INCOSE
SoS Working Group

SoS Pain Point Survey Results

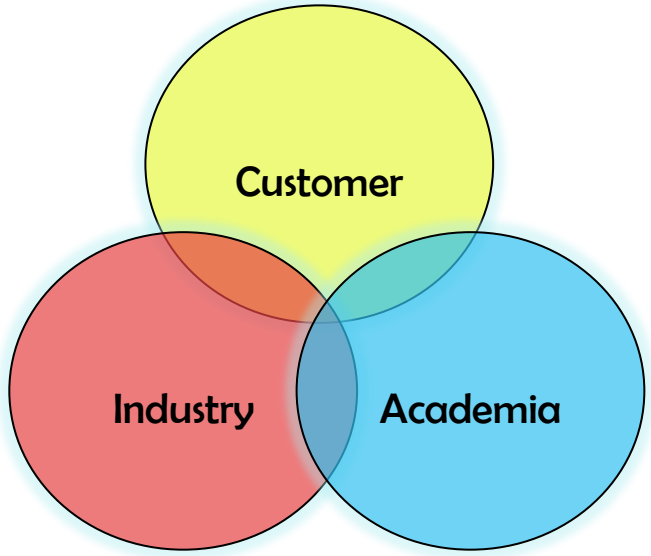
Presentation to
SoS Track at NDIA SE Conference
October 25, 2012

INCOSE Systems of Systems Working Group

Our intentions in founding the group

- To promote the application of Systems Engineering to SOS through a global working group
  - Inform and up-skill practitioners
  - Develop guidance and advice – sharing available know-how
  - Develop practice – where there is both need and enthusiasm
  - Exert influence on standards, bodies of knowledge, research priorities
  - Liaise with relevant organisations within and outside INCOSE

  - Multiple domains
    - Defence
    - Energy
    - Transportation
    - Biomedical
    - etc.



INCOSE
International Council on Systems Engineering

SOS Working Group model

Develop Guidance & Advice
- Types of SOS
- SOS Architecture
- SOS Modelling & Simulation

Inform & Upskill Practitioners
- Webinars
- Tutorials & Seminars
- Symposium Papers
- Bibliography

Exert Influence
- BKCASE
- Standards
- Competencies & Certification
- Research Agenda

Develop Practice
- Process
- Assets/Templates

Liaise
- With other INCOSE groups (e.g. Architecture, Transportation)
- With other SOSE groups (e.g. IEEE SOSE)

