Agenda

- The purpose of modelling
- A solutions based approach
- Model-Based Engineering
  - SysML
  - UPDM
- Examples
- Quality and Process
- Questions?
Model-Based Engineering

- Model-based Systems Engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing through-out development and later lifecycle phases.” (INCOSE, 2007).

- Modeling is at the heart of all aspects of the development effort
  - Covers the complete product and project lifecycle
  - Has a direct effect on any generated artifacts.
  - MBE encompasses architecture, systems and software development.
What was the question?

- “All models are wrong, some models are useful.”
  Professor P.E. Box

- Models are an abstraction of the problem or solution space
  - Reflect an abstraction of one or more viewpoints

- A model should be created to answer one or more questions
  - Performance
  - Functionality
  - Timing
  - Structure
  - Usability
  - Project, Product, and Enterprise
    - Lifecycles
    - Efficacy
  - Etc.
Some sample questions

- How to communicate with non-experts?
- How to avoid the problems of stovepipe development?
- How to ensure that the model is consistent?
- How to ensure that systems deployment is in line with capability deployment requirements?
- How to ensure system interfaces are compatible?
- How to integrate requirements management into modeling?
- How to effectively use MBSE to provide measures of effectiveness/trade-off analysis?
- How to reuse architectures?
- How to support the development of safety critical and technical systems?
- Etc.
Outline

- Why?
  - The need for UPDM.

- When?
  - The history and projected timetable for UPDM.

- Who and Where?
  - Who is in the UPDM RFC Group?

- How?
  - How was the specification created?

- What?
  - What is UPDM in general?
    - A detailed look at a few things.

- Questions and answers?
Modeling at Multiple Levels of the System

Architecture Models

Systems Models

Component Models
Fit-for-Purpose describes an architecture that is appropriately focused and directly support customer needs or improve the overall process undergoing change. The models provide *choices*, based upon the decision-maker needs.
Essential Observation: Architectures Are Key

- Architecture: the structure of components, their relationships, and the principles and guidelines governing their design and evolution over time.
  - DoD Integrated Architecture Panel, 1995, based on IEEE STD 610.12, 19903

- The structure of components, their relationships, and principles and guidelines governing their design and evolution over time
  - IEEE STD 610.12

- An architecture is the fundamental organization of a system embodied in its components, their relationships to each other, and to the environment and the principles guiding its design and evolution
  - IEEE STD 1472

Architecture frameworks such as the DoDAF provide a consistent way to organize information about the architecture
What is UPDM? - Summary

- UPDM is a standardized way of expressing DoDAF and MODAF artefacts using UML and SysML
  - UPDM is **NOT** a new Architectural Framework
  - UPDM is not a methodology or a process
  - UPDM 2.0 DoDAF 2.0, MODAF, and NAF

- UPDM was developed by members of the OMG with help from industry and government domain experts.

- UPDM is a DoD mandated standard

- UPDM has been implemented by multiple tool vendors.
  - Tools supporting UPDM are available now.
Why? The need for UPDM.

Motivation

- US DoD and UK MOD interested in leveraging commercial standards for their Military Architecture Framework
- Military Architecture Framework Tool Interoperability
  - Key Goal for DoD, MOD, Enterprise and System Architects and Engineers
- Formal MetaModel basis for the Military Architecture Framework
  - Critical to Interoperability Objectives
  - Critical to Understanding Profile Requirements

Proliferation of Military Architectural frameworks

- DoDAF, MODAF, DNDAF, NAF, AGATE, ADOAF, MDAF, etc.
- Defence organizations, contractors and tool vendors are hoping to find a way out of the alphabet soup.
Why and When: Historical Development of AF’s.

* C4ISR Architecture Framework v1.0 (1996)
* DoDAF v1.0 (1997)
* MODAF v1.0 (2003)
* DoDAF v1.0 (1997)
* C4ISR Architecture Framework v1.0 (2005)

**DoDAF**
- DoDAF v1.0 (2003)
- DoDAF v1.1 (2007)

**MODAF**
- MODAF v1.0 (2005)
- MODAF v1.1 (2007)
- MODAF v1.2 (2008)

**NAF**
- NAF v1.0 (2003)

**DNDAF**
- DNDAF v1.7 (2008)

**DoDAF 2.0**
- DoDAF V2.0 (2009)

**Scope of UPDM 1.0**
- Started Sept 2009

**Scope of UPDM 2.0**
- Started Sept 2009

Approved Sept 2008
Who and Where: UPDM Team Members

- US DoD Liaison - DoD/DISA, OSD CIO, Mitre, Silver Bullet
- UK MOD Liaison - UK MOD, ModelFutures
- Canada DND Liaison – DND and ASMG Ltd
- NATO – Generic AB on behalf of SwAF and on contract by FMV
- Tool Vendors – Adaptive, Atego (Co-Chair), EmbeddedPlus, IBM (Co-Chair), Mega, NoMagic (Co-Chair), Sparx Systems, Visumpoint
- Aerospace – BAE Systems, General Dynamics, L3 Communications, Lockheed Martin, Northrop Grumman, Raytheon, Rolls-Royce, Selex SI, Thales, Unisys
- Advisors – Decisive Analytics
- Distributed multi national team (US, UK, France, Sweden, Lithuania, Australia, Canada, Thailand, Italy)
How: UPDM Features

