

## **EU Core Technical Framework Study: Semantic Mapping among M&S and Systems Engineering Standards**

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### **ABSTRACT**

*In cooperation with EDA (European Defence Agency), EU Core Technical Framework Study was conducted during 2008-2009. The goal of the study is to enable a framework that promotes secure, multinational distributed simulations. The main domains targeted are Training, Simulation Based Acquisition (SBA) and Concept Development and Experimentation (CD&E). On developing such a framework, efforts have been made to reuse the existing state-of-the-art methods and techniques without reinventing the wheel, which would increase usability and acceptance of the framework.*

*This paper gives an overview of the Core Technical Framework developed during the study and then presents a part of the results in more detail, i.e. semantic mapping among the M&S and Systems Engineering standards. The mapping has been made between the specification documents produced from the standards. Such a mapping contributes to increased communication between different types of stakeholders, reuse of M&S artefacts and interoperability.*

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### 1 INTRODUCTION

Typically system development including simulation model development and its intended deployment needs to be performed by considering a number of different aspects from different stakeholders with different responsibility and interests. In the past these different stakeholders usually had their own methods, representation languages and terms to describe their parts of the system from their perspectives which fit for their own purpose. Three major problems with this way of working are:

- It is difficult for the different stakeholders involved to communicate with each other in efficient manner due to lack of common base.
- It is difficult to establish a holistic view of the whole system.
- Consequently, verification and validation (V&V) can not be conducted effectively or efficiently.

An architecture framework<sup>1</sup> provides a collection of views each of which is intended to describe different parts and aspects of a system from the viewpoints of different stakeholders. Using an architecture framework each of the stakeholders can express his/her concerns in terms of views in a manner consistent and communicative with other views that are also provided by the same framework, and that describe other stakeholders' concerns. Further, system descriptions captured in such views can be reused within current or future projects. Thereby an holistic and consistent description of a complex problem from different perspectives can be achieved, ensuring traceability between the developed distributed simulation, various tactics, techniques, procedures, strategy or doctrinal guidance, system and organizational processes and functions etc. Further, it ensures all participating stakeholders develop a common understanding of the problem in focus, e.g. organizational and system capability.

One may say that architecture framework approaches, e.g. MODAF (Ministry of Defence Architecture Framework), DoDAF (Department of Defence Architecture Framework) and NAF (NATO Architecture Framework), originate from the Systems and Software Engineering (S/SE) community. Nevertheless we claim that architecture frameworks are equally applicable to M&S as well for at least two reasons:

- M&S can be considered as a subset of S/SE.<sup>2</sup>
- Architecture framework can be preferably used as a hub to create an alignment among the M&S and S/SE approaches (standards, methods, techniques).

Section 2 provides an overview of the proposed Core Technical Framework which contains among others the mapping between Systems Engineering and M&S as a subcomponent. Section 3 contains a general discussion about architecture and architecture framework. Then the mapping is presented in detail in Section 4, and final remarks are made in Section 5.

### 2 OVERVIEW OF THE CORE TECHNICAL FRAMEWORK

#### 2.1 Purpose

The purpose of the EU Core Technical Framework Study has been to define an EU-wide Distributed Simulation Architecture enabling secure, cost-efficient, multinational, distributed simulation experimentation and training across the participating member states (pMS).

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<sup>1</sup> "Architecture framework" and "architecture" will be defined in Section 3.

<sup>2</sup> We are aware that this may be a very strong statement. There are M&S-specific issues indeed that are not covered sufficiently in S/SE. For example, VV&A in M&S and S/SE are different from each other. What we mean is, from the system viewpoint, a simulation model is a system as well.

The main benefit of a Core Technical Framework is to promote reuse of earlier simulation efforts, to support collaborative efforts, to ensure interoperability and to provide methods, capabilities and technical solutions to enable cost effective use of distributed simulations in the whole lifetime cycle.

## **2.2 Scope and Effect**

Constructing an EU Core Technical Framework is not a simple task due to the increasing complexity of the operative environment and the diversity of distributed simulations that now need to be integrated.

The operations of today are characterized by the collaboration of a growing number of players, in a multi-national environment with different organizations, methods, technologies and policies & regulations. Such Multi-Dimensional Mission Operations (MDMO) is ranging from non-military tasks as humanitarian relief operations or crisis management activities to pure military operations.