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Background and Purpose

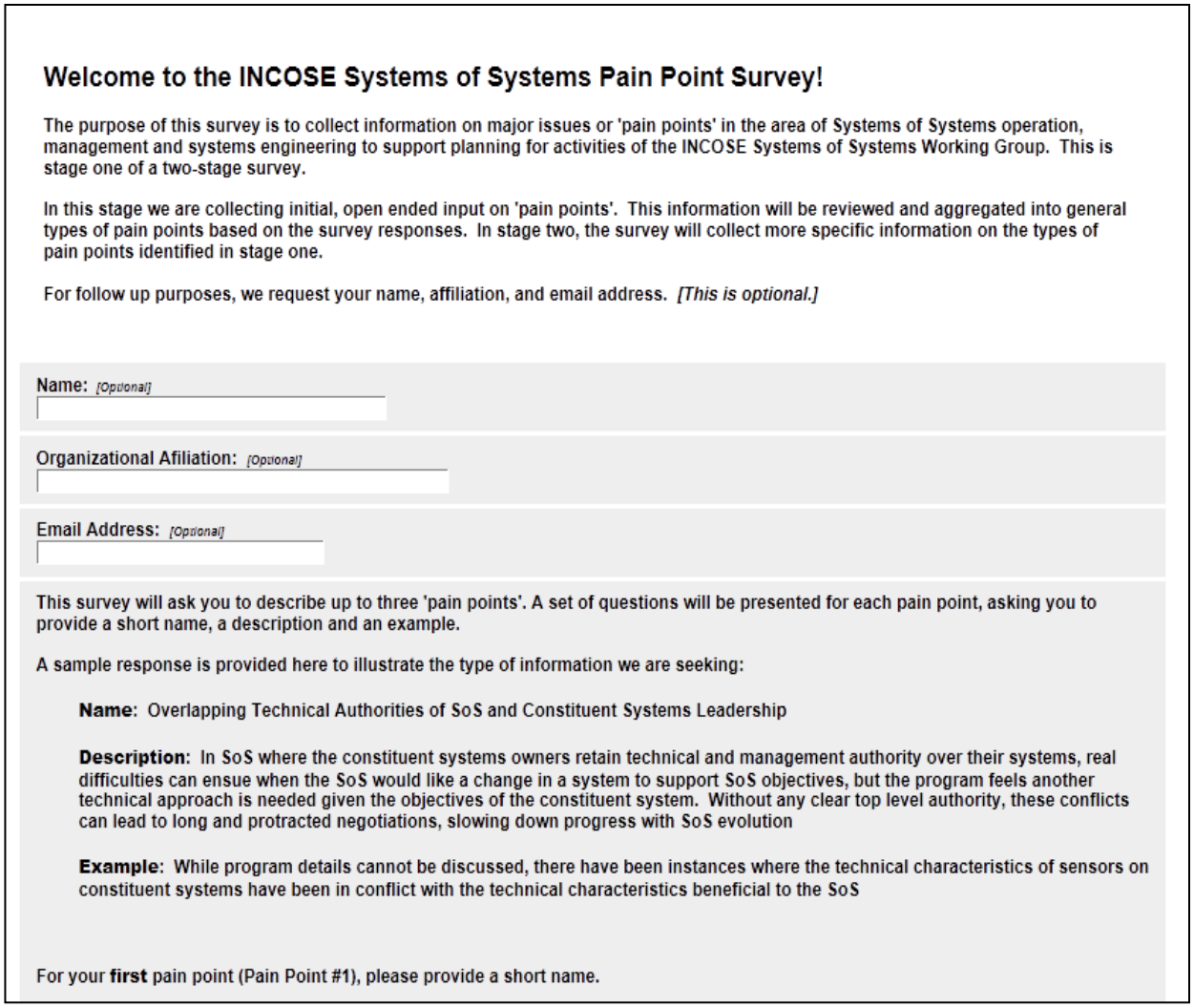
- INCOSE SoS Working Group (SoSWG)
  - Meeting in January 2012 in Jacksonville Florida
  - Identified the need to understand the SoS issues of importance to working group members as an initial SoSWG activity
- Agreed to conduct an "SoS Pain Point Survey"
  - To collect information on major issues or 'pain points' in the area of Systems of Systems operation, management and systems engineering
  - To support planning for activities of the INCOSE Systems of Systems Working Group

This presentation summarizes the initial results of the SoS Pain Point Survey conducted during spring of 2012

SoS Pain Point Survey

- Survey logistics
  - Developed during February and March, with several drafts and pretests
  - Released to the community in April with a cutoff of respondents in Mid-May.
  - Administered over the internet using KWIK Surveys (www.kwiksurverys.com)
- Survey questions
  - Asked respondents to identify and describe their priority SoS areas of concern: describe up to three 'pain points' including a short name, a description and an example
- Analysis
  - Results were analyzed, a paper on the results was drafted and circulated for comment

Survey Respondents



Welcome to the INCOSE Systems of Systems Pain Point Survey!

The purpose of this survey is to collect information on major issues or 'pain points' in the area of Systems of Systems operation, management and systems engineering to support planning for activities of the INCOSE Systems of Systems Working Group. This is stage one of a two-stage survey.

In this stage we are collecting initial, open ended input on 'pain points'. This information will be reviewed and aggregated into general types of pain points based on the survey responses. In stage two, the survey will collect more specific information on the types of pain points identified in stage one.

