PULSAR - DECISION SYSTEM FOR INTEGRATED SHIP COORDINATION

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ABSTRACT

Currently operational scenarios in which naval units are requested to operate reinforce the need to investigate new methods of synthesis of information, available from onboard sensors, to support the choices of the command team responsible for managing the ship, both during the mission planning phase (forecast) that in critical operational situations.

In the frame of the research activities financed by the MIUR (Ministry of Education, Universities and Research), an innovative decision system for integrated ship coordination (PULSAR) has been presented by an Italian industry consortium (ORIZZONTE SISTEMI NAVALI, FINCANTIERI, SELEX-SI, SEASTEMA, IBR S.r.l., MAST S.r.l.) and University of Genoa (DYNATECH, DISFOR, DIME, DIBRIS, ISME e DICAT) to DLTM (Distretto Ligure delle Tecnologie Marine) receiving full approval.

In this paper the efficiency of this method to assess the likelihood of success of the proposed actions by the command team will be analyzed, taking into account the uncertainty of the boundary conditions as, likely presence of threats and efficiency of the on-board combat and platform systems.

Keywords: decision support system, interoperability, VV&A

1. INTRODUCTION

The Italian industrial reality, thin to today it has tried to pursue the objective to gather in a single and cooperative working team, the companies historically dedicated to the platform ship definition (FINCANTIERI) with the company representing the supplier of the SubSystems for the Ship Combat System (SELEX SISTEMI INTEGRATI), pursuing the concept of Whole Warship (WW).

The constitution of the ORIZZONTE SISTEMI NAVALI (OSN) company was the first concrete result in this direction.

Exclusively from the point of view of the WW definition, the objective that this project, proposed to the DLTM, intends to pursue is to extend the concept of platform and Combat System integration according to the followings other two points of view:

- of the decisional support: defining and developing a prototype of system (PULSAR) finalized to valorize / integrate the information provided by the ship platform and by the Combat Management System;
- of the operational naval tasks: analyzing a modern operational scenarios where the Ship has to operate: "asymmetric scenario", in which the interaction between platform ship and Combat System is extremely critic;

This integration between Ship platform and Combat Management System is not only exploited in the design project phase, but also during the period in which the Naval Unity has to operate: currently it doesn't exist, among the embarked systems, any Support Tool to the Decisions of the Commander of the ship that implements the concept of the WW.

The PULSAR decision support system should be able to optimize the various activities (patrol of critical areas, individualization of a path to least risk, refueling, etc.) considering different aspects: the probability of presence of threats (asymmetrical threat, mines, etc.), the available resources of command and control (sensory, weapons, organic vehicles) and the resources of the platform (mobility, maneuverability and signatures).

2. MAIN CHARACTERISTICS OF THE PULSAR SUPPORT SYSTEM

Two considerations can be done with reference to the standpoints described in the previous section:

A) From the point of view of the "decision support", in naval sector, the tools/applications currently used by the crew don't implement the concept of the Whole Warship; besides, the Systems of the Combat System (C/S) are mainly directed to the contrast of the threats, for which all the aspects that involve the ship platform, particularly for military operations of different nature (as for instance support in humanitarian disasters), are only marginally considered..

Currently the modern operational scenarios where the Naval Unities have to operate, make always stronger the need to integrate all the information to support command decisions, to increase the ship reactive abilities in all the warfare domains (above surface, air and under water) and to have the supervision of the tactical and strategic mission.

The PULSAR decision support system, developed in the project, is not aimed at substituting human operators in the decision responsibility, but it must offer to the personnel employed to the command all the relevant information and the necessary supports to take the decisions in the shortest possible time (so keeping the "man in the loop").

The poject deals to define and to develop a Test Bed for an application that allows to consider the immediate threat framing it in a context in which are also taken into account: the objectives of the mission assigned in the different domains of activity, the functions and the available resources and the limits of the resources of C/S and ship platform, both because they are already assigned to a specific programmed activity, present or future, both for intrinsic characteristics (i.es signatures, acceleration and manoeuvre capability of the ship).

