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MEYER TURKU
SHIPYARD 1737

Modular Systems Simulation Using SSP, FMI and OPC UA

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Background

- Established in 2007
- Located in Espoo, Finland
- VTT Technical Research Centre of Finland background

Expertise

- Highly skilled, **multidisciplinary team** of software developers, automation and system engineers, as well as modeling and simulation specialists
- A third of the company holds a PhD degree

Focus areas

- **Development and maintenance** of **system simulation tools** for process industry such as Apros
- **Industrial Simulation-Based Digital Twins**
  - Cloud-based simulation turn-key solutions
- Engineering **automation solutions**
- **Life Cycle Assessment** solutions

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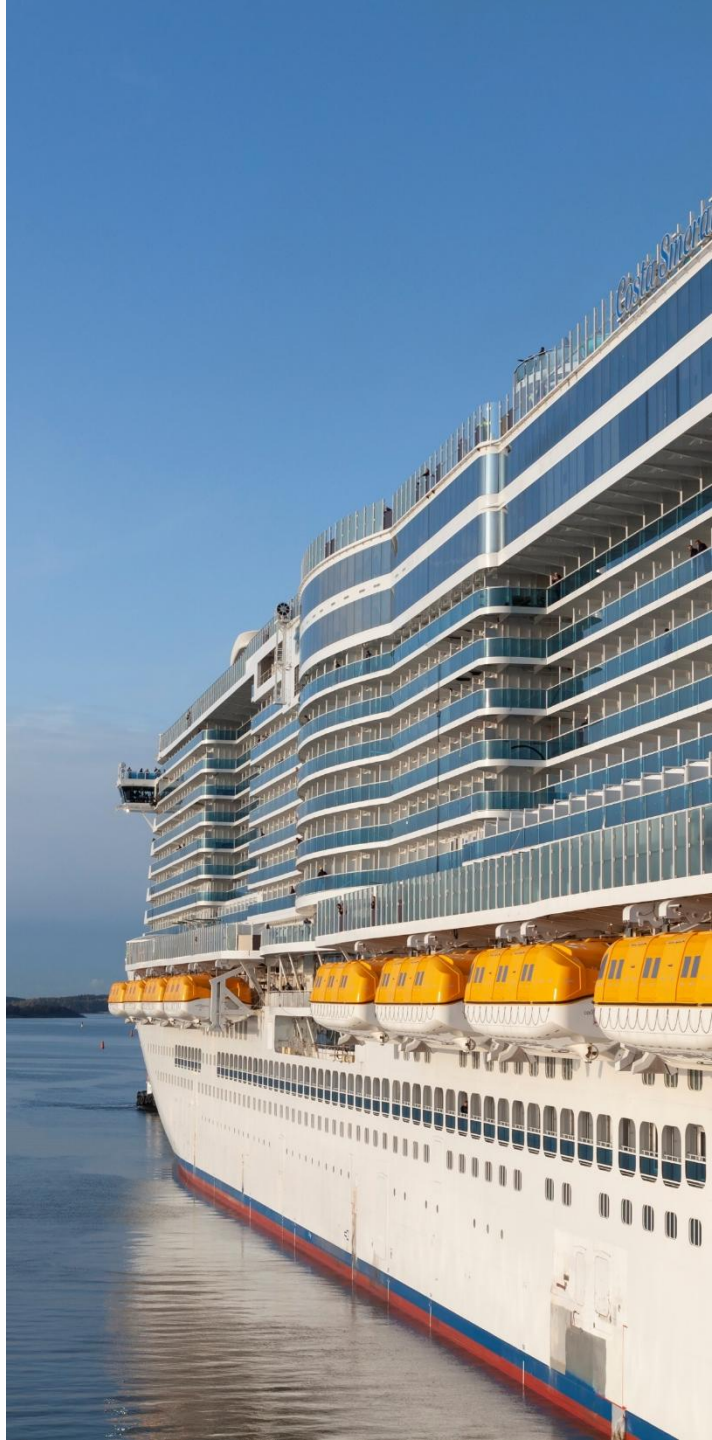
Modularization