Peace-keeping/enforcement operations are examples of such operations, which are conducted by joint military forces from different allied countries acting together for the accomplishment of a common strategy through partnership, cooperation and interaction beyond national borders. Combined operations, e.g. humanitarian relief operations, which may include cooperation with civilian organizations, such as local government, police and non-governmental organizations like the Red Cross are also needed.

These operations benefit from a wide distributed simulation capability, which enables joint acquisition, training, execution, examination and evaluation in order to handle complex situations and achieve operational effects. Design, planning, performance and evaluation of distributed simulations are, however a complex task where multiple dimensions of complexity need to be covered.

This study encompasses distributed simulations in the domains:

- Concept Development & Experimentation (CD&E) utilizes the joint network of connected real-world and simulated systems to investigate and develop requirements on technical systems, doctrines and operational processes;
- Simulation Based Acquisition (SBA) for material procurement or capability development can be performed in a cost-effective way through the availability of real-world systems and simulators in a net-centric environment;
- Joint and Combined Distributed Training at different operational levels, to achieve a functional and effective organization using live systems connected to simulator systems and training centres.

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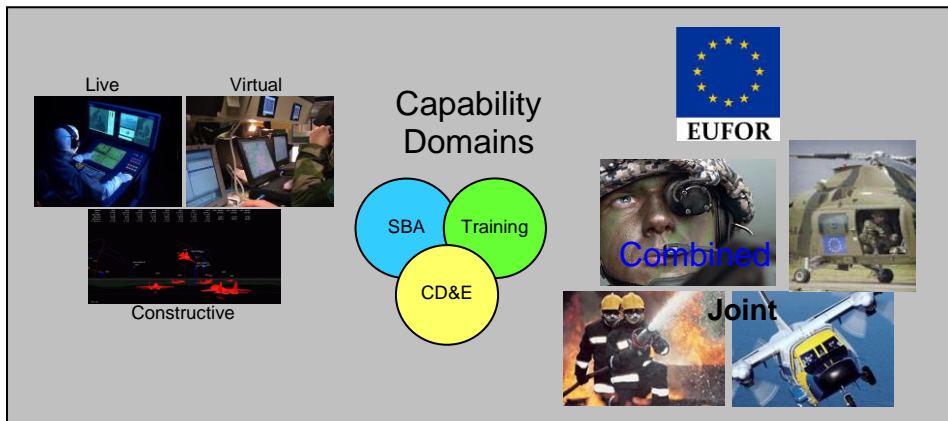


Figure 1: Distributed simulations and domains [1]

By using distributed simulations EU participating member states are saving money (e.g., by using simulation assets like simulators, intelligent agents in combination with physical resources), time (e.g., units get ready faster for a certain culture/environment/operation), diminishing environmental impact (e.g., use of flight simulators instead of aircrafts to train tactical behaviour), increased safety (e.g., increased survivability of both own units and population in crisis area), security (e.g., in a acquisition process country A does not want to give insight into a certain simulation model of an aircraft to country B but it allows its remote use in a distributed simulation).

Finally, the modern armed forces, especially peacekeeping units, usually face long lasting, low intensity campaigns. In such settings, there are two concurrent forces: the need to keep relatively high alert levels, and in the same time having a good troop proficiency training schedule. This dictates the possibility to safely conduct simulated training, tactics development and experimentation, while part of the system remains operational. The need is to switch between combat readiness by training with the operational equipment and combat alert, thus safety and speed of recovery should be considered.

From a Modelling & Simulation perspective distributed simulations for combined operations are complex, since multiple simulation standards usually are used, different operational levels require different aggregation levels, i.e. whether the forces are handled as single units or battalions, use of both live, virtual and constructive (L-V-C) simulations, handling communication simulation and design, planning, execution and evaluation of the distributed simulations.

### 2.3 Needs and requirements

The EU Core Technical Framework (CTF) addresses the participating member states need for:

- Collaborative work
- Interoperability
- Reuse of simulation assets
- Use-worthiness focusing on efficiency, effectiveness and satisfaction in aspects of cost, time, shared resources and impacts
- Security that takes account of security policies, information zones and levels etc
- Flexibility, openness, scalability and modularity

The CTF is a *descriptive* text document, not prescriptive. It describes a set of methodologies, processes, state of the art paradigms, applicable practices and recommendations in order to support distributed simulation for CD&E, SBA and Training.

