Welcome to the 2019 System of Systems Engineering Collaborators Information Exchange (SoSECIE)

We will start at 11AM Eastern Time
Skype Meeting +1 (703) 983-2020, 46013573#
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https://www.acq.osd.mil/se/outreach/sosecollab.html
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NDIA System of Systems SE Committee

• Mission
  • To provide a forum where government, industry, and academia can share lessons learned, promote best practices, address issues, and advocate systems engineering for Systems of Systems (SoS)
  • To identify successful strategies for applying systems engineering principles to systems engineering of SoS

• Operating Practices
  • Face to face and virtual SoS Committee meetings are held in conjunction with NDIA SE Division meetings that occur in February, April, June, and August
  • SoS Track at NDIA 22nd Annual Systems Engineering Conference, Grand Hilton Tampa Downtown, Tampa, FL, October 21-24, 2019
    • Conference Info: http://www.ndia.org/events/2019/10/21/22nd-annual-systems-and-mission-engineering-conference

NDIA SE Division SoS Committee Industry Chairs:
  Mr. Rick Poel, Boeing
  Ms. Jennie Horne, Raytheon

OSD Liaison:
  Dr. Judith Dahmann, MITRE
Simple Rules of Engagement

• I have muted all participant lines for this introduction and the briefing.
• If you need to contact me during the briefing, send me an e-mail at sosecie@mitre.org.
• Download the presentation so you can follow along on your own
• We will hold all questions until the end:
  • I will start with questions submitted online via the CHAT window in Skype.
  • I will then take questions via telephone; State your name, organization, and question clearly.
• If a question requires more discussion, the speaker(s) contact info is in the brief.
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February 19, 2019
Systems of Systems Engineering Managerial and Operational Affinity
Dr. Mike Yokell, Lockheed Martin Fellow and Deputy Director, Systems Engineering

March 12, 2019
Mission Engineering Competency Model
Dr. Nicole A. Hutchison, Stevens Institute of Technology

March 26, 2019
Practical Modeling Concepts for Engineering Emergence in Systems of Systems
Dr. Judith Dahmann, The MITRE Corporation
Ms. Philomena Zimmerman, OUSD(R&E)

April 16, 2019
Mission Analysis and Operational Architectures
Mr. Mark Simons, Vitech Corporation

April 30, 2019
Digital Engineering Transformation
Mr. Thomas McDermott, Georgie Tech Research Institute, SERC

2019 System of Systems Engineering Collaborators
Information Exchange Webinars
Sponsored by MITRE and NDIA SE Division
May 14, 2019
Toward Scaling Model-based Engineering for Systems of Systems
Dr. Ryan B. Jacobs, The MITRE Corporation

May 28, 2019
Mission Engineering and Prototype Warfare
Mr. Matthew Horning, US ARMY FUTURES COMMAND

June 11, 2019
TBD
TBD

June 25, 2019
A Tool for Architecting Socio-Technical Problems: SoS Explorer
Dr. Cihan Dagli

July 16, 2019
Modular Online Open SoS Education (MOOSE)
Mr. Kyle Hastings, The MITRE Corporation
SYSTEM OF SYSTEMS (SOS) MANAGERIAL AND OPERATIONAL AFFINITY

ASSESSING AND IMPROVING RELATIONSHIPS WITHIN SYSTEMS OF SYSTEMS
System of Systems Engineering
Collaborators Information Exchange (SoSECIE)

February 5th, 2019
11:00 a.m. to Noon Eastern Time

Dr. Mike Yokell, ESEP
Lockheed Martin Fellow and Deputy Director, Systems Engineering
Mike.R.Yokell@LMCO.com
OUTLINE

• Background on Systems and Systems of Systems
• Clarifying the Relationship
• SoS Operational Affinity
• SoS Managerial Affinity
• Summary and Additional Observations
BACKGROUND ON SYSTEMS AND SYSTEMS OF SYSTEMS
MOTIVATION

- According to Maier [1], two key characteristics of SoS are
  - Managerial Independence
  - Operational Independence

- What do these mean?
  - Binary (dependent/independent)?
  - Or a spectrum?

