NATO STANDARD

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NATO MODELLING AND SIMULATION STANDARDS PROFILE

Edition C Version 1

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NATO LETTER OF PROMULGATION

6 March 2015

1. The enclosed Allied Modelling and Simulation Publication AMSP-01, Edition C, Version 1 NATO MODELLING AND SIMULATION STANDARDS PROFILE, which has been approved by the nations in the NATO MODELLING AND SIMULATION GROUP, is promulgated herewith.

2. AMSP-01, Edition C, Version 1 is effective upon receipt and supersedes AMSP-01, Edition B, Version 1 which shall be destroyed in accordance with the local procedure for the destruction of documents.

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

Edvardas MAŽEIKIS
Major General, LTUAF
Director, NATO Standardization Office

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

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 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, which are not developed by official organizations but 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 (C) and it includes more than 40 M&S related standards (see Annex B). 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,

Wim HUISKAMP, Chairman of NMSG

Grant BAILEY, Chairman of MS3

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INTRODUCTION
Publication Alliée N° 01 sur la Modélisation et la Simulation (M&S) (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 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» (ceux qui ne sont pas développés par des organisations officielles), mais 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, puis, une seconde version, en Janvier 2012. Il fournira une mise à jour régulière de ce document. La version actuelle est AMSP-01 (C) et comprend plus de 40 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,

Wim HUISKAMP, Président du NMSG

Grant BAILEY, Président du MS3

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TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION

1.1. REFERENCES

1.1.1. NATO Regulations on Standardization

1.1.1.1. NATO Policy for Standardization
C-M(2010)0063

1.1.1.2. NATO Intellectual Property Rights Policy for NATO Standardization Documents and NATO Dispositions Related to the Issue of Copyrights for NATO Standardization Documents
C-M(2008)0017

1.1.2. Related Allied Publications

1.1.2.1. Production, Maintenance and Management of NATO Standardization Documents
AAP-03

1.1.2.2. NATO Glossary of Standardization Terms and Definitions (English and French)
AAP-42

1.1.2.3. Publishing Standards for Allied Publications
AAP-32

1.1.2.4. NATO Glossary of Terms and Definitions (English And French)
AAP-06

1.1.3. Other Documents

1.1.3.1. NATO Modelling and Simulation Master Plan
AC/323/NMSG(2012)-015

1.1.3.2. Standardization and Related Activities - General Vocabulary
ISO/IEC Guide 2 (© ISO/IEC)

1.1.3.3. CNAD Letter Tasking NMSG Delegated Tasking Authority for NATO M&S Standardization
DI(2003)243, 29 August 2003)

1.1.3.4. SISO Policy and Procedures Document
SISO-ADM-002-008

1.1.3.5. Distributed Simulation Engineering and Exploitation Process (DSEEP)
IEEE 1730

1.1.3.6. HLA Federation Development and Execution Process (FEDEP)
IEEE 1516.3

1.1.3.7. NATO MSG-058 Task Group Final Report
RTO-TR-MSG-058 AC/323(MSG-058)

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1.2. PURPOSE

1. The primary purpose of the Allied Modelling and Simulation Publication AMSP-01, the NATO Modelling and Simulation Standards Profile, is to provide guidance on the selection and use of Modelling and Simulation (M&S) standards to promote interoperability. The document 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. A secondary purpose of AMSP-01 is to inform NATO M&S stakeholders on new/emerging standards and also on commercial or government-owned products that are in common use and sometimes improperly called “standards”. This concerns “de facto” standards, products, methodologies, processes, etc. that are not “formal” standards”, but are widely used within industry and nations and could be relevant to NATO M&S activities. This secondary purpose explains the large number of products that are mentioned and described in this document, even if they are not all “official standards” as defined in section 2.1.

3. The standards that have been selected by NATO M&S Group (NMSG) experts to be included in the Profile are considered to further both purposes of AMSP-01 – to support interoperability and to provide information. The Standards Profile is 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.

4. **The standards and other products included in the Profile are either selected for information purposes or recommended by the NMSG to promote M&S interoperability. Their selection is the result of a formal selection process (see paragraph 2.6.) by NATO and national M&S experts. 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. AMSP-01 maintains information on M&S standards and recommended practices relevant to achieving interoperability and re-use of components, data, models or best practices. The AMSP-01 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 Model;

e. Software Engineering.

f. Synthetic Natural Environment, with sub-categories:

(1) Data sources and formats;

(2) Imagery, 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 ‘obsolete’, ‘aging’, ‘current’, or ‘emerging’, as appropriate. These categories are defined as follows:

a. ‘Obsolete’ standards are identified as those that are not being maintained and have been superseded. Users should plan replacement activities. For various reasons, existing projects that can no longer be modified or maintained may need to use “obsolete” standards. For new projects, these standards should not be applied.

b. ‘Aging’ standards are identified as those that are mature and in wide use, but may have limited capability. In these cases, the use of ‘current’ or ‘emerging’ standards should be considered in the context of future project improvements.

c. ‘Current’ standards are identified as those that are in use and are currently being maintained and developed. For new projects, these standards should be applied.

d. ’Emerging’ standards are identified as those that are being developed (e.g. to meet gaps in capability), which are not yet fully formalised or not yet widely accepted. For new projects, these standards should be considered.

1.4. NATO DEFINITION OF A STANDARD

1. NATO recognises the ISO/IEC[1] 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.

1.5. 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) e.g:

(1) Implementation Guides;

(2) Catalogues of National Data;

(3) User Manuals;

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

(4) Handbooks;

(5) Best Practice;

(6) Guidance.

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.

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 responsible for:

a. identifying Military standardization requirements, especially in Force Proposals and force goals or in lessons learned;

b. indicating their priority and the required levels of standardization; and

c. implementing STANAGs, within their area of responsibility, which affect forces allocated to NATO, taking into account national reservations.

1.5.1. NATO Standardization Office

1. The NSO is an independent NATO Office that reports to the Committee for Standardization (CS) for Standardization Policy and Management and to the Military Committee (MC) for corporate oversight and issues relating to operational standardization. The Office's mission of the NSO 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 ISO, IEC, ETSI, CEN, CENELEC, ANSI, GS1, SAE, SISO and IEEE. Others will follow in the near future.

1.5.2. NATO Modelling and Simulation Group (NMSG)

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 STANAGs and

other standardization documents, such as this publication, in support of NATO Modelling and Simulation activities.

1.5.3. NATO Modelling and Simulation Standards Subgroup (MS3)

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 AMSP-01 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.

1.6. 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;

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.

1.7. 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[2]

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 became a promulgated NATO STANAG. Annex E provides a list of well-known SDOs. A majority of M&S standards described in this profile are official standards in consistency with the NATO definition of standards (see section 1.4.).

2. **"De-facto standards"**, ("in practice") are commonly used technologies, protocols, processes, etc. Sometimes referred to as little's' standards, 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 description in Annex B), 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, simply 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;

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

[2] 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 E 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 DODAF included in this profile.

2.2. PREFERRED CHARACTERISTICS OF STANDARDS

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;

   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[3] is “the ability to act together coherently, effectively and efficiently to achieve Allied tactical, operational and strategic objectives”[4].

      (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:

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

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

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

(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. 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, steps a-d 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 AMSP-01 STANDARDS

1. The scope of standards that are considered for inclusion in AMSP-01 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 AMSP-01:

a. Existing standards;

b. Emerging standards; and

c. Expected standards.

3. The AMSP-01 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 COTS tools.

4. The AMSP-01 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 AMSP-01 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.

2.6. PROCEDURES

1. The AMSP-01 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 AMSP-01 based on the policy outlined in 2.5. Proposals will be submitted in the form of a completed profile consistent with Annex A. Submissions shall be sent to NMSG via e-mail msg@cso.nato.int.

b. The MS3 votes on the inclusion of standards in the AMSP-01 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. Abstentions do not count in the percentage.

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 AMSP-01 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 AMSP-01 may be addressed via the points of contact or directly to the secretary of MS3 (see Annex C 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.

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 DSEEP[5], which is an approved IEEE recommended practice developed by SISO that supports the overall M&S lifecycle. DSEEP is based on the formerly widely accepted HLA Federation Development and Execution Process (FEDEP) (see reference 1.1.3.6).

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

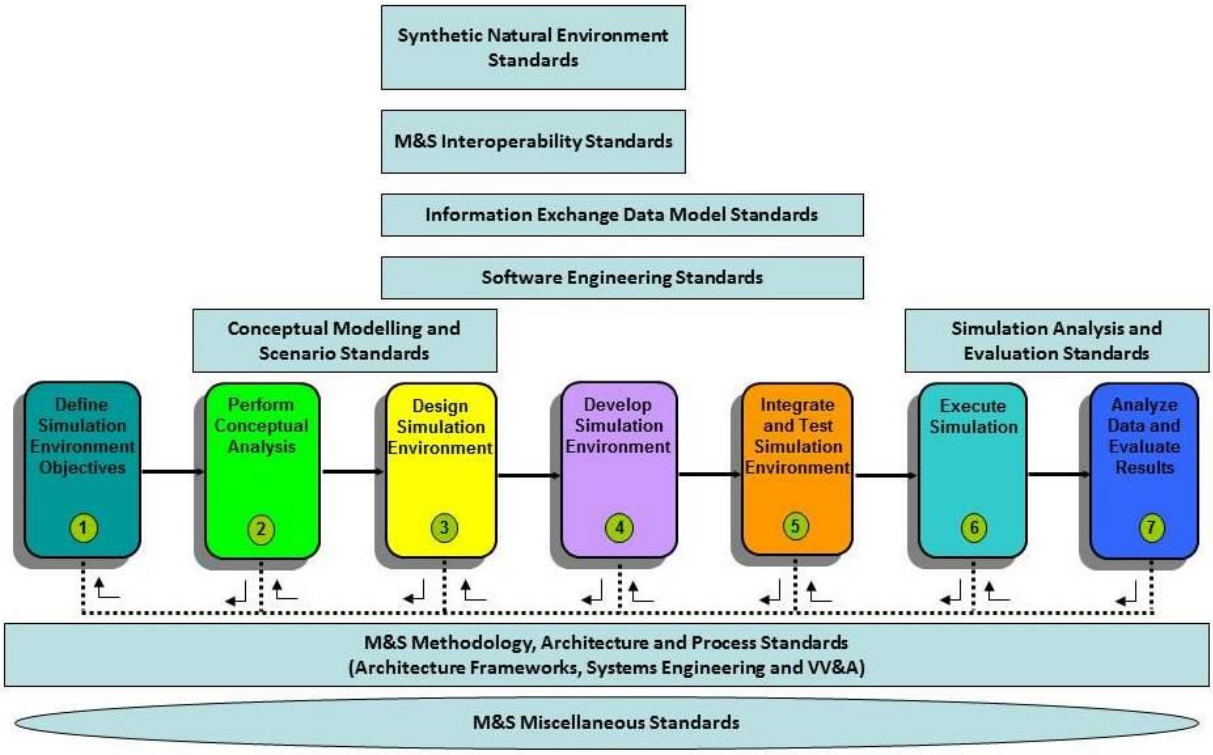

Figure 3-1: The 7-step DSEEP simulation engineering process and the standards categories

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 B.

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, although they are still applicable. An example standard is the well-known US DoD Architecture Framework (DODAF);

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. M&S-specific examples include the above-mentioned FEDEP and DSEEP; and

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 HLA FEDEP"; 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[6]) 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 them using standardised 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.

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 High Level Architecture (HLA), which is an IEEE standard and mandated by the NATO M&S Interoperability STANAG 4603.

[6] 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

3.1.4. 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 C4ISR 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 “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 two-dimensional images and three-dimensional entities are to be stored. Example standard includes Collada;

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

d. Production processes: for standards that define how environmental data is to be produced. Example standard includes Reuse and Interoperation of Environment Database Development Process (RIEDP, expected);

e. Visual Systems Interfacing: for standards that define how visual data is to be offered for visualization, such as the emerging 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 Synthetic Environment Data Representation and Interchange Specification (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 expected Distributed Debrief Control Architecture (DDCA) which is being developed under SISO auspices.

3.1.8. M&S Miscellaneous

This large category mainly concerns Steps 3 and 4 of the DSEE This category covers standards that generally concern all DSEEP steps, some or none. The Lua scripting language standard is a typical example.

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. For example, XML, which is clearly a software engineering standard, is also widely used in M&S as a data format. In such cases, the description of the standard should include all of the categories into which it falls and explain the reasons why it does so. The detailed descriptions of all of the standards are given in Annex B.