## 2.4 Approach

The Core Technical Framework (CTF) takes legacy, mandatory and upcoming standards, into account when developing and using distributed simulations. These standards span a number of modelling and simulation standards like High Level Architecture (HLA), Distributed Interactive Simulation (DIS) and Test & Training Enabling Architecture (TENA), software engineering standards like Model Driven Architecture (MDA), architecture frameworks (e.g., MODAF), and information security standards. Additionally, the CTF is oriented towards a net-centric way of thinking involving service paradigm and consistent documentation according to architecture frameworks.



Figure 2: Net-centric approach to distributed simulations [1]

Moreover the CTF supports M&S life cycle from scenario generation and experiment planning to execution and After Action Review (AAR) using a *common development process* handling *heterogeneous simulation architectures* in an integrated manner.

The CTF can serve a wide range of stakeholders with different needs and interests, dependency of work processes, methods and technical platforms for distributed simulation.

## 2.5 Core Technical Framework structure and contents

The Core Technical Framework (CTF) introduced is composed of four main components and several subcomponents:

- Smorgasbord which is a collection of applicable standards, methods and services from which the user may select the ones appropriate for his needs. It is a union of following:
  - Architecture framework views for consistent documentation of distributed simulation scenarios, assets and results.
  - A description of a number distributed modelling and simulation standards, software engineering standards and information security standards

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- A service framework for distributed simulations that facilitate use of services from a net-centric perspective.
- Reference Model which consists of two subcomponents:
  - A collection of most relevant terms used throughout the framework and explanations of them, i.e. a taxonomy.
  - Mapping between some simulation standards and systems engineering standard.
- Simulation architecture which describes technical approaches and high level design to support distributed simulations from planning to evaluation promoting reuse, resource management and automation.
- Methods & recommendations which describe how processes, architecture frameworks like MODAF views and design recommendations could facilitate development and reuse.

