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№ 4599

Simulation in NATO Federated Mission Networking

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November 19, 2020

Paper Draft for
International Command and Control Research and Technology Symposium 2020

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Abstract:
Two decades ago in Afghanistan, NATO's International Security Assistance Force learned by doing: the multinational force was hampered in operations until the Afghan Mission Network (AMN) was assembled to support collaboration and coordination of forces. Today Allied Command Transformation is preparing for a future where coalition forces have a network far superior to AMN on Day Zero of coalition operations. Toward this end, the Federated Mission Networking (FMN) project is assembling a framework of NATO and commercial standards with the expectation that the 30 member nations will configure their networking capabilities to interoperate over the FMN standards.

The NATO Modelling and Simulation Group (MSG) Technical Activity 145 and SISO Product Development Group for the C2-Simulation Interoperation (C2SIM) have been working together to standardize and operationalize a new capability, which has been described in previous ICCRTS papers by the authors. The team that assembled C2SIM standards now finds a new challenge: assembling and justifying a collection of standards for modeling and simulation (M&S) that suit FMN needs, with C2SIM an obvious cornerstone of that collection. This paper addresses, from a systems engineering viewpoint, the technical issues and process whereby standards for networked computer simulation within the FMN are nominated. The paper introduces the FMN concept, followed by a discussion of the role of M&S in coalition operations, and finishes with a review of likely standards for networked military simulation that will be included.

1 Introduction

1.1 Background

During the Cold War and in its aftermath (1949-1995), most National land force contributions to NATO in the land environment were based on the Corps level of command. Interoperability was based on the deployment of Liaison Officers (LNOs) who were attached to a flanking formation on right of the sending organization and one to each subordinate command. They would have radio communications with their parent headquarters but any other form of interoperability posed a challenge. After 1995, which saw NATO deployment of multinational forces, there were issues in balancing the command authority requirements of a force commander versus the reluctance by nations to relinquish national command and control (C2) of forces to a foreign commander. Coupled with this were difficulties that affected the effectiveness of multinational logistics and Communications and Information Systems (CIS) support, where national laws and financial regulations were seen as outweighing the needs of the commander of a multi-national force.

1.2 Digitization

From 1995 onwards, nations sought to embrace new digital communication technologies to securely enhance the decision-making process. Examples of such initiatives were the UK's Network Enabled Capability (NEC) and the USA's Network-Centric Warfare (NCW). NATO Partner-for Peace Australia developed the concept of Ubiquitous Command and Control (UC2) [1], which not only included network-enabled capability, but military intent and awareness. However, these initiatives also were standalone and were not necessarily designed with interoperability beyond the developing nation's armed force in mind, particularly in the land environment. The emergence of these standalone networked CIS systems from 1995 created some added unforeseen problems because of different interpretations that related to security regulations, standards, procurement strategies, industrial self-interest and operating practices. As a result, without major effort and strong leadership the ability to interconnect these networks was challenging. In the C2 domain, this led to deployment of "swivel-chair" interfaces (a situation not dissimilar to that seen even today in simulation interoperability) where an operator used USB sticks and CD-ROMs to bypass the airgaps built into national systems. This in turn led to security breaches and other operational problems that sadly exhibited themselves in Afghanistan during the NATO led operations from December 2001 when the International Security Assistance Force (ISAF) was established.

In 2005, in order to address the problems associated with standalone systems, the NATO Network Enabled Capability (NNEC) Feasibility Study was published [2]. The capability it described was meant to provide a robustly networked force that, with improved information sharing, would give commanders and their staff better situational awareness, the ability to collaborate, self-synchronization, enhanced sustainability and speed of command. Like national initiatives, NNEC was ambitious and did not deliver on its promise as experienced by those forces deployed early on in the Afghanistan Area of Operations. Due to the issues faced by forces from NATO and coalition partners in early deployments, the Afghan Mission Network

(AMN) was conceived and successfully developed, although it was not without some challenges in its implementation. AMN used some of the basic tenants from NNEC and was designated as the primary Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Network for the coalition. Thus, it became a "weapon platform" in its own right and most communities of interest moved their C4ISR tools from national networks onto the common information sharing platform. Its topology was not directly related to the structure of the chain of command, enabling efficiencies in CIS resources and sharing of services in different locations.

1.3 Why Federated Mission Networking?

In the aftermath of a number of NATO's operations, and predominantly because of their deployment to Afghanistan, a key lesson identified was the need to have its command and control processes and supporting technology interoperable from the start of a mission, in what is termed "Day Zero Interoperability." In order to achieve this, it was decided by NATO's Military Committee (MC) in 2012 that NATO had to develop Federated Mission Network (FMN) as a common capability among NATO nations [3]. The FMN concept paper was endorsed by nations, an Implementation Plan was drawn up [4], and the North Atlantic Council (NAC) endorsed Version 4 of the FMN Implementation Plan in 2015. In 2016 at the NATO Warsaw Summit, it was stated by NATO leaders that "Interoperability of our armed forces is fundamental to our success and an important added value of our Alliance" [5].

