

Combined Naval Event

Concepts for warships Specification and Design

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Farnborough, UK



Concepts For Warship Specifications and Design

Affording Sustainable Ships

- **Modelling and simulation for warship requirements and specification**
- **System of systems concept for future warships**
- **ILS and System Engineering to assure sustainability**



JS Elcano: resilience after 95 years in service



JS Elcano: environmental conditions in Cape Horn





Topics

Roadmap to Acquire Sustainable Ships

Modelling to support a better acquisition Process

ILS to make ships more sustainable

The future: System of Systems and System Engineering in shipbuilding

Take out message

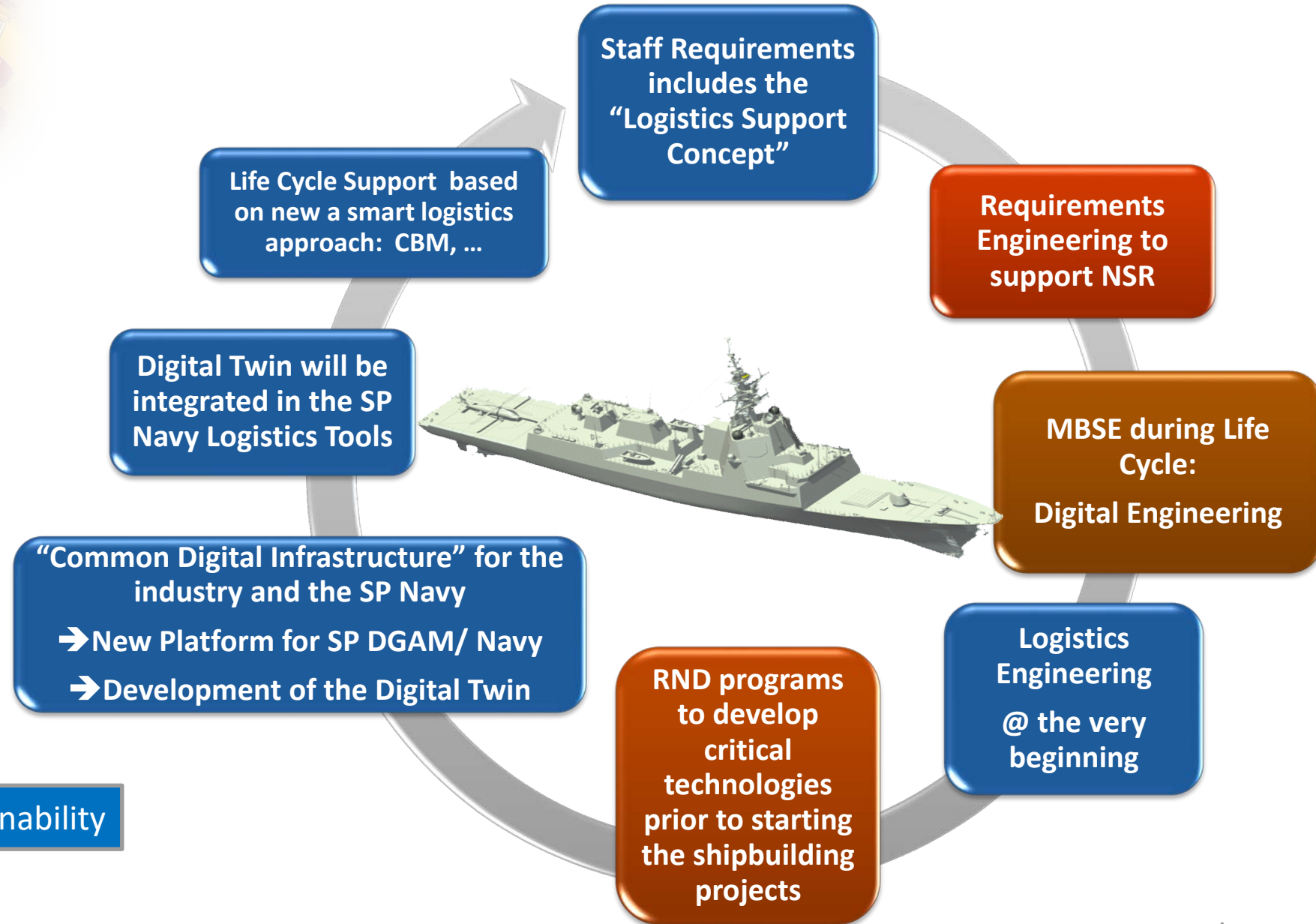


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Roadmap to Acquire Sustainable Ships



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Sustainability



Acquisition Process

The problem is to think in advance and “understand” the future in terms of technology and threats: this is common to defense and aeronautics

Problem Statement

*“Effective military capabilities can take decades to research, develop, procure, field and integrate. But **new threats** can emerge with little warning. To address this imbalance, European militaries and the European Defence Agency (EDA) must plan ahead to **anticipate future capability needs** and **adapt to the fast pace of change in the technology and threat environments**”*



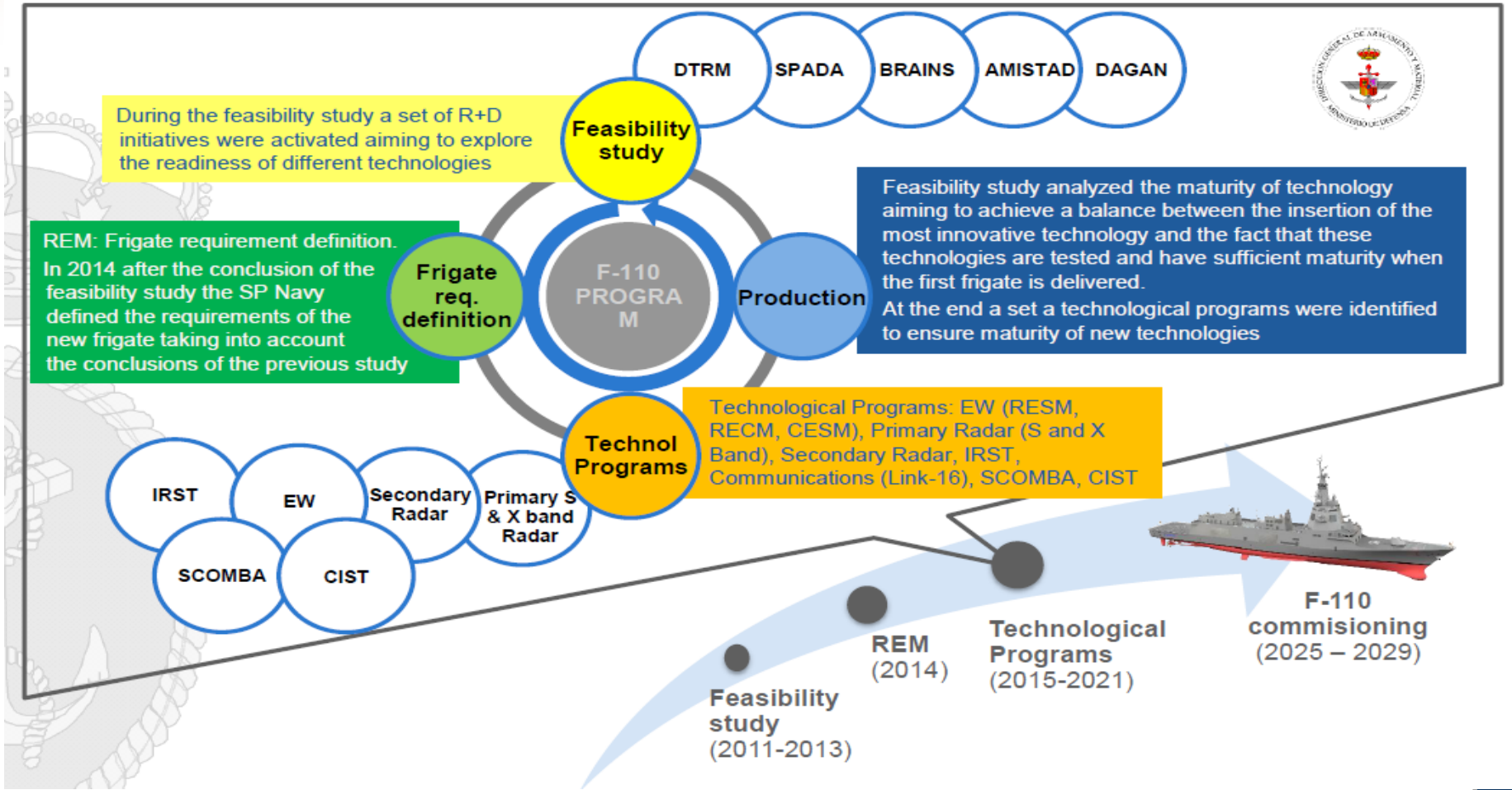
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New Programs: need to shorten the acquisition process

An Example: The F-110 Program: 13 years from white sheet and the 1st Ship Delivered



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Warships Operational Domains

Navies operate in the most complex environment

- Maritime operations are the most challenging.....
- A warship (frigate) operates in 5 domains simultaneously: air, underwater, surface, space, and “bottom sea surface” + cyber in a highly integrated manner.
 - Air: predictable and under “Maxwell Equations”. New Threats such as hypersonic missiles.
 - Underwater: unpredictable and difficult to detect and track. Limited communications / AI for underwater signal intelligence.
 - Surface: intersection of both. Difficult to manage and full of clutter and a lot of environmental “noise”. Asymmetric threads.
 - Space: based on MTMD requirements, Satellite communications + PNT
 - Bottom sea: Surveillance and protection of strategic assets, materials and infrastructure.



