An Update on the Developments and Maturity of the NATO Education and Training Network (NETN) Federation Architecture and Federation Object Model (FOM)

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ABSTRACT

The purpose of this paper is two-fold: firstly, to summarise the technical developments made to the NATO Education and Training Network (NETN) Federation Object Model (FOM); and secondly to describe the final verification and validation activities which have exercised and validated the recommendations made within the Allied Modelling and Simulation Standards Profile (AMSP)-03 [8], and integrated and evaluated the NETN FOM developments within an operational use case. Additionally it documents an example where the NETN FOM has been used to support a large-scale exercise.

The NETN initiative was instigated to integrate and enhance existing national simulation capabilities, by delivering a persistent infrastructure, distributed training and education tools, and standard operating procedures to enable nations to collaborate more effectively in modelling and simulation application. The NATO Modelling and Simulation Groups (NMSG) 068 [1] and the following MSG-106 [2] were initiated to support this activity, which delivered a way forward for interoperability and technical standards, and a reference architecture that could be used to link NATO and National Training and Education centres together as a persistent capability. A key output of this was the NETN Federation Architecture and Federation Object Model (FOM) Document (FAFD) which provides an agile modular mechanism to define data models, an improvement over previous monolithic approaches.

The paper gives a high-level overview of the operational benefits of these technical developments, including those derived from RPR-FOM modularisation, scenario initialisation mechanisms using MSDL [3], federation execution control, transfer of modelling responsibilities, multi-resolution modelling, simulation to C2 system interoperability using C-BML [4], and support to the Chemical, Biological and Radiological community with the CBR FOM [5]. It also summarises findings from the MSG-106 final integrating experiment.

It has been written to inform the NATO community on the latest state of the NETN FOM and to capture evidence where the NETN FOM has been used to support an operational need. This is to support individual nations in understanding the maturity of the NETN FOM and to help inform its fitness-for-purpose against National requirements.

1.0 INTRODUCTION

The NATO Education and Training Network (NETN) initiative was instigated to integrate and enhance existing national simulation capabilities, by delivering a persistent infrastructure, distributed training and education tools, and standard operating procedures that will enable nations to collaborate more effectively in modelling and simulation applications. NATO Allied Command Transformation (ACT) requested the initiation of a NATO Modelling and Simulation Group (NMSG) panel in order to support technical development. As a result, MSG-068 [1] was formed in 2007 which delivered a way forward for interoperability and technical standards, and produced a reference architecture that could be used to link NATO and National Training and Education centres together as a persistent capability. A key output of this was the NETN Federation Architecture and Federation Object Model (FOM) Document (FAFD) which provides an agile modular mechanism to define data models, an improvement over previous monolithic approaches.

A NATO MSG panel on "Enhanced Computer Aided Exercise (CAX) Architecture, Design and Methodology" (MSG-106) was created in 2012 [2] to further the work of MSG-068, and has developed an improved methodology for planning, executing and evaluating CAX, particularly considering the relationship between exercise control (EXCON) and simulation control (SIMCON) staff functions. The group has also undertaken further technical development of simulation interoperability patterns[1], using the HLA Evolved architecture and the NETN FOM, now based on the emerging Real-time Platform Reference (RPR-FOM) version 2 standard [7].

The NMSG-106 panel, now in its concluding phase, will deliver three key outputs:

1. The Allied Modelling and Simulation Publication (AMSP-03) [8] which recommends key modelling and simulation standards and approaches;

2. A CAX handbook, which supports the integration of EXCON and SIMCON staff to deliver CAX;

3. The reference Federation Agreement and FOM Document (FAFD), which includes extensions to the NETN FOM.

The purpose of this paper is two-fold: firstly, to summarise the technical developments made to the NETN FOM; and secondly to describe the final validation experiment which exercised and validated the recommendations made within AMSP-03, and integrated and evaluated the developments within an operational use case. Additionally it documents an example of where the NETN FOM has been used to support a large-scale exercise.

This paper describes the background and context of the NETN, the High Level Architecture [9], Federated Object Models and the NATO Modelling and Simulation Groups that have undertaken research and development in this area. It describes the current state of the NETN FOM and highlights recent technical developments undertaken in MSG-106, introducing a number of new concepts. It gives a high-level overview of the operational benefits of these technical developments, including those derived from RPR-FOM modularisation, scenario initialisation mechanisms using the Military Scenario Definition Language (MSDL) [3], federation execution control, transfer of modelling responsibilities, multi-resolution modelling, simulation to C2 system interoperability using the Coalition Battlespace Modelling Language (C-BML) [4], and support to the Chemical, Biological, and Radiological community with the CBR FOM [5].

Verification and validation activities are also described, including verifying the new capabilities through experiments, internal trials and validation through a multi-national training event. The paper concludes with a short statement of recent exploitation by the UK and Sweden and the future plans and direction of research in this area.