Besides the difficulty to develop a context in which these considerations are properly organized and connected, PULSAR would like to define a right integrated graphic representation for objectives, threats, critical areas and constrains.

This representation must be in sense compliant with the mental model of the Commander, in order to favor the effectiveness of the understanding and the inclusion of the "man in the loop."

The research proposed in this area can be classified with the term of "Cognitive Engineering".

B) From the point of view of the operational naval tasks, the attention will be given to the asymmetric threat, in which the component of WW (integration between platform and SdC), must be very strong.

The state of the art, related to the ability of integration among the systems performing detection and classification functions is not so strong against this typology of threat; then it could be some critical aspects related to classification and threat evaluation for this type of threat (a suicidal attack with a small boat, or as attacks to unity anchored from divers, etc).

For the analysis of such typology of the scenario suitable methodologies of Operational Research will be used: simulation and multi-objectives optimization. These methodologies are well developed in scientific field, but their applications to the problem characterizing the present context, are still limited in international naval field and completely absent in the national field.

It can be notice that many studies related to the asymmetrical explored single aspects, such as:: detection, classification, identification or engagement. These studies are not generally devoted to the Whole Warship (WW), but to a specific sub-system and to its peculiar performances, as for instance a specific sensor or the particular employed weapon.

Particular emphasis will be given to the identification, in comparison to the innovative technologies that are also finding implementation in other fields (i.es safety and/or defense..

Besides the traditional sensors (RADAR, IR, ..) used in the naval unities, the employments of different systems of surveillance and contrast (not lethal) will be investigated, based on unmanned vehicles, sensor-suite, systems of non-lethal reaction against the threats, systems of detection characterized by interaction of the different sensors (i.e: IR, Radar, television cameras.).

3. INDUSTRIAL PURPOSES OF PULSAR

The industrial purposes of the PULSAR support system can be summarized in two following points:

1. defining and developing a prototype of a Decision Support for the Ship Commander (PULSAR) to valorize / integrate the available information provided by: Combat Systems, Platform (SMS) and external communications;
2. realizing a Test Bed that allows to stimulate Pulsar simulating the available information provided by the Command and Control, platform (SMS) during operational scenarios.

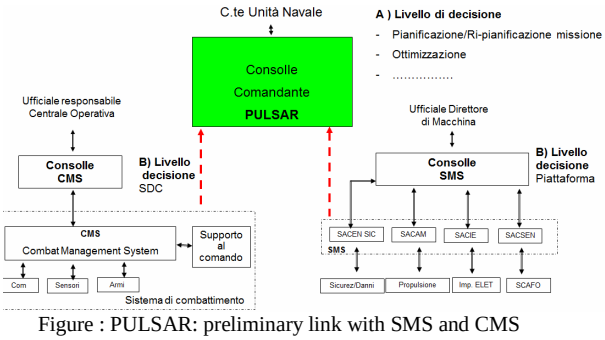

Figure : PULSAR: preliminary link with SMS and CMS

The next section describes the main objectives of the research project detailing the state of the art, on the

principal problem of R&S and finally the innovation that PULSAR would like to achieve.

3.1. Decision Support: State-of-the-art

All the activities of planning and supervision related to a naval mission, in terms of coordination of the different resources on board (i.es organic elements) and with the other naval Unit, are left to the experience and the professional ability of the Commander.

It doesn't exist tools and applications which introduce the Warship to the Commander, in terms of the relationships among "Ship platform", Systems of the Combat System and operational scenarios where the ship must operate which the scope to support him in the decisional choices.

In international field integrated decisional supports have not been developed and this industrial working team, supported by University of Genoa (UNIGE), desire to overcome the problem above described.

3.2. Main critical aspects of R&D

In order to obtain and to pursue the PULSAR definition, it will be necessary:

1. to define a common language among the platform and C/S experts.
2. to face the multi-dimensionality: defining an unique structured environment for the ri-planning of the naval mission in according to evolve of the environment and the operational scenario.
3. to use the Artificial Intelligence (A.I.) to support of the Commander.
4. to introduce the "Support to the Decisions" on board of the naval unit: typically used in the logistic planning and in the production and in the commercial strategies.

