STANREC 4800 - AMSP-04 NATO Education and Training Network Federation Agreement and FOM Design

Björn Löfstrand
Pitch Technologies
Linköping
SWEDEN

bjorn.lofstrand@pitchtechnologies.com

ABSTRACT

Efficient and effective use of NATO and national Modelling & Simulation (M&S) capabilities requires standards for networking and simulation interoperability. The NETN FAFD is a NATO standard recommendation (STANREC 4800) how to represent shared data in distributed simulation environments where M&S services (federates) are connected and federated using the NATO mandated High-Level Architecture standard (STANAG 4603).

In March 2018, the NATO Education and Training Network Federation Agreement and FOM Design (NETN FAFD) document was released as the Allied Modelling and Simulation Publication (AMSP-04) covered by NATO STANREC 4800. This release can be considered the culmination of work, related to Federated Simulation Architecture and Design, conducted over a series of NATO Research Task Groups from MSG-027 starting in June 2003, MSG-052, MSG-068, MSG-106 until MSG-134 ending in December 2017. Although this version of the NETN FAFD is a major milestone, the work continues and the standard evolves based on feedback, new requirements, new concepts, new technologies and updated standards.

This paper describes the background & purpose of NETN FAFD, its current modules and rationale for each, examples of use in major exercises such as Viking, and finally a description of what is going on right now in MSG-163 with evolving the standard and some ideas on what we can expect in future versions of the standard.

1.0 BACKGROUND

Efficient and effective use of NATO and national Modelling & Simulation (M&S) capabilities requires standards for connecting and integrating M&S components across the training system enterprise.

The NATO Education and Training Network (NETN) initiative was created 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 started in 2007, which delivered a way forward for interoperability and technical standards by developing a reference architecture to link NATO and National Training and Education centres together as a persistent capability [1]. A key output of this task group was the NETN Federation Architecture and Federation Object Model Design (NETN FAFD) document, which provides an agile modular mechanism to define data models to support distributed simulation interoperability.

The NETN FAFD delivered by MSG-068 is composed of modules addressing different aspects of simulation interoperability. Modules were selected based on NATO and national experiences, identified priorities and availability of input and expertise in the task group. This included experiences and work done in previous pathfinder task groups MSG-027 and MSG-052 related to federated system architecture and design as well as NATO and national experiences from integrating federated simulation systems. At the time, most NATO nations also ratified STANAG 4603 [4], which also influenced NETN FAFD modules to primarily be based on the High Level Architecture (IEEE 1516) [5] standard. Major input to the initial design of NETN FAFD were JMRM (NATO), KOSI (Germany), P2SN (Sweden), ALLIANCE (France) and RPR Federation Object Models (SISO) and associated federation agreements.

The culmination of the MSG-068 work was a large distributed experimentation involving multiple national and NATO sites connecting over the Combined Federated Battle Laboratories Network (CFBL-net) but also using the NATO General Communication System. Multiple federated systems interoperated using agreements based on NETN FAFD and several scenarios were demonstrated to invited operational and technical experts.

A NATO MSG panel on "Enhanced Computer Aided Exercise (CAX) Architecture, Design and Methodology" (MSG-106 SPHINX) was created in 2012 to further the work of MSG-068, and also to develop an improved methodology for planning, executing and evaluating CAX, particularly considering the relationship between exercise control (EXCON) and simulation control (SIMCON) staff functions [2]. The group also undertook further technical development of the NETN FAFD with the aim to release it as an Allied Modelling and Simulation Publication (AMSP). Additional NETN FAFD modules were added and several improvements of existing modules were made. At the 2014 I/ITSEC conference/exhibition these new NETN FAFD capabilities were successfully demonstrated and a draft AMSP-04 was delivered to NMSG Modelling and Simulation Standards Subgroup (MS3) for standardization.