1.4 What is FMN?

The mission of FMN is:

Enhanced Operational Readiness & Effectiveness Today and in the Future

And its vision is:

Day Zero Interoperable Forces

Day Zero capability refers to the minimum capability required to support the needs of the Commander during the pre-deployment and initial deployment phases of an operation, and to support rapid, smooth, and efficient transition from pre-deployment to initial operations. As articulated by NATO Allied Command Transformation (ACT), the FMN vision has two components: 1) *Operate Together: Exploit our Strategic Advantage* and 2) *Adapt Together: Effectively Transform Capabilities to Maintain our Edge* [6]. The first relies on having FMN Ready Forces before the start of a mission. This means that national contributions to a NATO Response Force (NRF) must be declared as FMN compliant, which is achieved through testing and validation activities. The second component is tacit recognition that, in an era of constrained resources and a wide range of potential missions, FMN reflects the need for *federation* as the means to achieve economy of scale and maximum reuse while achieving the full benefit of information sharing.

The word "Network" has subsequently been replaced by "Networking" to reflect the fact that FMN is based on an interoperable capability of each nation, as is not deployed as a single network under unified management. The FMN capability is composed of a number of elements that collectively comprise the ability to provide mission networking in a federated environment.

The primary goal of the FMN capability is to support C2 and decision-making in future operations through improved information-sharing. The approach is distinctive in that it provides the ways and identifies the means to deliver better information sharing. The implementation of this capability is intended to deliver a toolset of processes, organizations, training, technology, and standards provided, in a coordinated approach, by NATO, NATO Nations, and non-NATO nations cooperating together.

The starting point for FMN was based on the lessons identified from the successful implementation of the AMN. FMN itself, it is realized, cannot be developed in one large acquisition program as was envisaged by concepts like the NNEC, NEC, NCW and UC2. It will evolve over time though "spiral development" with requirements for each spiral established by military needs (see section 3 below). Modeling and Simulation (M&S) was not considered in the early spirals because the priority there was to establish a limited set of functions that could be achieved rapidly. It was however an aspiration from the inception of FMN that M&S, although mainly recognized for its role in supporting training, also would need to be incorporated to support future decision making through Course of Action (COA) analysis, Wargaming and Mission Rehearsal.

FMN Ready Forces are those forces assigned to the NRF, who six months prior to taking on their role within the NRF are interoperable in all elements agreed that will form part of the Spiral Specification. The diagram at Figure 1 illustrates the concept.

Figure 1 – FMN Ready Force Requirements [7]

2 Modeling and Simulation in the FMN

2.1 The Benefits of M&S to FMN

M&S is a fundamental adjunct to many NATO capabilities because it can provide a safe, often cost-effective means of de-risking, training, evaluating and developing capabilities, equipment and processes. As such, there are a number of benefits in bringing M&S to FMN. However, in line with the FMN development philosophy, M&S capabilities should be provided as part of the accredited portfolio of FMN capabilities. This section gives a short summary of what M&S is, how it may be used, and, by extension, how it may be used in FMN.

2.2 An Overview of M&S

M&S have been defined in NATOTerm [8] in the following way:

- *Model*: A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.
- *Simulation*: The execution of a system model over time.

Traditionally, simulation is categorized as either (1) live, where real people use real systems; (2) virtual, where real people use simulated systems, e.g. a part task driving simulator; or (3) constructive, where the human aspects, behaviors and decision making, are simulated by agent models, scripted logic or human intervention. All three types of simulation have applicability in FMN, particularly the constructive.

A typical simulation has representations of the operational environment, the actors (active objects), and their behaviors. These are supported by an underpinning simulation engine which manages such things as communication among systems, scheduling, and interaction with any operator by means of user interfaces and graphical environments. Simulations execute scenarios, which encapsulate the required operational environment – locations, units, required actions, etc. It is usual to include a logging and replay capability to assist in after action review and analysis processes. Simulation time management is often real-time but there are situations where faster-than-real-time or slower-than-real-time simulation execution is required, for example to quickly assess alternative course of action or to understand quickly evolving situations.

The operational environment can include natural and man-made topography and bathymetry, time-varying weather and oceanographic effects, and electronic environment. Physical models of the units, individuals and equipment, which in turn are represented by sub-models for their components, interact with other physical and environmental models. Behaviors include individual, group, equipment, doctrinal and population and may be 'natural', tasked or requested, background or reactive. Players may be assigned to sides and teams, given allegiances and placed in organizational hierarchies for operational and communication purposes.

Recently there has been a focus on greater composability of simulations and a move towards modeling much more complex environments such as the so-called mega-cities, cyber environments, and a greater number of non-military actors and effects such as social media information (or misinformation) networks. These developments often include technical developments derived from the computer games industry but, when used in support of military ends, are required to comply with approved standards. In line with this, there is also a move towards the use of cloud-based simulation capabilities such as NATO's M&S as a Service (MSaaS) [9].

A number of processes and information exchange standards that have been developed to support the development, integration and execution of M&S systems are introduced later in this paper.

2.3 Potential Application of M&S in FMN

M&S has been used to support a number of military needs such as:

- Individual and collective training;
- Mission rehearsal;
- Operational planning;
- Concept development and experimentation; and
- Acquisition programs, e.g. to support system evaluation.

All these use cases entail M&S interacting with human operators via operational C2 applications that provide means for displaying reports, communicating with other personnel, and preparing plans, orders, tasks and requests. They all can benefit from FMN connectivity and all can support the MDMP and aspects of military operations.

