Modelling & Simulation Support to the Effects Based Approach to Operations – Observations from Using GAMMA in MNE 4

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ABSTRACT

NATO participates in the Multinational Experiment series (MNE) on the Effects Based Approach to Operations (EBAO). These experiments look on a new concept to plan, execute and assess complex crisis response operations. Modelling and Simulation can help in many ways to support the Effects Based Approach to Operations and can help on the other hand to set up the experimentation environment to develop new concepts.

NC3A supported MNE 4 with its collaborative planning support system EB-TOPFAS (Effects Based Tools for Operational Planning Force Activation and Simulation) and with the simulation and course of action assessment tool GAMMA (Global Aggregated Model for Military Assessment). The paper is based on the experiences of the author supporting the Combined Task Force with GAMMA in MNE 4.

The paper will describe the setup of the experiment and the role of modelling and simulation in MNE 4. The use of GAMMA in the EBAO context will be explained. Major activities and observations will be described. Conclusions and recommendations will conclude the paper.

1.0 INTRODUCTION

Although most (if not all) military and political decision makers must have considered the potential effects of their actions throughout time, Effects Based Approach to Operations[1] (EBAO) is an emerging and improved way of planning and conducting operational campaigns based on a holistic understanding of the operational environment taking all instruments of power of the political, military, civil and economic (PMCE[2]) spectrum into account.

Assistant Chief of Staff (ACOS) Implementation of the Allied Command Transformation (ACT) sees new and broader alliance missions in

- Conflict Prevention and Crisis Management
- Peacekeeping - Humanitarian Operations -Disaster Relief
- Stabilization and Support to Reconstruction

[1] Also known as the Effects Based Operations (EBO).

[2] NATO uses the term PMCE (Political, Military, Civil, Economic) in contrary to the term DIME (Diplomatic, Information, Military, Economic), because as alliance of nations NATO is more acting on a political level than having own diplomatic resources.

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which needs to harmonise efforts with other actors like International Organisations (IOs), National Governments, Non-Governmental Organisations (NGOs) and Industry [1]. Therefore ACT is supporting experimentation and conceptual development which could lead to comprehensive changes in organisation, processes, policy, doctrine, strategy and training and education to enable EBAO for NATO.

Eight nations and NATO support the series of Multinational Experiments (MNE) to test and validate EBAO concepts and tools. The MNE 4 experiment took part in February/March 2006. NATO C3 Agency supported the experiment with EB TOPFAS (Effects Based Tools for Operational Planning Force Activation and Simulation) and GAMMA (Global Aggregated Model for Military Assessment). The experiment showed how important decision support systems and modelling and simulation (M&S) support are for the EBAO concept.

In section 2 of this paper the EBAO concept is briefly explained. Section 3 shows the setup of MNE 4 and discusses the role of M&S in MNE 4. GAMMA is described in section 4. The use of GAMMA in MNE 4 is described in Section 5. Section 6 summarizes the paper with conclusions and recommendations.

2.0 EFFECTS BASED APPROACH TO OPERATIONS (EBAO)

The multinational concept of operations (CONOPS) document [3] developed for MNE 4 describes a sound way of planning and conducting EBAO. It introduces several new operational concepts and defines a process for organizations to carry out EBAO. The NATO Military Committee (MC) has expressed its position on the EBAO and as a result the EBAO Implementation Working Group in NATO is established who is tasked to develop a viable roadmap for NATO with respect to EBAO. The description in this paper is based on the CONOPS (see [2]).

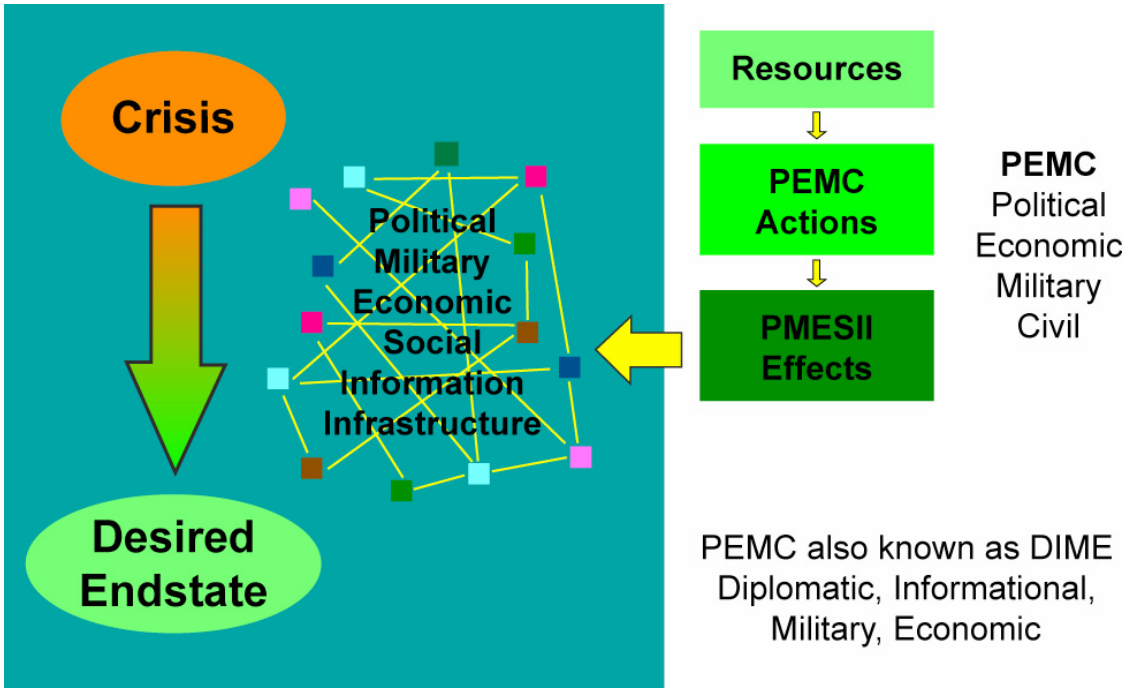

Figure 1: Effects Based Approach to Operations (EBAO)