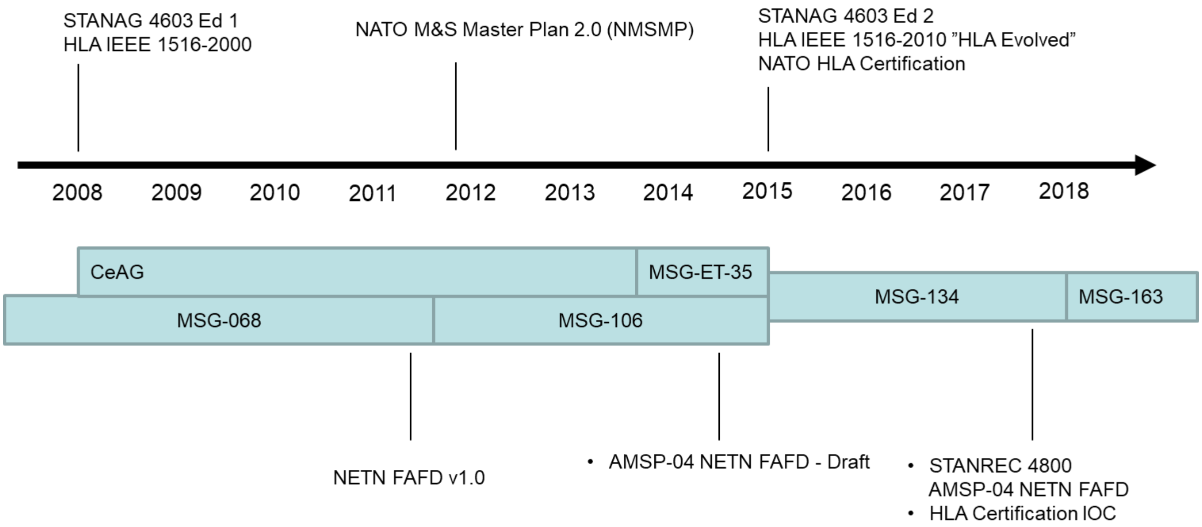

Figure 1: NETN FAFD Development Timeline

In parallel to the development of the NETN FAFD, activities focusing on supporting certification of simulation compliance with STANAG 4603 were led by the NMSG Certification Advisory Group (CeAG). MSG-ET-035 identified the need to develop tools and processes for supporting HLA Integration, Verification, Certification and Testing (IVCT). The results from MSG-106 and MSG-ET-035 led to the creation of MSG-134 [3] focusing on developing the NATO HLA Certification Process including certification of NETN FAFD compliance. MSG-134 was also tasked with supporting NMSG/MS3 with the work required to formally release NETN FAFD as AMSP-04. In addition, feedback and change requests were collected and prepared by MSG-134 to serve as input for future revisions of the NETN FAFD document.

In late 2017, the NATO Simulation Interoperability Test and Certification Service became operational and in March 2018, the AMSP-04 was promulgated and covered by STANREC 4800 [6]. The work to evolve both the Certification Initial Operational Capability (IOC) and the AMSP-04 continues in MSG-163.

2.0 WHAT IS NETN FAFD TODAY

AMSP-04 NETN FAFD [7]. is a NATO standard recommendation (STANREC 4800) how to represent and manage shared data in distributed simulation environments where M&S services (federates) are connected and federated using the NATO mandated High-Level Architecture standard (STANAG 4603).

The specification consists of a set of modules each addressing different aspects of distributed modelling and simulation. Some modules focus on how to represent the simulated entities and events. Other modules focus on how to dynamically manage and control the distributed simulation itself.

Associated with some/most of the AMSP-04 modules are STANAG 4603 (HLA) FOM Modules. Together these constitutes what is called the NETN FOM. These FOM modules extends and complements the RPR-FOM v2.0 [8].

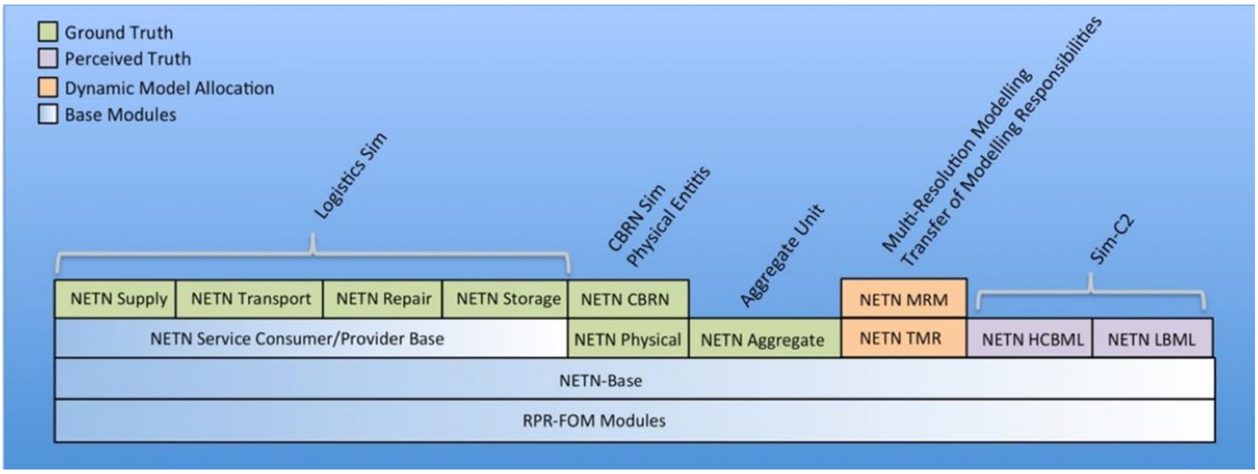

Figure 2: Current NETN FAFD FOM Modules

2.1 Transfer of Modelling Responsibilities

In a distributed simulation, the responsibility of modelling the synthetic environment can be shared among different networked systems. During simulation, each system manages updates of models according to their allocated responsibility. In a federated simulation, this responsibility is well defined and documented in agreements and in the design of the federation.

Being able to dynamically, during run-time, select and change modelling responsibility is a key feature in NETN based simulations. The NETN Transfer of Modelling Responsibility (TMR) module control and manage this dynamic change of responsibility. This allows run-time selection of the most appropriate system to model certain aspects of a simulated entity and to delegate the responsibility of updating corresponding attributes in the federation.

High-Level Architecture defines the core services necessary for TMR and the underlying RTI implementation provide these during runtime to ensure that only a single federate at any time has the permission to update attributes of an object instance in the federation. However, the HLA Ownership Management services are not enough to fully control and manage TMR and therefore additional control interactions are included in the NETN FAFD.

