SoSECIE Webinar

Welcome to the
2021 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

To add/remove yourself from the email list or suggest a future topic or

speaker, send an email to sosecie@mitre.org

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

Join us for the NDIA's Virtual Systems and Mission Engineering Conference

Dates: Monday, December 6th through Wednesday, December 8th

- **Why Attend?**
  - Gain insight on improving acquisition and performance of defense programs and systems.
  - Hear from Program Managers, Systems Engineers, Chief Scientists, and Engineers and Managers.
  - Participate in Q&As with session speakers; getting your most pressing systems engineering questions answered.
  - View handouts to supplement and enhance your virtual experience.
  - Network and build relationships with like-minded professionals during virtual networking opportunities.

- **Topics**
  - Engineering and Manufacturing
  - Human Systems Integration
  - Systems Architecture
  - Systems Security Engineering
  - Systems of Systems Engineering

Register online at
https://www.ndia.org/events/2021/12/6/24th-sme-conference-virtual/registration

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 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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- Reference in any presentation to any specific commercial products, processes, or services, or the use of any trade, firm or corporation name is for the information and convenience of the participants and subscribers, and does not constitute endorsement, recommendation, or favoring of any individual company, agency, or organizational entity.

2021-2022 System of Systems Engineering Collaborators Information Exchange Webinars
Sponsored by MITRE and NDIA SE Division

December 14, 2021
A Heterogeneous Autonomous Collaborative System for Powerline Inspection Using Human-Robotic Teaming
Srikanth Vemula, Jovany Avila, and Michael Frye

January 11, 2022
Approach for Complex Deterministic and Nondeterministic Systems (ACDANS)
Dr. Paul C. Hershey

January 25, 2022
Applying SoSE in Healthcare: the case for a soft systems methodology approach to Digital-first Primary Care
Iqra Shahzad, Melanie King, and Michael Henshaw

https://www.mitre.org/capabilities/systems-engineering/collaborations/system-of-systems-engineering-collaborators

2021-2022 System of Systems Engineering Collaborators Information Exchange Webinars
Sponsored by MITRE and NDIA SE Division

February 8, 2022
Empowering Adaptive Human Autonomy Collaboration (DUAL) with Artificial Intelligence
Dr. Mark Chattington

February 22, 2022
System of Systems Engineering Conference (SoSE) and Industry Perspectives and the Role of SoSE:
INCOSE and IEEE Collaborations
Paul Hershey, Garry Roedler, and Mo Jamshidi

March 8, 2022
An Event-based Microservice Platform for Autonomous Cyber-Physical Systems: the case of Smart
Farming
Mara Nikolaidou

May 3, 2022
Cross-Domain Stakeholder-Alignment in Collaborative SoS – Lego Serious Play as a Boundary Object
Johann Shuetz, Julia Koehlke, and Sebastian Hanna

Should I Stay or Should I Go? How Constituent Systems Decide to Join or Leave Constellations in Collaborative SoS