- Integrates with SoaML – The Service Oriented Architecture Modelling Language
- SysML Extensions with UPDM level 1
  - Facilitates integration of DoDAF and MODAF models for system of systems modeling with SysML models for systems modeling
  - Enables UPDM to fully leverage SysML features
How: UPDM Level 1 Compliance SysML Extensions

- Enables UPDM to leverage SysML features
  - SysML blocks to represent structural elements such as operational nodes, artifacts (systems), capability configurations, which enable the use of flow ports, item flows, and value properties with units and distributions
  - SysML activities to support continuous flow modeling, activity hierarchies, and support for enhanced functional flow block diagrams
  - SysML parametrics to enable the integration of engineering analysis with the architecture models (e.g., performance parameters in an SV-7 can be captured in parametric equations)
  - SysML allocations to support various types of mappings such as an SV-5 that maps system functions to operational activities

- Other SysML Features
  - SysML requirements enable text based requirements to be captured and traced to other model elements using the satisfy, derive, verify and refine relationships
  - SysML view and viewpoint enable provide for multiple perspectives of the model, and to manage, control, and organize information.
  - Callout notation
Select the Viewpoints That Fit-the-Purpose

Architecture viewpoints are composed of data that has been organized to facilitate understanding.

- **Capability Viewpoint**
  Articulate the capability requirement, delivery timing, and deployed capability

- **Operational Viewpoint**
  Articulate operational scenarios, processes, activities & requirements

- **Services Viewpoint**
  Articulate the performers, activities, services, and their exchanges providing for, or supporting, DoD functions

- **Systems Viewpoint**
  Articulate the legacy systems or independent systems, their composition, interconnectivity, and context providing for, or supporting, DoD functions

- **Standards Viewpoint**
  Articulate applicable Operational, Business, Technical, and Industry policy, standards, guidance, constraints, and forecasts

- **Data and Information Viewpoint**
  Articulate the data relationships and alignment structures in the architecture content

- **All Viewpoint**
  Overarching aspects of architecture context that relate to all models

- **Project Viewpoint**
  Describes the relationships between operational and capability requirements and the various projects being implemented; details dependencies between capability management and the Defense Acquisition System process.
Color scheme

- Capability element
- Operational element
- System element
- Technical element
- Project element

Association (link) entity shown as lollipop
Capability viewpoint meta-model terms

Enterprises have phases that provide temporal context for capabilities, OVs etc.

Capabilities are enduring and have properties that describe their characteristics.

- **Enterprise Vision** has **EnterprisePhase** has **Enterprise Goal** supports **Capability** fulfills need for **System/Resource** delivers **Operational Activity**
- **Capability Increment** owns **EnterprisePhase** has sub-enterprise
- **Enterprise Goal** has **Enterprise Vision**
- **Capability** owns **System/Resource**
- **Operational Activity** depends on **Capability**
- **Capability** enables ability to conduct

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Operational viewpoint meta-model terms

- **Information Exchange**
- **Information Model**
- **Info Element**
- **(assembly of) Operational Activity***
- **(assembly of) Performer***
- **Location**
- **System/Resource**
- **organizational Resource**

- Conveys
- Bundles
- Defined by
- Conducts
- Realised by
- Has required
- Located at
- Organisational Resources are either types of organization or types of Post

* = can have operational behavior (e.g. statecharts)

Connections can also be material, personnel or energy flows

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Operational viewpoint meta-model terms – focus on organizations

DoDAF has typical organizations and actual organizations (the latter appear in Fielded Capabilities and PV-1 programme structures)
System viewpoint meta-model terms

System Port* provides System (assembly of) hosted on Physical Asset

Data Exchange realizes function flow carried by System Port* for part of System Element

Data Element conveys function flow realized by Physical Data Model

Physical Data Model defined by System Viewpoint encompasses solutions composed of system elements – this slide focuses only on equipment

Operational Activity supports Function (break down)
A project need not be an acquisition project; it could be a research programme etc.

A workstream may deliver any of the capability configuration elements.
Technical standards viewpoint meta-model terms

Standard

Operational Constraint

Constraint

System Constraint

Any Model element

is type of

Protocol

stacks

applies to

types of
Questions, Comments, Discussion
The “Yacht in Distress” Scenario

- The Sample Problem applies UPDM to a common scenario in civilian maritime Search and Rescue (SAR) operations -- a Yacht in distress. A Monitor Unit picks up the Distress Signal from the Yacht and passes it on to the Command and Control (C2 Center). The C2 Center coordinates the search and rescue operation among the Rescue Helicopter, a Naval Ship and a Rescue Boat.

