AMSP-01

NATO MODELLING AND SIMULATION STANDARDS PROFILE

Edition (B) Version 1

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NORTH ATLANTIC TREATY ORGANISATION

ALLIED MODELLING AND SIMULATION PUBLICATION

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NORTH ATLANTIC TREATY ORGANIZATION

NATO STANDARDIZATION AGENCY (NSA)

NATO LETTER OF PROMULGATION

26 January 2012

1. AMSP-01(B) – NATO MODELLING AND SIMULATION STANDARDS PROFILE is a non classified publication.

2. AMSP-01(B) is effective upon receipt. It supersedes AMSP-01(A) which should be destroyed in accordance with local document destruction procedures.

Cihangir Aksit, TUR/Civ
Director, NATO Standardization Agency

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RECORD OF CHANGES

Change Date	Date Entered	Effective Date	Entered By

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. HLA - the High Level Architecture,
- Data interchange standards - e.g. SEDRIS - Synthetic Environment Data Representation and Interchange Specification, and
- Best practices - e.g. DSEEP – Distributed Simulation Engineering and Execution Process.

The NATO Modelling and Simulation Group (NMSG), the NATO Delegated Tasking Authority for standardisation in NATO M&S has developed NATO Standardisation 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 organisations 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 (B) and it includes more than 40 M&S related standards. 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 Organisations (SDOs) for new standardisation 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/docu/stanag/amsp/AMSP-01.pdf).

Respectfully,

Niels Krarup-Hansen, Chairman of NMSG

Wim Huiskamp, Chairman of MS3

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TABLE OF CONTENTS

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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 FRAMEWORK FOR CIVIL STANDARDS

C-M(2004)0009.

1.1.1.3. 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 OF MILITARY SIGNIFICANCE FOR USE IN NATO (ENGLISH AND FRENCH)

AAP-06.

1.1.3. OTHER DOCUMENTS

1.1.3.1. NATO MODELLING AND SIMULATION MASTER PLAN

AC/323(SGMS)D/2 Version 1.0

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)

1.2. PURPOSE

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 following objective of the NATO M&S Master Plan (see reference 1.1.3.1).

a. Establish a Common Technical Framework to Foster Interoperability and Reuse.

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 large use and sometimes improperly called “standards”: this concerns “de facto” standards, products, methodologies, processes, etc. that are not “official standards”, but that are widely used within industry and nations and could be relevant for 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

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 - support interoperability and provide information. The standards profile is aimed specifically at NATO member nations and partner nations, as well as national and NATO organisations, which have requirements to effectively use M&S in support of NATO, coalition and national requirements.

The official 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 Standardisation Agreement (STANAG).

1.3. SCOPE

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.

Standards are classified in the following categories:

a. M&S methodology, architecture and processes with sub-categories:

   1. Architecture Frameworks;

   2. Systems Engineering processes;

   3. Verification and Validation;

b. Conceptual Modelling and Scenarios;

c. M&S Interoperability ;

d. Information Exchange Data Model;

e. Software Engineering;

f. Representation of natural and human-made environment with sub-categories:

 1. General;

 2. Data sources and formats;

 3. Imagery, 3D Models;

 4. Interchange of environmental data;

 5. Production processes;

 6. Visualization;

g. Simulation Analysis and Evaluation;

h. M&S Miscellaneous.

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 which are not being maintained and have been superseded. Users should plan replacement activities. For new projects these standards should not be applied.

b. ‘Aging’ standards are identified as those which 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 developments.

c. ‘Current’ standards are identified as those which 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 which 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

NATO recognises the ISO/IEC[1] concept of a standard as follows: “*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*”. 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).

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

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

1.5. BACKGROUND ON NATO STANDARDISATION

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).

The NATO Standardisation Process involves proposing, developing, agreeing, ratifying, promulgating, implementing and updating NATO standardization documents. The primary products of this process are:

a. Covering documents:

    1. Standardisation Agreement (STANAG);

    2. Standardisation Recommendation (STANREC);

b. Allied Standards:

    1. Allied Publication (AP);

    2. Multinational Publication (MP).

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

The Director of the NATO Standardisation Agency is responsible for the promulgation of agreed NATO standardisation documents.

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

A TA may delegate its responsibility to a subordinate Body, which then becomes a delegated tasking authority (DTA). A DTA cannot delegate its responsibility further.

As an example, the NATO M&S Group is the Delegated Tasking Authority (by the Conference of National Armaments Directors, CNAD) in the NATO M&S standardisation domain.

The NATO Bodies are responsible for:

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

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

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

1. NATO STANDARDISATION AGENCY (NSA). A key part of the NATO Standardisation Organisation is the NSA that reports to the NATO Committee for Standardisation (NCS) for general oversight and direction. For issues relating to operational standardisation, the NSA reports directly to the Military Committee. The Agency's mission is to foster NATO standardisation with the goal of enhancing the combined operational effectiveness of Alliance military forces.

The NSA, as the focal point for NATO standardisation efforts, accomplishes its mission through the promotion of co-ordination among all NATO Committees/Working Groups dealing with standardisation. Furthermore, it provides support to multiple operationally oriented working groups that have been established by the Service Boards (Joint, Army, Naval and Air) pursuant to authority delegated by the Military Committee. A small staff co-ordinates Agency activities and supports the Director of the NSA.

The NATO Policy for Standardisation states that "NATO will use suitable civil standards to the maximum practicable extent. Only when no applicable standard is available, will a NATO standard be developed". The aim is to use resources in the most efficient way.

In 2009, the NCS has tasked the NSA 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 Organisations (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. The maintenance of the new civil standard is the responsibility of the civil SDO with NATO participation.

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

The legal basis for cooperation of NATO with civil SDOs consists of Technical Cooperation Agreements (TCAs). So far, NSA has established TCAs with ISO, IEC, ETSI, CEN, CENELEC, ANSI, GS1, SAE and IEEE. Others will follow in the near future. A TCA between NATO and SISO was signed in July 2007 by the NMSG.

2. NATO MODELLING AND SIMULATION GROUP (NMSG). The NMSG is part of the NATO Research and Technology Organization (RTO). 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 Research and Technology Agency (RTA), which is the permanent body supporting the NATO RTO. 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 standardisation, education, and associated science and technology. The activities of the Group are governed by the NATO M&S Master Plan. The Group provides M&S expertise in support of the tasks and projects within the RTO 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 standardisation documents, such as this publication, in support of NATO Modelling and Simulation activities.

3. MODELLING AND SIMULATION STANDARDS SUBGROUP (MS3). To achieve the standardisation 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 Terms of Reference (ToR) were officially approved by the NMSG in October 2007.

1.6. INTELLECTUAL PROPERTY RIGHTS

The NATO Policy on Intellectual Property Rights (IPR) for NATO Standards is stated in reference 1.1.1.3 and is available on the NSA protected website. The document outlines procedures to ensure the protection of intellectual property rights of NATO standardisation community from the civilian standardisation community.

These procedures will resolve potential conflicts between the objective of standardisation (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).

The NSA owns the NATO copyrights in all NATO standardisation documents and retains the right to exploit such copyrights.

NSA will grant Member States and PfP countries a license, free of charge, to:

a. Reproduce, translate and adapt in whole or in part, in any material form, all NATO standardisation 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 standardisation document, or translations or adaptations thereof;

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

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

Concerning referenced standards developed by civil organizations, they have specific copyrights requirements which can be different from one organization to another one. It is the responsibility of standards users to check these restrictions and comply with them. No responsibility will be assumed by the NSA or the NMSG.

1.7. NATO STANDARDISATION DOCUMENTS COPYRIGHT

The Director of NSA is responsible for ensuring that NATO standardisation documents comply with NATO requirements related to the issue of copyrights for NATO standardisation documents (see reference 1.1.1.3) 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 NSA.

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 kinds of standards:

a. **“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 F 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.).

b. **“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 world. 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.).

c. **“Open standards”:** A lot of slightly different definitions and meanings can be found that describe this term. For the purpose of this profile, we will retain the following one: "Specifications that are developed by a standards organization 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 key points which qualify standards openness are:

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

   2. Public availability of the standard once it is completed;

   3. Possibility to use it free of charge for any purpose.

   The use of Open standards in a user application should be free and without restrictions and the necessary documentation should be available on fair and equitable terms. Standards that do not respect this principle of openness were not selected in this profile.

d. **"Local/Specific" versus "General/International" standards**: The term "standard"

[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 F and reference 1.1.3.4) that is a key standards organisation for the M&S community.

is used by different communities at different levels: one product or process can be a considered as 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 like NATO, UN or ISO.

Local standards can also be very specific and of interest only to a particular community: for example there is a current effort in NATO to elaborate standards on the virtual prototyping of military ships. This is an international initiative, but also a very specific standardisation 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

The main qualities which 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, in an efficient manner, to ensure that the product is useful to the community;

d. Reviewed by the technical community to which the product applies & large acceptance;

e. Generality: standards should be as general as possible, while still maintaining usefulness, to support the broadest community of current and future users;

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

g. Supportability: Standards should maintain the integrity of the existing product suite and the needs of the user.

SDOs generally recognized these important features in their own policy and procedures documents and do develop good standards. As an example, the SISO Policy and Procedures document (see reference 1.1.3.4) uses the following terms to characterize its General Operating Principles:

a. Responsiveness and Responsibility;

b. Quality;

c. Discipline;

d. Fairness;

e. Openness;

f. Consensus.

