MARITIME SECURITY: EMERGING TECHNOLOGIES FOR ASYMMETRIC THREATS

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ABSTRACT

This paper analyses the evolution of a complex scenario for security: maritime environment and in particular coastal areas and harbors the critical nodes in the whole system. In new technologies provide an effective support in this asymmetric framework for situation awareness and threat assessment. M&S, CGF, Data Fusion are techniques that allow the users to obtain efficient awareness on the general on-going situation in real time and to support decision over complex scenarios.

Keywords: *Maritime and Harbor Security, Human Behavior Modeling, Computer Generated Forces, Data Fusion*

INTRODUCTION

This paper provide an overview on a combined approach using M&S (Modeling & Simulation) and Data Fusion techniques to analyze complex scenarios involving asymmetric marine environments; the idea to use intelligent agents (IAs) as driver for Computer Generated Forces is a very critical aspect for modeling scenarios where many entities interact (i.e. commercial and nautical traffic around a port); in order to succeed in this sector it is critical to identify the requirements for such combined solution; the authors focus this paper on the following aspects

- To provide a quick Overview on the Modern Complex Scenarios and to identify the related Challenges
- To present the Potential of R&D within this Framework
- To Outline innovative enabling Technologies, Methodologies and Solutions for succeeding
- To present actions, investments on the R&D Tracks to support these activities
- To outline R&D potential Outcomes
- To present Examples and Approaches in this context

SECURITY IN MARITIME: AN EVOLVING SCENARIO

Today Maritime Security is a very critical aspect on Marine Framework introducing the concept of Asymmetric Marine Environment with new special attention to Threats such as:

– **Piracy**
– **Conventional Terrorism**
– **CBRN (Chemical, Biological, Radiological and Nuclear) Threats**

Some important aspects are expected to increase over Next Years their impact in General as well in Marine Framework increasing on Asymmetric Threats such as:

- Movement of European Region Social Economic Center of Gravity to South increasing maritime traffic with North Africa
- Stabilization and Normalization Processes and Country Reconstruction Initiatives Overseas
- Overseas Developing Areas Growth, Production/Demand & Sustainability Issues Technologies
- Easier access to New Dimensions for preparing and creating critical threats (i.e. Cyberspace)
- Multiple opportunities to Access to Resources to develop WMD (i.e. smallpox, RDD)
- IT & Web empowering the potential of individuals and small groups (i.e. C2 capabilities)
- Increasing new reachable targets such as Oil Platform, Environmental Threats, Social Service Political Issues
- Political Instability on Critical Regions (i.e. Africa)
- Evolution of Principle of Nations and Populations (i.e. Commercial States)
- Evolution of new critical issues requiring rational on joint Defense and Homeland Security Budgets (i.e. natural resource issues: water)

The Real World: Multi Dimension and Multi Layer Resolution

Asymmetric warfare is a very complex framework and modeling and simulation need to properly address all the related issues; in fact this context is:

- A Real World on ***5 Dimensions***:
  - Surface
  - Underwater
  - Air
  - Space
  - Cyber
- A ***Multi Layers & Resolutions*** *Frame*
  - Fleets and Parties
  - Ships and Commercial Traffic
  - Crew & People Acceding Ports/Vessels
  - Services & Infrastructures

As explanatory Example from the new challenges in this context it could be useful to consider the evolution over the years; in fact today Modeling is critical to evaluate Strategies in Threat Identification, Decision Making & Evolution Prediction based on their behavior much more respect on their features:

- Once upon Time people were used to identify threats based on Platform Detection, Identification and Classification
- In Some case the same Platform is in use on multiple sides by different actors, someone friendly and someone "extremely foe".
- In some case the Platform is becoming a Menace just based on own it is operating

It is sufficient to consider the case of piracy to realize that the problem is not to detect the kind, class or even name of a ship based on their silhouette or using EMS, but to identify suspect behaviors that suggest presence of pirates inside a fisherman boat.

Port Protection and Asymmetric Naval Warfare

For facing threats in asymmetric naval warfare it is necessary to develop new Models and Solutions able to Interoperate with the critical components of such Scenarios such as:

- Non Conventional Operations
- Human Behaviors on (i.e. Crew, Stakeholders, Domestic Opinion)
- Services & Infrastructures
- Commercial Traffic & Yachting
- Port Infrastructures and Resources
- Joint Operations (i.e. Ship Inspections, Littoral Control, C5I2)

NEW ENABLING TECHNOLOGIES

The existing and new technologies have a great potential in this area; for instance communication infrastructures and mobile solutions allows today to distribute information as well as data collection, data processing and decision making over a large complex network; in addition to physical technologies and infrastructures it is even more important the benefits provided by innovative soft computing techniques and methodologies.

