System Engineering Frameworks and needs of interoperability standards

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Airbus Helicopters roadmap to model based engineering

- Architecture Frameworks (AF’s) as core of mbse processes & methodology
- Use cases of interoperability with AF based mbse
- Overview of interoperability standards in the field of mbse
- Mapping approach UPDM on STEP AP233
- Analyses proposal of interoperability standards on mbse interoperability use cases & way ahead
System Engineering Architecture Frameworks (SE-AF’s) as core of mbse processes & methodology

NATO Architecture Framework (NAF), DODAF, MODAF, the OMG Unified Architecture Framework UAF and DS /ARCADIA
Convergence of main AF approaches towards the Unified Architecture Framework UAF

Nearly in parallel around 2003/4 the ministries of defense of UK (MODAF), USA (DODAF) and NATO (NAF) issued architecture frameworks based on EAV to support Defence planning and Defence products specification. They do this by enabling the capture and presentation of information in a rigorous, coherent and comprehensive way that aids the understanding of complex issues.

Starting from 2015 the Object Management Group (OMG) took the lead on developing the Unified Architecture.
Overview on NAF – Diagrams & use in the mbse
Example system views (physical architecture) on Helicopter landing gear

**Nsv1 signal flow**

- EBC: Electrical Brake Controller
- VMS: Visual Management System
- ra: Radio Altimeter
- Ig: Landing gear
- AMC: Aircraft Management Computer
UPDM defines a semantic data model for the NAF/ UAF & defines description methods

The SE Architecture framework

The semantic data dictionary

The development method

Unified Profile for DoDAF and MODAF (UPDM)

The model descriptions methods

Business process modeling language
A.2.3.2 OV-2 - DMM

MODAF: The Operational Node Relationships Description (OV-2) addresses localization of operational capability.

DoDAF: The Operational Resource Description (OV-2) DoDAF-described View applies the context of the operational capability to a community of anticipated users.

View definition in the UPDM domain meta model (DMM)

- Unified Profile for DoDAF and MODAF (UPDM); Version 2.1, Object Management Group, 2013;
  http://www.omg.org/spec/UPDM/2.1
8.3.1.1.2.3.1 Activity

UPDM: An abstract element that represents a behavior (i.e., a Function or OperationalActivity) that can be performed by a Performer.

MODAF: NA

DoDAF: Work, not specific to a single organization, weapon system or individual that transforms inputs (Resources) into outputs (Resources) or changes their state.

Note: Activity is abstract.

Data object definition in the UPDM domain meta model (DMM)

- Unified Profile for DoDAF and MODAF (UPDM); Version 2.1, Object Management Group, 2013; http://www.omg.org/spec/UPDM/2.1
An alternative SE-AF ARCADIA driven by Thales
Dassault Systèmes Architecture Framework approach

DS M&MS methodology: **Modeling & Methodology for Systems**

<table>
<thead>
<tr>
<th>System Visions</th>
<th>States</th>
<th>Static</th>
<th>Dynamic</th>
<th>Physical/Topology</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operational</strong></td>
<td>Missions</td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td><img src="image3" alt="Diagram" /></td>
<td><img src="image4" alt="Diagram" /></td>
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<tr>
<td>System Services</td>
<td><img src="image5" alt="Diagram" /></td>
<td><img src="image6" alt="Diagram" /></td>
<td><img src="image7" alt="Diagram" /></td>
<td><img src="image8" alt="Diagram" /></td>
<td><img src="image9" alt="Diagram" /></td>
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<tr>
<td><strong>Functional</strong></td>
<td>Functional Architecture</td>
<td><img src="image10" alt="Diagram" /></td>
<td><img src="image11" alt="Diagram" /></td>
<td><img src="image12" alt="Diagram" /></td>
<td><img src="image13" alt="Diagram" /></td>
</tr>
<tr>
<td><strong>Component</strong></td>
<td>Components Architecture</td>
<td><img src="image14" alt="Diagram" /></td>
<td><img src="image15" alt="Diagram" /></td>
<td><img src="image16" alt="Diagram" /></td>
<td><img src="image17" alt="Diagram" /></td>
</tr>
</tbody>
</table>
The Dassault Systemes Architecture Framework realization in 3D Experience

3D Experience toolset
Some mbse-tools covering architecture frameworks

And other tools: Vitech, Modellio, ….
Use cases of interoperability with AF based mbse

Interactive tools integration / model exchange & archiving
Use case #1 MBSE interoperability: Interactive tools integration.