3.2.1. M&S Methodology, Architecture and Processes Standards

This very general category comprises three subcategories.

3.2.1.1. Architecture Frameworks

1. This subcategory contains no M&S-specific standards. The following guidance documents are common standards in systems engineering:

a. DODAF (The US DoD Architecture Framework) – current; and

b. NAF (The NATO Architecture Framework) – current.

2. These Architecture Frameworks are mainly popular in the world of 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:

   a. The IEEE 1516.3 HLA Federation Development and Execution Process (FEDEP) – obsolete; and

   b. The IEEE 1730 DSEEP – current. This process is generic in the sense that it is not dedicated to a specific interoperability standard like the FEDEP, which was limited to the HLA

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) – current;

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

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

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

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) – current;

b. The Unified Modelling Language (UML) from the Object Modelling Group (OMG) – current;

c. XML Metadata Interchange (XMI) from the OMG – current;

d. The Systems Modelling Language (SysML) from the OMG – current; and

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

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 - UML, XMI and SysML - are not specific to M&S, but are considered useful for modelling. All three could also be listed in the Software Engineering category.

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 time and resource consuming. MSDL was developed to address these issues. MSDL is derived from previous US Army efforts. It should evolve and become more general while staying consistent with the Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM) and C-BML developments (see section 3.2.4. and Annex B 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 (HLA) – current;

b. The SISO Dynamic Link Compatible (DLC) HLA API – current;

c. The IEEE 1278 Standard Series for Distributed Interactive Simulation (DIS) – current; and

d. The US Army Test and Training Enabling Architecture (TENA) – current.

3. DIS, HLA and TENA often compete for acceptance even though they have different qualities and inherent limitations. Among the three, both DIS and HLA are official standards developed by SISO and published by the IEEE. In contrast, TENA is a “de facto” standard developed by the US Army and mainly used in the USA.

4. The DLC HLA API standard was developed by SISO to complement the HLA standard and compensate for lack of compatibility between commercial HLA software. It has been included in the latest version of the HLA (approved and published in 2010) but is still an official standard.

5. 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 recommended 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 – current;

b. The DIS Enumerations and encoded values, which is one component of the overall DIS standard – current;

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

d. The Link 16 BOM Simulation standard – current;

e. The Link 11 BOM Simulation standard development – emerging;

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

g. Joint Consultation, Command and Control Information Exchange Data Model (JC3IEDM) – current; and

h. The NATO STANAG 5602 Standard Interface for Multiple Platform Link Evaluation (SIMPLE) – current.

2. The HLA OMT is the HLA-specific data exchange standard. It is also the metadata underlying the Base Object Model (BOM) standard.

3. DIS Enumerations 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. They are also used in the RPR-FOM.

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 DIS enumerations 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: simulation of Link 11 and Link 16 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 C3I systems and simulations. It is a current standard.

7. JC3IEDM is a NATO STANAG developed by the Multilateral Interoperability Programme (MIP); it supports the exchange of operational orders and reports between C3I systems. The M&S community recognizes the JC3IEDM as the reference standard for operational data description and exchange; in fact, C-BML and MSDL are both developed to be consistent with the JC3IEDM.

8. Similar to JC3IEDM, SIMPLE is not M&S-specific, but it was included since it is often used to exchange Link 11 and Link 16 data in M&S applications.

3.2.5. Software Engineering Standards

1. The following standards are general-purpose standards that are very well suited to M&S and are sometimes erroneously considered specific to M&S.

2 This standards category includes:

a. The Model Driven Architecture (MDA) from the OMG – current; and

b. Extensible Markup Language (XML) – current;

3. The MDA and its supporting process, Model Driven Engineering (MDE), are clearly suited to M&S activities and simulation system development.

4. XML is a software engineering standard that is very widely used on the Internet as well as M&S. More specifically, it is used to define the data format of some of the standards cited in this profile including those listed in the previous category.

5. As previously mentioned, many standards listed in preceding categories could be listed here such as UML, SysML and XMI.

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 currently only contains one standard, 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 all 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 all the 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

1. This subcategory, which broadly specifies the structure of common environmental data files, contains the following standards:

   a. Vector MAP (VMAP) – aging;

b. Digital Terrain Elevation Data (DTED) – current;

c. Keyhole Markup Language (KML) – current;

d. Shapefile – current; and

e. S57 – current.

2. VMAP is a data format derived from the DIgital Geographic information Exchange STandard (DIGEST), which identifies physical terrain features such as roads. It conforms rigorously to a USA military standard to ensure interoperability. Although still produced, its use is being superseded by Shapefile.

3. DTED is a format for representing terrain elevation data; it is widely used in M&S, especially with imagery overlaid to produce realistic 3D views of terrain.

4. KML is an XML-based language schema for expressing geographic annotations and visualizing two-dimensional maps and three-dimensional Earth on Web-based browsers. KML was developed for use with Google Earth.

5. Shapefile is a popular geospatial vector data format for geographic information systems (GIS). It is a broadly open specification for GIS feature vector data interoperability. A Shapefile stores non-topological geometry and attribute information for the spatial features in a data set. It can support point, line, and area features. It is a “de facto” standard for source vector data that is used to produce M&S environmental/terrain databases.

6. S57 is the standard to be used for the exchange of digital hydrographical data between national hydrographical offices and for its distribution to manufacturers, mariners and other data users.

3.2.6.3. Imagery and 3D-Models

1. This standards subcategory includes the following:

a. X3D (XML 3-Dimensional) – emerging;

b. OpenFlight – current;

c. GeoTIFF– current; and

d. COLLAborative Design Activity (COLLADA) – current.

2. X3D is an ISO/IEC standard file format and run-time architecture for visualizing real-time, interactive 3D scenes and objects in web browsers or stand-alone viewers. Note that the Virtual Reality Modelling Language (VRML) is also a file format for describing interactive 3D-objects and worlds. VRML is an ISO/IEC standard that was last published in 1997, was assessed as aging and superseded by X3D. VRML was not included in this profile.

3. OpenFlight is a commercial “de facto” standard. It is a file format for describing 3D-scenes and entities.

4. GeoTIFF stands for “Geographic Tagged Image File Format”. It is a public domain metadata standard which allows geo-referencing information to be embedded within a TIFF image file. The main objective of GeoTIFF is to enable cartographic information to be included in a TIFF image.

5. Collada defines an XML-based schema to transport 3D assets between applications, enabling diverse 3D authoring and content processing tools to be combined into a production pipeline. The intermediate language provides comprehensive encoding of visual scenes including geometry, shaders and effects, physics, animation, kinematics, and even multiple version representations of the same asset. Collada was not developed by the M&S community, but by the entertainment and gaming industry. COLLADA is an ISO/PAS standard.

3.2.6.4. Interchange of Environmental Data Models

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. Only three standards are listed in this subcategory. Data formats used to exchange environmental data are not included in this category:

   a. SEDRIS Transmittal Format (STF) – current;

   b. Geographic Markup Language (GML) – current; and

   c. City Geography Markup Language (CityGML) – current.

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. GML is an ISO/IEC standard for the transport and storage of geographic information. GML defines an XML-based schema, mechanisms and conventions that provide an open, vendor-neutral framework for the description of geospatial application schemas for the transport and storage of geographic information.

5. CityGML is an OGC Encoding Standard for the representation, storage and exchange of virtual 3D city and landscape models. CityGML is implemented as an application schema of GML version 3.1.1 (GML3).

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 the Reuse and Interoperation of Environment Database Development Process (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.

3.2.7. 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

1. This category contains those standards that do not readily fall into any of the other categories. Currently it only contains one standard - Lua.

2. Lua is a dynamically typed language intended for use as an extension or scripting language. Lua is very well suited for modelling (human) behaviour (AI) in simulations and games. Except for Lua, there is currently no other (open standard related to Human Behaviour Representation (HBR).

3.3. SUMMARY

The following table summarizes the grouping of M&S standards in categories and sub-categories. In addition it also shows how some standards relate to secondary categories.

Categories	Sub-categories	Standards attached to the category	Possible standards (Secondary attachment)
M&S methodology, architectures and processes	**Architecture Frameworks**	DoDAF, NAF	
	System Engineering Processes	DMAO, FEDEP, DSEEP	
	V&V	SISO GM-VV, V&V Overlay on HLA FEDEP, VV&A RPG (US DoD), VV&A Templates (US DoD)	
Conceptual Modelling and Scenarios		BOM, MSDL, SysML, UML, XMI	Link 11, Link 16
M&S Interoperability		DIS, DLC API, FEAT, HLA, TENA, WebLVC	
Information Exchange Data Model		C-BML, DIS Enum, HLA OMT, JC3IEDM, Link 11, Link 16, NETN-FAFD, RPR-FOM, SIMPLE,	BOM, XML
Software Engineering		MDA, XML	SysML, UML, XMI
Synthetic Natural Environment	**Data sources and formats**	DTED, KML S57, Shapefile, VMAP	
	Imagery, 3D Models	COLLADA, GeoTIFF, OpenFlight, X3D,	
	Interchange of environmental data	CityGML, GML, SEDRIS STF	COLLADA, GeoTIFF, S57
	Production processes	*None* *(but commercial or project-related approaches such as CDB, GEMS, MTDB (SE CORE), NPSI)*	
	Visual Systems Interfacing	CIGI	
	Multiple	SEDRIS (SRM, DRM & EDCS)	SEDRIS STF
Simulation Analysis and Evaluation		DDCA (expected)	
M&S Miscellaneous		Lua	

CHAPTER 4 GAPS

1. Chapter 3 lists and categorizes many M&S standards, which are described in Annex B. The number of standards suggests that the M&S standardization effort is relatively complete; however, MS3 participants generally feel that the standards are insufficient to achieve 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 HBR and live simulation, which MS3 participants unanimously agreed were both particularly important, are not sufficiently covered by standards.

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. Despite an urgent need, no adequate open standards for HBR methods and/or languages have been developed so far, although Lua is a first initiative towards a “de facto” standard.

4. Live training systems are often also proprietary as they are developed by individual vendors and have been (to date) generally not interoperable. NATO working groups have been addressing this issue in close collaboration with procurement offices and industry, including MSG-063, Urban Combat Advanced Training Technology 2 - UCATT 2, MSG-098 UCATT Architecture, MSG-099, UCATT Standards and MSG-140 UCATT Live Simulation Standards. A first draft release for a simulation standard has been created (for LASER encoding) under a newly established SISO PDG as UCATT moves towards its first Open Standard. The MS3 recognises, however, that much more work is required before open M&S standards 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 under development, 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 the only area that has been identified as an area clearly requiring M&S standards, as previously discussed. The Task Group MSG-127 Reference Architecture for Human Behaviour Modelling addressed this topic.

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. Examples AFs include:

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

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

c. The Canadian Dept. of National Defence AF (DNDAF);

d. The UK Ministry of Defence AF (MoDAF); and

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

2. Following the voting process in the MS3 (see paragraph 2.6.), only DoDAF and NAF were included in the AMSP-01 so far.

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. Thus, simulation system engineering is considered as well covered in general.

2. The only gap identified in this subcategory is the lack of an engineering process dedicated to the development and exploitation of standalone simulations. Although such activities may be considered addressed by more general standards, the latter are unnecessarily complex for standalone simulation development and they may not be used at all as a result.

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 neither shared nor unanimously adopted by other nations. In fact, only one internationally recognized standard has

been developed to date: the IEEE 1516.4 "VV&A Overlay on the HLA 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 human behaviour representation

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 has 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).

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. The task to develop a comprehensive approach to CM is being addressed by the SISO Simulation Conceptual Modelling PDG. This PDG used the findings of MSG-058 as a sound basis for its activities.

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 Task Group MSG-086, Simulation Interoperability has developed a "Guideline on Scenario Development for (Distributed) Simulation Environments". The purpose of the guideline is to provide detailed information regarding the development

of scenarios for distributed 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.

6. The only known M&S scenario standard is SISO's MSDL which has its origins in the army/land-domain. A "joint version" of the MSDL is required to better support the needs of the other services while staying consistent with the JC3IEDM and further C-BML developments.

4.3. M&S INTEROPERABILITY

1. Many standards exist in this category. IEEE DIS and HLA, the US DoD TENA, and the OMG CORBA are just a few. So many standards exist that the USA has completed an activity to assess how to improve the current situation called LVCAR. The LVCAR results points 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. 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-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 AMSP-01.

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 completely 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. Such data is rarely available, much less in a form that readily supports convenient or automated determination of model interoperability. A well-defined conceptual modelling standard should enable the achievement of substantive interoperability of simulations.

f. The only simulation interoperability standard that has been ratified as a NATO Standardization Agreement is the HLA, in 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 AMSP-01.