It has been written to inform the NATO community on the latest state of the NETN FOM and to capture evidence where the NETN FOM has been used to support an operational need. This is to support individual nations in understanding the maturity of the NETN FOM and to help inform its fitness-for-purpose against National requirements.

[1] A pattern in this context refers to a reusable and generic solution to a recurring problem, in this case the ability to interoperate simulation systems, that is implementation agnostic.

2.0 BACKGROUND AND CONTEXT

2.1 The High-Level Architecture (HLA) & Federation Object Models

High-Level Architecture (HLA) is an IEEE standard [9] to support simulation interoperability. The standard consists of three parts: 1) an interface specification with sets of well defined services for synchronized data exchange between distributed simulation systems 2) a standard format for defining information exchange data models (Object Model Template) and 3) sets of rules for individual simulation systems (federates) and the resulting distributed simulation system (federation).

An HLA Federation is a set of simulation systems (federates) joined together by using general HLA services to exchange domain specific information specified in a structured Federation Object Model (FOM) compliant with the HLA Object Model Template. HLA defines generic services to support simulation interoperability each federation relies on so-called Federation Agreements to specify how these services are applied and which FOM to use. A Runtime Infrastructure (RTI) provides the HLA services and acts like a distributed operating system for simulation. Standard HLA Application Programming Interfaces (APIs) and RTI certification ensures that federates can operate with different RTI implementations.

The latest version of HLA (IEEE 1516-2010) also known as HLA Evolved introduced the concept of modular FOMs. This concept allowed federates to only deal with pieces of the entire FOM and to dynamically load new FOM modules into a federation during runtime. This new concept has proven to be a useful approach to developing federation agreements and has been extensively used in the NATO work in extending standard FOMs like the Real-Time Platform Reference FOM (RPR-FOM) [7] to support CAX and C2 Training.

Development of the HLA standard began in the mid-90s and was first released as a US DoD sponsored standard. IEEE 1516 versions released in 2000 and 2010 were developed through the Simulation Interoperability Standards Organization (SISO) [10]. SISO is currently supporting the HLA Product Support Group (PSG) and is responsible for maintaining and initiating development of future updates of the standard.

Due to its general purpose architecture, HLA has a substantial user-base in not only defence but also in space, air traffic management, energy, off-shore, railway and car industry, manufacturing and health care to support training, experimentation, acquisition, analysis and engineering.

HLA Services includes not only common data exchange services like publish/subscribe/send and receive, but also more advanced services for time synchronization of distributed simulation, attribute ownership transfer and smart data distribution. Together, these services provide a very powerful toolbox for the federation developer to construct advanced distributed simulations. However, guidance [11] on how to use this toolbox is needed to maximize interoperability and reuse.

2.2 The NATO Education and Training Network (NETN)

NATO is recognizing 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 other future NATO missions. The initial vision to address this challenge was established by NATO Allied Command Transformation (ACT) as:

> *"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."

In 2006/2007 ACT initiated the NETN program a.k.a. Snow Leopard to accomplish this vision. The program consisted on three pillars: 1) Education, 2) Shared Scenarios and 3) Modelling and Simulation (M&S) toolsets. All of them to be provided distributed over NATO Wide Area Networks (WAN). In 2010 the program name was changed to Distributed Training and Exercises (DTE). The vision to connect and leverage national training and education capabilities has not changed and is also reflected in the current NATO Connected Forces Initiative (CFI).

Although, the term NETN is no longer directly referred to by NATO ACT in its current programs it is still used within the NATO M&S community to refer to technical specifications and agreements on distributed simulation for supporting CAX.

2.3 MSG-068 NETN

In 2007, ACT tasked the NATO Joint Warfare Center (JWC) to chair and the Joint Force Training Center (JFTC) to participate in a NATO Modelling and Simulation Group (NMSG) research task group called MSG-068 NETN.

The main objective of this group was to investigate M&S standards and make recommendations to the then ACT NETN and national programmes. MSG-068 also recommended and demonstrated a way forward for interoperability, technical standards and architectures to link these training and education centres to provide a persistent capability.

One of the fundamental deliverables from MSG-068 is a Reference Federation Agreements Document and Federation Object Model (FOM) that will support the development and integration of NATO and national distributed simulation systems to support CAX. A technical subgroup in MSG-068 consisting of 70+ experts on distributed simulation and CAX developed and delivered the NATO Federation Agreements and FOM Document [12] (FAFD v1.0) with the following key contents:

- Modular FOM approach and use of STANAG 4603 (IEEE 1516-2010)
- Harmonized FOM representation and federation agreements related to entity level and aggregated level simulated objects
- Service based simulation patterns
- Support for advanced distributed simulation of aggregate and entity level logistics operations

MSG-068 recommendations were tested in a standalone distributed experimentation event between October 25 and November 5, 2010. Ten (10) Nations (Bulgaria, France, Germany, Hungary, Netherlands, Spain, Sweden, Turkey, UK, US) and five (5) NATO HQs/organizations (HQ-SACT, JWC, JFTC, NC3A, M&S CoE) joined the experiment from one of five (5) different locations (Bydgoszcz, Paris, Ottobrunn, Porton Down, The Hague). JTLS, JCATS and PLEXCOMM from the U.S., TYR from Sweden, 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 the NETN FAFD v1.0 recommendations. A demonstration at I/ITSEC 2010 repeated parts of the experiment and presented the results to a wider audience.

