NATO EDUCATION AND TRAINING NETWORK

1.0 INTRODUCTION

In the light of future operations and real-life challenges, NATO is recognising the need for development of a distributed and networked education and training capability which will integrate and enhance existing national capabilities and will focus on the education and training of NATO Operational and Tactical Headquarters' staffs and NATO forces preparing to execute NATO Response Force (NRF), Combined Joint Task Force (CJTF) and International Security and Assistance Force (ISAF) and any other future NATO missions.

To meet this operational demand, NATO Allied Command Transformation (ACT) established a vision to:

> **Deliver to Alliance and Partners a persistent, distributed education and training capability able to support training spanning from strategic down to tactical level across the full spectrum of operations, leveraging national expertise and capabilities.**

ACT initiated the NATO Snow Leopard program to accomplish this vision. Snow Leopard is synonymous with NETN. NATO Snow Leopard is composed of the following components:

- Education;
- Shared scenarios; and
- Modelling & Simulation (M&S) toolsets.

All of them distributed over NATO Wide Area Network (WAN).

The WAN includes but is not limited to NGCS (NATO General Purpose Communication System). The Joint Warfare Centre (JWC) and Joint Forces Training Centre (JFTC) provide the backbone infrastructure by hosting the core services and functionality for each NATO Snow Leopard component. JWC and JFTC core capability must be easily extendable and reconfigurable to reach and provide services to NATO HQs, Centres Of Excellence (COE), NATO Schools, governmental and non-governmental agencies and appropriate national centres, ranges, or virtual simulators, depending upon exercise specifications and National needs and desires. NATO Snow Leopard instituted a common set of standards, protocols, interface middleware and procedures for M&S, C4ISR and live systems integration. These establish the foundation for NATO-wide interoperability and reuse in the training and education domain. The education component capitalizes on the latest web enabled technologies for Advance Distributed Learning (ADL). A scenario management framework allows rapid scenario generation and sharing in a collaborative environment while enforcing version control, user access rights and retrieve and storage mechanisms.

NATO Snow Leopard was planned to be a multi-year phased program. The NATO Snow Leopard NATO Training Federation (NTF) met Initial Operational Capability (IOC) in 2008 by supporting Steadfast Joiner 08. In this exercise, JWC hosted a distributed, multi-level NATO Response Force (NRF) Computer-Assisted Exercise (CAX). The NATO Live, Virtual and Constructive (NLVC) federation infrastructure met IOC in 2010 during the MSG-068 Stand Alone Experiment (SAE). NATO Snow Leopard Full Operational Capability (FOC) was expected in 2011 – 2012 timeframe. It was also expected that NATO Snow Leopard would demonstrate FOC by supporting a NATO event, meanwhile NETN development will continue to support operational requirements through a dynamic, evolving environment to provide flexibility and promote reusability.

In 2010, ACT changed the Snow Leopard Program name to Distributed Training and Exercises (DTE) to more clearly identify the program's purpose. DTE will progressively expand to capitalize on emerging technologies and include other NATO and Partner Nations as they acquire new capabilities. A fully operational, networked education and training capability lead by Headquarters, Allied Command Transformation (HQ ACT) and centered at the Joint Warfare Centre (JWC), Joint Forces Training Centre (JFTC) and NATO School will allow NATO to distribute training and exercises across Alliance education and training centres, while at the same time enabling those forces to train together using the same key decision points and objectives necessary to make the NRF, CJTF, ISAF staffs and assigned forces ready to deploy.

NATO's transformation process builds on education and training by developing and inoculating interoperability, especially through linking NATO and national systems, forces and headquarters – and routinely practicing and refining tactics, techniques, and procedures to meet the evolving operational requirements. NATO DTE is a critical element of that solution set and will bring education and training to those who need it anywhere at anytime and will transform NATO intellectually, culturally and militarily.

Upon request by HQ-SACT, NMSG formed MSG-068 NETN to support NATO's DTE vision. Many of the previous experiences and products from NMSG activities, such as, MSG-027 (Pathfinder Integration Environment), MSG-001 (Exercise First WAVE), MSG-052 (Knowledge Network for Federation Architecture and Design), as well as from national and NATO distributed simulation events, established the starting conditions for MSG-068. In particular, MSG-001 (Exercise First WAVE), set the standard for MSG-068. MSG-001 and the NATO SAS-034 Task Group collaborated in a joint project executed between 2000 – 2004 to develop a prototype NATO synthetic Mission Training through Distributed Simulation (MTDS) environment to support a multi-national exercise and assess its potential to support training to enhance NATO's operational effectiveness in multi-national air operations. This 7-nation activity (CAN, DEU, FRA, GBR, ITA, NLD, USA) was known as "Exercise First WAVE" (Warfighter Alliance in a Virtual Environment), the first large simulation-based aircrew training exercise organised in NATO. The exercise explored issues of matching training requirements and technical capability and exposed the need for a multi-national exercise development team to address both these aspects. This experiment used DIS as its interoperability protocol and was run as unclassified event. The network infrastructure was based on commercial leased lines and was dismantled the day after the exercise finished.

In compliance with STANAG 4603, MSG-068 selected the High-Level Architecture (HLA) as the technology for integration and interoperability between simulation assets. Specifically, MSG-068 focused on HLA-evolved, which became IEEE standard 1516-2010 during the MSG-068 tenure, and one feature of IEEE 1516-2010, FOM modularity, was a key element in achieving the desired flexibility and maintainability level.

2.0 OBJECTIVES

The **objective of the MSG-068 NETN Task Group** is to assess the distributed simulation and learning capabilities that NATO, Partner and Contact Nations, Schools, and Agencies have that could contribute to the development of a NETN capability. The Task Group (TG) also recommends and demonstrates a way forward for interoperability, technical standards and architectures to link these training and education centres to provide a shared persistent capability. Finally, the TG identifies and recommends roles and responsibilities of the NATO, Partner and Contact Nation organizations responsible for distributing and maintaining M&S capabilities within the scope of NETN.

The following topics were covered under this TG to meet the objectives:

- Assessment of distributed simulation and learning capabilities with potential for inclusion in NETN.

- Recommendations for interoperability and technical standards.
- Recommendations for the development of NETN architectures.
- Recommendations for the assignment of roles and responsibilities for distributing, managing and maintaining NETN capabilities.
- Identify, develop and conduct experiments enabling NATO/PfP Nation's capabilities to participate in NETN.
- Roadmaps and technical reports in support of NETN.
- Demonstration of a limited NETN realization comprising JWC, JFTC and national simulation centres and systems.
- Run preparatory tests at ACT and national facilities and evaluate the results from these tests for risk reduction of the demonstration of the feasibility of the NETN-concept.
- Perform a demonstration of the feasibility of the NETN concept of a distributed networked training capability embracing JWC, JFTC and national simulation centre and the corresponding simulators, simulation systems and C2-systems.

