Systems Engineering and Defence

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Agenda

1. A historical approach to Systems Engineering in defence sector
2. Systems Engineering in the Spanish Ministry of Defence (MoD)
3. Success stories in Isdefe
4. Horizons Network and the Observatory for Systems Engineering
5. Lessons Learned

1. The VASA disaster

- On January 16, 1625, the King Gustav II Adolf ordered the **construction of four large warships**
- Afterwards the King requested that the keel of the ships **be enlarged up to 120 feet** (more guns were needed),
- Later on, he ordered that the VASA **be enlarged to 135 feet** and that it also had a **second deck**.

- **As the keel had already been laid down**, it was necessary **to increase the breadth of the hull in its upper part** affecting the stability of the ship
- The number and caliber of the guns were modified several times which **further complicated the stability of the VASA**
- The **keel prevented the placing of the ballast,** although there were not precise stability predictions.
- **Most simple stability tests were interrupted** upon the worrying lists developed by the ship.
- On August, 10, 1628 the VASA set sails on its maiden voyage. **After sailing less than one nautical mile the ship listed to port, capsized, sunk and about 50 sailors drowned.**

1. The VASA disaster

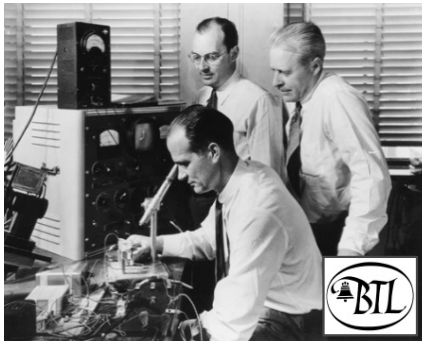
The capital errors in the VASA project:

1. **Initial requirements incomplete and fuzzy.**
2. **Continuous changes of requirements.**
3. **Excessive calendar pressure.**
4. **Lack of a documented project plan.**
5. **Inappropriate definition of responsibilities.**
6. **Too many innovations and poor risk management.**
7. **Lack of knowledge and scientific methods.**
8. **Lack of holistic view.**
9. **Lack of professional ethics.**

TOTAL LACK OF SYSTEMS ENGINEERING

1. A historical approach to Systems Engineering in defence

The origin of SE



1940: *Bell Telephone Laboratories*

The increase of complexity of Defence Systems

1939-45: WWII

1947-91: Cold War

Systems Engineering regulations

1969 — **MIL-STD-499**
1st Military Norm on SE (USA Air Force)

1974 — **MIL-STD-499A**
Standard on SE for acquisitions

1990 — **Foundation of INCOSE**

1992 — ~~**MIL-STD-499B**~~
Common standard between Defence and Industry

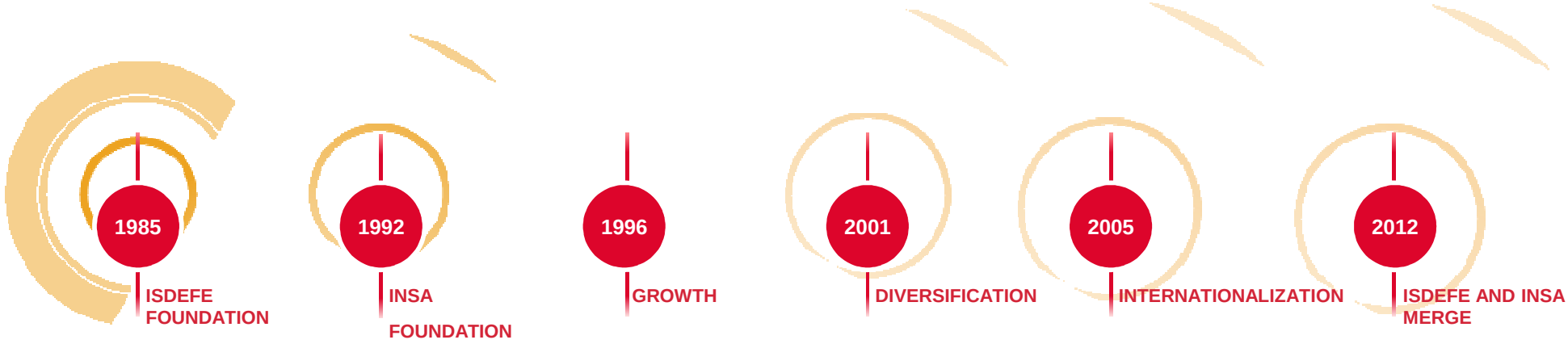
1994 — **EIA/IS-632**
IEEE-1220
Proliferation of Standards on SE

2004 — **DAG**
Defence Acquisition Guide (DoD USA)

2015 — **ISO/IEC 15288**
Joint revision of the processes within DAG

1. Systems Engineering in the Spanish defence sector

- **Ingeniería de Sistemas para la Defensa de España** (Isdefe) is a state-owned consulting and engineering company established in 1985.