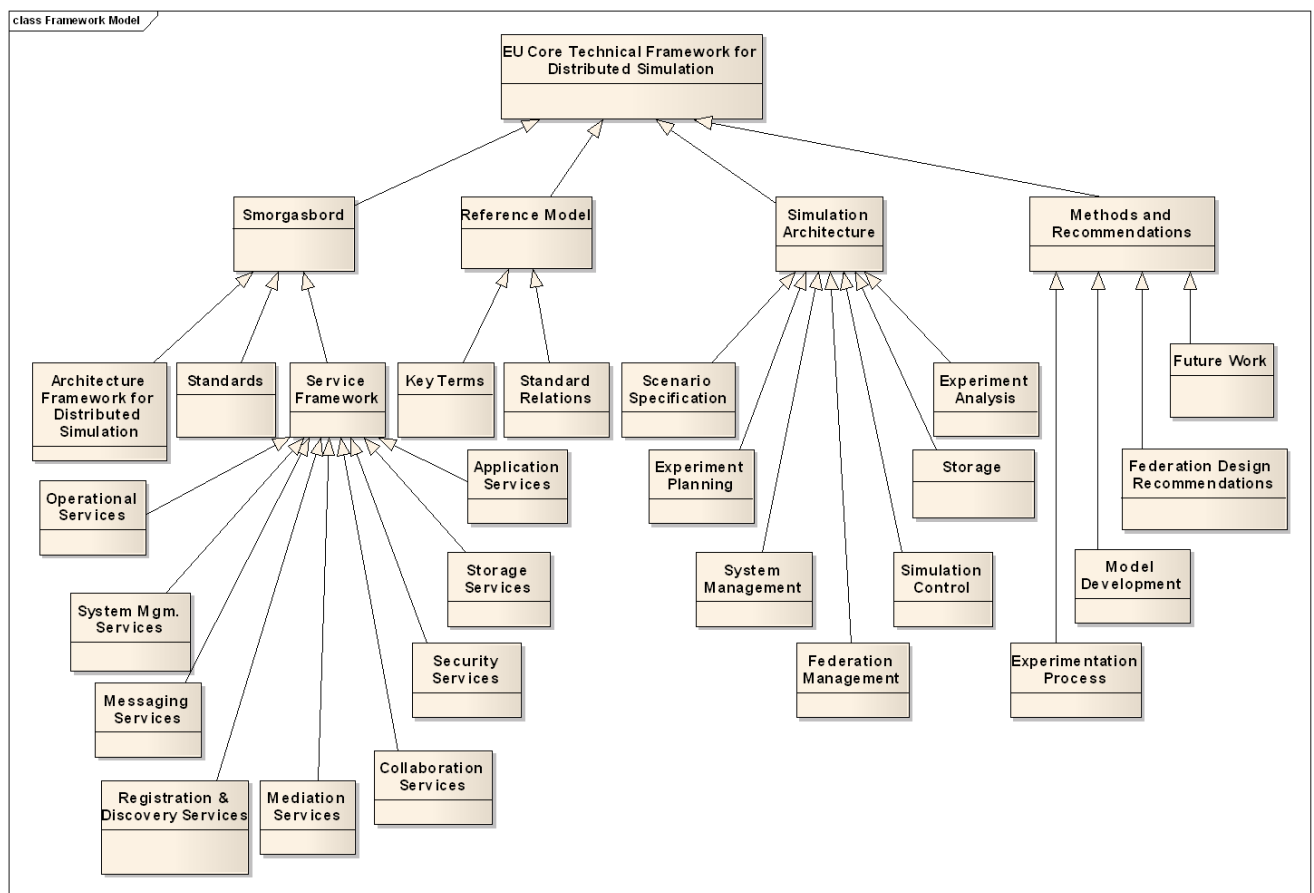


Figure 3: The structure of the Core Technical Framework [1]

The CTF is described pictorially in Figure 3.

## 3 ARCHITECTURE AND ARCHITECTURE FRAMEWORK

### 3.1 Architecture

Architecture is how a system is built or will be built, whether it is a house, a software system or a business. If you want to analyse that system to see how to improve it then you would look at the model for that system, as the model gives you a simplified view of the system. In the case of a house this model could for example be building plans and ventilation charts, for a business it could be process flows and organisation charts.

If you look at a whole enterprise it consists of many different kinds of activities, organisations and systems. A distributed simulation for SBA/training/experiment across different pMS is an example of such an enterprise where different organisations collaborate in achieving a mutual goal. It is often quite complex and therefore it is difficult to get a good understanding of all the details of the enterprise. In other words it is not easy to describe the architecture of the enterprise. The problem is that not only is there a need to understand the enterprise and its architecture, there is also a need to communicate this understanding to other parts of the enterprise. Today this is often tackled by creating documents which describe and regulate the business. The problem with this approach is the difficulty to maintain *consistency* between the different documents and to find the areas which have been left uncovered. In any enterprise but the smallest, this is in the end unavoidable with a document based approach. The way to solve this problem is to use an architecture description in form of models where you can link different areas with each other to maintain consistency.

The need to describe your architecture is becoming ever more important as the complexity increases due to international cooperation and increasing demands on the enterprise. International cooperation also requires common standards and processes and it changes the focus of standardisation from individual systems to interoperability between systems and organisations. Another reason is the need for handling large amounts of information which requires better structure and management of the information in the enterprise and its systems. The need for flexibility is high to be able to more quickly adapt to changing demands, for example due to increasing environmental awareness. This means that the systems need to be more loosely coupled, as is the case in distributed simulations.

There is a need for a *framework* which describes how to use the different models and how they tie together. This framework also needs to be based on well known standard so as to be able to use experience from other enterprises and ensure the existence of supporting tools and methods.

### 3.2 Architecture framework

An architecture framework is a standard way to describe architecture. A good framework will support the linkage between different parts of the architecture description so as to keep the description consistent and clearly show which parts are not covered. This means you can identify conflicts so they can be resolved and also enable reuse. It also supports tracing requirements from their identification to how they were or will be implemented in systems. This enables validation that the requirements have been correctly implemented.

The framework is an enabler, and as such it creates the basis for good architecture descriptions, but it does not automatically mean that all descriptions produced according to the framework are good descriptions. A framework with its service views enables utilization of different conceptual approaches like Service Oriented Architecture (SOA) for distributed simulations.



