Technology Update on the Unified Architecture Framework (UAF)

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Abstract. Architecture frameworks continue to evolve. The Unified Profile for the Department of Defense (DoD) Architecture Framework (DoDAF) and the UK's Ministry of Defence Architecture Framework (MODAF) (UPDM) provides a standard means of representing DoDAF, MODAF, and NATO Architecture Framework (NAF) conformant architectures using the Unified Modeling Language (UML), and Systems Modeling Language (SysML). Since the UPDM V2.0 publication, further information has emerged such as the June 2011 NATO study entitled: "Development of The AMN (Afghanistan Mission Network) Architecture In 2010 – Lessons Learned," by Torsten Graeber of the NATO C3 Agency. This report identified the following in section 4.1-ARCHITECTURE FRAMEWORKS, sub-section 4.1.2 Observations (Need for a Unified Architecture Framework) and stated that:

- differences in DoDAF, MODAF, and NAF make it difficult to match the metamodel one to one.
- some of the concepts in the frameworks have the same name but different definitions, i.e. different semantics.
- difficult to cross-walk the concepts between the different frameworks leads to miscommunication between architects using different frameworks.

Based on the above, the NATO Architecture Capability Team (Architecture CaT) meeting on Sept. 10-11, 2012 committed to move to a single world-wide Architecture Framework. Consequently, a new architecture framework profile supporting a unified framework is needed. It is intended that this framework bring the different architecture frameworks together. The UPDM V3.0 domain metamodel shall be derived from MODEM (the MODAF metamodel) and the DoDAF 2.0 metamodel (DM2), both of which are based upon the International Defence Enterprise Architecture Specification Foundation [IDEAS]. This paper will document the rationale behind the UPDM 3.0 as well as its new name of the Unified Architecture Framework (UAF).

Military Architecture Frameworks

The two most widely used military frameworks are the Department of Defense (DoD) Architecture Framework (DoDAF) in the USA and the Ministry of Defence (MOD) Architecture Framework (MODAF) in the UK. Military Architectural Frameworks such as

DoDAF define a standard way to organize an enterprise architecture (EA) or systems architecture into complementary and consistent views. DoDAF originally only contained four basic views: the overarching All Views (AV), Operational View (OV), Systems View (SV), and the Technical Standards View (StV/TV). Each view is aimed at different stakeholders, and it is possible to create cross-references between the views. Although they were originally created for military systems, they are commonly used by the private, public and voluntary sectors around the world, to model complex organizations such as humanitarian relief organizations and public services such as the Federal Emergency Management Agency (FEMA). Their goal is to improve planning, organization, procurement and management of these complex organizations. All major DoD weapons and information technology system procurements are required to document their enterprise architectures using DoDAF.

Evolution of Frameworks. Since the introduction of DoDAF, military architectural frameworks have been extended, resulting in several different versions. A short list includes MODAF (UK), NAF (NATO), AGATE (France), DNDAF (Canada), MDAF (Italy), and AusDAF (Australia). Each one adds to, redefines and/or clarifies the concepts, views, viewpoints and concerns contained within Military Architectural Frameworks, with the intention of improving procurement, planning, and implementation of military systems. However, supporting multiple and sometimes divergent frameworks leads to problems for industry, military organizations and tool vendors alike. In this age of globalization, mil-aero companies provide systems across the world to multiple governments. Often they must be specified in the local Architectural Framework creating extra overheads. Incompatible frameworks cause interoperability problems between governments because models cannot be exchanged. Interchange, even between modeling tools supporting the same framework, is difficult, if not impossible due to the different underlying implementations. Finally, having to support several constantly changing framework formats means that modeling tool vendors have a support nightmare. Figure 1 shows the evolution and relationships between DoDAF, MODAF, DNDAF and NAF.

