Developing Standards for Systems of Systems (SoS) Engineering
IS0/IEC/IEEE 21839: SoS Considerations through the Lifecycle of a System

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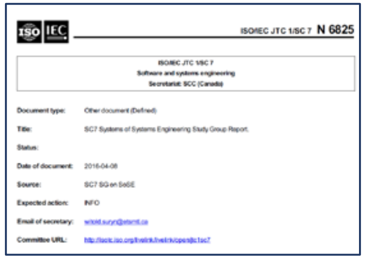
Introduction

- Systems of systems engineering (SoSE) practice is maturing to the point that the International Organization for Standardization (ISO) has initiated the development of a set of SoSE Standards
- Following the recommendations of a 2016 Special Study Group on SoS Standards, three new work item proposals for SoS standards were approved and work has begun
- This presentation presents
  - The background on the new SoS standards development
  - Describes the new standards in development including the content and conclusions of the ISO Special Study Group report which provided the basis for the proposed new standards for SoSE
  - Discusses the three development activities particularly ISO/IEC/IEEE 21839

2016 Special Study Group on SoS Standards



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Software and systems engineering
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Report
of the
SC7 SG on Systems of Systems
Engineering

June 2016

- Study Group was chartered at SC7 Plenary in 2015
- Focused on
  - SoSE State of the Practice
  - SoS Applications
  - Current Standards
  - Recommendations for SoSE standards development
- Report was issued in June 2016

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Three SoSE Standard Developments

- ISO/IEC/IEEE 21839

  Systems and software engineering -- System of systems considerations in life cycle stages of a system
- ISO/IEC 21841

  Taxonomies of SoS Types
  - Elaboration of ISO/IEC 15288 Annex G)
  - Initial CD now complete and out for review
- ISO/IEC 21840

  Application of SE Processes for SoSE across the life cycle
  - Elaboration of ISO/IEC 15288 Annex G
  - Working draft out for review

ISO/IEC/IEEE 21839: Systems and Software engineering – SoS considerations through the lifecycle of a system

- Jointly developed with the IEEE Computer Society
- Based on work done as part of The Technical Cooperation Program (TTCP)
  - Technical Panel of Systems Engineering for Modernization which produced a guide to SoS Considerations for Engineering Systems.
  - This group is largely focused on defense systems but the guide has broad applicability
- Progress
  - **June 2016**: Working draft based on TTCP guide was circulated as part of the new work item proposal
  - **September 2016**: Kickoff of standard development
  - **March 20l7**: Committee draft release for comment
    - Based on lifecycle stages in ISO 24748 – Systems and software engineering lifecycle management, part 1
    - Generalized beyond defense
  - **September 2017**: Updated CD released for comment

Scope

- **Provides a set of critical considerations to be addressed for systems created by humans**
  - Concerns those systems that are man-made and are configured with one or more of the following: hardware, software, humans, procedures and facilities
  - Wide variety of systems in terms of their purpose, domain of application, complexity, size, novelty, adaptability, quantities, locations, life spans and evolution.
  - Applies to one-of-a-kind systems, mass produced systems, or customized, adaptable systems
- **Addresses system of systems (SoS) considerations that apply to systems at each stage in the life cycle of a system**
  - Aligned with ISO/IEC/IEEE 15288 and the ISO/IEC/IEEE 24748 framework for system life cycle stages and associated terminology
  - Selected subsets of these considerations may be applied throughout the life of systems
  - Accomplished through the involvement of all stakeholders
- **This document does not detail**
  - The approach to addressing system of systems considerations in terms of methods or procedures
  - The described documentation in terms of name, format, explicit content, and recording media of documentation.

Ultimate goal to achieve user satisfaction by ensuring that when delivered, the system will operate effectively in the operational or business environment which will typically be characterized as one or more SoS

Key Definitions

system of systems

set of systems that interact to provide a unique capability that none of the constituent systems can accomplish on its own.

Note 1 to entry: Each constituent system is a useful system by itself, having its own management, goals, and resources, but coordinates within the SoS to provide the unique capability of the SoS.

[Source: ISO/IEC/IEEE 12207]

system life cycle

evolution with time of the system from conception through to disposal

[Source: ISO/IEC/IEEE 24748-1]

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Life Cycle Stages from ISO/IEC 24748 - Part 1

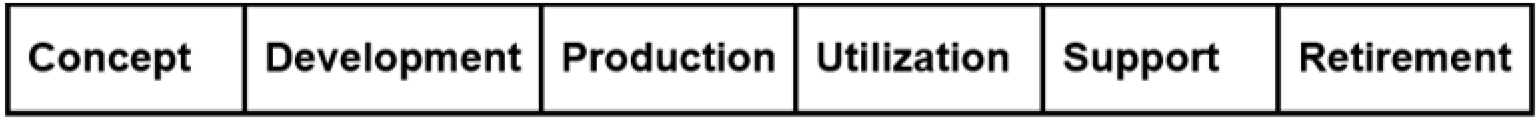

Figure 1 -- Life cycle stages
(From ISO/IEC/IEEE 24748-1, Figure 5 – Representative life cycle model, page 15)

