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Integration of C2 and M&S Elements in CAX for Crisis Management¹

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ABSTRACT. Paper presents experience in integrating real Command and Control systems with federation of modeling and simulation tools for performing Computer Assisted Exercises (CAX) in Crisis Management Area. Proposed Service Oriented Architecture for CAX support is based on experience of EU TACOM SEE-2006 exercise. Described approach is used to prepare Joint Training Simulation and Analysis Center for interagency concept development and experimentation in the area of civil security. Key element is development of federation of models management mechanism and connectivity with real systems transparently for the participants in the exercise.

KEYWORDS: Modelling and Simulation, Computer Assisted Exercises, Crisis Management, Federation of Models, Service Oriented Architecture

Computer Assisted Exercises (CAX) is one of the main tools for training and respectively change management of complex systems [7]. The integrated emergency management system (as an example of most comprehensive crisis management system) is a typical element of complex adaptive system, which needs effective change management internally and at the same time is an effective change management tool for the entire security sector, currently in transition from a traditional national security model to the civil security concept [5].

CAX requires integration of traditional Command & Control (C2) systems with Modeling & Simulation (M&S) tools to provide real test-bed for new concepts and new technologies including the key element – people in the loop.

There is a set of critical elements in CAX architecture – real C2 system and training system with simulation cell, training operations cell and analytical cell that need conceptual, information, hardware and software

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integration in order to support realistic flow of the training process as well as planning and analysis cell.

This paper presents a model of such integration based on static and dynamic technological diagrams with distributed nodes in the aforementioned cells.

The background and first research task of this paper is a definition of a model of concept development and experimentation (CDE) based on Computer Assisted Exercise (CAX). The second research task is to develop model for integration of C2 system with a training system and in this context the third research task is to outline scheme for federation of models-modules management.

CAX Based Model for Concept Development and Experimentation

CAX is considered a tool for transformation, supporting the CDE process [6]. For the purpose of this paper, we consider the development and experimentation of the concept of civil security and, more specifically, the integrated emergency management system (IEMS).

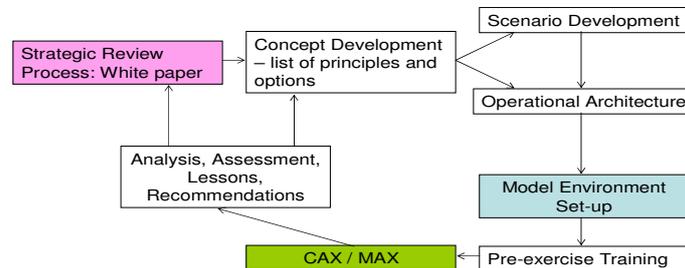


Fig. 1. CAX based Model for Concept Development and Experimentation

In order to successfully implement CAX as a tool, it is necessary to develop the environment to plan, perform and analyze the exercises. At a lower level, CAX can be replaced by a simple Model Assisted Exercise and the environment can be typical for Top Table Exercises (TTE). For an effective CAX, there is a need for effective environment, which we name Joint Training Simulation and Analysis Center in Civil-Military Emergency Planning (JTSAC-CMEP)².

² Joint Training Simulation And Analysis Center – Civil-Military Emergency Planning / Civil Protection was developed under IPP-BAS based Project with MoSPDA-Bulgaria and European Commission Directorate

JTSAC-CMEP is based on a model specially developed for concept development and experimentation in the area of civil security through CAX. This model is the base for the change management process – the transformation of the security sector into an integrated network-enabled organization. The integrated security sector is a part of the third generation of security sector reforms enabling the state to address the challenges of terrorism and other asymmetric threats.