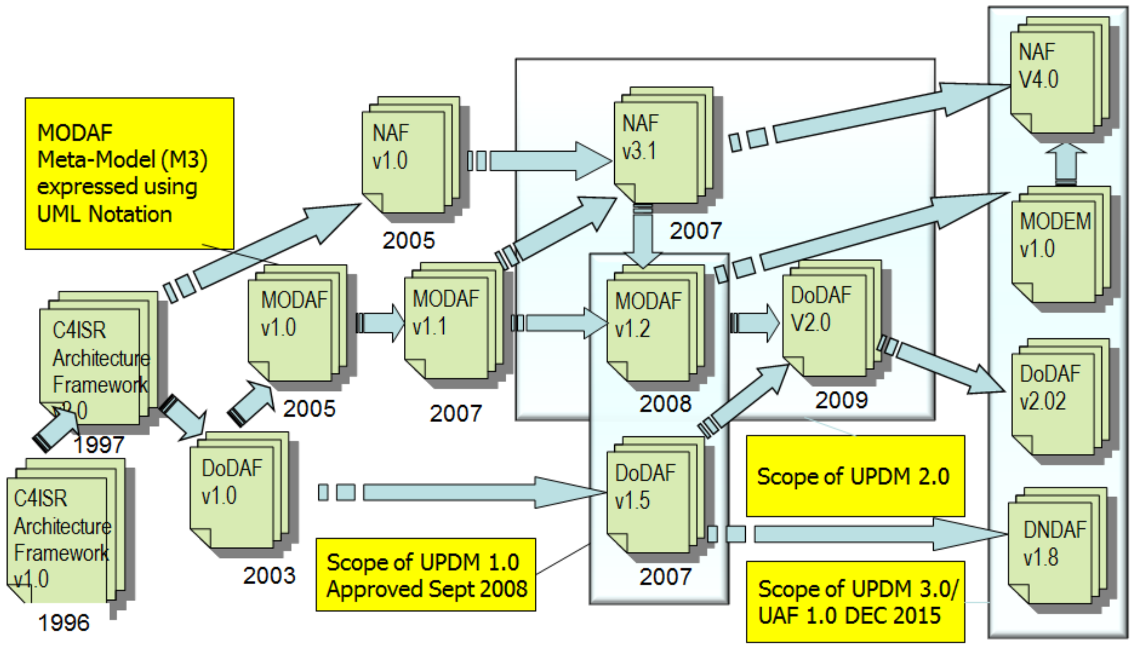


Figure 1. A Simplified History of DoDAF, MODAF and NAF

Framework Family History. Figure 1 shows how the different frameworks all started with C4ISR, but have iteratively diverged and merged over time. For example, MODAF kept compatibility with the core DoDAF viewpoints in order to facilitate interpretation of architectural information with the US. However, MODAF v1.0 added two new viewpoints. The new elements were the Strategic (DoDAF Capability) and Acquisition (DoDAF Project) Viewpoints. These were added to better contribute to MOD processes and life-cycles, specifically the analysis of the strategic issues and dependencies across the entire portfolio of available military capabilities within a given time frame. In MODAF v1.2, Service views were added to support the development of Service Orientated Architectures (SOA). These were based on the NAF 3.0 service views, as well as the DoDAF 2.0 Service (SvcV) views. In order for meaningful interchange to take place, it is necessary for the different frameworks to have the same semantic and ontological concepts and relationship. This is the purpose of the International Defense Enterprise Architecture Specification for exchange (IDEAS) Group. (IDEAS, 2015)

IDEAS

The latest versions of DoDAF, MODAF, and NAF all use the IDEAS Ontology to model their core concepts. The IDEAS Group was set up in 2005 to examine the issue of interoperability of Enterprise Architecture Data. The group consists of subject matter experts on the Australian, Canadian, UK and USA defense architecture frameworks. NATO and Sweden are observer members. These experts have been working together in the IDEAS Group to define a common information structure for data exchange.

Further Adoption of IDEAS

The current versions of NAF and MODAF are influenced by IDEAS to some degree but are still UML profiles. An update to MODAF called MODEM has however been prepared which is based entirely on the IDEAS Foundation ontology. This more direct implementation of the IDEAS foundation elements means that MODAF will be expressed as an ontology. MODEM has been proposed as a candidate for the next version of NAF, which would make NAF and MODAF the same to all intents and purposes. For more information on the NAF/MODAF mapping see appendix D of the UPDM specification (OMG, 2012).

The Evolution of UPDM

The Unified Modeling Language (UML) and the Systems Modeling Language (SysML) can be used as an underlying mechanism for all of these frameworks. SysML is an example of a UML Profile. SysML includes new concepts such as enhanced interface and flow specifications, system concepts, parametrics, integrated requirements and others. UPDM inherits all of these concepts providing additional systems engineering capabilities as well as a mechanism for traceability to SysML implementation models.

The UPDM Group. In March 2008, the UPDM Group was re-formed by members of INCOSE and the OMG to create the Unified Profile for DoDAF and MODAF (UPDM) using UML/SysML. Members of the UPDM Group were tool vendors, members of industry and representatives from the US DoD, British MOD, NATO, Canadian and Swedish armed forces. Members of the DoDAF 2.0 taskforce were heavily involved to ensure that DoDAF 2.0 and UPDM converged as much as possible. (OMG 2005, OMG 2009a). Tools supporting UPDM have been available for some time and are in use on multiple projects.

What is UPDM? It is important to stress that UPDM is not a new Architectural Framework. Instead, UPDM provides a consistent, standardized means to describe DoDAF, MODAF and

NAF architectures in UML-based tools as well as a standard for interchange. UPDM, like DoDAF, MODAF and NAF is also process agnostic and it is also not a methodology. The goals of UPDM are to significantly enhance the quality, productivity, and effectiveness associated with enterprise and system of systems architecture modeling, promote architecture model reuse and maintainability, improve tool interoperability and communications between stakeholders, and reduce training impacts due to different tool implementations and semantics. Customized views can still be created, but they are based on core UPDM rather than requiring bespoke development. Finally, the SysML foundation will improve the integration between architectural framework modeling and system modeling to support post acquisition life-cycle design and implementation. In summary, UPDM provides a common meta-model within which MODAF, DoDAF and NAF architectures can be developed and interchange can be realized between tools developed by different UPDM tool vendors.