4. The Task Group MSG-086, Simulation Interoperability has compiled a detailed catalogue of 45 issues that currently 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. Examples of standards under development include Discrete EVent systems Specification (DEVS), the Simulation Reference Markup Language (SRML) and the Open M&S Architecture.

b. Numerous COTS products are not interoperable although this gap may be covered by the emerging SISO Commercial-Off-The-Shelf (COTS) Simulation Package Interoperability (CSPI) standard.

c. The 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.

4.4. INFORMATION EXCHANGE DATA MODEL

Many data exchange standards are available, but they are more or less inadequate. The JC3IEDM STANAG is generally recognized as the basic standard within NATO and allied nations but it is neither sufficiently used nor sufficient for many M&S activities. For example, JC3IEDM is lacking support for data exchange between C2 and simulation systems. A promising effort in that respect is the SISO C-BML standard, which is supported by NATO through the MSG-048 Task Group and its follow-on effort MSG-085. In the data exchange domain, many national efforts exist but the results are not always shared between nations - sometimes for security reasons so future release is unlikely. As an example, NATO lacks reference FOMs, the RPR-FOM being the only well recognized standard; presumably, other FOMs have been developed and could be shared. One example would be the effort undertaken by the Task Group MSG-106 Enhanced CAX Architecture, Design and

Methodology, which builds on the results of MSG-068 NATO Education and Training Network (NETN).

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 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, etc. Thus, existing standards will need to be heavily modified or new ones developed.

4.6.2. Imagery and 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. The OpenFlight specification is owned by Presagis, a CAE company, 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.

2. GeoTIFF is a very popular format for encapsulating geospatial data with TIFF-formatted imagery. The “standard” is maintained by an open user community and can be used royalty-free by any company but it has not become a standard of any legally-recognized standards bodies such as ISO or the IEEE.

3. X3D, the successor to VRML, is relatively new and is very unlikely to replace OpenFlight in popularity.

4. The ‘de facto’ standards such as OpenFlight and GeoTIFF 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.

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 AMSP-01. 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.

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.

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. The task group has also initiated a SISO Standing Study Group that works towards a PDG regarding a security overlay for DSEEP.

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 AMSP-01 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 AMSP-01 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 Allied M&S Publication (AMSP-01) 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 an 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 consider developing and maintaining an Allied M&S Publication that covers terms and definitions that are relevant to the NATO M&S domain in consistency with national glossaries.

5.4. SPECIFIC RECOMMENDATIONS

1. As far as the categories of standards and actual standards are concerned, 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 C3I community based on its current reference standards like JC3IEDM. The M&S community should carefully follow JC3IEDM development and contribute elements that support C2-Simulation interoperability;

d. 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;

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

f. 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 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 identifier:

STANAG 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.*

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ANNEX B STANDARDS WITH APPLICABILITY IN 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**									
CIGI												**X**			
CityGML										**X**					
Collada									**X**	x					
DIS					**X**										
DIS Enum						**X**									
DMAO / DSEEP Multi-Architecture Overlay		**X**													
DoD Architecture Framework	**X**														
DSEEP		**X**													
DTED								**X**							
Dynamic Link Compatible (DLC) HLA API					**X**										
FEAT					**X**										
GeoTiff									**X**	x					
GML										**X**					
GM-V&V			**X**												
HLA					**X**										
HLA - OMT						**X**									
HLA FEDEP		**X**													
JC3IEDM						**X**									
KML								**X**							
Link 11 Simulations				x		**X**									
Link 16 Simulations				x		**X**									
LUA															**X**
MDA							**X**								
MSDL				**X**											
NATO-AF V3 (2003) NATO - Architecture Framework	**X**														

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		
NETN FAFD						**X**									
OpenFlight									**X**						
RPR FOM						**X**									
S57								**X**		x					
SEDRIS DRM													**X**		
SEDRIS EDCS													**X**		
SEDRIS SRM													**X**		
SEDRIS STF										**X**			x		
ShapeFile								**X**							
SIMPLE						**X**									
SysML				**X**			x								
TENA					**X**										
UML				**X**			x								
VMAP								**X**							
VV&A Overlay to FEDEP			**X**												
VV&A RPG			**X**												
VV&A Templates			**X**												
Web LVC					**X**										
X3D									**X**						
XMI				**X**			x								
XML						x	**X**								

Base Object Model (BOM)

Standard Title: Base Object Model (BOM)
Standard Identifier: This standard is comprised of two documents**:**

- the "BOM Template Specification", SISO-STD-003-2006,
- 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 identifier: N/A
STANAG 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]: One freeware tool implements the BOM standard. First uses of BOMs are 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: 2 April 2013
Keywords: Automation, Behavior, BOM, Components, Composability, Conceptual Model, FEDEP, Interoperability, Metadata, Patterns, Requirements, Reuse

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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 identifier: N/A
STANAG status: N/A
Abstract: A Battle Management Language (BML) is an unambiguous language used to:

- Command and control forces and equipment conducting military operations.
- Provide for 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).
Phase 1 describes a sufficient data model to unambiguously define a set of military orders using JC3IEDM as a starting point and extending it as necessary so that the orders can be interpreted by C2, M&S, and ultimately autonomous systems. This 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 the next version of MSDL and C-BML will be undertaken by a single SISO PDG, C2SIM PDG/PSG - Command and Control Systems - Simulation Systems Interoperation, to ensure that the two standards apply in concert with one another.
Technical Maturity [Current]: Version 1.0 of the C-BML was approved 14 Apr 2014. Future C-BML development will include grammar and ontology. 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 with predecessor activities that have led to the current standard.

Limitations of this Standard: Phase 1 of C-BML focuses on 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: 21 October 2014
Keywords: C2, Simulation, MSDL

Common Image Generator Interface (CIGI)

Standard Title: Common Image Generator Interface
Standard Identifier: CIGI
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 identifier: N/A
STANAG 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 real-time 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.
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 organising 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: 6 November 2014
Keywords: Image Generator, Interoperability, CIGI

CityGML

Standard Title: OpenGIS® City Geography Markup Language (CityGML) Encoding Standard
Standard Identifier: OGC 12-019
Version Identifier: Version: 2.0.0
SDO: Open Geospatial Consortium (OGC)
STANAG identifier: N/A
Abstract: OpenGIS® Encoding Standard for the representation, storage and exchange of virtual 3D city and landscape models. CityGML is implemented as an application schema of the Geography Markup Language version 3.1.1 (GML3). CityGML models both complex and geo-referenced 3D vector data along with the semantics associated with the data. In contrast to other 3D vector formats, CityGML is based on a rich, general purpose information model in addition to geometry and appearance information. For specific domain areas, CityGML also provides an extension mechanism to enrich the data with identifiable features under preservation of semantic interoperability. Targeted application areas explicitly include urban and landscape planning; architectural design; tourist and leisure activities; 3D cadastres; environmental simulations; mobile telecommunications; disaster management; homeland security; vehicle and pedestrian navigation; training simulators and mobile robotics. CityGML is considered a source format for 3D portraying. The semantic information contained in the model can be used in the styling process which generates computer graphics represented e.g. as KML/COLLADA or X3D files. The appropriate OGC Portrayal Web Service for this process is the OGC Web 3D Service (W3DS).
Technical Maturity [Current]: CityGML has been developed since 2002 by the members of the Special Interest Group 3D (SIG 3D) of the initiative Geodata Infrastructure North Rhine-Westphalia (GDI NRW) in Germany. The SIG 3D is an open group consisting of more than 70 companies, municipalities, and research institutions from Austria, Germany, Switzerland, UK and working on the development and commercial exploitation of interoperable 3D models and geo-visualisation. Another result of the work from the SIG 3D is the proposition of the Web 3D Service (W3DS), a 3D portrayal service that is also being discussed in the Open Geospatial Consortium (OGC Doc. No. 05-019). CityGML has been successfully implemented and evaluated in several pilot projects e.g. “Pilot 3D” in Germany.
Applicability: CityGML is used for representation, storage and exchange of virtual 3D city and landscape models (Urban Feature Data).
Information on implementation: CityGML was used for the official 3D city model of several cities e.g. Berlin, Stuttgart, etc.
Limitations of this Standard: unknown.
Standard Type: Synthetic Natural Environment – Interchange Environmental Data.
Public Availability: Freely accessibly on the OGC website.
URL or instructions to Access or Acquire:
www.opengeospatial.org/standards/citygml
Input Date: 04 May 2009
Last Updated: 04 April 2013
Keywords: GIS, Navigation, Synthetic Environment

COLLADA

Standard Title: COLLADA which stands for "COLLAborative Design Activity"
Standard Identifier: COLLADA
Version Identifier: COLLADA 1.5.0, October 2008
SDO: Originally created by Sony Computer Entertainment as the official format for PlayStation 3 and PlayStation Portable development, it has since become the property of the Khronos Group, which now shares the copyright with Sony. The Khronos Group is a member-funded industry consortium, "creating open standards for the authoring and acceleration of parallel computing, graphics and dynamic media". Early Khronos members included Alias Systems Corporation, Criterion Software, Autodesk, Inc., and Avid Technology.
STANAG identifier: N/A
Abstract: COLLADA defines an XML-based schema to transport 3D assets between applications enabling diverse 3D authoring and content processing tools to be combined into a production pipeline. The intermediate language provides comprehensive encoding of visual scenes including: geometry, shaders and effects, physics, animation, kinematics, and even multiple version representations of the same asset.
Technical Maturity [Current]: Several graphics companies collaborated with Sony from COLLADA's beginnings to create a tool that would be useful to the widest possible audience, and COLLADA continues to evolve through the efforts of the Khronos contributors.
Applicability: COLLADA was not developed by the M&S community but by the gaming industry. Nevertheless it allows building 3D content as support for the services of a simulation program. COLLADA is using an XML schema that enables the powerful capability of validating data, as well as the possibility of using many existing commercially available or public-domain tools. The primary goal of COLLADA was to create a working group enabling collaboration among all the partners to standardise on the representation of all the features required by interactive applications.
Information on implementation: supported by a dedicated API (open source) and by leading 3D content production software. Commercial game studios and game engines have adopted the standard. Google has chosen COLLADA as a base for its interchange format for Google Earth collaborative content.
Limitations of this Standard: COLLADA is a versatile, state-of-the-art file format aimed at data interchange and therefore not efficient as a runtime format.
Standard Type: Synthetic Natural Environment / Imagery and 3D Models.
Public Availability: COLLADA is an open de facto standard. The Collada DOM and OpenCollada are the main API's and are actively maintained. The COLLADA schema and specification are freely available from the Khronos group.
URL or instructions to Access or Acquire: www.khronos.org/collada . There is also a COLLADA community web site (http://collada.org).
Input Date: 22 August 2008
Last Updated: 19 November 2013
Keywords: XML, 3D, 3D computer graphics, digital content creation, videogame

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DIS

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

- IEEE 1278-1993 - Standard for Distributed Interactive Simulation - Application Protocols
- IEEE 1278.1-1995 - Standard for Distributed Interactive Simulation - Application protocols
- IEEE 1278.1-1995 - Standard for Distributed Interactive Simulation - Application protocols - Errata (May 1998)
- IEEE 1278.1A-1998 - Standard for Distributed Interactive Simulation – Supplement to Application Protocols – Enumeration & Bit-encoded Values
- IEEE-1278.2-1995 - Standard for Distributed Interactive Simulation - Communication Services and Profiles
- IEEE 1278.3-1996 - Recommended Practice for Distributed Interactive Simulation - Exercise Management and Feedback.
- IEEE 1278.4-1997 - Recommended Practice for Distributed Interactive Simulation - Verification Validation & Accreditation

  1278.1 and **1278.2** are under revision by the Simulation Interoperability Standards Organization (SISO).

  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))"

  1278.4 is planned to be reaffirmed and eventually should be replaced by a new IEEE standard (Annexe B to the VV&A Overlay to the 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 identifier: no current STANAG: 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 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 15 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: 2 April 2013
Keywords: PDU, DIS, Distributed Interactive Simulation, simulation, exercises, distributed, interoperability

DMAO

Standard Title: Distributed Simulation Engineering and Execution Process (DSEEP) Multi-Architecture Overlay (DMAO)
Standard Identifier: IEEE DMAO
Version Identifier: IEEE P1730.1
SDO: SISO on behalf of IEEE
STANAG identifier: None
STANAG 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 draft P1730.1 has been submitted to the IEEE Standards Association Standards Board (IEEE SASB) for approval. Currently remains in draft until comments received have been resolved and a subsequent ballot takes place.
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. While a baseline overlay currently exists, broader participation in this effort is requested to improve the quality and completeness of this important product. Anyone with experience (or even a general interest) in how multi-architecture LVC environments are developed is cordially invited to participate in the activities of this PDG.
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: When approved, 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: 25 October 2012.