Impact of Innovative Technologies such as IA, CGF and HBM in Marine Frameworks

In fact, innovative ***IA*** (*Intelligent Agents*), ***CGF*** (*Computer Generated Forces*) & ***HBM*** (*Human Behavior Modeling*) represent a Strategic Issues in different application areas to be applied to asymmetric marine warfare; in particular it is possible to consider the following application area and related benefits provided by these innovative solutions:

- **Simulation Based Acquisition and Test & Analsysis**
  - Capability to Proceed in Data Farming on Different Hypotheses on Vessel and System Design on Virtual Prototypes
- **Training and Exercise**
  - Reduction of human personnel for Training & Exercising
  - New Scenarios involving Dynamic Simulated Complex System vs. the old pre-defined scripts
- **Operational Planning**
  - Reducing Time for Planning Development due to the reduction of human experts employed in the different roles
  - Possibility to Experiments different Alternatives by replicated runs carried out in Automatic way
- **Mission rehearsal and conduct operations**
  - Capability to keep the simulation on-line and to conduct statistical experimental analysis

Therefore, in order to apply R&D to current and future Asymmetric Marine Framework, the authors identified the following innovation tracks to be investigated:

- **Cognitive Technologies**
  - Data Fusion (i.e. Situation Assessment)
  - Human Behavior Models
  - Intelligent Agents & CGF
  - Decision Support Systems (i.e. Web 3.0)
- **Modeling & Simulation**
  - Concept and Doctrine Development (i.e. Interoperable Simulation)
  - Simulation Based Acquisition (i.e. Virtual Prototyping)
  - Training (Mobile Training, Serious Games)
  - Serious Games used to create complex scenarios with multiple players and to investigate different strategies
- **Equipment & Devices**
  - Integrated Solutions (i.e. Mobile Tactical Control Systems)
  - Platforms (i.e. UAV, AUV, NMM)
  - Sensors (i.e. Through Wall Sensors)
  - Weapons (i.e. Non Lethal Weapons)

AVAILABLE EXPERIENCES

The authors have experience in using several of these techniques in different applications, for instance, currently, the authors are developing a solution (PANOPEA), to test complex scenarios related to piracy and to investigate different C2 solutions as well as strategies and technologies within this framework; obviously the authors have even long experience in traditional applications (i.e. data fusion over conventional air naval scenarios). In the paper some experience and simulation model are presented as example of the potential of these techniques within marine asymmetric scenarios.

An Example of Simulated Attack to a Port

As Example of Port Attack Simulation it is proposed an unclassified simulation scenario developed in cooperation among Bulgarian Academy of Sciences, Lockheed Martin Canada, MISS DIPTEM Univ. Genova, CRTI, NATO PBIST Experts, Port Authorities, CUBRC within a NATO working group; the scenario is based on the following objects and hypotheses:

- Small boat (fishing or pleasure normally seen in the harbour, not regulated by ISPS code) filled with a mixture of explosive and CBRN;
- The boat is heading for a oil Terminal or tanker within a port
- No predicted pattern from the pleasure boat is available
- No clear strategic warning available until close to the attack
- Necessity to concentrate on attack assessment and response
- A Priori and HUMINT information are essential in the fusion process and need specific models

For this scenario it is necessary to model and simulate available technologies such as:

- Tracking small targets : Track continuity
- Sensors for CBRN detection
- Unusual maneuver detection for threat assessment
- Data fusion for Recognizing in a very short time the attacking boat
- Solutions for permanent and continuous observation and surveillance

The use of simulation is an important benefits to address critical questions that are necessary to clarify for port security assessment, for new equipment design and for security procedure definition; an example of this question is following: *if no automated radiation detectors are available in an Harbor Area, when is the true nature of the threat discovered?*

Information	Source
Ship track and maneuver	Sonar, HFSWR, optical, acoustic
Radiation signature	Radiation detector
Human Intelligence	Police, government agencies in order to identify the crew; unusual behavior of the crew

In the following figures the different fallout areas and contamination risks are summarized respect different kind of CBRN devices

Fig.1 Areas of contamination Case 1: 100Ci 241 Am Two oil-well logging sources

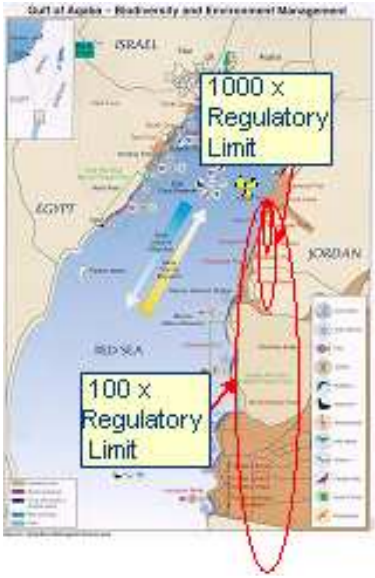

Fig.2 Areas of contamination Case 2: 20kCi 90SrRussian RTG

*Fig.3 Areas of contamination Case 3: 10kT Nuclear **Weapon***

It is evident the importance to define best solution to face these challenges by considering the area impact of such devices as well as the implication of a port attack in term of economic costs and strategic issues. The use of M&S, CGF, and Intelligent Agent CGF is critical to test new algorithms to detect suspect behaviors or to develop the requirements for new security solutions; today the use of mobile networks provides very interesting opportunity to share info quickly and easily and to develop deployable netcentric solutions, therefore the use of M&S is critical to properly design the specific configuration and operative modes.