Maritime **Specific** Requirements

- Sensor complexity when operating in “saturated” environments
- **Huge amount of data available to take decisions in hard real time**
 - **Requires super-computing capabilities on board and extra wide-band secure communications**
- **Highly sophisticated weapons and C2 to engage in a 5D threat environment simultaneously**
- **EM complexity for MBSE and antenna topside characterization and design**
- Energy management and efficiency: new systems are “power hungry”
- Safety first
- New materials and 3D printing
- Signatures optimization
- **System of systems complexity: on board and UMST / organic assets.**
- **Sustainability maintained over the time** when operating in highly demanding environment
 - Requires a predictive maintenance approach on board and on site



From Concept to Life Cycle: supportability and digitalization

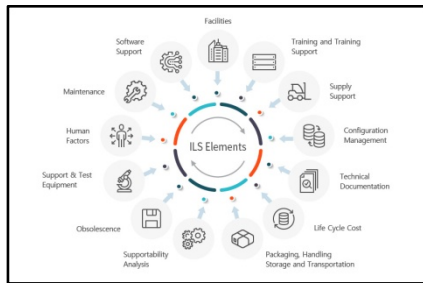


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Looking for a Superiority

MBSE: Rqmts Engineering (NSR) → Supportability Rqmts: ILS → Identification of Technology → Digital Engineering to support SI



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Life Cycle Logistics

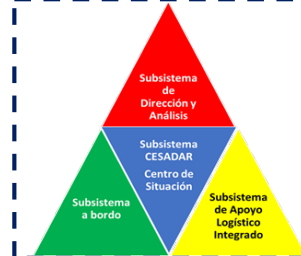
Digital Shipyard → T&V: LBTS + CIST →



Predictive maintenance →



→ Armada Logistics & Material

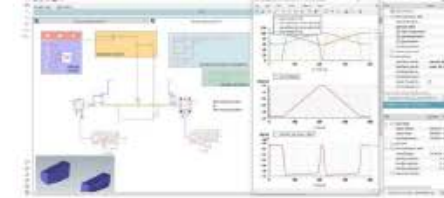


Modelling and Simulation for LC Engineering

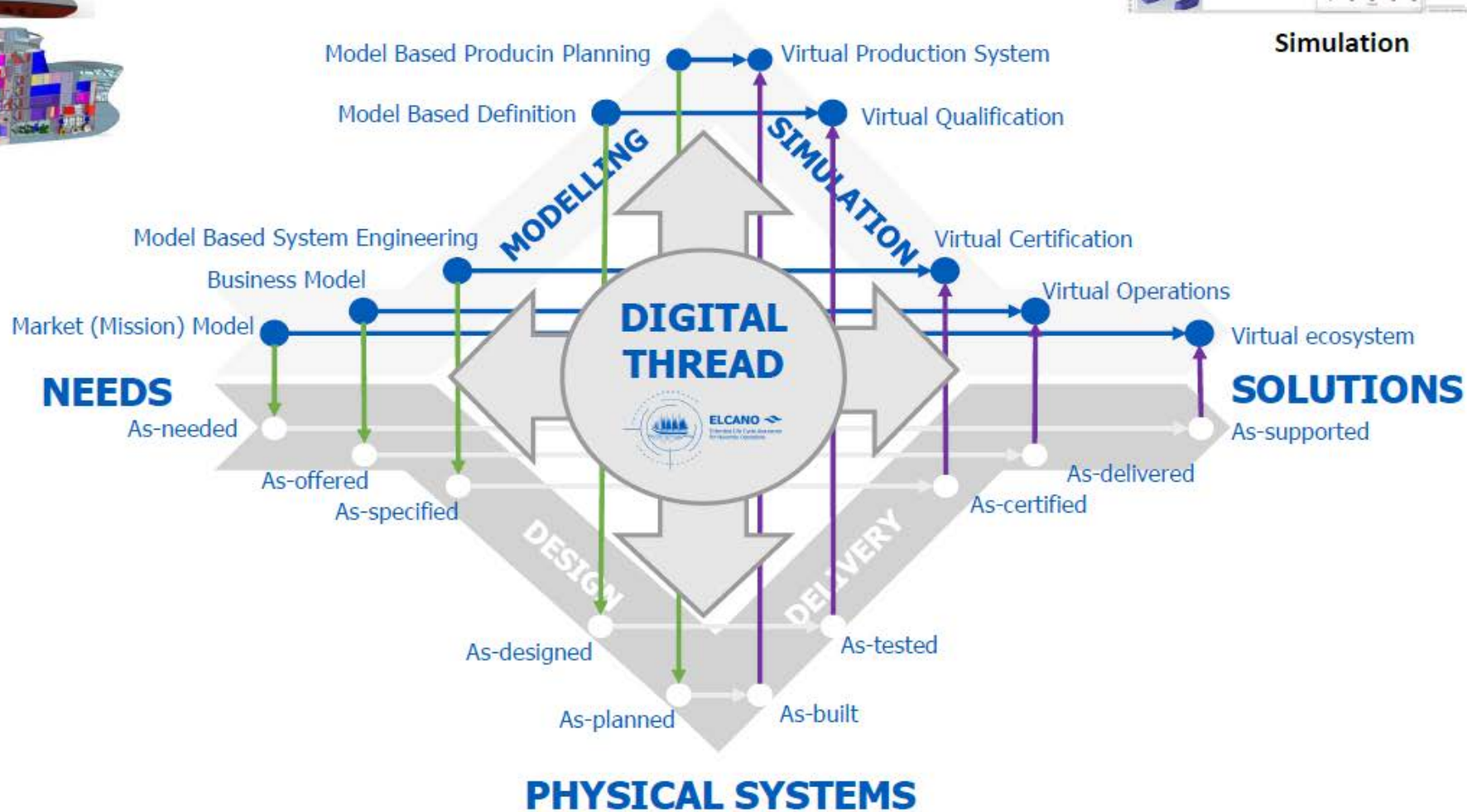
Physic and Virtual System Integration



Modelling



Simulation



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An example: F-110 Program: Road to NSR

Iterative Process along with OEMs (RFIs) and Design Authority



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FASE DE VIABILIDAD NAVANTIA Descripción del Proceso

	Dotación	Propulsión	Sonar VDS	Cañón	...
Alt 1	150+30	CODOG	CAPTAS 2		
Alt 2	150+50	CODELAG	CAPTAS 2		
Alt 3	150+65	CODELAG	CAPTAS 4		



Reuniones
EMA-JAL
Navantia, Indra



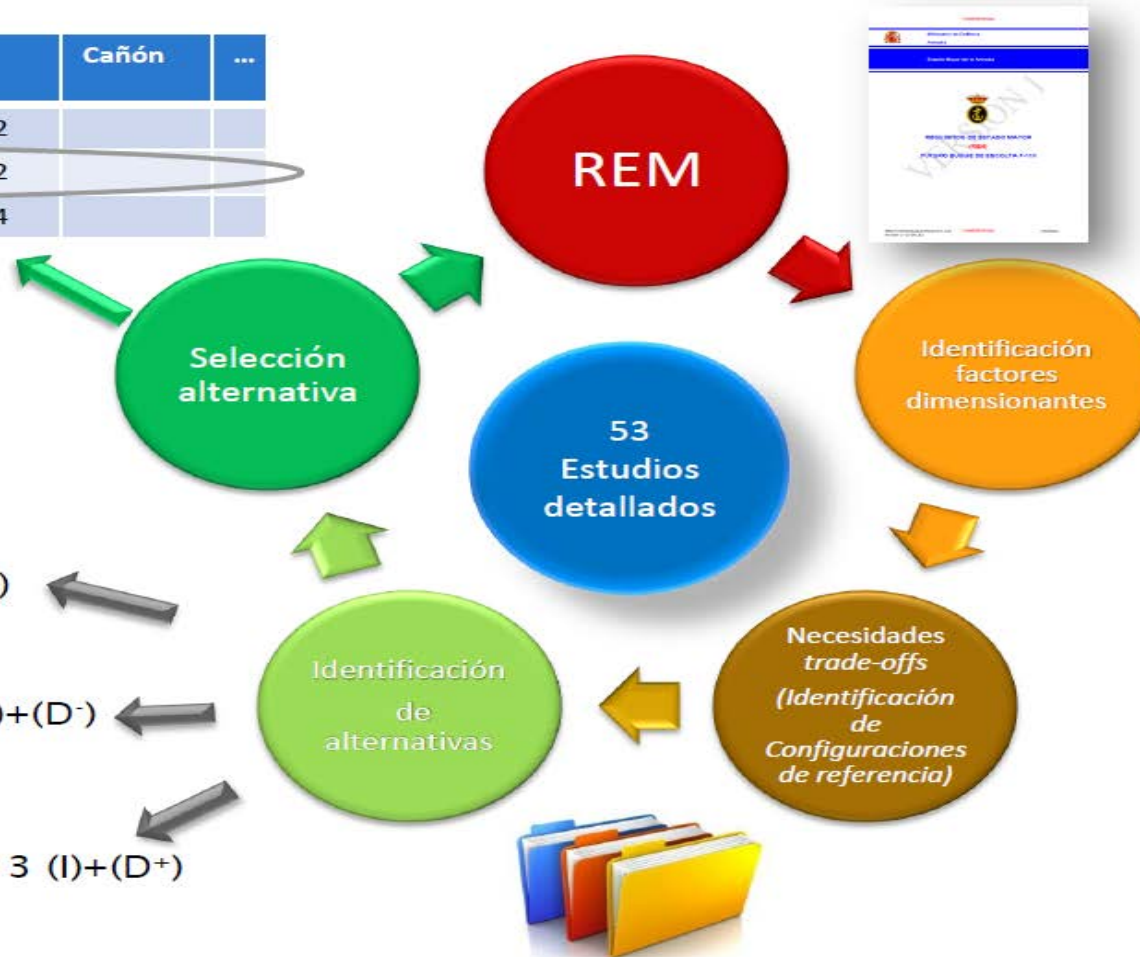
Alt 1 (I)



