CAX METHODOLOGY FOR CIVIL PROTECTION OPERATIONS AND CIVIL MILITARY CO OPERATION

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ABSTRACT

The main idea of this paper is to prove that Computer Assisted Exercises methodology, based on modeling and simulation for military operations mainly, can be used for civil protection operations and civil – military co operation.

Beginning with a general overview of the fundamentals of CAX and continuing with a proposal for reforming the methodology in a more appropriate way for civil protection operations, there is a first contact and understanding of it. CAX can become the important tool for creating "reactions" for national, multinational and international organizations in order to face unexpected actions that may harm the security, health and even life of civilians.

By playing scenarios representing rational or irrational situations threatening civilians life in general, all agencies responsible for civilian protection can be trained in a realistic environment and test their capabilities. Matters of training costs and exercise budgets are also discussed here as it is obvious that the usage of CAX methodology can eliminate both.

Furthermore, the presentation of game theory models for improving all phases of the CAX methodology is providing an innovative idea which is maximizing the benefits of a CAX and produces a secure path for studying the results of it.

Key words: Computer Assisted Exercise, Civil Protection Operations, Civil – Military Co operation, Game Theory Models.

1. INTRODUCTION

During the last twenty years, mostly in NATO nations the usage of Computer Assisted Exercise (CAX) methodology has become an important tool for operational staffs and decision makers in general. This methodology based on modeling and simulation, especially discrete events simulation, has been developed very fast in addition to simulation models providing results through stochastic processes. Simulation models for military purposes, such as Joint Theatre Level Simulation (JTLS) or Joint Conflict and Tactical Simulation (JCATS), Marcus, etc., or even more simulation platforms and mathematical models used for military simulations have became extremely "realistic", simulating accurately military operations of different levels and services. Exercises in NATO and NATO nations have proven that CAX methodology is capable of achieving two very important objectives:

1. Reduce the training budget and at the same time provide a more realistic environment for the training audience.
2. Introduce modeling and simulation to military people in a way which has given them an alternative view for multilevel - multipurpose operations, mainly large scale operations in unknown environments with hostile populations.

As a matter of fact, the results of CAX methodology are impressive in the military area of interest. The result of this success brought up a vital question: Can the CAX methodology used for other than military operations? The answer is absolutely yes. In this paper, it will be presented how CAX methodology can be used for civil protection operations and civil – military cooperation purposes. Also, a new approach for CAX methodology is going to be described for all phases of a CAX and particularly the introduction of a new phase and the way that this new phase can provide to decision makers, think tanks and staffs, solutions to their real life scenarios and situations.

It is of great importance to understand the concept of the CAX methodology and this is the reason for giving first of all some definitions and descriptions of the CAX methodology that NATO uses. At the same time, it is necessary to refer to the role of modeling and simulation to CAX methodology. Inserting game theory tools and mathematical models of conflict and co operation in CAX methodology, is extremely innovative and it may be a challenging beginning for producing a more effective and efficient approach. The results of such an approach will surly give decision makers, think tanks, staffs and organizations managers the capability of "translating" the conclusions of simulation to acting plans without waste of time and in a costless way.

It has to be mentioned that there are not many available resources referring to CAX methodology and many of the CAX results are of high classification. This fact is slurred over by the author's experience in the area due to his military background, as he has contacted more than 120 national and international CAX's. The improvement of CAX methodology and its usage for civil protection operations and civil – military co operation needs to be relied on three pillars:

1. Operational research tools.
2. Multilevel, multipurpose simulation models.
3. Accurate and secure simulation results analysis.

Finally, for every one of the above pillars there is a certain level of importance which is going to be discussed separately for everyone of them and at the same time the role of each of them needs to be clarified in order to have a full picture of how the CAX procedures will be formed efficiently for civil operations and civil – military co operation simulation.

2. COMPUTER ASSISTED EXERCISES (CAX)

Application of simulation models in CAX methodology is representing an educational method, which is dynamically introducing operational conditions of real systems in synthetic environment. Dynamic training system is consisting of digital terrain, environment and equipment allowing to the exercise participants to gain new knowledge, skills and behavior. Each CAX is also a research method, because is fulfilling a few conditions for that, for example:

1. Novelty of the problem.
2. Importance and applicability of solutions for the practice.
3. Level of interest in problem solving processes.
4. Available equipment and other research conditions.
5. Actuality of research results.
6. Possibility to find solution for the decision making problems by research.