2.3. RATIONALE FOR THE ESTABLISHMENT AND THE USE OF M&S STANDARDS

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, but adopt 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 (end-80s, early-90s). Reuse of different simulators/simulation applications developed under different technological approaches and implemented on different platforms became possible: a requirement for developing interoperability protocols and/or architecture standards emerged. While simulation interoperability spurred the development of many standards, there are other types of M&S and M&S-related standards, e.g., engineering practices.

After some years of standards development, it appears that existing standards were only partial solutions to the overall interoperability problem. The current situation is improving, but a lot has still to be done. Standards development and maintenance is an evolutionary process. Existing standards must mature to meet changing requirements. When new requirements emerge or technical innovations become possible, new standards will likely be needed.

a. **Improved interoperability**

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”.

When speaking about M&S, interoperability is defined as the “…capability for simulations to physically interconnect, to provide (and receive) services to (and from) other simulations, to use these exchanged services in order to effectively work together”

This definition was given in the NATO M&S Master Plan (1998) (see reference 1.1.3.1). It suggests an additional comment: it refers mainly to “technical interoperability”, that means the possibility to physically interconnect and communicate. A lot of additional work has to be done after interconnection is ensured, to reach higher levels of interoperability (semantic or substantive interoperability). Why is interoperability so important? Because we have moved

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

from individual/team training to collective training (combined, joint, multi-national), multi-level training, In order to preserve investments in (existing) individual/team training simulation assets they should become interoperable to also support collective training.

Interoperability does not only include Simulation to Simulation data exchange, but also interoperability between Simulations and Live systems (e.g. through Link16) and with Command & Control applications.

b. **Good reasons to develop and use standards:**

Overall, there are many benefits to using standards:

1. Standards can improve operational capabilities by supporting **higher reliability** and facilitating **new technology insertion**.

2. Standards allow people working with different systems to **cooperate** and allow **collective training or experimentation**.

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

4. They **protect investment**: for example, scenario descriptions, models and data bases may be reused in a variety of applications. They also allow upgrading to newer systems or changing to systems from another vendor.

5. They should allow **access to the best of the technology** (standards are supposed to represent the state-of-the-art; they 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.

7. Finally, standards can **reduce complexity** and produce more modular and reconfigurable implementations thus **reducing development risk**.

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

- No one feels in a dominant position;
- This avoids lengthy negotiations;
- They are neither an unacceptable constraint nor a performance overhead: on the contrary, they are an enabler for asset protection and industrial co-operation (standards allow everybody to speak the same language and understand each other).

c. **Standardisation phases:**

In general, three phases are often seen in the standards development activity, and M&S standards followed that pattern:

1. The “age of heroes”: early technology development (DIS), the early days of

collective training;

2. The "maturity phase": from technology to engineering process (HLA, FEDEP), development of large collective training applications;

3. Use in other application areas: use in non-training applications, for example operational support or simulation in support of acquisition.

There is a general consensus that the M&S standardisation activity is now in phases 2 and 3. M&S standardisation is now recognized as indispensable for a mature simulation activity and is a recognized part of the M&S body of knowledge.

2.4. DEVELOPMENT OF STANDARDS

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 ensures 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. In the parlance of SISO, this is known as a Product Nomination. If the SDO approves this 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 typically a more formal process than the draft development described in step 2. 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 who 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. For SISO, this group is known as a Product Support Group.

e. At the end of a specified period (typically 5 years) the SDO requires that the standard be **revised, renewed without changes, or retired**.

For open standards processes, steps a-d above typically take 2-3 years. Controlled standards (those that do go not through open balloting), typically 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

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

1. 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.

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

3. Technical interoperability standards (e.g. the High level Architecture, HLA), data standards (e.g. Synthetic Environment Data Representation and Interchange Specification, SEDRIS) and best practices (e.g. the DSEEP, Distributed Simulation Engineering and Exploitation Process).

b. In terms of maturity the following are considered for inclusion in the AMSP-01:

1. Existing standards applicable to M&S development, integration and employment. These standards may be classified as ‘obsolete’, ‘aging’ or ‘current’.

2. Emerging standards, i.e. standards that are in an advanced state of development.

3. Standards which are expected to be produced where a group has been established with that mission (e.g. NATO MSG-058 on Conceptual Modelling).

c. The AMSP-01 does not include:

1. 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).

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

d. The AMSP-01 contains only ‘open’ standards as defined as those standards upon which government and commercial organisations may develop products freely. Candidate standards can be developed by internationally recognised SDOs, industry consortiums, governmental organizations/agencies or vendors.

2.6. PROCEDURES

a. The AMSP-01 is developed and maintained using the following NMSG process.

1. Any member of the NATO MSG MS3 may propose standards for inclusion in or removal from the AMSP-01 based on the policy listed above. Proposals will be submitted in the form of a completed profile consistent with Annex A. Submissions shall be sent to the Secretary of MS3.

2. Task Group Chairpersons and NMSG members may also submit standards for consideration via the process described in step ‘1’ above.

3. 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 a simple majority (above 50%) is reached for inclusion, the standard shall be included. Abstentions do not count in the percentage.

4. All email votes in step ‘3’ shall be held for a period of two calendar weeks

5. 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 ‘3’ above.

6. The process in steps ‘1’ to ‘5’ occurs on a continuing basis. The product of these evolutions will be internal to the MS3.

7. On a yearly basis, the revised AMSP-01 shall be provided to the NMSG for approval. Upon the NMSG approval, the document shall be posted to the NMSG Web site and provided to NSA for publication.

b. The same rules shall apply for modifying or deleting items from the profile.

c. 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 according to the categories as given in Chapter 1.

3.1. DEFINITION OF THE MAIN CATEGORIES OF STANDARDS

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 organisational 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. Representation of natural and human-made environment;

g. Simulation Analysis and Evaluation;

h. M&S Miscellaneous.

Following subsections describe each category in detail.

The choice of categories was influenced by the DSEEP, which is an approved IEEE standard developed by SISO that supports the overall M&S lifecycle. Although the DSEEP (see reference 1.1.3.5) is very new, it is based on the widely accepted HLA Federation Development and Execution Process (FEDEP) (see reference 1.1.3.6); thus, the DSEEP is a very suitable reference.[4]

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

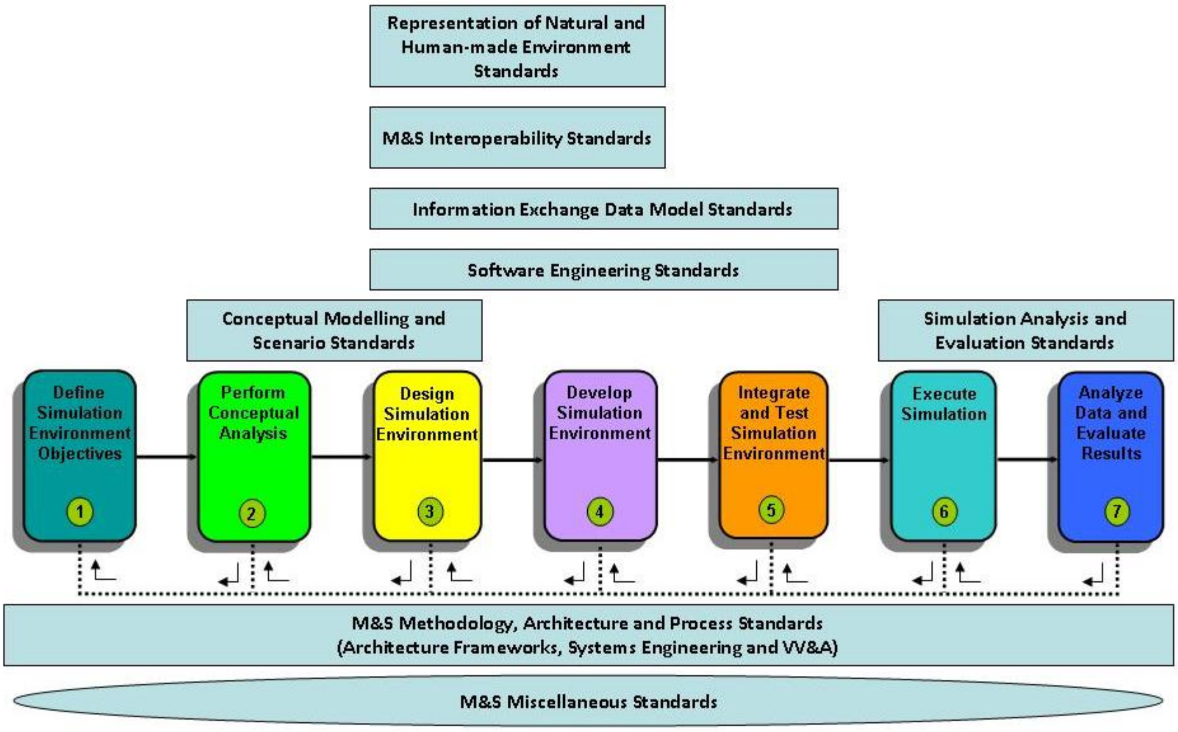

Figure 3-1: The 7-step DSEEP simulation engineering process and the standards categories

Figure 3-1 indicates the relationships between the standards categories and the seven main DSEEP steps.[5] The eight rectangles above and below the centre row of DSEEP steps represent the standards categories and five are linked to the DSEEP steps where the standards are most applicable. Rectangles representing more general standards, such as “Architecture Framework Standards” in the top-left corner, 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.

The following subsections describe the type of standards in each category and the relationships between the categories and the DSEEP steps.

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:

[5] DSEEP steps have been reproduced with permission of the IEEE.

a. **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).

b. **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.

c. **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

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.

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.

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

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.

[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

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.

3.1.4. INFORMATION EXCHANGE DATA MODELS

This category is closely related to the previous one, M&S interoperability, because data needs 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.

