MODULAR AND RECONFIGURABLE SIMULATORS FOR COMPLEX SYSTEM DESIGN, VALIDATION AND PILOT TRAINING: NH90 MISSION SYSTEM DEVELOPMENT SIMULATOR, AN OPERATIVE EXAMPLE

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Abstract

A cost-effective methodology and suitable R&D tools are required to face the challenge of the complete mission system definition. This paper outlines the mission requirements capture methodology and rapid prototyping tools developed in Agusta to deal with the issues of designing the NH90 mission suite.

1. Introduction And Definition

The crew work-load in the NH90-NFH European Helicopter is the result of three components:

- Piloting;
- Aircraft and basic avionics managements;
- Tactical management of the mission.

Due to the specificity of these three components and to the task assignement to the three (four) crew members, although concurring to the total crew work-load, the three components are complementary, but independent and de-correlated; each of these components can be optimized and its contribution assessed separately using a specific simulation section that will be representative of the configuration item to be qualified. Therefore the NH90 simulation logic includes three different simulation sections:

- Flight simulation
- Core system simulation
- Mission system simulation

The specific design of each simulation sections is optimized to best perform the simulation and assessment of the specific crew task:

- Task related to piloting and handling qualities will be optimized and assessed on the flight simulator section;
- Task related to the management of the aircraft and to the management of basic systems will be optimized and assessed on the core system simulator section;
- Task related to the tactical management of the mission and to the management of the mission system will be optimized and assessed on the mission simulator section.

This paper specifically focuses on the mission simulator section developed by Agusta to assist the NH90 - NFH mission system design, development and validation.

The NFH mission simulator is an engineering design and development tool, which intended use is to support the definition/validation process of aspects related to the Air Crew interface, to support the definition and validation process of the functionalities implemented in the NFH Tactical Control System TCS), and to support the assessment of the Air Crew work-load for the aspects related to the tactical management of the NFH missions.

2. Tactical Control System (TCS) Overview

The NFH TCS is designed to implement up to four Air Crew stations; three of them are included in the basic configuration; the fourth is a possible additional cabin operator station.

General lay-outs of the TCS Air Crew stations are reported in Figures 1, and 2.