For follow up purposes, we request your name, affiliation, and email address. *[This is optional.]*

Name: *[Optional]*

Organizational Afiliation: *[Optional]*

Email Address: *[Optional]*

This survey will ask you to describe up to three 'pain points'. A set of questions will be presented for each pain point, asking you to provide a short name, a description and an example.

A sample response is provided here to illustrate the type of information we are seeking:

Name: Overlapping Technical Authorities of SoS and Constituent Systems Leadership

Description: In SoS where the constituent systems owners retain technical and management authority over their systems, real difficulties can ensue when the SoS would like a change in a system to support SoS objectives, but the program feels another technical approach is needed given the objectives of the constituent system. Without any clear top level authority, these conflicts can lead to long and protracted negotiations, slowing down progress with SoS evolution

Example: While program details cannot be discussed, there have been instances where the technical characteristics of sensors on constituent systems have been in conflict with the technical characteristics beneficial to the SoS

For your **first** pain point (Pain Point #1), please provide a short name.

- 38 survey respondents
- 65 SoS 'pain points' reported
- Respondent location
  - US (86%).
  - UK (8%)
  - Australia (6%)
- Respondent SoS experience
  - Extensive (60%)
  - Some (37%)
- Almost all (94%) are from defense sector

Results Overview

- The results of the survey were reviewed and sorted into major affinity groups or issue areas
  - The key areas and the issues are summarized based on those areas where there were multiple related responses
  - Key questions raised by the areas have been identified for possible consideration by the SoS WG
- Reported pain points have be divided into categories
  - Management:
    - Lack of SoS Authorities and Funding,
    - Constituent Systems
    - Leadership
  - Technical:
    - Emergence,
    - Capabilities and Requirements,
    - Testing, Validation and Learning;
    - SoS Principles and Thinking Skills

The rest of the presentation will review the results in each area and present questions evoked by the results

SoS Authority and Funding

18%, 12/65 Points Pains

- Largest number of pain points in the survey
- Key points
  - All responses referred to defense specific issues
  - Authority implies a certain approach to organization
    - Defense system counterpoint:
      - Acquisition is very "top-down"
      - Effective military forces value initiative in certain contexts.
    - Restructuring to provide clear authority and funding is often difficult or impossible due to:
      - Current defense acquisition organization
      - Predominance of multi-mission systems
  - Alternatives to top-down authority and funding for SoS may be needed
  - Situation may require innovation, including:
    - Alternatives to top down authority and funding in SoS?
    - New collaboration patterns in systems of systems.

Question 1:
What are effective collaboration patterns in systems of systems?

Constituent Systems Perspectives/Issues

14%, 9/65 Pain Points

- Key Points
  - Issues associated with the coordination and management of multiple independent constituent systems in SoS include:
    - Legacy systems which "… not configured or managed to allow insertion into the over-all system of systems. This creates interoperability concerns between the older and newer systems."
    - Managerial and evolutionary independence can mean that "Constituent systems change in response to the perceived goals for that system, usually with little regard for the impact on SoS goals or behaviors."
  - Issues of constituent system SoS support beyond data exchange

    "In the cases where systems are owned/operated by different organizations … the systems may transfer data and information reliably between systems (if you're lucky), but different processes, cultures, working practices between different participating organizations can lead to problems."

Question 2: What are effective approaches to integrating constituent systems into a high functioning SoS?

Leadership
8%, 5/65 Pain Points

- An issue for both defense and non-defense
- Leadership is implied in many of the authority and funding pain points
  - Lack of structured control assumed by SE for systems faces a void, calling for alternatives to provide coherence and direction, including influence and incentives.

Question 3: What are the roles and characteristics (including skills) of effective SoS leadership?