EBAO is based on a holistic understanding of the operational environment looking at both physical and behavioural aspects of a system (ie conflict state) to be changed taking all instruments of power of the

PMCE spectrum into account (see figure 1). The conflict state is described by its associated PMESII (Political, Military, Economic, Social, Information, Infrastructure) elements in a system of systems approach. Elements with their links and relationships represent the system. The effects based approach comes into play in looking at the effects (required changes in the system state) that have to be achieved to reach the desired endstate. In order to achieve effects, actions throughout the PMCE spectrum have to be carried out using all available and capable resources. A mathematical State-Space Formulation for Effects Based Operations can be found in [4].

Figure 2 shows a view of the processes in EBAO (see [6]). In the centre of this model is the System State, which is represented in the Knowledge Base. The assessment of the system state in Effects Based Assessment (EBA) and Effects Based Planning (EBP) (situation awareness and understanding) starts the process. If the present system state is not acceptable the planning phase is started. The desired endstate is defined and the effects to be achieved, including their sequencing, to reach the endstate is assessed. The next step is to match actions and resources to gain the desired effects. EBP includes the synchronization of all actions and the development of an Effects Based Plan (EB Plan) with a Course of Action (COA).

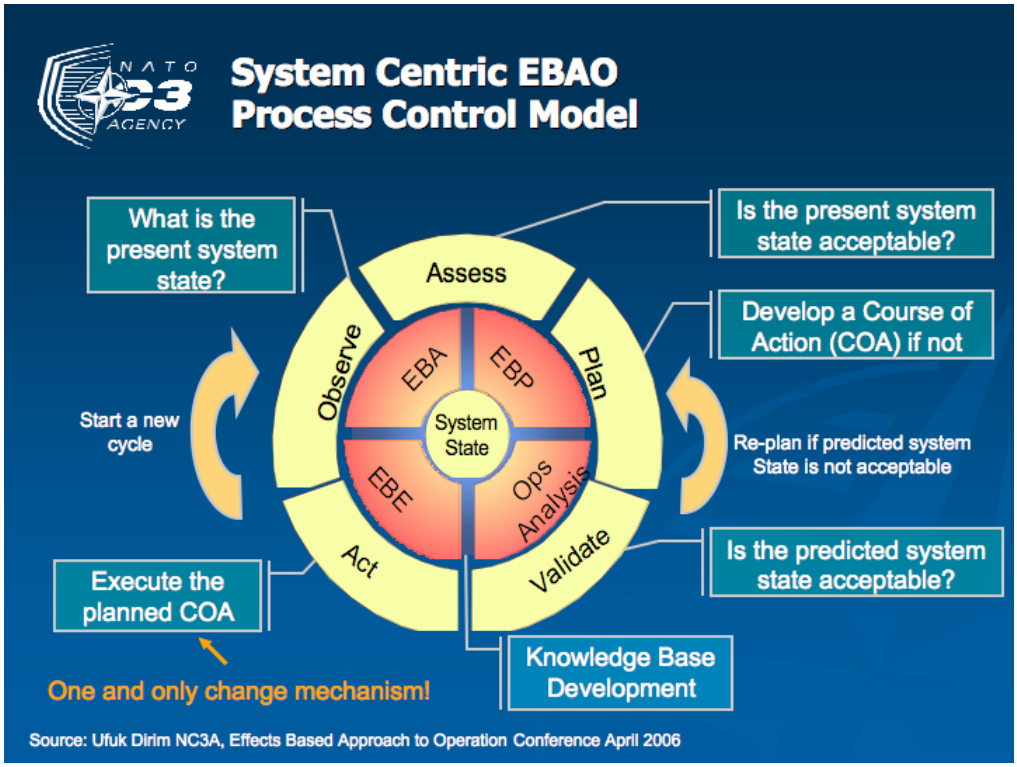

Figure 2: System Centric EBAO Process Control Model

Already during this process Operational Analysis (Ops Analysis or OA) with the use of respective tools helps to generate alternatives and to assess different courses of action. The chosen EB Plan is wargamed and validated. This plan then forms the basis for operational execution (Effects Based Execution or EBE). Effects Based Assessment tries to capture all relevant data to assess the status of the plan achievements during and following execution. This is done using the measures defined during the planning phase: measures of performance (MOP – action related) and measures of effectiveness (MOE – effects related). Operational analysis can support this process with various tools and a forecast of the situation based on the findings.

3.0 MNE 4 SET-UP AND THE ROLE OF M&S

Multinational Experiment 4 (MNE 4) was the fourth in a series of multinational experiments designed to test and validate EBAO concepts and tools. The MNE 4 participants were Australia (Observer), Canada, Finland, France, Germany, Sweden, The United Kingdom, The North Atlantic Treaty Organization (NATO) and the United States. The entire range of EBAO was tested including: knowledge-base development and Effects-based planning, execution and assessment.

The MNE 4 experiment held in February/March 2006 consisted of two parts: a CTF (Coalition Task Force) size part which was conducted in a distributed manner with the participating nations and an NRF (NATO Reaction Force) size part which was conducted in Istanbul, Turkey (see Figure 3). The aim of the two parts of the experiment was identical:

To explore concepts and supporting tools for Effects Based Approach to Operations (EBAO) within a coalition environment involving stability operations with increasing levels of conflict in order to assist the development of future processes, organizations and technologies at the operational level of command.