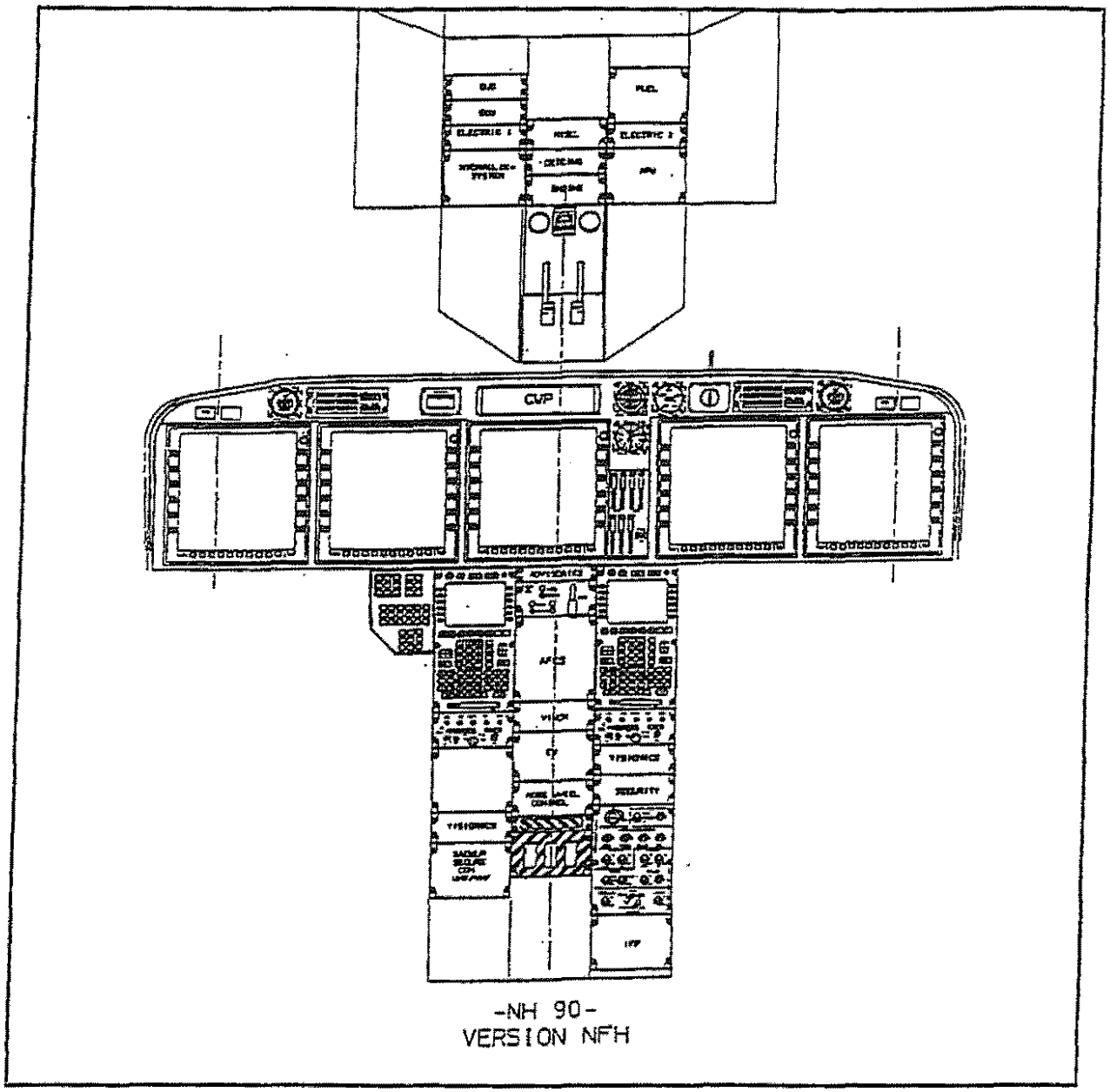

Figure 1: *NH90 pilot/copilot stations proposed lay-out*

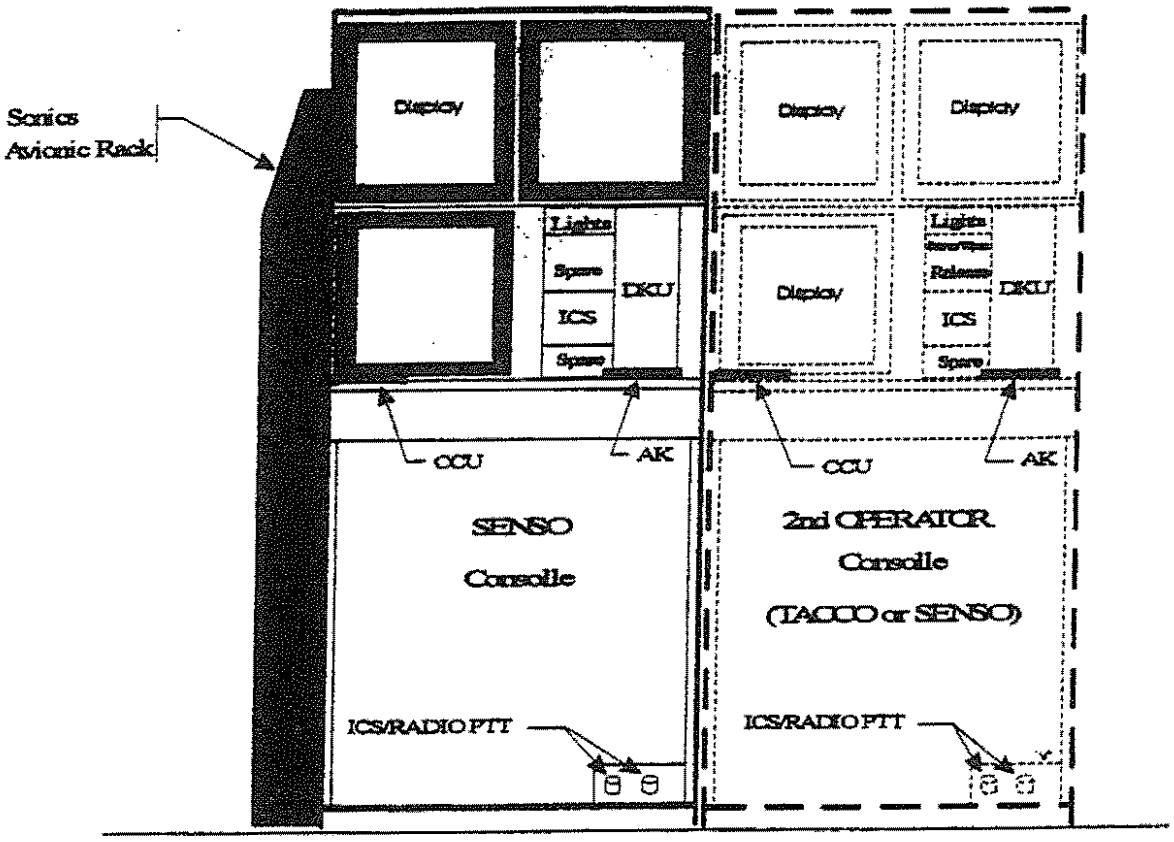

Figure 2: *NH90 mission operator station(s) proposed lay-out*

2.1 TCS General Description

The four Air Crew stations are described below:

Pilot Station: this station is located in the cockpit and it includes mainly the instrument panel, the central console and the overhead console; the TCS can be operated by the pilot, using the following I/O devices:

- three Multi Functional Display (MFDs): one of these MFDs is shared with the Co-Pilot/TACCO station; when this MFD is used for tactical purpose, it is normally used by the Co-Pilot/TACCO as part of its MFD suite;
- one Display and Keyboard Unit (DKU);
- one Auxiliary Keyboard (AK);
- one Cursor Control unit (CCU)
- one set of dedicated Control Panels.

The Co-Pilot/TACCO station: this station is located in the cockpit; the TCS can be operated by the copilot, using the following I/O devices:

- three Multi Functional Displays (MFDs);
- one Display and Keyboard Unit (DKU);
- one Auxiliary Keyboard (AK);
- one Cursor Control Unit (CCU);
- one set of dedicated Control Panels.

The SENSO station: this station is located in the cabin, within the cabin console; the TCS can be operated by the SENSO, using the following I/O devices:

- three Multi Functional Displays (MFDs);
- one Display and Keyboard Unit (DKU);
- one Auxiliary Keyboard (AK);
- one Cursor Control Unit (CCU);
- one set of dedicated Control Panels.

The SENSO/TACCO station: this station is located in the cabin, within the cabin console; the TCS can be operated by the SENSO/TACCO, using the following I/O devices:

Dedicated control panels for the Operator Stations are used to control functions directly related to the mission management (e.g. weapon/stores hardwired safeties, sonar dome control, etc.); the status of the selections entered by the crew on these panels is continously monitored by the TCS.

2.2 TCS Architecture

The TCS is based on a dual architecture including the following main components:

Mission Tactical Computers (MTCs) with the following main functions:

- Mission Data Bus Controller (BC) and Back-up Bus Controller (BBC);
- Interface between core and mission systems;
- Host of TCS functions.

Mission Symbol Generator Units (MSGUs) with the following main functions:

- Sensor interface;
