Experimentation on CIMIC and PSYOPS Simulators

Agostino Bruzzone[(a)], Francesca Madeo [(b)], Claudia Frydman [(c)], Simonluca Poggi [(d)], Marina Massei [(e)], Gregory Zacharewicz [(f)]

[(a)] DIME, University of Genoa - URL www.itim.unige.it
[(b)] Simulation Team - *URL* www.simulationteam.com
[(c)] LSIS Marseille - *URL* www.lsis.org
[(d)] MAST srl - *URL* www.mastsrl.eu
[(e)] Liophant Simulation - *URL* www.liophant.org
[(f)] IMS Bordeaux University - *URL* www.ims-bordeaux.fr

[(a)]agostino@itim.unige.it, [(b)] madeo@simulationteam.com, [(c)] Claudia.frydman@lsis.org, [(d)] simonluca.poggi@mastsrl.eu, [(e)] massei@itim.unige.it, [(f)] gregory.zacharewicz@u-bordeaux1.fr

ABSTRACT

The research proposes a simulation model developed by the authors to support CIMIC (Civil- military cooperation) and PSYOPs (psychological operations) operational planning in complex scenarios (i.e. Afghanistan) characterized by crisis and conflicts.
The research is related to CAPRICORN R&D Project (CIMIC and Planning Research In Complex Operational Realistic Network), sponsored by EDA (European Defense Agency). The CAPRICORN model is based on a new generation of IA-CGF (Intelligent Agents for Computer Generated Forces) that is developed by the authors and is able to reproduce human factors as well as social and cultural aspects within the population. The authors provide the experimentation approach used to validate and test the model by strongly involving users and SME (Subject Matter Experts) and present the experimental analysis of results based on Design of Experiment techniques: MSpE (Mean Square pure Error) and sensitivity analysis.

1. INTRODUCTION

In the last decades, in countries such as Kosovo, Afghanistan or Iraq, characterized by conflicts and civil wars, after the pure coercive military actions, it is becoming necessary to face new post-conflict threats such as terrorism, insurgency or economic disruptions by engaging military forces in stability operations (Galula 1964; Chauvancy 2011). The main goal of this kind of operations is to recover social, economic and political conditions in these countries.
Therefore military defense is facing new issues and challenges and new activities are emerging such as Civil Military Cooperation (CIMIC) and Psychological Operations (PSYOPS) (Kallmeier et al. 2001). The CIMIC and PSYOPS operations now days constitute a significant portion of the total military effort. In effect, the forces engaged in operations not Art. 5/St.Petersburg, both for their value in the territory that for the external visibility of the operations themselves, are under the world opinion evaluation (Haugh 2000; Hue 2007; AJP-3.10.1; AJP-9).
CIMIC and PSYOPS are critical issues in S&R (Stabilization and Reconstruction) operations as well as during Stabilization and Normalization phases of most of current scenarios (Rehse 2004; Rietjens & Bollen 2008).
The authors present CAPRICORN Project that is devoted to the creation of new IA-CGF specific for the simulation of CIMIC and PSYOPS, able to consider key operational and territorial factors, and to the development of a demonstrator, able to show Modeling and Simulation potentials and capabilities in supporting Operational Planning (Bruzzone, Frydman & Tremori, 2009; Bruzzone et al. 2010). In effect Simulation represents one of the most important approaches to address this context even due to the high influence of stochastic factors and the complexity of the system, including social, economic, political, cultural and psychological aspects (Amico et al. 2000).
This paper proposes an overview of CAPRICORN Project concepts and Models and present the experimentation carried out to test and validate the proposed simulation model.

2. CAPRICORN PROJECT OVERVIEW

The research is related to CAPRICORN R&D Project (CIMIC and Planning Research In Complex Operational Realistic Network), that is an EDA (European Defense Agency) project sponsored by Italian and French Ministry of Defense and it is devoted to the development of capabilities in the complex and critical sector of Military Operation Planning, specifically for Not-Article5/San Petersburg Operations (Bruzzone, Frydman, Tremori 2009). CAPRICORN Project was lead by DIPTEM University of Genoa in partnership with LSIS, MAST srl and ITESOFT (acting as subcontractor of LSIS) and patronage from Liophant Simulation and Simulation Team.

