Establishing a HLA Certification Process in NATO

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ABSTRACT

NATO relies on standards and agreements. Especially in distributed simulation, standards are evident e.g., AMSP-01, NETN FAFD, STANAG 4603 and many more. There had been the HLA Federation Compliance Test Tool (FCTT), provided by the USA, but since 2004 there were no more updates available. The NATO Exploratory Team (ET-035) concluded in 2014 that HLA compliance testing is still important and that it needs to be extended beyond the HLA interface and data exchange testing and to address more complex federation agreements and requirements. In conjunction to the development of a new certification tool there is a need to maintain and update the NETN FAFD, as well. The NATO Modeling & Group (MSG-134) began its work in October 2015 and will deliver an *Integration, Verification and Certification Tool* (IVCT), a *Concept of Operation* and an updated *NETN FAFD* in October 2017. During the development of the open source tool, it will be tested in a real use-case of CWIX 2017 at JFTC, in June 2017.
The expectation is the broad use of IVCT in NATO and on national level in the procurement process of simulators and by industry during the development process of simulators. Testing and certifying of systems and issuing badges (according on the requirements) will result in an increased interoperability of simulators in distributed networked simulation systems.

ABOUT THE AUTHORS

Björn Löfstrand is a senior systems architect in modelling and distributed simulation design. Mr. Löfstrand has been engaged in national, international (SISO) and NATO M&S standardization activities for over 15 years participating in the development of standards like High-Level Architecture and engaging in MSG projects such as MSG-027, MSG-052, MSG-068 and MSG-106. Currently Mr. Löfstrand is the NMSG-134 FAFD activities lead. Mr. Löfstrand has a M.Sc. in Computer Science from the University of Linköping (Sweden) and he is the Services and Training Manager at Pitch Technologies.

Horst Behner is a Civilian Officer in the Modelling and Simulation Coordination Office at the Bundeswehr Joint Material Office in Koblenz, Germany. He received his M.Sc. in Physics from the University of Karlsruhe, Germany. The first 5 years he was responsible for the development of a trainer for the German Anti-Aircraft-Tank GEPARD (Cheetah). Then he participated in the Exchange Program for Engineers and Scientists and worked as a lead engineer for the US Navy at NAVAIR in Orlando, Florida, for one year. Back in Germany he became German Speaker and Chairman in several NATO MSGs. From 2005 to 2011, he was the German Liaison Officer for C4ISR at *CERDEC* in Fort Monmouth, New Jersey, and at the *Center of Excellence Team C4ISR* in Aberdeen Proving Ground, Maryland. Since 2012, he is back in Germany and became Chairman of several NATO MSGs and also the German CapTech National Coordinator with the European Defense Agency (EDA) and national budget coordinator for S&T in M&S. In 2017, he became Head of Section of the German M&S / CD&E -Coordination Office.

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BACKGROUND

Integration of distributed simulations and tools into interoperable federations of systems is a complex and time consuming task requiring extensive testing of individual components, interfaces and the integrated solution. To support this task, NATO relies on standards and agreements and their application. Increasing the interoperability, reuse and cost effectiveness of **Modelling and Simulation** (M&S) when integrating solutions to support NATO and national simulation and training is a long-term goal with several challenges along the way. An incremental and iterative approach for harmonizing distributed simulation federation agreements is required to cope with issues related to legacy systems, multiple architectures, new advances in IT and software technologies, industry adoption of standards, new business models and the process of developing open standards.

