NATO STANDARD

AMSP-01

NATO MODELLING AND SIMULATION STANDARDS PROFILE

Edition D Version 1
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NORTH ATLANTIC TREATY ORGANIZATION

ALLIED MODELLING AND SIMULATION PUBLICATION

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

NATO STANDARDIZATION OFFICE (NSO)

NATO LETTER OF PROMULGATION

23 February 2018

1. The enclosed Allied Modelling and Simulation Publication AMSP-01, Edition D, Version 1, NATO MODELLING AND SIMULATION STANDARDS PROFILE (NMSSP) , which has been approved by the nations in the NATO MODELLING AND SIMULATION GROUP, is promulgated herewith. The agreement of nations to use this publication is recorded in STANREC 4815

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4. This publication shall be handled in accordance with C-M(2002)60.

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Major General, LTUAF
Director, NATO Standardization Office

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS

Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.

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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
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ACKNOWLEDGEMENTS

This document was created as a community effort by the Modelling and Simulation Standards Subgroup (MS3, see members in Annex D). This subgroup was chartered by the NATO Modelling and Simulation Group in March 2007.

The drafting team acknowledges the input of many national experts that contributed to the development and review of the standards description pages listed in the Annex C of this document.

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MANAGEMENT SUMMARY
Allied Modelling & Simulation Publication 01 (AMSP-01)
- NATO M&S Standards Profile (NMSSP) -

Open and common standards are essential enablers for simulation interoperability and re-use. This includes:

- Technical architecture standards - e.g. the High Level Architecture (HLA),
- Data interchange standards - e.g. Synthetic Environment Data Representation and Interchange Specification (SEDRIS), SEDRIS Transmittal Format (STF), and
- Best practices - e.g. Distributed Simulation Engineering and Execution Process (DSEEP).

The NATO Modelling and Simulation Group (NMSG), the NATO Delegated Tasking Authority for standardization in NATO Modelling and Simulation (M&S), has developed NATO Standardization Agreements (STANAGs) in the M&S domain (e.g. HLA and SEDRIS). However, the need was identified to provide and maintain an overview or a "Standards Profile" of existing or emerging standards for M&S, above and beyond the STANAGs, in order to promote interoperability and reuse. This profile includes "de facto" standards that have emerged and are in large use within the international community and could be useful in NATO and national activities. The NMSG established the Modelling & Simulation Standards Subgroup (MS3), consisting of NATO and national M&S experts, which were tasked with creating and maintaining the NATO M&S Standards Profile. The Standards Profile is published under the NATO reference "AMSP-01".

The MS3 issued the first release of the AMSP-01 in October 2008 and provides a regular update of this document. The current release is AMSP-01 (D) and it includes more than 20 M&S focussed standards (see Annex A). The standards and products included in AMSP-01 are not formally mandated by NATO, unless they are supported by a specific STANAG. However, all identified standards/products were included in AMSP-01 following a formal selection and classification process by the MS3 experts and should therefore be considered as relevant for the M&S domain. Each of the identified standards is briefly described according to a metadata template, which includes: the standard title, identifier, version, description, maturity level, availability and several other key parameters. The AMSP-01 also provides recommendations to NMSG and other Standards Developing Organizations (SDOs) for new standardization priorities based on the identified areas where additional standards are needed.

The NMSG recommends wide distribution of the AMSP-01 within national organizations responsible for M&S-related matters. You are kindly requested to support the NMSG in the dissemination of this reference document and thereby increase the awareness and use of the Open and Common M&S standards identified in this document. This document is publicly available on the NATO website (www.nato.int).

Respectfully,

Leigh YU, Chairman of NMSG

Grant BAILEY, Chairman of MS3

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INTRODUCTION
Publication Alliée N° 01 sur la Modélisation et la Simulation (AMSP-01)
- Profil OTAN de Standards pour la M&S -

Des standards ouverts et communs sont des catalyseurs essentiels pour l'interopérabilité des simulations et leur réutilisation. Cela comprend:

- des normes d'architecture technique - par exemple, la HLA - l'architecture de haut niveau,
- des normes d'échange de données - par exemple, SEDRIS – pour la représentation des données d'environnement et les spécifications d'échange de données,
- des guides de bonne pratique - par exemple le DSEEP - processus d'ingénierie et d'exécution pour la simulation distribuée.

Le Groupe OTAN sur la Modélisation et la Simulation (NMSG), qui est l'autorité déléguée de l'OTAN pour la normalisation dans le domaine Modélisation et la Simulation (M&S), a développé des accords de normalisation OTAN (STANAGs) spécifiques au domaine M&S (par exemple, HLA et SEDRIS). Toutefois, le besoin a été identifié de fournir et de maintenir une vue d'ensemble ou «profil» de normes existantes ou émergentes pour la M&S, en plus des STANAGs spécifiques de la M&S, afin de promouvoir l'interopérabilité et la réutilisation des simulations. Ce profil comprend aussi des standards «de facto» qui ont émergés et sont, de fait, utilisés par l'ensemble de la communauté internationale, dans la mesure où ils pourraient être utiles dans les activités M&S de l'OTAN, comme dans des activités nationales. Le NMSG a créé un « Sous-groupe sur les Standards pour la Modélisation & Simulation » (MS3), composé de représentants des organisations OTAN et d'experts nationaux. Ce sous-groupe est chargé de créer et de maintenir un «profil» OTAN de standards pour la M&S. Ce profil de standards est publié sous la référence OTAN "AMSP-01".

Le MS3 a publié la première version de l'AMSP-01, en Octobre 2008, et il fournira une mise à jour régulière de ce document. La version actuelle est AMSP-01 (D) et comprend plus de 20 normes spécifiques de la M&S. Les normes et les produits inclus dans le document ne sont pas officiellement mandatés par l'OTAN sauf si elles sont appuyées par un STANAG spécifique. Toutefois, tout les normes / produits cités ont été inclus dans l'AMSP-01 à la suite d'un processus formel de sélection et de classement, par les experts du MS3 et devraient donc être considérés comme pertinents pour le domaine M&S. Chacune des normes identifiées est brièvement décrite selon un modèle de métadonnées qui comprend: le titre du standard, son identifiant, sa version courante, une courte description, son niveau de maturité, de disponibilité et plusieurs autres paramètres clés. L'AMSP-01 fournit également des recommandations pour le NMSG et les autres organisations de développement (SDO) pour de nouvelles priorités de normalisation, fondées sur des domaines identifiés où des normes supplémentaires sont nécessaires.

Le NMSG recommande une large diffusion de l'AMSP-01 au sein des organisations nationales chargées de la M&S. Vous êtes priés de soutenir le NMSG dans la diffusion de ce document de référence et ainsi augmenter la prise de conscience et l'utilisation de normes ouvertes et communes du domaine M&S citées dans le présent document. Ce document est accessible au public sur le site Internet de l'OTAN (www.nato.int).

Cordialement,

Leigh YU, Président du NMSG

Grant BAILEY, Président du MS3

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1.2. PURPOSE

1. The purpose of the Allied Modelling and Simulation Publication (AMSP-01), the NATO Modelling and Simulation Standards Profile (NMSSP), is to serve as an authoritative reference for NATO and nations on Modelling and Simulation (M&S) standardization products and their applications. The NMSSP provides guidance on selection and use of standards to promote interoperability, best practice and reuse in the M&S domain. The NMSSP is intended to address and support in particular, the establishment of a common technical framework to foster interoperability and reuse as defined in the NATO M&S Master Plan (see reference 1.1.3.1).

2. In support of the main objective as described above, the NMSSP also:

   a. Informs NATO and national M&S stakeholders on new/emerging M&S standards;

   b. Details where gaps have been identified that are either being addressed or need to be addressed by specific M&S standards development activities;

   c. Promotes coherence of M&S standards references and descriptions;

   d. Provides an introduction on M&S best practices;

   e. Provides information and clarification on commercial or government-owned M&S products that are in common use and sometimes improperly called “standards”. This concerns “de facto” M&S standards, products, methodologies, processes, etc. that are not necessarily “formal standards”, but are widely used within industry and nations and could be relevant to NATO M&S activities; and

   f. Provides NATO directed NATO Modelling and Simulation Group (NMSG) input for M&S-specific standards into the NATO Interoperability and Standards Profile (NISP)[1] (see para 1.6.2).

3. It should be noted that:

   a. The NMSSP avoids duplication of references to non-M&S specific standards as these will be detailed in other NATO documentation.

   b. The standards included in the NMSSP have been selected by the NMSG M&S Standards Subgroup (MS3) experts and are aimed specifically at NATO member nations and partner nations, as well as national and NATO organizations, which have requirements to effectively use M&S in support of NATO, coalition and national requirements.

[1] See Annex A

c. The standards and other products included in the NMSSP have been chosen as the result of a formal selection process (see paragraph 2.6) by the MS3. Standards and products included in the Profile are not formally mandated by NATO, unless they are supported by a specific NATO Standardization Agreement (STANAG).

1.3. SCOPE

1. The NMSSP maintains information on M&S standards and recommended practices relevant to achieving interoperability and re-use of components, data, models or best practices. The NMSSP provides recommendations that can be used as guidance in the selection and use of M&S standards for NATO and national activities, e.g. coalition training and experimentation.

2. Standards are classified in the following categories:

a. M&S Methodology, Architecture and Processes, with sub-categories:

(1) Architecture Frameworks;

(2) Systems Engineering Processes; and

(3) Verification and Validation.

b. Conceptual Modelling and Scenarios;

c. M&S Interoperability;

d. Information Exchange Data Models;

e. Software Engineering.

f. Synthetic Natural Environment, with sub-categories:

(1) Data Sources and Formats;

(2) 3D Models;

(3) Interchange of Environmental Data;

(4) Production Processes;

(5) Visual Systems Interfacing; and

(6) Multiple (of the above subcategories).

g. Simulation Analysis and Evaluation; and

h. M&S Miscellaneous.

3. In terms of maturity, standards and guidance documents are characterised as either Current, Emerging, Superseded, Obsolete or Cancelled as appropriate in order to provide alignment with the NATO Interoperability Standards and Profiles (NISP) publication. These categories are defined as follows:

a. **Current:** A current standard is one of the latest issue or amendment and not superseded, obsolete or cancelled. The status usually applies to standards for equipment or processes that are up-to-date or are in-general use.

b. **Emerging:** A standard is considered emerging if it is sufficiently mature to be used within the definition of future planned systems.

c. **Superseded:** A superseded standard is one that has been replaced by a later issue or amendment. They may be superseded by either the same document with a higher issue or amendment level, or by an entirely different standard.

d. **Obsolete:** Obsolete standards contain accurate information at the date of being made obsolete, but are no longer applicable to equipment or processes. Provided that subsequent information has not invalidated the content, an obsolete standard could still be of use to historic systems or processes.

e. **Cancelled:** Cancelled standards have been totally withdrawn from service and are not to be used. A particular revision or issue of a document can be classified as cancelled and the next issue or revision of the same document can supersede the cancelled document.

4. Further to the terms of maturity as described above, an additional category of Mandated is also applied where deemed applicable. A mandated standard is a ***current*** standard that requires compliance for Coalition Operations where an entity (Nation/Organization) wishes to participate in a NATO Operation (including training, exercise, real op, etc.), in which case the use of the respective standard(s) is obligatory.

1.4. RELATIONSHIP WITH OTHER NATO TOOLS AND PUBLICATIONS

1. The NMSSP as AMSP-01 is designed to support the other AMSPs that provide advice and guidance on M&S architecture and implementation as well as feed into the NISP publication and *NATOTerm*[2] the official NATO terminology database.

2. Pictorially, this relationship is shown below:

[2] https://nso.nato.int/natoterm

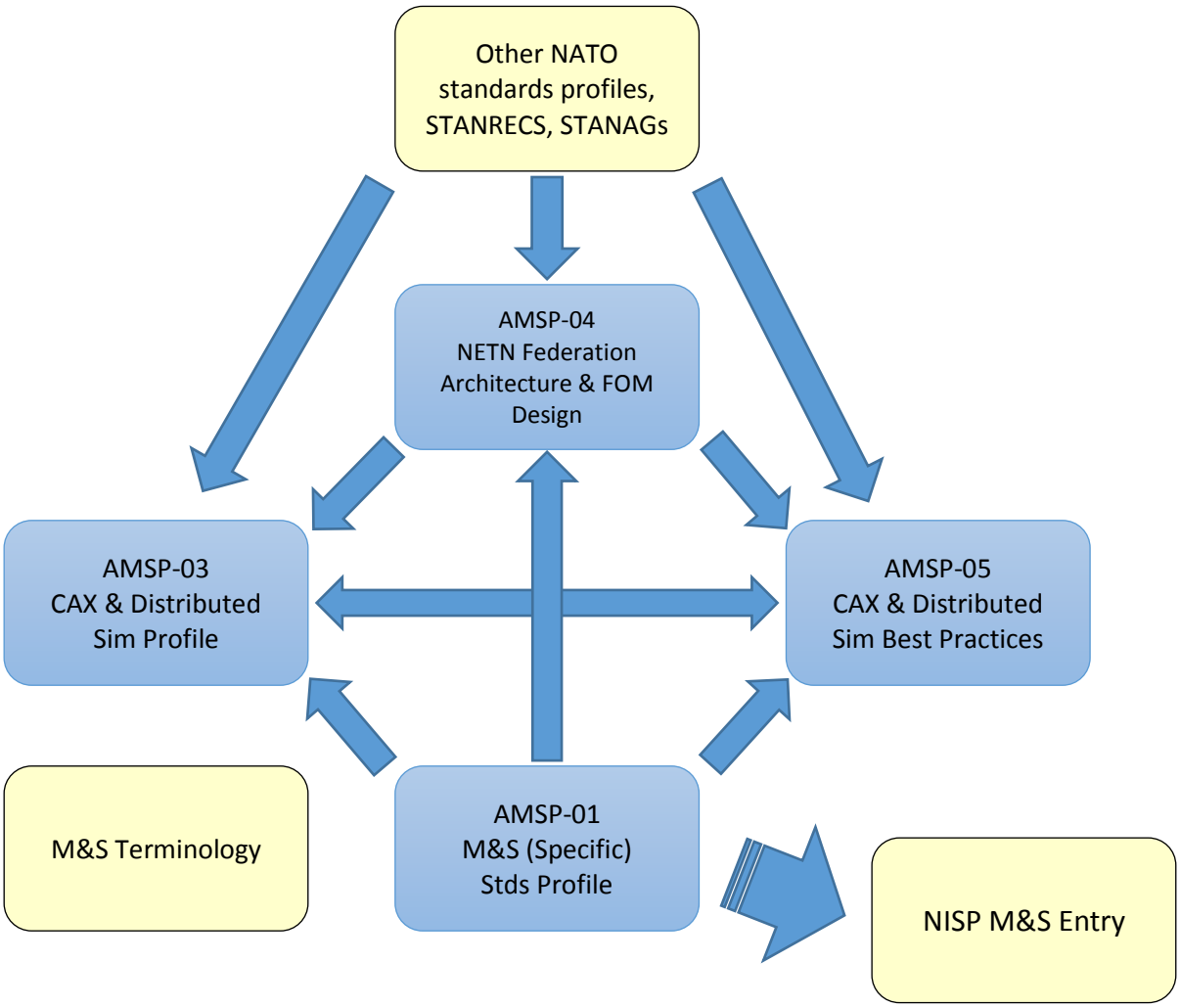

Figure 1-4: Relationship between AMSPs and the NISP

1.5. NATO DEFINITION OF A STANDARD

1. NATO recognizes the ISO/IEC[3] concept of a standard: "*A standard is a document, established by consensus and approved by a recognized Body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context*".

2. It is noted that "*a standard should be based on the consolidated results of science, technology, experience and lessons learned*" (see references 1.1.2.2 and 1.1.3.2).

3. A NATO standard is a standard developed by NATO and promulgated in the framework of the NATO standardization process.

[3] ISO/IEC: International Organization for Standardization / International Electrotechnical Commission (see reference 1.1.3.2)

1.6. BACKGROUND ON NATO STANDARDIZATION

1. NATO Standardization is defined as "*the development and implementation of concepts, doctrines, procedures and designs in order to achieve and maintain the compatibility, interchangeability or commonality which are necessary to attain the required level of interoperability, or to optimise the use of resources, in the fields of operations, materiel and administration*" (see reference 1.1.2.2).

2. The NATO Standardization Process involves proposing, developing, agreeing, ratifying, promulgating, implementing and updating NATO standardization documents. The primary products of this process are as follows (see reference 1.1.2.1):

a. Covering documents:

(1) NATO Standardization Agreement (STANAG); and

(2) NATO Standardization Recommendation (STANREC).

b. Allied Standards:

(1) NATO standards; and

(2) External standards used by NATO, called non-NATO standards.

c. Other standards-related documents (SRD) may include, but are not limited to the following:

(1) Standard Implementation Guides;

(2) User Manuals or Handbooks;

(3) Catalogues; and

(4) Best Practice.

3. The production of NATO standardization documents is the direct responsibility of the so-called Tasking Authorities (TA). TA is a senior committee that makes all its decisions by consensus. The responsibility includes the management, harmonization and maintenance of all their NATO standardization documents, the identification, formulation and agreement of new NATO standardization documents, the establishment of the promulgation criteria of all their STANAGs and recording of national ratification, implementation details, comments, reservations and objections.

4. The Director of the NATO Standardization Office is responsible for the promulgation of agreed NATO standardization documents.

5. Member Nations are responsible for the ratification or approval and the implementation of the NATO standardization documents, and may identify

standardization requirements. Partner Nations are invited to contribute to the refinement of NATO standardization documents and to adopt STANAGs, when appropriate.

6. A TA may delegate its responsibility to a subordinate body, which then becomes a Delegated TA (DTA). A DTA cannot delegate its responsibility further. As an example, the Conference of National Armaments Directors (CNAD) designated the NMSG as the DTA for standardization in NATO M&S domain.

7. The NATO Bodies are expected to implement the relevant STANAGs, contribute to the refinement of NATO standardization requirements and documents and inform relevant TA/DTA about any standardization issues or lessons learned.

1.6.1. NATO Standardization Office (NSO)

1. The NSO is an independent Office that reports to the NATO Committee for Standardization (NCS) for Standardization Policy and Management and to the Military Committee (MC) for corporate oversight and issues relating to operational standardization. The Office's mission is to provide Standardization Management for NATO. Standardization Management encompasses in particular standardization policy; harmonization of NATO standardization activities; rules and regulations for development, ratification, promulgation, and support to implementation of standardization products; standardization management support to Tasking Authorities; terminology policy and guidelines, cooperation with civilian standardization bodies; publishing of NATO standards and standardization promotion.

2. The NSO is the focal point for standardization in NATO headed by a Director supported by a small personal staff. The Policy & Coordination Branch supports the CS responsible for overall standardization policies, defence planning, civil standards, terminology and NATO partners. The operational Branches (Joint, Naval, Army and Air) provide support to MC Standardization Boards (Joint, Maritime, Land and Air), the Medical and Logistic Committee Standardization Board.

3. The NATO Policy for Standardization states that “The Alliance will use suitable civil standards to the maximum practicable extent unless there are compelling reasons not to do so. Only when no applicable civil standard is available, will a NATO standard be developed” (see reference 1.1.1.1). The aim is to use resources in the most efficient way.

4. In 2009, the NCS tasked the NSO to launch a campaign to promote the use of civil standards in NATO, particularly in the materiel domain. It is foreseen that suitable NATO standards will be transferred to civil Standards Developing Organizations (SDOs) and converted to civil standards. NATO will participate in the conversion process to ensure that the new civil standard meets NATO requirements. After promulgation of the new civil standard by the respective civil SDO, NATO can adopt it by means of a cover STANAG or STANREC as appropriate. The

maintenance of the new civil standard is the responsibility of the civil SDO with NATO participation.

