SEVENTH FRAMEWORK PROGRAMME

DANSE

Designing for adaptability and evolution in system of systems engineering

Report on DANSE relation to existing world standards and practices

D_4.5

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1 Introduction

1.1 Overview, Purpose and Scope

Several DANSE partners are actively contributing to standardisation bodies, which are relevant to promote important innovations developed in the course of the project. These innovations include systems engineering methodologies, languages, and tool interfaces.

This report summarizes the work done in the area of standardisation, as required by the DANSE DOW (Task T4.5):

- Review existing relevant standards;
- Participate in the international forums that promote standards for systems engineering, to promote DANSE results in the future versions of their standards.

1.2 Contents

The report is organized as follows:

- Chapter 2 is the review of existing standards;
- Chapter 3 is a summary of promotion actions done;
- Chapter 4 highlights the strategy for next steps (as standardisation is a long process, some actions have to continue beyond the project contractual end date);
- Chapter 6 provides technical details on specific DANSE contributions to standards.

2 Review of existing world standards

Most standards reviewed below were identified in the DOW as relevant to DANSE, and this has been confirmed. In addition, the FMI standard has been identified as fully relevant for the simulation framework, and has been added to this review.

2.1 SysML

2.1.1 The standard

The Systems Modelling Language (SysML) is a general-purpose, graphic, semi-formal language for systems engineering. It aims at supporting the specification, analysis, design, verification and validation of a broad range of systems, including systems-of-systems.

SysML was originally developed as an initiative of the systems engineering community in 2001. It was later defined as an extension of a subset of the Unified Modelling Language (UML) using UML's profile mechanism.

The Unified Modelling Language (UML) is a general-purpose graphic, semi-formal language designed to provide a standard way to visualize the design of a software system. It was created and developed by Grady Booch, Ivar Jacobson and James Rumbaugh at Rational Software in the mid 90's, and strongly influenced by the "object-oriented" software engineering approaches developed in the 80's.

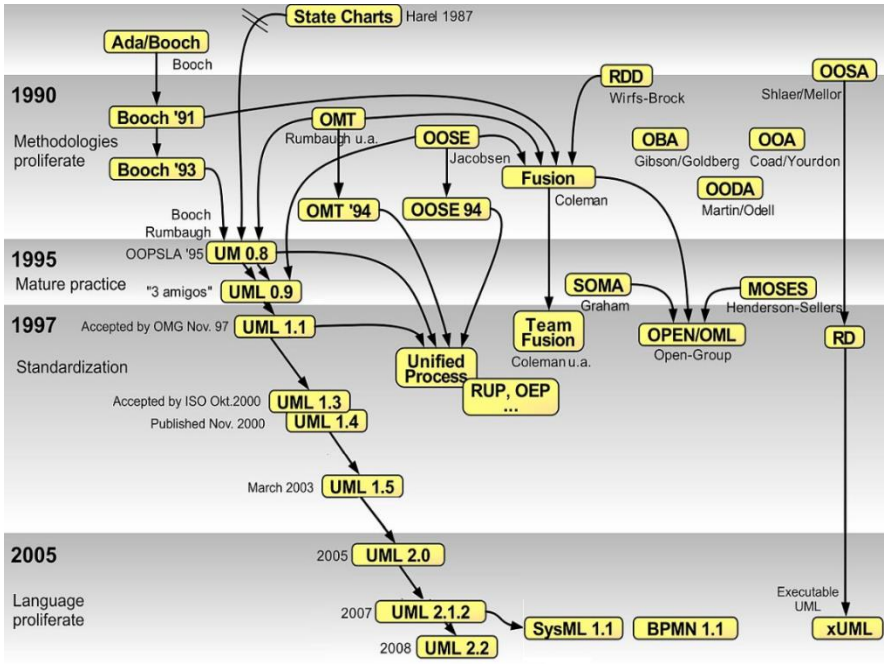

Figure 2-1: UML Genealogy (Wikipedia UML, 2014)

As suggested in Figure 2-1 above, the UML genealogy is complex, and UML has been evolving along time. This had an impact on the definition of SysML, but a full discussion would exceed the scope of this report.

The interested reader could refer to (Wikipedia UML, 2014), which provides complementary information on the history of UML.

Though SysML was at the very beginning developed as an independent graphical modelling language, it was adopted as a standard by the Object Management Group (OMG) in 1997 and has been managed by this organization ever since. It has been periodically revised to keep in pace with the evolution of UML.

The relationship of SysML with UML makes it easy to understand by the software engineering community who is familiar with UML, but also brings some complexity seen from a system engineering perspective, both for technical and fundamental reasons. Among the fundamental reasons, is the “object oriented” concept of UML, which is natural for some software application domains (e.g., information systems) but not obviously useful for systems engineering. Conversely, some key concepts in system engineering (e.g., representation of continuous time) are missing in SysML. This reality is partially captured by the usual introduction to SysML, depicted by the figures below.

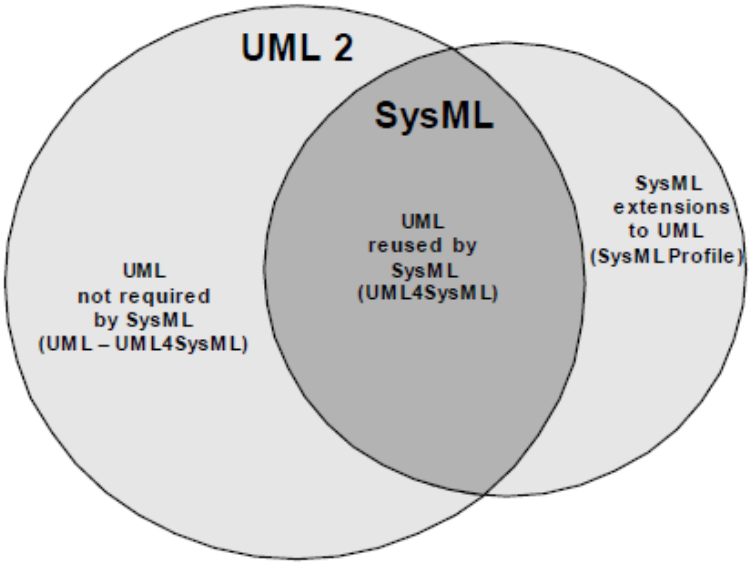

Figure 2-2: SysML as an extension of a subset of UML (OMG SysML, 2012)

