UDT
Undersea Defence Technology
13-15 May 2019
Stockholmsmässan, Sweden

#UDT2019

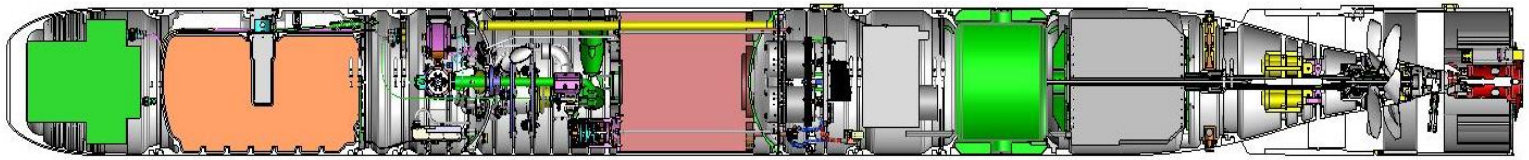
Heavyweight Torpedoes program

Management of Validation and Qualification process

NAVAL GROUP

Situation (1/3)

21th century scientific progress delivered a new impulse to Heavy Weight Torpedoes design and development. Tactical advantage and technical benefit for navies are the most visible parts of the iceberg. The invisible part is a far more complex validation and qualification process which grows-up in the industrial world with potential time and money issues.



A modern HWT is now a real time digital machine with an architecture based on powerful embedded computers working in severe environment.

Situation (2/3)

Based on Navy operational need, the story shall start with strong and efficient requirements in engineering methods as late detection of forgotten requirements cannot be tolerated. This can be achieved thanks to powerful off-the shelf existing tools.

This approach leads to a step by step requirements allocation, from elementary sub-systems to complete Heavy Weight Torpedo.

Situation (3/3)

Each step needs then a dedicated shore test bench; the main sub-systems areas are :

- Embedded Software,
- Sonar performances,
- Energy connected/coupled to the Propulsion system.

Far more than the Light Weight (fire and forget concept), the Heavy Weight Torpedo has to comply with launching platform safety requirements (launching depth and speed).

Nuclear submarines dramatically increase this safety constraint and thus the need for the need for strong shore test results before embarkation authorization is obtained

Integration Validation Qualification (IVQ) : a step by step process

Based on Navy operational need, a governmental procurement agency (for example DGA in France) issues a top level Weapon System Specification (WSS).

Complete and deep analysis of the System Specification is the first major step for the industrial company in charge of the contract.

Final weapon qualification is the key milestone for the HWT end user (French and/or Foreign navies). It occurs at sea (live firing from a submarine) but also through intermediate land/shore tests.

Shore test means purpose is multiple:

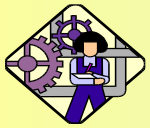
- Qualification cost reduction,
- Risk mitigation before wet firings,
- Growth potentials anticipation, analysis and preparation.

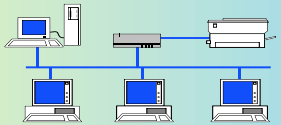
Integration Validation Qualification (IVQ)
A step by step process