The CAPRICORN Project main objectives are:

1. Define requirements and features to investigate Basic Operational Planning. One of the final goal is to provide simulation users with intelligent CGF (computer generated forces) and with the capability to elaborate and verify in normalization and stabilization scenarios operational plans foreseeing events where coalition forces, local population and non conventional Op-forces (e.g., terrorism, peace-keeping, peace-enforcing, urban riots, etc.) are involved .
2. Analyze the Human Behavioral Factors to be modeled in order to improve realism and reliability of the simulations results considering aspects related to both psychological and sociological aspects for representing collective behavior (problems: psychology, cultural, social, etc) (Bruzzone 2010).
3. Develop CIMIC, PSYOPS Humanitarian support or other non-conventional operations models by CGF managed by Intelligent Agents (Bruzzone & Massei 2010).
4. Enhanced Interoperable Multilevel Models: improve the PIOVRA project capability for the creation and management of interoperable multilevel models (Bruzzone et al. 2004).

The final goal of the project was to create a demonstrator using the up-to-date development in Interoperable Simulation in order to integrate all the different components in the CAPRICORN Demonstrator/Federation.

Simulators such as CAPRICORN guarantee a methodical simplification and an improved accuracy into the military operational planning processes; in effect the use of simulation in this context speeds up planning generation enabling the development of simpler and emendable plans in accordance with real life elements, scenario evolution and parameters changes (Bruzzone, Tremori & Massei 2011). Therefore in order to be effective in operational planning these simulators require to integrate advanced models and algorithms capable to reproduce complex scenarios as well as a robust and rational Validation and Verification process that should be applicable by users in short term and the limited resources (Bruzzone et al., 2009). CAPRICORN is focusing on identifying the requirements and developing models and algorithms for this application. The purpose is to provide a simulation system capacity to carry out an evaluation of effectiveness of various hypothetical courses of action. In addition CAPRICORN model is designed based on an HLA federation in order to integrate it with other models and tools and simulate in a more realistic and detailed way the effects that may have CIMIC activities (or PSYOPS).

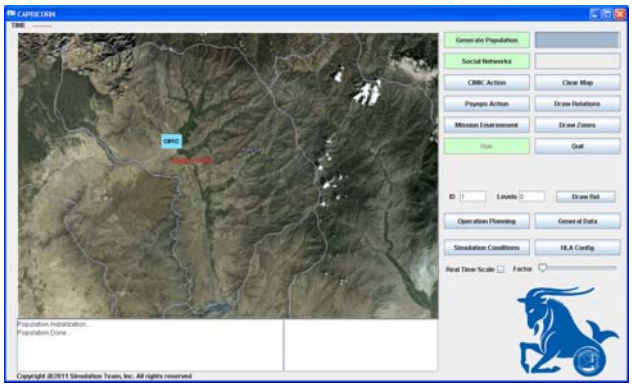

Figure 1. CAPRICORN Demonstrator

3. CAPRICORN MODELS AND KEY ASPECTS

CAPRICORN Simulation Model is based on the concept of Multilevel Modeling. As matter of fact, CAPRICORN Objects are organized by a multilevel approach and some concepts are inspired by PIOVRA models (a previous EDA Project devoted to develop new Intelligent Agents to reproduce units such as Urban Rioters, gangs, police etc.), where the structure was based on Action Objects (entity on the field) and Comportment Objects (Organizations/Groups with specific attitudes). Anyway CAPRICORN context is more complex due to several aspects (Bruzzone & Massei 2007; Bruzzone, Massei et al. 2011) :