ASYMMETRIC THREATS: ASYMETRIC MODELING

The complexity of marine scenarios is due often to the involvement of many entities that generate a very challenging framework for detecting real asymmetric threats from false alarms or uncommon behaviors; in order to face this challenge it is necessary to create models able to reproduce complex behaviors such as that ones that characterize general cargo operations, commercial traffic, pleasure boats as well as the threat tactics. By this approach it is possible to create models that support the marine asymmetric threats assessment.

Human Factors and Marine Simulation

Most of the critical issues in generating and simulating large maritime scenarios is dealing with the necessity to model the humans factors that affect the activities of the vessels, boats, airplanes, coast infrastructures as well as all the other elements present in a specific framework; in fact the complexity to Coordinate Humans in not-conventional operations for improving their coordination and capabilities to face complex challenges is a well known element in Navy. So considering asymmetric threats it is even more important to models these Human Factors both for the directing the threats, for reproducing the boundary elements as well as for being actors for our resources; this point is even more evident by a simple example: looking to each single Vessel it is evident that for Simulating its capabilities in reacting to threats it is very critical to model the crew and its human behavior modifiers (i.e. stress, fatigue, harmony).

IA-CGF & Human factors in maritime security

The authors have developed models for reproducing human factors and to represent intelligent agents able to direct objects within interoperable simulators; in fact the Simulation Team create a new generation of CGF, titled IA-CGF (Intelligent Agent Computer Generated Forces) for this purpose and some application within marine environment is already available and in the experimentation phase over complex scenarios.
These new *IA-CGF* are organized based on Modules that are interoperable in HLA Federation (High Level architecture) and they include:

- IA-CGF Units (i.e. commercial ships, contractors on the ship, special teams, fisherman boats, coast guard units)
- IA-CGF HBL Human Behavior Libraries (i.e. fatigue, stress, aggressiveness, trustiness)
- IA-CGF NCF Non-Conventional Frameworks devoted to reproduce specific scenarios (i.e. piracy)

The IA-CGF are available to support different aspects in the marine asymmetric threat simulation, such as:

IA Drive the General Traffic & Critical Entities

In fact the use of Intelligent Agents provide the capability to create large simulation frameworks where airplanes, yachts, ships, ground entities act in consistency with their nature and within the Scenario and react dynamically to the Simulation Evolution.

IA Direct the Port and Coast Protection within its 5 Dimensional Space

IA are able to direct actions of the different resources for port and coast protection, so it becomes possible to run extensive experimental campaigns by simulation for defining optimal protection solution and to assess the threats over a complex scenario; these results are achievable by testing and evaluating the effectiveness and efficiency of the all Naval Resources, including platforms, weapons, individual sensors, ground infrastructures, C2 and different information sources for protecting assets against new threats including not conventional use of civil resources.

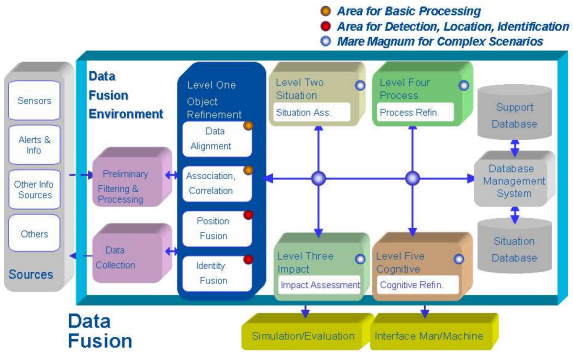

Fig.4 Asymmetric Data Fusion

In the following part of the paper, different Interoperable M&S solutions, developed by the authors for Marine Environment are presented as example of their potential in facing the above mentioned challenges.

PANOPEA

PANOPEA is a IA-CGF NCF that use IA for reproducing a complex framework related to piracy involving several thousands of vessels, plus all related activities (i.e. intelligence, ports, special forces, contractors, helicopters, UAV, etc.) In fact PANOPEA simulation allows to model Piracy activities; a specific study on-going by using this simulator is related to the evaluation of different strategies in NEC C2 M2 (Net-centric Command and Control Maturity Models) and in quantify benefits related to guarantee C2 agility. PANOPEA reproduces military vessels, helicopters, ground base units, cargos, as well as small medium boats, fishermen and yachts traffic as well as Pirates; all these entities are driven by Intelligent Agents and apply strategies for succeeding in their specific tasks.

