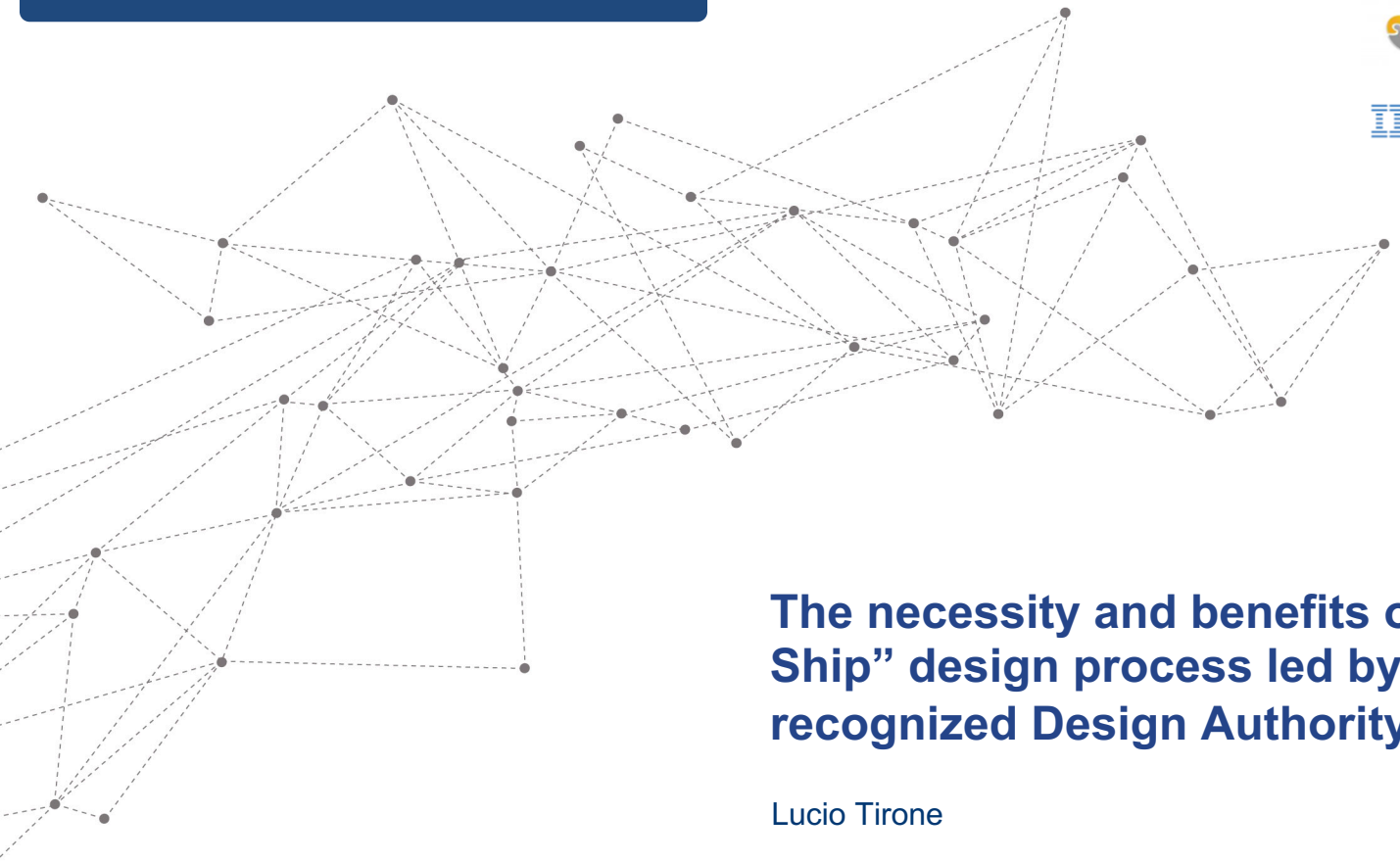
SESE 2019 | The South European Systems Engineering Tour | Trieste May 22



The necessity and benefits of a “Whole Ship” design process led by a recognized Design Authority

Lucio Tirone

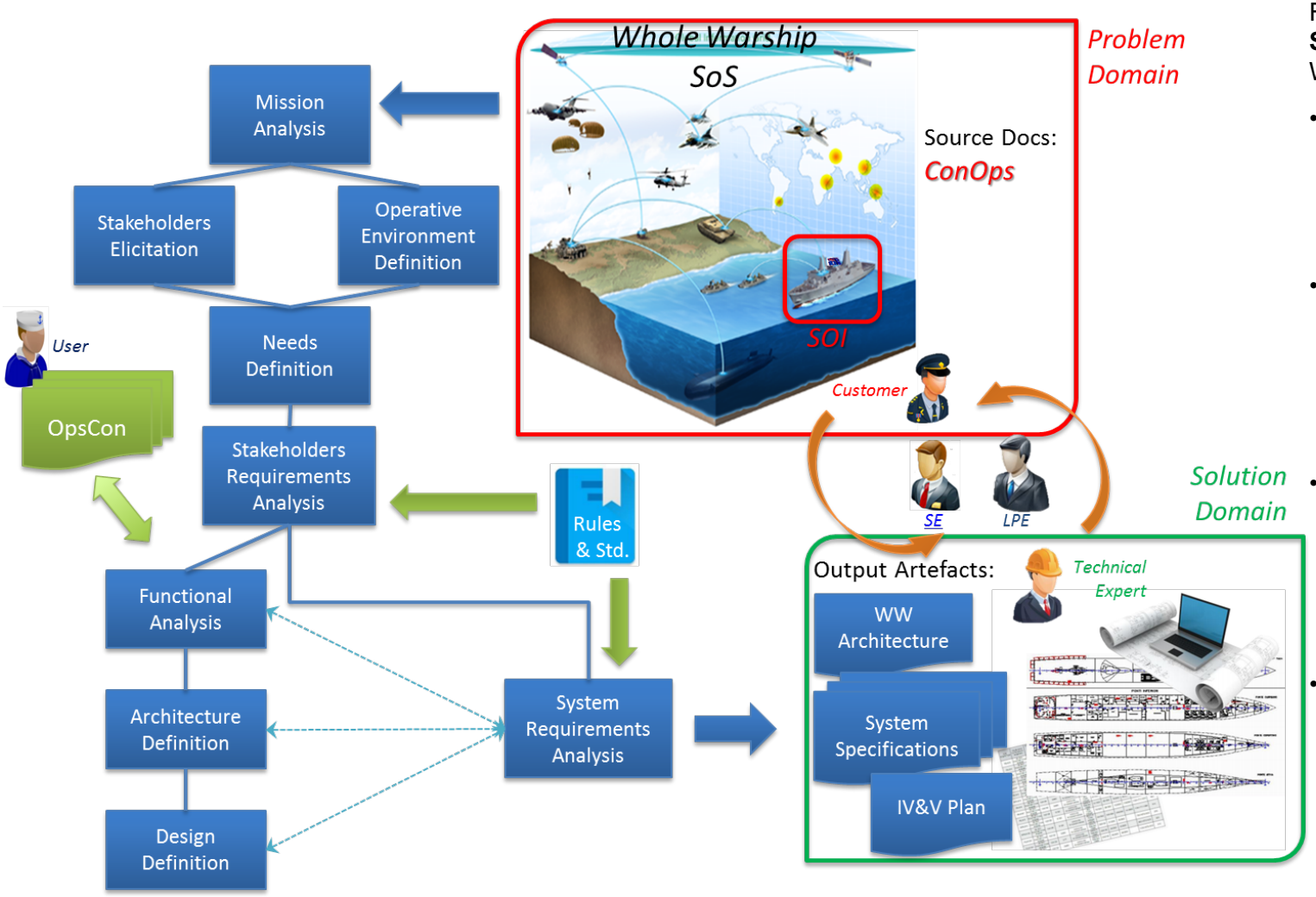
FINCANTIERI
The sea ahead

AGENDA

- The MBSE Design Approach in FINCANTIERI
  - The need for a Design Authority
  - Benefits of the Design Authority approach