Alt 2 (I)+(D)



Alt 3 (I)+(D)

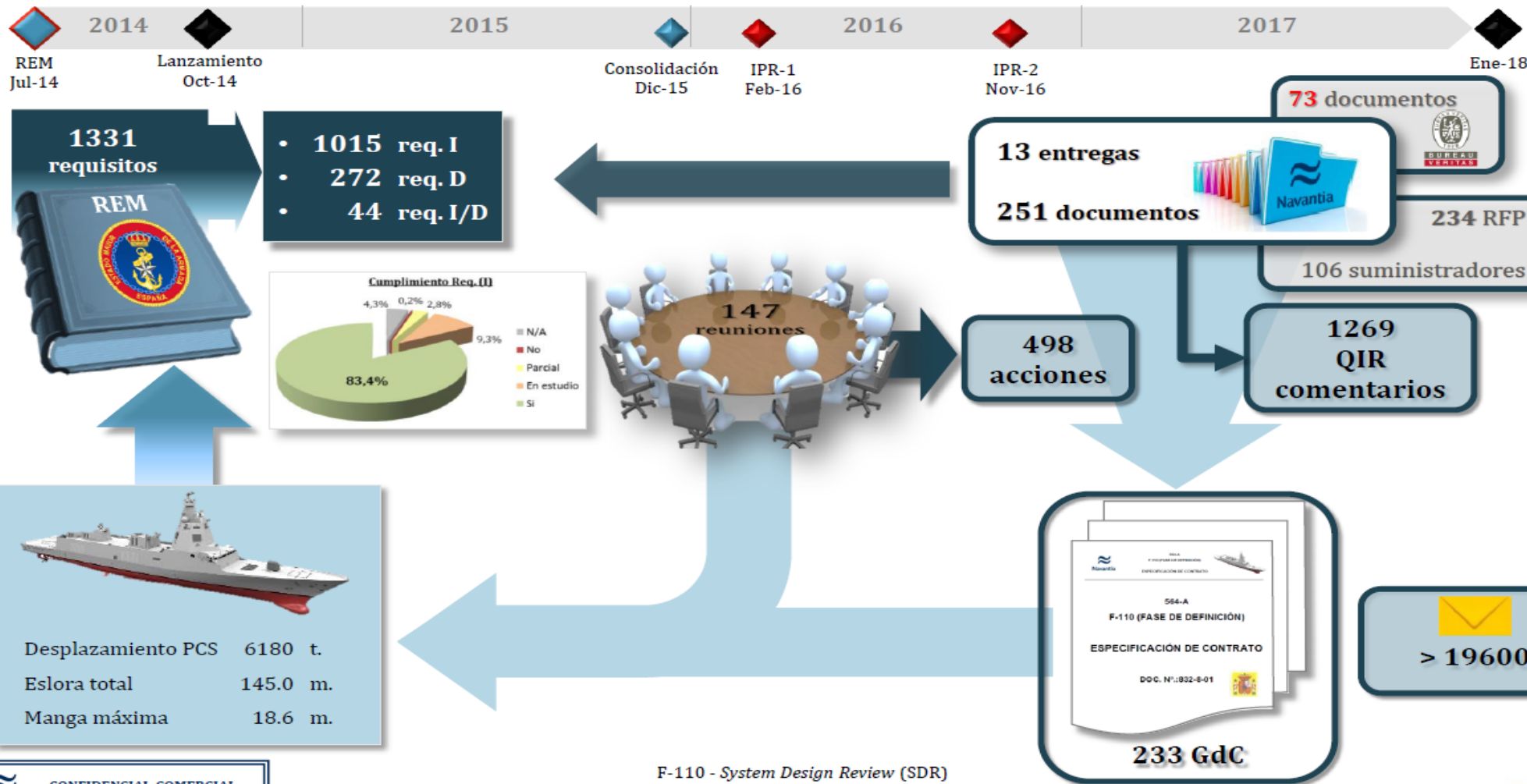


An example: F-110 Program: Road to SDR

Modelling and Digital Engineering to reach SDR

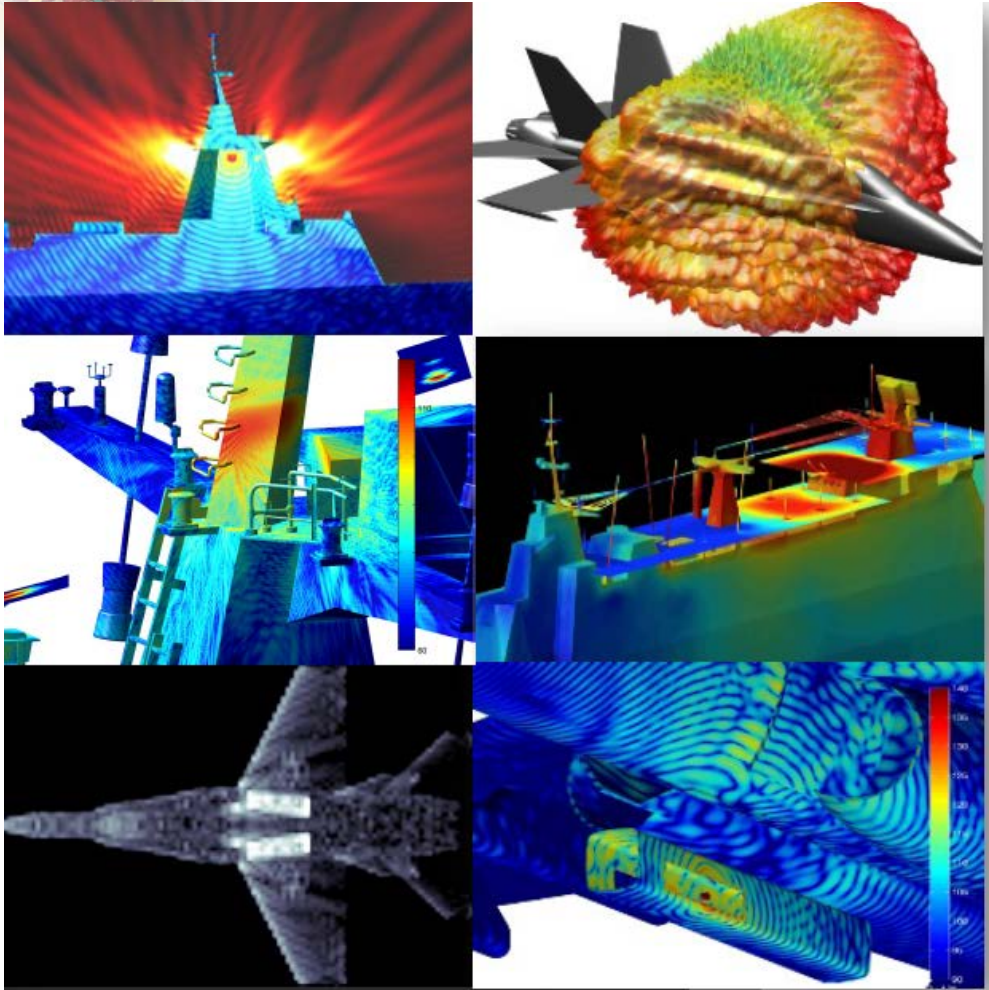


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Naval Systems M&S

EM Characterization in warships



- ✓ Warships presents the most complex EM environment.
- ✓ Tens of antennas from multiple systems in a confined available space.
- ✓ High Power transmitters close to High Sensitivity receivers operating in a very wide rank of frequencies (10 Kh-36 Ghz)
- ✓ Electro Magnetic Effect: EMI/ EMC/ RADHAZ