DODAF

Standard Title: DoD Architecture Framework (DoDAF)
Standard Identifier: None
Version Identifier: Version 2.02 dated 30 September 2010
SDO: The DoDAF Working Groups.
STANAG identifier: N/A
STANAG status: N/A
Abstract: The Department of Defense Architecture Framework (DoDAF), Version 2.0 is the overarching, comprehensive framework and conceptual model enabling the development of architectures to facilitate the ability of Department of Defense (DoD) managers at all levels to make key decisions more effectively through organized information sharing across the Department, Joint Capability Areas (JCAs), Mission, Component, and Program boundaries. The DoDAF serves as one of the principal pillars supporting the DoD Chief Information Officer (CIO) in his responsibilities for development and maintenance of architectures required under the Clinger-Cohen Act. DoDAF is prescribed for the use and development of Architectural Descriptions in the Department. It also provides extensive guidance on the development of architectures supporting the adoption and execution of Net-centric services within the Department. [Ref: DoD Architecture Framework Version 2.02 dated 30 Sept 2010]
Technical Maturity [Current]: Version 1.0 of the DoDAF was first approved in 30 August 2003. The C4ISR Architecture Framework was the predecessor to the DoDAF. Multiple commercial tools produce documentation consistent with the DoDAF.
Applicability: The DoDAF enables architectural content that is "Fit-for-Purpose" as an architectural description consistent with specific project or mission objectives. Because the techniques of architectural description can be applied at myriad levels of an enterprise, the purpose or use of an architectural description at each level will be different in content, structure, and level of detail. Tailoring the architectural description development to address specific, well-articulated, and understood purposes, will help ensure the necessary data is collected at the appropriate level of detail to support specific decisions or objectives.

[Reference: DoD Architecture Framework Version 2.02 dated 30 September 2010]
Information on implementation: Required for use within US DoD major acquisition programs. Adopted (e.g. France), and in some cases modified, by other nations (e.g. UK MODAF).
Limitations of this Standard: Limited support for systems of systems architectures.
Standard Type: M&S Methodology, Architecture and Processes: Architecture Frameworks
Public Availability: The DODAF is available publicly.
URL or instructions to Access or Acquire: This standard is accessible at:
http://dodcio.defense.gov/dodaf20.aspx
Input Date: 8 April 2008
Last Updated: 2 April 2013
Keywords: DoDAF, architecture, framework, Joint Capability Area, JCA

DSEEP

Standard Title: IEEE Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP)
Standard Identifier: IEEE 1730™
Version Identifier: IEEE 1730™ (24 January 2011)
SDO: SISO acting as an IEEE (Institute of Electrical and Electronics Engineers) sponsor.
STANAG identifier: N/A
STANAG status: N/A
Abstract: The DSEEP is intended as a high-level process framework into which the lower-level systems engineering practices native to any distributed simulation user and can be easily integrated. DSEEP describes processes and procedures that should be followed by practitioners to develop and execute distributed simulation systems. This recommended practice is not intended to replace low-level management and systems engineering practices native to user organizations, but is rather intended as a higher-level framework into which such practices can be integrated and tailored for specific uses.
DSEEP is intended to be a generic process and not linked to any specific interoperability standard; nevertheless there are specific annexes covering HLA, DIS and TENA.
Technical Maturity [Current]: DSEEP has been officially published by IEEE in January 2011, building on the experience of the IEEE 1516.3 FEDEP (2003) . It is now in large use and no concerns have been raised by first users.
Applicability: The DSEEP is widely used in current projects as was the FEDEP in previous HLA federation developments. Specialisations and extensions of DSEEP are in progress in SISO such as the IEEE Recommended Practice for
Distributed Simulation Engineering and Execution Process Multi-Architecture Overlay (DMAO) that was recently approved by IEEE.and recently introduced in this version of AMSP-01;
Information on implementation: Some papers published in main M&S conferences and SISO workshops.
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. This document is freely available only to SISO members.
URL or instructions to Access or Acquire: www.ieee.org and www.sisostds.org (for SISO members only).
Input Date: 28 July 2008.
Last Updated: 14 November 2013
Keywords: HLA, process, engineering, FEDEP, federation, development

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DTED

Standard Title: Digital Terrain Elevation Data
Standard Identifier: DTED
Version Identifier: Military Specification Mil-PRF-89020B, "Digital Terrain Elevation Data", 23 May 2000
SDO: US National Geospatial-Intelligence Agency (NGA)
STANAG identifier: 3609
STANAG status: promulgated (19 January 2004)
Abstract: DTED is a standard that specifies how low-high resolution terrain elevation data is to be stored. It was originally developed in the 1970s to support aircraft radar simulation and prediction and was derived from the DLMS (Digital Land Mass System) format. Terrain elevations are expressed by reference to the geodetic systems EGM96 and WGS84.
DTED specifies an altitude value for points on a regular grid, the spacing of which varies according to the selected DTED "Level." Three different levels are specified in the standard:

- DTED Level 0, which has a post spacing of 30 arc seconds in latitude direction (around 900 meters).
- DTED Level 1, which has a post spacing of 3 arc seconds (around 90 meters).
- DTED Level 2, which has a post spacing of 1 arc seconds (around 30 meters).

Those resolutions are valid for the main geographical zone (between the equator and the 50th parallel). Outside this area (North and South), the grid resolution is adapted to take into account the earth curve. Three higher-resolution levels (3-5) have yet to be standardised. DTED is provided in one or more files, each of which corresponds to a one-degree square cell that is aligned with meridians and parallels.
Technical Maturity [Current]: Old and mature format but kept current and in use world-wide.
Applicability: DTED is widely used to represent terrain elevation in military simulations and operational systems although the data is usually combined with other types of data (e.g. imagery) to provide a more complete representation of terrain.
Information on implementation: Since it is a straightforward "Data Standard" that specifies how data is stored in files, it is a relatively simple to implement.
Limitations of this Standard: Elevation values between grid points must be interpolated thus the accuracy of such values cannot be guaranteed; true elevation values may be significantly higher or lower, the difference depending on the DTED Level. Further, DTED provides no other information other than elevation data; for example, it cannot specify if the terrain at a grid point is land or water. Since many applications require more information than just elevation data, DTED is often combined with other data sets. When DTED grid points do not coincide with the measurement points of the other data sources, data correlation problems are introduced.
Standard Type: Synthetic Natural Environment / Data Sources and Formats.
Public Availability: Yes. The availability of DTED *data* is a separate issue and its availability reduces as the DTED Level increases.
URL or instructions to Access or Acquire: The DTED may be downloaded for free at:

https://www1.nga.mil/ProductsServices/TopographicalTerrestrial/DigitalTerrainElevationData/Related%20Documents/89020B.pdf
Input Date: 11 December 2008
Last Updated: 22 October 2013
Keywords: Elevation Model, Terrain Data, DTED, Terrain Modelling, 3D Modelling, 3D Terrain Visualization

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 identifier: None
STANAG status: Not applicable
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 [Current]: 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 Programer Interface, RTI, Run Time Interface, interoperability, architecture, simulation

FEAT

Standard Title: Federation Engineering Agreements Template
Standard Identifier: FEAT
Version Identifier: SISO FEAT standard is under development:
Standard Development Organization: Simulation Interoperability Standards Organization (SISO)
STANAG identifier: unknown
STANAG status: unknown
Abstract: FEAT is described by SISO as "The Federation Engineering AGreements Template (FEAT) will benefit all developers, managers, and users of distributed simulations by providing an unambiguous format for recording agreements about the design and use of the distributed simulation. The template will also benefit this community by enabling the development of federation engineering tools that can read the schema and perform federation engineering tasks automatically." The standard is an XML schema designed to be a detailed, unambiguous template for recording federation agreements that were determined to be of use to federation developers and participants.
Technical Maturity: The standard is based on lessons learned from experimentation (e.g. US LVCAR Implementation program, MSG-052) and will be further evaluated in MSG-106 (2012-2013).
Applicability: capture and document federation agreements for the benefit of all stakeholders in a simulation.
Information on implementation: Used only in experimentation so far. The XML schema have been implemented in a prototype open-source FEAT editor tool.
Limitations of this Standard: FEAT XML descriptions are currently undergoing balloting and may change. 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: http:www.sisostds.org
Input Date: 15 May 2014
Last Updated: 12 October 2012

GeoTIFF

Standard Title: GeoTIFF
Standard Identifier: Geographic Tagged Image File Format (TIFF)
Version Identifier: GeoTIFF Revision 1.0 Specification, version 1.8.2, 28 December 2000
SDO: N/A The GeoTIFF format was originally created by Dr. Niles Ritter while he was working at the NASA Jet Propulsion Laboratory. GeoTIFF represents an effort by over 160 different remote sensing, GIS, cartographic, and surveying related companies and organizations to establish a TIFF based interchange format for geo-referenced raster imagery. GeoTIFF is a public domain de facto standard.
STANAG identifier: N/A
STANAG status: N/A
Abstract: GeoTIFF is a metadata standard (a format) which allows geo-referencing information to be embedded within a TIFF image file (see more information below about TIFF). The potential additional information includes projections, coordinate systems, ellipsoids, datums, and everything else necessary to establish the exact spatial reference for the file.
About the supporting TIFF : it is a file format for storing images, including photographs and line art. The TIFF format is widely supported by image-manipulation applications, by publishing and page layout applications, by scanning, faxing, word processing, optical character recognition and other applications. As of 2009, TIFF is under the control of Adobe Systems that holds the copyright to the TIFF specification. TIFF has not had a major update since 1992, though several technical notes have been published with minor extensions to the format, and several specifications, including TIFF/EP and TIFF/IT (ISO 12639) have been based on the TIFF 6.0 specification. The GeoTIFF format is fully compliant with TIFF 6.0, so software capable of reading and interpreting the specialized metadata will still be able to open a GeoTIFF file.
Main objective of GeoTIFF is to allow describing any cartographic information related to a TIFF image whatever its origin is.
Technical Maturity [Current]: Mature since based on the old and stable TIFF standard. Does not seem to have evolved since 2000.
Applicability: Useable by GIS and imagery systems.
Information on implementation: Largely used in the M&S world for environment database generation and visualization
Limitations of this Standard: Unknown
Standard Type: Synthetic Natural Environment: Imagery and 3D Models.
Public Availability: Yes
URL: http://trac.osgeo.org/geotiff/, primary GeoTIFF web site, specification available at http://www.remotesensing.org/geotiff/spec/contents.html
Input Date: 28 August 2009
Last Update: 14 November 2013
Keywords: environmental data, georeferenced data, bitmap, digital terrain, GIS

GML

Standard Title: Geography Markup Language
Standard Identifier: ISO 19136
Version Identifier: ISO 19136/2007
SDO: ISO/IEC
STANAG identifier: N/A
STANAG status: N/A
Abstract: The Geography Markup Language (GML) is an XML encoding in compliance with ISO 19118 for the transport and storage of geographic information modelled in accordance with the conceptual modelling framework used in the ISO 19100 series of International Standards and including both the spatial and non-spatial properties of geographic features. ISO 19136/2007 defines the XML Schema syntax, mechanisms and conventions that:

- provide an open, vendor-neutral framework for the description of geospatial application schemas for the transport and storage of geographic information in XML;
- allow profiles that support proper subsets of GML framework descriptive capabilities;
- support the description of geospatial application schemas for specialized domains and information communities;
- enable the creation and maintenance of linked geographic application schemas and datasets;
- support the storage and transport of application schemas and data sets; and
- increase the ability of organizations to share geographic application schemas and the information they describe.

Technical Maturity [Current]: The standard was developed by the Open Geospatial Consortium (OGC) starting in 1998. It is widely spread in the Geo-community and was a mature OGC standard before it became an ISO standard. There is no doubt about its importance or usability.
Applicability: The standard may be used as the foundation for GML/XML based geospatial data exchange. It is needed for any web service infrastructure based on OGC web services.
Information on implementation: GML is used in NATO CoreGIS (NCIA).
Limitations of this Standard: unknown
Standard Type: Synthetic Natural Environments – Interchange Environmental Data.
Public Availability: The standard is freely accessible via OGC website but can also be acquired from ISO.
URL or instructions to Access or Acquire: www.opengeospatial.org/standards/gml
Input Date: 04 May 2009
Last Updated: 08 April 2013
Keywords: GIS, Navigation, Synthetic Environment

GM-VV

Standard Title: Guidance for a "Generic Methodology for Verification and Validation and Acceptance[7] 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 09 December)
SDO: Simulation Interoperability Standards Organization (SISO)
STANAG identifier: None
STANAG 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.