- A reference Architecture for the Whole Ship
  - «ESWBS» view of the Ship Architecture
  - «Systemic» view of the Ship Architecture
  - Identification of a "hybrid" approach
  - Example of the SysML model of a Whole Ship

THE MBSE DESIGN APPROACH IN FINCANTIERI

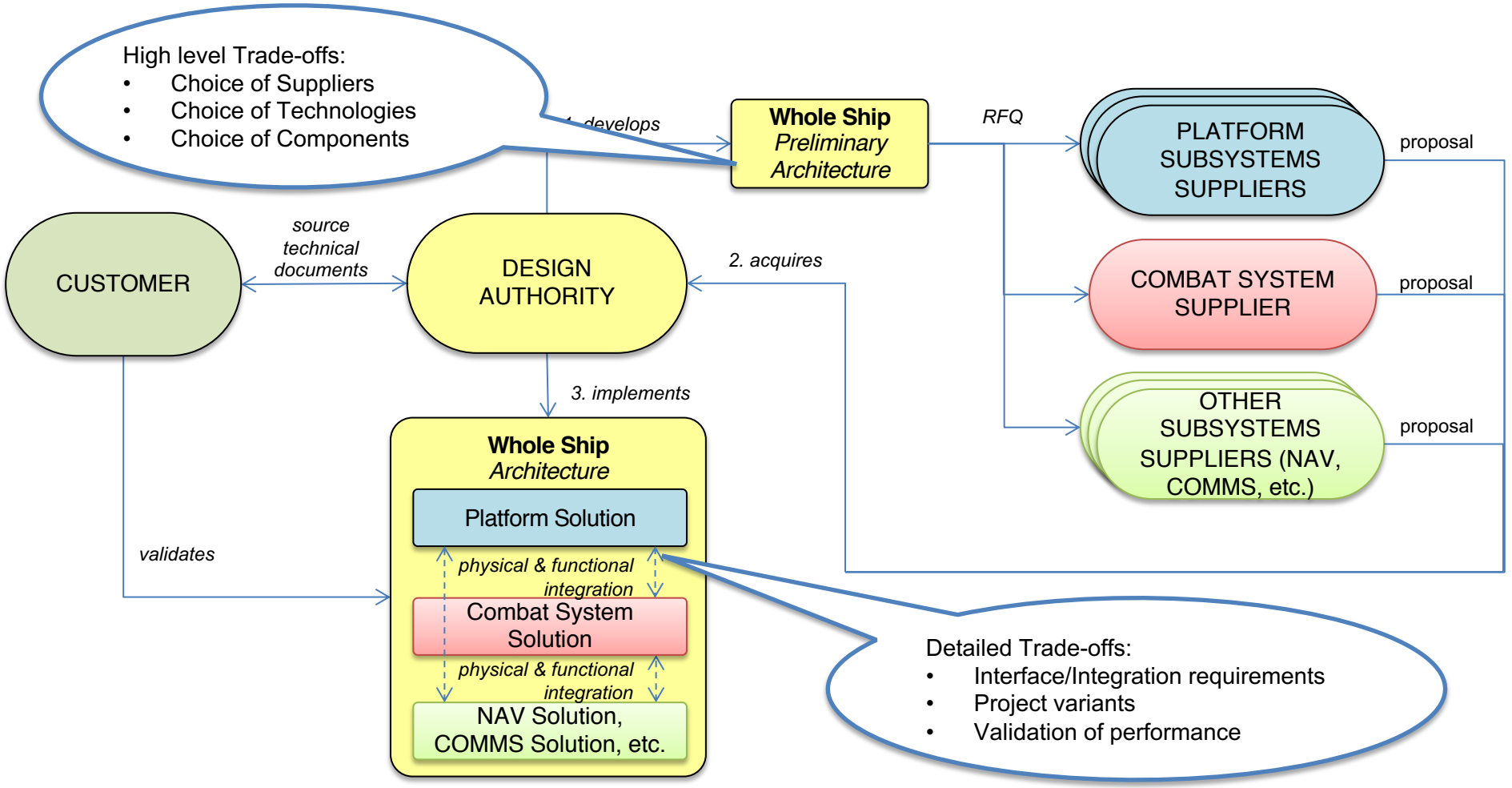


Fincantieri adopts a **Model Based Systems Engineering** approach for Whole Ship design, in order to:

- **Investigate the capabilities** that the Ship (System-of-Interest) under development is required to exhibit in order to support the Task Force (System-of-Systems) Missions
- **Analyze the design alternatives** supporting the decision making process through coverage/impact analyses, and seeking value in lessons learned from previous programs
- **Provide a broad vision of the Ship's response** to the real world in terms of "what" the Ship shall do, demonstrating "how", and also "whit what", while guaranteeing continuous traceability
- **Fill the gap in communication and understanding** in technical processes between outsiders and insiders, from needs analysis, to requirements definition, to IV&V

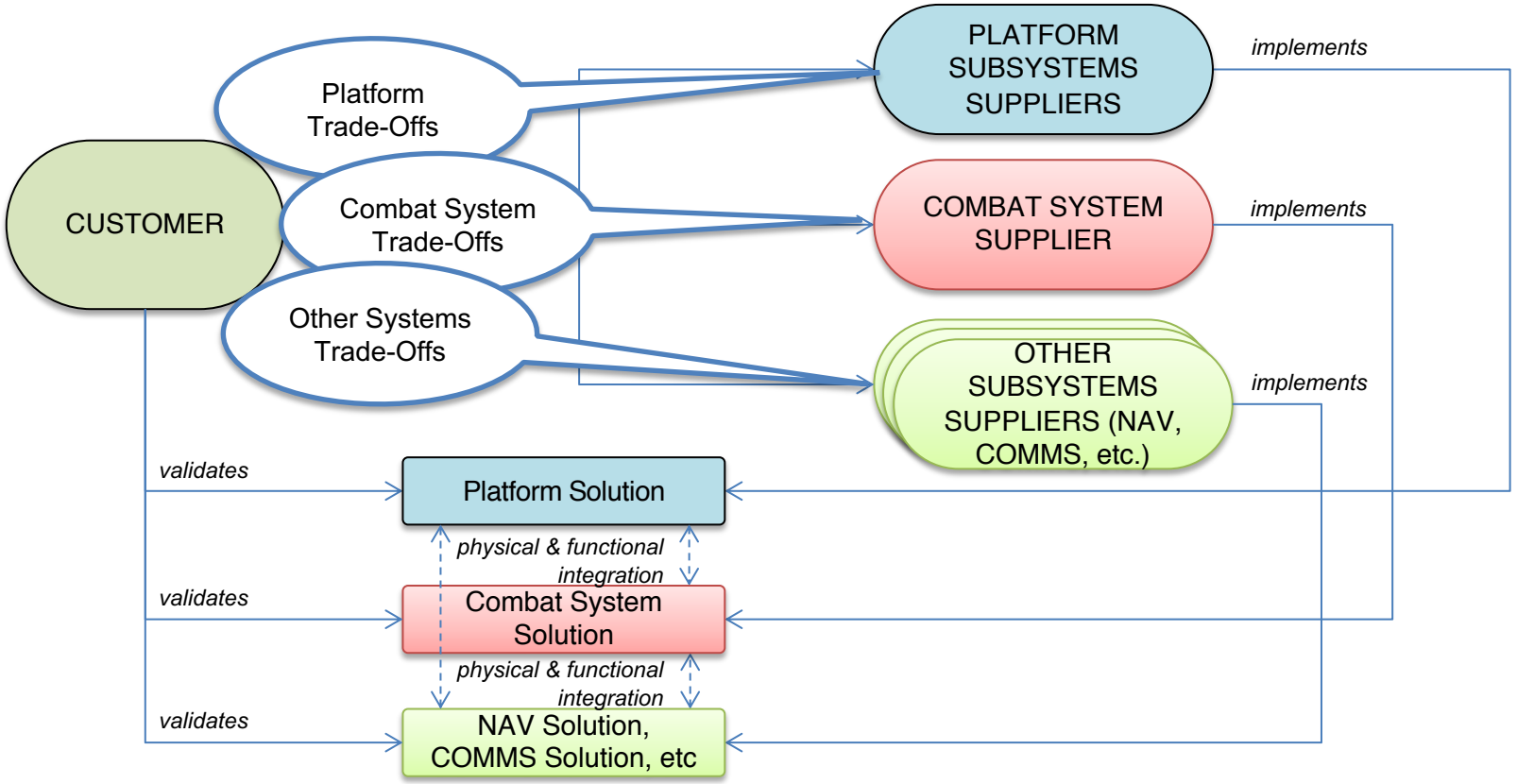
THE NEED FOR A DESIGN AUTHORITY

In order to allow the transformation of the end customer's needs into a technically and economically feasible architectural solution, it is necessary to apply trade-off criteria that affect the Naval Unit as a whole, as part of a decision-making process that takes into account of all the Stakeholders involved.



