The Technical Cooperation Program

Australia - Canada - New Zealand - United Kingdom - United States of America

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TTCP TECHNICAL REPORT

TR – JSA/TP4 -1- 2014

Recommended Practices: System of Systems Considerations in the Engineering of Systems

August 2014

Acknowledgements

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Contents

List of Figures

I. Introduction

A. Background

The international defense community is paying increasing attention to the capabilities and engineering challenges of systems of systems (SoS). With the advent of networking in the battle space, along with the extended range of both weapons and sensors today, many military capabilities consist of the coordinated execution of multiple systems to support end-to-end missions. Consequently, there has been considerable attention across the international systems engineering (SE) community to the application of SE principles to SoS[1]. In selected cases, this has led acquisition authorities to facilitate SE for SoS as systems in their own right[2]. However, this has generally been limited to key areas where the importance of the mission has been clearly recognized and specific organizations and funding earmarked for mission level SoS investment and engineering.

In reality, and conversely, most defense acquisition is focused on the development and engineering of individual systems. National defense organizations as a rule allocate resources to individual systems and focus engineering attention on achieving system level objectives. To the degree that to be effective, the systems require the ability to work as part of one or more SoS, it has been recognized that systems need to be developed with their operational context, particularly their relationships with other systems, as a key element of effective design. Performing effective SoS SE in this largely compartmentalized, non-collaborative environment is obviously extremely challenging. To address these systemic challenges, this paper presents recommended practices for addressing SoS considerations throughout the development of systems.

B. The Technical Cooperation Program Technical Panel 4 System of Systems Work Stream

This set of recommended practices has been developed by the SoS Work Stream of The Technical Cooperation Program (TTCP) Technical Panel (TP) on Systems Engineering and Modernization.

TTCP is an "international organization that collaborates in defense scientific and technical information exchange; program harmonization and alignment and shared research activities for

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[1] Systems of Systems (SoS) is defined as "A set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities." U.S. Defense Acquisition Guidebook, 2008.

[2] SoS defined as "The process of planning, analyzing, organizing, and integrating the capabilities of a mix of existing and new systems into a system-of-systems capability that is greater than the sum of the capabilities of the constituent parts." U.S. Defense Acquisition Guidebook, 2008.

the five nations."[3] TTCP is organized into Groups and TPs focusing on a variety of research areas. This product has been produced by TP-4 of the Joint Systems Analysis (JSA) Group. TP-4, "Systems Engineering for Defense Modernization" has the following as its objectives[4]:

- TP-4 will exploit SE and systems thinking knowledge, methods, tools, and practices with the objective of modernizing and enhancing current and future defense capabilities.

  To achieve this, TP-4 will actively engage practitioners and policy makers as well the relevant research communities to identify, develop, apply, and promote advancements in approaches to SE and systems thinking that will further TP-4's objective. TP-4 will also engage those parts of industry and academia and other parts of government that are active in and support defense SE.

- TP-4 will adapt its strategy and program to serve the needs of executive decision makers and defense planners in defense departments, defense acquisition agencies, and the military, as well as colleagues working on science and technology.

- TP-4 will use delivery mechanisms appropriate to the audience and employ a diversity of communication routes including workshops, presentations, briefing notes, and advice. Delivering advice on guiding principles and practice and the development of skills and human capital, training, and education is an increasing feature of this.

- TP-4 activities will be directed to supporting JSA Strategic Thrusts as follows:

  - *Championing SoS*
  - Modernizing defense processes
  - Enabling TTCP synergies.

- Lastly, TP-4 will provide access to a knowledge network and an intellectual resource that can provide a source of advice and awareness on crosscutting issues.

The nations participating in TP-4 include the United Kingdom (UK), Australia (AU), Canada (CA), and the United States (U.S.).

The TP-4 SoS Work Stream has been an activity of TP-4 since 2008, as is shown in Figure 1[5]. All four TP-4 nations are active participants in the SoS Work Stream.