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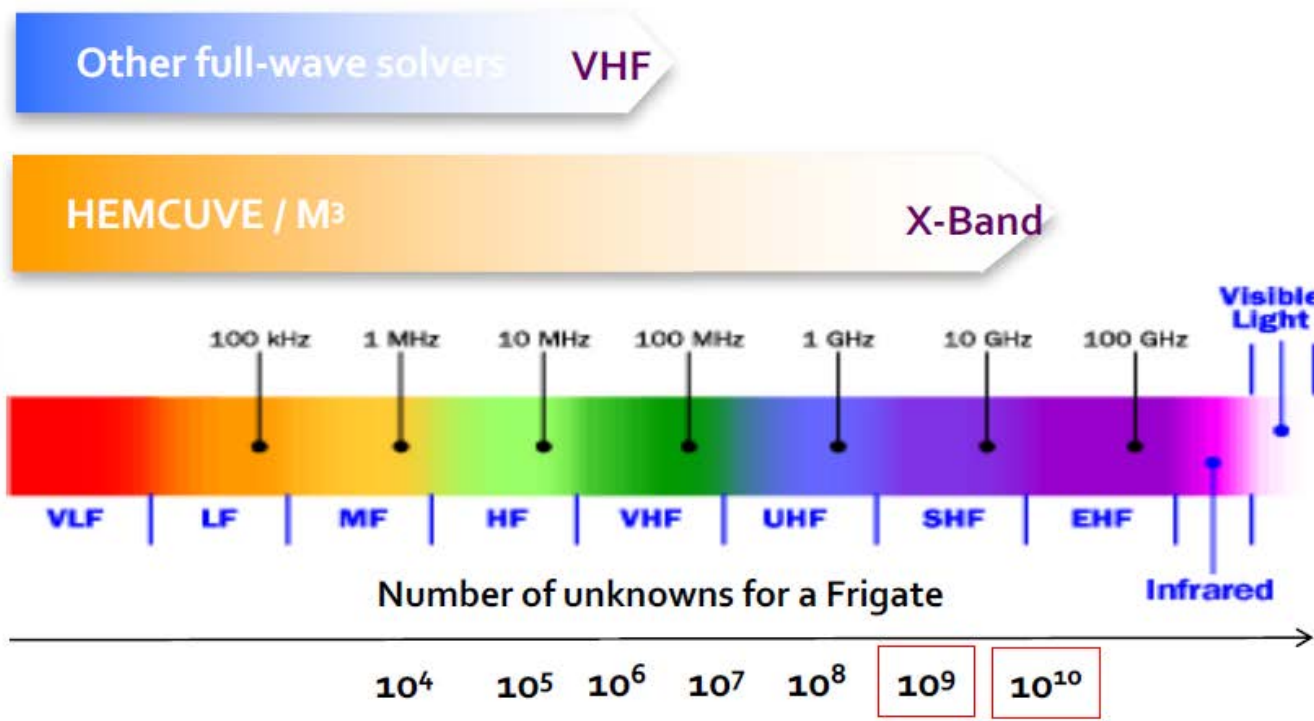


EM Modelling: EM Computational Complexity



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Extremely Intensive computation effort for frigates class warship EM modeling and simulation



Record Mundo Electromagnetismo Computacional
10⁹ incógnitas (año 2010)
HEMCUVE / M3
WORLD RECORD (2010)

E3 Applications from EM3 Works (U_Vigo, Spain)

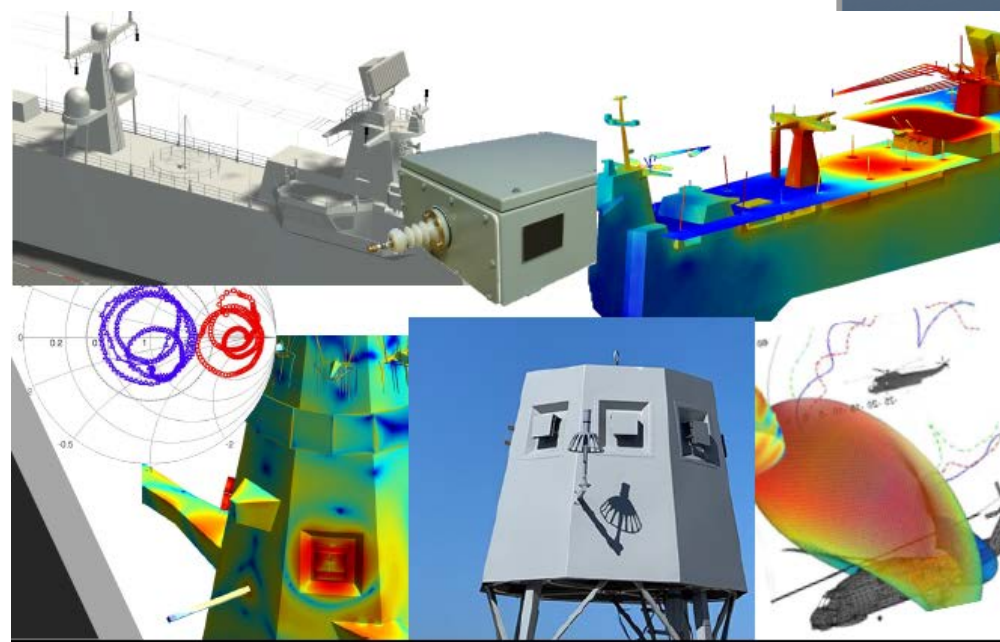
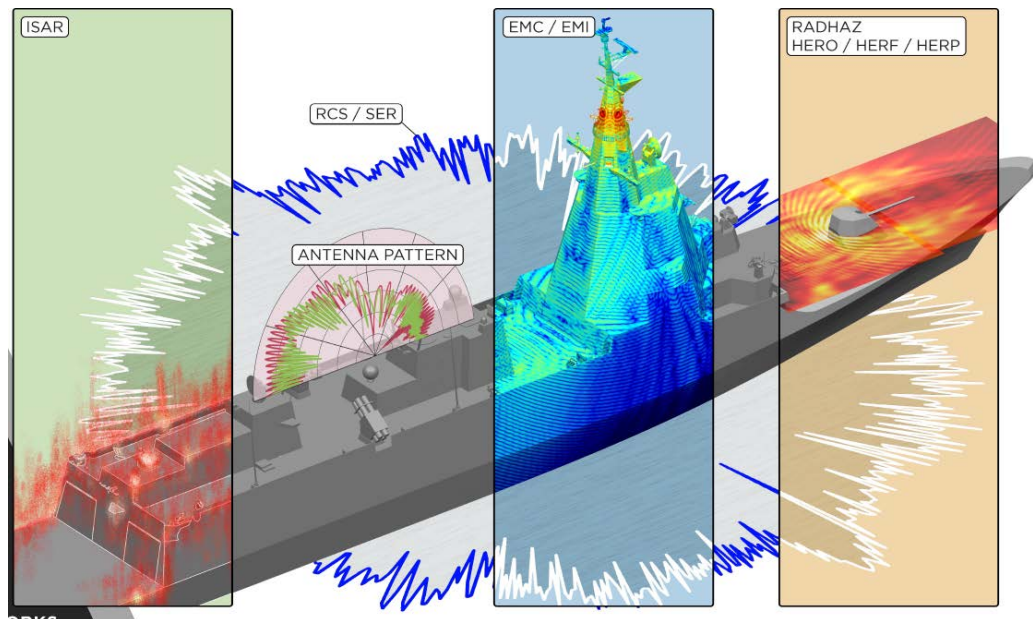


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M&S with EM3Works for radar cross section signature

EM3Works for sensor allocation in the topside

Antenna Design

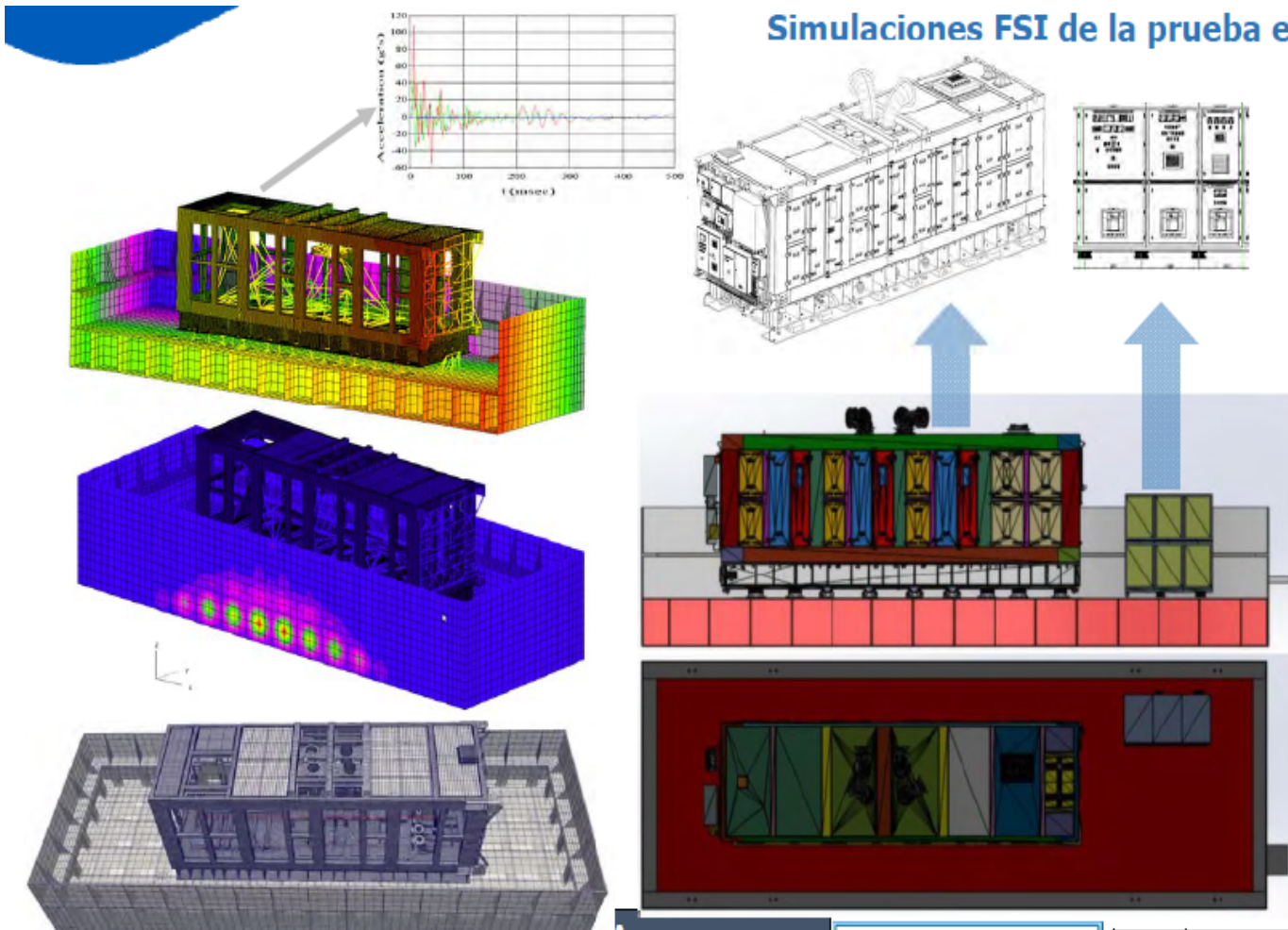


M&S Environmental Reqmts

Shock Test of Diesel-Generators and Electric Boards

Environmental Reqmts are tested at “model” level before real testing.
FSI (*Fluid Structure Interaction*) to test shock @ MIL-STD 901 standard .

