Development of Advanced Models for CIMIC for Supporting Operational Planners

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ABSTRACT

The authors present the first step in the development of new CGF (Computer Generated Forces) to provide CIMIC (Civil Military Co-operation) Modeling capabilities in the complex and critical sector of military operation planning training. The proposed CGF, based on intelligent software agents, were demonstrated, in terms of feasibility and initial development, by PIOVRA (Poly-Functional Intelligent Operational Virtual Reality Agents) research project results. These new CGF are designed as HLA federates so that external federated simulation systems can simulate the effects of CIMIC activities more realistically and in greater detail: i.e. the perception of the presence of different ethnic civilian groups on their territory. This supports training activities for planners or Operations Commanders, providing realistic scenarios in which they must choose between different options with a higher degree of certainty that the foreseen results will be similar to what is expected from their actual implementation. The authors are proposing a general architecture and agent structure for demonstrating and testing these concepts by integrating these CGF in an HLA federation with a constructive simulator. As a result, it will be possible to evaluate the impact of this approach when combined with existing systems and to carry out VV&A (Verification, Validation and Accreditation) on these developments.

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INTRODUCTION

CIMIC (Civil Military Co-Operation) are very critical elements in Operational Planning, and even more so in the world's current economic and social situation. However they are also a very critical framework owing to the complexity represented by the high number of factors and doctrines involved and due to the strong impact of human factors and stochastic components (Amico et al. 2000). Extensive experience in each specific scenario is needed to acquire a solid background and skills in this framework.

Even so, the dynamic nature of such a context as well as the very broad set of activities are very strong obstacles in this direction. Furthermore, today it is fundamental for a large number of resources on all the different levels of the hierarchical command chain to develop these capabilities. With this in mind it is very important to develop tools, models and procedures in order to support the cultural growth, education and training of the personnel involved in these initiatives.

The authors provide an overview of this application area and existing approaches as well as a proposal for developing new solutions based on interoperability among models reproducing different critical aspects (Bruzzone, Mosca, Massei, Bocca 2008). In fact, the authors are Army training simulation experts as well as researchers who recently developed new HBM (Human Behavior Models) and Intelligent CGF driven by Intelligent Agents that can reproduce civilians and other complex elements (Bocca et al. 2006).

A proposal is presented to combine these aspects in order to meet the challenges of CIMIC operations with a strong emphasis on the user viewpoint as the first step forward in developing a new project that focuses on such issues (Bruzzone, Cantice 2008): CAPRICORN (CIMIC And Planning Research In Complex Operational Realistic Network).

THE REAL FRAMEWORK: STABILIZATION AND RECONSTRUCTION OPERATIONS

In order to properly proceed in CIMIC M&S it is critical to define the application framework; in these day a key aspect is related to S&R (Stability & Reconstruction) operations. S&R are complex activities that include the full range of military and civilian activities, from conflict to peace. They are used to establish or maintain order and provide security for reconstruction activities.

These reconstruction activities are used to influence the security, political, social, economical and informational aspects of the operational environment through a combination of activities to neutralize the crisis and the spread of riots, insurgency and popular discontent. S&R operations aim to reestablish governance as well as security, judicial, health, transportation and commercial infrastructures, and many others, of a crisis region. Activities encompass identification and training of appropriate personnel (governmental employees, Army, Police, etc.), reestablishment of transportation, health, education and communication services as well as water, waste disposal, gas, electric, oil utilities and other state institutions (Chait et al. 2006).

Combat and combat support units are important pawns in S&R operations. These include resources such as technicians (i.e. engineers) as well as sectors such as Transportation, Civil Affairs (CIMIC – Civil & Military Cooperation), and often supported by non-military personnel in other Defense Departments, GO (Governmental Organizations) and NGO (non-governmental organizations).

These operations are not isolated activities but are part of the same battle space with other major and secondary military activities, as complementary and parallel operations supporting the full spectrum of military operations. A successful stabilization operation can: improve security in a specific AO (Area of Operation); start reconstruction activities at the same time to help the local population to return to a normal life; and reduce stress and help the local population perceive the temporary presence of soldiers as positive and necessary to guarantee security until it will be able to defend and protect itself.

In this paper the authors provide an overview of current issues in the development of models for supporting operational planners in relation to CIMIC. User needs are outlined in order to define requirements for applying modeling and simulation in this context. An approach is proposed to combine different innovative solutions within CAX for studying these problems and reproducing complex interactions as well as the effect of all boundary conditions.

