

# SoSECIE Webinar

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#*

*You can download today's presentation from the OUSD(R&E) Website:*

*<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](mailto: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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# 2019 System of Systems Engineering Collaborators Information Exchange Webinars *Sponsored by MITRE and NDIA SE Division*

***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

**LOCKHEED MARTIN**



Dr. Mike Yokell, ESEP  
Lockheed Martin Fellow and  
Deputy Director, Systems Engineering  
[Mike.R.Yokell@LMCO.com](mailto: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

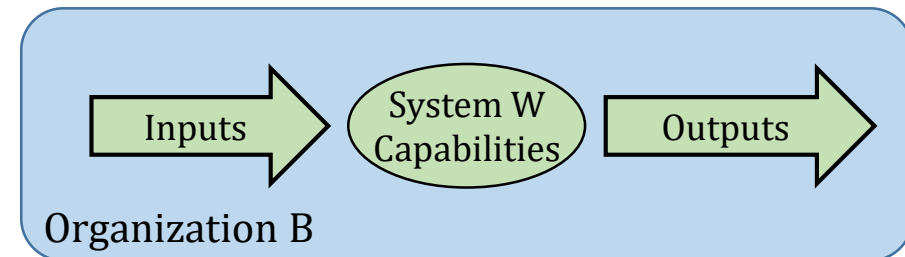
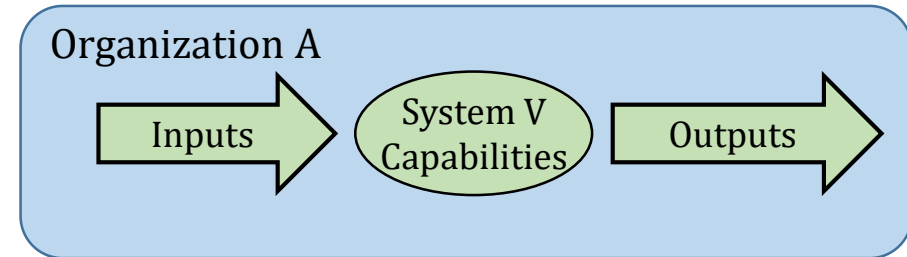
MANAGERIAL  
INDEPENDENCE

OPERATIONAL  
INDEPENDENCE

# OPERATIONAL AND MANAGERIAL INDEPENDENCE

- Systems V and W
  - Operationally Independent
- Organizations A and B
  - Managerially Independent

= Two Systems (not SoS)

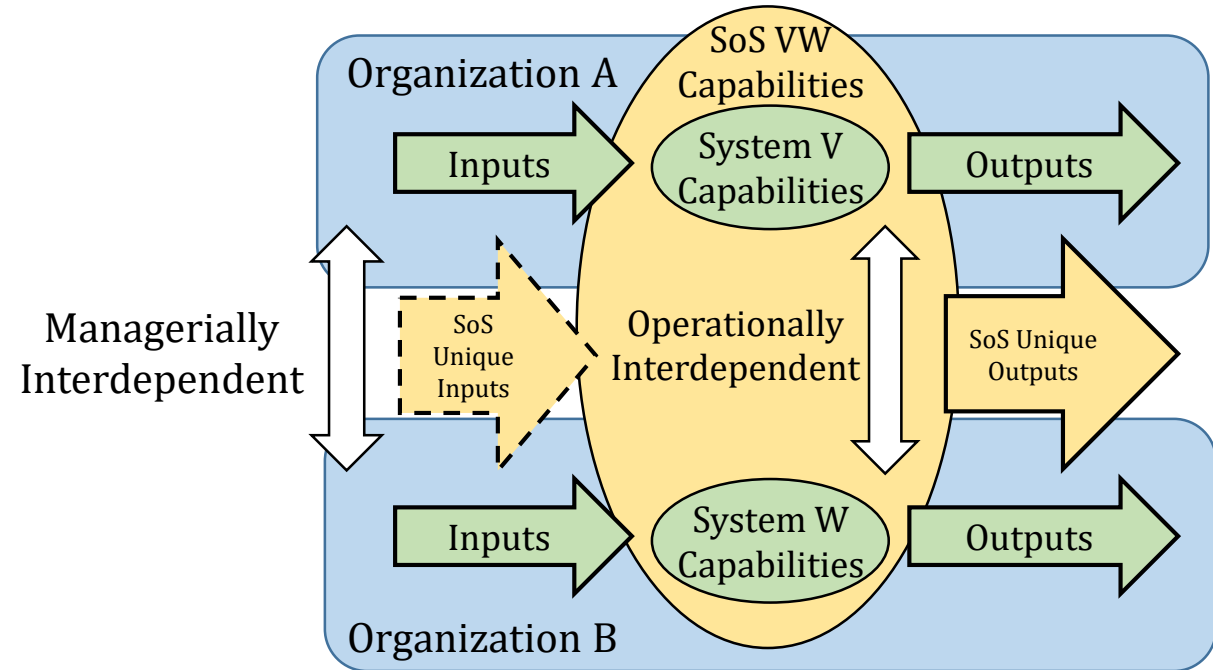


# SYSTEMS OF SYSTEMS (SOS) DIFFER FROM SYSTEMS

- 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)