[7] 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: 16 December 2013

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: Simulation Interoperability Standards Organization (SISO) acting as an IEEE (Institute of Electrical and Electronics Engineers) standards sponsor.
STANAG identifier: 4603
STANAG 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 were 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 standard may be purchased from IEEE.
URL or instructions to Access or Acquire: www.ieee.org
Input Date: 8 April 2008
Last Updated: 19 February 2015
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 model

HLA FEDEP

Standard Title: IEEE Recommended Practice for the High Level Architecture (HLA) Federation Development and Execution Process (FEDEP)
Standard Identifier: IEEE 1516.3
Version Identifier: IEEE Std 1516.3™-2003, dated 23 April 2003
SDO: SISO acting as an IEEE (Institute of Electrical and Electronics Engineers) standards sponsor.
STANAG identifier: 4603 (the FEDEP is referenced in the HLA STANAG)
STANAG status: Promulgated 2nd July 2008
Abstract: This IEEE document is a part of the 1516 family on the High Level Architecture (HLA). The processes and procedures that should be followed by users of the HLA to develop and execute federations are defined in this recommended practice. This recommended practice is not intended to replace low-level management and systems engineering practices native to HLA user organizations, but is rather intended as a higher-level framework into which such practices can be integrated and tailored for specific uses.
Technical Maturity [Obsolete]: The document was published and copyrighted in 2003. This document is based upon a US Department of Defense (DoD) Defense Simulation and Modeling Office (DMSO) publication entitled High Level Architecture Federation Development and Execution Process (FEDEP) Model, version 1.5, dated December 8, 1999. A replacement for this recommended practice was approved by IEEE in 2010 and published as "IEEE 1730™ Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP)". IEEE 1730 has superseded IEEE 1516.3.
Applicability: The HLA has been designed to be applicable across a wide range of functional applications. The purpose of this document is describe a high-level process by which HLA federations can be developed and executed to meet the needs of a federation user or sponsor. It is expected that the guidelines provided in this document are generally relevant to and can facilitate the development of most HLA federations.
Information on implementation: Widely implement across NATO and PfP nations.
Limitations of this Standard: Primarily meant for use with HLA-based federations. Distributed simulation environments constructed using other protocols would have needed to adapt this document to suit the needs to the particular environment. The new DSEEP standard is better adapted to non-HLA federations.
Standard Type: M&S Methodology, Architectures and Processes: Systems Engineering Processes
Public Availability: Copies of this standard may be purchased from IEEE.
URL or instructions to Access or Acquire: www.ieee.org. or www.sisostds.org for SISO members only.
Input Date: 8 April 2008.
Last Updated: 2 April 2013
Keywords: High Level Architecture, HLA, FEDEP, federation, engineering

JC3IEDM

Standard Title: Joint Command, Control and Consultation Information Exchange Data Model (JC3IEDM).
Standard Identifier: JC3IEDM
Version Identifier: 3.1.4
SDO Multilateral Interoperability Programme (MIP).
STANAG identifier: 5525
STANAG status: Ratified.
Abstract: JC3IEDM specifies the minimum set of data that needs to be exchanged in coalition or multinational operations.
JC3IEDM is intended to represent the core of the data identified for exchange across multiple functional areas and multiple views of the requirements. Toward that end, it lays down a common approach to describing the information to be exchanged in a command and control (C2) environment.
Technical Maturity [Current]: Highly mature in use in numerous nations and in NATO. It is in continuous development since 1984; current version released in 14-Feb-2012.
Applicability: For the specification of NATO C3 systems and national systems wherever required to aid full interoperability of NATO Forces.
In general for facilitating the timely flow of accurate and relevant information using the Information Exchange Mechanisms specified by MIP between the different national C2IS.
Due to its broad coverage of information relevant to C2 systems, the JC3IEDM serves as source of semantics for other standards dealing with C2 information (e.g. C-BML) and is also used to encode information in simulation systems.
Information on implementation: This standard has been used in programs and products within NATO and non-NATO nations. It is the basis for developing simulation data standards like C-BML and MSDL. More information can be found on the MIP website: www.mip-site.org
Limitations of this Standard: Not known.
Standard Type: Information Exchange Data Model
Public Availability: From the MIP website.
URL or instructions to Access or Acquire: https://mipsite.lsec.dnd.ca
Input Date: 20 March 2008
Last Updated: 04 April 2013
Keywords: MIP BL 3, C2IS

KML (Keyhole Markup Language)

Standard Title: Keyhole Markup Language (KML)
Standard Identifier: OGC 07-147r2
Version Identifier: version 2.2, 2007
SDO: Open Geospatial Consortium (OGC)
STANAG identifier: N/A (STANAG 7074 for Digital Geographic Information Exchange Standard)
STANAG status: N/A
Abstract: KML is an XML-based language schema for expressing geographic annotation and visualization on Web-based, two-dimensional maps and three-dimensional Earth browsers. KML was developed for use with Google Earth, which was originally named Keyhole Earth Viewer. It was created by Keyhole Inc., which was acquired by Google in 2004. Nevertheless, the standard is open, and there are several 3rd party KML products, e.g. WorldWind or Virtual Earth.
Technical Maturity [Current]: In use.
Applicability: geographic visualization, including annotation of maps and images.
Information on implementation: Used by Google Earth and Google Maps, ArcGIS Explorer, FME. KML is also supported by a wide community.
Limitations of this Standard: To be investigated, most known limitations come from viewers such as Google Earth.
Standard Type: Synthetic Natural Environment: Data Sources and Formats.
Public Availability: Available to the public, OGC Open Standard
URL or instructions to Access or Acquire:
http://www.opengeospatial.org/standards/kml/
Input Date: 28 August 2008
Last Updated: 04 April 2013

Link 11 Simulations

Standard Title: Standard for LINK 11/11B Simulation
Standard Identifier: SISO-STD-005-200x
Version Identifier: Draft Version 9
SDO: Simulation Interoperability Standards Organization (SISO).
STANAG identifier: No specific STANAG, but should be consistent with and in support of STANAG 5602
STANAG status: Promulgated
Abstract: A SISO standard that defines the methods to simulate a Link 11/11B Network within the Distributed Interactive Simulation (DIS) or High Level Architecture (HLA) framework. The SISO standard has 3 levels of fidelity, from message exchange only to Link 11/11B network modelling. The NATO STANAG 5602 "Standard Interface for Multiple Platform Link Evaluation" (SIMPLE) standard another protocol. SIMPLE address not only Link 11 but all other Tactical Data Links. While SIMPLE is based on DIS, SISO Link 11/11B standard will address both DIS using Transmitter and Signal PDUs, and HLA under the BOM and RPR FOM paradigms.
Technical Maturity [Emerging]: Near Completion. September 2010 SISO conference incorporated comments from draft 8 and release draft version 9 which will be ready for SISO standard balloting. Will benefit from the experience of the "Link 16 Simulation" standard (SISO-STD-002-2006, 10 Jul 06).
Applicability: There are immediate and overdue operational requirements for existing military simulations to exchange Link 11/11B data using a single interoperable method.
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. They are awaiting the final approved standard for official implementation..
Limitations of this Standard: This standard should only apply to Link 11/11B.
Standard Type: Information Exchange Data Model
Public Availability: Draft 9 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: 08 April 2013
Keywords: Tactical Data Link, CROP

Link 16 Simulations

Standard Title: Tactical Data Information Link – Technical Advice and Lexicon for Enabling Simulations (TADIL TALES)
Standard Identifier: SISO-STD-002-2006 *(approved 10 Jul 06)*
Version Identifier: 1.0 (10 June 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: Promulgated
Abstract: There are immediate operational requirements for existing military simulations to exchange Link 16 data using a single interoperable standard. The purpose of this standard is to meet this need by providing a standard for simulating the Link 16 protocol. This standard defines 5 fidelity levels, from message exchange only to Link 16 network modelling, including Return Trip Timing messages, Net Entry and Exit, Actual versus Perceived location, and encryption methods. The NATO STANAG 5602 "Standard Interface for Multiple Platform Link Evaluation" (SIMPLE) Link 16 standard is one such protocol. SIMPLE address not only Link 16 but all other Tactical Data Links. While SIMPLE is based on DIS, it was originally intended to test Link 16 terminal connections. That use has been expanded to include Link 16 training, and as such, does not adequately model some Link 16 network parameters. The SISO Link 16 standard addresses this in DIS using Transmitter and Signal PDUs, and HLA under the BOM and RPR FOM paradigms.
Technical Maturity [Current]: In use for 2 years by the U.S. Air Force, Navy, and Marines for distributed simulation training. Regularly updated.
Applicability: The main objective of Link 16 protocol is to establish a standard for Link 16 message exchange and JTIDS network simulation in the DIS and HLA interoperability paradigms. The intent is to prescribe the content of the standard fields of the Transmitter and Signal PDUs (and the corresponding RPR-FOM Transmitter Object and Signal Interaction) and establish procedures for their use. Compliance with these procedures will facilitate interoperability among Link 16 simulation systems.
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: 08 April 2013
Keywords: Tactical Data Link, CROP

Lua

Standard Title: Lua
Standard Identifier: Lua
Version Identifier: 5.2.2, released 27 March 2013
SDO: LabLua, PUC-Rio (Pontifical Catholic University of Rio de Janeiro), Brazil
STANAG identifier: N/A
STANAG status: N/A
Abstract: Lua is a dynamically typed language intended for use as an extension or scripting language, and is compact enough to fit on a variety of host platforms, making it ideal for configuration, scripting, and rapid prototyping. These features make that Lua is very well suited for modelling (human) behaviour (AI) in simulations and games, e.g. Lua is used in many commercial entertainment games and related middleware products. Lua is largely used in commercial CGFs allowing users to script specific behaviours for their own applications.
Lua provides a small set of general features that can be extended, as needed, to fit different problem types, rather than providing a more complex and rigid specification to match a single paradigm. By including only a minimum set of data types, Lua attempts to strike a balance between power and size.
Technical Maturity [Current]: Highly mature, in use for 20 years, regularly updated, well documented. Future version 5.3 should be available soon.
Applicability: behaviour / system modelling in software / simulation and games.
Information on implementation: Lua is in use among many industrial applications and researchers since 1993. Lua is the most used scripting language for (commercial) computer games. It is free software
Limitations of this Standard: unknown
Standard Type: M&S Miscellaneous
Public Availability: Free for use without restrictions (including commercial). Copyright owned by PUC-Rio
URL or instructions to Access or Acquire: http://www.lua.org
Input Date: 14 September 2009.
Last Updated: 27 November 2013.
Keywords: Modelling, Human Behaviour modelling

MDA

Standard Title: Model-Driven Architecture
Standard Identifier: MDA™
Version Identifier: 1.0.1
SDO: OMG
STANAG identifier: Not applicable
Abstract: MDA™ is a software design approach launched by the Object Management Group (OMG) in 2001. It is a variant of the Model Driven Engineering (MDE).
The MDA principle is to create a Platform Independent Model (PIM) of a system which describes the business logic and rules behind a specification without taking care of its possible implementations. Then model transformations have to be defined to convert the PIM into Platform Specific Models (PSM) which contain implementation details. PSMs may need to be completed after the transformation. There are as many PSM as possible implementations. The PSM may then be transformed into an even more detailed PSM or into text (e.g.: code, documentation).
Since MDA separates concerns, there is no need to be a technology expert to create a PIM but only a subject matter expert. To complete the PSM there is a need to be a technology expert not a business expert. Model transformation is the key of the MDA process and captures the best proven implementation practices on technologies.
MDA is built on the solid foundation of well-established OMG standards, including:

- Unified Modelling Language™ (UML®), UML which is a modelling notation used and supported by every major company in the software industry
- XML Metadata Interchange (XMI®), which is the standard for storing and exchanging models using XML.
- Query View Transformation (QVT) which is a standard for expressing model transformation.