JTSAC is an instrument through which Center of Excellence in Operational Analysis (CoE-OA) extends research, including M&S in crisis management, to support CAX in this area [3]. Especially in the context of the EU TACOM SEE-2006 exercise (EU terrorist attack consequence management in SEE exercise), and in particular its CAX component, the CoE-OA provided (see Fig. 1):

- Strategic review of the civil protection system in Bulgaria and its EU/NATO/regional context;
- Development of Civil Security Concept for Bulgaria;
- Development of General scenario, Operational Architecture and Message Flow for EU TACOM SEE-2006;
- Establishing a model environment based on JTSAC for implementation of the Operational Architecture and Message Flow for EU TACOM SEE-2006;
- Individual and pre-exercise training of the participants in the exercise;
- CAX implementation;
- Draft analysis, assessment and lessons learned from the exercise;
- Updates to the White paper on Civil Protection and Concept for Civil Security,

CAX has a key role in the process of CDE, because it integrates different organizations and technologies as well as involves people in the loop of experimentation. In a sense, CAX itself is both the motivation and the tool for joint work and well-documented experimentation, providing objective material for analysis and adaptation of the concepts.

M&S Capabilities of CAX Environment

JTSAC-CMEP, considered to be an integrated environment for CAX, is planned to use M&S in four main elements, covering the following areas:

General Environment: European Union Terrorist Act Management in South-East Europe Full Scale Exercise (EU TACOM SEE 2006) in partnership with CNSDR-BAS and NOA-Germany, team leader – V. Shalamanov.

- ***Planning and Analysis Cell*** (not considered here, because is connected with general management issues)
 - Planning and resource management
 - Assessment of CAX
- ***Simulation cell / White Cell***
 - Concept development, including general architecture
 - Concept to scenario transition support
 - Simulation of scenario and environment
 - Simulation of Integrated Early Warning System/ Notification System as well as all other not presented by real C2 system and training elements
- ***Operations Center***
 - Training Operations Cell
 - Communications Cell planning and management tolls, including connectivity with real C2 system
- **Analytical Cell Decision-Making Support (DMS) tools**

The general architecture for CAX environment [1] is further developed in current CoE-OA studies. Such an architecture, presented on Fig. 2, includes different cells: planning and analysis; administration and security; briefing cell, VIP cell, Press/PR cell, computer cell; communications cell; operations cell; analytical cell; simulation cell; field C2 cell. During the exercise these elements were divided between different structures of the Operational Architecture, including Operations centers on national and district level, field operations centers, international and ministries' operations centers and, of course, a White Cell to run simulation and information collection for further analysis.

The main dividing line is between the emulation of Integrated Emergency Management System (IEMS) and the White cell.

The JTSAC-CMEP is considered a test-bed for a new decision-making software and information sharing technologies as well as a tool for adding exercise participants in the loop for experimentation of the concepts and acquisition of new knowledge in the area of CMEP. Therefore, the focus of the environment is on modules for support of the exercise (MOSEX) [2], including planning and management, to achieve higher effectiveness and efficiency of the experimentation and training process.

The Modelling and Simulation software is the main engine of the CAX-environment and is tailored and adapted for the Bulgarian context to be applied in the "Terrorist Act Consequences Management in South East Europe" exercise (EU TACOM SEE 2006) sponsored by the European Union.

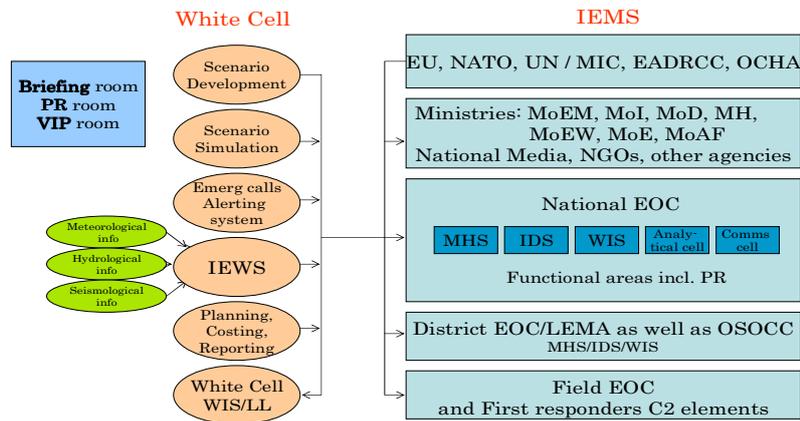


Fig. 2. Architecture of Joint Training Simulation and Analysis Center in Civil-Military Emergency Planning / Response (JTSAC-CMEP)

A limited budget and manpower for the preparation of software was available for the extremely short duration of the exercise. Low cost, standard basic software was selected, which provides the minimum of required functionality such as message handling, display capabilities and simulation tools. (MS-Office, MS-Visual Basic, Map Objects / ArcView, PowerSim).