As usual simulation represents an enabling technology and a support tool for specific tasks and projects; from this point of view it is very critical to combine the description of the application framework with the needs and goals of the possible users of CIMIC operation in S&R

USER NEEDS: MAJOR AREAS OF THINKING/MILITARY CAPABILITIES FOR OPERATIONAL PLANNERS IN AN URBAN/S&R ENVIRONMENT

Moving forward in the analysis of the benefits of CIMIC M&S it is fundamental to outline the operational planners and military users needs.

In fact the major areas of thinking/military capabilities with a focus on S&R operations are listed below (Marburger et al. 2008); these issues needs to match with the future CIMIC M&S .

BC (Battle Command): The most important issues for a military operational planner in a complex urban environment are described here below.

- **transmission**: saturation level of commercial radio frequencies, obstacles to the use of friendly radio frequencies, GPS (global positioning system) management activities, reception & emissions; the density of users, facilities/infrastructures/buildings, obstacles;
- **distinction**: identification of people in Urban Areas, tracking of individual friendly personnel (military deployed for specific missions and civilians employed in reconstruction activities);
- **representation**: clear and universal capability to represent on the BC systems the OPFOR, IED, or other foreseeable threats;
- **integration**: ability to plan, organize and execute integrated (interoperable) S&R missions through the integrated BC (like C2 - Command and Control) chain. Integration provides a COP (Common Operating Picture) for all active friendly elements (including civilian and governmental population support activities) and helps guarantee security for all personnel and missions;
- **assessment**: the BC chain requires continuous evaluation of BC processes and communications;
- **communications**: this need is underscored by the limited range of the actual portable devices used inside or near buildings and urban areas. Satellite communications are a partial solution and the use of repeaters is expensive. Solutions like those used by the police and other government departments are useful but require repeaters and military standards to be employed; using vehicles as repeaters are not always possible.
- **language and cultural obstacles**: can be a problem especially in joint operations with local friendly forces and with non-interoperable BC/C2 systems.

Urban environments: While, in general, it is difficult for heavy vehicles to maneuver within urban environments, a compromise must still be reached to ensure the survivability of the crews and (dismounted) support personnel. Some urban environments may become off limits due to a number of obstacles (cars, pedestrians, children, suburb size, etc.), thus leading to a ban on using the main weapon systems, making units become truly vulnerable. Other limitations are the viewing systems, the mounted machine guns that expose personnel, the lack of mounted external devices to communicate with dismounted personnel, and rear vulnerability.

SA (Situational Awareness): This problem is related to BC; each soldier must be linked to the system in an Urban Operation.

- **limited SA capability**: is a major concern for leaders as they can rapidly lose visual contact with personnel and can't easily obtain their locations or details on a digital device to coordinate their efforts (problems with official devices and lack of maps on commercial solutions).
- **incomplete update of net-centric organization**: the lack of details from some elements will give a partial COP to the Command Posts, in this case also for reconstruction activities.

Intelligence: Tactical intelligence is used to avoid/mitigate counteractions against the S&R activities as intelligence can be involved with many other functions and military/civilian capabilities.

- **data integration and correlation**: need for Data Mining to process large quantities of data to increase knowledge and awareness among own forces and through friendly multinational contingents.
- **sensors**: important to monitor human activities also from static bases.
- **"Through the Wall" Capability**: infrared technology could detect personnel in critical urban areas, buildings, facilities.

Force Protection: In the S&R operations environment, personnel must execute and perform their duties within a cordon of security to begin rebuilding in a post-conflict environment.

- **Rapid location of point of origin with regard to snipers and attacks**: very difficult to identify attackers in the middle of the population. Identification can limit collateral damage that might influence the local population's perception of S&R operations. Accurate and rapid identification of combatants becomes a key capability.
- **Inability to quickly check vehicles, people and personal items**: causes an imbalanced control of checks on civilians and on the flow of commercial traffic.

Unmanned systems: They are fundamental for many critical tasks like intelligence, surveillance, reconnaissance, EOD, counter-IED etc.

- **flying systems**: airspace restriction and high cost items could jeopardize the use of this tool.

non-lethal capabilities: Important capability to control crowds, suppress riots, and limit the spread of disorder. In this situation only some systems are used by operational personnel and mainly for detention and persuasion activities.

IO (information operations): Psychological, strategic communication and information campaigns are important to increase the participation of and thus the influence on the populations involved.

M&S tools for training: Lack of preparation of personnel about S&R operations. Need for a training standardization program to understand the S&R operations environment. Expertise can be easily created, in particular regarding skills like languages and cultural knowledge; these skills need to be increased for a certain period of time, especially in the pre-deployment phase. M&S and Simulators have the potential to train personnel in "on site" and embedded solutions to improve S&R missions also for civilian elements. New Gaming technology will add more flexibility to simulation platforms. An important issue is the interoperability of Training Simulation (LVCG-I) and BC/C2 systems with multinational/coalition/partner systems, to drive all training activities in the same direction (Bruzzone, Williams 2005).