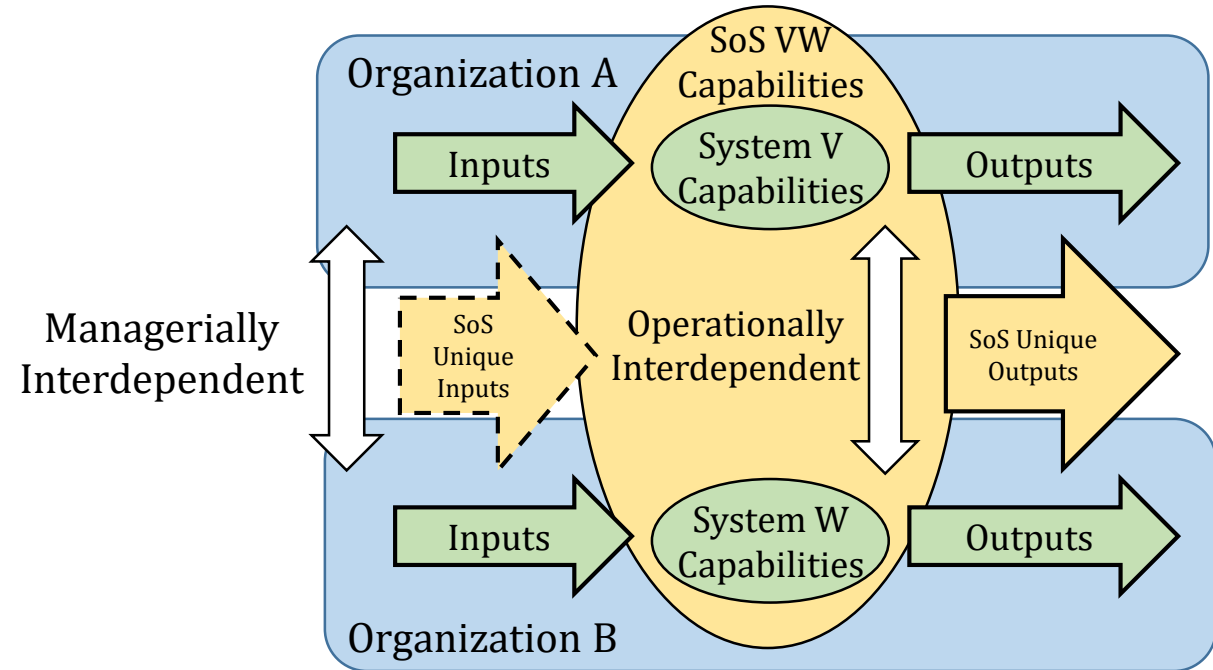
SoS = set of systems and system elements that interact to provide a unique capability that none of the constituent systems can accomplish on its own.

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”



“Supplier”



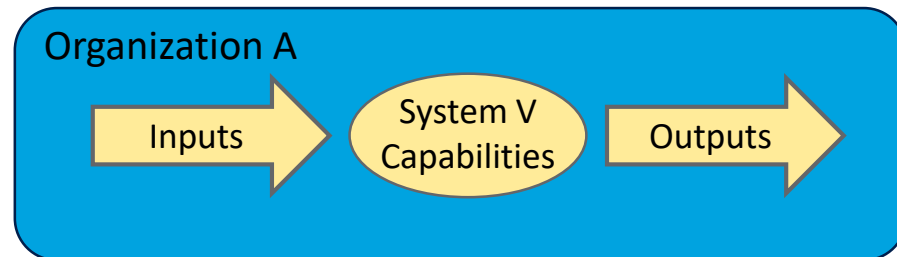
“Acquirer”

From ISO/IEC/IEEE 15288 [3]

# SYSTEM OPERATIONAL RELATIONSHIPS (SYSTEMS = PRODUCER/CONSUMER)

## System V

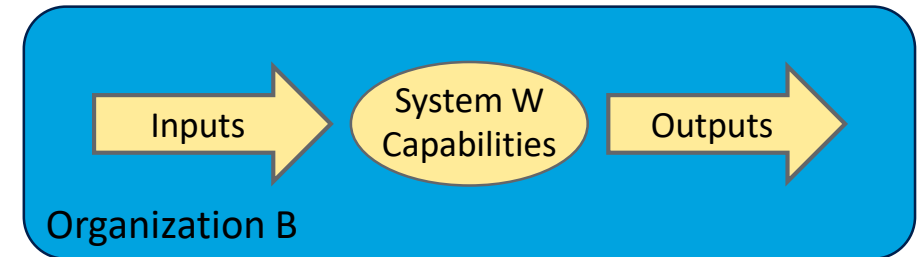
- Consumes Inputs (from somewhere)
- Produces Outputs
- “I produce outputs for System W”



“Producer”

