From Dual VEE to Dual Use

Introducing the SoS-VEE™ Model

Improving the Acquisition, Interoperability and Performance of Large System-of-Systems [SoS] Programs

National Defense Industrial Association [NDIA]
18th Annual Systems Engineering Conference – Track 5 System of Systems [Session 17887]
Springfield, VA – October 27, 2015

Oliver Hoehne, PMP, CSEP, CSM
Senior Professional Associate & Project Manager
Parsons Brinckerhoff
hoehneom@pbworld.com
Tel.: (973) 353-7617
Cell: (862) 371-7314
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

PROGRESS

- **Problem Statement**
  - Challenges of System of Systems Engineering

- **Objectives**
  - Simple Model Useful for System of Systems Engineering

- **Offered Solution: SoS-VEE Model**
  - Main Building Block
  - Building the Model
  - Review against Objectives

- **Proof of Concept**
  - Application to System of Systems Engineering
  - Application to Project Management
  - Application to Conceptual MBSE (Outlook)

- **Summary**
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

Source: http://nagsma.nato.int/images1/AGS2_large.jpg
Bundeswehr: New machine gun MG5 makes problems

The new machine gun the army causes problems. According to information obtained by SPIEGEL, the MG5 does not fit the guns of tanks and all-terrain vehicles. The conversion will cost millions.

Source: http://panteres.com/2015/09/12/bundeswehr-new-machine-gun-mg5-makes-problems

Bundeswehr: Neues Maschinengewehr MG5 passt nicht auf Panzer

Auch das neue Maschinengewehr der Bundeswehr bereitet Probleme: Laut Informationen des SPIEGEL passt das MG5 nicht auf die Lafetten von Panzern und Geländefahrzeugen. Die Umrüstung kostet Millionen.

Source: http://www.spiegel.de/politik/deutschland/bundeswehr-neues-maschinengewehr-mg5-macht-probleme-a-1052458.html
Germany axes Euro Hawk drone program

BERLIN — Germany has canceled a planned “Euro Hawk” drone program over fears that European authorities will not certify them, a defense ministry source said Tuesday after reported European safety concerns.

Germany had “no hope” of seeing the unmanned aircraft, part of a program that would have cost more than €1 billion (US $1.3 billion), approved for use, said the source, speaking on condition of anonymity.

The European Aviation Safety Agency has said it would certify the drones only to fly over unpopulated areas because of a lack of an anti-collision system to protect airliners, according to German press reports.

“The equipment is not ready for approval without immense expenditure,” the source added.

Germany has already spent €508 million on a Euro Hawk prototype and was due to fork out a further €500 million on four more models.

Source: http://archive.defensenews.com/article/20130514/DEFREG01/305140015

German Euro Hawk Drone Cancelled

Lack of Anti-Collision System (Interface with Civilian Air Traffic Control)

Equivalent (in %) of ca. $10 Billion Compared to US DoD Budget
“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

Air Traffic Managem.  
Civil Air Traffic Ctrl.  
NATO AGS System  
UAV  
Ground Vehicle Sys.  
Ground Vehicle  
Machine Gun

System of Systems (SoS)  
Constituent Systems & System Elements
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
# Challenges of System of Systems Engineering (SoSE)

**SoS Challenges as Defined by INCOSE**

<table>
<thead>
<tr>
<th>SoS Challenges*</th>
<th>Description*</th>
</tr>
</thead>
<tbody>
<tr>
<td>System elements are operated independently</td>
<td>➢ Each system element within SoS likely to operate independently</td>
</tr>
</tbody>
</table>
| System elements have different life cycles | ➢ SoS involves more than one system element  
➢ Some system elements are possibly in development life cycle, while others are being deployed and operated, or in extreme cases even scheduled for disposal |
| Initial SoS requirements are likely to be ambiguous | ➢ Requirements for system element are maturing during development, even more so for SoS under development |
| Complexity is a major issue | ➢ Complexity of system interaction grows in non-linear fashion if system elements are added  
➢ Conflicting or missing interface standards can make it hard to define data exchange across system element interfaces |
| Management can overshadow engineering | ➢ Each system element may have own project/product office  
➢ Coordination between requirements, budget constraints, schedules, interfaces, upgrades, etc. further complicates SoS development |
| Fuzzy boundaries cause confusion | ➢ Definition and scope of SoS, management of boundaries are typically not controlled by one entity  
➢ Results in non-definition of external interfaces |
| SoS engineering is never finished | ➢ Even after successful SoS deployment, management of various system element life cycles need to be managed due replacements, improvements, etc. |