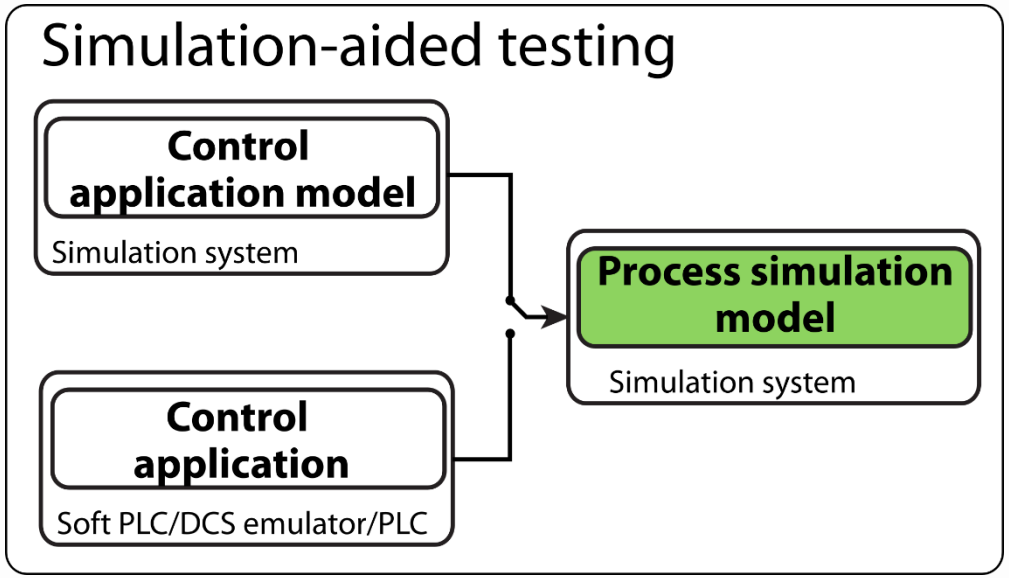
- Meyer Turku shipyard is a large system integrator
- Modularization is a trend in shipbuilding
  - Ships are assembled using physical structural modules built outside of the shipyard
  - Allows components to be built in different locations
  - Allows companies to rely on their expertise to deliver sub-components



Modular virtual testing

- Beyond structural modularization
  - Build a ship's processes and automation systems from modules
  - Includes equipment from various companies

- Benefits of modular virtual testing
  - Validate the process and its automation systems in a co-simulation environment
  - Verify system correctness
    - Before purchase and physical installation
    - Can be done before sea trials



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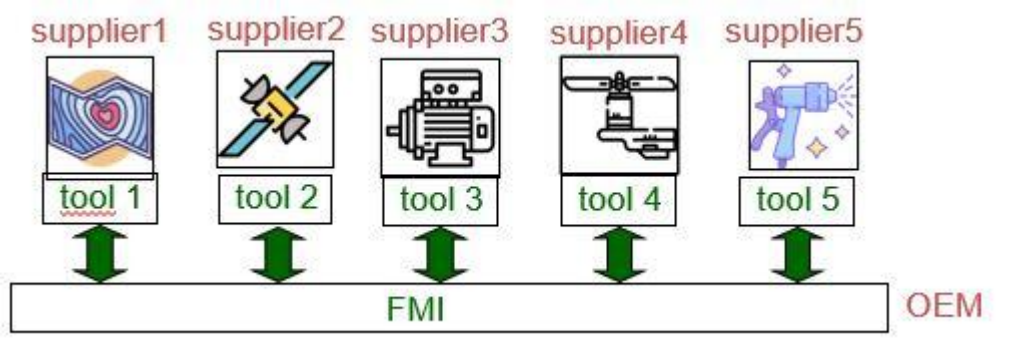
Modular simulation: Background Technology

Functional Mock-Up Interface (FMI)

- Functional Mock-Up Interface
  - A model implementing FMI is called an “FMU” (Functional Mock-Up Unit)
  - A self-contained package containing a virtual version of a component
  - Typically, an archive-file containing:
    - A .dll (Windows) or a .so (Linux) file (the code part)
    - A modelDescription.xml (the model’s capabilities listed in XML format)
- FMI standard demands that a model is on the same ‘local’ server
  - IP Protection not as robust as in OPC UA
  - But communication overhead is completely gone: Faster simulation for tightly coupled systems with smaller step-sizes



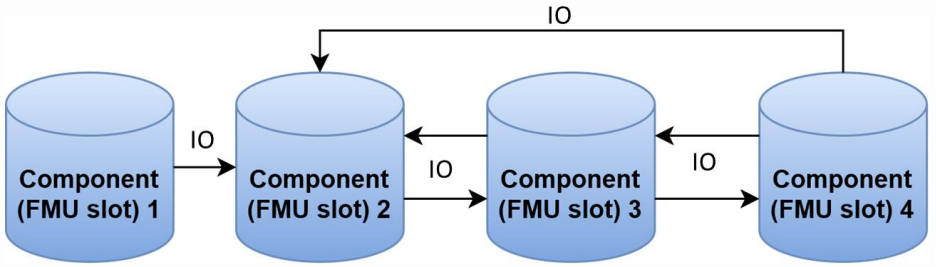
System Structure & Parameterization (SSP)