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[3] From http://www.acq.osd.mil/ttcp/

[4] From TP4 Terms of Reference

[5] Past products include:
Kristen Baldwin et al. "An Implementer's View of Systems Engineering for Systems of Systems." Proceedings of the IEEE International Systems Conference, Montreal, Canada, April 2011.

Spring 2008 CAN	Fall 2008 UK	Spring 2009 US	Fall 2009 AUS	Spring 2010 UK	Fall 2010 CAN	Spring 2011 US
SoS Added to TTCP TP4 Topic of Interest	Briefs on SoS Activities of Each Nation	SoS Workshop Identified Common Interests	Exchange on SoS National Updates	Exchange on SoS National Updates	Exchange on SoS National Updates	Exchange on SoS National Updates
AUS-US Bilateral on SoS Artifacts	US-CAN Action to Review Joint Fires and SoS	TP4 Endorsed SoS Artifacts Initiative	SoS Artifacts Review	Review of Revised Artifacts As Applied in Each Nation	Review of SoS Implementers' View By Nations	Planning for Next Phase of Work
			US-CAN Joint Fires and SoS Review	IEEE Paper on SoS Artifacts	IEEE Paper on SoS Implementers' View	

Figure 1. Overview of TTCP TP4 Systems of Systems Work Stream Past Activity

In 2012, work on this product was initiated, given the recognition of the growing need for added attention to SoS aspects of defense systems across the four participating nations. The resulting best practices combine knowledge from across the participating nations for broader benefit of all nations, both government and industry.

Dahmann J., G. Rebovich, J. Lane, and R. Lowry. "System Engineering Artifacts for Systems of Systems." Proceedings of the Institute of Electrical and Electronics Engineers (IEEE) Systems Conference, April 5-8, in San Diego, CA, 2010.

II. Purpose

A. Objective

This set of recommended practices brings together the collective knowledge from across the TTCP nations on the SoS considerations to be addressed at key points in the system development process, to ensure that systems are engineered to operate in today's enterprise environment where they will, in almost every case, be a part of one or more SoS environments.

Recognizing the importance of non-material aspects of systems, the focus of these recommended practices is on material systems.

B. Audience

The recommended practices are intended for use by systems engineers, program managers, and acquisition oversight organizations in government and industry who are engaged in the development of defense systems in particular, but they apply more generally across large systems in other domains as well.

C. Anticipated Use of the Product

The tables presenting the recommended practices are structured with the expectation that users will adapt the information to augment or evolve their current practices to incorporate the SoS considerations specified for key points in the systems development process as they relate to their particular system acquisition process.

As a result, the tables use very general terminology anticipating that users will need to tailor this to their specific situations and vocabulary. The tables adopt definitions from the SE Body of Knowledge (SEBoK[6]) to the degree possible, again so the product is based on a broad SE context.

These recommended practices are especially important to defense acquisitions challenged by the traditional nature of individual service appropriations. It is expected that national acquisition agencies will incorporate these SoS considerations into their current system-focused reviews and management processes.

[6] www.SEBoK.wiki

III. Methodology

Because these recommended practices are drawn from experience in a variety of different national defense acquisition settings and, similarly, they are intended to be used across diverse environments, an international standards-based framework was used to structure the materials. In the development of the recommended practices, team members drew from their national experience and translated this into the shared standards-based framework.

In particular, the life-cycle phases of International Organization for Standardization (ISO) 15288[7] were used as the foundation for the capture and presentation of recommended practices. As is shown in Figure 2, several selected key review points were identified and used to organize the information. It is recognized that SoS factors may be considered at other points in system development but the focus on these points was chosen with the idea that they provide the basis for addressing other points in the process. The focus was also on the early phases up to final design, since subsequent reviews will be driven by elements well established by this point; that is, once SoS considerations are factored into the requirements and design, normal testing will capture SoS aspects as a matter of course. The post-deployment, in-services reviews, were included recognizing the long service life of many defense systems and the fact that systems are often called upon to operate in a variety of contexts through their active lives.