SoSECIE webinar 2021-11-30
Based on SoSE 2021 paper

Pontus Svenson & Jakob Axelsson
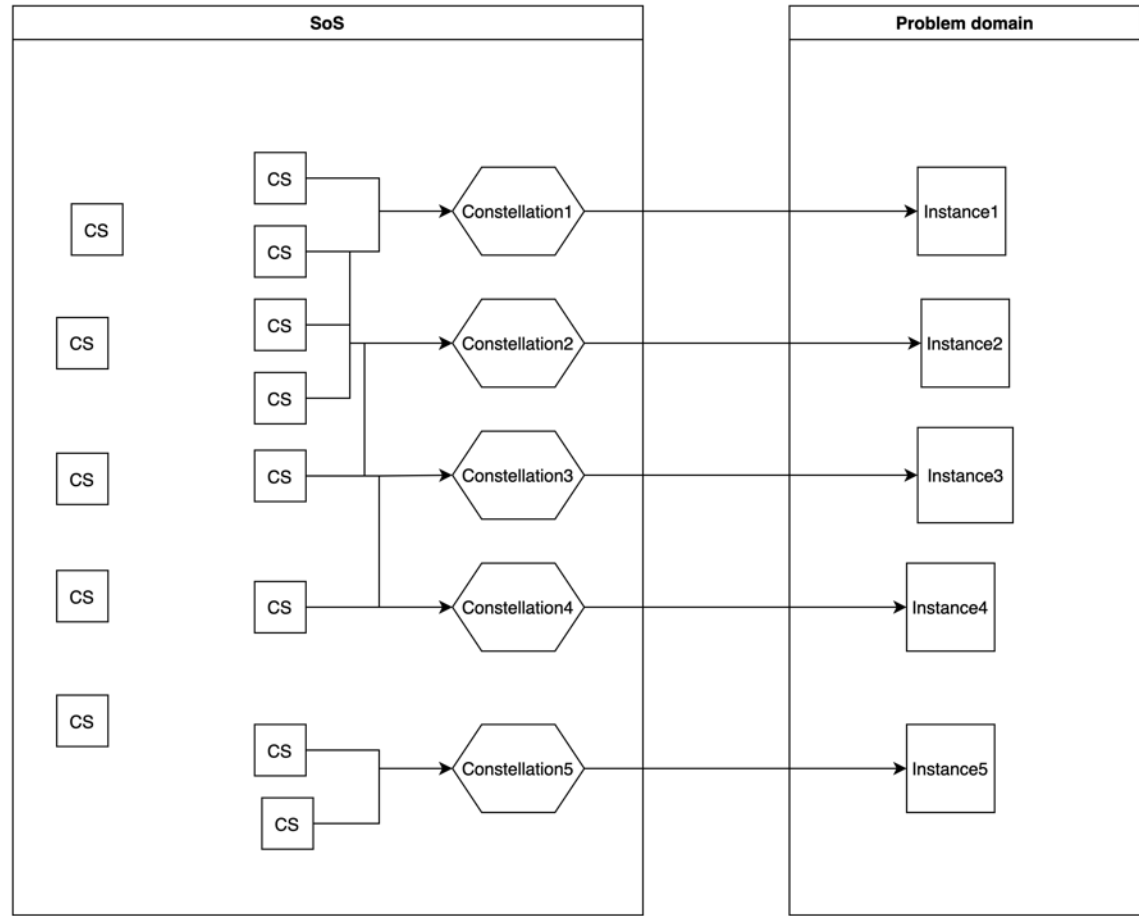RISE Research Institutes of Sweden
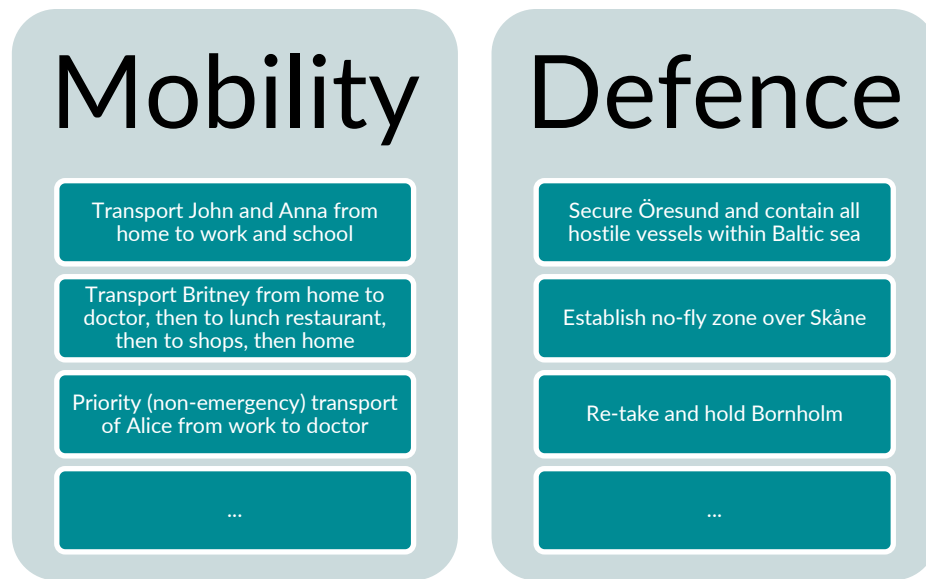
Pontus.Svenson@ri.se
Jakob.Axelsson@ri.se