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: a good example is the emerging “Coalition Battle Management Language” (C-BML) that will facilitate 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, etc. Such standards are mainly used in Steps 3 and 4 of the DSEEP.

3.1.6. REPRESENTATION OF NATURAL AND HUMAN-MADE ENVIRONMENTS

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

The development, archiving and reuse of natural and human-made environmental databases is a very important part 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.

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. **General**: 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.

b. **Data sources and formats**: for standards that define the organization of structured data such as Digital Terrain Elevation Data (DTED), which defines how terrain relief data is to be represented.

c. **Imagery and 3D-models**: for standards that define how two-dimensional images and three-dimensional entities are to be stored. Example standards include GeoTIFF and OpenFlight.

d. **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.

e. **Production processes**: for standards that define how environmental data is to be produced.

f. **Visualization**: for standards that define how visual data is to be offered for visualization, such as the emerging Common Image Generator Interface (CIGI).

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.

Unfortunately, no example standards could be found for this category, presumably because the capture and analysis of data is so situation-dependent. For instance, how frequently the speed of an entity has to be logged depends on its maximum acceleration, so standards are hard to define. Similarly, analysis techniques depend on the type of simulation and which ones to use are best left to subject matter experts.

That said standards could still be defined to ensure that:

a. data is captured using common data formats and structures, perhaps in popular spreadsheet formats;

b. simulation metadata is captured to preserve knowledge of what simulation data represents;

c. data is stored for convenient After-Action Review (AAR).

3.1.8. M&S MISCELLANEOUS

This category covers standards that are difficult to assign elsewhere. The standards generally concern all DSEEP steps - or none! Lua 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; as a matter of fact, XML supports many M&S standards such as the HLA and C-BML. 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

This very general category comprises three subcategories, all of which cover the seven steps of the DSEEP.

3.2.1.1. ARCHITECTURE FRAMEWORKS

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;

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

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

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) – current;

b. The European Synthetic Environment Development and Exploitation Process (SEDEP) – obsolete. This process was developed within a European project and its custodian has declared that it will be superseded by the DSEEP process described hereafter;

c. The IEEE 1730 DSEEP – emerging. 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.

The DSEEP, which was recently approved by SISO and the IEEE, is intended to supersede both the FEDEP and SEDEP.

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)

This category includes the following standards:

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

b. The European "Referential for VV&A" (REVVA1) – obsolete;

c. The "V&V Information Exchange" from the International Test Operations Procedures (ITOP) consortium – aging;

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

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

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

REVVA1 is being superseded by the emerging SISO GM-VV standard. REVVA1 was followed by REVVA2 effort and its final output was the baseline for the GM VV SISO PDG. The V&V Information Exchange will not evolve further since the ITOP working group – the author of the work – was disbanded years ago. Many NATO and partners nations have established national standards. Current SISO efforts on GM-VV should address the lack of internationally recognized V&V standards.

3.2.2. CONCEPTUAL MODELLING AND SCENARIOS

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.

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;

e. Integration Definition for Function Modelling (IDEF0), which was developed by the USA National Institute of Standards and Technology (NIST) – aging;

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

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.

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.

IDEF0 has been used in DODAF Operational View (OV) level-5 descriptions and could be put in the Architecture Framework subcategory as well.

Concerning MSDL: for a long time, it has been recognized that a way of describing, archiving, exchanging and reusing scenarios was of paramount interest to M&S as scenario development is very time and resource consuming. 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. Interface and 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

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.

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;

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

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 in use in the USA.

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.

The US DoD is currently investigating what could be done to improve this situation towards aligning these standards; this effort is named the Live, Virtual and Constructive Architecture Roadmap (LVC AR).

It is important to remember that there is only one STANAG related to this topic, that is, the HLA (STANAG 4603). Thus, the HLA is the unique interoperability standard recommended by NATO.

3.2.4. INFORMATION EXCHANGE DATA MODELS

This category includes some 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 SISO Realtime Platform Reference Federation Object Model (RPR-FOM) –

current;

d. The Link 16 BOM Simulation standard of SISO – current;

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

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

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

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

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

DIS Enumerations are unique identifiers for simulated entities that represent real-world vehicles, life forms etc. They are also used in the HLA Real Platform Reference Federation Object Model (i.e. RPR-FOM).

The above-mentioned RPR-FOM is a “reference FOM” that is widely used in the HLA community. It obviously respects 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.

The next two standards cover specific modelling needs of the military domain: simulation of Link 11 and Link 16 Tactical Data Links. They could also be listed in the “Conceptual Modelling” category as well.

The C-BML effort addresses the crucial interoperability problem between C3I systems and simulations. It is a current development effort and the future standard should be a great step forward.

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.

Like 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

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

This standards category includes:

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

b. The Common Object Request Broker Architecture (CORBA), also developed by the OMG – aging;

c. Extensible Markup Language (XML) – current;

d. Integrated Computer-Aided Manufacturing (ICAM) DEFinition language (IDEF1X) – aging.

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

CORBA was sometimes used as an M&S interoperability standard, even in NATO, but was very limited compared to dedicated standards like DIS or HLA (see section 3.2.3.).

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 many standards cited in this profile including those listed in the previous category.

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

3.2.6. REPRESENTATION OF NATURAL AND HUMAN-MADE ENVIRONMENTS

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

3.2.6.1. GENERAL STANDARDS

This subcategory only contains one standard: SEDRIS, which is in fact a series of 8 ISO/IEC standards. These standards have been grouped into three proposed STANAGs, which are submitted to nations' ratification.

SEDRIS provides the concepts to represent all environmental domains (terrain, ocean, atmosphere, and space) in an integrated manner, including urban and littoral areas while many other standards are only dealing with "terrain" representation. It provides a geometry-based data representation model (DRM) augmented with an environmental data coding specification (EDCS), which identifies what geometry data represents (e.g. a tree). SEDRIS also includes a spatial reference model (SRM), which provides coordinate transformations. These three components are the major SEDRIS standards:

a. SEDRIS Data Representation Model (DRM) – current;

b. SEDRIS Environmental Data Coding Specification (EDCS) – current;

c. SEDRIS Spatial Reference Model (SRM) – current;

Used together, SEDRIS DRM and EDCS provide mechanisms to unambiguously specify objects used to model environmental concepts. SEDRIS SRM provides the binding mechanisms to bind the environmental objects to terrain locations. SEDRIS EDCS and SEDRIS SRM could be used standalone.

SEDRIS also includes the following standard:

d. SEDRIS – SEDRIS Transmittal Format (STF) – current.

The STF is better placed in another subcategory since it is a format used for environmental data exchange rather than modelling environments.

3.2.6.2. DATA SOURCES AND FORMATS

This subcategory contains the following standards, which specify the structure of common environmental data files:

a. Vector MAP (VMAP) – aging;

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

c. Keyhole Markup Language (KML) – current;

d. Shapefile – current;

e. S57 – current;

f. DFAD (Digital Feature Analysis Data) – obsolete.

VMAP is a data format derived from the DIgital Geographic information Exchange STandard (DIGEST), which identifies physical man-made 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.

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

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.

Shapefile is a popular geospatial vector data format for geographic information systems (GIS). It is a (mostly) open specification for 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 synthetic environment databases.

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”.

DFAD is also a data format that was mainly used to represent natural entities such as forests or rivers and also human made entities like roads or buildings. Maintenance support for DFAD ended in November 2001, so DFAD was assessed as obsolete and not included in this profile.

3.2.6.3. IMAGERY AND 3D-MODELS

This standards subcategory includes:

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

b. OpenFlight – current;

c. GeoTIFF (XML 3-Dimensional) – current;

d. Collada – current.

X3D is a standard 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. Note that the Virtual Reality Modelling Language (VRML) is also a file format for describing interactive 3D-objects and worlds. It is an ISO/IEC standard, the last version of which was published in 1997. It was assessed as aging and superseded by X3D so it was not included in this profile.

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

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, regardless of the image origin.

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 gaming industry. It is a 'de facto' standard.

3.2.6.4. INTERCHANGE OF ENVIRONMENTAL DATA MODELS

This subcategory contains standards that are specific to environmental data and should not be confused with those in the previous category (Information Exchange Data Models), which are more general and not specifically related to environmental data: their main purpose is not to model entities or large physical spaces; instead, they are designed to support reuse of environmental databases, which are so costly to develop.

Only three standards are listed in this subcategory (even if it is recognized that all data formats could have also been put in this category since they could be used to exchange environmental data!):

a. SEDRIS Transmittal Format (STF) – current;

b. Geographic Markup Language (GML) – current;

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

STF enables the exchange of environmental data between different databases by providing a common intermediate format. Once a two-way converter has been created that can translate STF files into another data format, data can be transferred between any two databases that have STF converters by using an STF file as an intermediary. STF is one of the ISO/IEC SEDRIS standards (see Annex B for more information).

The Geography Markup Language (GML) is an ISO/IEC standard for the transport and storage of geographic information. It defines an XML 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.

City-GML is an OpenGIS® 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

An international standard that describes accepted practices for producing environmental database does not exist yet. Proprietary processes exist, like GIS Enabled Modelling & Simulation (GEMS), 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.

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

Since Spring 2010, SISO has set up a study group named Reuse and Interoperation of Environment Database Development Process (RIEDP) that could recommend the development of a future standard in this category.

3.2.6.6. VISUALISATION

There is a single standard in this subcategory:

a. CIGI, Common Image Generator Interface – current.