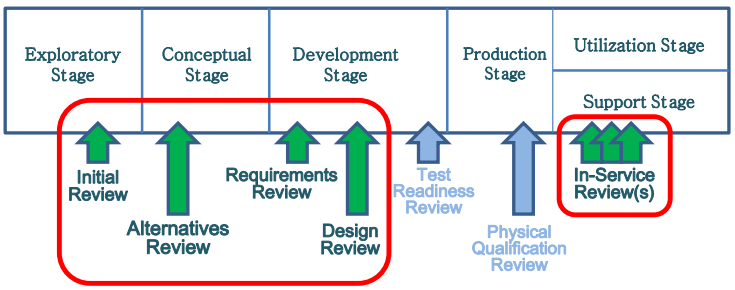


Figure 2. ISO 15288 Framework for Recommended Practices

The development of these best practices was based on an iterative collaborative approach. Starting with the framework, each nation contributed their experience into the common format. Iterative releases were generated and reviewed by the nations over a three-year period. The last two product review cycles included engagement with external SE organizations for comment and feedback. This includes the International Council on Systems Engineering

[7] International Organization for Standardization (ISO)/International Electrotechnical Commissions (IEC) 15288:2008 Systems and software engineering -- System life cycle processes; See http://www.iso.org/iso/catalogue_detail?csnumber=43564.

(INCOSE) SoS Working Group[8] and the National Defense Industrial Association (NDIA) SoS Committee[9]. These external reviews included input from both industry and academia as well as reviews from the national defense organizations.

[8] The SoS Working Group of the International Council on Systems Engineering (INCOSE) is devoted to the application of systems engineering (SE) to SoS. See http://www.incose.org/practice/techactivities/wg/details.aspx?id=sos.

[9] The Systems of Systems Committee of the Systems Engineering Division of the National Defense Industrial Association (NDIA) is a forum for addressing issues related to SoS. See http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Pages/SystemsofSystemsCommittee.aspx.

IV. Structure of the Recommended Practices Tables

The recommended practices are presented in a series of tables, one for each review point. The structure of these tables is shown in figure 3, which provides a schematic of the tables and a brief description of the content of each section of the tables.

Each table includes a comprehensive list of considerations applicable to that particular review; items carry from one review to the next if they continue to be applicable. Hence, what may appear to be redundancy across tables reflects the need to continue to address the same questions at subsequent stages in the development and review points.

- **Review Point**

Tables are organized by review point, since the concept is that the information provided in each table would be used at each review. The green arrow is positioned on the graphic to indicate where the review point fits into the ISO 15288 development phases.

The next three topics: State of the Program at This Review Point, Information Available at This Review Point, and Systems Issues at the Review Point are reflective of the current practices across the TTCP nations. These are the typical **system considerations** currently addressed at each review point. They are included as reference points for the new information provided in the remaining sections of the table which address the recommended practices for **SoS considerations**.

- **State of the Program at This Review Point**

This information is used to orient the reader to what would be expected of an acquisition program at this review point. What activities have been completed and what are the next activities anticipated. This is included because users of the tables will be translating this information to their own acquisition process and this will help them position this review point to their local context.

- **Information Available at This Review Point**

As systems reach each review point in development there is typically a set of information expected to be available for the system reflecting its stage of development.

- **Systems Issues at This Review Point**

Today, systems are reviewed at each point in terms of the state of the system. The set of typical questions used to assess system maturity at each review point are provided here.

The two remaining sections are the core of the recommended practices for **SoS considerations** in the development of the system. It is anticipated that these SoS considerations will be

Review Point: Review Name

State of Program at this Review Point:

This section describes the acquisition program as you would expect it at this review point including what has been accomplished so far and what nest steps are anticipated.

Information Available at this Review Point

- This section lists the information about the system which you would expect to be available at this review point

System Issues at this Review Point

Questions

This section lists the types of questions which are typically asked at this point to assess whether the system development is mature enough to proceed further.