An ‘extension’ of the FMI standard

- Describes in XML format how multiple components connect
- Input / Output mapping
- Initial conditions (parameters)

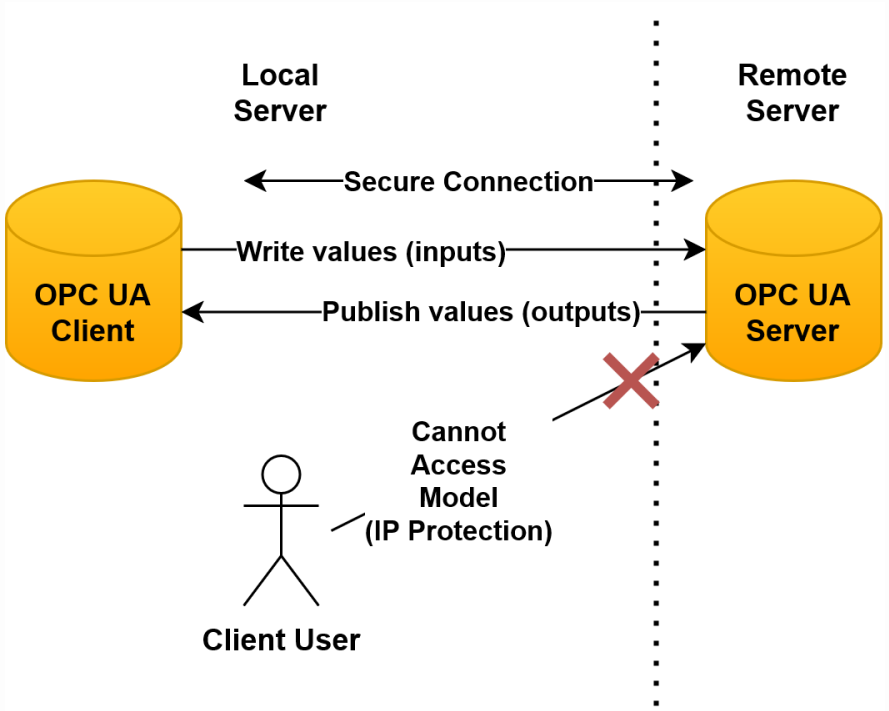
An SSP model has “slots” for FMI models called *Components*

- Pre-defined inputs and outputs for each “slot”, defined in the SSP model. The FMU models must implement the same inputs and outputs



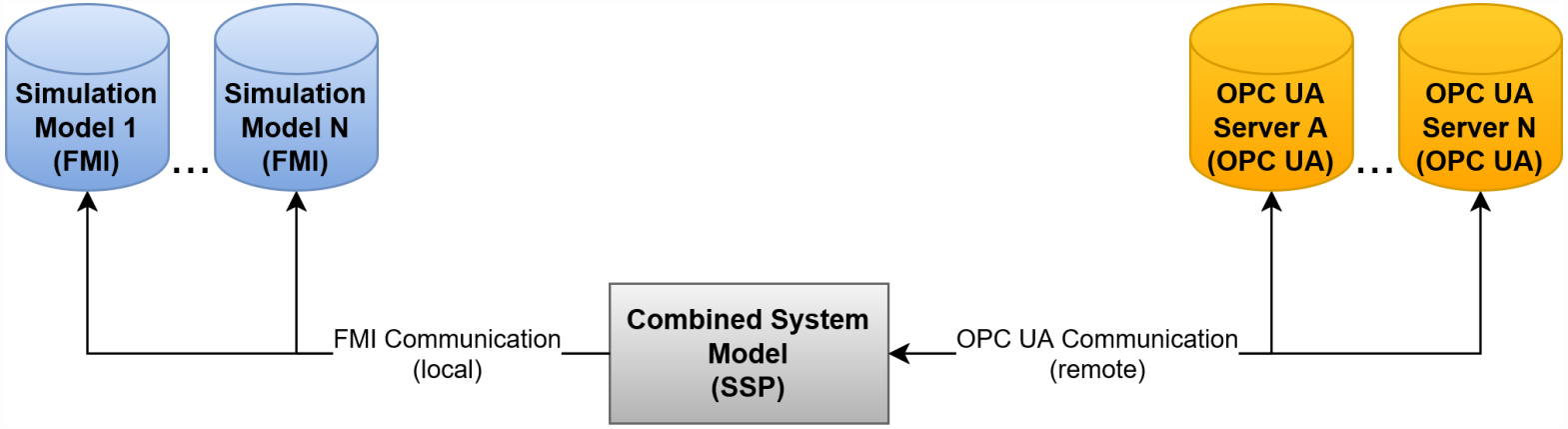
OPC UA

- Client-Server architecture
  - Publish / Subscribe data
  - Platform independent
    - Client and server can be different operating systems
  - Distributed computations
    - Model does not have to be on the same server as the client
  - IP protection