5. The NSO has started to implement the necessary measures to enhance co-operation and co-ordination with civil SDOs of interest to NATO.

6. The legal basis for cooperation of NATO with civil SDOs consists of Technical Cooperation Agreements (TCAs). So far, NSO has established TCAs with International Organization for Standardization (ISO), International Electrotechnical Commission of ISO (IEC), European Telecommunications Standards Institute (ETSI), Comité Européen Normalisation (CEN), Comité Européen de Normalisation Électrotechnique (CENELEC), American National Standards Institute (ANSI), Global Standards One (GS1), Society of Automotive Engineers (SAE), Simulation Interoperability Standards Organization (SISO) and Institute of Electrical and Electronic Engineers (IEEE). Others will follow in the near future.

1.6.2. NATO Interoperability Standards and Profiles

1. The NISP prescribes the necessary technical standards and profiles to achieve interoperability of Communications and Information Systems, including M&S, in support of NATO's missions and operations. In accordance with the Alliance C3 Strategy (ref. C-M(2014)0016) all NATO enterprise entities shall adhere to the NISP prescribed standards and profiles. Allies and Partners, in order to achieve Nation to NATO and Nation to Nation technical interoperability, are advised to adhere to these standards and profiles. These standards and profiles are mandatory for those Allies and Partners joining a federated network implemented for a NATO-led mission.

2. In order to satisfy the above NISP requirement, Annex A provides the direct input into that publication and will be refreshed each time that the NMSSP is updated. Annex A contains M&S specific standards only although other commonly used standards are referred to in the main body of this document.

1.6.3. NATO Modelling and Simulation Group

The NMSG is part of the NATO Science and Technology Organization (STO). It is assigned responsibility for coordinating and providing technical guidance for NATO M&S activities undertaken by NATO and partner nations. The administration of M&S activities is the responsibility of the NATO Modelling and Simulation Coordination Office (NATO MSCO) of the NATO Collaboration Support Office (CSO), which is the permanent body in the NATO STO structure. The mission of NMSG is to promote cooperation among Alliance bodies, NATO, and partner nations to maximise the effective utilisation of M&S. Primary mission areas include: M&S standardization, education, and associated science and technology. The activities of the Group are governed by the NATO M&S Master Plan (see reference 1.1.3.1). The Group provides M&S expertise in support of the tasks and projects within the STO and from other NATO bodies. As mentioned above, the NMSG was officially named as the Delegated Tasking Authority for NATO M&S standards by CNAD (see reference

1.1.3.3). In that role the NMSG is responsible for the development of standardization documents in support of NATO Modelling and Simulation activities.

1.6.4. NATO Modelling and Simulation Standards Subgroup

To achieve the standardization mission of the NMSG, the MS3 was formed as a permanent NMSG subgroup. Specifically, the MS3 was tasked with producing the NMSSP and administering its development and evolution. Creation of the MS3 and its initial Terms of Reference (ToR) were officially approved by the NMSG in October 2007. The NATO and National points of contact in MS3 are available in Annex D of this document.

1.7. INTELLECTUAL PROPERTY RIGHTS

1. The NATO Policy on Intellectual Property Rights (IPR) for NATO Standards is stated in reference 1.1.1.2 and is available on the NSO protected website. The document outlines procedures to ensure the protection of intellectual property rights of NATO standardization community from the civilian standardization community.

2. These procedures will resolve potential conflicts between the objective of standardization (the widespread diffusion of a common technology) and the principles of protecting intellectual property rights (the securing of private monopoly rights over a technology as an incentive to develop new products and processes).

3. The NSO owns the NATO copyrights in all NATO standardization documents and retains the right to exploit such copyrights.

4. NSO will grant Member States and Partnership for Peace (PfP) countries a license, free of charge, to:

a. Reproduce, translate and adapt in whole or in part, in any material form, all NATO standardization documents for the Member States' or PfP country's own use;

b. Issue reproductions of, lend, or communicate, in whole or in part, in any material form, all NATO standardization documents, or translations or adaptations thereof; and

c. License or permit the sub-licensing of any of these rights to non-member nations or PfP countries.

5. The rights provided above do not extend to commercial sales of the NATO standardization documents.

6. Concerning referenced standards developed by civil organizations, they have specific copyrights requirements, which can be different from one organization to another. It is the responsibility of standards users to check these restrictions and comply with them. The NSO or the NMSG will assume no responsibility for misuse of such copyrights or restrictions by standards users.

1.8. NATO STANDARDIZATION DOCUMENTS COPYRIGHT

The Director of NSO is responsible for ensuring that NATO standardization documents comply with NATO requirements related to the issue of copyrights for NATO standardization documents (see reference 1.1.1.2) and shall include the copyright marker and disclaimer (see reference 1.1.2.3). The disclaimer is included in the NATO Letter of Promulgation issued by the Director of NSO.

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CHAPTER 2 MODELLING AND SIMULATION STANDARDS

2.1. CHARACTERIZATION OF M&S STANDARDS[4]

The purpose of this section is to better specify the term **standard**, which is in large use in the M&S community with different meanings. First, there is a need to distinguish between different types of standards:

1. **"Official Standards":** Standards are called "official", or "de jure", or "by law", if they are "developed by standards development bodies with legal and recognized standing", such as ISO or SISO. The High Level Architecture (HLA) is a good example of an official M&S standard: it was developed by SISO, published by IEEE and also adopted by NATO via a STANAG. Annex F provides a list of well-known Standards Developing Organizations (SDOs). A majority of M&S standards described in this profile are official standards in consistency with the NATO definition of standards (see section 1.5.).

2. **"De-facto Standards"**, ("in practice") are standards that have achieved a commonly used position by public acceptance or market forces. They mainly originate from industry and their use has expanded in the wider M&S community for practical reasons. A good example of a "de facto" standard is OpenFlight (see Annex C), which is in large use in the M&S community. A small number of 'de facto' standards are included in this profile. Some well-known "de facto" standards were excluded, even if they are in use in industry, because they do not meet the established criteria (see section 2.5.).

3. **"Open Standards":** Several slightly different definitions and meanings can be found that describe this term. This profile uses the following definition: "Specifications that are developed by an SDO or a consortium to which membership is open, and are available to the public for developing compliant products (with or without some license fee)". The use of Open standards in a user application should be without restrictions and the necessary documentation should be available on fair and equitable terms. The key points which qualify standards to be open are:

   a. Membership to the developing organization is open, thus allowing users to influence the development of standards;

   b. Public availability of the standard once it is completed; and

   c. The option to use it for any purpose as deemed fit (e.g. development of supporting tools).

[4] This section was inspired by an I/ITSEC 2009 seminar on "Standardization in Modelling and Simulation", Prepared and introduced by Dr. Katherine L. Morse, JHU/APL, Mr. Roy Scrudder, US DoD M&S CO, Dr. Margaret L. Loper, GTRI; it is also influenced by the policy and working mode of the Simulation Interoperability Standards Organization (SISO, see Annex F and reference 1.1.3.4) that is a key standards organization for the M&S community.

4. **"Local/Specific" versus "International/General" Standards**: The term "standard" is used by different communities at different levels: one product or process can be considered a "standard" within a specific organization, but is not in use in a larger national or international community or in a similar but different community. For example, a national Air Force can have its own standard policy and organization and define its own internal set of standards. In this case they can be qualified as "local standards". They may not be used either at "national" level or at the "international" level such as NATO). Standards qualified as "international" are officially recognized by at least one international organization such as NATO, UN or ISO. Local standards can also be very specific and of interest only to a particular community: for example, it has been an effort in NATO to elaborate standards on the virtual prototyping of military ships. This is an example of international initiative, but also a very specific standardization effort, which may be of little interest for a larger M&S community. In this NATO M&S Standards Profile, the selected standards are mainly international, with some exceptions when a "local" or "national" standard is “de facto” used or officially recognized by more than one nation. An example of such a standard is the national US DoD Verification Validation and Accreditation Recommended Practice Guide (VV&A RPG) included in this profile.

2.2. STANDARDS CHARACTERISTICS

1. The main qualities that make good standards are the following:

   a. Relevance: a standard shall be relevant to the targeted user/developer community;

   b. Substantive content: a standard shall provide meaningful information and/or results;

   c. Timely: production and publication shall be done in an efficient manner to ensure the standard is useful to the community;

   d. Vetted: The product shall be reviewed and approved through consensus by the technical community to which the product applies;

   e. Generality: standards shall be as general as possible to support the broadest community of current and future users;

   f. Stability: standards shall be established, and changed only as necessary. They shall be prototyped and tested before being proposed for adoption to demonstrate their maturity; and

   g. Supportability: Selected standards shall be supported.

2. SDOs generally recognize these important features in their own policy and procedures documents.

2.3. RATIONALE FOR THE DEVELOPMENT, SUPPORT AND USE OF M&S STANDARDS

1. M&S technology is becoming a mature industry but is still too diverse in general approaches and technical solutions. A mature M&S community should not depend on unique/proprietary solutions, rather it should actively adopt and use generally accepted standards. Historically, the need for establishing M&S standards became apparent with the emergence of the distributed simulation concept and the associated technology (late-80s, early-90s).

2. Reuse of different simulators/simulation applications developed under different technological approaches and implemented on different platforms is possible via the use of interoperability protocols and/or architecture standards. While simulation interoperability spurred the development of many open standards, there are other types of M&S and M&S-related standards that are of interest. e.g., system engineering practices.

3. After some years of standards development, it appeared that existing standards were only partial solutions to the overall interoperability problem. The current situation is improving, but still more has to be done. Standards development and maintenance is an evolutionary process with existing standards needing to evolve to meet changing requirements. When new requirements emerge or technical innovations become possible, new standards are likely to be needed.

4. M&S standardization is now recognized as indispensable for a mature simulation activity and is a recognized part of the M&S body of knowledge.

5. The benefits of using M&S standards are as follows:

   a. Improved interoperability

      (1) According to the NATO definition, interoperability[5] is “the ability to act together coherently, effectively and efficiently to achieve Allied tactical, operational and strategic objectives”[6]; and

      (2) Interoperability does not only include Simulation to Simulation data exchange, but also interoperability between Simulations and Live systems (e.g. through Link16 with Hardware-in-the-loop or with Command & Control applications through Coalition Battle Management Language, C-BML).

   b. More specific benefits to using standards:

[5] See NOTICE AC/281-N(2009)0066-REV2 dated 16/7/2009.

[6] Specifically for M&S, interoperability can be defined on technical, syntactical, semantic, and pragmatic levels. For further details refer to STO-TR-MSG-086.

(1) Standards allow people working with different systems to **cooperate** and promote **collective training or experimentation**;

(2) Standards **reduce costs**, including development, lifecycle, and implementer training costs; standards are a natural way to share investments avoiding duplication of efforts on new technologies while reducing risk linked to their use;

(3) Standards can improve operational capabilities by supporting **higher reliability** and facilitating **new technology insertion**;

(4) Standards **protect investment**. For example, scenario descriptions, models and databases may be reused in a variety of applications. Standards also allow upgrading to newer systems or changing to systems from another vendor;

(5) Standards allow **access to the best of the technology** (standards are supposed to represent the state-of-the-art; standards are built on experience and are generally based on more recent technological developments);

(6) Since standards require a **large consensus** and are developed in open organizations (SDOs) there is less reluctance and risk to their use; and

(7) Standards can **reduce complexity** and produce more modular and reconfigurable implementations thus **reducing development risk**.

6. From an industry perspective, use of standards facilitates co-operation among traditional competitors on large multinational programmes:

a. No one feels in a dominant position;

b. Use of standards avoids lengthy negotiations; and

c. Use of standards are neither an unacceptable constraint nor a performance overhead; on the contrary, standards are an enabler for asset protection and industrial co-operation as standards allow everybody to ‘speak the same language’ and understand each other.

2.4. DEVELOPMENT OF STANDARDS

1. The process of developing standards varies depending on the SDO involved, but most of the steps are common, especially across SDOs developing open standards. All SDOs establish policies, procedures and processes, and ensure they are followed. The main steps in a typical SDO process are:

a. **A need is identified and described**, along with identification of key individuals and organizations that will participate in the standards development. If the SDO approves a standard proposal, a working group is formed to develop it. Working group membership in the standards development process must not be unduly restrictive. Voting rights are uniformly and fairly applied;

b. The majority of the effort and time in the standards developing process is the **development of a draft specification** for balloting. This is true for both open standards development processes as well as closed processes such as the development of a proprietary standard. Typically a series of drafts are developed, reviewed, commented upon, and comments resolved until the working group agrees that sufficient consensus has been achieved to proceed to balloting. At each stage of development, members are allowed to comment and given sufficient time to do so;

c. The **balloting process** is usually a more formal process than the draft development described in step b. Typically all objections require the specification of alternate text to satisfy the commenter (where during the drafting process, less precise comments and identification of concerns are permitted). Balloting processes have a threshold in terms of a percentage of votes that must agree to pass the ballot. If that threshold is not reached, then a recirculation of the ballot is required, after making modifications to the balloted specification to address comments. Finally, consensus, but not unanimity, must be achieved;

d. Once the ballot is passed, the SDO **publishes the specification**. The standard is made readily available (with or without license fee). Then a **maintenance period** is started. During the maintenance period, any errors and problems are reported to a maintenance group; and

e. At the end of a specified period (typically 5 years) the SDO requires that the standard be reviewed, and as needed it may be **reaffirmed without changes, revised, or retired**.

2. For open standards processes, the steps above typically take 2-3 years. Standards that do not go through open balloting can have much shorter revision cycles. The SDOs that are most relevant to the M&S community are briefly described in Annex F.

2.5. POLICY FOR NMSSP STANDARDS

1. The scope of standards that are considered for inclusion in the NMSSP include:

a. M&S development, integration and employment standards that have been widely adopted and commonly used, and standards that have the potential to be used by, and are available to, NATO;

b. Standards that are specific to M&S, as well as general purpose standards for systems and software engineering (e.g. programming language standards) that have specific implications for M&S; and

c. Technical interoperability standards, data standards and best practices.

2. The following maturity levels of M&S related standards are considered for inclusion in the NMSSP:

a. Existing standards;

b. Emerging standards; and

c. Expected standards.

3. The NMSSP contains mainly ‘open’ standards and attempts to avoid proprietary standards. Although this is not always possible those proprietary standards that are chosen must be common or de facto standards such that they can be opened and converted by a suitable array of Commercial-Off-The-Shelf (COTS) tools.

4. The NMSSP does not include:

a. Standards that will require a fee to implement. For example, if those implementing the standard must pay a royalty fee to the publisher of the standard for every instance of use. This does not imply that a standard will be precluded from the NMSSP just because products based on the standard are sold or licensed. Also, this does not mean that the standard profile excludes standards for which the user must pay a fee to obtain a copy (e.g. IEEE standards); and;

b. General information technology and software related standards (e.g. programming languages such as C++) unless they have a specific implication for M&S.

5. Should a standard included in the NMSMP become obsolete, it will not be removed from the document as long as it is not superseded by another suitable standard. However, the description of such standard will reflect its status as accordingly.

2.6. PROCEDURES

1. The NMSSP is developed and maintained using the following NMSG process:

a. Any member of the NMSG MS3, as well as Task Group chairpersons or NMSG members may propose standards for inclusion in, or removal from, the NMSSP based on the policy outlined in para 2.5. Proposals will be submitted in the form of a completed profile consistent with Annex B. Submissions shall be sent to NMSG via e-mail msg@cso.nato.int.

b. The MS3 votes on the inclusion and retirement of standards in the NMSSP by an audio or video teleconference, face-to-face meeting, or email. If a standard receives a 75% vote for inclusion, it will be included. If the 75% threshold is not met, a discussion period of two working weeks (with the exclusion of holidays) shall be observed, followed by an email vote. If the 75% threshold is not met again, then the standard shall not be included. 75% threshold applies to the votes cast. Quorum is established at 75% of MS3 National voting membership.

c. All email votes in step ‘b’ shall be held for a period of two calendar weeks.

d. All standards must be reviewed at least once every three years, and the MS3 membership shall vote for continued inclusion or modification using the voting procedures described in ‘b’ above

e. The process in steps ‘a’ to ‘d’ occurs on a continuing basis.

f. The NMSSP shall be reviewed in a period not to exceed two years and any changes made submitted to the NMSG for approval. Upon the NMSG approval, the document shall be posted to the NMSG web site and submitted to NSO for promulgation.

2. Any other comments or proposals regarding the NMSSP may be addressed via the points of contact or directly to the secretary of MS3 (see Annex D for details).

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CHAPTER 3 STANDARDS OF INTEREST

Standards of interest to NATO are listed in accordance with the categories described in Chapter 1. It should be noted that this NMSSP only lists M&S specific standards as these fill gaps that would otherwise exist, however other key specific standards used for M&S purposes are referenced.

3.1. DEFINITION OF THE MAIN CATEGORIES OF STANDARDS

1. In its preliminary work on this profile, the MS3 identified dozens of normative and guidance documents that could support NATO M&S activities. The documents contained very diverse standards, although some were specific to M&S life cycle steps. For clarification and organizational reasons, the MS3 decided to categorize the standards. The following eight categories were chosen:

a. M&S methodology, architecture and processes;

b. Conceptual Modelling and Scenarios;

c. M&S Interoperability;

d. Information Exchange Data Models;

e. Software Engineering;

f. Synthetic Natural Environment;

g. Simulation Analysis and Evaluation; and

h. M&S Miscellaneous.

2. Following subsections describe each category in detail.

3. The choice of categories was influenced by the Distributed Simulation Engineering and Execution Process (DSEEP[7]) which is an approved IEEE recommended practice developed by SISO that supports the overall M&S lifecycle.

[7] The DSEEP was designed to be a generic process that would be very broadly applicable, unlike the FEDEP, which is HLA-specific.

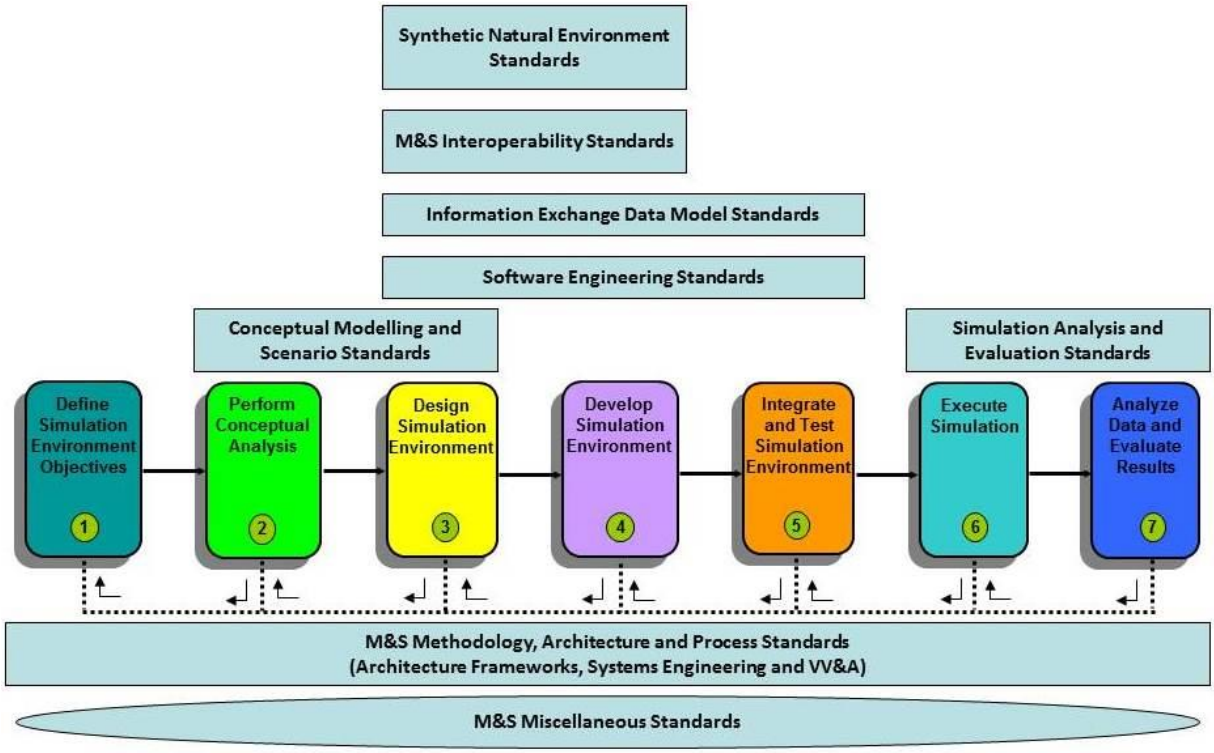

Figure 3-1: The 7-step DSEEP simulation engineering process and the standards categories

4. Figure 3-1 indicates the relationships between the standards categories and the seven main DSEEP steps. The light blue shapes above and below the centre row of DSEEP steps represent the standards categories and six are linked to the DSEEP steps where the standards are most applicable. Shapes representing more general standards, such as “Architecture Framework Standards”, are not tied to any particular step. Note that the term “Simulation Environment,” which appears on the DSEEP steps, refers to any distributed simulation system - a “federation” in HLA terminology.