Table 1 – Life cycle stages, their purposes and decisions
(From ISO/IEC/IEEE 24748 -1, Table 1 An example of stages, their purposes and major decision gates)

LIFE CYCLE STAGES	PURPOSE	DECISION OPTIONS
CONCEPT	Identify stakeholders' needs Explore concepts Propose viable solutions	- Begin subsequent stage or stages - Continue this stage - Go to or restart a preceding stage - Hold project activity - Terminate project
DEVELOPMENT	Refine system requirements Create solution description Build system Verify and validate system	
PRODUCTION	Produce systems Inspect and test	
UTILIZATION	Operate system to satisfy users' needs	
SUPPORT	Provide sustained system capability	
RETIREMENT	Store, archive or dispose of system	

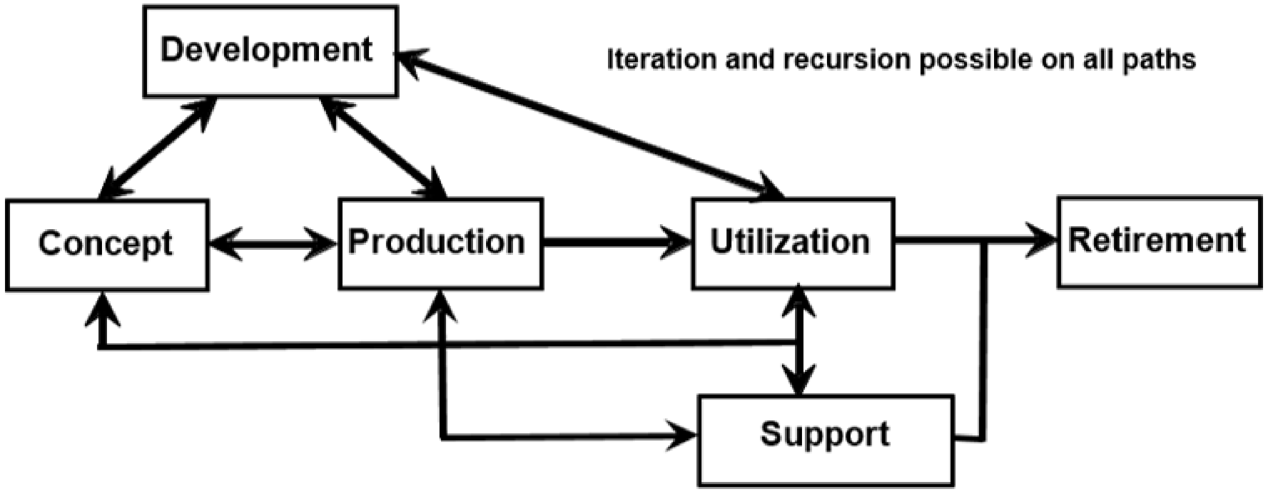

Figure 2 – Possible progress of life cycle stages
(From ISO/IEC/IEEE 24748-1, Figure 6 – Life cycle model with some of the possible progressions)