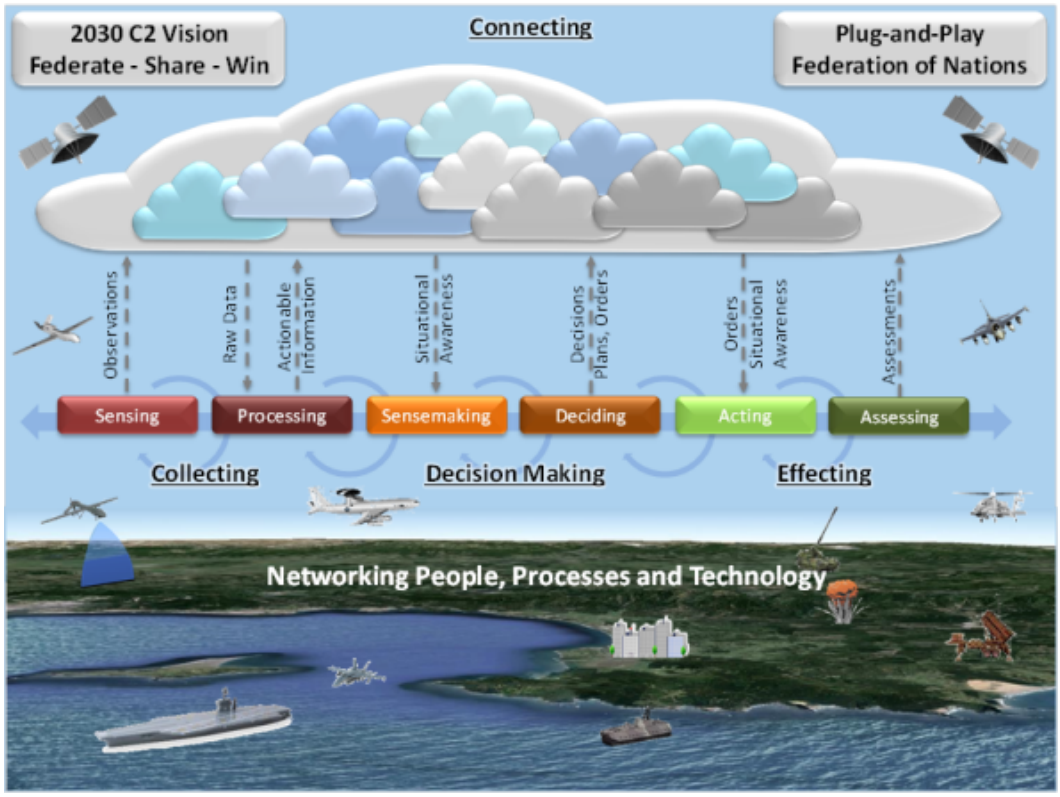

Figure 2 – NATO's 2030 C2 Vision (NATO C2 COE)

In an FMN environment, there are a number of equivalent use cases where M&S could be used to advantage. In a *training environment* the training audience, is presented with an operational situation to work, using their regular operational C2 equipment. A typical set of operational processes, as outlined in NATO's C2 Vision for 2030 [10], covers information collection, decision making and effecting. The information gathering of a live system can be represented using M&S: simulated sensor feeds, blue-force tracker data, reports from battle-space entities and other emulated messages. The information bearers can be represented using a so-called digital

range which can represent ideal communications or degradation due to factors such as insufficient bandwidth, jamming or cyber-attack. If the training audience sits at the decision-making part of the process, then their decisions will be based on the information received from the simulated information gathering components. When the training audience has made an assessment and reached a course of action then they can task a simulation to execute the plan thus completing the cycle [11]. As part of a training course, a number of prepared scenarios may be enacted, not only simplifying the roles of the trainers but also helping compare the performance of the different training audiences.

Mission rehearsal is special training given for a specific mission. Here the simulation will replicate as faithfully as possible the proposed mission environment so special care is needed to prepare everything.