- Generate up to six independent video presentations (twelve when both MSGUs are available);
- Cockpit and cabin MFDs interface;
- CCUs interface.

I/O Devices previously listed.

3 Mission Simulator Objectives and Functionalities

The Mission System Developent Simulator (MSDS) is a ground system based on "of the shelf" general purpose computer systems. The system design is performed with an extensive use of commercial development tools.

3.1 Definition and Validation of the Air Crew Interface

The NFH Mission Simulator will be extensively used to support the definition and validation process of aspects related to the Air Crew interface front-end such as:

- Fast virtual prototyping of MFDs, CDUs and dedicated control panels;
- Optimization of the MFD useful screen area, with respect to both tactical situation presentation and sensors information presentation;
- Definition and optimization of presentation techniques (Interactive Dialogue Windows (IDW));
- Definition and optimization of tactical symbology, alphanumeric characters and other graphic characteristics of colour MFD presentations;
- Definition and validation of MFD formats and formats tree with respect to both tactical and sensor information presentations;
- Definition and validation of selective information decluttering technics (Tactical Display Information Set Filters);
- Definition and validation of CDU pages layout and page tree.

3.2 Definition and Validation of TCS Functionalities

The NFH mission simulator will be extensively used to support the definition and validation processes of the functionalities implemented in the NFH TCS; this will be achieved through two parallel but closely interacting activities carried out within the NFH mission simulator environment:

- Developing an "off-line", non-real-time finite-state model of the TCS, thereby:
    - Tracing the TCS requirements;
    - Detailing the TCS functionalities, identifying the logical states, the transitions between the logical states, the processes which are active in each logical state, the data flows between the processes and the algorythms within each process;
    - Detailing the design of TCS HW and SW configuration items;
- Developing and running a finite-state model of the TCS to validate it from the functional and logical point of view;
- Developing an "on-line", real-time simulation of the TCS to be used during the assessment of the Air Crew work-load.