- This model is based on a UK MOD example model.
How to communicate with non-experts?
OV-1a: Operational Context Graphic

Operational Concept

Concept Role

Arbitrary Relationship

Concepts can reference model elements
OV-1: Operational Context Graphic

Replaced boxes with graphics

Provides a means to communicate with non-technical stakeholders while maintaining model consistency.
OV-1 Mission Usage
How to avoid the problems of stovepipe development?
Capability

- DoDAF: The ability to achieve a desired effect under specified [performance] standards and conditions through combinations of ways and means [activities and resources] to perform a set of activities.

- MODAF: A high level specification of the enterprise's ability.

- DoDAF provides a means for capability acquisition and not just equipment acquisition
CV-1 Capability Vision

CV-1 [Architectural Description] Enterprise

WholeLifeEnterprise

Search and Rescue

startDate
2010-01-01 00:00:00

endDate
2014-06-01 00:00:00

Learn and Search

Event

startDate
2010-01-01 00:00:00

endDate
2010-12-01 00:00:00

Learn and Search

Event

startDate
2012-12-01 00:00:00

endDate
2014-06-01 00:00:00

Learn and Search

Event

goals
«EnterpriseGoal» Fulfill International Obligations

visions
«Vision» SAR Vision

exhibits
«Capability» Assistance
«Capability» Recovery
«Capability» Search

Learn and Search

Event

goals
«EnterpriseGoal» Maintain SAR Responsibility

visions
«Vision» SAR Vision

exhibits
«Capability» Assistance
«Capability» Recovery
«Capability» Search

Temporal Phases

High level view of enterprise goals and capability phasing

Measurements

Goals

Provided Capabilities

Vision
CV-2 Capability Taxonomy

“Capability dictionary” helps prevent stovepipes and duplication
CV-4 Capability Dependencies

- Required Capability
- Capability dependencies provide context for capability phases and resource deployment
How to coordinate systems and capability deployment?
# CV-4 Capability Phasing (Fragment)

## Capabilities (Coverage)

<table>
<thead>
<tr>
<th>Capabilities</th>
<th>Timeline</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
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<td><strong>Assistance</strong></td>
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<td></td>
</tr>
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<td>J F M A M J J A S O N D</td>
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<tr>
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<td></td>
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<td>weatherConditions = Heavy Rain</td>
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<td></td>
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<tr>
<td>[no measurements]</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>findTime = &lt;5 hours</td>
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<td></td>
</tr>
<tr>
<td>persistence = &gt;20 hours</td>
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<tr>
<td>weatherConditions = Stormy</td>
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<tr>
<td><strong>Distress Signal Monitoring</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[no measurements]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PV-1 Project Definition

Project Type

Provides milestone status as DOTMLPF or as custom definition

Configurable Project Themes

Sub-Project

Milestone Type

PV-3 [Architectural Description] Project Definitions

```
«ProjectType»

Development

themes

Equipment : DOTMLPF Status
Training : DOTMLPF Status
Concepts & Doctrine : DOTMLPF Status
Personnel : DOTMLPF Status
Information : DOTMLPF Status
Organization : DOTMLPF Status
Infrastructure : DOTMLPF Status
Logistics : DOTMLPF Status
Interoperability : DOTMLPF Status
```
PV-1 Actual Project

Definition of projects, sub-projects, milestones and dependencies
PV-2 Project Timelines

Dashboard view provides project status at a glance: generated from model
SV-1: Resource Interaction Specification

Associated Milestones

Systems aware of associated Milestones.
How to ensure that the model is consistent?
OV-2 Operational Nodes (Performers)

Architecture can be decomposed multiple levels. Optional ports can provide interface consistency.
OV-5 Activity Diagram

Activity Decomposition

«Activity(Operational)» Search

«ActivityPerformedByPerformer» «ActivityPerformedByPerformer» «ActivityPerformedByPerformer» «ActivityPerformedByPerformer»

«StandardOperationalActivity» Find Victim

«Activity(Operational)» Send Warning Order

«Activity(Operational)» «block» Search


«Activity(Operational)» Receive Distress Signal

«StandardOperationalActivity» Monitor Health

Provides activity decomposition and links to performers

Performer
OV-5 Search Activity Diagram (Fragment)

Parameters define interfaces. Activities can be reused.