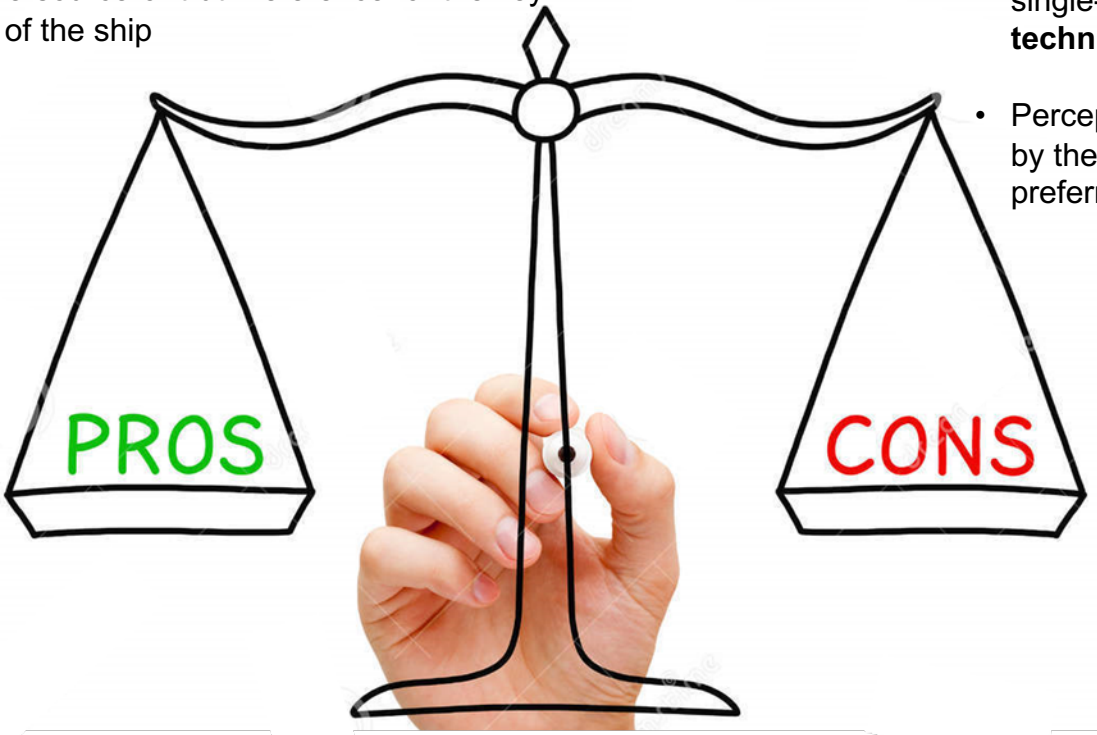
WHEN A DESIGN AUTHORITY IS NOT DEFINED

This management approach is opposed to the one in which the Trade-offs for Platform, Combat System (CS) and the other systems are substantially evaluated and managed by several distinct industrial entities which interact directly with the Customer, each with a certain degree of autonomy.



BENEFITS OF THE DESIGN AUTHORITY APPROACH

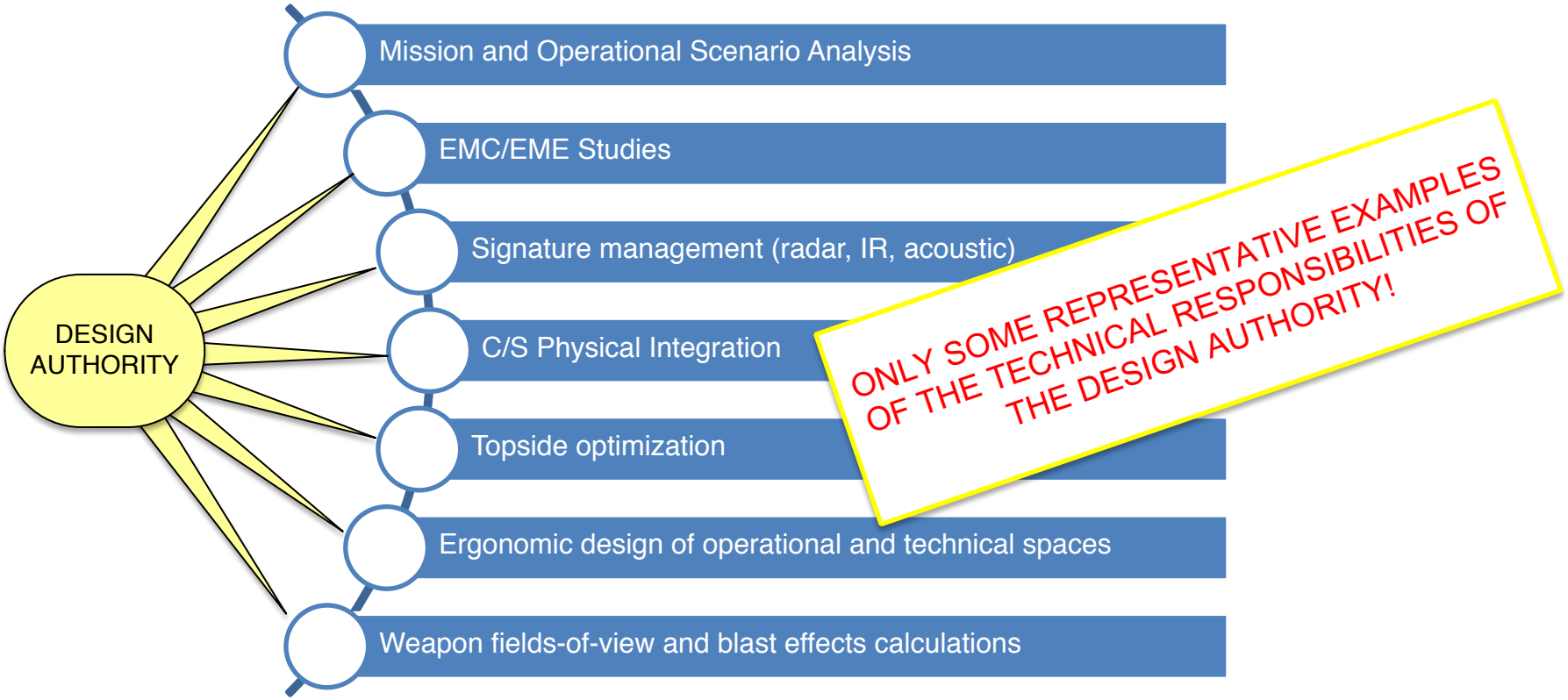
- **Single interface** for the acquisition of the Customer's **needs**, and for their "translation" into technical requirements
- Design **Trade-Offs** can be conducted at **Whole Ship level**, considering all engineering aspects of the ship design
- A **Whole Ship Architecture** can be established by the Design Authority, being the single-source-of-truth reference for the key technical characteristics of the ship



- Single-source-of-truth = single-point-of-failure = **technical responsibility**!
- Perception of less **freedom** by the Customer in identifying preferred solutions

TECHNICAL RESPONSIBILITIES OF THE DESIGN AUTHORITY

Enabling factor for an effective WW design is the identification by the Customer of a Design Authority (DA) characterized by a recognized **technical authority**: the DA must be equipped with all the transversal skills necessary to manage the Customer's requirements, allocate them to the various Ship components, carry out an integrated project and evaluate the relevant trade-offs.



Additionally, a key aspect is that the roles of Prime Contractor of the enterprise and Design Authority must be covered by the same entity, to guarantee that all the trade-offs are evaluated in full autonomy.

