

# SoSECIE Webinar

Welcome to the  
2020 System of Systems Engineering Collaborators  
Information Exchange (SoSECIE)



*We will start at 11AM Eastern Time*

*You can download today's presentation from the SoSECIE Website:*

*<https://mitre.tahoe.appsembler.com/blog>*

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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

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 Teams.
  - 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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# **2020-2021 System of Systems Engineering Collaborators Information Exchange Webinars**

*Sponsored by MITRE and NDIA SE Division*

*November 3, 2020*

*Challenges for System of Systems in the Agriculture Application Domain*

*Dr. Benjamin Weinert and Dr. Mathias Uslar*

*November 17, 2020*

*Achieving System-of Systems Interoperability Levels Using Linked Data and Ontologies*

*Dr. Jakob Axelsson*

*December 1, 2020*

*Achieving System Integration through Interoperability in a large System of Systems (SoS)*

*Mr. Oliver Hoehne*

# **2021-2022 System of Systems Engineering Collaborators Information Exchange Webinars**

*Sponsored by MITRE and NDIA SE Division*

*January 26, 2021*

*Addressing the Sustainable Development Goals with a System-of-Systems for Monitoring  
Arctic Coastal Regions*

*Evelyn Honoré-Livermore, Roger Birkeland and Cecilia Haskins*

*February 23, 2021*

*Interface Management- the Neglected Orphan of Systems Engineering*

*Paul Davies*

*March 9, 2021*

*Distributed Architecture for Monitoring Urban Air Quality: A Systems Engineering Approach*

*Adrián Unger, Tom McDermott and Philip Dewire*

*April 6, 2021*

*Holistic architecture description for a future Global Health Assurance Systems of Systems*

*Adrián Unger*

# Situation Awareness and Decision Making for Constituent Systems

System of Systems Engineering  
Collaborators Information Exchange (SoSECIE)

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# Takeaway message

- Constituent systems need to have an accurate *situation awareness*, i.e., an understanding of the environment they are in, what other elements are present therein and how this will develop in the future
- This is needed throughout the life-cycle of a constituent system
- The information needs change as the constituent system evolves
- A *world model* that includes information and inferences about other objects is needed



# Definitions

- *Systems of systems (SoS)* are independently operated and managed systems that are geographically distributed, undergo evolutionary development and display emergent behavior
- The individual systems are named the *constituent systems (CS)*
- A set of constituent systems that operate together is a *constellation* in the overall SoS
- *Collaborative SoS*: CS voluntarily agree upon the purposes, without central controller that enforces collaboration

# Example: vehicle platooning

- Vehicles drive with very short distances => fuel savings
- Trucks are CS
- Platoons are constellations
- Need coordination and synchronization
- Allow others to join platoon
- Handle cut-ins

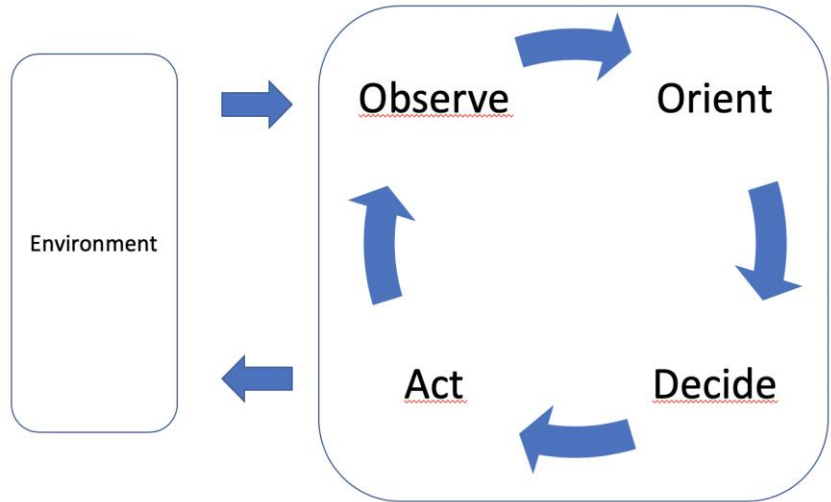


# Situation awareness

- Mica Endsley: "the perception of environmental elements with respect to time and/or space, the comprehension of their meaning, and the projection of their status after some variable has changed, such as time"
- Each CS needs to be aware of its relevant environment in order to make decisions about its role in the SoS and constellation as well as about its operation