OV-2 Context

Sub-Roles Correspond to OV-2

Data/Resource Flow

Parameter
DIV-2 Data Model

**Exchange Element**

**Data Definition**

**Data Relationship**

**Comprehensive data dictionary**
### OV-3 Operational Resource Flow Matrix (Fragment)

#### [Architectural Description] Notes

Generated automatically from the architecture

<table>
<thead>
<tr>
<th>Information</th>
<th>Producer</th>
<th>Needline</th>
<th>Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Conveyed</td>
<td>Performer</td>
<td>Activity (Operational)</td>
</tr>
<tr>
<td>DS2</td>
<td>«Information Element»</td>
<td>«Performer» Person in Distress</td>
<td>«Activity (Operational)» Send Distress Signal</td>
</tr>
<tr>
<td>DS2</td>
<td>«Information Element»</td>
<td>«Performer» Person in Distress</td>
<td>«Activity (Operational)» Send Distress Signal</td>
</tr>
<tr>
<td>DS3</td>
<td>«Information Element»</td>
<td>«Performer» Person in Distress</td>
<td>«Activity (Operational)» Send Distress Signal</td>
</tr>
<tr>
<td>DS3</td>
<td>«Information Element»</td>
<td>«Performer» Person in Distress</td>
<td>«Activity (Operational)» Send Distress Signal</td>
</tr>
<tr>
<td>Tsk</td>
<td>«Information Element»</td>
<td>«Performer» SAR Asset Control</td>
<td>«Activity (Operational)» Send Distress Signal</td>
</tr>
<tr>
<td>Tsk</td>
<td>«Information Element»</td>
<td>«Performer» SAR Asset Control</td>
<td>«Activity (Operational)» Send Distress Signal</td>
</tr>
<tr>
<td>Tsk</td>
<td>«Information Element»</td>
<td>«Performer» SAR Asset Control</td>
<td>«Activity (Operational)» Send Distress Signal</td>
</tr>
<tr>
<td>WO</td>
<td>«Information Element»</td>
<td>«Performer» Search</td>
<td>«Activity (Operational)» Send Warning Order</td>
</tr>
<tr>
<td>WO</td>
<td>«Information Element»</td>
<td>«Performer» Search</td>
<td>«Activity (Operational)» Send Warning Order</td>
</tr>
</tbody>
</table>
OV-6 Operational State Transition

Provides a definitive behavioral specification for owning element.

Owning Element: Waiting for Distress Signal
- Triggering Event: Monitor For Distress Signal
- Decision: [Receive Distress Signal] / Send Warning Order
- Transition: [Search Cancelled]
  - State: Search
  - Activities: Monitor Health
- Decision: [Victim Found]
  - Transition: [No Assistance Required]
    - State: Monitoring Victim
      - Activities: Monitor Health
- Decision: [Victim Secure]
  - Transition: [Victim Stable]
    - State: Rescuing Victim
      - Activities: Recover Victim, Transit to SAR Operation
Search and Rescue

Description:

- **PerformerRole**: Tactical C2
- **PerformerRole**: SAR Asset Control
- **PerformerRole**: Search
- **PerformerRole**: Monitoring
- **PerformerRole**: Rescue
- **PerformerRole**: Person in Distress
- **PerformerRole**: Place of Safety

**OV-6 Event Trace Transition**

**Owning Context**

PID broadcasts distressSignal
MN station detects PID distressSignal, triangulates location of source and transmits trackInfo to TC2N
TC2N sends request to SAR AC

par
SAR AC transmits tasking orders SN assets in vicinity of trackInfo
SAR AC (also) transmits tasking orders RN assets in vicinity of trackInfo
also par
TC2N assumes & maintains Command & Control of tasked SN assets throughout current SAR operation.

TC2N assumes & maintains Command & Control of tasked RN assets throughout current SAR operation.

end par

loop until each PID reaches PoS DO:

par
Continually monitor distressSignal and locate victims
Continually monitor distressSignal, locate victims and render aid
also par
Update SN assets of status of victims and vessels in operation
Transmit warningOrder to PoS on status of operation and victims
end par
end loop

**Exchanges (From OV-2)**

- Provides a means of validating the architecture using scenarios
How to model consistent organizational structures?
OV-4 Organizational Template

OV-4 [Architectural Description] Typical Organizations

Sub Organization Type

Organization Type

Owned Organization

Person Role Type (Billet)

Organization Member

Person

Defines organizational template from which actual organizations can be created
OV-4 Actual Organizations

Actual organization: conforms to template

«Organization»
Department Of Transport

«ActualOrganizationRelationship»
«Organization»
Maritime & Coastguard Agency

«ActualOrganizationRelationship»
«Organization»
Department Of Defense

«ActualOrganizationRelationship»
«Organization»
Volunteer Rescue Organization

«ActualPerson»
Danny Driver

«ActualPerson»
Ron Radio

«ActualPerson»
Sam Swimmer

«ActualOrganization»
Coastguard

«SubOrg»
«ActualOrganization»
«FillsPost»

«IndividualPersonRole»
Lifeboat Driver

«IndividualPersonRole»
Radio Operator

«IndividualPersonRole»
Rescue Swimmer

«IndividualPersonRole»
Rescue Helo Pilot

«ActualPost»
«FillsPost»

