CGF for NATO NEC C2 Maturity Model (N2C2M2) Evaluation

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ABSTRACT

Since Command and Control (C2) in a Network-Centric Environment (NEC) introduces challenges, an approach must be developed to support training in such a framework and to investigate parameters such as reliability, efficiency and effectiveness within credible complex scenarios. The aim of this paper is to develop interoperable CGF (Computer Generated Forces) to create complex scenarios devoted to evaluation and training on the NATO NEC C2 Maturity Model (N2C2M2). C2 does in fact focus on organizations, while NEC requires mature models that consider each single entity in relation to the entire information flow. In addition, C2 is effective only if information flows are reliable, consistent and influential. In this sense a mature model must take into account different approaches and methodologies designed to identify inaccurate or non-influential pieces of information. Thus, different architectures need to be tested, reproducing "intelligent" information processing. Considering these aspects, interoperable CGF designed to direct entities and to operate C2 in NEC allows us to simulate information sharing by applying various criteria and thus to identify more appropriate C2 policies. In this paper the authors describe how CGF can be used to create and develop scenarios and to verify the real performance of new network maintenance policies and/or improvements in network robustness in addition to in-network functions (i.e. in-network data fusion and aggregation, and routing). A very important aspect is related to the effect of human factors affecting elements in the organizations involved in C2 (i.e. stress). It is evident that a C2 Mature Model should include these HBM (Human Behavior Modifiers). The authors propose an innovative methodology based on interoperable models integrated in an M&S environment aiming at testing the N2C2M2. The key to obtaining successful results is to create a Networking M&S environment that interoperates with new CGF. These CGF can be utilized to train on complex scenarios, taking into account technological, functional as well as procedural aspects.

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INTRODUCTION 1

Considering current worldwide events, military and civilian organizations are under great pressure to train their people to deal with the ever-changing battlefield. The simulation has helped solve this training problem by reducing costs and increasing the number of scenarios that can be investigated. Computer Generated Forces are tools designed to support this kind of simulation.

Computer Generated Forces (CGF) are automated or semi-automated entities (such as tanks, aircraft, infantry) in a battlefield simulation that are generated and controlled by a computer system, perhaps assisted by a human operator, rather than by human participants in a simulator.

Three possible types of CGF implementation are critical:

- *Training*. Training simulations, in general, are designed to induce learning of some kind in (human) participants. CGF systems are often used in training simulations to improve participants' skills and their interoperation.
- *Analysis*. CGF systems are also used to generate entities in battlefield simulations used for non-training purposes, such as analysis and experimentation. The analysis is used to test diverse scenarios to obtain results from various situations.
- *Experimentation*. The experimentation application is similar to analysis, in that the simulation and CGF system are used to answer questions, but in experimentation the questions are more open-ended and exploratory.

After less than twenty years of growth in military simulation environments, CGF appears to be at a new stage in its evolution with regard to both design and development trends. In fact, today, domain experts are talking about a "third revolution". After having totally or partially acquired modularity/composability capabilities ("second revolution") and providing significant enhancements in terms of main model accuracy, some other aspects must be tackled, such as:

- Full level interoperability and real time distributed simulation;
- Defining moderators (fatigue, stress, etc…) for human behaviour models which usually represent perfect soldiers;
- Enhancement of (and often providing) representation of low intensity conflict, multi-sided, without clearly identified friends, enemies or neutrals, civilians, non-governmental organizations, in urban environments, etc.

The first point can be considered the pipe dream of every institutional client (and the US DoD administration in particular): systems are expected to work together, exchange data, perform distributed computing, allow some benchmarking, etc. Such a situation can be implemented to rationalize the efforts that have been made to the present with regard to project costs or the high level of redundancy between tools.

