Vessel Traffic management Systems (VTS)

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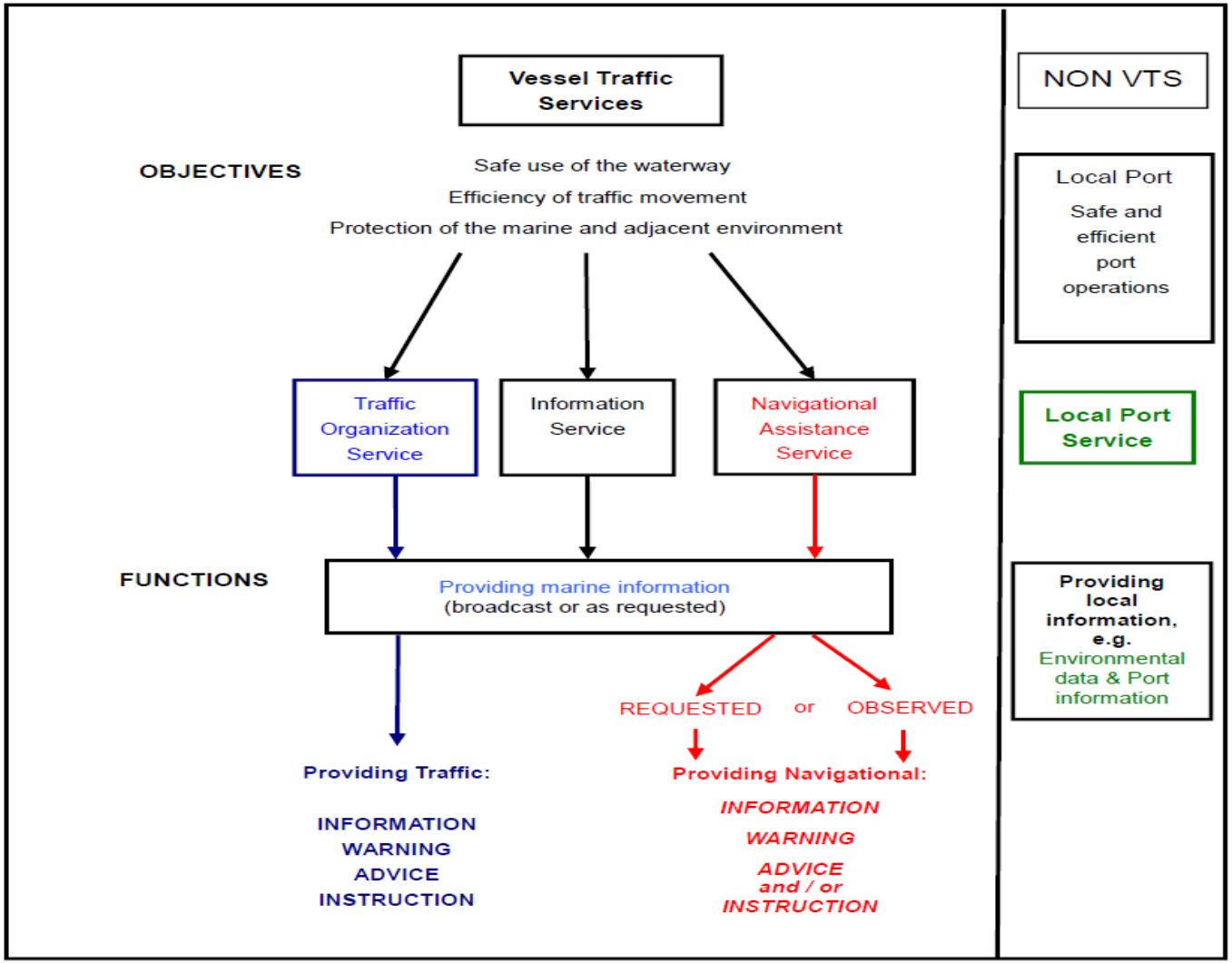
Objectives of vessels traffic mgt

- The objective of a modern VTS is to support *safety* and *efficiency of navigation*, and *protection* of the marine environment, adjacent shore areas, work sites and offshore installations from possible adverse effects of maritime traffic