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A good architecture framework is expected to support the following:

- **Consistency** is supported by creating one object which is then reused in different parts of the architecture, as well as by linkages between different objects so that you can identify what effect changes to an object will have to other objects.
- **Traceability** is supported by allowing you to follow the effect of decisions and requirements through the architecture. For example how a requirement for exchange of certain type of information leads to the use of a particular data format, e.g. requirement on other HLA Base Object Model (BOM).
- **Context** is supported by giving the surrounding of the sought after object placing it in its context. For example by showing the supporting activities to exercise/SBA/experiment management so as to identify outer limits on those.
- **Flexibility** is supported by creating a well described surrounding and thus it is easy to see what is affected by change and what still needs to be supported by the new objects. For example when implementing new services which will replace old point to point connections it is possible to identify which systems need to be able to access the new service that can be shared between the different stakeholders.
- **Reuse** is supported by having a well defined architecture description where it is easier to find already described objects and reuse them directly as they are described in the correct way. An example of such an object could be a federate description.
- **Understanding** of other architecture descriptions is supported by having a well defined architecture description, which makes it easier to compare other architecture descriptions to it and therefore relate to them.

Currently several architecture framework approaches are available, e.g. MODAF, DODAF, and NAF. While some differences exist between these approaches, the differences are of minor importance from the viewpoint of this study. Here follows description of views from NAF. The architecture framework consists of views. Each of the views presented consist of sub-views.

- **All View** covers the overarching aspects of an architecture that relates to all views. Most importantly it covers the scope of the architecture description and the definition of the concepts used in the architecture.
- **Capability View** supports the process of analysing and optimising the enterprises capabilities. A capability is a high level description of the enterprise's ability to perform actions.
- **Operational View** is a description of the tasks and activities, operational elements, and information exchanges required to accomplish business goals.
- **Service-Oriented View** focuses on identifying and describing services it also captures mapping of services to operational activities. The views support the concept of a Service-Oriented Architecture (SOA). An example of a service could be a discovery service that finds available and suitable federates.
- **Systems View** describes systems and system interconnections providing for, or supporting, operational activities. It is here you would capture a common technical infrastructure to support the operational activities, like which technical artefacts like federates and technical nodes support operational activities of training /SBA/experimentation.
- **Technical View** is a set of rules or standards to ensure that a system satisfies a specified set of operational requirements. For example mandatory standards are covered by this view.

- **Programme View** describes how the capabilities and services relate to the various programmes and projects being implemented. This information can be further leveraged to show the impact of acquisition decisions on the architecture.

The views are not standalone but are tied together by a common model (called the Meta model) which is intended to ensure consistency between the different views.

## 4 SEMANTIC MAPPINGS AMONG THE M&S AND SE STANDARDS

### 4.1 Delimitation

The relations will be established by mapping the products of the standards to each other through MODAF (to be precise, MODAF 1.2) views. The standards participating in the mapping are:

- FEDEP (Federation Development and Execution Process)
- MDA (Model Driven Architecture)
- ISO 15288 System Life Cycle Processes Standard

By “products” we mean the specification documents from the standards. In this sense it is “product oriented”. One may think of “process oriented” mapping as well, i.e. relating the phases of the standard processes to each other. We consider, however, the product oriented mapping provides more tangible output. On the other hand, the process oriented mapping is to be recommended when, e.g. coordinating activities of different stakeholders involved in a project.

Further, relations are defined over some of the major standards only by extending previous results made somewhere else. A complete mapping is beyond the scope of the study, because the mapping is demonstrated as a proof of concept. Also, a major guideline for this study was to reuse the state-of-the-art findings without reinventing the wheels from the scratch.

### 4.2 Related work

Connecting architecture framework with M&S has been proposed for different purposes by several researchers previously. Roughly these approaches can be classified in two groups:

- Using M&S for architecture framework
- Using architecture framework for M&S.

In [2] within the first group, DoDAF has been extended with two new Operational Views to make the DoDAF views compliant with DEVS (Discrete Event System Specification) which is a computer executable formal language. Thereby the DoDAF views become executable, i.e. they can be simulated, e.g. to verify the consistency of the view themselves, to assess and examine the feasibility of operational concepts and operational plans described in the views. Similar approach has been presented in [3]. The goal of this study was to test the hypothesis that Executable Architecture (architecture framework combined with M&S) provides an effective methodology or framework to address and analyze counter-terrorism and homeland security Capability gaps. Another effort to make the DoDAF executable was presented by [4].

The work of [5] is an approach within the second group. This work was inspiring to us and at the same time confirmed our initial ideas concerning the need of semantic mappings between and among M&S and S/SE standards. Figure 4 below shows a mapping from DoDAF and FEDEP products to the process of MDA.