Redundancy concerns a general set of systematically offered functionalities and another larger set of much more specific functionalities that are rarely provided. The proposed strategy consists in the design and development of a set of specific tools for particular aspects, plugged into a central system that provides functionalities. These tools must be able to communicate using a standardized protocol and language. Specialization of such a development approach increases the chances of success as the quality and accuracy of results improve. The other way to tackle the first issue is to define and diffuse standard representations of some CGF components, like scenarios with MSDL (Military Scenario Definition Language). For the two other points the situation is more complicated. Accuracy and realism of modeled

behaviors mainly depend on the level of aggregation/de-aggregation accessibility for a model. Thus, such a capacity relies on the cognitive models used to make decisions when human entities are managed and fully simulated.

Last year the MISS DIPTEM Simulation Team developed PIOVRA (Poly-functional Intelligent Operational Virtual Reality Agents) CGF, demonstrating their potential in modeling human behavior of civilians, neutral entities as well as complex stabilization scenarios with riots, demonstrations, gang activities, etc.

PIOVRA CGF are designed to implement high-level capabilities to demonstrate intelligent behaviors within a predefined analysis range: i.e. cooperative actions among CGF, self organization, intelligent movement to avoid risks, ability to reproduce human behavior in terms of stress, fatigue, aggressiveness, fear, etc.

These CGF are important in usual scenarios, but become very critical when many elements must be introduced into an exercise characterized by dynamically evolving behavior and not clearly directed or affected by HBM that have an effect on their capabilities. With regard to netcentric warfare it becomes evident that a large set of CGF with the previously mentioned characteristics becomes very critical. In fact, we need to reproduce the interaction of widely distributed resources that instead of being involved in force-to-force operations must meet new challenges and carry out new types of tasks.

In such a context the network plays a crucial role as it directly impacts the information flow and therefore the situation awareness of the CGF units. Accordingly, network models should be included in the simulation environment recalling that the information flow is a function of the CGF behaviors and achievements and that it influences CGF behaviors. Including network modeling in the simulation is also essential because strategies cannot ignore the impact of certain choices on network performance. On the contrary, strategies should consider the establishment of the communication network, its management and operations as well as its task of protecting the strategic goals to be achieved.

In fact, for this paper the authors have focused on a main goal: to support CAX involving new policies related to netcentric warfare and the NEC C2 Maturity Model initiative in particular. In this case the CGF are essential to demonstrate benefits, criticalities and new issues regarding centralized vs. netcentric policies. The users of such an exercise will learn how to use these new opportunities and to improve their communication and operative logistics skills and the extent of their interoperability. For instance, they will learn how to visually monitor the battlefield in order to solve contingency ammo problems and how to manage the delivery of such ammunition, learning/creating new procedures.

CGF STATE OF THE ART 2

According to a survey on CGF and based on the authors' previous experience in current trends, we can highlight the following:

- Improvements in human behavior models at the level of individuals or small groups.
- Interoperability and federation of M&S tools (despite HLA and others). Command posts not only require a response to a specific combat threat, but also a solution that reduces M&S investments, fosters interoperability and reutilization in various M&S domains and meets future requirements.
- Development of specialized tools and models for MOOTW (Military Operations Other Than War), for instance in urban environments with great variability of involved agents and goals.

Verification and validation of models and outcomes could also be included in this list, but these recurrent topics and needs are not specific to the current stage of evolution. To illustrate the first point it is important to understand the real trend and impasse that designers are tempted to tackle, exploiting the accessibility provided by present-day technology. Such a problem has already been thoroughly detailed [11]. Human decision making depends largely on mental models of the situation within which the decision is to be made. These mental models usually take the form of enactive (mental) imagery. There is currently an implicit assumption that the best mental model in this context is an information-rich picture. This assumption leads to the provision of IT that focuses on the delivery of increasing quantities of data. This can be observed in the continuing quest to provide greater bandwidth to Command Posts (CPs).

Another increasingly important issue is that of embedded simulation tools. Surdu, Haines and Pooch, who believe that this kind of capacity should be added to the CGF system, have listed the properties that an operationally-focused simulation should be able to use during operations [15]:

- The simulation must run from a single workstation with a single user;
- The simulation must run on low-cost, open systems with multi users and in multi-platform environments;
- The simulation must be capable of running in slow time real time and fast time;
- The simulation must be able to receive and answer queries from external agents.

