NORTH ATLANTIC TREATY ORGANIZATION

SCIENCE AND TECHNOLOGY ORGANIZATION

AC/323(MSG-163)TP/1049

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STO TECHNICAL REPORT **TR-MSG-163**

Evolution of NATO Standards for Federated Simulation

(Évolution des normes OTAN pour la simulation fédérée)

MSG-163 final report.

Published March 2022

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The NATO Science and Technology Organization

Science & Technology (S&T) in the NATO context is defined as the selective and rigorous generation and application of state-of-the-art, validated knowledge for defence and security purposes. S&T activities embrace scientific research, technology development, transition, application and field-testing, experimentation and a range of related scientific activities that include systems engineering, operational research and analysis, synthesis, integration and validation of knowledge derived through the scientific method.

In NATO, S&T is addressed using different business models, namely a collaborative business model where NATO provides a forum where NATO Nations and partner Nations elect to use their national resources to define, conduct and promote cooperative research and information exchange, and secondly an in-house delivery business model where S&T activities are conducted in a NATO dedicated executive body, having its own personnel, capabilities and infrastructure.

The mission of the NATO Science & Technology Organization (STO) is to help position the Nations' and NATO's S&T investments as a strategic enabler of the knowledge and technology advantage for the defence and security posture of NATO Nations and partner Nations, by conducting and promoting S&T activities that augment and leverage the capabilities and programmes of the Alliance, of the NATO Nations and the partner Nations, in support of NATO's objectives, and contributing to NATO's ability to enable and influence security and defence related capability development and threat mitigation in NATO Nations and partner Nations, in accordance with NATO policies.

The total spectrum of this collaborative effort is addressed by six Technical Panels who manage a wide range of scientific research activities, a Group specialising in modelling and simulation, plus a Committee dedicated to supporting the information management needs of the organization.

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These Panels and Group are the power-house of the collaborative model and are made up of national representatives as well as recognised world-class scientists, engineers and information specialists. In addition to providing critical technical oversight, they also provide a communication link to military users and other NATO bodies.

The scientific and technological work is carried out by Technical Teams, created under one or more of these eight bodies, for specific research activities which have a defined duration. These research activities can take a variety of forms, including Task Groups, Workshops, Symposia, Specialists' Meetings, Lecture Series and Technical Courses.

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Published March 2022

ISBN 978-92-837-2367-7

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List of Acronyms

AA	Accreditation Authority
AIS	Automated Identification Service
AMSP	Allied Modelling and Simulation Publication
ATC	Abstract Test Case
ATI	Accredited Test Inspector
CA2X2	Computer Aided Analysis, Exercise, Experimentation (NATO CA2X2 Forum)
CAX	Computer Aided Exercise
CB	Capability Badge
CE	Certification Entity
CGF	Computer Generated Forces
CI	Continuous Integration
CONOPS	Concept of Operations
CS	Conformance Statement
DMaSC	Defence Modelling and Simulation Coherence (United Kingdom)
DIS	Distributed Interactive Simulation
ETC	Executable Test Cases
FAFD	Federation Architecture and FOM Design
FOC	Final Operating Capability
FOM	Federation Object Model
IEEE	Institute of Electrical and Electronics Engineers
IOC	Initial Operating Capability
I/ITSEC	Interservice/Industry Training, Simulation, and Education Conference
IR	Interoperability Requirement
IT2EC	International Training Technology Exhibition and Conference (formally ITEC)
IVCT	Integration, Verification, and Certification Tool
HLA	High Level Architecture
M&S	Modelling and Simulation
MSaaS	Modelling and Simulation as a Service
M&S COE	Modelling and Simulation Centre of Excellence
MSG	Modelling and Simulation Group (also NMSG)
NATO	North Atlantic Treaty Organization
NETN	NATO Education and Training Network
NMSG	NATO Modelling and Simulation Group (also MSG)
PDG	Product Development Group
PSG	Product Support Group
RPR	Real-time Platform Reference (FOM)
RTI	Run Time Infrastructure
SISO	Simulation Interoperability Standards Organization
SIW	Simulation Interoperability Workshop

SOM	Simulation Object Model
STANAG	Standardization Agreement (NATO)
STANREC	Standardization Recommendation (NATO)
STO	Science and Technology Organization (NATO)
SuT	System under Test
UK	United Kingdom

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Evolution of NATO Standards for Federated Simulation

(STO-TR-MSG-163)

Executive Summary

The overall objective of NATO Modelling and Simulation Group 163 (MSG-163) was to evolve and promote NATO standards for Federated Simulation through work on five (5) sub-objectives:

1) Maintenance and update of the NATO Allied Modelling and Simulation Publication 04 (AMSP-04) (NATO Education and Training Network Federation Architecture and FOM design) standard delivered as NATO AMSP-04 Ed B Draft for NATO Modelling and Simulation Group (NMSG) approval and publication by NSO.
2) Maintenance and update of the NATO Integration, Verification and Certification Tool (IVCT) delivered as Open Source Software.
3) Update of the Concept of Operations (CONOPS) for High-Level Architecture (HLA), STANAG 4603, Certification Service. Delivered as updated 'Draft CONOPS' for NMSG MS3 approval.
4) Support to 'HLA Certification Entity' as 'Accredited Test Inspectors' (ATI) for 'HLA Certification' provided by members of MSG-163.
5) Perform awareness activities in regard of these before mentioned products and disseminate results delivered as papers, presentations, lectures, and workshops.

Additional 'Federation Object Model' (FOM) modules have been added to the AMSP-04 standard based on feedback from its use in several Computer Assisted Exercises (CAX) and input from other Research Task Groups. These new modules include, for example, representation of organizations, communication networks, and weather. Modules for multi-resolution modelling, dynamic transfer of modelling responsibilities, and logistics have been significantly updated for generalization and harmonization that simplifies their use and covers more use-cases.

MSG-163 made significant improvements to the NATO HLA Certification Service CONOPS by detailing roles and responsibilities, relationships between actors, and the associated business model. MSG-163 supported the transition from Initial Operating Capability (IOC) to a Final Operational Capability (FOC) of the HLA Certification Process.

Based on feedback from using the NATO IVCT, MSG-163 has continued maintenance and evolution of the IVCT software to version 4.0. The FOC version of the IVCT provides now a fully functional web-based user interface, a logging and reporting service, and test case engines for all major HLA Run Time Infrastructure (RTI) products. The IVCT is cloud-enabled and it is available as Open Source Software on GitHub. The IVCT software is fully integrated within a Continuous Integration (CI) framework. Thus, it automatically compiles, tests, and builds executable software images ready to be used within containerized deployment environments.

MSG-163 continued to support the NATO Modelling and Simulation Centre of Excellence (MSCoE) as the 'HLA Certification Entity' to improve the overall Certification Process and has acted as the 'Accredited Test

Inspector' (ATI). System designers can use the IVCT to test their system under development, or it can be used as an acceptance tool when testing a system as part of the procurement process.

The HLA Certificate is a documented proof of compliance with the HLA Standard that can be used during the procurement and acceptance test.

MSG-163 elaborated on the concept of Capability Badges and introduced additional badges defining interoperability requirements that will benefit the community by easily identifying capable systems and reducing integration time of distributed simulations.

Papers and publications that cover AMSP-04, IVCT and HLA Certification, have been presented at various conferences, e.g., IT2EC, I/ITSEC, SISO SIW, NATO CA2X2 Forum and NMSG Symposia. MSG-163 delivered a series of extended, in-depth workshops and tutorials at SIW 2020, CA2X2 Forum 2020 and vI/ITSEC 2020.