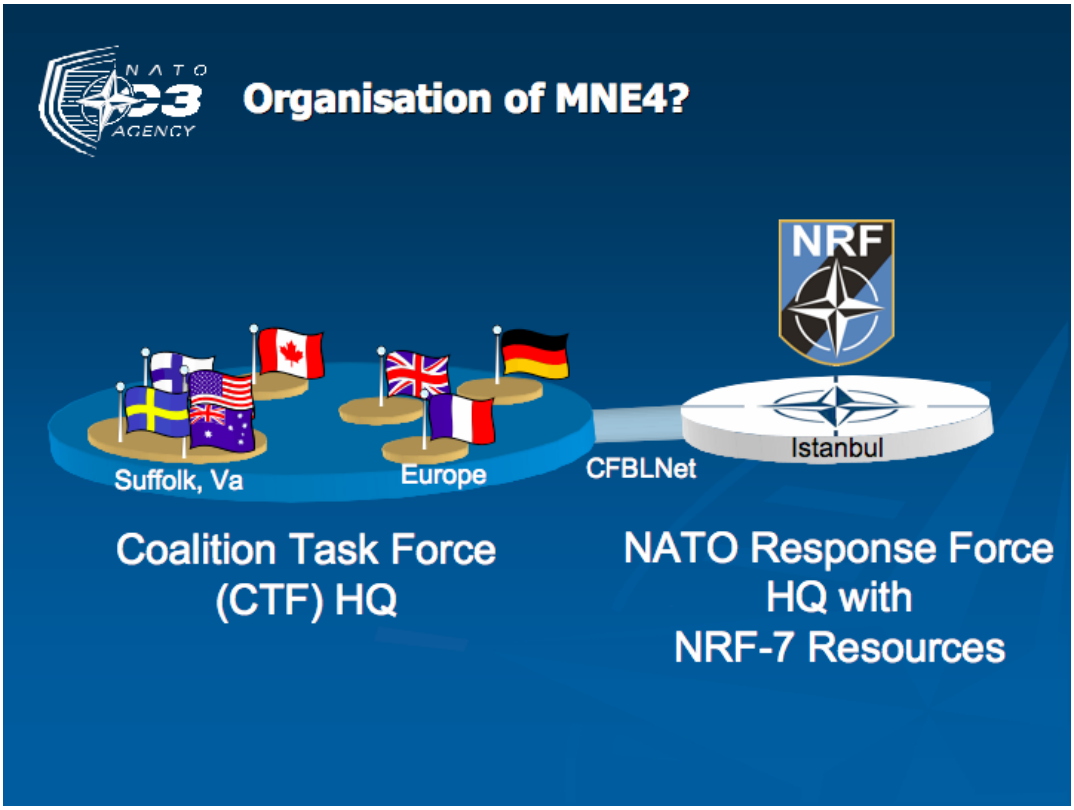

Figure 3: Organisation of MNE 4

The preparation for the experiment consisted of a series of limited objective experiments, planning sessions and virtual meetings to setup a plan to being executed in the experiment. Parallel to the concept development and the preparation of the experiment itself with the scenario definition (Afghanistan) and plan generation, tools to support Effects Based Approach to Operations (EBAO) were selected in a series of workshops. These tools covered a spectrum of different functionality in enabling staff work, providing a dynamic situation for the experiment based on the scenario and on injects and in giving support to planning, executing and assessing of operations.

Primary tools selected for MNE 4 were:

- **Info Work Space (IWS)** was the primary real-time collaborative tool supporting MNE4. IWS provides for virtual meeting rooms, a desktop to conduct real-time PowerPoint briefs with voice from distributed locations, text chat, private chat, note boards, and a file cabinet for reference and draft documents to be shared by distributed work groups.
- **Cross Domain Collaborative Information Environment (CDCIE) Portal** supported all functional phases of EBO. Included was MNE4 Coalition Homepage displaying the Battle Rhythm, functional calendars, specific assignments/meetings / deliverables, and both general and time critical experiment information and guidance. Additionally, there were EBP, EBE, EBA, and National webpages.
- **Systemic Approach / Mind Manager** enabled analytical processing of data. Mind Manager was used by the analysts to process System of Systems Analysis (SoSA), intelligence preparation of the battlespace (IPB), analysis by participating Centers of Excellence (COEs), academia, and directed research by the planners and KBD Chief. The Systemic Approach/ Mind Manager supported the EBO process from a server hosted in Germany.
- **Operational Net Assessment Tool Version 4.0 (SoSA/ONA4.0)** was used by the analysts to create the network of PMESII system elements (political, military, economic, social, infrastructure, and information system "nodes" or system elements).
- **EBTOPFAS** (Effects-Based Tool for Operational Planning, Force Activation and Simulation developed by NATO Command and Control Agency (NC3A)) was the primary planning tool for MNE4. The planners used the tool for planning and displaying the synchronization matrix to link effects, actions, system elements, and required resources to achieve the end state. These planning actions were linked to a common database with the ONA4.0 tool.
- **WebCOP**. The Common Operational Picture was supported by the WebCOP display, GCCS4.0. The M&S Federation fed the COP and the MNE4 simulated "reality." The WebCOP display appeared as a "portlet" on the MNE4 Coalition Homepage on the CDCIE Portal. By clicking on the sample display, designated participants were able to view events occurring in the simulated operational environment.

One use for M&S in MNE 4 was the dynamic representation of the situation during the experiment. A federation of models from France (Alliance), Germany (JOANA) and US (JSAF) was used.