Further Integration of Frameworks

As mentioned earlier, the various national architecture frameworks will continue to evolve over time. Creating and maintaining the mapping between the different frameworks takes a considerable amount of time, effort and money on the part of the nations, the tool vendors, and industry. In addition, each nation maintaining its own framework is also an enormous undertaking. In these days of limited budgets, austerity measures and "Doing more without more", this may be a luxury that the nations can no longer afford. These and many other reasons are the driving force behind the development of a Unified Architecture Framework, or UAF. The start of detailed discussions concerning how to merge DM2 with MODEM is the starting point for the development of the UAF. A unified framework could also easily take into account the needs originating from Canada's DNDAF regarding security views as well as additional views from other frameworks such as Human Factors Views.

UPDM 3.0

In March of 2014, a Request for Proposal for UPDM 3.0 was created with the following preface: "The scope of UPDM V3.0 includes support for modeling architectures, heretofore referred to as Architecture Descriptions (ADs) as defined in [ISO/IEC/IEEE 42010:2011], based on SysML V 1.3, where such an AD consists of a collection of views and constituent model (s) that represent a set of UPDM-specified governing viewpoints (stakeholders' concerns). The scope of UPDM V3.0 also includes mechanisms for developing custom views to represent user-specified viewpoints. The intent is to use the UPDM V3.0 to provide a standard representation for AD support for Defense Organizations. Another intent is to improve the ability to exchange architecture data between related tools that are UML/SysML based and tools that are based on other standards. The profile should include support for developing an AD for a set of viewpoints such as project, operational, capability, services, systems, standard, security and performance viewpoints, to include modeling and relating such elements as activities, nodes, system functions, ports, protocols, interfaces, systems' physical properties, and units of measure as defined by the architecture frameworks DoDAF, MODAF/ MODEM, NAF, and the Security Viewpoint from DNDAF. In addition, the profile should allow for the modeling of related domain concepts such as DoD's Doctrine, Organization, Training, Materiel, Leadership & education, Personnel, and Facilities [DOTMLPF], the UK Ministry of Defence Lines of Development [DLOD] elements which are: Training, Equipment, Personnel, Information, Concepts and Doctrine, Organisation, Infrastructure, Logistics (TEPID OIL), and the NATO equivalent." (OMG, 2014) The first draft of the specification will be submitted in December, 2015, and the final draft in March 2016.

Implementation Philosophy

The UAF Profile (UAFP) was developed using a model-driven approach. A simple description of the work process is:

- The Domain Metamodel (DMM) was created using UML Class models to represent the concepts in DoDAF, MODEM, NAF, DNDAF and the other contributing frameworks.
- The concepts from these frameworks were aligned and unified (where possible) to provide a common domain metamodel that could be used by all the contributing frameworks thereby separating the metamodel from the presentation layer defined in the contributing framework.
- The viewpoints defined in the various frameworks were also aligned and renamed to provide a common generic name for each viewpoint. It should be noted that the term viewpoint here is used in the context of ISO 42010 where a viewpoint is the specification of a view. These viewpoints were then mapped to the corresponding viewpoint in the relevant contributing framework. This provides an abstraction layer that separates the underlying UAF from the presentation layer.
- The intent of the UAF is to provide a Domain MetaModel that can be used by non UML/SysML tool vendors who may wish to implement the UAF in their own tool and metalanguage.
- The DMM concepts were mapped to corresponding stereotypes in the Profile.
- The Profile was analyzed and refactored to reflect language architecture, tool implementation, and reuse considerations.
- The Profile diagrams, stereotype descriptions, and documentation were added.
- The specification was generated from the profile model.

This approach allowed the team to concentrate on architecture issues rather than documentation production. The UML tool automatically maintained consistency. The UML tool also enabled traceability to be maintained between the profile and the DMM where every stereotype is linked to the DMM element using UML Abstraction relationship. There are two key parts to this submission:

1. A UAF (Appendix A) which provides the domain meta-model and viewpoints for the framework. This enables non-UML tool vendors to implement it.
2. A UAF Profile for UML/SysML derived from the UAF that specifies how UML/SysML tool vendors should implement the profile.

The intent from this two-document approach is to make the specification practical to implement for both UML/SysML and non-UML/SysML tool vendors. The way that the DMM and profile has been defined enables SysML tool vendors (if their tools allow) to carry out behavioral analysis based upon simulation and the evaluation of non-functional requirements based upon parametric diagram execution and analysis. For implementers of non-SysML tools it is hoped that they can achieve similar types of analysis using proprietary technology. It is expected that implementers of this specification should follow the view naming conventions of the framework they are intending to implement based on this specification.

