

## CWIX Testing of M&S Standards for FMN

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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 “History of Standardized C2-Simulation Interoperability (C2SIM),” one of 16 topics presented during the overall course. The paper describes NMSG activities testing M&S standards as part of the annual NATO CWIX exercise. The approaches described in this paper are intended to be illustrative, not exhaustive. As the engineering community works with M&S in FMN, expanded alternatives will be identified.*

### **1.0 WHY AND HOW VALIDATION**

This class describes the technical validation process, as carried out by NMSG in CWIX for multiple years, for M&S standards proposed for use in the FMN. We will consider what has been done, why it was done, and how it was done, in the context of the annual NATO *Coalition Warrior Interoperability Exploration, Experimentation, Examination and Exercise (CWIX)*.

Why we do these things: Testing shows the system works as specified; experimentation shows it actually is effective working as designed. We did some of each in 2019 validation of C2SIM. This is a step beyond experimentation, which generally is intended to determine whether a particular approach is beneficial.

### **2.0 OVERVIEW OF VALIDATION EVENTS**

NMSG has brought M&S standards to CWIX for several years. Following earlier experimentation by MSG-048 to show technical feasibility and by MSG-085 to show operational utility, C2SIM was brought to CWIX in 2017 and 2018 to test workability of the proposed standard before balloting. Subsequently the proposed Service Instructions for M&S were tested in CWIX 2022 and 2023, including limited Mission Rehearsal exercises employing the M&S standards proposed for FMN.

By CWIX 2018 we had a considerably more sophisticated system to test (see Figure 1). Norway brought a Web interface (SWAP) to their national C2IS (NORCISS), Germany brought their ground training simulation KORA and JSAF came back for air operations. The C2SIM Sandbox had the C2SIMGUI and VR-Forces. We planned to use the secure network CFBLNet between CWIX at the Joint Forces Training Center in Poland; US Army Test and Evaluation Command in Huntsville, Alabama; Defence Science & Technology Laboratory in Portsdown, UK; MSCOE in Rome, Italy, and Norwegian Lab FFI in Kjeller, Norway. In the end, only FFI was able to get certified for secure operation. Fallback was to run the complete Sandbox at JFTC where KORA was already planned to be and NORCISS/SWAP from FFI as planned. We learned not to count on complex network plans that cannot be tested in advance. We still achieved first-time testing with Norwegian and German systems.

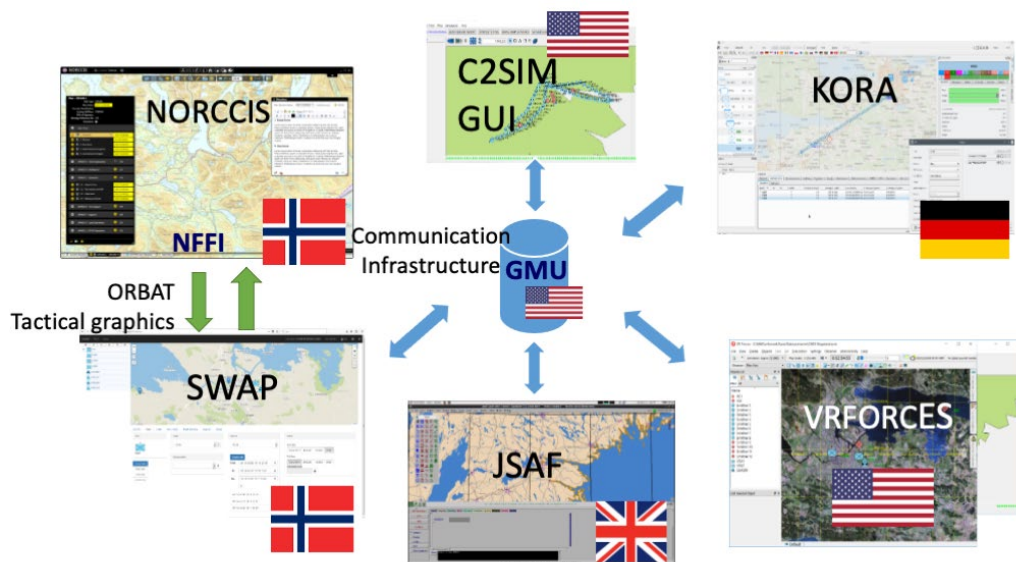


Figure 1: MSG-145 testing CWIX 2018.