Based on the success of MSG-068 and the interest and engagement from NATO and partner nations, the task group also recommended initiating a follow-on activity (MSG-106).

2.4 Standardising Chemical, Biological and Radiological (CBR) M&S Interoperability

Work conducted by NATO MSG 049 [13] (Modelling and Simulation System for Emergency Response Planning and Training) highlighted that there was a lack of standards for interoperating CBR M&S systems for use in CAX using distributed simulation. Where interoperability mechanisms did exist, they were not aligned to NATO M&S guidance on use of standards.

The UK therefore submitted a proposal for a NATO M&S Group to overcome these identified capability gaps. As a result of this, NATO MSG 096 [14] (Consequence/Incident Management for Coalition Operations) was initiated to research how CAX simulation systems could be developed to support enhanced modelling of CBR scenarios relevant to NATO operations to provide training benefit. A key objective of this group was to provide recommendations on how CAX simulation systems interoperate with specialised CBR simulation systems through common NATO standards.

A recommendation from MSG-096 was that no standalone CBR standards should be developed to support CBR M&S interoperability, instead the recommended M&S standards for NATO CAX specified in Annex C of the draft Allied Modelling and Simulation Publication 03 (AMSP-03) [8] should be updated to provide specific CBR content. Notably, recommendations were made for the use of the following standards:

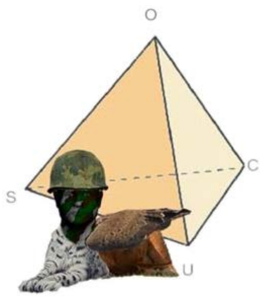
- **CBR Executable Scenario Description**: Standards for CBR executable scenario description do not currently exist. It is desirable to use the MSDL to define the Executable Scenario description, however MSDL does not currently have any CBR content and therefore it was recommended that CBR aspects of this standard be developed in the future to provide this capability.

- **CBR M&S Interoperability**: The Institute of Electrical and Electronics Engineers (IEEE) 1516-2010 version of the HLA standard is identified in AMSP-03 as the recommended standard to be used for interoperability between models and simulations in NATO/Multinational exercises. However, a CBR Information Exchange Data Model did not currently exist within AMSP-03. Therefore, it was recommended that a CBR Federate Object Model (FOM) was developed and integrated within the NETN FOM as the recommended Information Exchange Data-Model. The IEEE 1278 Distributed Interactive Simulation (DIS) standard was identified as an alternative approach but likewise does not have any CBR capability and would need to be extended to include a CBR DIS enumeration set within a CBR Protocol Data Unit (PDU).

Following these recommendations, a CBR Task Team was initiated within NATO MSG-106 to follow up on the recommendations of NATO MSG-096.

3.0 TECHNICAL DEVELOPMENTS

3.1 NATO MSG-106



As follow-on to MSG-068 and with an extended focus "Enhanced Computer Aided Exercise (CAX) Architecture, Design and Methodology" a.k.a. SPHINX was started in 2011 (as MSG-105) and in 2012 as MSG-106 [2]. This new task group was created not only to address key areas of further research identified in MSG-068 but also to focus on the Operational and Governance aspects of CAX.

MSG-106 has over 100 members from 18 NATO nations, 2 PfP nations, 7 NATO organizations including ACT, JFTC, JWC, M&S COE, JCBRN COE, NIAG, NCIA. This makes MSG-106 the current flagship of the NATO Modelling and

Simulation Group (NMSG).

The objectives of MSG-106 includes 1) providing guidelines for EXCON and SIMCON in performing CAX, 2) to improve and extend the MSG-068 deliverable NETN FAFD and 3) to provide recommendations for governance and maintenance of the MSG-106 products. Three main deliverables will come from MSG-106:

1. A NATO CAX Handbook as a complement to Bi-SC 75-3 [6]
2. M&S Standards Profile for NATO and Multinational Computer Assisted eXercises with distributed simulation
3. NETN FAFD v2.0 including updated FOM Modules

MSG-106 is organized into three subgroups OPS, GOV and TEK addressing operational, governance and technical issues respectively and to produce the three deliverables. This paper focuses on the work and results of the TEK subgroup and the NETN FAFD v2.0 in particular.

The main technical focus of MSG-106 is standards for distributed simulation interoperability and Simulation-C2 stimulation to support CAX. The purpose is to promote reuse of national simulation and training assets by providing interoperability standards and agreements on their use.