## System W

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

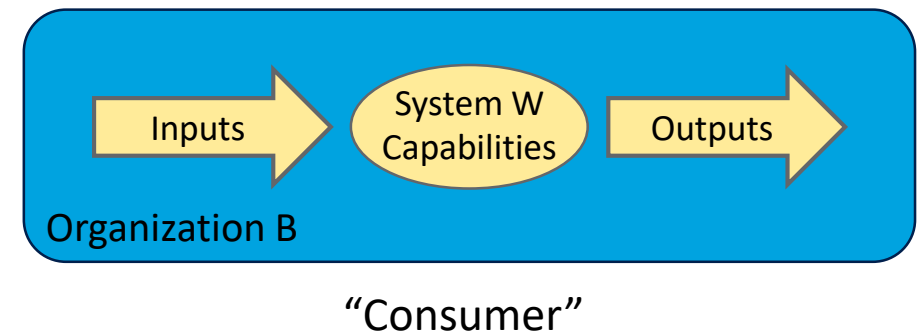
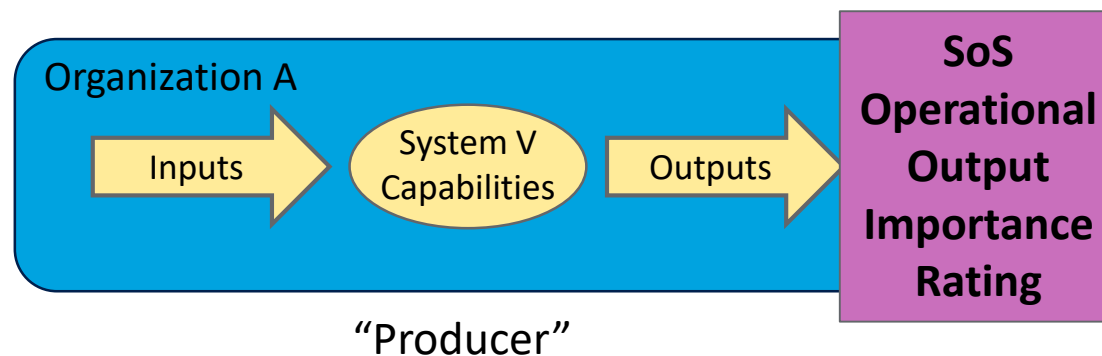


“Consumer”



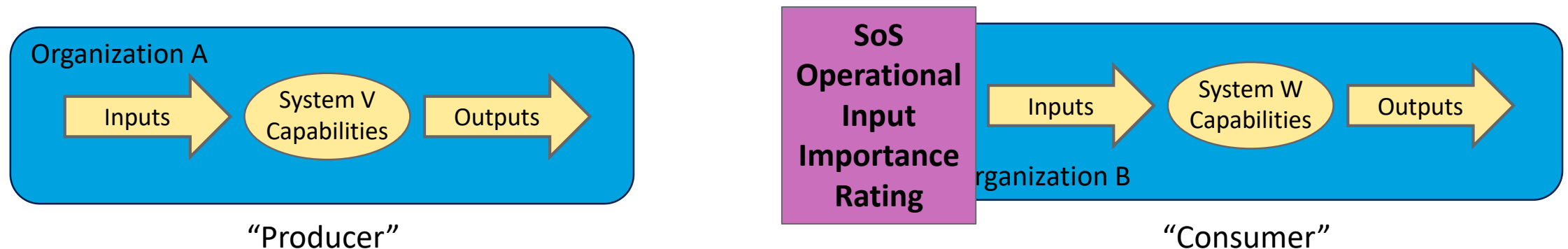
# PRODUCER'S VIEW: SoS OPERATIONAL OUTPUT IMPORTANCE RATING

Rating	The consumer system (or output provided to this consumer) is:
?	Rating has not yet been completed
2	Highly important to my system in a positive way
1	Somewhat important to my system in a positive way
0	Not important to my system
-1	Somewhat important to my system in a negative way
-2	Highly important to my system in a negative way