CIGI proposes an interface designed to promote a standard way for a host device to communicate with an arbitrary number of image generators. CIGI was initially developed by the Boeing company but it is a 'de facto' standard and could become a SISO standard. In fact, CIGI is not really a "visualisation standard" but it strongly relates to this category. In fact there is no other standard to this very specific activity characterized by proprietary approaches.

3.2.7. SIMULATION ANALYSIS AND EVALUATION

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

A unique related effort, a SISO Study Group named Distributed Debrief Control Protocol (DDCP), has recently completed its work. It demonstrated a general interest in having such a standard but the development activity has not started.

3.2.8. M&S MISCELLANEOUS

This category contains those standards which do not readily fall into any of the other categories. It contains the following three standards:

a. SCORM (Sharable Content Object Reference Model);

b. SCORM Sim (SCORM Simulation Interface Standards);

c. Lua.

SCORM is not an M&S standard but an IEEE standard for describing and exchanging contents of learning courses that have been developed under the Advanced Distributed Learning (ADL) concept. This standard will be considered for inclusion in the profile to facilitate the understanding of the follow-on SISO effort named SCORM-Sim, which intends to standardise the integration and use of simulation in distant learning systems. Unfortunately, no evidence could be found that a SCORM-Sim standard will be developed in the short term but there is a general feeling that it would be useful.

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 Lua, there is currently no other (open) standard related to Human Behaviour representation.

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	IDEF0
	System Engineering Processes	FEDEP, DSEEP	
	V&V	SISO GM-VV, V&V Information Exchange (ITOP), V&V Overlay on HLA FEDEP, VV&A RPG (US DoD), VV&A Templates (US DoD)	
Conceptual Modelling and Scenarios		MSDL, UML, XMI, SysML, BOM, IDEF0	Link 11, Link 16, Lua
M&S Interoperability		DIS, HLA, TENA *(DLC API to be retired)*	CORBA
Information Exchange Data Model		HLA OMT, DIS Enum, C-BML, Link 16, Link 11, RPR-FOM, SIMPLE, JC3IEDM	BOM, XML, IDEF1X
Software Engineering		CORBA, MDA, XML, IDEF1X	UML, SysML, XMI

Categories	Sub-categories	Standards attached to the category	**Possible standards** (Secondary attachment)
Representation of natural and human-made environment	**General**	SEDRIS (SRM, DRM & EDCS)	SEDRIS STF
	Data sources and formats	DTED, VMAP, KML, Shapefile, S57	
	Imagery, 3D Models	GeoTIFF, OpenFlight, X3D, Collada,	
	Interchange of environmental data	SEDRIS STF, CityGML, GML	Collada, GeoTIFF, S57
	Production processes	*None (but commercial or project-related approaches: CDB, GEMS, MTDB (SE CORE), NPSI)*	
	Visualization	CIGI	
Simulation Analysis and Evaluation		DDCP	
M&S Miscellaneous		SCORM Sim, Lua	

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CHAPTER 4 GAPS

Chapter 3 lists and categorized many M&S standards, which are described in Annex B. The number of standards suggests that the M&S standardisation 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 standardisation activities. This chapter discusses the gaps that have been identified in each of the standards categories that were introduced in Chapter 3.

In addition, the areas of Human Behaviour Representation (HBR) and live simulation, which MS3 participants unanimously agreed were both particularly important, are not sufficiently covered by standards.

Although 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 analyze 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.

Live training systems are often also proprietary as they are developed by individual vendors and are thus far generally not interoperable. Some NATO working groups are addressing this topic in close collaboration with procurement offices and industry, including NMSG-063 “Urban Combat Advanced Training Technology - UCATT 2.” The MS3 feels, however, that much more work is required before M&S standards will enable general interoperability of live training systems and interoperability of live systems with virtual or constructive simulations.

Other standards for modelling specific military domains are available or under development, such as SISO standards for modelling 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.

4.1. M&S METHODOLOGY, ARCHITECTURES AND PROCESSES

4.1.1. ARCHITECTURE FRAMEWORKS (AFS)

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 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);

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

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

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

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’s DSEEP 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.

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. The lack of a specialized process is surprising, especially since it could be easily addressed.

4.1.3. VERIFICATION AND VALIDATION (V&V) STANDARDS

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, the following observations have been made:

a. Some of the standards are old, not evolving and/or soon to be obsolete; examples include the European REVVA1 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.

d. No methodology or process exists to support the V&V of human behaviour representation.

Thus, the current set of standards is inadequate. Given that international cooperation on this topic is very modest, as indicated by the number of countries participating in SISO V&V PDGs and MSG-073 Task Group on “Generic Methodology for Verification and Validation of Models, Simulations and Data,” NATO must realize that it should better support and coordinate the development of common V&V standards.

4.2. CONCEPTUAL MODELLING AND SCENARIOS

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

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

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

The Task Group MSG-058 has recently 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 Conceptual Modelling. Examples are:

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

b. The OMG's Unified Modelling Language (UML), XML Metadata Interchange (XMI), Model Driven Architecture (MDA) and Systems Modelling Language (SysML).

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 will be addressed by the recently established SISO Product Development Group (PDG). This PDG will use the findings of MSG-058 as a sound basis for its activities.

The Web Ontology Language (OWL) also appears relevant to CM; however, it was not included in this profile because its impact could not be adequately assessed based on available evidence and a decision to include it would have been premature.

The only known M&S scenario standard is SISO's Military Scenario Definition Language (MSDL), which is currently very 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

Many standards exist in this category: the IEEE DIS and HLA, the US DoD TENA, and the OMG CORBA to name just a few. So many standards exist that the USA has initiated an activity to assess how to improve the current situation; it is called the Live, Virtual, Constructive Architecture Roadmap (LVC AR). The LVC AR results seem to point in the direction of slowly 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. The MS3 will follow the progress of this initiative and should encourage participation by the NMSG members

Although so many interoperability standards exist that they often overlap, the following must be considered:

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 "substantive" (or “semantic”) interoperability, which deals with the much more difficult problem of ensuring that all simulations treat shared data in a consistent and appropriate manner.

d. Substantive interoperability does occur when models are built for a particular purpose; however, documentation standards do not exist that enable any developer to readily determine if two or more models are interoperable. Specifications must be available that completely define:

   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;

   5. any assumptions that were made during model development and its intended use.

   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.

e. The only simulation interoperability standard that has been ratified as a NATO Standardisation 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.

f. 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.

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.

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 DEVS, the SRML and the Open M&S Architecture.

b. Numerous COTS products are not interoperable although this gap may be covered by the emerging SISO COTS Discrete Event Simulation Package Interoperability (CSPI) standard.

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

Thus, relevant standards for discrete event simulation are forthcoming; however, gaps in standards are likely to persist for a number of years because standards development—not to mention adoption—typically takes 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 currently undertaken by the Task Group MSG-068 (NETN).

4.5. SOFTWARE ENGINEERING

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.

Even if the M&S community may identify gaps in software engineering standards, it 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. REPRESENTATION OF NATURAL AND HUMAN MADE ENVIRONMENT

4.6.1. GENERAL

Standards in this subcategory are supposed to be broadly applicable and their emphasis is the representation of natural and human-made 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 a cost, which is 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.

4.6.2. DATA SOURCES AND FORMATS

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.

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.

4.6.3. IMAGERY AND 3D MODELS

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.

Given that Collada is maintained by the Khronos Group, a “not-for-profit” technology consortium, it is also unlikely to be adopted by nations as a standard.

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.

X3D, the successor to VRML, is the only standard in the category that is both current and recognized by a standards organization, that is, ISO. However, it is relatively new and is very unlikely to replace OpenFlight in popularity.

The above indicate that the options for open imagery and 3D-model standards that are recognized by standards organizations are extremely limited; X3D is the only possibility. 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.

4.6.4. INTERCHANGE OF ENVIRONMENTAL DATA

This category mainly emphasizes the SEDRIS Transmittal Format (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.

4.6.5. PRODUCTION PROCESSES

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.

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.

4.6.6. VISUALISATION

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.

4.7. SIMULATION ANALYSIS AND EVALUATION

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.

The above suggests that standards for simulation analysis and evaluation should be independent of any particular application area, which suggests that 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 do not already exist for an application area of concern.

4.8. M&S MISCELLANEOUS

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..

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. SISO is addressing this apparent gap in the recently started SCORMsim initiative.

Information exchange between nations and organisations 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. The simulation 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 newly established Task Group MSG-080 will investigate this problem and will in due time make recommendation for the way-ahead.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

5.1. PRELIMINARY OBSERVATION

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.

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 accepted by the nations.

5.2. CONCLUSIONS

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 organisations that have to effectively use M&S in support of NATO and national requirements.

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 NATO M&S Standards, 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.

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:

a. 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.

b. 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.

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

d. Review and update of the publication be done on an annual basis.

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

f. Review of the selection criteria be part of the periodic review.

g. The procedure for submitting standard to be added to the profile.

h. The NMSG actively solicit support of standards development organisations to address gap issues. This supposes a large diffusion of the AMSP-01 inside and outside NATO.

i. 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

As far as the categories of standards and actual standards are concerned:

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. Standardisation 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.

h. Data standards are a weak area of the overall standardisation 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.

Standardisation 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.