Systems of systems

- *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)

    – Mediators – SoS elements that help CS collaboratore

- A set of constituent systems that operate together is a *constellation* in the overall SoS

- Focus: collaborative SoS, no central controller that can enforce collaboration; settings where the SoS is intended to solve many problem instances simultaneously

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SoS with constellations solving many problem instances, and some passive CS
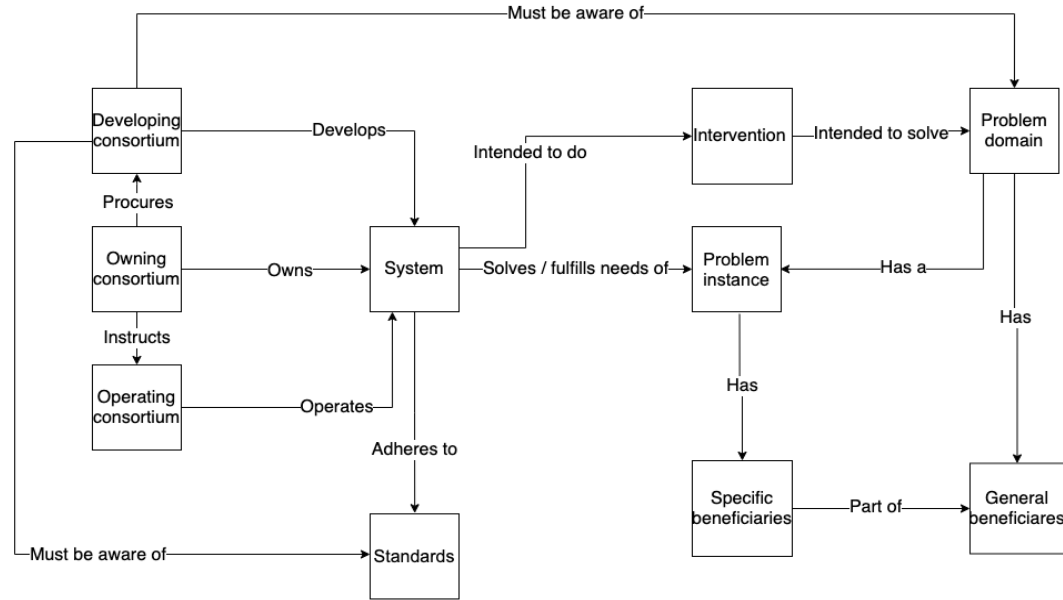
Problem domains and instances

Mobility

- Transport John and Anna from home to work and school
- Transport Britney from home to doctor, then to lunch restaurant, then to shops, then home
- Priority (non-emergency) transport of Alice from work to doctor
- ...

Defence

- Secure Öresund and contain all hostile vessels within Baltic sea
- Establish no-fly zone over Skåne
- Re-take and hold Bornholm
- ...

The SoS must be able to solve several problems simultaneously (cf "missions")

Each instance is solved by a constellation of CS

A CS can participate in multiple constellations – Britney and John share ride, air surveillance craft Argus supports both Skåne and Bornholm missions

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# A system is intended to intervene in a problem domain by solving a problem instance