The exercise was supported by a set of tools generated with add-ons to MS-Office, some tailoring of existing display software, and quick prototyping. The objective is to demonstrate the possibility to utilize existing low-cost, off-the-shelf software for command and control and to prototype already useful simulation models without great effort.

For the JTSAC-CMEP, there is another architectural model, depicted in Fig. 3, oriented towards the services provided for CAX. The main elements provide:

- Scenario modelling for the selection of the right operational architecture and message flow;
- Simulation of message flow and events;
- Modeling and simulation of “white” systems not included in the main program for the exercise including notification, hydro-meteorological early warning and forecast, seismological monitoring, development of the “objective processes” – physical, chemical, psychological, etc.
- Information management (IM) in the operations centers, including message handling system (MHS), web information system (WIS), databases, communications, etc.

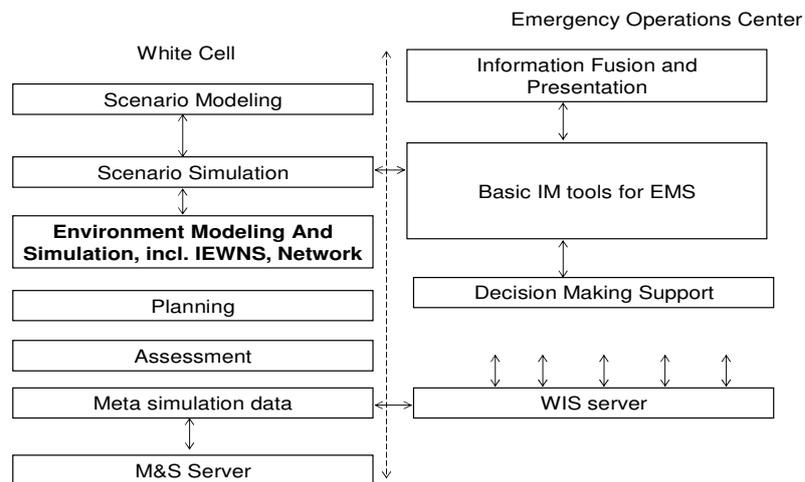


Fig 3. M&S in JTSAC Service Oriented Architecture

- Information fusion and display in the operations centers, including integrated display system (IDS).
- M&S to support the decision making process for the participants in the operations centers.
- Planning support and reporting, including financial management.
- Assessment support and analysis
- There are three main areas where M&S plays critical role in CMEP related elements of JTSAC considered in next subchapter:
 - Scenario development
 - Environment simulation
 - Decision making support

Integration between the CAX Training System (M&S System) and the C2 System

In order to be really instrumental in change management, and effective in the training process CAX has to be linked with a real C2 system. In this context there are several options:

- ***CAX without a real C2 system***
- ***CAX with a real C2 System***

- Direct link
 - C2 => M&S
 - M&S => C2
 - M&S ⇔ C2
- Link through “air gap” and human processing
 - Trainees
 - Support staff
 - Combined

There are three critical elements in a CAX architecture – the simulation cell, the operations cell and the analytical cell – that need conceptual, information, hardware and software integration to support the realistic flow of the training process.

The real challenge is to integrate commercial, off-the-shelf IM systems with commercial Emergency management tools and to add them to all specific M&S tools in order to support experimentation and training. CAX requires integration of traditional C2 system with M&S tools to provide a real test-bed for new concepts and new technologies including the key element – people in the loop.

The model used for general integration on the functional level of M&S and C2 system is based on static and dynamic technological diagrams with distributed nodes in three cells – analytical, operations and simulation. The EU TACOM SEE-2006, the main approach was to integrate different sub-systems on the data level through an open operational web server. Work is under way to add to this a data proxy server to “translate information” to and from the third component – the M&S server that works over “meta simulation data”.

