**TERMS OF REFERENCE**

Crisis Management and Disaster Response Centre of Excellence (CMDR COE) is the 21st NATO accredited COE and its activation as a NATO Military Body with a granted international status under Article 14 of the Paris Protocol, as recommended by HQ SACT.

The CMDR COE has met the accreditation requirements set by the MC and will provide support to NATO transformation and to the enhancement of NATO capabilities in the field of Crisis Management and Disaster Response, thereby adding value.

The CMDR COE had more than 20 NATO requests for support in 2014 and a further more for 2015. The Centre is working closely with HQ SACT, SHAPE and NATO HQ to make valuable contributions to various NATO initiatives in its field. Most notably, the CMDR COE has agreed to deliver a Study to the NATO Military Authorities that examines the impact on NATO military operations based upon the potential crises and consequences of urbanization between now and 2035. The Centre is also ready to contribute to NATO Policy, Doctrine and Concepts related to crisis management and disaster response activities.

Following its strategic aims for research, development and improvement of capabilities for crisis management and disaster response, the Center’s mission is to serve Nations, NATO and partners’ long-term interests by combining efforts, increasing interoperability, standardization and effectiveness in support of capability development to prepare, predict, prevent and respond to crises and disasters.

The capabilities of the CMDR COE is expected to be greatly enhanced with the implementation of some unique crisis management and disaster response tools, software and simulation systems. For that purpose M&S Laboratory will be established under the governance of CoE that will enable the CMDR COE to provide NATO with a unique comprehensive training and analytical capability unmatched anywhere in the world. This M&S Laboratory would be able to support large scale crisis management and disaster response distributed exercises and analysis with specific crisis management and disaster response tools and simulations. This would greatly increase the credibility and visibility of the CMDR COE and provide a critical new capability for NATO.

The CMDR M&S Laboratory should have its initial operational capability established in 2018 and operational in time to support the planned NATO Crisis Management Exercises as well any regional or EU ones.

CMDR CoE is in process of procurement of powerful software tools and solutions for Simulation and Training, which will bring benefits to NATO and NATO Nations capabilities to manage crises and are unique to NATO and enable non-military type operations.

The purpose of the current document is to provide a detailed technical specification of a demanded by COE CMDR constructive simulation software for crises management and disaster response training.

**Principal applications of the Software**

The simulation Software should have wide range of applications, but not limited to:

* Large Scale Training Center
* Command post training, from battalion to division level
* C2 Simulation & Stimulation (such as Course of Action Analysis)
* Command post training, from battalion to division level
* Officer Self-Training
* Doctrine & Equipment Analysis – to allow CoE CMDR to set up and test new architectures (units, equipment, etc.), orders of battle, or doctrines in various conditions to synchronize new operational capabilities to combat elusive and adaptive adversaries;
* Public safety, crises and emergency management – to deliver relevant information to various target clients. Dispatching information through web­-services to enable different types of organizations to train or exercise, especially for humanitarian, crisis and risk management scenarios.
* Emergency plan verification - users can assess whether their disaster plans are satisfactory or if they need to be updated or changed, by simulating the key elements of each plan
* Decision support for C2 systems

**Key requirements**

* Constructive – all units and equipment are simulated within the simulation
* Minimizing the manpower needed trough automation and Artificial Intelligence
* Customization
* Usability
* Adaptability
* Easy to deploy
* Interoperability
* Scalability and Modularity
* Support for Complex Operations
* Efficient Integration

**Main features**

In a general context the Software should be and provide:

* **High level of realism:** Ability to represent high-­fidelity emergency response units and teams immersed in complex crisis and disaster scenarios through the use of physical models and advanced interoperability features.
* **Automated units:** Emergency response units and teams in the software should be intelligent and autonomous. The trainees and their crisis team members should give instructions to the subordinate level using their standard means of communication. These high-level instructions should then be executed automatically, without any additional input from the players, with teams on the field adapting their behavior accordingly as the situation evolves. The Artificial Intelligence implied should then determines the impact on the situation and its evolution.

Also platoons and companies in the Software should be intelligent and autonomous. They can receive operational orders and execute them without additional input from the operators, while adapting their behavior accordingly as the situation evolves. Such a level of fidelity on combat actions, the operations of battalions, brigades, army divisions and higher, provides commanders and their staff with remarkably reliable simulation exercises.