3.0 THE REQUIREMENTS FOR NETN

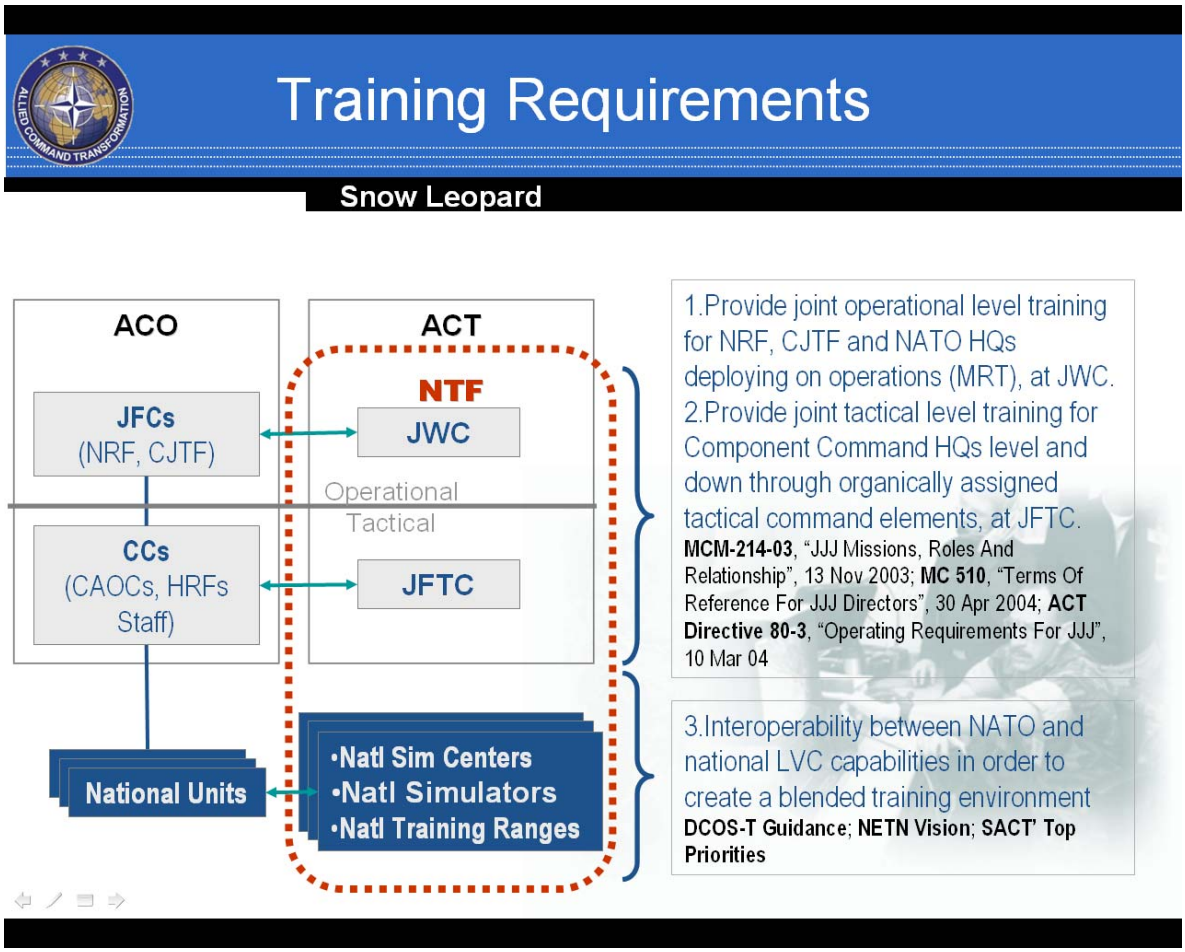
Over the last decade the world's strategic geopolitics have changed tremendously and NATO as a central key player has adapted itself to the new realities:

- NATO is fully committed in Afghanistan with some 30,000 troops conducting warfighting activities in certain areas.
- As part of the NRF concept, NATO might deploy a multi-national force out of Europe within a few weeks.

When NATO forces are deployed in theatre to conduct a joint operation, all forces from the Joint HQ down to the unit in the theatre of operation have to be trained on the specificities of the mission within a reduced time frame, typically less than 9 weeks. Depending on the command level of the force, the training is a NATO or a national responsibility and the most relevant vehicle of the training is different: aggregated constructive simulation, high resolution constructive simulation, virtual simulation and/or live simulation. Each type of simulation provides the details required to portray an operation at the appropriate resolution and to feed C2 information systems in a realistic manner.

In addition, the technology evolution over the last few years in the fields of communication systems, information sharing and multi-media means has impacted the way military forces are managing crises. New concepts such as Network Centric Warfare and Time Sensitive Targeting are using those technologies as a force multiplier by tying force components tightly together and reducing decision cycle processes. NETN should provide a solution at the NATO level to the challenging requirement of training a joint multi-national force in managing crises in this new era of warfare.

In this section we examine why NETN is needed and how it can serve this purpose. To do this we answer three questions, which appear as section headings of the section.



** The term "Nations" refers both to NATO and Partner Nations.*

Figure 1: Training Requirements.

3.1 Why Do NATO and Nations Need Multi-Level and Cross-Level Training?

NATO has a joint, multi-level command structure that needs to operate together. This necessitates multi-level and/or cross-level training. When multi- and/or cross-level training is conducted there may be parts of a Training Audience (TA) that have a set of training objectives different from the other parts of the TA. For example the training objectives of a maritime component command may be different from the ones for a JFC that joins the same exercise. If the training objectives are determined with a focus on a part of the TA, then the overall exercise is designed accordingly, which means the exercise may not fulfil the requirements of all of the TA. New multi-resolution exercise methodologies, constructs and technologies are needed to ensure all TA training objectives are met in the face of the following challenges:

- The training objectives of echelons differ from each other.
- There is a need to conduct an exercise in an overarching environment providing the possibility of high detailed realistic information.
- There is a need to practice information flow among the echelons.

- The decision cycles of forces deployed in theater are interdependent.
- The combined and joint nature of force structures has been increased.
- Most operations are conducted by diverse force elements that must work synergistically at all levels, from strategic down to tactical levels.

Despite those challenges, NATO anticipates the following benefits:

- Combining training events into a reduced number of multi/cross-levels training events yields efficiencies and reduces costs.
- Multi- and cross-level training can provide dynamic, capability based training across a full range of integrated operations between NATO forces, member forces, and partner forces.
- If the Nations train as they fight, both on the strategic and tactical level, then they will learn to operate as a cohesive force.

3.2 Why Do NATO and Nations Need LVC?

Training audiences should be immersed in a realistic environment and situation that can be consistently maintained throughout the exercise. Constructive systems adequately simulate most theatre assets, but live and virtual systems are increasingly necessary to more accurately represent special assets present in current operational environments or to emulate C4ISR feeds available to Warfighters. For example, increasing use of UAVs in theatre has led to not only more detailed representation of UAV platforms in simulation environments, but the need to provide video feeds to training audiences expecting similar capabilities in theatre. All the components of this synthetic world must work together cohesively in order to achieve the training promises afforded by multi-resolution and LVC capabilities:

- True multi-level and cross-level training can only be achieved through LVC.
- LVC will support a broad spectrum of joint training requirements.
- LVC provides the capability to conduct coherent joint training across different levels of TA, and hence it will provide a seamless and more realistic training environment.
- NATO may need LVC to support exercises that include NATO-owned platforms, e.g., AWACS or specific nationally provided platforms that require specific interoperability measures.
- LVC training is required to achieve the necessary immersion of decision makers.
- LVC simulation systems are needed to standardize preparation for operations in an international environment; to reduce health and material risk; to make better use of resources (efficiency and effectiveness); to compensate for restrictions (e.g., environment protection, access to scarce resources by replacing them with simulated assets).
- The LVC will allow Nations to participate in a full spectrum training environment providing combined task force commanders and staffs a cost effective way to fully train disparate national forces into a cohesive fighting force.