Logistics: Logistics is important to keep the units ready and materiel is important to rebuild the physical assets of a nation (Bruzzone, Kerckhoffs 1996). The humanitarian and medical missions are carried out together with the S&R missions.

- **specific equipment**: long-duration equipment can help the population believe in a durable stabilization time (generators, water supply, food, etc.).
- **simplification of personal combat equipment**: by this approach humanitarian and medical equipment is more effectively supported

MODELING ISSUES: REPRESENTATION OF NEEDS, VARIABLES, SCENARIOS AND MODELS

Based on the S&R framework basic description and on the user requirements outlines, it emerges the need to model CIMIC considering an extended concept of "Urban Culture Geography"; in fact Urban Culture Geography refers to the culture and the geographical space occupied by a civilian population in a conflict environment during Stability Operations.

Using a scenario developed through a multi-agent system model to simulate the civilian population is fundamental to explore the response of a civilian population to insurgents, with government capabilities and stability force actions in a counterinsurgency environment considered as variables (Hamilton et.al 1996).

The aim of this approach is to understand how actions, information, perceptions and beliefs can affect public opinion about the legitimacy of the host nation's government or other entities like military troops. M&S and IA (Intelligent Agents) represent a new enabling architecture to deal with these concepts.

SIMULATION MODEL

Obviously in order to be successful in representing S&R operations from user point of view by modeling Urban Culture Geography it is critical to properly define the components and elements of the simulation model to be used. In this case the model proposed herein requires an initial functionality to include:

- civilian population entities
- select beliefs and positions held by those entities
- social network connecting the population entities
- a set of actions that can influence the population entities.

In the model, civilian entities refer to the typical members of the society we want to represent (individuals, families, clans or tribes, etc.). These entities, as IA (Intelligence Agents), are cognitive agents in a multi-agent system (Bruzzone, Cantice 2008). The model also includes other reactive agents that have to interact with each other (stability forces, host nation entities, insurgents, etc.). The civilian population is led by positions of public importance and by the underlying beliefs that support some political/religious/social positions. Civilian population entities are directly influenced by actions/events and indirectly influenced by other agents in the social network that connect the entities and allow them to exchange information.

Analytic Models:
The evolution of the situation requires the integration of the general architecture analytic models (Fishwick 1995) 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.

STATE OF THE ART

The number of entities and the complexity of their interaction for simulating the above described models and components requires to improve current capabilities of CGF. In fact to create models that effectively represent CIMIC, it is necessary to create CGF that can manage these aspects and handle all mutual interactions. This area offers many solutions that have been developed over the years initially to solve basic issues (grouping and assigning joint basic commands) and subsequently to demonstrate intelligent capabilities. Some of these are described below (Bruzzone, 2007). WARSIM is designed to train US Army command and staff. This constructive training simulation system can also be used to train commanders and battalion staff at the theatre level in joint and combined scenarios. The SAF Janus environment was created in the Livermore laboratory (USA) in 1979 to model the effects of atomic weapons. In the 1990s it was modified and adopted by the Army as its standard model for teaching tactics at the small-unit level (squad/platoon/company). The software was adapted by France (until 1992) to the national norms prescribed by the Army operational and simulation research center (CROSAT). Spectrum was designed in 1995 by the National Simulation Center, as a command and control training simulation, to address a deficiency in command and control training in Military Operations Other Than War (MOOTW), Stability and Support Operations (SASO) or again in complex contingency operations (CCO). It was designed at a time when other military simulations modeled force-on-force combat operations.
Some CGF are rather old but remain omnipresent in current environments (i.e. Close Combat Tactical Training CCTT Saf). Another existing solution is represented by OneSAF, a Constructive/Virtual and CGF (Computer Generated Forces) Simulation System that uses a high resolution terrain representation as well as an environment and scenario representation for stability and reconstruction operations, urban operations, support operations, etc. Recently updated, it is used for CD&E (Concept Development and. Experimentation) and in international development and cooperation programs. In this sense research projects have been designed to analyze how to create agents that can reproduce aspects for our framework. For instance, Pythagoras (currently available at the SEED, Simulation Experiments & Efficient Design, Naval Post Graduate School) is an agent-based environment originally developed in relation to the Albert Project, a USMC–international sponsored initiative that focused on human factors. In this context Pythagoras was designed to define and manage agents by assigning them behaviors based on motivators and detractors (Henscheid et al. 2007).