Through the process of CAX we are undoubtedly optimizing current staff procedures and decision making processes in synchronization with all other stakeholders in the area of responsibility.
In order to properly apply above mentioned training methodology, it is of utmost importance to understand the potential needs of the country, organization, or in any case the "clients'" needs. Ultimate goal is to provide training conditions for audience in order to achieve training objectives. That will prepare them for the real world crisis decision making process on strategic, operational or tactical level.

The main issue here is the method or the process that we need to use for understanding the needs of the final "client" or even more the capability of the CAX organizational structure to produce certain results based on discrete and explicit requirements.

If for example the requirement is to plan, prepare and execute a CAX based on an earthquake or more generally speaking a natural disaster scenario involving national, multinational and international organizations and agencies, we need to describe - model in a simulation system the capabilities, structures, doctrines, means and possible reactions of all entities that will have a role in this scenario.

These entities will be the units of countries that will take action to save civilians (army, police, fire brigades, special forces, etc.), the organizations that will control the operations, the C2 systems, the facilities that will be used and every other autonomous and partially described forces that can affect the situations or the events of the scenario.

Definition 1: A CAX is usually defined as a type of Synthetic Exercise (SYNEX) where forces are generated, moved and managed in a simulation environment based on the commands coming from the exercise participants (Cayirci – Marincic 2009).

CAX is above all a methodology and a way to provide results based on simulation. Decision makers, think tanks, staffs and command and control teams are not supposed to follow the row of simulation but is more than enough for them to understand that processes and procedures are close to their directives and doctrines.

As a matter of fact, CAX can provide wide area training for different kind of operations and levels. Therefore, CAX support is often thought limited to installing and running a military constructive simulation during a CPX (Command Post Exercise). In this perception CAX support is to replace or to help Response Cells, Higher Level Commands (HICON), Lower Level Commands (LOCON) to find out the possible outcomes of the decisions or requests coming from the Training Audience (TA) by running a set of stochastic processes. However, CAX is in essence a CPX where electronic means are used:

1. To immerse the TA in an environment as realistic as possible.
2. To help the exercise planning group (EPG) and the exercise control (EXCON) staff for controlling the exercise process (EP) so that it achieves the objectives as effectively as possible.

In the execution phase of a CAX, most of times we use discrete events dynamic simulation to represent complex operations. Constructive simulation systems are commonly used to simulate those operations. They can interact with the Training Audience through the CAX experts and in the very high resolution analysis level (tactical or operational, depending on the kind of

operations) visualization is also used to represent specific events of a structured scenario or activities that guide the Training Audience to certain actions.
The simulation cycle is followed in order to express the interaction between Training Audience and simulation system. CAX experts are receiving orders from Training Audience and C2 systems, they put them to the simulation system and they are feeding back the Training Audience with the results of simulation, as shown in the following picture:

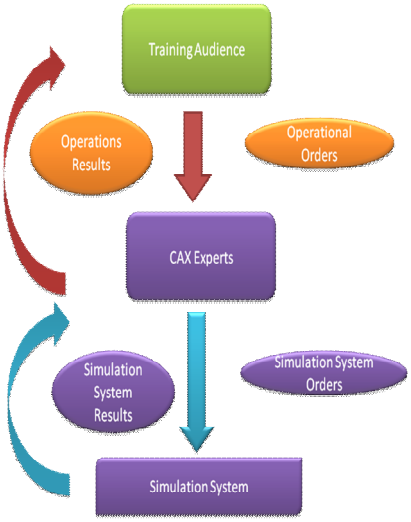

Figure 1: From the Training Audience to the Simulation system

CAX is ensuring high quality of individual and collective training on decision making processes on tactical, operational and strategic level (Cayirci – Marincic 2009).

2.1. Typical NATO CAX Architecture

There is a typical NATO architecture and methodology followed by a serious number of countries, agencies and organizations, based on NATO's doctrine *Bi 75-3*.

Some vital meanings and issues used in this methodology have to be mentioned and defined, through which the whole structure of a CAX will be more easily understood.

A CAX in NATO needs about 12 – 18 months of planning and preparation and usually takes about 10 – 15 days for its execution phase. After Action Review and Lessons Learned can be referred as the last phase of a CAX.

NATO CAX methodology consists of the following phases:

1. Planning Phase
2. Preparation Phase
3. Execution Phase
4. After Action Review Phase

Before the Execution Phase a number of conferences is being held for coordination purposes and these are the following:

- Initial Planning Conference (IPC)
- Main Planning Conference (MPC)
- Final Co ordination Conference (FCC)

During the preparation a number of conferences is taking place basically for commanding and controlling the project. There are two main architectures for a CAX:

- Distributed CAX, where all the participants are sited in their natural positions.
- Non distributed CAX where all participants are in the same place.