- Importance to identify, not only, the HBM and its evolution, but even to direct emotions and attitudes to specific subjects based on the events and actions as well as on the people perception (i.e. an attack to the population should be attributed to the insurgent or to the coalition by a village depending on its point of view and awareness)
- Necessity to model a small region, district or village group in order to support decisions related to activities with an impact on a large area
- Medium Long Time Simulation with more articulated effects of HBM (Human Behavior Modifiers) respect short time simulation
- Necessity to model the change of attitude and profile of the population along time simulation as result of CIMIC/PSYOPS activities

- Higher importance of Social and Cultural Background in addition to psychological factors (i.e. religion, ethnic group)

Due to these reasons the CAPRICORN models have a specific structure tailored for these cases; in particular the objects related to modeling the humans in CAPRICORN are represented in two major classes: People and Groups; People and Group classes are the basis to instantiate objects; each of this object will be driven by an intelligent agent in coherence with its characteristics, history and scenario awareness (Bocca et al. 2007; Bruzzone 2008).

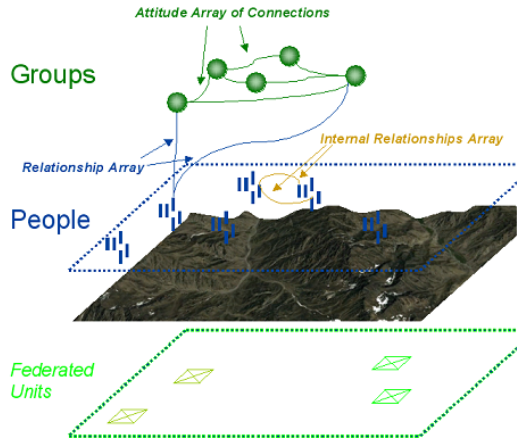

Figure 2. CAPRICORN Multilevel Model & Conceptual Architecture

The People Layer reproduces the individual and small group/entities. In addition in CAPRICORN there is a specific class for representing units on the field (i.e. a platoon taking care of patrolling activities, intelligence assets, logistics units, NGO), while CAPRICORN Action Object are devoted to reproduce Units and Special Entities operating on the field, in addition Activity Objects represent activity or task that could require People, Action or Group support and that are used to model the CIMIC and Psyops Courses of Actions.

A new challenging issue is related to Social Network Modeling in term of relationships generation and evolution (Bruzzone et al.2009). People Objects in CAPRICORN represent elements of the population and they have their own social network at their level; this network is defined by links (i.e. family, work position). Therefore in addition to these social networks the People Objects could be related even to higher level entities defined as Group Object (i.e. interest groups such as farmers or elders); however the dependence of People and Group objects could be structured on multilayers.

In fact Group Objects are even related among themselves; and each people object could be linked to several Group Objects as well as to several other people objects, in similar way group objects could be related each other.

In addition relations are even used to model all the links referring to People attitudes; these relations are not just discrete set of values (i.e. neutral, foe, friend), but results from the belonging to groups and to people/unit characteristics by the fuzzy variables; in fact these relations, as all the relations, are defined by using fuzzy representation.

In general the relations are defined in term of type, connected objects and attitude; the attitude is a fuzzy variable able to reproduce smooth and mixed feelings (i.e. friend 5%, indifferent 40%, hostile 55%); there are different kind of links that are classified as following:

- Attitude Connections: these links connect the group objects among themselves, these connections define how strong is the relation and how it is articulated (i.e. negative 30%, neutral 20%, positive 50%)
- External Relationships: this class of links connects a people object with a group object; each people object could be connected to multiple groups and in each relationship it is defined the strength characterizing the link as well as the attitude (i.e. positive or negative)
- Internal Relationships: this class of links connects people object among themselves

So considering the above mentioned list of relationships it is possible to define the structure of the social networks; for instance People Objects are characterized by a list of Internal Relationships that keep memory of family, work and friendship relations through links to other corresponding people objects. Group objects are also characterized by Lists of Attitude Connections. This approach allows to register actions impacts and effects on the single individual through their social network as well as on their group of interest. This means that if an action has a negative impact on a person belonging to a specific group, all the members of that group will be influenced, obviously with an impact that depends on several factors (i.e. attenuation factors, importance of the individual in the group, threshold levels for the perception, etc).