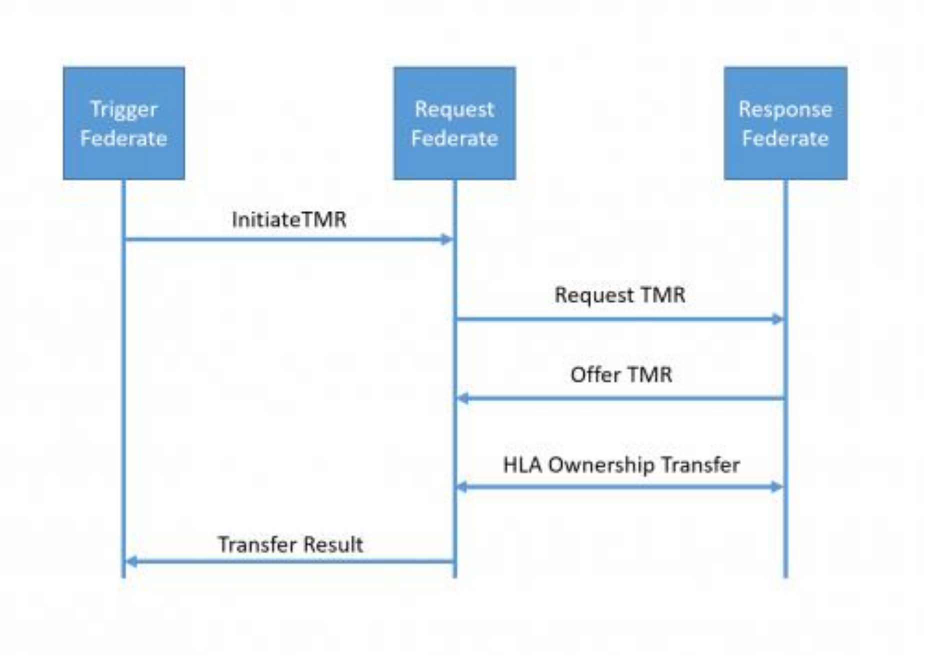

Figure 3: Transfer of Modelling Responsibility (Pull)

The TMR process is initiated either by the system requesting the modelling responsibility (pull) or by the system divesting responsibility (push). There can be many reasons for initiating TMR, including the triggering from a user or another federate. Triggering interactions, transfer requests, offers and results of transfer are all modelled using HLA interactions. A successful TMR negotiation between two federates (requesting and offering TMR) is followed by an HLA Ownership Transfer to complete the process.

Examples of TMR use:

- Recorded (or Live) entities are replayed in the federation but when engaged by a constructive entity the responsibility of the recorded entity is transferred to a simulation to model the behaviour of the entity and result of the engagement. (Note: the vice versa is substantially more difficult).

- A low fidelity CFG models a unit or entity and at a specific point in the scenario a higher fidelity model is required. The responsibility is transferred from the low fidelity CGF to a higher fidelity simulation. Similarly, a transfer of modelling responsibility from a high to low fidelity CGF is also possible.

- Transfer of responsibility from a constructive simulation to a virtual simulation during run-time to include a man-in-the-loop non-deterministic element in the scenario.

- Load balancing between multiple CGFs by transferring responsibility to simulations running on different host. Also allows transfer of responsibility to simulations running at different sites for latency and optimization purposes.

- Transferring responsibility to another simulation to manage system failure and simulation errors where hand-over is required.

- Runtime delegation of modelling subsets of entity aspects such as modelling movement, damage, sensors, tactical behaviour, etc.

2.2 Multi-Resolution Modelling

The NETN Multi-Resolution[1] Modelling (MRM) module provides a way to manage aggregation and disaggregation of simulated units and physical entities. MRM can be combined with the TMR module for transferring modelling responsibilities between federates that simulate the entity at different levels of resolution.

An Aggregate Unit is a model of an organizational unit with hierarchical relationships to other units in the same organization, aggregated state information and holdings representing the unit's supplies, equipment and personnel.

A federate implementing an MRM Service (MRM Service Provider) use information about the unit's organizational relationships and holdings to manage and control aggregation and disaggregation, e.g. registering entity instances based on holdings when disaggregating an Aggregate Unit. The MRM Service Provider also triggers any Transfer of Modelling Responsibilities (TMR) required as part of aggregation and disaggregation.

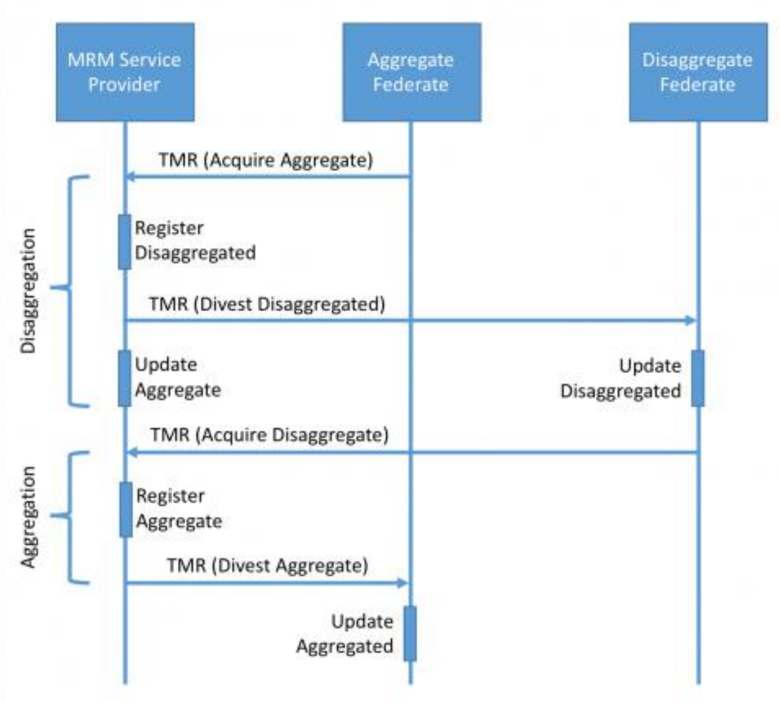

Figure 4: Dynamic Disaggregation and Aggregation of Units

Disaggregation is the process changing the level of modelling from an Aggregate Unit to its constituent parts as either sub-units and/or physical entities such as ground vehicles, aircraft, surface vessels etc. The disaggregation of an Aggregate Unit requires the transfer of modelling responsibility of all (non static) attributes to the MRM Service Provider. During a disaggregated state the MRM Service Provider will be responsible for updating all the aggregate unit (non static) attributes (a fully disaggregated unit is considered inactive). The MRM Service Provider registers disaggregated units and/or entities resolution entities and

[1] Resolution is defined as the degree of detail used to represent aspects of the real world by a model.

transfers responsibility using NETN TRM to federates with the capability of modelling at the required level of resolution.