In both cases we can have *distributed* or *non distributed simulation*, which depends basically in the type of simulation model(s) that is (are) going to be used in the CAX. The CAX architecture is not affecting the type of simulation (distributed or not). In both cases, the architecture fundamentals are shown in the next figure:

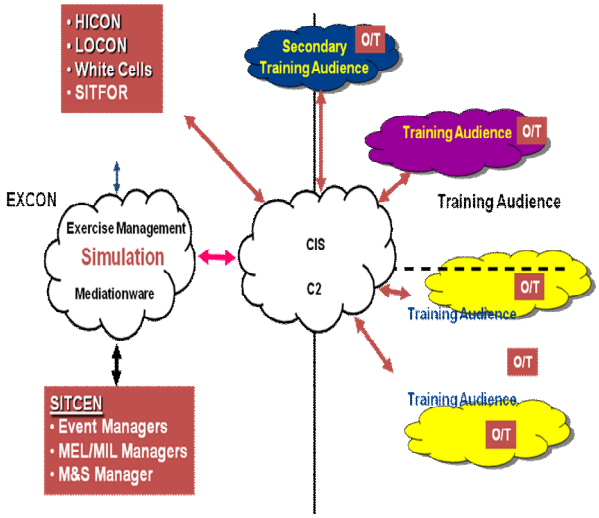

Figure 2: Architecture for Distributed CAX

The above figure describes the architecture for distributed CAX's as it fits perfectly with NATO's requirements and mostly with NATO's operational needs (Cayirci and Marincic, 2009).

Training Audience can be:

- Cross leveled, which means that it is coming from same level of command but from different services.

- Multi leveled, meaning that it is coming from the same service but different command levels
- Multi – Cross leveled, both from different services and different command levels.

Training Audience represents friendly side(s) and the opposing forces are usually called Situational Forces (SITFOR). Other organizations or agencies, playing important or less important roles in the scenario are represented as Gray Cells or White Cells.

Response Cells (RC) are the representations of higher and lower commands of friendly side(s). In the next figure there is a typical structure of a RC:

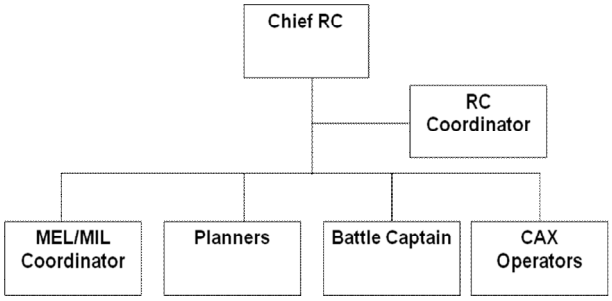

Figure 3: Typical Structure of a RC

Battle Captain's role is to translate Training Audience with CAX Operators and transport simulation results to operational people.

Main Events List / Main Incidents List Coordinator is responsible for checking if simulation follows the scenario major events and planning.

Another important element of the CAX methodology is the Exercise Centre which controls the CAX during the execution phase and at the same time has the full responsibility for running the simulation. EXCEN has the following roles:

1. Is connecting, in a way, simulation personnel with operational personnel.
2. Assists operational staff to understand the concept of simulation for given scenarios.

In other words, EXCEN is the most vital element of a CAX procedure and the main factor that can guarantee the success of the CAX.

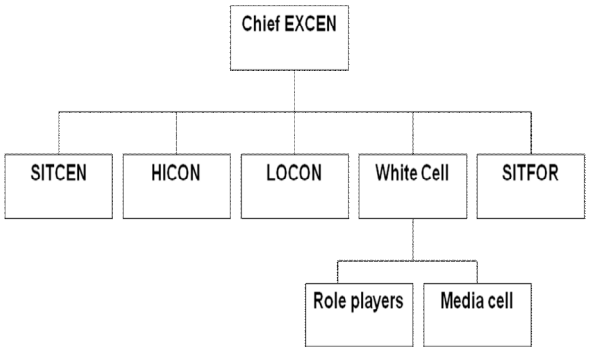

Figure 4: Exercise Centre

After concluding the execution phase of a CAX there is always an After Action Review procedure concerning mainly the analysts and the planners of the exercise. In many cases, participants in the After Action Review procedure are the Training Audience (Primary and Secondary), depending on the level of the exercise, the objectives and special features of it. The final products of the above procedure are lessons learned and lessons indentified. Both of them are not coming directly from the simulation results but they are analysis conclusions and many times even research based on some of the simulation results.

It has also to be mentioned that C2 systems, networking, non simulation software and informatics tools are used to support a CAX during the execution phase.