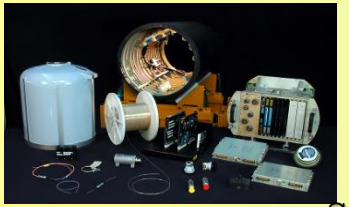
Section level design

Torpedo level integration

Wet trials





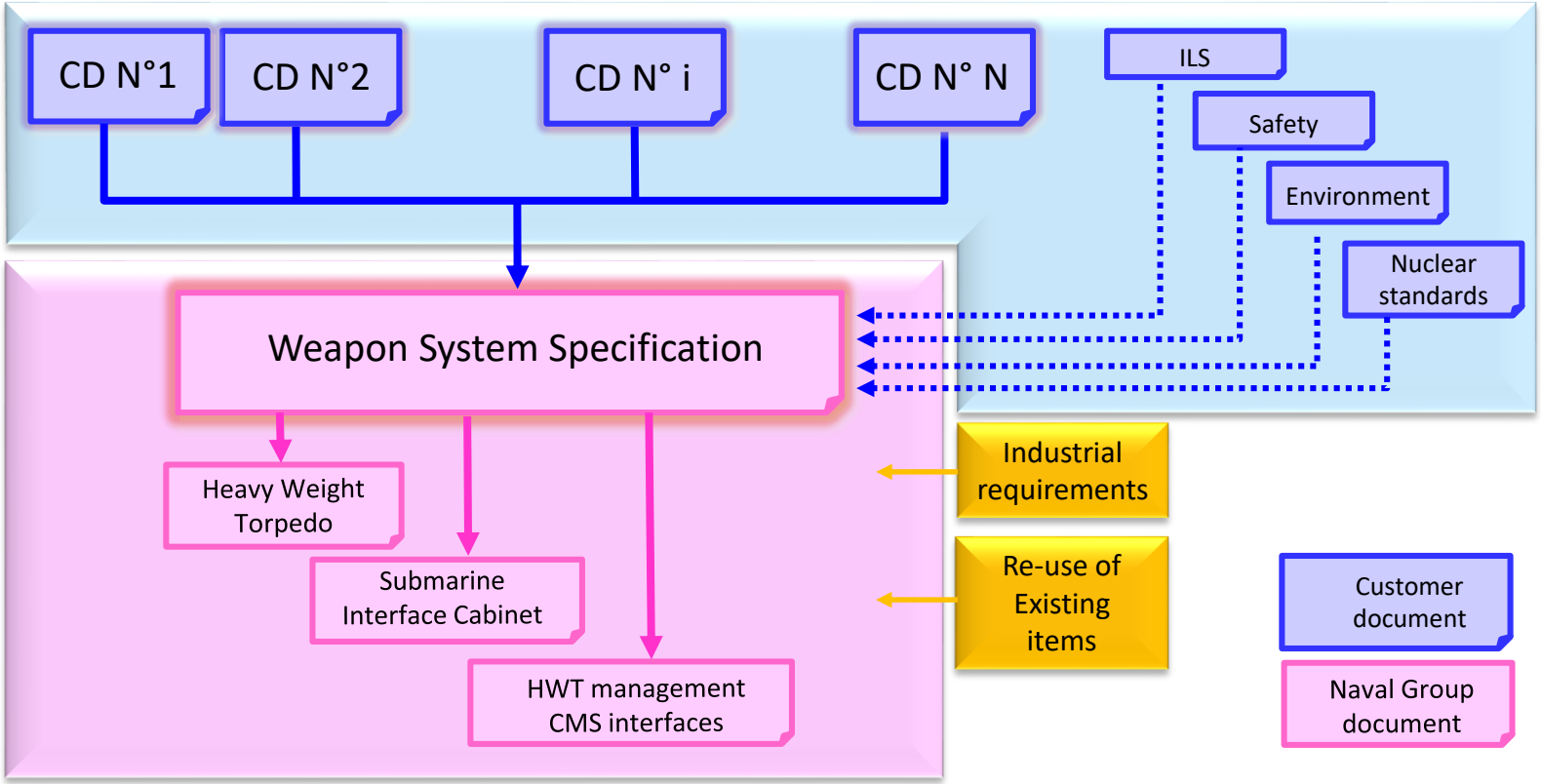


Factory

Shore Integration Platform (SIP)
Hybrid Simulation (HIL)

Offboard integration
Quay / Sea

Weapon System Specification analysis

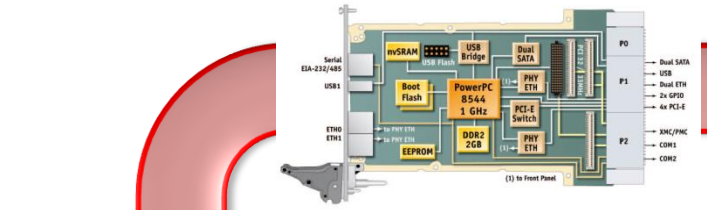


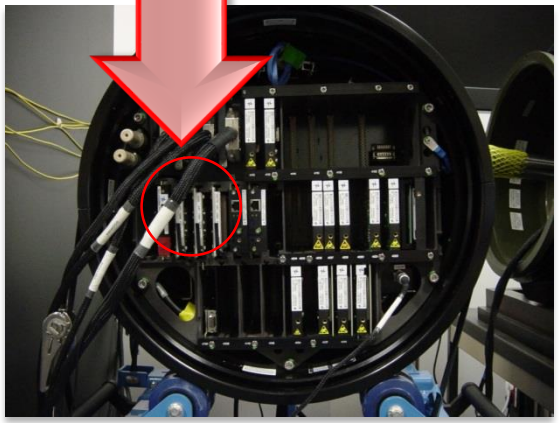
Shore Integration Facilities
Embedded software

Embedded software development & testing is a key point in a HWT program

- Safety Development standards are used
- SW running on Target Machine is started at shore level
- Test bench is made of embedded software coupled with simulated environment :
  - ✓ Vehicle
  - ✓ Sonar
  - ✓ Energy