Results and experiences from MSG-068 experimentation, demonstration and national use of the NETN FAFD v1.0 provided the starting-point for MSG-106 technical development. Key topics identified included Multi-Resolution Modelling (aggregation/disaggregation), dynamic (runtime) transfer of modelling responsibilities, efficient ORBAT initialization and agreements on Simulation-C2 interoperability based on results from MSG-085. Additional input from the MSG-106 OPS subgroup provided further guidance on prioritized topics, which included aspects of modelling and simulation of maritime operations and CBR.

3.2 NETN FAFD Concepts

Fundamental to the NETN FAFD is the use of STANAG 4603 (HLA IEEE 1516). Almost all simulation interoperability agreements included in the NETN FAFD are based on the use of services as defined in the latest HLA standard. Included in the NETN FAFD is a set of FOM modules defined according to the IEEE 1516-2010 Object Model Template (OMT) and with dependencies among themselves and with other standards HLA FOM modules.

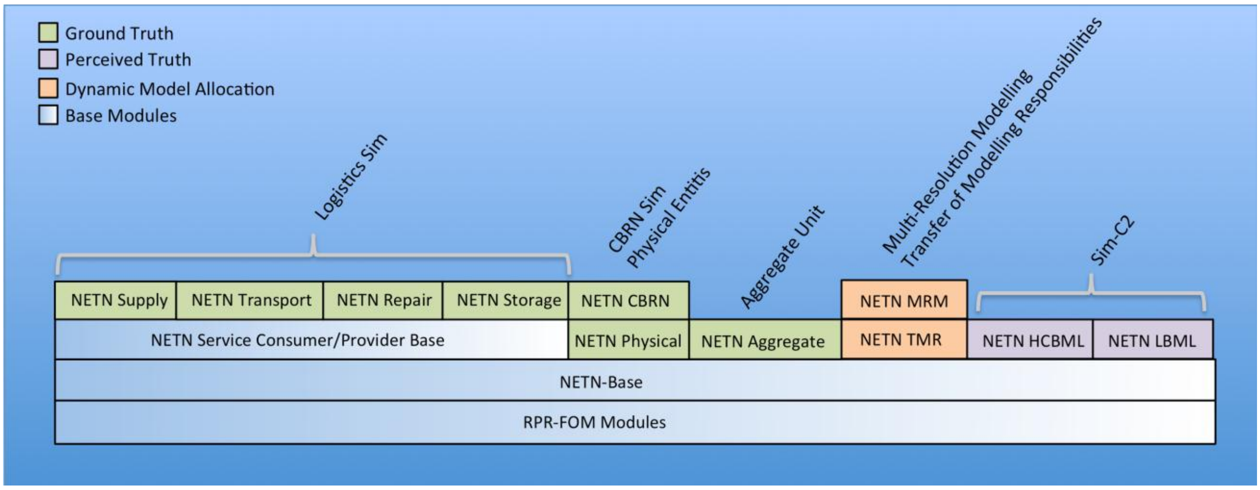


Figure 1: NETN FAFD v2.0 FOM Modules

One of the early outputs of MSG-106 was the proposed modularization of the Real-Time Platform Reference FOM (RPR-FOM) v2.0 D17 [7]. A proposal was submitted to SISO RPR-FOM PDG and during the finalization of the RPR-FOM new drafts have been tested and incorporated in the NETN FOM Module structure. The final and standardized RPR-FOM v2.0 will be used by NETN FAFD v2.0.

The NETN FAFD extends the RPR-FOM with modules for ground-truth representation and adds modules for dynamic model allocation and simulation-C2 interaction. It also provides FOM common base modules for managing service negotiation between federates and for NETN common datatypes and structures.

Dynamic transfer of modelling responsibilities (TMR) of simulated entities from one federate to another is a powerful NETN FAFD construct. It allows the user to dynamically change which federate is currently modelling aspects of a simulated object, e.g. unit or platform. As an example, higher-fidelity modelling can be accomplished within areas of interest, such as handover to a high-fidelity UAV simulation with tracking and visual capability when supporting a tactical mission vs. a low-fidelity representation when in a holding pattern. Another example might enable the handover of damage state to be set by a “fair fight” federate (combat adjudication), or handover of damage state to a CBR modelling entity. Additionally, this development enables improved technical management such as load-balancing and fault management and recovery, particularly within distributed environments. TMR has been created based on the NETN Service Provide-Consumer Pattern and correlates TMR interactions and HLA Ownership services. The transfer may be triggered both from external and internal to the requesting federate. This enables the potential for significant increases in the agility of simulation systems.

Also based on the TMR pattern and using the TMR FOM Module is the **Multi-Resolution Modelling (MRM)** design. MRM allows dynamic change of resolution by supporting aggregation and disaggregation of units and platforms. The MRM design includes triggering of aggregation/disaggregation and negotiated change (including TMR) of aggregation level. Requirements for a MRM service provider to maintain consistency and to manage co-existence of multiple resolution representations in the simulation are identified.