VTS evolution

- VTS evolved from simple radar and voice radio systems, with the aim of enhancing navigation in poor visibility, to modern systems using multiple sensors
- Nowadays, ships targeting (or, more in general, marine objects targeting) is performed by using a large variety of different sensors
  - each with its own capabilities and operating modes
- Data generated from sensors vary in content, quantity, and use different formats
- VTSs provide integration of such different data sources to track and identify ships navigating within the area of interest

VTS as systems of systems

- VTS are systems of systems run by port authorities
- Deployed in harbors and coastal areas, they integrate:
  - Sensors (radars)
  - Automatic Identification Systems (for collaborative ships, with transponders)
  - Direction Finders, to receive information of vessels position and movement
  - Communication systems (including radio communications)
  - Surveillance systems (CCTV cameras, for visual situation assessment)
  - Meteorological systems

VTS as systems of systems

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VTS operational environment

SLC issues

- *Temporal mismatch*: subsystems/components are not all available at the same moment at a similar maturity level
- *Geographical mismatch*: subsystems/components may be located in geographically separated areas not easily accessible remotely
- *Documentation lack*: lack of adequate documentation about the behaviour and dynamics of interaction of COTS components
- Lack of standards

Challenge

- Operational integration of VTSs is expensive
- On site integration (i.e., in the actual deployment site) leads to late verification and has very high costs
- The assessment of performance and dependability attributes of such a SoS requires the simulation of several of such test scenarios
- Each scenario can be repeated a large number of times with different settings, and each simulation can require up to several hours to complete
- An example scenario is the generation of an increasing load for the VTS.
  - The workload consists of an increasing number of simulated marine objects (ships, buoys, wrecks) ranging from 100 to 5000
  - Each marine object follows a different path
  - A typical operation scenario includes several sensors, such as an Identification Base Station, 10 radar, 4 cameras, 1 weather station, and 4 Direction Finders.
  - Data collected by sensors are updated every 3 seconds
  - The network scenario involves geographical WAN links, both the up-link and down-link, at a throughput of 3,5 Mbps, LAN connection at 100Mbps

- The GAUSS project will investigate them in the areas of:
  - in-fabric simulation, emulation and testing;
  - context and policies modeling for run time (self-)adaptation

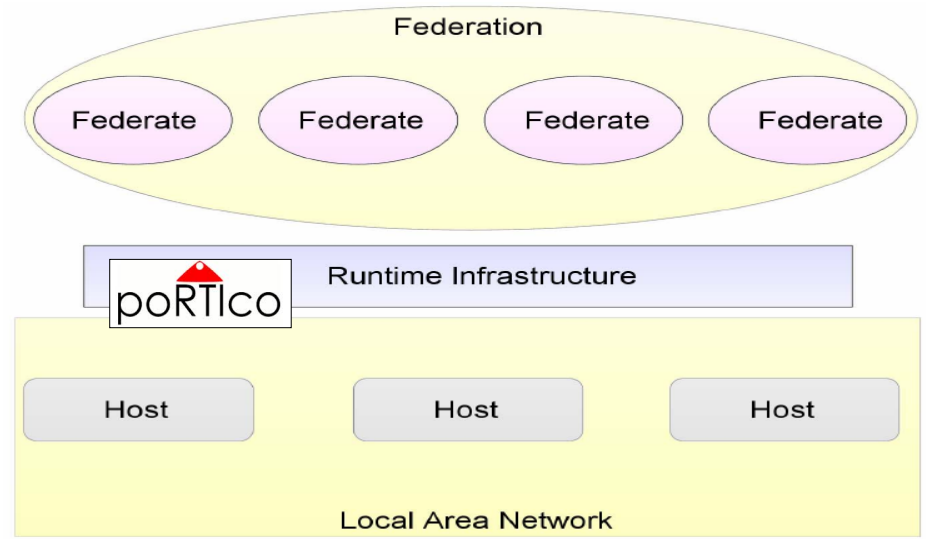
Past experience – Leonardo-UNINA

- PON Project DISPLAY - Distributed hybrId Simulation PLAtform for ATM and VTS sYstems
- In factory reproduction of SoS by means of:
  - Simulation of components not yet developed/available
  - Emulation of network infrastructures for data exchange emong subsystems
  - Use of available systems
- Enabling technology: hybrid simulation
- Hybrid simulation combines simulation and emulation, integrating them with real subsystems

The HLA standard

HLA fornisce linee guida per sviluppare architetture per la simulazione distribuita

Proposto dal DoD nel 1995, HLA è evoluto nello standard IEEE 1516 nel 2000 (2010 *last version*)



RTI valutate (GPL, LGPL, Apache Licence, …)

- Open RTI
- CERTI
- EODiSP HLA
- **poRTIco**
- ….