3.3 Assessment of the Air Crew Work-Load Related to the Management of the NFH Missions

The NFH mission simulator will be extensively used to support the assessment of the Air Crew work-load for the aspects related to the tactical management of the NFH mission; for this purpose, it will be used for:

- Modeling the reference NFH mission scenarios;
- Modeling the relevant functionalities and behaviour of the NFH mission system sensors;
- Modeling the TCS functionalities;
- Modeling the relevant functionalities and behaviour of the core system;
- Modeling the relevant behaviour of the air-vehicle;
- Running a real-time simulation based on the above models as part of the assessment of the Air Crew work-load related to the management of the NFH Missions.

4. Mission Simulator Architecture

The design of the NFH mission simulator is based on proven concepts and design philosophy derived from previous Agusta simulation experiences, with the improvements deriving from the extensive use of today's state of the art HW and SW technologies.

4.1 Functional Architecture

The functional architecture of the NFH mission simulator is shown in Figure 3.

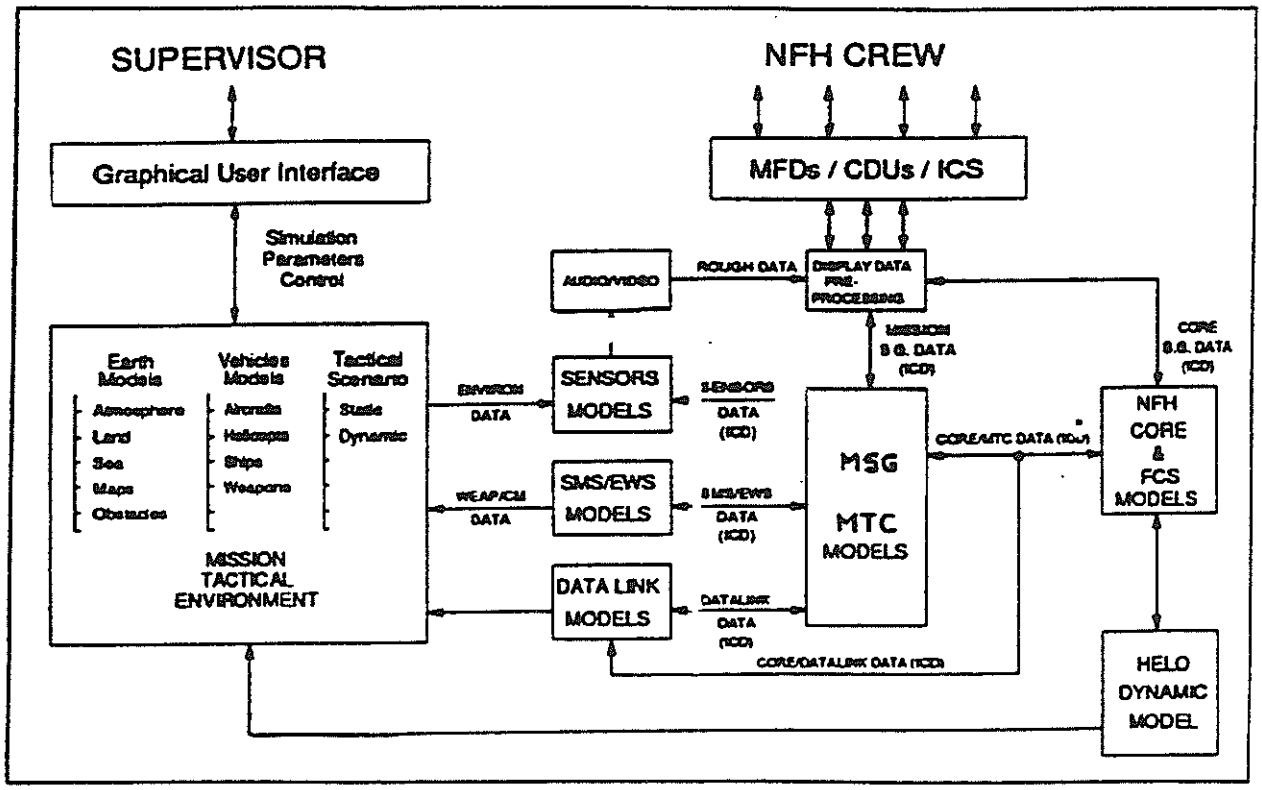

Figure 3: *NH90 mission simulator functional architecture*

The functional architecture fully applies to the development phases of the NFH mission simulator. In particular, the main functional blocks which compose the NFH mission simulator are described.