As seen in Figure 2 Operational Analysis (OA) plays a major role in the EBAO concept. Operational Analysis means in this context the application of scientific methods and tools (e.g. M&S) to support all functions of EBAO. This could be in

- Effects Based Planning
  - "What-if" Analysis for situational understanding
  - Effect-Action-Resource Allocation
  - Red and Green Actors Worst Case Assessment
- Effects Based Execution
  - "What-if" Analysis Action development
  - Validation of Plan Changes
- Effects Based Assessment
  - Estimate of Missing Measurable Data
  - Calculation of Measures of Effectiveness and Performance

Each NATO HQ has an OA Cell (mostly part of the Command Group) manned with military and civilian operational analysts who are integral part of the staff. In the NRF part of MNE 4 the OA Cell was manned by NC3A (one analyst for the whole time of the experiment). The CTF part had OA support in the planning cell in Suffolk, VA (one analyst from NC3A and one from US JFCOM). The OA cell is normally the user of M&S tools because the users must understand capabilities and limitations of the tools as well as how to use the tools most effectively.

Following M&S tools were selected to support OA:

- NATO's **GAMMA** was selected as the primary M&S tool for the Effects-Based Planning (see section 4)
- The Swedish **STRATMAS** (Strategic Management System) is used for the simulation of military and civilian operations. The program was used in the Red and Green teaming cell by a civilian contractor.
- The German **JOANA** system was beside its use as scenario driver also used to support the German team in their table-top gaming approach. Results of JOANA were interpreted by an expert group and used for their own manual wargaming.
- The US **SEAS** (Synthetic Environments for Analysis and Simulation) was selected but not used during the experiment.
- The French **PEPSI** system is a prototype for the analysis of asymmetric scenarios. It was used only by France to test its capabilities.

4.0 GAMMA (GLOBAL AGGREGATED MODEL FOR MILITARY ASSESSMENT) AND ITS USE IN MNE 4

GAMMA is a highly aggregated simulation and assessment model which is designed to evaluate military courses of action (COA) at the operational level in high and low intensity conflict scenarios and thus supports COA selection as a decision aid (see a more detailed description of GAMMA in [10]). GAMMA includes strong interdependencies of military and non-military issues, multinational (including Non-NATO) operations, asymmetric warfighting, multi-faction conflicts, tasks other than (traditional) military tasks, and severe political constraints on military (or non-military) operations. GAMMA uses PMCE (Political, Military, Civil, Economic – also known as DIME (Diplomatic, Informational, Military, Economics)) action-reaction modelling and simulation. The aggregated or detailed state in a given scenario is assessed using PMESII (Political, Military, Economic, Social, Information, Infrastructure) effects.

The concept of GAMMA is based on an open architecture, which describes all interacting objects such as military units, assets, geographic objects etc. in very general terms. New types of entities, for example new military unit types of all services or non-military elements such as refugees, civilian population, or civilian organisations (such as The Red Cross), infrastructure elements such as power plants or cities etc. can be defined and instantiated easily without requiring program changes. New simulation modules can also easily integrated as GAMMA components using COM. All components (see Figure 4) use the same user interface, simulation framework and XML based data providers. GAMMA includes an agent-based incidents module, which allows to model agents, entities or organizations that create incidents (positive and negative). A multi-criteria decision support tool called ZETA (Effects Based Tool for Assessment), which is integrated into GAMMA, assesses the impact of these incidents and of the planned actions on a given situation. This tool gives feedback on the PMESII factors over time and the degree of achievement of the Operational Endstate.

