Using Conceptual Model Based Systems Engineering [MBSE] to Increase the Effectiveness of System Acquisitions

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ACKNOWLEDGMENTS

- **Garry Roedler**: “Iteration and Recursion”, Systems Engineering Handbook, Fourth Edition, Figure 3.5, Garry Roedler
- **John O. Clark, CSEP, MSEE**: "SoSE from the SE Standards, INCOSE SE Handbook, and Dual V-Model Perspective", INCOSE Webinar 72, Feb 18, 2015, John Clark
- **Dr Kevin Forsberg**: Dual V-Model, The Center for Systems Management (CSM) Inc., Kevin Forsberg and Harald Mooz
- **L. Mark Walker, ESEP**: “Model Based Systems Engineering Initial Stages, Get It Right in the First Stages” Presented at INCOSE IS2015, Mark Walker
PROGRESS

- **Problem Statement**
  - Individual System Acquisition in System of Systems Environments

- **Objectives**
  - Increasing the Effectiveness of System Acquisitions

- **Offered Solution: Conceptual MBSE**
  - Basis: SoS-VEE Model™
  - MBSE Building Block
  - MBSE Example

- **Proof of Concept**
  - Application to UAV in NATO AGS System

- **Summary**
  - What Does it Mean to You
PROBLEM STATEMENT

STOVEPIPED ACQUISITIONS IN COMPLEX SYSTEM OF SYSTEM ENVIRONMENTS

What Does it Mean to an Individual Acquisition?

Example: NATO Alliance Ground Surveillance (AGS) System
PROBLEM STATEMENT (CONT'D)

Challenges of Stovepiped Acquisitions (Cont'd)

New machine gun MG5 makes problems

Bundeswehr: New machine gun MG5 makes problems

Source: The Pentagon Wars
https://www.youtube.com/watch?v=iDYpRhoZqBY

PROBLEM STATEMENT

Germany axed Euro Hawk drone program

Source: http://panorama.com/2012/08/15/germany-axed-euro-hawk-drone-program/
“Systems-of-Systems” (SoS) are systems-of-interest whose system elements are themselves systems, typically these entail large-scale interdisciplinary problems involving multiple, heterogeneous, distributed systems. These interoperating collections of component systems usually produce results unachievable by the individual systems alone. (Source: SE Handbook 3.2.2, Section 2.5 Systems-of-Systems).
PROBLEM STATEMENT
NATO AGS SYSTEM PRESENTED AS A SYSTEM OF SYSTEMS
**CHALLENGES OF SYSTEM OF SYSTEMS ENGINEERING (SoSE)**

SoS CHALLENGES AS DEFINED BY JOHN CLARK

What is Different About SoSE?  
– My Perspective

- The management (e.g., acquisition) processes are inadequate, not the technical (SE Standards) processes:
  - There is no god (no overall Program Manager) of a SoS (Dr Larry Pulman)
  - **Acquisitions are stovepipes (single systems, not SoS)**
  - Systems are directed to “integrate” with other systems, often after fielding
  - Suppliers don’t cooperate with each other (they believe it’s not in their best interest)
  - Acquirers don’t cooperate with each other for the same reason
  - SoS costs more up-front to develop (but saves much more later)
  - **Interoperability is hampered by lack of SoSE**

Source: "SoSE from the SE Standards, INCOSE SE Handbook, and Dual V-Model Perspective", INCOSE Webinar 72, Feb 18, 2015, John Clark
UNDESIRABLE OUTCOMES
RESULTS OF STOVEPIPING OR SILO ENGINEERING

Source: http://i81.photobucket.com/albums/j236/dimitri_the_pirate/RedneckCarAirConditioner.jpg
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OBJECTIVES
INCREASING THE EFFECTIVENESS OF SYSTEM ACQUISITIONS

ANNOUNCEMENT
A major conference focusing on improving acquisition and performance of Defense programs and systems, including net-centric operations and data/information interoperability, system - of - systems engineering and all aspects of system sustainment, will be convened in Fall of 2015. This conference is sponsored by the National Defense Industrial Association, Systems Engineering Division, with technical co-sponsorship by IEEE AES, IEEE Systems Council and the International Council on Systems Engineering, and is supported by the Office of the Deputy Assistant Secretary Defense for Systems Engineering in the Office of Under Secretary of Defense for Acquisition, Technology and Logisticand Office of the Director Information Officer.