Évolution des normes OTAN pour la simulation fédérée

(STO-TR-MSG-163)

Synthèse

L'objectif général du Groupe OTAN sur la modélisation et la simulation 163 (MSG-163) était de faire évoluer et de promouvoir des normes OTAN pour la simulation fédérée, par un travail sur cinq (5) objectifs secondaires :

1) Mise à jour de la publication interalliée de l'OTAN sur la modélisation et la simulation 04 (AMSP-04) (architecture de fédération et conception FOM du Réseau OTAN de formation et d'entraînement), norme fournie sous la forme de la version préliminaire NATO AMSP-04 Ed B Draft soumise à l'approbation du Groupe OTAN sur la modélisation et la simulation (NMSG) et destinée à être publiée par la NSO.
2) Mise à jour de l'outil d'intégration, vérification et certification (IVCT) de l'OTAN, fourni en tant que logiciel open source.
3) Actualisation du concept d'opération (CONOPS) pour l'architecture de haut niveau (HLA), STANAG 4603, service de certification. Soumis, en tant que « CONOPS préliminaire » mis à jour, à l'approbation MS3 du NMSG.
4) Soutien à l'« entité de certification HLA » en tant qu' « inspecteurs d'essai agréés » (ATI) pour la « certification HLA » fournie par les membres du MSG-163.
5) Exécution d'activités de sensibilisation aux produits mentionnés plus haut et diffusion des résultats sous forme d'articles, exposés, conférences et séminaires.

D'autres modules de « modèle d'objets fédéré » (FOM) ont été ajoutés à la norme AMSP-04, sur la base des retours d'expérience de plusieurs exercices assistés par ordinateur (CAX) et sur la base d'informations d'autres groupes de recherche. Ces nouveaux modules incluent, par exemple, la représentation d'organisations, de réseaux de communication et de la météorologie. Les modules destinés à la modélisation multirésolution, au transfert dynamique des responsabilités de modélisation et à la logistique ont été considérablement actualisés de manière à être généralisés et harmonisés, donc plus simples à utiliser, et à couvrir plus de cas d'utilisation.

Le MSG-163 a apporté des améliorations importantes au CONOPS du service de certification HLA de l'OTAN en détaillant les rôles et responsabilités, les relations entre les acteurs et le modèle économique associé. Le MSG-163 a soutenu la transition de la capacité opérationnelle initiale (IOC) vers une capacité opérationnelle finale (FOC) du processus de certification HLA.

À partir du retour d'expérience de l'IVCT de l'OTAN, le MSG-163 a continué à maintenir et faire évoluer le logiciel d'IVCT en version 4.0. La version FOC de l'IVCT fournit maintenant une interface utilisateur par navigateur Internet entièrement fonctionnelle, un service de journalisation et de compte rendu et un moteur de cas d'essai pour tous les grands produits HLA Run Time Infrastructure (RTI). L'IVCT est compatible avec le cloud et disponible en tant que logiciel open source sur GitHub. Le logiciel IVCT est entièrement intégré dans un cadre d'intégration continue (CI). Par conséquent, il compile, teste et construit automatiquement des images de logiciel exécutable prêtes à l'emploi au sein d'environnements de déploiement conteneurisés.

Le MSG-163 a continué à soutenir le Centre d'excellence de modélisation et simulation de l'OTAN (MSCoE), en qualité d' « entité de certification HLA » pour améliorer le processus de certification général, et a joué le rôle d' « inspecteur d'essai agréé » (ATI). Les concepteurs de système peuvent utiliser l'IVCT pour tester leur système en développement ou comme outil d'acceptation pendant l'essai d'un système dans le cadre du processus d'acquisition.

Le certificat HLA est une preuve documentée de conformité avec la norme HLA, qui peut servir pendant l'essai d'acquisition et d'acceptation.

Le MSG-163 a précisé le concept des insignes de capacité (capability badges) et introduit d'autres insignes définissant les besoins d'interopérabilité, qui bénéficieront à la communauté, en identifiant facilement les systèmes capables et en réduisant le temps d'intégration des simulations distribuées.

Des articles et publications portant sur l'AMSP-04, l'IVCT et la certification HLA ont été présentés lors de diverses conférences, par exemple l'IT2EC, l'I/ITSEC, la SIW de la SISO, le Forum OTAN CA2X2 et le colloque du NMSG. Le MSG-163 a tenu une série de séminaires et de tutoriels prolongés et approfondis lors de la SIW 2020, du Forum CA2X2 2020 et de la vI/ITSEC 2020.

EVOLUTION OF NATO STANDARDS FOR FEDERATED SIMULATION

1.0 INTRODUCTION

1.1 Objectives

The objective of MSG-163 was to evolve the NATO standards for Federated Simulation. This included developing processes and tools for simulation interoperability certification, and updates to the NATO Education and Training Network (NETN) Federation Architecture and FOM Design (FAFD) (AMSP-04/STANREC 4800) based on existing input, and verification and validation through experimentation. The aim was to harmonize NATO standardization agreements, recommendations, and standards profiles, by:

a) Collaborating with the Simulation Interoperability Standards Organization (SISO) to contribute actively to the new version of the HLA Standard.

b) Evaluating the new features of the evolving HLA Standard.

c) Improving the NATO data products regarding HLA Federation Object Model (FOM), Federation Architecture and FOM Design, etc.

d) Improving the NATO HLA Certification Service.

e) Updating the NATO reference documents regarding HLA (STANAG, STANREC and AMSP, etc.).

1.2 Major Items of Work

Major items of work were divided into three main areas addressing a set of scientific topics related to the objectives:

AMSP-04

- **Topic c1.** Maintain and evolve the NETN FAFD and FOM based on NATO and National feedback and proposals for improvements.
- **Topic c2.** Propose a process for long-term maintenance and development of STANREC-4800 by NATO/NMSG.
- **Topic e1.** Provide recommendations for the implementation of the new HLA Standard.
- **Topic e2.** Propose updates to the NATO reference documents for HLA (STANAG-4603, STANREC-4800 and AMSP-01) as needed.

Certification Service

- **Topic d1.** Collect national feedback from using the NATO HLA Certification Service (IOC).
- **Topic d2.** Provide advice to NATO HLA Certification Actors.
- **Topic d3.** Contribute to the NATO HLA Certification Repository (e.g., new Capability Badges, new Abstract Test Case, and new Executable Test Cases).
- **Topic d4.** Improve the process and tools of the NATO HLA Certification Service (FOC).
- **Topic d5.** Evaluate NATO HLA Certification Service and Tools in CAX and NATO Experimentation events such as CWIX.

IVCT

- **Topic a1.** Collaborate closely with SISO HLA PDG by aligning tasks with PDG activities, and exchange results (including the track of the HLA comments listed in the ET-046 final report).
- **Topic b1.** Invite and communicate with RTI vendors to obtain early releases of RTI implementations of the new HLA Standard.
- **Topic b2.** Test and evaluate early releases of new HLA services with national reference applications through experimentations.
- **Topic b3.** Test and evaluate early releases of new HLA services with the NATO HLA certification tool (IVCT).
- **Topic d4.** Improve the process and tools of the NATO HLA Certification Service (FOC).
- **Topic d5.** Evaluate NATO HLA Certification Service and Tools in CAX and NATO Experimentation events such as CWIX.
- **Topic d6.** Evaluate hosting and delivery mechanisms for NATO HLA Certification Services and Tools based on NATO Modelling and Simulation as a Service (MSaaS) recommendations.