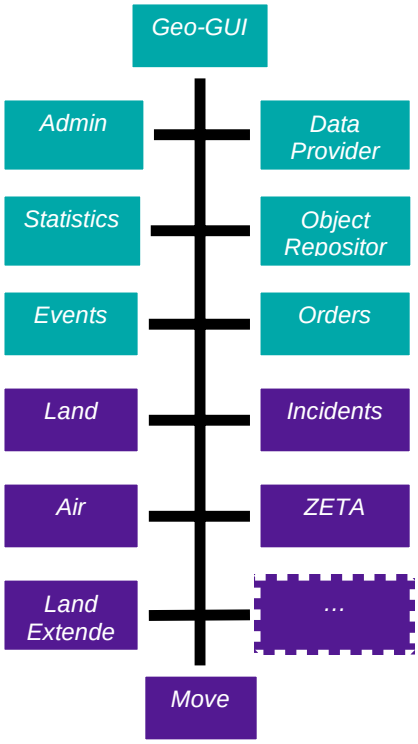

Figure 4: GAMMA Components

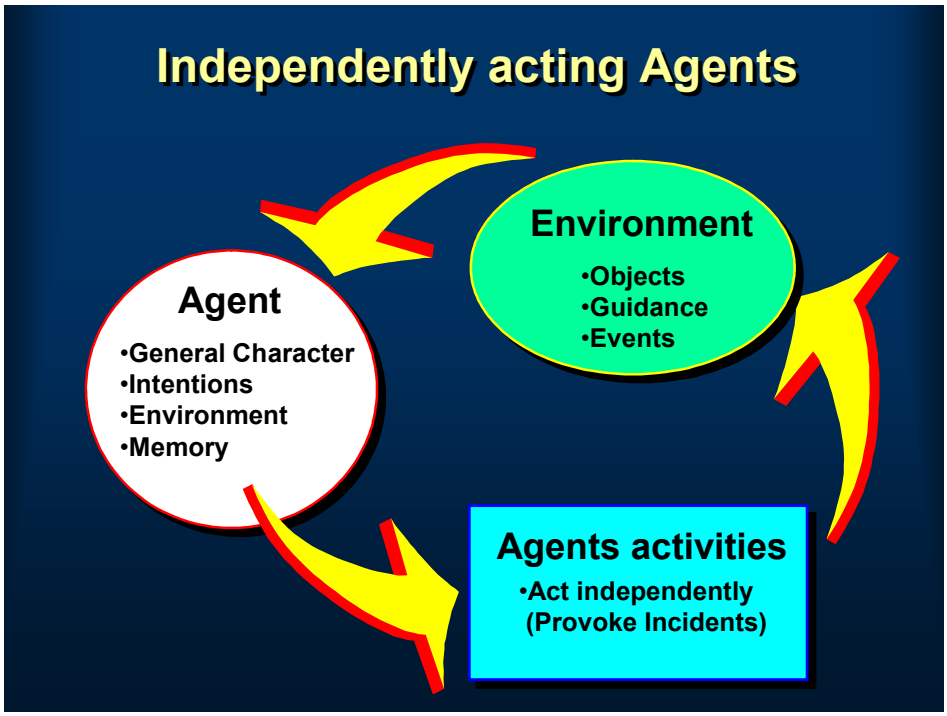

Figure 5: Independently acting agents

4.1 GAMMA Incidents Model

Agents are used in GAMMA to represent paramilitary or terrorist groups (insurgents), groups of civilians such as local populations, NGOs and IOs. Each agent is described by its general character, its intentions and current state, which includes agitation level, perception of the environment and memory (see figure 5). The general character includes a level of violence acceptance and readiness to risk. Agent intentions can be measured by its interest in the specific PMESII factors (e.g. political or military interest).

Based on the environment and the characteristics of the agents, the incidents model creates incidents. Incidents are scenario specific and can be defined by the user. Examples are:

- Demonstration
- Public riot
- Occupation of media or embassy
- Robbery
- Drugs trafficking
- Destruction of private property
- Destruction of military infrastructure
- Sniper attack
- Bomb attack
- Suicide Bombing

Each of these incidents has a target object, which can be:

- Cities
- Civil persons
- Buildings
- Industrial plants
- Military elements
- Etc…

With each potential incident a pre-determined violence and agitation level must be met by an agent in order to provoke a specific incident. The violence level of an agent may change over time. Triggers for changes could be special events such as collateral damage or other actions such as information operations or psychological operations. The agitation level describes the ability of an agent to provoke incidents. It will be lower following an incident and the agent will need time to refresh his ability.

Risk assessment is conducted by the agent and depends on the current situation at the target object in relation to an incident (eg. Enemy patrols, protection levels of critical infrastructure, etc).

The decision by the agent which incident is created in a specific situation depends also on his interests. GAMMA provides two different methods: 1. The importance for different PMESII factors (ie potential targets) will be specified for each incident and will be taken into account when looking at the interest of the agent, 2. The ZETA model (see below) is used to find a suitable incident, which optimizes the impact by the agent on the current situation.

The incident model provides a statistical output indicating which type of incidents occurs over time in specific locations (see figure 6). This output can be used for manual analysis by the OA expert or be used as input to the ZETA model.

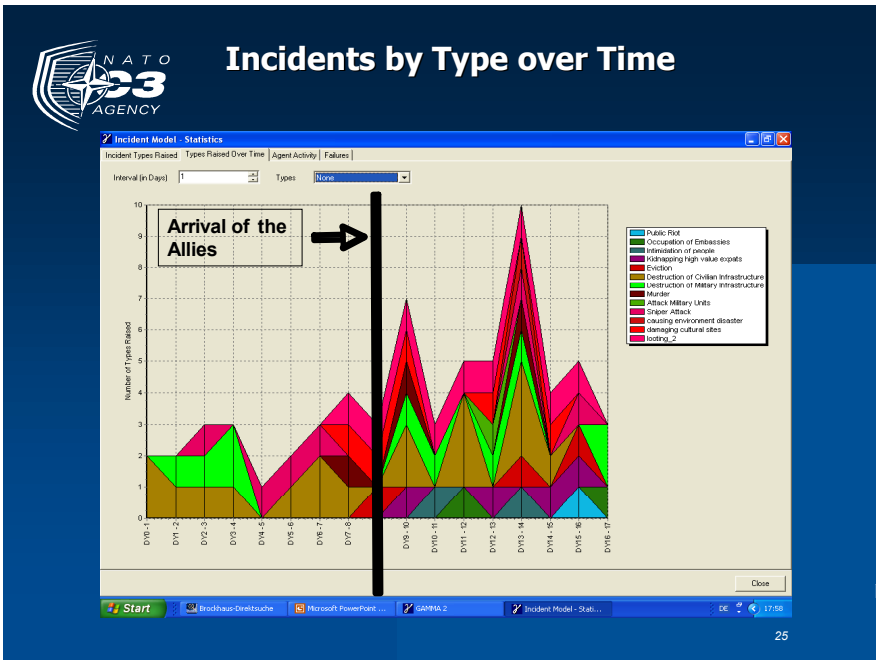

Figure 6: Number and type of incidents over time

4.2 GAMMA ZETA Model

ZETA is a generic time-step based dynamic simulation designed to explore and display interdependencies and influences of factors within a system. The system may be defined as a theatre of operations, or may be scaled to higher or lower levels of definition. The model was developed in order to provide operational analysis decision support to the joint operational level campaign planning process in the context of asymmetric conflict occurring most likely within a Phase IV stability operation utilizing effects based approach to operations (EBAO) theory.

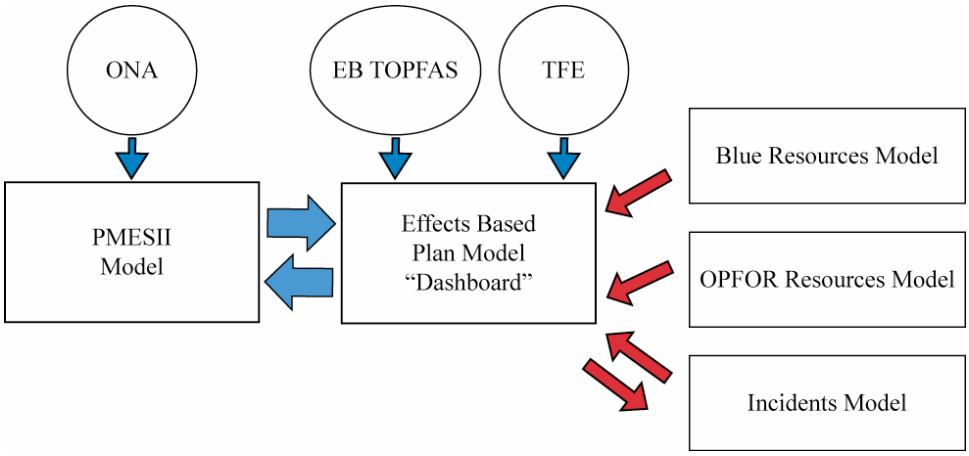

Figure 7: ZETA Layout

Figure 7 shows the layout of ZETA. The tool has a PMESII Model in which all relevant elements of the system and there relationships are described. The aggregated value of the PMESII represents the functionality of the system over time. The "Dashboard" or Effects Based Plan Model represents the effects