Aggregation is the process of changing the level of modelling by combining constituent parts into an Aggregate Unit, i.e. the opposite of disaggregation. The aggregation of an Aggregate Unit involves transferring modelling responsibilities of attributes of multiple simulated entities potentially modelled by different federates. The MRM Service Provider acquires the required modelling responsibility and on completion the disaggregated entities are either deleted or inactivated. The MRM Service Provider creates/activates the Aggregate Unit and transfers the modelling responsibility to a federate capable of modelling the unit at the required level of resolution.

The NETN concept of MRM allows units to be represented at different levels of resolution in the federation. Fully aggregate, partially disaggregated and fully disaggregated states are defined and the representation and responsibility of modelling these states including definitions of accuracy[2] and fidelity[3] are defined in the AMSP-04.

2.3 Initialization

The NETN Initialization module provides a standard way of documenting and providing key data related to the initial states and relationships among units represented in a scenario. Preparation of a distributed CAX environment includes the distribution and initialization of common data including but not limited to Order of Battle (ORBAT), environment datasets and other initial scenario settings. The Military Scenario Definition Language (MSDL) [9] is the core standard used by NETN to represent ORBAT and initial scenario data.

NETN also defines the following MSDL extensions:

- Initial allocation of modelling responsibilities as additional deployment information
- Extended unit and equipment type identification based on SISO-REF-010 enumerations
- Representation of a unit's holdings of platform, equipment, human and other resources
- Extended description of humans to capture rank and category codes
- Embarkment added as new type status for a unit's support role to indicate that a unit or equipment is embarked on another unit.

The representation of Aggregate Units and Physical Object in NETN is based on the RPR-FOM representation with extensions to better reference data captured in MSDL. In particular, a Universally Unique IDentifier (UUID) is added to all Aggregate and Physical Entities in the federation. The UUID use the same format as in MSDL and is used to provide a unique identifier of simulated objects to its corresponding scenario description in MSDL format. The RPR-FOM has been extended with subclasses for all platforms and the AggregateEntity object class to add the UUID attribute and additional information.

The MSDL standard is currently undergoing revision and new versions of this standard will impact how initialization data is represented in future versions of NETN FAFD. Representation of task organization, internal organizational relationships and relationships between different organizations may in some situations need to change dynamically during execution of a federation. Future versions of the NETN Initialization module will provide standards for both initialization and dynamic update of this type of information.

[2] Accuracy is defined as the maximum allowed difference between a simulated aspect of a model and the corresponding real-world value.

[3] Fidelity is the combination of resolution and accuracy concepts. Higher-Fidelity means higher resolution and/or higher accuracy. Lower-fidelity less resolution and/or less accuracy.

2.4 Logistics

The Logistics module defines patterns used by federates to negotiate and deliver logistics simulation as a service during runtime. It uses the concept of a service provider and a service consumer that modelled in two different federates. The federates use the NETN logistics pattern to manage the service negotiation and delivery using HLA interactions and in some cases other NETN patterns such as NETN TMR.

The Logistics services include:

- Supply service provided by a facility, a unit or entity with consumable materials supply capability. Resources are transferred from the federate modelling the service provider to the federate modelling the service consumer.
- Storage service provided by a facility, a unit or entity with consumable materials storage capability. Resources are transferred from the federate modelling the service consumer to the federate modelling the service provider.
- Repair service can be performed on equipment (i.e. non-consumables items such as platforms) by facilities or units capable of performing the requested repairs. Modelling responsibility is by default not transferred from federate modelling the service consumer (e.g. a damaged platform) to the application with modelling responsibility for the service provider (i.e. repairing facility). However, modelling responsibility can be transferred with the inclusion of the Transfer of Modelling Responsibility (TMR) pattern.
- Transport service is provided by a facility, a unit or entity with transportation capability of non-consumable materials, e.g. units and platforms. Transported units are embarked, transported and disembarked. Modelling responsibility is by default not transferred from the federate modelling the service consumer (transported unit) to the federate modelling the service provider (transporter). However, modelling responsibility can be transferred with the inclusion of the Transfer of Modelling Responsibility (TMR) pattern. Units or platforms being transported are modelled as inactive during transportation.

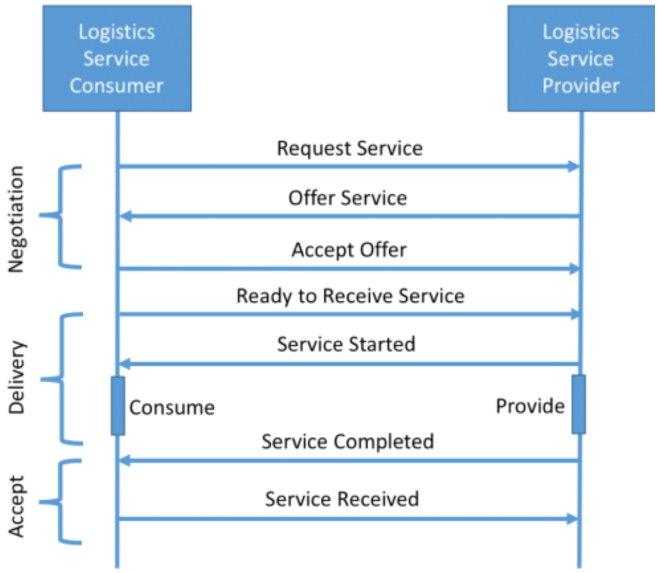

Figure 5: Logistics Model as a Service

Examples of uses:

- Supply of fixed wing aircraft in airports or during aerial refuelling.
- Supply of helicopters in assembly areas.
- Repair of damaged platforms by a maintenance unit without changing platform's location.
- Maintenance of damaged platforms previously deposited in a facility.
- Transport of units, platforms, and humans by e.g. train, ship, or aircraft.
- Embarkment and disembarkment of units.