MSG-145 had two major goals with regard to C2SIM: (1) assess the standard and (2) apply the standard. The first was intended to:

- Support the work of the **SISO C2SIM PDG** in assessing the Draft C2SIM standard, in providing recommendations and in proposing best practices:
  - Review the usability of the core data model.
  - Experiment the mechanism of extending the core LDM.
  - Check the usefulness of the land operation extension.
  - Review the combination of initialization and tasking/reporting.
  - Check the effectiveness and completeness of documentation.
- Validate the standard: 6 nations CWIX 2019.

The other part of MSG-145 was to apply the standard in various use cases. This was achieved by each nation implementing a use case that was of interest to that nation as part of the CWIX testing:

- Implement C2SIM standard and where necessary extend for a number of use cases .
  - Provide a distributed environment for test, evaluation and experimentation (C2SIM Sandbox).
  - Adopt operational, conceptual and execution Scenario development process.
  - Use NAF to express C2SIM exchange requirements.
  - Develop extensions to the C2SIM LDM core for specific functional areas.

The CWIX Testing Regimen is shown in Figure 2 below. It is implemented in an HTML-based “wiki” which enforces the information flows shown.

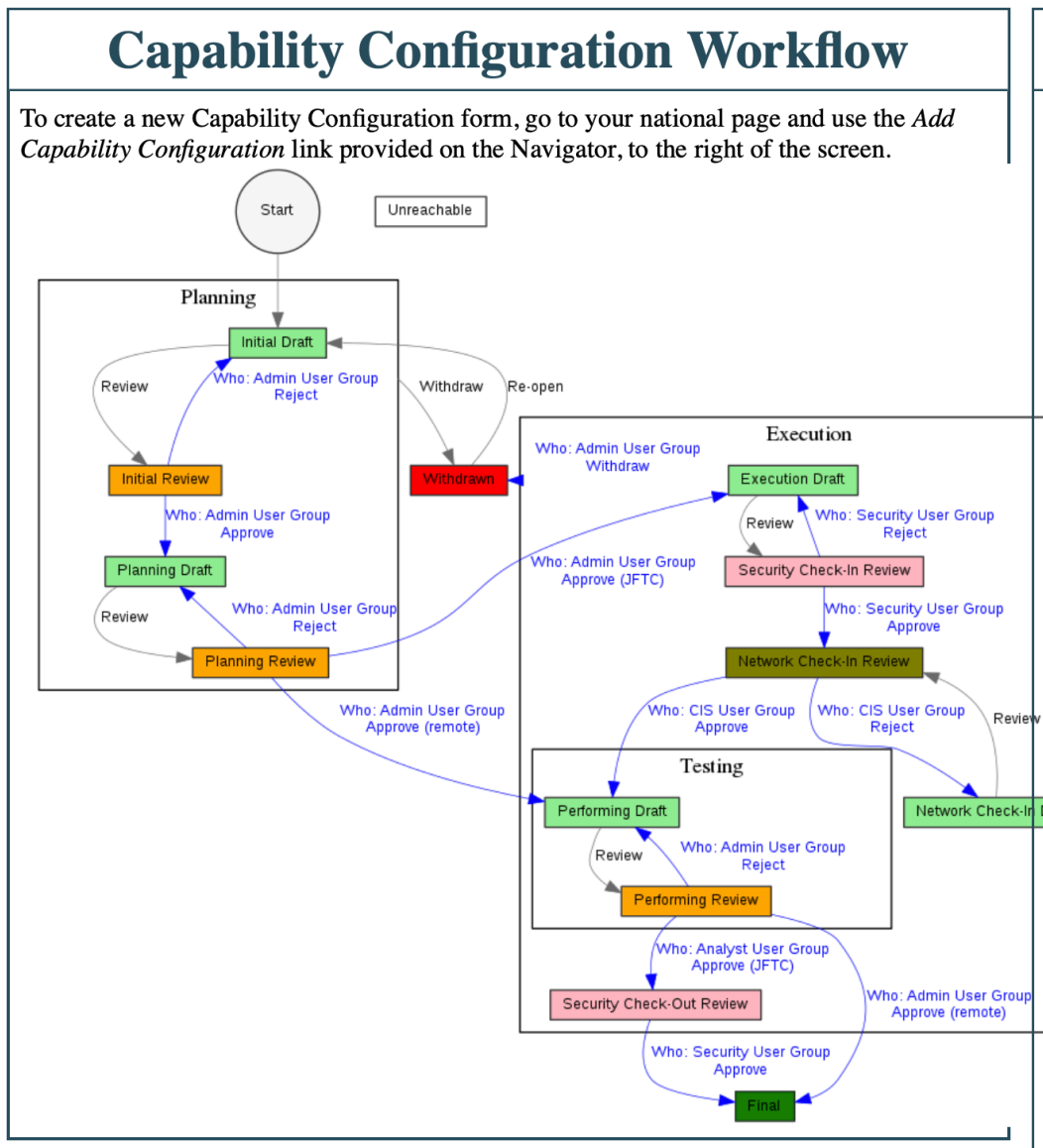


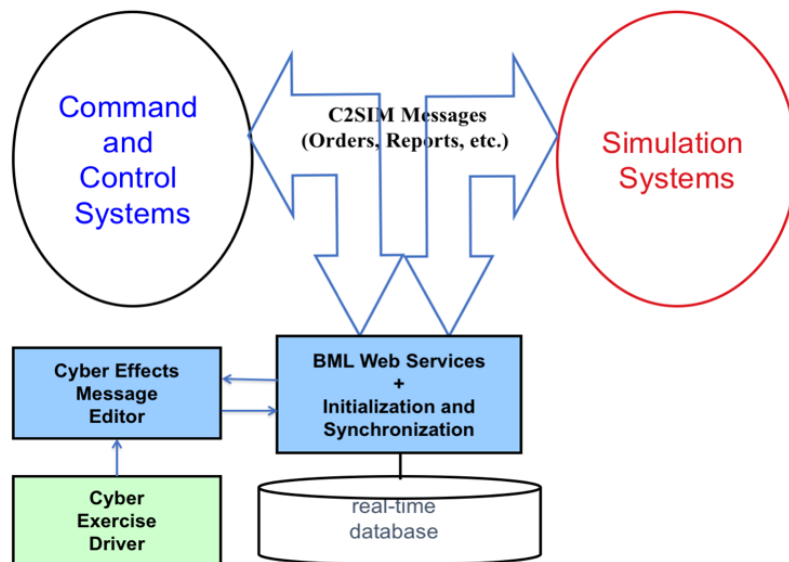
Figure 2: CWIX testing workflow.

The following implementations of C2SIM were completed in the period January to May 2019 and tested in CWIX June 2019 [1]:

- France: MASA – Sword
- Germany: iABG – KORA
- Italy: NATO M&S Centre of Excellence:
  - Autonomous Systems Extension (ASX) [2]
  - VRForces plugin for autonomous aircraft
  - SWORD for autonomous ground vehicle
- New Zealand: Defence Tech Agency – VBS3
- United Kingdom: Legacy JSAF UAVs

- USA:
  - Army Test & Evaluation Command: OneSAF + SitaWare
  - Naval Postgraduate School: VRForces + SitaWare
  - George Mason University: Server and Editor in C2SIM Sandbox (described in class 2.3)
- Systems interoperated via Internet VPN; those without SitaWare used GMU Editor surrogate.
- Testing included imposing cyber effects on C2SIM messages passing through server [3].
- Eleven of twelve tests “fully successful”:
  - Twelfth was “limited success” – problem corrected next day.

A use case that was of interest to GMU’s sponsoring US Army Modeling and Simulation Office (AMSO) was use of C2SIM to impose cyber effects on operational training (not cyber expert training). To do this we added to the Reference Implementation Server a capability to modify C2SIM messages under scripted control. We tested this first in CWIX 2018 and showed the mechanism worked but were unable to evaluate whether training users could detect and respond appropriately to the cyber effects. In 2019 GMU persuaded out MSG-145 colleagues to spend part of the testing time in a mode where they might detect the cyber effects and respond appropriately. Most of this testing was fully successful, but the one partially successful test was the last of the cyber effects tests, where we found a bug that could not have been detected in simpler testing. The modified C2SIM architecture used for cyber effects testing is shown in Figure 3 below.