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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 STANDARDARDS 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	Representation of Natural & Human Made Environment						Simulation Analysis & Evaluation	M&S Miscellaneous
	Architecture Frameworks	System Engineering Process	V&V					General	Data Sources & Formats	Imagery & 3D Models	Interch Environmental Data	Production Process	Visualisation		
BOMs				X		x									
C-BML						X									
CIGI													X		
CityGML											X				
Collada										X	x				
CORBA					x		X								
DIS					X										
DIS Enum						X									
DoD Architecture Framework	X														
DSEEP		X													
DTED									X						
Dynamic Link Com-patible DLC HLA API					X										
GeoTiff										X	x				
GML											X				
GM-V&V			X												
HLA					X										

STANDARD	CATEGORIES														
	M&S Methodology, Architectures and Processes			Conceptual Modelling & Scenarios	M&S Interoperability	Information Exchange Data Model	Software Engineering	Representation of Natural & Human Made Environment						Simulation Analysis & Evaluation	M&S Miscellaneous
	Architecture Frameworks	System Engineering Process	V&V					General	Data Sources & Formats	Imagery & 3D Models	Interch Environmental Data	Production Process	Visualisation		
HLA – OMT						X									
HLA FEDEP		X													
IDEF0	x			X											
IDEF1X						x	X								
JC3IEDM						X									
KML									X						
Link 11 Simulations				x		X									
Link 16 Simulations				x		X									
LUA				x											X
MDA							X								
MSDL				X											
NATO-AF V3 (2003) NATO – Architecture Framework	X														
OpenFlight										X					
RPR FOM						X									
S57									X		x				
SEDRIS DRM								X							
SEDRIS EDCS								X							

STANDARD	CATEGORIES														
	M&S Methodology, Architectures and Processes			Conceptual Modelling & Scenarios	M&S Interoperability	Information Exchange Data Model	Software Engineering	Representation of Natural & Human Made Environment						Simulation Analysis & Evaluation	M&S Miscellaneous
	Architecture Frameworks	System Engineering Process	V&V					General	Data Sources & Formats	Imagery & 3D Models	Interch Environmental Data	Production Process	Visualisation		
SEDRIS SRM								**X**							
SEDRIS STF								**x**			**X**				
ShapeFile									**X**						
SIMPLE						**X**									
SysML				**X**			**x**								
TENA					**X**										
UML				**X**			**x**								
V&V Information Exchange			**X**												
VMAP									**X**						
VV&A Overlay to FEDEP			**X**												
VV&A RPG			**X**												
VV&A Templates			**X**												
X3D										**X**					
XMI				**X**			**x**								
XML						**x**	**X**								

Legend: **X** - main category of the standard, **x** - secondary category of the standard (overlapping standards)

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: 15 November 2010

C-BML

Standard Title: Coalition - Battle Management Language (C-BML).
Standard Identifier: SISO-REF-016-2006
Version Identifier: Under development.
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.

It can be seen as a standard representation of a digitized commander's intent to be used for real troops, for simulated troops, and for future robotic forces. 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 C4ISR 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.
Technical Maturity [Emerging]: This language is under development. Different experimentations have been completed which prove the validity of this concept.
Applicability: One significant effort to leverage interoperability between C4I systems and simulations.
Information on implementation: Many experiences in different nations with predecessor activities that have led to the current standardisation effort.
Limitations of this Standard: Still different approaches being considered.
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: 17 November 2010

Common Image Generator Interface (CIGI)

Standard Title: Common Image Generator Interface
Standard Identifier: CIGI
Version Identifier: Version 3.3
SDO: CIGI development has been started in 2000 by The Boeing Company. From 2003 up to now, CIGI is being matured under supervision of a SISO Standing Study Group (CIGI SSG).
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. It should be noted that CIGI is under supervision of a SISO Standing Study Group, indicating the need for a certain degree of maturity and/or potentially the provision of support to the software.
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 standard allows for a certain degree of customization. This implies the need for an agreement on a number of things instead of a plug-and-play approach.

- User-defined data packets: Everyone is free to insert new data packets in CIGI. Whenever a CIGI-compliant application with user-defined data packets is distributed, the receiver should know exactly what has been changed with respect to the original library. For compliancy, other CIGI applications then need to be modified as well.
- IG-compliancy: A small number of packets contain information which is IG-dependent (typically, for example, a simple ID indicating surface condition). To guarantee the host's compliancy, it should be made sure that it is compatible with any of the IG-dependent information. The opposite case, the existence of host-dependent information, may also occur.

Standard Type: Representation of Natural and Human Made Environment / Visualisation
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://cigi.sourceforge.net
Input Date: 28 September 2009
Last Updated: 22 November 2010

CityGML

Standard Title: OpenGIS® City Geography Markup Language (CityGML) Encoding Standard
Standard Identifier: OGC 08-007r1
Version Identifier: Version: 1.0.0
SDO: Open Geospatial Consortium (OGC)
STANAG identifier: N/A
STANAG status: 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 Germany, Great Britain, Switzerland, and Austria 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: Representation of Natural and Human Made Environments – 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: 15 December 2010

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
STANAG status: 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: Representation of Natural and Human Made 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.kronos.org/collada . There is also a COLLADA community web site (http://collada.org).
Input Date: 22 August 2008
Last Updated: 23 November 2010

CORBA

Standard Title: Common Object Request Broker Architecture (CORBA).
Standard Identifier: CORBA
Version Identifier: 3.1 – Jan 2008
SDO: OMG
STANAG identifier: Not applicable.
STANAG status: Not applicable.
Abstract: CORBA, the Common Object Request Broker Architecture, is OMG's open, vendor-neutral architecture and infrastructure that computer applications use to work together over networks. Using the standard protocol IIOP®, a CORBA-based program from any vendor, on almost any computer, operating system, programming language, and network, can interoperate with a CORBA-based program from the same or another vendor, on almost any other computer, operating system, programming language, and network.
Technical Maturity [Aging]: CORBA is a mature, standard middleware that combines the interoperability, deterministic execution, and absolute dependability required by distributed embedded systems.
Applicability: Has been used for simulation interoperability even though it was not dedicated to simulation. Has been use by some HLA and TENA middleware designers.
Information on implementation: Many uses in different countries and on different platforms but few uses for simulations.
Limitations of this Standard: Through its history, CORBA was plagued by shortcomings of its implementations.
Standard Type: Software engineering
Public Availability: Via OMG web site.
URL or instructions to Access or Acquire: http://www.omg.org/spec/CORBA/3.1/
Input Date: 20 March 2008
Last Updated: 15 Nov 2010

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 P1730™ 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: 15 November 2010

DODAF

Standard Title: DoD Architecture Framework (DoDAF)
Standard Identifier: None
Version Identifier: Version 2.01 dated 28 May 2009
SDO: The DoDAF Working Groups.
STANAG identifier: N/A
STANAG status: N/A
Abstract: The DoDAF is a three-volume set that inclusively covers the concept of the architecture framework, development of architecture descriptions, and management of architecture data.

- Volume 1 (Manager's Guide – Introduction, Overview, and Concepts) introduces DoD architecture concepts and provides general guidance for development, use, and management of DoD architectures.
- Volume 2 (Architect's Guide – Architectural Data and Models) describes the Meta-model data groups, and their associated models from a technical viewpoint.
- Volume 3 (Developer's Guide – DoDAF Meta-model Physical Exchange Specification) relates the Conceptual Data Model structure, Logical Data Model relationships, associations, and business rules to introduce the Physical Exchange Specification which provides the constructs needed to enable exchange of data and derived information among users and Communities of Interest.

  [Reference: DoD Architecture Framework Version 2.0 dated 28 May 2009]

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 is the prescribed framework for all US DoD architectures, and represents a substantial shift in approach. It places emphasis upon a disciplined process of defining the purpose, scope and information requirements of the architecture up-front, followed by collection of data in accordance with a standard vocabulary. Data collected through the architectural process is delivered to the customer in either standard models or "Fit for Purpose" presentations.
[Reference: DoD Architecture Framework Version 2.0 dated 28 May 2009]
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://cio-nii.defense.gov/sites/dodaf20/products/DoDAF_v2-01_web.pdf
Input Date: 8 April 2008
Last Updated: 15 November 2010

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) standards 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; there are specific annexes covering HLA DIS and TENA.
Technical Maturity [Emerging]: Currently DSEEP has been officially approved then published by IEEE in January 2011, building on the experience of both the IEEE 1516.3 FEDEP and the European SEDEP effort (that is now superseded by DSEEP).
Applicability: It is likely that the DSEEP will be widely used in future projects as was the FEDEP in previous HLA federation developments. Specialisations and extensions of DSEEP are already in progress in SISO and elsewhere;
Information on implementation: As it is very recently published, there is no known implementation yet.
Limitations of this Standard: Needs to be tailored for specific uses and interoperability standards selected.
Standard Type: Simulation Systems Engineering
Public Availability: Copies of this standard may be purchased from IEEE. The first version is freely available only to members.
URL or instructions to Access or Acquire: www.ieee.org and www.sisostds.org (for SISO members only).
Input Date: 28 July 2008.
Last Updated: 31 January 2011

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: Representation of Natural and Human Made 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: 24 November 2010

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: 15 November 2010

GeoTIFF

Standard Title: GeoTIFF
Standard Identifier: Geographic Tagged Image File Format (TIFF)
Version Identifier: GeoTIFF Revision 1.0 Specification, version 1.8.2 , last modified 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 standard.
STANAG identifier: N/A
STANAG status: N/A
Abstract: GeoTIFF is a public domain metadata standard (a format) which allows geo-referencing information to be embedded within a TIFF image file (see 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 (abbreviation of Tagged Image File Format): 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 incapable 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
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: Representation of Natural and Human Made 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: 23 November 2010

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; * 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 necessity.
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 and therefore essential for a service-oriented interoperable technical environment.
Information on implementation: GML is used in NATO CoreGIS (NC3A).
Limitations of this Standard: unknown
Standard Type: Representation of Natural and Human Made 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: 15 December 2010

GM V&V

Standard Title: Guidance for a "Generic Methodology (GM) for Verification and Validation (V&V) and Acceptance[7] of Models, Simulations, and Data".
Standard Identifier: GM-VV
Version Identifier: Draft in discussion within the GM-VV SISO Product Development Group (PDG)
SDO: Simulation Interoperability Standards Organization (SISO)
STANAG identifier: None
STANAG status: N/A
Abstract: This product will provide 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 1516.4 "Overlay of the HLA FEDEP", the former REVVA 1 project, the former V&V International Test Operations Procedures (ITOP) Working Group output, and the US DoD VV&A Recommended Practices Guide (RPG). The initial GM-VV draft documents have been produced by the REVVA2 consortium. REVVA2 was a REVVA1-following effort led by France and supported by Canada, Denmark, the Netherlands and Sweden. The GM-VV products will include the following:

GM-VV Vol. 1 **"Introduction and Overview"**: will provide the methodology deployment and utilization – targeted to newcomers – a high level description of the methodology.