«ActualPerson»
Peter Pilot

Post Dates

startDate
2010-01-01 00:00:00
endDate
2014-01-01 00:00:00

startDate
2010-01-01 00:00:00
endDate
2014-01-01 00:00:00

startDate
2010-01-01 00:00:00
endDate
2014-01-01 00:00:00

startDate
2010-01-01 00:00:00
endDate
2014-01-01 00:00:00

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How to ensure system interfaces are compatible?
SV-1: Resource Interaction Specification

Systems can also be specified as services

Defines system and human interface requirements and interactions

Owning Context

System

Overlap

Person Role From OV-4

Interface
### SV-3 Connectivity Matrix

<table>
<thead>
<tr>
<th>Sending Resource</th>
<th>Receiving Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>「Material」 Link 1G (SAR Architecture:Resource:Resource Artifacts)</td>
<td>X</td>
</tr>
<tr>
<td>「PersonRoleType」 MRT Boat Driver (SAR Architecture:Organizational:Typical Organizations)</td>
<td>X</td>
</tr>
<tr>
<td>「PersonRoleType」 MRT Communicator (SAR Architecture:Organizational:Typical Organizations)</td>
<td>X</td>
</tr>
<tr>
<td>「PersonRoleType」 MRT Helicopter Pilot (SAR Architecture:Organizational:Typical Organizations)</td>
<td>X</td>
</tr>
<tr>
<td>「PersonRoleType」 MRT Searcher (SAR Architecture:Organizational:Typical Organizations)</td>
<td>X</td>
</tr>
</tbody>
</table>

Generated automatically. Summarizes interfaces.

Indicates connection.
SV-2: Resource Interaction Specification

**Owning Context**
- **System**: Maritime Rescue Architecture v1

**System Role**
- **Yacht**: Boat
- **Rescue Unit**: Maritime Rescue Unit v1
- **MR Aircraft**: Aircraft
- **MR Boat**: Boat

**Materiel Role**
- **Distress Beacon**: Lighting Device
- **Monitor**: ESM System
- **Radio**: Communication Device

**Resource Connector**
- **DS**: distressSignal
- **TRK1**: track
- **TRK2**: track

**Port (Typed by Exchange)**
- **RI1**: radioInstruction
- **RI2**: radioInstruction

**Standards Conformance**
- **conformsTo**: «Standard» MIL-STD-6016

**Defines how systems will interact to provide capabilities**

**Note reuse of Link 16**
SV-2: Internal Detail of Link 16

Ports: Consistent with reuse.

Ports (Typed by Exchange)
**SV-6 Connectivity Matrix**

Generated automatically. Summarizes interactions.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Producer</th>
<th>Connector/Protocol</th>
<th>Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Conveyed</td>
<td>Activity (System)</td>
<td>Name</td>
</tr>
<tr>
<td>AI</td>
<td>«Data»</td>
<td>«Person Role Type»</td>
<td>Resource Interface</td>
</tr>
<tr>
<td></td>
<td>aircraftInstruction</td>
<td>MRT Helicopter Pilot</td>
<td></td>
</tr>
<tr>
<td>BCI</td>
<td>«Data»</td>
<td>«Person Role Type»</td>
<td>Resource Interface</td>
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<td>«Person Role Type»</td>
<td>Resource Interface</td>
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<td>boatInstruction</td>
<td>MRT Boat Driver</td>
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</tr>
<tr>
<td></td>
<td>radioInstruction</td>
<td>MRT Communicator</td>
<td></td>
</tr>
</tbody>
</table>
These standards deal with procedures as well as the technical aspects of systems and communications. They are both national and international.
### StdV-1 Standards Profile

**Model Elements**

<table>
<thead>
<tr>
<th>Conforming Elements</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>«Materiel»</td>
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<tr>
<td>Link16</td>
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<td>«Resource Port»</td>
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<td>dstln</td>
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<tr>
<td>(SAR Architecture::Resources::Resource Artifacts::BSM System)</td>
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<td>dstOut</td>
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<td>(SAR Architecture::Resources::Resource Artifacts::Lighting Device)</td>
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<tr>
<td>receiver</td>
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<td>(SAR Architecture::Resources::Resource Artifacts::Communication Device)</td>
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<td>«Resource Port»</td>
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<tr>
<td>(SAR Architecture::Resources::Resource Artifacts::Link 16)</td>
<td></td>
</tr>
</tbody>
</table>

**Generated automatically. Summarizes standards conformance**
How to model services? – An alternative
SoV-1: Service Taxonomy

Service interfaces define provided and required services.
OV-2 Operational Nodes - Detail

OV-2 [Node] Search and Rescue (Without Ports)

**Provided Services**
- SAR AC : SAR Asset Control
- TC2N : Tactical C2
- MN : Monitoring

**Required Services**
- PoS : Place of Safety
- SAR AC : SAR Asset Control
- MN : Monitoring

**Defined Services**
- Defines service requirements at the operational level.

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SV-2: Resource Interaction Specification