The systems of systems we study are intended to intervene in a problem domain by solving multiple problem instances
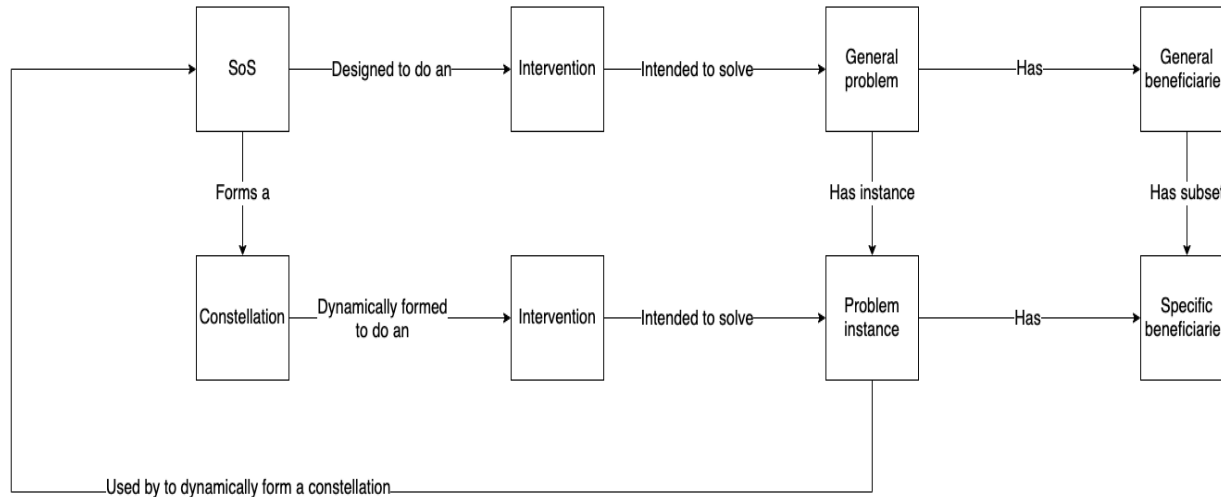
SoS

- CS have their own purpose – intended intervention in (another) problem domain

- SoS has a purpose – is intended to do an intervention in some problem domain (see Svenson, Reichenberg, Axelsson, SoSE2021)

- Constellation: set of CS that act as an instantiation of the SoS to do an intervention
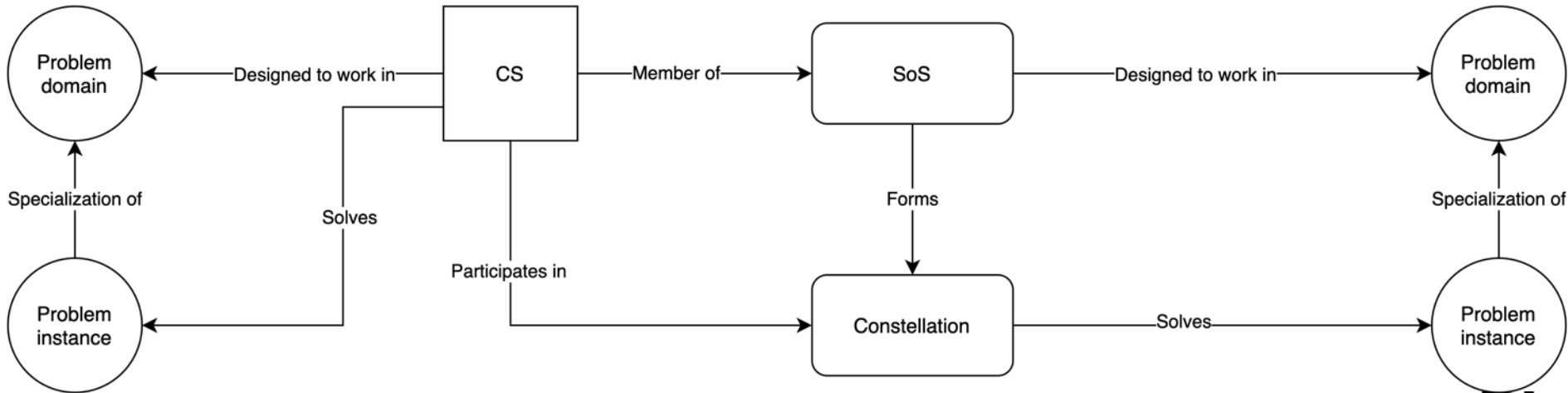
The life cycle of a CS