Modular simulation

- Individual simulation models are either
  - FMI models
  - OPC UA Servers
- Combined system model is an SSP model



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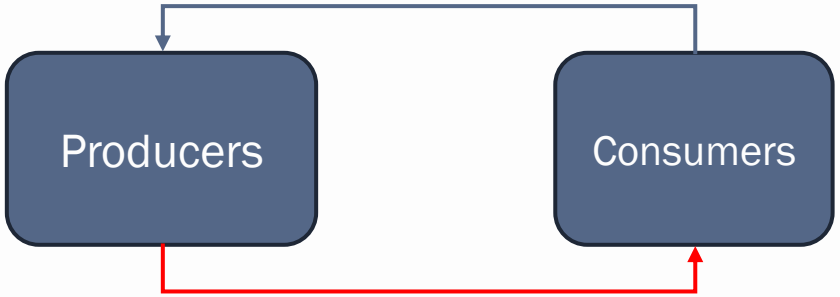
Waste heat recovery (WHR) circuit of a cruise ship

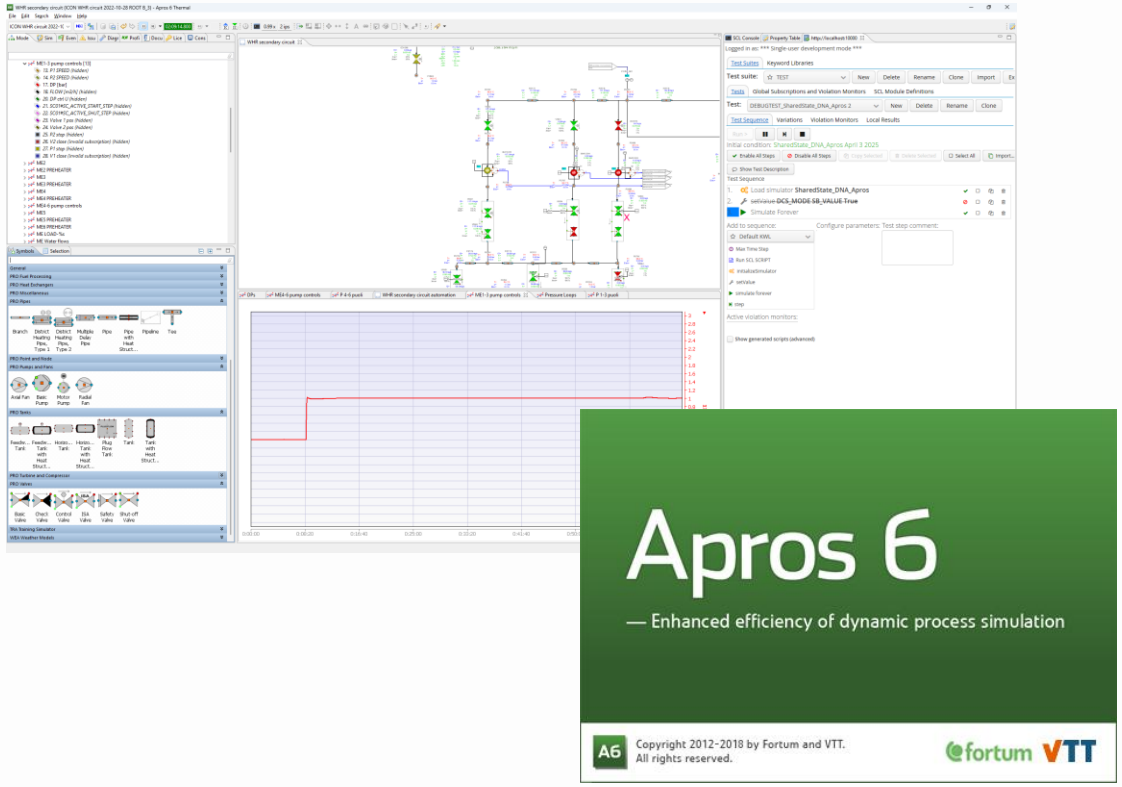
WHR Circuit

- Waste heat produced by engines is used by different equipment onboard for different hotel functions
  - Production of drinkable water, HVAC, laundry, etc.
- WHR circuit transfers heat from producers to consumers
  - Hot water flows from producers to consumers
  - Consumers extract some of the heat → water cools
  - Cold(er) water returns to producers
- Process DCS delivered by Valmet
  - DNA



