

Overview of Modelling and Simulation Standards for NATO Federated Mission Networking

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ABSTRACT

NATO Modelling and Simulation Group 211 (MSG-211) developed a Research Technical Course titled “Modelling and Simulation Standards in NATO Federated Mission Networking.” The course will be presented in 2023 and 2024 in hybrid format. This Educational Notes paper presents the course content for the topic “Overview of Modelling and Simulation Standards for Federated Mission Networking,” one of 12 topics presented during the overall course. The paper provides a brief introduction to modelling and simulation standards and best practices identified for use in the NATO Federated Mission Networking (FMN) program. These standards and best practices include:

- 1) High Level Architecture (HLA), standardized under the Institute of Electrical and Electronic Engineers (IEEE) and approved under NATO Standardization Agreement (STANAG) 4603 Ed 03;*
- 2) NATO Education and Training Network Federation Object Model (NETN-FOM);*
- 3) Command and Control Systems – Simulation Systems Interoperation (C2SIM) (approved under STANAG 4856 Ed 01);*
- 4) Modelling and Simulation as a Service (MSaaS).*

Other Educational Notes prepared for the course provide additional details into each of the standards and best practices introduced here.

1.0 INTRODUCTION

NATO operational commands have undertaken a major initiative to specify Federated Mission Networking (FMN), defining how NATO and coalition partners’ information systems will interoperate in the future, with emphasis on coalition-wide command, control, and consultation capabilities [1].

There are many reasons to integrate modelling and simulation (M&S) into the FMN, to include:

- 1) Collective training;
- 2) Mission planning;
- 3) Mission rehearsal;
- 4) Test and evaluation; and
- 5) Operation reconstruction and analysis.

For example, Spiral 5 and Spiral 6 development of FMN focus on use of M&S to support mission rehearsal. For this purpose, a planned operation is represented in the simulation to enable examination of schedules of manoeuvres and fires against estimated enemy forces for coordination, firepower buildup, and identification of possible scheduling conflicts. It is often necessary to configure a distributed set of simulation systems and

command and control (C2) system to allow military operators to exercise the plan using their operational C2 systems so that processes and procedures can be examined as part of the rehearsal. Architecting distributed systems-of-systems requires application of standards for system interoperation so that the integrated architecture can be configured rapidly and reliably, thus contributing to the FMN goal of “zero-day interoperability” for coalition operations.

The content of this paper is drawn primarily from material prepared by the author for the NMSG Symposium held at the Naval Postgraduate School, Monterey, California from 19 – 20 October 2023 [1]. This paper is organized as follows. Section 1 provides an introduction and describes the content of the paper. Section 2 provides brief introductions to each of the standards and best practices identified for use in FMN Section 3 summarizes the information presented here.

2.0 M&S STANDARDS FOR NATO FEDERATED MISSION NETWORKING

To begin integration of M&S capabilities into FMN, MSG-194 and MSG-201 identified a number of standards and best practices that would provide an initial foundation for development; namely,

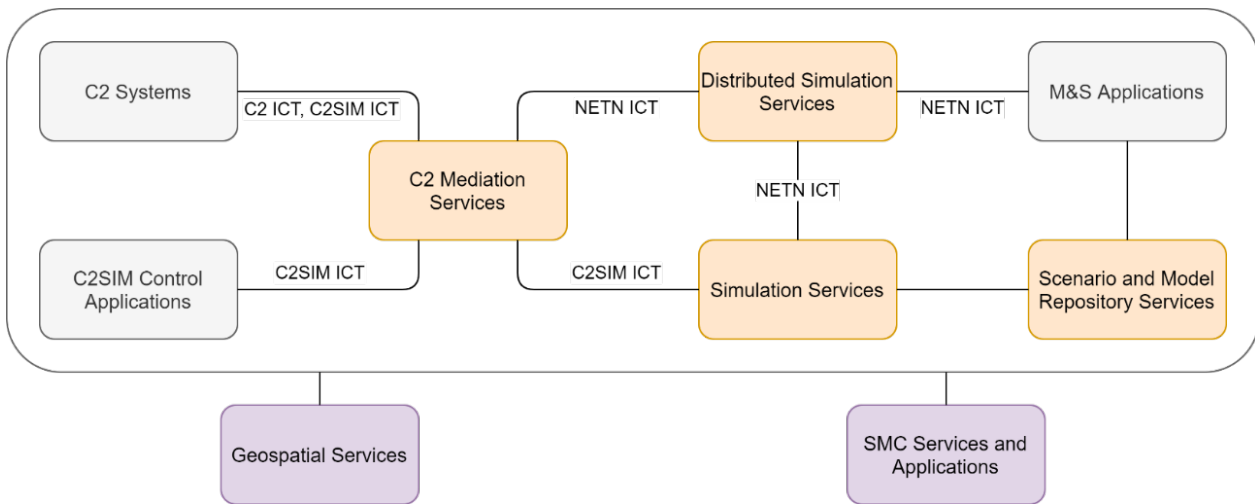
- 1) High Level Architecture (HLA) [2];
- 2) NATO Education and Training Network Federation Object Model (NETN FOM) [3];
- 3) the C2 Systems – Simulation Systems Interoperation (C2SIM) standard [4]; and
- 4) Modelling and Simulation as a Service (MSaaS) [5].