SoS Issues Impacting the System

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
Issues are grouped by area.	Specific questions to be addressed at this review point *[Previous Review]*	The value of addressing the issue	The risk the program will face without successfully addressing the issue	What you should look for to assess whether the question has been addressed	Things you can do mitigate the risks if the question has not been addressed

SoS Supporting Technical Base

- The types of system of systems level technical information ideally available to support addressing these SoS considerations for individual systems

Figure 3: Description of Table Layout and Content

integrated into the national review processes to supplement the current system-focused review questions.

- **SoS Issues Impacting the System**

This section is the focus of the recommended practices. It provides a list of questions in table format along with supporting material which highlight the SoS considerations to be addressed at each review point. This includes:

- Area: SoS considerations are grouped into four areas: Capability, Technical, Management, and Cost.
- Questions: The recommended SoS considerations are formulated in terms of the questions which are to be addressed when reviewing systems at each review point. If a question also applies to a previous review point, this previous review point is noted following the question in *italics*. As noted above, some questions will apply to multiple review points.
- Benefits: It is important to understand the benefit to the system of addressing these SoS questions.
- Risk: Likewise, it is important to understand the risks associated with failing to successfully address the SoS questions.
- Evidence/Metrics: This section identifies the type of information or artifacts that provide the information needed to address the questions.
- Potential Actions/Mitigations: Finally, this section suggests possible mitigating actions when the questions cannot be satisfactorily addressed.

V. Recommended Practices Tables

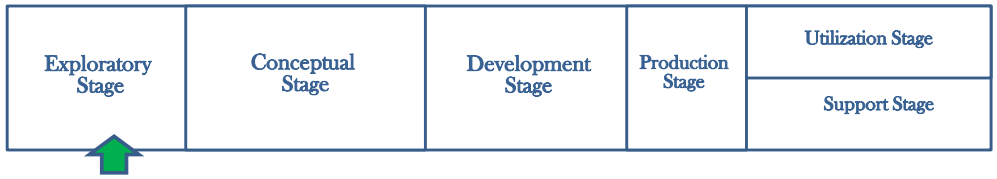
What follows the set of tables presenting information relevant to each of the review points.

VI. Glossary

Term	Definition[10]
Agreement	Mutual acknowledgment of terms and conditions under which a working relationship is conducted (International Organization for Standardization [ISO]/Institute of Electrical and Electronics Engineers [IEEE] 2008, 1, Section 4.4)
Architecture	The fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution (ISO/IEC 2008, Section 4.5)
Baseline	A specification or product that has been formally reviewed and agreed upon that thereafter serves as the basis for further development and that can be changed only through formal change control procedures (ISO/IEEE 2008)
Capability	The ability to perform a function, task, or action (SEBoK 1.2)
Emergent Behavior	The principle that whole entities exhibit properties which are meaningful only when attributed to the whole, not to its parts. Every model of a human activity system exhibits properties as a whole entity which derive from its component activities and their structure but cannot be reduced to them. (Checkland 1999)
Interface	A shared boundary between two functional units defined by various characteristics pertaining to the functions, physical signal exchanges, and other characteristics (ISO/IEC 1993)
Interoperability	Degree to which two or more systems, products, or components can exchange information and use the information that has been exchanged (ISO/IEC 2009)
Life Cycle	The organized collection of activities, relationships, and contracts which apply to a system-of-interest during its life (Pyster, A. (ed.). 2009. *Graduate Software Engineering 2009 (GSwE2009): Curriculum Guidelines for Graduate Degree Programs in Software Engineering*. Integrated Software & Systems Engineering Curriculum Project. Hoboken, NJ, USA: Stevens Institute of Technology, September 30, 2009)
Scenario	A set of actions/functions representing the dynamic of exchanges between the functions allowing the system to achieve a mission or a service (Faisandier, A. 2012. Systems Architecture and Design. Belberaud, France: Sinergy'Com)

[10] Definitions have been drawn from the Systems Engineering Body of Knowledge (SEBoK 1.2). See http://www.sebokwiki.org/wiki/Guide_to_the_Systems_Engineering_Body_of_Knowledge_(SEBoK).

