

International Standards for Systems of Systems Engineering (SoSE)

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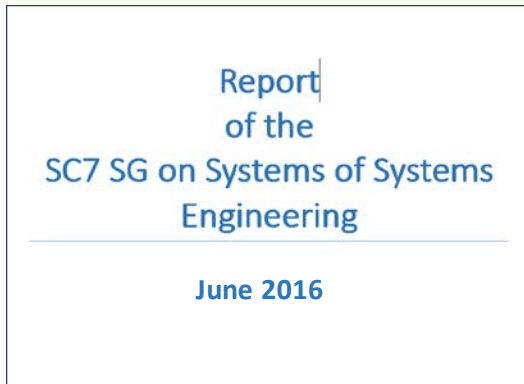
Introduction

- Systems of systems engineering (SoSE) practice is maturing to the point that the International Organization for Standardization (ISO) and the Institute of Electrical and Electronics Engineers (IEEE) 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

2016 Special Study Group on SoS Standards



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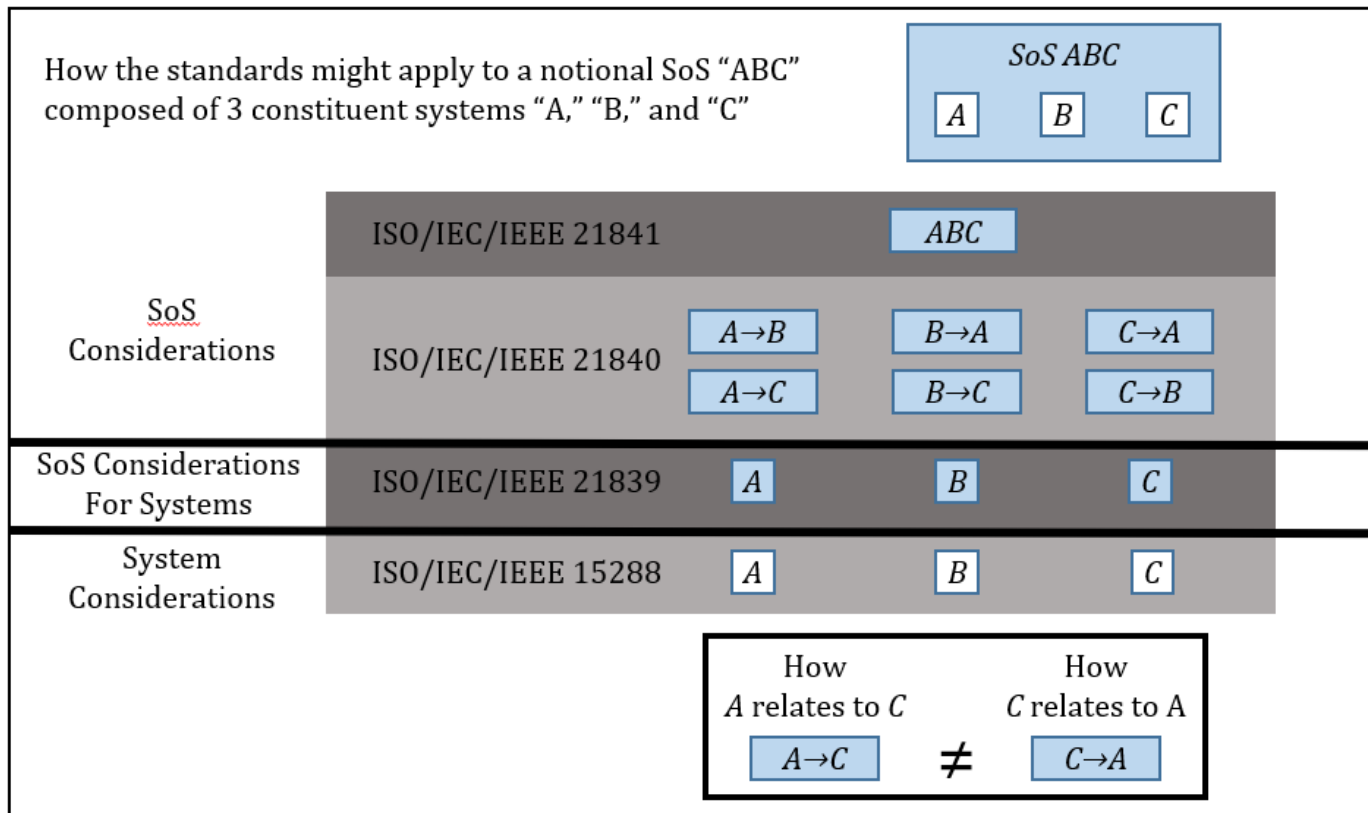