3.3 What Are the Benefits of NETN for NATO and Nations?

We can summarize the benefits of NETN for NATO and Nations as follows:

For NATO:

- NETN will reduce the educational and training costs for all participants.
- NETN will improve the interoperability among all participants (NATO, Members and Partners).
- The NETN will be a persistent global network of live, virtual and constructive components, to include collaborative tools and services that provide a seamless training environment that supports a broad spectrum of NATO and Nations training requirements.
- It will support coherent training across different levels of TA, and it will provide a seamless and more realistic training environment. Moreover, it will deliver to the Alliance and Partners a distributed Education and Training Capability that will comprise distance learning and shared scenarios database capability.
- NETN will provide NATO and the Nations with the means to plan, conduct and control a comprehensive building block approach to the training of a multi-national force in the context of a common scenario and with a coordinated approach to training design and observation.
- NETN will improve the exercise quality and efficiency.
- Nations will have a better understanding of NATO's role and how to interact with NATO as well as ensure national forces are ready to conduct NATO operations in a coalition force structure.
- NETN will help to achieve better effects through standardization, reduced cost, resource savings, and certified units.
- Better and less expensive possibilities to do mission rehearsal.

For Nations:

- Nations can conduct mission rehearsal with others (NATO/Nations) before going to mission (Train as you fight).
- NETN will reduce the cost for establishing training and experimentation networks.
- NETN will help to improve communications and exchange of experience among NATO Members. This is an excellent opportunity for education and training.
- NETN will provide means for cooperation between NATO HQ's, national HQ's and other members forces HQ's and units in collectively distributed LVC environments.
- NETN will improve interoperability between simulated or emulated national C2 systems in the NATO simulation environment.
- NETN will improve interoperability between NATO and national LVC.
- Nations will be able to access to standardized scenarios and geo-databases.
- Nations will be able to access to unified ADL content.
- Nations will be able to access to key technologies, technical standards and advance architectures for distributed LVC environments.
- Nations will be able to develop interfaces between national LVC systems and NTF.
- Nations will learn from experiments enabling new services for NETN.

- Nations will benefit from the improved environment NETN offers for crisis management training and education for civilian responding entities.
- Nations will benefit from the opportunities NETN provides for technology research, learning, innovation and business opportunities for SMEs and research organizations.

4.0 ASSESSMENT OF DISTRIBUTED SIMULATION AND LEARNING CAPABILITIES

MSG-068 conducted a survey to assess interest in NETN capabilities. The following questions were answered by Nations and organizations:

- Which Nations would like to join NETN?
- Which simulation centres would the Nations like to utilize for NETN?
- Which simulation systems, C2 systems, CIS systems, architectures, environments and tools are in use and will be in use in these simulation centres?
- What are the future developments that will impact NETN and Nations capabilities?
- What is the Nation's level of commitment to adopt NETN?

The following Nations are interested in NETN and have simulation centres that can participate in NETN: Australia, Belgium, Bulgaria, France, Germany, Italy, Netherlands, Norway, Romania, Slovenia, Spain, Sweden, Turkey, UK, USA.

There are many varied and numerous simulation and C2 systems that Nations use and which any NETN architecture would need to accommodate. Nations and organizations use different architectures and standards for constructing training and learning environments. Our findings in the survey can be summarized as follows:

- More joint and system-of-systems environments are required.
- National training networks should be integrated in NETN.
- Different architectures (mixed architectures, e.g., DIS and HLA), RTIs and federation agreements need to be integrated.
- Integration of COTS and live assets is also needed.

In general, the Nations which responded are committed to the NETN approach. This is corroborated by the following Nations which participated in MSG-068 and contributed in order to develop and demonstrate the feasibility of the NETN approach: Australia, Bulgaria, France, Germany, Hungary, Netherlands, Romania, Spain, Turkey, UK, USA.

5.0 RECOMMENDATIONS FOR INTEROPERABILITY AND TECHNICAL STANDARD

In order to achieve interoperability and rapid integration of simulation systems, MSG-068 developed a baseline NETN Reference Architecture. This architecture is defined in terms of a persistent infrastructure, federation agreements, shared resources, and common tool sets.

5.1 Persistent Infrastructure

Although NATO and Nations conducted geographically distributed CAXs in the past, these used infrastructure that had to be re-established for every exercise. That proved costly and unresponsive. Technological advances suggest more cost effective, responsive, and efficient means to support current and future training requirements. MSG-068 established an infrastructure sub-group to investigate a number of options for a more persistent and cost effective infrastructure approach. This MSG-068 sub-group consisted of 15+ experts that worked collaboratively to develop the recommendations summarized below. The research results and recommendations with respect to the NETN persistent infrastructure are detailed in Annex C and E.

5.1.1 Exercises Requiring a Secure Infrastructure

MSG-068 recommends the Combined Federated Battle Laboratories Network (CFBLNet) as the persistent backbone for NETN up to NATO SECRET. CFBLNet provides secure and managed services over a bearer network. Persistent in this context means services are provided with a guaranteed network availability and quality of service. The CFBLNet architecture allows users to create enclaves with various classification levels up to NATO Secret. An enclave can only have a single level of security classification at a time. However, the security classification of an enclave can be changed from one event to the other. A CFBLNet enclave may also be accessible by Partnership for Peace (PfP), Mediterranean Dialog (MedDialog), Istanbul Cooperation Initiative (ICI), Contact Nations, and the other Nations when the security classification of the enclave is established to allow these participants. The Nations may extend the CFBLNet to include their own training sites or, alternatively, connect the national CFBLNet Point-of-Presence (PoP) to a national secure network infrastructure. Notwithstanding the recommendation to use CFBLNet, MSG-068 found several issues which require improvement:

- The procedures for joining CFBLNet or extending an existing PoP should be simplified and clarified.
- When CFBLNet is used, it introduces another technical management level on top of the technical administration of the bearer networks. The user needs to manage these two layers separately for multiple sites, which is not always practical. A scheme to unify the management of infrastructure (i.e., to provide single point of contact for the infrastructure) needs to be developed.

5.1.2 Unclassified Exercises

Not all exercises require the services for security and management provided by CFBLNet together with its attendant overhead and cost. It is possible to operate NETN federations over the Internet when the services provided by CFBLNet are not required. VPN over the internet may provide sufficient security or information protection for many events. The selection between the persistent CFBLNet solution and semi-persistent solutions like the Internet depends on the frequency of need for a classified (CFBLNet) capability. However, even Nations or organizations with infrequent classified event requirements may find that CFBLNet has a cost-benefit advantage in avoiding the engineering time in installing and closing networks and in the higher user fees paid for temporary installation.

5.1.3 Multi-Level Security Domains

MSG-068 did not have time or resources to investigate multi-level security or cross-domain information exchange. Clearly this field is of interest and importance due to the mix of organizations, NATO, PfP, NGO, etc., and consequent need for improved policies and tools for information exchange. MSG-068 recommends better, more reliable, robust and practical multi-level security protocols and procedures. This topic is currently addressed by on-going NMSG studies, notably MSG-080, Security in Collective Mission Simulation.