**Figure 3: C2SIM modification for cyber/EW effects.**

Figure 4 shows the network diagram used for CWIX 2019 (including a validation exercise “MiniEx” by MSG-145. We were especially pleased that New Zealand joined us for the MiniEx and interfaced a different simulation, VBS3, to do so. The VBS3 C2SIM interface was released to the GitHub OpenCSIM repository by New Zealand so others may use it.

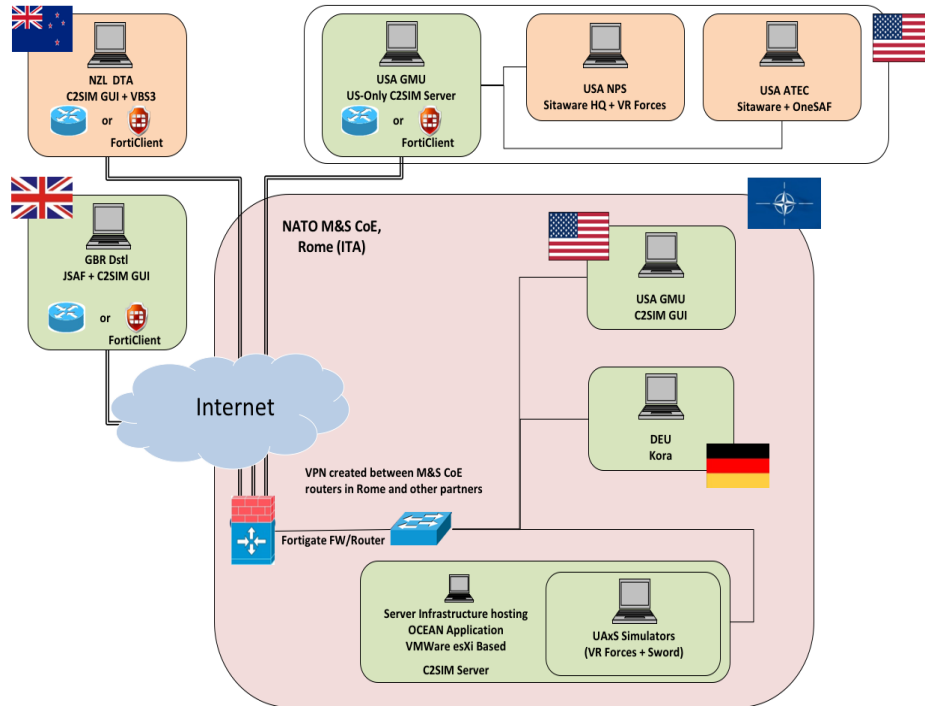


Figure 4: Network diagram for MSG-145 CWIX 2019.

### 3.0 MSG-201 CWIX 2022 AND 2023

MSG-201 increased its activity in CWIX starting 2022, to focus on M&S requirements of FMN. They emphasized (1) proper operation of the proposed standards: C2SIM, NETN/HLA, and MSaaS and (2) application of these standards to support the FMN requirement Mission Rehearsal (MR). CWIX 2022 testing was expanded in 2023 and involved the complex combination of players shown in Figure 5 below.

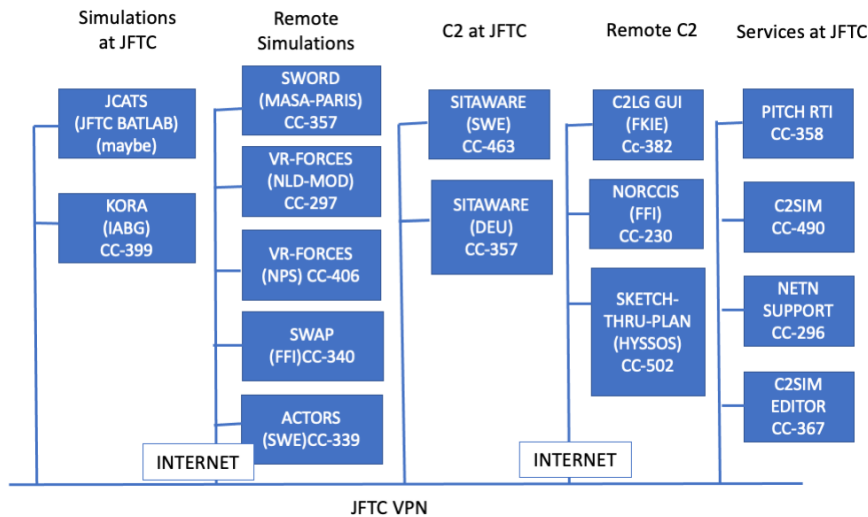


Figure 5: CWIX 2023 configuration.