**Rationale:** Inner company process integration.

Only if the digital continuity is achieved and the SE-model itself becomes the deliverable and can be reused process downstream without recoding, we can speak truly of a Model-based System Engineering.

- Mission analyses /conops
- Functional architecture
- Physical architecture & Physical behavior
- Doors Requirements Management
- LMS-Amesim
- Modelica
- MATLAB Simulink
- IGE-XAO Electric logic design

Resulting requirement: small fragments of model, high frequency, including transactional statements: get, put, del, checkin/out
Use case #2 MBSE interoperability: cross company model exchange and archiving

**Rationale:** extended enterprise & long term archiving

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**Resulting requirement:** large model portion or complete model, precise semantic capture, additional information identification, versioning, baselines and approval needed
Overview of interoperability standards in the field of mbse

OSLC, XMI & STEP AP233
Starting from the catalog you can discover services and their capabilities. This is a common pattern in OSLC.

OSLC capabilities:

- **Delegated UI Dialog** allows you to create or find resources using a UI provided by the OSLC tool.
- **Creation Factory** allows you to create resources programmatically.
- **Query Capability** allows you to query for resources.
XML: XML Metadata Interchange (XMI)

XML Metadata Interchange (XMI) is an Object Management Group (OMG) standard for exchanging metadata information via Extensible Markup Language (XML).

UPDM- XMI mapping existing

XMI is based on description language UML/SysML and does not bring an schema independant semantics, that would enable exchange between different SE-AF
The SEDRES Project: 

*The Roots of AP233*

(Systems Engineering Representation and Exchange Standardization)

SEDRES Project consisted of European aerospace companies

- Aerospatiale, Alenia, British Aerospace (now BAE Systems), DASA (now DaimlerChrysler), SAAB

Joint projects

- Gripen
- Eurofighter (EF2000)

Project focused on specific SE data exchanges

SEDRES initiated NWI in TC184/SC4 in 1998 to provide a means of publishing its work

Demonstrated that STEP could be used to exchange systems engineering information

The project was ahead of time:

- no real standard toolset existing at that time
The composite - component view is represented by Functional_element_usage instances relating the functional elements in the breakdown which are represented by Functional_elements.

EXAMPLE  A functional breakdown provides a decomposition of an aircraft in terms of high-level functional processes such as flight, taxiing and at rest all the way down to low-level processes such as detect onboard fuel level, move tail rudder and provide standard tow attachment point.
Mapping approach UPDM on STEP AP233
First mapping proposals of 2009 helped to clarify some ‘mechanics‘ but are not successful with more semantics.

Results of an INCOSE/ OMG Workshop 2009 to map SysML constructs on STEP AP233

<table>
<thead>
<tr>
<th>SysML</th>
<th>AP233</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block</td>
<td>System View Definition → System Version → System</td>
</tr>
<tr>
<td>Composition Association</td>
<td>Assembly Component Relationship relating two System View Definitions</td>
</tr>
<tr>
<td>Generalization</td>
<td>View Definition Relationship + Classification('Generalization')</td>
</tr>
<tr>
<td>Part/Part Definition</td>
<td>View Definition Relationship</td>
</tr>
<tr>
<td>Nested Part</td>
<td>Component Upper Level Identification</td>
</tr>
<tr>
<td>Multiplicity</td>
<td>Next Assembly Usage.quantity</td>
</tr>
<tr>
<td>Connector</td>
<td>Interface Connection</td>
</tr>
<tr>
<td>Port/Port Definition</td>
<td>Interface Connector</td>
</tr>
<tr>
<td>Delegation Port</td>
<td>Hierarchical Interface Connector</td>
</tr>
</tbody>
</table>

SyML and AP233 have a complete different level of semantic granularity!