Focus of 21839

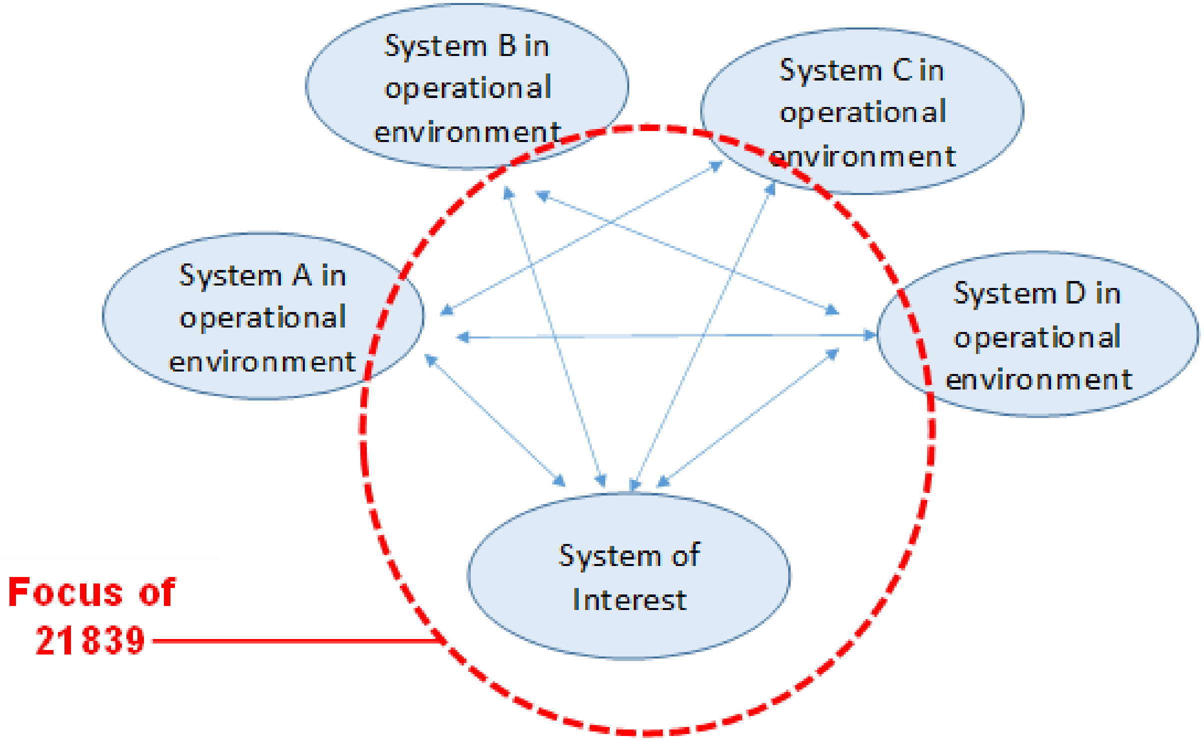

Figure 3: Focus of the document is on the constiuent system in an SoS

Focus is on constituent systems and their relationship to other systems in the one or more SoS where they will be deployed

Three areas of SoS Considerations for Systems
Capability Considerations

- Capability refers to the ability to achieve user objectives in a mission or business context
- User capabilities are often based on the
  - Collective effects of multiple systems (‘material’) as well as other
  - Factors beyond the systems themselves (training, procedures, etc. or ‘non-material’)
- Typically, the development of a system begins with a user need based on a gap in needed capability and a proposed system focuses on filling that capability gap
- Consequently, right from the earliest point in a system life cycle, need a description of
  - Role of a new system in supporting the needed user capability
  - How the system is envisioned to function in the operational or business context
    - Including the constraints that context places on the system and the relationships, interfaces and dependencies with other systems supporting the capability.

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Three areas of SoS Considerations for Systems
Technical Considerations

- To assess alternative approaches to address a needed user capability -- consider technical impacts on external stakeholders or systems affected by the proposed system, includes both
  - Systems/services on which the new or upgraded system depends and
  - Systems/services that depend on the new or upgraded system
- Once these have been identified, assess the ability to influence resource changes in associated systems, infrastructure, or nonmaterial factors
  - Constraints on the system are imposed by its SoS context -- consider these in selecting the system solution.
  - As the system moves into requirements definition and design, the technical considerations play a larger role

Three areas of SoS Considerations for Systems
Management Considerations

- Consider management issues when dependencies resulting from interactions need to be negotiated with other systems involved
  - Such as interfaces, new or changed functionality in other systems
- If there is an entity with some type of responsibility that spans an SoS, establish management arrangements with that entity
- SoS related cost and schedule considerations need to be addressed
  - Includes identifying costs and schedules associated with external systems
- Mechanisms should be in place to monitor progress in the areas of cross-system dependencies for prompt identification of any changes or delays which could mean added cost and time
  - Plans need to be formulated to accommodate these if necessary

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Document Structure

- Sections for each of the stages with considerations in each area as they apply to the stage

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Excerpt from Concept Stage Capability Considerations

Prior to entry into the **Concept Stage**, all available information should be evaluated to help ensure the understanding of the situation and identify any missing information . In particular, the following questions concerning the **capability being sought** and **the context of that capability** need should be addressed:

- Has the operational or business **context** of the capability gap (user need) been described?
- Has the **existing capability** been described, including the **systems that currently support** that capability?
- Have operational or business context constraints on potential solutions been identified?
- How would any new system which might address the gap **fit into current operations** or business processes?
- If a new system were to be considered, have **interfaces with or required changes to current systems or systems which are planned or in development been identified**?

An early description of the SoS context and its potential impact on system requirements and dependencies will provide a **solid basis for development of a system that will meet user needs, including quality characteristics. Identifying and addressing constraints are key to effective solutions**. Early identification of potential changes in interfaces or to other systems allow for **organizational negotiations** and agreements to be put in place as well **as multi-lateral trade-off analysis** of whether changes should be implemented and where changes can best be implemented. **Identifying these factors early** can contribute to a sound solution selection, including an understanding of risks. This is particularly important for any long lead items.

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Summary and Next Steps

- The review of the second Committee Draft ISO 21839 was completed in December 2017.
- Updates are in progress.
- The Draft International Standard (DIS) will be submitted for review in February.

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