5.2 NETN Federation Architecture and FOM Agreement

A MSG-068 Federation Architecture and FOM Design (FAFD) technical sub-group was created with 70+ representatives from the participating NATO and Partner Nations and organizations.

The purpose of the group was to develop a Federation Agreements and FOM Design Reference Document that will support the initial NETN Reference Architecture for NATO and the Nations.

The document provides a common reference Federation Agreements Document (FAD) for all federations in the NATO Education and Training Network (NETN) including a modular FOM with detailed information on data and information exchange between simulation systems in an NETN federation. The FAD and FOM are designed to be generic and can be used for live, virtual, constructive and multi-resolution federations at any level.

The FAFD group represents a broad community of practice with respect to federation architecture and design. Major systems, federations and training networks were represented in the FAFD group. The input provided and the harmonization of federation architecture and design agreements forms the basis of the NETN Federation Agreements and FOM Design Reference Document.

Key input to the development of the federation agreements includes:

- ALLIANCE (France);
- CASIOPEA (Spain);
- JLVC (USA);
- JMRM (US and JWC);
- KOSI (Germany);
- NLVC (NC3A, Netherlands);
- P2SN (Sweden); and
- RPR-FOM v2.0 (SISO).

The recommendations from the MSG-068 FAFD sub-group are summarized below:

- In compliance with STANAG 4603 [9], MSG-068 recommends that the backbone of any NATO simulation federation is the latest version of the High-Level Architecture (HLA). IEEE 1516-2010 is the current HLA version and provides services and concepts that enable flexible and modular FOM development (see Figure 2).

- The Simulation Interoperability Standards Organization (SISO) has defined the Real-time Platform Reference FOM (RPR-FOM). MSG-068 recommends the SISO standard RPR-FOM v2.0 to represent ground-truth of platform and aggregate level simulated entities. The RPR-FOM object classes are extended with more detail in the NETN Aggregate Unit FOM Module.

- MSG-068 recommends the SISO standard Link 16 BOM for simulation of Link16 messages. This module also extends the RPR-FOM.

- MSG-068 recommends a new NETN Service Consumer-Provide FOM Module for modeling request, negotiation and delivery of services (see Annex C). This FOM module does not extend any other FOM module. The Service Consumer-Provider Pattern defines two types of entities:

- Service Consumer Entities; and
- Service Provider Entities.

Similarly federates that model these entities are called Service Consumer Federates and Service Provider Federates, respectively. If service entities are modeled in different federates the interactions will be published and subscribed using HLA services.

- MSG-068 recommends a new NETN Aggregate Unit FOM Module. This module is based on the Service Consumer-Provider Pattern with extensions to support aggregate and entity object attributes not contained in the RPR FOM. The NETN Aggregate Unit FOM Module also includes provisions for a combat adjudication service; this service will be addressed in further detail below.

- MSG-068 recommends a new NETN Logistics FOM Module. This module is based on the Service Consumer-Provider Pattern with extensions to support the following specific logistics services:
  - Supply;
  - Storage;
  - Repair;
  - Transport;
  - Embarkment; and
  - Disembarkment.

- The FAFD sub-group identified additional FOM Modules and also conducted some preliminary work on these. Due to time constraints and priorities these modules have not be finalized and verified in experimentation. The FAFD sub-group recommends that future work will continue to investigate and experiment with these modules in order to have them included in future versions of the FAD and FOM. These modules are: Federation Execution Control and Monitoring and Transfer of Modeling Responsibility.

- The FAFD sub-group identified additional IEEE 1516-2010 features that the team was unable to implement and test due to time constraints. The FAFD sub-group recommends future development and testing of smart update rate reduction, fault tolerance, Data Distribution Services as an enabler of scalability, web services, etc.

- The FAFD sub-group caveats the above recommendations by acknowledging that:
  - FAFD did not implement or test the combat adjudication service or Combat Adjudication Service Federate (CASF) described in the NETN Aggregate Unit FAD. The FAFD sub-group recommends future development of a CASF to evaluate the CASF FAD and FOM constructs. FAFD anticipates iterative development and testing of the CASF and FAD and FOM constructs will be required before the combat adjudication service can be recommended for inclusion in the MSG-068 Reference Federation Architecture.
  - FAFD did not test the SISO standard Link 16 BOM. The FAFD sub-group recommends future testing of the Link 16 BOM to evaluate its sufficiency for DTE use.
  - FAFD used only a sub-set of the object classes and interactions comprising the RPR FOM. The FAFD sub-group therefore recommends modularizing the RPR FOM in accordance with IEEE 1516-2010 FOM modularity principles.

- FAFD used and tested only a sub-set of the NETN Logistics FOM Module services. In the process of developing, testing, and assessing the NETN Logistics FOM Module, the FAFD sub-group concluded that it is unnecessarily monolithic and therefore recommends modularizing it in accordance with IEEE 1516-2010 FOM modularity principles.

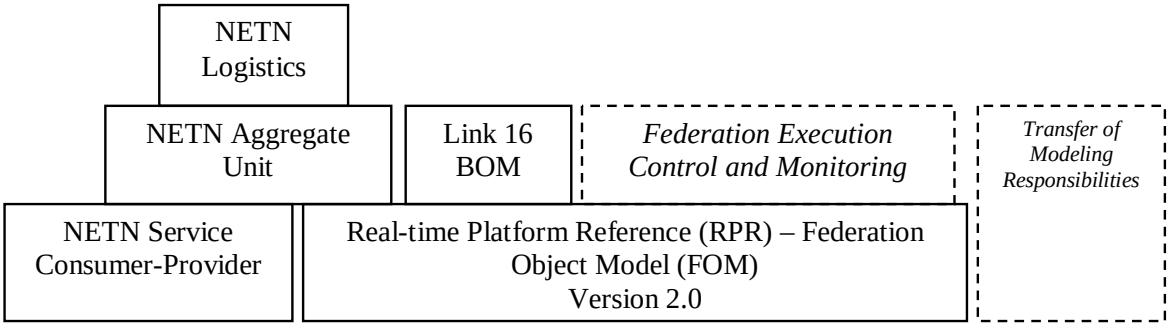


Figure 2: Modular FOMs Recommended for MSG-068 Reference Federation Architecture (Modules with dashed frame require additional work before inclusion in the FAFD).

The complete NETN Federation Architecture and FOM Reference Document can be found in Annex C.

5.3 Shared Resources

MSG-068 did not directly address shared resources. However, a separate study by HQ-SACT [11] has addressed shared scenarios. The most important findings of the shared scenarios study are summarized below:

- The primary existing capability to share NATO produced operational level Scenarios and Settings (S&S) is provided by the Joint Warfare Center. This capability includes geo databases, the geo-strategic narrative situation, theatre of operations information, strategic initiation documents, crises response planning information, force activations and deployment information, main event and master incident lists (i.e., Joint Exercise Management Module databases) and simulation databases (i.e., Joint Theater Level Simulation and Virtual Battle Space databases). However, this capability is based on a manual process, limited to NATO headquarters and Nations, and has issues related to IT infrastructure.
- The premise that NATO HQs, Nations and non-NATO users would wish to re-use JWC S&S material remains to be proven. However, many organizations that use JWC-produced S&S for their internal exercises do not understand how to adapt material to suit their own training objectives and spend considerable effort trying to achieve this.
- There exists a NATO Simulation Resource Library (NSRL) [20]). This existing capability needs to be further improved such that it can allow the submission of new S&S meta data (i.e., information about the scenarios and scenario modules) and the access by a wider community. A prototype has been prepared for this purpose and tested during MSG-068 NETN Standalone Experiment.
- Collaborative ways of working based on Web 2.0 technologies should be considered.