5. The following subsections describe the type of standards in each category and the relationships between the categories and the DSEEP steps. See also the table in section 3.3 and the table in Annex C.

3.1.1. M&S Methodology, Architecture and Processes

This category groups general standards that cover the overall life cycle of M&S and affect all seven steps of the DSEEP. It comprises the following three subcategories:

1. Architecture Frameworks: This subcategory contains standards that govern high-level development of systems, typically at the enterprise level. Such standards are typically very general and not specific to M&S system development (hence not listed in the NMSSP itself), although they are still applicable. An example standard is the NATO Architecture Framework (NAF).

2. Systems Engineering processes: This subcategory includes both generic and M&S-specific systems engineering processes, which typically describe the steps that must be followed in order to successfully develop a system. A M&S-specific example is the above-mentioned DSEEP.

3. Verification and Validation (V&V) standards: V&V is a key M&S issue because they ensure that M&S systems are built according to specification, fit for their intended use, and documented accordingly. Since software engineering standards are not sufficient, the M&S community has developed M&S-specific standards such as the "VV&A overlay on the High Level Architecture (HLA) Federation Development and Execution Process (FEDEP[8]"); however, more complementary standards are required. Note that V&V is not a unique acronym in this area; VV&A, which stands for Verification, Validation and Accreditation (or Acceptance[9]) is also widely used.

3.1.2. Conceptual Modelling and Scenarios

1. Standards in this category mainly apply to the second and third steps of the DSEEP, which translate user simulation objectives, such as "determine which tactic is best," into the design of an appropriate system of hardware and software, including the scenario(s) to be run.

2. Conceptual modelling (CM) is the translation of the user requirements into formal statements that are understandable by both humans and machines. It is an active research area but CM-specific standards have yet to be developed; in the meantime, some software engineering standards are used.

3. The purpose of scenario standards is to enable the exchange, archiving and reuse of scenarios by describing those using standardized means. An example is the Military Scenario Description Language (MSDL), a SISO standard, which has been designed to enable different simulation programs or federates to share scenario description files, rather than having to recreate a scenario in multiple proprietary file formats, one for each (federated) application.

4. Based on initial work done by Task Group MSG-086 on "Simulation Interoperability", SISO is developing a "Guideline on Scenario Development for Simulation Environments" (GSD). The purpose of the guideline is to provide detailed information regarding the development of scenarios for simulation environments and the relationship of the scenario development process with the overarching simulation environment engineering process. The guideline is based on DSEEP and augments DSEEP with additional information specific to scenario development.

[8] Included as relevant although FEDEP has been retired. A successor based on DSEEP is planned.
[9] Note that outside of the USA, there may not be a formal accreditation process and the terms "acceptance" or "accepted for use" may be used; the term acceptance is the decision to use a simulation for a specific purpose and the term accreditation is the official certification that a model or simulation is acceptable for use for a specific purpose

3.1.3. M&S Interoperability

1. This category contains standards that support the development and execution of distributed M&S systems, and support the reusability of artefacts when combined with other systems that are compliant with the same standards. Such standards mainly relate to Steps 3, 4, and 5 of the DSEEP, which address simulation system development, and support simulation execution in Step 6.

2. A very well-known example is the HLA, which is an IEEE standard and mandated by the NATO M&S Interoperability STANAG 4603.

3.1.4. Information Exchange Data Models

1. This category is closely related to the previous one, M&S interoperability, because data need to be exchanged between components of distributed simulation systems and the structure of the data (number of fields in a message, number of bytes per value, etc.) affects system development. Thus, standards in this category also relate to Steps 3-6 of DSEEP.

2. Some of these standards are in fact a part of the main M&S interoperability standards. The HLA Object Model Template is a typical example. Some standards belonging to this category are not related to any particular interoperability standard such as the “Coalition Battle Management Language” (C-BML) that facilitates data exchange between Command and Control (C2) systems and simulations.

3.1.5. Software Engineering

Many software engineering standards, such as UML (Unified Modelling Language), have been adopted by the M&S community because simulation systems depend so heavily on software. Such standards cover a very wide range of issues from software development methodologies, programming languages, data formats, data modelling, process modelling, etc. Such standards are mainly used in Steps 3 and 4 of the DSEEP.

3.1.6. Synthetic Natural Environment

1. This large category mainly concerns Steps 3 and 4 of the DSEEP.

2. The development, archiving and reuse of natural and human-made environmental databases are very important parts and a significant cost driver of M&S systems. Database development is a complex process and the interoperability of environmental databases is also a key issue. Many standards in use for M&S purposes are from the Geospatial community and therefore are not listed in the NMSSP as not being M&S Specific noting that they are listed in standards profiles elsewhere. Also, many “de facto” standards are in use and official standards are few or just emerging.

3. Categorising such standards appeared very important because all standards are not equal and many come from different domains such as gaming or digital geography. Thus, this category was decomposed into the following subcategories:

a. Data sources and formats: for standards that define such things as elevation data, vector data and imagery. Example standards include Digital Terrain Elevation Data (DTED), Vector Map (VMAP), Geographic Tagged Image File Format (GeoTIFF);

b. 3D-models: for standards that define how three-dimensional objects are to be stored. Example standards are Collada and Open Flight;

c. Interchange of Environmental Data: for standards whose primary purpose is to provide a format to exchange or archive environmental data. The Synthetic Environment Data Representation and Interchange Specification (SEDRIS) Transmittal Format (STF) is an example standard;

d. Production processes: for standards that define how environmental data is to be produced. An example standard is Reuse and Interoperation of Environmental Data and Processes (RIEDP) which is being developed by SISO;

e. Visual Systems Interfacing: for standards that define how visual data is to be offered for visualization, such as Common Image Generator Interface (CIGI); and

f. Multiple: for standards that are very flexible and do not predefine how environments are to be modelled. An example is the SEDRIS series of standards.

3.1.7. Simulation Analysis and Evaluation

This category covers Steps 6 and 7 of the DSEEP. It is intended to include standards that define how simulation data is captured at run-time and processed afterwards for analysis purposes. An example standard for this category is the Distributed Debrief Control Architecture (DDCA) developed by SISO.

3.1.8. M&S Miscellaneous

This large category mainly concerns Steps 3 and 4 of the DSEEP. This category covers standards that generally concern all DSEEP steps, some or none.

3.2. CATEGORISATION OF STANDARDS

This section proposes the allocation of existing standards onto the eight categories described in the previous subsections. Note that standards may appear in more than one category if deemed appropriate. The detailed descriptions of the M&S standards are given in Annex C.

3.2.1. M&S Methodology, Architecture and Processes Standards

This very general category comprises three subcategories.

3.2.1.1. Architecture Frameworks

1. There are no M&S-specific standards and therefore there are no entries in the NMSSP for this subcategory. However, the NATO Architecture Framework (NAF) is a common standard in systems engineering and therefore its use is recognized and supported.

2. Architecture Frameworks are mainly used in the world of Command, Control, Communications and Intelligence (C3I) systems, but they are also widely used for M&S and recognized as of interest by the NMSG.

3.2.1.2. Systems Engineering Processes

1. Many general systems engineering processes are applicable to M&S but this subcategory only contains those that are specific to M&S. The M&S community felt that the development of simulation systems should be supported by specific methods and processes and, as a result, developed its own. This standard subcategory includes the IEEE 1730 DSEEP.

2. Other systems engineering standards exist and are recognized by ISO and the IEEE; however, they are not included in this profile because they are redundant given the M&S-specific processes above.

3.2.1.3. Verification and Validation (V&V)

1. This category includes the following standards:

    a. The SISO Generic Methodology for Verification and Validation and Acceptance of Models, Simulations and Data (GM-VV);

    b. The IEEE 1516.4 "VV&A Overlay on the HLA FEDEP";

    c. The US DoD "VV&A Recommended Practice Guide" (RPG); and

    d. The US DoD "VV&A Templates".

2. Many NATO and partner nations have established national V&V standards. The SISO and NMSG efforts on GM-VV have started to address the lack of internationally recognized V&V standards.

3.2.2. Conceptual Modelling and Scenarios Standards

1. This category lists standards that support modelling activities. Some are very general and useful in describing requirements and preliminary simulation system designs; others are more specific and support particular aspects of military activities.

2. This category includes the following standards:

   a. The SISO Base Object Models (BOMs);

   b. The SISO Military Scenario Definition Language (MSDL), which is the only known standard for storing and exchanging scenarios.

3. The SISO BOMs support conceptual modelling and are considered important for translating military requirements into simulation technical specifications and, more generally, for supporting V&V activities.

4. The three following standards - Unified Modelling Language (UML), eXtended Mark-up Language (XML) Metadata Interchange (XMI) and Systems Modelling Language (SysML) - are not specific to M&S and therefore not listed, but are considered useful for M&S.

5. It has been recognized that a generic method of describing, archiving, exchanging and reusing scenarios is of paramount interest to M&S because scenario development is very resource consuming. MSDL was developed to address these issues. It should evolve and become more general as it merges with C-BML to create Command and Control Systems - Simulation Systems Interoperation (C2SIM) (see section 3.2.4. and Annex C for more information on these standards).

3.2.3. M&S Interoperability Standards

1. M&S interoperability standards were developed to support distributed simulations development, beginning as early as the late 1980s or early 1990s. Such standards mainly support the interconnection of simulation applications, simulators, live systems and supporting tools, especially the efficient distribution of simulation data over computer networks. Currently, they do not support semantic interoperability and should be superseded or completed by more elaborated standards or technologies in the future.

2. This standards category includes:

   a. The IEEE 1516 and NATO STANAG 4603 High Level Architecture;

   b. The SISO Dynamic Link Compatible (DLC) HLA Application Programmer Interface (API); and

   c. The IEEE 1278 Standard Series for Distributed Interactive Simulation (DIS).

3. DIS and HLA often compete for acceptance even though they have different qualities and inherent limitations. Both DIS and HLA are official standards developed by SISO and published by the IEEE.

4. The DLC HLA API standard was developed by SISO to complement the HLA 1516-2000 and HLA 1.3 standards and compensate for lack of compatibility between commercial HLA software. The latest version of the HLA, 1516-2010, incorporates the changes made by the DCL API.

5. The Web Live Virtual Constructive (WebLVC) is a protocol under development by SISO in order to extend traditional M&S federations (e.g. HLA and DIS) to the Web browser environment.

6. The task group MSG-136 “Modelling and Simulation as a Service: Rapid deployment of interoperable and credible simulation environments” investigates how to improve M&S interoperability through M&S services.

7. It is important to note that there is only one STANAG related to this category, that is, the HLA STANAG 4603. Thus, the HLA is the unique interoperability standard mandated by NATO.

3.2.4. Information Exchange Data Models Standards

1. This category includes standards that are typically required to support M&S interoperability:

a. The HLA OMT (Object Model Template), which is one of the three components of the HLA standard;

b. The SISO Enumerations for Simulation Interoperability;

c. The Real-time Platform Reference Federation Object Model (RPR FOM);

d. The Link 16 Simulation standard;

e. The Link 11 Simulation standard development;

f. Coalition Battle Management Language (C-BML);

g. Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM) – not M&S specific and not listed; and

h. The NATO STANAG 5602 Standard Interface for Multiple Platform Link Evaluation (SIMPLE) not M&S specific and not listed.

2. The HLA OMT is the HLA-specific data exchange standard. It is also the metadata underlying the BOM standard.

3. Enumerations for Simulation are unique identifiers for simulated entities that represent real-world vehicles, life forms, and other objects or phenomena that may be present in the simulation. SISO-REF-010 Reference for Enumerations for Simulation Interoperability specifies numerical values and associated definitions for fields that are identified as enumerations in SISO Standards Products and SISO-sponsored standards published by IEEE for High Level Architecture (HLA) and Distributed Interactive Simulation (DIS).

4. The RPR FOM is a “reference FOM” that is widely used in the HLA community. It obviously conforms to the OMT formalism, but in addition it is consistent with the Reference Enumerations for Simulation Interoperability and facilitates data exchange between HLA and DIS-based distributed simulation systems.

5. The next two standards cover specific modelling needs of the military domain: Link 11 Simulation and Link 16 Simulation Tactical Data Links. They are in this category because it is deemed the most appropriate.

6. The C-BML effort addresses the crucial interoperability problem between C2 systems and simulations. It is a current standard but it is being developed and merged with MSDL to create C2SIM.

7. STANAG 5602 SIMPLE is not M&S-specific, but is often used to exchange Link 11 Simulation and Link 16 Simulation data in M&S applications. SIMPLE is also relevant in LVC simulations since the standard is widely implemented in operational tactical data link equipment.

3.2.5. Software Engineering Standards

There are no M&S specific standards for this category but there are general-purpose standards that are very well suited to M&S such as Model Driven Architecture (MDA), Model Driven Engineering (MDE) and Extensible Markup Language (XML).

3.2.6. Synthetic Natural Environment Standards

There are many standards related to environmental data representation. They are classified in the following subsections.

3.2.6.1. General Environmental Standards

1. This subcategory contains only SEDRIS, which is a suite of 8 ISO/IEC standards published as the ISO/IEC 180xx series. These standards have been grouped into three promulgated STANAGs: 4662, 4663, and 4664.

2. SEDRIS provides the concepts, the semantics, and the infrastructure for representing, modelling, and exchanging data from all environmental domains (terrain, ocean, atmosphere, and space) in an integrated manner, including urban and littoral areas, as well as 3D icons/models. While many other standards only deal with a specific subset of the environment (such as terrain surface or

ocean/atmosphere volume), SEDRIS provides an object-oriented approach for representing aspects of the natural and/or human-made environment.

3. SEDRIS provides a Data Representation Model (DRM), augmented with a rich feature/object classification and attribution standard (Environmental Data Coding Specification (EDCS)) and a unified approach for specifying positions and orientations of features/objects (Spatial Reference Model (SRM)), which in combination allow a wide range of environmental data and objects to be expressed, represented, and modelled. These three components are the major SEDRIS standards:

a. DRM, a data representation model encompassing data requirements of synthetic environments used in every type of simulation application – current;

b. EDCS, a mechanism to specify the environmental components that a particular data model construct is intended to represent – current; and

c. SRM allows the context in which coordinates, directions, and distances are defined to be known succinctly, and converted accurately into multiple definitions and representations of geo- and non-georeferenced space – current.

4. Each has a corresponding API specification and a language-binding standard (both of which are current). The suite of standards is rounded by two other standards that allow exchange of data expressed using the above components: the abstract transmittal format and the SEDRIS Transmittal Format (STF) (both of which are current). The EDCS and the SRM, and their associated APIs and language-binding standards, are each designed to be standalone and can be used separately from the other components.

3.2.6.2. Data Sources and Formats

This subcategory entirely comprises standards from the geospatial community and so they are not listed in the NMSSP. In common use in M&S are: Digital Terrain Elevation Data (DTED), Keyhole Markup Language (KML), Shapefile and GeoTIFF.

3.2.6.3. 3D-Models

With the exception of OpenFlight this standards subcategory includes standards borrowed from other communities such as X3D (XML 3-Dimensional), and COLLAborative Design Activity (COLLADA). OpenFlight is a commercial “de facto” standard, a file format for describing 3D-scenes and entities.

3.2.6.4. Interchange and/or Sharing of Environmental Data

1. This subcategory contains standards that are specific to environmental data and should not be confused with those in the previous category which are relative to Imagery and 3D-Models. The main purpose of the standards listed here is not to

model entities or large physical spaces but to support the reuse of environmental databases.

2. SEDRIS Transmittal Format (STF) is listed in this subcategory. It should be noted though that Geographic Markup Language (GML) and City Geography Markup Language (CityGML) are heavily used for M&S purposes.

3. STF enables the exchange of environmental data between different systems and applications by providing a common intermediate format. STF is one of the ISO/IEC SEDRIS standards.

4. CDB is an open standard that describes the data formats, naming conventions and metadata for elevation, imagery, vector and 3D model data. A CDB dataset can be used as either a run-time database for simulations or as a data repository for that can be converted or shared to other runtime formats. CDB is not a true database; it is a collection of files that are saved with very specific naming conventions and metadata schemas. The files are all common formats that can be edited by a number of standard tools.

3.2.6.5. Production Processes

1. An international standard that describes accepted practices and processes for producing an environmental database does not exist yet. Some processes exist, but they are typically the result of contracted activities for large military projects such as the Synthetic Environment Core Master Terrain Database process (SE Core MTDB) of the US Army or the Naval Aviation Simulation Master Plan (NASMP) Portable Source Initiative (NPSI) of the US Navy.

2. No production processes have been proposed for standardization and none satisfies the selection criteria described in Chapter 2. Their commercial ties or specificity prevents them from being included in this profile.

3. Since the spring of 2010, SISO members have been developing RIEDP that is expected to culminate as a future standard.

3.2.6.6. Visual System Interfacing

The Common Image Generator Interface (CIGI) standard details an interface designed to promote a common way for a host device to communicate with an image generator. CIGI is defined by SISO-STD-013-2014 approved 22 Aug 2014.

3.2.6.7. Multiple

SEDRIS is an example of a product that encapsulates multiple standards.

3.2.7. Simulation Analysis and Evaluation Standards

This category has been recognized as important but, unfortunately, no official or “de facto” standard could be identified for this domain.

3.2.8. M&S Miscellaneous Standards

This category contains those standards that do not readily fall into any of the other categories. As yet, there are no M&S specific standards available identified under the miscellaneous banner.

3.3. SUMMARY

The following table summarizes the grouping of M&S standards in categories and sub-categories. Note that this includes standards identified as being “Emerging”. Note also that some standards in the table below can be relevant to one or two categories/sub-categories (overlapping standards – see also Table C-1 in Annex C).