GM-VV Vol. 2. **"Implementation Guide"**: will provide guidance on how to apply the GM-VV.

GM-VV Vol. 3 **"Reference Manual"**: will provide the technical concepts and the components specification of the methodology.

Only first and second documents will be balloted SISO standards. The third one is a supporting document not submitted to a vote of the SISO GM-VV PDG.
Technical Maturity [Emerging]: all 3 documents have already gone under comment rounds in SISO.
Applicability: GM-VV methodology has been experienced in some benchmarking cases (in Canada ("MALO case") and in Europe ("NBC study", "Driving simulator" and "Heavy weather" cases"))
Information on implementation: Testing cases have been introduced in past SISO workshops
Limitations of this Standard: Some lack of maturity, which is too early to formally identify.
Standard Type: M&S Methodology, Architecture and Processes, Verification and Validation (V&V)
Public Availability: SISO draft standard (available to SISO members under usual SISO copyright conditions).
URL or instructions to Access or Acquire: www.sisostds.org
Input Date: 26 February 2008
Last Updated: 07 December 2010

[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.

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 2nd July 2008
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: 16 November 2010

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 [Current]: 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 is already approved by IEEE and about to be published --"IEEE 1730™ Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP)". When IEEE 1730 is published, the FEDEP standard could become obsolete.
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: 16 November 2010

IDEF0

Standard Title: Integration Definition for Function Modelling (IDEF0).
Standard Identifier: IEEE 1320.1-1998
Version Identifier: none
SDO: The US National Institute of Standards and Technology (NIST)
STANAG identifier: N/A
STANAG status: N/A
Abstract: IDEF0 function modelling is designed to represent the decisions, actions, and activities of an existing or prospective organization or system. IDEF0 graphics and accompanying texts are presented in an organized and systematic way to gain understanding, support analysis, provide logic for potential changes, specify requirements, and support system-level design and integration activities. IDEF0 may be used to model a wide variety of systems, composed of people, machines, materials, computers, and information of all varieties and structured by the relationships among them, both automated and non automated. For new systems, IDEF0 may be used first to define requirements and to specify functions to be carried out by the future system. As the basis of this architecture, IDEF0 may then be used to design an implementation that meets these requirements and performs these functions. For existing systems, IDEF0 can be used to analyze the functions that the system performs and to record the means by which these are done.
Technical Maturity [Aging]: The standard was approved in 1993.
Applicability: The use of this standard is strongly recommended for projects that:

- Require a modelling technique for the analysis, development, re-engineering, integration, or acquisition of information systems;
- Incorporate a systems or enterprise modelling technique into a business process analysis or software engineering methodology.

Information on implementation: Examples of current uses of IDEF0 are more evident in the examples of the use of the DoDAF OV-5 Operational View Diagrams. Some older examples of OV-5 can be found in the US DoD Architecture Framework Version 1.0 Deskbook dated 15 August 2003. Also used in other nations.
Limitations of this Standard: Strictly an activity modelling language. Does not include full process semantics (e.g., dependency and synchronization of operations)
Standard Type: Conceptual Modelling and Scenarios
Public Availability: Copies of this standard may be purchased from IEEE.
URL or instructions to Access or Acquire: www.ieee.org
Input Date: 09 April 2008
Last Updated: 15 November 2010

IDEF1X

Standard Title: Integration Definition for Information Modelling (IDEFIX)
Standard Identifier: IEEE 1320.2-1998
Version Identifier: none
SDO: The USA National Institute of Standards and Technology (NIST)
STANAG identifier: N/A
STANAG status: N/A
Abstract: IDEF1X97 consists of two conceptual modelling languages. The key-style language supports data/information modelling and is downward compatible with the USA government's 1993 standard, FIPS PUB 184. The identity-style language is based on the object model with declarative rules and constraints. IDEF1X97 identity style includes constructs for the distinct but related components of object abstraction: interface, requests, and realization; utilizes graphics to state the interface; and defines a declarative, directly executable Rule and Constraint Language for requests and realizations. IDEF1X97 conceptual modelling supports implementation by relational databases, extended relational databases, object databases, and object programming languages. IDEF1X97 is formally defined in terms of first order logic. A procedure is given whereby any valid IDEF1X97 model can be transformed into an equivalent theory in first order logic. That procedure is then applied to a meta model of IDEF1X97 to define the valid set of IDEF1X97 models.
Technical Maturity [Aging]: The standard was approved in 1993. Multiple products exist that implement the standard.
Applicability: This standard is the reference authority for use by information modellers required to utilize the IDEF1X modelling technique, implementers in developing tools for implementing this technique, and other computer professionals in understanding the precise syntactic and semantic rules of the standard.
Information on implementation: Multiple commercial tools implement the IDEF1X language. The language is widely used in documenting data standards, such as the JC3IEDM maintained by the Multinational Interoperability Programme.
Limitations of this Standard: Based on relational theory; does not address object modelling.
Standard Type: Software Engineering
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: 15 November 2010

JC3IEDM

Standard Title: Joint Command, Control and Consultation Information Exchange Data Model (JC3IEDM).
Standard Identifier: JC3IEDM
Version Identifier: 3.0.2
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. In continuous development since 1984. Current version released in 14-May -2009.
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.
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: 15 December 2010

KML (Keyhole Markup Language)

Standard Title: Keyhole Markup Language (KML)
Standard Identifier: OGC KML
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: Representation of Natural and Human Made 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: 22 November 2010

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: 15 December 2010

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. Its consistency with the SIMPLE STANAG NATO STANAG 5602, edition 1, Standard Interface for Multiple Platform Link Evaluation (SIMPLE) 20 Feb 2001.
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: 15 December 2010

Lua

Standard Title: Lua
Standard Identifier: Lua
Version Identifier: 5.1.4, released August 22, 2008
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 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 since 1993, and updated regularly. Latest version is 5.1.4, released August 22, 2008
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.
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: 23 November 2010.

MDA

Standard Title: Model-Driven Architecture
Standard Identifier: MDA™
Version Identifier: 1.0.1
SDO: OMG
STANAG identifier: Not applicable
STANAG status: 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.
- Productivity

Technical Maturity [Emerging]: 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: 15 November 2010

MSDL

Standard Title: Military Scenario Definition Language (MSDL).
Standard Identifier: SISO-STD-007-2008.
Version Identifier: Version 1.2 (approved 14 Oct 2008)
SDO: SISO.
STANAG identifier: Not applicable.
STANAG status: Not applicable.
Abstract: The Military Scenario Definition Language (MSDL) is intended to provide a standard 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 to 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) SISO Product Development Group.
Technical Maturity [Current]: MSDL Specification Version .01 is a product of the USA OneSAF development provided the basis for the MSDL current version. MSDL v.01 has been matured through the development of the Close Combat Tactical Trainer Commander's Exercise Initialization Toolkit, the OneSAF Objective System (OOS) and the OneSAF Testbed Baseline (OTB), and currently through the enhancements proposed by the USA MATREX federation, and through MSDL PDG comments to the originally proposed OneSAF MSDL specification.
Additionally, the MSDL PDG established and executed a disciplined review process and associated change request form to affect modifications to MSDL. It is expected that MSDL will continue to evolve and that a disciplined change management process is critical to MSDL's long-term viability.
MSDL 1.2 is an official SISO standard – approved 14 Oct 2008.
Applicability: MSDL provides the M&S community with the ability to create military scenarios that can be shared and reused among a variety of simulations. Furthermore MSDL provides a mechanism for reusing military scenarios between independent simulations and federated simulations.