In addition to the study, MSG-068 identifies the need for standard taxonomy, terminology and data formats for the reusability of settings, scenarios and scenario modules. There are already standards and directives for this purpose, such as, Military Scenario Definition Language (MSDL), Bi-SC Collective Training and Exercise Directive 75-3, C2 Information Exchange Data Model (C2IEDM), etc. The use of the above mentioned

standards is recommended in the NATO Allied M&S Standards Profile AMSP-01 [19]. However, all these can support only a sub-set of the shared scenario requirements.

In mid-tenure, MSG-068 evaluated using unique identifiers and the Joint Training Data Services (JTDS) Order of Battle Service (OBS) to provide scenario initialization information to all NETN federates. Providing common scenario initialization information to all federates enables data correlation among federates and reduces, if not precludes, instances of data mapping errors. While MSG-068 was, in the end, unable to make use of OBS, and consequently suffered numerous data mapping errors during the experiment, the NETN FOM does include provision for use of a unique identifier for each object instance. Evaluating these identifiers and a scenario initialization service must necessarily devolve to another NMSG, but MSG-068's experimental results clearly indicate the criticality of a comprehensive data strategy, particularly given the diverse systems envisioned for use in NETN.

5.4 Common Tools

In order to enable interoperability and the use of the infrastructure for events, we recommend the following key common tools:

- **CIS:** Collaborative tools are essential to support the development of Federation Agreements and to support test and integration. MSG-068 used a Wiki-based Collaborative Work Environment (CWE) as recommended by MSG-052. Telephone and video conferences were conducted using regular phones and Skype. In order to have a common tool for visualization of the simulation data Google Earth together with the tool Pitch GE Adapter was used. The simulation voice communications application PLEXCOMM was provided to allow users to role play various actors in vignettes and coordinate technical control matters.
- **Mixed Architecture:** The backbone needs to be the latest version of HLA. However, to support legacy and COTS simulation systems we recommend that gateways between the different architectures should be allowed.
- **Test and Integration:** MSG-068 established an experimentation and demonstration sub-group to provide services related to test and integration. We recommend a network overlay tool to simplify the technical set up for test and integration. In MSG-068 we used the Pitch Booster for this purpose.
- **Exercise and Scenario Management Tools:** These tools can be used for the automation of processes, information management and information exchange throughout an exercise process. They can help the preparation and management of scenario as well as the Main Event and Master Incident Lists (MEL/ MIL). A MEL/MIL tool can also be very useful in synchronizing and managing the flow of an exercise according to the exercise objectives, as well as, planning, collecting and analyzing the observations. In MSG-068 we used JEMM (Joint Exercise Management Module) for this purpose.
- **Patterns:** MSG-068 recommends use of design patterns in developing FOM modules and corresponding FADs. Design patterns promote reuse by abstracting purpose from implementation. MSG-068's development and use of the Consumer-Provider design pattern exemplifies this abstraction and resultant reuse. Defining and documenting the conceptual relationship between a consumer and provider distinct from the specific implementation of a tanker resupplying fuel or maintenance personnel repairing a truck, enabled specification of the higher level key actions and important entities. These were then reused in not only instances of resupply or repair, but other situations, e.g., the "service" provided by a Combat Adjudication Service Federate (CASF). Design patterns complement FOM modularity, for example, the Consumer-Provider FOM module is distinct from the FOM modules supporting resupply or combat adjudication.

- **FEDEP-DSEEP:** MSG-068 recommends following the FEDEP [10] and the DSEEP standards to develop the NETN simulation federations and to execute the training and exercise events. NMSG-068 used the principles of FEDEP, particularly in developing the federation agreements and design, and in executing the experimentation and demonstrations.

6.0 RECOMMENDATIONS FOR THE DEVELOPMENT OF NETN ARCHITECTURES

MSG-068 recommendations are not complete to bridge the recommended reference architectures and operational processes and architectures. To fill this gap, we recommend a follow on technical activity, which focuses on the operational issues related to NETN.

6.1 Reference Architecture

The NETN Reference Architecture comprises guidance for:

- Persistent Infrastructure;
- NETN Federation Architecture and FOM Agreement;
- Shared Resources; and
- Common Tools.

The NETN Reference Architecture provides the foundation for developing national and NATO training networks (NETN Target Architecture). An NETN Target Architecture is a tailored instantiation of the NETN Reference Architecture for a (Target) Exercise Architecture.

MSG-068 recommends that the core documents in the NETN reference architecture are managed by NMSG. Nations and organizations implementing NETN target architectures should use the recommendations provided by this group and provide feedback regarding improvements or extensions that should be integrated in the reference architecture (e.g., new FOM modules). Further research with respect to extending the reference architecture should be coordinated by a persistent NMSG sub-group in charge of technical guidance, i.e., the M&S Standards Sub-group (MS3).

6.2 Exercise Architecture

Exercise architecture has two main components: Training Audience (TA) and Exercise Control staff (EXCON). TA is the focal point in an exercise structure. TA can be single level, multi-level, cross-level and both cross- and multi-level as shown in Figure 3:

- Single level training audience represents a single level of command trained at the same time in the context of a single scenario.
- Multi-level training audience represents multiple levels of command trained at the same time in the context of a single scenario.
- Cross-level TA includes units or headquarters at the same level of command. When the units in a cross-level TA are from different services, the exercise becomes joint.
- Multi- and cross-level is a mix between multi-level and cross-level.

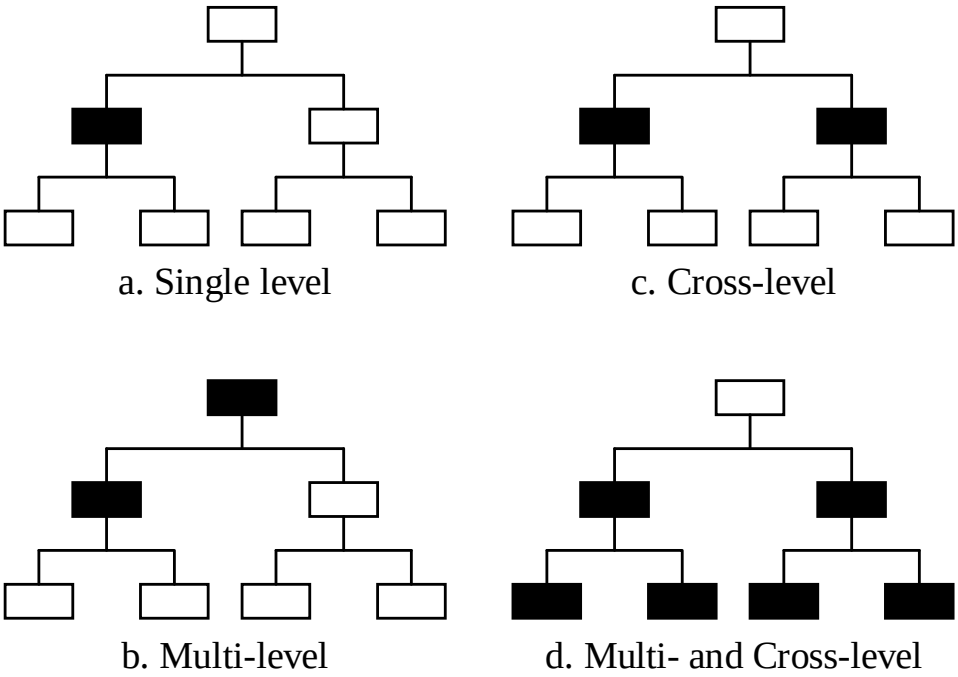


Figure 3: Training Audience.