- Once categorized, now what?
  - Need some tangible, actionable guidance
OPERATIONAL AND MANAGERIAL INDEPENDENCE

• Systems V and W
  • Operationally Independent

• Organizations A and B
  • Managerially Independent

= Two Systems (not SoS)
SYSTEMS OF SYSTEMS (SOS) DIFFER FROM SYSTEMS

• Systems V and W
  • Operationally Independent
  • Operationally Interdependent

• Organizations A and B
  • Managerially Independent
  • Managerially Interdependent

= Three Systems
  • System W
  • System V
  • SoS WV (or VW)

SoS = set of systems and system elements that interact to provide a unique capability that none of the constituent systems can accomplish on its own.

Note: System elements can be necessary to facilitate interaction of the constituent systems in the system of systems.

[SOURCE: ISO/IEC/IEEE FDIS 21839]
**NEED: CLARIFY THE RELATIONSHIP**

- Recall: Organizations may establish priorities for their systems
- What if one or more of those consumers is another system?
- If the organizations have common goals and objectives
  - Perhaps they might be willing to work together
  - Provide new SoS outputs in addition to their own
- What if they don’t?
CLARIFYING THE RELATIONSHIPS
ORGANIZATIONAL MANAGERIAL RELATIONSHIPS
(ORGANIZATIONS = SUPPLIER/ACQUIRER)

Organization A

• Acquires Inputs (from somewhere)
• Supplies Outputs
• “I supply outputs to Organization B”

Organization B

• Acquires Inputs from Organization A
• Supplies Outputs (for others)
• “I acquire inputs from Organization A”

From ISO/IEC/IEEE 15288 [3]
SYSTEM OPERATIONAL RELATIONSHIPS (SYSTEMS = PRODUCER/CONSUMER)

System V

• Consumes Inputs (from somewhere)
• Produces Outputs
• “I produce outputs for System W”

System W

• Consumes Inputs from System V
• Produces Outputs (for others)
• “I consume inputs from System V”

Inputs
System V Capabilities
Outputs

Organization A

“Producer”

Inputs
System W Capabilities
Outputs

Organization B

“Consumer”
**PRODUCER’S VIEW:**
**SoS OPERATIONAL OUTPUT IMPORTANCE RATING**

<table>
<thead>
<tr>
<th>Rating</th>
<th>The consumer system (or output provided to this consumer) is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>?</td>
<td>Rating has not yet been completed</td>
</tr>
<tr>
<td>2</td>
<td>Highly important to my system in a positive way</td>
</tr>
<tr>
<td>1</td>
<td>Somewhat important to my system in a positive way</td>
</tr>
<tr>
<td>0</td>
<td>Not important to my system</td>
</tr>
<tr>
<td>-1</td>
<td>Somewhat important to my system in a negative way</td>
</tr>
<tr>
<td>-2</td>
<td>Highly important to my system in a negative way</td>
</tr>
</tbody>
</table>

**Organization A**

- **Inputs**
- **System V Capabilities**
- **Outputs**

**“Producer”**

**SoS Operational Output Importance Rating**

**Organization B**

- **Inputs**
- **System W Capabilities**
- **Outputs**

**“Consumer”**

**PRODUCER’S VIEW:**
**SoS OPERATIONAL OUTPUT IMPORTANCE RATING**

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<tr>
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</tr>
<tr>
<td>-2</td>
<td>Highly important to my system in a negative way</td>
</tr>
</tbody>
</table>
## CONSUMER’S VIEW: SOS OPERATIONAL INPUT IMPORTANCE RATING

<table>
<thead>
<tr>
<th>Rating</th>
<th>The provider system (or input from this provider) is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>?</td>
<td>Rating has not yet been completed</td>
</tr>
<tr>
<td>2</td>
<td>Highly important to my system in a positive way</td>
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<td>1</td>
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</tr>
</tbody>
</table>

### Organization A
- **Inputs**
- **System V Capabilities**
- **Outputs**

### “Producer”

### Organization B
- **Inputs**
- **System W Capabilities**
- **Outputs**

### “Consumer”

SoS Operational Input Importance Rating
SoS OPERATIONAL AFFINITY
COMPARING VIEWS OF THE RELATIONSHIP

Output
Importance Rating

Input
Importance Rating

Assess the Affinity

SoS Operational Affinity

Organization A
Inputs
System V Capabilities
Outputs
"Producer"

SoS Operational Input Importance Rating

SoS Operational Output Importance Rating

Organization B
Inputs
System W Capabilities
Outputs
"Consumer"