Mandatory Requirements

The following mandatory requirements were defined for UPDM V3.0. The current draft specification addresses all of these requirements.

1. Provide Domain Metamodel (Abstract Syntax and Constraints)

   The domain metamodel captures the concepts of the domain without regard to the target implementation selected. This means that non-UML based tools will be able to implement the UPDM 3.0 domain meta-model. The Domain Metamodel shall be derived from MODEM and DM2. The domain metamodel shall be expressed using a domain specific extension of UML. This same notation was used for the definition of DoDAF and MODEM. The purpose of the domain metamodel is to ensure that the concepts of the domain are adequately covered and provide a "native language" implementation of UPDM V3.0.

2. An Architecture Framework Profile Using SysML

   The decision was made to implement UPDM in SysML rather than UML in order to preserve the technical nature of the profile and ensure a traceable transition to systems engineering models and representations.

3. Enable the Expression Of Business Process Models

   BPMN is commonly used for the description of operational/business process models (i.e., OV-5b). Currently the BPMN and DoDAF models are disjointed and disconnected. Integrating the two will result in an integrated framework. An example model to illustrate the use of BPMN in applicable operational/business views will be provided. The standard BPMN syntax and semantics to enable the expression of business process models will also be used. The elements appearing on a business process model shall be integrated and constitute part of the AD from an operational/business process model viewpoint.

4. Architecture Modeling Support for Defense Organizations

   Submitters shall provide the ability to represent an internally consistent common core of artifacts for a set of defined viewpoints that support Defense Organizations' modeling needs. Submitters shall conform to the definitions of viewpoint, view, and constituent models provided in Appendix A.2 as sourced from [ISO/IEC/IEEE 42010:2011].

   Submitters shall provide the ability to represent viewpoints defined in DoDAF, MODAF/ MODEM, NAF, and the Security Viewpoint from DNDAF. A common core of elements and relationships needed to support these frameworks' viewpoints is expected to form the UPDM V3.0. For specific versions of architecture frameworks such as NAF, the versions to be implemented shall be the latest approved versions published at the websites. It is expected that updates to the supported frameworks will be ongoing and that updates to the submission will occur in accordance with OMG defined processes.

5. Use of SysML Requirements Elements and Diagrams

   Submitters shall provide the ability to use SysML Requirements Elements with visualization on SysML Requirements Diagrams, Tables, and Matrices, and to define relationships to relevant architecture elements.

6. Use of SysML Parametrics Elements and Diagrams Mapped to Measurements

   Submitters shall provide the ability to use SysML Parametrics, Elements and Diagrams to specify mathematical constraints on the structural elements of an AD. These elements shall be reflected in the UPDM V3.0 views and constituent models that represent a measurement viewpoint, such as SV-7.

7. Support for Data and Information Viewpoints: Conceptual, Logical, and Physical Schema Views and Constituent Models

   The purpose of a data model is to design the data structure, handling, and storage functionality of an information system. The terms "conceptual, logical, physical" are frequently used in data modeling to differentiate levels of abstraction versus detail in the model. Submitters shall provide the ability to develop a conceptual data model showing how the operational/business world sees information. Submitters shall provide the ability to develop a logical data model. Submitters shall provide the ability to incorporate by external reference a physical data model from within the architecture model. The physical data model specifies implementation details which may be features of a particular product or version, as well as configuration choices for that database instance.

8. Traceability Matrix for Backward Compatibility with UPDM 2.x

   Submitters shall provide a non-normative mapping table from UPDM V2.x to UPDM V3.0. The purpose of the mapping table is to provide a path for tool vendors to offer backward compatibility at the profile element level. This includes elements that have been added, removed, and extended, and in many cases this will not be a one-to-one element mapping.

9. Requirements Traceability Matrix to Supported Frameworks

   Submitters shall provide a requirements traceability matrix to the supported frameworks DoDAF, MODAF/MODEM, NAF, and DNDAF. 100% compliance will not be deemed necessary. Traceability will be from the framework specifications to the UPDM V3.0 domain metamodel.

10. Example Architecture Description

    Non-normative: Submitters shall provide an expanded architecture description example to illustrate the majority of the viewpoints defined in the unified framework. The example shall include informative guidance on traceability of elements and relationships across artifacts.

11. Matrix of Applicable Elements and Relationships For Each Presentation Artifact

    Normative: Submitters shall provide a traceability matrix for each supported diagram, matrix, table, etc. artifact that lists mandatory UPDM V3.0 elements and relationships for that artifact.

