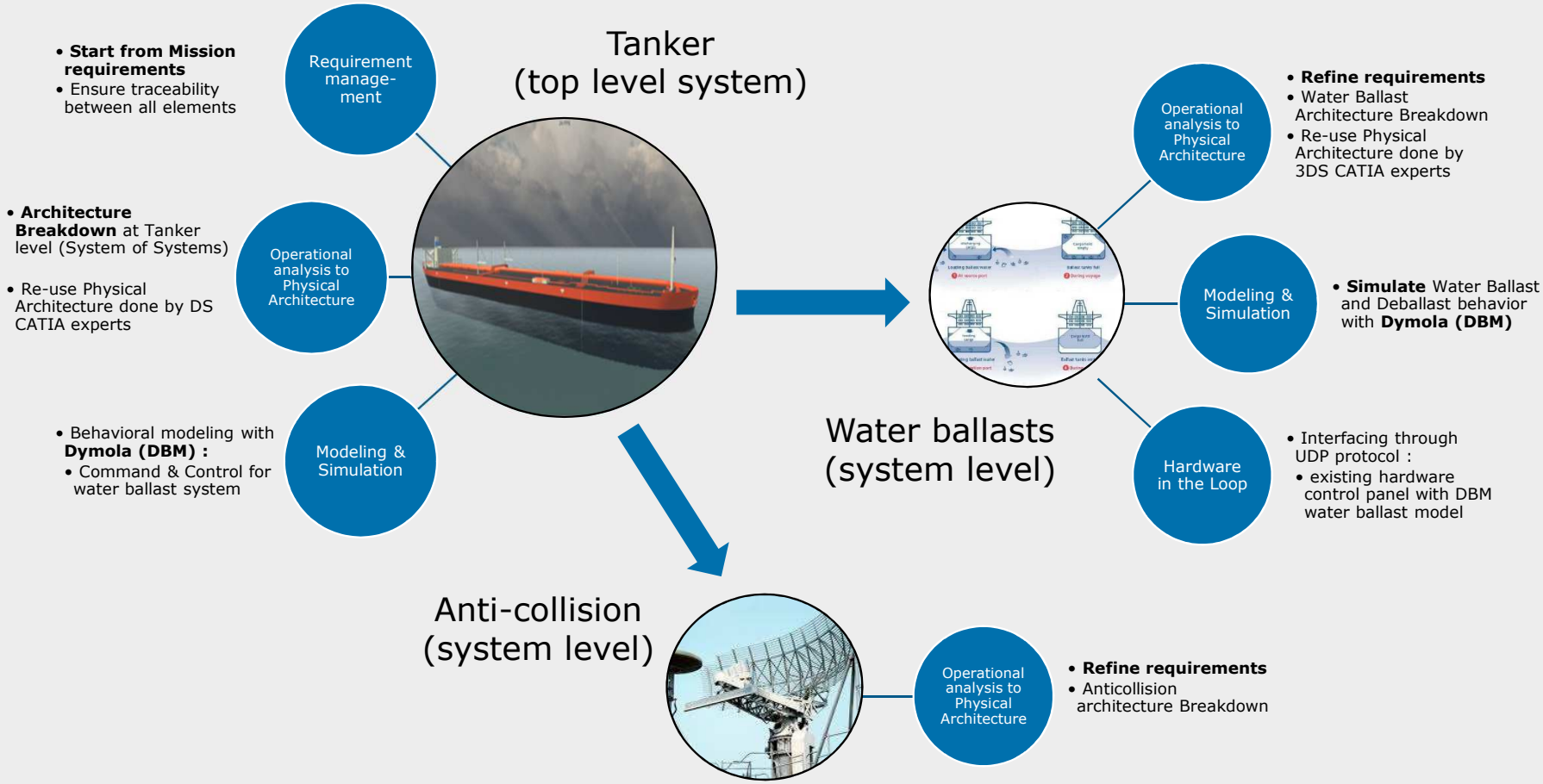


Extern models integration to analyze parameters and to cover requirements

Virtual SE demo

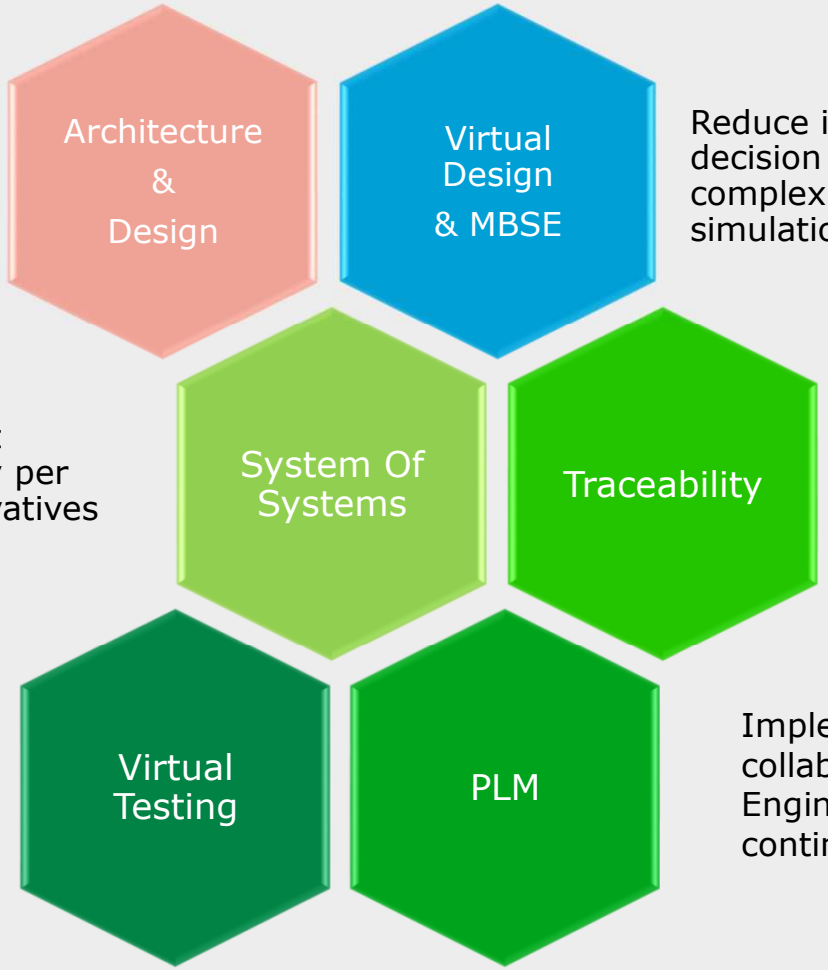
Capgemini

System breakdown approach



Key takeaways

Anticipate and check specification, assess cost & performances trade off prior to build



Reduce inconsistencies & Accelerate decision making process thanks to complex system modeling and simulation

Establish an efficient product line strategy per platformes and derivatives based on reuse

Ensure coherence at all breakdown levels

Integrate and validate quickly systems and partner ecosystem

Implementation of a collaborative System Engineering ensuring digital continuity

Back up

People matter, results count.

About Capgemini

A global leader in consulting, technology services and digital transformation, Capgemini is at the forefront of innovation to address the entire breadth of clients' opportunities in the evolving world of cloud, digital and platforms. Building on its strong 50-year heritage and deep industry-specific expertise, Capgemini enables organizations to realize their business ambitions through an array of services from strategy to operations. Capgemini is driven by the conviction that the business value of technology comes from and through people. It is a multicultural company of 200,000 team members in over 40 countries. The Group reported 2016 global revenues of EUR 12.5 billion.

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As a tool for the alignment and acceleration of Capgemini and clients' ambitions, the University plays a key role in developing employees' skills and capabilities by delivering a learner centric end-to-end experience, leveraging the principles of Digital Age Learning. Capgemini University was first accredited by the European Foundation for Management Development (EFMD) in 2009, and reaccredited in 2014. In 2016 the University delivered over 4.1 million learning hours to over 182,000 employees.

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