CGF & Data Fusion for Simulating Harbor Protection & Asymmetric Marine Scenarios

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Objectives

• To provide an Overview on the Modern Complex Scenarios and to identify the related Challenges
• To present the Potential of Modeling & Simulation (M&S) within this Framework
• To Outline on enabling Technologies and Solutions for succeeding: i.e. CGF (Computer Generated Forces) and Data Fusion Methodologies
• To present Examples and Approaches in this context
The Real World: Multi Dimension and Multi Layer Resolution

- 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 Accessing Ports/Vessels  
  - Services & Infrastructures
M&S for Port Protection and Asymmetric Naval Warfare

- It is necessary to Create Models and Modules able to Interoperate within Federation for including the critical Components of such Scenarios:
  - 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, Litoral Control, C5I2)
Using IA, CGF and HBM in Marine Frameworks

- New **IA** (Intelligent Agents), **CGF** (Computer Generated Forces) & **HBM** (Human Behavior Modeling) represent Strategic Issues in different Application Areas such as:
  - **Simulation Based Acquisition and Test & Analysis**
    - 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
Vessel Modeling: Critical Elements & CGF Role

- Vessel Platform
- Weapon Systems
- Vessel Systems
- Vessel Subsystems

- Crew & Human Factors
- Threats
- Ship Services
- Logistics Infrastructures
- External Traffic
- Litoral Resources
- NEC Players
Vessel Traffic and Naval Asymmetric Warfare

- The IA-CGFs need:
  - To be able to adopt "Intelligent Behaviors"
    - conservative and smart use of sensors
    - adopting behavior of general traffic
    - compromising info source
    - grouping and desegregating on the coast
  - To have Capabilities in Scenario Awareness and
  - To have Capabilities in term of Autonomy
  - To have capabilities in Coordinating different Agents
## Intelligent Agents Measurable Characteristics

<table>
<thead>
<tr>
<th>Situatedness</th>
<th>Receives some form of sensory input from its environment; Perform some action that changes its environment.</th>
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<tr>
<td>Autonomy</td>
<td>Can act without direct intervention by humans or other agents; Has control over its own actions and internal state.</td>
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<td>Adaptivity</td>
<td>Reacting flexibly to changes in its environment; Exercising goal-directed initiative when appropriate;</td>
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<td>Sociability</td>
<td>Interacting in a peer-to-peer manner with other agents or humans. Perform some action that changes its environment.</td>
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<td>Behaviour moderators</td>
<td>Stress Level Indicator applicable for the entities behaviour definition; Implementation of Typical Human Behaviour (survival instinct and moral/ethical motivations, psychological Behaviour etc...)</td>
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<td>Scalability</td>
<td>Capability to aggregate and desegregate Units</td>
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<td>Capability to distribute hierarchically the Orders</td>
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<td></td>
<td>Capability to collect and reorganise hierarchically the orders</td>
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<td>Federation</td>
<td>HLA Standard development procedures</td>
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<td>HLA Federation Execution</td>
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<td>Composability</td>
<td>Ability to configure and initialise a pool of reusable elements (Physical and behaviour models)</td>
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IA-CGF Experiences & Background

Experiences and Demonstration have been achieved by use of Intelligent CGF (i.e. PIOVRA, Polyfunctional Intelligent Operational Virtual Reality Agents) where the following Object was created:

**Comportment Objects** are dedicated to the simulation of actors that represents behaviors of Parties, Movements or other Entities (i.e. Pirates, Local Authorities, etc.).

**Action Objects** representing active entities (i.e. Vessels, Terrorist, Cargo) or events (i.e. Riots); Action Objects are referencing corresponding Comportment Object with mutual and are characterized by mutual influence.

**Support Objects** include objects representing influent phenomena corresponding to boundary conditions such as Environment Data Representation including Zone, Layer and Weather Objects.
Action & Comportment Objects

- The different Units are driven by the Agents and apply different procedures and ROE based on:
  - Their configuration and Nature
  - The Perception of the Scenario
  - The Order Received
  - The Previous Experiences
IA-CGF Elements

The new IA-CGF Modules devoted to create the CIMIC simulation include:

IA-CGF Units

• IA-CGF Human Behaviors
• IA-CGF Non-Conventional Frameworks
IA-CGF Units

IA-CGF Units are a set of interoperable units with capability to be integrated in constructive simulation

- Police
- Gangs
- Pirates
- Local Population
- Cargo Traffic
- Yachting
- Local Authorities
- Warlords
- Criminal Organizations
- NGOs
- Cyber Services
- Air Traffic
- Domestic/National Situation (for instance for troops moral):
  - Population
  - Media
  - Lobbies
- International Public Opinion
- International Diplomacy
- New Threats (i.e. 2nd Generation Terrorists)

These are examples of non-conventional units controlled by IA-CGF
**IA-CGF Human Behaviors**

Specific modules with *IA-CGF Human Behaviors*:

- Fear
- Stress
- Fatigue
- Training Level
- Aggressiveness
- Crew Harmony
- Combat Skills/Experience
- Other Factors (i.e. Ethnic, Religious, Social)

*IA-CGF Human Behaviors* operate as a set of further characteristics to be added to each unit in constructive simulation.