12. Model Interchange

Submitters shall support XMI as the model interchange mechanism for UPDM V3.0 It is an OMG requirement that submissions contain an XMI export of any profile. See table in section 6.3.1 for XMI version. The Model Interchange Special Interest Group (MISIG) is currently developing UPDM-related test cases.

13. Extensibility to Enable The Definition Of Custom Viewpoints

Submitters shall provide extensibility mechanisms to allow end users to define custom viewpoints. This is to enable end users to present information in the AD that cannot otherwise be described using the unified profile's set of prescribed viewpoints .

Non-mandatory features

Optional requirements for the UPDM V3.0 are presented in this section:

1. UML Profile for NIEM

Submitters may integrate the UML Profile for NIEM [NIEM]. This profile will enable the integration of Information Exchange Definitions conforming to the NIEM 2 specification, if that Profile has been finalized. These concepts are addressed in the [NIEM]. The integration of the UML Profile for NIEM will support:

2. Information Exchange Packaging Policy Vocabulary

Submitters may integrate the UML Profile for the Information Exchange Packaging Policy Vocabulary [IEPPV]. Finalization of the specification is expected to complete in March 2014.

3. Viewpoints in Support of SoS Life Cycle Processes and Analyses

Submitters may define a set of viewpoints and provide the end users with an ability to develop views for System of Systems (SoS) life cycle processes that support analyses needed to answer SoS review questions.

4. Support for Additional Viewpoints

Submitters may define additional viewpoints beyond those defined in DoDAF, MODAF/ MODEM, NAF, and the Security Viewpoint from DNDAF; and may provide the end users with an ability to develop views for additional unique artifacts (e.g., the Risk Assurance profile from OMG, cost-schedule, reliability, political and/or other viewpoints.)

5. Export to RDF

Submitters may define the profile as a metamodel that is sufficiently formal such that instance ADs (developed using this profile) can be exported to RDF in a standard format (e.g., Turtle, OWL) selected by the submitters.

6. Human Systems Integration (HSI)

Submitters may provide support for HSI: this optional requirement for HSI is to examine the abilities contained within the supported frameworks and demonstrate in a non-normative example how HSI can be expressed and/or evaluated. The submission may also identify any capability gaps in this area.

[Note]: The term Human Systems Integration is not universal in its meaning, connotation and denotation. The US DoD Defense Acquisition Guidebook describes Human Systems Integration (HSI) as manpower, personnel, training, environment, safety and occupational health, human factors engineering, survivability, and habitability. These can and should be used to help determine and address the science and technology gaps to address all aspects of the system (hardware, software, and human). There have been various initiatives by the DoD, MOD and NATO to integrate HSI into architectural frameworks. These have all been useful and informative. However, none of these has emerged as an internationally recognized standard or been officially integrated into the corresponding architectural framework.

7. Use of Diagram Definition Specification

Submitters may provide the ability for modeling and interchanging graphical notations, specifically node and arc style diagrams as found in UML, SysML, and BPMN, through The Diagram Definition (DD) specification [DD].

8. Architecture Data Interchange Mappings and Transformations

Submitters may provide mappings and transformations to proprietary data schemas which are outside the scope of the OMG standards. These mappings and transformations will enable tools that implement UPDM V3.0 to more readily import and export architecture data that otherwise would not be directly interoperable with UPDM V3.0 architecture data.

A Unified Architecture Framework (UAF)

In September of 2012, there was a multi-national meeting at NATO headquarters in Brussels to discuss the development of UAF. Each organization presented their view of the project requirements, the current issues, potential solutions and a projected timetable to work towards an agreement. Note: This section does not contain any specific references. Okon (2012) contains a summary of the meeting reports and is detailed below:

The requirements were laid out as follows:

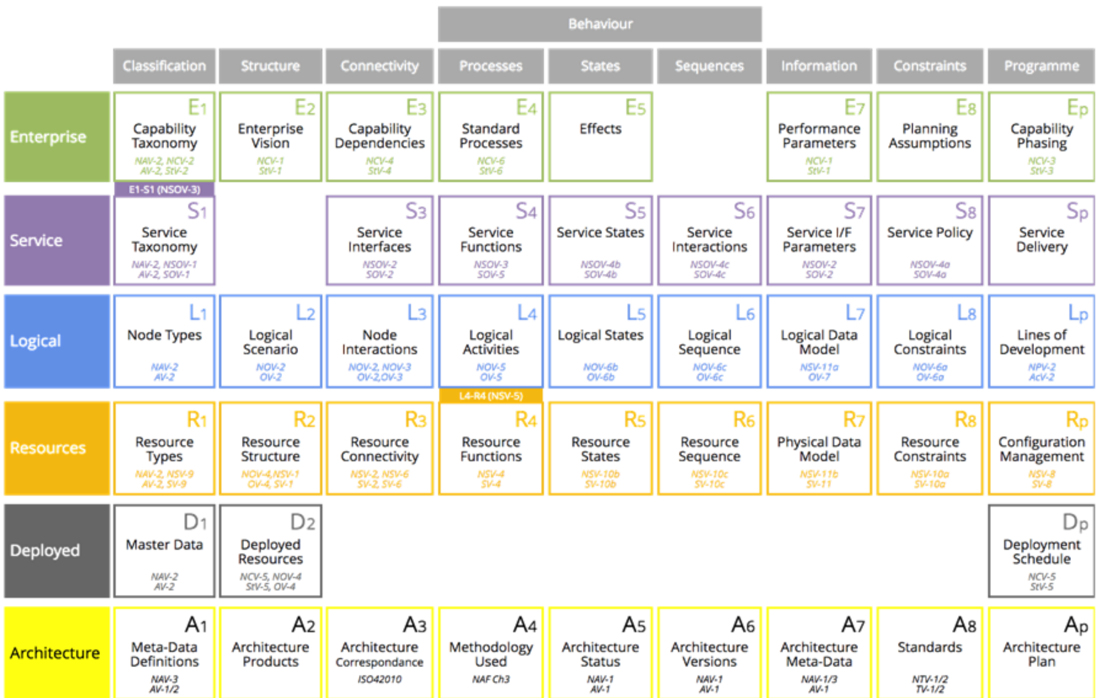
- Australia, Canada, UK, USA and Sweden have a history of military co-operation and coalition.
- How do we ensure coalition interoperability?
- Need to understand:
  - Each other's capability and functionality.
  - How to interface with coalition systems.
- To do this we need to be able to produce and share architectures.
- Each nation has its own architecture framework.
  - Requirement to share architectural information between nations to enable interoperability at the operational and system levels.
  - Need a standard data format for architectural interoperability.
  - Nations using different tools and data formats.
- The various national and coalition frameworks are both costly to maintain and have differences in interpretation/meaning which make them sub-optimal when planning coalition operations.

- A move towards a unified framework which will reduce development costs and on-going maintenance costs whilst improving interoperability is the preferred way forward.
- Having defined the requirements and the common issues facing the group, the major objectives for the group were then laid out.
- Develop a Unified Enterprise Architecture Metamodel to provide a basis for a Unified Architecture Framework
- Deliver a specification for the exchange of architectural documentation and artifacts between coalition partners for the purpose of Capability based Coalition Military Operations.
- To establish an oversight mechanism to perform configuration control activities.
- To develop a roadmap for implementation of the Unified Metamodel.
- To move towards a Unified Architecture Framework.
- The benefits of a UAF were listed as follows:
    - Reduced national, NATO and coalition investment in Architecture framework development
    - Standardization of Frameworks will enable more interoperable tools to support planning using an architectural approach
    - By greater shared awareness and frameworks the risk of misinterpretation is reduced ultimately reducing front-line risk

The authors of this paper, who are also submitters to the UPDM 3.0 specification, believe that the UPDM 3.0 submission meets the requirements listed above. For this and many other reasons outlined in this paper, we have renamed UPDM 3.0 to UAF 1.0.

View Matrices

Figure 2 contains a proposed matrix for the NAF 4.0 views to be released at some point in the future. (NATO, 2016)



- Figure 2. NATO NAF View Matrix

Along the left side of the matrix are the different levels of abstraction of the architecture: enterprise, service, logical, resources, deployed and architecture. Across the top of the matrix are the different types of diagram categories: classification, structure, connectivity, processes, states, sequences, information, constraints and programme. In the intersection of the matrices are the different views as well as a translation to the previous views for NAF and MODAF. For example, the intersection of logical connectivity is the operational node diagram OV-2 and the OV-3 generated report, called the node interaction view. By changing the format to the matrix view shown in Figure 2, it more clearly represents the different concerns and provides a means of defining further fit for purpose views. Figure 3 shows the UAF view matrix with some modifications from the NAF version.