1.3 Deliverables

The MSG-163 deliverables and end products are the following:

- Technical Report, including recommendations for continued maintenance and evolution of the products.
- New release of the certification process (CONOPS) and tool (IVCT).
- New release of AMSP-04 NETN FAFD.
- Papers and publications (e.g., IT2EC, I/ITSEC, vIITSEC, SISO SIW, NATO CAX Forum and NMSG Business Meeting and NMSG Symposia).

1.4 Timeline

MSG-163 started in Q1 2018 and worked for the scheduled three-year period until March of 2021 (Figure 1). Meetings were held regularly in the form of face-to-face meetings and virtual WebEx meetings. The NATO CSO's 'Science Connect' was used as a collaborative work environment to support the group's activity. During 2020 Q2-Q4 only virtual meetings were held due to the COVID-19 pandemic. A total of twenty meetings were held.

The status of the work was reported to NATO Modelling and Simulation Group (NMSG) Modelling and Simulation Standards Subgroup (MS3) in conjunction with the NMSG Business Meetings in the spring and the fall of each year. The status of the work has also been published in numerous papers, presentations and tutorials.

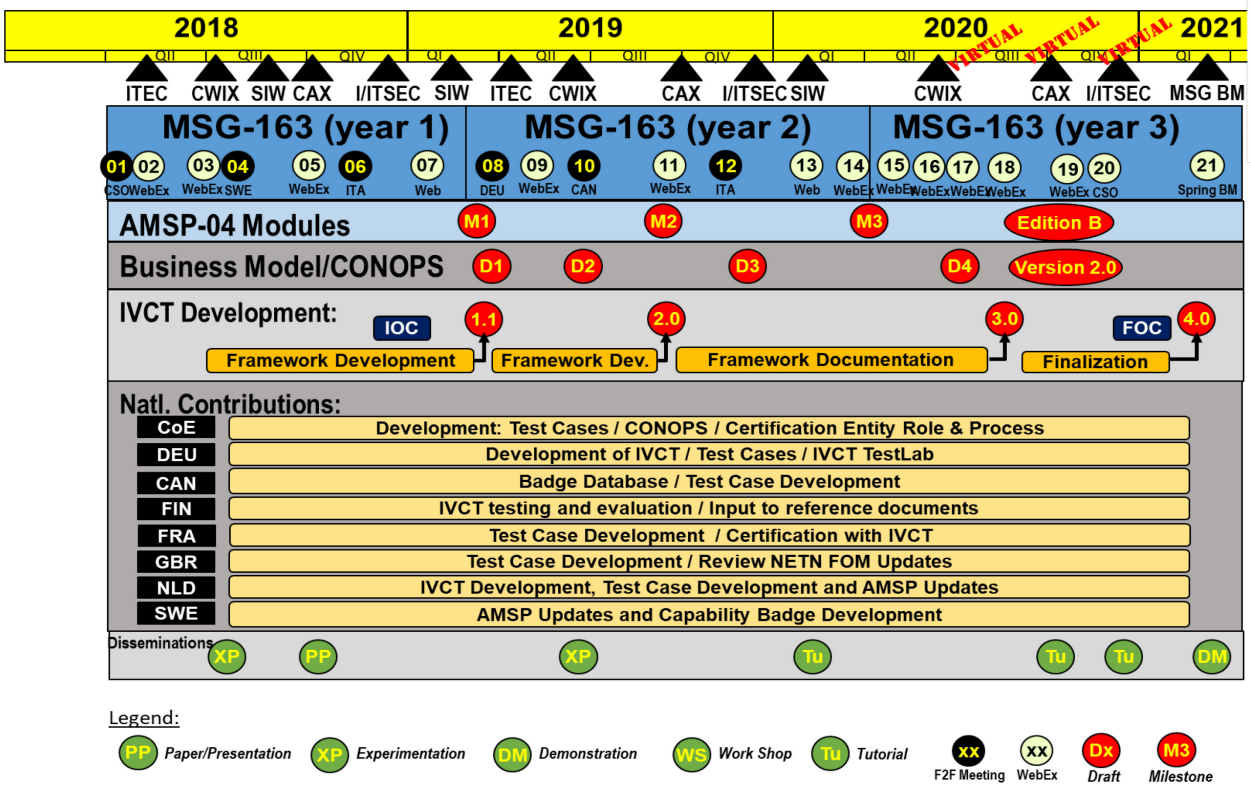

Figure 1: MSG-163 Timeline and Milestones.

1.5 National Contributions

1.5.1 Germany

Germany has contributed to all objectives a, b, c, d and e listed in the introduction with the following contribution:

- Germany proposed a new feature for the HLA Standard to make use of the certificates while joining a federation. This ensures a required level of quality of service when establishing simulation federations. The proposal has been adopted by the HLA Product Development Group of SISO and is planned to be included in the next version of the HLA Standard.
- The development of new features within the HLA Standard needs to be accompanied with the development of testing and certification services. Germany supported this by preparing the IVCT tools for these new developments, such as the generation of digital certificates that are to be used in joining access-controlled federations.
- Germany supported the improvements of NATO data products by adapting the IVCT software to new concepts and requirements. An example is the automated generation of test reports, as part of the certification process within the CONOPS.
- Germany's main contribution improving the Certification Service has been the development of the IVCT software and the deployment and maintenance concepts.
- All contributions to NATO reference products have been documented in the associated documents (STANAG, STANREC and AMSP, etc.).

1.5.2 France

France participated in the group with the following elements:

- France has defined new Abstract Test Cases (ATC) but has not been able to implement them as Executable Test Cases (ETC). These are ATCs related to time and attribute ownership management. The ATCs is documented on the IVCT GitHub.
- France followed up on comments from ET-046 to PDG-HLA. France has also formulated a new comment related to the "Sharing" status in the Simulation Object Model (SOM) and FOM files after using the IVCT in version 1.0 with the HLA_Base ETC by FRA (see SISO HLA PDG comments).
- France updated the HLA_Base ETC to make it compatible with the new version of IVCT 2.0 (Docker version) and uploaded them to IVCT GitHub.

1.5.3 Canada

Canada utilizes both HLA and DIS for simulation interoperability within our training and experimentation establishment. For MSG-163 our focus was on promoting the usability of the IVCT, creating test cases, and exploring application of the tools to DIS; all activities that fall under objective D.

To support the certification service, we continued to update and develop the Capability Badge Database. This included a complete re-write of the system to work with the new WordPress based NATO M&S COE website. Documentation for both end users of the database and future developers has been created and added to the GitHub repository Wiki for the database.

From a survey of Canadian HLA users two common problem areas were identified: basic entity information, and basic warfare interactions. Tests for these were developed as part of the previous activity and were updated as part of MSG-163. Interoperability badges will be defined for these tests and they will be integrated into the latest version of the IVCT before the end of the activity.

While DIS was not within the scope of this group, it is still in common use in Canada, particularly for army simulation systems. Canada adapted the IVCT to work with DIS and created a separate GitHub project to hold that code and its documentation [1]. This work identified some changes that could be made to the IVCT that would make it more easily adaptable to other simulation standards. While we had hoped to directly reuse some HLA test cases in the DIS version, it was more practical to write new tests based on the original test cases.