The following subsections provide a brief description of each of these components.

To place the selected standards and best practices in an architectural context, Figure 1 identifies key aspects of the M&S architecture proposed for FMN [6]. The architecture enables the exchange of initialization, control, tasking, and reporting (ICT) information among C2 systems and M&S applications through C2 Mediation Services, Distributed Simulation Services, Simulation Services, and Scenario and Model Repository Services. The C2SIM Control Applications coordinate cross-system initialization and control of cross-system message interchange (e.g., such functions as pause/resume, record/playback, among others) in conformance with the C2SIM standard. Distributed Simulation Services manage execution and information exchange across the distributed simulation systems operating under the HLA standard in accordance with specification of objects and interactions in the NETN FOM. Simulation Services coordinate the information translation between C2SIM messages and NETN FOM messages used in the HLA framework. The Scenario and Model Repository Services employ MSaaS mechanisms to store and access scenario information used by the simulation systems.

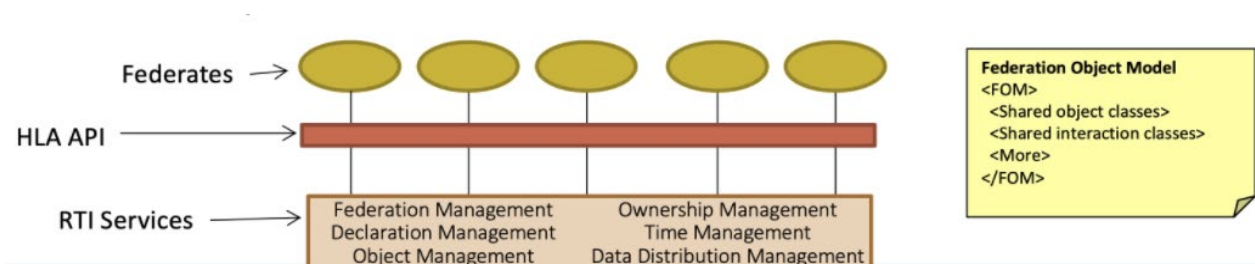
2.1 High Level Architecture

The High Level Architecture (HLA) for M&S is an international standard developed by the Simulation Interoperability Standards Organization (SISO) under the authority of the Institute of Electronic and Electrical Engineers (IEEE) [6]. NATO has adopted HLA as Standardization Agreement 4603 [7]. The HLA standard specifies a set of rules and a software framework for managing the exchange of information across distributed simulation systems and coordinating the execution of the distributed simulation systems. Figure 2 illustrates the HLA concept where individual simulations or other software applications (“federates”) interchange information and send/receive control information through a specified application program interface (API). Users of the HLA standard specify a simulation data exchange model in accordance with a standardized Federation Object Model (FOM) format identifying objects and interactions for the specific federation.



Legend: C2: Command and Control; C2IS: C2 Information System; C2SIM: C2 Systems – Simulation Systems Interoperation; ICT: Initialization, Control, Tasking and Reporting interactions; M&S: Modelling and Simulation; NETN: NATO Education and Training Network

Figure 1: M&S Architecture in FMN [6].



Legend: API: Application Program Interface; FOM: Federation Object Model; RTI: Run-Time Infrastructure

Figure 2: HLA Concept [8].

2.2 NATO Education and Training Network Federation Object Model

The NATO Education and Training Network Federation Object Model (NETN-FOM, v3.0) [3] defines the objects and interactions needed for information interchange across HLA-conformant distributed simulation systems operating in the FMN environment. The NETN-FOM is composed of several modules (see Figure 3) representing different classes of information, most prominently the NETN-ORG describing military organizations defined in the scenario and NETN-ETR (Entity Tasking and Reporting) defining orders and reports to be exchanged across the federates.

2.3 Command and Control Systems – Simulation Systems Interoperation

The Command and Control Systems – Simulation Systems Interoperation (C2SIM) is an international standard produced by SISO for specifying information interchange across C2 systems, simulation systems, and robotic and autonomous systems (RAS) [4]. Figure 4 illustrates the C2SIM concept for information interchange across different classes of systems.