- Study Group was chartered at SC7 Plenary in 2015
- Focused on
 - SoSE State of the Practice
 - SoS Applications
 - Current Standards
 - Recommendations for SoSE standards development
- Report was issued in June 2016

Three SoSE Standards

- ISO/IEC/IEEE 21839
 - Systems and software engineering -- System of systems considerations in life cycle stages of a system
- ISO/IEC 21840
 - Guidelines for the utilization of ISO/IEC/IEEE 15288 in the context of System of Systems (SoS) Engineering
 - Application of SE Processes for SoSE across the life cycle
 - Elaboration of ISO/IEC 15288 Annex G
- ISO/IEC 21841
 - Taxonomies of Systems of Systems
 - Elaboration of ISO/IEC 15288 Annex G

Relationship Between The Standards





Related Systems and Software Engineering Standards

Number	Title
ISO/IEC/IEEE 15288:2015	System life cycle processes
IEEE 15288.1: 2014 (ISO/IEC/IEEE 24748-7)	Application of Systems Engineering on Defense Programs
IEEE 15288.2: 2014 (ISO/IEC/IEEE 24748-8)	Technical Reviews and Audits on Defense Programs

SoSE Standards

- Joint project between ISO/IEC SC7, Systems and Software Engineering and 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

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 12070]
 -
- system life cycle
 - evolution with time of the system from conception through to disposal
 - [Source: ISO/IEC/IEEE 24748-1]

Life Cycle Stages from ISO/IEC 24748 - Part 1

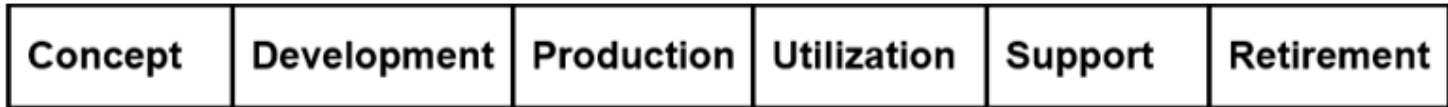


Figure 1 -- Life cycle stages

(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	<ul style="list-style-type: none"> - 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	

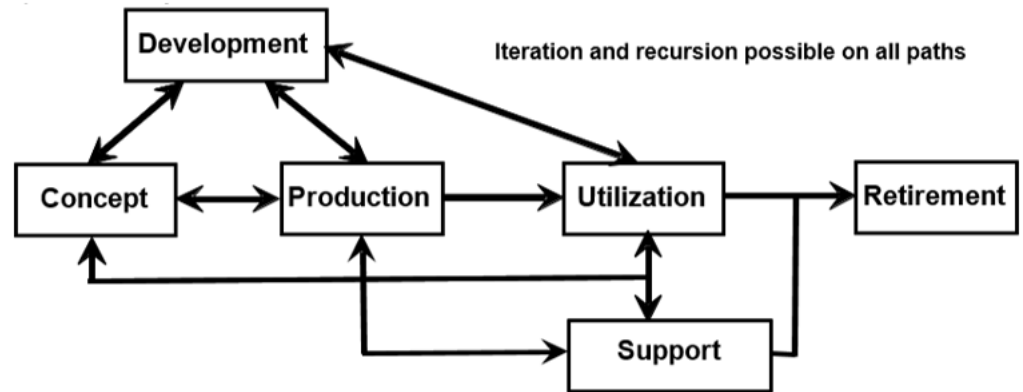


Figure 2 – Possible progress of life cycle stages

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



ISO/IEC/IEEE 21839: System of Systems (SoS) Considerations in Life Cycle Stages of a System