Table 1: Initial Review



Review Point Initial Review

State of Program at this Review Point

Gap or need has been identified by users and a range of potential solution options has been identified; an initial decision is needed about whether to proceed with actions to initiate a possible system acquisition/ modification at this time, and to proceed to solution alternatives formulation and assessment. The purpose of the review is to assess whether the program is technically ready for a commitment to formally explore alternatives for addressing gaps and needs, through means ranging from paper exercises and modeling, to competitive prototyping.

Information Available at this Review Point

- **Statement of Capability Deficiency**
  - Gap(s) or need(s) are described in terms understandable to reviewers (mission performance impact, cost, obsolescence etc.), are quantified if possible and qualified to the extent they have specific impact to current missions or mission threads, or operational risk to conceptualized future missions (if left unaddressed). This includes operational tasks expected to be performed by the human element of the system, and how the human element will interact with the proposed gap-filling system.
  - Architectural artifacts that model the capability gap in terms of desired mission effects and outcomes, tasks to be performed, the political, military, economic, social, infrastructure, and information conditions under which this must take place and quantitative metrics to be achieved for the effects, outcomes, and task performance.
  - Operational vignettes for current or possible future systems that addresses evolution of, or new, doctrine (if applicable).
  - Description of the how the users propose to conduct the future mission operations (if different from current).
  - Report of user experience with current system(s), indicating what cannot be done due to gaps or unfilled needs, ideally at both the strategic/doctrinal level, and tactical/tasking level.
  - Performance reports or artifacts that indicate shortfalls or inability to meet performance goals using current system(s).

- **Option Set for Consideration**
  - Initial record of candidate materiel solutions and attributes that should address gaps/needs.

- Understanding of future technologies or lab-based efforts that may serve as a future gap-filler when mature and transitioned, resulting in a need for a near-term system to fill the gap over the interim.
- Architectural artifacts that model operational resource requirements and flows for current and future missions, mission threads, and operations identifying required interoperability need lines to establish resource flow and interoperability requirements for alternative solutions to set the stage for understanding other factors that may impact a new 'system'.
- Evaluation of gaps, analysis confirming mission needs and risks, and a notional recording of how candidate alternatives might address gaps/needs.
- Initial rough cost/schedule/budget scoping estimates.

System Issues at this Review Point

Questions

- Has there been analysis to clearly demonstrate the capability gap?
- Has the operational risk of this gap been demonstrated?
- Are there candidate materiel solution approaches with the potential to effectively address the capability gap(s) with the desired operational attributes and associated dependencies?
- Are there a range of technically feasible solutions generated from across the entire solution space, as demonstrated through early prototypes, models, or data?
- Have potential different solutions been characterized in terms of cost/schedule? Are these potential solutions within the anticipated cost/schedule constraints?
- Have infrastructure, personnel, training, maintenance, etc. issues been vetted for the various potential solution spaces? Over the lifecycle?
- Have relevant end-to-end (e.g., sensor-to-shooter) metrics been characterized that will inform choices being made during the interface design process?
- Are the environmental factors being defined in a design reference mission (DRM) or similar document (e.g., threat, weather, transportation)?