WHR simulation model

- Semantum and Meyer Turku have developed a dynamic simulation model of the WHR circuit of the ship.
  - Including process and automation system
- OEMs develop a detailed simulation models of other equipment
  - For example, evaporator and absorption chiller
- Simulated in Apros



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WHR modular simulation system

WHR Circuit + Absorption Chiller + Evaporator

Absorption chiller produces chilled water for, e.g., HVAC

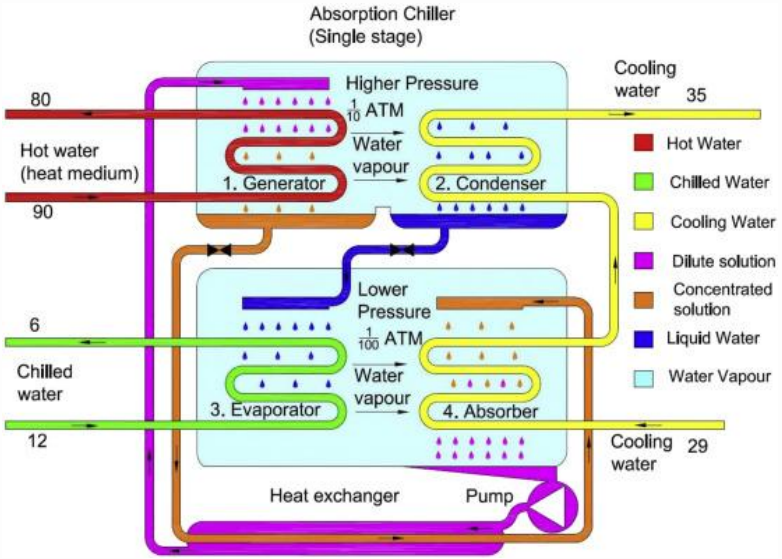
- Utilizes waste heat to achieve this

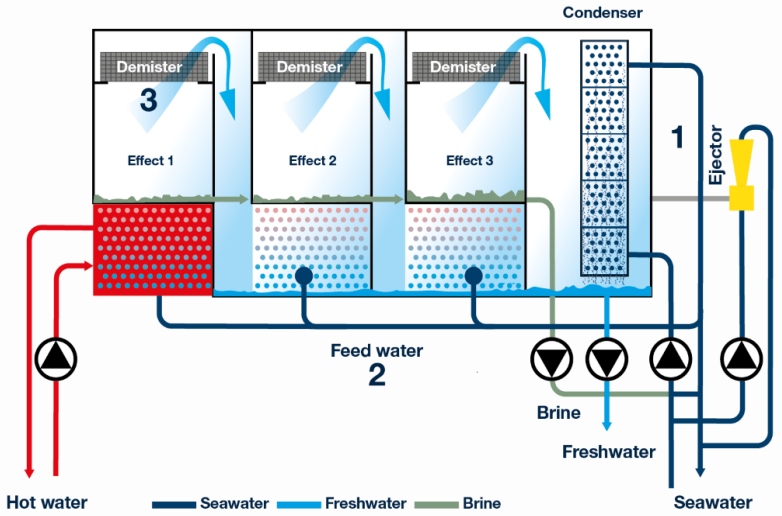
Evaporator produces fresh water from seawater

- Achieves this by evaporating the water using waste heat
- Resulting vapor is later condensed back to water