A TA can have Headquarters (HQ) and/or forces from different Nations, which makes the exercise combined. In more and more exercises civilian national/international agencies and organizations like police, fire department, health agencies and UN are involved in. These civilian organizations usually become a part of EXCON and constitute white or grey cell. They may also be a part of TA. EXCON structure and white/grey cell concept is explained later in this section.

TA can be co-located or various parts of TA can be located in geographically remote sites (i.e., different cities, countries or continents). The exercises that have TA components located remote sites are called distributed exercises. Please note that distributed simulation means different from distributed exercise. A distributed exercise can be supported by a centralized simulation system or a centralized exercise can be supported by a distributed simulation.

In NETN, TA can be more complex than a typical NATO or national exercise, such as the following:

- TA composed of HQs or forces from several Nations (any composition of NATO, PfP, MedDialog, ICI, contact or coalition) without a NATO HQ; and
- TA composed of HQs or forces from several Nations (any composition of NATO, PfP, MedDialog, ICI, contact or coalition) with a NATO HQ.

The other component in an NETN exercise structure is the Exercise Control staff (EXCON). A typical EXCON structure is shown in Figure 4. Training Team (TT) consists of mentors, Observer/Trainers (O/T), Subject-Matter Experts (SME) and analysts. TT is deployed with TA, observe TA, provide onsite instructions and training, and collects inputs for AAR and the evaluation of TA. The Exercise Center (EXCEN) is the organization responsible for the consistent and coherent flow of the exercise according to the Exercise and Training Objectives (ETO). EXCEN is explained in detail below. Experimentation team runs the experiments planned in conjunction with

the exercise. Finally support team has the elements like Real-Life Support (RLS), Visitor Officer Bureau (VOB), Public Information Centre (PIC), security office and computers/communications support team.

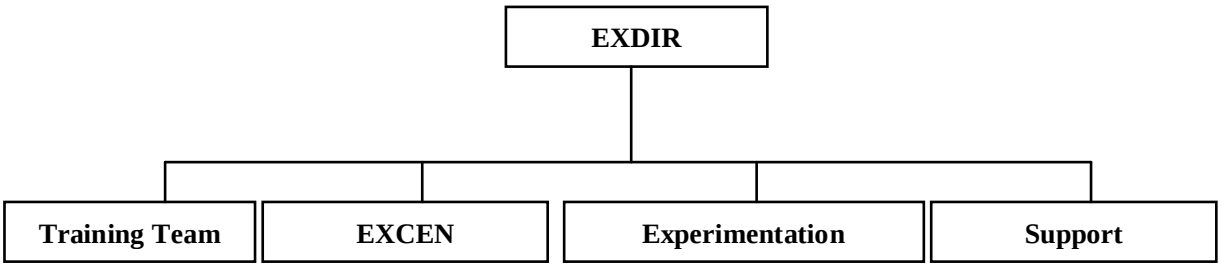


Figure 4: EXCON Structure.

EXCEN functions (see Figure 5) can be categorized into five broad classes as Control Centre (CONCEN), Higher Control (HICON), Lower Control (LOCON), white/grey cell and Situation Forces (SITFOR). CONCEN monitors the current status of the exercise closely and steers it according to the ETO. HICON and LOCON represent the command levels/echelons that would normally be at the level above and below the TA respectively. LOCON and HICON consist of Response Cells (RC). The number of RC is dependent on the scenario and the TA. Each RC is made up of a number of planners, a number of simulation operators and coordination staff. RC are the main interface between simulation and exercise as explained later in this section. White/grey cell is a response cell that is composed of Subject-Matter Experts (SME) or role players representing agencies, organizations, institutions and individuals outside of the own or opposing force structure. SITFOR is the cell that manages the status of all the own and opposing forces in the scenario except for the ones represented by HICON and LOCON. When opposing side is also played by a part of the TA, only the parts of forces not controlled by the TA is managed by SITFOR.

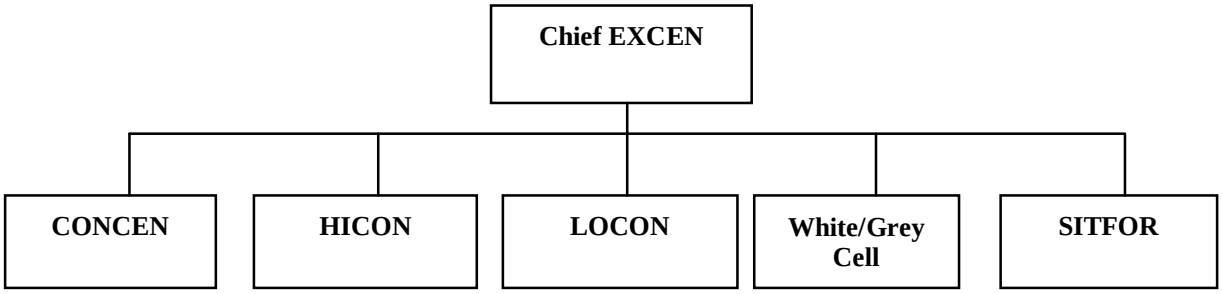
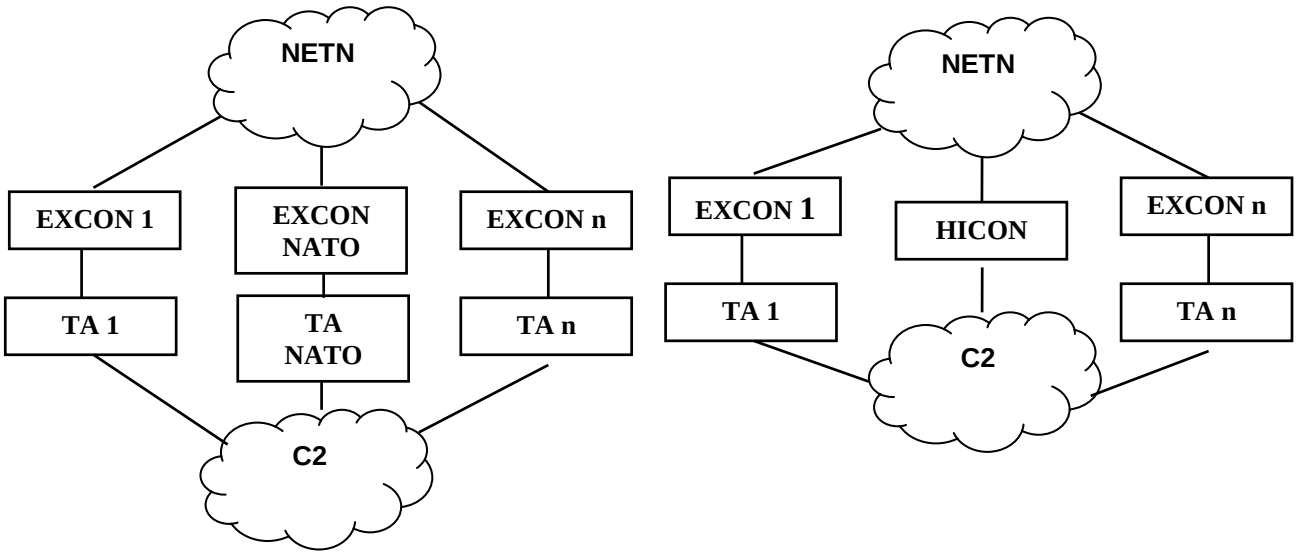


Figure 5: EXCEN Structure.