In normal C2 system all nodes will “sit” in operations and analytical cells, with the tendency the majority to be concentrated in the analytical cell, thus providing the scientific best solution for problems arising during crisis management scenario. During an exercise, the simulation cell has to cover all nodes that could not be covered by operations and analytical cells. So on the one hand, there is a system with participants in the exercise only looking at closed simulation run by the simulation cell, without any input from the operations or analytical cell. And on the other - when we have some nodes implemented in the analytical or operations cell there is a full C2 system with no elements in the simulation cell – all of the nodes are implemented in operations and analytical cell.

A static technological diagram is used to organize access to different functions at every work-station through easy-to-use menu system. This static diagram is designed according to the functional account of the work-station.

Dynamic technological diagram is covering the event/message flow in the system as a whole and it is a representation of the scenario, where events and messages are linked with work stations or other physical elements of the operational architecture.

An open operational web server is used to integrate all the messages exchanged and through IDS provides a display at the work station or on a data wall/collective screens of different types of information (including geographic information) associated with the message.

Meta simulation data is a service under development to provide data required by models from the operational web server, and to submit back simulation results as a message.

CAX Federation Management

This paper presents a model of federation management based on an extension to the static and dynamic technological diagrams with distributed nodes in different cells of the architecture. Idea is to integrate M&S with distributed web based game technology that connects a real C2 system with a virtual system for replacing non existent/unused elements in certain experimentation/training situations. This integration is based on CAX federation of components to include real C2 systems, elements for scenario development, planning and assessment of CAX, systems for modelling and simulation of natural environment, elements to support decision making and to provide standard services for data base management and geographic information.

On Fig. 4. the model for CAX federation is presented based on Federation BUS.

In the federation for providing environment for a communications and computing environment there is a need for Internet services and e-GRID modules as well as standard services for message handling (MHS), web information services (WIS) and integrated display system (IDS). The key element in the area of communications is the subsystem for modelling of the network between nodes – real and virtual of the distributed C2/M&S system.

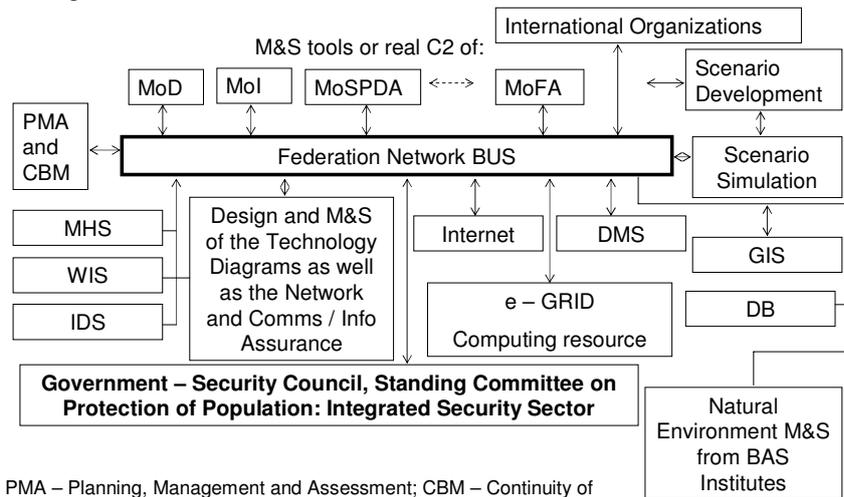
In this federation model, the most significant organizational role is given to the Integrated Security Sector bodies on Government level which are main users of this experimental environment.

In order to achieve a comprehensive integration process that is spiral and evolutionary by nature, the considered Interoperability patchwork model can potentially include:

- Memorandum of Understanding between organizations
- Standard Operating Procedures / Documents

- Scenario as event/message list (Operational Architecture related)
- Basic MHS/WIS/IDS to support interagency cooperation on proxy basis
- GIS and DB (common for all organizations on proxy basis)
- Environment simulation from different BAS Institutes – hydrology, meteorology, seismology, remote sensing, etc.
- Internet simulated communications and computing power
- CAX Federation BUS management based on Technological Diagrams
- Integrated Implementation Plan and Balance Score Card Assessment

Fig. 4. CAX Federation



PMA – Planning, Management and Assessment; CBM – Continuity of Business Management; DMS – Decision Making Support; M&S – Modeling and Simulation; DB – Data base; GIS – Geographic Information System; e-GRID – European R&D network of computing resources

JTSAC-CMEP is a base for development of prototypes and further implementation with business partners of required elements, integration and testing of federation and its use for training and experimentation of new concepts. It suggests that pure mathematical work is minimal – but undoubtedly of great importance to the overall effort. Integration, management, assessment and continuous process of change are a real challenge for the people involved.