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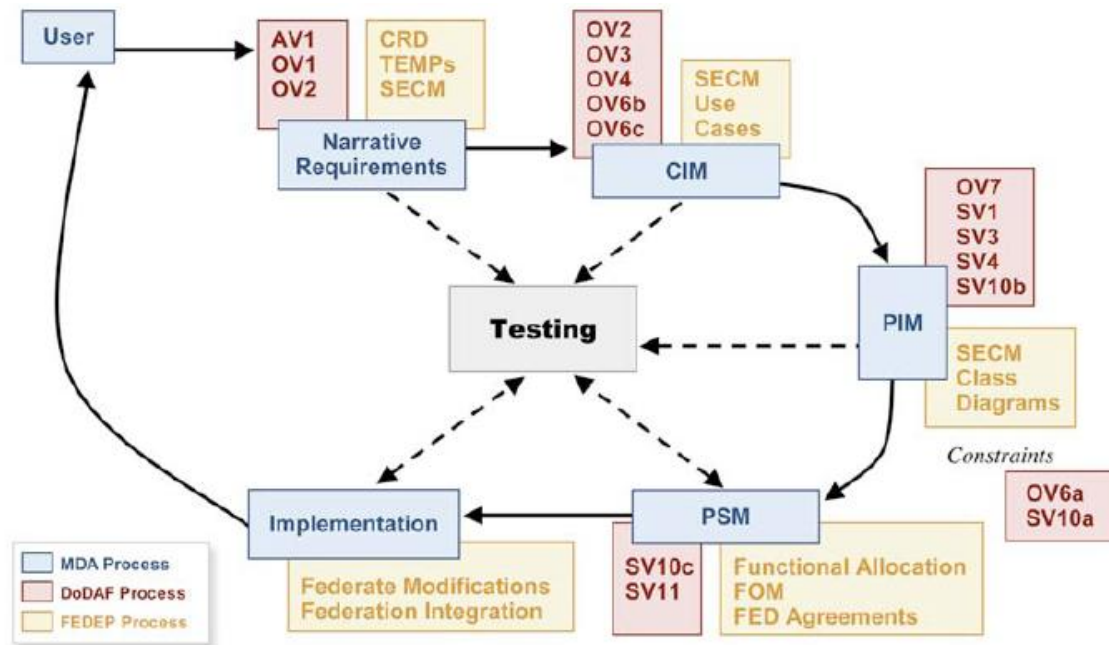


Figure 4: FEDEP, DoDAF and MDA connection [5]

The authors observe that:

“Currently, system creation is habitually setback due to a lack of understanding of the problem space. This is exacerbated by the introduction of capabilities based development, which demands interoperability, modularity, platform independence, distributed processing, and composable capabilities. These requirements can be realized through an alignment of operational requirements documentation (DoDAF) with a simulation testing environment (FEDEP) in a platform independent development process (MDA). ... Use of an aligned SE process will enhance communication between architectural developers and software experts.”

The mapping identified in their work, see Figure 4, is included in our mapping to be presented later in this section.

### 4.3 The mapping

The products of the M&S and Systems Engineering standards that are mapped to the MODAF Views are listed below. For space reason, these standards and their products are not described in detail in this paper. For detail the readers are referred to, e.g. [1].

- Federation Development and Execution Process (FEDEP)
  - Federation Objective (FO)
  - Federation Conceptual Model (FCM)
  - Federation Object Model (FOM)

- Model Driven Architecture (MDA)
  - Computation Independent Model (CIM)
  - Platform Independent Model (PIM)
  - Platform Specific Model (PSM)
  
- ISO 15288: Outcomes from the following processes
  - Stakeholder Requirements Definition Process (SRD)
    - Required characteristics and context of use of services
    - Constraints on a system solution
    - Basis for defining the system requirements
  - Requirement Analysis Process (RA)
    - Functional and performance requirements for a product solution
    - Constraints affecting the architectural design and implementation
    - Integrity and traceability of system requirements to stakeholder requirements
  - Architecture Design Process (AD)
    - Architecture design baseline
    - Specification of implementable set of system elements that satisfy the system requirements
    - Interface requirements
    - Traceability of architectural design to system requirements
  - Project Planning Process (PP)
    - Project plan
    - Definition of roles, responsibilities and authorities
    - Formal request of resources and services necessary to achieve the project objectives
    - Definition of project performance measures