Simulaciones FSI de la prueba en barcaza.



DIESEL GENERADOR (DDGG)

- ✓ Cualificación a choque por prueba en barcaza
- ✓ Pre-cualificación por análisis finalizada
- ✓ Pre-cualificación por prueba de componentes en desarrollo.

CUADRO PRINCIPAL (CCPP):



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Vibration Behavior Models

Forced Vibration Analysis

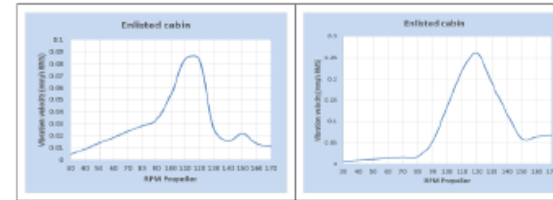
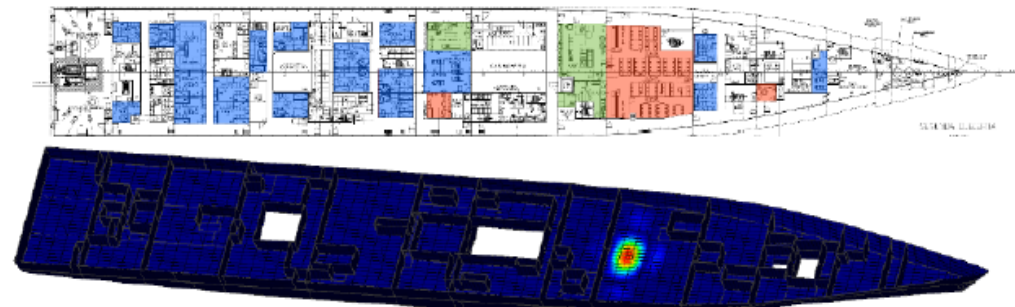
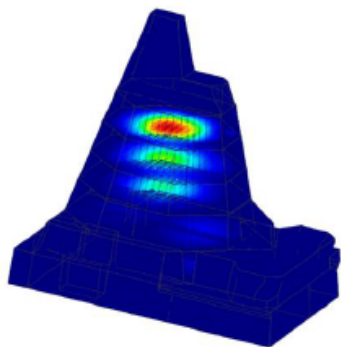
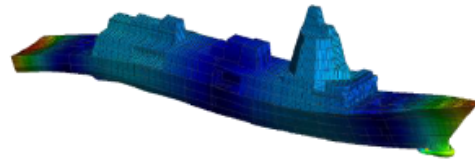
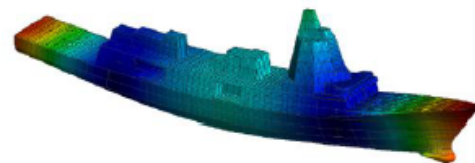
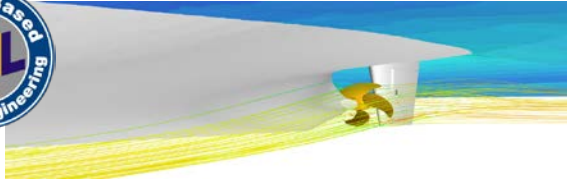


Figure 7-11: Vibration levels in point 3 and point 4

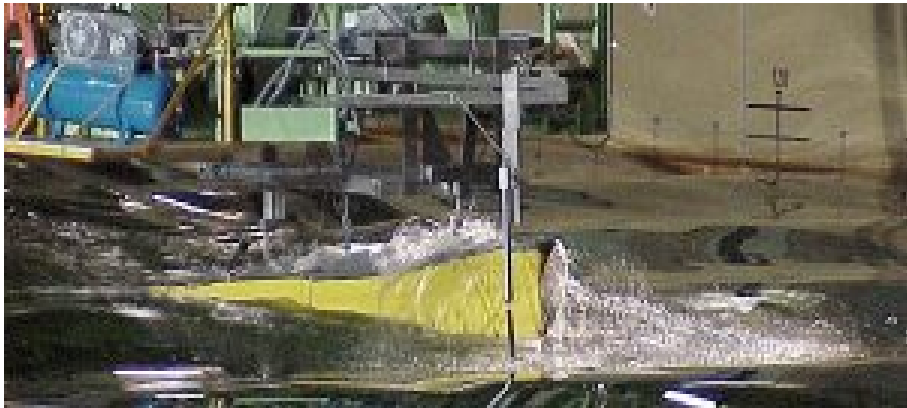


- Identificación de áreas con riesgo de resonancias (global y local)
- Predicción de los niveles de vibración a bordo mediante MEF del buque y las fuentes de excitación
- Comparativa con los niveles de confort requeridos para F-110
- Modificaciones estructurales en fases tempranas

Digitalization : Models to improve design and production



Hull M&S : CFDs & Super-computation



Design Validation in Hydrodynamic channels



Connected Shipyard 4.0:

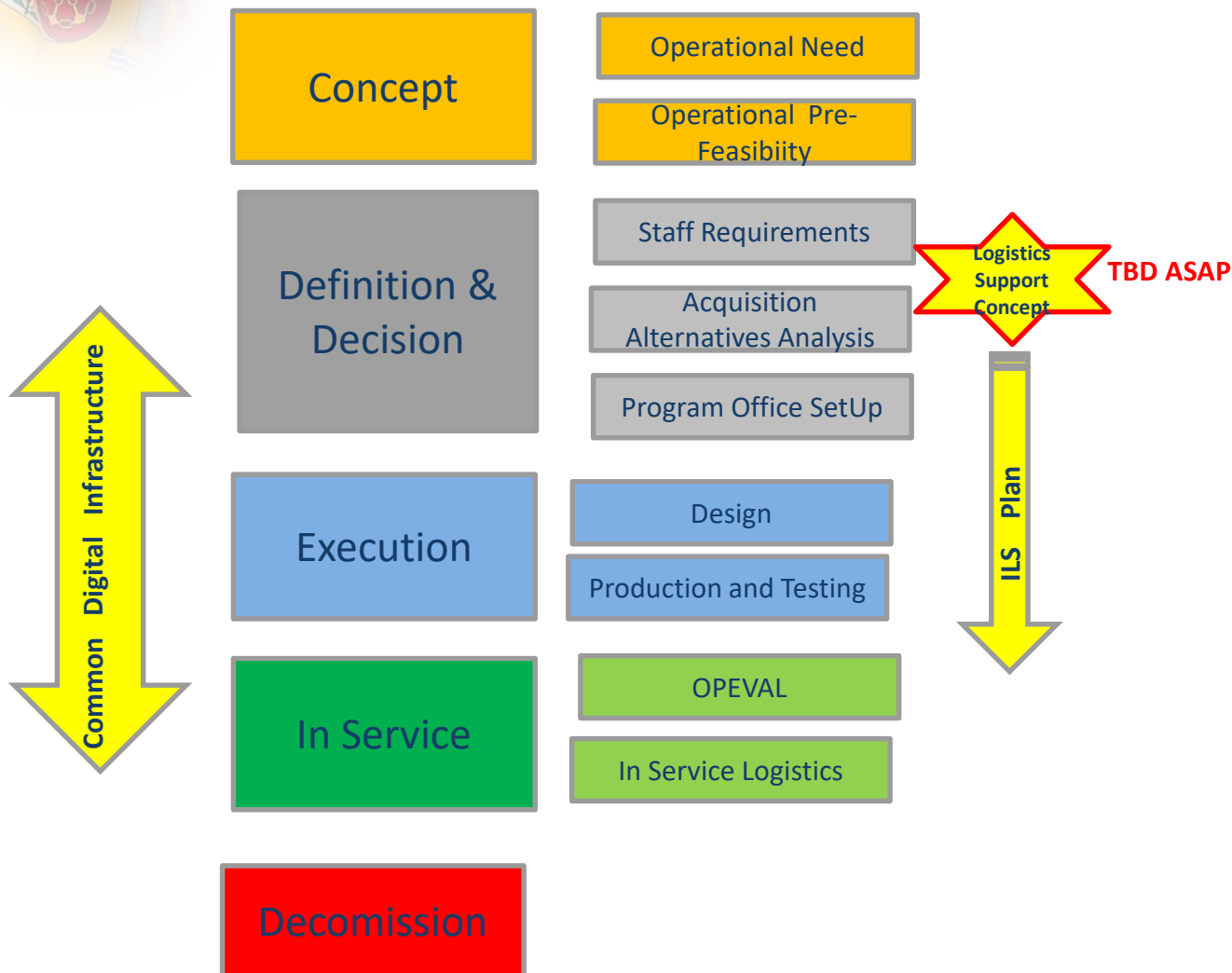


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Digitalization drives design optimization and productivity