HLA Terms & Concepts:

- **Federate**: applicazioni (*software, virtual simulators, live components*) che supportano HLA e capaci di partecipare ad una simulazione
- **Federation**: un sistema di simulazione distribuita costituito da un numero di componenti (*federate*) cooperanti al fine di raggiungere un obiettivo di simulazione condiviso (*System of Systems approach*)
- **Run-time Infrastructure (RTI)** implementa un numero di servizi per l'interazione (Publish/subscribe model) e la sincronizzazione tra i federati
- L'interazione tra i *federate* è descritta tramite ***Federation Object Model (FOM)***

The DISPLAY framework

Model Driven Engineering of SoS

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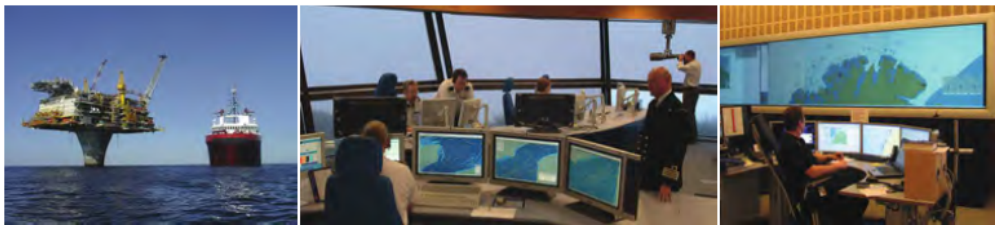
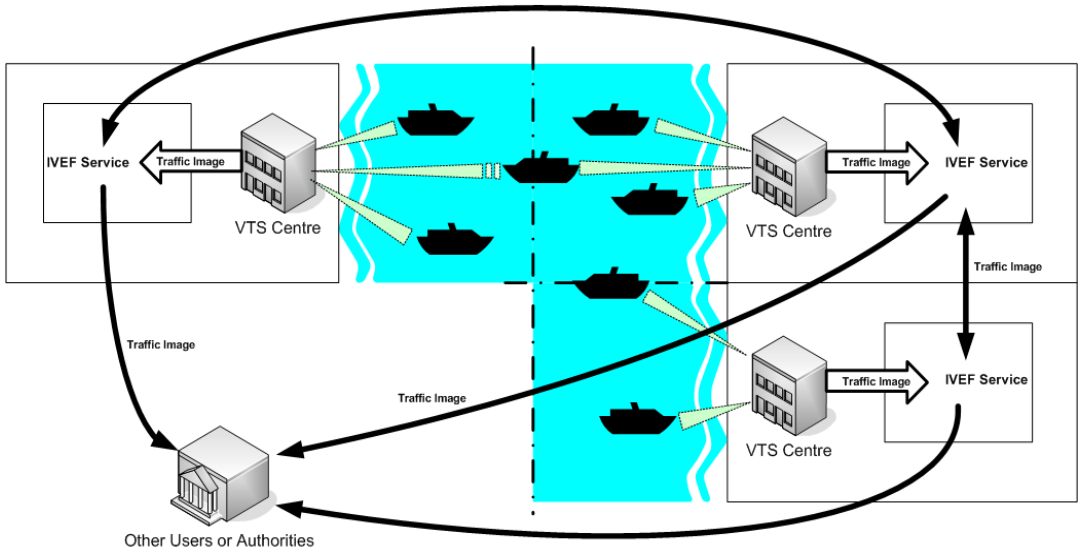
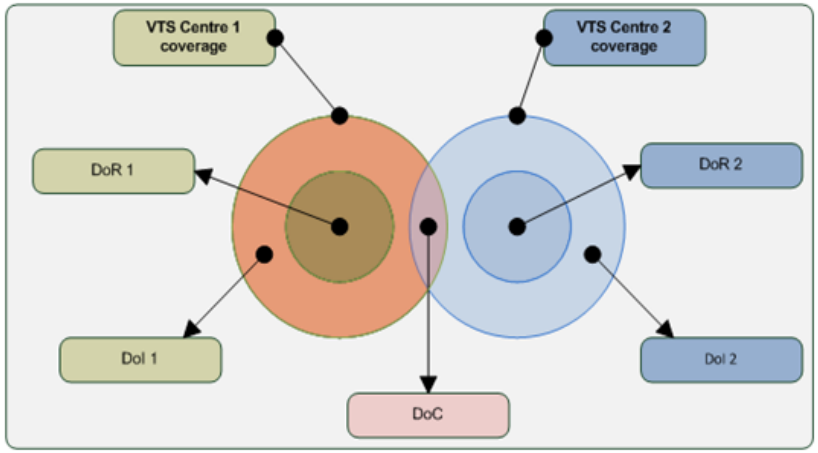
Case study: The Inter-VTS Exchange Format (**IVEF**) Service