Absorption chiller and Evaporator FMUs were developed for this use case

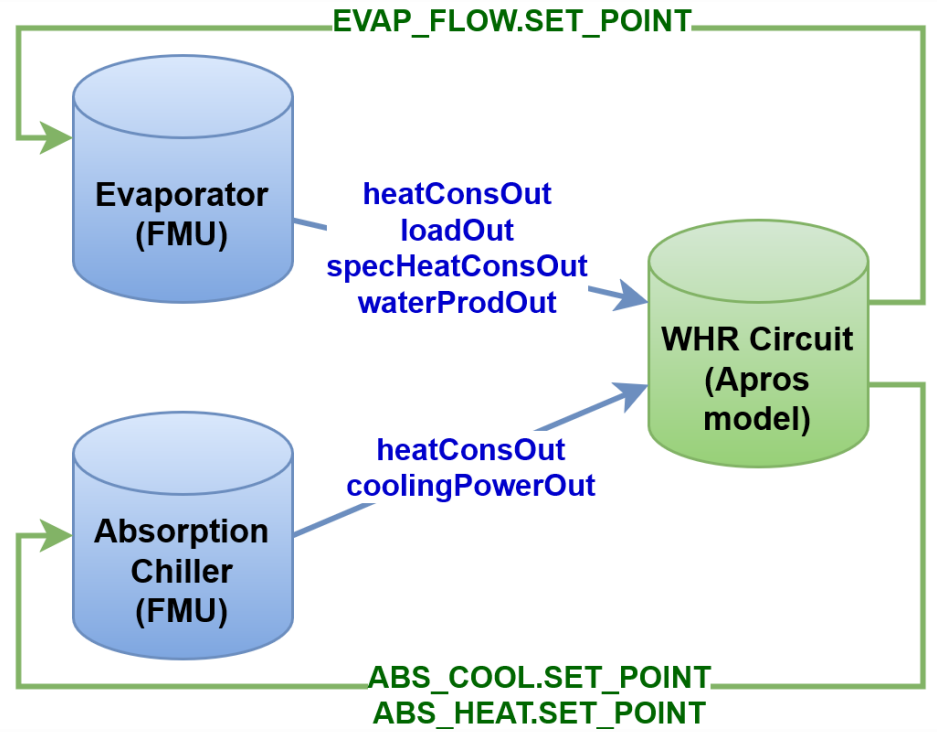
- The FMUs take in certain equipment dimensioning parameters and inputs relating to the prevailing operating conditions
  - As outputs we get how many kWs of waste heat they require from the WHR system
  - This value is then fed to the Apros WHR model as boundary condition