Obviously CAPRICORN Project introduced new intelligent agents specific for CIMIC and PSYOPs operations simulation and to model human behavior modifier, with special focus on trustiness among two people or groups.

In addition for the Population generation, the Group Configuration Objects are introduced in order to generate statistical distributions based on historical data and hypotheses to define people characteristics. These objects identify the different groups in term of social, religious, political, ethnic and physiological aspects. The Population is created for each statistical group in references with their statistical characteristics based on Monte Carlo Technique extracting data from defined statistical distributions based on Group Configuration Objects. Therefore in CAPRICORN the population is

driven by agents and the virtual people are generated by applying Monte Carlo Technique to specific group statistics in order to represent a region. Each agent is assigned to places inside different zones in term of Home and Working location based on compatibility algorithm.

4. CAPRICORN DEMONSTRATOR

CAPRICORN Demonstrator is developed on Windows environment and implemented by using Java language. The CAPRICORN Demonstrator Development is based on the strong involvement of military users for: requirements collection, design, implementation, validation and verification, maintenance (Bocca et al. 2010; Bruzzone & Massei 2011). So, all the results are compared and evaluated with users expectations and requirements. Therefore during the software development, user feedback was very critical during the whole process.
The CAPRICORN Demonstrator includes a Mission Environment Generator and a Simulator; the internal architecture of the Simulator is based on stochastic discrete event simulation and applies Scan and Rescan scheme on the event.

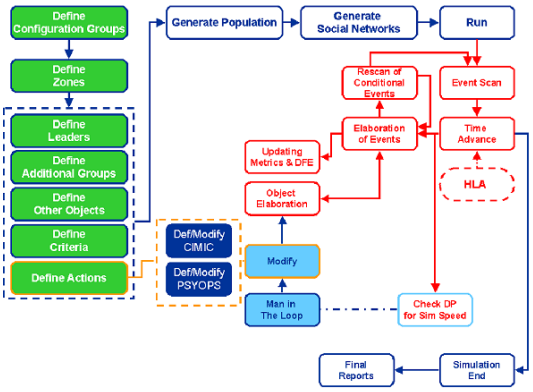

Figure 3. CAPRICORN Acquisition & Simulation architecture within CAPRICORN Demonstrator

The CAPRICORN Demonstrator generates the population and social networks based on Monte Carlo Technique; the people and groups generated interact with the action objects and CIMIC/PSYOPS applying discrete-event methodology; the parameters related to actions and events are regulated by stochastic phenomena (i.e. setting time to be ready to move); dynamically during each simulation and starting from random seed related to the specific experiment, the CAPRICORN Simulation extract by Monte Carlo Technique, the required values from statistical distributions used to reproduce the stochastic factors
The following active functions are provided to the users:
- Mission Environment Definition: before running the simulation, the user is required to set up the Mission Environment by defining all the boundary conditions for a Specific Scenario (i.e. Configuration Groups, Zones & Areas, Leaders, Additional Groups).
- Operational Planning: the user is able to add new actions (CIMIC/PSYOPs) or modify the existing ones before the simulation execution or during the run execution.
- Definition of Simulation Parameters and Run: the user is allowed to set the simulation conditions (such as simulation duration, time factor, HLA mode); to generate the population and the social networks and to run the simulation.