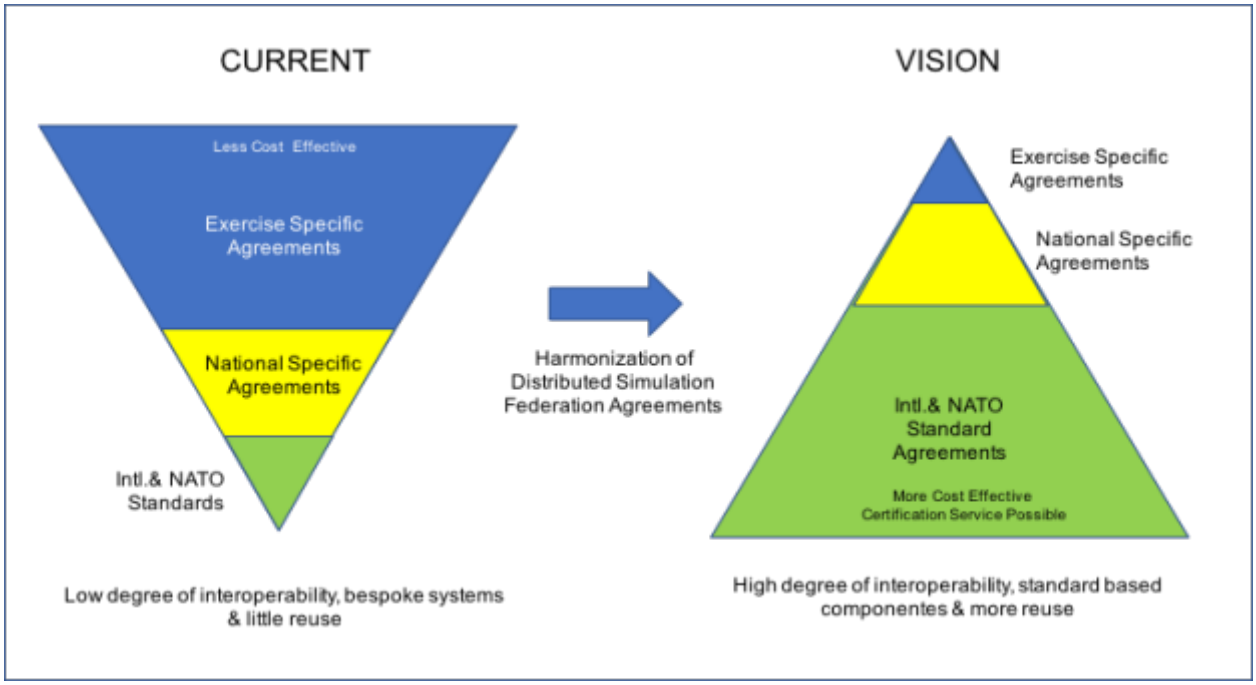


Figure 1: Increase Interoperability, Reuse and Cost Effectiveness

The **Allied Data Publication** 34 (ADatP-34) **NATO Interoperability Standards and Profiles** (NISP) [1] covered by NATO STANAG[1] 5524 identifies and catalogues **Consultation, Command and Control** (C3) standards and provides guidance to apply these in NATO project implementations and **Federated Mission Networking** (FMN). A standards profile specific to Modelling and Simulation is maintained by the NATO **Modelling and Simulation**

[1] Standardization Agreement (STANAG)

Group (NMSG) as an **Allied Modelling and Simulation Publication** (AMSP-01) – the NATO M&S Standards Profile [2]. It provides a more specific list of M&S related standards for use in NATO distributed simulations.

NATO STANAG 4603 [3] is identified in AMSP-01 as one of the core standards for distributed simulation. It states that participating nations agree to use High-Level Architecture (IEEE[2] 1516) [4] for distributed simulation and to utilize the HLA[3] Compliance Certification Process established by NMSG which is also implemented by several partner nations in NATO. By testing and verifying compliance with STANAG 4603, individual M&S components are certified to comply with the basic rules of HLA and federation agreements.

A software tool to support compliance testing developed by the US was released to NATO in 2004. France, Sweden, Canada and the UK implemented the NATO HLA Compliance Certification Process based on the US tool and have provided HLA certification services for national and NATO M&S components. Due to export restrictions, updated versions of the US testing tool were not released to NATO. Based on feedback from users of the tool, NMSG established in 2014 an **Exploratory Team** (ET-035) to investigate the feasibility of developing a new tool to address the reported shortcomings and to extend the certification to more complex federation agreements and interoperability requirements.

The **NATO Education and Training Federation Architecture and FOM Design Document** (NETN FAFD) [5] is a set of HLA **Federation Object Model** (FOM) modules extending existing FOM standards such as the SISO[4] RPR-FOM[5] v2.0 [6] and guidance on how to apply these FOM modules for NATO **Computer Assisted eXercises** (CAX). The NETN FAFD is maintained by NMSG as AMSP-04 and provides additional agreements on the use of standards to support distributed simulation.

In 2015, a new **Modelling and Simulation Group 134** (MSG-134) was established by NMSG to update the NATO HLA Certification process and to develop supporting tools. The group also was delegated the responsibility of updating the NETN FAFD and to extend the testing to also include NETN FAFD compliance verification.

WHY M&S CERTIFICATION?

Standards, federation agreements, compliance testing and certification are important tools that reduce integration time and risks, increase reuse of existing systems and support procurement of new interoperable simulation components. Updated and new standards for simulation interoperability require the NATO simulation certification service to be continuously maintained and updated to manage more complex test cases using the latest versions of applicable standards. Certification of simulation components requires additional testing beyond the core HLA services interface and should also include testing of compliance with federation agreements.