- A framework for the exchange of maritime information between VTS systems
- An ongoing standardization effort (IALA Recommendation V-145)







MDE of SoS - CIM

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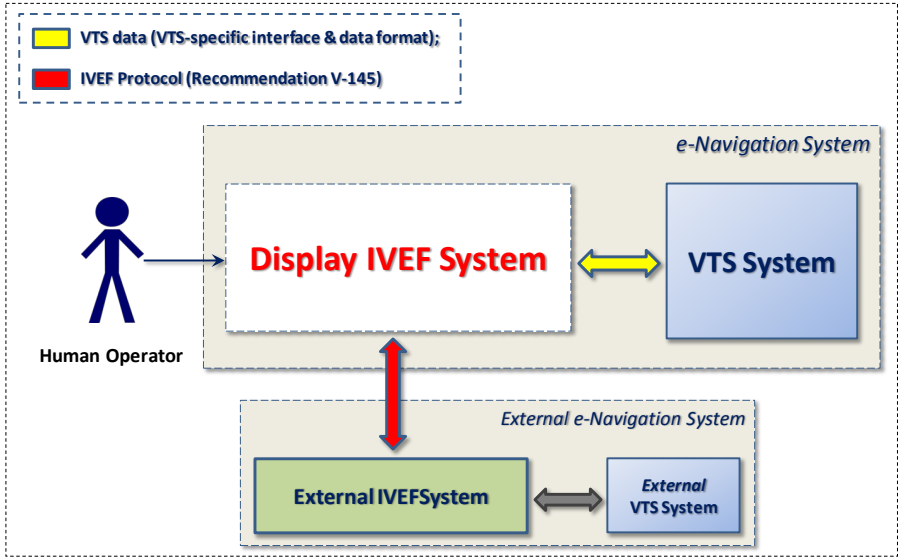
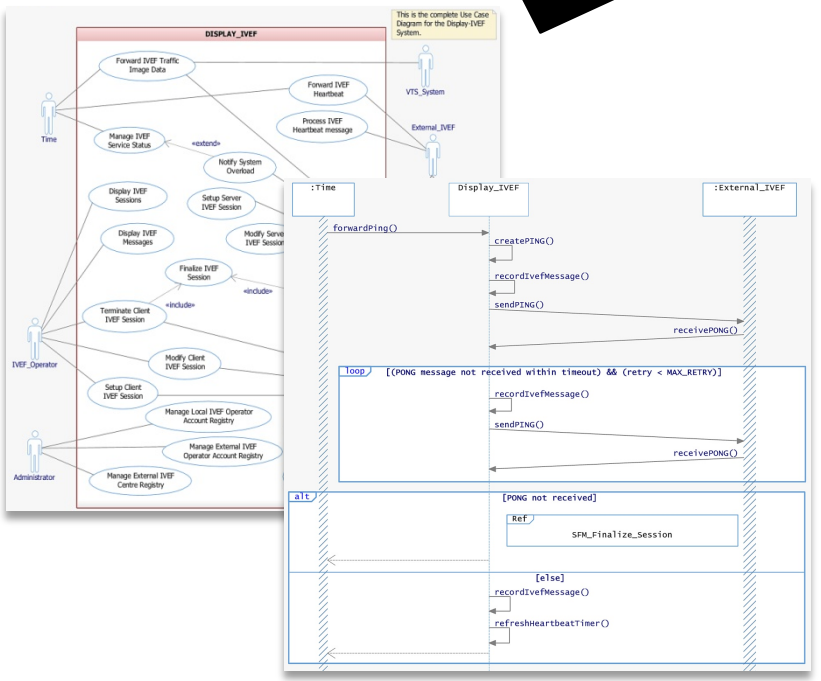
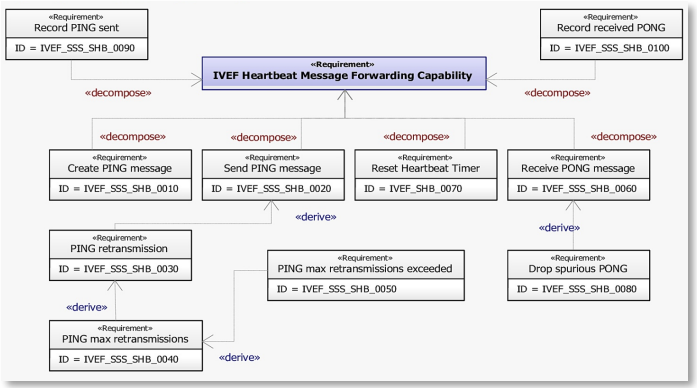
System Requirements Specification (CIM)



