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**EH101 MISSION AND COMMAND CONTROL OPERATIONAL
SOFTWARE DEVELOPMENT PROJECT**

BY

**A. FALTONI, C. PAPI
DATAMAT , ITALY**

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A. Faltoni, C. Papi

Datamat, Rome, Italy

1. EH101 MISSION

The EH101 Helo was designed to carry out the following two primary missions:

- anti submarine warfare (ASW)
- anti surface ship warfare (ASUW) including "over the horizon targeting (OTHT);

The main tasks related to ASW are:

- search, long distance detection, position and course/speed determination of any subsurface object, through an array of active and passive sensors;
- classification and identification of the detected objects via analysis of their acoustic characteristics and the assessment of their position and behavior;
- generation and assessment of the underwater tactical situation;
- attack and destruction of the objects identified as hostile targets, in full autonomy or in cooperation with friendly forces;
- assessment of own and cooperating units attacks.

The main tasks related to the ASUW are:

- search, long distance detection, position and course/speed determination of any surface objects through active (radar) and passive (ESM) sensors;
- identification of the detected tracks by various means like IFF (Identification Friend and Foe - Interrogator) visual, target position and behavior, data link;
- generation and assessment of the surface tactical situation;
- attack and destruction of the hostile surface targets, in full autonomy or in cooperation with friendly forces;
- assessment of own and cooperating units attacks.

All the above mission tasks are to be carried out:

- in full autonomy
- in all weather and sea conditions, both by day and by night;
- in full cooperation and coordination with other friendly surface and/or air units, via voice communication and first of all through real time data exchange (Data Link 11);
- fully integrated in a naval attack or supporting task force.

2. EH101 Mission Fit

To carry out the above missions and tasks, the on board mission sensors, subsystems and weapons, which had been envisaged by the Italian Navy as fully integrated in the EH101 P6 prototype, were:

- the sonics subsystem composed of:
 - High performance dunking sonar,
 - Magnetic Anomaly Detector (MAD);
 - Active and Passive Sonobuoy Subsystem.

The sonics subsystem in its entity is capable of long distance detection, automatic tracking as well as, classification and identification of underwater hostile targets
- the radar, which has the capability to search, locate and automatic tracking of surface and low flying targets and to provide the means to conduct the EH101 missile attack or to assist other units in their attack, including against over the horizon targets;

- the ESM which has the capability to detect and identify airborne and ship borne very short radar emissions, with threat warning when the case;
- IFF interrogator; a question and answer equipment which provides the means to identify friendly units;
- IFF transponder; an equipment which provides the means to be identified by friendly forces;
- Link 11, it is a data Link which allows the exchange of data and information in real time among all friendly units in the net. With Link 11, the EH101 can become a fully integrated component of a task force, able to receive, store, process and display all tracks seen by the other units in the net. The Link 11 permits also automatic correlation between own (local) and remote (received) tracks. In this way, the EH101 CC can generate, maintain and assess a complex and integrated tactical situation. It's almost like having on board the sensors of the naval task force.
- armament subsystem composed of:
 - the store management system (SMS);
 - the torpedo launch and control system;
 - the missile launch and control system

Some changes are expected for the production version of the EH101.

As you can notice, the sensors and weapons fit on board of the EH101, is of a complexity and size comparable to the one of a Frigate class ship. We call it, in fact, the Maestrone class helo, being the Maestrone the most modern Frigate class of the Italian Navy.

Besides that, it is to be mentioned that the EH101 sensors and weapons systems are fully integrated in the mission command and control system: there are no specific sensor and weapon control panels and everyone of them is fully controlled and monitored from the two operator control stations.

In fig. 1, you can notice that, the entire mission system is fully integrated in the CC through a redundant 1553 data bus.

And you can also notice that the mission system is managed by only 3 operators; 1 TACCO or Tactical Evaluator and 2 sensors management and tactical situation generation operators, one for the surface/air component and the other for the subsurface component.