Shore Integration Facilities
Embedded software





Control & Guidance Section

Real Time monitoring Tols

Closed Loop Platform

Models Library

Targets

Motor

Vehicle

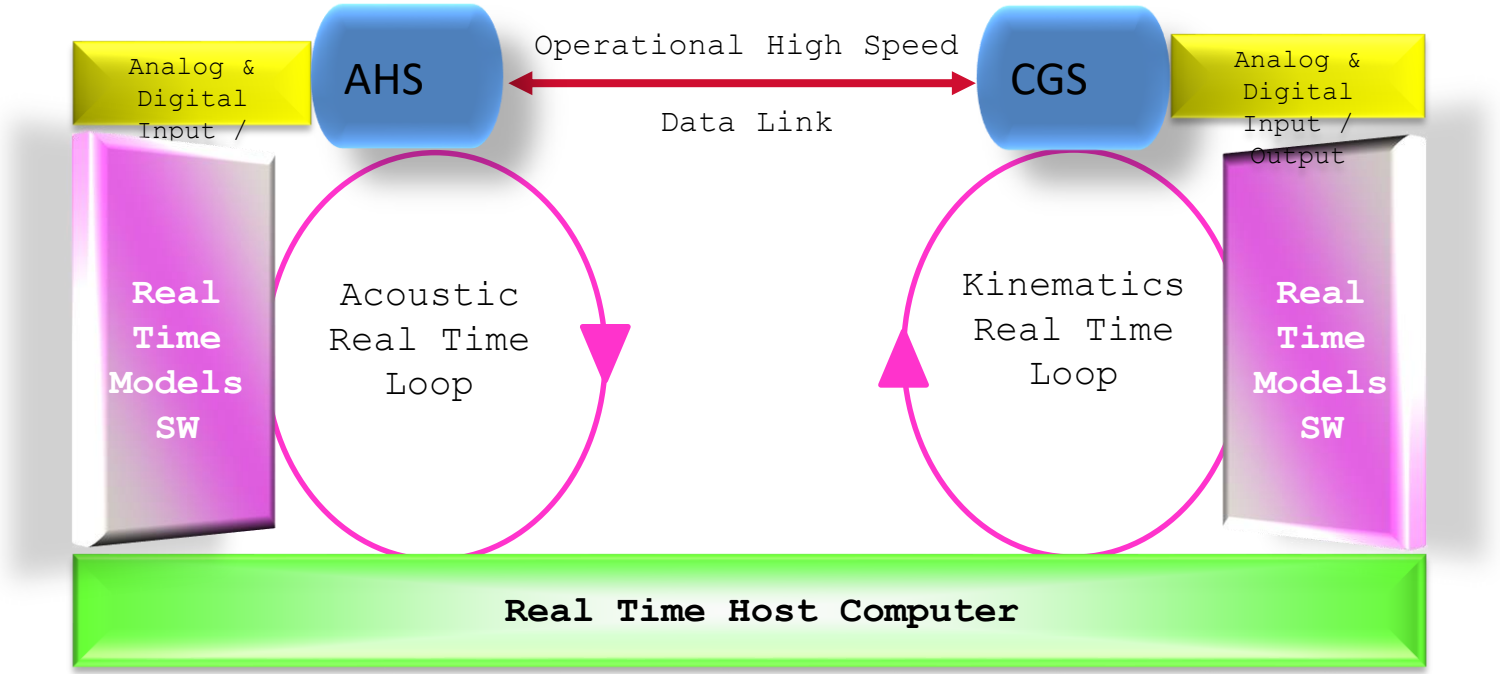
Sonar

Energy

Shore Integration Facilities

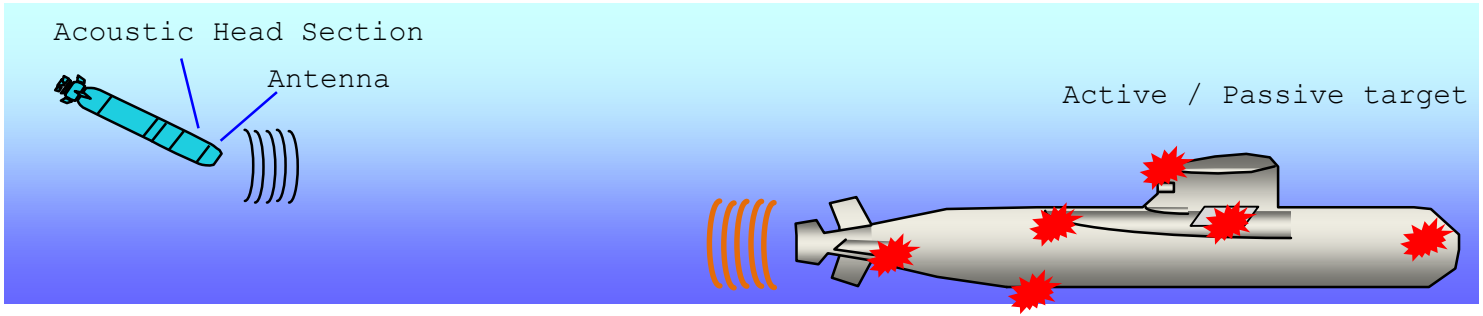
Hybrid Simulation (Hardware In the Loop)

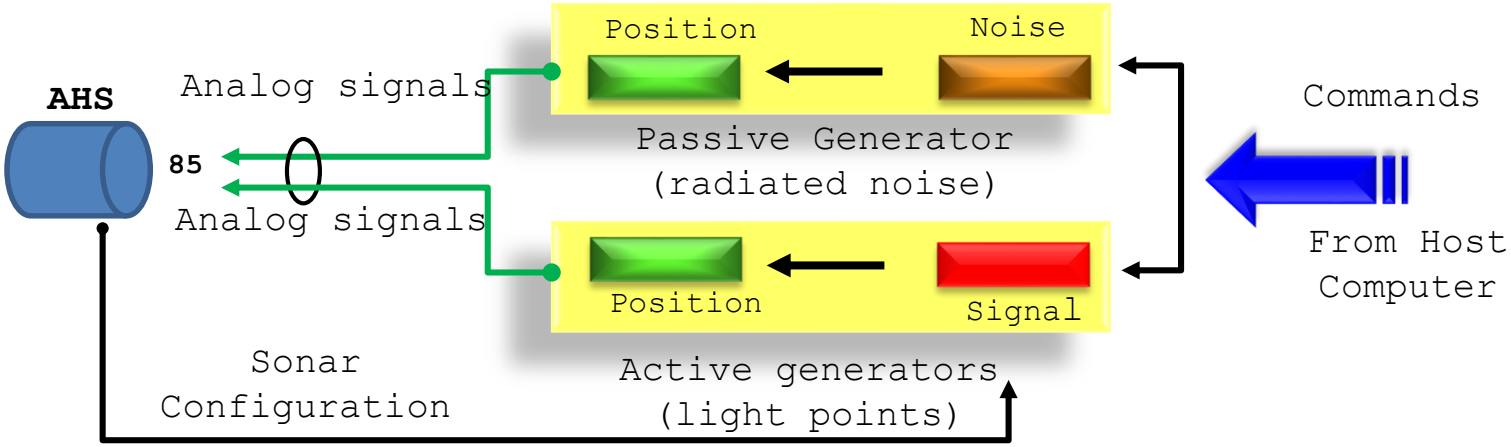
General spirit : Homing and Guidance



Shore Integration Facilities

Hybrid Simulation (Hardware In the Loop)





Shore Integration Facilities

Hybrid Simulation (Hardware In the Loop)