System V
Capabilities

System W
Capabilities

Organization A
Organization B

Inputs
Outputs

SoS Operational Affinity

? 2 1 0 -1 -2

? 2 1 0 -1 -2
**SUPPLIER’S VIEW:**
**SOS ACQUIRER ALIGNMENT RATING**

<table>
<thead>
<tr>
<th>Rating</th>
<th>The Acquirer’s priorities and incentives are:</th>
</tr>
</thead>
<tbody>
<tr>
<td>?</td>
<td>Rating has not yet been completed</td>
</tr>
<tr>
<td>2</td>
<td>Strongly aligned to my organization’s in a positive way</td>
</tr>
<tr>
<td>1</td>
<td>Somewhat aligned to my organization’s in a positive way</td>
</tr>
<tr>
<td>0</td>
<td>Not aligned to my organization’s</td>
</tr>
<tr>
<td>-1</td>
<td>Somewhat aligned to my organization’s in a negative way</td>
</tr>
<tr>
<td>-2</td>
<td>Strongly aligned to my organization’s in a negative way</td>
</tr>
</tbody>
</table>

**Inputs**
Organization A  
System V Capabilities  
System W Capabilities  
Outputs

**Outputs**

---

**“Supplier”**

---

**“Acquirer”**
## ACQUIRER’S VIEW: SOS SUPPLIER ALIGNMENT RATING

### The Supplier’s priorities and incentives are:

<table>
<thead>
<tr>
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</tr>
</thead>
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</tr>
<tr>
<td>-2</td>
<td>Strongly aligned to my organization’s in a negative way</td>
</tr>
</tbody>
</table>

### Organization A
- **Inputs**:  
- **System V Capabilities**:  
- **Outputs**:  

### Organization B
- **Inputs**:  
- **System W Capabilities**:  
- **Outputs**:  

### “Supplier”

### SoS Supplier Alignment Rating

### “Acquirer”
SOS MANAGERIAL AFFINITY
COMPARING VIEWS OF THE RELATIONSHIP

Organization A
Inputs → System V Capabilities → Outputs → SoS Acquirer Alignment Rating → Organization B
“Producer”

SoS Managerial Affinity

Organization B
Inputs → System W Capabilities → Outputs → SoS Supplier Alignment Rating → Organization A
“Consumer”

Output Importance Rating

? 2 1 0 -1 -2

Assess the Affinity

Input Importance Rating

? 2 1 0 -1 -2
SOS OPERATIONAL AFFINITY
SOS OPERATIONAL AFFINITY

• Map the Consumer’s View to the Producer’s View
• 5 by 5 matrix
**SOS OPERATIONAL AFFINITY**

- None (No Affinity)
- Hidden Consumer
- Hidden Producer
- Cooperative
- Symbiotic
- Antagonistic
- Toxic
- Unwanted Consumer
- Freeloader
- Unwanted Producer
- Spammer

---

<table>
<thead>
<tr>
<th>Consumer’s View</th>
<th>SoS Operational Input Importance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (No Affinity)</td>
<td>-2</td>
</tr>
<tr>
<td>Hidden Consumer</td>
<td>-1</td>
</tr>
<tr>
<td>Hidden Producer</td>
<td>0</td>
</tr>
<tr>
<td>Cooperative</td>
<td>1</td>
</tr>
<tr>
<td>Symbiotic</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Producer’s View</th>
<th>SoS Operational Output Importance Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (No Affinity)</td>
<td>-2</td>
</tr>
<tr>
<td>Hidden Producer</td>
<td>-1</td>
</tr>
<tr>
<td>Cooperative</td>
<td>0</td>
</tr>
<tr>
<td>Symbiotic</td>
<td>1</td>
</tr>
<tr>
<td>Spammer</td>
<td>2</td>
</tr>
</tbody>
</table>

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**SOS OPERATIONAL AFFINITY: “ANTAGONISTIC”**

<table>
<thead>
<tr>
<th>Output Operational Affinity</th>
<th>Input Operational Affinity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance Rating</td>
<td>Importance Rating</td>
</tr>
<tr>
<td>&lt; 0</td>
<td>&lt; 0</td>
</tr>
</tbody>
</table>

**Meaning:** The Producer and Consumer have identified a negative emergence or adverse implications of the exchange.

**Guidance to Producer:** Renegotiate terms to improve the relationship or seek alternate consumers.

**Implications:** The exchange is unwanted by both systems, potentially adversely affecting operations for both systems.

**Guidance to Consumer:** Renegotiate the relationship or seek alternate Producers and eventually replace the problematic Producer.
SOS MANAGERIAL AFFINITY
SOS MANAGERIAL AFFINITY