PLACRA

The Placra simulator was developed by the authors in order to reproduce the crew activities and behavior on Oil Platforms as well as on vessels; in this case the simulator takes care of reproducing operative procedures, on-board micrologistics as well as the human behavior modifiers and their impact on crew efficiency; the model consider the workload, individual and team characteristics, their history and previous experiences as well as the platform infrastructures and equipment; the simulation evolve over a scenario where regular or critical events have to be handled.

MESA

MESA is an integrated environment, developed by the authors, to perform simulation and risk analysis in ports and maritime sector considering the evolution of emergencies; MESA combines the simulation with GIS to support safety and security assessment plans and operations; in fact MESA is devoted to support port organizations, entities and operators in Emergency & Environmental Management. MESA is a modular system based on combined simulators running on PC able to export directly the results on WWW servers.

FLODAF

As Asymmetric Data Fusion example FLODAF framework was developed by the authors as tool devoted to support engineering and performance estimation of Data Fusion architectures and algorithms; this suite includes a Scenario Generator and a Simulator for analyzing the Data Fusion performances over complex Air-Naval scenarios including surface and underwater vessels, aircrafts.

ST-VP

ST-VP was by Simulation Team originally as a framework to support Training in marine evnrionemtns; in fact the Interoperability of ST-VP simulators is based on HLA and guarantees in addition to traditional stand-alone training, even Concurrent Cooperative Training in complex Operations and Policies; ST-VP have a long experience in being applied within commercial ports.

In fact The ST-VP includes all the different port equipment and even other marine devices and platforms; ST-VP in addition to Operator Training supports even Safety and Security Training, Procedure Definition, Equipment Design and Virtual Prototyping; among ST-VP innovative capabilities the following aspects are interesting

- ST-VP is a fully containerized real-time distributed HLA Simulator reproducing Marine Environments and Ports. ST-VP is integrated within a 40’ High Cube Container ready to be used on site immediately after arrival.
- ST-VP Simulator allows to operate all the different Equipment in a Virtual World by an immersive Cave (270 ° Horizontal and 150° Vertical), reproducing Sounds, Vibrations, Motion in all weather conditions
- ST-VP includes a Full-Scope Simulation for Training Operations & Procedures, an Integrated Class Room, the Instructor Debriefing Room, and secondary Interoperable Simulators of all the Port Cranes and a Biomedical Module for Safety, Ergonomic and Posture Enhancement.
- ST-VP World is customizable for each Port, Procedure and Equipment

An example of ST-VP federation applied to a marine security scenario is proposed in the following scheme:

In fact ST-VP is able to interoperate with other simulators (virtual and constructive) as well as with real equiptent; among the others it is possible create connections with: ST_PT & ST_RS Simulators

(driving simulatgors), Seaports (Simulator of Terminal and Ports Security Procedures and Operations), TRAMAS (Simulation of the Logistic Network & Impact on the Town of port activities), KATRINA LIKE (regional scenario simulation reproducing a large scale crisis)

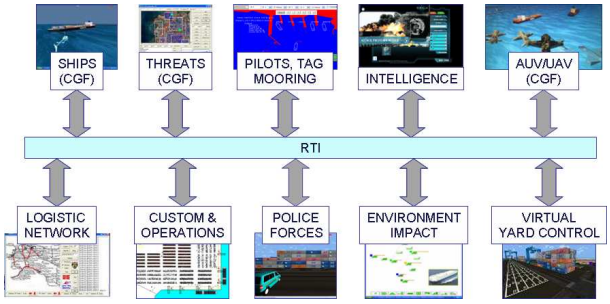

Fig.5 ST_VP FEDERATION

CONCLUSIONS

It evident that Maritime Security is part of a wide Scenario and need to be addressed by an integrated approach: due to the complexity of the framework the use of simulation is very effective and this paper proposes some of the critical methodologies and techniques to be used in this direction

In addition it important to outline that Marine Asymmetric Warfare is fast evolving introducing new issues and new threats affecting more and more subjects, so it is becoming very urgent to create capabilities in defining, evaluating and optimizing solutions to face these challenges; so it becomes evident that Simulation and Cognitive Technologies are the key issues for succeeding in this goal; in fact today it is very critical to proceed in research and investigation on these domains respect the new evolving threats and to develop of New models and simulators for supporting the development of Systems, Devices and Equipment.

In fact the importance of these aspects suggests that it is critical to create new capabilities in security for Maritime Scenario and to network with all international research centers operating in this context

In order to succeed it is critical to develop critical assessments as well as to establish connections with Agencies, Companies and Institutions operating in this area.

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