2.2. The SEESIM CAX

In many cases, like the South Eastern Europe Simulation (SEESIM) project, held by the South Eastern Europe Defense Ministerial (SEDM), the CAX methods are being followed in another way, trying to simulate the procedures and processes of the military – civilian organizations- agencies reactions in a multinational environment. The structure of SEESIM04 is shown in the figure:

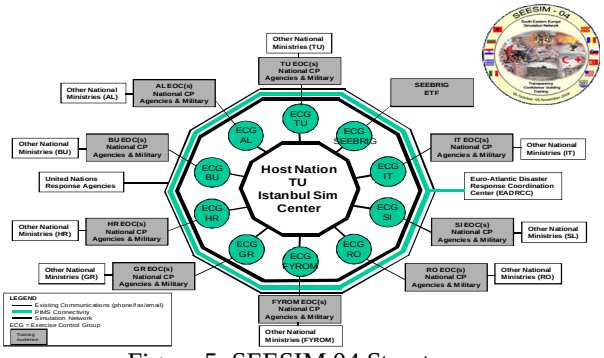

Figure 5: SEESIM 04 Structure

As one of the participants was the South East Europe Brigade (SEEBRIG), SEESIM is the most suitable example of a multinational CAX for civil protection and civil military co operation. The scenarios used for

simulation were describing a wide range of destructions (coming from nature's or terrorists' "actions") and events affecting mainly civilians and critical national infrastructure. The main objectives of this CAX were:

- Practice and improve standard procedures for training the participants' national Emergency operational Centers (EOC) and SEEBRIG HQ in regional information management, communication flow, and coordination of humanitarian assistance, consequence management and disaster response operations.
- Promote national and regional preparedness for civil and military agencies and SEEBRIG in order to respond effectively in terrorist activities.
- Practice timely information exchange between national and regional emergency centers for quick counteracting terrorist, Chemical, Biological, Radiological and High Explosive proliferation activities or mitigate effects of disasters.

For achieving the above objectives the SEESIM CAX's 2002 till 2010 methodology differ in some points from NATO's methodology, mainly because of the differences of national EOC's and the interference of non military agencies. A standard CAX methodology was followed, most of times taking in consideration the special features, relations and restrictions of the South East European countries.

Some of the negative conclusions that SEESIM project experienced are the following:

- CAX methodology can be surly used for civil protection operations and civil – military co operation.
- Even an inter ministerial co operation in one country has to be very carefully and detailed described in order to be simulated in the most realistic way.
- Time limitations in all phases were not followed and reaction time during simulation from agencies and / or organizations were too long.
- Data given from participants (nations) for building simulation models databases were changing till the last moment.
- Working Groups managers couldn't easily balance the differences between nations and philosophy of exercises.
- Simulation process was not running properly and a great number of mistakes happened due to untrained personnel.
- After Action Review process gave some general and uncertain results mainly because the simulation was not running properly and analysts couldn't understand nations' activities for facing specific scenario problems.

The SEESIM project was supported by a number of CAX experts and advisors coming from US JFCOM (which was later transformed in JCW). The idea of simulating physical disasters and asymmetric threats and the reactions of agencies and organizations of Southeast Europe nations, brought up a vital question: Was CAX methodology used by US JFCOM proper for such a project? After five exercises we can certainly give an answer: The above conclusions showed, up to a point, that it had some kind of success but the organizers did not get what they expected. As a result SEESIM 12 will be supported from NATO / JWC, which means that a methodology closest to NATO's one may be more proper.

Based in this methodology, in the following paragraphs it will be presented a more convenient and suitable philosophy for CAX's dealing with civil protection operation and civil military co operation.

3. FUNTEMENTALS OF CAX METHODOLOGY FOR CIVIL – PROTECTION OPERATIONS AND CIVIL – MILITARY CO OPERATION

In many cases we have seen in the past natural disasters, humanitarian crisis, violence in metropolitan cities and even more disasters coming from unexpected recourses affecting the life of civilians and bringing serious problems in the rest of the world. "Katrina", the Thailand tsunami, Somalia, violent behavior even in schools in US, can affect lives and people in a very short time limit. To improve our reaction, is absolutely necessary to find the "optimal paths" and the proper models for "guessing" what may happen and how we can manage it.

First of all the need a wider and more comprehensive definition of CAX are obvious that it is necessary, mainly for two reasons:

- To include the simulation cycle during the execution phase of a CAX
- To express the expectations / outcomes from a CAX.

