A systems engineering approach to M&S standards development: Application to the coalition battle management language

Bowers, Andy

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A Systems Engineering Approach to M&S Standards Development

Application to the Coalition Battle Management Language

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Authors

**Andy Bowers**  
The MITRE Corporation  
Hampton, VA 23666  
757-766-4582  
bowsera@mitre.org

**Curtis L. Blais**  
MOVES Institute  
Naval Postgraduate School  
Monterey, CA 93943  
831-656-3215  
clblais@nps.edu

**Kevin Galvin**  
Thales  
UK BTC  
Manor Royal, Crawley  
West Sussex, RH10 9HA, UK  
+44 1293 580353  
kevin.galvin@uk.thalesgroup.com

**Kevin Gupton**  
Applied Research Laboratories  
The University of Texas at Austin  
10,000 Burnet Rd.  
Austin, Texas 78758  
512-835-3679  
kgupton@arlut.utexas.edu

**Kevin Heffner**  
Pegasus Research & Technologies  
CP Plateau Mont-Royal  
Montreal (QC) H2S 2S8 Canada  
514-600-0141  
k.heffner@peretec.com

**Lionel Khimeche**  
Délégation Générale pour l’Armement (DGA)  
16 bis, avenue Prieur de la côte d’or  
94114 ARCEUIL CEDEX France  
+33 1 79 86 45 46  
lionel.khimeche@dga.defense.gouv.fr

**Hakan Savasan**  
Turkish Navy Research Center Command  
Ankara Cadesi No:252 P.K. 252  
Pendik-Istanbul, Turkey  
+90 216 493 82 83  
savasan.h4464@dzkk.tsk.tr
Presentation Outline

• Introduction & Background
• Systems Engineering Vee-Models
• Using the Iterative Vee-Model for Standards Development
  – Requirements Management
  – Operational Activities and Information Flows
  – Formal Data Model
  – Derived Product Generation
• Conclusions & Future Work
Introduction

The work presented in this presentation has been conducted by:
Introduction

• Development of SISO Coalition Battle Management Language (C-BML) has taken over 7 years... and still is not finished!

• There are multiple reasons cited for the delays in producing C-BML:
  – Complexity of the standard;
  – Complexity of the approach;
  – Inability to efficiently resolve differences among contributors;
  – Insufficient resources;
  – Lack of clear scope and requirements;
  – Irregular and insufficient involvement of stakeholders

• Other standardization bodies have faced similar challenges!

• Several have adopted a Systems Engineering approach to developing and maintaining technical interoperability standards, including the use of Enterprise Architecture Principles and Methodology.

• This paper considers the benefits of applying such an approach to the next phases of development of the C-BML standard.
System Engineering Vee-Model

A structured approach for defining, designing, verifying and testing complex systems.

But the Vee-Model is considered by many to be flawed, since it does not fit well with agile processes...
The advantages of the structured Vee-model combined with an agile, iterative development cycle.
Using the Iterative Vee-Model for Standard Development (1/2)

Provides a structured approach based on Systems Engineering Principles and Best Practices, and provides for:

- Defining scope and managing requirements;
- Verifying that technical specifications have been followed; and
- Validating that the derived products meets stakeholder expectations.
However, the Vee-Model is intended for system development and not for standard development. Therefore, it is necessary to adapt it to the needs of defining and maintaining technical interoperability standards, particularly in the area of validation:

- The end-product cannot easily be validated by stakeholders since the standard is a technical product and cannot necessarily demonstrate directly that operational requirements have been satisfied.
A Standard Development Framework*
A Requirements-Driven, Architecture-based Approach

*See Paper 12F-SIW-045
Requirements and Capability Development

Sustaining versus Disruptive Technologies

Short-Term

EMERGING REQUIREMENTS
Train & Adapt TTP
Optimize use of Existing Products & Tools

FUTURE REQUIREMENTS
NEW CONEMP
NEW CAPABILITIES

REvised TTP
Improve/Extend Existing Product & Tools

NEW TTP
New/Unexpected Products & Tools

NEW CONOPS

Long-Term

SUSTAINING
DISRUPTIVE

TECHNOLOGY

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Requirements and Capability Development

Sustaining versus Disruptive Technologies Examples

**Short-term**
- Translation of current operational tactical messages
- Agent-based systems (inference, reasoning)
- **Current** Command & Staff Training
  - But lower cost,
  - Reduced lead-time
- Natural Language Translation Interfaces
- **Intelligent Chat,**
  - **NG C2 Operator Interface**
  - Voice-to-Message (e.g. 9-Liners)

**Long-term**
- Self-synchronization
- Integrated Dynamic Command & Control
  - Also, NATO COPD

**Sustaining**

**Disruptive**

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How can we relate the different activities to the different types of requirements?
The use of DoD Af, MoDAF, NAF can leveraged for Technical Standards Development
SISO C-BML Phase 1 did not have a requirements management process.
Operational Activity Description Example

Call For Fire OV1a

Forward Observation Officer (FOO)

Observed Fire on Target

Message to Observer Voice or Data

Call or Request for Fire

Fire Detection Center / Regimental or Battery Command Post

Operational Message Voice or Data

Digital Device and supporting Application e.g. UK Fire Control BISA

Firing Unit(s)