UML/SysML Behavioral Diagrams
- System Capabilities





SysML Requirement Diagrams
- Functional non-functional

MDE of SoS - PIM L0

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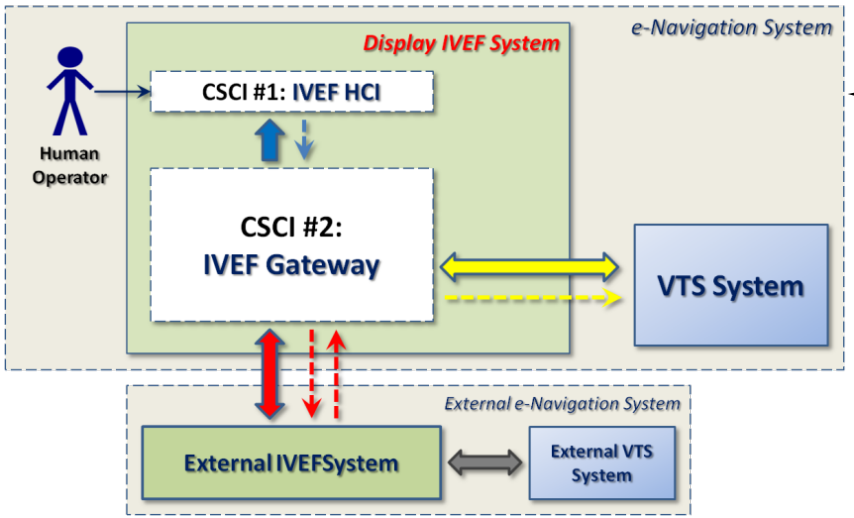
System Design (PIM L0)