SoS Issues Impacting the System

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
Capability	Has the operational context of the capability gap been described? Have operational context constraints on the candidate solutions been identified? How would any new system which might address the gap fit into current operations? If a new system were to be considered, have interfaces with or required changes to current/legacy systems or infrastructure been identified (both national and coalition)? Have non-material approaches and factors (e.g. personnel, training,	A clear, early understanding of the SoS context and its potential impact on system requirements and dependencies will provide a solid basis for development of a system which will meet user needs. Constraints are key to effective solutions. Understanding these early can contribute to a sound solution selection including an understanding of risks. Early identification of potential interface and infrastructure changes allow for organizational negotiations and agreements to be put in place as well	If materiel or non-materiel impacts or factors from the SoS or its other constituents have not been considered, the risk is that the solution considered/selected will either not achieve expected capability results or will incur added, unexpected costs or schedule slips, or result in unwanted effects on other capabilities.	Understanding of current operation (e.g. use case or mission thread). Delineation of systems currently supporting capability and the number and nature of interdependencies associated with alternative approaches to addressing the gap. Identification of number and nature of interdependencies associated with current systems in operation or planned. Identification of number and nature of interdependencies associated with systems in development (other projects). Identification of non-material impacts of alternatives and their	Consideration of the full impact of alternatives (both new system and impact on other systems or non-material factors) in the assessment of possible approaches to addressing gap. Required changes to operations including current systems and non-material factors can be analyzed across the portfolio to avoid unwanted effects on other capabilities.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	how the users will conduct the operation, other) been considered?	as multi-lateral trade-off analysis of whether changes should be implemented and where changes can best be implemented. Considering non-material factors early provides sufficient lead-time to address cross organizational enablers such as resources, organization impact, training, personnel multi-role postings and recruitment focus.		implications.	
Technical	Have the external stakeholders or external systems/infrastructure affected been identified? This includes both i. Systems/services on which the new or upgraded system depends; and	Early identification of key external parties impacted by the new system and their ability to affect and provide the resources for the needed changes will provide a realistic planning basis for the system	If there is inadequate understanding of the systems context for the acquisition, the risk is that the selected solution may not be feasible due to needs of stakeholders of affected systems or	Lists of external stakeholders and of dependent systems and their proponents and resource sponsors, including maintainers for in-service systems. Early list of assumptions and dependencies.	Identify and contact potentially affected stakeholders. Stakeholders identify subject matter experts (SMEs).

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	ii. Systems/services that depend on the new or upgraded system. Is there an understanding of the ability to influence resource changes in associated systems, infrastructure, or non-material factors?	development. Including identification of any potential or current shared developmental costs and tools.	an inability to adjust associated systems to address capability gaps.		
Management	If the system will support one or more acknowledged or directed SoS, what organization (if any) is responsible for the SoS(s) which this acquisition program supports? What management arrangement has been established between the program and the SoS? Have these been formalized (e.g.	Identifying and working with an established SoS level organization right from the start can provide the system development ready access to key information and existing arrangements to ensure the system development is aligned with the larger SoS.	If the role of the proposed system solution is not understood in the context of an acknowledged or directed SoS, as the program develops, the risk is that the system solution may not be compatible with or operationally suitable for the current and future direction of the SoS or it may incur added costs and	Management arrangements with the SoS, either in the form of an MOA or MOU, and cooperative action plan including how the systems will work together over time (over lifecycle) that provide insight into the role of the system in the SoS and enable the development of system requirements, implementation, test, etc.	Arrange to work with the SoS. Engage with the SoS manager or systems engineer, to ensure that plans for the system and SoS are aligned. Revisit as needed to assure continued alignment. Identify software and hardware lifecycles of other systems

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	MOUs, MOAs)? Have these arrangements been implemented?		time for necessary rework.		
Management	If there is no acknowledged or directed SoS management, then what management arrangements have been made with other systems which impact this system (including when a system participates in multiple SoS)? Have these arrangements been implemented?	Establishing arrangements with other systems early in development can provide a key foundation of collaborative efforts throughout the system development.	If the role of the proposed system solution is not understood in the context of an SoS, as the system develops, there is the risk that the system solution will not be compatible with the current and future direction of the SoS, and will not be operationally suitable or will incur added costs and time for necessary rework.	Management arrangements with the relevant systems, either in the form of an MOA or MOU, and cooperative action plan including how you will work together over time (over lifecycle) to support the development of system requirements, implementation, test, etc.; this may include data sharing agreements.	Engage with the managers or systems engineers of the relevant systems, to ensure that plans for the system align with those of the other systems.