based plan coming from EB TOPFAS. In the "Dashboard" the blue resources are assigned to actions with their modeled capabilities. The OPFOR Resources Model represents the capabilities of the OPFOR forces to create incidents and their effectiveness. The incidents model as described above generates the incident. A graphing capability (see Figure 8) allows the analyst to track the aggregated system value over time and relate it to other values such as the aggregated Dashboard value and the number of OPFOR incidents being generated. In addition, the values of specific actions and effects contained in the Dashboard may be displayed along with the values of any sub-system or system element in the PMESII. As ZETA is a deterministic model, the alteration of any single value in the scenario may be traced through to the aggregated level, thus allowing for a correlation of factors leading to a sensitivity analysis.

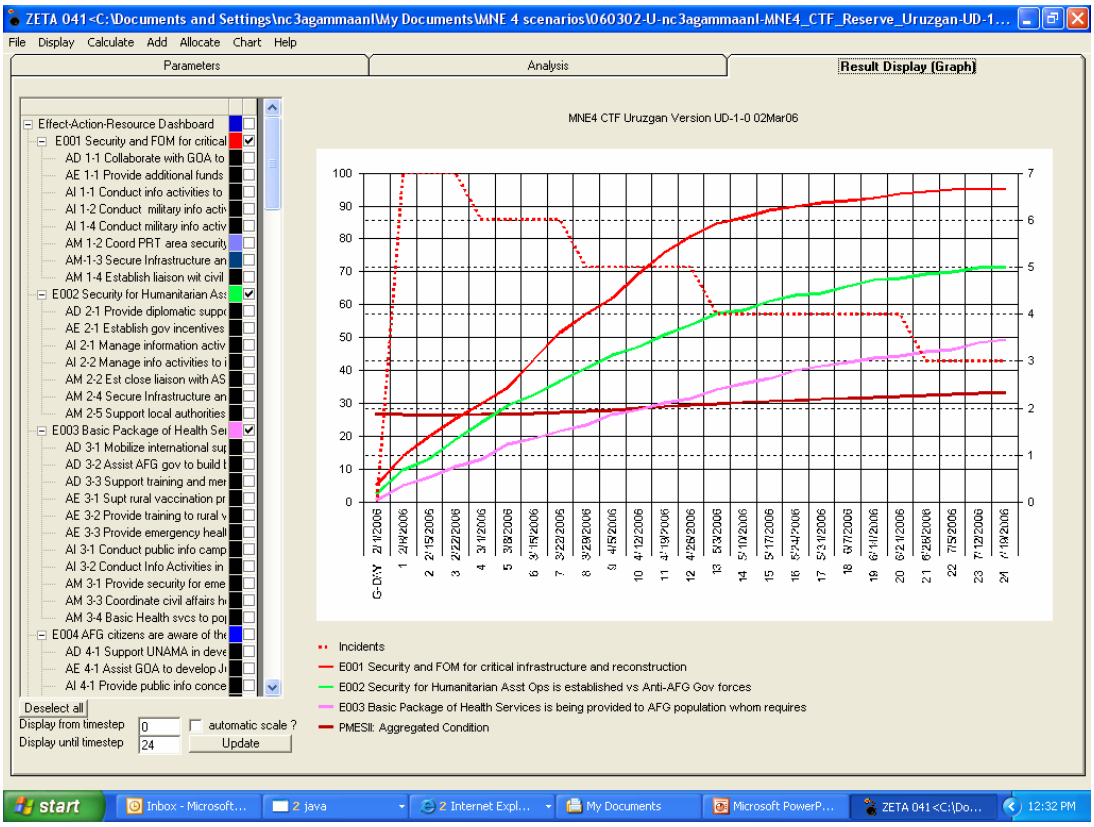

Figure 8: ZETA Graphic Output

5.0 USE OF GAMMA IN MNE 4

5.1 Setup of GAMMA support in MNE 4

GAMMA was the chosen supporting tool for wargaming of Courses of Action (COA) and decision support. It was originally planned to use it in the Effects Based Planning (EBP) process as showed in Figure 9. During the experiment it became clear that GAMMA could as well support Effects based Execution (EBE) and Effects based Assessment (EBA).