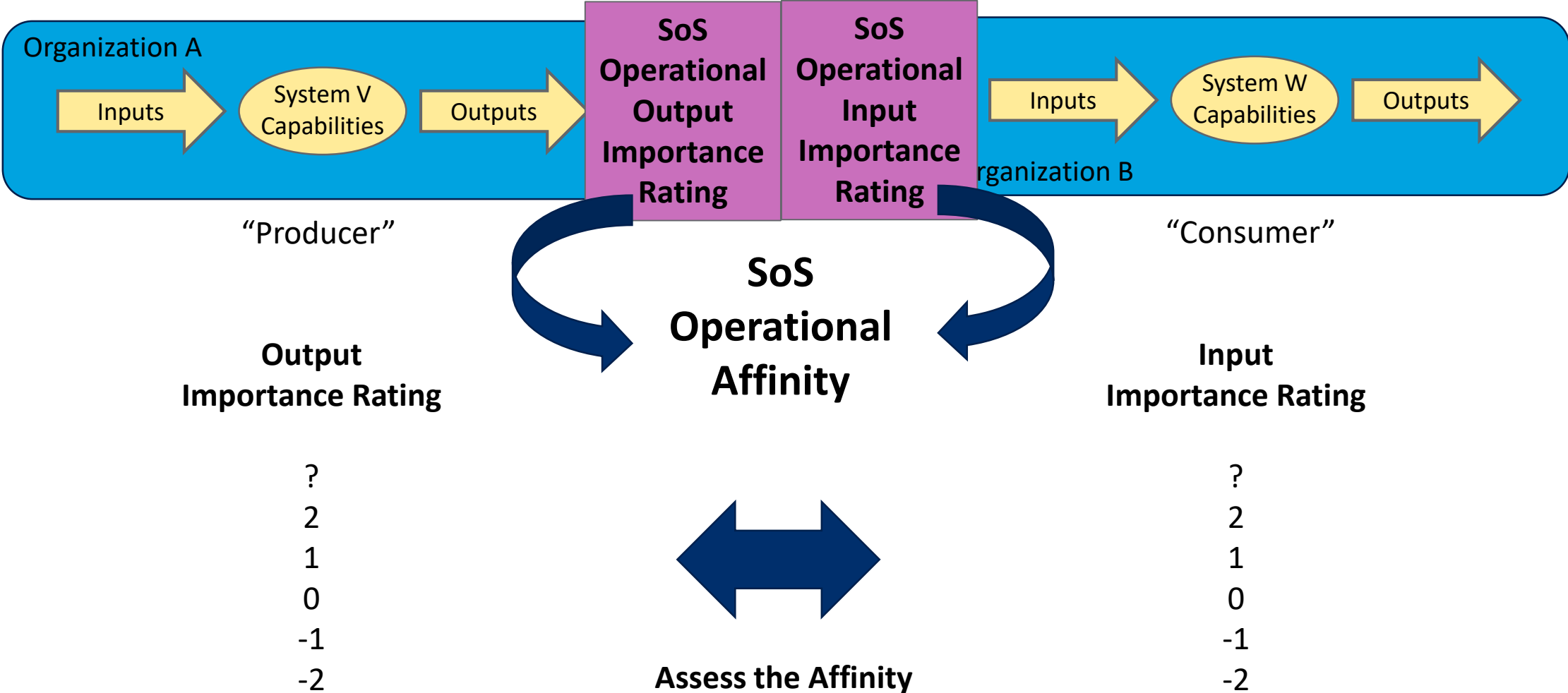
# CONSUMER'S VIEW: SoS OPERATIONAL INPUT IMPORTANCE RATING

Rating	The provider system (or input from this provider) is:
?	Rating has not yet been completed
2	Highly important to my system in a positive way
1	Somewhat important to my system in a positive way
0	Not important to my system
-1	Somewhat important to my system in a negative way
-2	Highly important to my system in a negative way



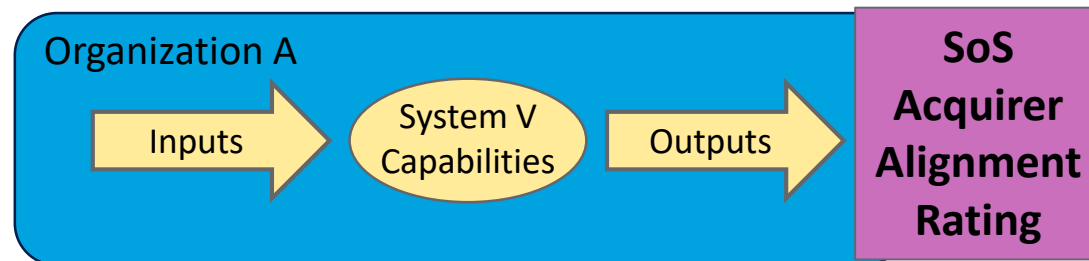
# SoS OPERATIONAL AFFINITY

## COMPARING VIEWS OF THE RELATIONSHIP

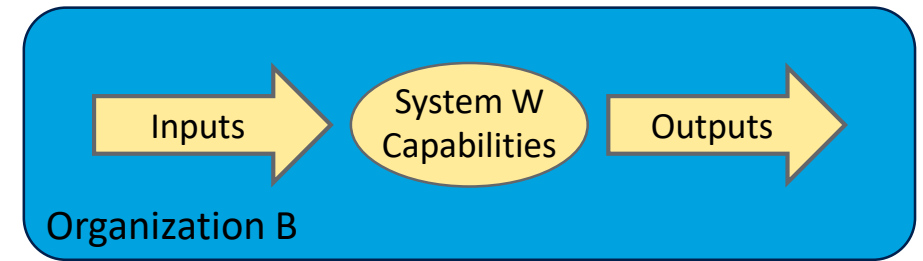


# SUPPLIER'S VIEW: SoS ACQUIRER ALIGNMENT RATING

Rating	The Acquirer's priorities and incentives are:
?	Rating has not yet been completed
2	Strongly aligned to my organization's in a positive way
1	Somewhat aligned to my organization's in a positive way
0	Not aligned to my organization's
-1	Somewhat aligned to my organization's in a negative way
-2	Strongly aligned to my organization's in a negative way



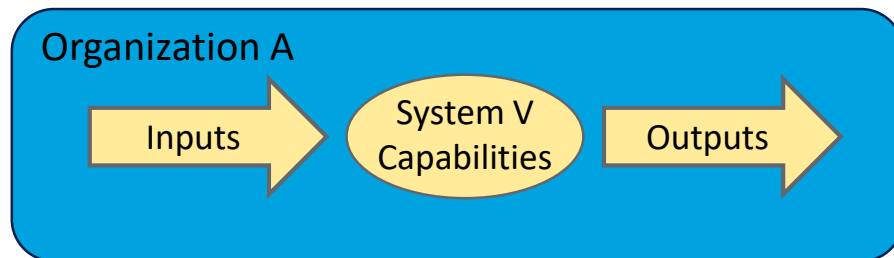
"Supplier"