- Supervisor This block includes the following functionalities:
  - "off-line" to generate and modify the tactical scenario including the geographic area, the environmental conditions, the characteristics of actors and ownhelo (dynamics, sensors, weapons, tactical performances);
  - "on-line" to control the relevant parameters of the tactical scenario (environmental conditions, availability of sensors and weapons of actors and ownhelo);
- NFH Crew Interface implemented by:
  - virtual I/O devices
  - models of the actual TCS I/O devices
- TCS Model including:
  - components
  - functionalities
- Air Vehicle and Core System Models This models simulate only those aspects relevant for the tactical management of the simulated missions, including simplified models of:
  - Air Vehicle plants
  - Core components
  - Core functionalities
- Air Vehicle dynamic performances and FCS Models This models simulate only those aspects relevant for the tactical management of the simulated missions.

4.2 Configuration

The hardware architecture of the NFH mission simulator is shown in Figure 4.

The task allocated to the NFH mission simulator are highly demanding in terms of both HW and SW capabilities; therefore its components have been chosen selecting the best ones among the state-of-the-art HW platform and commercial SW packages.

In the first stages of the simulation activity, the configuration is "virtual"; each one of the three (four) operator stations will be simulated using up to four workstations where the TCS I/O devices are represented using fast virtual prototiping techniques.

In the final stage of the development, the configuration is modified, replacing the standard workstation monitors with the "S" models of the TCS I/O devices. They are installed in the mock-up of the NFH cockpit and cabin. This "realistic" configuration is used to perform assessment of the crew woark-load induced by the tasks related to the tactical management of the mission.

5. NFH Mission Simulator Development Process

The NFH mission simulator development process will follow a staggered waterfall approach; two major development phases are identified:

- Part Task Simulations;
- Full Task Simulations;

5.1 Part Task Simulations

Part task simulations essentially consist of the activities leading to the stand-alone parallel development of the Air Crew front-end and of the various models required to run the real-time overall simulation of the NFH mission system. Simulation activity will be considered mature to launch the subsequent phase of full task simulation, when a complete single operator (Air Crew member) station can be simulated in real-time with the proper interactions between mission scenario, sensors, TCS models and Air Crew interface front-end.

Part task simulation activity will continue in parallel with full task simulations as required to modify existing models or develop new ones in a stand-alone environment, therefore without interfering with the main flow of the full task simulation activities.