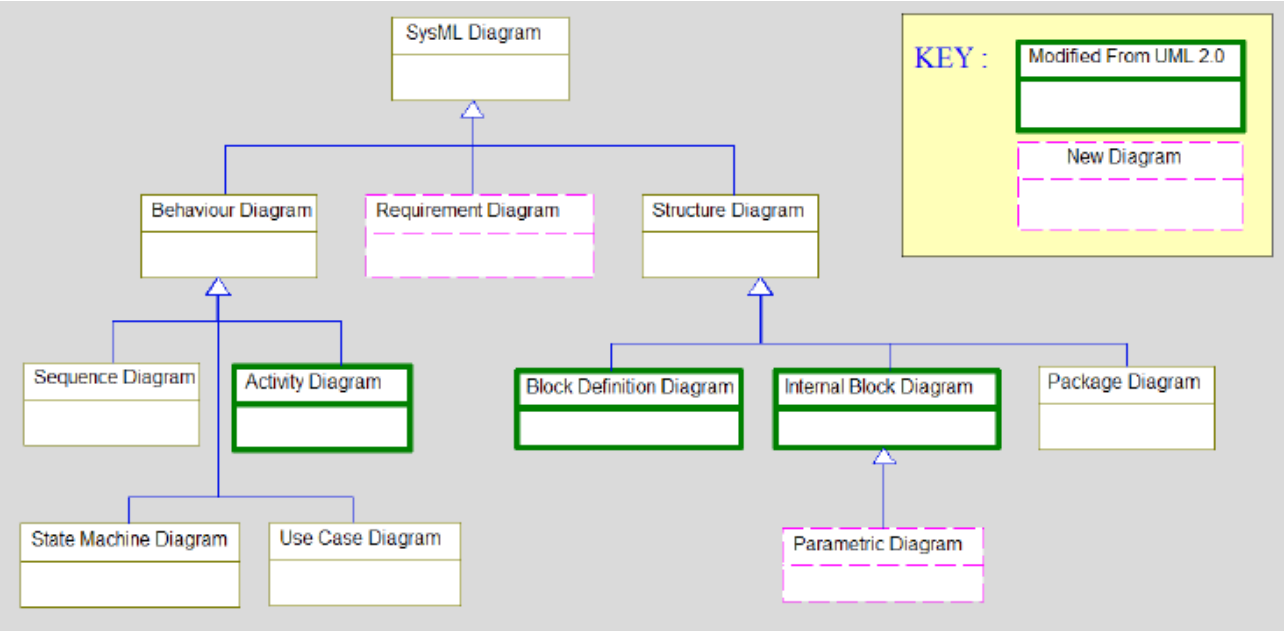

Figure 2-3: SysML diagrams

2.1.2 The organization(s)

The Object Management Group (OMG, 2014) is the maintainer of the SysML standard. Created in 1989 to promote a distributed object software standard (CORBA) OMG has extended its scope to a range of "modelling" (not necessarily "object") oriented standards. Beyond the core software community, OMG hosts different "Special Interest Groups", enabling links with other communities, for beyond the initial core business of the organization. Among DANSE partners, IBM and Thales are members of the board of directors of OMG. Other partners including EADS, INRIA, OFFIS are actively participating.

INCOSE (International Council on Systems Engineering) initiated in the early 90's has been and remains the active community for the definition and evolution of SysML. Among DANSE partners, IBM and EADS are members of the board of directors of INCOSE. Other partners including Honourcode, Thales, IAI, INRIA, OFFIS are actively participating. The MBSE4OSLC WG of OMG has been established to foster OSLC compliance with architecture modelling beyond the very limited OSLC-AM standard, based on SysML. IBM is a member of this WC. A proposal to also define a formal OWL ontology for SysML has been made by IBM and has been positively accepted. The rational for that has been the value this has for semantic mediation to facilitate interoperability among SysML-based tools.

2.1.3 Relevance to DANSE

From a strategic and technical perspective, SysML is fully relevant to DANSE, since the initial objectives of INCOSE, then supported by OMG, were to promote Model-Based Systems Engineering (MBSE), including Systems of Systems.

MBSE is defined by INCOSE as "the formalized application of modelling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and

continuing throughout development and later life cycle phases. MBSE is part of a long-term trend toward model-centric approaches adopted by other engineering disciplines, including mechanical, electrical and software. In particular, MBSE is expected to replace the document-centric approach that has been practiced by systems engineers in the past and to influence the future practice of systems engineering by being fully integrated into the definition of systems engineering processes."

From a business perspective, SysML is also relevant to DANSE. However, it should be recalled that industrial deployment of SysML for system architecting has probably not yet reached the same level as, for example, UML for software architecting.

The development of a formal OWL ontology for SysML is an essential enabler of interoperability among SysML-based tools as demonstrated in the DANSE tools-net use cases.

2.2 Architecture Frameworks

2.2.1 The standard(s)

The DoDAF (DoDAF, 2011), MoDAF (Wikipedia MoDAF, 2014) and NAF (NAF, 2007) standards are the architecture frameworks defined respectively by the US Department of Defence, the UK Ministry of Defence, and NATO. The motivations are the same, namely the combination of different views, from different stakeholders (including customer and users) in the definition of the architectures of large systems, with complex integration and interoperability challenges.

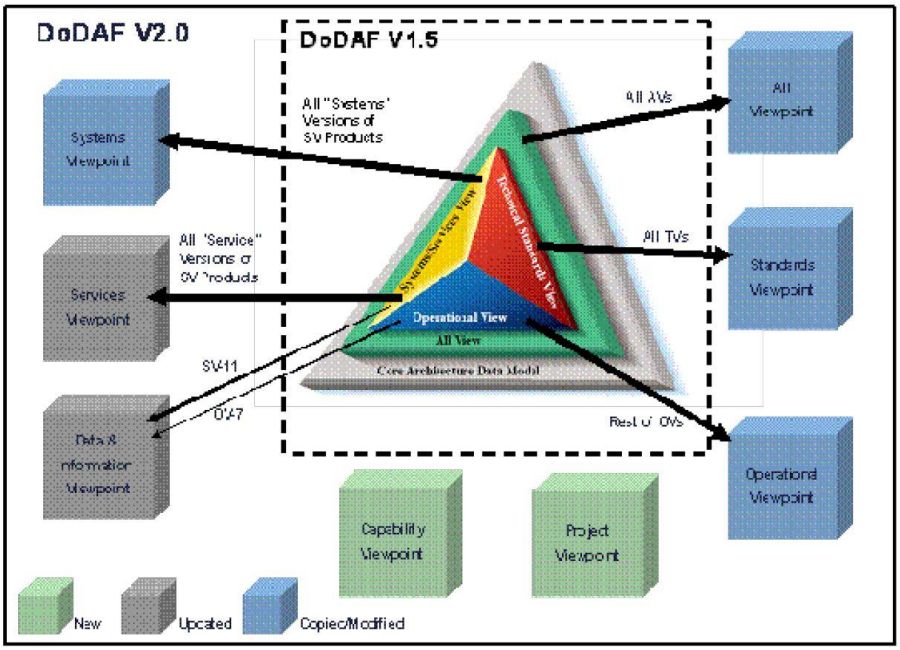

Figure 2-4: DoDAF overview (Wikipedia DoDAF, 2014)

These standards are evolving. The initial thoughts on DoDAF were published in the 1990s. As shown in Figure 2-4 above, some major changes are still occurring (DoDAF V1.5 was published in 2007, while V2.0 was published in 2009).

2.2.2 The organization(s)

There is no single standardisation authority on architecture frameworks:

- DoDAF authority is US DoD;
- MODAF authority is UK MOD.

