SYSTEM-OF-SYSTEMS (SoS)
WORKSHOP 2
SICS & INCOSE 2015-03-13
AGENDA

- 10.00-10.15: Introduction
  - Short presentation of everyone
  - Background: The SoS Agenda project
- 10.15-11.00: Summary and analysis of WS1 + discussion
- 11.00-11.15: Introduction to group work
- 11.15-12.00: Group work 1
- 12.00-12.45: Lunch
- 12.45-13.15: Report from group work 1, 3 x 5 min + 15 min discussion
- 13.15-14.00: Presentation Mikael Hagenbo, FHS – 30 min + discussion
- 14.00-14.45: Group work 2
- 14.45-15.15: Report from group work 2, 3 x 5 min + 15 min discussion
- 15.15-15.30: Summary of the WS and next steps
- 15.30-16.00: Slack
PURPOSE OF WORKSHOP

• Dig deeper into challenges in SoS
• Continue to build a network of individuals interested in SoS
SOS AGENDA PROJECT

- Objective: Formulate a strategic research and innovation agenda for the area SoS
- Duration: Jan-June 2015
- Funding: Vinnova
- Expected outcomes:
  - An agenda document, with the preliminary title "System-av-system för gränsöverskridande innovation i det digitala samhället: En strategisk forsknings- och innovationsagenda"
  - Side effect: creation of an expert network
PARTNERS

• SICS (project leader)
• Saab Aeronautics
• FOI
• Volvo Cars
• Volvo Technology
• Volvo Construction Equipment
• Syntell
• Decisionware
• INCOSE Sweden
• And everyone who is interested in joining!
PROJECT PARTS

• Actors
  • Current status
  • Potential and future challenges
  • Common concerns
  • Mainly executed as a series of workshops
• Research
  • Current status in Sweden and Internationally
• Synthesis
  • Identify actions
  • Document in agenda
ANALYSIS OF WS1
WHAT IS AN SOS?

• And is it even a meaningful concept? Or are normal SysEng practices enough to handle them?
• An SoS is a system
  • It is being composed of elements, etc.
  • The elements are called constituent systems
  • Implication: Generic SysEng practices should apply
• But not all systems are SoS
  • Implication: Specific practices for SoSEng are required
• Intuitive definition of SoS = independent interacting systems
• A completely precise definition is harder to give, but some characteristics can be identified
## SOS CHARACTERISTICS

<table>
<thead>
<tr>
<th>Maier, 1996</th>
<th>Boardman &amp; Sauser, 2005</th>
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</thead>
<tbody>
<tr>
<td>Operational independence</td>
<td>≈ Autonomy</td>
</tr>
<tr>
<td>Managerial independence</td>
<td>≈ Belonging</td>
</tr>
<tr>
<td>Evolutionary development</td>
<td>≈ Connectivity</td>
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<tr>
<td>Emergent behavior</td>
<td>≈ Emergence</td>
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<tr>
<td>Geographical distribution</td>
<td>Diversity</td>
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- Two definitions from literature, with a large overlap
- The first four are core, the other two maybe not?
- A given SoS may exhibit these characteristics in various degrees, no strict definition
- For example, some constituent systems may be more independent than others
KEY FACTORS

Lifecyle  Ownership  Value  Emergence
LIFECYCLE

The different constituent systems have different, unsynchronized lifecycles. This means that the SoS will evolve, and changes may occur on the fundamental structure of the SoS, including which constituent systems it consists of, and what the links are between them.

- **Consequence 1:** The architecture of the SoS must be focused on being open to changes, and evolve over time to encompass new situations. The architecture of potential constituent systems also should be targeted at flexibility, in particular in its interfaces.

- **Consequence 2:** There is a need for managerial principles to ensure that the purpose of the SoS can be upheld while the system is changing.

- **Consequence 3:** The traditional project oriented management models will most likely not work. Each constituent system is subject to its own ongoing change projects, and these must interconnect with the evolution of the SoS.
OWNERSHIP

The different constituent systems may have different owners, who are stakeholders in both their own system and in the SoS.