FULL TRUST BETWEEN CUSTOMER AND DESIGN AUTHORITY

In order for the Whole Ship design to be perceived by the Customer as an **advantage** in terms of optimizing the proposed solution, it is necessary for DA to be carried out in a completely **transparent** manner, providing **full visibility** on the rationale underlying each design choice.

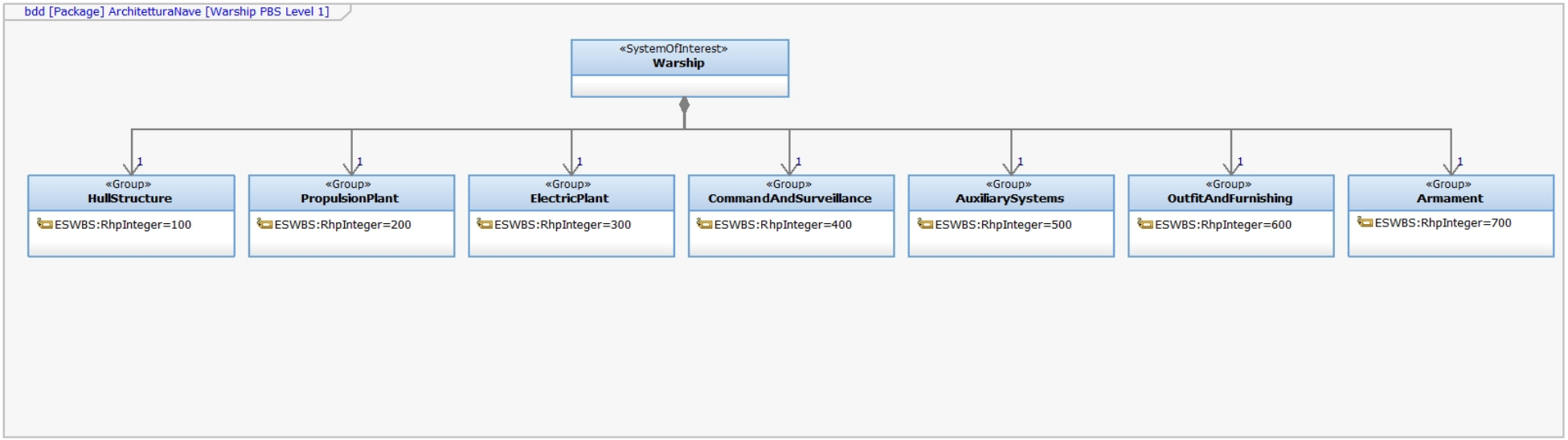
This approach is well reflected in the current market opportunities for the supply of naval units, which increasingly require direct engagement with a single interlocutor who takes on the burden of managing suppliers, integration of the system components, and all the related risks.

A REFERENCE ARCHITECTURE FOR THE WHOLE SHIP

One of the main tools that the Design Authority can put in place to achieve the purposes stated in the previous slides, and at the same time one of his key responsibilities, is the definition of a «Reference Architecture» for the Whole Ship.

The Whole Ship Architecture can be represented at the highest level according to two different points of view:

- N.1 - «ESWBS» Viewpoint
  - ✓ It is based on the Extended Ship Work Breakdown Structure (ESWBS) as defined by the MIL-STS-881: 2011 US DoD "Work Breakdown Structure for Defense Material Items" and the "ESWBS Glossary" of the Inspectorate for Logistic Support and Lighthouses of Italian Navy, 2012
  - ✓ Represents the Military Ship as constituted by a set of 7 «Groups», indicated in the regulation as «Subsystems»:



«ESWBS» VIEW OF THE SHIP ARCHITECTURE

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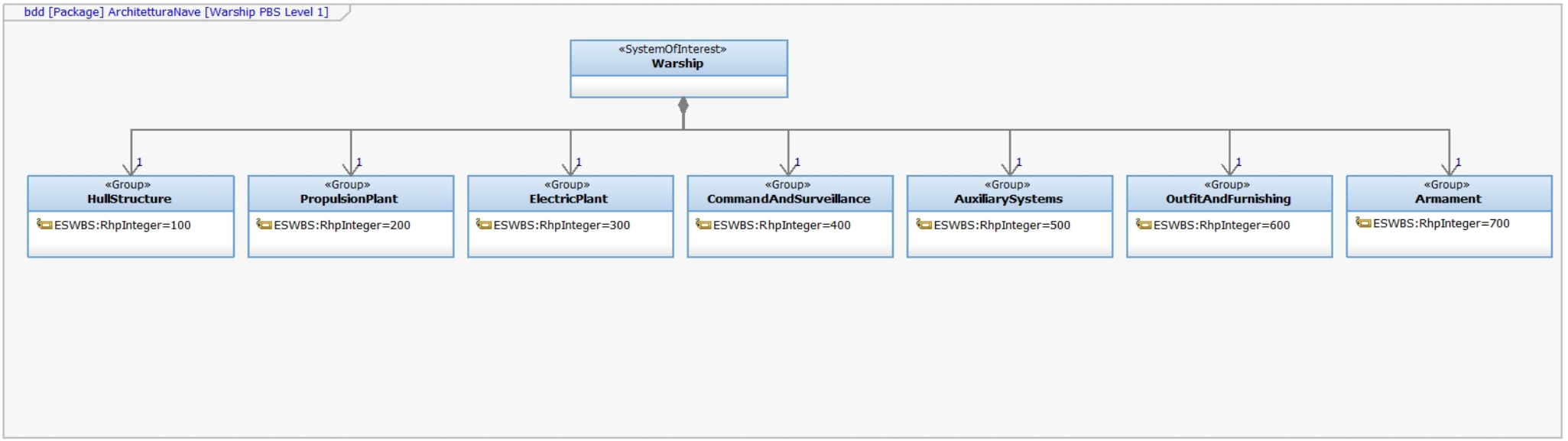
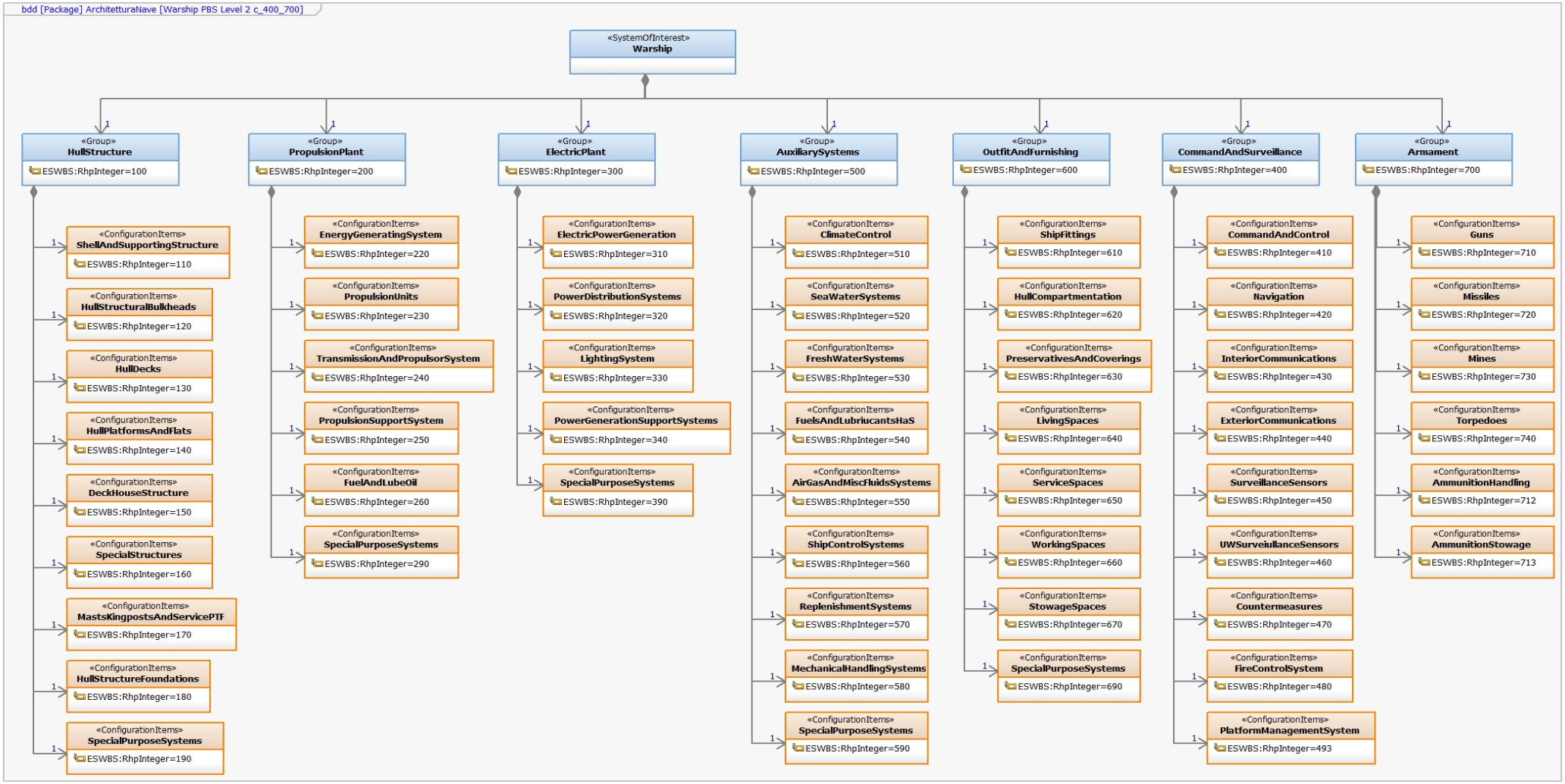