* Source: Excerpted from Systems Engineering Handbook 3.2.2, Section 2.5 Systems of Systems
UNDESIRABLE OUTCOMES
RESULTS OF STOVEPIPING OR SILO ENGINEERING

Source: http://i81.photobucket.comalbums/j236/dimitri_the_pirate/RedneckCarAirConditioner.jpg
PROGRESS

➢ Problem Statement
  o Challenges of System of Systems Engineering

➢ Objectives
  o Simple Model Useful for System of Systems Engineering

➢ Offered Solution: SoS-VEE Model
  o Main Building Block
  o Building the Model
  o Review against Objectives

➢ Proof of Concept
  o Application to System of Systems Engineering
  o Application to Project Management
  o Application to Conceptual MBSE (Outlook)

➢ Summary
## Joint Capabilities Integration Development System (JCIDS)

### Identification of Capability Requirements

| Operational Planning | JCTDs/JUON/JEON/Experiments |
| CBAs & Other Studies | JIEDDO Initiatives |
| Exercises/Lessons Learned | Defense Business Sys |

### Outputs

| Mission & Problem | Operational Risk |
| Capability Gaps | Non-Materiel Approaches |
| Tasks | Materiel Approaches |
| Performance | Recommendations |

### JCIDS and Acquisition

- **key acquisition activities/documents**
  - Analysis of Alternatives (AoA)
  - Technology Development Strategy (TDS)
  - Test & Evaluation (T&E) Strategy (TES)
  - System Engineering Plan (SEP)
  - Acquisition Strategy
  - T&E Master Plan (TEMP)
  - SEP
  - Final Design
  - Developmental T&E (DT&E)
  - Operational Assessments
  - Revise KPPs/KSAs
  - Acquisition Strategy
  - Acquisition Program Baseline (APB)
  - TEMP
  - SEP
  - Low Rate Initial Production (LRIP)
  - Initial Operational T&E (IOT&E)
  - Acquisition Strategy
  - APB
  - TEMP
  - SEP

---

**Getting the Front End Right is Key**

OBJECTIVES

COMPATIBLE WITH EXISTING DEFENSE ACQUISITION PROCESSES

OBJECTIVES

ADDRESSING THE SoS CHALLENGES

Focus on Controlling the **Interfaces** between Systems Elements and External Systems

Be Aware of and Mitigate the **Risks** of the Seven Challenges

Part of the systems engineer’s job in an SoS environment is to be aware of and mitigate the risk of each of these seven challenges. Focus is placed on controlling the interfaces between system elements and external systems. It is especially important to ensure that the interfaces are still operational when an older component system is replaced with a newer version. Verification and validation (V&V) processes play a critical role in such transitions.

**Verification and Validation** Processes Play a Critical Role

**Ensure Interfaces** are still Operational when replacing Element Systems

* Source: Systems Engineering Handbook 3.2.2, Section 2.5 Systems of Systems
OBJECTIVES
CREATE SIMPLE MODEL USEFUL FOR SoS ENGINEERING

Everywhere should be made as simple as possible, but not simpler.
Albert Einstein

If you can’t explain it simply, you don’t understand it well enough.
– Albert Einstein

Source: "SoSE from the SE Standards, INCOSE SE Handbook, and Dual V-Model Perspective", INCOSE Webinar 72, Feb 18, 2015, John Clark
**Problem Statement**
- Challenges of System of Systems Engineering