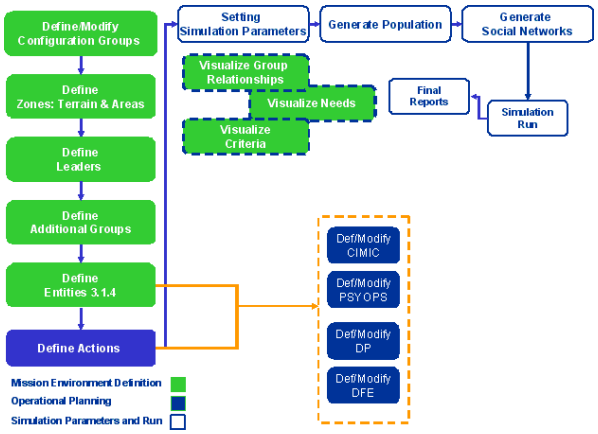

Figure 4. CAPRICORN Demonstrator functions

The CAPRICORN Simulation allows to investigate how a mission plan (CIMIC or PSYOP) affects human behaviour and social network, in particular it provides different outputs related to:

- Information about the action process (phases, time, costs and involved resources)
- Information about the relationship evolution between the groups involved in the action

So the final outputs present the following information:
-CIMIC Phase and correspondent time
- Time, available Cash for CIMIC, available Cash for PSYOP, Relationship ID e Trustiness Level
For instance for a Digging Well operation the reports are like the following:

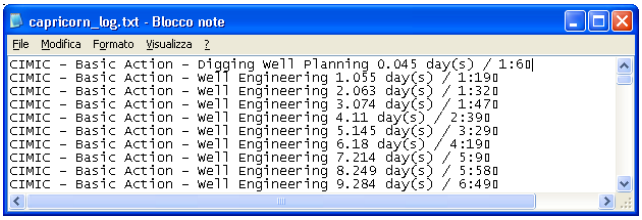

Figure 5. CAPRICORN Report

Obviously it is possible to plan a set of CIMIC and PSYOPs actions in different zones and affecting different groups; so it will be available the overall report including the information related to their development and their impact on the population. CAPRICORN Simulation results are therefore useful to evaluate and test different mission plans in order to take in account the possible effects of these actions on the population behavior.

5. CAPRICORN EXPERIMENTATION

The Experimentation Plan is included in the VV&A (Verification, Validation and Accreditation) Process and it includes two main phases, one devoted to review requirements and involve Subject Matter Experts and military users in order to obtain feedback and comments about CAPRICORN conceptual Models and CAPRICORN Demonstrator Specifications; the second devoted to define together with selected users (CAPRICORN Users Champion) a Specific Mission Environment to be simulated and run (Tremori et al. 2009; Frydman et al. 2011). In particular CAPPRICORN Demonstrator is set in Kapisa, the smallest Afghan Region and it allow to simulate the following CIMIC and PSYOPs operations (Digging Well, Building Police Station, Building a School, Radio Messages, TV Shows, Leaflet). Therefore CAPRICORN Experimentation has strongly involved military users and subject matter experts to:

- collect users requirements
- develop and validate CAPRICORN conceptual models
- define the specific mission environment implemented in CAPRICORN Demonstrator
- validate the Demonstrator functions and features including interoperability capability
- test CAPRICORN Demonstrator and analyze simulation results

Along the whole project several meetings and workshops were held with Subject Matter Experts and Users Champion and CAPRICORN Experimentation is set up to allow users to test directly the demonstrator both in stand alone and federated mode. In particular these events were carried out:

- Preliminary National Testing & Experimentation to finalize details and solve bugs, problems and misunderstanding; this activity is carried out in cooperation by CAPRICORN Partners and CAPRICORN Champions
- Final National Experimentation to demonstrate the CAPRICORN Demonstrator Capabilities and proposed approach; this activity is carried out in cooperation by CAPRICORN Partners and CAPRICORN Champions
- Synthetic Experimentation Presentation to exploit the CAPRICORN Project Result in National MoD Communities; this activity is carried out in cooperation by CAPRICORN Partners and CAPRICORN Champions

6. CAPRICORN EXPERIMENTAL ANALYSIS

The authors provide the experimental analysis carried out through the final reports of CAPRICORN simulation; in effect it is possible to evaluate and test different courses of actions by planning and simulating different CIMIC/PSYOPs in term of type, location, target group, promoting group, duration, budget, resources.