Within the M&S community, it is generally recognized that the technical interoperability between systems is no longer a fundamental problem. However, high-level interoperability is still considered a major challenge in establishing reliable and trusted federations of distributed simulations. The required degree of interoperability not only depends on the purpose and objectives of the simulation system but also on the federation design and interoperability capabilities of specific system components. Early identification of interoperability issues reduces risk and costs associated with effects caused by less interoperable system components. A high degree of interoperability allows more flexible federation designs, and composability of simulation systems without significantly increasing the risk and costs associated with test and integration. [8]

Depending on the degree of interoperability between participating simulation components, the integration of federates into complex federations can be a time-consuming and ambitious task. Tools, processes and services to support early detection of interoperability issues will significantly reduce integration time and cost. Verification of compliance to standards and interfaces is not only relevant to support certification but can also be valuable for the system integrator and simulation system developer.

[2] Institute of Electrical and Electronics Engineers (IEEE)
[3] High-Level Architecture (HLA)
[4] Simulation Interoperability Standards Organization (SISO)
[5] Realtime Platform Reference Federation Object Model (RPR-FOM)

Compliance testing of a system component on interoperability standards and agreements is the basis for the verification of interoperability. Testing and verification of simulation components' interoperability capabilities are fundamental for enabling rapid design and integration of heterogeneous distributed simulation systems. Readily available, up-to-date and trusted tools are key in supporting compliance testing.

A certification service can provide unbiased compliance testing on a set of standards of interoperability requirements based on conformance statements describing the System under Test (SuT). Certificates are provided by authorized certification entities and are tokens of achieved compliance with interoperability requirements as specified in conformance statements. Simulation components are required to have, or obtain, certificates to be candidates for procurement, or as acceptance test requirements as specified in STANAG 4603.

The following effects are anticipated by composing a simulation environment based on pre-tested and verified simulation components with certified interoperability capabilities:

- Reduced Cost of Distributed Simulation Integration
- Reduced Risk in Distributed Simulation Integration
- Reduced Integration Time
- Increased Level of Interoperability in Distributed Simulation

NATO SIMULATION INTEROPERABILITY TEST AND CERTIFICATION SERVICE

MSG-134 was tasked with establishing a NATO Simulation Interoperability Test and Certification Service based on existing standards and experiences from using previous tools and certification processes. The focus and priority in the MSG-134 project was to provide tools for certification services based on HLA and NETN FAFD.

Figure 2. NOV-1 NATO Simulation Interoperability Test and Certification Service

The NATO Simulation Interoperability Test and Certification Service is composed of tools, processes and organizations that manage and deliver services for testing, verification and certification of simulation components to enable efficient integration. These services must be self-sustaining, meaning there must be a business

case with clear definitions of roles and responsibilities of the organizations involved. To be viable, the proposed services must provide a benefit for customers. The main added value is the common understanding and description of NATO defined interoperability compliance. A **Concept of Operations** (CONOPS) document was developed by MSG-134 to describe the certification process, organization, business model and key concepts and components used to support certification.

The scope of interoperability certification provided by the system is wider than previous systems that were limited to HLA certification of primarily technical interoperability, only.