The result of the mapping is described in Table 1 below. As mentioned previously, the mapping between MDA, FEDEP and MODAF are directly based on [5].<sup>3</sup> The readers are referred to the paper for detailed discussion. Definitions of the MODAF Views and the products of the standards are not very precise like mathematical formulae. They are not intended to be so either. Consequently, it is not straightforward to match the artefacts, and the degree of matching varies. Furthermore we had own interpretations and assumptions in some places, but these assumptions and interpretations are based on general system development principles and praxes. For example, the term “capability” in MODAF was interpreted as Stakeholder needs/requirements/expectations in some places, but also as “services” somewhere else. Thus this mapping should be seen as a high level guideline for identifying related specifications.

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<sup>3</sup> Their mapping was made for DODAF Views, but the difference between DODAF and MODAF Views concerned is marginal from the viewpoint of this study. They are considered to be interchangeable.

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Recall that Service Oriented Architecture (SOA) is not an S/SE standard yet, though it is a most predominant approach within S/SE today indeed. Thereby no products are identified for SOA or mapped to MODAF Views. On the other hand, the benefit of SOA technology for distributed simulation has been discussed by [6].

**Table 1: MODAF mapping to FEDEP, MDA and ISO 15288**

MODAF Views	Description	FEDEP	MDA & ISO 15288	Comments on ISO 15288
AV-1 Overview & Summary Information	An overview for an architecture description, i.e. executive-level summary information in a consistent form that allows quick reference and comparison between Architectures. Includes assumptions, constraints, and limitations that may affect high-level decisions relating to the Architecture.	FO	SRD PP	SRD: System purpose and constraints on system solutions.  PP: Roles, responsibilities, authorities.
AV-2 Integrated Dictionary	Presents all the Elements used in an architecture as a specialisation hierarchy, provides a text definition for each one and references the source of the element (e.g. MODAF Ontology and IDEAS Model)			Simple definitions of the key terms are provided by the standards, but not the modelling elements.
StV-1 Enterprise Vision	Describes how high level goals and strategy are to be delivered in capability terms.		SRD	Stakeholder requirements & needs in SRD are interpreted as “high level goals”.
StV-2 Capability Taxonomy	Specifies a hierarchy of capabilities.		SRD RA	Stakeholder needs & expectations in SRD are assumed to be decomposed.  RA transforms SRD to functional and performance requirements.

StV-4 Capability Dependencies	Dependencies between planned capabilities.		SRD RA	Stakeholder needs & expectations in SRD are assumed to be decomposed.  RA transforms SRD to functional and performance requirements.
StV-5 Capability to Organisation Deployment Mapping	Shows deployment of Capability Configurations to specific organisations.			SRD may be a right place for this, but not prescribed specifically.
StV-6 Operational Activity to Capability Mapping	Mapping between the capabilities required by an Enterprise and the operational activities that those capabilities support.		SRD	SRD defines a set of activity sequences to identify all required services that correspond to anticipated operational and support scenarios and environments.
OV-1 (OV-1a, OV-1b and OV-1c)	High level operational concepts related to one or more missions. An OV-1 describes a mission, class of mission, or scenario; and highlights the main operational elements and interesting or unique aspects of operations.	FCM	CIM SRD	SRD describes characteristics and context of use of services. Operational scenarios are also covered in SRD.
OV-2 Operational Node Relationship Description	Provides the focus for the expression of capability requirements within an operational context; expresses a capability boundary; defines a logical network of information flows.	FCM	CIM SRD	Data flow requirements are described by AD (logical architectural design), but at a lower level of abstraction. Thus AD not mapped here.
OV-3 Operational Information Exchange Matrix	Operational information exchanges between nodes.	FCM	CIM SRD	Operational scenarios in SRD are assumed to reflect such information exchanges.
OV-4 Organisational Relationships Chart	Organisational structures and interactions.	FCM	CIM SRD	Operational environment and conditions are assumed to cover this.