1.5.4 The Netherlands

The main contributions were to objectives c, d and e, and include:

- Updates and additions to the NETN FOM and associated AMSP-04 documentation. In particular in the area of simulation initialization, control of simulation entities (either aggregate or platform level), and vessel traffic simulation.
- Improvements to the IVCT. This concerns the introduction of Docker container technology and the containerization of the IVCT components; software and container build automation (via Travis, Docker Hub); support for the VT MäK and Portico RTIs; and a contribution to the documentation for operating the IVCT.
- Improvements to the IVCT Test Suites. This includes the addition of a new test suite for Target Designation and the verification of existing test suites against VT MäK VR-Forces, a Computer-Generated Forces (CGF) application from VT MäK. The Target Designation test suite was made available as open source under the IVCT GitHub project.

- Donation of open source materials for the containerization of HLA-based applications, under a new, but related GitHub project "hlacontainers" [2]
- Review of all Task Group products. This includes text contributions to the IVCT CONOPS.

1.5.5 Sweden

Sweden applies NATO STANAG 4603 (IEEE 1516-2010 aka. HLA Evolved) as the core standard for simulation interoperability and uses NATO STANREC 4800 (NETN FAFD) as the core Object Model for distributed simulation. Sweden has invested in, and will continue to invest in, developing and maturing these standards for distributed simulation and training, and evolving the HLA Standard (HLA 4) to even better support MSaaS requirements for composition, deployment and execution. This includes improved support for multi-level and cross-domain security, evolving NATO STANREC 4800 based on national experiences and requirements for smaller M&S components potentially delivered as services.

Sweden's main priorities and interest in the Task Group were to:

- Reduce time and cost in preparation and execution of CAX and increase the quality of training;
- Identify and define requirements for interfaces in modern C2 Training Systems based on modular services and components; and
- Evolve existing standards to meet current requirements. Primarily in collaboration with NATO MSG Task Groups and SISO Product Support Groups (PSG) / Product Development Groups (PDG).

Sweden participated in MSG-163 with a primary focus on evolving the STANAG 4800 – AMSP-04 to an updated Edition B "NETN FAFD v3.0". Sweden contributed with maintenance and updates of the NETN FAFD based on provided feedback, experience, and suggested additions. Sweden also worked to define interoperability requirements and develop Capability Badges for NETN FAFD. Sweden provided experts on training system requirements and M&S standards, as well as software licenses to facilitate development, test and verification of the NETN FAFD modules and to support the IVCT and Certification Services activities.

1.5.6 NATO Modelling and Simulation Centre of Excellence

The NATO Modelling and Simulation Centre of Excellence (M&S COE) mainly contributed to objective d by:

- Acting as the Certification Entity for the NATO HLA Certification Process.
- Providing and improving the web pages for the NATO HLA Certification Process.
- Testing and improving the NATO HLA Certification Process.
- Contributing to the NATO HLA Certification Repository (new Capability Badges, new Abstract Test Cases, and new Executable Test Cases).
- Identifying and Implementing the requirements for reaching FOC at the end of MSG-163.

1.5.7 United Kingdom (UK)

Through the Defence Modelling and Simulation Coherence (DMaSC) Modelling and Simulation (M&S) Standards Profile (DMSP), the UK government asserts that HLA and NETN FAFD are mandated to be used by contractors fulfilling M&S contracts.

The evolution of HLA, NETN and the FAFD are of interest to the UK, as well as the use of IVCT in UK Ministry of Defence DMaSC Common Services for Defence, managed by the Defence Simulation Centre. Another area of interest is HLA RTI configuration for modern (AAS) use cases and the management of their reuse.

The UK reviewed and contributed to ensure changes to HLA, the NETN FOM and FAFD are understood and aligned with its needs and has worked with MSG-163 to incorporate UK use cases within the IVCT. Work has included trialing of IVCT and the provision of use cases.

1.5.8 Finland

Finland recognizes modelling and simulation as one of the key enablers for effective training and increased force readiness. Finland is currently exploring and experimenting on ways to conduct cost-effective and realistic large-scale Computer Assisted eXercises (CAX) in a distributed LVC simulation environment. This development will be aligned with NATO STANAG 4603 (IEEE 1516-2010) and NATO STANREC 4800 (NETN FAFD).

Finland's main priorities and interest in the Task Group were to:

- Increase interoperability, reuse, and cost effectiveness in CAX.
- Enhance and coordinate training system procurement with simulation standards and services for integration, verification, and certification.
- Identify new requirements and evolve existing simulation standards.

For this Task Group Finland provided experts on training and simulation requirements, and contributed with testing, evaluating, and giving feedback on the IVCT software releases and documentation. Finland also supported updating the NATO reference documents regarding HLA and the Certification CONOPS.

2.0 AMSP-04

2.1 Background

The Allied Modelling and Simulation Publication (AMSP-04), NATO Education and Training Network Federation Architecture and FOM Design (NETN FAFD), was released as Edition A in March 2018 [3]. The standard is covered by STANREC 4800, also published in March 2018. AMSP-04 is maintained by NATO NMSG MS3 with Sweden assigned as primarily responsible for the standard within MS3. Over time, the maintenance and update activities associated with the standard have been delegated to NMSG research task groups MSG-068, MSG-106, MSG-134 and recently MSG-163.

2.2 Scientific Objectives

The scientific objectives in MSG-163 related to AMSP-04 are:

- **c1.** Maintain and evolve the NETN FAFD and FOM based on NATO and national feedback and proposals for improvements.
- **c2.** Propose a process for long-term maintenance and development of STANREC-4800 by NATO/NMSG.
- **e1.** Provide recommendations for the implementation of the new HLA Standard.
- **e2.** Propose updates to the NATO reference documents for HLA (STANAG-4603, STANREC-4800 and AMSP-01) as needed.

2.3 Result

2.3.1 Objective (c1): Maintain and Evolve the NETN FAFD and FOM

MSG-163 has performed maintenance and update activities on the AMSP-04 NETN FAFD standard, including the NETN FOM. The result is an updated AMSP-04 (Edition B) which includes the NETN FOM v3.0. The revised NETN FOM includes both updated and new HLA FOM modules based on feedback and input from the community and experience from using the NETN FOM in real exercises, e.g., Viking 18. MSG-163 has also collaborated with other task groups, e.g., MSG-164, MSG-156, MSG-147 to receive additional requirements and to harmonize FOM module design.

MSG-163 has developed and presented multiple papers, presentations and tutorials for awareness and dissemination of NETN FOM information.

The main improvements and updates have been made and are included in NETN FOM v3.0.

Module	Description	Changes
NETN-AIS	Represent vessel traffic in a simulation using AIS messages.	New Module in NETN FOM v3.0.
NETN-BASE	Common definitions of datatypes and extends the RPR-BASE FOM Module.	Harmonization and inclusion of additional datatypes.
NETN-CBRN	Representation of CBRN release, detection, effects, and protective measures in a federated distributed simulation.	Only minor updates of documentation.
NETN-COM	Representation of Communication Networks and the status of communication links.	New Module in NETN FOM v3.0.
NETN-ETR	Interface for sending simulation tasks to entities represented in a federated distributed simulation.	Renaming of LLBML Module and updated with additional tasks.
NETN-LOG	Negotiation, delivery, and acceptance of logistics services between federates modelling different entities involved in the service transaction.	This new module is a merge of previous logistics modules. The pattern for logistics has been simplified.
NETN-METOC	Representation of weather conditions and primary effects of weather on terrain, on water surfaces, in the atmosphere and subsurface water conditions.	New Module in NETN FOM v3.0 based on input from several sources including CIGI, MSG-156, the German Maritime FOM (GMF) and various other FOM representations and METOC service implementations.
NETN-MRM	Aggregate level entity simulation, aggregation and disaggregation of units. Division and merging of unit resources.	Updated module with simplified patterns for aggregation and disaggregation. NETN-Aggregate module has been merged with NETN-MRM.
NETN-ORG	Representation of the state of units including command structure and relationship between organizations.	New Module in NETN FOM v3.0.