In NETN, there can be multiple EXCON (see example Figure 6a) or split EXCON (see example Figure 6b) that work collaboratively or in coordination. In the Figure 6b, the HICON is a part of EXCON NATO. For the other TA, the higher level command is the TA NATO.



a) With a NATO HQ

b) Without NATO HQ

Figure 6: Examples for NETN Target Architectures.

6.3 Using NETN

In order to support training, an exercise architecture that meets the requirements of the specific exercise is required. To develop this exercise architecture, the NETN reference documents provide some support. However, to meet the objectives of an exercise, operational objectives need to be transformed into technical federation requirements.

Processes such as FEDEP/DSEEP can be used to support the development of NETN exercise architecture to fit operational requirements. The current NETN Reference Architecture does not include specific recommendations to support the development of NETN exercise architecture. Experimentation within MSG-068 had technical objectives only. No experiment related to the process transforming operational objectives to technical federation requirements was conducted. Therefore MSG-068 recommends tailoring DSEEP to support this transformation to technical requirements.

7.0 RECOMMENDATIONS FOR THE ROLES AND RESPONSIBILITIES

MSG-068 NETN TA recommendations for the roles and responsibilities are as follows:

- Maintenance of the NETN Federation Architecture and FOM Design (FAFD) Reference Document: MSG-068 recommends that a focus group working under the NMSG M&S Standards Sub-group (MS3) is given the task to maintain the core NETN Reference Architecture documents including federation agreements and the NETN FOM modules. Configuration management related to the individual FOM Modules and the entire reference agreements are to be handled by this group. The group should report to MS3 and NMSG on the current state of the documents and make recommendations to task groups concerning its use. The group should also receive input and feedback from users (including NMSG Task Groups) on their requirements, proposed updates or new additions related to federation agreements and FOM modules.

- Operations and maintenance of an NETN persistent infrastructure and services: MSG-068 recommends that NATO establish and maintain a persistent infrastructure and provide common services as described in Annex D. The establishment of this persistent infrastructure should be based on a capability package. The maintenance team should report to NMSG on the current state of the infrastructure and make recommendations regarding updates, proposed research work, etc., based on input and feedback from users.
- Verification, Validation and Accreditation (VV&A): MSG-068 recommends that NATO and Nations should perform VV&A on simulation assets according to the Generic Method for Verification and Validation (GM-VV) procedures that are currently being developed by a joint team of MSG-073 and SISO. Depending on future developments, a NATO body may become available to provide this service for NATO assets as well as for Nations if desired.
- Configuration management of the components (simulations and tools) within NETN: MSG-068 recommends that all assets belonging to NETN are configuration managed and maintained by an appropriate body to ensure continued FAFD compliancy. That role may be a NATO body or a Nation depending on the asset that acts as the custodian of the asset.
- Configuration management of NETN Federations (NATO and Nations): Specific Federations may have extended Federation Agreements and FOMs that are not likely to become part of the Reference NETN. MSG-068 recommends that all Federations based on NETN are configuration managed and maintained by an appropriate body to ensure continued FAFD compliancy. That role may be a NATO body or a Nation depending on the asset that acts as the custodian of the Federation.
- Settings and Scenarios (NATO and Nations): MSG-068 recommends that all Settings and Scenarios that are used in (one or more) Federations based on NETN are configuration managed and maintained by an appropriate body to ensure continued FAFD compliancy. That role may be a NATO body or a Nation that acts as the custodian of the target Federation.
- Development and continuous improvement in NETN (NMSG): Further research with respect to addressing some of the gaps identified in the reference architecture should be coordinated by the NMSG through the establishment of technical Task Groups (TG). These TGs could for example investigate issues like C2-Simulation interoperability, which is a special case of interoperability with live systems, or topics like multi-level security.
- Procedures for certification of federates and federations: MSG-068 recommends that NATO and Nations should perform HLA certification on simulation assets that are intended for NETN according to the procedures defined by the NMSG Certification Advisory Group (CeAG). Note that CeAG reports to NMSG MS3. Several commercial organisations and some government offices provide Certification services according to the CeAG procedures. MSG-068 also recommends that CeAG should further develop its procedures and tool support to provide a deeper, more comprehensive and thus more valuable certification that extends beyond basic HLA compliancy.
- Integration and testing of federations: Certification of individual assets is a first step towards improved integration and testing of federations. MSG-068 recommends that NATO and Nations should follow current best-practices according to FEDEP/DSEEP. There is however certainly work to be done by NMSG to develop more guidance in this area.

8.0 EXPERIMENTATION AND DEMONSTRATION

MSG-068 recommendations were tested in a standalone distributed experimentation event between October 25 and November 5, 2010. Ten Nations (Bulgaria, France, Germany, Hungary, Netherlands, Spain, Sweden,

Turkey, UK, US) and 5 NATO HQs/organizations (HQ-SACT, JWC, JFTC, NC3A, M&S CoE) joined the experiment from one of 5 different locations (Bydgoszcz, Paris, Ottobrunn, Porton Down, The Hague). JTLS, JCATS and PLEXCOMM from the U.S., TYR from Sweden, VBS2 from Australia (three separate copies of VBS2), MARCUS from Hungary, ORQUE and WAGRAM from France, VR-Forces from Spain, FACSIM from the Netherlands, KORA from Germany and ITC/FLAMES from NC3A were federated by using MSG-068 Reference Federation Architecture during the experiment.

The experiments are grouped into three categories as technical experiments for the infrastructure, technical experiments for the reference federation architecture and operational use case experiments for the NETN federations. The following two incidents were designed for the technical experiments for the reference federation architecture:

- Incident 1 (Campaign 1) consists of a sea lift, a UAV recce, a cruise missile strike, a ground strike with close air support and indirect fires, a blocking by marines and a MEDEVAC.
- Incident 2 (Campaign 2) consists of a UAV recce, an air strike, two ground strikes, a blocking by marines, a hostage situation, repair of equipments and ammunition resupply.