NATO, which is the authority defining the NAF standard, is mainly in a position of “follower” of US/UK and commonwealth initiatives.

IDEAS (International Defence Enterprise Architecture Specification for exchange) has been an important actor for the convergence of these closely related national standards. IDEAS was set up in 2005 as an initiative of the Australian, Canadian, UK & US defence departments (NATO is involved as an observer). A

major objective is to allow different countries from the same coalition to exchange data about their respective systems.

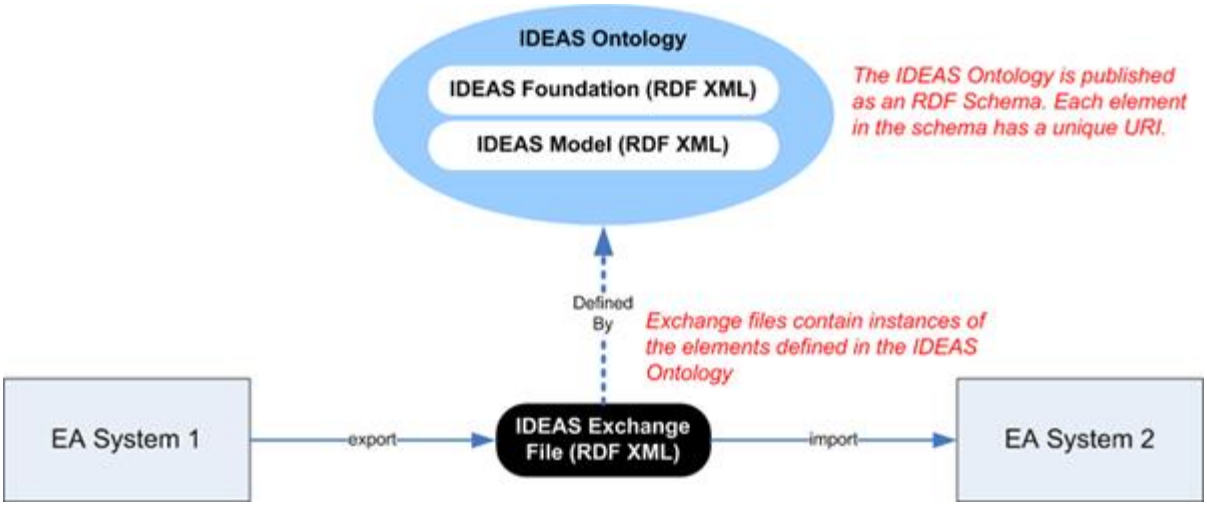

Figure 2-5: IDEAS Ontology based interoperability

Ontologies (see Figure 2-5 above), and a methodology called BORO (a structured approach to define ontologies) are at the core of the solutions promoted by IDEAS. A tangible result is the definition by the IDEAS group of the DM2 (the DoDAF Meta Model).

IDEAS is a network of experts, supporting the US DoD and providing quite valuable technical contribution, but not a standardisation authority.

In practical terms, US DoD is the de facto authority on Architecture Frameworks in the defence domain; Europe being in a “follower” position.

The Open Group aims at having a similar role in the information systems domain through the TOGAF standard (The Open Group Architecture Framework).

The specification of architecture frameworks is in the scope of ISO (ISO/IEC/IEEE 42010:2011, Systems and software engineering — Architecture description). IEEE Std 1471:2000, Recommended Practice for Architectural Description of Software-intensive Systems addresses the same type of needs as DoDAF, but at a more theoretical and “meta” level. For example, it defines requirements on the contents of architecture descriptions, definitions on architecture frameworks and architecture description languages – but does not propose a particular architecture framework or architecture description language. ISO hosts a working group on architecture frameworks (WG42). This working group has recently published a long list of “examples of architecture frameworks”, including of course DoDAF, MODAF, NAF, ESAAAF (i.e. ESA Architecture Framework), TOGAF, and many more. The next steps could be an assessment of the level of compliance of these various architecture frameworks, and a selection of a subset for convergence. However it does not seem that ISO/IEEE is moving in this direction.

Among DANSE partners:

- Thales is involved in ISO/IEEE WG42 and NAF,
- EADS has been participating to IDEAS,

- IBM is one of the 5 platinum members of The Open Group.

2.2.3 Relevance to DANSE

Most standards and organizations reviewed in this section are to some extent relevant to DANSE.

DoDAF is fully relevant since its scope includes the very complex, evolutionary systems that are familiar to the defence industry and defence customers. Though such huge systems remain a niche market for system engineering tools, the level of technical ambition and the strategic nature of such systems is calling for technical innovation.

TOGAF, and to some extent the IEEE/ISO recommendations, are relevant; although their scope appears more limited (i.e., information systems rather than complex heterogeneous systems), in practice the information systems, distributed throughout complex heterogeneous physical systems, play a key role in operation and evolution of any type of complex systems.

2.3 UPDM

2.3.1 The standard

The Unified Profile for DoDAF/MODAF (OMG UPDM, 2013) is a standard of the Object Management Group initiative to support both the USA Department of Defense Architecture Framework (DoDAF) and the UK Ministry of Defence Architecture Framework (MODAF). The latest release, version 2.1, published in 2013, is based on UML 2.0 (OMG UML, 2011), and is aligned with DoDAF v2.02 (DoDAF, 2011).

It basically includes a translation of the DoDAF v2.02 meta-model as an UML profile – hence reusing/extending UML and/or SysML concepts. There are actually two levels of possible conformance defined for UPDM implementations. Level 0 is based on UML2, and partial import of stereotypes from the SoaML profile. Level 1 is based on UML2, and full SysML (with all its sub-profiles). These two levels are depicted by the Figure 2-6 below.