There are several problems in using current CGF systems: some operations are not supported, the system is too complex and some entities are inflexible (hard-coded). Many of the still unresolved critical issues are related to Stability and Support Operations (SASO) and to low intensity conflicts, to human behavior models at a multilevel scale, to interoperability and federation of M&S tools (despite HLA and other technologies) and to

MOOTW (Military Operations Other Than War) in which there is extensive variability in terms of the agents involved and the goals (Bruzzone, Tremori Massei 2008). Other critical issues are linked to R&D initiatives by Scientific Societies (i.e. Military Operations Research Society MORS) acting as a facilitator for the transformation process through meetings involving an exchange of information about particular aspects, such as:

- Combat Analyst: Deploying Quantitative Support to the Combatant Commander
- Decision Aids / Support to Joint Operations Planning
- How Cognitive and Behavioral Factors Influence C2
- Operations Analysis Support to Network Centric Operations, and The Global War on Terrorism: Analytic Support, Tools and Metrics of Assessment

These meetings provide an opportunity for practitioners and operations research military users for exchanging information, and for achieving an effective common understanding of these issue. The main goal of these meetings is to provide an opportunity for working together on initiatives directly or indirectly related to stability operations. The subject matter expert's community is expected to be able to determine the capabilities of military analyses and to identify promising techniques and methodologies for conducting supporting stability operations and for finalizing directives devoted to develop training solutions (Ross-Witkowski 2005).

This research was developed by evaluating the impact on stability operations on training approaches and virtual technologies, with specific emphasis on intercultural engagement skills; in fact research has been used to train intercultural communication and mental agility with special attention to convoy operations and foot patrols (i.e. PEOSTRI, Program Executive Office for Simulation Training & Instrumentation) providing interesting results (Rayburn et al. 2008).

POLY-FUNCTIONAL INTELLIGENT OPERATIONAL VIRTUAL REALITY AGENTS

The authors development experience in modelling intelligent CGF compliant with requirements for CIMIC Modelling, especially with PIOVRA (Poly-functional Intelligent Operational Virtual Reality Agents) project; in fact PIOVRA was developed by the DIPTEM/LSIS Simulation Team for the European Defense Agency (EDA)and successfully delivered in 2007 (fig.1). PIOVRA CGF were able to simulate "Intelligent" behavior and to interoperate in an HLA Federation.
These new CGF should be "Intelligent" to some extent, meaning that they should demonstrate co-operative and competitive behaviors (coordinating units both during operative actions and situation evaluations) based on the current boundary conditions and situation (Bruzzone, Petrova et al.2004).

To meet the future requirements of the armed forces PIOVRA developed HLA models that simulate friends, foes (including terrorists) and neutrals (Kuhl et al. 1999). In particular, the PIOVRA project paid great attention to modeling neutral units representing civilians and their specific behaviors and logic in civil disorders (Bruzzone, Massei et al. 2007).

The PIOVRA CGF are designed to incorporate a hierarchical scalable structure in order to achieve a high level of detail (i.e. single persons) without losing the possibility of modeling large entities and with autonomous reporting capabilities for justifying their choices to external users. PIOVRA focuses on defining conceptual models that can simulate the co-operative behavior of PIOVRA CGF, allowing them to aggregate or separate depending on the situation, while keeping in mind the command hierarchies for military units and managing their dynamic evolution during actions (see table I).

The PIOVRA project focused on the development of human behavior models. The objectives achieved by the PIOVRA project support modeling of the agents leading units according to the Rules Of Engagement (ROE) and "intelligent" behaviors (co-operative/competitive) based on evolving scenarios and on the characteristics of each unit (Bruzzone, Bocca et al. 2006). Feedback and reports allow the user to change the ROE of the PIOVRA CGF. The PIOVRA entities include psychological parameters and models (i.e. "stress level" as a result of the evolution of the phenomenon and on the basis of current actions, external events and the surrounding situation).
Modeling complex human behavior and simulating intelligent reaction capabilities require a detailed definition of the scenario and action range to be reproduced in order to obtain successful results with current technologies. Therefore, PIOVRA includes a detailed scenario definition to be used for metrics and to evaluate the performance of the models developed along with their reliability and effectiveness.

The use of Artificial Intelligence in hybrid hierarchical models was based on the integration of different

architectures: Fuzzy Logic, Artificial Neural Networks, KBS, Data Fusion and Swarm Intelligence.
PIOVRA conceptual models were designed and developed in a G-DEVS/HLA framework, tailored for PIOVRA, in order to consider both the continuous (i.e. movement) and discrete (i.e. events and actions) components integrated in High Level Architecture (Ziegler et al. 1999).