**Objectives**
- Simple Model Useful for System of Systems Engineering

**Offered Solution: SoS-VEE Model**
- Main Building Block
- Building the Model
- Review against Objectives

**Proof of Concept**
- Application to System of Systems Engineering
- Application to Project Management
- Application to Conceptual MBSE (Outlook)

**Summary**
SoS-VEE Model
CREATING THE MAIN BUILDING BLOCK

(Desired) System

User & System Requirements

Verification & Validation

(Final) System

Architecture (Decomposition)

System Elements

Implementation

Integration

System Elements

S

SE

SE
SoS-VEE Model
CREATING THE MAIN BUILDING BLOCK (CONT'D)

What is a System? (cont)

System and System Element Relationship

(System concept is critical to understanding 15288 and the INCOSE SE Handbook)

- System
- System element
- System element
- System element

A system is completely composed of a set of interacting system elements

PROCESS INPUT
- Customer Needs/ Objectives
- Requirements
- Mission/Operations
- Measures of Effectiveness
- Environment
- Constraints
- Technology Base
- Prior Output Data
- Program Decision Requirements
- Requirements from Tailored Standards and Specifications

Requirements Analysis
- Analyze Missions & Environments
- Identify Functional Requirements
- Define/Refine Performance & Design Constraint Requirements

Synthesis
- Transform Architectures (Functional to Physical)
- Define Alternative Product Concepts
- Define/Refine Physical Interfaces (Internal/External)
- Define Alternative Product & Process Solutions

MIL-STD-499B and EIA/IS-632 SE Process

Systems Analysis & Control
- Select Preferred Alternatives
- Trade-Off Studies
- Effectiveness Analysis
- Risk Management
- Configuration Management
- Interface Management
- Data Management
- Performance-Based Progress Measurement
- SEMS
- TPM
- Technical Reviewers

PROCESS OUTPUT
- Integrated Decision Data Base
- Decision Support Data
- System Functional & Physical Architectures
- Specifications & Baselines
- Balanced System Solution


SoSE from the SE Standards, INCOSE SE Handbook, and Dual V-Model Perspective, INCOSE Webinar 72, Feb 18, 2015, John Clark*
OBJECTIVES
APPLY ITERATION AND RECURSION PRINCIPLES

Source: Systems Engineering Handbook, Fourth Edition, Figure 3.5, Garry Roedler
OBJECTIVES
APPLY ITERATION AND RECURSION TO NATO AGS SYSTEM

Air Traffic Managem.

Civil Air Traffic Ctrl.

NATO AGS System

UAV

Ground Vehicle Sys.

Ground Vehicle

Machine Gun
SoS-VEE Model
CREATING AN SoS-VEE (ENTITY) LAYER

*Source: “SoSE from the SE Standards, INCOSE SE Handbook, and Dual V-Model Perspective”, INCOSE Webinar 72, Feb 18, 2015, John Clark*
SoS-VEE Model
ASSIGN REVIEW AND AUDIT MILESTONES

*Source: “SoSE from the SE Standards, INCOSE SE Handbook, and Dual V-Model Perspective”, INCOSE Webinar 72, Feb 18, 2015, John Clark
SoS-VEE Model
BUILDING THE HIERARCHY

Dual V-Model Backplane
by Dr Kevin Forsberg*

*Source: “SoSE from the SE Standards, INCOSE SE Handbook, and Dual V-Model Perspective”, INCOSE Webinar 72, Feb 18, 2015, John Clark
SoS-VEE Model
IMPLEMENTING SYSTEM ELEMENTS

Dual V-Model by Dr Kevin Forsberg*

*Source: "SoSE from the SE Standards, INCOSE SE Handbook, and Dual V-Model Perspective", INCOSE Webinar 72, Feb 18, 2015, John Clark
SoS-VEE Model
SYSTEM WITH SEVERAL SYSTEM ELEMENTS
SoS-VEE Model
DANSE SoS LIFE CYCLE vs. SoS-VEE

DANSE SoS Life Cycle

Single model to embody the integrating thoughts
- An initiation phase
- Optional creation phase
- Forward movement through the SoS life
- Constant cycling of events/scenarios
- A "capability learning cycle"
  - Where the DANSE benefit happens!
- Normal Vee-based SE in the constituent systems