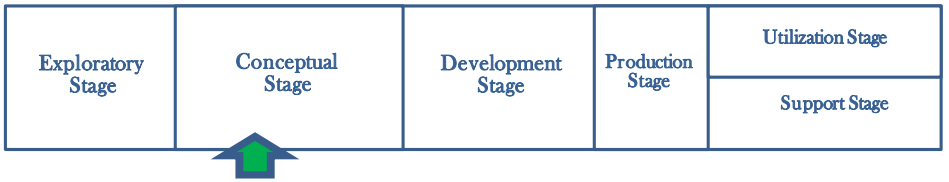
SoS Supporting Technical Base

Analysis has been conducted to understand end-to-end capability objectives, performance metrics and current performance data, systems supporting those objectives, technical baseline, gaps, etc. to provide needed context. This includes an understanding of

- The lifecycle dependencies between SoS components in the form of an acquisition roadmap.

- How systems currently support the capability (including functionality, performance, capacity, interfaces, protocols/standards, data exchanges etc.) as well as the current concept of operations – how the systems are employed by users in an operational setting to deliver the capability objectives. This could be described as an architecture or a model.
- Dependencies and interdependencies among systems, and material and non-material aspects supporting the capability.
- Other capabilities which are dependent on the same current systems and non-material resources (or subset thereof) since systems on which this new effort is depending may also be key to other capabilities.
- Constraints on any solutions.

Table 2: Alternatives Review



Review Point Alternatives Review

State of Program at this Review Point

Decision has been made to investigate a material acquisition to address a user need (capability gap), a set of alternative solutions has been analyzed and a preferred solution (e.g. a type of system, e.g. a UAS versus a fixed wing aircraft) has been identified. This may include modifications to an existing system. The purpose of this review is to review the conduct and results of the analysis of alternatives and the preferred solution.

Information Available at this Review Point

- Description of how the users will conduct the operation, how they expect to use the new system in this context, If multi-mission system this will address major mission areas, scenarios, etc.
- Statement of need in terms oriented to the system user(s), the stakeholder(s), and independent of specific technology solutions, the program should be able to describe what this system is required for and why, connected to strategic aims of the organization and the structured business/mission processes that fulfill those aims.
- The required characteristics and context of use of services and operational concepts are specified.
- Major stakeholder requirements should be identified and documented, but detailed requirements analysis is yet to be completed.
- The constraints on a system solution are defined.
- Results of an analysis of alternatives, a comparative analysis of candidate solutions (identified in the initial review), with a recommended preferred solution
- Stakeholder requirements for validation are identified.
- Updated preliminary system architecture – based on the work done prior to Initial Review, the architecture should be extended, in reach and in detail. This includes initial interface definitions, constraints and limitations that the system may be confronted with, ranging in scope and scale from size, weight, power, and cooling (SWAP-C) considerations, to security and safety (e.g., airworthiness, weapons, hazmat).
- Initial plans for systems engineering, providing the notion of “how” this system can be realized, including the level of process and process maturity needed to generate a system of the required complexity and depth and the systems and partners that need to come together to properly deliver the required capability.

- Initial definition of the environment including reference material that defines the characteristics of the threat and natural environment in sufficient detail to support effective analyses.
- Initial test & evaluation strategy including test cases derived from user operational vignettes, concept of operations and capability description should be captured at this stage, showing that a system is testable from its onset with expectations which are aligned with the metrics established at the initial review.
- Input into technology development strategy; as the system architecture and conceptual vision unfold, it should be possible to understand where the greatest challenges may lie, in terms of creating or using technology. Where overall technological maturity may be low, these challenges should be listed and dealt with deliberately, with contingency available in case of continued problems.

System Issues at this Review Point

Questions

- Can the proposed material solution(s) satisfy the user needs?
- Have cost estimates been developed and were the cost comparisons across alternatives balanced and validated?
- Can the solution be implemented within cost (full lifecycle) and schedule constraints?
- Is the proposed material solution(s) sufficiently detailed and understood to begin technical development with acceptable technical risk?
- Has a preliminary system specification, consistent with technology maturity levels, the proposed performance requirements, proposed program costs and schedule, been captured in the system technical baseline?
- Is the initial test strategy aligned with the initial user needs (e.g. metrics established at initial review)?
- Is the system's software scope and complexity sufficiently understood and addressed to enable an acceptable/manageable level of software technical risk?
- Have required investments for technology development, to mature design and manufacturing related technologies, been identified and funded?
- Is a commercial of the shelf (COTS) solution desired and/or available? Has this been considered? If a COTS solution has been selected, what are the associated risks (life cycle support, security, integration, etc.)?
- Was the technical maturity of the alternatives considered, and is the recommended solution at an appropriate level of technical maturity?