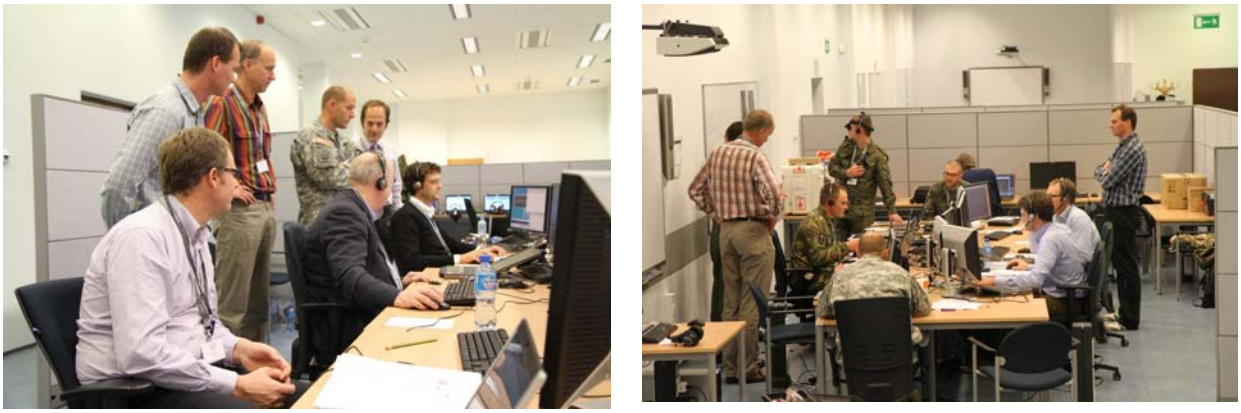


Figure 7: Experiment Cells.

In every part of these incidents multiple federates (i.e., simulation systems) were involved in and interacted with each other through a federation built on NETN Reference Federation Architecture. Both Campaign 1 and 2 were run first in the Internet. Then Campaign 1 was run in the CFBLNet when the bearer was NGCS. Finally Campaign 2 was run in the CFBLNet when the bearer was the Internet.

Figure 8: Experimentation Center.

Also the following four incidents were executed to test the operational use cases: a MEDEVAC incident, a VBS2-NATO demonstration for advanced distributed C-IED training, a Forward Air Controller (FAC) training by using NLVC and a shared scenarios demonstration. FAC training by NLVC consisted of a Forward Air Controller in Bydgoszcz, an F-16 pilot in The Hague, a UAV in Porton Down and a second UAV in Bydgoszcz. The vignette was repeated three times for a different FAC each time. The FACs were operational people from Poland (2x) and Germany, the FAC instructor came from the Dutch Air Ground Operations School.

First impression report of MSG-068 Final Experiment is at Ref. [12]. NC3A also conducted a survey during the experiment. The results of this survey are at Ref. [13]. Based on the analysis of comments provided by respondents of the NETN Survey, the following additional recommendations can be made:

- Enhance the technical standards to include areas such as:
  - Distributed exercise preparation and management;
  - Integration of NATO and national C2 systems with the training environment;
  - Allocation of the execution of tasks within the federation;
  - Management of perception;
  - Management of multi-granularity (multi-resolution);
  - Shared scenarios; and
  - Federation management.

  Benefit: Wider application potential of the recommendations to the exercise domain.

- Expand procedures and tools to ensure compliance of federates and processes with the complete set of technical standards. The responsibility and roles in compliance testing should be assigned explicitly.

  Benefit: If compliance is ensured, composing and configuring a federation for a distributed exercise will require less time and the risk during execution will be reduced significantly.

- Sustain the use of CFBLNet, but validate the assumption about CFBLNet's ability to provide secure services.

  Benefit: Efficient environment for federation composition and expansion.

During the I/ITSEC 2010 conference MSG-068 provided also a live demonstration of the core NETN technologies. Systems from France, Germany, Spain, Sweden, UK, USA, NC3A, Joint Warfare Center (JWC) and Joint Force Training Center (JFTC) were connected in a distributed federated simulation running both locally in the booth and connected to remote sites in Europe. The following simulation systems participated in the demonstration:

- ORQUE, WAGRAM (France);
- JTLS (JWC);
- VBS2 (UK);
- KORA (Germany);
- ITC FLAMES/ICC (NC3A, JFTC);
- TYR, pRTI1516 Evolved (Sweden);
- PLEXComm (USA);
- JCATS (USA); and
- VR Forces (Spain).

9.0 CONCLUSION AND WAY AHEAD

NATO Modelling and Simulation Group of NATO Research and Technology Agency started MSG-068 NETN upon request by HQ-SACT in 2007. Thirteen Nations and five NATO organizations contributed to MSG-068 to develop and demonstrate standards and recommendations for a persistent education and training network that comprises of tools for advanced distributed learning, resource sharing and distributed simulations.

MSG-068 conducted a standalone experiment in order to validate the MSG-068 recommendations for:

- A secure, persistent, on-demand training capability that integrates national centres and NATO;
- Capability and readiness of NATO, Nations and national simulation centres to link into NETN;
- Distributed simulation integrating NATO and national M&S capabilities;
- Multi-granularity;
- Technical standards;
- Distributed training involving national and NATO C2 and simulation systems; and
- Shared scenarios.

The experiment achieved the objectives in validating the recommendations and clarifying the requirements for further improvements. The requirements for future work can be categorized into three classes:

- The requirements related to infrastructure can be listed as follows:
  - The procedures for joining CFBLNet or extending an existing PoP should be simplified and clarified.
  - When CFBLNet is used, it introduces another technical management level on top of the technical administration of the bearer networks. The user needs to manage these two layers separately for

multiple sites, which is not always practical. A scheme to unify the management of infrastructure (i.e., to provide single point of contact for the infrastructure) needs to be developed.

- Better, more reliable, robust and practical multi-level security protocols and procedures are yet to be investigated and developed for more flexible infrastructure.
- CFBLNet may be a semi persistent solution used for specific events when needed for some Nations. The selection between persistent and semi persistent solution depends on the frequency of CFBLNet usage. The implications of this approach needs to be further studied with more detailed technical and procedural perspective by a focus group.
- Further clarification and experimentation with respect to integration of other simulation architectures into NETN (e.g., gateways integrating live players) is required.

- The requirements related to FAFD can be further grouped as follows:
  - The FAFD issues identified but not addressed:
    - Transfer of Ownership (Modeling Responsibility);
    - Further modularization of FOM Modules, e.g., RPR-FOM;
    - Extension of NETN FOM modules to support the other data links; and
    - Agreements on scalability and performance.
  - The issues requiring additional development, test and experimentation:
    - Protocol for Aggregation/De-aggregation;
    - Transfer of Control in Aggregation/De-aggregation;
    - Combat Adjudication;
    - Federation Execution Control; and
    - Exceptions and Variations of Logistics Patterns.
  - The requirements related to shared scenarios has been grouped as follows:
    - HQ-SACT has completed a project on shared scenarios, and the results from this project are included as a reference [11] in this report. The project determined some shortcomings in shared scenarios concept in particular on how to apply the available material to user needs. MSG-068 recommends that ACT develops and organizes a training program for this purpose.
    - Providing common scenario initialization information to all federates enables data correlation among federates and reduces, if not precludes, instances of data mapping errors. MSG-068 recommends further study of common scenario initialization methodologies and tools.

Apart from the infrastructure, FAFD and shared scenarios, MSG-068 also developed recommendations with respect to roles and responsibilities, and additional work. This set of recommendations need to be implemented by NATO and the Nations to achieve the NETN vision. For NATO, MSG-068 recommends either a new capability package or an amendment to an existing capability package to act on the recommendations.

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