Required Services

Provided Services

Standards Conformance (Next Slide)

Demonstrates how services will be provided by system Configurations.
How to map across the different views?
SV-5 Operational to System Activities

- «Activity(System)» Move
  - implements
  - «Activity(Operational)» Search (out updatedCondition, out udpatedLocation, in reportedLocation, in reportedCondition)
  - «Activity(Operational)» Rescue ()
  - performedBy «System» Maritime Rescue Unit v1

- «Activity(System)» Reassure Victim
  - «ImplementsOperational»
  - «ImplementsOperational»
  - «ImplementsOperational»

- «Activity(System)» Transport
  - «Activity(System)» Rescue Victim
    - «ImplementsOperational»
    - «ImplementsOperational»
    - «ImplementsOperational»

- «Activity(System)» Implement «Activity(Operational)» Rescue ()
  - performedBy «Materiel» Aircraft

- «Activity(System)» Implement «Activity(Operational)» Search (out updatedCondition, out udpatedLocation, in reportedLocation, in reportedCondition)
  - performedBy «Activity(System)» Move (in location)
  - «Activity(System)» Reassure Victim (in victimName)
  - «Activity(System)» Rescue Victim (in reportedLocation, in name, ...)
  - «Activity(System)» Transport (in destination)
  - «Activity(System)» Apply First Aid (in condition, out updatedCond ...)
  - «Activity(Operational)» Search (out updatedCondition, out udpatedLocation, in reportedLocation, in reportedCondition)
  - performedBy «System» Maritime Rescue Unit v1

- «Activity(System)» Implement «Activity(Operational)» Rescue ()
  - performedBy «PersonRoleType» MRT Searcher

- «Activity(System)» Implement «Activity(Operational)» Search (out updatedCondition, out udpatedLocation, in reportedLocation, in reportedCondition)
  - performedBy «PersonRoleType» MRT Searcher

The diagram defines the operational to system activity mapping.
CV-6: Operational Activity to Capability Mapping

CV-6 [Architectural Description] Capabilities (Mappings)

- **Search**
- **Inform**
- **Recovery**
- **Assistance**

**Operational Activity**

- **Find Victim**
- **Transit to SAR Operation**
- **Provide Medical Assistance**
- **Track Victim**
- **Recover Victim**
- **Assist Victim**

**Activity Supports Capability**
### CV-5: Capability To Organization Mapping

#### Organizational Resources

<table>
<thead>
<tr>
<th>«Organization»</th>
<th>Responsible Organization/Person</th>
<th>Capability</th>
</tr>
</thead>
</table>

#### Capabilities

- Information
- Maritime Search And Rescue
- Maritime Search And Rescue
### SV-8: System Evolution Description

<table>
<thead>
<tr>
<th>Capability</th>
<th>Realizing Resource</th>
<th>Sub-Components</th>
<th>Milestone Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maritime Rescue Unit v1</td>
<td></td>
<td>Increment, Retirement</td>
</tr>
<tr>
<td></td>
<td>Automated Rescue Unit v1</td>
<td></td>
<td>Increment, Retirement</td>
</tr>
<tr>
<td></td>
<td>Maritime Rescue Unit v1</td>
<td></td>
<td>Increment, Retirement</td>
</tr>
<tr>
<td></td>
<td>Automated Rescue Unit v1</td>
<td></td>
<td>Increment, Retirement</td>
</tr>
</tbody>
</table>
SV-12: Service Provision

Service Interfaces:

System Resources

- «Materiel» Aircraft (SAR Architecture::Resources::Resource Artifacts)
- «Materiel» Boat (SAR Architecture::Resources::Resource Artifacts)
- «Materiel» Communication Device (SAR Architecture::Resources::Resource Artifacts)
- «PersonRoleType» MRT Searcher (SAR Architecture::Organizational::Typical Organizations)
- «System» Maritime Rescue Unit v1 (SAR Architecture::Resources::Capability Configurations)
- «System» Maritime Rescue Unit v2 (SAR Architecture::Resources::Capability Configurations)
- «System» Monitor (SAR Architecture::Resources::Capability Configurations)

System Implements Service.
SV-1: Showing links from a resource to its milestones

Associated Milestones

Systems aware of associated Milestones.
How to integrate requirements management into modeling?
The SysML Requirements Diagram

- Captures requirements hierarchies and the derivation, satisfaction, verification, copy, trace, and refinement relationships.
  - Relate requirements to
    - one another
    - system design model elements
    - test cases.
  - The «rationale» concept used to annotate any model element to identify supporting rationale including:
    - analysis and trade studies
    - derived requirement
    - Design decision, etc.

- The requirement diagram provides a bridge between typical requirements management tools and the system models.