- *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

- *Active:* CS is actively collaborating with other CS in a constellation

Axelsson, 2019
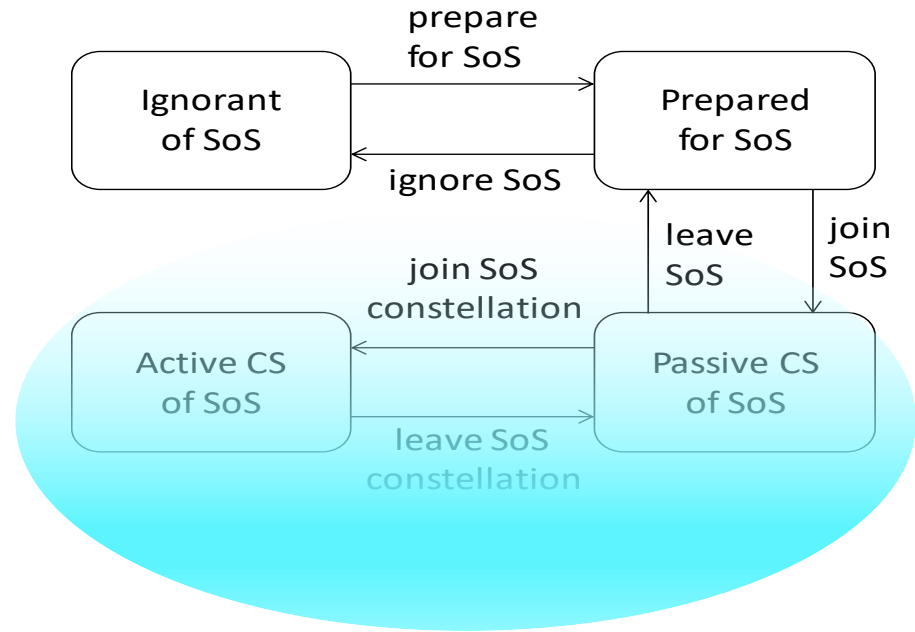
Focus of this paper

How should a CS decide?

- To join a constellation

- To leave a constellation and join another

- To leave a constellation and continue as a singleton
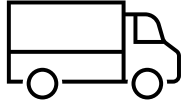
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Example: vehicle platooning

- Vehicles drive with very short distances => fuel savings

- Trucks are CS

- Platoons are constellations

- Need coordination and synchronization

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Example platooning: three constellations and a passive CS
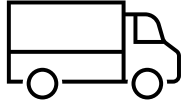
Key problem: CS decision-making – join or leave a constellation?

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This is an issue also in defence!

- Navy platform lacks long-range radar, so needs fire-control radar from aircraft

- Turning on radar will expose aircraft to fire from hostile vessel and aircraft

- When should the aircraft allow the ship to use its radar?

See, e.g., Lantz, Strömberg, Task management in sensor-provided operator platforms, IEMC 2003