Needs for using HBM and Intelligent CGF in NEC C2 Maturity Models 2.1

In this paper the authors focus on organizations, considering them as complex systems due to the fact that they are driven by human behavior and that the related performance results are strongly affected by HBM (Human Behavior Modifiers).
Artificial Intelligence (AI) offers suitable tools to deal with these types of problems. In particular, according to D. Fogel: "*…the ultimate A.I. breakthrough would be the creation of a machine that can learn or otherwise change as a result of its own experience…"*
In many simulation sessions SW or Intelligent agents can be used to inoculate newer and smarter CGF, Specialized soldiers/platform/capabilities, PSYOPOS and CIMIC in CAP/CPX. As previously mentioned, the authors are developing new opportunities for integrating advanced human behavior hierarchical models, obtained from PIOVRA and Capricorn (CIMIC and planning in complex realistic networks). Capricorn is a research project designed to develop capabilities in the complex Military Operational Planning sector by using CGF.
In fact, we observe that CGF are suitable to:

- Create scenarios;
- Focus on the important aspects of human factors.

The last point is of particular importance in order to determine NATO NEC C2 maturity models; in fact the following is a brief review of the NATO NEC C2 Maturity Model related to the on-going NATO SAS-065 WG activities. For NATO, Network Enabled Capability (NEC) is a high priority alliance goal. NATO is thus in the process of developing a maturity model to improve force capability and transformation. Achieving this goal clearly depends on the development of an appropriate approach to NATO Consultation, Command and Control and the identification of a corresponding Command and Control (C2) Maturity Model. In general, in order for NATO and its member nations to meet the challenges of the 21st century a coalition force must be created that pursues related but not identical goals. This ensemble consists of a number of 'contributing entities', both military and non-military, from the various NATO nations (and also from non-NATO countries, international organizations as well as NGOs and PVOs). The heterogeneous make-up of the enterprise implies that no single element is 'in charge' of the entire endeavor. In looking at the overall "Collective" (i.e. multiple, loosely-coupled organizations that might work together if in their best interest, or sometimes for the greater good or a collective purpose), there is no single person or organization that has overriding authority. The interactions between and among these contributing elements must be considered in terms of the Physical, Information, Cognitive, and Social Domains. This also clearly implies a strong commitment in the analysis and development of continuous and up-to-date innovative training procedures. Five levels of C2 maturity have been defined in the SAS-065 C2 Maturity Model. These five levels and their relationship to the NEC Capability Levels are depicted in Figure 1.

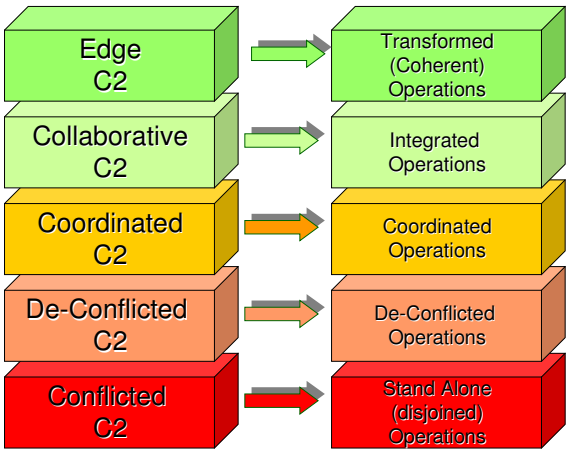

Figure 1. Relation between C2 Maturity Levels and NEC Capability Maturity Levels

It's interesting to note the "geometric" approach to Command and Control. We can see the maturity models in the C2 approach space where C2 Maturity Levels occupy a region defined by the following parameters:

- Allocation of decision rights,
- Patterns of interaction,
- Distribution of information.