The main tasks of the 3 operators are:

- Tactical Evaluator
 - Assistance in the identification and classification of all targets;
 - Tactical surface, subsurface and air situation assessment;
 - Tactical navigation;
 - Tactical maneuvers (search plans and patterns);
 - Attack maneuvers and weapons delivery;
 - Attack assessment;
 - Internal and external voice communication.

- Surface/air tactical situation and sensor controller
 - Control and monitor of RADAR, IFF, ESM, Link 11;
 - Surface/air tracks identification and correlation;
 - Integrated surface/air tactical picture and situation generation, updating and monitoring;
 - Internal and external voice communication.

- Subsurface tactical situation and sensor controller
 - Control and monitor of SONAR, MAD, Sonobuoys;
 - Subsurface tracks classification and identification
 - Integrated subsurface tactical picture and situation generation, updating and monitor
 - Internal and external voice communication

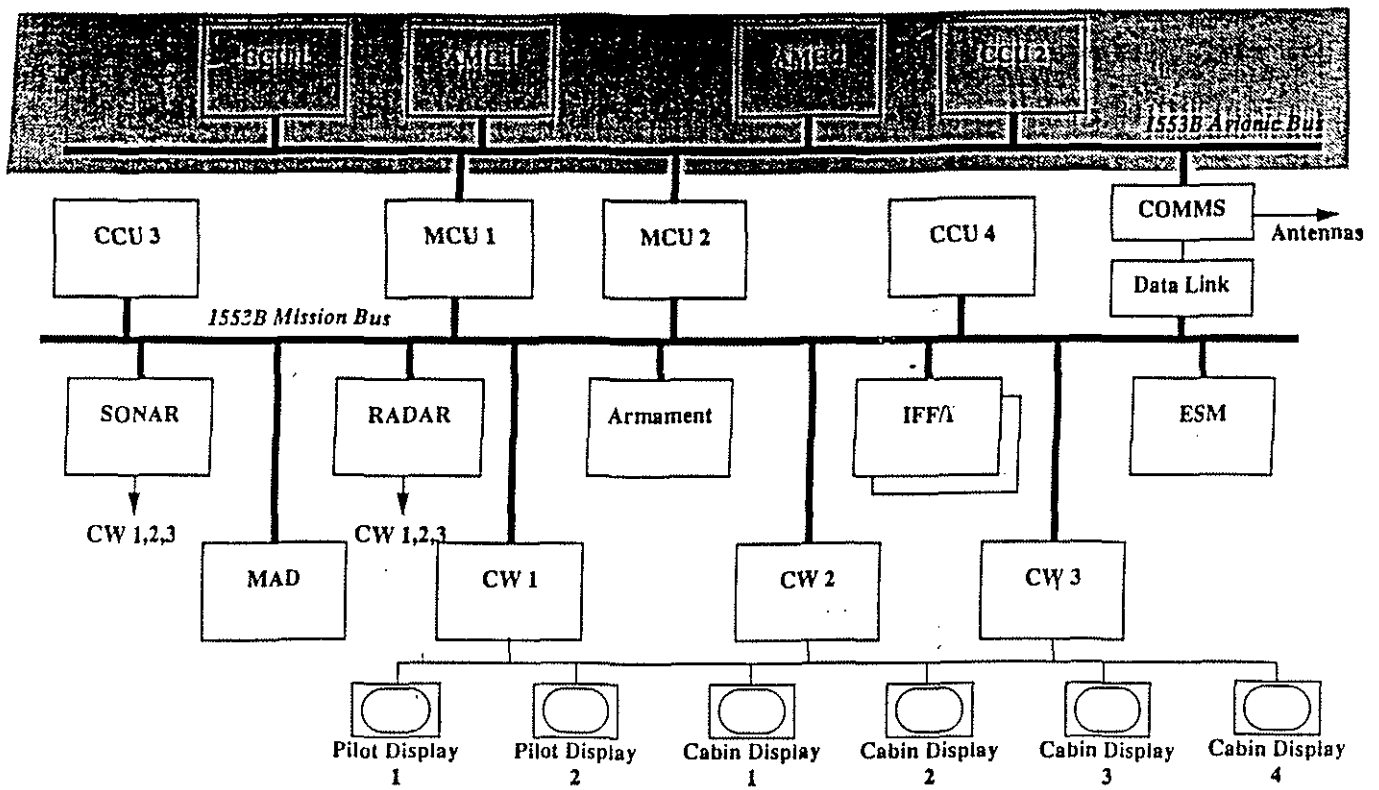


Fig. 1 - Mission System Structure

As you can notice, the functions to be carried out by each operator are many and very complex. You must think that the Maestrale class CIC (Command Information Center), in order to perform comparable functions, is manned by 10 (ten) operators, and this without taking in consideration that some sensors (sonar, ESM) and weapons (A/A missile and torpedo systems) have their own specific control stations and operators not included in that number.

Besides that, each operator has to be able to perform all functions in order to be able to assist and give help to the other operators, when particularly overloaded.

So from the beginning of the definition phase of the Mission CC System, it was clear that the main problem would be the operators workload: so a major effort had to be put into the automation, to the limits of technologies, of the operational functions, and of the sensors and weapons control and monitoring.

To allow a fully exploitation of the EH101 operational capabilities, the following operational functions had to be automated to the limits of the available technology:

- control and monitoring of sensor and weapons systems
- surface, air and subsurface tactical situation generation and management, through correlation and fusion of all data and information originated from own sensors and from the other platforms in the Link 11 net;

- tactical evaluation and decision taking through graphical, tactical and decision support aids;
- employment of the helo and its weapons through the automatic computation of tactical maneuvers (like sonar search plans), attack maneuvers and subsequent automatic steering of the helo on the computed maneuver;
- tactical navigation.

Another aspect that had to be of special study to decrease the operators workload was the man machine interface (MMI), which had to be implemented in a very friendly and guided way.

At the end, the EH101 main CC characteristics, to fully permit the carrying out of the mission, had to be:

- full integration of all sensors and weapons;