The interoperability of the PIOVRA components is strictly based on HLA in order to maximize their integration capabilities and to improve the efficiency of their hierarchical structure. PIOVRA VV&A represented a very important and significant task that guaranteed the project's success. PIOVRA was extensively tested and integrated with a MOOTW (Military Operations Other Than War) tool where PIOVRA intelligent agents had to deal with civil disorders and stabilization activities; example for T&E (Test & Evaluation) are proposed in table I. In these experiments, PIOVRA Agents interoperated concurrently with JTLS (Joint Theater Level Simulation) war gaming systems to reproduce detailed operations affecting strategic issues on theater scenarios (Bruzzone A., et. al. 2006). Obviously, this is an important benefit since it means that intelligent agents can take independent action in directing detailed operations.

THE THREE BLOCK WAR: PLANNER CIMIC TRAINING NEEDS

Considering the potential of using Intelligent Agents in CIMIC Model, it is critical to introduce the three block war: a modern military concept about operations based on military force simultaneously involved in peacekeeping, humanitarian assistance and medium intensity conflict (according to the latest trends, a fourth block has also been identified: all INFOPS operations are considered a "mediatic/psychological" activity). Thus, the criticality that operational planners are educated and trained with regard to CIMIC is evident: it is fundamental to define how the different choices an operational planner makes affects the scenario in relation to other aspects and to determine the impact of boundary conditions (Surdu et al. 2005).

POSSIBLE PROCEDURES & OUTCOMES

In CIMIC training and education, the simulation must be able to support several operational aspects. Some of the most important aspects include the following:

- to plan a large number of executions and replications of each single action to achieve the designed effect.
- to modify the social network parameters to verify how external variables can influence the reference lifestyle and social behavior.
- to study the dynamics of interrelations among entities.
- to collect data in each state/action/reaction for each agent.
- to analyze data and results to verify if agent behaviors correspond to what was planned.
- to verify the percentage of results around the sustainable and realistic position correlated with the social model used, after verifying the position of each agent comprising the scenario (friendly, adversary, neutral, impressionable, extremist, etc.).
- to verify the sensibility of agents to the change of reference lifestyle in a scenario context and the reaction to Stability & Reconstruction operation activities.

EXAMPLE OF SCENARIO FOR VALIDATING MODELS IN CIMIC

A scenario example is a Peace Support Operation that can put together an active insurgency and S&R operations. The scenario should be set to enhance the focus on the civilian population's response when exposed to a set of actions.

The social network is the main way to interact and represents the population. The relationships should be symmetric but the level of the relationships may differ.
Some issues, as a set of actions to propose, could include: requests for independence (Federalism or Autonomy), increased crime, distribution of relief aid, distribution of wealth, representation in political legislature, participation in government, budget management.

The data collection will be a distribution of beliefs and positions regarding each action/reaction by the entities which will be stimulated with appropriate solicitations. The complexity and multi sided nature of each agent's position on issues as a single response or various means of interpretation for the survey will have to be defined based on what we want to measure or check (we might consider the agent and his decision as an individual or as part of a community in supporting any positions and the proportion as minority or majority to any act). The events in the scenario can influence behaviors because they can translate actions from the scenario into the population entity and influence their positions. Each action influence supports one set of beliefs and one issue position. The weight of the action effect depends on the level of the relationship between the influenced agent and the influencing agent in the social network.

INTEGRATING PIOVRA IN THE CIMIC TRAINING PATH

Considering the above described framework, different kinds of Conceptual Objects are required in order to reproduce the scenario player's behavior:
- Comportment Objects
- Action Objects
- Support Objects

Comportment Objects are dedicated to the simulation of players that represent the behaviors of populations, movements or similar entities to which the units in the field belong.

Action Objects are units whose task is to simulate particular elements, acting in the scenario like a military unit, a terrorist or a political representative (see figure 2). They can also simulate particular events like riots, demonstrations, etc. Part of the Action Objects is generated in relation to a particular state of one or more Comportment Objects. Support Objects include all the objects that instead of human players in the scenario represent influential phenomena.

In the CIMIC scenario Comportment Objects will reproduce:

- Population
    - Ethnic Groups
    - Cultural Layers
    - Social Layers
    - Local Communities
- Public Institutions
    - Governmental Entities
    - Local Administrations
    - Schools
    - Health Care Systems
    - Political Parties
- Military Organizations
    - Local Army
    - Allied Forces
    - Opposite Forces
    - Neutral Forces
    - Paramilitary Organizations
    - Police Forces
    - Warlords
    - Insurgents
    - Terrorists

Each entity will generate and manage the Action Objects through PIOVRA CGF. PIOVRA CGF are expected to interoperate with different systems within a CIMIC FEDERATION involving Multilevel modeling from Constructive Simulation (i.e. Entity Level) and Tools for Modeling strategic issues (i.e. economy, social aspects, communications, etc.)