Module	Description	Changes
NETN-Physical	Representation of Physical Entities in a federated distributed simulation.	Minor updates.
NETN-SE	Representation of persistent abstract geographical objects that can be (re-)used and referenced for specifying locations, paths, etc. The module also includes the representation of facilities with a function or capability to perform activities.	New Module in NETN FOM v3.0.
NETN-TMR	Negotiated and coordinated transfer of attribute modelling responsibility between federates.	Updated and simplified pattern for transfer of modelling responsibilities.

The following modules are no longer included in NETN FOM:

- NETN-Aggregate: merged with NETN-MRM.
- NETN-LLBML: renamed to NETN-ETR.
- NETN-SCP-BASE: merged with NETN-LOG.
- NETN-Supply: merged with NETN-LOG.
- NETN-Storage: merged with NETN-LOG.
- NETN-Repair: merged with NETN-LOG.
- NETN-Transport: merged with NETN-LOG.
- NETN-HCBML: put on hold awaiting the new C2SIM standard.

2.3.2 Objective (c2): Propose a Process for Long-term Maintenance and Development

MSG-163 recommended, and MS3 approved, the use of GitHub to store, disseminate and maintain the NETN FOM modules. Therefore, all NETN FOM modules have been made publicly available on the GitHub) [4]. All modules are represented in GitHub repositories and issues are tracked for each module. Anyone can submit issues, but the maintenance of the modules is limited to MS3 delegated individuals or task groups. The GitHub AMSP-04 organization account is owned by the NATO Modelling and Simulation Coordination Office (MSCO).

MSG-163 recommended, and MS3 approved the following text for licensing of the NETN FOM (included in all relevant documents and on GitHub):

> *Copyright © 2020 NATO/OTAN. This work is licensed under a Creative Commons Attribution-NoDerivatives 4.0 International License.*
>
> *Above licence gives you the right to use and redistribute the NETN FOM Module (XML file and Documentation) in its entirety without modification. You are also allowed to develop new FOM Modules (in separate XML files and separate documentation) that build-on/extends the NETN module by reference and including necessary scaffolding classes. You are NOT allowed to modify this FOM Module or its documentation without prior permission by the NATO Modelling and Simulation Group.*

2.3.3 Objective (e1): Provide recommendations for the implementation of the new HLA Standard.

Coordination with SISO specifically on the development and early use of HLA 4 has been limited due to delays in HLA 4 development. However, MSG-163 has followed the development of both HLA 4 and the Real-time Platform Reference (RPR) FOM v3.0 to prepare for future maintenance activities. The group recommend that the next generation of NETN FOM (v4) should be based on HLA 4, RPR-FOM v3, and specifically utilize new FOM merging rules for simplifying the way NETN extends existing object models.

2.3.4 Objective (e2): Propose, if needed, updates to the NATO reference documents for HLA (STANAG-4603, STANREC-4800 and AMSP-01).

Feedback to MS3 on the description of the AMSP-04 standard as part of the NATO M&S Standards Profile (AMSP-01) has been provided. STANAG-4603 HLA is currently scheduled for review, but update activities have not taken place during the execution of MSG-163. An updated proposal for STANREC-4800 to cover the AMSP-04 Ed B has been delivered and forwarded to NMSG and NSO for promulgation.

3.0 CERTIFICATION SERVICE

3.1 Background

The integration of distributed simulations and tools into interoperable federations is a complex and time-consuming task requiring extensive testing of individual components, interfaces, and the integrated solution. The M&S community still considers establishing a reliable and trusted federations of distributed interoperable simulations a major challenge. To overcome this challenge NATO STANAG 4603 mandates the use of a capability to verify and certify systems for compliance with NATO interoperability standards for modelling and simulation, and to provide certificates of compliance for simulation components that successfully complete the certification.

MSG-134 CONOPS [5] and an Initial Operational Capability (IOC) of a NATO Simulation Interoperability Test and Certification Service was established in 2017. The CONOPS covers the organization, process, and tools to support the certification of the interoperability capabilities of simulation components or simulation systems. This initial capability is operated by the NATO M&S COE as an accredited Certification Entity (CE) and MSG-163 was tasked to support and further develop the process and tools to enable transition to a Final Operational Capability (FOC).

The certification service relies on the use of the Integration, Verification and Certification Tool (IVCT) and executable test cases designed to verify sets of interoperability requirement defined as Capability Badges. The maintenance and updates of the IVCT software and extended suite of executable test cases by MSG-163 is described in Chapter 4.

3.2 Scientific Objectives

One of the main objectives of MSG-163 was to improve the NATO HLA Certification Service with the following scientific topic:

- **d1.** Collect national feedback from using the NATO HLA Certification Service (IOC).
- **d2.** Provide advice to NATO HLA Certification Actors.
- **d3.** Contribute to the NATO HLA Certification Repository (e.g., new Capability Badges, new Abstract Test Cases, and new Executable Test Cases).

- **d4.** Improve the process and tools of the NATO HLA Certification Service FOC.
- **d5.** Evaluate NATO HLA Certification Service and Tools in CAX and NATO Experimentation events such as CWIX.

3.3 Results

3.3.1 Objective (d1): Collect National Feedback from Using the NATO HLA Certification Service (IOC)

During the execution of MSG-163 very few certifications were conducted by the group itself in conjunction with experiments. No national feedback from the use of the NATO HLA Certification Service was provided.

3.3.2 Objective (d2): Provide Advice to NATO HLA Certification Actors

All members of MSG-163 have acted as Accredited Test Inspectors (ATI) and experts on the IVCT, executable test cases, and certification process to support the Certification Entity (NATO M&S COE).

3.3.3 Objective (d3): Contribute to the NATO HLA Certification Repository (e.g., New Capability Badges, New Abstract Test Cases, and New Executable Test Cases)

MSG-163 continued to develop the online repository for hosting information regarding defined Capability Badges with associated Interoperability Requirements and Executable Test Cases. A version of the database was populated, delivered and installed at NATO M&S COE in Rome and is accessible to the general public at the following web-address (https://www.mscoe.org/).

The following new badges, interoperability requirements and executable test cases were developed:

- Target Designation Badge, Interoperability Requirements, and Test Suite.
- Under development: Entity Integrity Test Suite.
- Under development: Dead Reckoning Test Suite.
- Under development: Warfare Interactions Test Suite.

3.3.4 Objective (d4): Improve the Process and Tools of the NATO HLA Certification Service FOC

MSG-163 has made significant improvements to the NATO HLA Certification Service CONOPS by detailing roles and responsibilities, relationships between actors, and the associated business model. Major changes include:

- Replacing the previous concept of Accredited Test Laboratories (ATL) with Accredited Test Inspectors (ATI).
- Including a description of the role “Test Case Developer”.
- Update of the business model.

The suggested changes to the CONOPS were presented to, and approved by, NMSG MS3 as the Accreditation Authority (AA).

The following key roles are defined in the CONOPS:

Accreditation Authority (AA): The Accreditation Authority is a NATO appointed organization responsible for maintaining the business model and procedures used by Accredited Test Inspectors and Certification Entities.

