# UDT 2019 – Heavyweight Torpedoes program – Management of Validation and Qualification process

**Abstract** — 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.
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.
Each step needs then a dedicated shore test bench. The main sub-systems areas are Embedded Software, Sonar performances and 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. Nuclear submarines dramatically increase this safety constraint and thus the need for strong shore test results before embarkation authorization is obtained.
Within this logic, Hardware In the Loop (HIL) concept remains the most efficient way to perform a successful system integration before wet trials.
Anyway, clear is the fact that sea remains a major test mean for the industry as well as the final step for the Navy before weapon hand-over.
Looking always forward, powerful shore test benches allow industry to anticipate on Navy future needs, based on software upgrades or research findings. Both parties are acting within a win-win working dynamics.

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## 1 Purpose / Objectives

This presentation aims to present the global Integration Validation and Qualification process (IVQ) within a Heavy Weight Torpedo (HWT) program. The process will be presented from the first step (customer system requirements engineering) to the last one (weapon qualification).

## 2 Introduction

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.

## 3 Approach

### 3.1 Weapon System Specification analysis

For a HWT weapon system deployed from a submarine, customer requirements are of course allocated to the HWT itself but also to several on board equipment, such as:

- External and internal HWT handling tools,
- Stowage racks
- Electronic interface cabinets,
- Combat Management System (CMS) consoles.

In the frame of Artémis program, F21 new HWT is to be deployed from:

- Existing submarine platforms (″Rubis″ class SSN and ″Le Triomphant″ class SSBN),
- New incoming submarine platforms (″Barracuda″ class SSN).

It is then vital not to forget or make wrong allocation of input requirements.

Naval Group deployed and used a powerful COTS Requirements Management Tool (RMT). It allows allocating requirements from System level down to HWT sections and sub-systems.

Weapon operational requirements as well as transverse requirements (logistics, safety, security …) are then processed. Because F21 HWT is deployed from nuclear platforms, safety and security issues are of great

importance. CMS software is also in the loop; dedicated HWT software modules receive also requirements allocation through RMT.
Last but not least, RMT manages also the requirements validation logic i.e.:

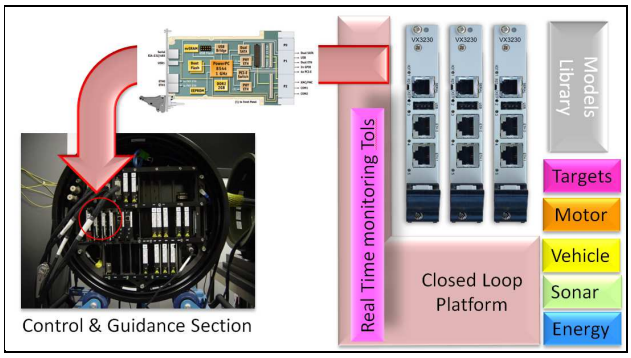
- Where: **F**actory, **S**hore **I**ntegration **F**acility (SIF), **H**arbour, **S**ea,
- How: **I**nspection, **A**nalysis, **D**emonstration, **T**est.

## 3.2 Shore Integration Facilities

The following shore tests facilities have been developed/adapted, qualified and deployed within IVQ process.
Sub-chapters hereafter describe these test means in a rough incremental complexity scale.

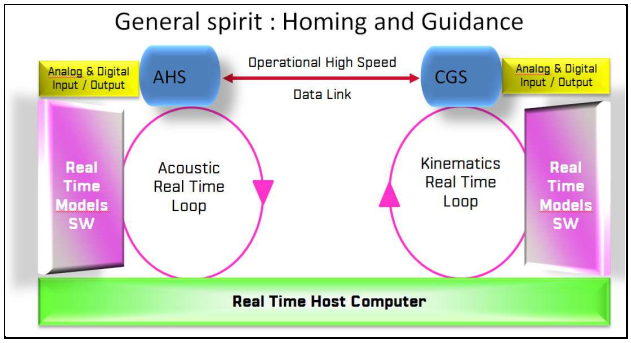
### *3.2.1 Embedded software*

Critical embedded software is mainly located in Acoustic Head Section (AHS) and Control and Guidance Section (CGS). Relevant software modules are developed and tested within a complete fully digital Simulation Bed. Environment and other HWT sub-systems are modelled on the basis of wet trials feedback.