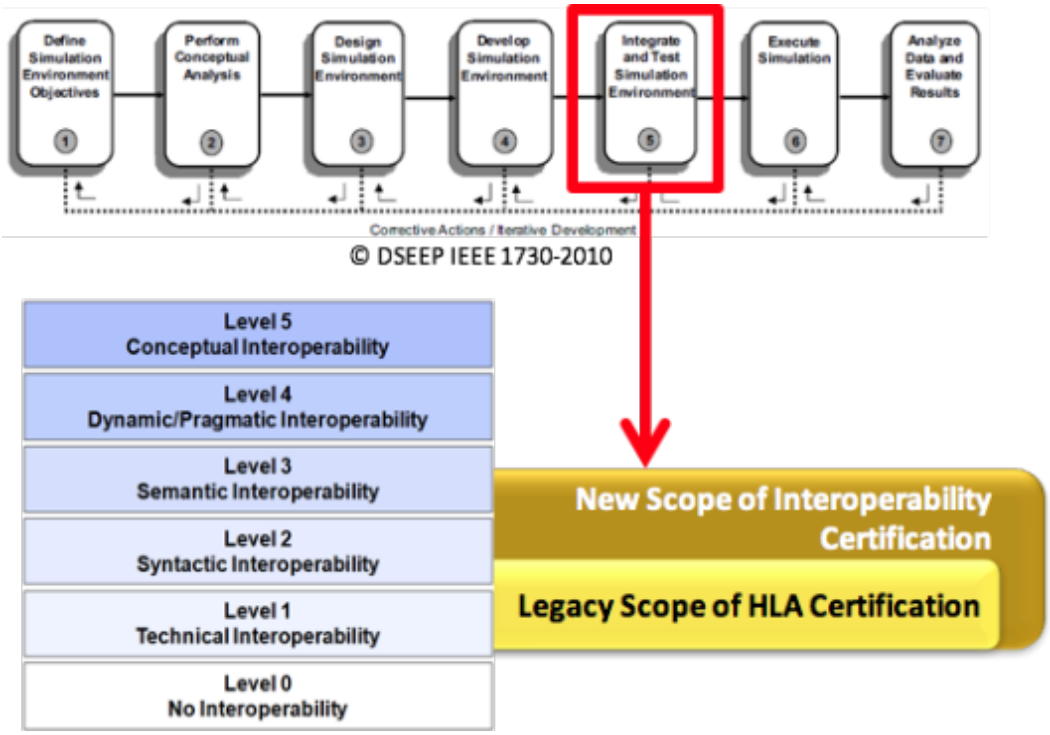


Figure 3. Scope of NATO M&S Interoperability Certification

The focus of the Certification service is to provide support for integration and test of simulation environments as defined in step 5 of the **Distributed Simulation Engineering and Execution Process** (DSEEP) (IEEE 1730-2010) [7] and to verify not only technical interoperability but also syntactical and to some extent semantic interoperability as defined by the **Levels 1 to 3 of the Conceptual Interoperability Model** (LCIM) [8].

Included in the scope of work of MSG-134 was the enhancement of the previous certification capabilities to address the following desired changes:

- A formalized process and procedures for compliance testing and certification
- Accreditation of test laboratories and certification entities
- Tools to support Federation Agreement testing
- Tools to support HLA (IEEE 1516-2010 and upcoming) testing
- Increase availability of tools to support development, test and integration
- Open source core for tools extendable by COTS[6] vendors
- Increase visibility of certification by using labels of compliance

[6] commercial off-the-shelf

In 2016 the MSG-134 established an **Initial Operating Capability** (IOC) of the Certification Service. Recommendations on how this IOC will evolve within the coming years to a **Final Operating Capability** (FOC) are (at the time of writing of this paper) still being defined.

KEY CONCEPTS AND COMPONENTS

The NATO Simulation Interoperability Test and Certification Service consists of tools, organizations and associated processes to deliver functional services related to test, verification, integration and certification of interoperability capabilities of simulation systems and components. To support these activities MSG-134 defined a set of core concepts and components:

A Simulation **Interoperability Requirement** (IR) is related to how distributed systems interact and exchange information to collectively meet overall simulation objectives. IRs are specified to ensure that a system component can be easily combined and interoperate with other system components. The ability of a system to interoperate can be described as the set of fulfilled IR requirements.

The term **System under Test** (SuT) is used for the M&S component currently being tested and verified. This does not mean that all interoperability capabilities of the SuT will be included in the test, therefore a **Conformance Statement** (CS) has to be provided to determine which Interoperability Requirements of the SuT should be verified.

An **Interoperability Capability Badge** (CB) is a way of grouping related Interoperability Requirements (IRs) to express a system's capability of being interoperable on a higher level than individual IRs. Capability Badges are also defined as a token of achievement in terms of passing tests related to IRs associated with the CB. Successful compliance tests, verification and certification of individual systems' compliance with sets of IRs can be labelled using a CB representing this achievement. The concept of using badges to indicate achievements is nothing new. It can be found in many other domains from the scouts to the military. In on-line gaming, badges are frequently used to display an individual gamer's skill, accomplishments and level of play. The semantics associated with badges and how they are used vary between different domains, and even within a single domain. You can find different types of badges showing skill, quantitative and qualitative achievements, specific mission badges, and badges showing general maturity or level. Applying a concept of badges to Interoperability Capabilities has been explored in research activities in the UK [9] and [10].

An **Abstract Test Case** (ATC) is a complete and implementation independent specification of the actions required to verify a specific test purpose expressed as a set of Interoperability Requirements associated with the ATC. This implies that the purpose of the ATC is to test all associated IR.

An **Executable Test Case** (ETC) is an implementation of an Abstract Test Case designed to be able to run in the testing framework together with the System under Test .