The main purpose of this research will be to establish the ways in which to use CGF to train operational planners on the tasks related to typical CIMIC elements, and to implement procedures and algorithms that can interact in a complex manner to simulate realistic human behavior.

In fact for HBM (Human Behavior Modifiers) modeling, a four-part categorization is proposed for behavioral modeling and simulation of individuals to societies (Massei et.al 2007):
(1) macro models
(2) micro models
(3) meso models
(4) integrated, linked micro-meso-macro models.

System theory offers a set of concepts and methods for modeling the dynamic behavior of complex systems by breaking down these systems into simpler interconnected components (coupled models). This recursive modeling stops when simple blocks can be defined (atomic models).

These concepts and methods are well-adapted for representing the behavior of humans in groups and organizations through macro models (Bruzzone, Page, Uhrmacher 1999). A macro model of humans in groups considers interactions between macro-level variables, such as unemployment, crime, education and poverty, just to name a few; figure 3 propose the fuzzy and statistical models used in PIOVRA for ethnic groups.

Micro models are concerned with the behavior of individuals. At this level, cognitive models and cognitive-affective models have been proposed to represent the effect of human emotions on cognition and behavior, and of behavior on emotions.

Meso models are formal models of human behavior at a level of aggregation and detail between the micro and macro levels. A meso model represents interactions and influences among individuals in groups. These models include social decision models, social network models and agent-based modeling. In the past decade, meso models (network models and agent-based models) have generated a lot of attention. Network models allow us to formalize, measure, and test loose concepts of social capital, centrality and connectedness. Agent-based modeling is a general-purpose technology that supports empirical description, empirical prediction, normative analysis, behavioral understanding and heuristic understanding. The challenge is to build an integrated framework in which we can combine models at different levels of granularity to represent large organizations, including details for all individuals. In other words, the framework must allow the three levels of modeling to be represented and simulated. It must be an integrated multilevel model framework. Notice that the simulation of a macro model of a large organization including all details of the two other levels can quickly lead to unmanageable size and computational infeasibility.

These objectives are supposed to be achieved, based on the PIOVRA experience, through implementation of HBM algorithms with enhanced Artificial Intelligence based on Genetic Algorithms, Fuzzy Logic, Neural Networks, Swarm Intelligence and Intelligent agents. The PIOVRA CGF intelligent agents will be the starting base, and thus the different techniques will be combined in order to solve specific aspects such as: cooperative behavior, autonomy, sociability and behavior moderators. CGF perception will require the use of intelligent agents that can apply data fusion methodologies to guarantee scenario awareness as well proper threat assessment.

From this point of view it is critical to reproduce human capabilities in terms of risk evaluation, since such capabilities are influenced by rational, emotional and social drives.

EXPERIMENTAL ANALYSIS

A strong benefit from continuing in this phase will arise from experience gained from using PIOVRA and it will be possible to extend some of the promising innovative modeling approaches into the new simulator.

The authors are working on the simulator in order to produce experimental data based on the results provided by PIOVRA in reference to CIMIC, correlating different factors such as boundary conditions characterizing the social/cultural framework or trainee's degrees of freedom and possible alternative actions: for instance based on Design of Experiments (DOE) and Response Surface Methodology (RSM as reporter in figure 4). The training value of these results is expected to be used to develop both the final simulator and the training procedures. In fact the authors completed sensitivity analysis and applied response surface methodology for co-relating the independent variables with the target functions for model validation and verification.

CONCLUSIONS

Authors' aims is to develop an educational path for creating common understanding of the S&R foundations. Main objective is to identify the best way to integrate the proposed architecture into a new training process involving CIMIC in SASO (Stability and Support Operations) scenarios.

The major benefit expected by applying PIOVRA to CIMIC operations is the possibility to introduce many agents able to drive and direct actions of involved entities and organizations.

PIOVRA agents make their decisions on scenario awareness. This is a major point, even considering operations dealing with complex scenarios such as CIMIC and SASO.

After successfully completing these early demonstrations, the authors plan to proceed with CAPRICORN developments and PIOVRA agent evolution by introducing new tailored entities and specific activities related to CIMIC scenarios/operations.