Certification Entity (CE): The Certification Entity is an organization accredited by the Accreditation Authority and given the authority to issue certificates of compliance to systems that have successfully undergone testing of Interoperability Requirements (IR). The CE is responsible for the management aspects of certification and is the initial point of contact for customers that want to certify their system (with the right to refuse the certification). The CE also maintains the official version of the Integration, Verification and Certification Tool and delivers it with the Executable Test Cases to ATIs.

Accredited Test Inspectors (ATI): An Accredited Test Inspector is given the official authority to perform certification tests of Interoperability Requirements (IR). The test results are recognized by the Certification Entity as valid for issuing certificates of compliance. The role of an ATI is to, upon request from a customer, conduct certification tests on a System under Test (SuT) on behalf of a CE according to the business model defined by the AA. ATIs use the IVCT and Executable Test Cases provided by the CE to verify IRs associated with Capability Badges (CB) defined in the SuT Conformance Statement (CS). The ATI delivers test results to the CE in a secure manner for official certification. ATIs provide feedback on the IVCT to the CE and propose improvements to the test system and procedures.

Customer: A customer of the NATO Simulation Interoperability Test and Certification Service is either a system owner or has obtained the rights from the system owner to initiate certification testing of the system. The customer initiates the certification process by contacting the CE and providing a request to certify a system against a Conformance Statement.

Figure 2 illustrates the key roles and the most relevant information they exchange.

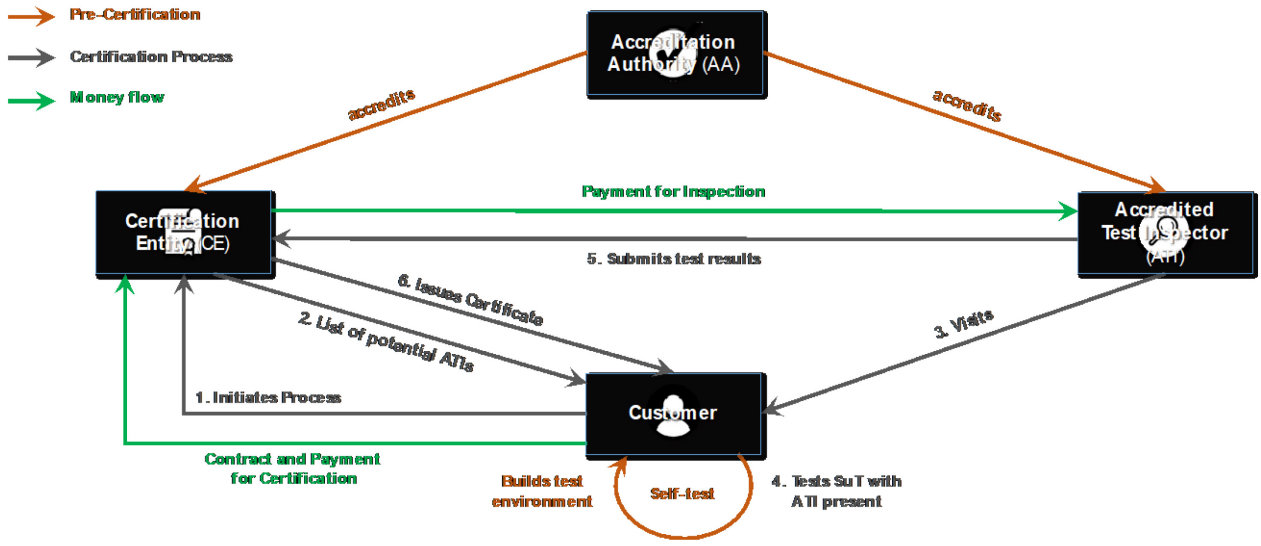

Figure 2: Key Roles of the Test and Certification Service.

Before initiating the process of certification, the customer should perform a self-test of the SuT. The customer can download the IVCT and executable tests cases for interoperability requirements relevant to the Capability Badges to be certified. After being satisfied that the system can successfully be verified, the customer contacts the CE to initiate the certification process. As part of the initiation, the customer provides information about the system to be tested and which Capability Badges to verify in the form of a Conformance Statement.

The CE provides a list of available accredited test inspectors to the customer and a visit is planned between the customer and the selected ATI. During the visit the ATI together with the customer performs tests using accredited versions of IVCT and executable test cases. The result of testing is forwarded by the ATI to the CE. If testing is successful and accepted by the CE, a certificate is issued to the customer.

In the proposed business model, the customer establishes a contract with the CE for the payment of the certification. The ATI is tasked and paid by the CE for work related to the certification. This means the ATI is acting as an agent for the CE and not for the customer.

The Certificate will contain the following information:

- Organization/Company name.
- System under Test:
  - Name, version.
  - If available: addons, modifications, configurations.
- Acquired Badges:
  - Name, version, date.
  - IVCT Version.
  - Test Cases.
  - Test Results.

3.3.5 Objective (d5): Evaluate NATO HLA Certification Service and Tools in CAX and NATO Experimentation Events Such as CWIX

The NATO HLA Certification Service and IVCT was an identified CWIX 2018 and 2019 Capability and were used to perform HLA certification experiments conducted by NATO M&S COE.

The tests were performed using executable test cases developed for CWIX experimentation purposes, mainly covering basic HLA verification and object publication. Only the Pitch RTI was used as the infrastructure for the federation. MSG 163 acknowledged the recommendations to test with different RTI vendors and with an increased number of ETCs in order to have a wider range of results to be used for further improvements of the IVCT.

4.0 IVCT

4.1 Background

The main objective of the IVCT development by MSG-163 is to deliver an updated and matured version of the tool that can be used by the M&S community and is part of the NATO HLA Certification FOC. To meet this objective, an improved GUI was created, improvements to the IVCT core framework, run-time environment, and its deployment concept have been made. Additional test suites have also been developed to extend the coverage of the test cases.

The starting point of MSG-163's work on the IVCT software was version 1.0 (IOC Release) delivered by MSG-134. This release implemented the basic design of the IVCT modules and was used in several experiments to gain experience with the core concepts and to collect user feedback. This feedback provided important information about the users' experience and lead to the implementation of additional features.

4.2 Scientific Objectives

- **a1.** Collaborate closely with SISO HLA PDG by aligning tasks with PDG activities and exchange results, including the HLA comments listed in the ET-046 final report.
- **b1.** Invite RTI vendors to obtain early releases of RTI implementations of the new HLA Standard.
- **b2.** Test and evaluate early releases of new HLA Standard with national reference applications through experimentation.
- **b3.** Test and evaluate early releases of new HLA Services with the IVCT.
- **d4.** Improve the process and tools for the NATO HLA Certification Service for the FOC.

4.3 Results

4.3.1 Objective (a1): Collaboration with SISO HLA PDG

A federated simulation environment represents a virtual environment used for a very specific purpose. Each federation participant has a specific role and must comply with the federation agreements. If a federate does not comply with these agreements, either because of insufficient code quality, or simply by some deployment issues, this federate may cause problems to the purpose of the federation. With the current HLA specification, there is no way to restrict the access of a federate to a given federation. Also, there is no way to define trusted relationships or to enforce the use of trusted tokens.

MSG-163 proposed an extension to the HLA Standard, to address this issue by introducing a Trust Service Provider. This proposal has been accepted as comment COM-66 (“Trusted Federation”) and is outlined in Figure 3. The concept proposes a plugin interface to the HLA Run-time Infrastructure, to validate credential tokens provided by federates. The plugin concept is designed to allow different types of credentials. The nature of a credential depends on the implementation of the plugin, which may request a simple password or a more complex construct, such as a digitally signed statement of a federated capabilities. The MSG-163 foresees an implementation which employs interoperability certificates created by the IVCT tool. With that extension it is possible to define federations accepting only certified federates.