3.3. Main critical aspects of R&D

During the phase of the definition of this research project, the industrial working Team established the following possible innovative aspects for PULSAR:

1. to define of new methods of synthesis and presentation of the information to the Commander with the purpose to identify constraints and relationships in order to favor the understanding of the operational problem;
2. to evaluate and to suggest changes to the mission planning, established at the beginning of the naval mission, following the new operational conditions: threat presence probability, dynamic variation of the available resources and/or variation of the ability of mobility and maneuverability of the Whole Warship;
3. to define a naval task ontology (classification) among naval missions, naval tasks, ship capabilities and functions, shared among C/S and platform experts;
4. to introduce in the naval field methods based on the Artificial (IA) Intelligence;
5. to evaluate the possibility to bring in the naval field the concept, as "direct prediction displays" or "ecological interface design" for the representation of the information with the purpose to support the complexity of the cognitive and decisional activity required by the Commander during the operational situations.

3.4. Quantitative results to be achieved

At the end of this research project, described in this paper, a technological demonstrator will allow to verify the characteristics of the defined decision support (PULSAR).

Using the technological demonstrator for PULSAR, it will be possible dynamically to define some test cases with the purpose to verify the logics implemented and therefore to evaluate the support provided to the Commander that such DECISION SUPPORT could be able to assure.

The idea is to evaluate the effectiveness of the new methods considering the new graphic representation of the information.

4. PROJECT WORK PACKAGES

The project is split in eight different work-packages (WPs) and each partners of the project will contribute with own know-how achieving the final scope which can be summarized in the implementation of PULSAR demonstrator.

Following the eight WPs:

1. Design Space definition
2. External Interface definition
3. Decision Logics definition
4. Methodologies for information representation
5. PULSAR: Software architecture and implementation
6. Test Bed requirement's definition
7. Test Bed implementation
8. PULSAR: Integration /Test and Validation

4.1. Design Space Definition

At the beginning of the project, it will be necessary to investigate directly with the Italian Navy the specific operative naval tasks in which it should be necessary to have a "decision support" during the operational contexts.

This activity will allow to define the PULSAR's requirements and it will be performed by Orizzonte Sistemi Navali (OSN) with the Selex Sistemi Integrati (SSI) and FINCANTIERI (FNC) technical support.

The main output of this activity will be the report related to the PULSAR's Requirements.

4.2. External Interface Definition

The macro activity is related to the individualization of all external interfaces toward the Subsystems (S/S) from which the system of the Decision Support (PULSAR) must receive the input data;

The main output of this activity will be the report related to link among PULSAR and other Sub-Systems of the Ship.

4.3. Decision Logics Definition

The purpose of this WP is to define a whole methods able to give a decisional support to the command considering the operational choices in a determined scenarios.

The scenarios, analyzed during the project, could include operational contexts (i.e. the patrolling of critical areas), the optimization problem (i.e finding paths at nimimum risk minimizing the threat risk), etc.

Considering PULSAR requirements and the functional diagram and the external interfaces, defined in the previous WPs, it will be:

- defined the PULSAR functional model to achieve the research purpose;
- investigated some studies on the methods for the Pulsar definition;
- to face the optimization approach;

The main output of this activity will be the report related to the logics which will be implemented in PULSAR to fit the Requirements.

4.4. Methodologies for information representation

The activity will be related to the development of methodologies of data representation, that should result innovative compared to the traditional geographical representation, and that should favor the understanding of the information in order to support the choices of the Ship Commander.

The purpose is to analyze and to define possible methodologies with the scope to represent information in innovative way, which allows the perception of the present situation in the different operational scenarios seen by the level of the Ship Commander.

For the correct formulation of the problem, it will be necessary to conduct an analysis of the problem and/or critical aspects currently existing in the actual representation of the information.