We will proceed in the following definition:

Definition 2: A Computer Assisted Exercise is a synthetic exercise where electronic means are used to simulate scenarios, processes and procedures of all kind and levels of operations, in complex environments. Simulation is executed by experts who receive operational orders from the Training Audience; they interact with simulation models and feeding back the Training Audience with the results of simulation. The products - objectives of a CAX are: realistic training for the Training Audience and control, evaluation and administration of

operations for the Exercise Control Group and Operational Planners.

In a perspective, the usage of CAX methodology for civil protection operations and civil military co operation requires:

1. Careful and detailed preparation.
2. Time Synchronization for all levels and all kinds of operations.
3. Applicability of simulation models.
4. Special analysis tools for building scenarios, including maps, statistics for natural phenomena, executive planning, terrorist and civilian "behaviors", mass and social media role and military involvement in civilian issues.
5. Support tools for scenario(s) and exercise management.
6. Interoperability of simulation systems for multilevel –multipurpose simulation.
7. Simple and clear scenario(s).
8. Experienced and expert operational and technical personnel.

To meet these requirements some vital changes have to be made in the whole philosophy of the CAX methodology.

Constructive simulation has to be used for producing more realistic results and also entities to be more detailed described. The need of multilevel – multipurpose simulation is also an important problem. This can be solved by using models' federations (FOM) which are communicating each other through High Level Architecture (HLA). Such a federation is NATO Training Federation, using Joint Theater Level Simulation (JTLS), Joint and Tactical Simulation (JCATS) and Visual Battle Space 2 (VBS2). In any case, HLA can offer us the capability of interoperable models which can simulate in a synchronized mode different kinds and levels of operations.

It is also important to insert the procedure of visualization for every level and kind of operation. Visualization assists operational people to understand better the environment of simulation and provides them with the capability of having pictures of what is going to happen in front of their eyes, which is easier to accept.

There is no need to have visualization process synchronized with simulation. Based on the results of simulation we can use other models to show "what happened". The critical idea here is to present to the Training Audience in the most realistic way the results of their reactions.

Last but not least, the absolute need of giving operational people real significant services, leads to a different approach regarding the After Action Review phase. Till now, everybody was happy with Lessons Learned and Lessons Indentified. But is this what a decision maker or a staff manager needs? The answer is absolutely no. After all, simulation provides a lot more than lessons. Simulation can be a small window to the future and is capable to reveal what may happen under given conditions and circumstances.

Based on this, by using proper tools, such as Game Theory models and Dynamic Programming, simulation's results can be further analyzed and extract solutions and planning tips for CAX planners.

By using Game Theory models of conflict and co operation there are several problems that can be solved. One of the most important is to reduce casualties, meaning that human lives can be saved by "building' a rational or irrational game between the "enemy" (that even nature can be) and friendly side(s). The outcomes of a realistic simulation may consist the parameters of the game(s) and what cannot be simulated can be introduced as the restriction(s) of the game(s).

On the other hand, dynamic programming is a mathematical tool which is solving a great number of problems regarding optimal processes. Linear Decision Making is offering to decision makers the capability to choose the optimal action between a numbers of proposed actions. By simulating a single event several times we can build a linear decision making problem and provide the decision maker with the optimal solution.

We can emphasize in the following conclusions:

1. CAX products must be proposals / solutions, which have been studied during and after simulation.
2. Decision makers can use those proposals immediately and without uncertainties or doubts for their planning and real life activities.
3. These proposals / solutions are the results of mathematical processes based on operational research tools (f.e. dynamic programming and game theory) which prove that they are the optimal for given scenarios.

3.1. A New CAX Model for Civil Protection Operations and Military Civilian Co Operation

In this paragraph it will be introduced a model of a new CAX model suitable for civil protection operations and civilian military co operation, Our basis for this model will be the NATO CAX methodology as described in NATO / ACT Doctrine *Bi 7-53 2007* and the experience of the SEESIM CAX. Additionally, some major changes regarding the After Action Review and the Lessons Learned phases will be included in order to optimize the results and conclusions of a CAX.