two CSCI

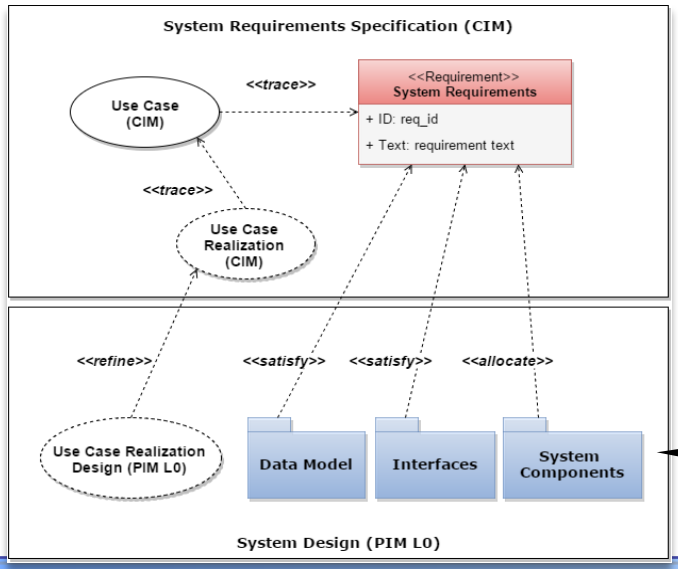
- IvefHci
- IvefGateway

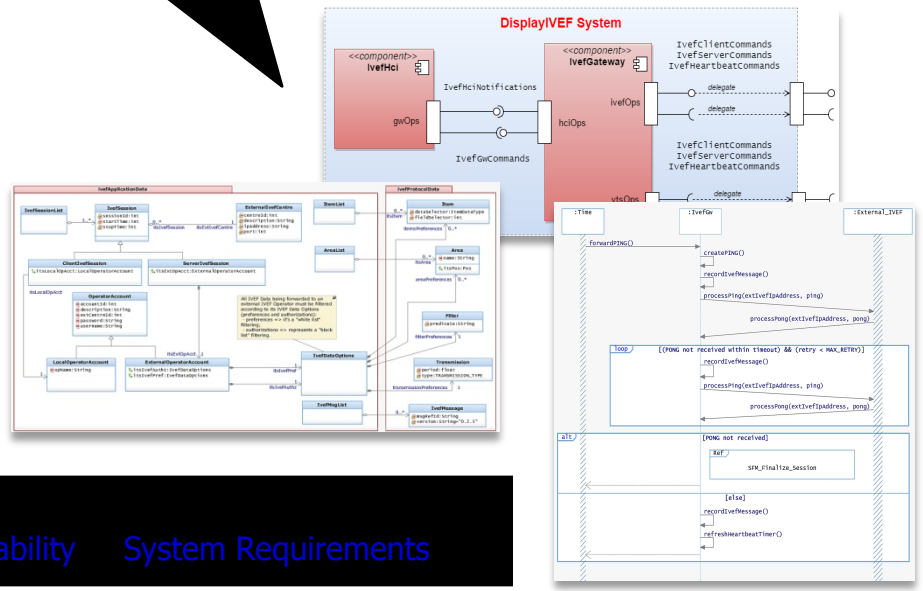
UML Structural Diagrams

- internal external interface
- Data Model

UML/SysML Behavioral Diagrams

- Use Case realization design





SysML

- Traceability System Requirements

MDE of SoS - PIM L1

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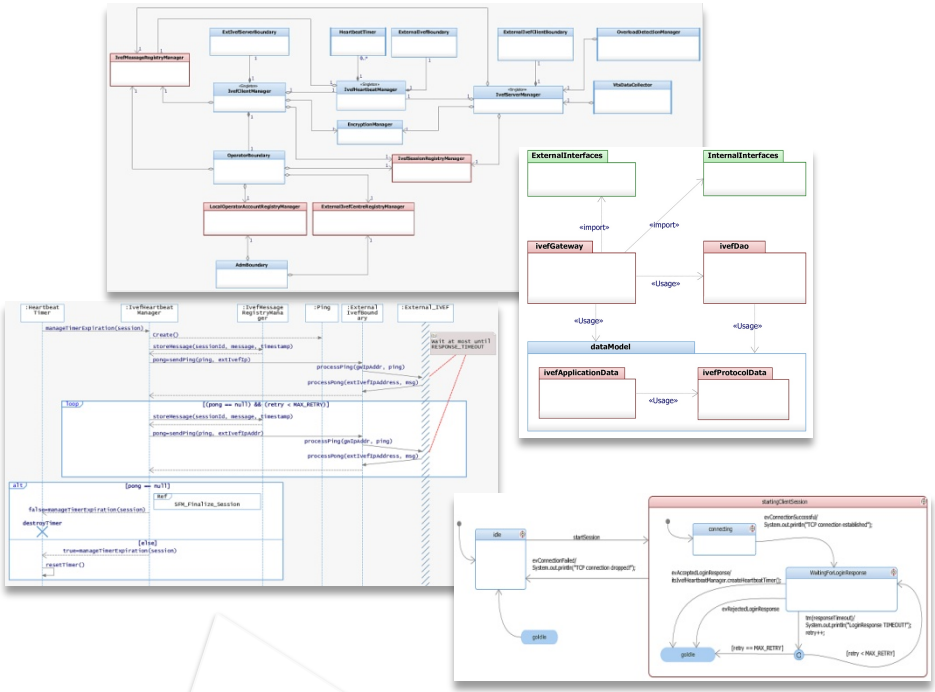
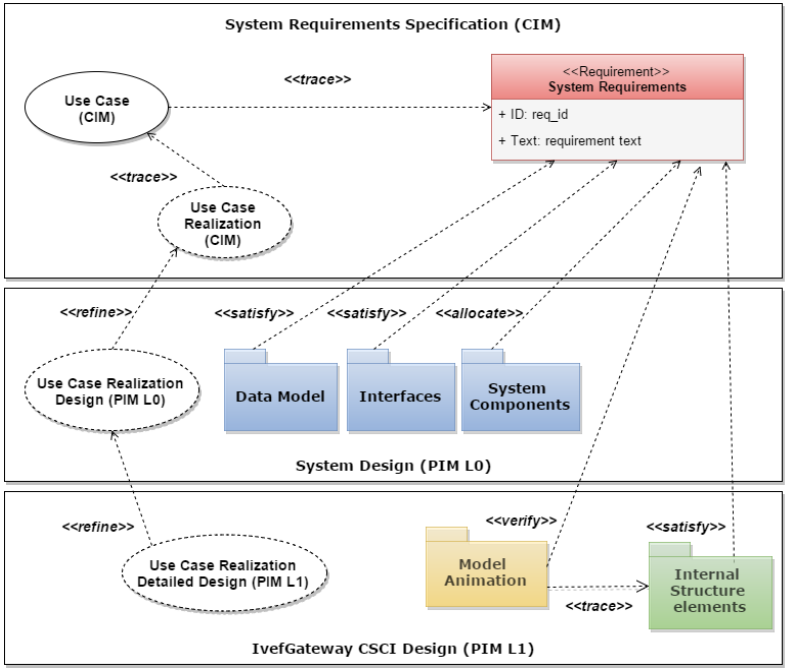
IvefGateway CSCI: Component Design (PIM L1)





UML Structural Diagrams
- Internal Structure Design

UML Behavioral Diagrams
- Use Case *detailed* realization design
- Internal elements behavior modeling

SysML requirement stereotype