M&S SPECIFIC STANDARDS IDENTIFIED		
Categories	**Sub-categories**	**Standards attached to the category**
M&S methodology, architectures and processes	**Architecture Frameworks**	*None M&S Specific*
	System Engineering Processes	***Mandated*** DSEEP ***Current*** DMAO
	V&V	***Current*** SISO GM-VV VV&A RPG (US DoD) VV&A Templates (US DoD) ***Obsolete*** V&V Overlay on HLA FEDEP
Conceptual Modelling and Scenarios		***Current*** BOM MSDL Link 16 Simulation ***Emerging*** GSD Link 11 Simulation
M&S Interoperability		***Mandated*** HLA ***Current*** DIS FEAT UCATT ***Emerging*** WebLVC ***Obsolete*** DLC API
Information Exchange Data Model		***Mandated*** Enumerations for Simulation ***Current*** HLA OMT

		BOM Link 16 Simulation RPR FOM NETN FAFD C-BML MSDL ***Emerging*** Link 11 Simulation C2SIM Space FOM
Software Engineering		*None M&S Specific*
Synthetic Natural Environment	**Data sources and formats**	*None M&S Specific*
	3D Models	***Current*** OpenFlight
	Interchange of environmental data	***Current*** SEDRIS STF CDB ***Emerging*** RIEDP
	Production processes	***Emerging*** *RIEDP*
	Visual Systems Interfacing	***Current*** CIGI
	Multiple	***Current*** SEDRIS
Simulation Analysis and Evaluation		*None M&S Specific*
M&S Miscellaneous		*None M&S Specific*

Table 1 – M&S Specific Standards Identified

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CHAPTER 4 GAPS

1. Chapter 3 lists and categorizes many M&S standards, which are described in Annex C. However MS3 participants acknowledge that M&S standards gaps remain that prevent the achievement of the important goals of M&S re-use and interoperability. This assessment is shared by partners outside of NATO, such as SISO, and is reflected in their ongoing standardization activities. This chapter discusses the gaps that have been identified in each of the standards categories that were introduced in Chapter 3.

2. In addition, the areas of Human Behaviour Representation (HBR) and live simulation, which MS3 participants unanimously agreed were both particularly important, are not sufficiently covered by standards although matters are improving with Urban Combat Advanced Training Technology (UCATT) in the live domain..

3. Although HBR has seen significant progress recently, partly due to the methods and tools developed in the gaming industry, the current modelling techniques are difficult to analyse because they are mainly proprietary. . The current NMSG and HFM cross-panel initiative MSG-127 aims to address this issue by developing initial proposals for a common Reference Architecture for Human Behaviour Modelling. However, HBR is a challenging problem and significant R&D effort is needed to achieve more interoperability and standard interfaces between these models and tools.

4. Historically, Live training systems were often proprietary, developed by individual vendors and with limited or no interoperability between different vendors or even across a vendor's product line. Successive NATO working groups comprising procurement offices, military and industry, (including MSG-032, MSG-063, UCATT-1, UCATT-2, MSG-098 UCATT Architecture, MSG-099, UCATT Standards and MSG-140 UCATT Live Simulation Standards) have tackled these issues.

UCATT has established the concept of a family of standards under the governance of SISO. The first of these standards to be made publicly available is the Standard for UCATT Laser Engagement Interface, SISO-STD-016-00-2016. In addition an overarching guidance and a reference document have been created. UCATT also provides SISO with required Product Development Group (PDG) as well as with the Product Support Group (PSG) for the existing product.

The MS3 recognises, however, that still much more work is required before open M&S standards fully enable the targeted interoperability of live training systems both with other live systems or with virtual or constructive simulations.

5. Other standards for modelling specific military domains are available or expected, such as SISO's modelling of Tactical Data Links. Although standards for modelling all military entities, organizations, and their individual and aggregate behaviours are lacking, HBR is only one example of areas that have been identified as clearly requiring M&S standards, as previously discussed.

4.1. M&S METHODOLOGY, ARCHITECTURES AND PROCESSES

4.1.1. Architecture Frameworks (AFs)

1. Concerning Architecture Frameworks (AFs), no significant gaps have been identified as numerous national and open standards are available. Example AFs include:

   a. The NATO AF (NAF), which is based on the DoDAF.

   b. The Open Group AF (TOGAF), which is open source;

   c. The United States of America (USA) Department of Defense AF (DoDAF), which is probably the best known and used by multiple nations;

   d. The Canadian Dep. of National Defence AF (DNDAF); and

   e. The UK Ministry of Defence AF (MoDAF)

2. Of course none of the above is M&S specific so that they have not been included in the NMSSP. MS3 continues to recommend NAF in favour of national derivatives.

3. Although the identified AFs are generally well suited to the development of individual systems, they are considered to have weaknesses at the "system-of-systems" level. Fortunately, the limitations are not considered significant for NMSG purposes.

4.1.2. System Engineering Processes

1. Systems engineering standards are mature and numerous, and many may be tailored to simulation system engineering. Other engineering processes may also be tailored to the development of distributed simulation systems and SISO DSEEP (IEEE 1730-2010) should provide the M&S community with an even more general and adaptable process. Existing overlays, e.g. the DSEEP Multi-Architecture Overlay (DMAO) provide additional guidance on tailoring the process for specific applications. New technologies such as M&S as a Service (MSaaS) that are addressed in MSG-136 task group will also benefit from additional DSEEP overlays. Thus, simulation system engineering is in general considered as well covered, but continuously needs to investigate and include new technologies.

2. The only gap identified in this subcategory is the lack of an engineering process dedicated to the development and exploitation of standalone simulations.

4.1.3. Verification and Validation (V&V) Standards

1. The number of V&V standards reflects the general consensus that the topic is very important and significant effort is needed to support it. The number of standards also suggests that V&V is adequately addressed; however, observations have been made as follows:

a. Some of the standards are old, not evolving and/or obsolete; examples include the European REVVA1, REVVA2 and ITOP "V&V Information Exchange" standards;

b. Many V&V efforts, such as the US DoD RPG, are national and the resulting standards are shared but not unanimously adopted by other nations. In fact, there are two internationally recognized standards that have been developed to date: the SISO GM-VV and the IEEE 1516.4 "VV&A Overlay on the HLA FEDEP" but it is recognized that work has commenced on a replacement focussing on DSEEP rather than FEDEP;

c. No international standard exists to support the V&V and certification of simulation input data; and

d. No methodology or process exists to support the V&V of HBR due to the unpredictable nature of humans.

2. Thus, the current set of standards is inadequate. However, the SISO and NMSG developed GM-VV standard provides a common approach that NATO should adopt.

4.2. CONCEPTUAL MODELLING AND SCENARIOS

1. Concerning conceptual modelling, the MS3 emphasizes the importance of a standardised guidance document to support the following:

a. The translation of M&S sponsor/user requirements into M&S technical specifications; and

b. The lifecycle of V&V of M&S systems and model input data.

2. The Task Group MSG-058 completed its final report (see reference 1.1.3.7), which provides a draft guide on Conceptual Modelling (CM). Past efforts of both SISO and NATO have resulted in many documents addressing this topic. Several available standards are applicable to support CM. Examples are as follows:

a. SISO's Base Object Models (BOMs) and Real-time Platform Reference Federation Object Model (RPR FOM); and

b. The OMG's Unified Modelling Language (UML), XML Metadata Interchange (XMI), Model Driven Architecture (MDA) and Systems Modelling Language (SysML) although these latter ones are not M&S specific.

3. These standards, many of which are data format specifications, do not address all CM issues. However, they are expected to be referenced in any guidelines or standards that are developed for CM.

4. The Web Ontology Language (OWL) also appears relevant to CM; however, it was not included in this profile because its impact has not yet been adequately assessed.

5. The only known M&S scenario standard is SISO's MSDL which has its origins in the army/land-domain. With the unification of MSDL and C-BML under C2SIM, MSDL will be superseded by C2SIM-Initialize. The Task Group MSG-145 Operationalization of Standardized C2-Simulation Interoperability is working in collaboration with the SISO C2SIM PDG.

4.3. M&S INTEROPERABILITY

1. Many standards exist in this category. IEEE DIS and HLA, the US DoD Test and Training Enabling Architecture (TENA), and non-M&S standards like Data Distribution Service (DDS), the Object Management Group (OMG) Common Object Request Broker Architecture (CORBA) and Web Services are just a few. So many standards exist that the USA has completed an activity to assess how to improve the current situation called LVC Architecture Roadmap (LVCAR). The LVCAR results point in the direction of merging the existing standards without formally mandating the use of a single particular standard or developing an entirely new standard. The first activities towards this goal are to develop common data interchange models and templates for federation agreements (e.g. Federation Engineering Agreements Template (FEAT)).

2. Although so many interoperability standards exist that they often overlap, pertinent issues must be considered as follows:

a. The various standards address different requirements and provide specialized solutions; for instance, one could think that standards may be created for real-time simulation and another for non-real-time simulation but, in many cases, there is a need to mix different time-management engines. No standard has ever tried to address every conceivable M&S issue because the need for such a comprehensive standard has never arisen and, presumably, the task would be too daunting.

b. A standard may address some key requirements in great detail, more general requirements in less detail, and not address some M&S requirements at all. For instance, the HLA standard specifies the federate Run Time Infrastructure (RTI) interface in great detail, rules for federation design in general terms, and nothing at all about how to model (military) systems. Thus, the HLA standard by itself is not sufficient to achieve interoperability; for example, additional agreements

and data model definitions are also required. This also applies to most other simulation interoperability standards identified in the NMSSP.

c. Existing interoperability standards address "technical" interoperability, which mostly deals with the transfer of data between simulations and time synchronization issues, rather than interoperability on higher levels (i.e. semantic and pragmatic interoperability), which deals with the much more difficult problem of ensuring that all simulations treat shared data in a consistent and appropriate manner.

d. Documentation standards do not exist that enable any developer to readily determine if two or more models are interoperable for a specific purpose. Specifications must be available that define the following items:

(1) What a model represents - for instance, a particular ship, a typical organization, a person, a chemical process, etc.;

(2) Its acceptable input values;

(3) The range of its output values;

(4) The model behaviour, that is, how its outputs depend on its inputs; and

(5) Any assumptions that were made during model development and its intended use.

e. The data listed above is rarely available, much less in a form that readily supports convenient or automated determination of model interoperability. A well-defined conceptual modelling standard is crucial to enable the achievement of substantive interoperability of simulations.

f. The only simulation interoperability standard that has been adopted via a STANAG by NATO is the HLA (STANAG 4603). Still, many nations continue to use and build systems using other standards (notably DIS) and few, if any, expect the HLA to ever be the only standard in use.

g. Due to the level of effort required and the costs involved, a system built using one M&S standard is rarely converted to another; instead, one system is interfaced to another using some form of gateway when the two must be made interoperable. Such an approach has significant limitations and cannot provide the level of interoperability that is sought by the NATO M&S community.

3. The above observations indicate that multiple M&S interoperability standards exist, but collectively they - and especially the lone STANAG - are far from adequate for ensuring M&S interoperability and re-use. Although a single standard is highly desirable, multiple standards must be accommodated for the foreseeable future,

especially if legacy systems are to be incorporated into new M&S systems. Further, multiple standards will be required to ensure substantive interoperability of models - and models interfaced to the real world, which is even more complicated - because no single M&S standard is expected to be sufficiently comprehensive. However, given the fact that some of the existing standards may partly overlap in capability, we do need more guidance on when to use a particular standard. The NATO M&S community should work out recommendations regarding the preferred solution for a particular type of application or problem. This recommendation should be formalised in a STANAG or in the NMSSP.

4. The Task Group MSG-086, Simulation Interoperability compiled a detailed catalogue of 45 issues that limit simulation interoperability. All issues are documented in detail and possible solution approaches are identified. One major finding of MSG-086 (besides the issue catalogue) is that simulation interoperability needs to be addressed in a holistic way along the whole simulation environment engineering process (e.g., DSEEP). Similarly, simulation interoperability is not primarily a technical issue. Achieving simulation interoperability requires efforts and standardization on the technical, the syntactical, the semantic, and the pragmatic level. Focusing only on standards for distributed systems or reuse of components will not lead to true simulation interoperability.

5. Another gap in interoperability standards is related to event-driven simulations, which are widely used in the military M&S domain. The following issues have been identified:

a. The concepts are only being standardised by academic and early SISO PDG efforts, which do not necessarily address the concerns of NATO or the militaries of its member nations.

b. Numerous COTS products are not interoperable; although this gap was examined by the SISO COTS Simulation Package Interoperability (CSPI) standard, there is still some way to go.

c. HLA addresses the interoperability of event-driven simulations and real-time applications but improvements are possible.

6. Thus, relevant standards for event-driven simulations are forthcoming; however, gaps in standards are likely to persist for a number of years because standards development as well as adoption, typically take five years.

7. A specific area of interoperability that requires attention is component based simulations. This topic addresses both traditional components (e.g. image generator, sensor simulation, propulsion etc.) that could be connected through middleware (e.g. HLA RTI) or as linked software libraries (e.g. DLLs) as well as a more ’service oriented’ solution. The first approach was investigated by the Exploratory Team MSG ET-044 on Modular Game Architectures. The additional challenge here is to provide the efficiency and performance sought by commercial game vendors. Solutions could perhaps be found in machine readable Interface Definition Languages (IDL) allowing tight integration of reusable components after compilation and linking. The service

oriented approach is addressed by MSG-136 MSaaS Task Group and may lead to more flexibility and facilitate composability.

4.4. INFORMATION EXCHANGE DATA MODEL

1. The HLA FOM can be thought of as an Information Exchange Data Model (IEDM). The most common being the RPR FOM mentioned earlier. MSG-106 produced the NATO Education and Training Network (NETN) FOM, which extends the RPR FOM to add capability without breaking backwards compatibility. Both the RPR and NETN FOMs are designed only for simulation interoperability and not simulation to C2.

2. This modular NETN FOM should be further developed and extended. Areas that should be addressed are:

   a. Cyber effects;

   b. Space (noting SISO Space FOM activity);

   c. Maritime (e.g. AIS messages); and

   d. (low-level) BML (extend work of MSG-106, MSG-085).

3. Many other Information Exchange Data Model (IEDM) standards are available, but not many are suitable for M&S. A well-known military standard is the Joint Consultation Command and Control IEDM (JC3IEDM), developed by the Multinational Interoperability Programme (MIP) and has been ratified under NATO STANAG 5525. JC3IEDM is a large one-to-many relational database model that was designed for C2-C2 interoperability. M&S was never considered during its design. Typically C2 update-rates are of the order of minutes as opposed to fractions of seconds in DIS or HLA simulations. MIP have developed the successor to JC3IEDM, the MIP Information Model (MIM).

4. C-BML is also an IEDM and it during its development many concepts were borrowed from the JC3IEDM. The new C2SIM effort from SISO and MSG-145 is developing the C2SIM Logical Data Model (LDM). The LDM development team are also following the developments of the MIM.

5. Tactical Datalinks (TDL) are a critical aspect of military systems (sensors, shooters, C2). Several data models are currently available to represent datalink information exchange (e.g. SIMPLE PDU, SISO Link16 module). New developments (e.g. Variable Message Format (VMF) covered in MIL-STD-6017, Link 22 etc.) have not yet been adequately covered. In addition there are several interoperability standards (see 4.3 M&S Interoperability) in use for Datalink communication (e.g. SIMPLE, HLA with SISO Link 16 module). This situation leads to many gateways and adapters in distributed simulation instances. A rationalisation would be desirable to improve interoperability and maintenance. In addition new requirements should be addressed related to propagation effects and cyber effects.

4.5. SOFTWARE ENGINEERING

1. Gaps related to software engineering are difficult to assess because so many issues are involved. However, considering the size of the software development industry and plethora of software engineering standards available, many gaps may be considered filled and any remaining are likely to be addressed in standards under development by the OMG, the World Wide Web Consortium (W3C), etc.

2. Even if the M&S community identifies gaps in software engineering standards, the M&S community is not likely to have a significant influence on the development of new standards because software engineering standards usually address the concerns of all possible users, not just those of a special interest group. This lack of influence might be considered a concern, but in practice, it has not been a significant issue; the M&S community has long been very successful in adopting state-of-the-art software engineering tools and techniques to its needs, whether or not they were specifically developed for M&S. The MS3 expects this trend to continue.

4.6. SYNTHETIC NATURAL ENVIRONMENT

4.6.1. Data Sources and Formats

1. This category contains a significant number of formats, most of which have been in use for many years. Collectively, they address many “traditional” M&S requirements such as terrain elevation data and geospatial features but they do not cover expected future M&S requirements very well.

2. As demands for ever more sophisticated M&S continues, the demands for more detailed environmental data will follow. For instance, time-variable data will undoubtedly be required, especially as live, virtual and constructive simulations are combined, to ensure synchronization between the real and simulated worlds. Such data is necessary to represent tidal data, river widths, snow cover, rain, clouds etc. Thus, existing standards will need to be heavily modified or new ones developed.

4.6.2. 3D Models

1. This category has a number of very well established standards such as OpenFlight, which is undoubtedly the most popular standard for databases of 3D models, many of which are not M&S specific. The OpenFlight specification is owned by Presagis, and is not an open standard although it is readily accessed. Its commercial ties are a significant obstacle to its adoption as an official standard of nations. OpenFlight also has significant deficiencies particularly in the areas of animation and articulation. The leading alternative, COLLAborative Design Activity (COLLADA), is conversely too loose allowing too many margins to be exploited around the standard without control.

2. XML 3-Dimensional (X3D), the successor to Virtual Reality Modelling Language (VRML), is relatively new and is very unlikely to replace OpenFlight in

popularity. X3D models can be used within HTML5 which could enable 3D through a web browser.

3. The ‘de facto’ standards such as OpenFlight are so well established that they cannot be dismissed as inappropriate for NATO purposes, either. Thus, this category would benefit from additional standards options in theory; unfortunately, the development effort might not be worthwhile given that the de facto standards are so well entrenched.

4.6.3. Interchange of Environmental Data

This category mainly emphasizes the STF, which is an ISO/IEC standard. Since its use is limited to SEDRIS-based concepts and some situations may only involve environmental data in other formats, it could be argued that additional standards are required. However, this situation is exactly what the suite of SEDRIS standards was designed to address, that is, how best to interchange geospatial data from one format into another given that there are a huge number of possible conversion combinations. Thus, until such time that the SEDRIS suite is shown to be inadequate for interchanging environmental data between some combinations of formats, this category is considered to have an adequate standard. Considering other data formats that could be used to exchange environmental data, it should be noticed that they mainly cover terrain data (the traditional “geospatial/GIS data) and not the full geospatial environment and not general requirements for exchanging environment representation.

4.6.4. Production Processes

1. This category definitely has a significant gap in standards. One of the major problems in developing simulations is environmental database preparation including such activities as ensure all data sets are aligned. When data from multiple sources is combined, mismatches invariably occur so a single source of data is preferred. However, this approach hinders multinational collaborative efforts.

2. If environmental data production was subject to standardised production processes, presumably data from multiple sources could be combined more easily and with fewer unexpected results. Such standards would facilitate data sharing and collaborative development efforts.

3. Under SISO, the Reuse and Interoperation of Environmental Data and Processes (RIEDP) PDG is addressing issues regarding the harmonization of environmental data representations and generation processes. In addition, it is also addressing an objective to retain the data form (or format) as close to the source data as possible in order to benefit from Geographic Information System (GIS) tools, while at the same time keeping the internal data consistency (intrinsic correlation factor).

4.6.5. Visual Systems Interfacing

This category is not specific to M&S and, except CIGI, no other visualisation standard is included in this version of the NMSSP. Some existing standards were identified but they were only partially assessed by the MS3. Nevertheless, evidence suggests that gaps exist in standards for M&S visualisation.

4.6.6. Multiple (of the Above Categories)

Standards in this subcategory are supposed to be broadly applicable and their emphasis is the synthetic natural environment, unlike those in the following subcategories which are much more “file-format” centric. Although SEDRIS is the most general, it has not been as widely adopted as it might have been. Its generality comes at the cost of complexity and admittedly, the success of other competing geospatial standards. Thus, the flexibility of SEDRIS is a double-edged sword. One or more standardised means of modelling common environmental features could simplify its use and subsequently increase its number of users.

CDB has the potential to fill some of the gaps that are currently experienced when representing the synthetic natural environment. It makes use of many of the geospatial standards already mentioned.