- Isdefe's **mission** is to provide engineering services, consulting and technical assistance to the Spanish Public Administration as well as public international organizations.

- It is a special company model: It is focused public sector, independent of commercial or industrial interests.

- **Services:** Consulting, Engineering and Turnkey Projects.

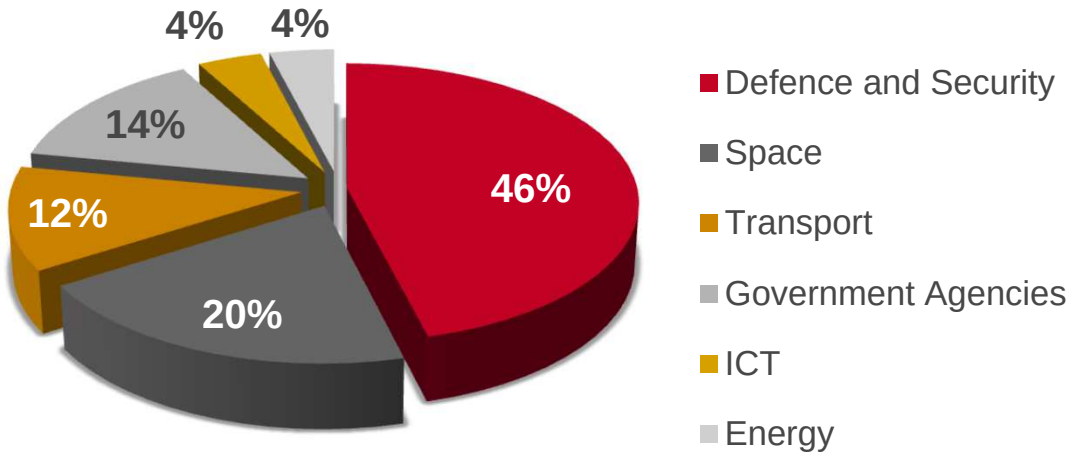
The best team

At Isdefe we have a team of highly skilled and qualified employees who are committed to the organization and to our clients.

Over 30 years of experience with a high level of specialization and driven by excellence.

2015 FY

Accounts & Balance Sheet	
Yearly turnover	143 million €
Profits	3,2%
Human capital	
Number of employees	1,548
Degreed Technical Personnel	80%
Average experience	9
Average age	42
Men/Women	62 / 38 (%)



Defence and Security

- Defence Planning.
- Command and Control Networks and Systems.
- Platform Acquisition and Maintenance Programmes.
- Technology Centers.
- Logistics and Supply Chain Systems.
- Intelligence and Electronic Warfare Systems.
- Cibersecurity.
- Strategic Infrastructure.
- Protection of Critical Infrastructure.
- Industrial and technological management.
- Border Surveillance and Control Systems.
- Crisis and Emergency Management Systems.

1. Other areas of activity

Space

- Space Stations and Infrastructures
- Satellite Applications

Transport

- Traffic Management
- GNSS applications and drones
- Transport Centres

Public Sector

- Improving and Modernizing Government Agencies
- Market Regulation and Oversight

Energy

- Energy Diversification and Efficiency
- Energy Security

ICT

- Radio Spectrum
- Communication Networks and Systems

2. The case for Defence: Planning and System Acquisition

Defence Planning is a strategic process that deals with military needs and resources to provide Armed Forces with military capabilities.