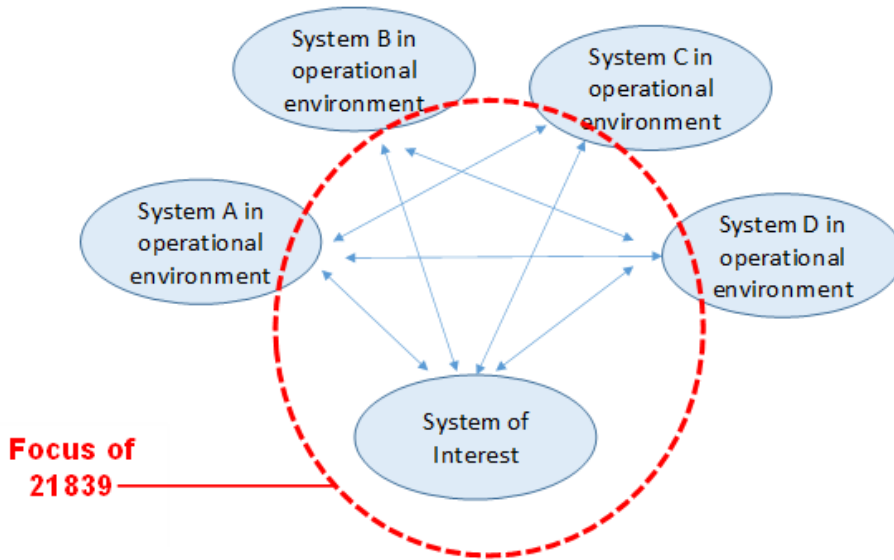
- Provides a set of critical considerations to be addressed at key points in the life cycle of systems created by humans.
- Refers to a constituent system that will interact in a system of systems as the system of interest (SOI).
- Considerations are aligned with ISO/IEC/IEEE 15288 and the ISO/IEC/IEEE 24748 framework for system life cycle stages and associated terminology.
- Selected subsets of these considerations may be applied throughout the life of systems.
- Editors
 - Dr. Judith Dahmann (US)
 - Co-editor: Garry Roedler (US)

21839 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

Focus of 21839



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

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

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.

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

Document Structure

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

- 5 Recommended practices.....
 - 5.1 SoS considerations in the concept stage
 - 5.1.1 General.....
 - 5.1.2 Capability considerations.....
 - 5.1.3 Technical considerations.....
 - 5.1.4 Management considerations.....
 - 5.2 Addressing SoS considerations in the development stage.....
 - 5.2.1 General.....
 - 5.2.2 Capability considerations.....
 - 5.2.3 Technical considerations.....
 - 5.2.4 Management considerations.....
 - 5.3 Addressing SoS considerations during production stage.....
 - 5.4 Addressing SoS considerations during utilisation and support stages....
 - 5.4.1 General.....
 - 5.4.2 Capability consideration.....
 - 5.4.3 Technical considerations.....
 - 5.4.4 Management considerations.....
 - 5.5 Addressing SoS considerations in retirement stage.....

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.

Next Steps for ISO/IEC/IEEE 21839

- Draft International Standard Reviewed and Approved
- Next Step: Address Comments and Proceed to Final Draft International Standard (FDIS)



ISO/IEC/IEEE 21840: Guidelines for the utilization of ISO/IEC/IEEE 15288 in the context of System of Systems (SoS) Engineering

- Addresses systems of systems (SoS) considerations that apply to systems at key stages in the life cycle of systems.
- Describes the systems of systems considerations that apply to any system.
- It does not
 - Detail the approach to applying 15288 SE processes to systems of systems in terms of methods or procedures.
 - Detail the described documentation in terms of name, format, explicit content, and recording media of documentation.
- Editor:
 - Dr. Mike Yokell (US)
 - Co-editor: Dr. Alejandro Salado (INCOSE)

Outline of 21840

1. Scope
 2. Normative References
 3. Terms and Definitions
 4. Relationship to Other Standards
 5. Key Concepts and Application
 6. Application of System Life Cycle Processes to SoS
- Bibliography

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ISO/IEC/IEEE CD2 21840:201x(X)
ISO/IEC/JTC 1/SC 7/WG 7 N23:xx
2018-06-xx
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Systems and software engineering — Guidelines for the utilization of ISO/IEC/IEEE 15288 in the context of System of Systems Engineering

CD 2

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For each process group in 15288, Clause 6

- Sentence to introduce the 15288, Annex G info, refer to box
- Box the 15288, Annex G info relevant to this process group
- Further elaborate the general guidance in the context of SoS

6 Application of system life cycle processes to SoS

6.1 Agreement processes

ISO/IEC/IEEE 15288, Annex G contains general information on the application of system life cycle processes to a system of systems. Details of ISO/IEC/IEEE 15288:2015, Annex G, clause G.3.2 Agreement processes are shown in Box TBD.