4.7. SIMULATION ANALYSIS AND EVALUATION

1. On one hand, the lack of standards in this category is understandable. Simulations can be used for an endless number of purposes and a matching-that is, endless-number of analysis standards is required in principle. Fortunately, simulation results may often be analysed using a combination of general purpose statistical methods, subject matter expertise, and application-specific standards, such as knowledge of emergency aircraft landing procedures. Thus, analysis techniques are already well defined in M&S application areas and such techniques do not need to be “recreated” as M&S related.

2. The above suggests that standards for simulation analysis and evaluation should be independent of any particular application area. They should address issues related to M&S technology, such as how to structure and replay simulation data using open-source viewers, and documentation standards that are broadly applicable. The latter might be very useful when documentation standards that do not exist for an application area of concern.

4.8. M&S MISCELLANEOUS

1. There are two gaps identified in this category, the lack of a standard to support the integration of simulation in distant learning courses and the issue of addressing security in distributed simulation.

2. Education and training have a high priority in NATO and some successful prototypes have been developed in the USA to demonstrate simulation and e-learning interoperability. While the IEEE Sharable Content Object Reference Model (SCORM) is a well-known standard that enables the sharing of course materiel

between different platforms, a SCORM extension to support on-line integration of simulations in course content does not exist. The impact on the M&S domain regarding technology to trace and monitor student performance (xAPI) should be considered.

3. Information exchange between nations and organizations is often restricted due to the classification levels of data. Distributed simulation is obviously affected by these restrictions also. Information such as weapons or sensor performance may need to be protected without invalidating the Joint or Combined simulation or training objectives. This simulation exercise is in a sense ‘different’ from the real-world due to the often used principle of exchanging ‘ground-truth’ between simulations. The difficult issue of addressing security challenges for M&S is currently not covered by any standards. The Task Group MSG-080 has investigated this problem and made recommendations for the way-ahead.

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CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5.1. PRELIMINARY OBSERVATIONS

1. Considering the large number of M&S standards and guidance documents identified in this profile, it is tempting to declare that the situation is rather satisfactory. Unfortunately, there are some observations that temper this conclusion. A quick assessment shows that there are overlapping standards in some specific areas and some obvious gaps in other areas. Where there are too many "standards" in support of a particular domain it means there is "no real standard", but sometimes many competing technologies or methodologies. Where gaps or unnecessary overlaps are identified in the previous chapters of this Profile, there is a need that NMSG cooperate with the M&S community and, in particular with SISO, in trying to fill the major gaps and align overlapping standards.

2. A second observation is that even where standards do exist, they must be maintained and endorsed by NATO and national organizations. The NMSSP is a suitable guideline document for the relevant M&S standards that should be used in development projects and procurement projects. The Profile needs to be widely disseminated by NMSG and the recommendations regarding standards should be strongly considered by the nations.

5.2. CONCLUSIONS

1. The objective of this publication is to provide guidance regarding modelling and simulation (M&S) standards and processes to NATO and partner nations, as well as national and NATO organizations that have to effectively use M&S in support of NATO and national requirements.

2. In support of this objective it was concluded that:

   a. Given the continuously evolving nature of M&S standards and processes, timely updates and review of the NMSSP guidance document are required to maintain currency of the information;

   b. Given the role and mandate of the NMSG, as the Delegated Tasking Authority for standardization in NATO M&S domain, a sub group of the NMSG is the appropriate body to implement and manage the task of developing and maintaining this publication;

   c. A framework structure was required, taking into account categories or functional areas of M&S standards as well as maturity levels of the various standards and processes;

   d. There are benefits to identifying and using common open standards, recognizing that due to breadth of application of M&S there is no ”one size fits all”;

e. There are many standards in existence that have or may have an indirect impact on M&S activities, such as, for example, system engineering standards. However only those standards directly applicable to M&S development, integration, and employment are considered for inclusion; this document is not intended to be an encyclopaedia of standards;

f. A specific procedure for submission and subsequent evaluation of a candidate standard be utilized to ensure consistency of acceptance for standards into the document;

g. Gaps exist within current standards development regarding certain functional areas of M&S and some gaps exist within current standards regarding breadth of application in a functional area; and

h. Specific efforts should be made by the NMSG and nations to encourage focus on identified gap areas.

5.3. GENERAL RECOMMENDATIONS

It is recommended that:

1. This AMSP-01, the NMSSP, be the document for meeting the NATO M&S guidance objectives, and that it be maintained by the NATO MSCO and made widely available including via the NATO Simulation Resource Library;

2. The NMSG continue tasking the MS3 subgroup to manage the process of review and maintenance of the AMSP-01. In addition, the role of the NATO MSCO as a permanent office in charge of supporting this activity and the focal point is to be emphasized. This NMSG task is to be formalized in the next update of the NATO M&S Master Plan, which is currently in progress;

3. NATO organizations, member and partner nations be encouraged to contribute in offering additional standards for consideration, and consider active participation in the MS3 subgroup;

4. Review and update of the publication be done on a bi-annual basis;

5. Review of the framework of categories and maturity levels be included in the periodic review;

6. Review of the selection criteria be part of the periodic review;

7. The procedure for submitting standard to be added to the profile;

8. The NMSG actively solicit support of SDOs to address gap issues. This supposes a large diffusion of the AMSP-01 inside and outside NATO; and

9. The NMSG should continue developing and maintaining the NATO M&S Terminology in the framework of NATOTerm database that covers terms and definitions that are relevant to the NATO M&S domain in consistency with national glossaries.

5.4. RECOMMENDATIONS ON STANDARDS DEVELOPMENT

1. The recommendations are as follows:

   a. Additional efforts need to occur to align national and international efforts on V&V; cultural differences of nations are slowing down the elaboration of international standards;

   b. Standardization trends in the development of engineering processes dedicated to simulation are generally satisfactory considering current harmonization efforts taking place in SISO; nevertheless there is a need to integrate, in the emerging and recently approved DSEEP, main concepts developed in Architecture Framework efforts which are currently too diverse;

   c. Efforts on standards for describing, archiving and reusing scenarios, orders and reports need to be continued and even reinforced in cooperation with the C2 community based on its current reference standards like JC3IEDM. The M&S community should carefully follow MIM development and contribute elements that support C2-Simulation interoperability;

   d. The service oriented approach which is addressed by M&S as a Service (MSaaS) should continue and contribute to the M&S interoperability standards in the future

   e. Efforts on standards for describing, archiving and reusing simulated Human Behaviour Representation (HBR) need to be continued and even reinforced in cooperation with the Human Factors and Medicine community. In particular, the non-kinetic aspects need attention. The M&S community should contribute its expertise in suitable architectures for behaviour models and interoperability between computer generated elements and live players;

   f. Considering modelling aspects, requirements are sometimes specific to a particular community of interest, such as Tactical Data Links; those communities are encouraged to draft their own standards as required and publish them to contribute to the M&S body of knowledge;

   g. The M&S community cannot influence software engineering evolutions but shall monitor this domain to take profit of emerging technologies as it was successfully done in the past;

g. M&S interoperability is a primary concern of NATO; efforts have to be maintained to improve the current situation of overlapping standards and make progress in direction to substantive interoperability; and

h. Data standards are a weak area of the overall standardization activity; there is a need to start a general reflection about the data issue in NATO, all the more important as NATO is initiating large simulation programs in support of education and training

2. Standardization efforts targeted to representation and visualization of simulated natural and human-made environment are even more critical realizing that “de facto” standards, commercial products and SEDRIS are competing; there is a lack of coordinated effort and of a general policy in this domain and the idea of a collective reflection should be promoted and better specified.

ANNEX A - NATO M&S STANDARDS PROFILE (NMSSP) – M&S STANDARDS SUBMITTED TO THE NISP

Categories	Sub-categories	Standards attached to the category
M&S methodology, architectures and processes	**Architecture Frameworks**	*None M&S Specific*
	System Engineering Processes	***Mandated*** DSEEP ***Current*** DMAO
	V&V	***Current*** SISO GM-VV VV&A RPG (US DoD) VV&A Templates (US DoD) ***Obsolete*** V&V Overlay on HLA FEDEP
Conceptual Modelling and Scenarios		***Current*** BOM MSDL Link 16 Simulation ***Emerging*** Link 11 Simulation
M&S Interoperability		***Mandated*** HLA ***Current*** DIS FEAT HLA UCATT ***Emerging*** WebLVC ***Obsolete*** DLC API
Information Exchange Data Model		***Mandated*** Enumerations for Simulation ***Current*** HLA OMT BOM Link 16 Simulation RPR FOM NETN FAFD C-BML ***Emerging*** Link 11 Simulation C2Sim
Software Engineering		*None M&S Specific*

Synthetic Natural Environment	**Data sources and formats**	***Current*** CDB
	3D Models	***Current*** OpenFlight
	Interchange of environmental data	***Current*** SEDRIS STF CDB ***Emerging*** *RIEDP*
	Production processes	***Emerging*** *RIEDP*
	Visual Systems Interfacing	***Current*** CIGI
	Multiple	***Current*** SEDRIS
Simulation Analysis and Evaluation		*None M&S Specific*
M&S Miscellaneous		*None M&S Specific*

Table A-1 – M&S STANDARDS SUBMITTED TO THE NISP

ANNEX B - STANDARD DESCRIPTION TEMPLATE

Standard Title: *Full title of the standard*

Standard Identifier: *Unique identifier; could be the one provided by an SDO.*

Version Identifier: *Alpha indicators designating Editions and Amendments.*

SDO:

STANAG/STANREC identifier:

STANAG/STANREC status: *(Study Draft, Approval/Ratification Draft, Ratif. Withdrawn, Promulgated, Inactive, Superseded, Cancelled)*

Abstract: *Description of the standard.*

Technical Maturity: *Description of how mature the standard is, e.g., how long it has been in evolution or existence, have implementations been developed, etc.*

Applicability: The intended uses of the standard.

Information on implementation: *Specific examples of how the standard has been used in programs and products within individual Nations and in NATO.*

Limitations of this Standard:

Standard Type: *Conceptual Modelling & Scenarios, M&S Interoperability, etc (see Ch. 3).*

Public Availability: *How the standard can be accessed by the general public*.

URL or instructions to Access or Acquire:

Input Date: *Date the standard was included in the AMSP-01.*

Last Updated: *Date of last update for the standard metadata.*

Keywords:

INTENTIONALLY BLANK

ANNEX C - STANDARDS WITH APPLICABILITY TO NATO M&S DOMAIN

STANDARD	CATEGORIES														
	M&S Methodology, Architectures and Processes			Conceptual Modelling & Scenarios	M&S Interoperability	Information Exchange Data Model	Software Engineering	Synthetic Natural Environment						Simulation Analysis & Evaluation	M&S Miscellaneous
	Architecture Frameworks	System Engineering Process	V&V					Data Sources & Formats	Imagery & 3D Models	Interch Environmental Data	Production Process	Visualisation Systems Interfacing	Multiple		
BOMs				**X**		x									
C-BML						**X**									
CDB								**X**							
CIGI												**X**			
DIS					**X**										
DMAO		**X**													
DSEEP		**X**													
Dynamic Link Compatible (DLC) HLA API					**X**										
Enumerations for Sim						**X**									
FEAT					**X**										
GM-VV			**X**												
HLA					**X**										
HLA - OMT						**X**									
Link 11 Simulations				x		**X**									
Link 16 Simulations				x		**X**									
MSDL				x		**X**									
NETN FAFD						**X**									
OpenFlight									**X**						
RPR FOM						**X**									
SEDRIS DRM													**X**		
SEDRIS EDCS													**X**		
SEDRIS SRM													**X**		
SEDRIS STF										**X**			x		
UCATT					**X**										
VV&A RPG			**X**												
VV&A Templates			**X**												
Web LVC					**X**										

Table C-1 – STANDARDS WITH APPLICABILITY TO NATO M&S DOMAIN

Note:
Some standards in the above table can be relevant to one or two categories. In this case a capital 'X' indicates its main category while a low case 'x' indicates the secondary one (see section 3.3 above).

Base Object Model (BOM)

Standard Title: Base Object Model (BOM)
Standard Identifier: This standard is comprised of two documents**:**
1. the "BOM Template Specification", SISO-STD-003-2006,
2. the "Guide for Base Object Model (BOM) Use and Implementation", SISO-STD-003.1-2006

Version Identifier: SISO-STD-003, year of publication: 2006
SDO: SISO
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: Base Object Models (BOMs) provide a component framework for facilitating interoperability, reuse, and composability. The BOM concept is based on the assumption that piece-parts of models, simulations, and federations can be extracted and reused as modelling building-blocks or components. The interplay within a simulation or federation can be captured and characterized in the form of reusable patterns. These patterns of interplay are sequences of events between simulation elements. The representation of the pattern of interplay is captured in the first BOM document. [Reference SISO-STD-003-2006]. The second document, the “Guide for Base Object Model (BOM) Use and Implementation”, introduces methodologies for creating BOMs and implementing them in the context of a larger simulation environment. The document is a means of familiarizing the reader with the concept of BOMs and providing guidance for BOM development, integration, and use in supporting simulation development. [Reference SISO-STD-003.1-2006]
Technical Maturity [Current]: The BOM specification and guide were published by SISO in 2006. First uses of BOMs were known to be successful.
Applicability: The BOM template has constructs that allow the expression of 1) a conceptual model (in terms of events and states), 2) a data exchange model based on the HLA OMT, and 3) the relationships between 1 and 2. Parts 1 and 2 can be use independently or together in combination with part 3. BOMs are intended to improve the reusability and composability of models, simulations and federations.
Information on implementation: Some evidence of successful initial use in the USA and France.
Limitations of this Standard: A more concise, but less rich in semantics, as compared with other generalized modelling standards such as UML. Specifically targeted to, but not limited to M&S.
Standard Type: Conceptual Modelling and Scenarios
Public Availability: The standard’s specification and guide can be accessed on the SISO website under the "products" heading.
URL or instructions to Access or Acquire: www.sisostds.org and www.boms.info
Input Date: 8 April 2008
Last Updated: 4 Aug 2017
Keywords: Automation, Behavior, BOM, Components, Composability, Conceptual Model, FEDEP, Interoperability, Metadata, Patterns, Requirements, Reuse

C-BML

Standard Title: Standard for Coalition Battle Management Language (C-BML) Phase 1, Version 1.0.
Standard Identifier: SISO-STD-011-2014
Version Identifier: 1.0
SDO: SISO
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: A Battle Management Language (BML) is an unambiguous language used to (a) Command and control forces and equipment conducting military operations and to (b) Provide situational awareness and a shared, common operational picture.
BML is particularly relevant in a network centric environment for enabling mutual understanding. A Coalition BML developed and applied by the all Services and by coalition members would not only allow interoperability among their C2 systems and simulations, but also among themselves. As it is almost impossible to imagine a situation in the future when a single Service will be unilaterally employed, these efforts must be embedded into international standards. Because future military operations, and a significant amount of training, will be Joint in nature, it is critical that a Joint Service approach be taken to the BML development effort.
The Coalition Battle Management Language (C-BML) is a standard language for expressing and exchanging plans, orders, requests, and reports across command and control (C2) systems, live, virtual and constructive (LVC) modelling and simulation (M&S) systems, and autonomous systems participating in coalition operations. C-BML task representation is organized according to the 5Ws (Who, What, When, Where, Why). The C-BML standard describes a sufficient data model to unambiguously define a set of military orders that can be interpreted by C2, M&S, and ultimately autonomous systems. The standard describes the data model as a subset of JC3IEDM and specifies the information exchange content and structure in the form of an Extensible Markup Language (XML) schema. The development of a second generation of standards – C2SIM, unifying MSDL and C-BML, are being undertaken by a single SISO C2SIM PDG.
Technical Maturity [Current]: Version 1.0 of the C-BML was approved 14 Apr 2014. Different experimentations have been completed which prove the validity of this concept.
Applicability: Any significant effort to leverage interoperability between C2 systems and simulations.
Information on implementation: Many experiences in different nations and MSG-activities with predecessor activities that have led to the current standard.
Limitations of this Standard: The first version of C-BML is based on an XML schema; later versions will include a standardized approach to extensibility.
Standard Type: Information Exchange Data Model
Public Availability: Via SISO web site
URL or instructions to Access or Acquire: www.sisostds.org
Input Date: 19 March 2008
Last Updated: 16 April 2017
Keywords: C2, Simulation, MSDL

CDB

Standard Title: CDB
Standard Identifier: CDB
Version Identifier: 1.0
SDO: Open Geospatial Consortium (OGC)
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: Intention of the CDB standard is to define the organization and storage structure of a worldwide single synthetic representation of the earth. It makes use of several commercial and simulation data formats (including e.g. TIFF, GeoTIFF, JPEG 2000, OpenFlight, and Shape) endorsed by leaders of the database tools industry. It uses the computer's native file system to store data in files and directories. A CDB data store thus contains a number of datasets organized in tiles, layers, and levels of detail (LODs), representing the features and models of a synthetic environment for the purposes of distributed simulation applications.
The CDB standard is composed of the below series of associated OGC documents approved 2016-09-23, defining rules and guidelines for data representation of real world features.

Document Title	Document #	Type*
Volume 0: Primer for the OGC CDB Standard: Model and Physical Data Store Structure	15-120r4	BP
Volume 1: OGC CDB Core Standard: Model and Physical Data Store Structure	15-113r3	IS
Volume 2: OGC CDB Core: Model and Physical Structure: Informative Annexes	16-005r2	BP
Volume 3: OGC CDB Terms and Definitions	15-112r2	IS
Volume 4: OGC CDB Best Practice use of Shapefiles for Vector Data Storage	16-070r2	BP
Volume 5: OGC CDB Radar Cross Section (RCS) Models	16-004r3	BP
Volume 6: OGC CDB Rules for Encoding Data using OpenFlight	16-009r3	BP
Volume 7: OGC CDB Data Model Guidance Formerly Annex A Volume Part 2	16-010r3	BP
Volume 8: OGC CDB Spatial and Coordinate Reference Systems Guidance	16-011r3	BP
Volume 9: OGC CDB Schema Package		Schema
Volume 10: OGC CDB Implementation Guidance	16-006r3	BP
Volume 11: OGC CDB Core Standard Conceptual Model	16-007r3	IS
Volume 12: OGC CDB Navaids Attribution and Navaids Attribution Enumeration Values	16-003r2	BP

** where Type stands for:*

- *BP: OGC Best Practice*
- *IS: OGC Implementation Specification*
- *Schema: OGC Schema Package*

Warning: OGC's Best Practices are subject to change without notice.

Technical Maturity [Current]: Version 1.0 of the standard was approved 23 September 2016 by the OGC. Consequences of further aligning CDB and other OGC standards (like GML, CityGML, and GeoPackage) cannot be anticipated yet.

Applicability:

- Best suited for native CDB-compliant client-applications including image generators, radar simulations, Computer Generated Forces, etc. (missing "CDB-aware" tools, data extraction complexity and costs increase for non-native CDB-compliant client-applications).
- Use of a CDB data store as an on-line database repository imposes runtime publishers to be developed for client-applications.

Information on implementation: CAE originally designed and developed the Common Database Specification for the United States Special Operations Command (USSOCOM). It was followed by several known implementations of the Common Database Specification, up to the version 3.2 (released by Presagis in March 2014), to which the US Government has unrestricted rights.
The structure of a CDB data store composed of tiles, layers, and levels of detail (up to 34 LODs) has been influenced by CAE runtime publishing requirements.

Limitations of this Standard:

- Missing at present "CDB-aware" tools to understand and access the overall construction / structure of a CDB data store (API and Starter Kit only exist for the Common Database version 3.2, released by Presagis).
- The number of files in a CDB data store representing a large-sized terrain database may result in a challenging deployment operation.
- Best practices (e.g. for use of OpenFlight and Shape files, Spatial and Coordinate Reference Systems) leave place for sufficient variations that interoperability and exchange results can vary significantly.
- The standard does not provide implementation details for developing specific off-line data store editors or runtime publishers.