BACKGROUND
The Department of Defense continues to seek ways to improve the acquisition of military equipment and capability to assist the warfighter in protecting the U.S. and its allies, and help oppressed nations around the world in a complex environment of ever-changing threats and conditions. The Weapon Systems Acquisition Reform Act (WSARA) of 2009 defines Systems Engineering as a key player in helping effect improvements in defense acquisition and program execution, to achieve more effective and affordable military systems. Better Buying Power provided guidance on increasing efficiencies to “do more, without more”. Systems Engineering is the “umbrella” engineering function that serves as the key integrating function for these initiatives and successful program execution and helping maintain the balance between requirements, performance, cost, schedule, and overall effectiveness and affordability. Systems Engineering principles embody strong technical and risk/
OBJECTIVES
GETTING IT RIGHT FROM THE BEGINNING

Joint Capabilities Integration Development System (JCIDS)

Getting it Right from the Beginning

This presentation contains notes pages to supplement main content.
OBJECTIVES
GETTING IT RIGHT IN THE FIRST STAGES*

Problem Statement (Purpose for Paper)-
Lack of Emphasis/Understanding of:

- **System Use Cases development with the Stakeholders/Users**
- **What should be done prior to a Request For Proposal**
  - And must be done first after receiving an RFP
- **Transitioning Knowledge/Info between 3 Teams:**
  - Pre-Development, Development, Operational Support Teams
- **Operational Concept Documents Critical Importance**
- **Establishing the First Baseline Products (Pre- RFP)**
- **The Method used to Implement:** **MBSE and SysML, etc.**
  - Object Oriented Systems Engineering Method (OOSEM)

*Source: “Model Based Systems Engineering Initial Stages, Get It Right in the First Stages” Presented at INCOSE IS2015, Mark Walker
Mark’s paper emphasizes the critical importance of an integrated architecture being developed along with (in parallel) with requirements development and analysis.
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Summary
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CONCEPTUAL MBSE: SoS-VEE Model (Recap)
CONCEPTUAL MBSE: SoS-VEE Model (Recap)
CONCEPTUAL MBSE
SE VS. SoSE USING SoS-Vee Model

- SoS Stakeholder
- SoS System Req.
- SoS Architecture
- SoS Validation
- SoS Verification
- SoS Integration

Constituent System #1
Constituent System #2

Improved Interoperability (Identified Interfaces)
Improved Acquisition (Allocated SoS Requirements)
Improved Performance (Integration, V&V of SoS)

Joint Capability Integration & Development
Individual Defense Acquisition

Improved Acquisition (Allocated SoS Requirements)
CONCEPTUAL MBSE
CREATING THE MBSE BUILDING BLOCK

Modeling of System of Systems to Define Constituent System Requirements and Interfaces

Source: INCOSE-OMGSysML-Tutorial-Final-090901
CONCEPTUAL MBSE
MBSE DURING CONCEPTUAL DESIGN

Determine Applicable System Requirements & Interfaces for System to be Acquired
CONCEPTUAL MBSE
MBSE EXAMPLE – ENTERTAINMENT SYSTEM

- Television
- DVD Player
- Sound System
- Remote

### Interface Diagram

- **TV**
  - Video
  - Audio
- **DVD Player**
- **Sound System**
- **Remote**

### Interface (N2) Chart

<table>
<thead>
<tr>
<th></th>
<th>TV</th>
<th>DVD</th>
<th>Sound</th>
<th>Remote</th>
</tr>
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<tbody>
<tr>
<td>TV</td>
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<td>---</td>
<td>X</td>
<td></td>
</tr>
<tr>
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### System Architecture

- **Interface Diagram** (Alternative)
CONCEPTUAL MBSE
USING SYSML TO CREATE USE CASE & SEQUENCE DIAGRAMS

Homeowner
Entertainment System

Use System
DVD
Sound
Remote

Entertainment System of Systems
Constituent System
Sequence Diagram

Actor: HomeOwner
Use Cases
Actor

Turn On Entertainment System
Turn On DVD Player

Message: message_0
Message: message_1 in SNR: Turn On DVD Player
CONCEPTUAL MBSE
CONSTITUENT SYSTEM REQUIREMENTS & INTERFACES