i.e. now in constructive simulation every unit in the scenario have infos about status and type of ammo, by IA-CGF it will be added dynamic information about level of fear and stress and the Units performing according to it.
IA-CGF Non-Conventional Frameworks

It is important to consider the integration in a scenario of the IA-CGF-Non-Conventional Frameworks (IA-CGF-NCF), each simulating specific events:

• IA-CGF FRAMEWORKS
  – Food Distribution
  – Cargo Inspection and Area Protection
  – Logistics Support

• IA-CGF Homeland Security and Civil Protection FRAMEWORKS
  – Natural Disaster (i.e. Hurricanes, Earthquakes)
  – Man Made Disasters (i.e. Explosion, Hazardous Material Spills)
  – Evacuation
  – Oil Platform Accident

• IA-CGF PSYOPS and INTELLIGENCE FRAMEWORKS
  – Possible integration with Sibilla® Serious Game for Intelligence Officers training

In non conventional scenarios for particular training purposes.
We can imagine to have active different non conventional Frameworks, in different locations, within the simulated theater.
Human Factors and Marine Simulation

• 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

• Today it is becoming important to models Human Factors as element of a Vessel for Simulating their capabilities in reacting to threats
Impact on Local, Regional & Domestic Population

The evolution of the situation requires models such as:

- Civilian Attitude Model: describes changes in population attitude as a result of Host Nation actions and insurgency activities, and perceived good/bad actions.
- Social Network Model: helps to describe civilian response to new factors that interact with civilian behaviors, social structures and specific communication parameters as hierarchy and message contents.
- Economic Model: describes how the economic decision of a Host Nation can affect and impact the attitude and activities of entities.
Experimental Analysis & VV&A as Critical Elements

Example of Response Surface Methodology and Design of Experiments obtained by running FLODAF Air Naval Simulator on Scenarios for detecting abnormal behaviors
Example of Scenario
JFCOM Haiti Demo
Example of Mutual Influence among Population

The Attitudes among the IA are based on Fuzzy Representation and their interaction are regulated by Artificial Intelligence techniques.
IA-CGF NCF Riots &
IA-CGF NCF Humanitarian Support

The simulation includes impact of food distribution point and tactical operation on population human factors such as aggressiveness, fear, stress and fatigue.
Computer Generated Forces & Data Fusion

Data Fusion is critical to support CGF in understanding the Scenario Evolution and in reproducing Complex Scenarios

- Usually we identify Threats based on the Platform Detection Identification and Classification

- In Some case the same Platform is in use on multiple sides

- In some case the Platform is becoming a Menace just based on own it is operating
Data Fusion Areas of Investigation

**Area for Basic Processing**
- Level One Object Refinement
  - Data Alignment
  - Association, Correlation
  - Position Fusion
  - Identity Fusion

**Area for Detection, Location, Identification**
- Level Two Situation
  - Situation Ass.
- Level Three Impact
  - Impact Assessment
- Level Four Process
  - Process Refin.
- Level Five Cognitive
  - Cognitive Refin.

**Mare Magnum for Complex Scenarios**

**Data Fusion Environment**
- Sensors
- Alerts & Info
- Other Info Sources
- Others

**Sources**

**Data Fusion**
- Preliminary Filtering & Processing
- Data Collection

**Support Database**

**Database Management System**

**Situation Database**

**Simulation/Evaluation**

**Interface Man/Machine**

UNCLASSIFIED
**Blended Approach in Term of Methods**

**Data Fusion Techniques**

- **Physical Models**
  - Simulation
  - Estimation
    - Kalman Filtering
    - Maximum Likelihood
    - Syntactic
      - Image Algebra

- **Inferential Techniques**
  - Parametric
    - Classical Inferential
    - Bayesian
    - Dempster - Shafer
    - Generalized Evidence Processing

- **Information Theoretic**
  - Parametric Templates
  - Neural Networks
  - Voting Methods
  - Pattern Recognition
  - Entropy Measure

- **Cognitive Models**
  - Fuzzy Set Theory
    - Logical Templates
    - KBS
Creating Complex Scenarios

- Not-Cooperative Behaviors in Other Entities
- Risk of Sensors & Information Sources Compromised
- Failures and Services Needs
- Foes adopting new Strategies
Agents Driving General Traffic & Critical Entities

- Agents have to be devoted to create a large simulation framework where airplanes, yachts, ships, ground entities act in consistency with their nature and with the Scenario and reacting dynamically to the Simulation Evolution.
Logistics, Services and Maintenance

- Modeling the Impact of Maintenance and Service due to the Different Conditions:
  - Operative Status
  - Crew
  - Infrastructures
  - Environment
    - Atlantic Ocean Impact on Radar Av.
    - Middle East Impact on HVAC and Compressors and Fans
IA Supporting Service Simulation and Model Identification

- Intelligent Agents for Identify and Correlating Data on Existing and New Devices respect Endogenous and Exogenous Factors
Port and Coast Protection in a 5 Dimensional Space

- Testing and Evaluating by Simulation the Naval Resources including Individual Sensors and Different Information Sours as protection against new threats including not conventional use of civil resources
Conclusions

• It becomes evident the importance to federate in a Simulation elements reproducing background environment as well as new threats
• To be effective the use of Intelligent Agents results really promising
• This approach will enable to investigate a wide spectrum of new Missions for supporting both Engineering, SAB, Test and Evaluation and Training Issues.
References

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