Because of this, this approach was not successful.
Semantic mapping proposal UPDM-DMM on AP233

UPDM –DMM definition

8.3.1.4.1.2 OperationalActivity
MODAF: A logical process, specified independently of how the process is carried out. DoDIF: An activity is an action performed in conducting the business of an enterprise.

8.3.1.7.4.17 SystemResource
UPDM: Abstract element used as placeholder for resource properties. A SystemResource is the supertype of a physical resource, a ServiceAccess or a System Architecture.

STEP AP233 definition

Functional_breakdown is a type of Breakdown that identifies a partitioning of a product into a set of related functional elements so as to form explicit structural views that comprise the product elements.

EXAMPLE A functional breakdown provides a decomposition of an aircraft in terms of high-level functional processes such as flight, taxiing and at rest all the way down to low-level processes such as detect onboard fuel level, move tail rudder and provide standard tow attachment point.

A System_breakdown is a type of Breakdown that identifies a partitioning of a system into a set of related elements so as to form explicit, assembly - component views that comprise the system elements.

EXAMPLE A system breakdown provides a decomposition of an aircraft in terms of high-level mechanisms such as fuel system or flight control system - which might, in the second example, further decompose into low-level systems such as autopilot system and instrument landing system.
A first mapping example 'UPDM Maritime Rescue' NSV2 diagram
A first mapping example 'UPDM Maritime Rescue' mapping breakdown to AP233
A first mapping example 'UPDM Maritime Rescue' mapping interfaces to AP233
Analyses proposal of interoperability standards on mbse interoperability use cases & way ahaed

Recommendation for next steps
## Analyses proposal of interoperability standards on mbse interoperability use cases

<table>
<thead>
<tr>
<th>Use case of MBSE interoperability</th>
<th>OSLC</th>
<th>XMI</th>
<th>STEP AP233</th>
<th>explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1: Interactive tools integration</td>
<td>+++</td>
<td>+</td>
<td>-</td>
<td>OSCL is optimized for a quick communication between clients and resource providers carrying just the necessary model fragments in the message and the necessary transaction need. STEP models are too heavy for this, STEP and XMI do not reflect transactional information</td>
</tr>
<tr>
<td>#2: Cross company model exchange and archiving</td>
<td>-</td>
<td>+</td>
<td>+++</td>
<td>Neither OSCL nor XMI have a strong semantic foundation. Most tools write XMI-files as add on templatet to UML, in some cases loosing the info, if block is an operational activity or a system ressource. A UPDM – XMI definition is existing, but not covering CAPELLA, RFLP and other AF's. The semantic well elaborated data model of AP233 can cover the UPDM DMM and is compatible to AP242/239 approach!</td>
</tr>
</tbody>
</table>

Go for OSLC with interactive tools integration & STEP AP233 for model dex & archiving
Conclusions & proposed way ahead

- Beside Requirements Management and Trade Off studies, the use of Architecture Frameworks as Methodology become more and more best practice
- The Architecture Frameworks enable to link information from early phases of conceptual operation down to physical architecture of subsystems – requirements are elicitated at each level of Architecture
- Interoperability of mbse with AF-approach is required for (minimum) two use case: #1 Interactive mbse tools integration and #2 cross company model exchange and archiving
- Where as for the use case #1 it seems to be recommended to go ahead with OSLC for use case #2 we still need semantically precise defined model as defined by STEP AP233.

Way ahead proposal

- Start an edition2 of STEP AP233, where the UPDM-DMM increments the business object model / Application reference model - thereby linking the both standards
- Discuss with the OSLC standardization to reuse semantic defined model elements from STEP AP233 within the Subject-Predicate-Object definition
- Establish with the mbse tool vendors mbse-implementors forum to implement OSLC-connectors AND STEP AP233 processors!
Thank you for your attention