SoS Technical Issues

62%, 40/65 Pain Points

- Emergence (6%, 4/65)
  - Combining component systems into SoS produce unexpected behavior.
    "Well-structured approaches for 'design for emergence' are not generally available."
- SoS Interdependencies (11%, 7/65)
  - Complex relationships among systems in an SoS are often poorly understood and difficult to analyze
    - "Systems often have interdependencies that are either unknown or unacknowledged. This is exacerbated by interdependencies between systems in development, a system in development and fielded systems, and fielded systems; further, this is compounded by multiple combinations of all of these."
    - "We lack methods for representing the SoS analytically so these interdependencies can be understood, and the SE of the SoS could examine impacts of different SoS changes."
  - Need for SoSE methods and tools which could support the modeling and prediction of complex SoS behaviors including:
    - Analysis methods
    - Architecting methods

Question 4: How can SoSE provide methods and tools for addressing the complexities (e.g. analysis, modeling, prediction, and architecture) of SoS interdependencies and emergent behaviors?

SE Processes
25%, 16/65 Pain Points

- About a quarter of the responses addressed issues with applying today's SE processes to SoS
  - Starting with requirements through configuration management and testing
- Several areas here were very defense centric such as comments concerning security and information assurance
- Others (CM and Cost Estimation) were noted but by only by single respondents.
- However, there were two areas with multiple respondents on areas of broad SoS applicability
  - Capabilities and Requirements
  - Testing and Validation

Capabilities and Requirements
9%, 6/65 Pain Points

- Key Points
  - "Rigid Requirements Development Process"
  - "Significant challenges exist in developing capabilities supported by a SoS due to the lack of overarching requirements. SoS requirements go beyond the sum of the individual system requirements."
  - "No formal S0S requirements– Individual system requirements are documented but not unified in a set of SoS requirements."
- In an SoS context, many people prefer to focus on capabilities and less on requirements, at least at a certain point
  - What seems to be clear is that we often think about requirements differently when working on an SoS

Question 5: How can SoSE address SoS capabilities and requirements?

Testing, Validation, and Learning
8%, 5/65 Pain Points

- Key Points
  - Highlight the fact that most defense SoS cannot be tested thoroughly prior to fielding leading to approaches like incremental validation
    - Due to the independent asynchronous evolution of components of an SoS
  - Reflect a perspective that looks at significant learning going on over the life of an SoS

Question 6: How can SE approach the challenges of SoS testing, including incremental validation and continuous learning in SoS?

SoS Thinking Principles

8%, 5/65 Pain Points

- Indicated were either [missing] or (needed) items for successful SoS, including:
  - ["Lack of] formalized processes"
  - ["Lack of] examples of SoS Success
  - ["SoS requires] better trust to the work flow
  - ("Keep a SoS together) – It is very important to plan, design, purchase and maintain a SoS entity based on the SoS idea."
- While there were only a few responses in this category
  - This seemed like a potential area for SoS WG attention, in support of the WG objectives
  - In particular, this area is one where progress in identifying and articulating SoS principles ('SoS Thinking') and examples, could have benefit to the discipline

Question 7: What are the key SoS thinking principles, skills and supporting examples?

Summary

- Lack of SoS Authorities and Funding
  Question 1: What are effective collaboration patterns in systems of systems?
- Constituent Systems
  Question 2: What are effective approaches to integrating constituent systems into a high functioning SoS?
- Leadership
  Question 3: What are the roles and characteristics of effective SoS leadership?
- Autonomy and Emergence
  Question 4: How can SoSE provide methods and tools for addressing the complexities (e.g. analysis, modeling, prediction, and architecture) of SoS interdependencies and emergent behaviors?
- Capabilities and Requirements
  Question 5: How can SE address SoS capabilities and requirements?
- Testing, Validation and Learning
  Question 6: How can SE approach the challenges of SoS testing, including incremental validation and continuous learning in SoS?
- SoS Principles
  Question 7: What are the key SoS thinking principles, skills and supporting examples??