The first parameter that differs is that the proposed CAX model is treated as a unique project consisting of several different tasks which are undertaken by Task Managers, who are responsible for Task Groups. The number of the Task Groups can be different in every

CAX. The whole project is running divided in certain time phases and has to follow a complete plan and prefixed timelines and milestones. Tasks are assigned in CAX Task Managers and the whole project is assigned to a CAX Project Manager, as shown in the following figure 6

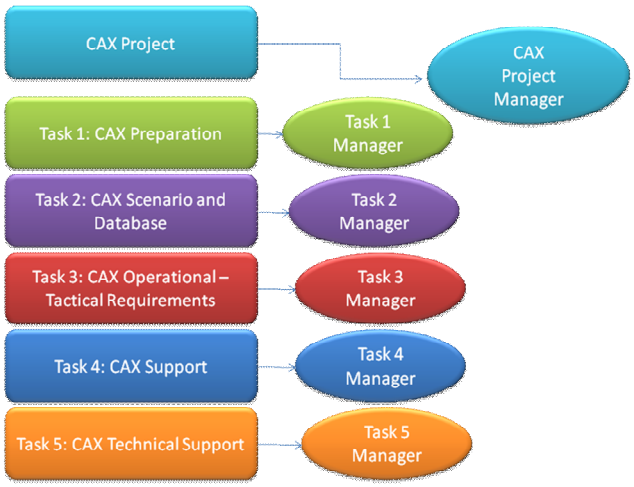

Figure 6: the CAX project

A second major change is concerning the phases of a CAX. These phases are basically time phases, in which tasks and sub tasks have to be concluded, based on a sequence of related activities. Also, there is a difference in the last phase which includes proposals, plans and solutions instead of After Action Review and Lessons Learned. These five discrete time periods – phases are:

1. Exercise Project Planning (1 -2 months).
2. Exercise Organization Procedures (3 – 5 months).
3. Exercise Execution (10 – 15 days).
4. Exercise Reports (2 -3 days).
5. Proposals – Plans – Solutions (10 – 15 days).

In every Task Group there are CAX experts who assist operational people in understanding the CAX features and special characteristics. By this way there is a significant time profit which leads to fewer costs. The Exercise Planning task has a main target: To define the training, exercise and simulation objectives. The final outcome of this task is the Exercise Plan (EXPLAN). The important and innovative intervention here is that in the EXPLAN must be mentioned time limits and milestones for the whole project, including and the after execution phases. Task Groups and Managers have to follow closely these time limits and millstones and deliver to the CAX Manager their work in the prearranged dates.

As shown, the preparation time of a CAX is limited to 4 -7 months, depending mainly on the following parameters:

1. The number of participants and the level of operations. Usually, tactical operations CAX needs less preparation time.
2. If the CAX involves international or multinational agencies and organizations. Multinational or international agencies need more time for coordination.
3. The entities analysis and scenario(s) length. Let's take an example: For building a realistic data base, coming from a 10 days earthquake or floods scenario, involving f.e. five nations and their Emergency Operations Centers (EOC), we may need more than 650 entities to describe the basic structure of operational, support units and facilities. This number is the average number of units used in SEESIM exercises for building JTLS database (units and targets).

The number of participants has to be defined by using an optimization process, which limits the personnel to the absolutely necessary. This leads to lower costs during the preparation of a CAX.

The optimization problem is described as follows: Let P the needed personnel for the preparation phases of a CAX, where $P = \sum_{i}^{k} p_i$ and p_i is defined as the needed personnel of the Task Group i. Every Task Group consists from different kind of personnel f.e. operational officers, technicians, CAX experts, etc.This can be represented as $p_i = a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{ik}x_m$, where $x_1, x_2, \ldots, x_m$ are the different kinds of personnel and $a_{i1}, a_{i2}, \ldots, a_{ik}$ are the multipliers for every kind of personnel. Defining the available personnel for every Task Group as v_i there must be $p_i \le v_i$. In this case the optimization problem is to minimize P. By constructing an objective function taking in consideration the CAX requirements we solve the problem using the Simplex algorithm.

Scenario and database building in a CAX preparation is one of the most important elements of it. The process of scenario building has the following stages:

- Stage 1: A step by step analysis of the exercise, training and simulation objectives leading to a set of scenario requirements.
- Stage 2: Scenario(s) scripting where discrete events are described and connected to scenario requirements as given from Stage 1. After scripting every event is analyzed in a number of incidents and

every incident in actions and injections. It is necessary to build a time schedule for coordination purposes.

- Stage 3: As an outcome of Stage 2, there is a full plan of structured entities with discrete roles in simulation. This plan is given to technical personnel (experts in simulation models) of the proper Task Group who proceeds to the following steps:
  - Model the entities
  - Building of the database in the simulation model
  - Verification
  - Validation
  - Testing and evaluation of the database
  - Documentation
  - Test scenario(s) and present to Exercise Planners.