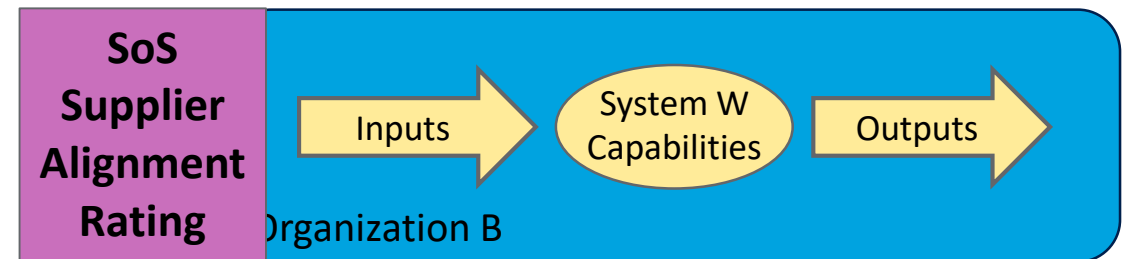
"Acquirer"

# ACQUIRER'S VIEW: SoS SUPPLIER ALIGNMENT RATING

Rating	The Supplier's priorities and incentives are:
?	Rating has not yet been completed
2	Strongly aligned to my organization's in a positive way
1	Somewhat aligned to my organization's in a positive way
0	Not aligned to my organization's
-1	Somewhat aligned to my organization's in a negative way
-2	Strongly aligned to my organization's in a negative way



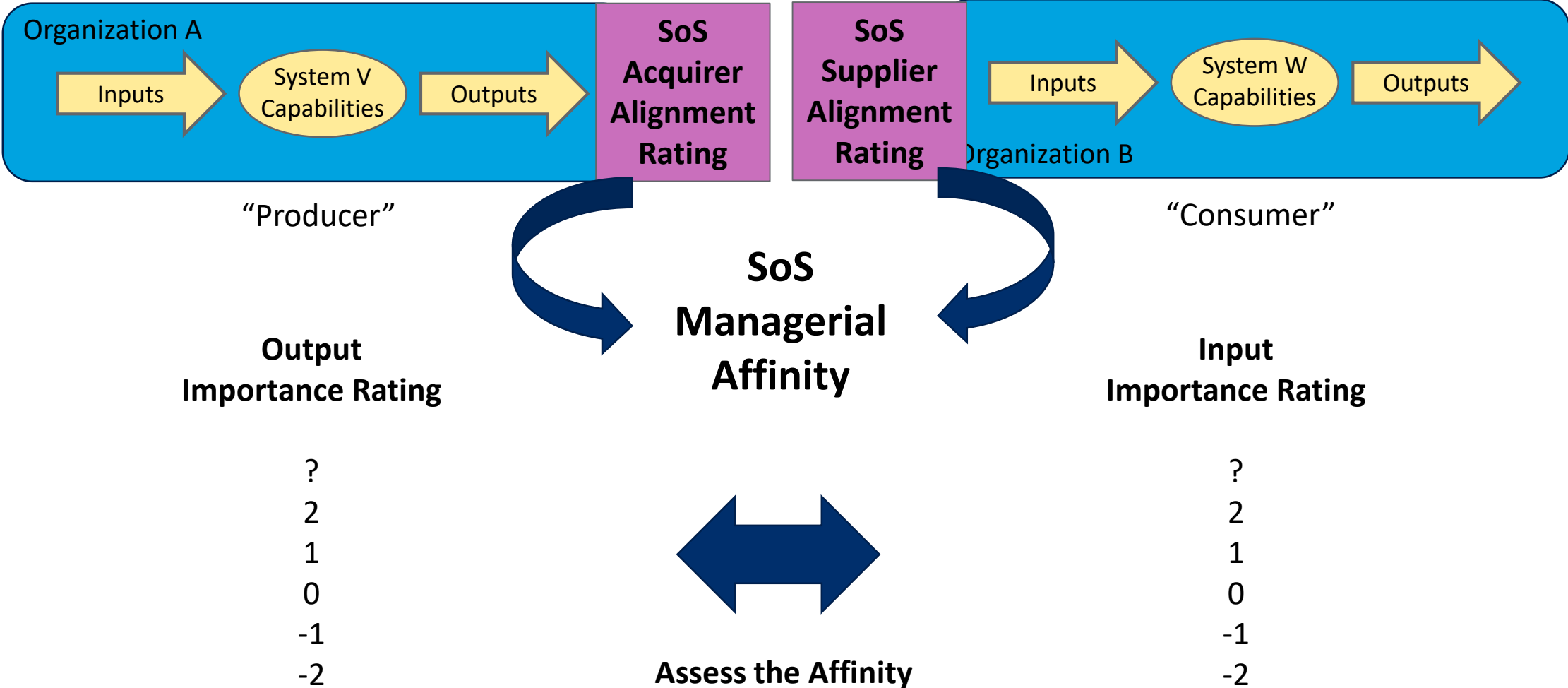
“Supplier”



“Acquirer”