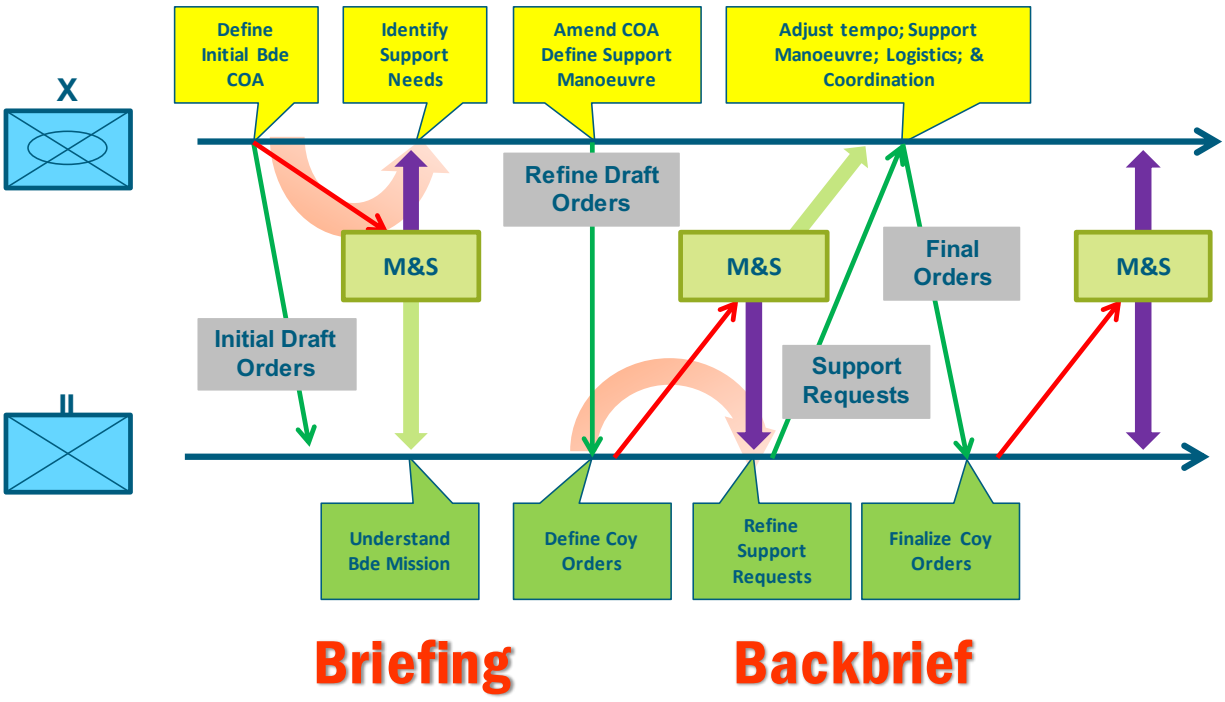

Figure 3 - M&S in Operational Planning

Operational planning can be undertaken in a collaborative way using multiple simulations running in a faster-than-real-time mode (Figure 3, where Coy abbreviates Company and Bde abbreviates Brigade). This allows alternative courses of action to be simulated by groups of planners working at, for example, different echelons or different specialties. Outside the FMN context, this has been demonstrated by NATO Modeling & Simulation Group (NMSG) 085 [12] in an experiment based on the NATO Comprehensive Operational Planning Directive (COPD) [13].

Concept development uses M&S to represent evolving processes and behaviors in a safe environment. This may well include implementing lessons identified in an operational environment.

Acquisition programs use M&S to simulate equipment before it has been built or put into production to help identify potential problems or to test operational capabilities. M&S can be used to help choose between rival suppliers' solutions by comparing them with a common set of simulated conditions, including ones which would be expensive, difficult or unsafe to test in a real-world situation.

2.4 Introducing M&S to FMN

It is usual to run a simulation on its own network enclave rather than a shared experimental or operational network. There are sound technical reasons for this, particularly as simulation networks tend to be high volume users and require low latency. The simulation traffic does not need to know about or share information with many of the other applications operating in an FMN environment, e.g. VOIP, operational C2 messaging, email services and shared document repositories. Where it does need to touch FMN is through the command and control applications. For this reason, C2-simulation interoperation is needed as a bridge to provide a compliant means of connecting M&S systems to FMN systems and services.

3 FMN Spiral process

3.1 Why Spirals?

The concept of FMN development laid out in [6] follows in a general way the spiral development approach that has become very popular in the commercial sector, where a short sequence of phases is continually repeated, with active user involvement, coming closer in each cycle to the goals of the development. The concept of developing systems in such "spirals" as described in [14] and [15] has been shown to be more effective at developing systems that meet user needs better, more rapidly, and at lower cost. Proponents contend that these benefits result from users coming to understand their needs better as they help steer the development toward better results, combined with developers achieving better technical results by frequent evaluation and, if necessary, revision of their work. The approach has been described as repeated plan-a-little/build-a-little/test-with-users/rethink-results [14]. Commercial development spirals can be as short as one month in duration.

The Spirals in FMN are much longer than those in commercial development; each one has planned duration of about two years. The phases of each Spiral are described in [4] as Operational and Security Requirements, Proposed Specifications, Final Specifications, Emerging Operational Use, and afterward Preferred Operational Use. The process is standards-based; products of each spiral are characterized as Requirements, Interoperability Architecture, Standards Profile, and Instructions. The approach has been driven by the need to involve 30 NATO nations that are at various levels of technical sophistication and the fact the process necessarily involves government bureaucracies. Like its commercial counterpart, each spiral builds on previous ones incrementally; but the Spirals are overlapped to shorten overall development time. This approach is seen by many as a great improvement over traditional military system development that takes many years and, as a result, often produces results that are outdated by the time the systems are produced. (Please note that here we are addressing

here systems that are primarily software based; developing major military hardware platforms necessarily has a different set of characteristics.)

3.2 How will Spirals work?

In addition to the Enabling Framework described above, per [7] the FMN will have "Common and Permanent Management." [16] defines a management structure consisting of overall management and support, plus a collection of *working groups* that meet separately and then come together in the FMN track of ACT's "TIDE Sprint" assembly twice yearly [17]:

- Overall management group
- Supporting secretariat staffed by Allied Command Transformation
- Operational coordination working group linking to NATO commands
- Multinational security management working group
- Capability planning working group and syndicates
- Change and implementation working group
- Coalition interoperability assurance and validation working group

Among the above, the colorfully-named *syndicate* is an interesting innovation. According to [18] "syndicates are informal working bodies - often already existing as collaborative undertakings for a specific subject, product or community of interest - focused at providing expert advice and tangible input for one or more FMN working groups." While this concept is not unheard-of in government, when combined with the Spiral concept it provides an interesting extension to the more typically bureaucratic structure of FMN management, allowing for participation of technical laboratory staff, industry experts, and academics. This is consistent with the FMN goal "adapting existing capabilities for quick start." As an example, FMN architectural planning is driven by the concept of a *mission thread*: an operationally driven, technically supported description of the end-to-end set of activities required to execute a mission or mission task.