- maximum automation of all operational procedures, functions and sensor/weapon control;
- optimization and communality throughout the system of the man machine interface;
- maximum flexibility in the functions assignment to the operators;
- redundancy with hot back up of mission computer and data bus;
- integration of the mission system with the aircraft avionic system for tactical navigation and control of the aircraft;
- automatic exchange of data with other units

But on implementing such complex and advanced system software, even with a formalized top down methodology according to MIL STD 2167A, the following main problems came into focus:

- at the start of the project, the operational and functional requirements had been defined only in general terms and so during Project Definition Phase these would have to be precisely defined in a very close cooperation and interaction with the USER;
- the mission system fit and especially some sensors were not already chosen or even defined;
- the MMI in a so complex system manned by only 3 operators had to be very much friendly and intuitive and such result was achievable only through practical trials with the users.

The above problems were to be overcome only with the adoption of a "top down evolutionary approach", which in turn required the implementation of an "engineering simulator" or "Mission System Development Rig (MSDR)".

3. MSDR Aims and Characteristics

The MSDR has been designed and implemented in order to fulfill the following aims:

- test, evaluate, optimize and validate the Man-Machine Interface;
- test, evaluate, refine and validate the operational functions in advance of their implementation on the actual system;
- test and evaluate the assignment of functions to the different operators according to the various operational situations;
- define the software requirements and, as a consequence, optimize the architecture and the technical/performance requirements of the final hardware.

Using specifically developed mock-ups, commercial computers and software packages (among them a Relational Data Base), the MSDR provides the following functions:

- replica of the physical and logical Man-Machine interface of the mission system;
- simulation of the functions of the mission system;
- simulation of the behavior of the mission sensors;
- simulation of a complex air/surface/subsurface scenario;
- simulation of the operational environment (e.g. meteo, wind);
- simulation of failures and alarms.

The use of a Relational Data Base allows a fast modification of various aspects of the simulation, thus speeding-up the evaluation of different alternatives.

The MSDR functions, that have been developed from the specifications of the real mission system, have been validated through a series of Evaluation Sessions performed by the Italian Navy crews.

The Evaluation Sessions were ranging from initial evaluations of single function/single operator's task to arrive, during the "Full Crew Operation" phase, to the evaluation, from the operative point of view, of the whole system, identifying the optimizations needed in order to reduce the crew workload.