- Traceability to System Requirements

Model-in-the-Loop testing

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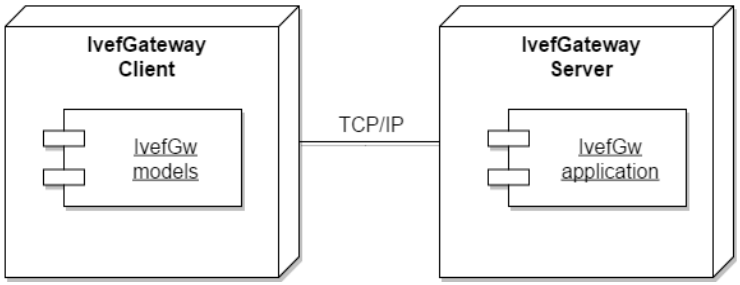
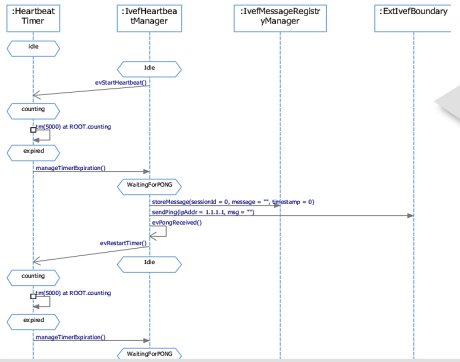
Hybrid Model Simulation: UML models interacting with a *real* application
- *early detection* of **design flaws**

Linking models and the real application by means of a **Java Wrapper**

Hybrid simulation test architecture





MDA tools used to **trace simulation execution** (with UML behavioral diagrams)

Design flaws identified on the ***real implementation*** of the **IvefGateway** :
- Requirement **IVEF_SSS_SHB_0070** not met
- **Software aging bug** related to db connections