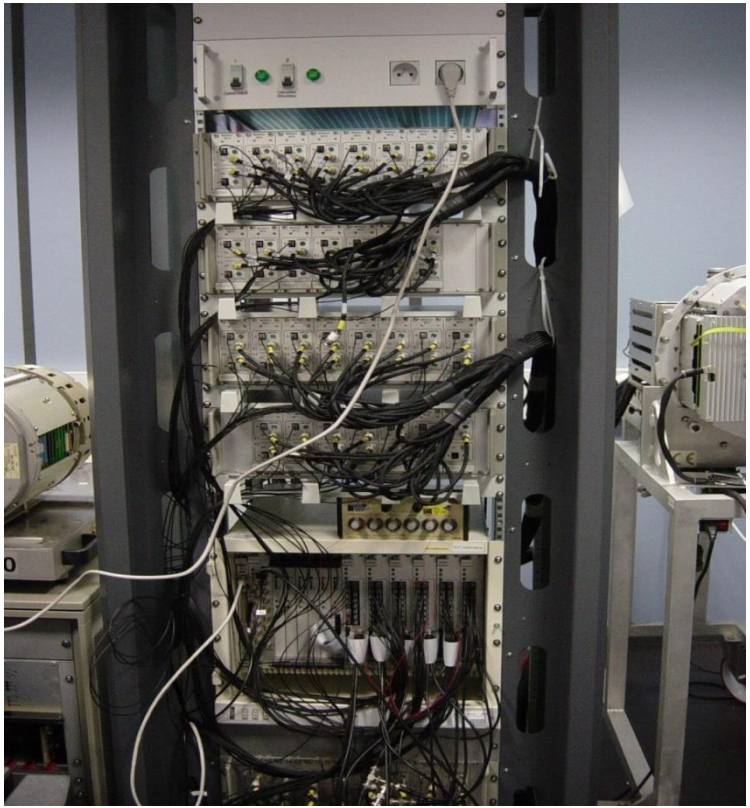
Real-Time Acoustical Loop for Torpedo Sonar (Acoustic Head Section)

Analog signals generated at transducers level

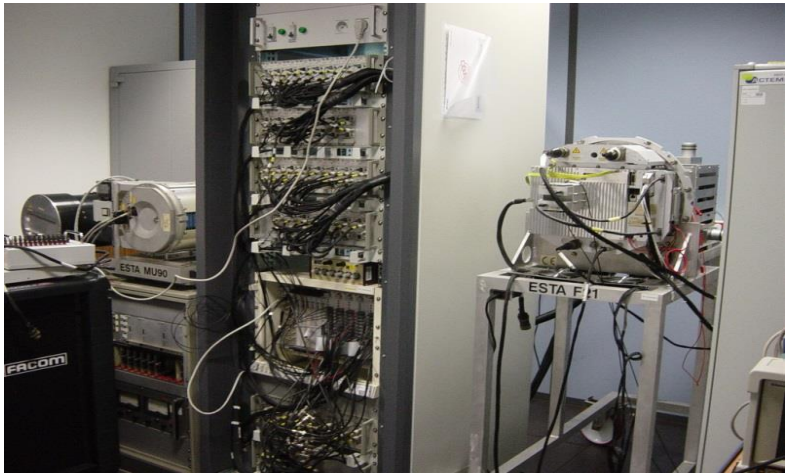
Active and passive targets, self noise, reverberation

Controlled parameters :

- Level (target strength),
- Frequency shift (Doppler),
- Phase (Bearing/Elevation),
- Time delay (echo date)



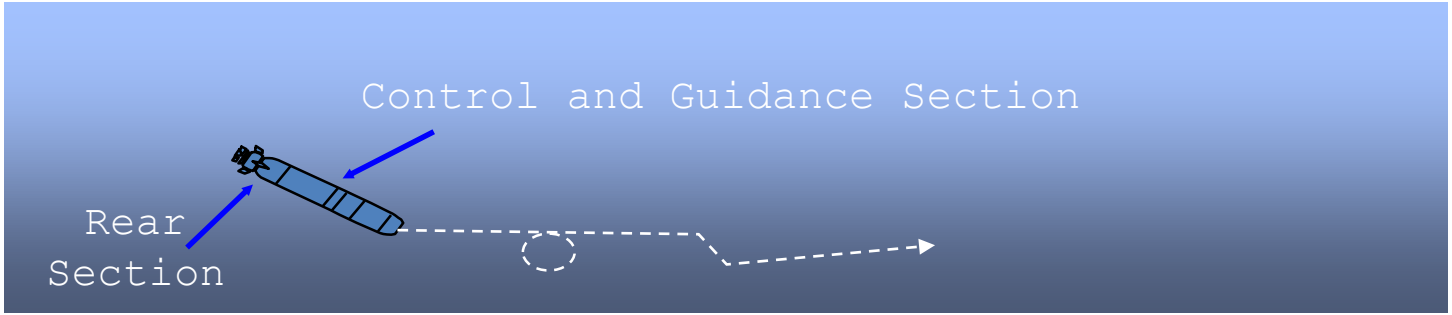
Shore Integration Facilities
Hybrid Simulation (Hardware In the Loop)