BUT....ILS is critical at the very beginning

Acquisition Phases of SP MOD Programs



What are we doing?:

- Joint ILS concept with Spanish DoD instructions SEDEF 67/2011 & 72/2012
- Update ILS instructions:
 - Studies of international standards
 - Review of ILS & LSA Guides
- Review and Standardization of Spanish Navy ILS processes, through drafting of new Guidelines
- Support to Spanish DoD Programs in ILS working groups
- Spanish Navy ILS processes and rules to the 4.0 environment



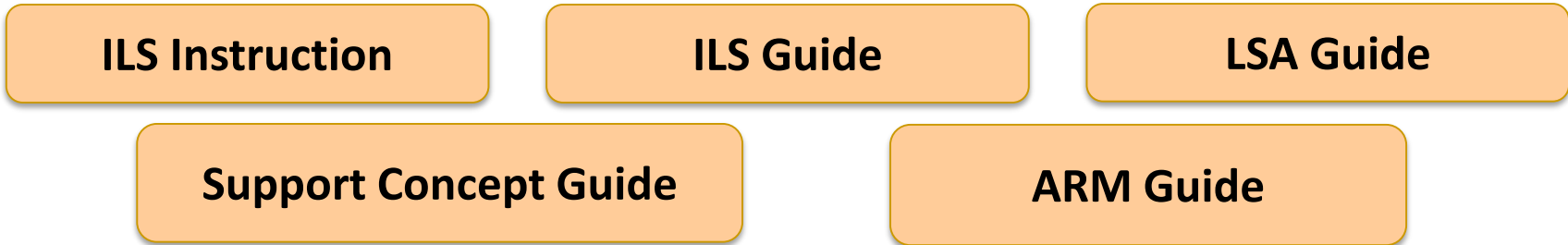
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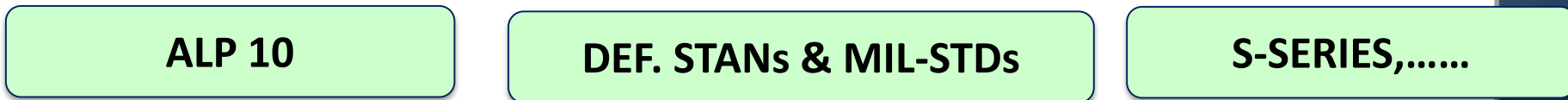
ILS in the shipbuilding programs in the Armada



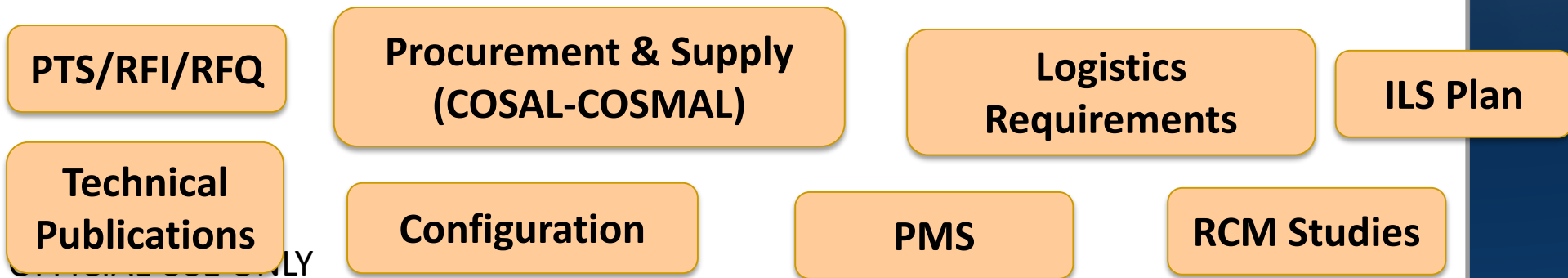
DRAFTING AND EDITING ILS & LSA INSTRUCTIONS AND GUIDES



STUDIES OF INTERNATIONAL STANDARDS



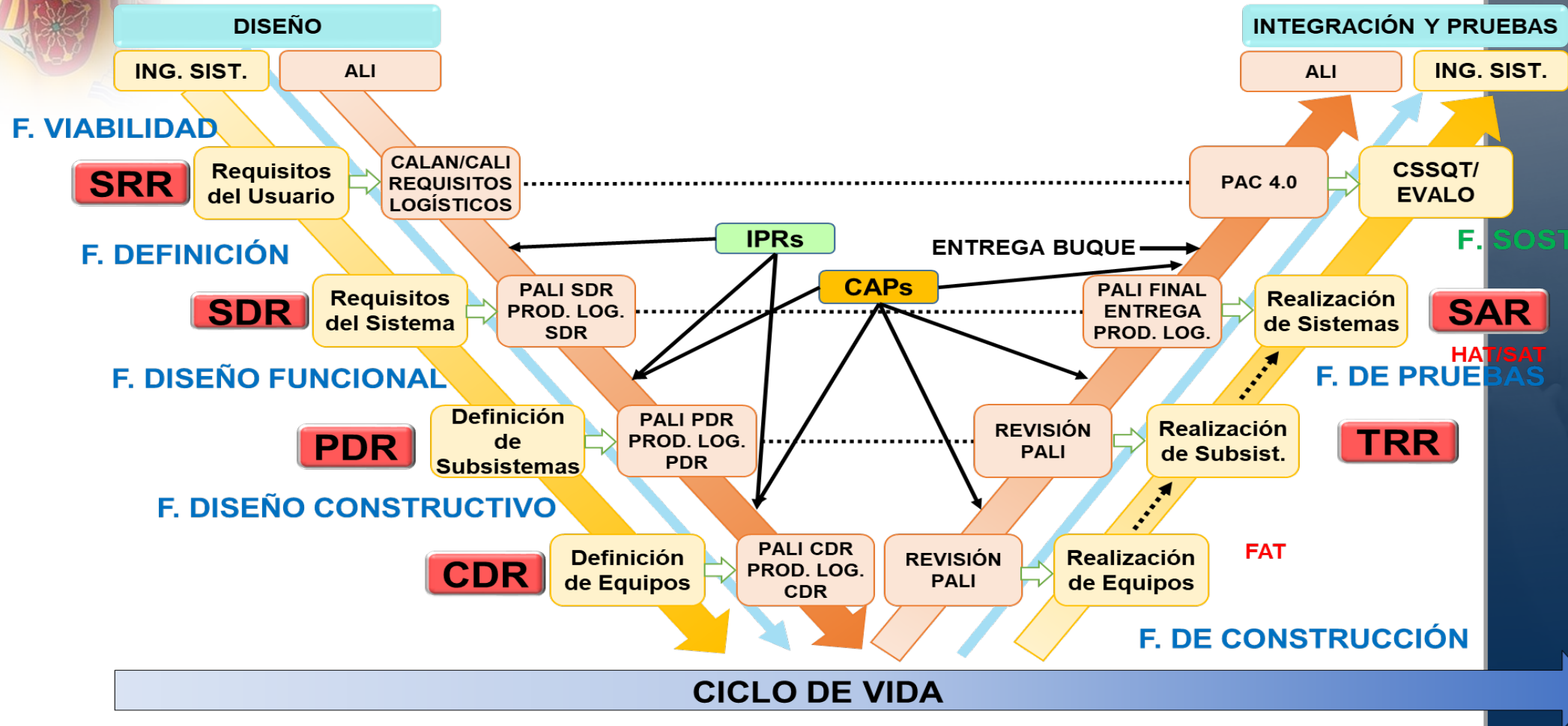
PROGRAMMES ILS WORKING GROUPS SUPPORT



Putting all together: System Engineering and ILS



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BUT....Going to the future : Think different for shipbuilding Warship as a mission oriented SOS




INCOSE

A System of Systems (SoS) is a collection of independent systems, integrated into a larger system that delivers unique capabilities. Each system contributes towards a global behavior that can't be achieved without the others.

SoS often have: stakeholders with competing interests; contradictory objectives between participating systems; unsynchronized lifecycles; disparate management; no clear accountability between the separate constituent systems; no clear escalation routes.



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No Consistent Understanding of What a System-of-Systems Is 

- **One big system with lots of subsystems** ~75%
■ This is just traditional Systems Engineering **Think this way**
■ We know how to do it
■ We don't always do it the way we know how... (that's another problem)
- **Lots of cooperating systems** ~20%
■ We know in advance they should play well together **Think this way**
■ We'll just build them in a way that allows them to play together
■ network enabled is a good first step... they all play on the network
- **Systems that will be brought together in the field**
■ It is a "pick-up" game, it will always be a pick-up game, needs will change
■ Wish they played together... but who could have predicted they would need to interact?
■ ...surprise synergy...can we build to support ultimate network centricity?