### **3.1 NETN Testing**

Testing under the NETN/HLA standards was designated OBJ-142: eXplore FMN SP 6 M&S SI

- This objective tested nine Capability Configurations (CCs) from NATO JFTC, Netherlands, Sweden, Norway, France and Germany.
- The purpose was to evaluate compliance with the HLA standard as configured under the NATO Education & Training Network (NETN) under AMSP-04 Edition B.
- Wiki shows 6 test case results; 3 limited or full success and 3 interoperability issue where one or more CCs did not comply, associated with lack of time synchronization (try again CWIX 2024).

A related objective was OBJ-143 to test MSaaS requirements eXplore FMN SP 6 M&S SI

- Achieved by operating in cloud environment.
- Wiki test case results: 3 full success; 1 interoperability issue related to ability to start/stop/restart in that environment.

### **3.2 C2SIM Testing**

Testing under the C2SIM standards (SISO and STANAG) was designated OBJ-144: eXplore C2 to Simulation Systems Interoperation.

- This objective tested ten Capability Configurations (CCs) from NATO JFTC, Netherlands, Sweden, Norway, France, Germany, and USA.
- The purpose was to evaluate compliance with C2SIM and HLA standards working together.
- Wiki shows 12 test cases, all full or limited result, and one not tested because the C2SIM System Message controls were not implemented.
- This is the fifth year of C2SIM testing in CWIX so the capabilities in general are mature (the one not implemented was new this year).

### **3.3 Mission Rehearsal Testing**

MSG-201 built on the work of MSG-145 to conduct testing, first of interactions among the implementations of M&S standards proposed for FMN Mission Rehearsal (MR), and then of complete (though limited) Mission Rehearsal exercises. Thanks to CWIX testing, we went into this sure that our systems were all able to exchange C2SIM messages, respond to orders, deliver resulting reports, and share simulation state using NETN/HLA. The next question was: could we work together across multiple sites, conduct a meaningful, and be satisfied that it represented a meaningful distributed Mission Rehearsal exercise? This was based on the initial FMN requirement for Mission Rehearsal. Its properties were:

- MR exercise preceded by individual simulation transaction testing:
  - Successful CWIX testing showed systems can exchange data effectively using C2SIM & HLA.
  - Exercise used six simulations interoperating with C2.
  - C2 function filled by GMU Editor (+ SitaWare DEU/SWE).
- Running all simulations together for realism was challenging but possible.

The MR scenario this was assembled by experienced military trainers. They had to make the scenario fit within the capabilities and use case interests of six nations and remain credible. They succeeded at that. The scenario worked like this:



- NATO ground forces deploying in Bogaland (a fictional country with a map derived from that of Sweden) to assist the Bogaland government in countering the increasingly aggressive activities of the WASA, the indigenous people of the Norrköping region.
- The WASA are receiving assistance from external nation-states. Information Operations and aggressive military activities have been initiated using the WASA as a surrogate.
- The WASA have been expanding their presence across the region along Highway E4 from Linköping to Norrköping, with the intent to move into Stockholm.
- To support operations, the WASA are using Braviken Bay for logistics operations. Additionally, they are seeking to create a new port at Oxelösund to begin their movement northward to Nyköping.
- As the WASA grows in strength, the Bogaland government requested NATO support to stop WASA's extensive usage of Braviken Bay and counter their movement towards Stockholm along Highway E4 north of Linköping.

Figure 6 shows the friendly force disposition for MR testing; Figure 7 shows the opposing force disposition; Figure 8 shows a typical simulation screen from the exercise.

## 1BCT H Hour Initial Locations



Figure 6: Friendly forces disposition for Mission Rehearsal exercise.

## Enemy Situation at H Hour



Figure 7: Opposing forces disposition for Mission Rehearsal exercise.