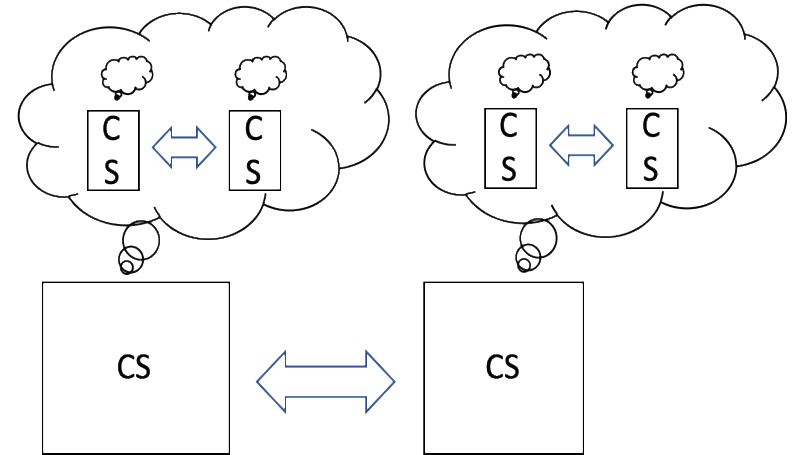
# Decision making: the OODA loop

- Observe-Orient-Decide-Act loop
- Originally from air combat
- Describes the decision making of an intelligent agent



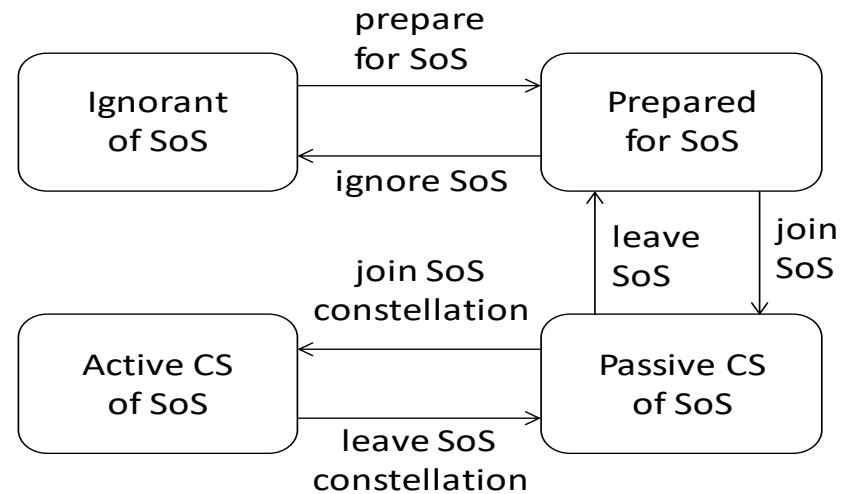
# World model and recursive knowledge

- World model must include all relevant objects as well as other CS, constellations, SoS, ...
- Needs to predict behaviours of others and their world models



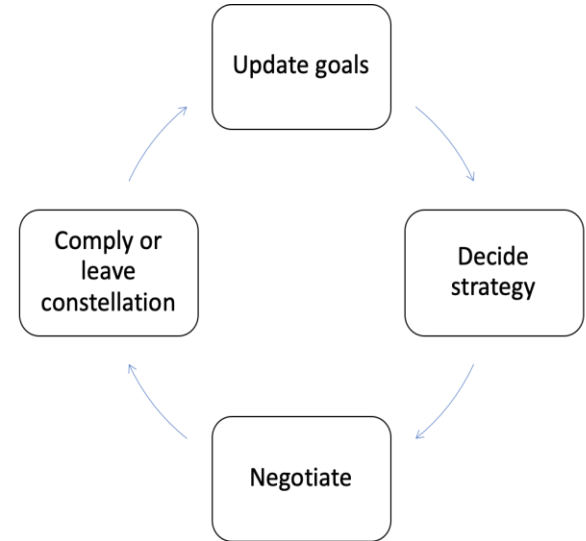
# What decisions must a CS make?