- Reports and analysis can be generated to show traceability completeness, traceability trees, etc.
SysML Example: Requirements Traceability

Integrates requirements into the model for direct traceability

Requirements and traceability can be synchronized with RM tools such as DOORS

Refine

Derived Requirement

Sub-Requirement

Trace

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How to reuse architectures?
The Package Diagram is used to show the structure of the model or sections of the model

- What packages exist
- How the packages are organized (scoped)
- Any package dependencies

Can also be used to show Views and Viewpoints
Packages

- Can be used to group any number and type of model elements
- Can contain other packages
- Are the basis for configuration management
- Their interdependencies can be modeled
How UPDM supports the specification of quantitative aspects at the Enterprise and Systems level.
Definition of metrics for reuse throughout the architecture.
# AV-3 Actual Measurements

<table>
<thead>
<tr>
<th>Actual Measurement Set</th>
<th>Initial Values: Maritime SAR Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Conditions</td>
<td>Sea State = Sea State 6</td>
</tr>
<tr>
<td>Area Coverage</td>
<td>Coverage = 500</td>
</tr>
<tr>
<td>Find Time</td>
<td>Elapsed Time = &lt;8 hours</td>
</tr>
<tr>
<td>Persistence</td>
<td>Elapsed Time = &gt;15 hours</td>
</tr>
<tr>
<td>Search Coverage</td>
<td>Coverage = 400</td>
</tr>
<tr>
<td>Weather Conditions</td>
<td>Weather Conditions = Heavy Rain</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Values: Maritime SAR Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Conditions</td>
</tr>
<tr>
<td>Area Coverage</td>
</tr>
<tr>
<td>Find Time</td>
</tr>
<tr>
<td>Persistence</td>
</tr>
<tr>
<td>Search Coverage</td>
</tr>
<tr>
<td>Weather Conditions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Values: Maritime SAR Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Conditions</td>
</tr>
<tr>
<td>Area Coverage</td>
</tr>
<tr>
<td>Find Time</td>
</tr>
<tr>
<td>Persistence</td>
</tr>
<tr>
<td>Search Coverage</td>
</tr>
<tr>
<td>Weather Conditions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UPDM: Standard SAR Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intention</td>
</tr>
<tr>
<td>Estimate</td>
</tr>
<tr>
<td>Area Coverage</td>
</tr>
<tr>
<td>Find Time</td>
</tr>
<tr>
<td>Persistence</td>
</tr>
<tr>
<td>Search Coverage</td>
</tr>
<tr>
<td>Weather Conditions</td>
</tr>
</tbody>
</table>
SysML Definitions

Value Type

- Coverage
  - Dimension: Area
  - Unit: SquareKilometers
- Sea State
  - Dimension: Wave Height
  - Unit: Meter
- Elapsed Time
  - Dimension: Time
  - Unit: Hours
- Weather Conditions
  - Unit: Weather Severity Index
- Terrain Type
  - Unit: Terrain Index

Unit

- Area
  - Unit: SquareKilometers
- Wave Height
  - Unit: Meter
- Time
  - Unit: Hours
- Terrain Index
  - Unit: Weather Severity Index
  - Unit: Terrain Index

Dimension

- Area
- Wave Height
- Time
- Terrain Index

Central definition of metrics reduces errors, provides consistency
### SV-7 System Measurements Summary

#### Linked Systems
- Maritime Rescue Unit v1
- Maritime Rescue Unit v2

#### Actual Measurement
- seaConditions
- areaCoverage
- findTime
- persistence
- searchCoverage
- weatherConditions

#### Measurement ID
- Initial Values
- Required Values
- Required Measurements
- Final Values

#### Measurement Values
- Minimum Value
- Actual Value
- Maximum Value
- Unit
- Dimension

#### SysML Unit and Dimension
- Meter
- SquareKilometers
- Area
- Hours
- Time
- Weather Severity Index

---

**Summary of metrics associated with Systems**

Measurements can also be associated with interactions and shown on the SV-6.
How to effectively use MBSE to provide trade-off analysis?
Parametrics – Trade-Off Analysis

- Used to express constraints (equations) between value properties
  - Provides support to engineering analysis
    - e.g. performance, reliability, etc

- Constraint block captures equations
  - Expression language can be formal
    - e.g. MathML, OCL …
  - or informal
  - Computational engine is defined by applicable analysis tool
    - and not by SysML

- Parametric diagram represents the usage of the constraints in an analysis context
  - Binding of constraint usage to value properties of blocks
    - e.g. vehicle mass bound to \( F = m \times a \)
SysML Parametrics – Mean Response Time

Context

BDD for Mean Response Time Analysis

Aircraft Values

Boat and Yacht Values

Environmental Values

Command Center Values
SysML Parametrics

Equation for calculating mean response times

Context

Property of System

Value Property

Parametric Equation

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SysML Parametrics – Tradeoff Analysis