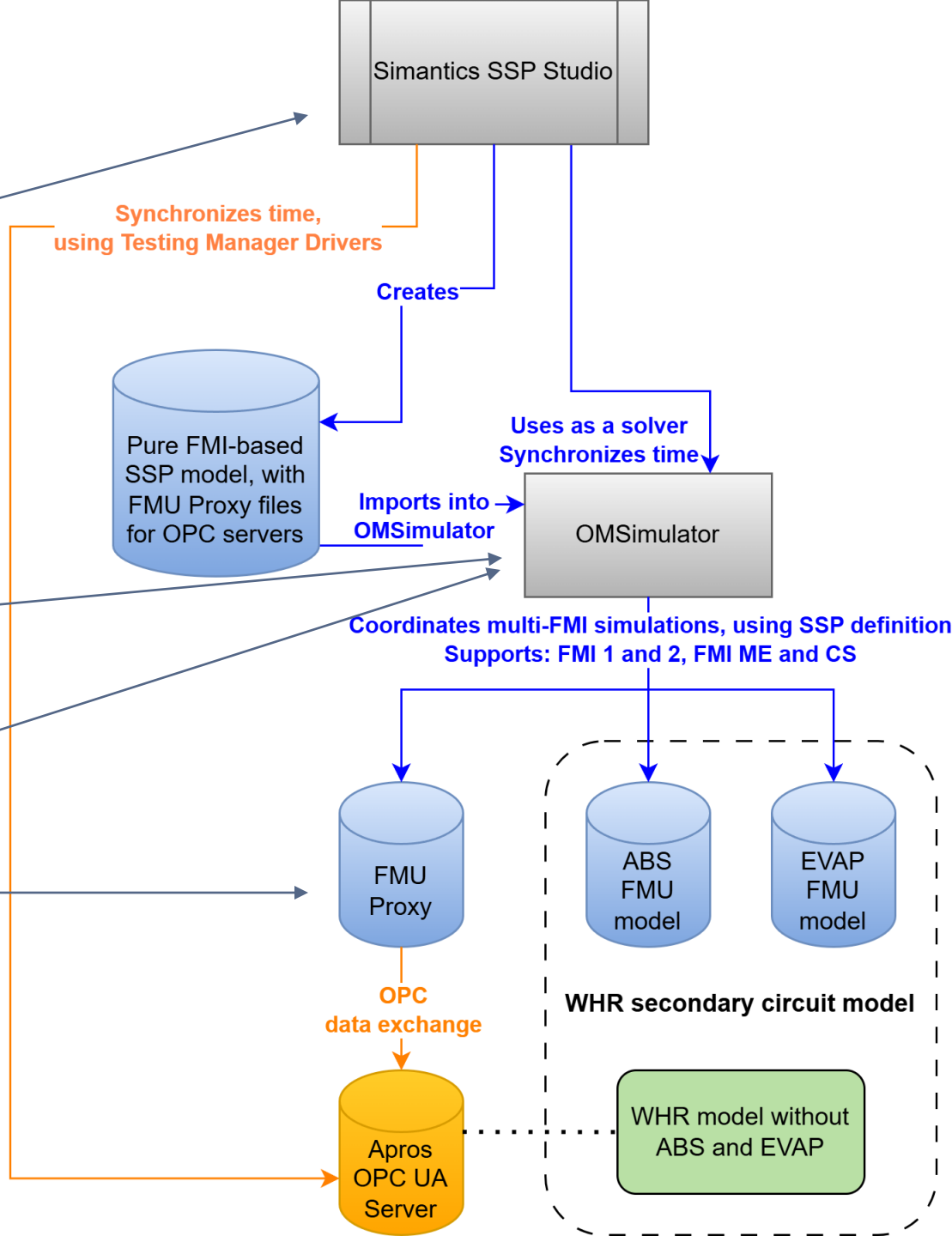
Simantics SSP Studio

- A co-simulation environment that allows connecting virtual system modules that implement FMI (Functional Mock-up Interface) and OPC UA interfaces.
  - SSP Standard is used to define how individual models are connected to form the whole system
- THE WHR demonstration:
  - WHR circuit in Apros (OPC UA Server)
  - Evaporator (FMU)
  - Absorption Chiller (FMU)

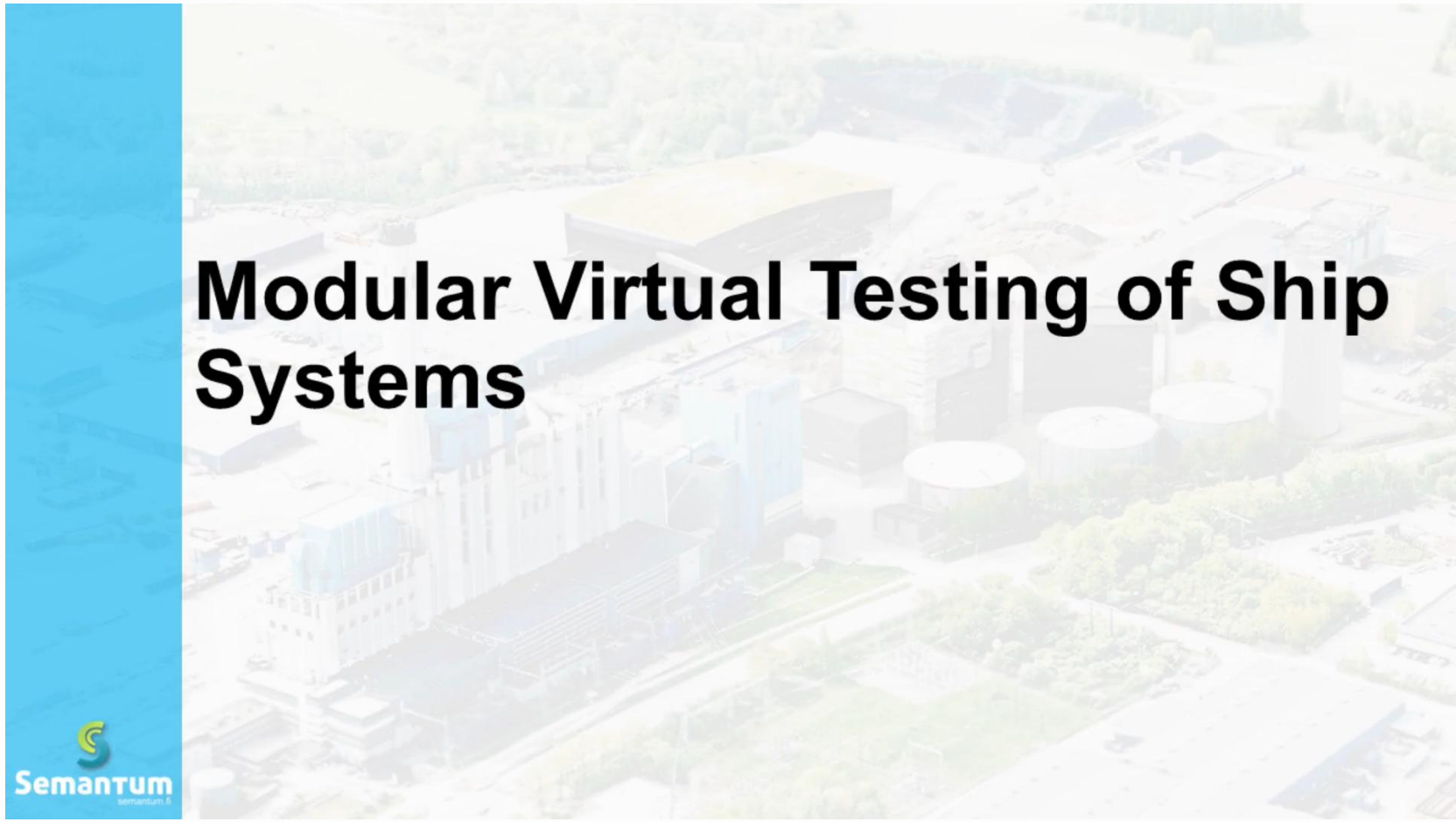


WHR Case: Architecture

- "Simantics SSP Studio" is capable of co-simulating FMU models and OPC UA Servers together
  - Underlying mathematical solver is "OMSimulator", an open modelica open-source project
  - OMSimulator's solver handles pure FMI systems
    - Simantics SSP Studio contains an FMU proxy implementation that handles FMI<->OPC UA communication