For the civil protection operations and military – civilian co operation we need to define a number of parameters to specify the scenario(s) requirements. The most significant of them are:

- Time limitations (T_l) and reaction time (T_r, by real world statistics) of the simulated entities (units, services, etc.).
- Command structure and logistics structure of all entities.
- Means and manpower of the entities.
- Geostrategic environment and international restrictions and affairs of the involved participants.
- Interrelations between military and civilian organizations and agencies.
- Discrete roles of military and civilian organization for every kind of operation.
- Support costs (s_c).
- Transportation costs (TR_c).
- Information exchange systems (C2, C3, C4I).
- Nations, agencies or / and organizations capabilities and experience in civil protection operations.

In the preparation phases (Planning and Organization procedures), there specific aspects that have to be taken in serious consideration in order to provide solutions for the execution phase. These aspects are grouped in two major categories, analyzed as follows:

1. Technical Capabilities:
   - IT systems that will be used and their capabilities.
   - Personnel's technical skills, experience and capabilities.
   - Type of reports of the simulation models, results computing, recovery processes, communications between Training Audience and other CAX elements during execution phase.
   - Data extracting and processing capabilities.

2. Operational (Tactical) Planning :
   - The level of operations that are going to be simulated and operations' complexity.
   - Extension and analysis level of information needed for modeling and simulation. Constructive simulation models and stochastic simulation usually need a great amount of information and deep analysis of entities' attributes.
   - Security restrictions and measures that can affect the realism of simulation. As a comment here we have to stress that the level of realism in a simulation is a function of several variables and it is not depending only to the level of details described in the modeling process.

During the execution phase, EXCON, RC and mainly SITCEN will suffer major changes. The main reason for this is to simplify the procedures. Another reason is that many times nature is involved as the "enemy" in SITFOR and also the "translator" between simulation and operational people has to be a CAX Expert with operational background. From this point of view, the people involved in RC's must have a detailed training in CAX issues. As a result of the above the following figure is showing a proposed structure for RC:

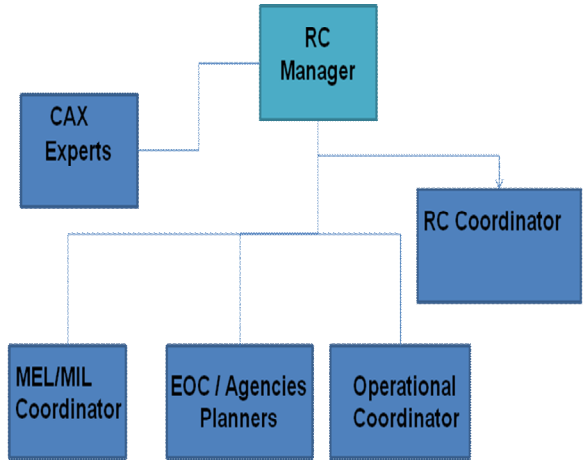

Figure 7:Structure of a RC

It has to be mentioned that the operational Coordinator will be the connector between CAX Experts and operational personnel and at the same time he will transfer operational orders from TA to CAX Experts.

Finally, there is a vital discussion here about introducing some mathematical models and methodologies that can provide more secure results and take less preparation time. Lets us see how Game Theory models may be a useful tool for all phases of a CAX. In

the next entity it will be examined the capability of Oceanic Games and especially Voting Games, to change processes and procedures of a CAX in order to achieve two basic targets: Exercises cost reduction and optimal usage of simulation conclusions.

4. GAME THEORY MODELS SUITABLE FOR CAX PROCEDURES

Game Theory is a branch of Operational Research which has been an extremely useful tool for a various range of applications, especially in the field of financial services. By using statistics, dynamic and linear programming and sometimes "difficult" mathematics has produced quite a success solving problems and giving solutions in complex problems.

A very special part in Game Theory is the Oceanic Games, which are used for solving problems related to decision making processes. A subset of Oceanic Games are the Voting Games, used to describe games in voting systems, political and financial organizations decision making procedures and how power is divided among the independent parts of such organizations.

The tool which these games are employing is Power Indexes. Power Indexes are mathematical modules in order to measure the power of every discrete "player" in a game. The most common used are the Shapley – Shubik and Banzhaf power indexes.

More analytical, a voting arrangement in which voters may control unequal number of votes and decisions are made by forming coalitions with the total of votes equal or in access of an agreed upon quota is called a weighted voting system. The usual notation is $[q : w_1, w_2, ..., w_n]$, where *n* is the number of voters; w_1, *i = 1, ..., n,* is the number of votes controlled by the *i-th* voter, and *q* is the passing quota.

In the theory of weighted voting system it's customary to refer to voters as players.

F.e., in the system [5: 3, 2, 1], all decisions could be made by the two principal players (3 and 2 votes, respectively), while that last player (the one with the single vote) has no influence whatsoever on the decision process. It is then clear that having a vote does not endow its owner with any real power in making decisions. (The last player in this example is known as a dummy.)