Standard Type: Synthetic Environment
Public Availability: The standard is available to the public at no cost (no login required); it can be found on the OGC website under the "Standards and Supporting Documents" heading.
URL or instructions to Access or Acquire:
http://www.opengeospatial.org/standards/cdb
Input Date: 19 May 2017
Last Updated: 31 May 2017
Keywords: geospatial data repository, geospatial formats, GEOINT

CIGI

Standard Title: Common Image Generator Interface
Standard Identifier: SISO-STD-013-2014
Version Identifier: Version 4
SDO: CIGI development began in 2000 by The Boeing Company. Over the years CIGI matured under supervision of SISO culminating in an approved open version in August 2014.
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: CIGI is an interface designed to promote a standard way for a host device to communicate with an image generator. As this interface is designed to be a realtime interface; bandwidth requirements have been minimized. CIGI is not to be associated with any particular hardware interface. With CIGI, it is possible to connect a host with an arbitrary number of image generators. The communications can be performed during either synchronous (the host's frame rate matches the image generator's frame rate) or asynchronous operation.
To construct complex simulations, a high level of abstraction is provided by CIGI, using so-called building blocks. Each of these building blocks is generic in nature and represents a related group of data. With these building blocks, things such as high-level image generator commands, out-the-window view portals, entities, special effects, articulated parts, atmospheric effects, mission functions and sensor simulation objects can be specified.
Technical Maturity [Current]: In use and supported by several commercially available image generators.
The SISO Product Support Group (CIGI-PSG) provides support to the generation of registered extension packet IDs as defined in section 6.3 of the CIGI standard.
Applicability: Specifically designed to support the communication between host devices and image generators.
Information on implementation: Supported by several commercially available image generators.
Limitations of this Standard: The first open version of the standard (v4) concentrated on organizing content rather than adding functionality. Future work on the standard will examine how functionality can be expanded.
Standard Type: Synthetic Natural Environment / Visual Systems Interfacing
Public Availability: CIGI is available a C++ class library or a C language SDK/API. Both are freely available at http://cigi.sourceforge.net as open source software under the GNU Lesser General Public License.
URL or instructions to Access or Acquire: http://www.sisostds.org
Input Date: 28 September 2009
Last Updated: 24 May 2017
Keywords: Image Generator, Interoperability, CIGI

DIS

Standard Title: "IEEE Standard for Distributed Interactive Simulation" (DIS)
Standard Identifier: DIS (IEEE 1278 series)
Version Identifier: Current official versions:

- IEEE 1278.1-2012 –Standard for Distributed Interactive Simulation – Application Protocols
- IEEE 1278.1A-1998 (R2002) - Standard for Distributed Interactive Simulation – Supplement to Application Protocols – Enumeration & Bit-encoded Values
- IEEE-1278.2-2015 - Standard for Distributed Interactive Simulation - Communication Services and Profiles
- IEEE 1278.3-1996 (R2002) - Recommended Practice for Distributed Interactive Simulation - Exercise Management and Feedback.
- ANSI/IEEE 1278.4-2002 - Recommended Practice for Distributed Interactive Simulation - Verification Validation & Accreditation
  1278.3 is planned to be reaffirmed and eventually should be replaced by a new IEEE standard (Annex B to the IEEE Standard "IEEE 1730™ Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP))"

SDO: "DIS workshops" organization until 1997, presently SISO, as a Standards Sponsor of The Institute of Electrical and Electronics Engineers, Inc. (IEEE)
STANAG/STANREC identifier: no current STANAG/STANREC: former STANAG 4482; "Standardised Information Technology Protocols for Distributed Interactive Simulation (DIS)", was promulgated in 1995. An updated version of STANAG 4482 was not ratified in 1999. STANAG 4482 was cancelled in 2010 -- superseded by the STANAG 4603 on HLA.
STANAG/STANREC status: Cancelled
Abstract: DIS is an interoperability standard based on exchanges of formatted messages between simulation applications/ simulators. Simulation state information and interactions are encoded in messages known as Protocol Data Units (PDUs) and exchanged between hosts using existing transport layer protocols, though normally broadcast User Datagram Protocol (UDP) is used.
Technical Maturity [Current]: More than 20 years of use in many NATO countries; very mature technology.
Applicability: Distributed Interactive Simulation (DIS) is a protocol for linking simulations of various types at multiple locations to create realistic, complex, virtual worlds for the simulation of highly interactive activities. This protocol can be used to bring together systems built for separate purposes, technologies from different eras, products from various vendors, and platforms from various services, and permits them to interoperate. DIS exercises are intended to support a mixture of virtual entities with computer controlled behavior (computer generated forces), virtual entities with live operators (human-in-the-loop simulators), live entities (operational platforms and test and evaluation systems), and constructive entities (wargames and other automated simulations).

Information on implementation: Many operational implementations in various nations. Best example is the US Air Force Distributed Mission Operation (DMO) programme
Limitations of this Standard: The primary limitation of this standard is that it is applicable to only real time (simulated time = wall clock time) simulation and has a fixed object model defined at the platform level.
Standard Type: M&S Interoperability.
Public Availability: Available to the public with an IEEE copyright and a fee
URL or instructions to Access or Acquire: www.ieee.org
Input Date: 28 February 2008
Last Updated: 28 May 2017
Keywords: protocol Data Unit, PDU, DIS, Distributed Interactive Simulation, simulation, exercises, distributed, interoperability, verification, validation, certification

DMAO

Standard Title: Distributed Simulation Engineering and Execution Process (DSEEP) Multi-Architecture Overlay (DMAO)
Standard Identifier: IEEE DMAO
Version Identifier: IEEE 1730.1-2013
SDO: SISO on behalf of IEEE
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: Many special issues must be addressed when building a distributed simulation environment that involves multiple simulation architectures (e.g., HLA, DIS, TENA). Issues like time management, interest management, and object model reconciliation are all more difficult to resolve when multiple simulation architectures are in play. While the DSEEP provides an architecture-neutral description of the process required to build distributed simulation environments, it does not address the unique issues/solutions associated with the development and execution of multi architecture simulation environments, leaving developers with little or no sources of practical guidance.
Technical Maturity [Current]: The Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP) Multi-Architecture Overlay (DMAO) was approved as an IEEE Recommended Practice (IEEE 1730) in January 2011.
Applicability: The DMAO extends the process described in the DSEEP to address multi-architecture development and execution. It is designed as an overlay, associating issues and solutions relevant to multi-architecture development to existing DSEEP activities.
Information on implementation: No known implementation yet.
Limitations of this Standard: Needs to be tailored for specific uses and interoperability standards selected.
Standard Type: M&S Methodology, Architecture and Processes: Systems Engineering Processes
Public Availability: Copies of this standard may be purchased from IEEE. The first version is freely available only to members.
URL or instructions to Access or Acquire: www.ieee.org. or www.sisostds.org for SISO members only.
Input Date: 25 October 2012.
Last Updated: 21 April 2017.

DSEEP

Standard Title: Distributed Simulation Engineering and Execution Process
Standard Identifier: IEEE Stds 1730™-2010
Version Identifier: 1.0
SDO: SISO
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: The DSEEP (Distributed Simulation Engineering and Execution Process) is the successor of former guides based on DIS and HLA. The most known is the FEDEP (Federation Development and execution process, whose full name is HLA FEDEP) which was a process of engineering in support of the development of federations of simulation based on the architecture HLA. The FEDEP evolved in two successive versions: the first one was based on HLA 1.3 and was published by the DOD (1998), the second is a standard IEEE (IEEE Stds 1516.3™-2003) published by the IEEE. Both versions of the FEDEP are now obsolete and are not any more accessible on the site IEEE: they are replaced by the DSEEP and the DMAO (*Distributed Simulation Engineering and Execution Process Multi-Architecture Overlay).*
The DSEEP is generic and makes a reference to no architecture or specific protocol; however, it proposes in appendices for the standards IEEE DIS, HLA and the architecture of the US ARMY TENA. The DSEEP is applicable to the distributed systems of simulation which use only one standard of interoperability either DIS, HLA, even TENA. The vocabulary used by the DSEEP is abstracted enough to avoid any reference to a particular standard: for example, we do not speak a federation, nor of federated…
For the distributed systems which use several architectures and/or protocols, the DSEEP was generalized in a more recent guide called DMAO (IEEE Stds 1730.1™-2013).
Technical Maturity [Current]: DSEEP is an update of the FEDEP standardized as IEEE Stds 1516.3™-2003
Applicability: Distributed systems of simulation
Information on implementation: Many experiences in different nations
Limitations of this Standard: Appendices only for standards IEEE DIS, IEEE HLA and US ARMY TENA
Standard Type: M&S methodology, architecture and processes
Public Availability: Via SISO and IEEE web sites
URL or instructions to Access or Acquire: www.sisostds.org
Input Date: 23 April 2003
Last Updated: 27 June 2017
Keywords: Distributed, Simulation, Engineering Process

Dynamic Link Compatible (DLC) HLA API

Standard Title: Dynamic Link Compatible HLA API Standard for the HLA Interface Specification
Standard Identifier: Dynamic Link Compatible HLA API Standard for the HLA Interface Specification (IEEE 1516.1 Version) [SISO-STD-004.1-2004].
Version Identifier: 2006 (year of publication)
SDO: Simulation Interoperability Standards Organization
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: This standard defines link compatible C++ and Java Application Programmer Interfaces (API) consistent with the High Level Architecture Interface Specification and is applicable to HLA Runtime Infrastructures and federates developed in compliance with that specification. The primary objective of this standard is to provide a mechanism to permit federates to utilize RTIs developed in compliance with the High Level Architecture and this specification, without recompiling or relinking federate code.
Technical Maturity [Obsolete]: In use for 4 years and incorporated into the 2010 version of the core IEEE HLA specification. However it was not declared obsolete by SISO as it can be still in use by people working with the 1516-2000 version.
Applicability: Applicable to the HLA federates using the C++ and Java interfaces to implement the IEEE 1516-2000 series of HLA specifications.
Information on implementation: Unknown within NATO applications.
Limitations of this Standard: This standard is intended to establish the C++ and Java API specifications but it is not intended to facilitate functional compatibility.
Standard Type: M&S Interoperability
Public Availability: Freely downloadable from the SISO web site.
URL or instructions to Access or Acquire: www.sisostds.org
Input Date: 21 August 2008
Last Updated: 2 April 2013
Keywords: HLA, High Level Architecture, API, Application Programmer Interface, RTI, Run Time Interface, interoperability, architecture, simulation

Enumerations for Simulation Interoperability

Standard Title: Reference for Enumerations for Simulation Interoperability
Standard Identifier: SISO-REF-010-2016
Version Identifier: Version 22, **year of publication:** 2016
SDO: Simulation Interoperability Standards Organization (SISO) as per the Standards Activity Committee Special Working Group (SAC SWG) Enumerations. The process and organization to capture, review, and approve enumerations is defined separately in reference document Enumerations for Simulation Operations Manual (SISO-REF-010.1-2016).
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: This reference product is essentially a data dictionary for distributed simulation. It specifies the numerical values and associated definitions for those fields that are identified as enumerations in SISO standards and in SISO-sponsored standards published by IEEE.
The reference product is made available in archive form; as such, it comprises the following files:

- README file
- Enumerations data file (XML) and related schema (XSD);
- Enumerations in a RPR FOM “RPR-Enumerations” module (XML);
- C99 Makefile;
- Enumerations document in Word format, PDF, and HTML format; and
- Translators (XSL) to:
    - Microsoft Excel;
    - C99 Header.

Technical Maturity [Current]: Version 22 of the reference product was approved 10 November 2016.
Applicability: Any distributed simulation architecture, but not limited to DIS, HLA, and TENA.
Information on implementation: Many operational implementations in various nations, all over the world.
Limitations of this Standard: None.
Standard Type: Information Exchange Data Model
Public Availability: The reference product is available to the public at no cost (no login required); it can be found on the SISO website under the "Products & Publications" heading.
URL or instructions to Access or Acquire:
https://www.sisostds.org/ProductsPublications/ReferenceDocuments.aspx
Input Date: 09 May 2017
Last Updated: 09 May 2017
Keywords: Enumerations, Interoperability, DIS, HLA

FEAT

Standard Title: Federation Engineering Agreements Template
Standard Identifier: FEAT [SISO-STD-012-2013]
Version Identifier: SISO FEAT standard (approved 2 Aug 2013)
Standard Development Organization: Simulation Interoperability Standards Organization (SISO)
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: The Federation Engineering Agreements Template (FEAT) provides a standardized format for recording federation agreements to increase their usability and reuse. The template is an eXtensible Markup Language (XML) schema from which compliant XML-based federation agreement documents can be created. Creating the template as an XML schema allows XML-enabled tools to both validate conformant documents, and edit and exchange agreements documents without introducing incompatibilities.
Technical Maturity [Current]: The standard is based on lessons learned from experimentation (e.g. US LVCAR Implementation program, MSG-052) and was further evaluated in MSG-106 (2012-2013).
Applicability: capture and unambiguously document federation agreements for the benefit of all stakeholders in a simulation.
Information on implementation: Used only in experimentation so far. JHU/APL has developed a FEAT Editor, a Java-based tool to simplify development of federation agreements conformant with the XML schema. http://sourceforge.net/projects/feateditor/
Limitations of this Standard: There is currently no documentation other than the schema.
Standard Type: M&S Interoperability.
Public Availability: freely available
URL or instructions to Access or Acquire: The data files associated with SISO-STD-012-2013 may be downloaded from the SISO Product Data Files webpage. http:www.sisostds.org
Input Date: 15 May 2014
Last Updated: 21 April 2017

GM-VV

Standard Title: Guidance for a "Generic Methodology for Verification and Validation and Acceptance[10] of Models, Simulations, and Data" (GM-VV).
Standard Identifier: GM-VV. The methodology consists of three documents:
GM-VV Volume 1 "Introduction and Overview"
GM-VV Volume 2 "Implementation Guide"
GM-VV Volume 3 "Reference Manual"
Version Identifier: Current status of the GM-VV documents:
GM-VV Volume 1 "Introduction and Overview", SISO-GUIDE-001.1-2012 (approved 5 October 2012)
GM-VV Volume 2 "Implementation Guide", SISO-GUIDE-001.2-2013 (approved 6 June 2013)
GM-VV Volume 3 "Reference Manual", SISO-REF-039-2013 (approved 9 December)
SDO: Simulation Interoperability Standards Organization (SISO)
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract This product provides the international community with guidance for a generic V&V and Acceptance methodology for models, simulations, and data. The product leverages and harmonizes with the contributions from other national and international V&V and Acceptance initiatives such as the current IEEE Std 1516.4™-2007 "IEEE Recommended Practice for Verification, Validation, and Accreditation of a Federation—An Overlay to the High Level Architecture Federation Development and Execution Process", IEEE Std 1278.4™-1997 "IEEE Trial-Use Recommended Practice for Distributed Interactive Simulation—Verification, Validation, and Accreditation", the REVVA projects, the V&V International Test Operations Procedures (ITOP) Working Group, and the US DoD VV&A Recommended Practices Guide. The initial GM-VV draft documents have been produced by the REVVA consortium. The GM-VV document set includes the following:

- GM-VV Vol. 1 "Introduction and Overview". This document provides an overall description of the methodology. It presents the core concepts of the methodology as well as how its architecture binds them together to establish the foundations of the tailorable implementation.
- GM-VV Vol. 2 "Implementation Guide". This document extends Volume 1 by providing guidance on how to apply the methodology. It unfolds the methodology's architecture by elaborating on the processes, products, interactions among the roles, and how to tailor the methodology.
- GM-VV Vol. 3 "Reference Manual"*:* This document presents the foundations of the concepts, their dependencies and rationale. This document is meant to be referenced whenever a deeper technical understanding of the methodology is required.

[10] Note that outside of the United States there may not be a formal accreditation process and the terms "acceptance" or "accepted for use" may be used; the term acceptance is the decision to use a simulation for a specific purpose and the term accreditation is the official certification that a model or simulation is acceptable for use for a specific purpose. The GM V&V standard should not treat accreditation aspects.

Vol. 1 and 2 are balloted SISO Guidance Products. Vol. 3 is a non-balloted SISO Reference Product.
Technical Maturity [Current]: The GM-VV products are building upon the contributions of mature national and international V&V projects. All three documents have been reviewed and commented within SISO. In addition, there have been case studies conducted (9 use cases introduced in Volume 3).
Applicability: GM-VV methodology was experienced in some benchmarking cases in Canada and Europe. One operational use has been announced (NLD).
Information on implementation: Use cases have been introduced in past SISO workshops.
Limitations of this Standard: A lack of maturity and limited tool support.
Standard Type: M&S Methodology, Architecture and Processes, Verification and Validation (V&V)
Public Availability: Via SISO website.
URL or instructions to Access or Acquire: www.sisostds.org
Input Date: 26 February 2008
Last Updated: 17 July 2017

High Level Architecture (HLA) for M&S

Standard Title: IEEE Standard for Modelling and Simulation (M&S): High Level Architecture (HLA)
Standard Identifiers: Three documents: IEEE 1516-2010 (Framework and Rules), IEEE 1516.1-2010 (Federation Interface Specification), IEEE 1516.2-2010 (Object Model Template)
Version Identifier: 2010 (year of publication), nickname: "HLA Evolved"
SDO: The IEEE 1516 series of standards are sponsored by the Simulation Interoperability Standards Organization (SISO) Standard Activities Committee, serving as the IEEE Computer/Simulation Interoperability (C/SI) Standards Committee.
STANAG/STANREC identifier: STANAG 4603
STANAG/STANREC status: Promulgated 17 Feb 2015 (Ed. 02)
Abstract: The High Level Architecture for M&S (HLA) is defined by 3 technical documents. The standards contained in this architecture are interrelated and need to be considered as a product set, as a change in one is likely to have an impact on the others. As such, the HLA is an integrated approach that has been developed to provide a common architecture for simulation.
The Framework and Rules is the capstone document for a family of related HLA standards. It defines the HLA, its components, and the rules that outline the responsibilities of HLA federates and federations to ensure a consistent implementation. The Federate Interface Specification defines the standard services of and interfaces to the HLA Runtime Infrastructure (RTI). These services are used by the interacting simulations to achieve a coordinated exchange of information when they participate in a distributed federation. The Object Model Template provides a specification for describing object models that define the information produced or required by a simulation application, and for reconciling definitions among simulations to produce a common data model for mutual interoperation.
Technical Maturity [Current]: The initial IEEE standard was published and copyrighted in 2000. HLA is considered a mature standard and is in use in numerous countries. The current version (published in 2010) is already in use even in NATO (Snow Leopard project).
Applicability: The High Level Architecture is a technical architecture developed to facilitate the reuse and interoperation of simulation systems and assets. The HLA provides a general framework within which developers can structure and describe their simulation systems and/or assets and interoperate with other simulation systems and assets. The HLA consists of three main components. The first component specifies the Framework and Rules. The second component provides the interface specifications. The third component describes the Federation Object Model requirements in the Object Model Template (OMT) Specification.
Information on implementation: Widely implemented within NATO and PfP nations; limited implementation of HLA in NATO federations. There are a wide variety of commercial, open source and government support tools. Many support the more recent and current version of the standard.
Limitations of this Standard: HLA is not "plug and play". Some parts of the standards are left open to the RTI implementer, thus different RTIs are not

guaranteed to interoperate but this situation is improving thanks to the more recent version of HLA.
Standard Type: M&S Interoperability
Public Availability: Copies of this document may be purchased from the Institute of Electrical and Electronics Engineers at the IEEE Customer Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, U.S.A. or via the IEEE website. SISO members may download one copy free via the SISO website.
URL or instructions to Access or Acquire: www.ieee.org; www.sisostds.org (SISO members only)
Input Date: 8 April 2008
Last Updated: 4 Aug 2017
Keywords: architecture, class attribute, federate, federation, federation execution, federation object model, framework, High Level Architecture, instance attribute, interaction class, joined federate, object class, object model template, rules, runtime infrastructure, simulation object mode