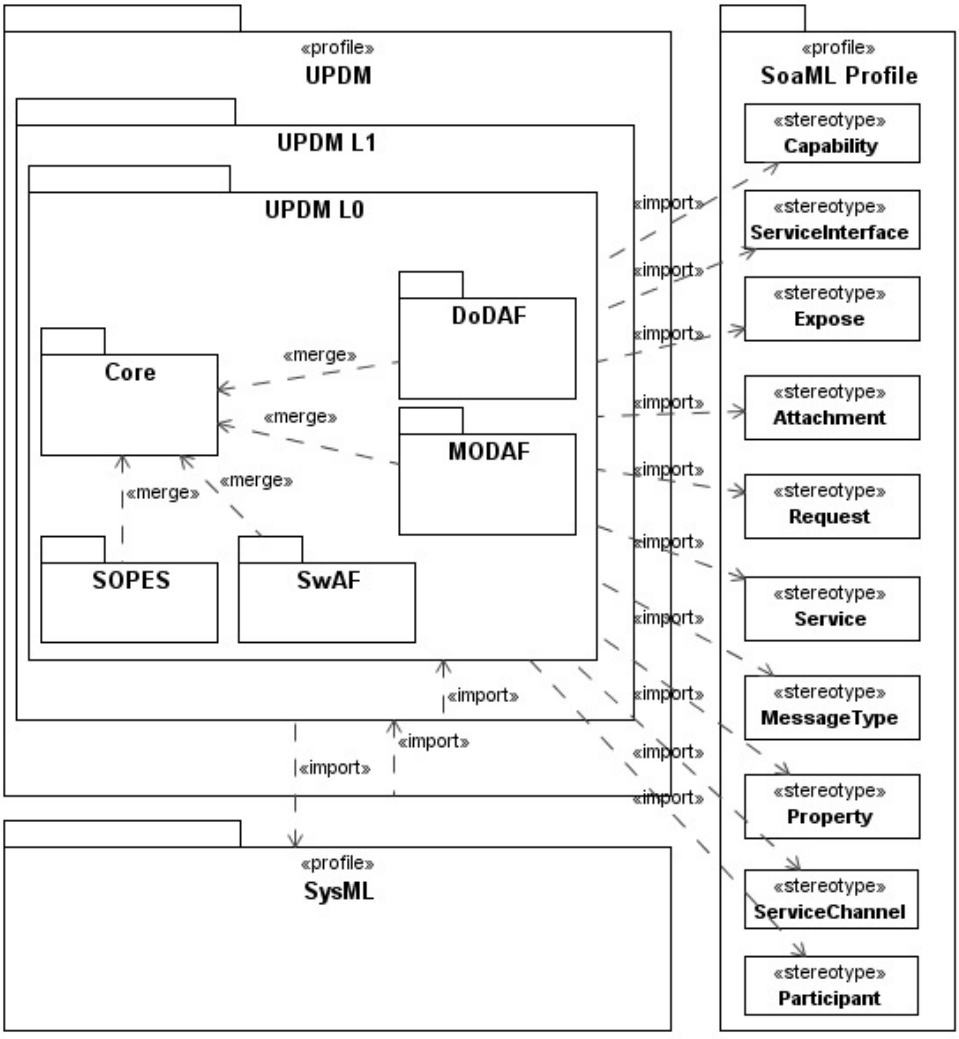

Figure 2-6: UPDM Compliance Levels (OMG UPDM, 2013)

2.3.2 The organization(s)

Please refer to §2.1.2 for a description of the Object Management Group.

The US DoD and UK MoD communities have pushed the UPDM standardisation initiative through the OMG. A strong motivation was to establish a link with commercial standards and commercial tool vendors, to extend the applicability of DoDAF/MoDAF through tool support. The goal was not to create a new architecture framework or a new methodology, but primarily to ensure tool vendors involvement.

In addition to government and defence industry companies, UML/SysML major tool vendors such as Atego, Nomagic are involved in the UPDM group at the OMG.

Among DANSE partners, Thales and IBM are active participants to this group.

2.3.3 Relevance to DANSE

UPDM is fully relevant to DANSE from different viewpoints: first as a “single point of contact” with the complex ecosystem of Architecture Frameworks (see §2.2); second, as it addresses the pragmatic objective of ensuring tool support.

The price to pay is:

- on one hand the added technical complexity of articulating UPDM with basic OMG standards UML and SysML (hence the different compliance levels L1/L2, aimed at a lowering the initial step for adoption by tool vendors);
- on the other hand, the introduction of a lead time between evolution of DoDAF standard and availability of tool support. For example, the latest UPDM 2.1 is compatible with DoDAF 2.0, but some commercial tools are at the moment only supporting UPDM 1.1, which is based on DoDAF v1.5.

Fortunately, IBM Rhapsody, used in DANSE, provides support for UPDM 2.1 at L2 (i.e., including SysML and all its sub-profiles).

2.4 MARTE

2.4.1 The standard

MARTE (OMG MARTE, 2011) is a UML profile introduced to complement UML in order to make it suitable for the design and analysis of Real-Time Embedded systems. Along its evolutions, UML itself, initially designed to answer the needs of non-real-time information systems, has been improved in terms of support of dynamic and parallel behaviour; for example, improved sequence diagrams, activity diagrams based on Petri nets, timing diagrams showing interactions between objects and their change in states have been introduced in UML 2.0. However, this was not enough: some core concepts regarding the execution semantics had to be clarified, and also a support for linking UML tools with pre-existing tools (e.g., performance analysis, schedulability analysis, electronic design automation tools) were missing.

The first version (MARTE 1.0) was published in 2009. An improved version (MARTE 1.1) was published in 2011. The MARTE revision task force is working towards version 1.2.

MARTE standard structure reflects the various motivations of the initial group of promoters, which included academics, industrial end users, and tool vendors. It is a 754 pages document (while the whole SysML standard is 260 pages). Fortunately, not all components of the standard are relevant for specific usages. As suggested in Figure 2-7, the scope of usages is quite wide. Even model designers, depending on application domain, may use only a different subset of the whole MARTE standard.

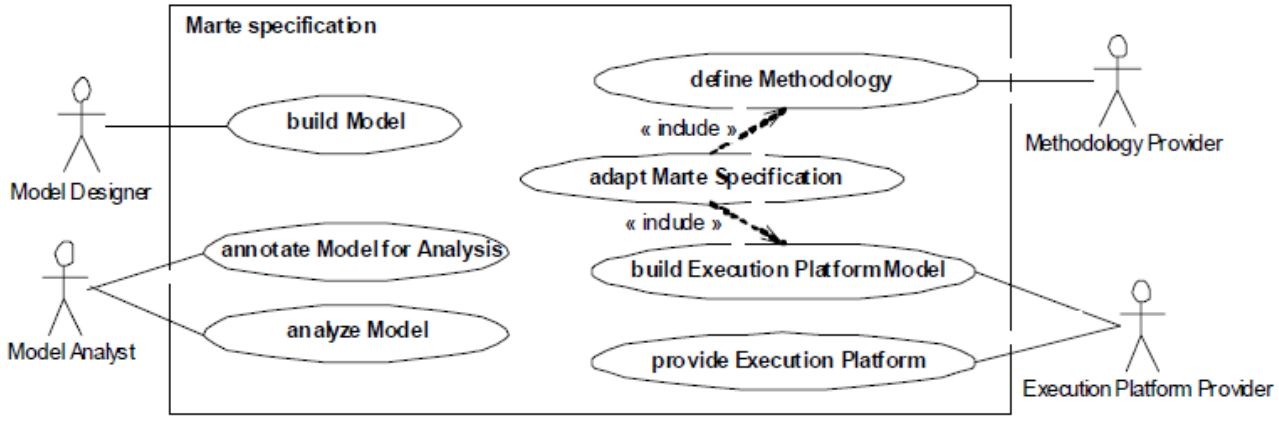

Figure 2-7: MARTE typical use cases (OMG MARTE, 2011)

The structure of the MARTE standard is given in Figure 2-8. It shows that:

- the MARTE foundations package is composed of five packages: Core Elements, Non Functional Properties (NFP), Time, Generic Resource Modelling (GRM), and Allocation;
- the MARTE design model package is composed of four packages: Generic Component Model (GCM), High-Level Application Modelling (HLAM), Software Resource Modelling (SRM), and Hardware Resource Modelling (HRM);

- the MARTE analysis model package is composed of three packages: Generic Quantitative Analysis Modelling (GQAM), Schedulability Analysis Modelling (SAM), and Performance Analysis Modelling (PAM);
- the MARTE annexes package is composed of three packages: Value Specification Language (VSL), Repetitive Structure Modelling (RSM) and the MARTE Library.