Alternate starting points:
- SoS is acknowledged among existing systems
- SoS is created by a Lead System Integrator

DANSE Methodology

SoS-VEE Model
INDIVIDUAL SYSTEM LIFE CYCLE NEEDS

System of Systems Engineering
Constituent Systems Engineering
Individual System Life-Cycle Needs
SoS-VEE Model
INDIVIDUAL SYSTEM LIFE CYCLE NEEDS

System of Systems Engineering

Constituent Systems Engineering

Individual System Life-Cycle Needs
SoS-VEE Model
INDIVIDUAL SYSTEM LIFE CYCLE NEEDS

SoS Stakeholder

SoS System Req.

SoS Architecture

SoS Validation

SoS Verification

SoS Integration

Constituent System #1

Constituent System #2

Constituent System #n

System of Systems Engineering

Constituent Systems Engineering

Individual System Life-Cycle Needs

SoS-VEE Model
INDIVIDUAL SYSTEM LIFE CYCLE NEEDS

SoS Stakeholder

SoS System Req.

SoS Architecture

SoS Validation

SoS Verification

SoS Integration

Constituent System #1

Constituent System #2

Constituent System #n

System of Systems Engineering

Constituent Systems Engineering

Individual System Life-Cycle Needs

SoS-VEE Model
INDIVIDUAL SYSTEM LIFE CYCLE NEEDS

SoS Stakeholder

SoS System Req.

SoS Architecture

SoS Validation

SoS Verification

SoS Integration

Constituent System #1

Constituent System #2

Constituent System #n

System of Systems Engineering

Constituent Systems Engineering

Individual System Life-Cycle Needs

SoS-VEE Model
INDIVIDUAL SYSTEM LIFE CYCLE NEEDS

SoS Stakeholder

SoS System Req.

SoS Architecture

SoS Validation

SoS Verification

SoS Integration

Constituent System #1

Constituent System #2

Constituent System #n

System of Systems Engineering

Constituent Systems Engineering

Individual System Life-Cycle Needs
SoS-VEE Model
SYSTEM VS. SYSTEM OF SYSTEMS ENGINEERING

Constituent System #2

SoS Stakeholder
SoS System Req.
SoS Architecture
Constituent System #1

SoS Validation
SoS Verification
SoS Integration
Constituent System #2

Constituent System #n

SYSTEMS ENGINEERING

SYSTEM OF SYSTEMS ENGINEERING
USING SoS-VEE MODEL
SoS-VEE Model
REVIEW AGAINST OBJECTIVES

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

- Joint Capability Integration & Development
- Individual Defense Acquisition
- Main Operating Base
- Integrated National Defense
- Joint Task Force
- JTLS Equipped National Security
- JSTARS
- Other National

- Constituent System #2
- Constituent System #n
- SoS Stakeholder
- SoS System Req.
- SoS Architecture
- SoS Validation
- SoS Verification
- SoS Integration
SoS-VEE Model
REVIEW AGAINST OBJECTIVES (CONT’D)

Getting it Right from the Beginning

Joint Capability Integration & Development

System of Systems Engineering

Requirements Management

Verification & Validation

Defense Acquisition

Based on SE Process

Simple, Modular & Scalable Model

Controlling the Interfaces
PROGRESS

- **Problem Statement**
  - Challenges of System of Systems Engineering

- **Objectives**
  - Simple Model Useful for System of Systems Engineering

- **Offered Solution: SoS-VEE Model**
  - Main Building Block
  - Building the Model
  - Review against Objectives

- **Proof of Concept**
  - Application to System of Systems Engineering
  - Application to Project Management
  - Application to Conceptual MBSE (Outlook)

- **Summary**
PROOF OF CONCEPT
APPLICATION TO OTHER INDUSTRIES

Turning Large Projects into Precision Guided Programs
A Case for a Program Development Life-Cycle Model

Oliver M. Hochne, PMP
Senior Professional Associate & Project Manager
Parsons Brinckerhoff, Transit & Rail Systems
2 Gateway Center, 18th Floor, Newark, NJ 07102
hochne@pbrworld.com

Copyright © 2013 by Oliver Hochne. Permission granted to INCOSE to publish this.