The use of the MSDR has allowed not only the optimization of the operator procedures through a continuous process of refinement but has also allowed the final customer (the Italian Navy) to acquire confidence on the compliance of the resulting system with its operational requirements.

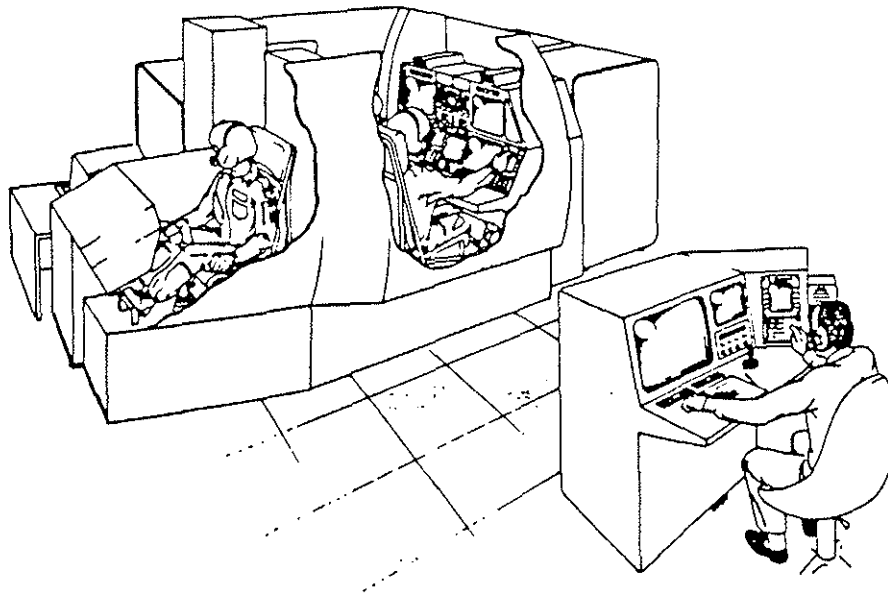


Fig. 2 - MSDR Pictorial View

As a final remark it must be emphasized that the MSDR at the end of its use can be easily transformed in a trainer, thus increasing the benefit of such investment.

4. Mission System Development

The Mission CC System has been developed using the "waterfall" methodology supported by advanced software tools (see fig. 3).

The advantages of this model are originated by the formalization of the activities to be done during the development and the definition of their input and output. In this way, the development status can be verified in any moment: infact, the intermediate products are well defined and their reviews are scheduled during the development.