The **Integration Verification and Certification Tool** (IVCT) is a framework to run Executable Test Cases (ETC) and to collect the results from testing a SuT. The IVCT is defined by MSG-134 as a software package supporting test and verification within the certification process. However, the IVCT is also available for other test and integration activities in other processes.

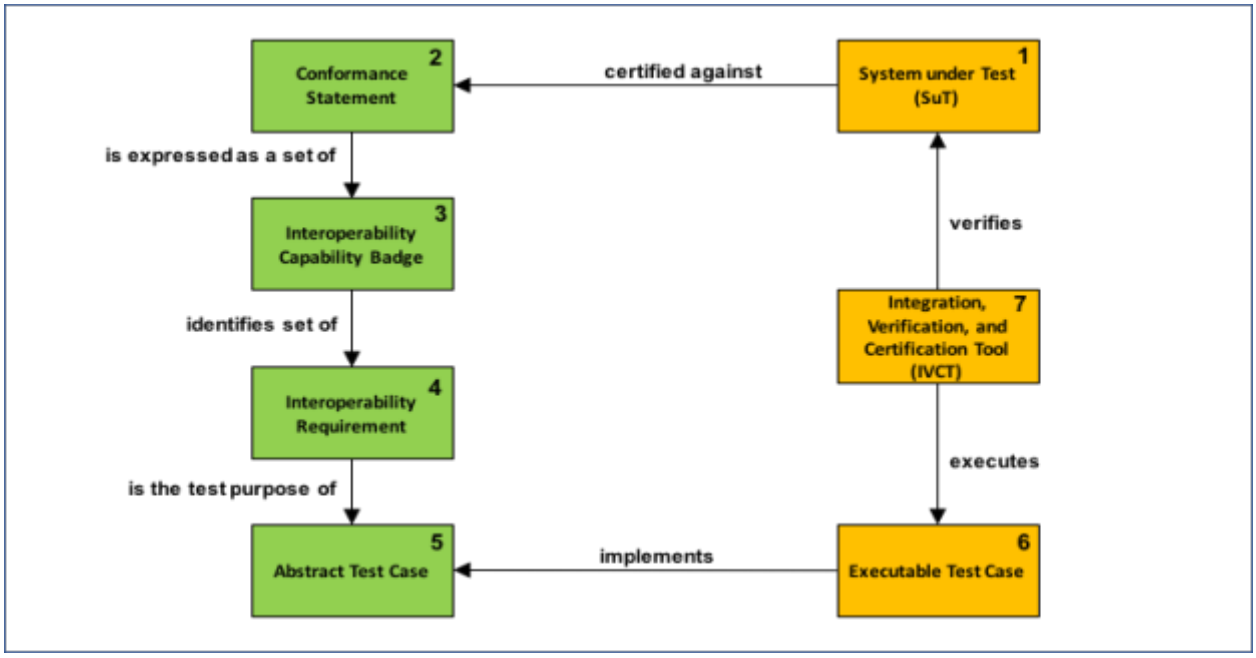


Figure 4. Key NATO M&S Interoperability Certification Concepts

Figure 4 describes the main relationships between these concepts and components. 1) A System under Test (SuT) is certified for a 2) Conformance Statement (CS) expressed as a set of 3) Interoperability Capability Badges (CB) identifying the 4) SuT Interoperability Requirements (IRs). 5) Abstract Test Cases (ATCs) describe how the IRs are tested and these are implemented in 6) Executable Test Cases (ETCs). The 7) Integration Verification and Certification Tool (IVCT) use ETCs to execute tests and to verify SuT compliance with IRs. A SuT that successfully completes verification can receive a certificate and CBs as tokens of interoperability compliance.

EXAMPLE CAPABILITY BADGE

The HLA-BASE-2016 Capability Badge defines the Interoperability Requirements for compliance with basic HLA services and the conformance statement specifying the **Simulation Object Model** (SOM). This Capability Badge corresponds to the type of requirements verified in the previous NATO HLA Federate Certification.

Among all the requirements associated with the HLA-BASE-2016 Capability Badge is a subset related to the HLA Declaration Management, see table below, and to test these an Abstract Test Case (ATC) has been defined and an Executable Test Case (ETC) has been implemented in such a way it can be executed in the IVCT.