# SoS Managerial Affinity

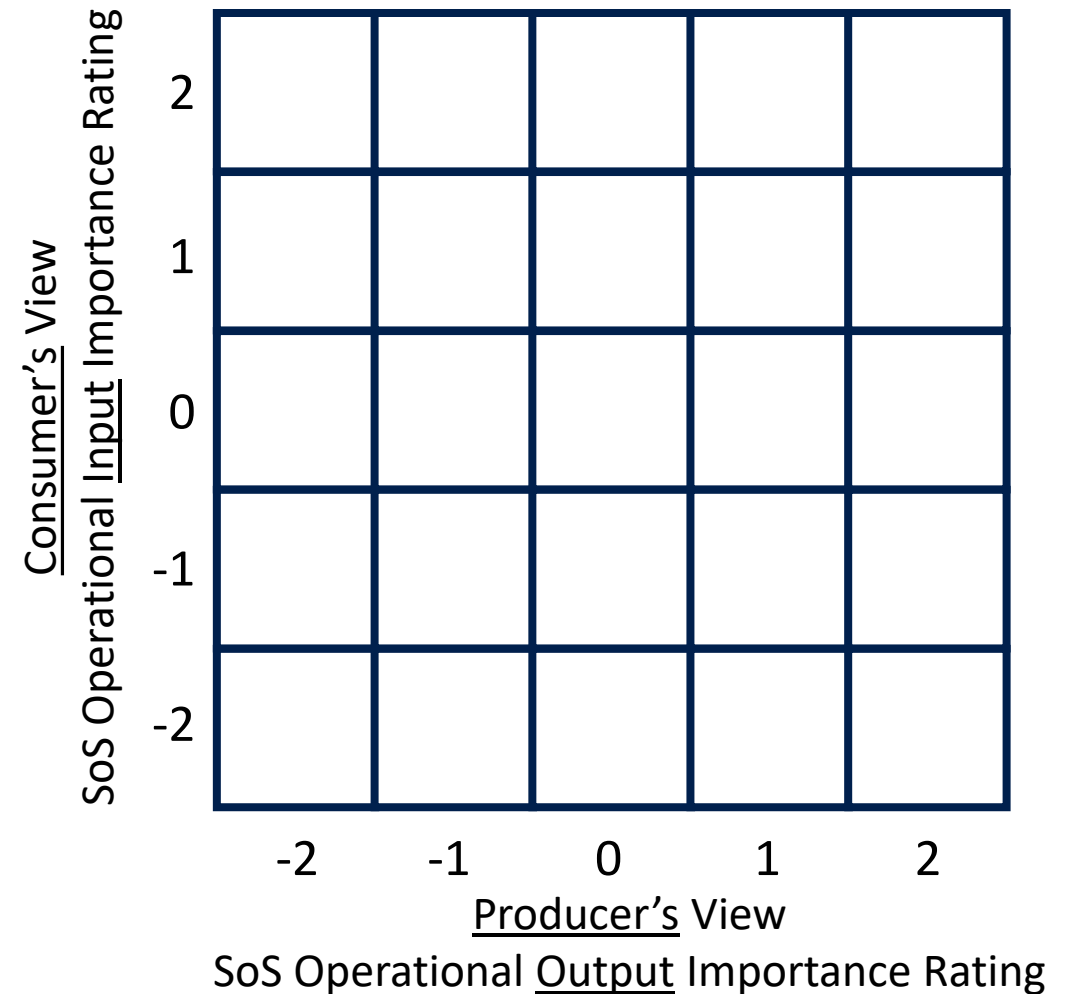
## Comparing Views of the Relationship



# SOS OPERATIONAL AFFINITY

# SoS OPERATIONAL AFFINITY

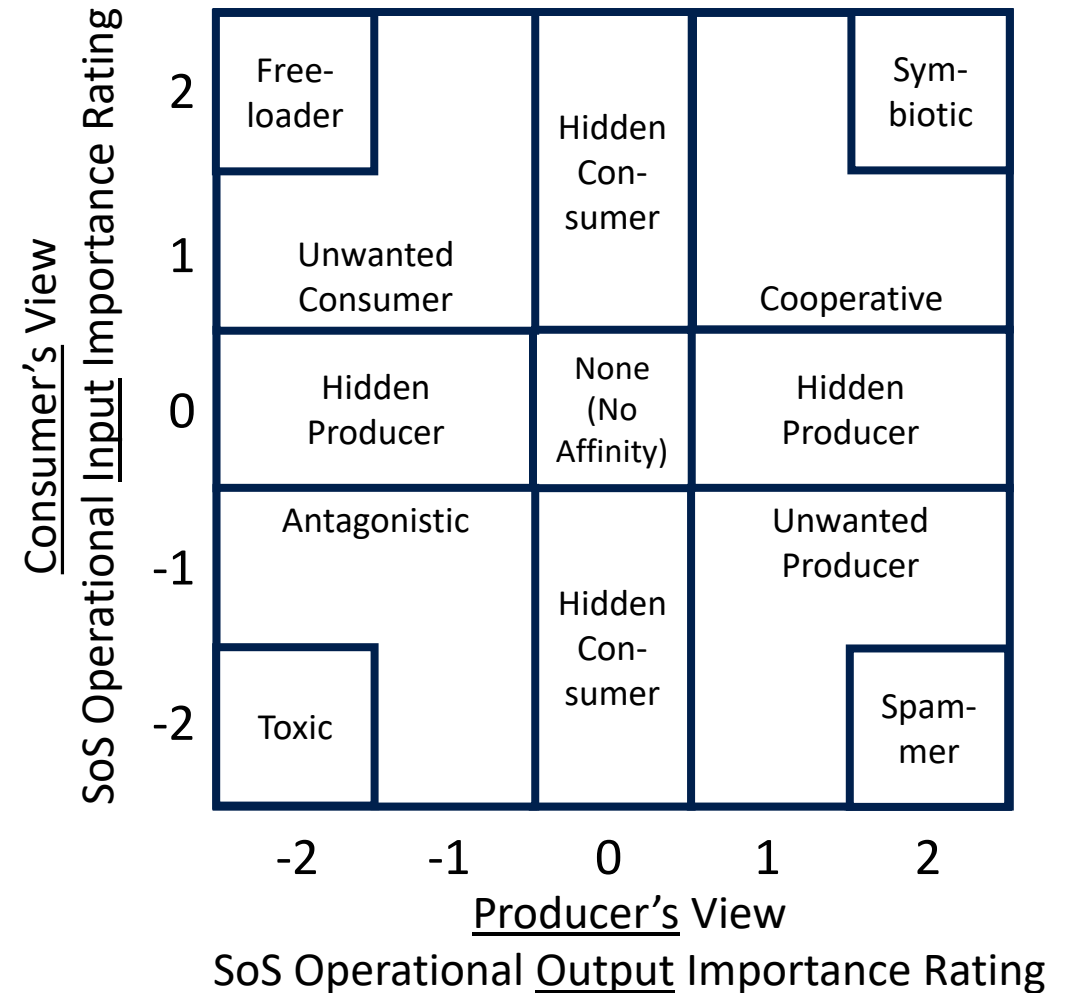
- Map the Consumer's View to the Producer's View
- 5 by 5 matrix





# SOS OPERATIONAL AFFINITY

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