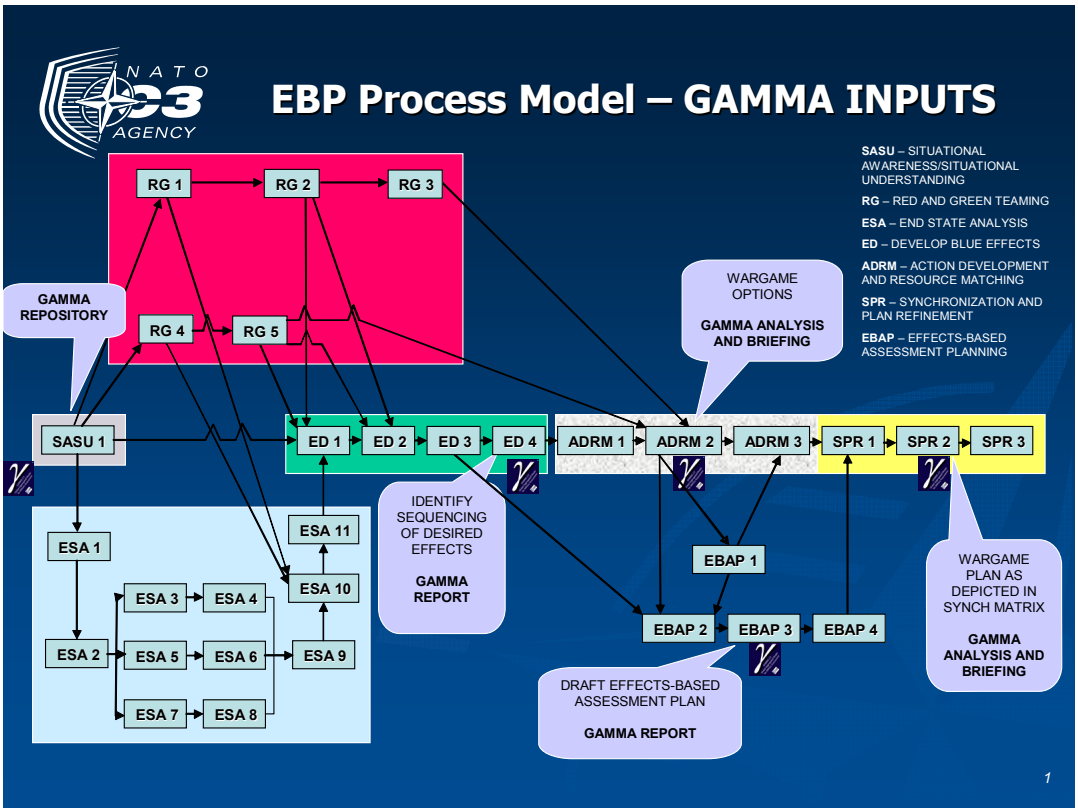

Figure 9: GAMMA inputs in EBP

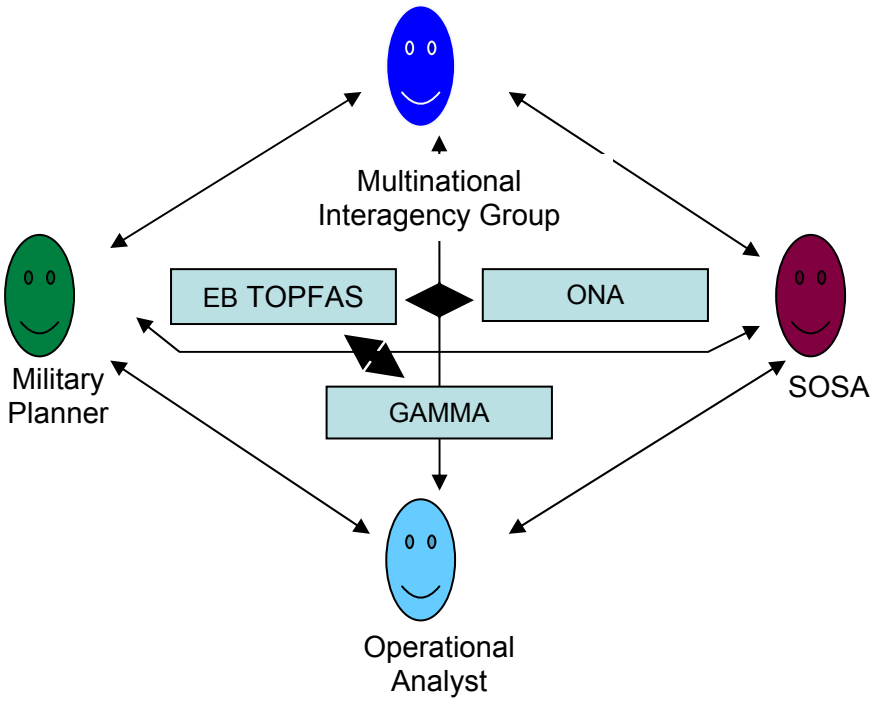

Figure 10: Use of GAMMA in Planning

The input data, which was needed for GAMMA, came from different sources (see Figure 10).

First the analysed and assessed scenario data from the knowledge base (System Of Systems Analysis (SOSA) data stored in the ONA (Operational Net Assessment) database and exported into EB TOPFAS) had to be put in. The ONA database is used by the SOSA analyst and is very detailed to allow him to do his analysis. It therefore includes much more data then needed for GAMMA (and even for the military planner). For GAMMA purposes an excerpt of this data with the most relevant information was needed. This was achieved by a manual filtering through the SOSA analyst who identified the most relevant information for the assessment of the operational plans. In this step he also added information based on his assessment, which is part of the analysis in GAMMA: the weighting of the relevant factors and an assessment about the substitution of specific factors.

Secondly the EB Plan had to be put into GAMMA. In MNE 4 a standalone version of GAMMA (ZETA) was used, which made a manual input based on the EB TOPFAS information by the OA Analyst necessary[3].

A further major point to mention is that GAMMA is not designed as a "black box" which is purely used by the military planner. The input and especially the output from the simulation and the assessment have to be interpreted. To do that the OA analyst needs an overarching picture of the to be analysed situation. Therefore a close contact to the planners and the MIAG (Multinational InterAgency Group) is for the future indispensable if a plan should be assessed with a holistic view. In MNE 4 on the CTF side OA was located with the Directing Staff, the component commands, the Intel cell and not with the CTF staff. This setup was based on the assessment that GAMMA was part of M&S and not integral part of the planning staff. But the virtual environment with IWS allowed it the OA analysts to follow not only the discussion in the planning group but also other relevant staff elements (e.g. EBE and EBA) and the plenary meetings (e.g. JCB, commanders update). The setup showed that the OA cell should be at least manned by two analysts to allow to follow the discussions, present the results and on the other hand to work on the analysis.