	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Interaction Scenarios Is	Information If	Parameters Pm	Constraints Ct	Roadmap Rm	Traceability Tr
Metadata Md	Metadata Taxonomy Md-Tx	Architecture Viewpoints Md-Sr	Metadata Connectivity Md-Cn	Metadata Processes[a] Md-Pr	-	-			Metadata Constraints Md-Ct		Metadata Traceability Md-Tr
Strategic St	Strategic Taxonomy St-Tx	Strategic Structure St-Sr	Strategic Connectivity St-Cn	-	Strategic States St-St	-			Strategic Constraints St-Ct	Strategic Deployment, St-Rm Strategic Phasing St-Rm	Strategic Traceability St-Tr
Operational Op	Operational Taxonomy Op-Tx	Operational Structure Op-Sr	Operational Connectivity Op-Cn	Operational Processes Op-Pr	Operational States Op-St	Operational Interaction Scenarios Op-Is			Operational Constraints Op-Ct	-	Operational Traceability Op-Tr
Services Sv	Service Taxonomy Sv-Tx	Service Structure Sv-Sr	Service Connectivity Sv-Cn	Service Processes Sv-Pr	Service States Sv-St	Service Interaction Scenarios Sv-Is	Conceptual Data Model,	Environment Pm-En	Service Constraints Sv-Ct	Service Roadmap Sv-Rm	Service Traceability Sv-Tr
Personnel Pr	Personnel Taxonomy Pr-Tx	Personnel Structure Pr-Sr	Personnel Connectivity Pr-Cn	Personnel Processes Pr-Pr	Personnel States Pr-St	Personnel Interaction Scenarios Pr-Is	Logical Data Model,		Competence, Drivers, Performance Pr-Ct	Personnel Availability, Personnel Evolution, Personnel Forecast Pr-Rm	Personnel Traceability Pr-Tr
Resources Rs	Resource Taxonomy Rs-Tx	Resource Structure Rs-Sr	Resource Connectivity Rs-Cn	Resource Processes Rs-Pr	Resource States Rs-St	Resource Interaction Scenarios Rs-Is	Physical schema, real world results	Measurements Pm-Me	Resource Constraints Rs-Ct	Resource evolution, Resource forecast Rs-Rm	Resource Traceability Rs-Tr
Security Sc	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	-	-			Security Constraints Sc-Ct	-	Security Traceability Sc-Tr
Projects Pj	Project Taxonomy Pj-Tx	Project Structure Pj-Sr	Project Connectivity Pj-Cn	Project Process PJ-Pr-	-	-			-	Project Roadmap Pj-Rm	Project Traceability Pj-Tr
Standards Sd	Standard Taxonomy Sd-Tx	Standards Structure Sd-Sr	-	-	-	-			-	Standards Roadmap Sd-Rm	Standards Traceability Sd-Tr
Actuals Resources Ar		Actual Resources Structure, Ar-Sr	Actual Resources Connectivity, Ar-Cn	Simulation					Parametric Execution/ Evaluation[b]	-	-
Dictionary Dc											
Summary & Overview Sm-Ov											
Requirements Req											

Figure 3. UAF View Matrix

Across the top of the matrix, roadmap has replaced programme and traceability has been added. Along the left of the matrix most of the elements have been replaced. These include Metadata, strategic, operational instead of logical, personnel has been added to reflect human views, security views have been added to support the implementation of the DNDAF security views, standards have their own section rather than reflect architecture constraints and actuals have been added for simulation and implementation architectures. These additional columns and rows allow for other frameworks to be mapped onto the grid putting the emphasis on the underlying metamodel to support a set of concerns realized as a viewpoint and instantiated as a view. Hence this creates a semantic unification of concepts and relationships. A summary of the views follows:

View Type (Columns)

- Taxonomy Tx: Presents all the elements as a standalone structure. Presents all the elements as a specialization hierarchy, provides a text definition for each one and references the source of the element
- Structure Sr: Describes the definitions of the dependencies, connections, and relationships between the different elements.
- Connectivity Cn: Describes the connections, relationships, and interactions between the different elements.
- Processes Pr: Captures activity based behavior and flows. It describes activities, their Inputs/Outputs, activity actions and flows between them.
- States St: Captures state-based behavior of an element. It is a graphical representation of states of a structural element and how it responds to various events and actions.
- Interaction Scenarios Is: Expresses a time ordered examination of the exchanges as a result of a particular scenario. Provides a time-ordered examination of the exchanges between participating elements as a result of a particular scenario.
- Information If: Address the information perspective on operational, service, and resource architectures. Allows analysis of an architecture's information and data definition aspect, without consideration of implementation specific issues.
- Constraints Ct: Details the measurements that set performance requirements constraining capabilities. Also defines the rules governing behavior and structure.
- Roadmap Rm: Addresses how elements in the architecture change over time. Also, how at different points in time or different periods of time.
- Traceability Tr: Describes the mapping between elements in the architecture. This can be between different viewpoints within domains as well as between domains. It can also be between structure and behaviors.

Domains (Rows)

- Metadata Md: Captures meta-data relevant to the entire architecture. Provides information pertinent to the entire architecture. Present supporting information rather than architectural models.
- Strategic St: Capability management process. Describes the capability taxonomy, composition, dependencies and evolution.
- Operational Op: Illustrates the Logical Architecture of the enterprise. Describes the requirements, operational behavior, structure, and exchanges required to support (exhibit) capabilities. Defines all operational elements in an implementation/solution independent manner.
- Services Sv: The Service-Orientated View (SOV) is a description of services needed to directly support the operational domain as described in the Operational View. A service within MODAF is understood in its broadest sense, as a unit of work through

which a provider provides a useful result to a consumer. The Service Views within DoDAF describe the design for service-based solutions to support operational development processes (JCIDS) and Defense Acquisition System or capability development within the Joint Capability Areas.