# SOS OPERATIONAL AFFINITY: "ANTAGONISTIC"

Output  
Importance Rating

< 0

SoS  
Operational  
Affinity

"Antagonistic"

Input  
Importance Rating

< 0

**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.

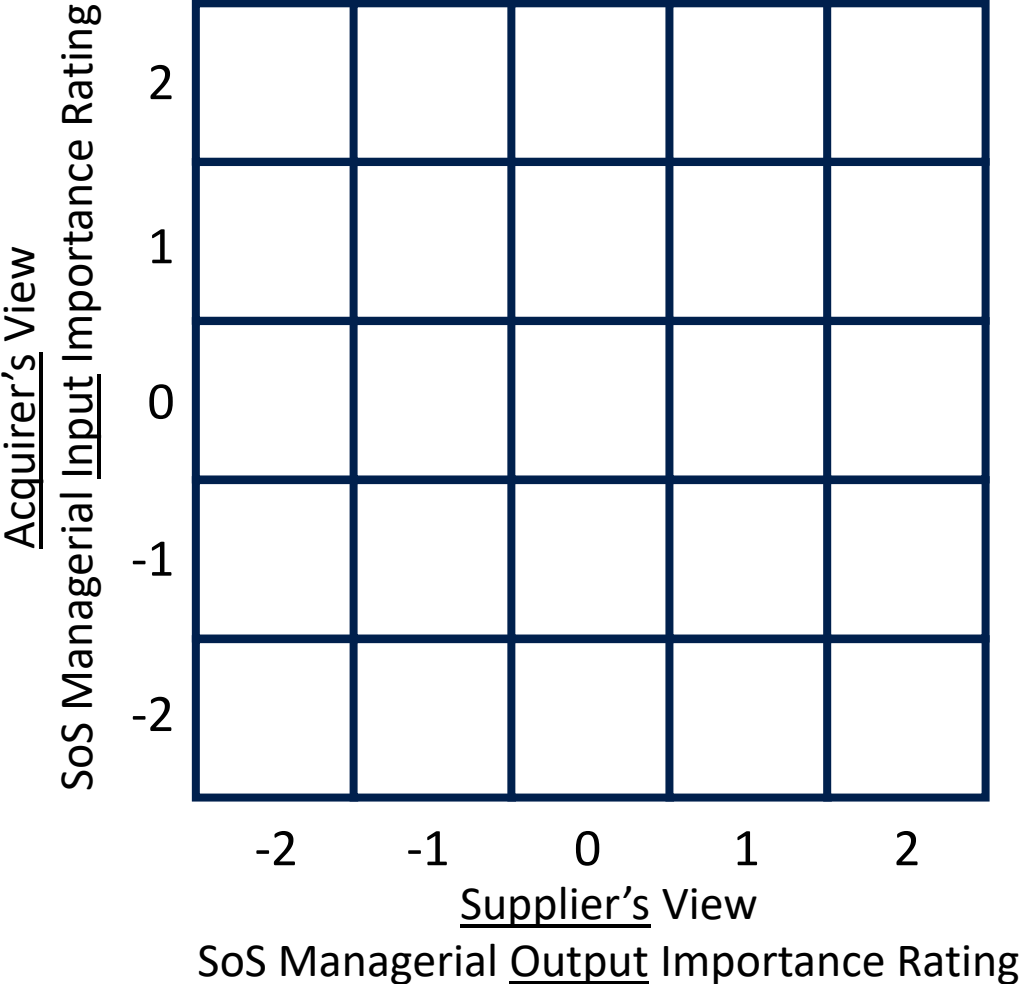
**Implications:** The exchange is unwanted by both systems, potentially adversely affecting operations for both systems.