The presentation of the results was done in the form of PowerPoint briefings, which could be used by the staff in their update briefings. Special questions to these briefings were answered online or in personal meetings. Additionally OA contributed to the virtual discussions on the virtual conference system IWS.

5.2 MAJOR ACTIVITIES AND OBSERVATIONS

The major activities for GAMMA in MNE 4 started already in the months before the exercise with the preparation of the scenario and the preparation of the plans to be used during the experiment. For the NATO part of the experiment NC3A did the setup of GAMMA for the provinces Farah and Herat (NRF experiment) and contributed to the development of the EB Plan. In conjunction with this work GAMMA was also technically tested and partly validated. For the CTF part the plan development conference in September was supported with two OA analysts. The EB Plan was then further developed in virtual meetings using IWS and directly at US JFCOM without GAMMA support (due to not availability of funding).

The setup of GAMMA for the CTF part in MNE 4 started 2 weeks prior to the experiment. An important enabling factor was the experience from the setup for the NATO part of the experiment. Without this experience the CTF setup wouldn't be completed in that short time. In this two weeks the by SOSA identified important factors with their weighting and criticality and a first setup of resources was put into GAMMA and tested. This work was already coordinated with US JFCOM J9 OA by exchanging of e-mails and sharing of files. The final EB TOPFAS version of the EB Plan was not available yet.

The week 0 of the experiment was mainly used to finalize the setup of GAMMA and to train the OA analyst from US JFCOM in the use of GAMMA. For the setup of GAMMA the in the meantime finished

[3] A new version of GAMMA with an interface to EBTOPFAS is as Beta Version available but couldn't be used in MNE 4.

version of the EBTOPFAS plan was used. This plan included the effects, the actions, the resources and their use but little information about the timely synchronization of the actions. A major part of the input work was the calibration of the resources with their capabilities in this scenario (5 provinces in comparison to only 2 in the NRF, not taking the geographical and other differences into account). The work on the input of the scenario and the plan was also used for a kind of on the job training for the US JFCOM OA analyst. Tools for this training were a user manual of GAMMA and an on the spot developed PowerPoint presentation of commented screenshots in a form of a "How to …". At the end of the first week GAMMA was used for the analysis of the EB Plan and a short presentation prepared.

During week 1 of the experiment the OA cell participated in all relevant updates of the staff (mainly commanders update brief and JCB). OA cell also participated actively in the discussions in the EBP and EBE cells. These cells asked OA for specific input regarding assessment of planning considerations (e.g. use of the operational reserve). OA analyzed these plans and asked for specific details if necessary (e.g. force holding). Most of these communications happened virtually only a few times personal contact with the planners was necessary.

GAMMA was during MNE 4 in the CTF only in the beginning used at a specific point in the process. In the course of the experiment it was used for ad hoc support in the planning process and for "what-if" analyses. This was mainly because no formal wargame happened during the planning.

A major break-through for the credibility of GAMMA was, that GAMMA was able to replay the situation from the start of the plan (D+0) to the by subject matter experts estimated situation at the start of the experiment (D+26 or 26 days later) after calibrating the parameters in a way that the assumed weather conditions and their impact on the effectiveness of the forces could be represented.

The experience showed that one analyst is needed to follow the discussion and to give input from OA side meanwhile another analyst is busy with the concrete analysis. During MNE 4 the OA analyst from US JFCOM was also very busy in his role as MNE 4 tool coordinator and spent a lot of time with the coordination of the use of EB TOPFAS, which reduces the capacity of the OA cell. But nevertheless all questions for analysis from EBE and EBP were answered in due time. Even the detailed analysis of the situation in one specific province (Uruzgan) with a completely new setup of GAMMA could be finished over night.

6.0 CONCLUSIONS AND RECOMMENDATIONS

This experiment and previous experience demonstrated that visualization, collaboration and assessment are the three main areas for tool support in EBAO (see also [8]). In MNE 4 the NATO planning tool EB TOPFAS (Tools for Operational Planning Force Activation and Simulation) was successfully used as the collaborative planning tool. It contains capability for the visualization of the plan (e.g. graphical display of effects, actions, resources and their synchronization). GAMMA was successfully used as assessment tool.

The setup of GAMMA including the input of the operational plan could be finished in relatively short time. Assuming that for real operations an ongoing contingency planning would be performed GAMMA could be on very short notice available to support the planning staff.

GAMMA is running very reliable even if it is still a prototype. Technical support would be welcome to add ad hoc functionality like additional output formats.

The extensive use of GAMMA for ad hoc analysis and setup of new scenarios in a short time during the experiment showed some need for the improvement of the user interface. This was reinforced by the use of GAMMA with different users.

The support by GAMMA was fruitful and well accepted by the military planners in the CTF. To give this support an OA cell with at least two trained analysts is necessary (and in NATO planned for). The experience with MNE 4 CTF showed that staff personal with a good background in OA is able to learn the use of GAMMA in a short time.

Many discussions in the planning process were related to the PMCE (Political, Military, Civil, Economics(or DIME (Diplomatic, Informational, Military, Economics) spectrum. Most of the times no short answer was available because the MIAG (Multinational InterAgency Group) was because of security reasons not represented in the virtual meetings and no analysis capacity was available. GAMMA could and should be extended to cover these aspects.[4]

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[10] Uwe Dompke, Stephan Leitner, Dan Eustace, “Effects Based Assessment of Crisis Response Operations – GAMMA “Global Aggregated model for Military Assessment””, in EURO SIW, Stockholm, 2006

[4] GAMMA is used for this analysis in the Integrated Battle Command (IBC) project of US DARPA (Defence Advanced Projects Agency)(see [8]).

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