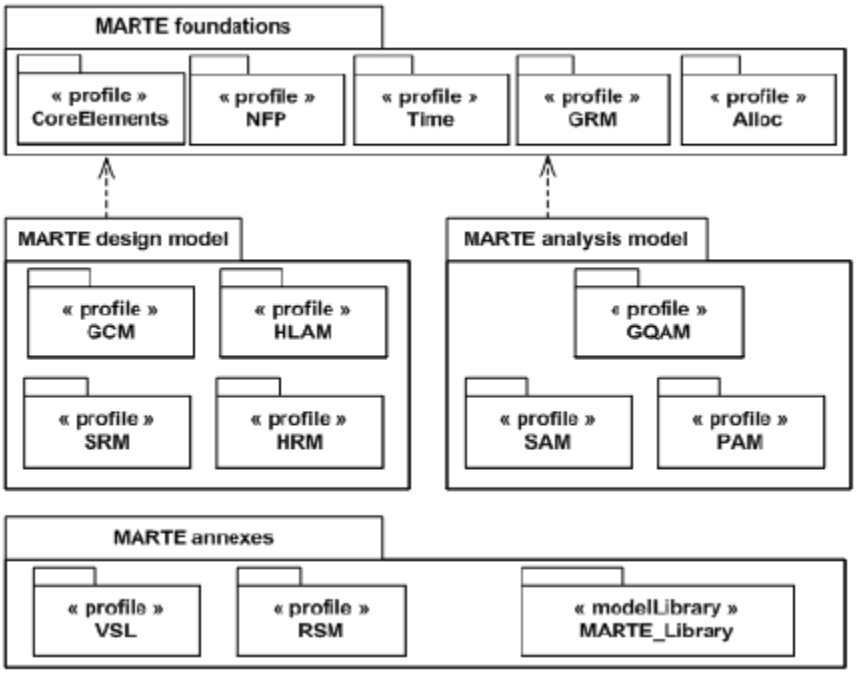

Figure 2-8: MARTE architecture

2.4.2 The organization(s)

Please refer to §2.1.2 for a description of the Object Management Group.

The Object Management Group (OMG, 2014) is the maintainer of the MARTE standard. Within OMG, the embedded real-time systems community has been pushing the creation of the MARTE standard (while the system engineering community was promoting SysML).

Among DANSE partners, INRIA and Thales have been part of the initial MARTE promoters at the OMG. Thales is co-chairing the MARTE standard revision task force. IBM is an active participant to this task force, in addition to a strong involvement at the OMG in general, and as a provider of reference implementations of MARTE.

2.4.3 Relevance to DANSE

Within this wide MARTE standard, the following components of MARTE foundations are fully relevant to DANSE:

- NFP (Non Functional Properties) and the associated concrete syntax (VSL – Value Specification Language) aim at the expression of “guaranteed” and “required” properties, attached as annotations in

design models. This is in line with DANSE GSCL (Goals and Contracts Specification Language) as the NFP expressions could be a subset of GCSL statements.

- The Time model is also of major interest, since it bridges a mathematical model of time with UML concepts and concrete syntax. The mathematical model covers both logical time and the usual physical time, allows the use of multiple scales of time, and supports partial ordering of events as well as the usual total ordering.
- The RSM (Repetitive Structure Modelling) is possibly of interest, as it could allow simplifying the representation of repetitive structures, typically in concise profile or design patterns.

2.5 OSLC

2.5.1 The standard

Open Service for Lifecycle Collaboration (OSLC) is originally an initiative from IBM, to define a set of specifications that simplify integration of software development tools, project management tools, and product lifecycle.

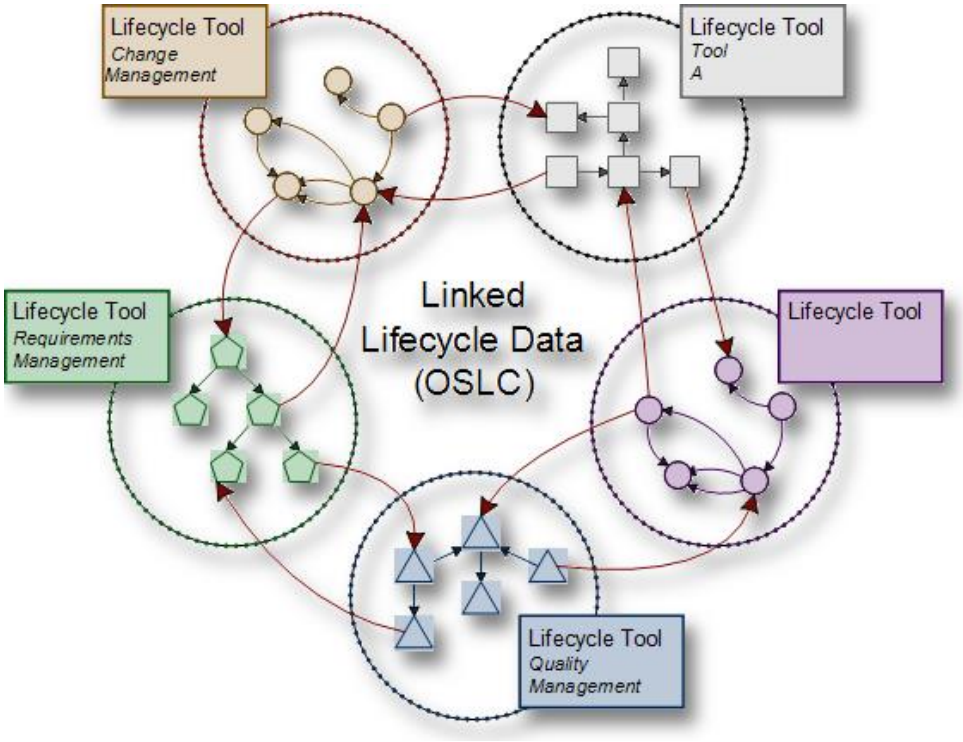

Figure 2-9: OSLC Overview

The initial motivation was to lower the barriers to tools integration by identifying “minimal” shared concepts. The OSLC community has identified workgroups, who are shaping the scope of the OSLC standard by producing specifications. The list below is a subset of the resulting chapters of the standard (with active working groups):

- Core (Integrating software with linked data);
- Automation (Reducing manual interactions in all phases of software development and operations);
- Change and configuration management (Tasks, defects, assets, and configurations);
- ALM-PLM interoperability;
- Architecture management (Modelling, diagrams, and use cases for software development);
- Performance monitoring;
- Quality management;
- Requirements management.

2.5.2 The organization

OSLC is hosted by OASIS (Open Advanced Standards for the Information Society). OASIS is a non-profit consortium that drives the development, convergence and adoption of open standards for the global information society. OASIS promotes industry consensus and produces worldwide standards for security, Internet of Things, cloud computing, energy, content technologies, emergency management, and other areas. The OASIS consortium includes more than 5,000 participants representing over 600 organizations and individual members in more than 65 countries.