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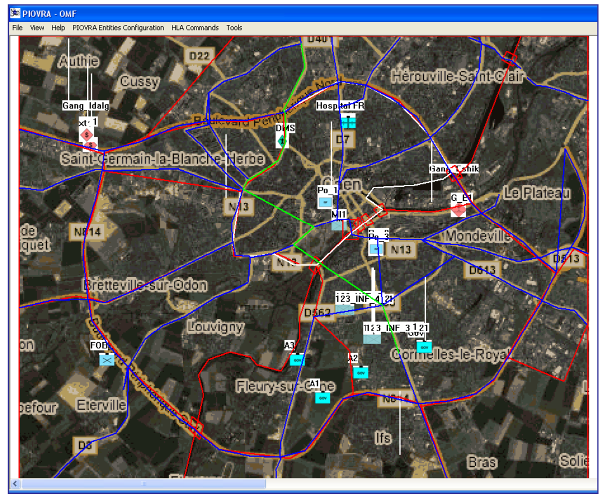

Figure 1. PIOVRA CGF User Interface

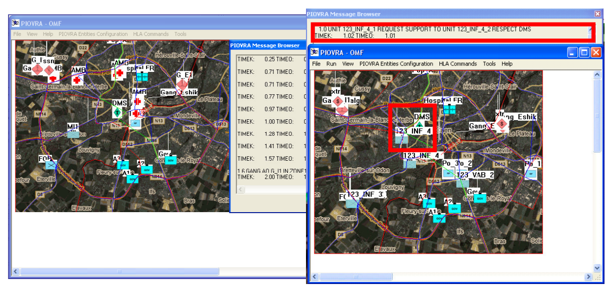

Figure 2. Example of Scenario Experimentation where terrorists and War Lords operates affecting Urban Environment and Ethnic Groups and their human behavior modifiers

Table I. Example of Testing the Features in PIOVRA

Feature/Objective	*Present*	*Example and Note*
1. User-Defined Initializing Parameters	YES	The user defined the profile of the Gang as well as the ROE to be used by Blue Units
2. Analyze Surrounding Envinronment and React Respectively Capability	YES	The Blue Units encountering the Riot and the Gang takes actions to stop the looting
3. Cooperation Capacity	YES	Some Blue unit are providing support on others reaching the demonstration/riot
4. Force Aggregating/Disaggregating Capability and relevant military hierarchy	YES	Disaggregation of Blue unit in two Squads after dissolution of the Riot
5. Resultant Aggregation Levels different from aggregating/disaggregating elements sum/subtraction	YES	The combination of Demonstration and Gang looting create impact on the area different from the sum of the single entities and introduces the generation of a riot
6. Limit Proper Autonomy to Achieve Common Objective Capability	YES	It is possible to enable/disable the possibility for the Blue Unit to request direct support to the other ones and to let the scenario evolve with this other condition
7. Stress Level Indicator applicable for the entities behavior definition	YES	These aspects affect both Population and Military Units all along the simulation
8. Implementation of Typical Human Behavior (survival instinct and moral/ethical motivations)	YES	It is possible to enable/disable the feature and check, versus critical riots, the different respect of ROE by Military Units
9. Distinct Friend, Foe and Neutral Units	YES	Distinction betweeen Gang and Militia
10. Explicit ROE justifying Proper Behavior	YES	Each entity provides a Log including the conditions under what each different ROE applied
11. Military Reports to Higher Commanders Capability	YES	Reporting that includes encounters with other units, Riots and situation evolution
12. Decision Process Traceability	YES	Each entity provides a Log related to the factors affecting their actions
13. Feedback capability	YES	Blue Unit moving among cells of an ethnic group affects the population evolution and the eventual creation of a Riot
14. CGF simulated - single entity	YES	A single entity is representing the agitators that change the attitude of the demontration/riot
15. CGF simulated - team	YES	The militia unit is corresponding to a team
16. CGF simulated - squad	YES	The Blue Unit in patrol corresponds to a Squad
17. CGF simulated - platoon	YES	The Blue Unit providing support corresponds to a Platoon
18. HLA Integration	YES	Reports about actions and events are distributed as interaction in the HLA Federation during Simulation Runs