Demo video



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Conclussions

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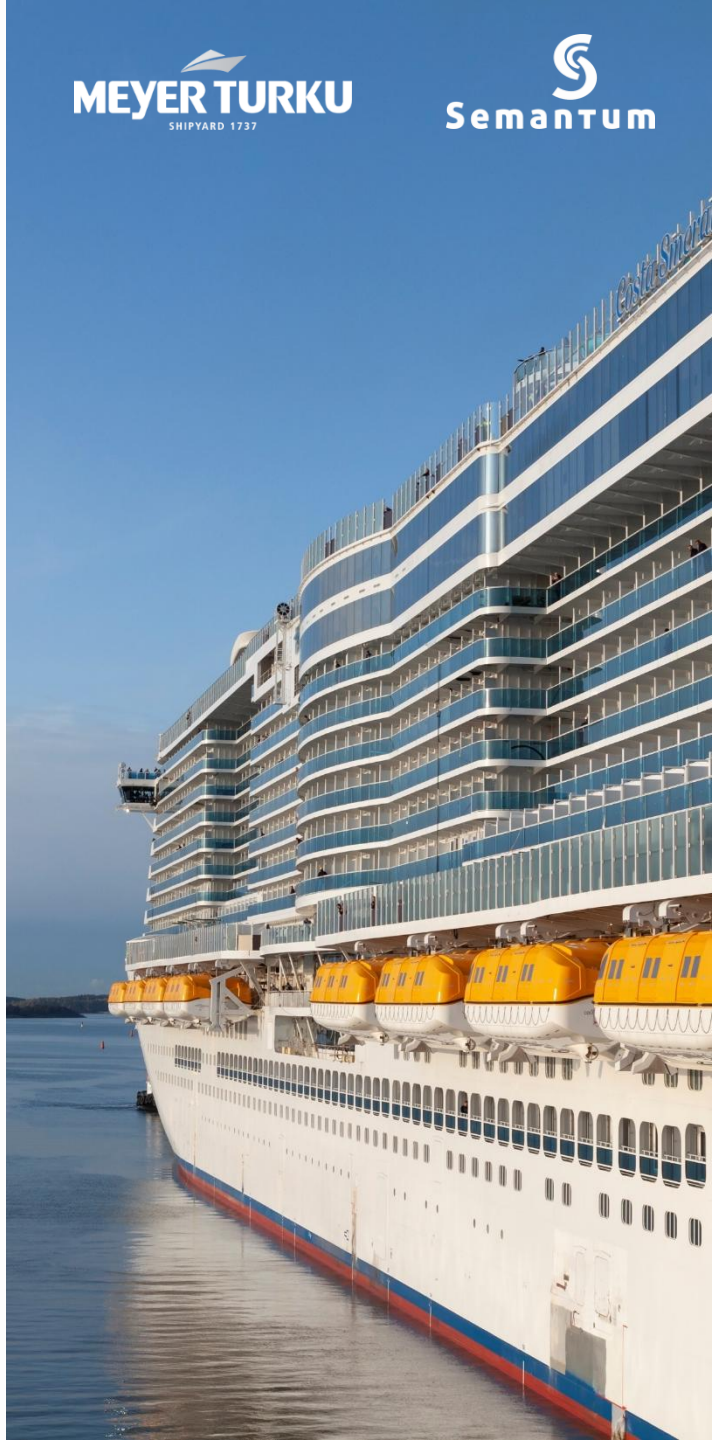
Conclusions

- FMI enables co-simulation of heterogeneous systems in a modular manner
- OPC UA is important for this use case
  - Control systems, SCADA and ERP systems are an important source of information for simulation studies
  - Data from these systems is usually available as OPC UA servers
- Interaction of FMUs with OPC UA modules is important
- Rigorousness of SSP enables scalability and repeatability of these type of implementations
  - Simantics SSP Studio and similar tools help reducing implementation time and work
- Modular simulations is highly important for simulation-aided testing



Thank you!

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