MDA main objectives are: Portability, Platform Independence, Domain Specificity, through Domain-specific models and Productivity.
Technical Maturity [Current]: The MDA has proven its efficiency in Software Oriented Architecture in particular in the Web development.
Applicability: Software design / engineering
Information on implementation: In use in various projects. Numerous tools are available including commercial or government-owned simulation frameworks.
Limitations of this Standard: MDA major drawback lays on reverse engineering to keep PIM coherent with PSM/Code. The engineering process has in fact an iterative nature which may make it difficult to apply strictly the MDA theory.
Standard Type: Software Engineering.
Public Availability: Via OMG web site. Many UML tools (including free ones) conform nowadays to this approach.
URL or instructions to Access or Acquire: http://www.omg.org/mda/
Input Date: 20 March 2008
Last Updated: 11 February 2014
Keywords: Model Driven Architecture, MDA, Model Driven Engineering, MDE, UML, XMI, Modelling, OMG

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 identifier: Not applicable.
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.) Command and Control (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 the next version of MSDL and C-BML will be undertaken by a single SISO PDG, C2SIM PDG/PSG - Command and Control Systems - Simulation Systems Interoperation, to ensure that the two standards apply in concert with one another.
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.
MSDL version 2 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 easily ported to military simulations.
- 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-085 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: 23 October 2014

NAF

Standard Title: NATO Architecture Framework (NAF).
Standard Identifier: As above
Version Identifier: Version v3 (2007) (AC/322-D(2007)0048-AS1)
SDO: NATO C3 Board (NC3B)
STANAG identifier: N/A
STANAG status: N/A
Abstract: NAF promotes the use of models to develop architecture core data and provides this data to architecture specialists. The purpose of an architectural framework such as NAF is to define the operational context (organizations, locations, processes, information flows, etc.), the system architecture (interfaces, data specifications, protocols, etc.), and the supporting standards and documents that are necessary to describe the enterprise. The information presented in an architectural framework is split into logical groupings – usually known as 'Views'. The same system and business elements may be present in more than one view, but the purpose of each view is different and so each provides a different viewpoint on the information. NAF views and sub views are created based on the architecture core data for the benefit of non-specialists. The views include Capability Views, Service Oriented Views and Programme Views. NAF has similarities with MODAF (and DODAF) Enterprise Architectures, but goes beyond these. The current version of NAF (v3) has seen extensions to improve support for Capability development, Service orientation as required by NATO Network enabled Capability (NNEC) and support for NATO transformation. NAF v3 supports Stakeholders so that an extensive analysis can be made to provide rationale for prioritization in decision making. NAF v3 has improved support for the achievement of NNEC and NATO transformation by facilitating the move from a system-oriented paradigm to a service-oriented paradigm, and by identifying mechanisms to handle the complexity of the relationships within the NATO federation of systems in a holistic manner. The NAF Meta-Model (NMM) and repository enable stakeholders and users to extract and exchange bespoke architecture information and make necessary analyses to support development, interoperability, acquisition or technical considerations.
Technical Maturity [Current]: NAF v3 was approved by NC3B in Nov 2007.
Applicability: NAF v3 is mandated for all NATO programmes
Information on implementation: Started immediately after approval.
Limitations of this Standard: None.
Standard Type: M&S Methodology. Architecture and Processes / Architecture Frameworks
Public Availability: Yes.
URL or instructions to Access or Acquire:
http://www.nhqc3s.nato.int/ARCHITECTURE/_docs/NAF_v3/ANNEX1.pdf
Input Date: 22 September 2008
Last Updated: 19 April 2013
Keywords: Architecture Framework, NATO, NAF

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NETN FAFD

Standard Title: NETN Federation Agreement and FOM Reference Document
Standard Identifier: NETN FAFD v1.0
Version Identifier: v1.0
Standard Development Organization: N/A
STANAG identifier: N/A
STANAG status: N/A
Abstract: The purpose of NETN Federation Agreement and FOM Reference 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. Templates for documenting required federation specific agreements are also provided. Principles and format for information exchange between federates in a NETN based federation is defined in the FAD. As part of the federation agreements a module based HLA reference Federation Object Model (FOM) is provided.
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-068 NETN. This task group was initiated to support the ACT Snow Leopard Program with M&S recommendations for establishing a NATO wide network for education and training (NETN), a.k.a. Snow Leopard. A technical subgroup of MSG-068, 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 input to the development of this FAD includes:

- ALLIANCE FOM
- CASIOPEA FOM
- JLVC FOM
- JMRM FOM
- KOSI FOM
- P2SN FOM
- RPR-FOM v2.0

Technical Maturity [Emerging]: The NETN FAFD has been used in experimentation (MSG-068 Final Experiment, SEESIM 12 NTF Experiment) and in exercises (Viking 11). The technical maturity is strong and proven. Continued work on developing the next version is conducted within MSG-106.

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). The technical maturity is strong and proven. Continued work on developing the next version is conducted within MSG-106.
Limitations of this Standard: not known
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 is available as Appendix C of the MSG-068 Final Report. The NETN FAFD v1.0 is under custodianship of NATO NMSG MS3.
URL or instructions to Access or Acquire:
http://www.cso.nato.int/Pubs/rdp.asp?RDP=RTO-TR-MSG-068
Input Date: Date the standard was included in the NMSSP: 02 Sep 2013
Last Updated: 05 Oct 2012

OpenFlight

Standard Title: OpenFlight Scene Description Database Specification ®
Standard Identifier: OpenFlight ®
Version Identifier: 16.4
SDO: None – Owned and controlled by Presagis
STANAG identifier: N/A
STANAG 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
Ref: OpenFlight® Scene Description Database Specification. Version 16.4, Revision A, June 2009. © Presagis USA 1997-2009.
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. 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/OpenFlight16.4.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: 22 October 2013
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-001.1-1999.
Version Identifier: 1.0. (Version 2.0 draft 18 still to be approved)
SDO: SISO
STANAG identifier: Not known
STANAG status: Not known
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 is a reference FOM that defines HLA classes, attributes and parameters that are appropriate for real-time, platform-level simulations. Applications that have previously used DIS (or would have considered using DIS), often use the RPR FOM (or a derivative of it) when they playing in an HLA world. 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.
A companion document, known as the GRIM (Guidance, Rationale, and Interoperability Mappings) provides documentation for the RPR FOM. This document is known as SISO-STD-001-1999.
Technical Maturity [Current]: RPR FOM 1.0 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 will correspond 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: 26 March 2013
Keywords: Distributed, Simulation, HLA

S-57

Standard Title: IHO Transfer Standard for Digital Hydrographic Data
Standard Identifier: Special Publication No. 57
Version Identifier: S-57 Edition 3.1 November 2000 (note, that this is a component document, the individual sections having different version identifiers)
SDO: International Hydrographic Organization (IHO)
STANAG identifier:
STANAG status: frozen
Abstract:
The publication "S-57—IHO Transfer Standard for Digital Hydrographic Data" describes the standard to be used for the exchange of digital hydrographic data between national hydrographic offices and for its distribution to manufacturers, mariners and other data users. For example, this standard is intended to be used for the supply of data for ECDIS. This transfer and distribution has to take place in such a way that none of the meaning of the data is lost. The Standard was prepared by the International Hydrographic Organization's (IHO) Committee on Hydrographic Requirements for Information Systems (CHRIS).
The Standard was adopted as the official IHO standard, by the XIV International Hydrographic Conference, Monaco, 4-15 May 1992.
The IHO S-57 version 4 was renamed S-100 in 2005 and covers different limitations of the S-57.
Technical Maturity [Current]:

- Edition 3.0 - November 1996
- Edition 3.1 - November 2000

Applicability: The Format S-57 is widely used within NATO and merchant Navies for Navigation as the carrier format for Electronic Navigational Charts (ENC) used in ECDIS (Electronic Chart Display and Information Systems) and WECDIS (Warship-ECDIS) following NATO-STANAG 4564.
Information on implementation:
NATO uses S-57 as the main carrier format for NATO-AML (Additional Military Layers) Version 1.0, 2.1 and 3.0 following NATO-STANAG 7170.
Limitations of this Standard: no support for future requirements (e.g. gridded bathymetry, time-varying information), restricted flexibility and capacity of using a wide range of transport mechanisms.
Standard Type: Synthetic Natural Environment: Data Sources and Formats
Public Availability: free
URL or instructions to Access or Acquire: http:/www.iho.int
Input Date: 04 May 2009
Last Updated: 16 October 2014
Keywords: GIS, Maritime Synthetic Environment, Hydrographic Data Modelling

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 under ratification process:

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)

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.

STANAG identifier: Part of STANAG 4664 **STANAG status:** Ratification in process.

Part 2: Abstract Transmittal Format

Standard Identifier: ISO/IEC 18023-2:2006(E)

Version Identifier: 2006 (year of publication)

Abstract: SEDRIS Part 2 defines the abstract semantics and abstract structure used to encode SEDRIS transmittals. The Abstract Transmittal Format (ATF) defines how concrete encodings are developed so that conversion can be performed with a minimum of effort. ATF also ensures that SEDRIS API implementations behave consistently regardless of transmittal encoding.

STANAG identifier: Part of STANAG 4664 **STANAG status:** Ratification in process.

Part 3: Transmittal Format Binary Encoding

Standard Identifier: ISO/IEC 18023-3:2006(E)

Version Identifier: 2006 (year of publication)
Abstract: SEDRIS Transmittal Binary Encoding defines the binary coding for Data Representation Model objects.
STANAG identifier: Part of STANAG 4664 **STANAG status:** Ratification in process.

Part 4: Language Bindings: C
Standard Identifier: ISO/IEC 18024-4:2006(E)
Version Identifier: 2006 (year of publication)
Abstract: The SEDRIS language binding defines a language dependent layer for the C programming language based on the 18023-1 Application Program Interface (API).
STANAG identifier: Part of STANAG 4664 **STANAG status:** Ratification in process.

STANAG 4662 -- SEDRIS — Environmental Data Coding Specification (EDCS)
Environmental Data Coding Specification (EDCS)
Standard Identifier: ISO/IEC 18025:2005(E)
Version Identifier: 2006 (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 identifier: Part of STANAG 4662 **STANAG status:** Ratification in process
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 identifier: Part of STANAG 4662 **STANAG status:** Ratification in process**.**

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 identifier: Part of STANAG 4663 **STANAG status:** Ratification in process.

SRM Language Bindings Part 4: C

Standard Identifier: ISO/IEC 18042-4:2006(E)

Version Identifier: 2006 (year of publication)

Abstract: This part of ISO/IEC 18041-4 specifies the language dependent layer for the C programming language based on the API defined in ISO/IEC 18026.

STANAG identifier: Part of STANAG 4663 **STANAG status:** Ratification in process.

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: 2 April 2013

Keywords: Data Interchange, Environmental Data, Geospatial Data, M&S, Modeling, Representations, SEDRIS, Simulation, Synthetic Environment Data Representation Interchange Specification, Virtual Environment

SHAPE FILE

Standard Title: Shapefile spatial data format
Standard Identifier: Shapefile
Version Identifier: 16.3
SDO: N/A. This format is developed and maintained by the US company Environmental Systems Research Institute, Inc (ESRI), acting in the Geographic Information Systems (GIS) area.
STANAG identifier: N/A
STANAG status: N/A
Abstract: Shapefile is a popular geospatial vector data format for geographic information systems software. It is a (mostly) open specification for data interoperability among ESRI and other software products.
A Shapefile stores non-topological geometry and attribute information for the spatial features in a data set. The geometry for a feature is stored as a shape comprising a set of vector coordinates. Shapefiles handle single features that overlap or that are non-contiguous. They can support point, line, and area features. Area features are represented as closed loop, double-digitized polygons. Attributes are held in a dBASE® format file. Each attribute record has a one-to-one relationship with the associated shape record.
Technical Maturity [Current]: Shapefile is a mature format existing since early 1990s.
Applicability: The actual specification is of most use to software developers for reading/writing vector geographical data.
Information on implementation: Shapefile is used as a default interchangeable GIS format. As such, it is the de-facto standard for source vector data to produce synthetic environment databases for simulation applications.
Limitations of this Standard: The format is owned by ESRI, Inc. and is protected under the copyright and trademark laws of the United States of America. It has some well known technical limitations: just as an example, the use of the old dBASE® format to describe attribute files that involves significant limitations.
Standard Type: Synthetic Natural Environment: Data Sources and Formats.
Public Availability: The file format technical description can be downloaded from ESRI's website (see link below).
URL: www.esri.com/library/whitepapers/pdfs/shapefile.pdf
Input Date: 08 December 2008
Last Updated: 14 November 2013
Keywords: environmental data, georeferenced data, vector, digital terrain, GIS