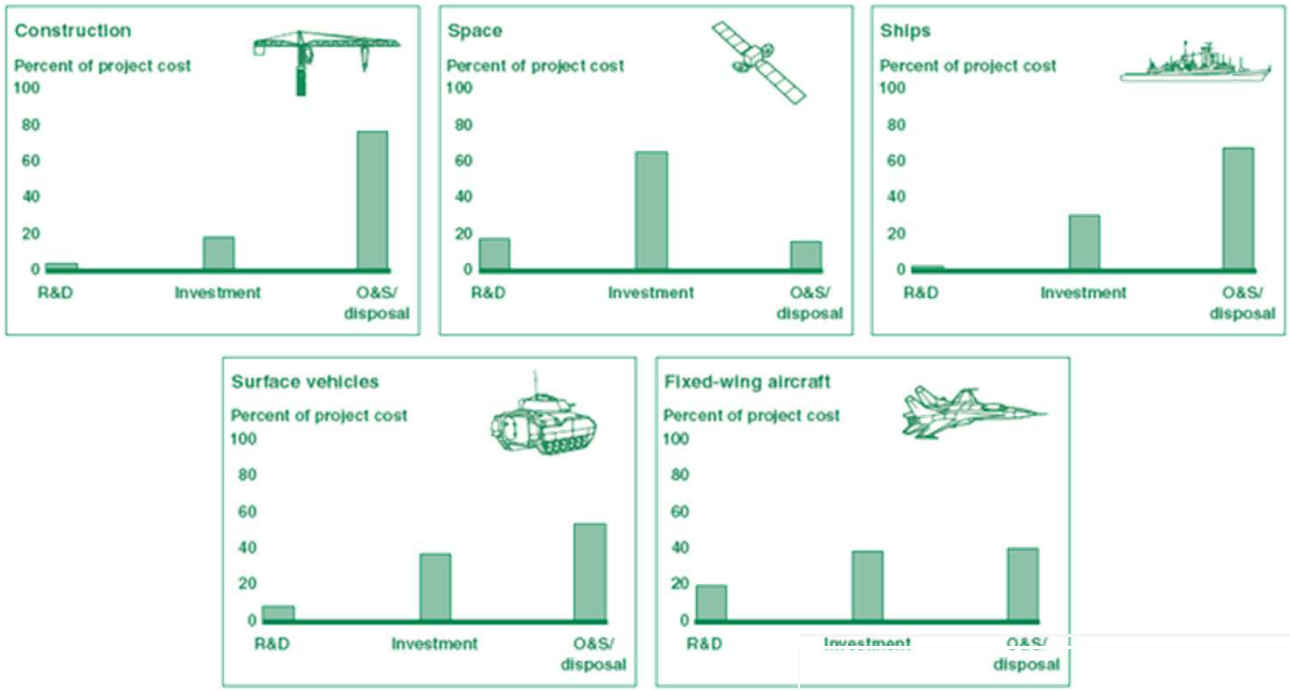
System Acquisition is the process to obtain a solution for a specific need.

While Defence Planning tackles many military needs at the same time, System Acquisition copes with only one at a time.

- All the **ongoing acquisition processes** underpin and **affect Defence Planning**
- **Any decision** made within a program **affects how resources are put to good use**.

2. The costs of the future are being committed today

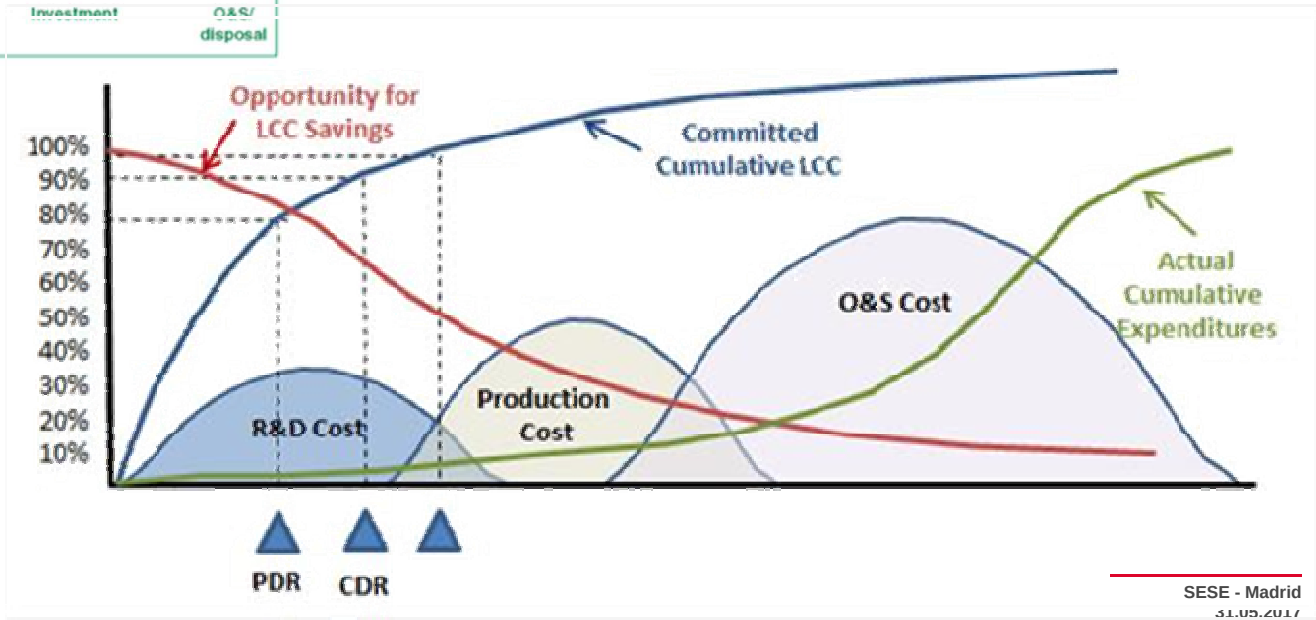
Cost vs Life-cycle



- Defence systems have long life-cycles with operational costs between 40%-70% of their LCC.