ID	Description
IR-SOM-0003	SuT shall publish all object class attributes defined as published in CS/SOM
IR-SOM-0004	SuT shall not publish any object class attribute that is not defined as published in CS/SOM
IR-SOM-0005	SuT shall publish all interaction classes defined as published in CS/SOM

IR-SOM-0006	SuT shall not publish any interaction class that is not defined as published in CS/SOM
IR-SOM-0007	SuT shall subscribe to all object class attributes defined as subscribed in CS/SOM
IR-SOM-0008	SuT shall not subscribe to any object class attribute that is not defined as subscribed in CS/SOM
IR-SOM-0009	SuT shall subscribe to all interaction classes defined as subscribed in CS/SOM
IR-SOM-0010	SuT shall not subscribe to any interaction class that is not defined as subscribed in CS/SOM

Table 1. Interoperability Requirements (IR) related to HLA Declaration Management

Abstract Test Cases are to define how interoperability requirements associated to a capability badge are verified. Several Abstract Test Cases may be defined to cover all associated requirements. An actual implementation of the test case that can also be executed in the IVCT is called an Executable Test Case.

INTEGRATION VERIFICATION AND CERTIFICATION TOOL (IVCT)

The IVCT has been designed as a framework to support test and verification activities required to reduce issues related to simulation interoperability among federated and distributed simulation systems. The tool itself has been developed as Open Source (Apache 2 license) and is available and shared using GitHub. The software documentation for setting up the system, running it and to develop new executable test cases (ETC) are all documented in the GitHub project Wiki. The current version of the IVCT can be freely downloaded. The focus of MSG-134 has been to implement the core testing engine and other core functional components. In the final phase, focus has been put into developing the User Interface. All IVCT components have been coded in Java to meet cross platform requirements.

IVCT consists of several components as depicted in figure 5 below.

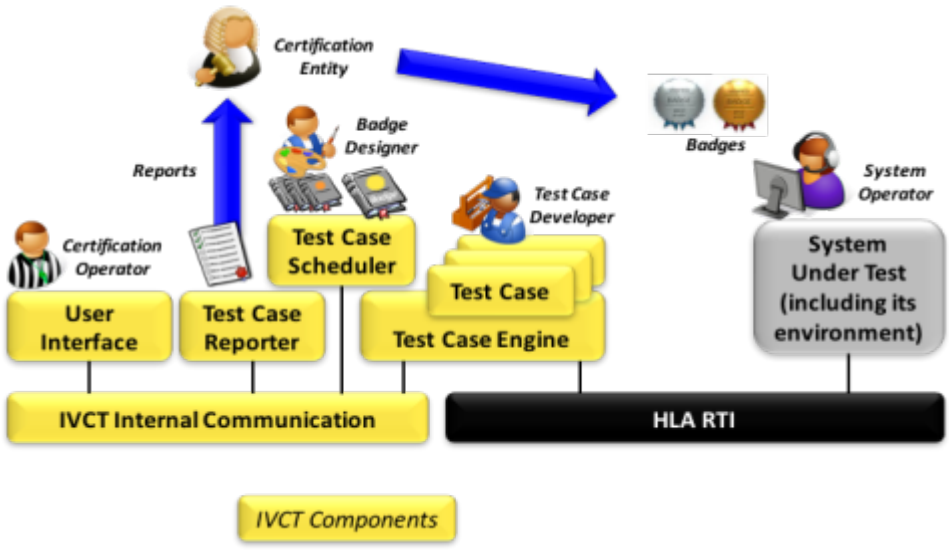


Figure 5. Core IVCT Components connecting to a System under Test

The IVCT allows test cases to be scheduled and run in batches using a Test Case Scheduler component. Each test case is executed in the Test Case Engine that will interact with the System under Test (SuT), currently using HLA IEEE 1516-2010 (HLA Evolved) compliant RTI. Result from tests are collected and provided as reports by the Test Case Reporter component.

When running an executable test case (ETC) the result is one of the following:

- INCONCLUSIVE: Corresponds to an error during initialisation or termination of the test. It is equivalent to FAILED
- FAILED: An error / a problem occurred during the execution of the ETC that leads to a failure
- PASSED: No error / no problem occurred during the execution of the ETC, the test is passed

KEY ROLES IN THE CERTIFICATION PROCESS

The Concept of Operation (CONOPS) is one of the NMSG-134 deliverables. It is the key document describing the business model of the proposed Integration Verification & Certification Tool (IVCT) software and the execution of the certification process and the individual roles and responsibilities and the proposed way of the implementation in NATO and the Nations.