Abstract. "In World War II it could take 600 bombs to hit a target the size of an aircraft shelter. In Vietnam, 300. Today we can do it with one laser-guided munition from an F-117." [1] The development of laser guided weapons (Figure 1) has dramatically improved the accuracy of GP (general purpose) weapon guidance and delivery (2).

As was the case in World War II and Vietnam, large programs undertaken in water are not hit their targets the first time either, and are often plagued by degraded project capabilities. INCOSE acknowledges that in addressing those issues and develops several systems approaches to manage projects successfully. However, none of the existing methodologies is as simple as the use of a system development life-cycle in an infrastructure. This paper describes the search for the "right" SDLC that is applicable to infrastructure programs. It considers the evaluation of existing methods, and determines that a new SDLC model may not be necessary. The author acknowledges that there may be one or more than one PDLC model. The proposed (as presented in Figure 2) is based on the standard VEE model and is a game changer for large projects. The presented PDLC model is shown in Figure 3 and will be described in this paper.

AFIS EMEA WORKSHOP
7-9 October 2015 • PARIS

From Dual VEE to Dual Use – Introducing the SoS-VEE™
Model to Improve the Acquisition Interoperability and Performance
of large System-of-Systems (SoS) Programs

Mr. Oliver Hochne, Parsons Brinckerhoff
PROOF OF CONCEPT
PROJECT MANAGEMENT

Stakeholder Needs & Requirements (SN&R) Definition Process

**Inputs**
- Source documents
- Project constraints
- Major stakeholders identification
- Preliminary life cycle concepts
- Problem or opportunity statement
- Business requirements
- Alternative solution classes
- Preliminary validation criteria
- Validated requirements
- Preliminary MOE needs
- Preliminary MOE data
- Business requirements traceability
- Life cycle constraints
- Stakeholder needs
- System requirements traceability

**Activities**
- Prepare for stakeholder needs and requirements definition
- Define stakeholder needs
- Develop the operational concept and other life cycle concepts
- Transform stakeholder needs into stakeholder requirements
- Analyze stakeholder requirements
- Manage the stakeholder needs and requirements definition

**Outputs**
- Stakeholder needs and requirements definition strategy
- Life cycle concepts
- System function identification
- Stakeholder requirements
- Validation criteria
- MOE needs
- MOE data
- Stakeholder requirements traceability
- Initial RVTM
- Stakeholder needs and requirements definition record

**Dependencies**

- **Acceptable**: Proceed with the next stage of the project.
- **Acceptable with reservations**: Proceed and respond to action items.
- **Unacceptable**: Do not proceed—continue this stage and repeat the review when ready.
- **Unacceptable**: Return to a preceding stage.
- **Unacceptable**: Put a hold on project activity.
- **Unsalvageable**: Terminate the project.

**Decision Gates**

Source: SE Handbook, Fourth Edition, Figure 4.4 and Section 3.2.2
Using Conceptual MBSE to Increase the Effectiveness of System Acquisition

Mr. Oliver Hoehne, Parsons Brinckerhoff
PROGRESS

- **Problem Statement**
  - Challenges of System of Systems Engineering

- **Objectives**
  - Simple Model Useful for System of Systems Engineering

- **Offered Solution: SoS-VEE Model**
  - Main Building Block
  - Building the Model
  - Review against Objectives

- **Proof of Concept**
  - Application to System of Systems Engineering
  - Application to Project Management
  - Application to Conceptual MBSE (Outlook)

- **Summary**
SoS-VEE Model

FINAL WORD: START SoSE EARLY

Thank You for Your Attention!

Oliver Hoehne, PMP, CSEP, CSM
Senior Professional Associate & Project Manager
Parsons Brinckerhoff
hoehneom@pbworld.com
Tel.: (973) 353-7617
Cell: (862) 371-7314