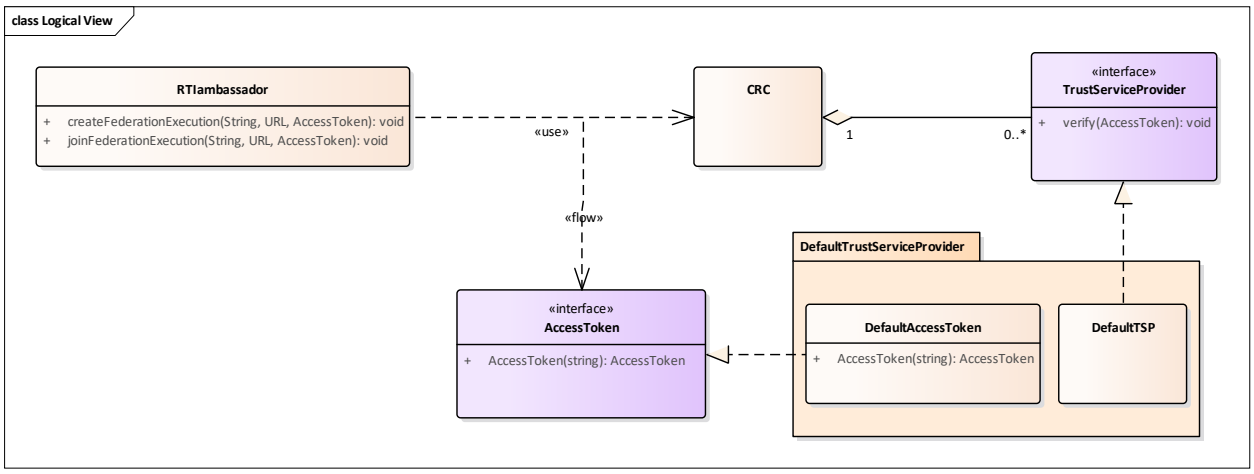

Figure 3: Concept Draft for TrustServiceProvider.

The MSG-163 has joined the Tiger Team to present and discuss this proposal, COM-66, with initial concept drafts. As a result of this, the concept of an authorization plugin has been included in the HLA 4.0 draft.

4.3.2 Objective (b1): Invite RTI Vendors to Obtain Early Releases of RTI Implementations of the New HLA Standard and Objective (b2): Test and Evaluate Early Releases of New HLA Services with National Reference Applications Through Experimentations

The release date for the new HLA Standard has been rescheduled until first quarter of 2021. Therefore, no implementations have been provided or evaluated.

4.3.3 Objective (b3): Test and Evaluate Early Releases of New HLA Services with the NATO HLA Certification Tool

During the development of the COM-66 proposal on including credentials for the federation building, design drafts for the HLA interface extension have been developed and evaluated. These interface extensions have not been included in any RTI implementation, yet; therefore, the evaluation focused on usability and functional completeness.

If COM-66 is accepted, it will have implications for the IVCT framework and test cases in regard to the use of digital certificates. The release of the new HLA Standard and the development of related RTI products are expected for the year 2021, these implications should be handled by future working groups.

4.3.4 Objective (d4): Improve the Tools of the NATO HLA Certification Service (FOC)

The experiences learned during the experiments have been prioritized and addressed in the development releases v2.0.0, v3.0.0 and v4.0.0. The final version produced by this working group is v4.0.0, and includes all features required for the 'final operational capability'. A detailed planning table was maintained on GitHub Projects and can be viewed online (https://GitHub.com/IVCTool/IVCT_Framework/projects).

All updates to the software are tracked by the version management of the GitHub repositories listed in the IVCT organization container (https://GitHub.com/IVCTool). The most notable updates are the following:

- **Restructuring of the core repositories:** IVCT_Framework with the core software and the documentation for framework developers. IVCT_TestSuiteDevelopment with example test case and system under test federate, along with a tutorial documentation for test case developers. IVCT_Operation with deployment configurations and documentations for end users. The built configurations for all repositories have been extended to create containerized deployment images.
- **Introduction of the Test Suite Concept:** in the early versions of the IVCT tool the definition of capability badges and the test case assignments were defined in 'combined definition files'. As the badges and the test cases are developed independently, and address separate concerns, now, these two aspects have been separated.
- **IVCT Operator Instructions:** the 'test case execution' sometimes requires specific actions to be performed by the operator of the IVCT tool. To support the IVCT operator, the framework has been extended to enable a communication dialog between the operator and the 'test case execution'. The test case is now able to send dialog messages to the IVCT operator, e.g., to start the SuT, and to wait until the operator confirms his action.
- **Test Case Trace View:** test protocol messages are now shown live inside the Test Case Execution View. This allows the IVCT operator to follow the execution of the test without the need for any additional terminal connections.
- **Conformance Report Generation:** generating a formatted test report document has been implemented as a new feature. At any given time, the IVCT operator is able to create a pdf-document about the current test status. This report can be used to document the test result. It may be signed by an ATI and sent to the Certification Authority as a proof of a successful conformance test.

4.3.4.1 Documentation

The compilation of the User Manual for the IVCT tools, as well as for Test Case Developers, has been one of the major tasks of the working group:

- IVCT Framework documentation.
- Explaining the background concepts to the IVCT framework.
- Introduction to the built process of the software and the docker images.
- Detailed information about specific modules.
- IVCT Test Suite Developer documentation.
- Including a detailed 'getting started' section for a basic understanding of the test concept.
- Complete test suite example walkthrough.
- Further reading material on various topics.
- IVCT Operation documentation.
- A 'getting started' section for a quick overview for new users.
- Description of the container image structure.
- Overview on various deployment options.
- Recommendations for data persistency.

4.3.5 Objective (d5): Evaluate NATO HLA Certification Service and Tools in NATO CAX and NATO Experimentation Events Such as CWIX

To gain confidence in the quality and usability of the IVCT, it has been used and tested in several experiments. During the three-year period of MSG-163, the following experiments have been conducted:

- CWIX 2019 – IVCT Capability tests lead by the NATO M&S COE.
- Two detailed feature reviews performed by Finland.
- HLA-BASE and TS-Designator Capability Badge test experiment for MäK VR-Forces (a CGF from MäK) with the aim to test and improve the currently existing test suites; performed by the Netherlands.
- HLA-BASE Capability Badge test experiment for Pitch Actors (a CGF from Pitch) with the focus on Services, Declaration and Object, performed by Sweden and Germany.
- Capability Badge tests experiment for ShipSim (a simple ship entity generator from Australia, provided as a container image from MSG-136/164), performed by the Netherlands and Germany.
- Run-Time Infrastructure experiments and tests with the Pitch, MäK, and Portico RTIs, performed by The Netherlands and Germany.

All significant findings during these experiments have been documented on GitHub in the IVCT_Framework repository (https://GitHub.com/IVCTool/IVCT_Framework).

4.3.6 Objective (d6): Evaluate Hosting and Delivery Mechanisms for NATO HLA Certification Services and Tools Based on NATO MSaaS Recommendations

MSG-163 decided to make the Delivery Mechanism of the IVCT based on the Docker Container Technologies, as default. The IVCT software is available on the public Docker Hub repository [6].

Instructions on how to pull and run the published IVCT container images is available on the IVCT GitHub page [7]. The IVCT Docker Container images are dependent on HLA RTI container images. Docker files and building instructions for the containerization of these images are open sourced in a separate GitHub project named "hlacontainers" (https://github.com/hlacontainers). The container images that are used by the IVCT are automatically built and published on the Docker Hub as part of the continuous integration setup.