Whatever way the Spirals are planned, their effectiveness depends on the various national affiliates collaborating to reach and test implementable specifications based on existing NATO and commercial standards. To that end, ACT carries out the annual *Coalition Warrior Interoperability Exploration, Experimentation, Examination and Exercise (CWIX)* interoperability testing, involving all stages of each ongoing Spiral tested either in person or via secure CFBLNet or semi-secure Internet VPN.

3.3 Current status of FMN spiral development

It should come as no surprise that an effort of such scope occasionally fails to meet its goals. Indeed, in CWIX there is a viewpoint that it is much better to have some early failures than to establish a Spiral specification that can't work or doesn't meet user needs. Such an early failure is seen as a success of a different sort and is consistent with the nature of the other major assembly sponsored by ACT, the twice-yearly *Think-Tank for Information, Decision and Execution Superiority (TIDE) Sprint*. (The term Sprint is taken from the Agile methodology [15] where each *sprint* makes rapid, short progress of one to four weeks toward a system goal.)

TIDE Sprint is scheduled for a one-week period twice a year, with location alternating between Europe and North America (but after the pandemic experience in 2020, likely also offering Internet participation). Its purpose is stated as “survey requirements, identify issues and make recommendations” [17] which then make their way into Spirals and from there to CWIX and deployment in NATO nations for Day Zero use.

Development of Spirals in FMN is ongoing; of the four stages Draft, Candidate, Proposed and Final, Spirals 1 through 4 have reached Final stage. Spirals 5 and 6 are Proposed and still the topic of ongoing work, while Spirals 7 and 8 are just beginning. Modeling and Simulation was scheduled to be addressed in Spiral 6 but currently lacks a Syndicate to support that. A proposal is expected in the NATO Science and Technology Organization (STO) Modeling and Simulation Group (MSG) to address this shortcoming by establishing a Specialist Team of MSG experts as an M&S Syndicate. This paper is a first step by its authors to prepare for participation in a possible Spiral 6 M&S Syndicate.

4 M&S in Coalition Operations

4.1 The use of M&S in Coalition Operation

In coalition operations, the role of M&S has tended to be restricted to its more traditional areas of use, namely mission training prior to deployment. Some Operational Analysis (OA) tools have been used to support formation level C2 processes, but these have been predominantly standalone applications and have been used predominantly at the Divisional or Task Force level of command. In January 2020 the UK Defence Science and Technology Laboratory (Dstl) established the Defence Wargaming Centre which is intended to provide support to decision making. This builds on the resurgence in the use of wargaming in support of decision making and on the back of OA that was successfully used to support UK military commanders in Afghanistan. For example, in 2011 Dstl’s Peace Support Operations Model (PSOM), a computer-based decision-making tool, was used by NATO’s ISAF Joint Command (IJC) to support its peacekeeping operations in Afghanistan. In a report from the time, IJC credited the tool with potentially saving many lives [19].

In addition to wargaming, M&S can play a major role in supporting the Military Decision-Making Process (MDMP) as demonstrations and experimentation have proved under the umbrella of the NATO Science and Technology Activities MSG-048, 085 and 145. NMSG-085 focused on the Land Component of Command with its final demonstration taking place in December 2013 and the MDMP as illustrated in Figure 3 above. In NMSG-145 the focus for its final event, a Mini Exercise (MiniEx) with military subject matter experts (SMEs) centered on Joint Operations set within the context of a number of vignettes that were based on national use cases. Technical trials were also held at CWIX in 2018 and 2019 prior to the Mini-Ex also reinforced the use of M&S in Coalition Operations. The ability to connect a number of national C2 systems with different simulation systems over a distributed network was made possible by the use of Internet and M&S standards.

With the use of standards that allow C2 and simulation systems to seamlessly exchange data from Day Zero as the FMN vision aims to deliver, M&S will not only provide support to training and in standalone wargaming activities in a national center of excellence it will also be used in the field on operations to conduct COAA which will include wargaming but also Mission Rehearsal. This will include reachback into a nation's home base where M&S experts and other specialist can be safely deployed to give 24/7 support to field commanders at all levels of command.

4.2 Future Scenario

Building on the NATO C2 Vision illustrated in Figure 2 and based on the deployment of forces assigned to an NRF in support of a military mission we can envisage that the following may take place in the context of a coalition operation.

During a period of tension, a nation that NATO and other allied partners have agreed to support, but is not a formal member of the Alliance, has requested the deployment of an International Security Force. NATO, in anticipation of the United Nations Security Council ratifying the deployment, starts to plan the mission. The NRF commander (one of two standing Joint Force Headquarters) is given a warning order and along with their staff they begin preparatory mission planning for a number of potential scenarios which will be dependent on when they can deploy to the designated Area of Operations. As part of the NRF there is a Very High Readiness Joint Task Force (VJTF) based on a national land brigade sized formation of 5,000 personnel but reinforced with air, maritime and Special Force components and they will provide the initial entry force. In addition, in response to a crisis, two further brigade sized formations can be deployed.