Link 11 Simulations

Standard Title: Standard for LINK 11/11B Simulation
Standard Identifier: SISO-STD-005-V13 Draft
Version Identifier: Draft Version 13
SDO: Simulation Interoperability Standards Organization (SISO).
STANAG/STANREC identifier: No specific STANAG, but should be consistent with and in support of STANAG 5602
STANAG/STANREC status: N/A
Abstract: A SISO standard that defines methods to simulate a Link 11/11B tactical data link network within a Distributed Interactive Simulation (DIS) or High Level Architecture (HLA) federation. The standard defines 3 levels of fidelity ranging from pure message exchange to sophisticated Link 11/11B network modelling. The three parts of the standard describe Link 11/11B network simulation using DIS (including some extensions), Link 11/11B network simulation using HLA, and a Base Object Model (BOM) as a general modelling approach to Link 11/11B network modelling. The DIS specific part of the Link 11/11B standard in more detail explains the usage of DIS Transmitter and Signal Protocol Data Units (PDUs). High Level Architecture/Real-time Platform Reference (RPR)-FOM based simulations also will be able to simulate Link 11/11B networks by incorporating the corresponding FOM extensions described by the Link 11/11B standard into their FOM/SOM. This is easily accomplished using the BOM defined in the appendix of the Link 11/11B standard.
Technical Maturity [Emerging]: Near Completion. September 2014 SISO conference incorporated comments and release draft version 13. This version is under revision at the time of writing and will be published as version 14.
Applicability: There are immediate and overdue operational requirements for existing military simulations to exchange Link 11/11B data using a single interoperability method (i.e. DIS or HLA) instead of implementing additional protocols like SIMPLE.
Information on implementation: There will be a draft implementation soon from the Canadian Defense Ministry, as well as the U.K. E-3D training program.
Limitations of this Standard: This standard should only apply to Link 11/11B network simulation via DIS or HLA.
Standard Type: Information Exchange Data Model
Public Availability: Draft 13 is available on the SISO Link 11/11B PDG website.
URL or instructions to Access or Acquire: **http://www.sisostds.org/**
Input Date: 07 July 2008
Last Updated: 30 September 2016
Keywords: Tactical Data Link, LINK 11, LINK 11B

Link 16 Simulations

Standard Title: Standard for LINK 16 Simulation
Standard Identifier: SISO-STD-002-2006 *(approved 10 Jul 06)*
Version Identifier: 10 July 2006
SDO: Simulation Interoperability Standards Organization (SISO).
STANAG identifier: No specific STANAG, but consistent with and in support of STANAG 5602 (edition 1)
STANAG status: N/A
Abstract: There are immediate operational requirements for military simulation applications to simulate the exchange of Link 16 data messages during a simulation execution. This standard provides means to incorporate the Link 16 message exchange into Distributed interactive Simulation (DIS) or High Level Architecture (HLA) simulation networks thus elimination the need for additional transport protocols such as Standard Interface for Multiple Platform Link Evaluation (SIMPLE). The Link 16 standard defines 5 fidelity levels ranging from pure message exchange only to sophisticated Link 16 network modelling including Return Trip Timing messages, Net Entry and Exit, Actual versus Perceived location and encryption methods.
The three parts of the standard describe Link 16 network simulation using DIS (including some extensions), Link 16 network simulation using HLA, and a Base Object Model (BOM) as a general modelling approach to Link 16 network modelling. The DIS specific part of the Link 16 standard in more detail explains the usage of DIS Transmitter and Signal Protocol Data Units (PDUs). High Level Architecture/Real-time Platform Reference (RPR)-FOM based simulations also will be able to simulate Link 16 networks by incorporating the corresponding FOM extensions described by the Link 16 standard into their FOM/SOM. This is easily accomplished using the BOM defined in the appendix of the Link 16 standard.
Technical Maturity [Current]: In use by the U.S. Air Force, Navy, and Marines for distributed simulation training. Product Support Group at SISO established.
Applicability: There are immediate and overdue operational requirements for existing military simulations to exchange Link 16 data using a single interoperability method (i.e. DIS or HLA) instead of implementing additional protocols like SIMPLE.
Information on implementation: In use in NATO and partner countries.
Limitations of this Standard: This standard applies only to Link 16/JTIDS/MIDS. It does not address Link 16 over SATCOM.
Standard Type: Information Exchange Data Model
Public Availability: On the SISO website.
URL or instructions to Access or Acquire: http://www.sisostds.org/
Input Date: 20 March 2008.
Last Updated: 30 September 2016
Keywords: Tactical Data Link, LINK 16

MSDL

Standard Title: Military Scenario Definition Language (MSDL).
Standard Identifier: SISO-STD-007-2008.
Version Identifier: Version 1 (approved 14 Oct 2008)
SDO: SISO.
STANAG/STANREC identifier: None
Abstract: The Military Scenario Definition Language (MSDL) is intended to provide a standard initialization mechanism for loading Military Scenarios independent of the application generating or using the scenario. Standard MSDL is defined utilizing an XML schema thus enabling exchange of all or part of scenarios between (e.g.) C2 planning applications, simulations, and scenario development applications. XML based scenario representations can readily be checked for conformance against the standard's schema. The scope of MSDL is bounded by the situation, defined at one instant in time, combined with the course of action about to be taken in context to that situation. The intent is for MSDL to include that information which is either core or common to the situation and course of action (COA) of a military scenario. Definition of COA falls under the scope of the Coalition Battle Management Language (C-BML). The development of a second generation of standards – C2SIM, unifying MSDL and C-BML, are being undertaken by a single SISO C2SIM PDG.
Technical Maturity [Current]: The MSDL Standard evolved from a common scenario format definition initiated by the USA OneSAF Program in 2001. The initial scenario format as proposed by OneSAF was matured and enhanced through additional US and international involvement as part of the SISO standards development process that resulted in a ratified MSDL standard in Oct 2008.
MSDL version 1 is an official SISO standard – approved 14 Oct 2008 and reaffirmed 11 May 2015. MSDL version 2 (C2SIM Initialize) is being developed under the auspices of the C2SIM PDG.
Applicability: MSDL provides the M&S community with the ability to create military scenarios that can be shared and reused among a variety of simulations. Furthermore MSDL provides a mechanism for reusing military scenarios between independent simulations and federated simulations.

- Facilitation of interoperability for multiple military simulation products.
- Real-world scenario data capture (e.g. C4I) easily ported to military sims.
- Easier comparison of military sim products using the same initial conditions.
- Enables third party products for military scenario design.

Information on implementation: User experience across NATO MSG-145 nations in support of standards-based C2 and simulation interoperation as well as the USA OneSAF community.
Limitations of this Standard: Mainly targeted to land operations; needs to be generalized to joint operations.
Standard Type: Conceptual Modelling and Scenarios.
Public Availability: Via SISO web site.
URL or instructions to Access or Acquire: **http://www.sisostds.org**
Input Date: 19 March 2008
Last Updated: 16 April 2017
Keywords: Scenario, Simulation, C-BML

NETN FAFD

Standard Title: NATO Education and Training Network (NETN) Federation Architecture and FOM Design (FAFD)
Standard Identifier: AMSP-04
Version Identifier: v2.0
Standard Development Organization: N/A
STANAG/STANREC identifier: STANREC 4800
STANAG/STANREC status: Project/ Study
Abstract:
The purpose of NETN Federation Architecture and FOM Design Document (FAFD) is to provide a common reference federation agreements document (FAD) for all federations in the NATO Education and Training Network (NETN). Agreements that are common to all NETN based federations are specified in this document. Principles and format for information exchange between federates in a NETN based federation is defined in the FAD. STANAG 4603 (HLA) is used and part of the federation agreements are provided as HLA Federation Object Model (FOM) modules.
The NETN FAFD is intended to be used as a template and/or reference when developing federation specific agreements. In any specific federation more detailed and other types of agreements are almost always required. This reference agreement document is not intended to replace the need for developing federation specific agreements.
This version of the NETN Reference FAD was developed by NATO Modelling and Simulation Group (NMSG) Task Group MSG-106 SPHINX. This task group was initiated to continue the work of MSG-068 and supporting the ACT with M&S recommendations for establishing a NATO wide network for education and training (NETN). A technical subgroup of MSG-106, Federation Agreements and FOM Design (FAFD) subgroup was created with representatives from the participating NATO and partner nations. This group represented a broad community of practice with respect to federation architecture and design. Major systems, federations and training networks were represented in the FAFD group. The input provided and the harmonization of federation architecture and design agreements forms the basis of this document.
Key modules included in the NETN FAFD v2.0 are:

- RPR FOM v2.0 (Final)
- RPR FOM v2.0 Extensions for representing platforms and aggregates
- Enhanced Logistics modelling using Service Consumer-Provider Patterns
- CBRN modelling
- Multi-Resolution-Modelling (Aggregation/Disaggregation)
- Transfer of Modelling Responsibilities (TMR)
- Simulation-C2 using C-BML and Simulator Instruction Modules
- Extensions of MSDL to support initial allocation of modelling responsibilities

Technical Maturity [Current]:
The NETN FAFD has been used in experimentation (MSG-068 Final Experiment, SEESIM 12 NTF Experiment) and in exercises (Viking 11 and Viking 14). The technical maturity is strong and proven. Maintenance of NETN FAFD v2.0 is conducted by MSG-134 on behalf of MS3. User feedback and proposals for new

modules are received through CSO and managed by MSG-134. AMSP-04 is in the process to be released by NSO as STANREC 4800.

Applicability:

The NETN FAFD is intended as a reference document for creating federation specific agreements on information exchange and simulation interoperability. The FOM modules described in the FAFD can be extended and complemented with additional modules.

Information on implementation:

The NETN FAFD has been used in experimentation (MSG-068 Final Experiment, SEESIM 12 NTF Experiment) and in exercises (Viking 11 and Viking 14). Extensive use of NETN FAFD is planned for exercise Viking 18 to federate simulation and C2 systems originating from NATO and Partner nations including USA, SWE, FRA, NLD, DNK. It has also been used extensively in various research activities in SWE and NLD. The technical maturity is strong and proven.

Limitations of this Standard: The standard does not cover all aspects of federated simulation interoperability and the set of modules represent the prioritization made by MSG-068 and MSG-106 when developing this version. The standard is extensible and will incrementally include additional modules.

Standard Type [Information Exchange Data Model]:

The NETN FAFD includes both a set of FOM Modules, associated descriptions and agreements on how to use and apply these modules.

Public Availability:

The NETN FAFD v2.0 is under custodianship of NATO Modelling and Simulation Group M&S Standards Subgroup (NMSG MS3) and is currently in the process of becoming AMSP-04 and covered by STANREC 4800.

URL or instructions to Access or Acquire:

Current version to be published on CSO website.

Input Date: 02 Sep 2013

Last Updated: 21 Apr 2017

OpenFlight

Standard Title: OpenFlight Scene Description Database Specification ®
Standard Identifier: OpenFlight ®
Version Identifier: 16.5
SDO: None – Owned and controlled by Presagis
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: OpenFlight is a widely adopted 3D visual database standard for real-time 3D visualization and has become the "de facto" standard in the visual simulation industry. The OpenFlight format is widely used today in the high-end real-time visual simulation industry as the standard interchange format between different image generation systems and is administered by Presagis. OpenFlight is intended for use in real-time systems and supports: variable levels of detail, degrees of freedom, sound, instancing (both within a file and to external files), replication, animation sequences, bounding volumes for real-time culling, scene lighting features, light points and light point strings, transparency, texture mapping, material properties, and many other features. Military visual simulation includes battle simulation, fighter jet flight simulation and tank simulation while visual simulation also includes geospecific terrain for accurate fly through of regions of the plant
Technical Maturity [Current]: OpenFlight is a very mature "de facto" standard although minor revisions occur periodically.
Applicability: The actual specification is of most use to software developers but it is also of interest to model developers (visual artists) as it determines what visual effects can be modelled (e.g. transparency) and how they are represented.
Information on implementation: The standard is used in a very large number of end-user applications (e.g. flight simulators) and in software development tools from Presagis and other companies. Many major commercial businesses have incorporated OpenFlight in their products.
Limitations of this Standard: OpenFlight is owned and controlled by Presagis and the standard or its open source availability may change at any time. Although the OpenFlight file format allows for vendor specific data field additions, some modelling and simulation tools may not fully support vendor specific additions to the file format. It is protected under the copyright and trademark laws of the United States of America.
Standard Type: Synthetic Natural Environment / Imagery and 3D Models
Public Availability: Documentation for the standard and its Application Programming Interface (API) are freely available.
URL or instructions to Access or Acquire: The standard specification can be downloaded for free at http://www.presagis.com/files/standards/OpenFlight16.5.pdf.
The OpenFlight API can be downloaded for free at
http://www.presagis.com/products_services/products/modeling-simulation/free_tools/openflight_api/.
Input Date: 29 April 2008
Last Updated: 10 November 2016
Keywords: 3D visualization format, Presagis, real-time visualization, OpenFlight, visualization database, 3D geometry model, interchange format

RPR FOM

Standard Title: Standard for Real-time Platform-level Reference Federation Object Model (RPR FOM).
Standard Identifier: SISO-STD-001-2015.
Version Identifier: 2.0
SDO: SISO
STANAG/STANREC identifier: None
Abstract: While the HLA Standards dictate how federates exchange data, it is a Federation Object Model (FOM) that dictates what data is being exchanged in a particular federation. HLA does not mandate the use of any particular FOM, however, several "reference FOMs" have been developed to promote a-priori interoperability. That is, in order to communicate, a set of federates must agree on a common FOM (among other things), and reference FOMs provide ready-made FOMs that are supported by a wide variety of tools and federates. Reference FOMs can be used as is, or can be extended to add new simulation concepts that are specific to a particular federation or simulation domain.
The RPR FOM was developed by a SISO Product Development Group (PDG). Its goal was not to just implement the DIS Protocol Data Unit structures within HLA object and interaction classes, but rather to provide an intelligent translation of the concepts used in DIS to an HLA environment.
The Real-time Platform Reference Federation Object Model 2.0 (RPR FOM 2.0) defines a hierarchy of object and interaction classes for the High Level Architecture (HLA) that provides the capabilities defined in IEEE Std 1278.1TM-1995, IEEE Standard for Distributed Interactive Simulation — Application Protocols, and its supplement, IEEE Std 1278.1aTM-1998, IEEE Standard for Distributed Interactive Simulation — Application Protocols. SISO-STD-001-2015, Standard for Guidance, Rationale, and Interoperability Modalities for the Real-time Platform Reference Federation Object Model encapsulates guidance in the use of RPR FOM 2.0. It provides descriptions of FOM classes and datatypes and the relationship between the Distributive Interactive Simulation and the HLA-based RPR FOM, as well as rules for accomplishing specific distributed simulation tasks.
Technical Maturity [Current]: RPR FOM 2.0 is based on the IEEE 1278.1-1995 version of the DIS Standard and became a SISO standard in 1999. It corresponds to the version US DoD 1.3 version of HLA. RPR FOM 2.0 corresponds to the IEEE 1516 version of HLA.
Applicability: Enables federations of real-time, platform-based simulations, typically allowing DIS users achieve HLA compliance.
Information on implementation: In use in many HLA federations.
Limitations of this Standard: Mainly targeted to entity-level simulations. Not suitable to be used at operation level.
Standard Type: Information Exchange Data Model
Public Availability: Via SISO web site
URL or instructions to Access or Acquire: www.sisostds.org
Input Date: 19 March 2008
Last Updated: 21 April 2017
Keywords: Distributed, Simulation, HLA

Synthetic Environment Data Representation and Interchange Specification (SEDRIS)

SEDRIS is a series of 8 ISO standards addressing:

- (a) the representation of environmental data, and,
- (b) the interchange of environmental data sets.

To achieve the first, SEDRIS offers a data representation model (DRM), augmented with its environmental data coding specification (EDCS) and spatial reference model (SRM), so that one can articulate one's environmental data clearly, while also using the same representation model to understand others' data unambiguously. Therefore, the data representation aspect of SEDRIS is about capturing and communicating meaning and semantics. While a data representation model is a necessary component of a standard, it is not sufficient to allow effective use. Thus the second aspect of SEDRIS addresses data interchange. In SEDRIS, data interchange is standardised through a SEDRIS Application Programming Interface (API) and a transmittal format (SEDRIS Transmittal Format or STF). The transmittal format and API are semantically coupled with the data representation model.
SEDRIS is introduced in the order of 3 corresponding STANAGs (4662 to 4664) that are promulgated:

STANAG 4664 - SEDRIS Functional Specifications and Abstract Transmittal Format

Part 1: **Functional Specification** (DRM, APIs, and STF)

Standard Identifier: ISO/IEC 18023-1:2006(E) , Amd: 1:2012
Version Identifier: 2006 (year of publication)
Abstract: This part of ISO/IEC 18023 addresses the concepts, syntax and semantics for the representation and interchange of environmental data. It specifies:

- (a)data representation model for expressing environmental data,
- (b) the data types and classes that together constitute the data representation model, and
- (c) an API that supports the storage and retrieval of environmental data using the data representation model.

ISO/IEC 18023-1 also specifies topological, rule-based, and other constraints that ensure appropriate data can be available for applications that rely on automatically generated behaviours when interacting with environmental data.
STANAG/STANREC identifier: Part of STANAG 4664 **STANAG/STANREC status:** Promulgated.

Part 2: Abstract Transmittal Format (ATF)

Standard Identifier: ISO/IEC 18023-2:2006(E)
Version Identifier: 2006 (year of publication)
Abstract: ISO/IEC 18023-2 specifies the abstract syntax of a SEDRIS transmittal. Actual encodings (e.g. binary encoding) are specified in other parts of ISO/IEC 18023.
STANAG/STANREC identifier: Part of STANAG 4664
STANAG/STANREC status: Promulgated.

Part 3: Transmittal Format Binary Encoding
Standard Identifier: ISO/IEC 18023-3:2006(E) , Amd: 1:2012
Version Identifier: 2006 (year of publication)
Abstract: SEDRIS Transmittal Binary Encoding defines a binary encoding technique that allows encoding DRM objects specified in ISO/IEC 18023-1 according to the abstract syntax specified in ISO/IEC 18023-2. The name of this binary encoding is SEDRIS Transmittal Format (STF).
STANAG/STANREC identifier: Part of STANAG 4664
STANAG/STANREC status: Promulgated.
Part 4: Language Bindings: C
Standard Identifier: ISO/IEC 18041-4:2007
Version Identifier: 2007 (year of publication)
Abstract: The SEDRIS language bindings standard specifies the binding of the application program interface (API) defined in SIO/IEC 18025 to the C program language
STANAG/STANREC identifier: Part of STANAG 4664
STANAG/STANREC status: Promulgated.

STANAG 4662 -- SEDRIS — Environmental Data Coding Specification (EDCS)
Environmental Data Coding Specification (EDCS)
Standard Identifier: ISO/IEC 18025:2014
Version Identifier: 2014 (year of publication)
Abstract: EDCS specifies objects used to model environmental concept. EDCS includes a collection of nine dictionaries that define environmental concepts, objects, attributes, and quantitative measures of objects. EDCS supports the encoding and communication of qualitative and quantitative information associated with physical environments, both real and virtual. This is accomplished by specifying nine EDCS dictionaries of environmental concepts and the EDCS application program interface. EDCS specifies labels and codes and environmental phenomenon to provide a standard way of identifying concepts.
STANAG/STANREC identifier: Part of STANAG 4662
STANAG/STANREC status: Promulgated.
EDCS Language Bindings Part 4: C
Standard Identifier: ISO/IEC 18041-4:2007(E)
Version Identifier: 2007 (year of publication)
Abstract: EDCS language binding specifies the binding of the Application Program Interface (API) defined in ISO 18023-6 to the C Programming language.
STANAG/STANREC identifier: Part of STANAG 4662
STANAG/STANREC status: Promulgated.