Mission Thread

Operational Activity

Information Flow

Information Exchange Requirements

Information Product

Information Object

Information Requirements

SISO
## Information Flow Example

<table>
<thead>
<tr>
<th>HEADING</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event</td>
<td>FO identifies Target in Battlefield</td>
</tr>
<tr>
<td>Actor Activity and Tools Used</td>
<td>FO, Target, Battlefield, map and compass, Radio, Speech Recognition System (SRS), Translator, FDC</td>
</tr>
<tr>
<td></td>
<td>FO transmits CFF Warning Order (WO)</td>
</tr>
<tr>
<td></td>
<td>Radio, SRS, Translator, FDC</td>
</tr>
<tr>
<td>Description of Processing</td>
<td>FO identifies Target in Battlefield and decides that he will need to adjust fire (i.e. he is not sufficiently confident of the target location to justify a FFE warning order). He transmits the CFF WO.</td>
</tr>
<tr>
<td></td>
<td>SRS converts speech to text.</td>
</tr>
<tr>
<td></td>
<td>Translator validates WO text to ensure proper formatting.</td>
</tr>
<tr>
<td></td>
<td>If valid, it translates the validated text to a C-BML message, and sends the C-BML message to the FDC.</td>
</tr>
<tr>
<td>Information Producer</td>
<td>FO</td>
</tr>
<tr>
<td>Information Receiver</td>
<td>FDC</td>
</tr>
<tr>
<td>Information to be Exchanged</td>
<td>A57 this is A71, Adjust Fire, over</td>
</tr>
</tbody>
</table>
Requirements Model Example

Example Information Exchange Requirements

- Message definition
  - Message Header definition
    - Message sender
    - Message security classification
    - Message sending time
  - Message recipients
  - Message urgency
  - Unique message identifier
  - Message meta-data definition
    - Message operation time
    - Message simulation time
  - Message body definition
    - Read acknowledgement body
    - Roger acknowledgement body
    - Refuse acknowledgement explanation
  - Message reference
    - Recipient 'read' acknowledgement required
    - Recipient 'roger' acknowledgement required
Requirements Model Example

Example Information Requirements

Air Tasking Orders

ATO - Internal Reference to ACO

ATO - External Reference to ACO

ATO - Acknowledgement

ATO - Temporal Validity

ATO - Geodatum

ATO - IFF/SIF Codes

ATO - Friendly Unit Locations

ATO - FAC Info

ATO - FAC Call Sign

ATO - FAC Internet Address

ORDERS

Air Tasking Orders

(from Air Tasking Orders)

Airspace Control Orders

(from Airspace Control Orders)

REQUESTS

ACM Requests

(from Airspace Control Means Requests)

Air Support Request

(from Close Air Support)

REPORTS

Battle Damage Assessment Report

(from Reports)

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A Standard Development Framework
A Requirements-Driven, Architecture-based Approach

Requirements
- Mission threads, use-cases, derived requirements from stakeholders.

Reference Architecture
- Content model, Message Structure, Interaction Protocols and Services Components.

Normative Specifications
- Defines: (1) Content & Structure specification; (2) Services Specification.

Specification Guidance
- Examples that illustrate use of normative specifications for specific protocols.

Reference Implementation
- Technology-specific examples of how standard can be implemented.
Model-Driven Standards Development

- Formalizing requirements
- Maintaining a requirements model and a related domain model
- Generating Artifacts (e.g. schemas)
- Automated documentation generation

SISO C-BML Phase 1 did not utilize or produce a formal data model!
• Requirements traceable to model elements

• VERIFICATION and DOCUMENTATION of Model
Example XML Schema

- XML Schema can be generated automatically from Model
- Traceability to UML Model **AND** Requirements (i.e. Verification)
- **Will be equivalent to generated HLA FOM Module**
Conclusions (1/2)

- Developing *international technical standards* is a labor-intensive, complex endeavor.
- It requires active involvement of end-user stakeholders (e.g. government) *and* solution providers (e.g. industry).
- Proper Requirements Management is essential to ensuring that stakeholder expectations are met in a *reasonable* timeframe.
- Standards are products that have *life-cycles* (i.e. they evolve over time) and therefore should be developed using a process that supports *evolving requirements*.
- Recent standards development activities outside of SISO have shown that *Systems Engineering* provides a framework for defining *product life-cycle processes* consistent with technical *standards development* needs.
Conclusions (2/2)

• C-BML has taken too long to become an official balloted standard.
  – Reasons cited include: lack of coordination among stakeholders, no formal requirements management, no deliberate process, no formal data model, lack of well-defined scope.

• Building and maintaining an UML Data Model and generating derived artifacts is a sustainable way to produce high-quality, usable equivalent, consistent, standards products (e.g. XML Schemas, OWL Ontologies, HLA FOM Modules)

• The NATO MSG-085 Technical Group and the CITT already have started to apply the approach outlined in this presentation.

• The Systems Engineering Iterative Vee-Model has been proposed as the underlying process for C-BML Phase 2 standard development and is recommended for consideration by other SISO standard development activities.
Future Work

• MSG-085 has formed a Common Interest Group (CIG) to define an iterative systems engineering Standards Development Process.

• This activity will leverage the latest MIP model (Block 4) and tools to prototype a sustainable production chain:
  ▪ MIP Information Model (greatly improved from JC3IEDM)
  ▪ MIP Change Proposal and Model Definition Tools
  ▪ MIP Schema Generation Tool

• To test this process and production chain, an unified MSDL/C-BML model will be constructed as well as a set of auto-generated XML schemas.

• The results of this activity will be provided to SISO as an official output of MSG-085 and will include a set of recommendations concerning its potential use by SISO for the C-BML Phase 2 Drafting Activity.
Questions ?