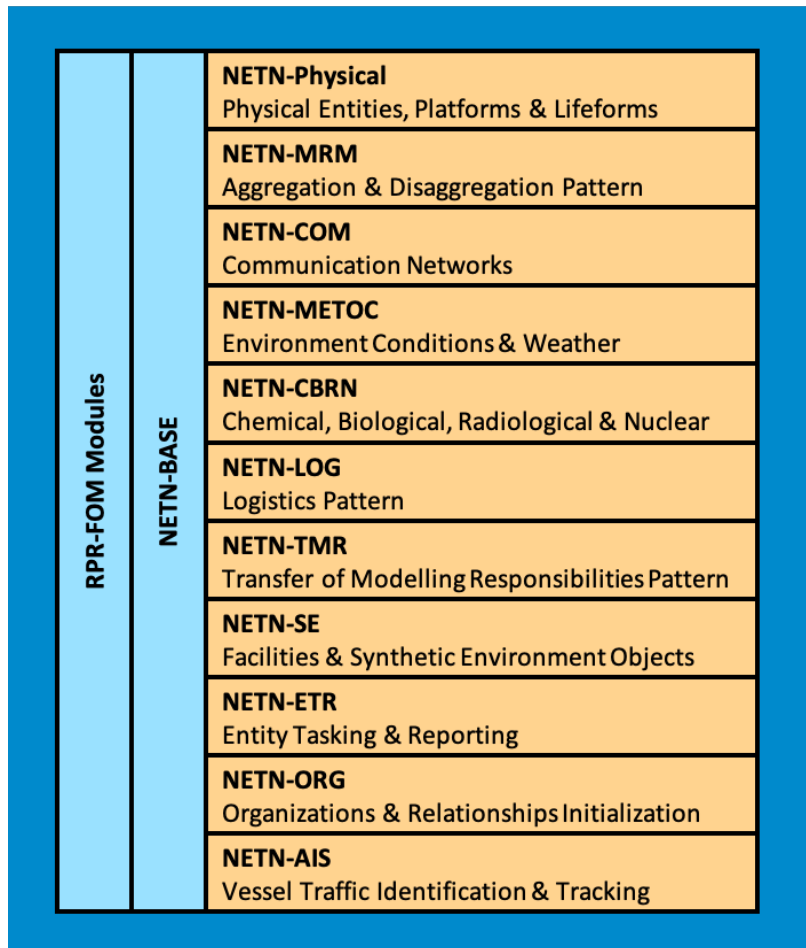


Figure 3: NETN-FOM Principal Components [9].

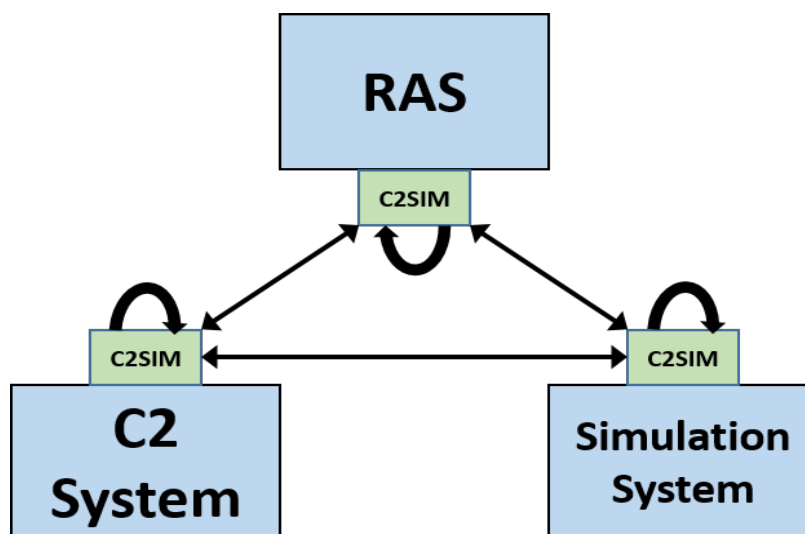


Figure 4: C2SIM Concept [10].

Data exchanged under C2SIM is specified as an ontology using the Web Ontology Language [11]. Use of an ontology permits expression of stronger semantics, offering benefits in automated reasoning, strong validation, query, and information-linking [12]. Other domain models can be included by developing extensions to the core C2SIM data model, as shown in the Land Operations Extension to C2SIM [13] and proposed for the cyberwarfare domain [14]. The C2SIM products from SISO include a guide providing information to help new users develop applications that are conformant to the C2SIM standard [15]. There are initial efforts to create explicit integration of NETN-FOM information with the C2SIM data model [16]. Furthermore, NATO has adopted C2SIM as Standardization Agreement 4856, Edition 0 [17].