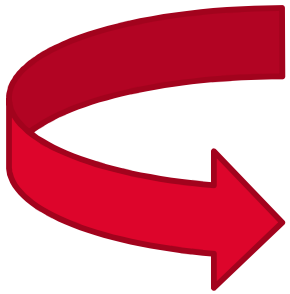
- At PDR, 80% of Life-cycle cost is committed.

- The more advanced the process is the more difficult and expensive the implementation of changes is.

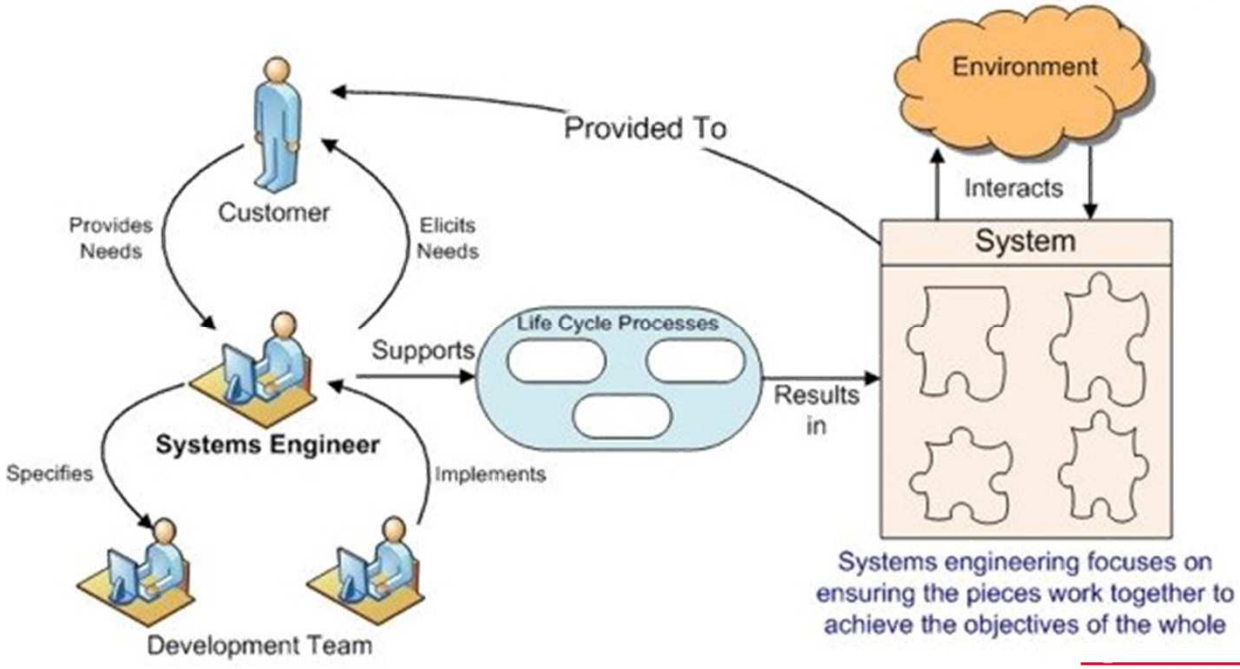


2. The need for the Systems Approach

- **Life-cycle cost**: the LCC must be a factor to consider at any moment of the acquisition process.
- **Cost/effectiveness**: there is a need to balance cost and requirements (affordability).
- **Global vision**:
  - the **system as a capability**: not only the system itself, but all the components that support it must be considered and must be programmed.
  - decisions to be made must be considered attending to possible **side effects**.



SYSTEMS ENGINEERING



2. Systems Engineering in the Spanish MoD regulations

Defence planning

Orden Ministerial 60/2015

Resource planning

Instrucción SEDEF 2/2011

System acquisition

Instrucción SEDEF 67/2011

Instrucción SEDEF 72/2012

Based on Systems Engineering

- **Problem domain and solution domain are clearly separate**.
- The selection of the design concept is a **decision gate according to the life cycle cost (affordability) and risk evaluation (feasibility)**.

2. Organizational model for armament acquisition

Systems Engineering

Problem domain

Operational need

General Staffs
(of the three services and UME)

Stakeholders requirements

Joint Staff

Solution domain

Design Concept

Affordability/Feasibility

Systems Requirements

System architecture

Verification

Production, Integration and testing

General Directorate
of Armament and Materiel
(Secretary of State for Defence)