SIMPLE

Standard Title: Standard Interface for Multiple Platform Link Evaluation (SIMPLE)
Standard Identifier: SIMPLE
Version Identifier: AC/322-SC/2 (Edition 3, 9 July 2010)
SDO: NATO Consultation, Command and Control Board (NC3B), C3 Capabilities Coherence Sub-Committee (C3CCSC)
STANAG identifier: 5602 (Edition 3)
STANAG status: Promulgated
Abstract: The aim of STANAG 5602 is to provide specifications for a common standard to interconnect ground rigs of all types (e.g. simulation, integration facilities etc.) for the purpose of Tactical Data Link (TDL) Interoperability testing. The STANAG specifies the distributed transfer using the IEEE Distributed Interactive Simulation (DIS) protocols which are defined in the IEEE Std.1278.1 and 1a.
Technical Maturity [Current]: Third version of SIMPLE was promulgated in 2010. The standard is evolving thanks to feedback coming from a large user community.
Applicability: The SIMPLE STANAG specifies the requirements for transfer of data between remote sites in different locations to support interoperability testing of TDL implementations in the different platforms of NATO Nations and Organizations.
Information on implementation: In use in NATO
Limitations of this Standard: This standard is not fully/only targeted to simulation interoperability. Originally SIMPLE was designed for testing not to model Link 16. The standard does not model all Link 16 capabilities, such as net entry, net exit, perceived versus actual position, Link 16 relay, message encryption, and Time Slot Reallocation. It is only based on DIS and does not address HLA federations' requirements. Applicable to Real Time simulation applications.
Standard Type: Information Exchange Data Model
Public Availability: Available on the NATO NSO web site (requires login access)
URL or instructions to Access or Acquire: http://nso.nato.int
Input Date: 10 July 2008
Last Updated: 16 Sep 2014
Keywords: Interoperability Testing, Tactical Data Link

SysML

Standard Title: The Systems Modelling Language
Standard Identifier: SysML™
Version Identifier: OMG SysML™ v1.2 (June 2010)
SDO: The SysML initiative originated in a January 2001 decision by the International Council on Systems Engineering (INCOSE). The standard is published by the Object Management Group (OMG).
STANAG identifier: N/A
STANAG status: N/A
Abstract SysML is a Domain-Specific Modelling language for systems engineering and is intended to unify the diverse modelling languages currently used by systems engineers. It supports the specification, analysis, design, verification and validation of a broad range of complex systems. SysML is defined as an extension to a subset of the Unified Modelling Language (UML) using UML's profile mechanism. SysML provides additional extensions needed to address the requirements in the UML for a Systems Engineering RFP. SysML also supports allocation tables, a tabular format that can be dynamically derived from SysML allocation relationships. SysML concepts are aligned with IEEE-Std-1471-2000 (IEEE Recommended Practice for Architectural Description of Software Intensive Systems).
SysML uses the OMG XML Metadata Interchange (XMI®) to exchange modelling data between tools, and is also intended to be compatible with the evolving ISO 10303-233 systems engineering data interchange standard.
Technical Maturity [Current] Several modelling tools offer SysML support. There is also a “Certification OMG Certified Systems Modeling Professional™ (OCSMP) model user” available
Applicability Applicable to M&S requirements capturing and conceptual modelling.
Information on implementation No example of implementation known so far in the military domain.
Limitations of this Standard: Applicable only in the design phase of the systems.
Standard Type Conceptual Modelling
Public Availability: The OMG SysML™ v1.3 was issued as a "Formal Specification" in June 2012. The specification documents and schema files can be found at the following website **http://www.omg.org/spec/sysml/1.3/.** SysML was originally developed by an open source specification project, and includes an open source license for distribution and use. Many books on SysML are available in English, French and German.
URL or instructions to Access or Acquire: http://www.omgsysml.org/
Input Date: 28 July 2008
Last Updated: 27 November 2012
Keywords: system engineering, language, XML, conceptual modelling

TENA

Standard Title: The Test and Training Enabling Architecture Reference Document
Standard Identifier: None
Version Identifier: 2002 (year of publication)
SDO: US Department of Defense Test Management Resource Center under the Central Test and Evaluation Investment Program (CTEIP)
STANAG identifier: N/A
STANAG status: N/A
Abstract: TENA is a product of the Foundation Initiative 2010 (FI 2010) project, sponsored by the Central Test and Evaluation Investment Program (CTEIP). The core of TENA is the TENA Common Infrastructure, including the TENA Middleware, the TENA Repository and the TENA Logical Range Data Archive. TENA also specifies the existence of a number of tools and utilities, including those necessary for the efficient creation of a logical range. Range instrumentation systems (also called range resource applications) and all of the tools interact with the common infrastructure through the medium of the TENA object model. The TENA object model encodes all of the information that is transferred between systems during a range event. It is the common language with which all TENA applications communicate.
Technical Maturity [Current]: Widely used with the USA range community and actively managed through an Architecture management Team.
Applicability: Live Range Interoperability, LVC Interoperability, Test Interoperability
Information on implementation: The initial implementation for TENA is to interoperate the USA National Test and Training Ranges. Has been used at USJFCOM to incorporate Live and Range assets into LVC Training exercises. See https://www.tena-sda.org/display/intro/news for extensive listing of program usage.
Limitations: Currently targeted for real-time applications only.
Standard Type: M&S Interoperability
Public Availability: See https://www.tena-sda.org for detailed information. Some restrictions on non-USA citizens. *(USA will establish exact restrictions/releasability)*
URL or instructions to Access or Acquire: This standard is accessible at https://www.tena-sda.org. An account is required for some information.
Input Date: 8 April 2008
Last Updated: 2 April 2013
Keywords: TENA, Test and Training Enabling Architecture, live, virtual, constructive, LVC, interoperability, distributed

UML

Standard Title: Unified Modeling Language™ - UML
Standard Identifier: UML
Version Identifier: Version 2.4.1 (Aug 2011)
SDO: OMG (Object Management Group)
STANAG identifier: Not applicable.
STANAG status: Not applicable.
Abstract: UML is a standardised specification language for object modelling. UML is a general-purpose modelling language that includes a graphical notation used to create an abstract model of a system, referred to as a UML model.
UML is officially defined at the Object Management Group (OMG) by the UML metamodel, a Meta-Object Facility metamodel (MOF). Like other MOF-based specifications, the UML metamodel and UML models may be serialized in XML Metadata Interchange (XMI). UML was designed to specify, visualize, construct, and document software-intensive systems.
UML has been a catalyst for the evolution of model-driven technologies, which include model-driven development (MDD), model-driven engineering (MDE), and model-driven architecture (MDA).
UML is extensible, offering the following mechanisms for customization: profiles and stereotype. The semantics of extension by profiles have been improved with the UML 2.0 major revision. Beginning with UML 2.0, the UML Specification was split into two complementary specifications: Infrastructure and Superstructure. The UML infrastructure specification defines the foundational language constructs required for UML 2.3. It is complemented by UML Superstructure, which defines the user level constructs required for UML 2.3. The two complementary specifications constitute a complete specification for the UML 2 modelling language.
Technical Maturity [Current]: UML has matured significantly since UML 1.1. Several minor revisions (UML 1.3, 1.4, and 1.5) fixed shortcomings and bugs with the first version of UML, followed by the UML 2.0 major revision. The current version available is 2.4.1 (Aug 2011).
Applicability: Not dedicated to simulation, but in very general use in the M&S domain.
Information on implementation: many commercial and free tools available
Limitations of this Standard: very specialized, requires detailed understanding.
Standard Type: Conceptual modelling.
Public Availability: Via OMG web site.
URL or instructions to Access or Acquire: http://www.uml.org/
Input Date: 20 March 2008
Last Updated: 11February 2014
Keywords: Unified Modelling Language, UML, Meta-Object Facility metamodel, MOF, Modeling,, model-driven development, MDD, model-driven engineering, MDE, model-driven architecture, MDA.

VMAP

Standard Title: Vector Map (VMAP).
Standard Identifier: MIL-STD-2407
Version Identifier: VMAP-1 (Future version VMAP 2i)
SDO: US Defense Mapping Agency
STANAG identifier: N/A
STANAG status: N/A
Abstract: A vector-based collection of Geographic information system (GIS) data about Earth at various levels of detail. An updated and improved version of the USA National Imagery and Mapping Agency's (NIMA) Digital Chart of the World (DCW).
Also known as Vector Smart Map; formerly known as Digital Chart of the World-DCW.
The vector map product comes in three flavours: low resolution (level 0), medium resolution (level 1) and high resolution (level 2).
Technical Maturity [Aging]: Used since 1993 in nations and NATO.
Applicability: Used to represent culture for Geographic Information Systems on applications such as synthetic natural environments.
Information on implementation: The use of VMAP is extremely widespread although more modern alternatives are now often preferred.
Limitations of this Standard: None.
Standard Type: Synthetic Natural Environment: Data Sources and Formats
Public Availability: Yes
URL or instructions to Access or Acquire: N/A
Input Date: 28 August 2008
Last Updated: 26 March 2013
Keywords: Vector data, GIS, terrain data

VV&A Overlay to the HLA FEDEP

Standard Title: "Recommended Practice for Verification, Validation and Accreditation (VV&A) of a Federation — An Overlay to the High Level Architecture (HLA) Federation Development and Execution Process (FEDEP)".
Standard Identifier: IEEE Std 1516.4™-2007
Version Identifier: IEEE Std 1516.4™-2007
SDO: Developed by the NATO NMSG Task Group 019 and the Simulation Interoperability Standards Organization (SISO, acting as a standards sponsor for The Institute of Electrical and Electronics Engineers, Inc. (IEEE)).
STANAG identifier: Not applicable (but this recommended practice is referenced in the current version (Ed. 2) of STANAG 4603 on HLA, ratified in 2013).
STANAG status: N/A
Abstract: This recommended practice defines the processes and procedures that should be followed to implement Verification, Validation and Accreditation (VV&A) for federations being developed using the High Level Architecture (HLA) Federation Development and Execution Process (FEDEP) or its updated version known as the "Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP)". This recommended practice is not intended to replace existing VV&A policies, procedures, and guidance, but rather is intended to focus on the unique aspects of the VV&A of federations. It provides a higher-level framework into which such practices can be integrated and tailored for specific uses.
Technical Maturity [Current]: It is a relatively recent recommended practice document but it benefits from 10 years' practical experience.
Applicability: Primarily targeted for users, developers and VV&A personnel working with simulations and simulation compositions based upon the HLA and the DSEEP. Users, developers and VV&A personnel working with simulations and simulation compositions not based upon the HLA can also benefit from the guidance in this document since the activities that this overlay describes can be tailored to support any type of distributed simulation application.
Information on implementation: Has been applied to federations in multiple nations, including USA and Canada.
Limitations of this Standard: It provides implementation-level guidance to VV&A practitioners; however, it does not describe the individual techniques that might be employed to execute the VV&A processes for federations. It focuses upon the VV&A processes that apply to federations and not the VV&A processes associated with individual simulations (federates), but does consider using the information produced by those processes.
Standard Type: M&S Methodology, Architecture and Processes: Verification & Validation (V&V)
Public Availability: Available to the public with an IEEE copyright and a fee. Freely available to SISO members
URL or instructions to Access or Acquire: www.ieee.org
Input Date: 19 March 2008.
Last Updated: 14 November 2013
Keywords: process, systems engineering, validation, verification, quality insurance, VV&A

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 identifier: Not Applicable
STANAG status: Not Applicable
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: www.msco.mil
Input Date: 27 August 2008
Last Updated: 2 April 2013
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 identifier: Not Applicable
STANAG status: Not Applicable
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: http://www.assistdocs.com
Input Date: 27 August 2008
Last Updated: 2 April 2013
Keywords: Verification, Validation, Accreditation, VV&A, Accreditation Plan, Accreditation Report, V&V Plan, V&V Report

WebLVC

Standard Title: WebLVC – a Protocol for Linking Web-based Federates with Traditional LVC Federations
Standard Identifier: WebLVC
Version Identifier: version 0.2 available Fall 2013 (emerging standard)
Standard Development Organization: Simulation Interoperability Standards Organization
STANAG identifier: N/A
STANAG status: N/A
Abstract: WebLVC will be an interoperability protocol enabling web-based applications (typically JavaScript applications running in a web browser) to interoperate in Modelling and Simulation (M&S) federations. WebLVC client applications communicate with the rest of the federation through a WebLVC server, which participates in the federation on behalf of one or more clients. The objective of the WebLVC protocol is the definition of a standard way of passing simulation data between a web-based client application and a WebLVC server - independent of the protocol(s) used in the federation. Thus, a WebLVC client can participate in a DIS exercise, an HLA federation, a TENA execution, or other distributed simulation environment.
Technical Maturity: While the protocol is just in the definition phase, experiments have been achieved and commercial versions of WebLVC Servers are already available.
Applicability: The WebLVC will support Service Oriented M&S in future federations whatever are the other protocol(s)/architecture(s) used.
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 all SISO standards
URL or instructions to Access or Acquire: http://www.sisostds.org
Input Date: April 2013
Last Updated: 22 Apr 2013