2.4 Modelling and Simulation as a Service

Modelling and Simulation-as-a-Service (MSaaS) is an architecture for exploiting extensible computing and storage resources “in the cloud,” combining “service orientation and the provision of M&S applications via the as-a-service model of cloud computing to enable more composable simulation environments that can be deployed and executed on-demand” [5]. M&S applications, data, and support tools are made available through well-defined services that can be accessed by anyone and any system operating in the FMN environment. Figure 5 identifies primary components of the MSaaS concept and the connections to systems supporting the warfighters. The cloud-based architecture is designed to adapt automatically to instantaneous changes in overall system demand for computing resources.

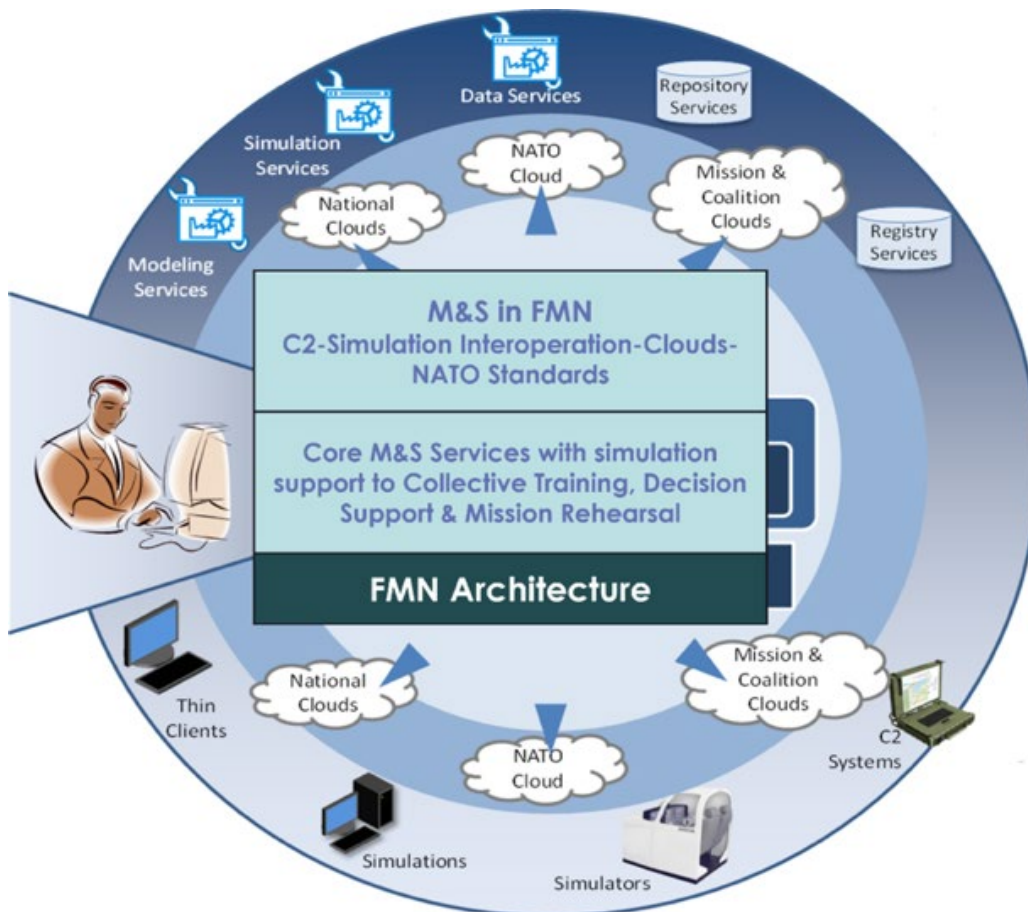


Figure 5: MSaaS in FMN [18].

3.0 SUMMARY

Modelling and Simulation (M&S) supports military operations in a variety of activities, including training, analysis, testing, planning, and execution. M&S is an identified requirement for Federated Mission Networking (FMN). Established standards and best practices provide a foundation for interoperability across the various systems that will support FMN operation. Instruction in “M&S Standards for NATO FMN” by the MSG-211 team helps equip FMN developers and users in essential knowledge to ensure success. This paper has provided a brief overview of the key standards and best practices identified for application of M&S in FMN. Other papers documenting this Research Technical Course provide more detailed descriptions of the standards and practices introduced here.

4.0 REFERENCES

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