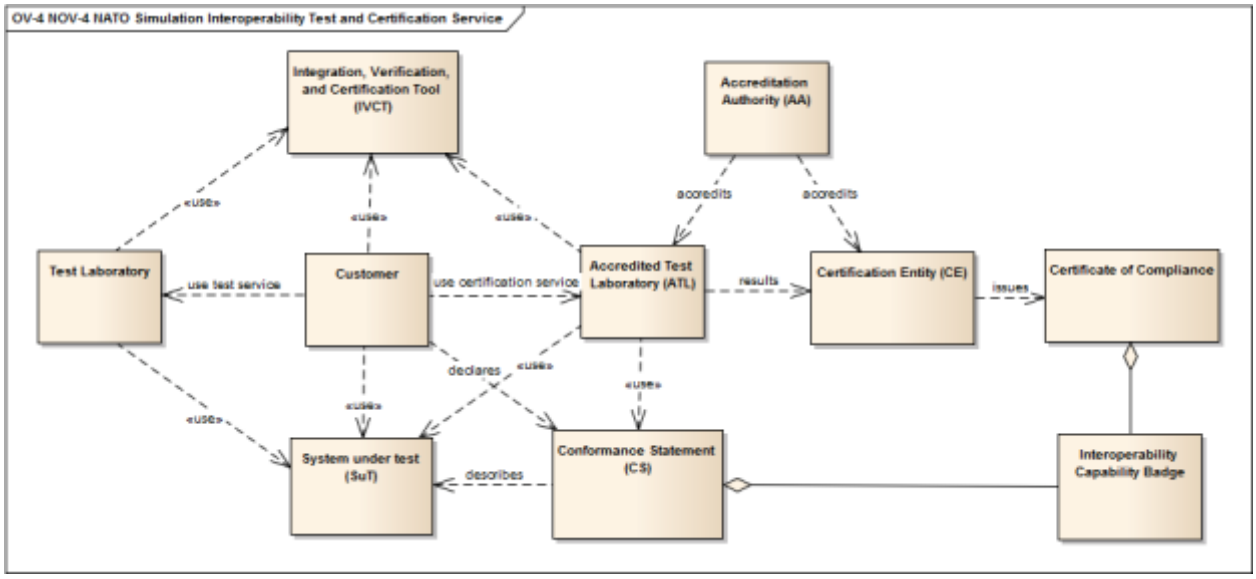


Figure 6: NOV-4 Organizational relationships and key roles

The **Accreditation Authority** (AA) is a NATO appointed organization responsible for maintaining the business model and the procedures used by Accredited Test Laboratories and Certification Entities. For the IOC, the NATO Modelling and Simulation Group (MS3) acts as Accreditation Authority.

The **Certification Entity** (CE) is an organization accredited by Accreditation Authority and given the authority of issuing certificates of compliance to systems that have successfully undergone testing of Interoperability Requirements. 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. The CE has the right to refuse the certification. The CE also maintains the official version of the IVCT and delivers it with the Executable Test Cases to ATLs. CE maintains a list of Accredited Test Laboratories and their testing capabilities. The CE evaluates and manages results from tests and issues certificates based on Capability Badges. For the IOC, the NATO M&S Centre of Excellence in Rome, Italy, has been accredited as the Certification Entity.

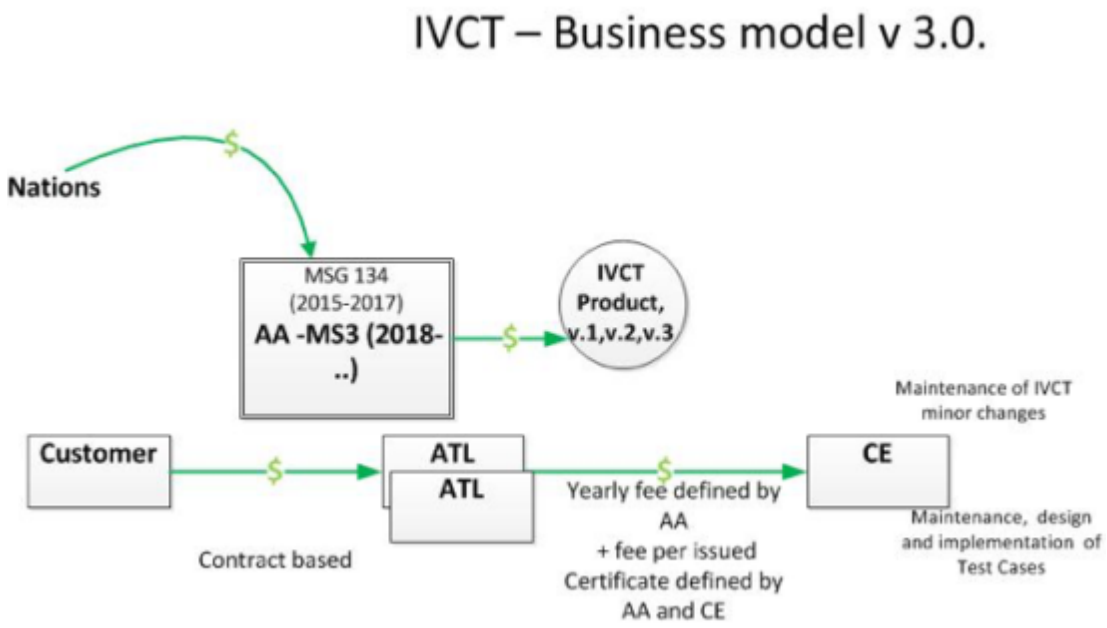
An **Accredited Test Laboratory** (ATL) is a Test Laboratory accredited by the Accreditation Authority and given the official authority to perform certification tests of Interoperability Requirements and of whom the test results are recognized by the Certification Entity as valid for issuing certificates of compliance. The role of an ATL is, upon request of a Customer, to conduct certification tests on a System-under-Test. The ATL uses the IVCT to run Executable Test Cases and to verify the Interoperability Requirements associated to the Capability Badges defined in the Conformance Statement. ATL sends the test results to the Certification Entity in a secure manner for official certification. ATLs continuously provide feedback on IVCT experiences to CE and propose improvements to the