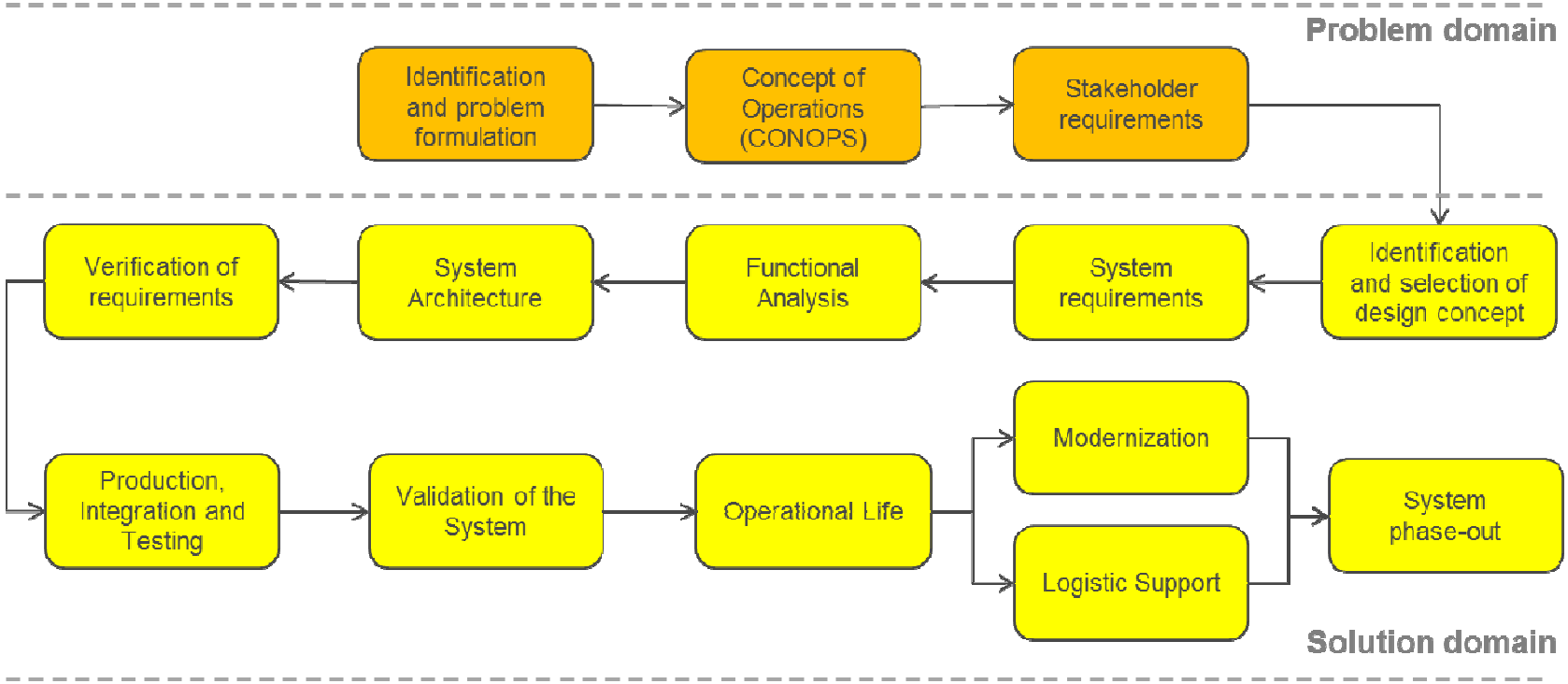
Validation

Logistic support

Modernization

Logistic Support
Commands

2. Implication into the Systems Engineering framework



- Isdefe is present at all the stages of this framework providing technical assistance and support in:
  - **Requirement engineering and management.**
  - **System architecture definition.**
  - **Contractual process: drawing up of technical specifications, evaluations of tenders,…**
  - **Verification and validation**
  - **ILS definition and in service support management**
  - **Program management: planning, cost analysis, risk analysis,…**

3. Success stories: Maritime Surveillance System (SIVE)

Initial operational need

- **1998**: To **detect irregular activities** at sea (mainly inmigrants flows and drug trafficking) with enough reaction time to intercept them before reaching the coast.

Up-to-date operational need

- **2013**: To **guard the EU maritime borders** through cooperating and interoperating with other european countries (EUROSUR) and agency (FRONTEX).

Proposed solution

- The system consits of:
  - Stationary, deployable and mobile ground stations with radar and optronic sensors
  - Commad and Control Centers to coordinate operations.
  - Helicopters, patrol boats and cars as reaction means.