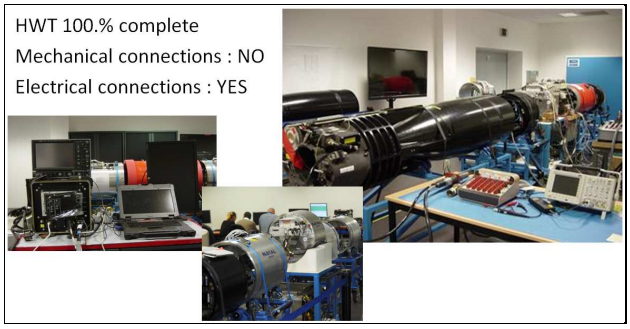

### *3.2.2 Hybrid Simulation (Hardware In the Loop)*

Embedded software is then loaded in embedded computers (AHS and CGS). This builds the Homing System (HS) which is the master piece of the HWT. Hardware In the Loop concept (HIL) has been chosen for testing. Two powerful real time loops are designed: one for sonar stimulation, the other one for navigation and control. Only electrical (analog and digital) connections are performed, power supplies are nominal.




### *3.2.3 HWT Integration Platform (with optional CMS)*

This real time platform integrates all sections including Secondary Battery (SB). Focus is done on HWT behaviour within power supplies up-down limits and generated digital links defaults. Such a platform is later on used for wet trials preparation with either simplified Fire Control System (FCS) or CMS console.




### *3.2.4 Primary Battery Test Bench*

HWT in combat configuration is fitted with a one shot Primary Battery Section (PBS) based on Silver Oxide Aluminium technology which is currently the most powerful source for electrical propulsion (endurance and speed). Before embarkation inside HWT, real discharge profiles at maximum power are performed with complete data instrumentation and monitoring.

### *3.2.5 Motor Test Bench with Secondary Battery*

HWT in training/exercise configuration is fitted with a rechargeable Secondary Battery Section (SBS) based on Lithium Ion technology. This SB is coupled with the Propulsion Motor Section (PMS). Propellers are removed and shafts are connected on dual-brakes equipment. Such a system allows then to perform full power an endurance profiles. Main points of attention are electromagnetic issues and cooling aspects.

### *3.2.6 Sonar static wet test*

After evaluation within HIL, sonar (AHS) needs to be confronted to sea before embarkation inside HWT. This is done in static conditions against actual moving targets (surface or submarine). This dedicated submerged system

is deployed at sea by an industrial surface ship. All data are digitally recorded and also available in real time for display on the vessel.

### 3.3 HWT live firings

The last IVQ step is live firings (exercise HWT) from two available launching platforms:

- Industrial surface ship (catamaran vessel).

- Rubis class SSN made (temporarily) available by French Navy.


## 4 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.

## 5 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.

## 6 Conclusions

The HWT incremental qualification logic, starting in shore conditions, has allowed working with suitable risk mitigation approach. Use of powerful shore test means is a mandatory process before starting complex and expensive wet/sea trials. Return On Invest (ROI) sounds today as evidence.

## 7 Author Biographies

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E. Lescoat graduated as a ″Signal processing″ Engineer in 1982 in Montpellier University (France) with additional ″Digital Embedded systems″ diploma in Marseille University (France) in 1984.

After Military Duty in the Air Force, and one year as Physics Professor in high school, he joined Naval Group as sea trials analysis engineer. Then he designed and developed Hardware In the Loop (HIL) platforms for Light Weight Torpedoes programs. After a period in the field of Navigation Systems, he came back to Heavy Weight Torpedoes world. His main activity is now Integration and Qualification for F21 HWT based on Shore Test Benches and Sea Trials.