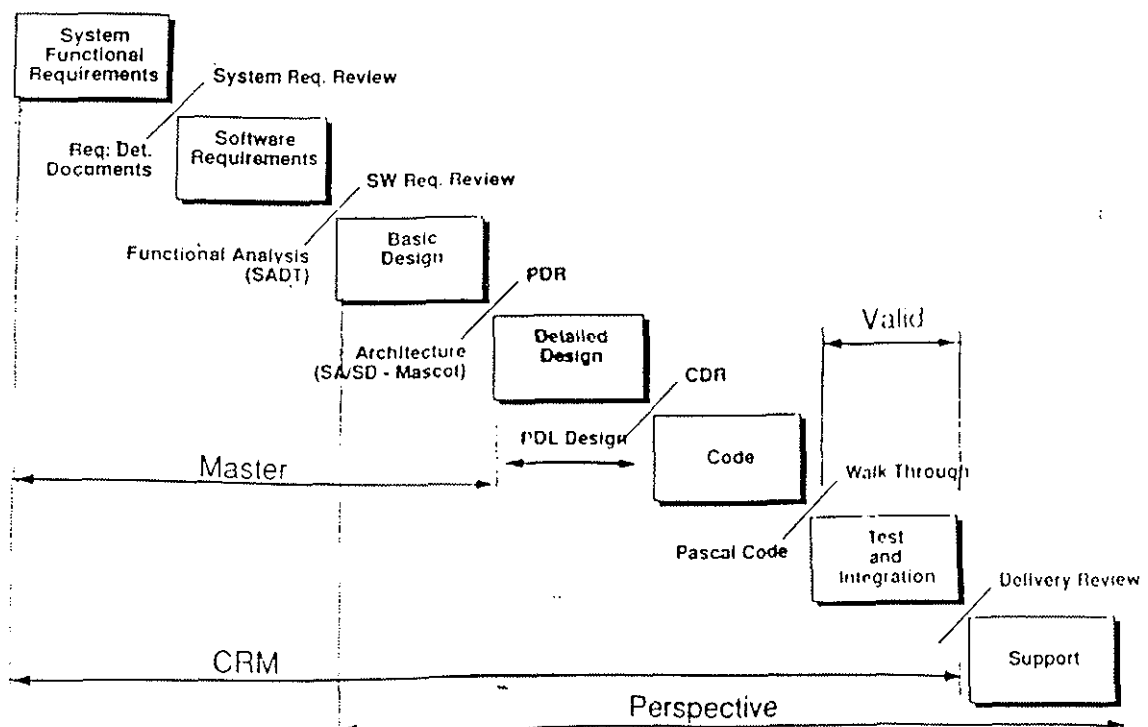


Fig. 3 - Waterfall Model and Relevant Tools

In conclusion, the use of methodologies and tools have allowed to formalize the phase and the relevant products and, in this way, has guaranteed, through a continuous verification process, the quality of the product and its manageability.

5. Mission System Integration

The integration of Mission CC System into the Equipment System has been executed in the following phases:

- Integration of the Mission CC System with the Equipment Simulators
As soon as new mission function was agreed on the MS DR and implemented in the real system, it was tested using the Equipment Simulators, software programs that simulate, from the 1553B bus point of view, the mission equipments. In this way, it was possible to test the Mission CC System from the first development phase, also in absence of the mission equipments.
- Integration of the Mission CC System with the Equipment Emulators
In a following phase, the Mission CC System has been integrated with the sensor prototypes or rig models, provided by the suppliers of the real sensors. By means of this activity, it was possible to find out and solve almost all the protocol integration problems in a very early stage.
- Integration of the Mission CC System with the real Mission Equipment.
In the final phase, the Mission CC System has been integrated with the real mission equipments with particular attention to the performances of the overall system.

The complexity of the Mission System structure and the number of commands and data exchanged on the 1553B Bus have originated the need for an high level tool to support both the integration test and the validation of the whole Mission System.

Because none of the tools available on the market had the sufficient performances and the necessary features for the management of the critical aspects of the integration of so complex system, a specific tool has been produced making use of specialized 1553B interfaces and dedicated software packages, developed on commercial computers.

The main characteristics of the EH101 Mission Integration System are:

- user friendly Man Machine Interface;
- monitoring on-line of the data exchanged on the 1553B Bus and recording capability;
- off-line analysis tools;
- presentation (in the on-line monitoring and off-line analysis) of the 1553B exchanged data in either engineering or raw format;

- simulation of the 1553B protocols.

In addition, for the acceptance test of the Mission System and for the test of the integration of the Mission CC System with the Mission Sensors, a test language has been developed and integrated into the tool in order to allow:

- the execution of integration and validation test in automatic way;
- the generation of formal test reports;
- a clear traceability of the tests versus the requirements.

Using the above facilities, it was possible to cover all the phases of the Integration/Test/Validation process, starting from the identification of the requirements through the definition of the test plan and the cross reference between tests and requirements, till the automatic execution of a single test or of the complete test plan.

With the automation of the complete test plan and the report generation, it is possible to fulfill non-regression tests and a complete configuration control of the performed test activities.

6. Conclusion

The adopted waterfall evolutionary and formalized implementation model supported by software tools and, most of all, by the MSDR and by the Integration Rig has been very successful and has allowed to obtain the following four main aims:

- the high quality of the delivered software system in which very few "bugs" were discovered during the flight tests;
- a total correspondence between the delivered system and the Italian Navy operational requirements;
- a very friendly and intuitive MMI, which has significantly decreased the operators workload;
- the avoidance of any request to make significant changes to the delivered mission software, changes which, as everybody knows, are very much costly.