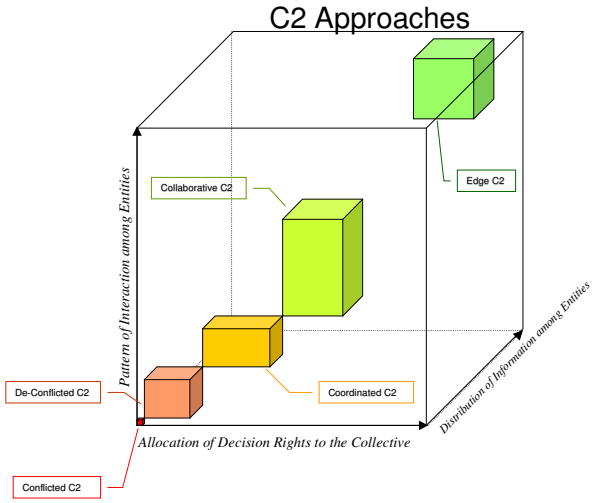

Figure 2. NEC Models and C2 Approaches

Normally the concept of the C2 approach is applied to a single organization. We are interested in the treatment of complex endeavors involving two or more entities and where one or more of the following conditions exists: the entities have a degree of common intent; the entities are operating in the same space at the same time; and, the actions taken by an entity can come into conflict with those taken by other entities. The temporal dynamics of the situation and the timeliness requirements associated with a response can vary widely.

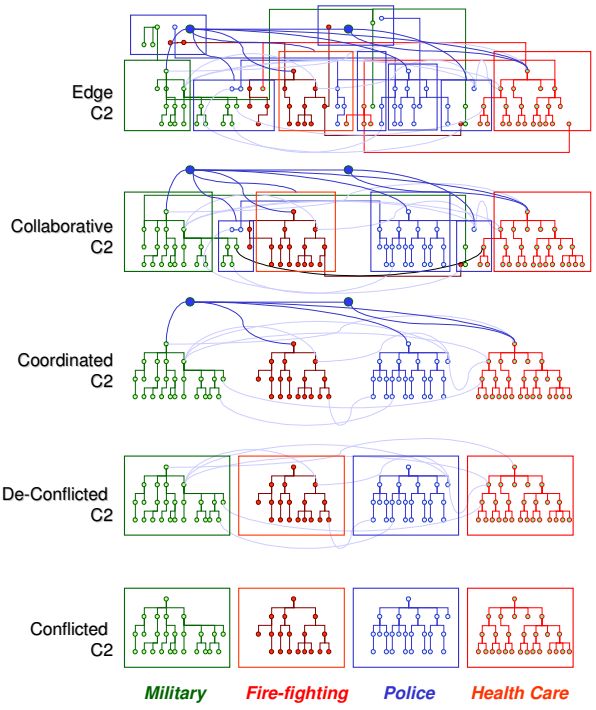

Figure 3. Example of NEC Maturity Models

A mapping could be done among network parameters (i.e. BER, Throughput, etc) for being correlated based on simulator results and C2RM reference variables (Network Reach, Information Transfer Approach, Network Assurance, Network Reliability.....); obviously the network model requires proper resolution and parameter aggregation for being efficiently related to C2RM. Therefore it is critical co correlate the network models with HBM and Operation Simulation to get real benefits in training and scenario analysis. To determine the maturity models we need to study the decision-making level approach. Generally speaking the approach is based on genetic algorithms (GA). GAs are based on the evolution of living beings, in the biological sense of the term. Hence, they are suitable for optimization problems, but cannot be used as a general tool for modeling human decision making simulations. The decision module evaluates the various causes of actions and ranks them according to a set of pre-determined and derived criteria. More specifically, development of fuzzy set theory and fuzzy logic was motivated, to a great extent, by the need for a computational framework that can deal with this type of complex system. The Italian Army is improving its synthetic environment with brand new software agents in order to obtain more precise and deductive rules in the training and experimental fields. The authors are going to use those Fuzzy logic and Data Fusion tools with the aim of defining a Maturity model.