Concerning with the experimental analysis, the authors applied Mean Square pure Error and Sensitivity Analysis for different CIMIC & PSYOP actions by considering a 2-level factorial design respect to the trustiness level as target function.

For instance, considering a CIMIC action Digging Well from COA pro Sunni in Zone 0 the MSpE (Mean Square pure Error) was the following:

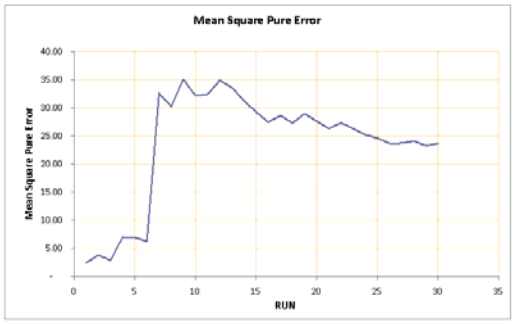

Figure 6. Mean Square pure Error Diagram for a CIMIC action Digging Well from COA pro Sunni in Zone 0 (Run expresses the pure number of replications; MspE express the trustiness variance; Trustiness [-100 to 100])

The Experimental Error is stable between the 26th to the 30th run. So it is possible to state that 26 run are needed for a correct evaluation of the experimental error.

By considering the sensitivity analysis related to the independent variables Resources and Budget, both are significant and have positive effects on the population trustiness level:

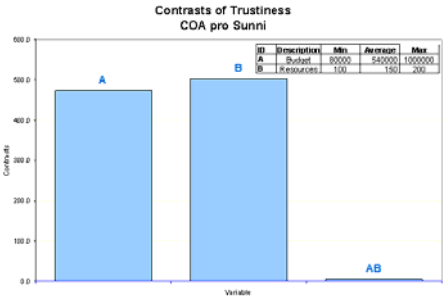

Figure 7. Contrasts Diagram related to Trustiness Target Function respect of Budget and Resources (Contrast represent the influence of a factor expressed respect trustiness as scalar [-100 to 100]; Budget [Euro] and Resource [people])

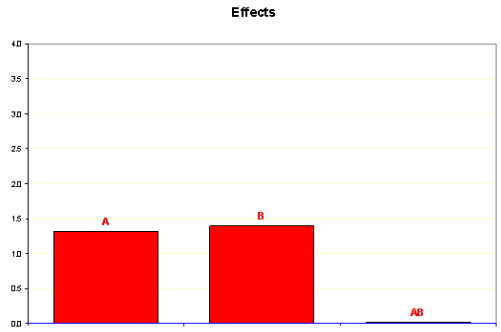

Figure 8. Effects Diagram related to Trustiness Target Function respect of Budget and Resources (Effect represent the influence expressed as ratio between contrast2 and the square pure error of trustiness scalar [-100 to 100]; A is the Budget; B the Resources and AB their combined effect)

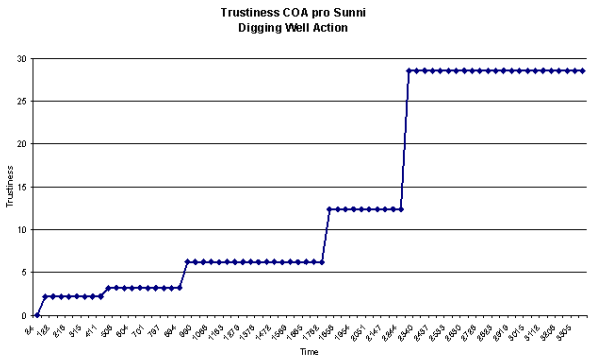

Figure 9. Trustiness evolution during the simulation of a CIMIC action Digging Well from COA pro Sunni in Zone 0 (Trustiness is expressed as scalar [-100 to 100]; Time [h])

Other experiments were carried out by considering different CIMIC and PSYOP actions.
In the following table it is proposed a comparative analysis carried out by ranking solutions in term of trustiness improvement [pure number]