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

# SOS MANAGERIAL AFFINITY

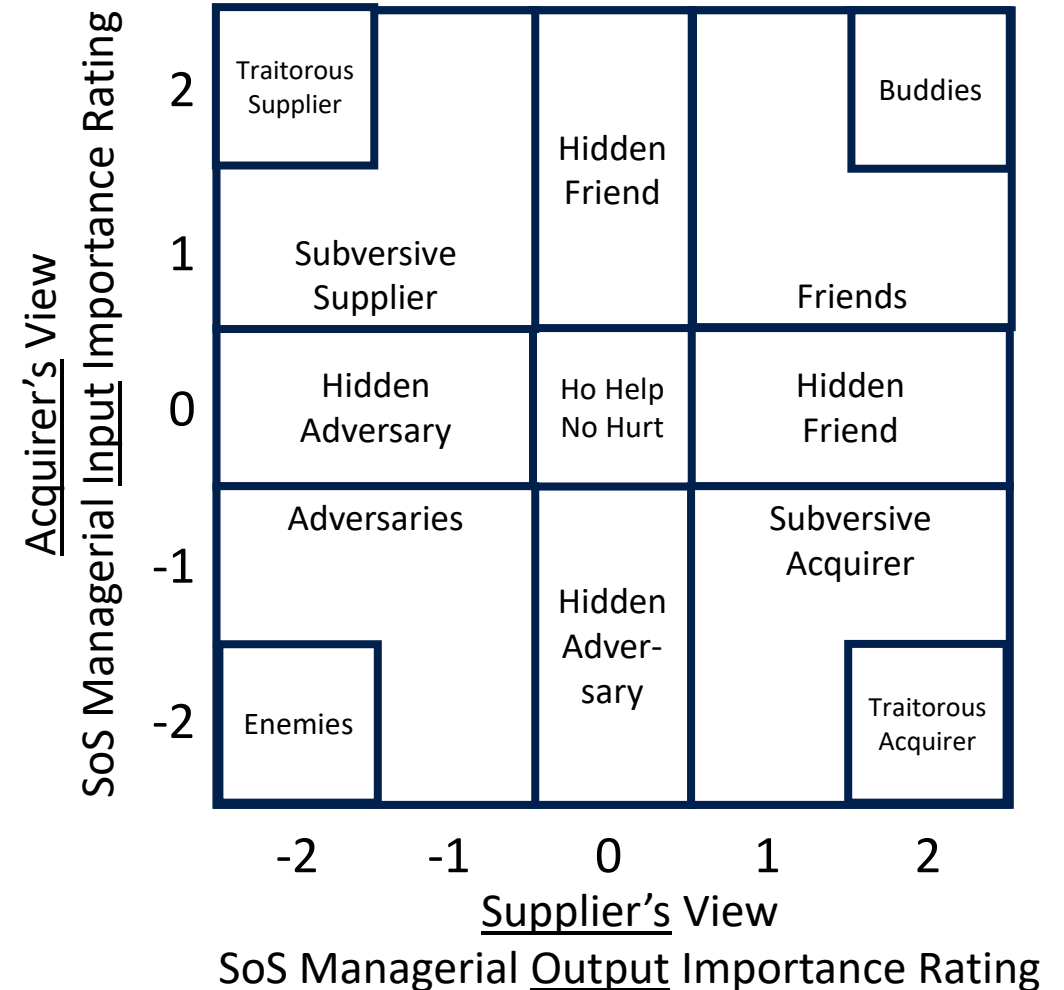
# SOS MANAGERIAL AFFINITY

- Map the Acquirer's View to the Supplier's View
- 5 by 5 matrix



# SOS MANAGERIAL AFFINITY

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



# SOS MANAGERIAL AFFINITY: “ADVERSARIES”

Supplier  
Alignment Rating

<0

SoS  
Managerial  
Affinity

“Adversaries”

Acquirer  
Alignment Rating

<0

**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.

***LOCKHEED MARTIN***



# REFERENCES

- [1] Maier, M. W., “Architecting Principles for Systems-of-Systems,” *Systems Engineering*, Vol 1: 267-284, 1998
- [2] ISO/IEC/IEEE 15288, Systems and software engineering - System life cycle processes
- [3] Dahmann J. and Baldwin K., Understanding the current state of US Defense systems of systems and the implications for systems engineering, *IEEE International Systems Conference*, 2008
- [4] Yokell, Mike R, “Systems of Systems Managerial and Operational Affinity – Assessing and Improving Relationships Within Systems of Systems”, *Lockheed Martin Journal of Systems Engineering and Architecture*, Volume 3, No. 1, Spring 2018.

# BIOGRAPHY



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