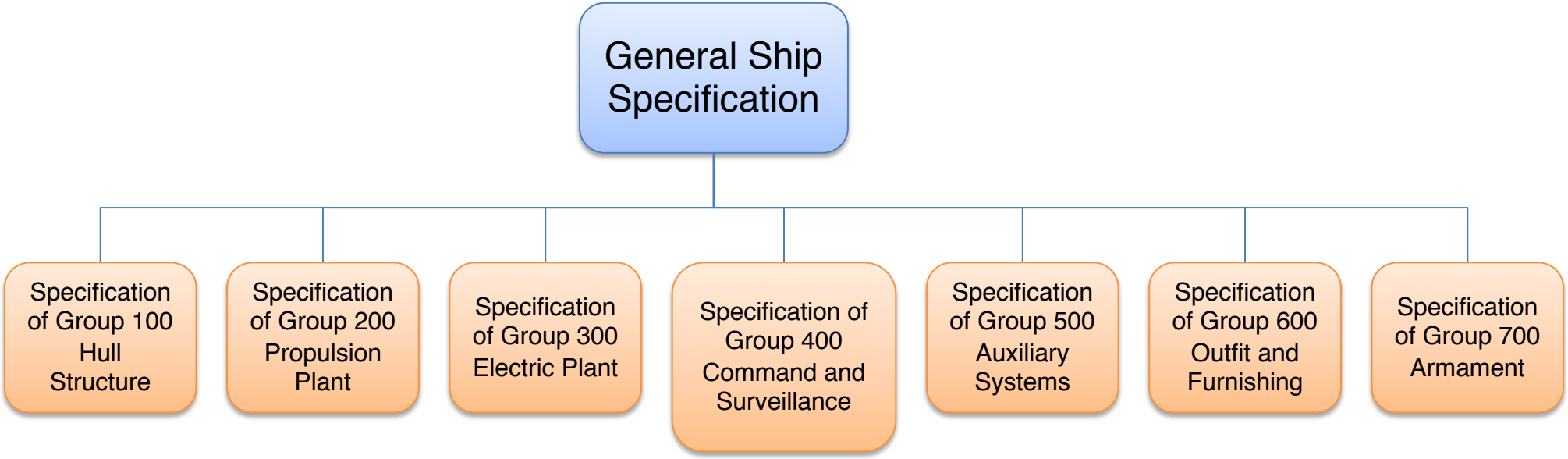
«ESWBS» VIEW OF THE SHIP ARCHITECTURE

- «ESWBS» View, Level 2



TECH. SPECS TREE WITH A «FULL ESWBS» APPROACH

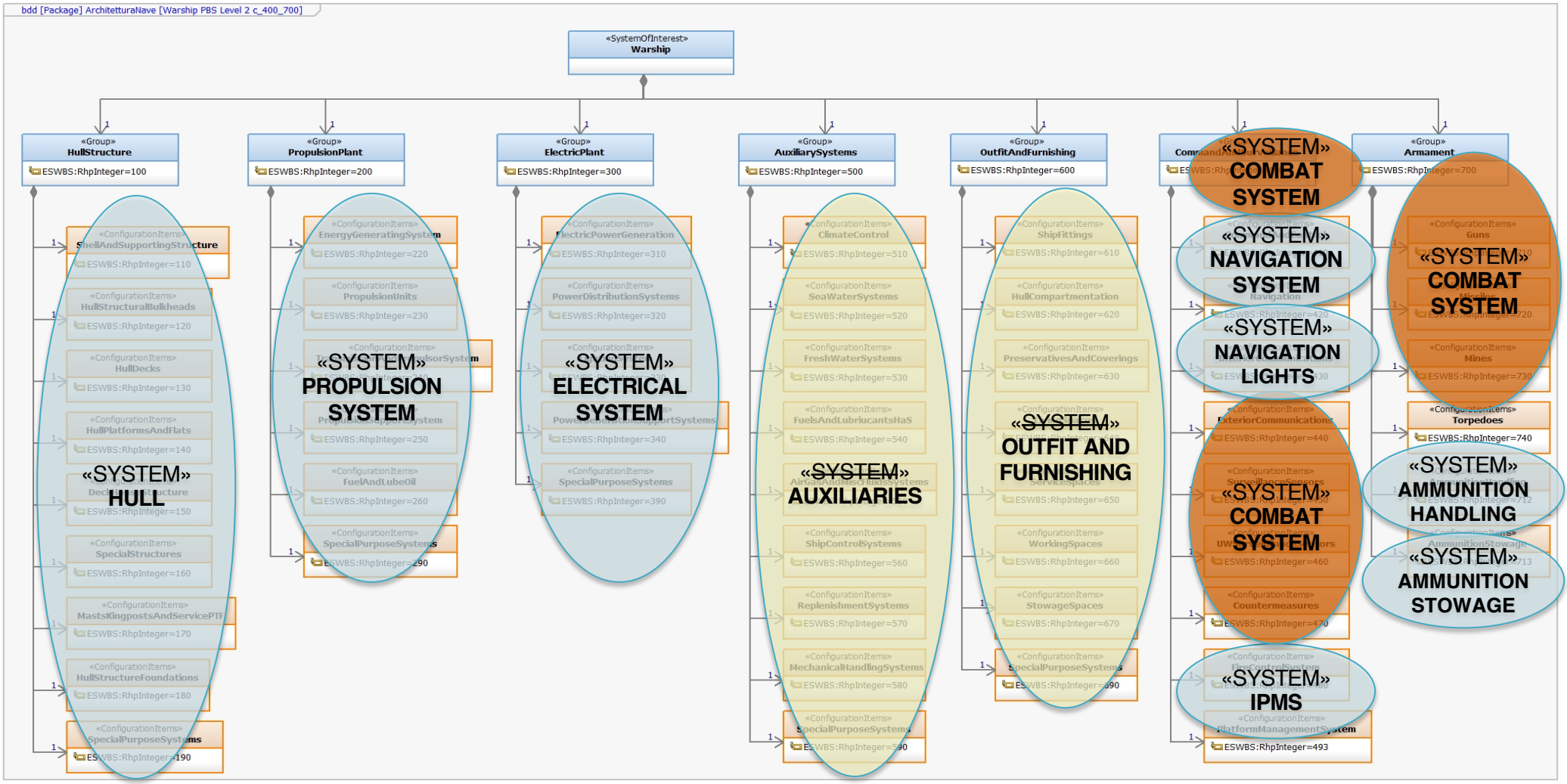
The "FULL ESWBS" approach consists in applying the ESWBS View for the composition of the Ship Specification Tree, with some hints derived from "MIL-STD-961E-CHG-3: 2015 US DoD" Defense and Program-Unique Specifications Format and Content»:



- PROS
  - ✓ Documents consistent with the structure defined in the ESWBS
  - ✓ Easy "localization" of each component in the product tree (PBS)

- CONS
  - ✓ Difficulties in representing Groups 500 and 600, being more collection of subsystems, rather then systems in their own respect
  - ✓ Even greater difficulty in representing the Combat System, which appears to be "distributed" in various sub-elements of the Specification of Groups 400 and 700, and in cohabitation with the Navigation System, Platform Management System and others in Group 400, with weapons support equipment in Group 700

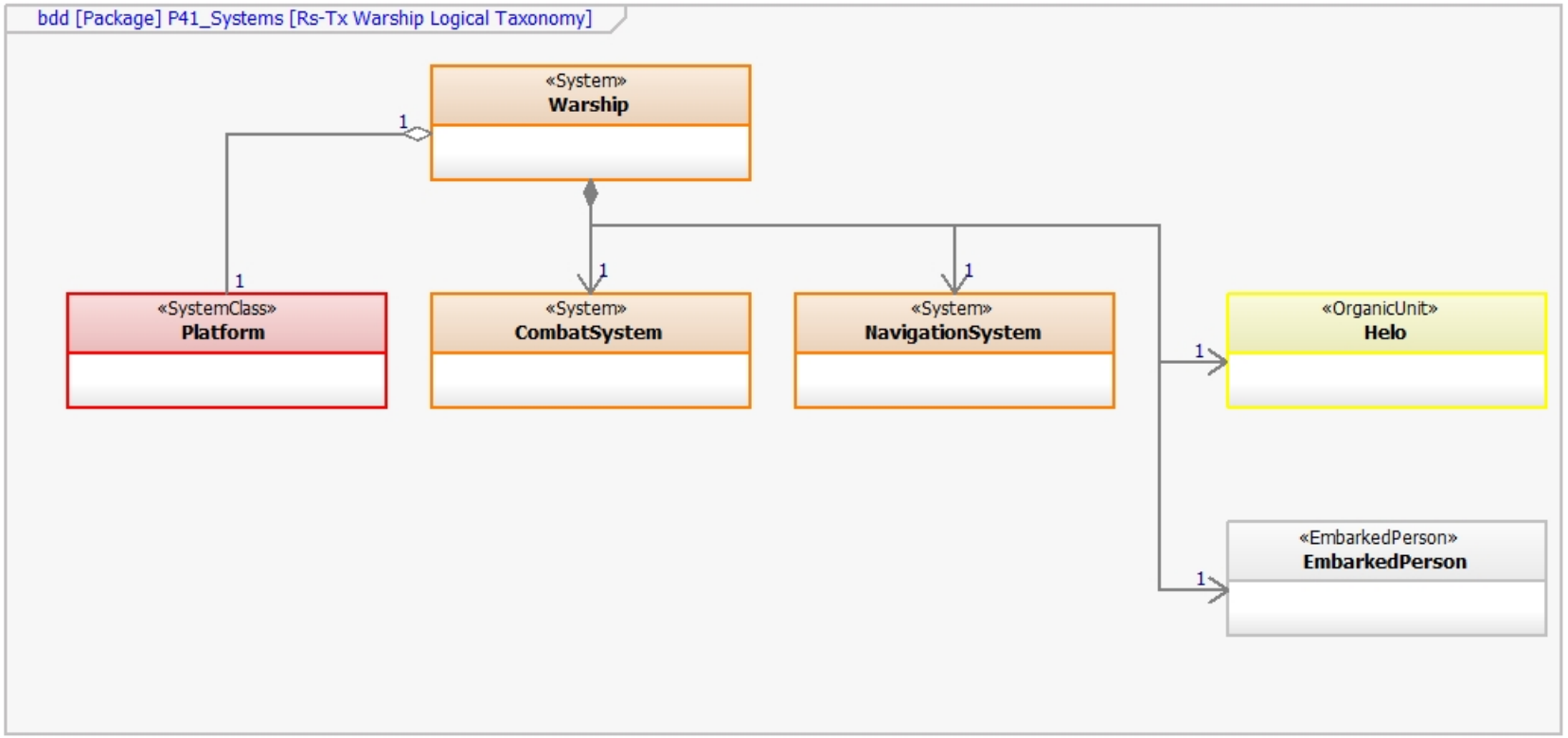
TECH. SPECS TREE WITH A «FULL ESWBS» APPROACH



«SYSTEMIC» VIEW OF THE SHIP ARCHITECTURE

The second point of view from which the Ship can be represented is the systemic one:

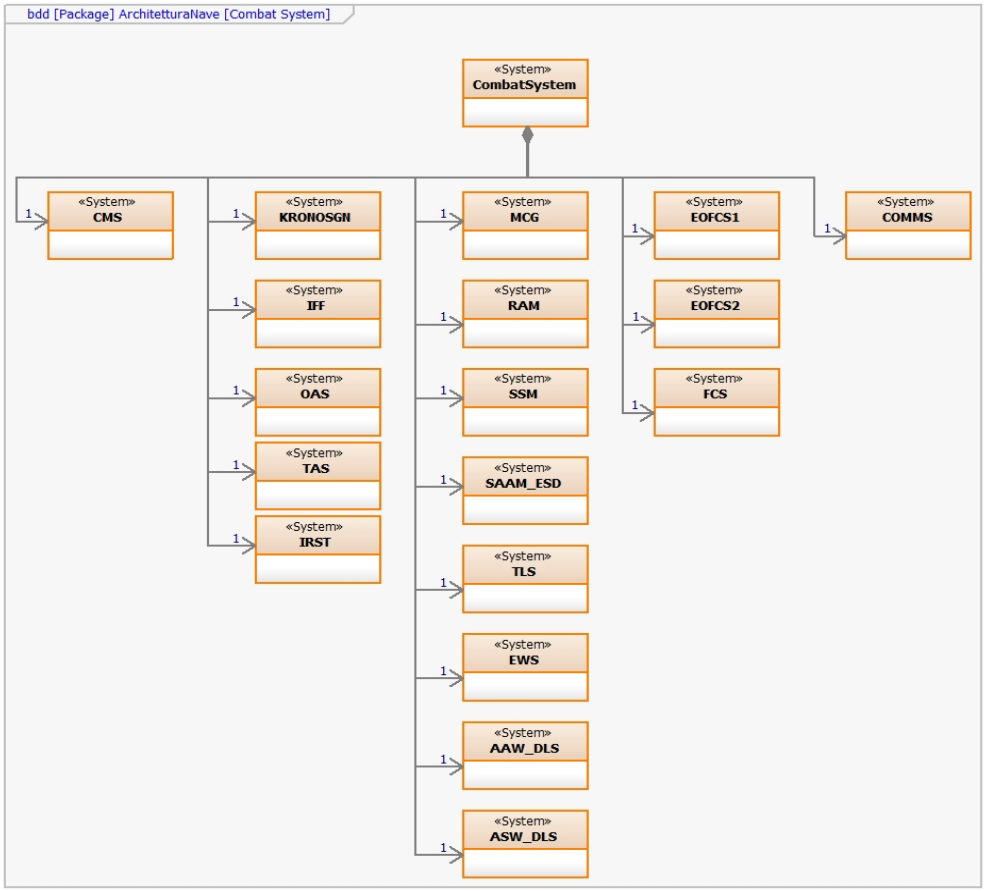
- N.2 - «Systemic» Viewpoint
  - ✓ It is based on the identification of the Systems as «functional» components of the Ship, in accordance with the MIL-STD-498 standard, and its evolutions EIA-J-STD-016 -> ISO / IEC / IEEE 12207: 2017 "Systems engineering and software - Software life cycle processes"
  - ✓ It represents the Military Ship as constituted by a set of «Systems»



«SYSTEMIC» VIEW OF THE SHIP ARCHITECTURE

In turn, Level 1 Systems can be broken down into Subsystems, again with a systemic approach:

- N.2 - Level 2 «System» view - Combat System



PROS

- Consistent with a full top-down system approach
- The breakdown of the complex Ship system into "functional" entities, allows each of them to be analyzed, understood and described in a clearer and more effective way, improving the communication of the characteristics and inter-relationships between these entities among the different development teams, with suppliers, with the final customer

CONS

- The reference standards for this approach derive from «Software development», and refer to «Software Systems»; even if they have been used in various domains to design complex systems, such as satellites, cars, railway networks, air, land and naval combat systems, they do not have a history of application to the design of naval platforms
- The separation between Specification Documents (SSS, what the system must do independently of the technological solution adopted) and Design Documents (SSDD, with which technological solution the system must meet the requirements expressed in the SSS), which is not easily suited for the description of the platform components

IDENTIFICATION OF A "HYBRID" APPROACH

Neither approach is "intrinsically" preferable to the other: both "ESWBS" and "Systemic" viewpoints are valid and not in contradiction with each other; they represent two different levels of abstraction of the same Ship System, and both will be present in the SysML model that represents the Ship Architecture.