The NETN Logistics module is not an extension of the RPR-FOM Logistics representation but should be viewed as an alternate approach or complementary approach to model some logistics aspects of simulation.

2.5 CBRN

The Chemical, Biological, Radiological and Nuclear (CBRN) module is used to support CBRN dispersion calculations and the dissemination of information about the dispersion effects on entities and the environment. The component specifies the use of a CBRN Federate to manage some of the CBRN related modelling.

The CBRN component consists of five parts:

- Source Release: A CBRN Release interaction is published in the federation to trigger the CBRN Federate to start simulation of the release. The interaction defines all of the information required to model a CBRN source release.
- Detectors: Detector properties is represented as a CBRN Detector objects and detections are published as CBRN Detector Alarm interactions. Sensor concentration readings is published using the CBRN Sensor object and CBRN Sensor Update interactions.
- CBRN Effects: The CBRN Human object class extends the representation of humans to include casualty state attributes. TriageLevel uses the NATO representation of triage category scores and IPE Type denotes the level of Individual Protective Equipment (IPE) that the unit is wearing according to Nuclear, Biological and Chemical (NBC) dress states. A CBRN Casualty interaction is also used to send notifications of casualty state change. Extensions to NETN Platform classes are also included to represent contaminated materials.
- Protective Measures: This part include both modelling of CBRN treatments and the modelling the level of individual (IPE) and collective CBRN protection equipment (COLPRO).
- Hazard Area: Representation of a contamination area used by simulation to model CBRN effects. It can be the output from a hazard prediction algorithm (a warning area defined in Allied Tactical Publication (ATP-45) or output from a dispersion model (contours).

Note that meteorological information and CBRN material properties are not part of the current NETN FAFD specification.

2.6 Sim-C2

The purpose of the Simulation-C2 Interoperability (SimC2) module is to automate the process of interaction between C2 systems and simulations. NETN SIM-C2 relies on the Coalition Battle Management Language (C-BML) [10] and provides a way to represent C-BML messages in a federated simulation environment without the need to implement peer-to-peer connections between C-BML services and individual simulation systems. Although, an individual simulation can use a C-BML interface to interact directly with a C-BML server the preferred NETN approach is to have a single C-BML gateway that interacts with the NETN federation regardless.

The C-BML language is a high-level language representing orders, reports and requests. Some simulations can process this information directly and perform meaningful modelling of activities but most entity-level simulations are task oriented and operate on a significantly lower level. The NETN SimC2 concept does not exclude the use of simulations that can process C-BML directly but identifies the need for components that can perform both aggregation and disaggregation of orders, reports and requests into smaller elements suitable for entity-level simulations. Lower-level tasks can be used to control simulations in the NETN federation using the Low-Level BML (LLBML) module.

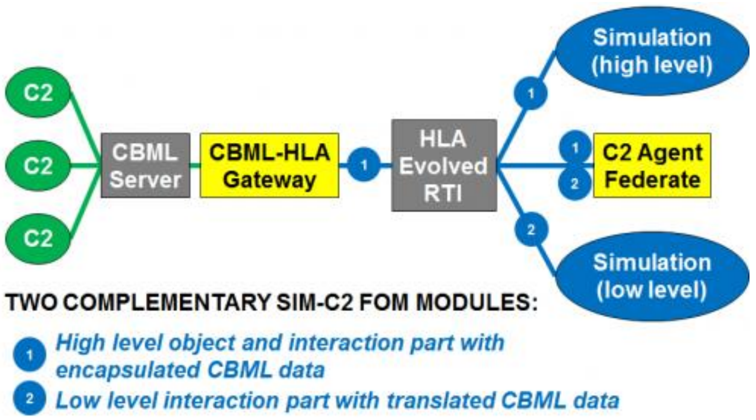

Figure 6: High-Level C-BML transformed by C2 Agent Federate to Low-Level BML Tasks

Two different FOM Modules support the NETN SimC2 module. The HCBML FOM module captures C-BML data and models them in HLA. The LLBML FOM Module defines lower-level tasks and reports suitable that can be produced by C2 Agent Federates that transform C-BML to low-level simulation tasks suitable for CGFs. The NETN SimC2 concept is based on research performed by FFI (Norway) and TNO (The Netherlands) [Alstad A. et al. 2013].

2.6.1 C-BML

The HCBML FOM module is a simple wrapper of C-BML messages where C-BML orders and requests are represented using its C-BML XML format without modification. Some information from the message header are extracted and used for routing of the message. Reports and acknowledgements are represented as interactions with parameters based on C-BML. The following reports are supported:

- TaskReport: Progress of current task
- SituationReport: Force Tracking information
- LogReport: Logistics report

2.6.2 Low-Level BML

The LLBML FOM Module represent lower-level tasks suitable for providing simulation instructions to federates modelling individual units or platforms.

LLBML provides a simulator independent way of command and control over simulated entities both from a simulator operator perspective and when modelling command and control interaction between federates in a distributed simulation. LLBML contains common low level tasks and commands that can easily be interpreted and executed by simulations that model the behaviour of entities. It also defines a set of reports used by simulations to provide status updates of the tasks being executed.