Within the full spectrum of NATO missions, the NRF may conduct:

- Non-combatant Evacuation Operations (NEO),
- Counter Terrorism Operations
- Embargo Operations,
- Quick Response Operations to support diplomacy as required.

The assigned NRF forces including the VJTF are from a number of contributing nations. The VJTF headquarters and signal component is provided by a single nation and up to five other nations provide maneuver units. Figure 4 illustrates a potential force.

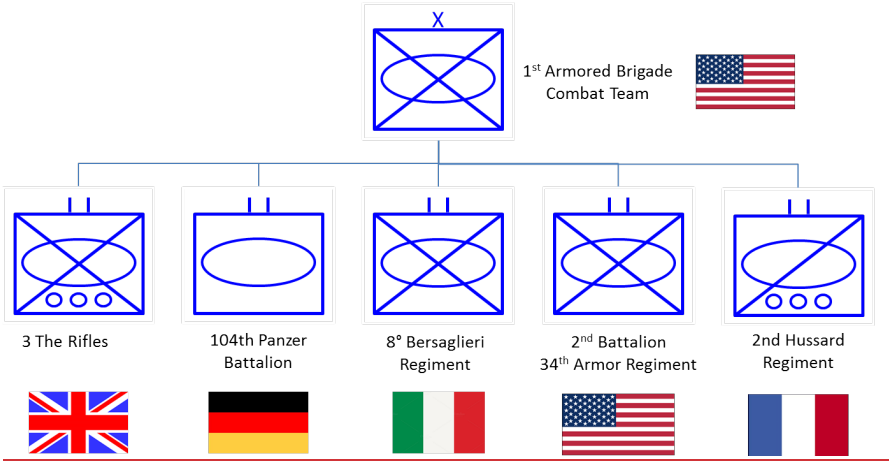

Figure 4: Very High Readiness Joint Task Force

The NRF commander and staff identify a number of COAs which are tested using M&S applications integrated with the C2 systems. A warning order to the VJTF commander enables them to conduct their own COAA in a distributed environment. The selected COA can then be back briefed to the NRF commander. The selected COA is then wargamed with subordinate commanders and their staffs over a secure network. Once the plan is agreed, the forces assigned to conduct a mission rehearsal.

After successful deployment, the VJTF and follow on forces a Combined Joint Task Force (CJTF) headquarters is established and is tasked with a number of missions which includes a NEO. This may be similar to the vignette that was run in the MiniEx that was run by NMSG-145 and supported by national reachback operational centers.

5. M&S standards for networked military simulation

The Simulation Interoperability Standards Organization (SISO) has been at the forefront in developing simulation standards and processes. These have all been developed by multi-national domain specialist teams drawn from across industry, government and academia. Many have been adopted by IEEE and NATO and are in widespread use.

5.1 Command and Control – Simulation Interoperation (C2SIM)

The SISO C2SIM standard [20, 21] has been developed to provide a means of exchanging information between C2 systems and modelling and simulation (M&S) systems, particularly, but not solely, constructive and virtual simulations. C2SIM can also be used to exchange information between different C2 systems and between C2 systems and autonomous systems. In Figure 5, C2SIM is represented by the arrows joining the different types of system.

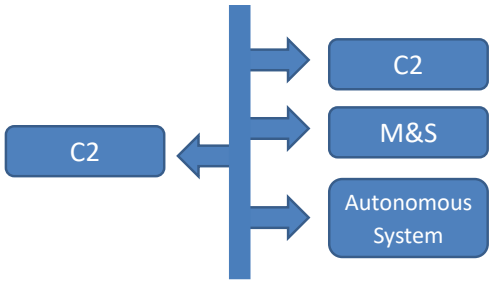

Figure 5: C2SIM Overview

C2SIM was developed by SISO, who are currently ratifying it, in collaboration with NATO STO and will be proposed as a NATO STANAG in 2020 allowing it to be specified in procurement proposals, etc. C2SIM uses a common data model which permits unambiguous data to be exchanged between systems to convey: initialization information (e.g. force structures and dispositions), plans, orders, tasks, requests and reports. Earlier work focused on the two standards: Military Scenario Definition Language (MSDL) and Coalition Battle Management Language (C-BML). C2SIM unifies and replaces these earlier standards.

C2SIM is highly pertinent to FMN in that it is aimed at plug-and-play compatibility between command and control information systems (called C2IS, C2 systems or Mission Command systems) and military simulations. Principal uses for this capability are coalition operational training, course of action analysis, and mission rehearsal [20]. The vision of C2SIM is articulated as:

> *We are working toward a day when the members of a coalition interconnect their networks, command and control (C2) systems, and simulations simply by turning them on and authenticating, in a standards-based network environment.*

This vision is for a system of systems where each national component uses its own, familiar C2 system and is represented in the simulated Coalition by a national simulation that accurately depicts its staffing, equipment, and doctrine. C2SIM was developed by the Simulation interoperability Standards Organization (SISO) working in cooperation with international teams from NATO STO. It is expected to be approved as a SISO Standard in June 2020, after which plans are already underway to propose it as a NATO Standardization Agreement (STANAG). It is SISO's second generation standard in C2-simulation interoperation and was subjected to extensive validation in CWIX 2018 and 2019. Implemented under FMN, C2SIM can bring the power of accurate simulation to Mission Command of a multinational coalition. The initial implementation is based around a server, but a multicast-based implementation is possible. C2SIM is completely compatible with all of the standards that are described below.