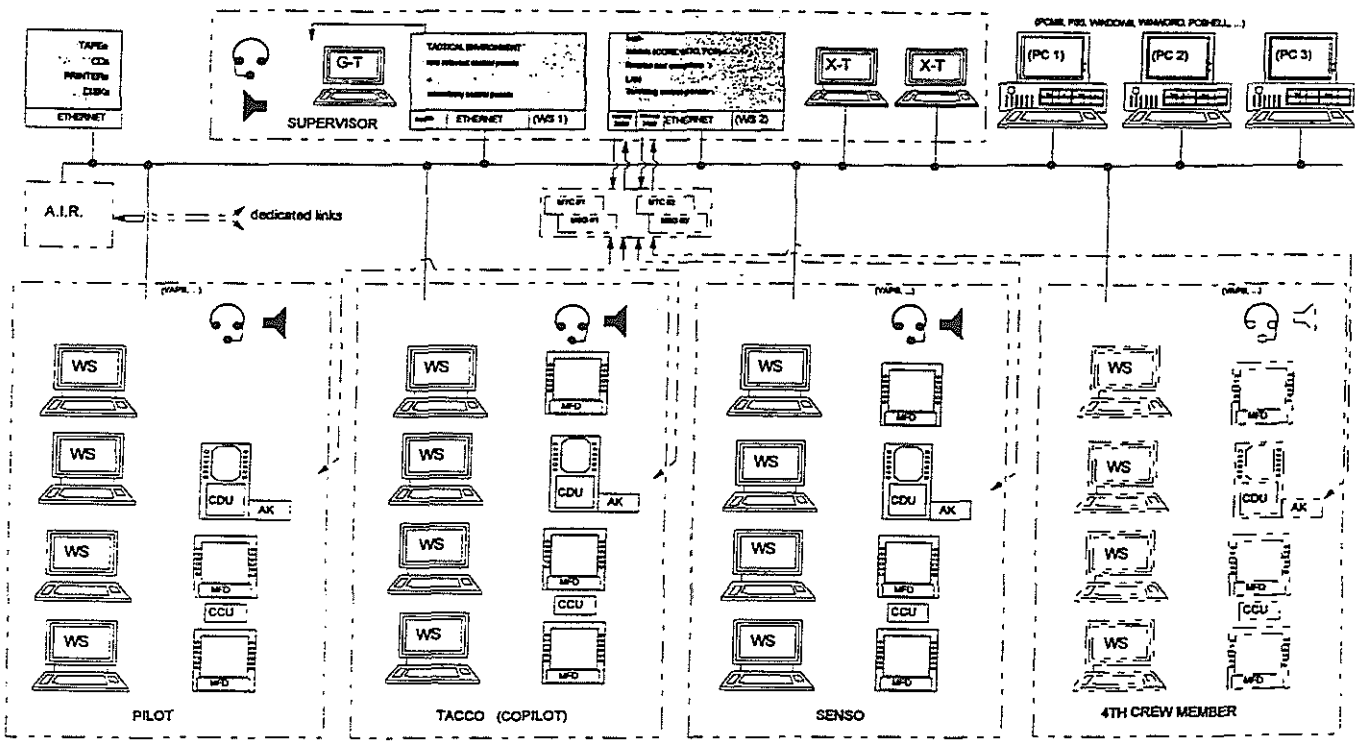

Figure 4: *NH90 mission simulator hardware architecture*

5.2 Full Task sSmulations

Full task simulations activity is the final goal of the NFH mission simulator, since it will allow the simultaneous real-time simulation of three (four) Air Crew stations with the proper interactions between mission scenario, sensors and TCS model and the Air Crew interface front-end, thus allowing the assessment of the Air Crew work-load.

Full task simulation activities will also proceed in a staggered waterfall approach to follow the parallel definition and development of the NFH mission system lay-ups:

- Lay-up 1: This lay-up will include the simulation of the interfaces between core and mission system plus tactical communications and tactical navigation functionalities;
- Lay-up 2: This lay-up will include the simulation of functionalities related to surface surveillance, therefore including the simulations of management and behaviour of the necessary mission sensors such as radar, IFF interrogator, ESM and FLIR;
- Lay-up 3: This lay-up will include the simulation of functionalities related to sub-surveillance, therefore including the simulations of management and behaviour of the necessary mission sensors such as sonics (sonar plus sonobuoys) and MAD;
- Lay-up 4: This lay-up will include the simulation of functionalities related to armaments/stores integration, therefore including the simulations of management and behaviour of torpedoes, missiles and other stores.

5.3 NFH Mission Simulator Activity Outputs

The activities carried out on the NFH mission simulator are closely linked to the preparation of the NFH mission system design specifications.

These are the inputs source for modelling activities but, at the same time they are subject to be updated following the validation activities on the NFH mission simulator.

This definition → validation → update loop process is of particular relevance for the TCS design document, which in turn, is the key document for TCS development, since it will detail the TCS functionalities down to the allocation to TCS HW components (MTCs, MSGUs and CDUs) and the corresponding SW configuration items.

Therefore, this process represents the most relevant ouput from the activities carried out on the NFH mission simulator.

6. Conclusions

The process described in Chapter 5. entails Customer involvement during both part task and full task simulation activities. It will be based essentially on:

- Meetings, in which the intermediate or partial results of a specific simulation activity will be presented and discussed with the Customer before proceeding with is further development and integration in the real-time simulation process;

- Design Reviews, in which the complete real-time simulation of one of the NFH mission system lay-ups will be presented, assessed and validated by the Customer.

This process, supported by the design simulator and carried out with the Customer involvment starting from the pre-prototyping phase, ensures full flexibility and represents a big improvement in terms of prototyping process efficency and cost-effectiveness for complex systems.

At the end, the simulator produced to assist the prototyping and the design phases, could be easily re-converted and re-used for training purposes.