Initial values and ranges set by engineer.
SysML Parametrics – Solution

<table>
<thead>
<tr>
<th>Bin</th>
<th>Frequency</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
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<tr>
<td>2</td>
<td>62</td>
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<tr>
<td>3</td>
<td>76</td>
<td>28.40%</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>46.40%</td>
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<tr>
<td>5</td>
<td>92</td>
<td>64.80%</td>
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<tr>
<td>6</td>
<td>69</td>
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<td>49</td>
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<td>8</td>
<td>38</td>
<td>96.00%</td>
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<tr>
<td>9</td>
<td>11</td>
<td>98.20%</td>
</tr>
<tr>
<td>10</td>
<td>9</td>
<td>100.00%</td>
</tr>
<tr>
<td>11</td>
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<tr>
<td>15</td>
<td>0</td>
<td>100.00%</td>
</tr>
<tr>
<td>More</td>
<td>0</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

mean response time 4.36
min response time 0.73
max response time 9.95

scan width 0.5 miles
20 x 20 mile area
150 mph helicopter
25 mph lifeboat

Optimized solution provided by equation solver
How does it all fit together? (Partial)
OV – Model Element References (Part 1)

Note: Not all relationships are shown.
OV – Model Element References (Part 2)

OV-2 Node Connectivity

OV-5 Activity Swimlane

OV-6c Event Trace

OV-7 Logical Data Model

OV-7 [Logical Data Model] Logical Data Model [OV-7]

«EntityItem» Intelligence
Sensor data : Sensor Data
Deployment data : Deployment Data

«EntityItem» Sensor Data
Real image : ImageData
Shape image : ImageData
Density reading : kg/m³
Video recording : AVRecording
Audio recording : AVRecording
Atmosphere analysis : ChemicalAnalysis

«EntityItem» Deployment Data
Name : String
Type : TargetType
Shape : 3DModel
Density : kg/m³
Mass : kg
Required damage level

«InformationElement» Sensor Data
«RepresentEntity»

«InformationElement» Search Parameters
«RepresentEntity»

«EntityItem» Status
Target obtained
Detected
Seeking

is set based on

is compared with

See [Node] Planetary Assault - Non-solution version [OV-2] diagram for details of Planetary Assault

Planetary Assault
Description
CI:Command Intelligence
GC:Ground Command
Echo Base:Rebel Base
SQD:Squadron
RS:Shield
Assault Command:Capital Ship
MIG:Mobile Information Gatherer

determine Rebel Base
defensive Shield characteristics
send Shield characteristics to Command Intelligence
request target strike
initiate target search
loop until target detected
receive target data
end loop
report target data
par task Ground Command to attack Rebel Base
send orders to Squadron
par task Capital Ship to attack Shield target strike request
attack Shield from orbit
end par
attack Rebel Base

Planetary assault from orbit and ground against a Rebel Base protected by a Shield

See [Node] Planetary Assault - Non-solution version [OV-2] diagram for details of Planetary Assault
OV – Model Element References (Part 3)

OV-7 Logical Data Model

OV-2 Node Connectivity

OV-5 Activity Swimlane

OV-3 Information Exchange Matrix
Conclusion
World-wide Adoption of UPDM

- Organizations within the following countries are investigating or have adopted UPDM.
  - United States
  - Great Britain
  - France
  - Sweden
  - Canada
  - Norway
  - NATO
  - Italy
  - Holland
  - Israel
  - Australia
  - India
  - Germany
  - Lithuania
  - Etc.

- Use of UPDM for non-military applications
  - Disaster planning, event planning, space missions: satellites, manned missions, non-military government departments, humanitarian relief operations, industry infrastructure planning, banking, European research project, etc.

All of the above cited standardization and interchange as essential reasons for considering UPDM
UPDM 2.1 Roadmap

- Submit UPDM 2.1 RFP September 2011
- UPDM 2.1 Submission March 2012
- UPDM 2.1 FTF completion/submission in September 2012
  - Expected target DoDAF 2.03
  - “MODAF 1.3” unlikely to be completed by then
  - DNDAF 1.7 may also be required by the Canadians
  - BPMN profile should be complete so could also be a candidate for inclusion
  - PES Support
  - Priorities will be based on demand and participation
Summary: Why UPDM?

- Standards based
  - OMG standard, ISO standard, Mandated DoD standard
  - Integration with OMG standards SysML, UML, SoaML, etc.
    - Provides flow-down, traceability, integration across sectors

- Interchange between tools
  - XMI provides data interchange
  - Diagram interchange under way
  - Prevents vendor lock-in – supported by several tool vendors
  - Promotes collaborative technologies and tools

- Interchange between frameworks
  - Between DoDAF, MODAF, NAF, BPMN, etc
Summary: Why UPDM?

■ Executable Architectures
  - State based models
  - Activity models
  - Integration with analysis tools: Matlab, Modelica, Mathematica, etc.

■ Extensibility
  - UPDM itself is an extension of UML and SysML
  - Fit For Purpose views can be easily added

■ DoD Support
  - UPDM is the ONLY DoDAF implementation that is mandated and supported by the DoD
Questions, Comments, Discussion