Legacy Systems to be evaluated 2.2

Currently, the authors are working to identify the legacy systems to be used in the development of this new training solution based on the previously outlined considerations. It also becomes critical to define the actions to guarantee their interoperability. The authors are considering the possibility of federating GESI, an acronym for the German words “gesellenschaft simulationen”, and PIOVRA, and to use them to simulate our C4ISTAR during the CAX. PIOVRA was designed as an HLA simulator and has been demonstrated with other wargames.The authors are currently evaluating the efforts and detailed activities needed to create a new federation with benefits on existing features. Therefore, it is evident that in order to integrate the C4ISTAR system with PIOVRA and GESI it will be necessary to develop new modules and to consider new variables and aspects. The communication network will be simulated through OPNETTM, an event driven communication network simulator which can be included into an HLA federation of simulators. OPNET is commercial software that includes communication equipment modules produced by most telecommunication appliance manufacturers. This is the major advantage of OPNET compared to other network simulation software, such as ns-2 and OMNET++. Since inclusion in the HLA federation occurs in accordance with a publish/subscribe discipline, it is fundamental to identify the most relevant variables.

NEW ARCHITECTURE REQUIREMENTS 3

Presently, Battle Labs need to run the same scenario (with different data) hundreds of times so the software agent can carry out this activity. The Software agent can leave traces and evidence in log files. This is one of the best instruments for analyzing and measuring experimental data (e.g. including those related to new TTPs and Doctrine). In addition, human factors such as

stress, fear, fatigue, etc. have a very strong influence on all the decision-making steps and, in particular, on the following topics:

1. The strategic Corporal-How can he affect C2?
2. Every soldier is a sensor-How can he affect C2?
3. Isolation syndrome?
4. Using communication tools-Human Factors?

They should be studied to minimize incidents like the one that occurred on 4/3/2005 in Iraq when a soldier, M.L.Lozano, shot N.Calipari, an Italian SISMI agent. Another incident, which demonstrates how fatigue and fear can affect C2, took place near Herat, Afghanistan, at the beginning of May 2009 when soldiers of an Italian convoy opened fire on a civilian car.

The scenarios can be replicated and injected into CAX for training operators, but it is very different from how scripts are currently prepared in order to develop a dynamic reactive framework. The main problems with scripts are:

- very difficult to prepare the scenario
- very rigid situations during CAX with very limited alternative evolution
- very personal evolution based on the subjects involved in managing these resources manually
- factors and variables do not correlate
- very low reliability of the script due to the available background and time constraints

For these reasons it becomes critical to introduce new intelligent CGF as an enabling technology. The authors are currently conducting research with the Italian Army and to this regard there is growing interest in multilevel modeling to create a new federation that combines constructive and virtual simulators, with obvious benefits for PIOVRA CGF.

For the virtual environment, Serious Games (SG) are a suitable solution, especially for training. In fact SG uses attributes and features of typical video games to create educational and engaging learning experiences and to deliver specified learning goals. This is the definition from the SG-ETS Serious Games Engaging Training Solutions project. Many levels of serious games are currently being evaluated to be integrated in the new federation and we are reviewing their principal characteristics.

1. Tools to support learning and role playing, training aids, research and conceptual experiments
2. Convergence of technologies to provide new applications and tools, extending their evolution.
3. Integration with different media and interactive resources, providing social software, collaborative tools and shared resources to create real potential for supporting distributed communities.
4. Close interaction between the LVC (live-virtual-constructive) federation and serious game Cores - for instance CGF, SW-A or other models that can be shared via HLA technology.

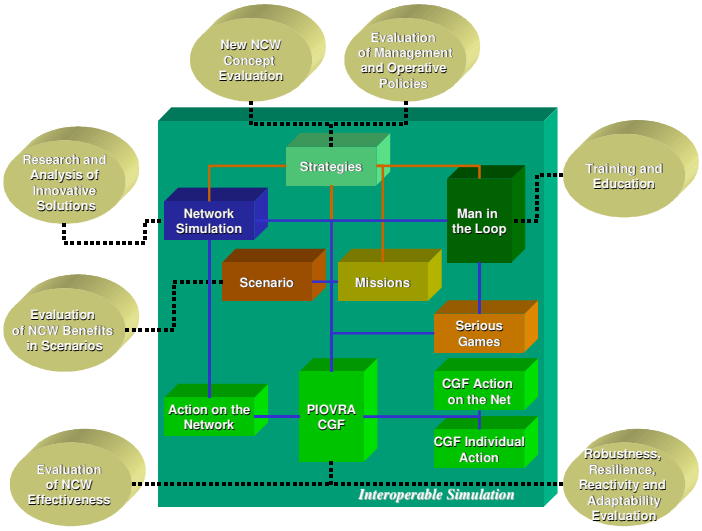

Figure 4. General Architecture vs. Applications

TEST SCENARIO 4

Proper comprehension of the communication flow (c.f.) in C2 is of fundamental importance to understand how human factors influence the decision-making process.