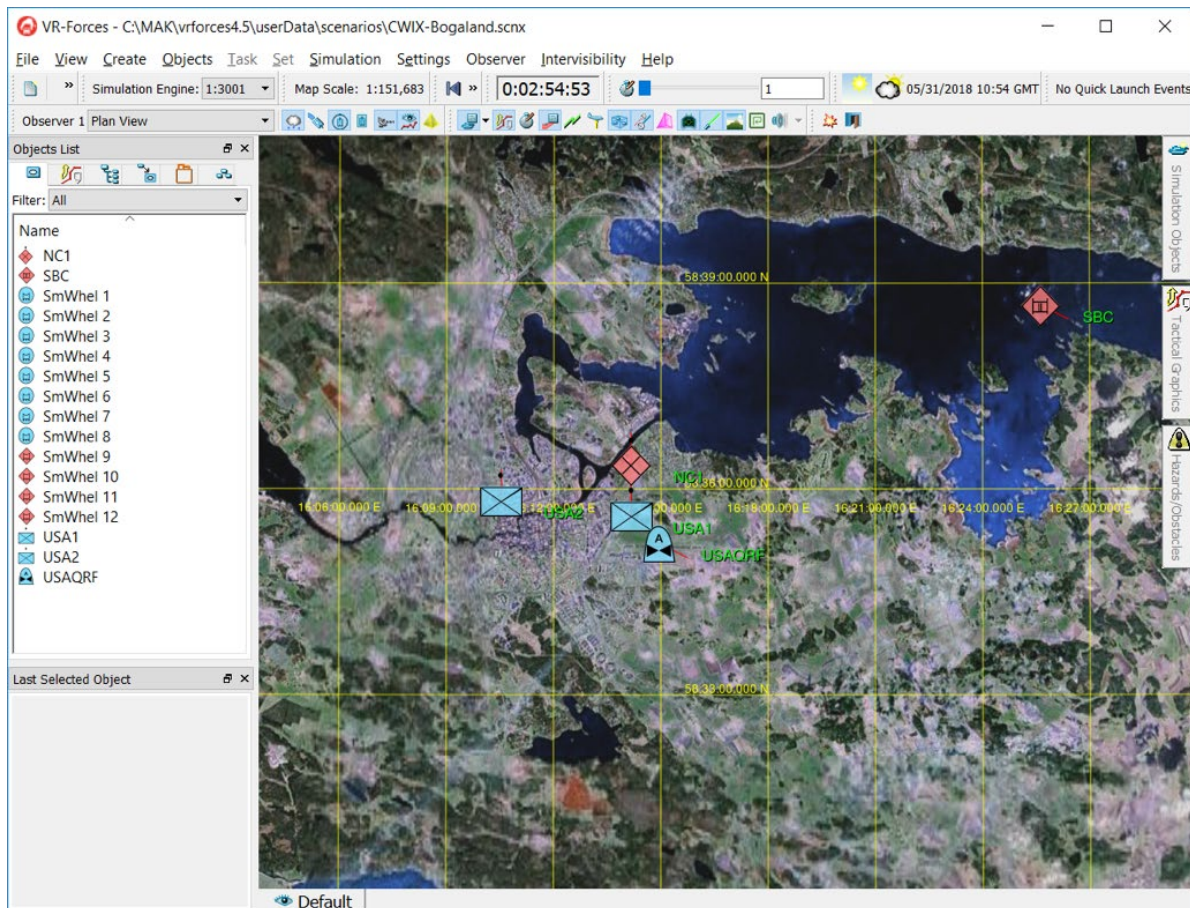


Figure 8: Typical simulation system screen for MR exercise (VRForces commercial military simulation).



#### **4.0 REFERENCES**

- [1] Pullen, J., Wardman, B. and Ruth, J. “Experimental Evaluation of a Command and Control – Simulation Interoperation Standard in a Coalition Environment,” International Command and Control Research and Technology Symposium 2019, Baltimore, MD, November 2019.
- [2] Pullen, J. and Corona, F. “Preparing for Operational Use of C2-Simulation Interoperation,” NATO Modelling and Simulation Symposium 2019, Vienna, Austria, October 2019.
- [3] Pullen, J. and Ruth, J. “Training Operational Military Organizations in a Cyber-active Environment Using C2-Simulation Interoperation,” International Command and Control Research and Technology Symposium 2018, Pensacola, FL, November 2018.
- [4] Galvin, K., Pullen, J., Jense, H, van den Berg, T., Blais, C., Dechand, M, “Advancing Modelling and Simulation in NATO Federated Mission Networking, NATO Modelling & Simulation Symposium 2023, Monterey, California, October 2023.