The following orders and reports are currently included in the LLBML module.

ChangeOrderedAltitude: Request new altitude.	**TurnToHeading**: Task entity to turn to the specified heading.	**AmmunitionStatusReport**: Report current amount of ammunition.
ChangeOrderedSpeed: Request new speed.	**TurnToOrientation**: Task entity to rotate to the specified orientation using pitch and roll parameters.	**DamageStatusReport**: Report when damage state changes.
FireAtLocation: Task entity to fire at a location.	**VehicleDismount**: Task entity to dismount from a vehicle.	**FuelStatusReport**: Report current amount of fuel left.
FireIndirectWM: Task entity to fire at a location with the specified weapon and munition.	**VehicleDismount**: Task entity to dismount from a vehicle.	**PositionStatusReport**: Report position, speed, and heading of simulated entity.
FireAtUnit: Task entity to fire at a specified unit.	**VehicleDismount**: Task entity to dismount from a vehicle.	**UnderAttackStatusReport**: Report when unit is under attack.
FollowUnit: Tasks entity to follow another unit.	**VehicleMount**: Task entity to mount a specified vehicle.	**SpotReport**: Report when unit's sensors detect opposing, neutral, or unknown unit.
Move: Task entity to move in the specified direction.	**Wait**: Tasks entity to wait until the specified end time.	**ActivitySpotReport**: Report the perceived current activity of a spotted unit.
MoveIntoFormation: Task an aggregate unit to move into specified formation and heading.	**CancelAllTasks**: Cancel all tasks. Tasks already started are aborted immediately.	**CurrentActivitySpotReport**: Report elapsed time and status of the current task.
MoveToLocation: Task unit to move to the specified destination.	**CancelSpecifiedTasks**: Cancel all specified tasks. Tasks already started are aborted immediately.	**NextActivitySpotReport**: Report time and start condition of the next activity.
MoveToUnit: Task entity to move to another unit.	**CurrentActivityStatusReport**: Report time and status of current task.	**InSensorReport**: Report sensor type and identifiers of detected entities.
SetRulesOfEngagement: Task a unit to change the rules of engagement.	**NextActivityStatusReport**: Report time and start condition of next activity.	**InWeaponRangeReport**: Report weapon type and identifiers of entities within weapon range.

Table 1: LLBML Orders and Reports

3.0 USE CASE: VIKING

Viking is a series of exercises providing a comprehensive and unique collective training opportunity for military, civilian organizations and police focusing on co-operation between all relevant actors in peace support operations and international crisis management. The Viking initiative and concept was defined and initiated by Sweden and the United States at the NATO 50th anniversary summit in 1999. Since the first exercise in 1999 there have been an additional 7 exercises to date.

The Viking Computer Assisted eXercise (CAX) uses a simulation based scenario and scripted incidents and injects to support the exercise control (EXCON) response cells in their interaction with the primary training audience. M&S is used as a tool to represent a large number of units and their operations and over the years a distributed federated simulation systems have evolved. In this evolution, NATO M&S research have been tested and feedback have been provided to ensure that NATO M&S standards such as the NETN FAFD also evolve to meet the requirements of Viking.

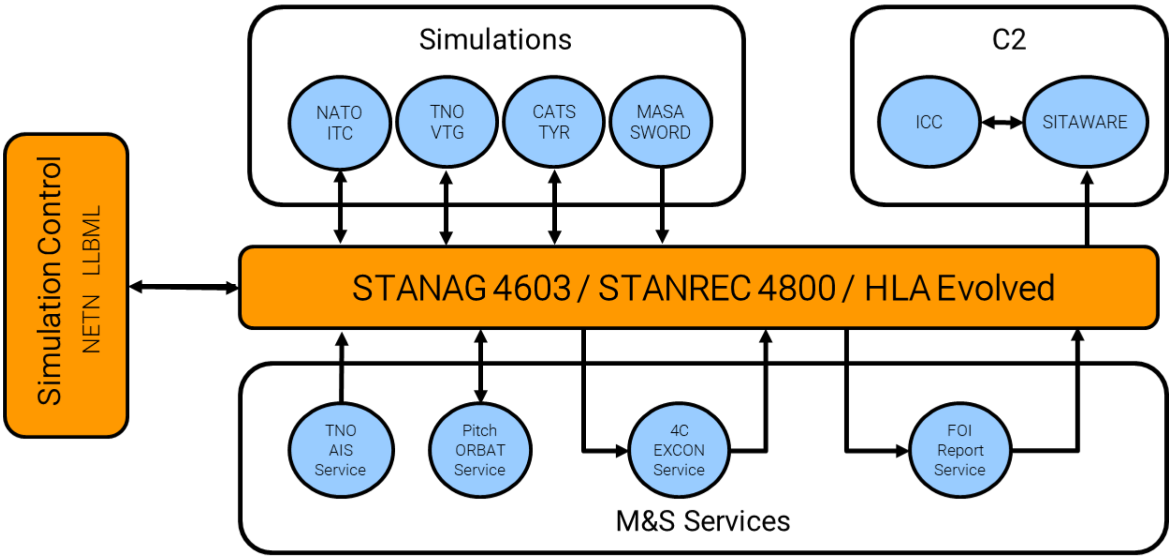

Figure 7: Viking 18 Gaming Architecture

In 2018 the Viking federated simulation consisted of core simulation systems, additional functional services and connections to C2 systems used by EXCON and the training audience. The exercise was distributed across 9 sites in Brazil, Bulgaria, Finland, Ireland, Serbia and Sweden (4 sites).