Based on the results of MSG-085 and SISO work with C-BML standard, MSG-106 proposes the use of two levels of BML FOM modules to support **Simulation-C2 Interoperability**. A high level C-BML based FOM module is used to capture and transfer C-BML messages using HLA services. A C-BML-HLA gateway is introduced as an architecture component to connect a C-BML server with a distributed NETN and HLA based simulation. Routing of C-BML messages within the NETN based federation utilizes HLA services and takes into consideration possible use of MRM and TMR that dynamically may change which federate(s) is actually going to process a C-BML order.

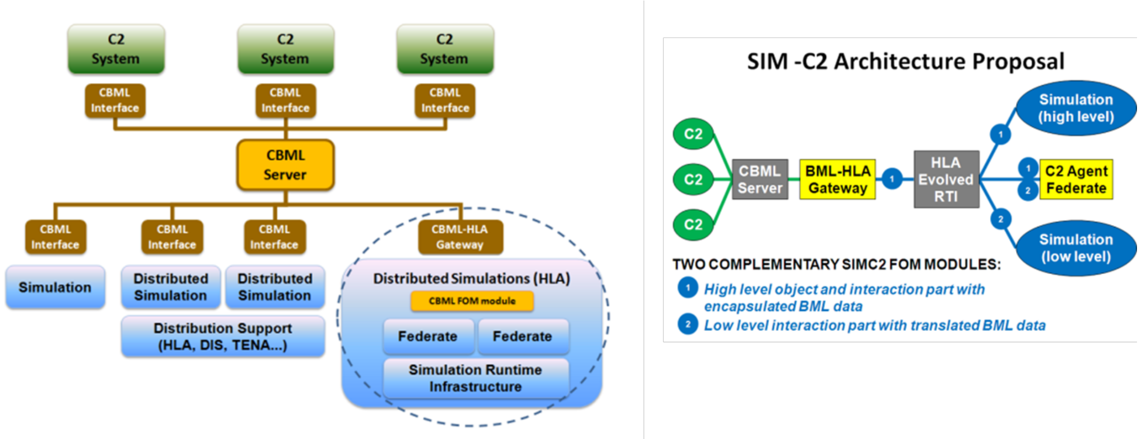
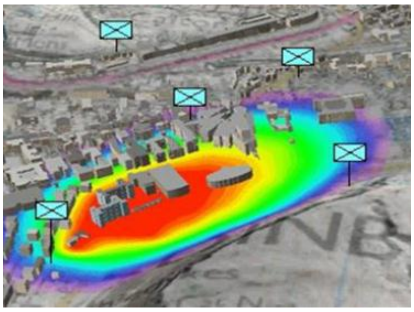


Figure 2: Simulation-C2 BML FOM modules

Additionally, the NETN FAFD introduces a Low-level BML FOM module and a C2 Agent Federate concept to act as an intermediary between C-BML and CGF commands.

A key aspect of interoperability is shared common representation of initial state and initial allocation of modelling responsibility. One of MSG-106 technical tasks was to propose technical solutions and support for **Common ORBAT and Initialization**. The NETN FAFD includes a proposal based on MSDL with extensions to include deployment information about initial allocation of modelling responsibilities to federates. Additional simulation related information is also included in the proposed MSDL extensions to capture Entity Type (RPR-FOM) data and initial embarkation state of units and platforms. The extended MSDL XML Schema is provided as part of the NETN FAFD.

A **Chemical, Biological and Radiological FOM** module was developed by MSG-106 to allow CBR modelling information to be exchanged within HLA federations. This built upon previous work undertaken by the UK to develop an Atmospheric Dispersion Base Object Model (BOM) [15]. This has been shared, trialled and further developed within the MSG-106 community. The CBR FOM Module covers a description of the initial CBR event through to the effects of that CBR event. The CBR FOM module can be broken down into the following sections:



- Source release modelling: Enables the transfer of information regarding a CBR release i.e. the source term parameters for an instantaneous chemical release (such as the mass and release location).
- Detector modelling: Enables the transfer of information required to perform detector modelling and the outputs from a detector model i.e. the CBR materials that a detector can detect or a detector's alarm state.
- Effects modelling: enables the transfer of information that is output from a CBR effects model i.e. the exposure data for a human or contamination status of a platform.
- Protective measure modelling: enables the transfer of information required to perform the modelling of protective measures as well as the output of the models i.e. individual and collective protective posture and protection factors.
- Hazard area information: enables the transfer of contour information for a CBR release i.e. the contours of the concentration, deposition and dosage of a CBR release as calculated by a dispersion model.

This information is summarised as the information that is imported in to a CBR M&S simulation federate so that it can perform dispersion modelling of the release, and the resulting information that can be extracted from this dispersion modelling. This is summarised in Figure 3.