OASIS is distinguished by its transparent governance and operating procedures. Members themselves set the OASIS technical agenda, using a lightweight process expressly designed to promote industry consensus and unite disparate efforts. Completed work is ratified by open ballot. Governance is accountable and unrestricted. Officers of both the OASIS Board of Directors and Technical Advisory Board are chosen by democratic election to serve two-year terms. Consortium leadership is based on individual merit and is not tied to financial contribution, corporate standing, or special appointment.

Among DANSE partners, IBM is a “foundational sponsor” of OASIS, Thales is a sponsor, and EADS is a contributor. IBM, Thales and EADS are contributing to the OSLC group. IBM and EADS are members of the OSLC steering committee.

IBM is also member in the Automation TC (Technical Committee) in which consideration for MBSE relevant automation has been introduce to be included as part of version 2.0 of this specifications, where the application of simulation is a special case of analysis and testing that has not been considered in the earlier revisions of the specifications.

2.5.3 Relevance to DANSE

From a general technical perspective, the principle of “minimal coupling” of software tools, encompassing engineering, management, operation throughout the systems lifecycle is of course fully relevant for DANSE.

The openness and lightweight governance principles promoted by OASIS are interesting as they allow to set up wide panels of experts on different topics.

Among the topics currently discussed, several are especially relevant to DANSE:

- Change and configuration management (as long as the evolutionary perspective of DANSE is addressed);
- Architecture management (especially interchange of modelling diagrams and architectural descriptions);
- Requirements management (as long as it could allow innovative approaches, such as translation of requirements in terms of “goals and contracts”).
- Automation TC is extending the relevant scenarios to include also simulation of cyber-physical systems as variants of testing automation.
- A collaboration with OMG to facilitate an elaboration of OSLC-AM according to the SysML standard is performed by the OMG OSLC4MBSE WG.

2.6 FMI

2.6.1 The standard

Functional Mock-up Interface (FMI) is a tool independent standard to support both model exchange and co-simulation of dynamic models using a combination of XML-files and compiled C-code (FMI, 2014).

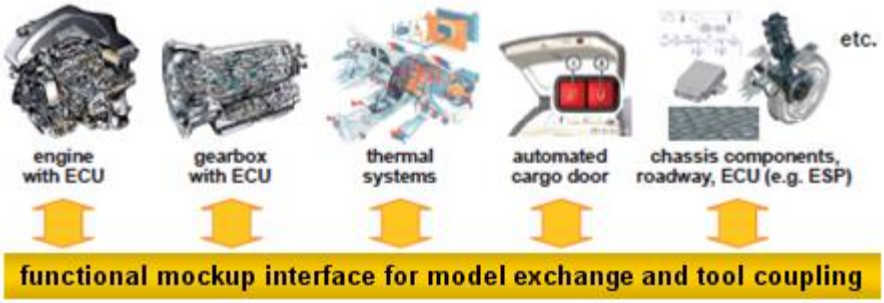

Figure 2-10: FMI Scope (FMI, 2014)

The first version, FMI 1.0, was published in 2010, followed by FMI 2.0 in July 2014. As suggested by Figure 2-10 above, FMI development was initiated by the automotive industry, in the context of European project MODELISAR, started in 2008, with the goal to improve the exchange of simulation models between suppliers and OEMs. As of today, development of the standard continues through the participation of 16 companies and research institutes. FMI is supported by over 35 tools and is used by automotive and non-automotive organizations throughout Europe, Asia and North America.

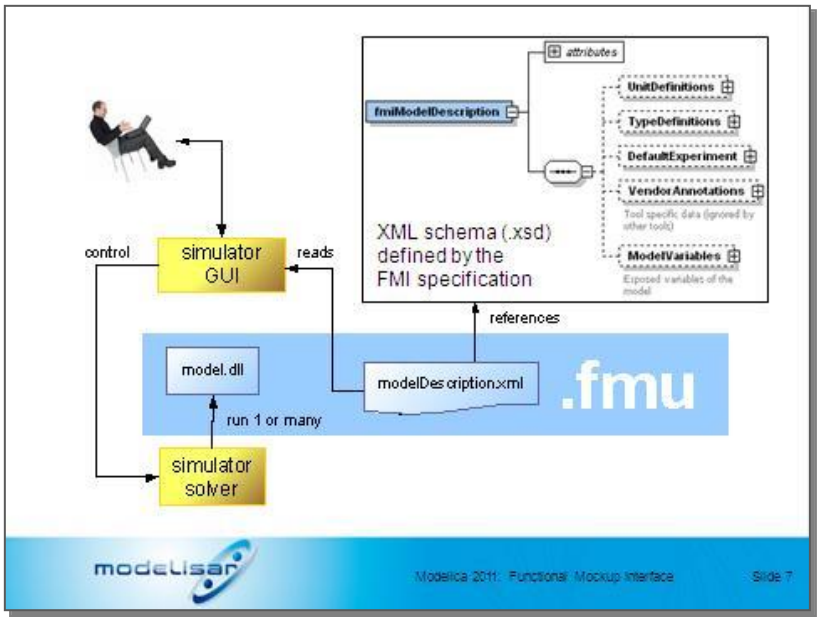

Figure 2-11: FMI Principle (simplified)

2.6.2 The organization

To continue the cooperation of the FMI development partners beyond the initial European cooperative project (2008-2010), the core development partners decided to host their activities within the Modelica Association (Modelica Association, 2014). According to the Bylaws of the Modelica Association, a new Modelica Association Project "Functional Mock-up Interface" was created.

Its objectives are the development, standardization and promoting the Functional Mock-up Interface (FMI) definition. The intention is that dynamic system models of different software systems can be used together for software / model / hardware-in-the-loop simulation, for cyber physical systems, and other applications.

The FMI specifications are published under the CC-BY-SA (Creative Common Attribution-ShareAlike 4.0 International) license, i.e., the license used by Wikipedia. Source code, such as C-header and XML-schema files, that accompany the specification documents are provided under the BSD license (BSD-2) with the extension that modifications must be also provided under the BSD license.

IBM is a member in advisory board of the standard. FMI specification v2.0 acknowledges contribution by IBM. The main contribution was focused on discrete and hybrid semantics of FMI standard.

2.6.3 Relevance to DANSE

FMI is technically fully relevant for the simulation capabilities of DANSE. It is also relevant:

- from a strategic perspective, since there is to our knowledge no competing standard, and also
- from a business perspective, since it was initiated by end users, and therefore, is vendor-independent; yet it is being adopted by major tool vendors such as TheMathworks, LMS-Imagine, Dassault-Systèmes, ANSYS, IBM, etc.