This activity would be ideally developed with a technical support of the operational Italian Navy Officers: traditional Graphical User Interfaces (for instance based only on a geographical representation) generally provide a rather poor and low level of the support to the Ship Commander in comparison to the complexity of the cognitive and decisional activity during the warship naval operations.

The purpose is the definition of interfaces in which the constraints and the complex relationships in the application domain of reference result "perceptively" evident to the Customer; in this way, the consumer (the Decision Maker) must not worry about to expressly appraise all the critical aspects but he can use own abilities for the “cognitive processes” in order to resolve the problem and to take decisions.

The main output of this activity will be the report related to methodologies analyzed to displayed the information.

4.5. Software architecture and implementation

This WP will be related to the hardware and software definition of the PULSAR decision support system.

The architecture will be defined keeping in mind that the assistant value of a decision support system is represented by the its optimization modules that, considering the boundary conditions, non-linearity and stochastic events , must propose a set of answers and solutions to the Decision Maker.

To face this necessity, a part of the activity will be devoted to the study of algorithms of optimization using and eventually integrating Genetic Algorithms, Stochastic Algorithms, Neural Network, Petri Nets, Fuzzy Logic, Swarm Intelligence etc.

Output of this activity will be the report related to innovative methods to represent the information

4.6. Test Bed requirement’s definition

The activity is related to the definition of the Test Bed used during the test and validation phases for the logics implemented in PULSAR. Activity will be related to:

- definition of the Test Bed parametric models, identifying the functionalities and the interface Requirements, based on initial requirements defined in the first WP; consistent parametric models will be established in order to evaluate the approximate calculation of the performances of the sensor systems and the probability that the Naval unity is revealed by other ships;
- definition of the Test Bed architecture to demonstrate the PULSAR capabilities.

Output of this activity will be the report related to the Test Bed’s requirements.

4.7. Test Bed Implementation

The activity is related to the implementation software for the PULSAR decision support system and for the Test Bed on the base of the requirements and specifications in the previous activities.

- For PULSAR, the purpose is that to foresee the possibility of integration of the software modules developed in the various activities with an interface conforming to what established in terms of external interfaces, application logics and methodologies of representation of the information.
- For the Test Bed, the purpose is that to develop the parametric models and the interfaces according to what defined in terms Scenario Simulator, sensor parametric models, signatures and interfaces toward the C4I and the SMS.

Output of this activity will be the report related to the Test Bed's implementation.

4.8. Integration /Test and Validation

The activity will be related to the integration of the models developed in the previous activities (WPs). Attention will be given to the development of innovative methodologies for the Validation, Verification & Accreditation (VV&A). These steps represent a very critical moment in every simulation project and a request a strong interaction with different Subject Matter Experts. The three steps, that it is crucial to underline will be performed during the whole project life time, can be summarized as follow:

- validation allows to appraise if the conceptual model is an accurate representation of the analyzed system;
- verification allows to appraise if the implemented Decision Support System (PULSAR) respects the requirements;
- accreditation (or test) serves for testing the potentialities and the domain of applicability of the simulation model implemented, and to receive final accreditation from potential final users.

To successfully complete the three steps during the whole PULSAR project life time it will be necessary to , to have contacts with operational Italian Navy officers in order to involve them in discussions about on the correctness of the model, to interact with potential decision makers of the PULSAR.

Subsequently, a series of empirical test will be executed with analysis of sensitivity to appraise if the outputs of the model are influenced by the change of variables and input data.

A final test to complete the VV&A activities will be finally performed with a comparison among the simulation outputs and the outputs of real systems.

The output of this activity will be the report with the description about the activity performed in terms of validation and testing.

5. CONCLUSIONS

The described researches represent a very ambitious and extended project that involved several partners with different skills and competencies. The concrete expected final results could lead to a very innovative approach to the Decision Process in naval operations and to the development of a new set of tools to support Commander analysis and decisions. The presence of a real multi-disciplinary project team and the continuous interaction and confrontation with Italian Navy will surely grant the success of PULSAR.

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