test system and procedure. For the IOC, the only accredited test laboratory is the MSG-134 group (the technical experts) itself.

The initial application of this service and the first certification testing was performed during CWIX[7] 2017 at JFTC[8].

BUSINESS MODEL

A preliminary approach for maintaining a NATO Simulation Interoperability Test and Certification Service is to implement a business model based on NATO nations' and partners' contribution for the IVCT development. An initial set of defined capability badges, abstract and executable test cases have been developed by MSG-134. Future major updates of the IVCT will require continued support by nations while day-to-day certification activities are funded by fixed ATL fees per year and by a fee per issued certificate. ATL relationship with customers using the service is contract based and the customer fees for performing certification may vary depending on if they rely on full funding to be covered by customers or if they, to some extent, receive national funding for maintaining this capability. Another much simpler option might be to provide the certification as a free service, covered by NATO. Currently (at the time of writing this paper), this is still in discussion by the NATO Working Group MSG-134.



At the time of writing this paper, the NATO Simulation Interoperability Test and Certification Service is still in an Initial Operating Capability stage with an ATL responsibility assigned to the MSG-134 group itself. Candidates for test laboratories with the ambition to become ATLs are being identified and the intension is to have at least one ATL operational during 2017. The business model needs to be evaluated and revisions to the model may become necessary to sustain the service.

CONCLUSIONS

We conclude that this new certification process will bring the M&S community a big step forward.

- In the procurement process of systems, the military will have a tool to support acceptance testing.
- Industry is looking forward to this certification process because this will become an internationally recognized standard for certification of simulation systems.

[7] Coalition Warrior Interoperability eXploration, eXperimentation, eXamination, eXercise (CWIX)
[8] Joint Force Training Centre (JFTC) is a NATO headquarters located in Bydgoszcz, Poland

- Developers will be able to test their systems on their own until it passes the tests.
- Between users and customers, there will be a better communication and understanding on the requirements for their systems, saving time, money, endless discussions, etc.

Since the IVCT is the first implementation of its kind, it is likely to contain some bugs like every other software system. There is no tool in existence for verification of the IVCT itself. The initial version of IVCT is implemented with the best quality as possible in mind by highly qualified software and simulation experts. It will mature over time based on feedback, experiences and community support.

In our first version, we have developed the IVCT for HLA (IEEE 1516-2010). Updated HLA versions are expected to evolve over time, and IVCT will have to get updated for dealing with these new standards. It will also be possible to extend IVCT to support other standards, e.g. DIS.

The introduced concept of the certification process caught the attention by many other projects that rely heavily on interoperability of their systems. They had been looking for a reliable and robust way of maintaining and enforcing standards within their domain for improving interoperability.

We all rely on interoperability supported by standards and. The more certified systems there are, the higher the level of interoperability there will be.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the work performed by the members of MSG-134, NMSG, the NMSG M&S Standards Subgroup (MS3), NATO Collaboration Support Office (CSO), The Swedish Defense Materiel Administration (FMV) for collaboration support tools environments and members of the M&S community providing feedback on the existing certification process, NETN FAFD and other related standards.

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