Ranking	*COA*	*Budget*	*Resources*	*Who*	*Where*	*What*	*Trustiness Improvement*
1	**CIMIC1**	**1'000'000**	**200**	**Coa? Sunni**	**Zone 0**	**Digging Well**	**43.79994**
2	PSYOPS1	500'000	200	Coa? Sunni	Kapisa	Radio messages	43.182137
3	CIMIC1	80'000	200	Coa? Sunni	Zone 0	Digging Well	26.775768
4	CIMIC1	1'000'000	100	Coa? Sunni	Zone 0	Digging Well	26.299814
5	PSYOPS1	100'000	200	Coa? Sunni	Kapisa	Radio messages	19.60504
6	PSYOPS2	150'000	150	Coa? Sunni	Kapisa	TV messages	15.526324
7	PSYOPS2	50'000	150	Coa? Sunni	Kapisa	TV messages	13.418227
8	CIMIC1	80'000	100	Coa? Sunni	Zone 0	Digging Well	12.568763
9	PSYOPS1	500'000	100	Coa? Sunni	Kapisa	Radio messages	7.4699154
10	PSYOPS1	100'000	100	Coa? Sunni	Kapisa	Radio messages	4.743664
11	PSYOPS2	150'000	50	Coa? Sunni	Kapisa	TV messages	4.72036
12	PSYOPS2	50'000	50	Coa? Sunni	Kapisa	TV messages	4.118518
13	CIMIC2	150'000	150	Coa? Shia	Zone 4	School Building	1.81875207
14	CIMIC2	50'000	150	Coa? Shia	Zone 4	School Building	0.74382114
15	CIMIC2	150'000	50	Coa? Shia	Zone 4	School Building	0.64544094
16	CIMIC2	50'000	50	Coa? Shia	Zone 4	School Building	0.43958664

Figure 10. Comparative Analysis among Different Course of Actions

In the following figure it is proposed the comparison in term of result distribution between two alternative CIMIC COA (two different budgets); this risk analysis allows to identify the distribution of the results in statistical terms

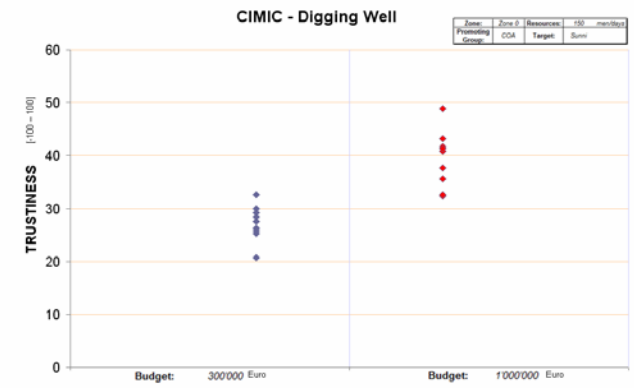

Figure 11. Comparison between two alternative CIMIC COA

7. CONCLUSIONS

The research addresses the problem of providing support in evaluating complex situations dealing with human factors in order to complete scenario analysis or decision making; the context of application is related to operational planning with special attention to stabilization and normalization process and to CIMIC and PSYOPS operations. The authors propose a simulation model, called CAPRICORN, to demonstrate the potential of the M&S use as a virtual framework to investigate alternative hypotheses on the scenario and different decision impacts. This simulator is designed for being used both by operational planners and trainers. Obviously, considering the high influence of HBM (Human Behaviour Modifiers), the resulting simulation solutions are not expected to be predictive tools, vice versa their goal is to estimate risks and confidence bands related to different alternatives.
The authors propose the CAPRICORN Experimentation carried out with military users and some experiments in order to test different alternative actions to evaluate the CIMIC and PSYOPs operations impacts and effects on local population in term of trustiness level.
The proposed experimentation is part of the CAPRICORN VV&A process and it shows the capability to quickly acquire data and analyze different hypotheses by using intelligence report estimation and operational people estimations.

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