Since 2011, the Viking federation agreements have been based on various versions of the NETN FAFD and different modules have been tested based on exercise requirements. The Viking 18 distributed simulation is based on the AMSP-04 Ed A NETN FAFD with extensions for specific requirements primarily to improve/automate work in the response cells. The specific NETN FAFD modules in focus for Viking 18 were:

- NETN SimC2 (LLBML/HCBML)
- NETN MSDL and NETN extensions to RPR Physical and Aggregate Entities

Additional modules and improvements were also tested:

- AIS Module for representation of Civilian Ship traffic
- MSDL FOM Module for representation of MSDL data in the federation to support dynamic ORBAT changes.
- MEL/MIL FOM Module for representation of Incidents and Injects to trigger events in the simulation
- Additional LLBML order and report types
- Improvements of HCBML reports

All findings and feedback from the Viking 18 exercise related to the use of NETN FAFD have been fed back to NATO MS3 as Proposal/Change Requests through MSG-163.

4.0 FUTURE EDITIONS OF NETN FAFD

The custodian of AMSP-04 is NMSG/MS3, however the responsibility of maintaining and updating the current version is currently delegated to a research task group (MSG-163 “Evolving NATO Standards for Federated Simulation”). A process for continuous management, maintenance and evolution of AMSP-04 is needed where different NATO Research Task Groups, NATO organizations and nations are invited to contribute to new and improved ASMP-04 modules.

Currently, MSG-163 collects input from the use of NETN FAFD in exercises such as Viking 18, from NATO and national stakeholders and from other NATO S&T research task groups and maintain a list of Problem/Change Requests (PCRs). To resolve these PCRs and to develop a new draft ASMP-04 Ed B, the MSG-163 liaison with other MSGs and stakeholders to provide support for updating or adding modules to the standard.

The current list of PCR can be characterized as follows:

New Modules

- Updated Initialization Module with an added MSDL FOM Module
- AIS Module
- MEL/MIL Module
- Synthetic Environment Module with RPR extensions
- Modules for Crisis Management and Disaster Response in collaboration with MSG-147
- METOC Module for representation of Weather in collaboration with MSG-156

Structural Changes

- Merging of NETN Logistics FOM Modules
- Split of SimC2 Module into HCBML and LLBML as separate modules in the document
- Module renaming

Module Updates

- Extend LLBML
- Extend HCBML
- Extend Physical
- Extend MRM
- MSDL Module updates

Future work also include promoting AMSP-04 and providing additional support for developers, integrators, federation architects and decision makers with respect to the use of NETN FAFD to achieve efficient and effective use of NATO and national Modelling & Simulation (M&S) capabilities.

AUTHOR

Mr. Björn LÖFSTRAND is a senior systems architect at Pitch Technologies and works mainly with federated system design focusing on distributed M&S systems. Mr. Löfstrand provide key support to the Swedish Defence Materiel Administration (FMV) and the Swedish Armed Forces in the transformation of simulation based training systems to meet current requirements and prepare for future requirements. Mr. Löfstrand also engage in NATO and international M&S standards development activities to evolve and develop standards that allow smart design of simulation systems. He has been engaged in M&S standardization activities for over 20 years participating in the development of standards like High-Level Architecture and engaging in NATO S&T projects such as MSG-027, MSG-052, MSG-068, MSG-086, MSG-106, MSG-134, MSG-136 and currently MSG-163 and MSG-164. Mr. Löfstrand has a M.Sc. in Computer Science from the University of Linköping Sweden and he holds the position as Head of Services at Pitch Technologies.

REFERENCES

[1] MSG-068 NATO Education and Training Network. Technical Report. https://www.sto.nato.int/publications/

[2] MSG-106 Enhanced CAX Architecture, Design and Methodology – SPHINX Technical Report. https://www.sto.nato.int/publications/

[3] MSG-134 Technical Report. https://www.sto.nato.int/publications/

[4] STANAG 4603 Ed 2 - IEEE 1516-2010 - High Level Architecture (HLA). http://nso.nato.int/nso/

[5] IEEE 1516-2010. https://standards.ieee.org/standard/1516-2010.html

[6] STANREC 4800 Ed 1- AMSP-04 Ed A - NATO Education and Training Network Federation Architecture and Federation Object Model Design. https://www.sto.nato.int/publications/

[7] AMSP-04 Ed A. NATO Education and Training Network Federation Architecture and FOM Design. https://www.sto.nato.int/publications/

[8] SISO-STD-001.1-2015: Standard for Real-time Platform Reference Federation Object Model (RPR FOM), Version 2.0 (10 Aug 2015). https://www.sisostds.org/ProductsPublications/Standards/SISOStandards.aspx

[9] SISO-STD-007-2008: Standard for Military Scenario Definition Language (MSDL) (reaffirmed 11 May 2015). https://www.sisostds.org/ProductsPublications/Standards/SISOStandards.aspx

[10] SISO-STD-011-2014: Standard for Coalition Battle Management Language (C-BML) Phase 1, Version 1.0 (14 Apr 2014). https://www.sisostds.org/ProductsPublications/Standards/SISOStandards.aspx

BIBLIOGRAPHY

Öhlund G., Löfstrand B., Hassaine F. (2007) Knowledge Network for Federation Architecture and Design. In: Proceedings from 2007 Fall Simulation Interoperability Workshop. 07F-SIW-024. - Paper & Presentation

Huiskamp W., Loper M., Cutts D. (2007) Federation Agreements - Observations, Considerations and Proposals out of the NATO MSG-052 Working Group “Knowledge Network for Distributed simulation Architecture and Design”. In: Proceedings from Fall 2007 Simulation Interoperability Workshop. 07F-SIW-058. Simulation Interoperability Standards Organization - Paper