However:

- FMI version 2.0 would be of interest to DANSE, but at the moment, most tools only support FMI v1.0;
- FMI was initially introduced for co-simulation of heterogeneous subsystems, such as the various control subsystems within a vehicle. Ensuring the scalability at the level of systems of systems may not be only an implementation topic, it may also impact the standard. A typical example is the need to cope with multiple, heterogeneous time scales (from milliseconds to years) and different time units (logical time, physical time).
- The DANSE tools net interoperability relies on FMI to facilitate the behaviour of model elements, thus FMU object are associated (via OSLC links) to these elements and mediated across different tools. FMUs from different tools can thus be integrated and used within a single simulation analysis of a complex system of systems.

3 Standards promotion actions done

3.1 IBM

During the project, IBM has been active within the OMG (SysML, UPDM), OSLC, MARTE, and FMI standardization organizations. Members of the IBM DANSE team were active in some of these bodies (OMG OSLC4BSE WG, OSLC Automation TC, and FMI v2.0 specifications) as describe per each case above. The following concrete impact has been achieved:

1. FMI specification v2.0 acknowledges contribution by IBM to extend discrete and hybrid semantics of FMI standard.
2. Presentation to the OMG OSLC4MBSE WG by IBM on the value of ontologies, to initiate a formal standard for a SysML ontology.
3. OSLC Automation specification v.2 to include simulation scenarios such as in complex cyber-physical systems.
4. Collaboration with Wolfram SystemModeler team to promote a Modelica ontology through the Modelica Association.

3.2 THALES

During the project, Thales has been active participant to all OMG Technical Meetings, as a co-chair of the MARTE Revision Task Force, as a contributor to SySML and UML working groups. Preliminary technical discussions in this context enabled Thales to propose the OMG standardisation strategy described in section 4 below.

Thales has been supporting the structuring of OSLC within OASIS, and has been a contributor to the “ALM-PLM Interoperability” Technical Committee of OSLC.

3.3 Honourcode

Throughout the DANSE project, Honourcode has continued its participation in the INCOSE Systems of Systems Working Group (SoS WG), the INCOSE Complex Systems Working Group (CxSWG), and the NDIA SoS WG. The goal has been to raise international visibility of the DANSE methodology and tools, such that there is outside impetus (beyond DANSE) for the acceptance of the DANSE products.

3.3.1 INCOSE Systems of Systems Working Group

The INCOSE SoS WG has had semi-annual formal meetings during the DANSE project, as well as continuing activity between the meetings. Co-chairs of the WG are Alan Harding (BAE Systems fellow), who has recently been elected an INCOSE President-Elect, and Dr. Judith Dahmann (The MITRE Corporation), who has been a widely-visible contributor to SoS thinking in US DoD and internationally. Eric Honour (Honourcode) has been a key contributor to the SoS WG, managing a series of monthly INCOSE webinars on SoS topics and also participating in the SoS WG planning. As such, this WG has been a strong avenue

for international visibility of DANSE. DANSE has made three presentations as part of the SoS webinars. The DANSE methodology has become a serious part of the international SoS thinking in this WG. The WG is launching new initiatives based on the DANSE Patterns work, the DANSE methodology, and the concepts of SoS joint simulation.

3.3.2 INCOSE Complex Systems Working Group

Eric Honour has been a co-chair of the INCOSE CxSWG during the DANSE project, guiding the thinking about complexity to incorporate the ideas of the DANSE methodology. The CxSWG created a Complexity Primer to guide systems engineers in their thinking about complexity; many of the DANSE concepts are included in the descriptions of the Primer.

3.3.3 NDIA Systems of Systems Working Group

The US National Defence Industry Association (NDIA) also sponsors an SoS WG, focused on the use of SoS concepts within the US Department of Defence (DoD). This group sponsors various initiatives to advance SoS concepts. The chair is again Dr. Judith Dahmann, who uses the NDIA SoS WG to develop new ideas that then have significant influence on other international efforts, Eric Honour is a contributing member of the NDIA SoS WG, providing DANSE methodology and tools concepts into the advances of the WG. The NDIA also sponsors a semi-monthly webinar series, and DANSE has made presentation to this group as well.

3.3.4 INCOSE Model-Based Systems Engineering Group

The INCOSE Model-Based Systems Engineering (MBSE) group is one of the most active efforts within INCOSE. Out of the MBSE group have grown such efforts as the original System Modelling Language (SysML) development, MBSE and SysML textbooks, architecture framework concepts, a strong relationship with the Object Management Group, and even the impetus for SysML commercial tools. The DANSE concepts have been presented to the MBSE group through its semi-annual workshops, to influence the entire international thinking about SoS.

4 Strategy for next steps

Section §2 above highlights the relevance of a number of standards, and the importance of sustained involvement within the corresponding organizations. It also illustrates the long timescales usually needed to establish standards, the complexity of the dependencies between standards, especially considering their evolution in time.

The type of collaborative standardization we are considering here is not a goal in itself, but a business enabler. The organizations we are considering, i.e., the OMG (OMG, 2014), Modelica Association (Modelica Association, 2014), International Council on System Engineering (INCOSE, 2014), are gathering senior experts representing end-users and providers of implementations. Providers (e.g., IBM and NoMagic) compete in the implementation, but cooperate in the definition of the standard; end-users (e.g., Thales and Rockwell) compete in the exploitation of the implementations, but cooperate in its definition.

Because of this competitive context and the possibly extremely complex technical dependencies, the standardization process is generally slow, and possibly stalled.

DANSE partners sharing a strong background in standardization processes have been discussing the best possible usage of standards, in order to bring DANSE innovations to the market. The outcome of these discussions is summarized in the following pages.

4.1 Towards OMG, regarding DANSE profiles

The latest (i.e. 1st August 2014) internal release of the “DANSE Modelling Extension profile for Rhapsody” consists of 8 sub-profiles. In the table below, we recall the characteristics of these sub-profiles, as standardization candidates.

DANSE sub-profile	Dependencies	Size (including documentation)	Standardisation candidate, from a technical perspective?
Stochastic Annotations	SysML 1.3	3 stereotypes 5 pages	Yes.
GCSL	SysML	1 stereotype 40 pages	Yes.
Simulation	SysML FMI	5 stereotypes 6 pages	Probably yes. Stability to be confirmed. Highly dependent on FMI (non OMG standard)
Architecture Generation	UML	10 stereotypes Documentation missing ?	Probably no. Needs more maturity; needs acceptance from broad base of users.
Concise Modelling	SysML	53 stereotypes 10 pages	Yes.
Pattern Library	UPDM (OV-5b	1 profile with 1	Probably no, as a repository.

DANSE sub-profile	Dependencies	Size (including documentation)	Standardisation candidate, from a technical perspective?
	and SV-1 diagrams)	stereotype per pattern. About 20 pages user manual for	Possibly yes, as a format for patterns. Needs public use and acceptance before initiating strong standardisation action.
SMC IBM Plugin	SysML, UPDM, and Modelica Ontologies	Initial ontologies as used in DANSE exist and can be contributed.	The SMC is a driver for developing ontologies of standards such as SysML, UPDM, and Modelica, which will enable to semantically bridge over these standards and allow tools implementing these standards to interoperate.