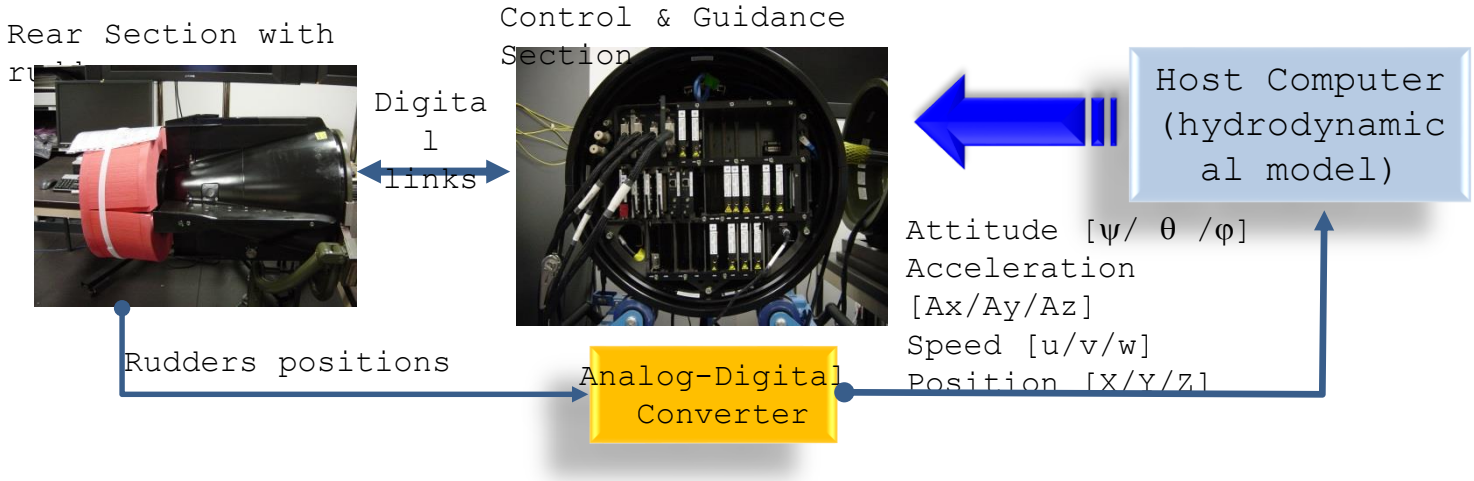


Same system for HWT and LWT

- Optimisation of development and testing
- Common models data base (enriched from wet sea trials)

Shore Integration Facilities
Hybrid Simulation (Hardware In the Loop)





Shore Integration Facilities

HWT Integration Platform (with optional CMS)

General spirit

- Complete vehicle configuration : Hardware & Software items
- Acoustic real time loop : NO
- Kinematics real time loop : YES
- Homing and Guidance functions : not used
- Test and evaluation of
  - ✓ Power supplies limits
  - ✓ Digital links failures
  - ✓ HW & SW safety loops

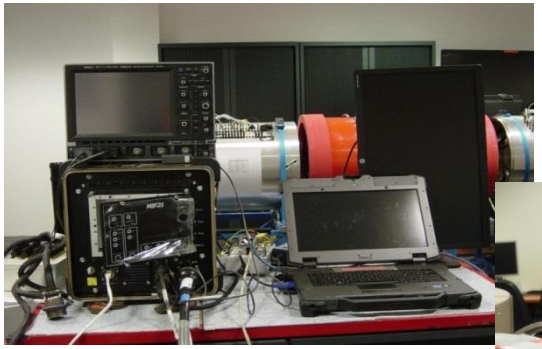
Shore Integration Facilities

HWT Integration Platform (with optional CMS)

HWT 100.% complete

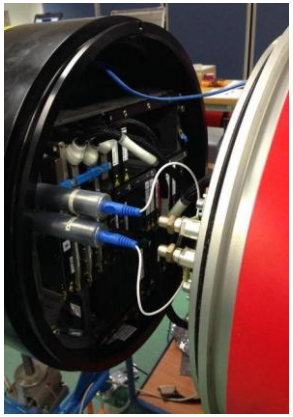
Mechanical connections : NO

Electrical connections : YES



Shore Integration Facilities

HWT Integration Platform (with optional CMS)



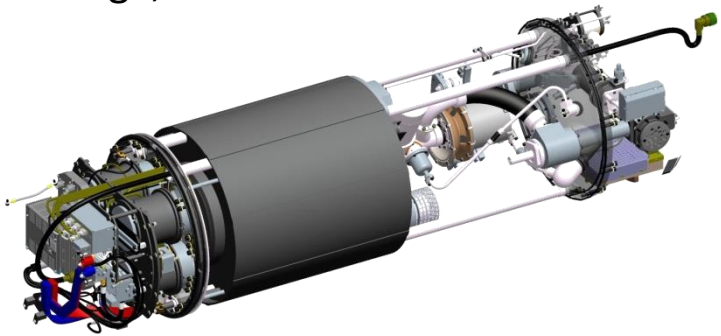
Instrumentation :

- Break-out boxes
- Time & Frequency analysis
- Acquisitions systems :
  - ✓ Analog
  - ✓ Digital (CAN Bus, Ethernet)
- 100.% COTS design