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

Information on implementation: Mainly used in the OneSAF Program.
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: www.sisostds.org
Input Date: 19 March 2008
Last Updated: 05 November 2010

NAF

Standard Title: NATO Architecture Framework (NAF).
Standard Identifier: As above
Version Identifier: Version v3 (2007).
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/HomePage.asp (follow link to ‘architectures’)
Input Date: 22 September 2008
Last Updated: 22 November 2010

OpenFlight

Standard Title: OpenFlight Scene Description Database Specification ®
Standard Identifier: OpenFlight ®
Version Identifier: 16.4
SDO: None – Owned and controlled by Presagis USA
STANAG identifier: N/A
STANAG status: N/A
Abstract: OpenFlight is a file format for describing 3D scenes and entities. The owner of the format, Presagis, sells software applications for creating and showing 3D scenes, but so do many other vendors because the standard is readily available. OpenFlight is intended for use in real-time systems and supports: multiple levels of detail, sound, animation sequences, bounding volumes for real-time culling, lighting effects, transparency, texture mapping, material properties, and many other features.
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 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: Representation of Natural and Human Made Environment / Imagery and 3D Models
Public Availability: Documentation for the standard is freely available as specified below. Although the documentation is available for free, Presagis sells its OpenFlight Application Program Interface (API). Software developers require Presagis' API, one that they wrote themselves or an equivalent from a third party to incorporate OpenFlight data into their programs. Information on purchasing Presagis' OpenFlight API is available at:
http://www.presagis.com/products_services/standards/openflight/more/introduction_to_openflight_apis/.
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.
Input Date: 29 April 2008
Last Updated: 24 November 2010

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: 17 November 2010

S-57

Standard Title: IHO Transfer Standard for Digital Hydrographic Data
Standard Identifier: Special Publication No. 57
Version Identifier: S-57 Edition 3.1.1 January 2007
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 XIVth International Hydrographic Conference, Monaco, 4-15 May 1992.
Technical Maturity [Current]:

- Edition 3.0 - November 1996
- Edition 3.1 - November 2000
- Edition 3.1.1 - January 2007

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: unknown
Standard Type: Representation of Natural and Human Made Environment: Data Sources and Formats
Public Availability: free
URL or instructions to Access or Acquire: http:/www.iho.shom.fr
Input Date: 04 May 2009
Last Updated: 15 December 2010

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 Standardisation (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: Representation of Natural and Human Made 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: 15 November 2010

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: Representation of Natural and Human Made 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: 23 November 2010

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 basis of users.
Applicability: 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: Not fully/only targeted to simulation interoperability. Was not originally designed to model Link 16 for training, but testing only. 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. 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 NSA web site (requires login access)
URL or instructions to Access or Acquire: http://nsa.nato.int
Input Date: 10 July 2008
Last Updated: 15 November 2010

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 of the Unified Modelling Language (UML) using UML's profile mechanism. SysML reuses a subset of UML 2 and provides additional extensions needed to address the requirements in the UML for SE RFP. SysML also supports allocation tables, a tabular format that can be dynamically derived from SysML allocation relationships.
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 already offer SysML support, or are being updated to comply with the SysML specification.
Applicability Applicable to M&S requirements capturing and conceptual modelling.
Information on implementation No example of implementation known so far.
Limitations of this Standard: Applicable only in the design phase of the systems.
Standard Type Conceptual Modelling
Public Availability: The OMG SysML™ v1.2 was issued as a "Formal Specification" in June 2010. The specification documents and schema files can be found at the following website **http://www.omg.org/spec/sysml/1.2/.** SysML was originally developed by an open source specification project, and includes an open source license for distribution and use.
URL or instructions to Access or Acquire: http://www.omgsysml.org/
Input Date: 28 July 2008
Last Updated: 23 November 2010

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: 15 November 2010

UML

Standard Title: Unified Modeling Language™ - UML
Standard Identifier: UML
Version Identifier: Version 2.3 (May 2010)
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 2.3 (May 2010).
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: 10 December 2010

V&V Information Exchange

Standard Title: General Procedure for Modelling and Simulation Verification & Validation Information Exchange.
Standard Identifier: ITOP 1-1-002
Version Identifier: 1-1-002
SDO: International Test Operations Procedures (ITOP).
STANAG identifier: no STANAG.
STANAG status: N/A
Abstract: This ITOP document describes general procedures for verification and validation (V&V) of Models and Simulations (M&S). It provides a standardised methodology to support the exchange of V&V information among the ratifying nations. It comprises procedures and guidance for planning, implementing, and documenting V&V efforts of M&S. It has influenced the work of the REVVA Consortium.
Technical Maturity [Aging]: The current version exists since 2004. This ITOP group has been disbanded in 2006.
Applicability: Used as part of contracts for the development and procurement of defence technology in T&E.
Information on implementation: This standard has been used in programs and products within four individual Nations. More information can be found on the ITOP website: https://itops.dtc.army.mil /MA63.html
Limitations of this Standard: Restricted to Four-Nation MoU.
Standard Type: Verification & Validation (V&V).
Public Availability Restricted to Four-Nation MoU
URL or instructions to Access or Acquire: https://itops.dtc.army.mil/MA63.html (access is restricted)
Input Date: 20 March 2008.
Last Updated: 15 December 2010

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: Representation of Natural and Human Made Environment: Data Sources and Formats
Public Availability: Yes
URL or instructions to Access or Acquire: N/A
Input Date: 28 August 2008
Last Updated: 17 November 2010

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 yet available (could be either a new AP or a part of a new version of STANAG 4603 (HLA)).
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). 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 FEDEP. Users, developers and VV&A personnel working with simulations and simulation compositions not based upon the HLA and the FEDEP 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.
URL or instructions to Access or Acquire: www.ieee.org
Input Date: 19 March 2008.
Last Updated: 23 November 2010.

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 Build 3.0
Version Identifier: RPG Build 3.0, September 2006
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 [Emerging]: 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: 15 November 2010

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: 15 November 2010

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: Representation of Natural and Human Made 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: 15 November 2010

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: 15 November 2010

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/TR/xml11/#sec-xml11
Input Date: 20 March 2008
Last Updated: 10 December 2010

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
CeAG	Certification Advisory Group (on HLA)
CMSD	Core Manufacturing Simulation Data
CNAD	Conference of National Armaments Directors (NATO)
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off-The-Shelf
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)
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

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

IDEF0 Integration Definition for Function Modelling

IDEF1X 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 Organisation for Standardisation

IT Information Technology

ITOP International Test Operations Procedures

J

JC3IEDM Joint Consultation, Command and Control Information Exchange Data Model

JTC Joint Technical Committee

L

LVC AR	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
NCS	NATO Committee for Standardisation
NIST	National Institute of Standards and Technology (USA)
NSA	NATO Standardisation Agency
NSO	NATO Standardisation Organisation

O

OMG	Object Management Group
OWL	Web Ontology Language

P

PDU	Protocol Data Unit (DIS)

PfP	Partnership for Peace (NATO)
POC	Point of Contact

R

REVVA	Reference for VV&A
RPG	Recommended Practice Guide
RPR FOM	Realtime Platform Reference (RPR) FOM
RTA	Research and Technology Agency
RTI	Run Time Infrastructure (HLA)
RTO	Research and Technology Organisation (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	Standardisation Agreement (NATO)
STF	SEDRIS Transmittal Format
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 GLOSSARY

A

accreditation. The Official Certification that a model or simulation or Federation is acceptable for use in relation to a specific purpose (e.g.: the decision-maker has stated, with a "seal of Approval", that the model is suitable for its purpose or use).

accreditation agent. The organization designated by the accreditation sponsor to conduct an accreditation assessment for a M&S application

acceptance. The decision to use a simulation for a specific purpose while the term accreditation is the official certification that a model or simulation is acceptable for use for a specific purpose.

accuracy. The degree of exactness of a model or simulation, high accuracy implying low error. Accuracy equates to the quality of a result, and is distinguished from precision, which relates to the quality of the operation by which the result is obtained and can be repeated.

aggregation. The ability to group entities while preserving the effects of entity behaviour and interaction while grouped. domains to interact at the combat object and event level.

algorithm. A prescribed set of well-defined, unambiguous rules or processes for the solution of a problem in a finite number of steps.

Application Programmer’s Interface (API). A library of function calls that allows a federate to interact with a software application.

architecture. The structure of components in a programme/system, their interrelationships and the principles and guidelines governing their design and evolution over time.

C

Command and Control Communication System (C3I). A communication system which conveys information between military authorities for command and control purposes.

Command Post Exercise (CPX). An exercise in which the forces are simulated, involving the commander, his staff, and communications within and between headquarters.

Computer Assisted Exercise (CAX). Contained within the SYNEX grouping is the Computer Assisted Exercise (CAX) which is a CPX where computers simulate the operational environment and provide event resolution that may be used in a distributed or non-diStributed form or a combination of both.

Computer-Generated Forces (CGF). A generic term used to refer to computer representations of forces in simulations that attempt to model human behaviour sufficiently so that the forces will take some actions automatically (without requiring man-in-the-loop interaction). CGFs are also referred to as Semi-automated Forces (SAF).

computer network. A network of data processing nodes that are interconnected for the purpose of data communication.

conceptual model. A statement of the content and internal representations that are the user's and developer's combined concept of the model. It includes logic and algorithms and explicitly recognises assumptions and limitations.

configuration management. The application of technical and administrative direction and surveillance to identify and document the functional and physical characteristics of a model or simulation, to control changes and to record and report change processing and implementation status.

constructive model or simulation. Models and simulations that involve simulated people operating simulated systems. Real people stimulate (make inputs) to such simulations but are not involved in determining the outcomes.

D

data. The properties of an entity expressed in discrete parametric values describing its attributes.

disaggregation. The ability to represent the behaviour of an aggregated unit in terms of its component entities. If the aggregate representation did not maintain state representations of the individual entities, then the decomposition into the entities can only be notional.

distributed exercise. An exercise where the training audience can be at different locations, i.e., different cities, countries or continents due to operational, technical or financial reasons. A distributed exercise can be supported by distributed or centralized models and simulations.

Distributed Interactive Simulation (DIS). (1) A government/industry initiative to define an infrastructure for linking simulations of various types at multiple locations to create a realistic, complex, virtual environment for the simulation of interactive activities. This infrastructure brings together platforms from different military services and systems built by various vendors using different technologies for different purposes and permits them to interoperate. (2) A time and space coherent synthetic representation of world environments designed for linking the interactive, free play activities of people in operational exercises. The synthetic environment is created through real-time exchange of protocol data units between distributed, computationally autonomous simulation applications in the form of simulations, simulators and instrumented equipment interconnected through standard interfaces.

distributed simulation. A simulation that has multiple modules, which can be run on multiple processors. The processors can co-located in the same room or located in remote sites.