- **Consequence 1**: Decisions about the design of the SoS will in most cases result in negotiations across organizational borders. Solutions must be found that does not restrict the autonomy of any individual system, but still makes it possible to fulfil the purpose of the SoS.

- **Consequence 2**: The liability of the SoS is shared between the organizations behind its constituent systems.
VALUE

In an SoS, the constituent systems do not give up their autonomy to be part of the system, but they partly modify their behavior to gain benefits. The original purposes thus remain, and can be pursued inside or outside the SoS.

• **Consequence**: There will always be a need for requirements trade-offs between the purposes of the constituent systems, and the purpose of the SoS. There must be a value created for all constituent systems, as well as for those who choose to create the SoS. The tension is both vertical (between the system level and the element level), and horizontal (there can be conflicts of interest between different constituent systems, that appear as they are brought together in the SoS).
EMERGENCE

The purpose of the SoS is fulfilled by the emergent behavior and properties resulting from letting the constituent systems interact.

• **Consequence**: There is a need to understand principles for controlling the constituent systems’ behavior to align that with the SoS’ purpose. Those principles may only exercise limited restrictions on the constituent systems’ autonomy, limitations which are less severe than the benefits those systems gain from being part of the SoS. Appropriate mechanisms need to be identified and understood, which can include both regulating mechanisms to minimize inappropriate behavior, and awarding mechanisms to encourage desirable conduct.
ARCHETYPES

- Directed:
  - SoS built for specific purpose
  - Central management
  - Constituent systems retain individual capability but are normally subordinated
- Acknowledged:
  - SoS built for specific purpose (similar to directed)
  - Central management, but constituent systems are not normally subordinated (similar to collaborative)
  - Typically, a result of building an SoS out of a combination of existing and new systems
  - Evolution is a result of collaboration between the constituent systems’ owners
- Collaborative:
  - SoS has agreed purpose
  - Central management, but with limited power; constituent systems collaborate voluntarily to fulfil agreed upon purposes
- Virtual:
  - No agreed upon SoS purpose
  - No central management,
  - SoS behavior is emergent, not caused by explicit mechanisms

Over time, a specific SoS may change its archetype evolutionary

## ARCHETYPES VS CHARACTERISTICS (SKETCH)

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Neither archetypes nor characteristics have precise enough definitions.
OTHER ASPECTS/CHALLENGES

• SoS are (always?) socio-technical systems
• The enabling systems of the constituent systems will also form an enabling SoS
• Describing SoS – modeling, simulation, etc
• Architecture
• Properties:
  • Resilience: Safety, Security, Robustness, ....
  • Privacy

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INTERNATIONAL RESEARCH
INTRODUCTION TO GROUP WORK
OBJECTIVE

• To understand the lifecycle processes of an SoS
• Assumption: Since an SoS is a system, the generic lifecycle processes of ISO 15288 should apply
• But what specific additions/adaptions are needed if the system-of-interest is an SoS?
GROUP WORK TASK

• System-of-interest: the SoS
• Organization: the organization-of-organizations
• Analyze the assigned lifecycle processes from the perspective of this organization:
  • What are the consequences on the processes, as a result of the SoS characteristics?
  • Do they differ between the archetypes?
  • Use examples from WS1, or your own experience, when needed
Session 1:
G1: Green
G2: Yellow
G3: Purple

Session 2:
G4: Orange
G5: Red
G6: Blue
REPORTING

- Each group creates a powerpoint presentation, approximately 1 slide per process, with additional slides for general observations
- Use that presentation for reporting
- E-mail the file to jax@sics.se before leaving the meeting
WRAP UP
NEXT STEPS

Actions after this WS:
• Summarize notes from group discussions
• Refine analysis of Swedish research actors
• Synthesis of data from different sources
• Continue with a deeper analysis of common challenges and needs to be addressed in a research and innovation agenda
• Write texts

Future events:
• Next meeting: TBD
• Plan to organize academic event:
  • Prel. title: 1st Swedish Workshop on Engineering of SoS (SWESOS)
  • May 27, 28, or 29
  • Depends on interest to present/participate