3. Success stories: Maritime Surveillance System (SIVE)

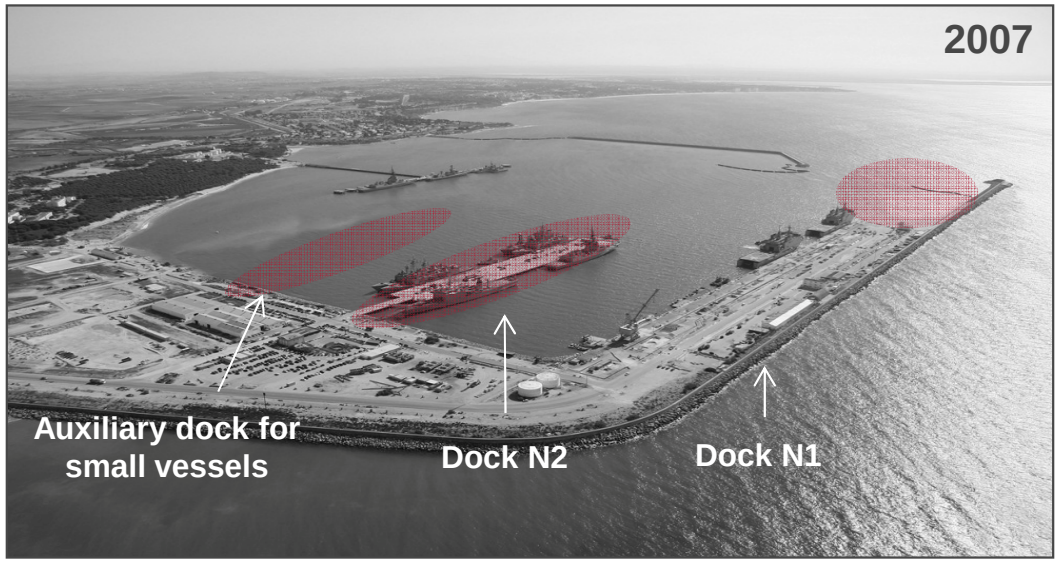
Isdefe participation

- **Requirements engineering and management**
- **Technology assessment** (radar, optronics, communcations, C2,…)
- **System architecture definition**.
- **Contractual support**
- **Follow-up of production and integration** activities through verification and validation.
- **Transition and In service support**.
- **Cooperation and interoperability** with other european countries.
- **Implementing european regulations and directives** (FRONTEX) to evolve EUROSUR.

3. Success stories: Rota Naval Base Upgrade

Operational need

- To **extend the capacity and services** of Rota Naval Base and **provide** ships with **access to NATO General Communications System (NGCS)**.



Proposed solution

- The system comprises:
  - New and refurbished docks.
  - Communication facilities: interconnection points, multiservice IP network, optical fiber,…
  - Improved services for resupply and management of waste materials at the disposal of ships.

3. Success stories: Rota Naval Base Upgrade

Results

- A **modernized and double-capacity naval infrastructure** for the deployment of ships in NATO operations.
- A totally **interoperable infrastructure** for any kind of ship regardless its nationality.

Isdefe participation

- **Analysis and evaluation** of the premises and services of the naval base ("As is").
- **Analysis of NATO requirements**: NSIP programmes: *In-Port Connectivity* and *Logistics support and resupply facilities for a multinational maritime force* ("To be").
- Being part of the PMO along with the Spanish Navy and NATO
  - **Proposal of projects to undertake** to fullfil the capability gap.
  - **Contractual support** (technical projects, technical specifications, evaluation of tenders,...)
  - **Follow-up of production and integration** activities through verification and validation.

3. Success stories: Military Unit for Emergencies (UME)

Operational need

- To develop a new **military capability to intervene in emergencies and natural disasters** in order to assure the security and welfare of the citizens.

Proposed solution

- The system consists of a military unit provided with:
  - Stationary and deployable C3 (Command, Control and Communications) nodes.
  - Terrestrial platforms: tow trucks, snowploughs, fire trucks, tank trucks, tactical vehicles…
  - Aircraft and helicopters for fighting fires and SAR.
  - Rigid-hulled inflatable boats (RHIBs)
  - Other assets: camp material, CBRN analysis and decontamination, reinforcing,…

3. Success stories: Military Unit for Emergencies (UME)

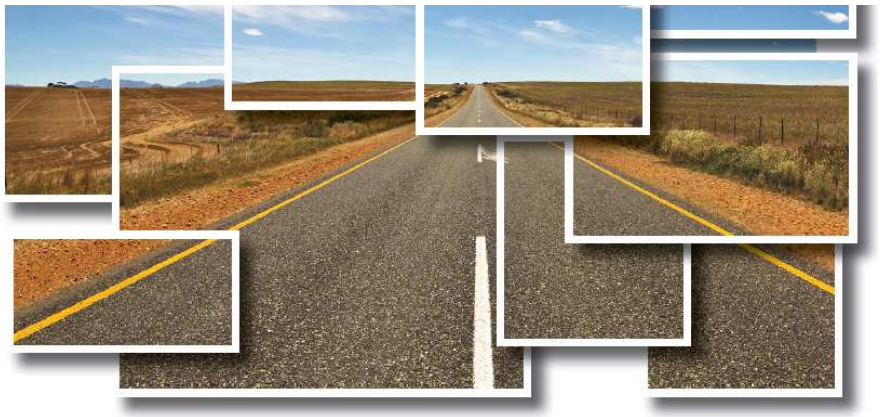
Results

- A **full operational and deployable unit** with capabalities **to intervene in major disasters** whether natural (snowfalls, floods, earthquakes,…) or not (CBRN threats, terrorists attacks,..), **and to assist affected population**.