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OV-5 Operational Activity Model	Operations that are normally conducted in the course of achieving a mission or a business goal. It describes operational activities (or tasks), Input/Output flows between activities and to/from activities that are outside the scope of the Architecture.		SRD	
OV-6a Operational Rules Model	Operational or business rules that are constraints on the way that business is done in the enterprise.			The constraints described in SRD are about system solution.
OV-6b Operational State Transition Description	A graphical method of describing how an Operational Node or activity responds to various events by changing its state.	FCM	CIM RA AD	The behaviour of system and system elements are described by RA resp. AD. Graphical description is not prescribed.
OV-6c Operational Event-Trace Description	A time-ordered examination of the information exchanges between participating Operational Nodes as a result of a particular scenario. Each event-trace diagram will have an accompanying description that defines the particular scenario or situation.	FCM	CIM SRD	Generally accepted way of modelling. Can be used for operational scenarios in SRD.
OV-7 Information Model	The structure of an Architecture domain's information types and the structural business process rules.		PIM RA	RA describes required characteristics and attributes for a product solution.
SV-1 Resource Interaction Specification	The composition and interaction of resources (systems, posts, organisations, software).		PIM AD	AD defines interfaces between system elements. Assumed to be covered by or derived from AD.
SV-3 Resource Interaction Matrix	A tabular summary of the resource interactions specified in the SV-1		PIM AD	See the comments on SV-1.
SV-4 Functionality Description	The functionality of resources in the architecture. Behavioural counterpart to the SV-1.		PIM AD	The functions of system elements described in AD.

SV-6 Systems Data Exchange Matrix	Specifies the characteristics of the system data exchanged between systems.		AD	AD describes data flow requirements.
SV-7 Resource Performance Parameters Matrix	Depicts the performance characteristics of a Resource (e.g. system, role or capability configuration).		RA AD	RA and/or AD depending on the chosen level of abstraction.  RA transforms SRD to functional and performance requirements, which are then partitioned into system elements.
SV-10a Resource Constraints Specification	Functional and non-functional constraints on the implementation aspects of the architecture.		RA AD	SRD addresses constraints on a system solution, but at a higher level.
SV-10b Resource State Transition Description	A graphical method of describing a resource (or function) response to various events by changing its state.		PIM RA AD	See the comments on OV-6b.  The functional descriptions of RA and AD are to contain this information.
SV-10c Resource Event-Trace Description	A time-ordered examination of the interactions between resources. Each event-trace diagram will have an accompanying description that defines the particular scenario or situation.	FOM	PSM AD	See the comments on SV-1.
SV-11 Physical Schema	Defines the structure of the various kinds of system data that are utilised by the systems in the Architecture	FOM	PSM AD	Data flow requirements in AD are assumed to cover this.
SV-12 Service Provision	Specifies configurations of resources that can deliver a service. Provides the mapping from services to the resources that provide those services.		AD	System functions are partitioned and allocated to system elements in AD. Note the notion of function in AD and that of service in MODAF may overlap but are not the same.
AcV-1 Acquisition Clusters	Represents an organisational perspective on programmes.		PP	PP defines necessary roles, authorities, resources for a project.



## 5 FINAL REMARKS

This paper addressed a part of the results obtained from the EU Core Technical Framework Study which is a first step to create an EU-wide simulation framework to support effective use of distributed simulations in a multi-national and heterogeneous environment. A basic approach taken was not to rely on one single simulation architecture or one single standard. Instead, in order to support heterogeneous distributed simulations, the framework should offer a smorgasbord of standards and services that could be selected.

The semantic mapping among the M&S and Systems Engineering standards is a subcomponent of the proposed smorgasbord. The mapping has been made between the specification documents produced from the standards. Such a mapping contributes to increasing: communication between different stakeholders, reuse of M&S artefacts and interoperability.

Different products of the standards and the MODAF views are, by nature, not defined very precise like mathematical formulae. Further different aspects these products and views are intended to describe are not clear-cut either, which is also in the nature of the things. Consequently, it is not straightforward to match the artefacts, and the degree of matching varies. In some places it was necessary to make own interpretations and assumptions, following general system development principles and practice. Thus this mapping should be seen as a high level guideline for identifying related specifications.

In the future the mapping needs to go deeper and be extended to cover other M&S standards, e.g. Distributed Simulation Engineering and Execution Process (DSEEP) and Military Scenario Definition Language (MSDL), and SE standards, e.g. Service Oriented Architecture (SOA) if/when it is established as a standard. In addition the proposed mapping needs to be evaluated in practice and stabilised.

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