SoS with constellations solving many problem instances
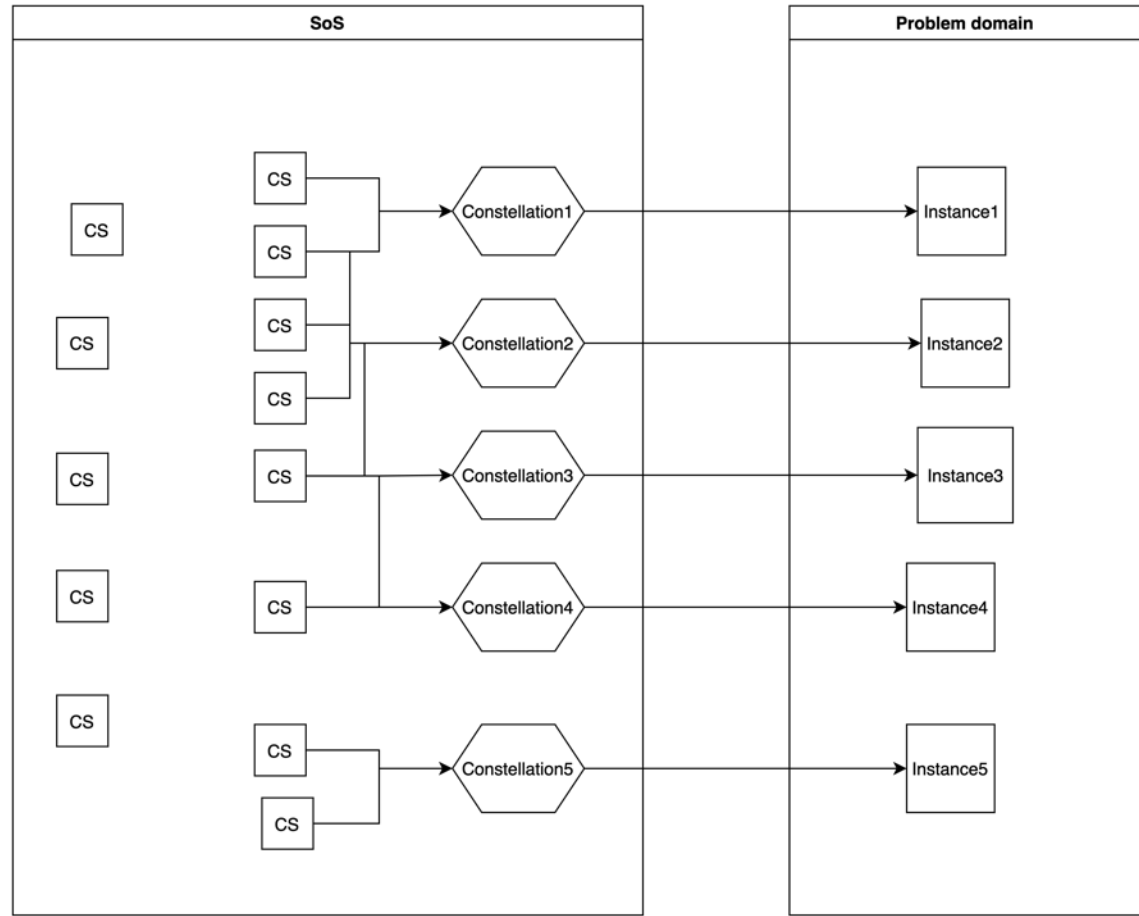
Decisions to take

- Leave an existing constellation?

- Join an existing constellation?

- Initiate formation of a new constellation?

- Accept an invitation to join a constellation?

- …

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Example: Mobility SoS in Harestad

- Autonomous vehicles ("pods") with different capacities combined with existing public transport system

- Travels to

  – Work

  – School

  – Shopping

  – Non-critical medical

Example decisions in mobility SoS

- where to go when empty (to maximise chance of receiving new assignment soon)

- whether to accept a proposed assignment or not

- which route to take when on assignment (to optimize both fuel use, time to goal, and opportunity to get more passengers/cargo)

- whether to abort an assignment, risking penalties but possibly gaining other business

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How does a CS make decisions?

- Could consult "fleet management", i.e., CS operator

- Could consult "decision support mediators", i.e., other elements of the SoS

- Could decide by itself – requires situation awareness and reasoning capability (Svenson, Axelsson, SoSE2020)

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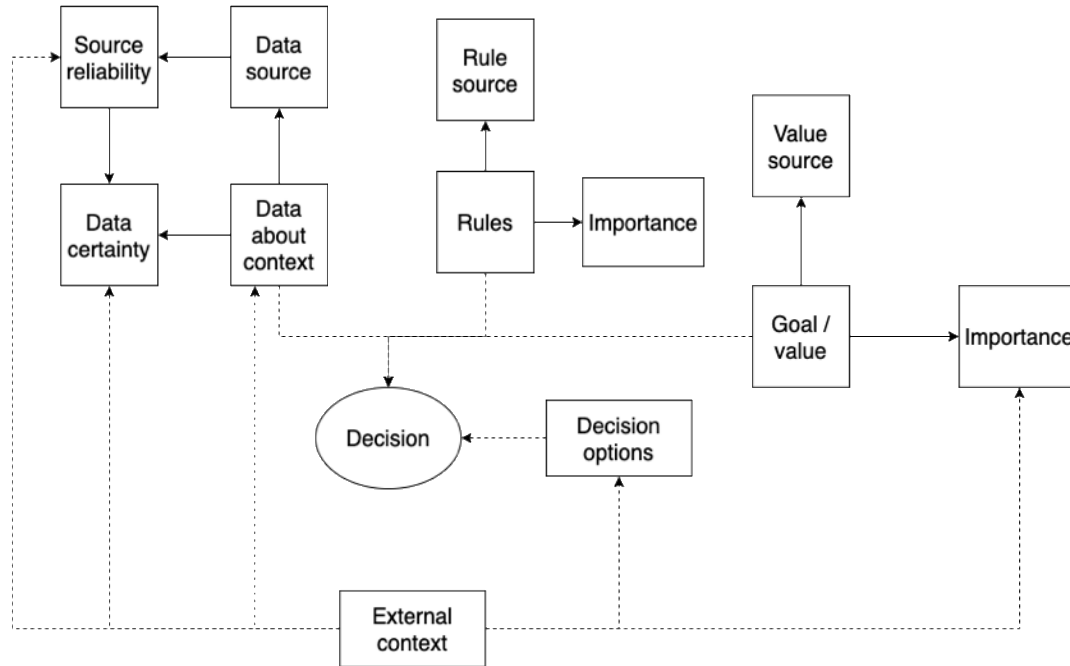# What factors influence the decision of the CS?