Shore Integration Facilities
Primary Battery Test Bench

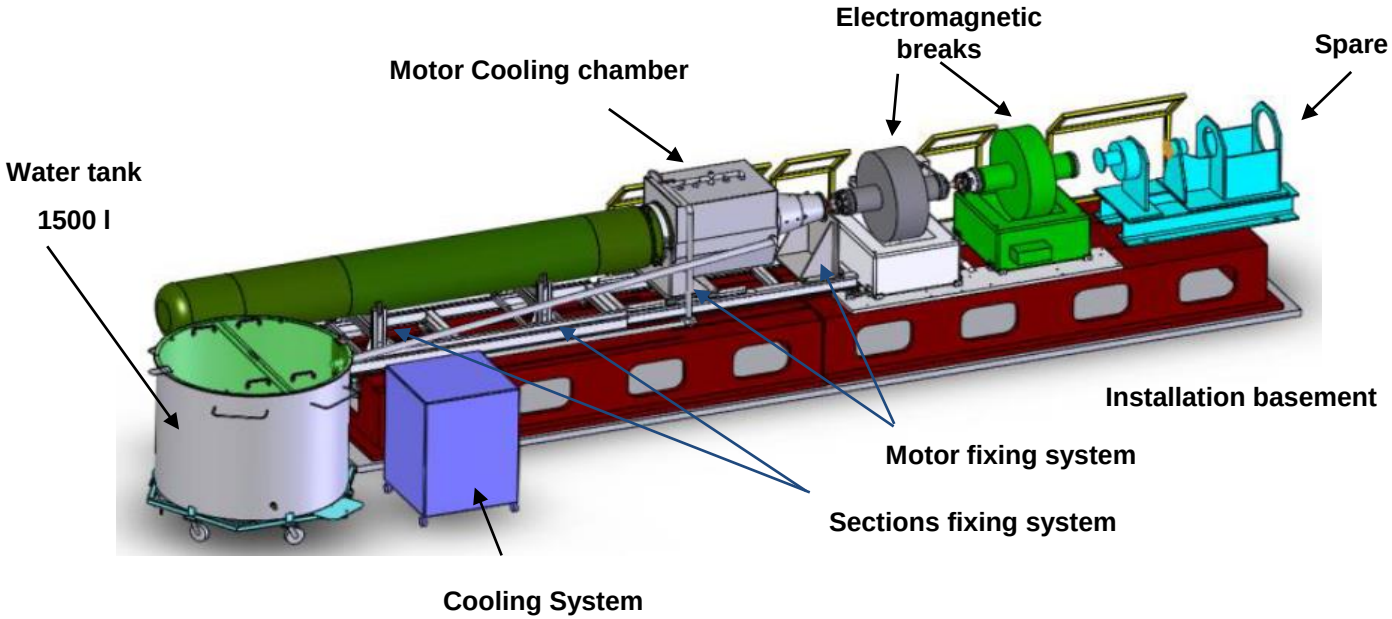
Primary Battery (Ag0-Al technology) shore evaluation

- Open loop system (resistive charge)
- Safety aspects analysis
- Power (HWT speed) and energy profiles (HWT endurance)
- Dedicated (internal & external) instrumentation: pressure, temperature, voltage, current



Shore Integration Facilities

Motor Test Bench with Secondary Battery



Shore Integration Facilities
Motor Test Bench with Secondary Battery

Situation and involved items

- Lithium-Ion technology Secondary Battery for Exercise trials
- Electrical propulsion Motor
- No propellers; shafts coupled to electromagnetic brakes

Purpose and test means

- Electrical & mechanical compatibility between energy and propulsion
- Safety loops (motor & Battery)
- Power (HWT speed) and energy profiles (HWT endurance)
- Dedicated (internal & external) instrumentation (Motor & Battery)

Shore Integration Facilities

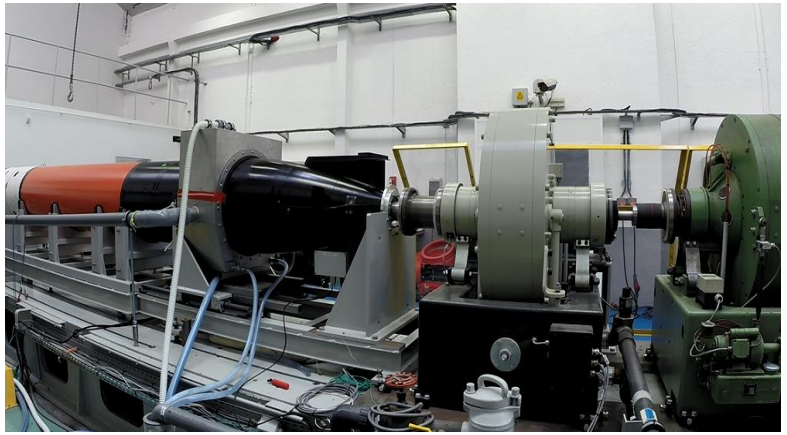
Motor Test Bench with Secondary Battery

Test of

- Power supplies limits
- Digital links failures
- HW & SW safety loops
- EMC aspects