To analyze these topics it is necessary to properly define scenarios that test, verify and validate the models. The authors are working to create a Federation to test different NATO NEC C2 Maturity Levels. A research project is being carried out to federate PIOVRA™, OPNET™, STAGE™ and GESI™ to test NEC maturity models, as shown in the following figure.

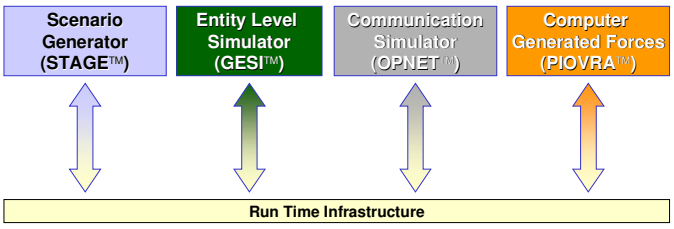

Figure 5. Federation for Initial Testing Activities

As a further development, the authors are interested in carrying out a Virtual Constructive test, integrating CAPRICORN and C4 in the federation as proposed in the architecture reported in figure 6.

In fact the authors already created scenarios in STAGE™ (scenarios generator) interoperating with SGA, a Technological demonstrator (DT) for CESIVA (Center for Simulation and VV&A), excellence center of the Italian Army.

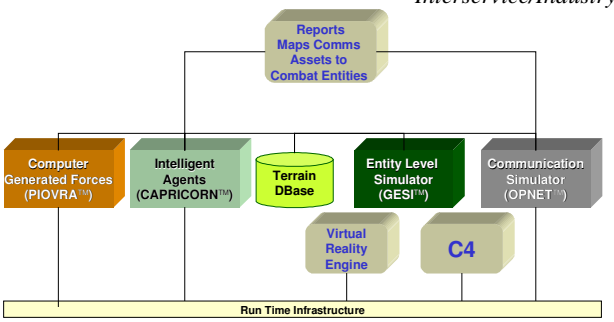

Figure 6. Final Architecture of Federation

CESIVA used SGA to study and validate the BIT (Integrated Terrestrial Brigade) architecture by developing a scenarios; for instance a patrolling operation is proposed as a test micro-scenario (inspired by current cases in Afghan villages); the graphic representation of this demonstration is proposed in the following figure

Figure 7. MicroScenario Simulation Animation

In the current scenario some patrols move and exchange radio signals with a Post Command (PC). A simulator models communications considering coverage and procedures along the command structure. The scenario includes military units, opposing forces, health care, police organizations as well as the population.

The scenario also includes hidden threats (i.e. snipers and insurgents) in the civil population, while the military, health care and police operate in this framework. The user must properly define performance metrics. In this case the authors propose to define the major steps involved in processing threats: detection, identification, engagement and clearance.

For this kind of evaluation it is necessary to define the Measure of Effectiveness (MOE). For the proposed micro-scenario it could be something like: "to determine the capability of Forces to manage the threats in the proposed scenario through different policies, organization and infrastructures in terms of exchanging data, sensors, information and management reports and in terms of handling responsibilities, actions and tasks". In this case, for the sake of simplicity, the authors propose a very basic Measure of Performances (MOP) that correlates available force and time effectiveness:

$$MOP_d = k_{Act} \frac{FEL_b}{FEL_{ref}} \cdot \left(\frac{t_d}{t_{Act}} \right)^{-1} \quad (1)$$

$$MOP_i = k_{Id} \frac{FEL_b}{FEL_{ref}} \cdot \left(\frac{t_i}{t_{Act}} \right)^{-1} \quad (2)$$