Isdefe participation

- **Consulting**
  - ❑ Analysis of current regulations, case studies, available means,...
  - ❑ Drawing up of the Global Concept of the unit
  - ❑ Implementation plan: from IOC to FOC.
  - ❑ Programming of acquisitions and set-up of program offices
- **Technical assistance**
  - ❑ Requirements engineering and management
  - ❑ System architecture definition (mainly of C3 and CBRN capabilities)
  - ❑ Contractual support
  - ❑ Follow-up of integration activities through verification and validation.
  - ❑ ILS definition and in service support management

4. Isdefe's Horizons Network - R&D Prospective



The Isdefe's Horizons Network is a tool intended to identify and analyze future challenges in its current sectors of activity and to develop innovative ideas to cope with them.

Medium and long term innovation programme lead by Isdefe aimed to:

- Enhance the corporate values of innovation and anticipation by undertaking foresight of emerging technologies, methodologies and management best practices.
- Build a network of academic experts in areas of strategic interest.
- Disseminate the knowledge generated via workshops and conferences.
- Develop a talent recruitment programme through the Network's participating universities.

4. Isdefe's Horizons Network – The Observatories

Isdefe's Horizons Network is based on **a group of observatories** run by its personnel and supported by the academia.

Universidad de Alcalá

etsiae UPM

ETSIT UPM

Cybersecurity

ATM

Defence & Security

HSN University College of Southeast Norway

Systems Engineering

Isdefe

Space

Economy and Public Management

Universidad Carlos III de Madrid

UNIVERSIDAD COMPLUTENSE MADRID

4. Why Isdefe´s Observatory for Systems Engineering

Rationale

- **Systems Engineering** has been **at the heart of Isdefe´s competencies** and skills from its foundation.

- Isdefe identified two threats related to these competencies :
  - There are **no specific degrees or master's degrees on these disciplines** in Spain, so new workers are not properly specialized.
  - **These competencies were getting blurred** within the workforce as the size of the company grew.

- Both threats
  - led to the establishment of this new Observatory for Systems Engineering.
  - determined one additional feature for it: **the need for Education and Training**.

4. Isdefe´s Observatory for Engineering

Scope

- The Isdefe´s Observatory for Engineering works in three courses of action.

1. Watch and foresight: Isdefe wants to get awareness of what is going on in these disciplines through gathering information from experts (institutes, conferences, universities, associations,...)

2. Outreach and visibility: Isdefe wants to keep on being perceived as a reference in these disciplines by its clients through producing quality outputs.

3. Education and Training: Isdefe wants to disseminate this information within the company and transform it into knowledge.

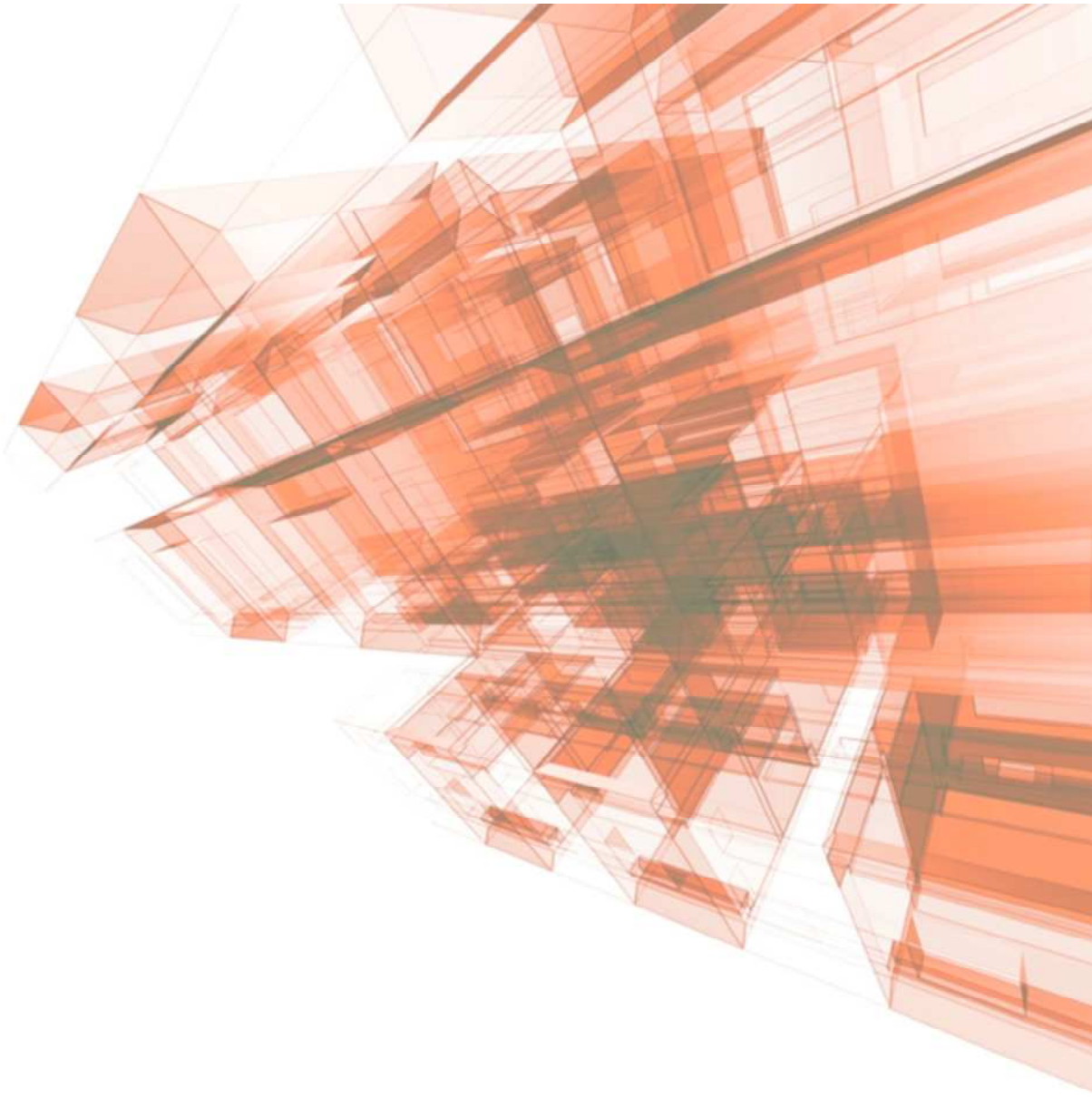
5. Lessons Learned (in Defence)