Banzhaf's is one possible indicator of the relevance of a particular player. Shapley-Shubik's is another. In both cases, the power wielded by a player is determined by the number of coalitions in which his or her role is important. However, the two indices formalize the notions of coalition and importance in different ways.

Coalition is any (non-empty) combination of the players. A coalition is winning provided the cumulative vote of its members is equal to or greater than the quota. A coalition is losing if it's not winning. A player is called critical to a winning coalition, if his or her removal from the coalition renders it losing. Banzhaf's index of a player p is the ratio of the number of winning coalitions to which p is critical to the total number of times the players are critical.

A coalition is just a set of its elements. No order is specified in which the players enter the coalition. Not so with the sequential coalition, used to define the Shapley-Shubik index.

A sequential coalition of n players $p_1, p_2, ..., p_n$ is any permutation $p_{i1}, p_{i2}, ..., p_{in}$ of that set. An element p_{ik} is said to be pivotal to a (sequential) coalition $p_{i1}, p_{i2}, ..., p_{in}$ provided the (regular) coalition $p_{i1}, p_{i2}, ..., p_{ik-1}$ is losing, whereas the (regular) coalition $p_{i1}, p_{i2}, ..., p_{ik}$ is winning.

Assuming that the quota does not exceed the total number of votes, every sequential coalition has a unique pivotal element. Shapley-Shubik's index of power of a player p is the ratio of the number of sequential coalitions for which p is pivotal to the total number of sequential coalitions, which is always *n!*.

After describing the mathematical background, the research activity related to the CAX procedures is going to be following:

1. During the phase of CAX planning the building of a voting game where the objectives of a CAX (exercise, training and simulation) will be measured in order to decide the significance of them and also the "simulation behavior" of them. The meaning of the "simulation behavior", is essentially how much effort in different areas, we have to put during the simulation process, in order to achieve a specific objective under given restrictions. Actually, these restrictions can describe the level of realism of simulation.
2. The phase of the CAX organizing is the most vital. We have to be very careful and sure about the steps we have to undertake in order to "drive" the CAX according to the objectives given from the previous phase. In this case, we are building another voting game and by measuring the power of the different components of the CAX, we can justify the timetables, milestones, line of procedures, planning activities and finally the full Exercise Structure via the calculation of the important values of the CAX.
3. The execution phase of a CAX is going to roll on if our work during the organizing phase is productive. There are numerous elements that have to be measured for assisting us to achieve the Exercise, Training and Simulation Objectives. We can give the following examples:

- Force ratios for ground forces in specified geographical areas. Such ratios are combined with

empirical knowledge to assess very rapidly what the trend of the exercise is and whether it is in line with the expected exercise flow. Should the actual trend deviate too much over time from the intended evolution, exercise directing staff may wish to capture the reasons for the deviation for after-action review purposes and may wish to introduce elements that may reduce the deviation without appearing to be artificial to the exercising headquarters.

- Attrition of high value assets for air and maritime forces. Given the many scarce resources that are employed in these forces and their potential to influence operations in a significant manner, any attrition needs to be reported and its causes identified. The directing staff must be able to make a timely assessment of the impact of the attrition on the course of the exercise and develop suitable courses of action from an exercise management perspective.
- Entities that represent civilian organizations, police, fire brigade, coastguard etc., are "fighting" against nature or against not recognizable enemies or even more against enemies without tactics and doctrines. In this case the kind of attrition is more or less following the ground units attrition rules for those entities that fighting in the ground and for all the others an attrition model that gives more probabilities to the "enemy".

Working exactly in the same way, building a voting game to calculate the important elements of every procedure and process and also to express in the most realistic way the results of simulation are providing a full description of the "behavior" of these elements under the restrictions of the simulation environment. How significant these restrictions can be, is measured by another voting game for calculating the power of specific data of this environment.

5. COST EFFECTIVENESS AND CONCLUSIONS

The vital targets by using CAX methodology for civil protection operations and civil – military co operation can be briefed as follows:

- Reduce the reaction time for civil protection operations and military – civilian co operation, which means fewer casualties in human lives.
- Reduce the costs of training, supporting and acting in civil protection operations and military – civilian co operation.

As a conclusion, we may say that by using CAX methodology we can surly achieve both the above targets, as it's already proved that this worked in the military area of interest. By accepting the fact that civil protection operation are not so complicated as military operations, especially in the operational and strategic level, it is obvious that by "tailoring" CAX methodology for civil protection operations we have good chances to succeed.

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