$$MOP_e = k_{Eng} \frac{FEL_b}{FEL_{ref}} \cdot \left(\frac{t_e}{t_{Act}} \right)^{-1}$$

$$MOP_c = k_{Clr} \frac{FEL_b}{FEL_{ref}} \cdot \left(\frac{t_c}{t_{Act} + \Delta t_{Clr}} \right)^{-1} \quad (3)$$

$$MOP_{All} = MOP_d + MOP_i + MOP_e + MOP_c \quad (4)$$

$MOP_{d,i,e,c}$	Performance Index on the Target Function (TF): detection (d), identification (i), engagement (e), clearance (c)
$t_{d,i,e,c}$	time of achievement of the TF, in case of failure $\rightarrow\infty$
t_{Act}	expected threat activation time
Δt_{Act}	reference delta time expected to engage and clear the threat
$k_{d,i,e,c}$	Coefficient for Target Function
FEL_b	Blue Force Equivalent Level
FEL_{ref}	Reference Force Equivalent Level
MOP_{all}	Overall Performance Index

Therefore, in case of failure in achieving any of these target functions (detection, identification, engagement and clearance) the corresponding MOP scores zero based on the assumption as described above.

Currently the experimental analysis focuses on investigating the different performances in each scenario configuration with respect to alternative maturity models, concentrating in particular on the conflicted, de-conflicted and coordinated aspects. The scenario considers the proposed human factors and the psychological factors with respect to the C2 architecture in particular. The experimental analysis should be based on Design of Experiments in order to carry out sensitivity analyses on the target functions with respect

to controlled variables (i.e. maturity level, stress level of the units, training level of the units and isolation factor level of the units). Obviously, any experimental results are strictly related to the specific scenario configuration and due to the complexity of the model, which is extremely non-linear, results cannot be generalized. Therefore, this approach can be used to create specific scenarios, properly set their configuration and conduct detailed experiments by means of a quantitative analysis based on simulation runs.

CONCLUSIONS 5

The paper will provide a proposal for defining what is needed for CGF to be effective in evaluating NEC C2 Maturity Models and to operate considering the constraints imposed by existing scenarios and realistic frameworks. The main goal is to provide guidelines and metrics for guaranteeing that their capabilities will be able to support both training and experimental analysis in this context. The project is currently in the demonstration phase and the concepts hereby proposed are currently being used to develop the framework and complete the first experimental design and simulation campaign.

It is evident that this scenario framework represents a complex case where stochastic factors have a great influence, so statistical analysis techniques are required to guarantee proper validation and verification of the proposed approach and to provide an effective measure of the intelligent agent performances. By using this approach it will be possible to move from an old script to a new interactive intelligent framework and to test the different maturity level models with the trainees.

REFERENCES

Alberts David S., Gartska J.J., Stein F.P. (2000) "*Net Centric Warfare"*, CCRP, Washington

Alberts David S., Hayes Richard E., (2006) "*Understanding Command and Control"*, Washington: CCRP, fig. 11, p. 35

Alberts D.S., Hayes R.E. (2003) "*Power to the Edge*", CCPR Publications, Washington D.C.

Alberts, D.S. (2007) "Agility, Focus, and Convergence: The Future of Command and Control." The Int. C2 Journal, Vol. 1, No. 1, 1-30

Alberts, D.S. (2008) "NATO NEC C2 Maturity Model Overview," Draft for Peer Review, SAS-065 Study Group, 2008.

Anderson N. (2006) "Are iPods shrinking the British vocabulary?", *Ars Technica On-Line Magazine*, December 15

Bruzzone A.G. (2008) "Human Behavior Modeling: Achievement & Challenges", *Invited Speech at SIREN Workshop*, Bergeggi, Italy, June 6th

Bruzzone A.G., (2007) "Challenges and Opportunities for Human Behaviour Modelling in Applied Simulation", *Keynote Speech at Applied Simulation and Modelling*, Palma de Mallorca

Bruzzone A.G., Viazzo S., Briano C., Massei M. (2004) "Modelling Human Behaviour in Industrial Facilities & Business Processes", *Proc. of ASTC*, Arlington, VA, April