Use System

Applicable System Requirements

DVD

Applicable Interface Requirements

Entertainment System of Systems

Constituent System
PROGRESS

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Proof of Concept
- Application to UAV in NATO AGS System

Summary
- What Does it Mean to You
APPLICATION TO NATO AGS SYSTEM
IDENTIFYING ACTORS OF THE SYSTEM

Source: http://nagsma.nato.int/images1/AGS2_large.jpg
**APPLICATION TO NATO AGS SYSTEM**

**OPERATIONAL CONCEPT (STAKEHOLDER REQS.)**

**Scenario X.Y – UAV Operation**

**Background**

The NATO-owned and -operated AGS core capability will enable the Alliance to have persistent surveillance over wide areas from high-altitude long-endurance (HALE) aircraft, operating at considerable stand-off distances and in any weather or light condition. Using advanced radar sensors, these systems will continuously detect and track moving objects throughout observed areas and will provide radar imagery of areas of interest and stationary objects. (Source: [http://www.nato.int/cps/en/natolive/topics_48892.htm](http://www.nato.int/cps/en/natolive/topics_48892.htm))

**Scenario X.Y-Z: Detect and Track Moving Object**

**Scenario Description ...**

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<th>Role and Responsibilities</th>
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<tr>
<td>N/A</td>
<td>UAV</td>
<td>Detects &amp; Track Moving Object, Provides Radar Imagery, ...</td>
</tr>
<tr>
<td>Detects Object of Interest</td>
<td>UAV</td>
<td>Detects Object of Interest, Reports Object of Interest to Main Operating Base, ...</td>
</tr>
<tr>
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<td>UAV</td>
<td>Processes Information Reported from UAV, Communicates with MOB Dissemination, ...</td>
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# APPLICATION TO NATO AGS SYSTEM
## DERIVING FUNCTIONAL REQUIREMENTS

### Scenario X.Y – UAV Operation

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**Functional Requirements**

1. **[FR #001]** The UAV shall be able to detect and track objects of interest.
2. **[FR #002]** The UAV shall be able to report objects of interest to the MOB.
APPLICATION TO NATO AGS SYSTEM
IDENTIFYING USE CASES (SYSTEM FUNCTIONS)

[FR #001]: The UAV shall be able to detect and track objects of interest.

[FR #002]: The UAV shall be able to report objects of interest to the MOB.
APPLICATION TO NATO AGS SYSTEM
PRESENTING THE HIERARCHY
APPLICATION TO NATO AGS SYSTEM
TRANSITIONING TO SEQUENCE DIAGRAMS
APPLICATION TO NATO AGS SYSTEM
SEQUENCE DIAGRAM

Applicable Interface Requirements

Applicable System Requirements

Non-Functional Requirement: Time between detection and reporting shall be less than X milliseconds.

Reporting shall use XYZ communication protocol.

Note: ...
APPLICATION TO NATO AGS SYSTEM
SEQUENCE DIAGRAM (CONT'D)

UAV Applicable Requirements & Interfaces

[SR#001]
Non-Functional Requirement: Time between detection and reporting shall be less than X milliseconds.

[SR#002]
Reporting shall use XYZ communication protocol.
APPLICATION TO NATO AGS SYSTEM
INPUT INTO THE ACQUISITION PROCESS

Requirements Exportable into DOORS

Use Requirements as Basis for V&V of Acquisition RFP
APPLICATION TO NATO AGS SYSTEM
UNIFIED MODEL INFORMATION APPLICABLE TO UAV

UAV Applicable Diagrams, Relationships
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CONCEPTUAL MBSE
WHAT DOES IT MEAN TO YOU

- **Improved Interoperability** (Identified Interfaces)
- **Improved Acquisition** (Stakeholder & Functional Reqs.)
- **Improved Performance** (Integration, V&V of SoS)
- Unified Model, Improved Communication, Configuration Mgmt.

**APPLICATION TO NATO AGS SYSTEM**

**IDENTIFYING USE CASES (SYSTEM FUNCTIONS)**

**APPLICATION TO NATO AGS SYSTEM**

**SEQUENCE DIAGRAM**

**PROBLEM STATEMENT**

**STOVIFIED ACQUISITIONS IN COMPLEX SYSTEM OF SYSTEM ENVIRONMENTS**

**Increased Effectiveness of System Acquisitions**
Thank You for Your Attention!

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