Conclusions

CAX is a very effective instrument for change management through the process of CDE, especially in the current situation where a growing number of new and diverse concepts require rapid experimentation and adaptation. Different concepts come with their respective different models to be integrated in the CAX environment.

There is understanding of the horizontal nature of the new concepts and as a result a growing need for cross culture training – cross agency, international, civil-military, public-private. These horizontal communications in the CAX environment require management of the federation of models as well as connectivity between real C2 systems and training models.

It is impossible to introduce new concepts only through new platforms and systems. The key element in concept implementation/change management is the personnel, so “people in the loop model” for experimentation is needed and it puts forth certain critical requirements that the CAX environment be flexible for different type of human involvement.

The change management process in the area of crisis management/integrated emergency management systems development requires a low cost flexible training environment as a prerequisite for large scale implementation amongst many agencies on the central and local level.

CAX environment is very convenient and effective, but not available for all aspects of rapidly developed concepts, therefore a CAX and MAX balance in training and experimentation is needed in order to ensure success.

Evolutionary development (prototyping) and rapid implementation of the results of experimented concepts is required. One model experimented in the last three years is based on development of CoE-OA under NATO SfP981149 project, that provided basis for establishment of JTSAC-CMEP using national funds and using it as an experimentation test-bed for EU TACOM SEE-2006 financed by EU. Experience from the exercise is an input for the USTDA sponsored IEMS Feasibility Study and the pilot project for the Ministry of State Policy for Disasters and Accidents (MoSPDA).

This model was the base for integration of efforts of Administration/Forces, R&D/E&T academic institutions and business entities around the M&S based CAX environment, that proved it is a feasible approach and may be considered as a “must” in future.

In order to implement the ideas and the model presented in this paper there is a need for a Proxy Organization to provide patchwork interoperability between all participant in the federation process – especially Administration/Forces, R&D/E&T academic institutions and business entities [4]. On a technical level, JTSAC-CMEP is a tool set to provide the environ-

ment for federation management, but there is higher challenge to develop and institutionalize the Proxy Organization as a tool for Concept Development (between administration and academic institutions) Experimentation (with active participation of business) and Implementation (between administration and business) support.

The Classic scientific challenges are in the areas of:

1. Conceptualization and high level modeling
2. Architecture development for the high level model and configuration management
3. M&S of the architecture dynamics
4. Experimentation and Implementation Planning and Assessment

Two more administrative issues are connected with:

5. Experimentation and Implementation Support and Management
6. Documentation and Reporting Management

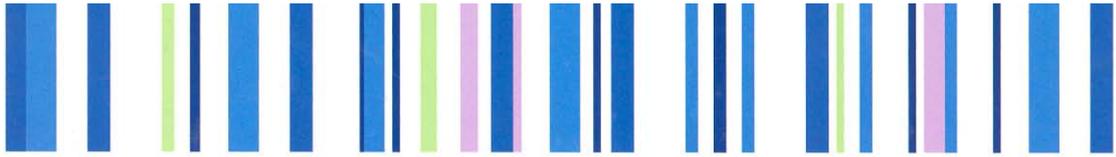
And in the end integration of all these disciplines in an organization for change management is based on the Change Management Theory for the Civil Security Oriented Integrated Security Sector

CoE-OA and JTSAC-CMEP are working very closely with other groups as the Center for National Security and Defense Research (CNSDR-BAS), the team of the SfP project for R&D Management in the University of World and National Economy and the SfP project for Maritime Security CAX environment in the Naval Academy. Efforts are focused in providing best possible/available Analytical Support for Decision Making in the Security Sector by Integration of C2 and M&S Elements in CAX for Crisis Management.

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