Table 4-1: DANSE profiles standardisation analysis

Stochastic annotations could probably be easily integrated in SysML. Currently SysML 1.3 includes (in annex D.6 which is part of the “non-normative extensions”) stereotypes to support distributions of properties for blocks. DANSE contribution is a straightforward complement to this optional extension.

FMI simulation support could be a topic for discussion in the OMG Systems Engineering Domain Special Interest Group (OMG SE DSIG, 2014). This group is the main link between the Systems Engineering community (INCOSE, 2014) and the Object Management Group (OMG, 2014). It has been elaborating SysML (OMG SysML, 2012), UPDM (OMG UPDM, 2013), and is active in bridging SysML with Modelica. SE DSIG is aware of FMI, which was presented and discussed at several recent technical meetings. The best path for standardization should be discussed in this group.

Assuming that initiating a standardization process is in line with the interests of the stakeholders in DANSE consortium, the Goal and Contract Specification Language (GCSL) profile on one hand, and the Concise profile on the other hand imply an effort orders of magnitude higher than the Stochastic and Simulation profiles.

GCSL is only one stereotype, easy to integrate e.g. as a non-normative SysML extension, but the GCSL language itself would deserve a dedicated standard. One could imagine that GCSL could be used outside SysML, typically as an extension of Domain Specific Languages. Furthermore, GCSL has strong links with other OMG standards, e.g. MARTE (see §2.4) and the Object Constraint Language (OMG OCL, 2014). A presentation of GCSL at a technical meeting of the MARTE RTF (Revision Task Force), in addition to other dissemination actions, could be the next step towards issuing a RFI (Request for Information) and then a RFP (Request for Proposals) for a dedicated OMG standard.

Concise consists of a large number of stereotypes, and the supporting tools are not fully integrated, as it relies on external Excel files for a complete description of model variability. However, this prototype implementation, as demonstrated in DANSE, is sufficient for experimentation by beta-testers on real applications. Maturation of the profile, based on continued experimentation, may be the next step before considering investing in a standardization action.

4.2 Towards OSLC Community, regarding interoperability

OSLC standardisation organization consists of 21 inter-related Technical Committees (TCs).
DANSE partners are involved in 7 of these. The following TCs appear as the most appropriate to continue DANSE results promotion, and to push for standards:

- "OSLC Automation TC", regarding Semantic Mediation (the action has already been initiated)
- "Requirements Management TC" should be appropriate for GCSL dissemination (IBM and Airbus are involved in this TC).

In addition:

- The "Core TC" is of course relevant for semantic mediation technologies;
- The "Embedded systems TC", where OFFIS is an active participant, is also more generally relevant for dissemination.

4.3 Towards Modelica Association, regarding Modelica Ontology

Some initial actions were taken by IBM in cooperation with a past partner in EU project SPRINT, to work with the Modelica Association to develop a formal ontology of the Modelica language so tools implementing Modelica can interoperate using the semantic mediation technology of SPRINT and DANSE.

5 Technical highlights

1. FMI specification v2.0 acknowledges contribution by IBM to extend discrete and hybrid semantics of FMI standard.
2. Presentation to the OMG OSLC4MBSE WG by IBM on the value of ontologies, to initiate a formal standard for a SysML ontology.
3. OSLC Automation specification v.2 to include simulation scenarios such as in complex cyber-physical systems.
4. Collaboration with Wolfram SystemModeler team to promote a Modelica ontology through the Modelica Association.

6 Abbreviations and Definitions

ALLOC	Allocation Modelling
BSD	Berkeley Software Distribution
CC-BY-SA	Creative Common Attribution-ShareAlike
DANSE	Designing for Adaptability and evolutioN in System of systems
FMI	Functional Mock-up Interface
GCM	Generic Component Model
GCSL	Goal and Contract Specification Language
GQAM	Generic Quantitative Analysis Modelling
GRM	Generic Resource Modelling
HLAM	High-Level Application Modelling
HRM	Hardware Resource Modelling
INCOSE	International Council on System Engineering
MARTE	Modelling and Analysis of Real-Time Embedded systems
NFP	Non Functional Property
OASIS	Organization for the Advancement of Structured Information Society
OMG	Object Management Group
OSLC	Open Services for Lifecycle Collaboration
PAM	Performance Analysis Modelling
RSM	Repetitive Structure Modelling
SAM	Schedulability Analysis Modelling
SED SIG	System Engineering Domain Special Interest Group
SRM	Software Resource Modelling
SysML	System Modelling Language
UML	Unified Modelling Language
UPDM	Unified Profile for DODAF & MODAF
VSL	Value Specification Language

Table 6-1: Acronyms

7 References

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FMI Functional Mock-up Interface [Online]. - Modelica Association Project, 2014. - 08 12 2014. - https://www.fmi-standard.org/.

INCOSE International Council on System Engineering [Online]. - INCOSE, 2014. - 08 12 2014. - http://www.incose.org/.

Modelica Association Modelica Association [Online]. - Modelica, 2014. - 08 12 2014. - https://modelica.org/association.

NAF NATO Architecture Framework, version 3 [Report] : Standard. - [s.l.] : North Atlantic Treaty Organization, 2007. - p. 882. - http://www.nhqc3s.nato.int/ARCHITECTURE/_docs/NAF_v3/ANNEX1.pdf. - ANNEX 1 to AC/322-D(2007)0048.

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OMG OCL Object Constraint Language [Report] = OCL : Standard. - [s.l.] : Object Management Group, 2014. - p. 262. - http://www.omg.org/spec/OCL/2.4. - formal/2014-02-03.

OMG SE DSIG Systems Engineering Domain Special Interest Group [Online]. - Object Management Group, 2014. - 08 12 2014. - http://www.omg.org/syseng/.

OMG SysML OMG Systems Modeling Language [Report] = OMG SysML™ : Standard. - [s.l.] : Object Management Group (OMG), 2012. - p. 271. - formal/12-06-01.

OMG UML OMG Unified Modeling Language, v2.4.1 [Report] = OMG UML : Standard. - [s.l.] : Object Management Group (OMG), 2011. - p. 748. - http://www.omg.org/spec/UML/2.4.1/Superstructure. - formal/2011-08-06.

OMG UPDM Unified Profile for DoDAF and MODAF [Report] = UPDM : Standard. - [s.l.] : Object Management Group (OMG), 2013. - p. 422. - http://www.omg.org/spec/UPDM/2.1/. - formal/2013-08-04.

Wikipedia DoDAF Department of Defense Architecture Framework [Online] // Wikipedia, the free encyclopedia. - Wikipedia , 27 11 2014. - 05 12 2014. - http://en.wikipedia.org/wiki/Department_of_Defense_Architecture_Framework.

Wikipedia MoDAF British Ministry of Defence Architecture Framework (MoDAF) [Online]. - Wikipedia, the free encyclopedia, 27 07 2014. - 05 12 2014. - http://en.wikipedia.org/wiki/MODAF.

Wikipedia UML Unified Modeling Language [Online] // Wikipedia, the free encyclopedia. - 4 12 2014. - 5 12 2014. - http://en.wikipedia.org/wiki/Unified_Modeling_Language.