- After more than 30 years of experience in Systems Engineering in Defence a group of conclusions must be stressed:

  - **Systems** must be considered **as a capability** since the very beginning.
  - **Overspecification** of requirements **must be avoided**.
  - **Design concepts** must be **thoroughly assessed**.
  - **Life Cycle** view as **a key element** through Design and Development processes
  - **Managing requirements** properly along a programme is **key to success**.
  - **Technology** has to be **mature enough** before being integrated into a new system.
  - **The promoter** of the system **must control** how **the program** comes along.
  - ***Continuous state-of-the-art refreshment on Systems Engineering is vital*** *for Isdefe to continue being a trustworthy provider of high qualified technical assistance.*

Isdefe

your best ally



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3. Success stories: Joint EW Program Santiago

Operational need

- To ensure a complete and effective acquisition of information on electromagnetic signals which, once correlated with the information obtained by other means, provides the commander with evaluated information in time for the support of the decision making process.

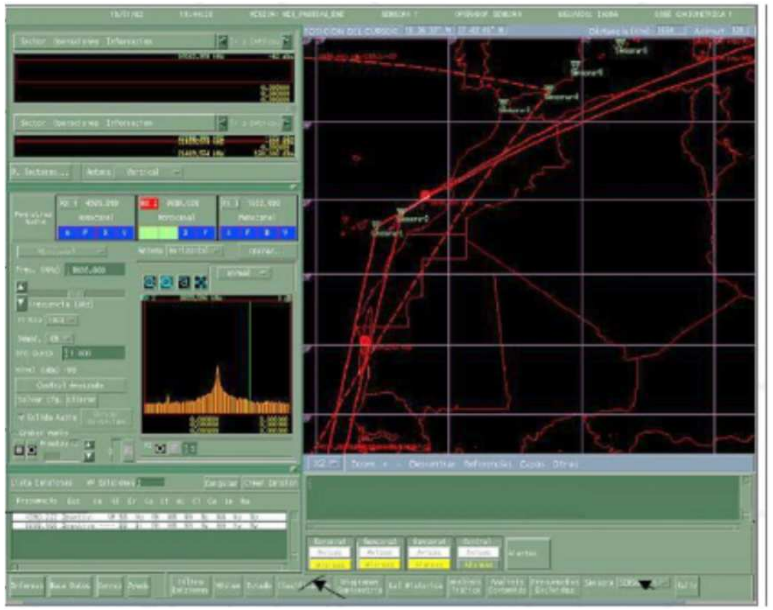
Proposed solution

- The system comprises:
  - COMINT, ELINT, OPTINT and IRINT sensors.
  - Acquisition from Global Coverage HF subsystems
  - Terrestrial, shipborne and airborne platforms.
  - Fusion centers.

3. Success stories: Joint EW Program Santiago

Results

- A joint electronic warfare (EW) capability.
- A joint signal intelligence (SIGINT) capability.



Isdefe participation

- Definition of **system requirements**.
- Definition of **software applications and tools** for signal processing and analysis.
- **System architecture definition** and **system configuration management**.
- **Follow-up of software and subsystems development**.
- Support to the **integration of subsystems** through verification and validation.
- Support to **transition, operation and maintenance** of the system
- **Program management** and **contractual processes**.