X3D

Standard Title: X3D – Extensible three-dimensional
Standard Identifier:

ISO/IEC 19775 Information Technology – Computer Graphics and Image Processing – Extensible 3D

Part 1: Architecture and Base Components - ISO/IEC 19775-1:2008
Part 2: Scene Access Interface - ISO/IEC 19775-2:2010

ISO/IEC 19776 Information Technology – Computer Graphics and Image Processing – Extensible 3D - Encodings

Part 1: XML Encoding - ISO/IEC 19776-1:2009
Part 2: Classic VRML Encoding - ISO/IEC 19776-2:2008
Part 3: Compressed Binary Encoding - ISO/IEC 19776-3:2007

ISO/IEC 19777 Information Technology – Computer Graphics and Image Processing – Extensible 3D – Language Bindings

Part 1: ECMA Script - ISO/IEC 19777-1:2006
Part 2: Java - ISO/IEC 19777-2:2006

Version Identifier: *See Most Recent Year of Publication*
SDO: ISO/IEC, Joint Technical Committee 1, Subcommittee-24
STANAG identifier: N/A
STANAG status: N/A
Abstract: X3D is the ISO standard XML-based file format for representing 3D computer graphics, the successor to the Virtual Reality Modelling Language (VRML). X3D features extensions to VRML (e.g. Humanoid Animation, NURBS, GeoVRML etc.), the ability to encode the scene using an XML syntax as well as the Open Inventor-like syntax of VRML97, and enhanced application programmer interfaces (APIs). X3D is a scalable, open standards file format and run-time architecture for defining and communicating real-time, interactive 3D scenes and objects using XML for visual effects and behavioural modelling.
Technical Maturity [Emerging]: It is in use in open source software applications. However, it has not received strong acceptance in proprietary software.
Applicability: There are several applications, which natively parse and interpret X3D files. The following website provides a search engine to locate X3D applications -- http://www.web3d.org/cgi-bin/tools/search.cgi
Information on implementation: Available at the following website: http://www.web3d.org/
Limitations of this Standard: See the following website -- http://www.web3d.org/
Standard Type: Synthetic Natural Environment, Imagery and 3D Models.

Public Availability: Yes
URL or instructions to Access or Acquire: http://www.web3d.org/
Input Date: 28 August 2008
Last Updated: 2 April 2013
Keywords: 3D graphics, virtual reality

XMI

Standard Title: XML Model Interchange (XMI)
Standard Identifier: Meta Object Facility (MOF) 2.0/XMI Mapping 2.1.1
Version Identifier: Version 2.1.1
SDO: Object Management Group (OMG)
STANAG identifier: None
STANAG status: Not applicable
Abstract: XMI is a model driven XML Integration framework for defining, interchanging, manipulating and integrating XML data and objects. XMI-based standards are in use for integrating tools, repositories, applications and data warehouses. XMI provides rules by which a schema can be generated for any valid XMI-transmissible MOF-based metamodel. XMI provides a mapping from MOF to XML. As MOF and XML technology evolved, the XMI mapping is being updated to comply with the latest versions of these specifications. Updates to the XMI mapping have tracked these version changes in a manner consistent with the existing XMI Production of XML Schema specification (XMI Version 2).
Technical Maturity [Current]: XMI version 2.0.1 has been promulgated as ISO/IEC 19503:2005.
Applicability: Commonly used for UML model interchange, providing portability across different modelling tools.
Information on implementation: Unknown within NATO applications.
Limitations of this Standard: None stated
Standard Type: Conceptual modelling and scenarios.
Public Availability: Freely downloadable from the OMG web site.
URL or instructions to Access or Acquire: www.omg.org
Input Date: 21 August 2008
Last Updated: 2 April 2013
Keywords: metadata interchange, XML

XML

Standard Title: Extensible Markup Language (XML)
Standard Identifier: XML 1.0 and 1.1
Version Identifier: Version 1.0 and Version 1.1 (Second Edition)
SDO: W3C
STANAG identifier: Not applicable
STANAG status: Not applicable
Abstract: The Extensible Mark-up Language (XML) is a general-purpose mark-up language. It is classified as an extensible language because it allows its users to define their own elements. Its primary purpose is to facilitate the sharing of structured data across different information systems, particularly via the Internet and it is used both to encode documents and to serialize data.
XML is recommended by the World Wide Web Consortium. It is a fee-free open standard. The W3C recommendation specifies both the lexical grammar and the requirements for parsing.
Technical Maturity [Current]: There are two current versions of XML:
The first (XML 1.0) was initially defined in 1998. It has undergone minor revisions since then, without being given a new version number, and is currently in its fifth edition, as published on November 26, 2008. It is widely implemented and still recommended for general use.
The second (XML 1.1) was initially published on February 4, 2004 and is currently in its second edition, as published on August 16, 2006. It contains features that are intended to make XML easier to use in certain cases. The main changes are to enable the use of line-ending characters used on EBCDIC platforms, and the use of scripts and characters absent from Unicode 3.2. XML 1.1 is not very widely implemented and is recommended for use only by those who need its unique features.
XML is used in many simulation standards like HLA.
Applicability: For sharing of structured data across different information systems, particularly via the Internet and it is used both to encode documents and to serialize data.
Information on implementation: XML 1.0 - widely implemented. XML 1.1 not very widely implemented.
Limitations of this Standard: n/a
Standard Type: Software Engineering.
Public Availability: Via W3C web site.
URL or instructions to Access or Acquire: http://www.w3.org
Input Date: 20 March 2008
Last Updated: 11 February 2014

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ANNEX C POINTS OF CONTACT

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ANNEX D ACRONYMS

A

ACT	Allied Command Transformation (NATO)
ADL	Advanced Distributed Learning
AMSP	Allied Modelling and Simulation Publication
AP	Allied Publication
API	Application Programming Interface

B

BOM	Base Object Model

C

C	C Programming Language (ISO/IEC 9899)
C-BML	Coalition Battle Management Language
C2	Command and Control
C3I	Command Control Communication and Information
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CeAG	Certification Advisory Group (on HLA)
CM	Conceptual Modelling
CMSD	Core Manufacturing Simulation Data
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

DEVS	Discrete-Event Systems Specification
DFAD	Digital Feature Analysis Data
DIS	Distributed Interactive Simulation

DISA	Defense Information Systems Agency (USA)
DISR	Department of Defense Information Technology Standards Registry (USA)
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
DTED	Digital Terrain Elevation Data

E

EDCS	Environmental Data Coding Specification (SEDRIS)

F

FEDEP	Federation Development and Execution Process
FOM	Federation Object Model (HLA)

G

GeoTIFF	Geographic Tagged Image File Format
GIG	Global Information Grid (USA)
GM V&V	Generic Methodology for Verification and Validation
GOTS	Government Off-The-Shelf

H

HBM	Human Behaviour Modelling
HLA	High Level Architecture

I

I**DEF0**	Integration Definition for Function Modelling
I**DEF1X**	Integration Definition for Information Modelling

IEC	International Electrotechnical Commission of ISO
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

LVCAR	Live Virtual Constructive Architecture Roadmap

M

M&S	Modelling and Simulation
MC	Military Committee (NATO)
MDA	Model Driven Architecture
MDE	Model Driven Engineering
MODAF	MOD Architecture Framework (UK)
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
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
NIST	National Institute of Standards and Technology (USA)
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

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
RTA	Research and Technology Agency (now CSO)
RTI	Run Time Infrastructure (HLA)
RTO	Research and Technology Organization (NATO)

S

SC	Subcommittee
SCORM	Shareable Content Object Reference Model (ADL standard)

SCORM Sim	SCORM-Simulation Interface Standards
SDO	Standards Developing Organization
SEDEP	Synthetic Environment Development and Exploitation Process
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)
SRML	Simulation Reference Markup Language
STANAG	Standardization Agreement (NATO)
STF	SEDRIS Transmittal Format
STO	Science and Technology Organization
SysML	Systems Modelling Language

T

TADIL	Tactical Data Information Link
TC	Technical Committee
TCA	Technical Cooperation Agreement
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 E STANDARDS DEVELOPING ORGANIZATIONS OF INTEREST TO M&S

E.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 157 national members out of the 195 total countries in the world. 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 16 000 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

E.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 2,100 IEEE standards, including

drafts. 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

E.3. THE WORLD WIDE WEB CONSORTIUM (W3C)

The W3C is an international consortium where member organizations, a full-time staff, and the public work together to develop Web standards. W3C's mission is to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure long-term growth for the Web. W3C develops Web Standards and Guidelines. W3C primarily pursues its mission through the creation of Web standards and guidelines. W3C also engages in education and outreach, develops software, and serves as an open forum for discussion about the Web. There are many other organizations developing standards for the Internet or the Web in general, and in some cases, their activities may overlap with W3C activities. To help coordinate the development of the Web, W3C engages in liaisons with numerous organizations after careful consideration of the costs and benefits. The Consortium is governed by its membership, which comprises about 400 organizations. Members include only businesses, non-profit organizations, universities, and governmental entities. There is no provision for individual membership. Since 1994, the W3C has published more than ninety such standards, called W3C Recommendations. The W3C is not officially recognized by NATO. Access to W3C Recommendations is under a royalty-free patent license, allowing anyone to implement them. The URL for W3C recommendations is www.w3.org.

E.4. 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.

E.5. THE OBJECT MANAGEMENT GROUP (OMG)

OMG has been an international, open membership, not-for-profit computer industry consortium since 1989. OMG produces and distributes only specifications – not software. Software products implementing OMG specifications – e.g. MDA (Model Driven Architecture), UML (Unified Modelling Language) or CORBA (Common Object Requesting Broker Architecture) – are available from hundreds of sources including vendor companies and sources of freeware and open-source software, including both OMG members and non-members. Dozens of standards organizations and other consortia maintain liaison relationships with OMG. OMG is an ISO Publicly Available Specifications submitter, able to submit specifications directly into ISO's fast-track adoption process. Any organization may join OMG and participate in standards-setting process. Membership includes over 800 companies from both the computer industry and software-using companies. Half of the OMG member companies are software end-users in over two dozen vertical markets, and the other half represent virtually every large organization in the computer industry and many smaller ones. Most of the organizations that shape enterprise and Internet computing today are represented on the Board of Directors. More than 170 specifications have been formally published. There is no official OMG recognition by NATO so far. All of OMG specifications may be downloaded without charge from OMG website: www.omg.org.

E.6. THE USA NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

The National Institute of Standards and Technology (NIST) was known as the National Bureau of Standards (NBS) between 1901 and 1988. It is a non-regulatory agency of the United States Department of Commerce. The mission of NIST is to promote U.S.A. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve quality of life. Two standards published and promoted by NIST are included in the AMSP-01: Integration Definition for Information Modelling (IDEF1X) and Integration Definition for Function Modelling (IDEF0). Standards promoted by NIST are available at their website: http://ts.nist.gov/Standards/ssd.cfm.

E.7. THE USA NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY (NGA)

The NGA and the National System for Geospatial-Intelligence (NSG) are responsible for establishing geospatial intelligence (GEOINT) standards for the United States defence and intelligence communities. GEOINT standards ensure the timely access to relevant and accurate GEOINT data, services, and products regardless of source, exploitation process, or production element. The National Center for Geospatial Intelligence Standards (NCGIS) at NGA and the Geospatial Intelligence Standards Working Group (GWG) provide critical support to this mission. The NGA has issued a new document that provides guidance and direction to develop an overall baseline for common geospatial standards used to share, manipulate, and exploit digital

geospatial data. The document, “Geospatial Intelligence Standards: Enabling a Common Vision," (http://www.nga.mil/NGASiteContent/StaticFiles/OCR/ncgis-eb.pdf) outlines the standards that will be used in the National System for Geospatial-Intelligence (NSG).

E.8. THE OPEN GEOSPATIAL CONSORTIUM (OGC)

The OGC is an international voluntary consensus standards organization. In the OGC, more than 370+ 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, 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 and Simple Features Access are ISO standards. Further information can be found at www.opengeospatial.org.

E.9. THE NORTH ATLANTIC TREATY ORGANIZATION (NATO)

The standardization activity in NATO is complex and covers multiple domains. As stated in the paragraph 1.5., 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, Conceptual Modelling, 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 1.5.

AMSP-01 (C)