- Personnel Pr: Defines and explores organizational resource types. Shows the taxonomy of types of organizational resources as well as connections, interaction and growth over time.
- Resources Rs: Captures a solution architecture consisting of resources, e.g. organizational, software, artifacts, capability configurations, and natural resources that implement the operational requirements. Further design of a resource is typically detailed in SysML.
- Security Sc: Security assets and security enclaves. Defines the hierarchy of security assets and asset owners, security constraints (policy, laws, and guidance) and details where they are located (security enclaves).
- Projects Pj: Describes projects and project milestones, how those projects deliver capabilities, the organizations contributing to the projects and dependencies between projects.
- Standards Sd: MODAF: Technical Standards Views are extended from the core DoDAF views to include non-technical standards such as operational doctrine, industry process standards, etc. The Standards Views within DoDAF are the set of rules governing the arrangement, interaction, and interdependence of solution parts or elements.
- Actual Resources Ar: The analysis, e.g. evaluation of different alternatives, what-if, trade-offs, V&V on the actual resource configurations. Illustrates the expected or achieved actual resource configurations.

Conclusions

Collaboration between the nations in pursuit of shared strategic goals is becoming the standard rather than the exception. Clear interchange of information, plans, strategies, goals, etc. is essential to successful collaboration. The plethora of different frameworks presents a barrier to clear interchange due to differences in frameworks, tools, standards, processes, interchange formats, terminology and process. UPDM advanced the development of architectures by virtue of its common framework, multiple tool implementations, and a common standard for interchange. A Unified Architecture Framework (UAF) will take this even further by providing a common framework. This will also help to reduce costs, improve understanding, and provide true interchange of data. Reference architectures will take this further by providing a meaningful definition of common concepts and architectures. It will also be necessary to further define interchange standards for non-UPDM tools. As it currently stands, a solution to the problems that we face does not exist. However, there is a determination to continue down this path until we have achieved our goals. And we believe that the UAF is the best way to achieve those goals together.

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Biography

Matthew Hause is an Engineering Fellow at PTC, the co-chair of the UPDM group, a member of the OMG Architecture Board, and a member of the OMG SysML specification team. He has been developing multi-national complex systems for almost 35 years. He started out working in the power systems industry and has been involved in military command and control systems, process control, communications, SCADA, distributed control, and many other areas of technical and real-time systems. His roles have varied from project manager to developer. His role at PTC includes mentoring, sales presentations, standards development and training courses. He has written a series of white papers on architectural modeling, project management, systems engineering, model-based engineering, human factors, safety critical systems development, virtual team management, systems development, and software development with UML, SysML and Architectural Frameworks such as DoDAF and MODAF. He has been a regular presenter at INCOSE, the IEEE, BCS, the IET, the OMG, DoD Enterprise Architecture and many other conferences.

Graham Bleakley Originally studied Mechanical Engineering, this was followed by a PhD in Model Based Systems Engineering and Process for Safety Critical Systems. Graham originally joined I-Logix in 2000 and was eventually acquired by IBM in 2008/9. Over the past 15 years he has worked as a senior consultant with a number of aero, defence (BAE, MBDA, Raytheon, Lockheed Martin, SAAB, Thales etc) and automotive companies (Volvo, Daimler, Lear, Valeo, GM), helping them implement model based systems engineering and use UPDM. He has written and presented a number of technical papers for INCOSE as well for other conferences and publications on the themes of Model Based Systems Engineering and Enterprise Architecture. He is currently a Solution Architect in IBMs IOT Watson group, where he helps develop integrated solutions based upon IBM development products. His latest projects are around developing solutions for the Industrial Internet of Things working with the IIC. He is also working on process and compliance modelling for ASPICE and how it integrates with ISO 26262. When not doing this, he works on Model Based System Engineering Process definition and Architectural Frameworks, he is the Lead Architect and one of the co-chairs of the OMG UPDM group and is one of the IBM representatives for the Industrial Internet Consortium.

Dr. Aurelijus Morkevicius is OMG Certified UML, Systems Modeling and BPM professional. He has 10 years of experience in Software and Systems Engineering. He has been with No Magic, Inc. since 2008. He started as a System Analyst for Defense Architecture solutions such as UPDM plugin for MagicDraw. In 2009 he moved to a Product Manager position for the Cameo Enterprise Architecture product. He is now a senior solution architect for model-based systems engineering (mostly based on SysML, UML) and defense architectures (DoDAF, MODAF, NAF) position. Currently he is head of the solutions department. He also participates actively in various modeling standards creation activities. He is a co-chair and one of the leading architects for the current OMG UPDM (UAF) standard development group. He is also actively involved in educational activities. He teaches Enterprise Architecture course in Kaunas University of Technology. He gained PhD in Informatics Engineering at the same university in 2013.