- Recall that a CS has its own goal as well as the joint, constellation goal:
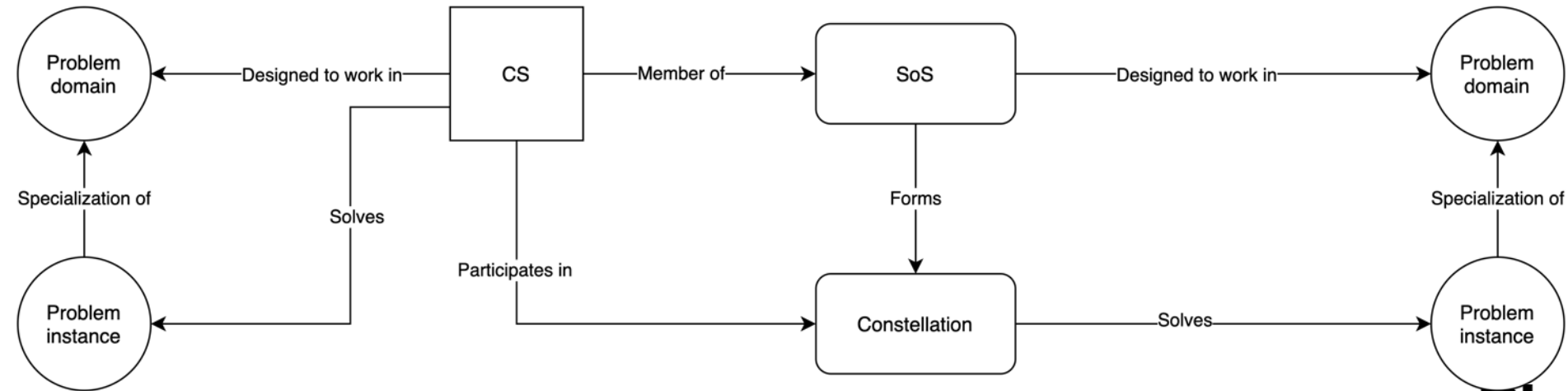
What factors influence the decision of the CS?

- Goals of CS

- Goals of operating and owning organizations

- Benefits by participating in constellation

- Laws and rules in society

- Rules and regulation in the SoS

  - E.g., penalties for leaving a constellation

- Data about the world/environment

- Situation awareness encompasses all these things

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Factors affecting a decision