Mission Threads is a NATO process [22] which has been developed to help develop operational scenarios in a uniform way in accordance with the NATO FMN Implementation Plan (NFIP). For FMN a mission thread is described as:

> *An operationally driven, technically supported description of the end-to-end interrelated activities required to accomplish the execution of a mission or mission task*

and is:

Comprised of the step-by-step description of a mission or activity, the information exchange requirements of the mission or activity and the identification of systems and services that are needed to accomplish it.

Mission threads, as developed for general use for FMN, provide a way forward to developing scenarios for C2SIM M&S applications.

5.2 Modeling and Simulation as a Service (MSaaS)

MSaaS [23] is a NATO approach to provide a means of delivering reusable, composable simulation to the user using a service-based architecture, typically, but not necessarily, cloud-based. MSaaS helps simulation designers provide better scalable and fault-tolerant simulations. MSaaS follows a three-stage process of discovery, composition and deployment/execution. The discovery phase uses searchable simulation repositories to find simulations appropriate for the simulation task in hand. Composition is the building and configuration of the simulation from discovered components. The composability approach has the advantage that 'best-of-breed' or new models may be used for particular aspects of the whole simulation. Deployment/execution is the final phase where the configured simulation is ready to be used.

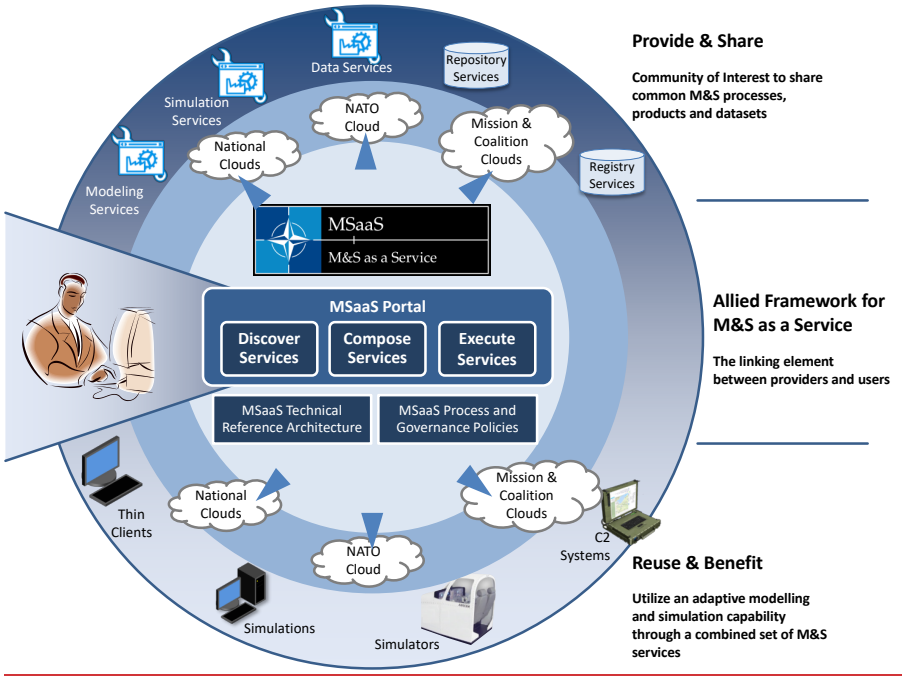

Figure 6: MSaaS Phase 2 [22]

MSaaS also represents a potential path into the FMN for the amalgamation of Live, Virtual, and Constructive training capabilities described in section 1, which presents significant technical challenges. Ideally, the combination of these disparate approaches will yield an experience that is experienced as seamless by the trainees. SISO been developing the WebLVC standard to combines the latest World-Wide-Web distributed system communication technologies with simulation as shown in Figure 7. WebLVC is nearing readiness for balloting as a SISO standard [24] and could be employed productively in the FMN to support coalition training.