* **Adaptable:** The Software should match the specificity of every possible crisis situation and adapts to the organizational structure and procedures. Emergency response vehicles, equipment, and material in the simulation should give a highly accurate representation of those deployed during the real crisis. Furthermore, human behaviors supplied should be equally realistic in such situations. Everything in the Software should be customizible to match the specificity of any doctrine: from vehicle speeds, weapon system performance and sensor accuracy, through unit composition, basic loads and logistics systems, to unit behaviors and missions.
* **Flexible:** Use cases of the Software should include high­-level crisis management training, validation of procedures/equipment/means of communication, and interoperability and emergency plans.  It should be also able to be used as a decision-support system during a crisis situation or as support for a large­-scale live exercise. It should be able to interoperate with other operational and simulation systems used by emergency response organizations.

Use cases of the Software should cover command staff large-scale training centers, officer self-training, course of action analysis, planning and decision support. Furthermore, support of interoperability standards should be provided for integration with existing command & control systems.

* **Out­-of-­the-­box content:** The Software should be delivered with a large number of predefined units including the emergency services (police, fire & rescue, ambulances), transportation, logistics, communication centers, hospitals, government agencies, NGOs, refugees and military units, but also with threats such as natural, man­made, chemical, petrochemical, nuclear and biological disasters. Also it should be delivered with a large number of predefined units including armed forces (infantry, tanks, artillery, engineering, army aviation, etc.), asymmetric threats (terrorists, militias, etc.).
* **All in one solution -** The Software should include a simulation server, a gaming client, a timeline, tools for scenario preparation, terrain generation, physical and decisional models adaptation, after action review, a self­-training launcher and a web­-based interface to manage distributed exercises.

The simulation Software should be compliant with the following features and functionalities:

* Provides generic physical and behavior database for Defense applications;
* Provides generic physical and behavior database for Public Safety applications;
* Designed to help users in the military, civil security and research communities develop and deploy complex, highly-realistic training scenarios and analysis;
* Displays automatic behaviors consistent with army doctrine and autonomous commanding entities;
* Units are driven by opportunistic behaviors (not pre-scripted), drastically reducing the required manpower;
* Provides a non-determinist rendering of complex situations involving collective human behaviors such as typical warfare, humanitarian operations and crowd control;
* Automation of control at the lowest tactical level;
* Simulation of human factors such as friction in the dissemination of a commander’s intent, fatigue, coolness under fire, or morale;
* Simulates entities with doctrine-compliant behaviors;
* The generic content should be NATO based and should include at least 300 automated missions (behaviors);
* The content of the simulation itself needs to be customizable and adaptable to the specific operational context of the simulated operations;
* Equipment, weapon systems, sensors or any other doctrine-related element to be easily modified and adapted by the end-user;
* Ability to either train an operator or to have operators self-trained. To be used for both modes of training;
* Simulation engine to be able to model the behavior of up to 10,000 units, through the use of aggregated models on a dedicated high performance server;
* The simulation should also operate on laptops with a lower number of entities;
* Terrains can be set to surfaces of at least 500x1000 km.;
* Enables “what if” analyses trying out alternative response strategies for one and the same incident, thus validating disaster plans and procedures;
* Able to represent high-­fidelity emergency response units and teams immersed in complex crisis and disaster scenarios through the use of physical models and advanced interoperability features;
* Based on a stochastic simulation - all calculations should come from a random seed and are based on probabilities (PH/PK probability of hit/probability of kill);
* The capacity to adapt, and autonomy given to simulated units (understanding and acknowledgement of orders and ability adapt to the tactical situation encountered without human intervention);
* Use of a realistic algorithm for pathfinding calculations, incorporating the tactical objectives of the mission and the constraints of the environment;
* Automatic route planning – all units should be able to analyze the terrain and move based on capability;
* Precise modeling of the perception of units, and the sharing of this knowledge with other Units;
* Realistic behavior at both low (itinerary calculations, shots) and high levels (contact management, movement coordination, support management, etc.) at every phase of the maneuver, as well as taking into account human factors like morale, fatigue and experience;
* Non-deterministic resolution of combat, where each unit accurately evaluates the conflict situation before deciding on coherent action with allied units: whether or not to engage in combat, the optimal target, and choosing the most suitable equipment;
* Complete training of the command chain, allowing operators to control both their units at squadron/platoon level, which provides training with a significant number of units without increasing the number of operators;
* Management of each branch of the army, as well as civilian populations and asymmetric forces, such as militia and terrorist forces. These non-military units interact dynamically with military units in accordance with ongoing events, which permit the running of highly complex scenarios;
* Use of autonomous units for friends and foes, which are able to understand and interpret operational orders given by a human operator, and adapt to any tactical situations encountered during their mission, without any additional human intervention;
* End to end solution, from content customization to After Action review, with powerful reporting and scoring tools;
* All interactions should be made using operational language and procedures, as close as possible to the real way of commanding units on the battlefield or response units during a disaster response;
* Mission term, boundaries, phase lines, and objectives should be directly taken into account by simulated units to set up a doctrine-compliant course of action;
* Intuitive concepts and user-friendly interface, for a quick adaptation to the tool. English should be natively supported, and the interface should be able to be fully translated;
* Integration of internal or external physical models, such as CBRN cloud movement, fire, volcanic eruptions, floods, or any other type of natural disaster;
* Integrated EPM system, enabling to plan and record simulation and external events. An intuitive and efficient tool to manage every event occurring during a disaster: phone calls, emails, fax, threats, actions on the field, etc.;
* Natively to provide a database incorporating at least 300 missions associated with more than 100 different types of unit (infantry, armored vehicles, engineering, artillery, police, ambulances, etc.), all capable of being enriched and modified;
* Supports the principal terrain formats, such as VMAP, DTED, and USRP, as well as Geotiff raster data, vectorial data such as Shapefiles or ArcSDE bases by ESRI, using GDAL and OGR bases;
* Native support of standards like DIS, HLA or BML that allows the integration and interconnection of the software within other simulation and information systems, such as Command & Control (C2) systems;
* Compatible with the principal communications formats (C-BML, DIS/HLA 15.16e, KML, WISE, RSS, etc.), and therefore able to interface with other simulations at the same level, playing for example with other forces (Naval, Air) or with allies, as in an international context, but also with operational systems in order to facilitate information exchange;
* Online administration for the remote management of exercises and replay sessions, combined with a light client for the deployment and running of remote exercises without the installation of a complex hardware architecture;
* Integrated operating tools, providing for the planning and recording of operation actions, whether they be internal (orders issued to units, the triggering of disasters, events), or external (an email, a fax, a telephone call, etc.);
* Provides an open and documented API that allow to interact directly with the simulation and integrate or develop a multitude of complementary plug-ins: creation of a new graphics client capable of interacting with the simulation; connection to a C² directly, rather than via a C-BML server; connection to a light client (such as Google Earth) or directly to another simulation, etc.;
* The software API should allow third party to develop:
* Situation export to an external viewer (SIG, Google Earth, etc.)
* Communication with C2 systems through standards (BML) or C2-specific API
* Mission planning (fire plans management, etc.)
* Course of action analysis
* Multi resolution modeling (connection with 3rd party simulation)
* Web based client
* Scripting – should be able to support LUA scripting to provide a complex story line to any exercise further reducing the need for operators;
* Maximum speed up of simulation, depending on the machine, but not less than 10x;
* Maximum number of workstations – not less than 20;
* Supporting any MS Windows version ( 32bits or 64bits);

**Situation assessment**

Units should automatically gather tactical information:

* position and strength of both friendly and enemy forces
* obstacles, position, etc.
* from direct observation, higher command, neighboring units or specific knowledge sharing procedures

**Detection algorithm**

* Unit available sensors
* Direct observation
* Knowledge groups
* Ray tracing detection
* Perceived position and extrapolation based on Intelligence.

**Decision making**

The decision making phase should take into account:

* The mission assigned to the unit
* The human factors: the unit’s experience, morale, tiredness
* The unit capabilities such as detection, movement and fire power
* The rules of engagement
* The threat presented by the known enemy units and the force ratio

**Actions**

Pathfinding algorithm:

* Specific unit movement capacity
* Adapt dynamically to environment
	+ Obstacles (avoid)
	+ Terrain (use based on mobility characteristics)

Non-deterministic combat resolution:

* Automatic relevant target selection
* Probability to hit
* Probability to kill