- Map the Acquirer’s View to the Supplier’s View
- 5 by 5 matrix
SoS MANAGERIAL AFFINITY

- No Help, No Hurt
- Friends
- Buddies
- Adversaries
- Hidden Friend
- Hidden Adversary
- Subversive Supplier
- Traitorous Supplier
- Subversive Acquirer
- Traitorous Acquirer

SoS Managerial Input Importance Rating

SoS Managerial Output Importance Rating

Supplier’s View

Acquirer’s View

-2  -1  0  1  2
-2  -1  0  1  2

-2  -1  0  1  2
-2  -1  0  1  2

Friends
Hidden Friend
Subversive Supplier
Hidden Adversary
Adversaries
Enemies
Traitorous Supplier
Hidden Friend
Traitorous Acquirer

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### SOS Managerial Affinity: “Adversaries”

<table>
<thead>
<tr>
<th>Supplier Alignment Rating</th>
<th>Acquirer Alignment Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0</td>
<td>&lt;0</td>
</tr>
</tbody>
</table>

**Meaning:** Priorities and Incentives in both organizations are aligned, but in a negative way.

**Guidance to Supplier:** Reconsider or improve the relationship, not just organizationally but between systems. Seek alternative Acquirers and Consumers.

**Implications:** The organizations are not likely to collaborate. The relationship between the managers or organizations may be adversarial. The managers or organizations may be undermining each other, threatening the operational outputs of the SoS.

**Guidance to Acquirer:** Reconsider or improve the relationship, not just organizationally but between systems. Seek alternative Suppliers and Producers.
SUMMARY AND ADDITIONAL OBSERVATIONS
SUMMARY

SoS Operational Affinity

• Assess the importance of a system-to-system exchange from both sides
  • SoS Input Importance Rating
  • SoS Output Importance Rating

• Clarify the relationship
  • SoS Operational Affinity
  • Meaning
  • Implications

• Take Action
  • Guidance for Producer
  • Guidance for Consumer

SoS Managerial Affinity

• Assess the importance of an organization-to-organization exchange from both sides
  • SoS Acquirer Alignment Rating
  • SoS Supplier Alignment Rating

• Clarify the relationship
  • SoS Managerial Affinity
  • Meaning
  • Implications

• Take Action
  • Guidance for Supplier
  • Guidance for Acquirer
ADDITIONAL OBSERVATIONS

- Affinities along the diagonal of the affinity matrixes (-2=-2, 0=0, etc) reflect known alignment of perspectives. These relationships represent known risks to operations.

- Affinities off the diagonal reflect misunderstandings regarding the alignment. These relationships represent unknown risks to operations. The greater the distance from the diagonal, the greater the risk.

- The affinities are not symmetrical or reciprocal because there is a flow from a supplier/producer to an acquirer/consumer. Directionality is important in some cases.

- Assessing relationships provides an opportunity to make improvements or mitigate risks, but the even attempting to make the assessment introduces other risks. A “Traitorous Supplier” may not like being labeled as such, even if true.

- SoS Operational Affinity appears to align well to technical perspectives that likely resonate with systems engineers. SoS Managerial Affinity appears to be more socio-political, something systems engineers may struggle with or actively avoid.

- The affinities are amenable to case studies, which would facilitate their understanding and use.
MORE ADDITIONAL OBSERVATIONS

• Maier’s taxonomy (directed, collaborative, virtual) [1] or Dahmann and Baldwin’s taxonomy (directed, collaborative, acknowledged, virtual) [3] could map to any of the SoS Operational Affinity cells or the SoS Managerial Affinity cells.

• Within a Directed SoS, for example, any of the SoS Affinities could appear.

• Multiple SoS Operational Affinities may appear within the same SoS.

• Multiple SoS Managerial Affinities may appear within the same SoS.

• A SoS exists when systems are independent and interdependent. When systems are interdependent, their owning organizations are also interdependent, whether they realized it or not.

• Organizations can be independent and interdependent without creating an SoS.

• Organizational Design Structure Matrix approaches may be useful in mapping multiple affinities within an SoS.

• The affinities have a longitudinal dimension as the SoS evolves over time.

• The affinities may be useful in mitigating risks related to constituent systems joining or leaving an SoS as it evolves.
REFERENCES


BIOGRAPHY

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Aeronautics

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