- Normal operation of the CS: truck braking, accelerating, steering
- Move between different life stages of a CS:
  - Operational decisions: join, leave, look for constellation
  - Strategic decisions of owning and operating organization: join, leave, prepare, ignore SoS



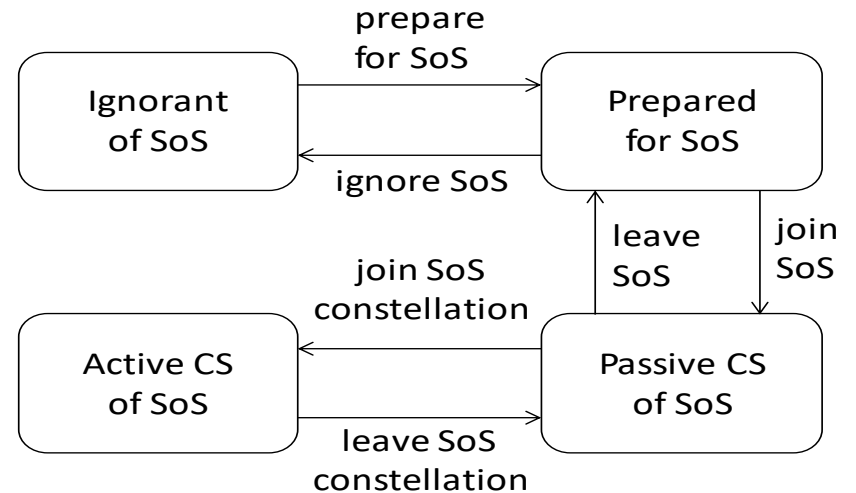
# Joint decisions in a constellation

- Allow another CS to join the constellation
- Joint change of behavior:
  - Determine braking strategy for vehicle platoon
- Negotiations needed for joint decisions – CS could decide to leave constellation if not satisfied with decision (must take account of penalties and agreements)



# The life cycle of a CS

- *Ignorant*: CS has relevant capabilities to contribute to the SoS, but does not meet the requirements of it
- *Prepared*: CS has been prepared so that it meets the requirements of the SoS, but has not explicitly joined i
- *Passive*: CS is in the SoS, but is not collaborating with other CS in a constellation. Either looking for a constellation or happy as it is
- *Active*: CS is actively collaborating with other CS in a constellation. Could be looking for a better constellation or happy as it is





# What are the information needs in different life cycle stages of a CS?

- In the ignorant state, the decision to develop the functionality needed to join a SoS has not yet been developed. The managerial organizations (*i.e.*, owning, operating and manufacturing organizations) need to be aware of the:
  - Development cost and time needed to prepare for SoS
  - Potential benefits of participating in SoS
  - Standards and interfaces needed in SoS
  - Applicable regulations
  - Possible SoS to participate in

# What are the information needs in different life cycle stages of a CS?

- In the prepared state, the CS has been equipped with the necessary equipment to join a SoS. The operating organization needs to be aware of the:
  - Potential SoS to be in (those that are compatible with the installed equipment)
  - Benefits and costs associated to each potential SoS
  - Applicable Regulations

# What are the information needs in different life cycle stages of a CS?

- In the passive CS stage, the CS has joined a SoS but is not active in a constellation. The CS in this stage needs to be looking for potential collaboration opportunities and could make use of resources and information from its operating organization as well as mediator services for doing this. Its information needs include
  - Potential constellations that are reachable and the steps needed to join them
  - Existing constellations that are reachable and the steps needed to join them
  - The operating and owning organizations of the members of a potential or existing constellation that should be considered, in particular the agreements and regulations applicable to them
  - The costs and benefits of joining an existing or a potential constellation
  - Potential changes in the environment that would change the benefits/costs of a potential or existing constellation

# Information needs in the active phase

- The current constellation members, their position and other data, operating and owner organization, their future plans
- Other potential and existing constellations as in the passive stage
- Accrued and future costs and benefits of the current constellation
- Updated models for predicting the costs and benefits of remaining in the current constellation or joining any of the others
- Updated models for predicting the possible costs and benefits of leaving the current constellation, either to join another or to continue as a passive CS
- The possible benefits and costs of assuming a different role in the constellation
- Potential changes in environment that would change the benefits/costs of a potential or existing constellation

# Discussion

- Only a first look at situation awareness for CS. Future work:
- Distinctions between decisions made by CS, operating organizations, owning organizations, mediating services, control towers, ...
- Situation awareness needs for negotiating CS
- Handling uncertain information and deception
- Method for building the world model, ontologies, fusion algorithms, ...

# Questions and comments?

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