Bruzzone A.G., Massei M., Simeoni S., Carini D., B.M. (2004) "Parameter Tuning in Modelling Human Behaviours by Using Optimization Techniques", *Proceedings of ESM*, Magdeburg, Germany, June

Bruzzone A.G., Figini F. (2004) "Modelling Human Behaviour in Chemical Facilities and Oil Platforms", *Proceedings of SCSC*, San Jose

Bruzzone A.G., Mosca R., Simeoni S., Massei M., B.M., B.C., (2004) "A Methodology for Estimating Impact of Different Human Factor Models on Industrial Processes", *Proceedings of EUROSIM*, Paris, France, September

Bruzzone A.G., Page E., Uhrmacher A. (1999) "*Web-based Modelling & Simulation*", SCS International, San Francisco, ISBN 1-56555-156-7

Bruzzone A.G., Giribone P. (1998) "Decision-Support Systems and Simulation for Logistics: Moving Forward for a Distributed, Real-Time, Interactive Simulation Environment", *Proc. of the Annual Simulation Symposium IEEE*, Boston

Bruzzone A.G., Giribone P. (1998) "Quality Service Improvement by Using Human Behaviour Simulation", *Proceedings of ESM*, Manchester, UK, June

Bruzzone A.G. (1996) "Object Oriented Modelling to Study Individual Human Behaviour in the Work Environment: a Medical Testing Laboratory ", *Proc. of WMC*, San Diego, January

Buckman T. (2005) "NNEC Feasibility Study", *Tech Report NCOIC Plenary Meeting EAPC*(AC/322)N(2006)0002, NATO

Cantice G. (2008) "Serious Games... Serious Experimentations?", *Proc. of SeriGamex*, November

CTA (2002) "Agents for Net-Centric Warfare and Time Critical Targets", *CTA Technical Report*

Fogel D. (2005) "Volutionary Computation-toward a new philosophy of machine intelligence", *IEEE Press series on Computational Intelligence*

Goldstein J. (2007) "Trial in Absentia Is Ordeal for Veteran Who Was Cleared by U.S. in a Killing", *NY Sun*, July 16

Krulak C.C. (1999) "The Strategic Corporal: Leadership in the Three Block War" *Marines Magazine*

Ladner R., Petry F. (2005) "*Net-Centric Web Approaches to Intelligence and National Security*", Springer, NYC

Ladner R., Warner E., Petry F., Katikaneni U., Shaw K., Gupta K., Moore P. (2009) "Web Services: Evolving Techniques in Net-Centric Operations", *Proceedings of MTS/IEEE OCEANS*,

Liddy L. (2005) "The Strategic Corporal: Some Requirements in Training and Education", *Australian Army Journal*, Volume II, Number 2, 139-148

Molagh J. (2009) "How Afghanistan's Little Tragedies Are Adding Up", *Time*, May 26

Moniz D. (2002) "Afghanistan's Lessons Shaping New Military", *USA Today*, October 7

Mosca R., Viazzo S., Massei M., Simeoni S., Carini D., B.C. (2004) "Human Resource Modelling for Business Process Re-Engineering", *Proceedings of I3M2004*, Bergeggi, Italy, October

Patton M.S. (2003) "ES2: Every Soldier is a Sensor", *The Washington Post*, November 5

Ray D.P. (2005) "Every Soldier Is a Sensor (ES2) Simulation: Virtual Simulation Using Game Technology", *Military Intelligence Professional Bulletin*

Reverberi A. (2006) "Human Behavior Representation & Genetic Algorithms Characteristics Fitting", *Invited Presentation on Piovra Workshop*, Savona, February 7

Viazzo S., B.M., B.C. (2005) "Human Behavioral Models For M&S Applications", *Proceedings of ESS2005*, Marseille, 20-22 October

Warne L., Ali I., Bopping D., Hart D., Pascoe C. (2004) "The Network Centric Warrior: The Human Dimension of Network Centric Warfare", *Tech.Report DSTO*, Edinburgh, Australia