To overcome the impasse, it is necessary to identify a synthesis of both approaches, which can be acceptable by the reference communities (final customer, designers, suppliers, control bodies) both on the Platform and on the Combat System side.

The guideline followed is to avoid the a priori separation Platform / Combat System, and to identify a "rationale" to identify two categories of systems:

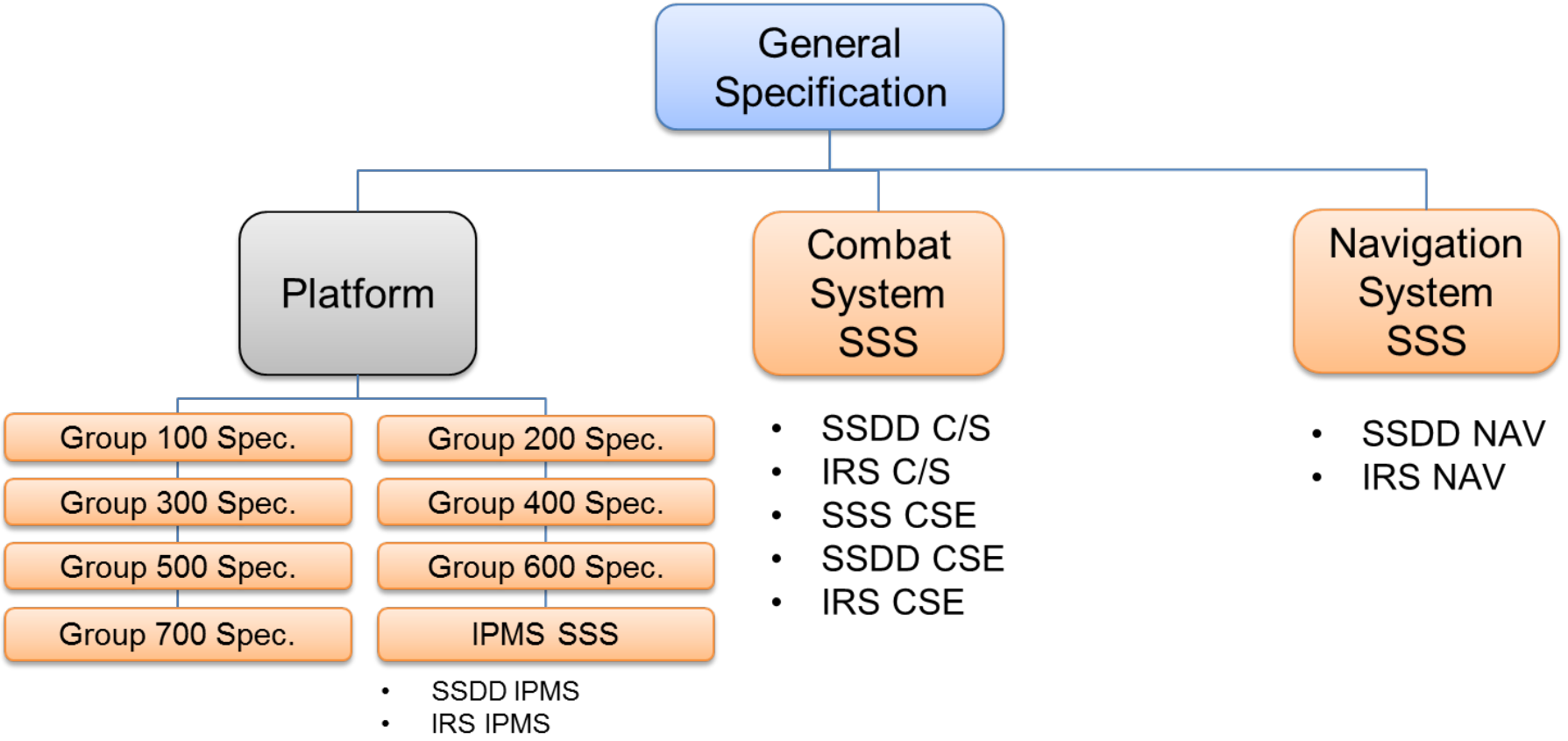
- ✓ Primarily Software Characterized Systems (Software Intensive): Those systems in which the functional aspects are dominant, and in which compliance with the performance requirements is (more or less directly) determined by the software; to characterize these systems operational / functional analysis, and the separation between Specification and Design, are necessary (and well established) aspects
- ✓ Primarily Hardware Characterized Systems: Those systems in which the performance is mainly determined by the hardware; to characterize such systems, domain engineering (naval, mechanical, electrical) is predominant, and any supporting software systems have a marginal role

The Combat System, the Navigation System and the Integrated Platform Management System belong to the first category. To the second the Platform, and most of its components.

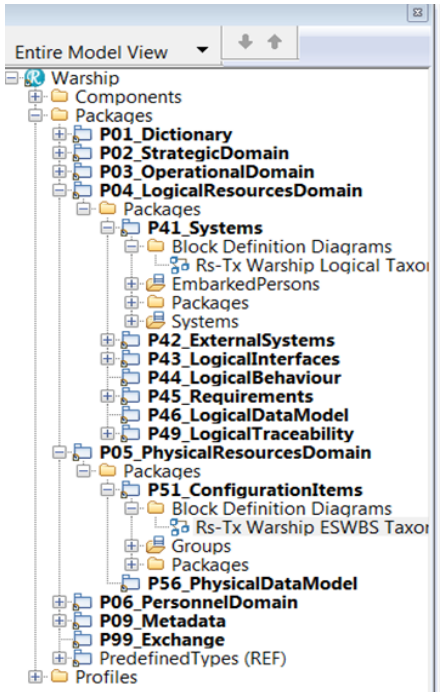
TECH. SPEC TREE BASED ON THE «HYBRID» APPROACH

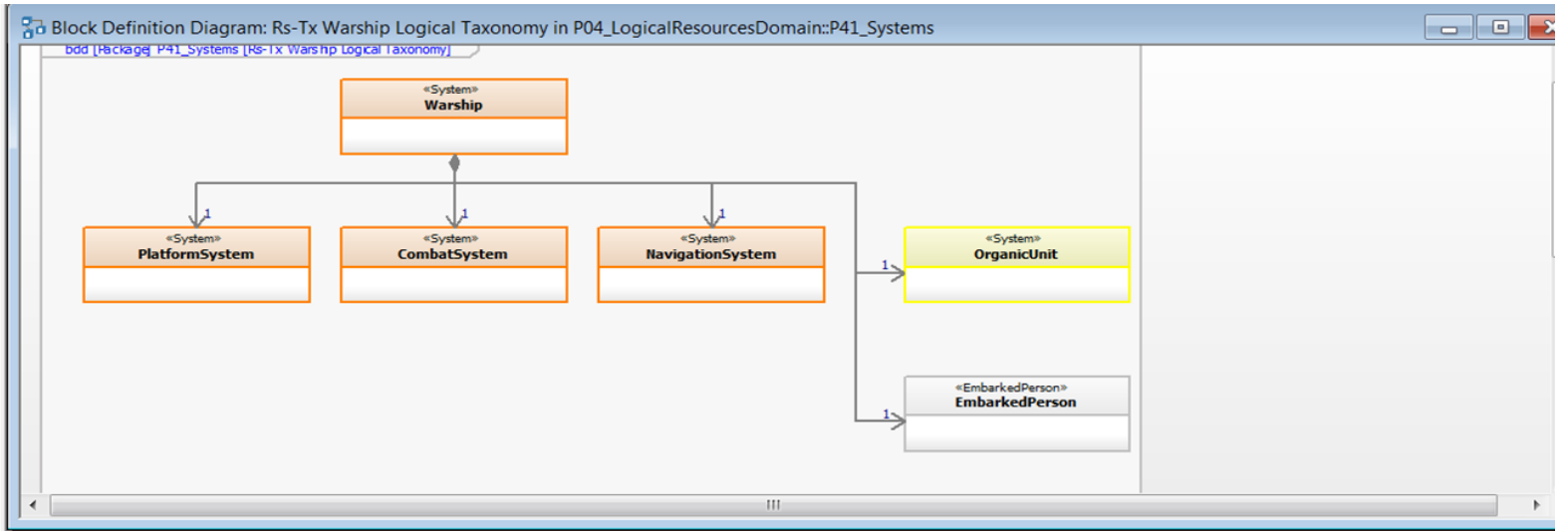
The «hybrid» approach involves the development of different Technical Specifications depending on the type of element of Architecture:

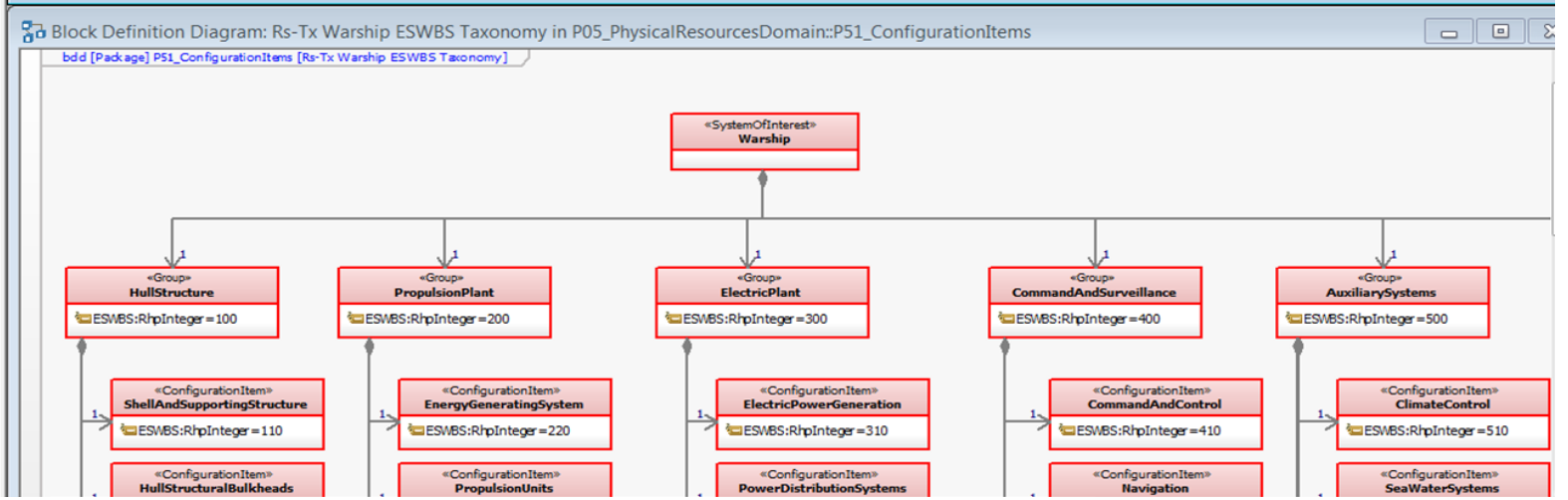
- For Primarily Software Characterized Systems , the Technical Specifications will be documents structured according to the ESWBS
- Primarily Hardware Characterized Systems, the Technical Specifications will consist of SSS / SSDD / IRS documents according to MIL-STD-498
- The General Specification will be organized according to the ESWBS, but will contain elements of the systemic approach:



EXAMPLE OF THE SYSML MODEL OF A WHOLE SHIP







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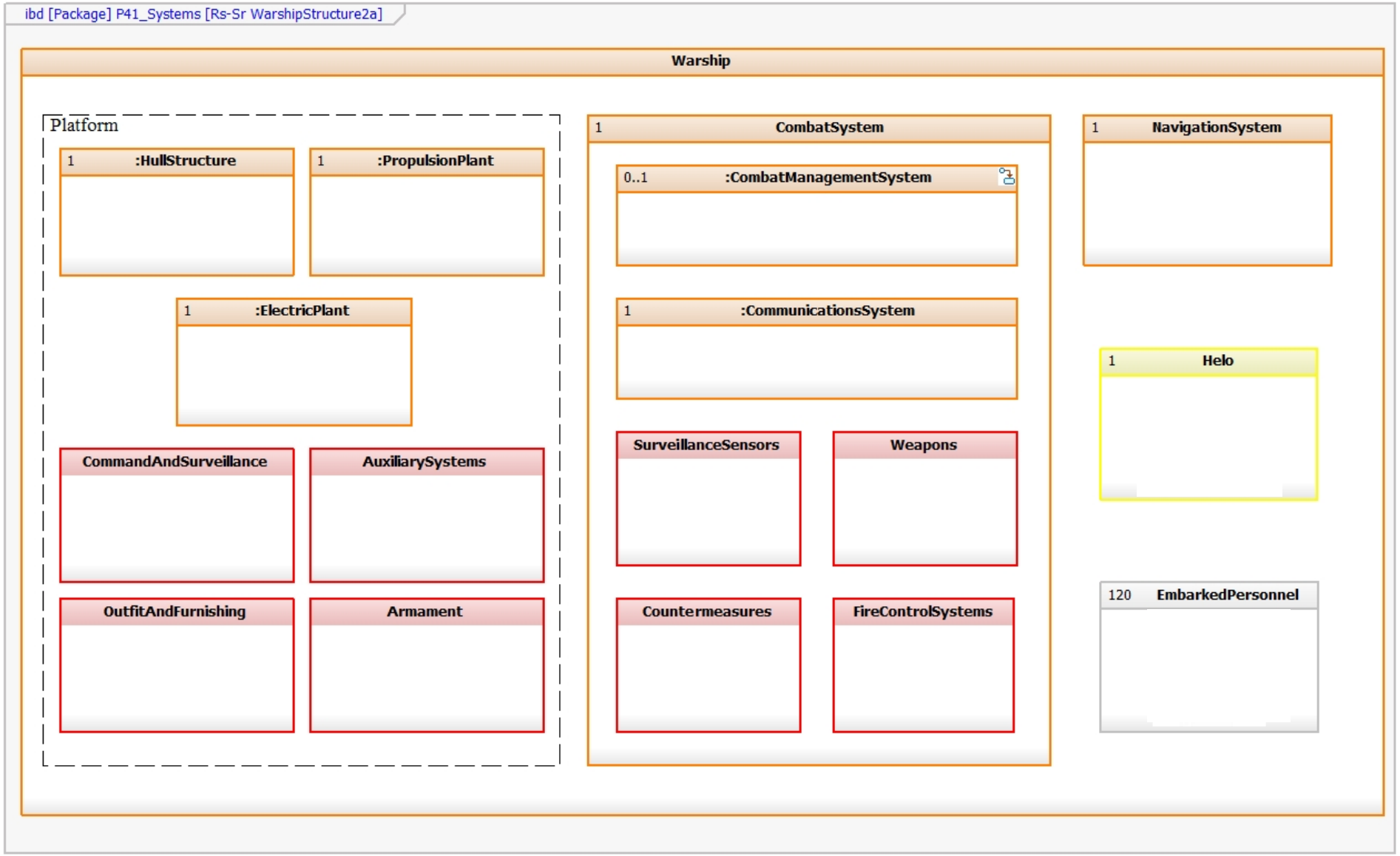

Thank you for your time!

Lucio Tirone
FINCANTIERI
lucio.tirone@fincantieri.it

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