STANAG 4663 -- SEDRIS —Spatial Reference Model (SRM)
Spatial Reference Model
Standard Identifier: ISO/IEC 18026: 2009(E)
Version Identifier: 2009 (year of publication)

Abstract: SRM provides aspects of spatial positioning of location, direction, distance, mapping, charting, geodesy, imagery, topography, etc. SRM provides for the description, and transformation or conversion, of geometric properties within or among spatial reference frames. SRM also supports specification of the positions, directions, distances, and times associated with spatial information. The SRM may be, and has been, used independently of the other components of SEDRIS standards.
STANAG/STANREC identifier: Part of STANAG 4663
STANAG/STANREC status: Promulgated.
Part 4: SRM Language Bindings: C
Standard Identifier: ISO/IEC 18042-4:2006(E), Amd 1:2011
Version Identifier: 2006 (year of publication)
Abstract: This part of ISO/IEC 18041-4 specifies a language-independent application program interface (API). For integration into a programming language, the Spatial Reference Model (SRM) API is embedded in a language-dependent layer obeying the particular conventions of that language. ISO/IEC 18042-4 specifies such a language-dependent layer for the C language.
STANAG/STANREC identifier: Part of STANAG 4663
STANAG/STANREC status: Promulgated.

SDO: International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) Joint Technical Committee 1 (ISO/IECJTC 1) Sub-Committee 24. (SC 24)
Technical Maturity: [Current]
Applicability: SEDRIS (ISO/IEC 18023) may be applied to the representation of any environmental data including: (a) terrain, (b) ocean, (c) atmosphere, and (d) space.
Information on implementation: Used widely in the USA, most frequently by ground forces. Some use in other nations (France, for example).
Limitations of this Standard: None identified
Standard Type: Synthetic Natural Environment: General, Interchange of Environmental Data
Public Availability: The standard can be accessed on the website at http://iso.org
URL or instructions to Access or Acquire: http://standards.sedris.org
Input Date: 9 April 2008
Last Updated: 4 May 2017
Keywords: Data Interchange, Environmental Data, Geospatial Data, M&S, Modeling, Representations, SEDRIS, Simulation, Synthetic Environment Data Representation Interchange Specification, Virtual Environment

UCATT Laser engagement Standard

Standard Title: Standard for UCATT Laser Engagement Interface
Standard Identifier: SISO-STD-016-00-2016
Version Identifier: Version 1.0, 9 May 2016
SDO: SISO
STANAG/STANREC identifier: None (Intention to cover by STANREC)
STANAG/STANREC status: N/A
Abstract: This standard applies to the optical interface primarily used to communicate a simulated weapon engagement from a weapon simulator platform to a target simulator platform. Additionally, the Laser Engagement interface has a secondary use to communicate administrative and other kind of information (i.e., umpire control-gun commands, indoor positioning and player association).
The Laser engagement Standard is the first physical implementation of an external interface defined in the UCATT functional Architecture for Live Simulation Training Systems
Technical Maturity [Current]: UCATT Laser engagement Standard is based on the optical code OSAG 2.0 standard which is widely used throughout various nations.
Applicability: Contributes to live simulation interoperability by providing a common Laser standard.
Information on implementation: Used in projects in FRA, DEU, USA, GBR, NOR, NLD, SWE, FIN, SVN (potentially some under the name “OSAG 2.0 Standard”)
Limitations of this Standard: Not known
Standard Type: Physical interface specification including data definitions
Public Availability: Via SISO web site
URL or instructions to Access or Acquire:
https://www.sisostds.org/ProductsPublications/Standards/SISOStandards.aspx
Input Date: 09 May 2016
Last Updated: 12 May 2017
Keywords: Live Simulation & Training, TES, TESS, Laser engagement, Optical Codeset, UCATT, OSAG, AGDUS, STC, SAT

VV&A Recommended Practices Guide (RPG) US DoD

Standard Title: Verification, Validation & Accreditation (VV&A) Recommended Practices Guide (VV&A RPG)
Standard Identifier: VV&A RPG
Version Identifier: RPG 2012
SDO: U.S. Department of Defense
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: The VV&A RPG provides general instructions on how, when, and under what circumstances formal VV&A procedures should be employed. In particular it:

- describes the interrelated processes that make up VV&A
- defines roles and responsibilities of the participants
- identifies special topics associated with VV&A
- identifies tools and techniques
- provides reference material on related areas.

This set of documents also includes an informal discussion of the key concepts of VV&A – the principles, rationale, terminology, and general approach to conducting VV&A for models and simulations. It provides an analogy from everyday life intended to demonstrate the practicality of VV&A, and concludes with a summary of the costs and benefits and an introduction to the remainder of the RPG.
Technical Maturity [Current]: Used on dozens of applications in the USA. Date of latest revision – 15 Sep 2006.
Applicability: This guide is applicable to the planning, conduction and documentation of all verification, validation and accreditation of models and simulations. Its recommendations should be tailored to the requirements of the specific M&S application.
Information on implementation: Use of the RPG is voluntary but recommended.
Limitations of this Standard: None
Standard Type: M&S Methodology, architectures and Processes: Verification & Validation
Public Availability: May be accessed freely from the Websites below.
URL or instructions to Access or Acquire: https://vva.msco.mil
Input Date: 27 August 2008
Last Updated: 17 July 2017
Keywords: Verification, Validation, Accreditation, Recommended Practices Guide, RPG

VV&A – Templates US DoD

Standard Title: U.S. Department of Defense Standard Practice, Documentation Of Verification, Validation, and Accreditation (VV&A) For Models And Simulations
Standard Identifier: [U.S. Dept. of Defense], number: **MIL-STD-3022**.
Supporting Data Item Descriptions (DIDs):
Number: DI-MSSM-81750, Accreditation Plan
Number: DI-MSSM-81751, Verification and Validation (V&V) Plan
Number: DI-MSSM-81752, Verification and Validation (V&V) Report
Number: DI-MSSM-81753, Accreditation Report
Version Identifier: U.S. Dept. of Defense **MIL-STD-3022, 28 January 2008**
SDO: U.S. DoD
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: This standard was developed by the US DoD Modeling and Simulation Coordination Office in coordination with the Military Departments. It establishes templates for the four core products of the Modelling and Simulation Verification, Validation, and Accreditation processes. The intent of this standard is to provide consistent documentation that minimizes redundancy and maximizes reuse of information. This promotes a common framework and interfacing capability that can be shared across all Modelling and Simulation programs within the US Department of Defense, other government agencies and allied nations.
Technical Maturity [Emerging]: Approved by the US DoD in January 2008.
Applicability: This standard is approved for use by all Departments and Agencies of the US Department of Defense.
Information on implementation: Not known
Limitations of this Standard: Not known
Standard Type: M&S Methodology, architectures and Processes: Verification & Validation
Public Availability: Yes, from US Dept. of Defense **MIL-STD-3022**
URL or instructions to Access or Acquire: https://vva.msco.mil
Input Date: 27 August 2008
Last Updated: 17 July 2017
Keywords: Verification, Validation, Accreditation, VV&A, Accreditation Plan, Accreditation Report, V&V Plan, V&V Report

WebLVC

Standard Title: WebLVC Protocol
Standard Identifier: WebLVC
Version Identifier: Version 0.5 – September 2016 (emerging standard)
Standard Development Organization: Simulation Interoperability Standards Organization
STANAG/STANREC identifier: None
STANAG/STANREC status: N/A
Abstract: WebLVC is a protocol for enabling web and mobile applications (typically JavaScript applications running in a web browser) to play in traditional M&S federations (which may be using Distributed Interactive Simulation (DIS), High Level Architecture (HLA), Test and Training Enabling Architecture (TENA), or related protocols and architectures). In a nutshell, WebLVC takes the semantics of DIS or HLA Federation Object Models (FOMs), and represents them using messages in the JSON (JavaScript Object Notation) format, which are typically passed between server and client using WebSockets
Technical Maturity: The WebLVC Protocol is used by numerous M&S organizations around the world. Currently SISO has a Product Development Group (PDG) working on the WebLVC. Current PDG efforts are focusing on increasing efficiency and making the protocol more robust. Product Nomination and a Standard is expected no earlier than mid-2017.
Applicability: Applies to anyone who wants to develop web-based applications, and achieve interoperability with traditional M&S applications and federations – whether those applications are used for training, experimentation, analysis, or other purposes. The Standard will allow web and mobile applications developed by different organizations to interoperate with each other, and with existing native M&S assets
Information on implementation: Commercial products available and successfully used
Limitations of this Standard: Unknown
Standard Type: M&S Interoperability
Public Availability: Will be publicly available and free to download as with all SISO standards
URL or instructions to Access or Acquire: http://www.sisostds.org
Input Date: April 2013
Last Updated: 22 November 2016

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ANNEX D - POINTS OF CONTACT

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ANNEX E - ACRONYMS

A

ADL	Advanced Distributed Learning
AMSP	Allied Modelling and Simulation Publication
AP	Allied Publication
API	Application Programming Interface

B

BOM	Base Object Model

C

C-BML	Coalition Battle Management Language
C2	Command and Control
C3I	Command Control Communication and Information
CM	Conceptual Modelling
CNAD	Conference of National Armaments Directors (NATO)
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off-The-Shelf
CSO	Collaboration Support Office
CSPI	COTS Discrete Event Simulation Package Interoperability

D

DDCA	Distributed Debrief Control Architecture
DEVS	Discrete-Event Systems Specification
DIS	Distributed Interactive Simulation
DLC	Dynamic Link Compatible (DLC) HLA API
DoD	Department of Defense (USA)
DNDAF	Department of Defence Architecture Framework
DODAF	DoD Architecture Framework

DSEEP	Distributed Simulation Engineering and Execution Process
DTA	Delegated Tasking Authority
DTED	Digital Terrain Elevation Data

E

EDCS	Environmental Data Coding Specification (SEDRIS)

F

FEAT	Federation Engineering Agreements Template
FEDEP	Federation Development and Execution Process
FOM	Federation Object Model (HLA)

G

GeoTIFF	Geographic Tagged Image File Format
GM V&V	Generic Methodology for Verification and Validation
GSD	Guideline on Scenario Development for Simulation Environments

H

HFM	Human Factors and Medicine (a CSO Panel))
HBR	Human Behaviour Representation
HLA	High Level Architecture

I

IEC	International Electrotechnical Commission of ISO
IEDM	Information Exchange Data Model
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
IT	Information Technology

ITOP International Test Operations Procedures

J

JC3IEDM Joint Consultation, Command and Control Information Exchange Data Model

JTC Joint Technical Committee

L

LDM Logical Data Model

LVCAR Live Virtual Constructive Architecture Roadmap

M

M&S Modelling and Simulation

MC Military Committee (NATO)

MDA Model Driven Architecture

MDE Model Driven Engineering

MIM MIP Information Model

MIP Multinational Interoperability Programme

MODAF MOD Architecture Framework (UK)

MSaaS Modelling and Simulation as a Service

MSCO Modelling and Simulation Coordination Office

MSDL Military Scenario Definition Language

MSG Modelling and Simulation Group (NATO)

MS3 Modelling and Simulation Standards Subgroup (subgroup of NMSG)

N

NAF NATO Architecture Framework

NATO North Atlantic Treaty Organization

NATOTerm The NATO Official Terminology Database (https://nso.nato.int/natoterm)

NGA National Geospatial-Intelligence Agency (USA)

NMSG NATO Modelling and Simulation Group

NMSSP	NATO M&S Standards Profile
NAC	North Atlantic Council
NC3A	NATO Command, Control and Consultation Agency (now NCIA)
NCIA	NATO Communications and Information Agency
NCS	NATO Committee for Standardization
NISP	NATO Interoperability and Standards Profile
NSA	NATO Standardization Agency (now NSO)
NSO	NATO Standardization Office

O

OMG	Object Management Group
OWL	Web Ontology Language

P

PDG	Product Development Group (in SISO)
PDU	Protocol Data Unit (DIS)
PfP	Partnership for Peace (NATO)
POC	Point of Contact
PSG	Product Support Group (in SISO)

R

R&D	Research and Development
REVVA	Reference for VV&A
RIEDP	Reuse and Interoperation of Environment Database Development Process
RPG	Recommended Practice Guide
RPR FOM	Realtime Platform Reference (RPR) FOM
RTI	Run Time Infrastructure (HLA)
RTO	Research and Technology Organization (NATO)

S

SC	Subcommittee
SCORM	Shareable Content Object Reference Model (ADL standard)
SDO	Standards Developing Organization
SEDRIS	Synthetic Environment Data Representation and Interchange Specification
SISO	Simulation Interoperability Standards Organization
SIMPLE	Standard Interface for Multiple Platform Link Evaluation
SRM	Spatial Reference Model (SEDRIS)
STANAG	Standardization Agreement (NATO)
STF	SEDRIS Transmittal Format
STO	Science and Technology Organization
SysML	Systems Modelling Language

T

TA	Tasking Authority
TC	Technical Committee
TCA	Technical Cooperation Agreement
TDL	Tactical Data Link
TENA	Test and Training Enabling Architecture (US DoD)
TG	Task Group
TOR	Terms of Reference

U

UCATT	Urban Combat Advanced Training Technology
UML	Unified Modelling Language
URL	Uniform Resource Locator

V

V&V	Verification and Validation
VMAP	Vector Map

VRML	Virtual Reality Modelling Language
VV&A	Verification, Validation and Accreditation (or Acceptation)

W

W3C	World Wide Web Consortium
WG	Working Group

X

X3D	XML 3-Dimensional
XMI	XML Metadata Interchange
XML	eXtended Mark-up Language

ANNEX F - STANDARDS DEVELOPING ORGANIZATIONS OF INTEREST TO NATO M&S

F.1. INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

The International Organization for Standardization, widely known as ISO, is an international-standard-setting body that promulgates world-wide proprietary industrial and commercial standards. ISO is composed of representatives from various national standards organizations, and acts as a consortium with strong links to member governments. Founded on 23 February 1947, the organization, headquartered in Geneva, Switzerland, has members from more than 160 countries and over 780 technical bodies to take care of standards development. While ISO defines itself as a non-governmental organization, its ability to set standards that often become law, either through treaties or national standards, makes it more powerful than most non-governmental organizations. ISO standards are developed by technical committees comprising experts from the industrial, technical and business sectors which have asked for the standards, and which subsequently put them to use. Many groups wish to contribute to the process of the development of International Standards, because they are affected by those standards. They participate in the technical work of ISO through national delegations appointed by the member bodies of ISO or through liaison organizations of international or broadly-based groups. Since 1947, the ISO has published more than 21 000 International Standards. The ISO's work program ranges from standards for traditional activities, such as agriculture and construction, through mechanical engineering, to medical devices, to the newest information technology developments, such as the digital coding of audio-visual signals for multimedia applications. ISO is officially recognized by NATO as an SDO, under a Technical Cooperation Agreement (TCA) signed by NSO. With the exception of a small number of isolated standards, ISO standards are normally not available free of charge, but for a purchase fee. The official URL for access to ISO Standards is www.iso.org

F.2. THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS STANDARDS ASSOCIATION (IEEE-SA)

The IEEE is one of the leading standards development organizations in the world. IEEE performs its standards development and maintenance functions through the IEEE Standards Association (IEEE-SA). IEEE standards affect modelling and simulation as well as a wide range of industries including: power and energy, biomedical and healthcare, Information Technology (IT), telecommunications, transportation, nanotechnology, information assurance, and many more. Individuals, including IEEE members of any grade, IEEE Society affiliates, or non-IEEE members are eligible for IEEE-SA membership. Corporate Membership is designed for corporations, government agencies, trade associations, user groups, universities and other standards developing organizations that want to actively participate in standards development. All IEEE members (individual or corporate) are entitled to ballot on an unlimited number of proposed standards projects. Non-members of the

IEEE can participate in the balloting process by paying a “balloting fee”. Currently, IEEE collection of standards consists of more than 1,300 IEEE standards, including projects under development. At the present time, IEEE is officially recognized by NATO. IEEE Standards Association ("IEEE-SA") offers copyright permission, on a non-discriminatory basis, for any and all uses. IEEE-SA associated materials include IEEE standards and drafts, IEEE-SA policies, procedures, by-laws and publications associated with the IEEE Standards Information Network ("IEEE-SIN"). The payment of royalty may be required, depending on the amount of material to be utilized and/or the intended use of those materials. The official URL for access to IEEE Standards is http://standards.ieee.org

F.3. THE SIMULATION INTEROPERABILITY STANDARDS ORGANIZATION (SISO)

SISO is an international organization dedicated to the promotion of modelling and simulation interoperability and reuse for the benefit of a broad range of M&S communities. SISO's Standards Activity Committee develops and supports simulation interoperability standards, both independently and in conjunction with other organizations. SISO is a Category C Liaison Organization with ISO/IEC (JTC 1) for the development of standards for the representation and interchange of data regarding Synthetic Environment Data Representation and Interchange Specification (SEDRIS). Each person who registers for and attends a Simulation Interoperability Workshop (SIW) is considered a member of SISO, effective as of the date of such registration. SISO membership automatically expires at the end of any calendar year in which a member fails to attend at least one SISO Workshop. SISO membership exceeds 1400 individuals from 28 countries, representing over 400 organizations. Currently, more than 35 SISO Standards and Reference products have been developed and approved. SISO is officially recognized by NATO as an SDO, under a TCA signed by the NMSG in 2007. SISO standards are normally free of charge. The official website for SISO standards is www.sisostds.org.

F.4. THE OPEN GEOSPATIAL CONSORTIUM (OGC)

The OGC is an international voluntary consensus standards organization (not for profit). In the OGC, more than 50 commercial, governmental, non-profit and research organizations worldwide collaborate in an open consensus process encouraging development and implementation of standards for geospatial content and services, sensor web and Internet of Things, GIS data processing and data sharing. Prior to 2004, the organization was known as Open GIS Consortium. Most of the OGC standards are based on a generalized architecture captured in a set of documents collectively called the Abstract Specification, which describes a basic data model for geographic features to be represented. Atop the Abstract Specification is a growing number of specifications, or standards, that have been (or are being) developed to serve specific needs for interoperable location and geospatial technology, including GIS. The OGC is divided into three operational units: The Specification program, the Interoperability Program, and Outreach and Community Adoption. The OGC has a close relationship with ISO/TC 211 (Geographic Information/Geomatics). The OGC

abstract specification is being progressively replaced by volumes from the ISO 19100 series under development by this committee. Further, the OGC standards Web Map Service, GML, Web Feature Service, Observations and Measurements, and Simple Features Access have become ISO standards. Further information can be found at www.opengeospatial.org.

F.5. THE NORTH ATLANTIC TREATY ORGANIZATION (NATO)

The standardization activity in NATO is complex and covers multiple domains. As stated in the paragraph 1.6., the NATO STO's NMSG is the Delegated Tasking Authority for standardization in NATO M&S domain. Dedicated NMSG Task Groups were established with the aim to develop NATO standardization documents, e.g. STANAGs and APs. Examples of STANAGs developed by NMSG include STANAG 4603 on HLA, 4662/4663/4664 on SEDRIS. The efforts of several NMSG Task Groups were continued by SISO and resulted in M&S standards (e.g. C-BML, GM-VV, UCATT, etc.). In the framework established by the NATO Standardization Policy, NMSG is actively involved in the SISO activities to ensure that the standards developed by SISO meet NATO requirements so they could be adopted by NATO via covering STANAGs/STANRECs. More details on the standardization process in NATO are available in the paragraph 1.6.

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