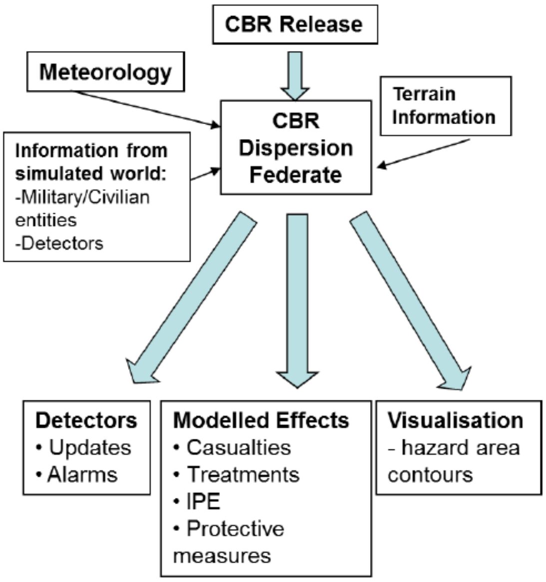


Figure 3: CBR Dispersion Federate

The CBR FOM module was peer reviewed by the nations participating in the group and also incorporated into the NETN FOM. The NETN FOM dependencies of the CBR FOM Module are shown in Figure 1.The German Navy has developed a **German Maritime FOM (GMF)** to enable interoperable simulations using the HLA Evolved architecture. This was developed from an internal German task analysis of Maritime requirements for simulation and builds upon the RPR FOM and NETN FOMs. The German Navy shared this FOM within MSG-106 seeking to provide a level of peer review and alignments, with consideration given to whether aspects of this should be incorporated into the NETN FOM. Nations undertook an operational and technical review of the GMF, delivering recommendations to both NETN development within NMSG as well as to the RPR FOM PDG (SISO). The following modules were considered:

- Acoustics module
- Sonobouy module
- Emitter module
- Transponder module
- Comms module
- METOC module
- Interchange base module

Broad interest and common requirement was identified across partner nations, and elements of the GMF were identified for possible alignment / extension to the NETN FOM. For example, the METOC capability is not currently a concept that NETN or the RPR FOM contain and will be considered for future inclusion.

4.0 VERIFICATION OF THE NETN FOM

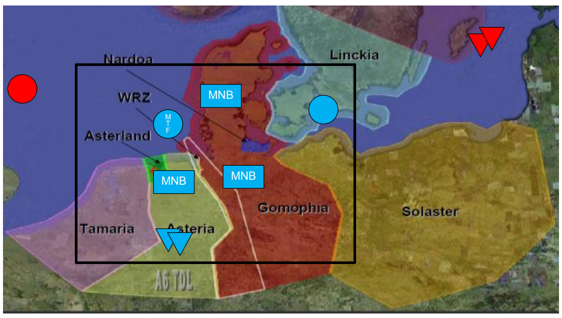
The process of verification confirms that a system is compliant with the defined requirement of specification. In partnership with validation, which confirms that a system meets the needs of the customer, it provides a mechanism, including evidence base, to support the acceptance and delivery of a system.

The NETN FAFD and associated FOM Modules have been tested by participating nations by implementing support in real simulation systems and in test tools to verify functionality, completeness and unambiguity of the FAFD specification. Each team lead was responsible for developing test cases and performing technical tests with at least two different systems from two participating nations. This ensured that developments were independently tested and that an independent consensus was reached. More complex test cases and scenarios have been developed to test scalability and performance.

To support the onwards acceptance and exploitation of the NETN FOM by partner nations, a final verification exercise was undertaken to integrate the full set of developments undertaken through MSG-106 and to exercise them within a representative operational context (scenario). Its purpose was to prove that the developments not only worked in isolation, but as a coherent whole, thereby raising the technology readiness level of the group's output.

In MSG-068 a persistent simulation network to support continuous and distributed testing was established and has continued to serve as the backbone for testing in MSG-106. The network itself is unclassified and runs over the Internet with additional software to create an overlay network that simplifies setup and connection to the shared simulation network. This so-called Booster Network also optimizes the distribution of simulation data between federates running on different sites in a wide-area network. Additionally, a set of test tools were made available on the Booster network to allow distributed testing of individual federates. Allowing federate developers to test their systems individually before integration testing has significantly reduced time spent on debugging that also cause idle time during integration events.

The purpose of the final verification activity was to integrate, experiment, verify (prove) and demonstrate the guidance (governance group) and technical developments (technical group) within a representative operational context (operational group). As defined in the CAX Handbook, the DSEEP process was followed as the planning, design, implementation, execution and analysis approach.



A scenario based on a CBR incident was implemented in order to exercise the technical developments, and was split into the following five mission phases:

- Initiation
- Ingress & Rendez-vous
- CBR Event & Dispersion
- Blue Forces at Risk
- Embarkation and Egress

Operational simulation systems were used to exercise the developments, including OneSAF (UK), SWORD (FR), CBR VB (UK), Pitch Actors (SW), VBS2 (UK) and an MRM Service Provider (SW).