Only ~5% **Think about it this way**

Source: INCOSE and USAF



SoS to warships: Thinking in Mission

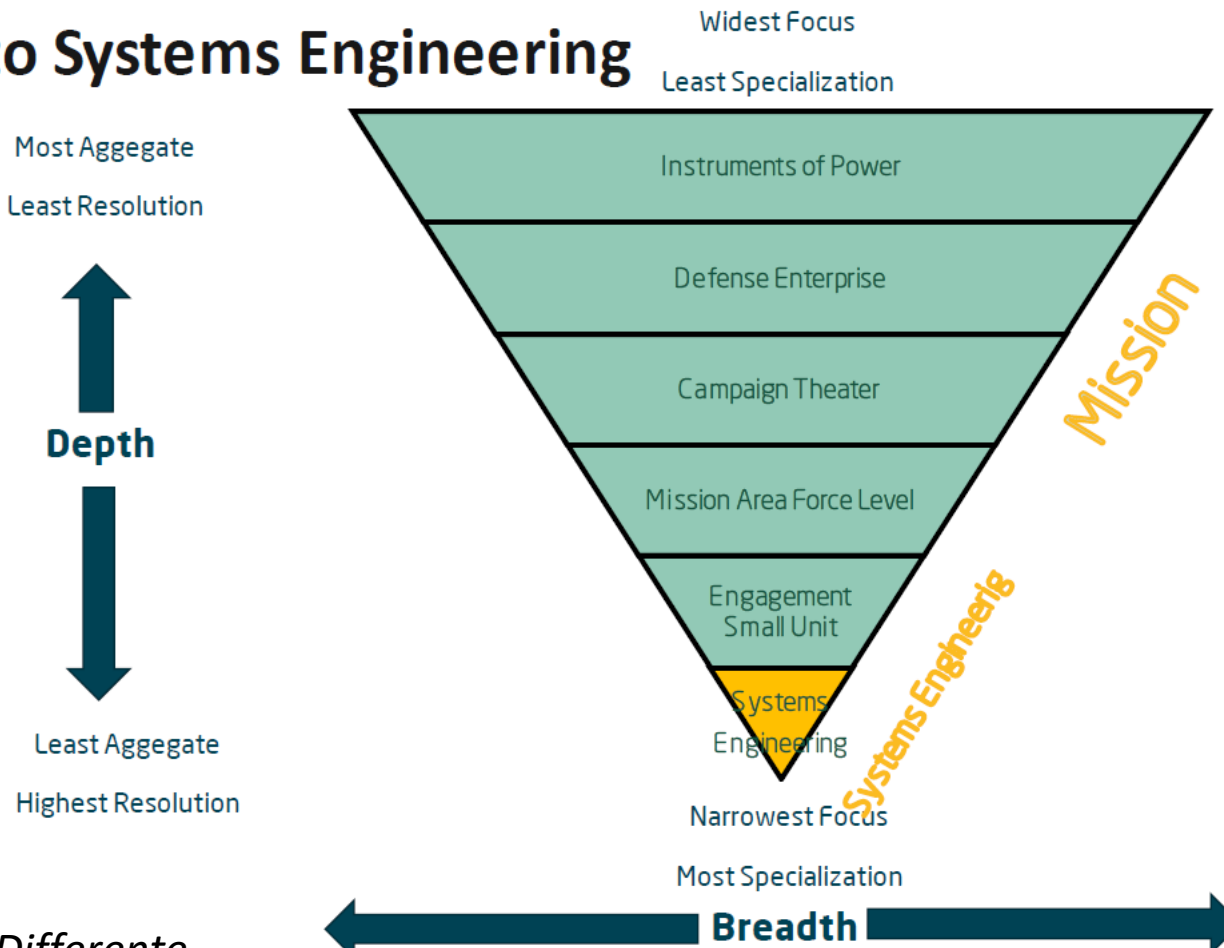
To be able to expand Warships SE to Mission related SE: interoperability with NGWS



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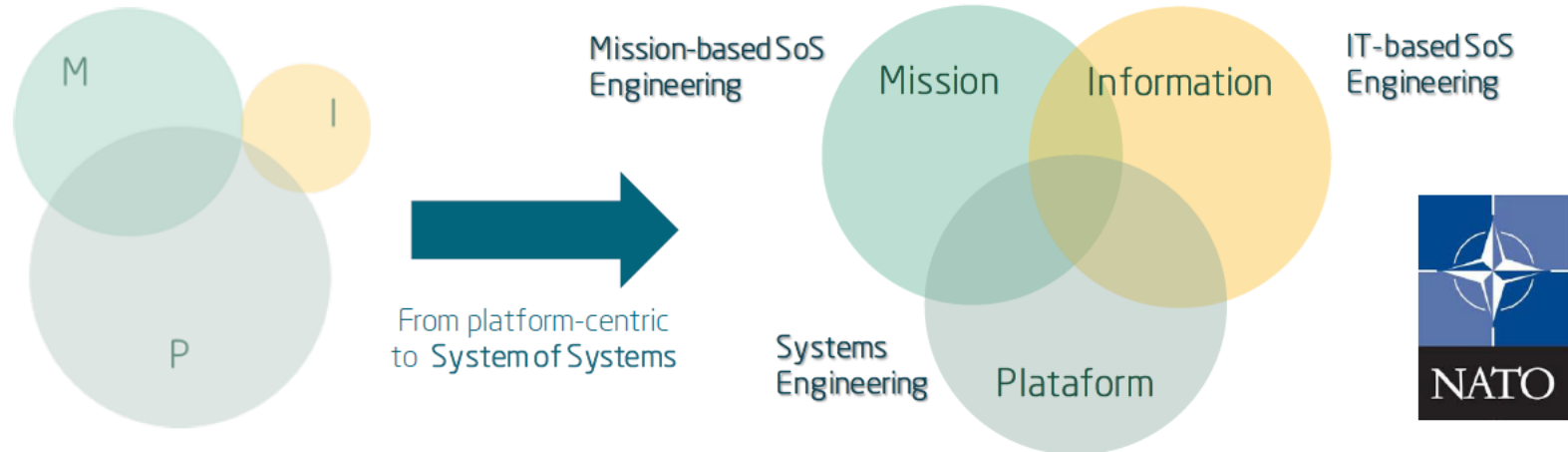
Mission Linked to Systems Engineering

Systems engineering is applied to the System of Systems (SoS) supporting operational mission outcomes



SoS Engineering for warships. Need to close the gap.

Mission Analysis and Systems Engineering Analysis (ii)



A shift in mindset will be necessary to move the industry forward to thinking about SoS Engineering as a discipline that builds upon traditional Systems Engineering approaches, but involves new approaches and enablers to evolve and sustain a SoS

The current state of systems engineering does not adequately support the development of complex, adaptive, and software-intensive SoS

There is no well-established SoS methodology and associated tools and techniques that can support faster engineering analysis and realization of required capabilities



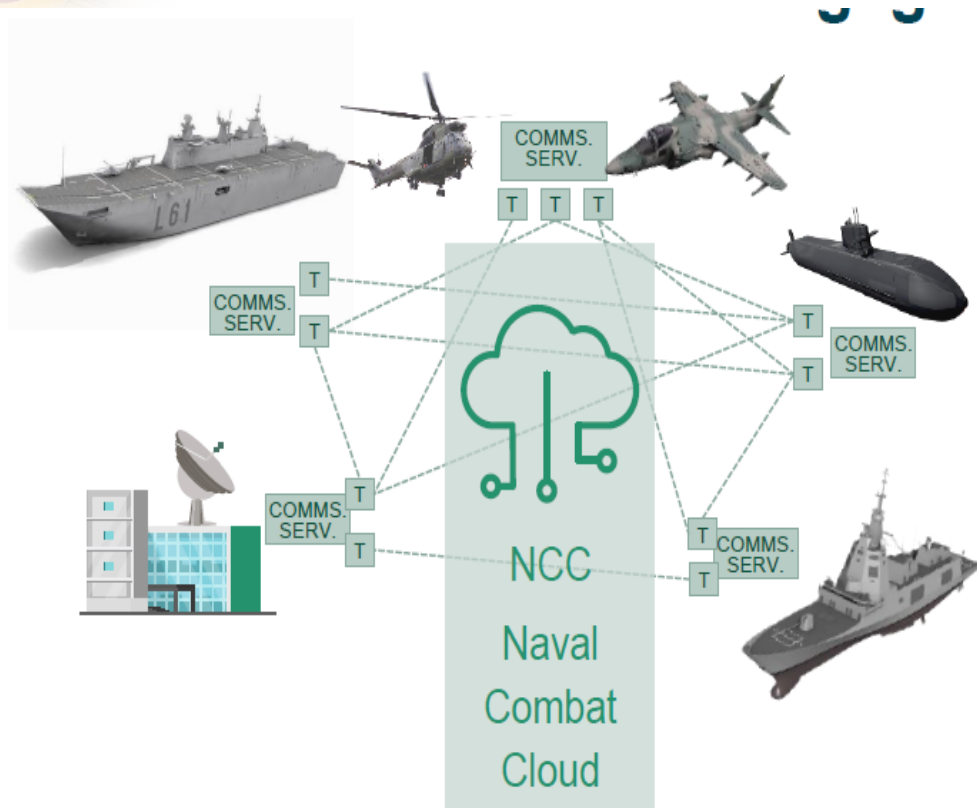
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The Future: Naval Combat Cloud: Enabler for a True Collaborative Engagement



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- Cooperative Engagement, extending the battle field, using the best capability, with the best location, in a collaborative and coordinate way.
- With a common aim, working as a System Of Systems, with the Naval Combat Cloud as enabler.
- Joint identification and tracking, for having a common operational picture, comprehensive and accurate.
- Targets precision tracking, by using sensors of different systems in a collaborative way.