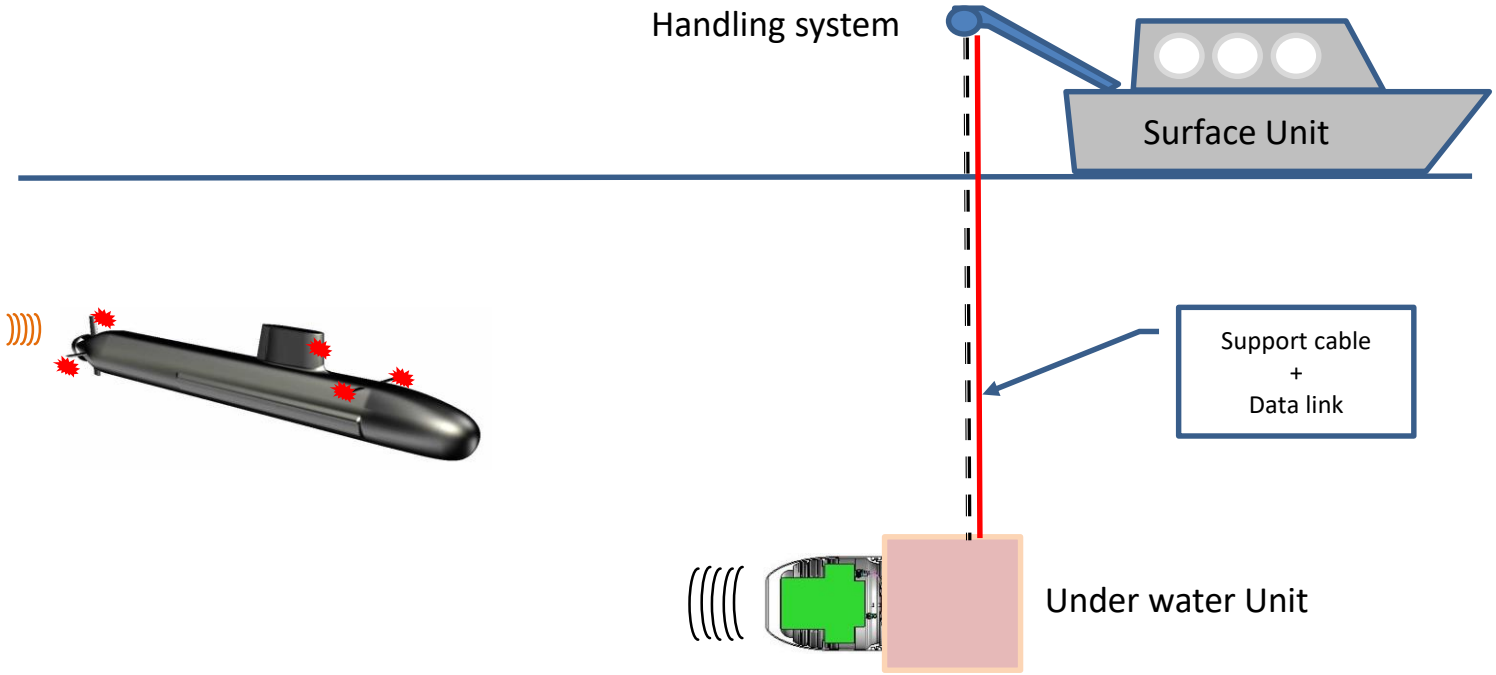
Instrumentation

- Time & Frequency
- Analog
- Digital (CAN Bus, Ethernet, …)
- 100.% COTS design



Shore Integration Facilities

Sonar static wet test



Shore Integration Facilities

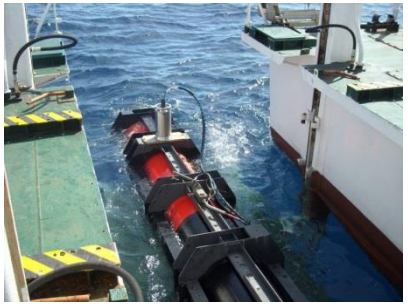
Sonar static wet test

Evaluation of Acoustic Head Section performances

- Open loop static system
- Display on Surface Unit
- Recording on Under water Unit
- Validation of Sonar digital signal processing at sea before embarkation inside HWT
- Test of SW evolutions in real environment
- Real targets (surface ships, submarines, CMs)