Huiskamp W., Cutts D., Chaigneau S. (2008) Improving the Federation Agreements Definition. New Proposals Out of the NATO MSG-052 Working Group “Knowledge Network for Federation Architecture and Design”. In: The NATO Modelling and Simulation Group (NMSG) Symposium (MSG-060) “How is Modelling and Simulation meeting the Defence Challenges”, Vancouver, Canada, October 2008. RTO-MP-MSG-060-02 - Paper

Löfstrand B., Khayari R., Keller K., Greiwe K., Meyer zu Drewer P., Hultén T., Bowers A., Faye J. P.,

(2009) Logistics FOM Module in Snow Leopard: Recommendations by MSG-068 NATO Education and Training Network Task Group. In: Proceedings of 2009 Fall Simulation Interoperability Workshop, 09FF-SIW-076. September 2009. - Paper & Presentation.

Cayirci E., Rong C., Huiskamp W., Verkoelen C. (2009) Snow Leopard Cloud: A Multi-national Education Training and Experimentation Cloud and Its Security Challenges. In: Jaatun M.G., Zhao G., Rong C. (eds) Cloud Computing. CloudCom 2009. Lecture Notes in Computer Science, vol 5931. Springer, Berlin, Heidelberg. - Paper.

Ruiz J., Désert D., Guillou P. (2012) Improvement of simulation interoperability by introducing the CBML benefits into the HLA world. In: Proceedings of 2012 Fall Simulation Interoperability Workshop, 12F-SIW-009, Simulation Interoperability Standards Organization, September 2012 - Paper & Presentation

Alstad A, Løvlid R. A., Mevassvik O. M., Nielsen M. N., Henderson H. C., Jansen R. E. J., de Reus N. M. (2013) Low-level Battle Management Language. In: Proceedings of 2013 Spring Simulation Interoperability Workshop, 13S-SIW-032, Simulation Interoperability Standards Organization, April 2013 - Paper & Presentation

Ruiz J., Désert D., Hubervic A., Guillou P., Jansen R. E. J., de Reus N. M., Henderson H. C., Fauske K. M., Olsson L. (2013) BML and MSDL for multi-level simulations. In: Proceedings of 2013 Fall Simulation Interoperability Workshop, 13F-SIW-002, Simulation Interoperability Standards Organization, September 2013 - Paper & Presentation

Nyløkke J., Horn B., Roos K., Solum E., Horn K., Newton N., Krarup-Hansen N., Morris S. (2014) Interoperability and harmonization analysis of the German Maritime Federation Object Model (GMF) in relation to SISO RPR FOM with possible extensions in a multinational forum. In: Proceedings of 2014 Fall Simulation Interoperability Workshop, 14F-SIW-004. Simulation Interoperability Standards Organization - Paper

Lloyd J., Newton N., Mifsud M., Ruiz J., Désert D., Hubervic A., Olsson L (2014) Chemical Biological Radiological modelling capability: UK and NATO HLA Evolved experimentation. In: Proceedings of 2014 Fall Simulation Interoperability Workshop. 14F-SIW-021. Simulation Interoperability Standards Organization - Paper & Presentation

Tard L. (2014) SPHINX: a Web-Based Tool for CAX Preparation and Capitalization. NATO Modelling and Simulation Group (NMSG) Multi-Workshop MSG-126, STO-MP-MSG-126-014. - Paper

Mifsud M., Löfstrand B., Lloyd J. (2014) An update on the developments and maturity of the NATO Education and Training Network (NETN) Federation Architecture and Federation Object Model (FOM) NATO Modelling and Simulation Group (NMSG) Multi-Workshop MSG-126, STO-MP-MSG-126-022. - Paper

Löfstrand B. (2014) NATO Education and Training Network - Federation Architecture and FOM Design (NETN FAFD v2.0). Presentation at 9th CAX Forum 2014

Löfstrand B., Hodicky J. (2015) NATO Distributed Simulation Architecture & Design, Compliance Testing and Certification - MSG-134 Presentation at 10th NATO CAX Forum 2015. September 2015

Herzog R., Johannes Mulder J., Horst Behner H., Löfstrand B. (2015) A Safe Way to Reliable Federations STO-MP-MSG-133-021. NMSG Symposium on M&S Support to Operational Tasks including War Gaming, Logistics, Cyber Defence. October 2015. Munich, Germany

Löfstrand B., Behner H. (2016) MSG-134 CONOPS, Business Model and Recommendations Modelling and Simulation Standards Subgroup (MS3) meeting at NMSG 37th Business Meeting. June 2016. Rome, Italy

Ruiz J., Behner H., Herzog R., Hodicky J., Löfstrand B., Vrieler S. (2016) Towards a new NATO certification capability for HLA interoperability In: Proceedings of 2016 Simulation Innovation Workshop, 2016-SIW-004. Simulation Interoperability Standards Organization - Paper & Presentation

Jan Hodicky J., Stefan Vrieler S. (2017) Establishment of HLA compliance certification within NATO SISO Seminar at ITEC 2017. May 2017. Rotterdam, Netherlands

Behner H., Löfstrand B. (2017) The New HLA Certification Process in NATO Paper 19. MSG-149 Symposium on M&S Technologies and Standards for Enabling Alliance Interoperability and Pervasive M&S Applications. Lisbon, October 2017

Löfstrand B. (2017) NATO Education and Training Network Federation Architecture and FOM Design (NETN FAFD) Presentation at 12th CAX Forum. Florence. September 2017

Behner H., Löfstrand B. (2017) Establishing a HLA Certification Process in NATO Paper 17058. Interservice/ Industry Training, Simulation and Education Conference. November 2017