E

entity. A distinguishable person, place, unit, thing, event, or concept about which information is kept.

environment. (1) The texture or detail of the domain, that is terrain relief, weather, day, night, terrain cultural features (such as cities or farmland, sea states, etc.); (2) the external objects, conditions and processes that influence the behaviour of a system (such as terrain relief, weather, day/night, terrain cultural features, etc.).

environmental representation. A representation of all or part of the natural or man-made environment, including permanent or semi-permanent man-made features.

events. Events are major occurrences or a sequence of related incidents which are actions or situations that provide greater clarity to an event.

exercise. A military manoeuvre or simulated wartime operation involving planning, preparation, and execution. It is carried out for the purpose of training and evaluation. It may be a combined, joint, or single service exercise, depending on participating organizations.

F

federate. A member of a simulation federation. All applications participating in a federation are called federates. In reality, these applications may include simulations, federate managers, data collectors, live systems, or passive viewers.

federation. A set of interacting simulations, real-world ("live") systems (e.g., Communication and Information Systems (CIS), weapon system hardware, instrumented ranges) and utilities (e.g., federation managers, data collectors, passive viewers), collectively termed "federates," which together provide users with a simulated system in which they can accomplish their objective. This term (and also the Federate term) were made popular by the HLA standard but they are now in larger use in the distributed simulation community.

Federation Object Model (FOM). An identification of the essential classes of objects, object attributes and object interactions that are supported by an HLA federation. In addition, optional classes of additional information may also be specified to achieve a more complete description of the federation structure and/or behaviour.

fidelity. The accuracy of the representation when compared to the real world.

H

highly aggregated model. Highly aggregated simulations are aggregate level simulations where collections of military assets, i.e., units, are the primary objects represented. They are designed for the higher military echelons such as corps level. They typically use lower resolution terrain data but they can simulate in very large areas as large as continents.

high resolution model. High resolution simulations are entity level simulations where singular military objects, e.g. a soldier, a tank, an aircraft, are the primary objects represented. They are typically designed for the lower military echelons such as platoon, company and battalion. They can also be used for operational level exercises. In high resolution models the resolution of terrain data is higher than high resolution models, i.e., sometimes up to the plans of individual buildings.

High Level Architecture (HLA). The High Level Architecture is composed of three parts: the HLA Rules, the HLA Interface Specification, and the Object Model Template (OMT). The HLA Rules describe the general principles defining the HLA, and delineate ten basic rules that apply to HLA federations and federates. The HLA Interface Specification defines the functional interface between federates and the Runtime Infrastructure (RTI). The Object Model Template Specification provides a specification for documenting key information about simulations and federations. Use of the OMT to describe Simulation and Federation Object Models (SOMs and FOMs) is a key part of the HLA. Major functional elements, interfaces, and design rules, pertaining as feasible to all DoD simulation applications, and providing a common framework within which specific system architectures can be defined.

Human-in-the-Loop (HITL). See interactive model.

I

Interactive Model or Simulation. A model or a simulation that requires human participation. Synonym: human-in-the-loop.

interoperability (as applied to M&S). The ability of a model or simulation to provide services to, and accept services from, other models and simulations and to use the services so exchanged to enable them to operate effectively together. (This definition is a slight change from the special case definition in NATO Publication AAP-6.)

L

live simulation. See Live, Virtual and Constructive Simulation.

live, virtual and constructive simulation. The categorisation of simulations into live, virtual and constructive is problematic because there is no clear division between these categories. The degree of human participation in the simulation is infinitely variable, as is the degree of equipment realism. This categorisation also suffers by excluding a category for simulated people working real equipment (e.g., robotics).

a. ***live simulation:*** a simulation involving real people operating real systems;

b. ***virtual simulation:*** a simulation involving real people operating simulated systems. Virtual simulations inject human-in-the-loop (HITL) in a central role by exercising motor control skills (e.g., flying an airplane), decision skills (e.g., committing fire control resources to action), or communication skills (e.g., as members of a CIS team);

c. ***constructive model or simulation:*** models and simulations that involve simulated people operating simulated systems. Real people stimulate (make inputs) to such simulations but are not involved in determining the outcomes.

live exercise. An exercise where troops are deployed to a field.

M

M&S reuse. The use of M&S resources, (e.g., models, simulations, databases, algorithms, tools) for purposes beyond those for which they were originally developed. Reuse can occur within an organization or in different organizations, or in different application areas.

Model. A representation of a system, entity, phenomenon, or process. Software models of specific entities are comprised of algorithms and data. A physical, mathematical, or otherwise logical representation of a syStem, entity, phenomenon, or process.

Multi-Resolution Modelling (MRM). Represents aspects of the real world at more than one level of detail.

N

Network. An arrangement of nodes and interconnecting branches.

O

Object Model. A specification of the objects intrinsic to a given system, including a description of the object **characteristics** (attributes) and behaviours. Include descriptions of the static and dynamic relationships that exist between objects.

Open System. A system in which the components and their composition are specified in a non-proprietary environment, enabling competing organizations to use these standard components to build competitive systems. There are three perspectives on open systems:

a. ***portability*** -- the degree to which a system component can be used in various environments;

b. ***interoperability*** -- the ability of individual components to exchange information; and

c. ***integration*** -- the consistency of the various human-machine interfaces between an individual and all hardware and software in the system.

P

physical architecture. The identification and arrangement of the physical components of a system architecture into an orderly framework that describes the physical structure, the technical functions, design features and technical attributes that can be achieved by each component and by the system within specified constraints.

R

real-time. In real-time modelling and simulation, simulated time advances at the same rate as actual time; for example, running the simulation for one second results in the model advancing time by one second. Contrast with: fast time; slow time.

real-world. The set of real or hypothetical causes and effects that simulation technology attempts to replicate. When used in a military context, the term is synonymous with real battlefield to include air, land and sea combat.

representation. The portrayal of an entity or process provided by a model, simulation, or federation.

representational resource. Knowledge about the real world (raw materials) used to develop a model, simulation, or federation. Representational resources fall into one of three categories:

a. ***Functional Description of the Mission Space (FDMS*****).** An operator's view of the entities, actions, relationships, interactions and environmental factors associated with a mission. Mission spaces may include any aspect of the real world, to include military operations, medical treatment, manufacturing, electrical power distribution, etc.

b. ***Characteristics and Performance Descriptions (C&PD).*** An expert's identification of the entity's nature, which are comprised of (1) attribute definitions, (2) algorithms and (3) data limits.

c. ***Scenario-specific Data.*** The particular information used by a given model, simulation or federation execution so that it may provide its representations in the context of a set of real-world circumstances. Scenario-specific data include terrain databases, order of battle, weather, plans and other state data.

resolution. The level of detail of a model or simulation. The degree of detail and precision used in the representation of real world aspects in a model or simulation.

Runtime Infrastructure (RTI). The general purpose distributed middleware that provides the common interface services during the runtime of an HLA federation.

S

scalability. The ability of a distributed simulation to maintain time and spatial consistency as the number of entities and accompanying interactions increase.

scenario. (1) Description of an exercise ("initial conditions" in military terms). It is part of the session database that configures the units and platforms and places them in specific locations with specific missions. (2) An initial set of conditions and time line of significant events imposed on trainees or systems to achieve exercise objectives.

Semi-Automated Forces (SAF). See Computer-Generated Forces.

simulation. The execution over time of models representing the attributes of one or more entities or processes. Human-in-the-Loop simulations, also known as simulators, are a special class of simulations. A method for implementing a model over time.

simulation centre. National facility which designs, develops and integrates all live, virtual, and constructive synthetic environments to support Concepts Development and Experimentation, Training, Exercises and Mission Rehearsal, and Research, Development and Acquisition.

Simulated Mission Space (SMS). A general term that describes the synthetic depiction of the real (or projected) world provided by a model, simulation, or federation.

Simulation Object Model (SOM). A specification of the intrinsic capabilities that an individual simulation offers to federations. The standard format in which SOMs are expressed provides a means for federation developers to determine quickly the suitability of simulation systems to assume specific roles within a federation.

system architecture**.** The logical structure and operating principles of a system.

V

validation. The process of determining the degree to which a model or simulation is an accurate representation of the real-world from the perspective of the intended uses of the model or simulation.

verification. The process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification. Verification also evaluates the extent to which the model or simulation has been developed using sound and established software engineering techniques.

Verification, Validation & Certification (VV&C). The process of verifying the internal consistency and correctness of data, validating that it represents real world entities appropriate for its intended purpose or an expected range of purposes, and certifying it as having a specified level of quality or as being appropriate for a specified use, type of use, or range of uses. The process has two perspectives: producer and user process.

virtual simulation. A simulation involving real people operating simulated systems. Virtual simulations inject human-in-the-loop (HITL) in a central role by exercising motor control skills (e.g., flying an airplane), decision skills (e.g., committing fire control resources to action), or communication skills (e.g., as members of a CIS team).

ANNEX F STANDARDS DEVELOPING ORGANISATIONS OF INTEREST TO M&S

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 NSA. 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.

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/.

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.

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.

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.

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..

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).

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

The North Atlantic Treaty Organisation (NATO). The standardisation activity in NATO is complex and covers multiple domains. As stated in the paragraph 1.5., the NATO RTO's NMSG is the Delegated Tasking Authority in NATO M&S standardisation domain. Dedicated NMSG Task Groups were established with the aim to develop NATO standardisation 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 Standardisation Policy, NMSG will be 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 cover STANAG. More details on the standardisation process in NATO are available in the paragraph 1.5.