The following architecture was represented in the experiment:

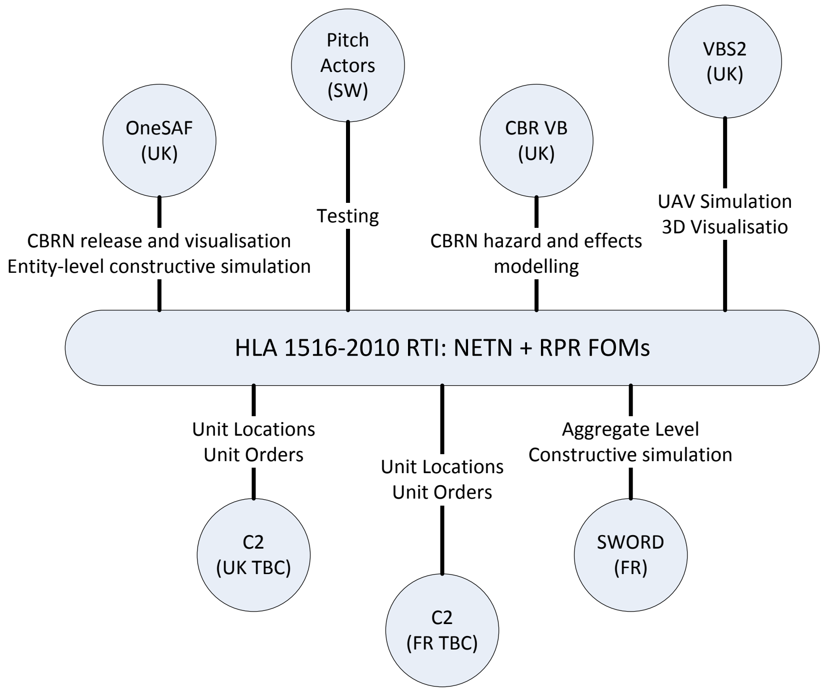


Figure 4: MSG-106 Experimentation Federation

The experiment concluded in October 2014 and final analysis is being completed (at the time of writing). It is expected that some minor updates to the NETN FOM Version 2 may be required and that an evidence base will be captured to support nations' acceptance requirements of the NETN developments.

5.0 VALIDATION OF THE NETN FOM: A USE CASE

The Viking Series of exercises is the largest multifunctional and multinational re-occurring civil-military exercise in the world. Based on a MoU signed between US and Sweden in 1999, Viking 14 is the 7th exercise and was conducted between 31 March and 10 April 2014. Each exercise has been designed to focus training on current operational situations.

The technical platform, simulation systems, tools to support exercise management and C2 systems are key components to a successful Viking CAX. The main driver behind the evolution of the Viking CAX technical solution is the need to reduce cost of preparation, integration and execution. By providing an environment that supports the concept of "few training many", Viking provides the training audience with a cost effective synthetic training environment. In Viking 14 the training audience consisted of 2200 people while the supporting training organization, including response cells, consisted of 300 people (not counting the 100 000+ simulated units). Viking exercises have always been distributed to support training audience and exercise control located on sites mainly across Europe and the USA. One of the main challenges has been to integrate national C2 and Simulation systems as part of technical solution. Issues related to networking, configuration and information management are also major challenges.

Distributed simulation has always been a fundamental component of the Viking technical solution. In Viking 14, simulation systems running at 8 distributed sites in Sweden (4 sites), Georgia, Serbia, Bulgaria and Ireland were connected using standards defined in NETN FAFD. A total of five (5) JCATS simulation servers, two (2) TYR (aggregated level) simulation servers and one (1) ITC/ICC were connected supported by HLA Evolved, RPR-FOM Modules, NETN Logistics FOM Modules and a variant of NETN Simulation-C2 stimulation. An additional 20 federates were connected to allow bridging, filtering, logging and monitoring of the simulated entities. The distributed simulation for Viking 14 was tested and executed using the same overlay network concept as used by MSG-106 for supporting distributed testing.

Results and feedback from the execution of Viking 14 have been provided as input to MSG-106 and future releases of the NETN FAFD will be taken into consideration when designing federated simulation systems to support future Viking exercises.

6.0 EXPLOITATION OF THE NETN FOM

The work conducted in MSG-068 and MSG-106 has focused on further development of standard agreements and existing standard FOMs to support NATO and national CAX. Leveraging and contributing to standardisation activities outside NATO has been a key activity in the technical subgroup. Early results of FOM modularisation of the RPR-FOM were provided to SISO and we now expect a finalised RPR-FOM v2.0 to be released during 2014. Technical results have been reported in numerous papers and presentations at SISO and NATO conferences. Members of the MSG-106 technical subgroup have been encouraged to engage in SISO standardisation activities and to provide their insights and expertise in activities related to M&S standardisation.