The IVCT framework software is integrated into the CI service, which allows consistent building of the software in various development environments. It also performs automated testing, building and publication, whenever a software change is conducted. Framework libraries are published as signed artefacts into the public Maven Central repository and Docker images are updated in the Docker Hub library. The IVCT framework repository is also pre-configured, allowing to be tested by an automated code quality testing service (Codacity) [8]. The current code quality rating is 'A', which is the highest possible rating.

5.0 DISSEMINATION ACTIVITIES

5.1 Papers and Presentations

Björn Löfstrand (Pitch Technologies), "NATO Education and Training Network Federation Architecture and FOM Design (NETN FAFD)". Presentation at 13th CAX Forum. Sofia. September 2018.

Tobias Kuhn (M&S COE), Björn Löfstrand, Pitch Technologies, "Make Your Simulation Compliant with NATO M&S Standards", NATO CA2X2 Forum, Paris, September 2019.

Björn Löfstrand (Pitch Technologies), "STANREC 4800 – AMSP-04 NATO Education and Training Network Federation Agreement and FOM Design", STO-MP-MSG-159-12. MSG-159 Symposium on Symposium on Multinational Interoperability, NATO Modelling and Simulation Group. Ottawa, Canada. October 2018.

Björn Löfstrand (Pitch Technologies), Reinhard Herzog (Fraunhofer IOSB), Tobias Kuhn (M&S COE), Horst Behner (Bundeswehr Joint Materiel Office), Tom van den Berg (TNO). "Evolution of NATO Standards for Federated Simulation", SISO-20W-025, SIW Simulation Innovation Workshop, Simulation Interoperability Standards Organizations. Orlando, Florida, February 2020.

5.2 Tutorials

Björn Löfstrand (Pitch Technologies), Horst Behner (Bundeswehr Joint Materiel Office) and Reinhard Herzog (Fraunhofer IOSB) "NATO Simulation Interoperability – Certification, Tools and Standards for Federated Simulation", vIITSEC (virtual I/ITSEC), December 2020.

Tobias Kuhn (M&S COE), Björn Löfstrand (Pitch Technologies), Horst Behner (Bundeswehr Joint Materiel Office) and Reinhard Herzog (Fraunhofer IOSB) "Tutorial on HLA Standards and Certification", NATO CA2X2 Forum, virtual, September 2020.

Björn Löfstrand (Pitch Technologies), Reinhard Herzog (Fraunhofer IOSB), Tobias Kuhn (M&S COE), Horst Behner (Bundeswehr Joint Materiel Office). "Evolution of NATO Standards for Federated Simulation", MSG-163 Tutorial at SIW Simulation Innovation Workshop, Simulation Interoperability Standards Organizations. Orlando, Florida, February 2020.

5.3 Other Events

Presentation slides for NATO booth at I/ITSEC 2019.

6.0 RECOMMENDATIONS

A follow-on activity to MSG-163 is recommended, and should include the following general objectives:

- Maturation and continued development of the IVCT and test suites;
- Maturation and extension of NETN FOM modules;
- Maturation of the NATO HLA Certification Service; and
- Promote adoption of NATO federated simulation standards, certification, and tools.

6.1 Maturing the IVCT

The IVCT is a software, and like all software, needs to be maintained and updated to remain relevant. The IVCT currently has a useful, though small, collection of test cases and interoperability capability badges available that must be expanded to provide better coverage of the NETN FOM described in AMSP-04. A capability badge roadmap should be developed in a follow up activity to help focus national efforts in badge and test case development, and to ensure the most important coverage-gaps being addressed first. The capability badge database software should also be maintained as part of the maturation of the IVCT.

There is also potential to extend the IVCT to other simulation standards that are commonly used besides HLA, for example DIS and TENA. Adoption of a version of the IVCT and the associated interoperability badges and tests by these other simulation communities would improve interoperability by establishing a common expectation for federate behavior.

6.2 Maturing the NETN FOM Modules

As the NETN FOM modules continue to be used, new simulation systems are developed, and HLA standards are updated, the NETN FOM modules will need to be adjusted and extended. Several other NATO groups are working on HLA FOM modules that potentially can be included or aligned with the NETN FOM. Three examples are the ‘Crisis Management and Disaster Response’ FOM, the ‘Cyber Effects’ FOM, and the ‘UCATT Live Simulation Standards’.

6.3 Maturing the NATO HLA Certification Service

As the NETN FOM is expanded and maintained, the certification service must be extended to support the new FOM modules and interaction design patterns that will emerge. This will entail the creation of new interoperability requirements, new capability badges, and new test cases to run with the IVCT. The CONOPS will need periodic updates based on the experience of the test inspectors and the certification authority.

In addition, maturing the certification service will provide a way to evaluate new versions of the IVCT and associated tools. The badge database content should also be kept up-to-date and hosted as part of the certification service.

6.4 Promote Adoption of NATO Standards, Certification, and Tools

In order to understand the benefits of certification it is important to mention that the process is actually in use, and the IVCT is being adopted within the simulation community. This should be done by:

- Establishing a wider IVCT community and supporting the community;
- Developing training materials for users and developers; and
- Providing (online) courses at relevant conferences;
- Providing a training course for test inspectors; and
- Promoting and supporting the utilization of the Certification Service and the IVCT for real exercises, experiments, and testing events.

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REPORT DOCUMENTATION PAGE

1. Recipient's Reference	2. Originator's References	3. Further Reference	4. Security Classification of Document
	STO-TR-MSG-163 AC/323(MSG-163)TP/1049	ISBN 978-92-837-2367-7	PUBLIC RELEASE

5. Originator

Science and Technology Organization
North Atlantic Treaty Organization
BP 25, F-92201 Neuilly-sur-Seine Cedex, France

6. Title

Evolution of NATO Standards for Federated Simulation

7. Presented at/Sponsored by

MSG-163 final report.

8. Author(s)/Editor(s)	9. Date
Multiple	March 2022
10. Author's/Editor's Address	**11. Pages**
Multiple	36

12. Distribution Statement

There are no restrictions on the distribution of this document. Information about the availability of this and other STO unclassified publications is given on the back cover.

13. Keywords/Descriptors

AMSP-04; Certification; HLA; IVCT; M&S; MSG-134; MSG-191; NATO standard; NETN FAFD; NSG-163; Test inspector.

14. Abstract

The overall objective of NATO MSG-163 was to evolve and promote NATO standards for Federated Simulation through work on five (5) sub-objectives: 1) Maintenance and update of the NATO Allied Modelling and Simulation Publication 04 (AMSP-04) (NATO Education and Training Network Federation Architecture and FOM design) standard delivered as NATO AMSP-04 Ed B Draft for NATO Modelling and Simulation Group (NMSG) approval and publication by NSO. 2) Maintenance and update of the NATO Integration, Verification and Certification Tool (IVCT) delivered as Open Source Software. 3) Update of the Concept of Operations (CONOPS) for High-Level Architecture (HLA), STANAG 4603, and the Certification Service. Delivered as updated 'Draft CONOPS' for NMSG MS3 approval. 4) Support to 'HLA Certification Entity' as 'Accredited Test Inspectors' (ATI) for 'HLA Certification' provided by members of MSG-163. 5) Improve awareness in regard of these before mentioned products and disseminate results delivered as papers, presentations, lectures, and workshops.

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ISBN 978-92-837-2367-7