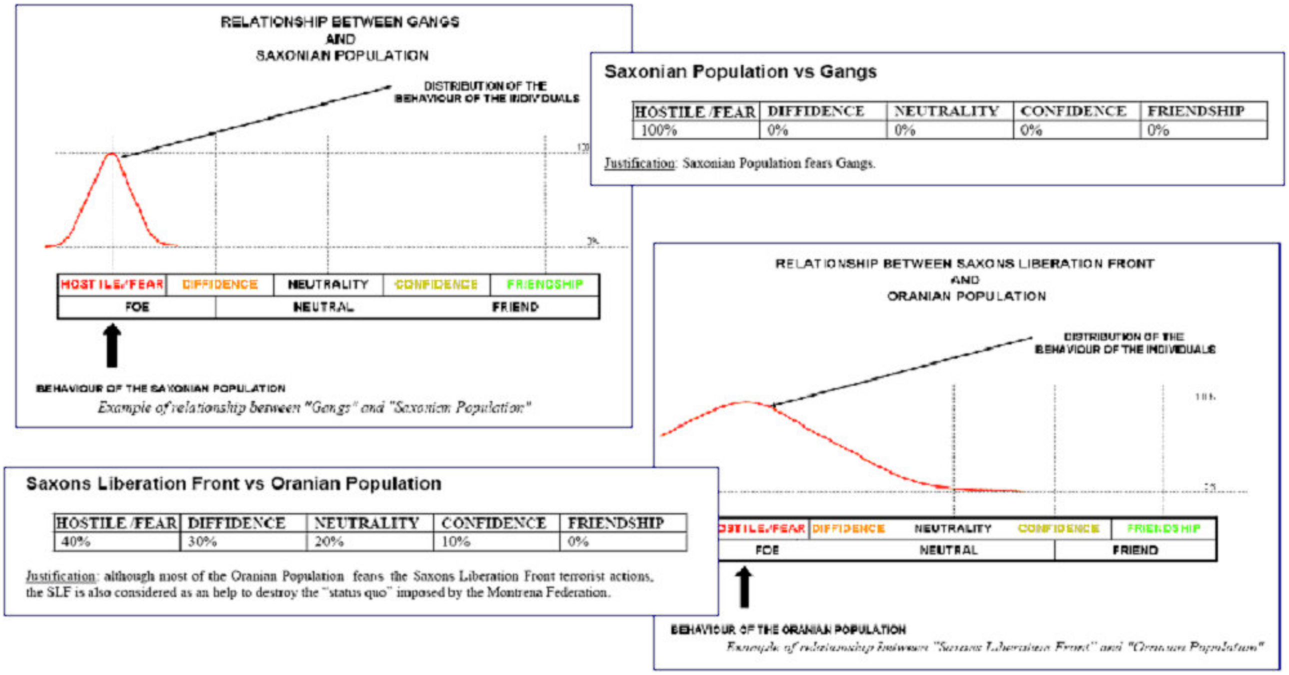

Figure 3. Mutual Influence among different ethnic groups related to actions in PIOVRA

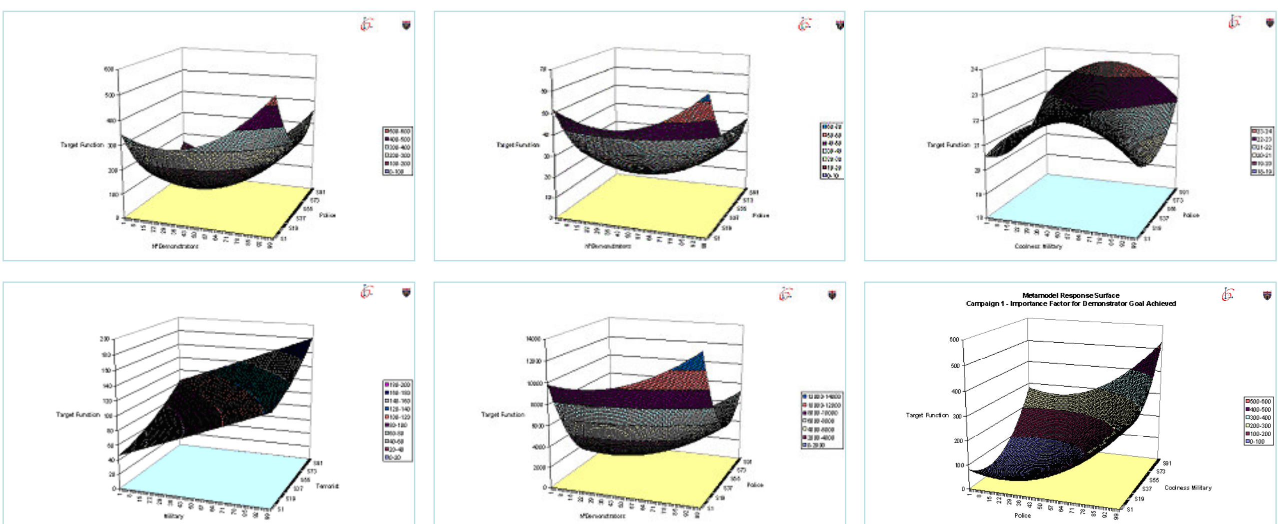

Figure 4. Example of Response Surface Methodology and Design of Experiments obtained by running PIOVRA scenarios and correlating urban stabilization metrics with operational planner actions.