Exploitation of the NETN FAFD and FOM requires additional support for efficient dissemination and to lower the threshold for use. Access to documentation, experts and means to collect comments, change requests and suggestions for new content requires a suitable organisation and tools to support its work. The NATO FAFD and FOM are delivered to NATO Modelling and Simulation Standards Subgroup (MS3), a persistent subgroup of NMSG. During the Spring NMSG BM members of NMSG Exploratory Team ET-35 (HLA certification) and members of the MSG-106 technical subgroup proposed a new activity (MSG-134) to support MS3 with tools and procedures for HLA and FAFD compliance verification. The group will also support and promote the use of the NETN FOM by providing/developing material and tools for use by NATO and partner nations in their implementation of NETN compliant distributed simulations to support CAX.

6.1 Exploitation in Sweden

Sweden is undergoing an incremental upgrade of its CAX training tools. This process includes a pro-active involvement by Sweden in NATO and SISO activities to ensure availability of modern interoperability standards for CAX and simulation. The next generation C2 training systems will be introduced gradually and rely on the use of advanced distributed simulation. Experiences from applying NATO and international interoperability standards in exercises like Viking as well as national M&S research and experimentation is shared with the NATO community through NMSG activities to ensure that current and future investments provides architectures that promote reuse, interoperability, incremental capability enhancement. The ambition of the Swedish defence procurement agency (FMV) is to use and integrate COTS tools in C2 and C2 training systems in order to lower/share maintenance costs. A successful COTS/GOTS market/marketplace for interoperable simulation and training components requires standards and customers that require the use of these standards.

6.2 Exploitation in the UK

The UK's Strategic Defence and Security Review (2010) highlighted that the UK needs to embrace a step change in its exploitation of modern simulation training systems in order to increase operational effectiveness, reduce costs and minimise the MOD's environmental footprint. The Defence Training and

Education Capability (DTEC) implementation programme was initiated to provide a UK defence-wide approach to deliver better training and education, reduce costs and to deliver environmental benefits. Furthermore, the UK Simulation Strategy defines the need to move away from stovepiped acquisition and technology and to promote standardisation, interoperability and reuse, as well as to build a common infrastructure and services for simulation.

As a result, the UK has committed to adopting advanced standards that enable these aims, and HLA Evolved and the modular NETN FOM, building upon RPR FOM, has been adopted as one of the UK's core simulation standards under DTEC. The UK is also developing organisational constructs ("a shelf") to enable the management of UK FOMs as extensions to NETN where required, whilst continuing to ensure interoperability with NATO partners.

7.0 FUTURE RESEARCH

The technical simulation interoperability issues addressed in MSG-106 and the resulting NETN FAFD v2.0 only captures a part of the agreements required for a successful CAX. Further research is required in several areas and additional agreements should incrementally be added to new versions of the document. NMSG research task groups (incl. MSG-134) continue to address specific areas of interoperability and it is vital that these agreements are captured and maintained in a coherent standards document as the NETN FAFD. MSG-106 have identified and worked on a number of areas that requires additional specification, test and experimentation in order to be ready for inclusion in the NETN FAFD. These areas include among others 1) Federation Execution Control, 2) Combat Adjudication Services, 3) Fault Tolerance support, 4) Scalability, 5) Streaming Data (terrain etc.), 6) MEL/MIL interoperability. Based on national experimentation, feedback on the use of the FAFD has already been received and more is expected.

MSG-136: "Modelling and Simulation (M&S) as a Service (MSaaS) – Rapid deployment of interoperable and credible simulation environments" is focusing on advancing the next generation of interoperability concepts. Seeking to move away from the current state where achieving interoperability requires significant effort with regards to time, personnel and budgets, this group is seeking to research and develop simulation standards, agreements and reference architectures at high levels of interoperability (inc. pragmatic and conceptual interoperability) and simulation credibility. Seeking to build upon the work of previous MSGs, such as MSG-106 (including HLA Evolved and the NET FOM), and other simulation standards, this group will seek to address two key topics:

1. Improving simulation interoperability and credibility by using M&S domain services, such as:

    a. Synthetic Environment Service to enable rapid initialization of participating simulation systems with correlated synthetic environment data

    b. Scenario management services to reduce development time by using a library of typical scenarios that may be re-used with minimum efforts

    c. Weapon Effects Services and Communication Effects Services to improve fair-fight conditions.

    d. C2 Planning Support Services to provide decision support to C2 planning activities.

2. Establishing sustainable and efficient management of M&S services in NATO by analyzing the organizational M&S services perspective (organisation, processes, infrastructure, policy, procedures), including consideration of:

a. Establishment of a "Defence cloud" (e.g., nation-wide, NATO-wide, coalition-wide)

b. V&V services.

c. Certification and compliance testing services.

d. Training needs analysis services.

e. Catalog services

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