G.3.2 Agreement processes

Agreement Processes are crucial for SoS because they establish the modes of developmental and operational control among the organizations responsible for the SoS and the often independent constituent systems. Constituent systems, which are acquired and managed by different organizations, often hold original objectives that may not align with those of the SoS. Except in the directed SoS case, the SoS organization cannot task a constituent system organization without their cooperation. In an acknowledged or collaborative SoS, these tasks are balanced against the tasks of the constituent system as a SOL in its own right. For virtual SoS, agreement processes may be informal, or considered only for analysis purposes

The Agreement processes description from ISO/IEC/IEEE 15288:2015 apply as stated with the following additions:

NOTE Constituent systems may interact even without agreement.

For each process in 15288

- Introduce the purpose from 15288
 - Note that the purpose remains the same or with any additions as needed
- Introduce the outcomes with a slight modification to 15288's introduction
- For each outcome
 - Echo the outcome from 15288
 - Provide SoSE guidance
- Acknowledge that there may be additional outcomes needed for SoS
- Do not address 15288's "Activities and Tasks"

6.1.1 Acquisition process

6.1.1.1 Purpose

The purpose of the ISO/IEC/IEEE 15288 Clause 6.1.1 'Acquisition process' is shown in the box.

The purpose of the Acquisition process is to obtain a product or service in accordance with the acquirer's requirements.

NOTE As part of this process, the agreement is modified when a change request is agreed to by both the acquirer and supplier.

The purpose of the ISO/IEC/IEEE 15288 Clause 6.1.1 'Acquisition process' applies as stated with the following additions.

NOTE 1 Acquisition of a product or service does not necessarily mean acquiring ownership of the product or service. For example, someone renting a car acquires the service of transportation provided by the car, but the renter does not acquire ownership of the car itself.

NOTE 2 In the context of an SoS, an acquirer acquires an outcome of a CS, sometimes without explicit agreement, without acquiring the CS itself that produced the outcome.

6.1.1.2 Outcomes

The outcomes of the ISO/IEC/IEEE 15288 6.1.1 'Acquisition process' apply as stated in the boxes with the following additions:

a) A request for supply is prepared.

An SoS request for supply may not have the same formality as might be expected within a system. Instead of a formal request for supply for specific products or services, a request for specific capabilities or a request for information about existing and planned capabilities can be made. In an SoS governance sense,

Next Steps for ISO/IEC/IEEE 21840

- Committee Draft #1 Reviewed and Approved with Comments
- Next Step: Address Comments (done) and Prepare CD #2
- Working Group convening at SoSE in Paris 6/18 to help steer development
- CD2 Due 8/15/2018



ISO/IEC/IEEE 21841

Taxonomy of Systems of Systems

- Define normalized taxonomies for systems of systems (SoS) to facilitate communications among stakeholders.
- Briefly explain what a taxonomy is and how it applies to the SoS to aid in understanding and communication.
- Editors:
 - Dr. Mike Yokell (US)
 - Co-editor: Dr. François Coallier (Canada)

Outline of Key Sections

4. Concepts and Application

4.1 Overview

4.2 Importance of Taxonomies to SoS

4.3 Use of the SoS Taxonomies

5. Taxonomies for Systems of Systems

5.1 Introduction

5.2 Directed, Acknowledged, Collaborative, Virtual

5.2.1 Overview

5.2.2 Description of the taxa

5.2.3 Examples of potential application of the taxa

5.2.4 When to use

5.2.5 How to use

5.2.6 Why to use

5.2.7 Limitations

5.2.8 Benefits of use

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ISO/IEC TC JTC 1/SC 7 ~~Nxxxxx~~

ISO/IEC/IEEE DIS 21841:###(X)

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2018-05-31

Secretariat: BIS

Systems and software engineering — Taxonomy of systems of systems

Ingénierie système et logiciel – Taxonomie des systèmes de systèmes

DIS

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Next Steps for ISO/IEC/IEEE 21841

- Draft International Standard (DIS) released for review and comment