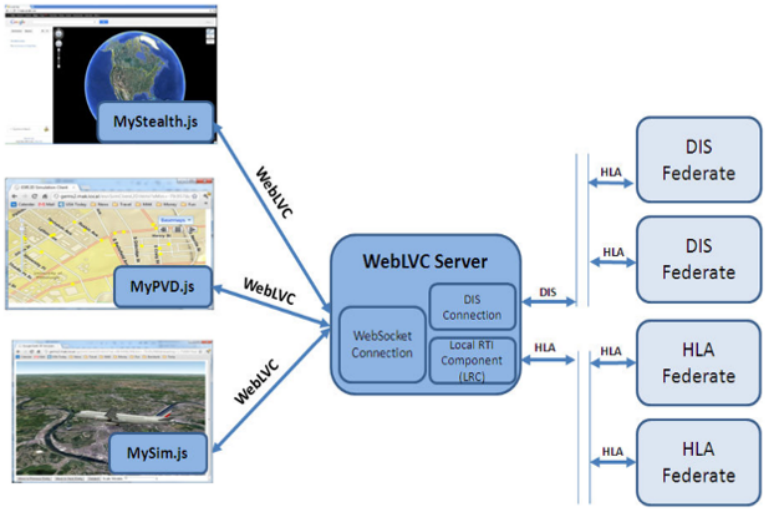

Figure 7: SISO WebLVC

5.3 High Level Architecture (HLA) for Modeling and Simulation

HLA [25] is an IEEE simulation interoperability standard developed by SISO that has been adopted as NATO STANAG 5603. HLA uses an object model approach to define the information that may be exchanged between simulations. The most important are objects (persistent items such as physical entities) and interactions (usually transient events such as weapon detonations). HLA is supported by its own management services for things such as object management and time management. The interfaces and underlying services are provided by a piece of software known as the Run-time Infrastructure (RTI). The objects, interactions and associated ancillary information are defined in a Federation Object Model (FOM). HLA terminology gives the names federate to any HLA-compliant application and federation to a group of federates operating together using the same FOM and RTI.

5.4 Distributed Interactive Simulation (DIS)

DIS is the original SISO standard for networked military simulation [26]. Using it, entity-based simulations interoperate by exchanging state several times per second over a broadcast or multicast network. Typically the simulations are physics-based and reflect the performance of a platform such as a tank or helicopter, although dismounted soldiers also are possible. The simulator displays show the out-the-window/viewfinder battlefield at the platform level along with vehicle dashboard status. This can support exercises in teamwork critical to military organization performance. DIS has the maturity of a 30-year-old technology and many implementations are available. It is notably simpler to implement and administer than HLA but is limited in scope to interactions of at most a few hundred battlefield objects (most often it is used for under one hundred battlefield objects, a reasonable match for recent NATO deployed

missions). DIS is generally considered to be simpler to implement that HLA due to its simple, real-time object model, However, it lacks the broader scope of HLA, which is able to federate a variety of advanced, complex composite and distributed systems, and has not been adopted as a NATO STANAG.

5.5 Verification, Validation and Accreditation (VV&A) of military simulations

The IEEE standard VV&A recommended practice for VV&A [27] was developed by SISO to help guide simulation developers through an accredited verification and validation process. These guidelines have been refined further by the US DoD MSCO, who have taken the process further, refined it as US Mil-Std 3022 and published [28] templates for V&V plans and reports and accreditation plans and reports. Providing these VV&A plans and reports fits in well with the FMN systems engineering acceptance process.

5.6 Distributed Simulation Engineering and Execution Process (DSEEP)

The IEEE standard DSEEP [29] gives a well understood way to manage a complete simulation process from an operational concept through to final execution and analysis. There are seven stages in DSEEP as shown in Figure 8.

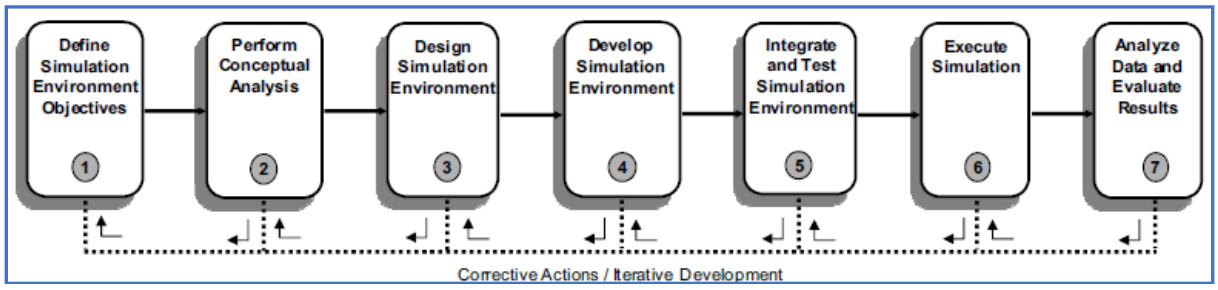

Figure 8 - DSEEP Phases

DSEEP does not explicitly address the design of scenarios, there are other processes for this such as the SISO GSD and NATO Mission Threads approach, but it does address the systems engineering aspects of designing a system to execute a scenario. SISO has defined a DSEEP overlay process which can be adapted for related activities, in the current case to introduce C2SIM capability into an FMN environment.

The GSD [30] is a document published by a SISO product development group, which aims to help a scenario developer work through stages 1 to 5 of DSEEP. It defines three phases of scenario development from the operational, usually provided in response to a requirement, possibly that of a military user, through a formalized conceptual specification, expressed, for example using C2SIM to a final executable scenario customized for the specific simulations it is to be run on. GSD is pertinent to development of simulation scenarios for FMN.

6 Conclusion

We have described the need, development methodology, and plans for Federated Mission Networking, a major step forward in preparing the NATO Coalition for multinational

deployments. The “Day Zero Interoperability” concept of FMN is well suited to incorporation of a variety of modeling and simulation standards as described above. It is our intention to participate in the FMN Spiral process to achieve this, in order that NATO will have capabilities necessary to continuing its role of sustaining international peace.

Ultimately, M&S in the FMN can extend the force-multiplier effect of the FMN beyond the initial coalition training M&S focus. Operational use of M&S for COA analysis and ultimately for mission rehearsal are capabilities that should extend the capabilities of NATO coalition forces, resulting in greater effectiveness and including the ability of smaller, more nimble forces to achieve NATO missions.

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