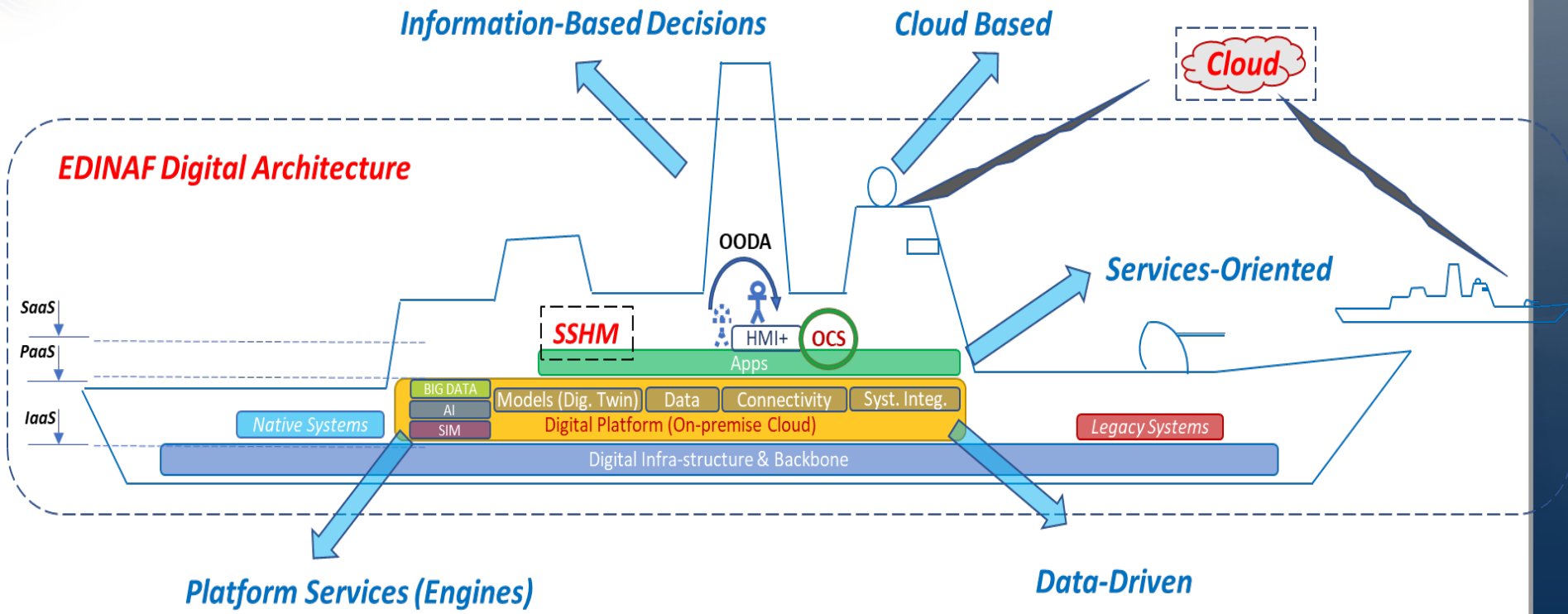
The Naval Combat Cloud is to a Naval Force as a Combat System is to a frigate.

Just as a Combat System's aim is to manage the mission and engagement of a combat ship, the Naval Combat Cloud's aim is to manage the engagement and mission of the whole Naval Force

Digital Architecture for Future Warships: EDINAF Concept



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Summary



Accelerate Acquisition Process



MBSE to ensure LCS



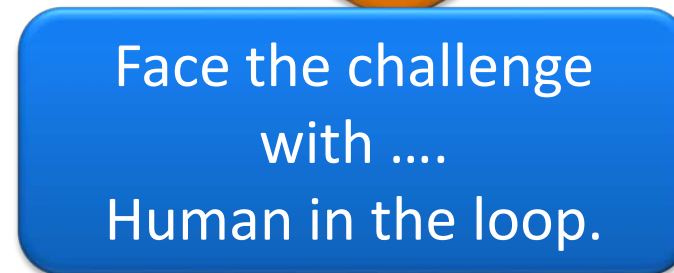
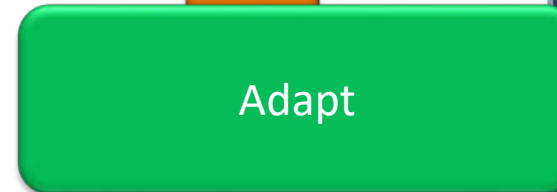
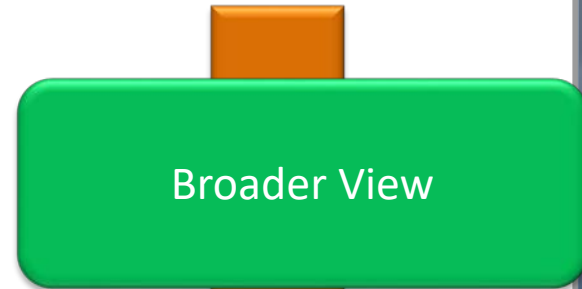
Logistics Support Concept & ILS to ensure Life Cycle Support

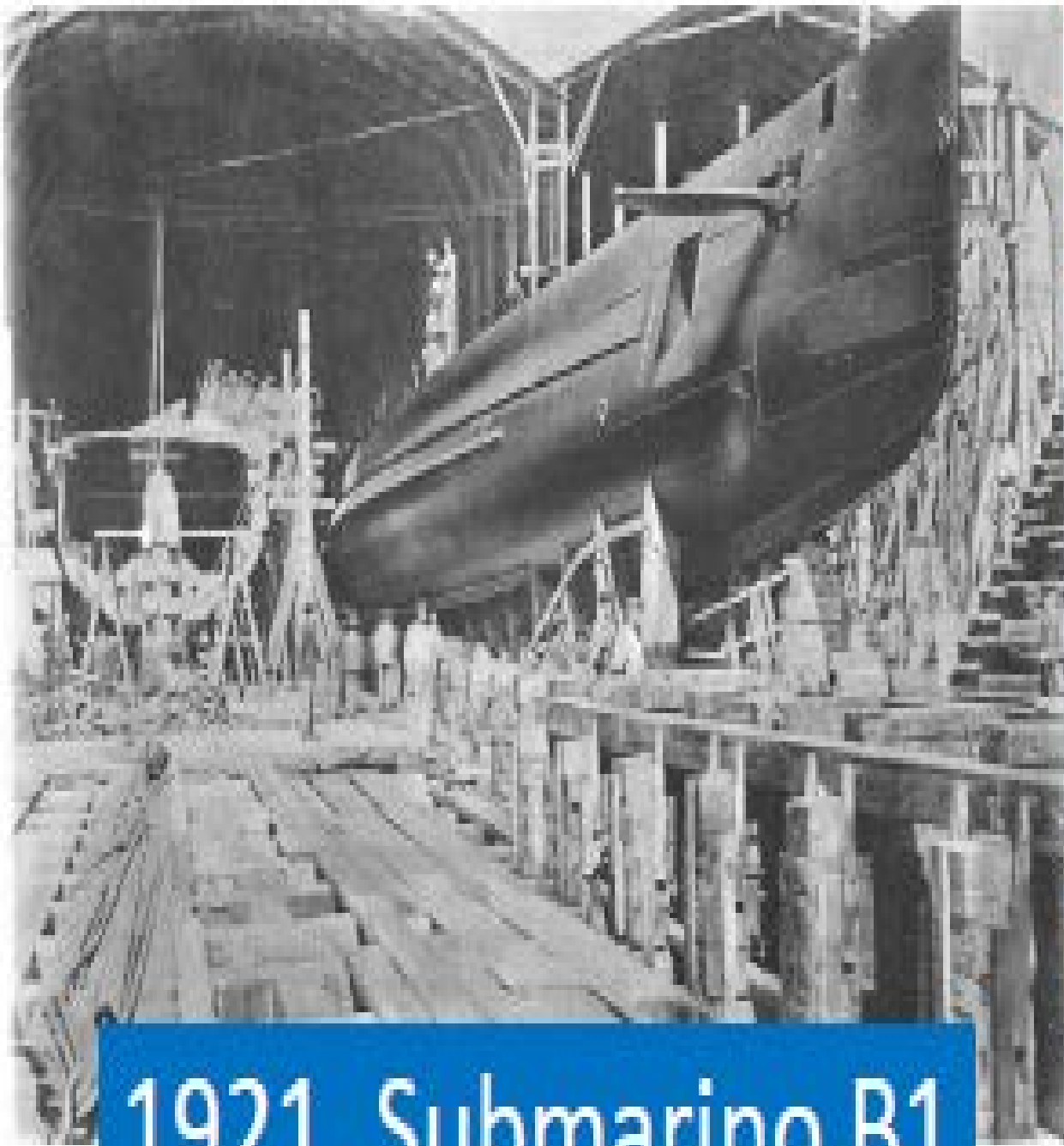


The Future is Now: think different



EDTs will drive current and future programs





1921. Submarino B1



2021. Submarino S-81