HWT live firings

Swim-Out from Naval Group catamaran



HWT live firings

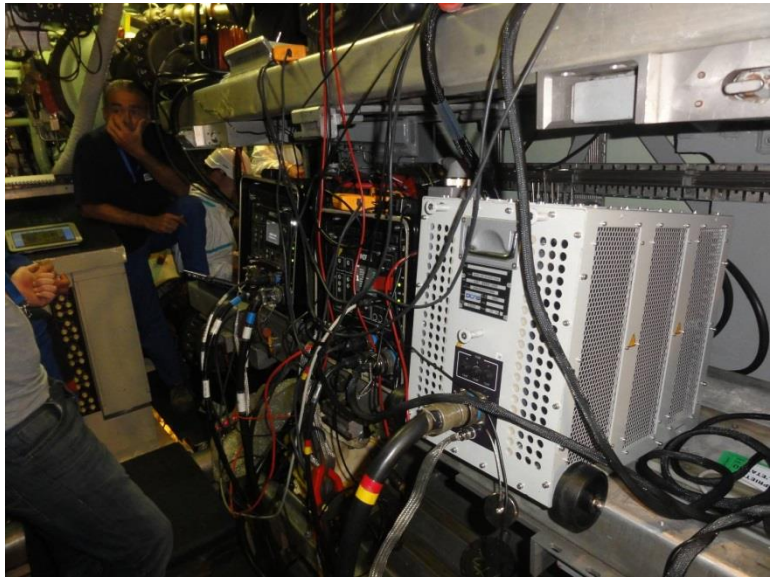
Push-Out from French Navy SSN

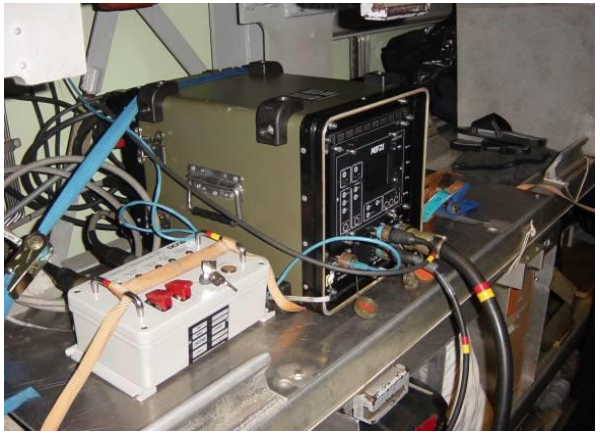
Exercise HWT embarkation

- Mechanical interfaces

HWT live firings

Push-Out from French Navy SSN



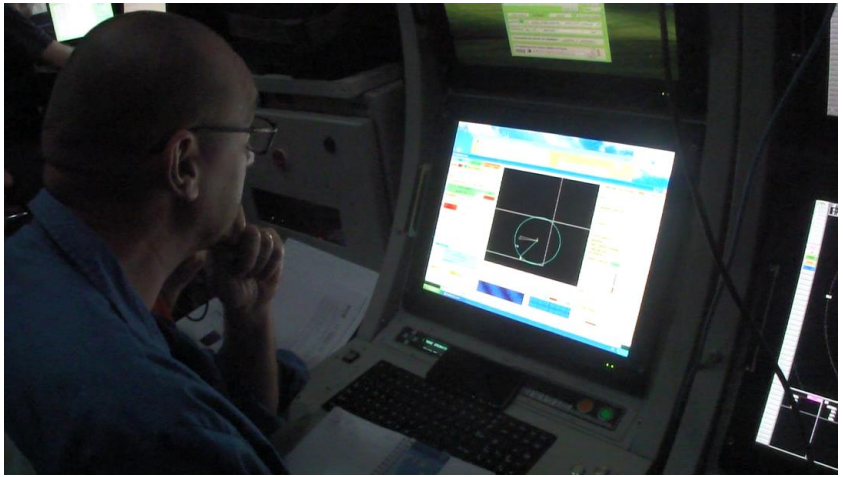


Exercise HWT integration

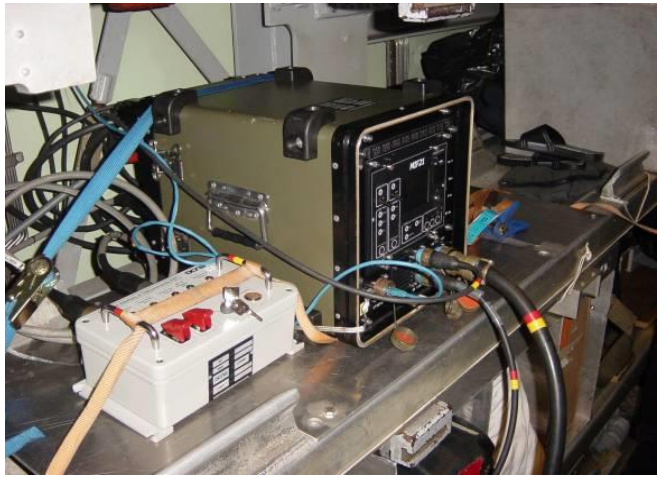
- Electrical interfaces

HWT live firings

Push-Out from French Navy SSN



HWT launching from FCS hosted in MFCC at COC



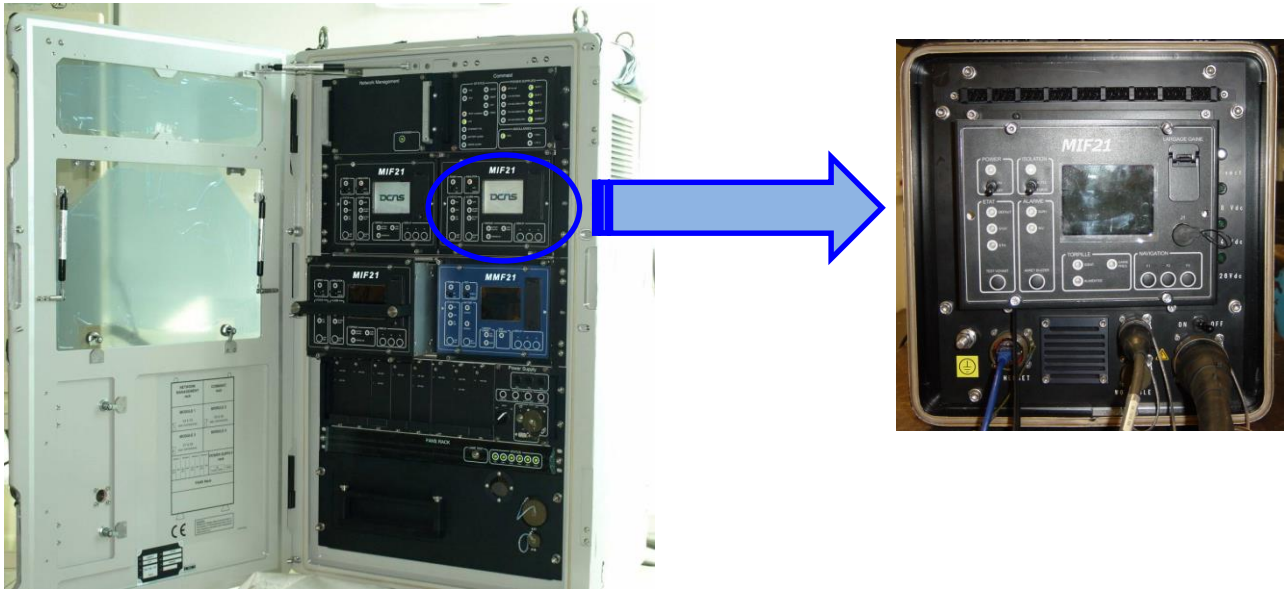
HWT Interface module in Torpedo Room

Equipment synergy for risk mitigation

Stand-Alone Firing Control System (FCS) is a simplified embedded system (1 HWT channel) used for all applications :

- Hybrid Simulation
- Shore Integration platform (SIF)
- Motor Test Bench
- Industrial sea trials
  - ✓ Swim-Out from catamaran
  - ✓ Push-Out from SSN

Synergy vs. risk mitigation



HWT management module (hardware and Software) is identical for submarines embedded cabinets and industrial stand-alone FCS

Results and Discussion

- A significant time/cost reduction has been reached.
- Governmental Procurement Agency (DGA) and French Navy personals are involved in the process.
- French Navy nuclear submarines are deeply involved in operational missions.
- Above described process allows making them available for HWT launching only when all validation pre-requisites are reached.

Lessons learned, Future work

- Test data issued from shore test means give a significant contribution to HWT knowledge library.
- In addition, cross data analysis between shore tests and wet trials allows to trim and tune models developed around HIL Platforms.
- Such new generation HWT design is based on powerful embedded computers; growth potentials are part of end user requirements. Representative Shore Platforms allow anticipating on operational future needs through close cooperation between DGA, French Navy and Naval Group.

Conclusions

The HWT incremental qualification logic, starting in shore conditions, has allowed working with suitable risk mitigation approach.

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Use of powerful shore test means is a mandatory process before starting complex and expensive wet/sea trials.

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Return On Invest (ROI) sounds today as evidence ...

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Thank you for your attention …

Any questions ?

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