RISE — Research Institutes of Sweden

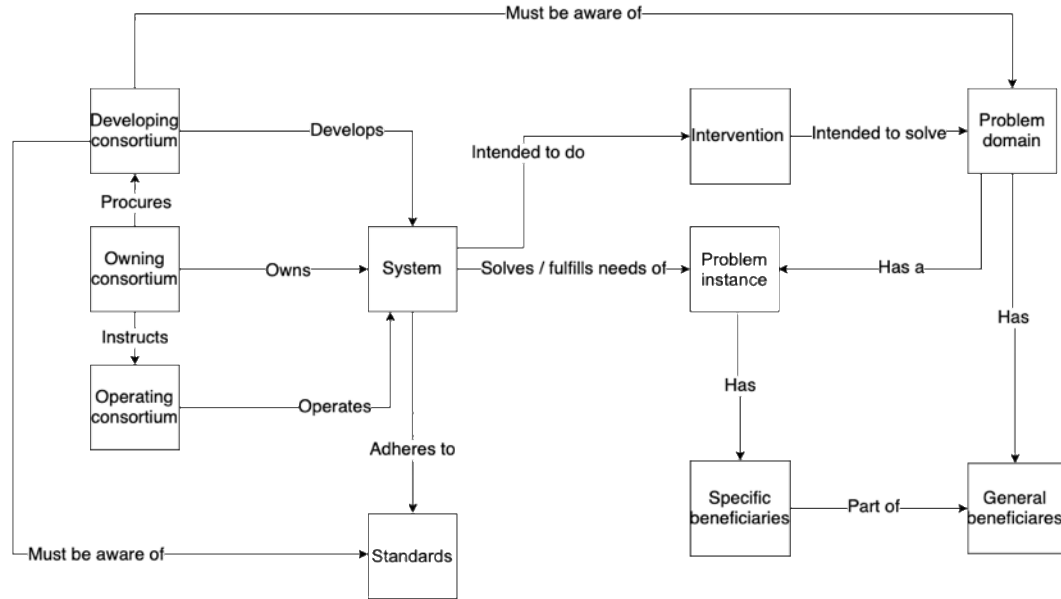# Flow of information affecting the decision
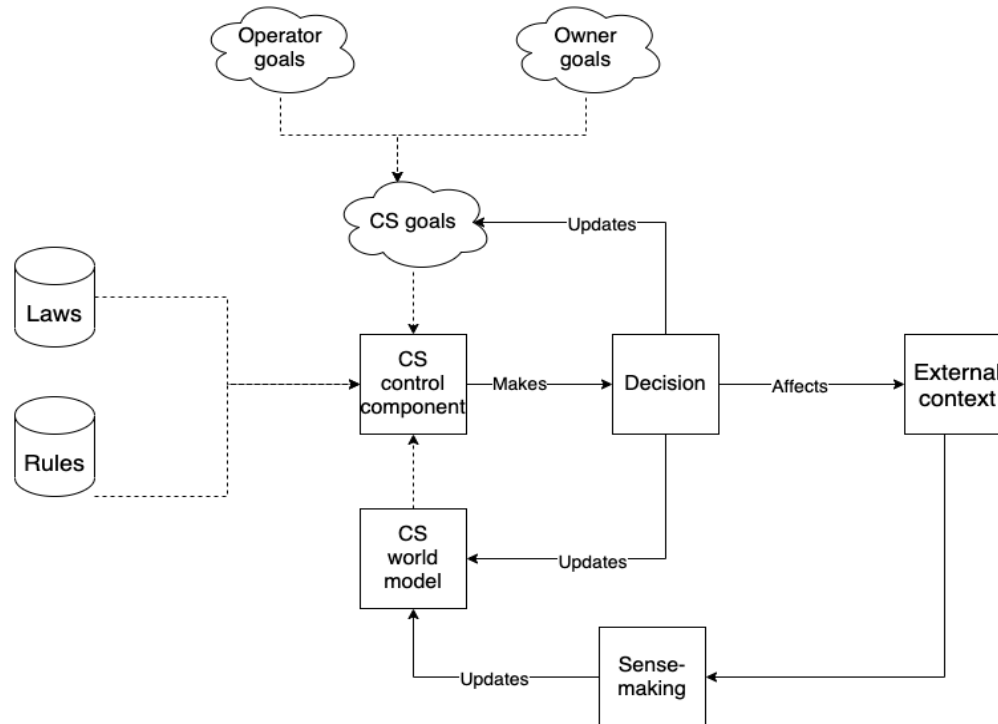
Summary

- CS operate independently

- They must make decisions all the time

- We discussed some of the factors that could influence these decisions and the information flow used

- Ongoing research... Comments very welcome!

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Questions and comments?

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