- Have initial producibility assessments of design concepts been completed?
- Have the preliminary manufacturing processes and risks been identified?
- Are the hazards sufficiently understood and addressed to achieve an acceptable/manageable level of environmental safety and health risk in the Technology Development phase?
- Does the recommended solution meet requirements for safe, secure, and compliant operation in the national security context?
- Is the system logistically supportable (based on initial support concepts)?
- Does solution reduce risk to military personnel or others affected by the solution?
- Is your contracting/acquisition strategy aligned with the technical approach?

SoS Issues Impacting the System

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
Capabilities	Is the SoS context (or multiple SoS contexts) clearly defined in an up-to-date description of how the users will conduct the operation and how they expect to use the new system? Have there been changes since the last review? How would your system fit into current operations? Have operational context constraints on the candidate solutions been identified? Has the relationship with the	A clear, early understanding of the systems context and its potential impact on system requirements and dependencies will provide a solid basis for development of a system which will meet user needs. Early identification of potential interface and infrastructure changes allow for	If there is no description of how users expect to use the new system that is coordinated with the overall description of how the users will conduct the operation as context for system use, the risk is that requirements and dependencies may be missed, leading to an ineffective	Written description with clear delineation of how the new system will work in the context of other systems and operational context. This delineation must also be consistent with the view presented in the description of how the users will conduct the operation and how the new system will be used with other systems to address the user's capability objectives.	Develop and validate how users expect to use the new system, clearly identifying the key elements external to the proposed system and their impact on system attributes and functionality, as well as impacts of the system on these external factors. Ensure compatibility with description of how the users will conduct the operation

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	other systems supporting the capability been considered? For example, have interfaces or protocols with or required changes to current systems or infrastructure been identified (both national and coalition)? Have these been communicated to these systems? Have interfaces with or required changes to systems in development or planned systems been identified? Have the benefits from and for other (both national and coalition) systems or infrastructure been identified? Have these been communicated to these systems? Has impact on non-material factors (e.g. personnel, training, description of how the users will conduct the operation, other) been described?	organizational negotiations and agreements to be put in place as well as multi-lateral trade-off analysis whether changes should be implemented and where changes can best be implemented. Early identification of dependencies between systems in development or planned systems provides the opportunity to 'future proof' the interoperability; that is, to ensure that interoperability will be maintain despite changes.	system, unexpected higher costs and/or schedule slip due to necessary rework.		overall, including the other systems supporting the operation.
Capabilities	How does the proposed	A clear	If the linkage	Results of analysis,	Using data from

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	Material solution address the gaps in the mission threads for the SoS capability? Is this still the case from the past review?	understanding of how the solution addresses the gap will provide the basis for understanding key attributes of the system and key relationships to be considered in requirements.	between the proposed system and the SoS capability gaps defined in user needs is not clearly defined, the risk is that the system may not meet user objectives.	simulation, prototyping or experimentation. Consistency or change from the last review.	simulations, prototypes or live events, conduct analysis of end-to-end mission threads based on a description of how the users will conduct the operations for both the SoS and the system, to verify that the system will support the capability need.
Capabilities	Have roles in different missions or mission threads been identified and prioritized?	Understanding the variety of roles a system will play will provide a strong foundation for system requirements.	If a system has roles in several missions and the capability development information requirements are not identified early to ensure availability of that information, the risk is that the system will not meet all user objectives.	Identification of mission/SoS interfaces information suppliers /protocols and standards responsibilities. Development of interoperability requirements.	Interoperability requirements can be identified or developed in order of priority within resource constraints. Driving interfaces along with protocols and standards can be identified.
	How critical are the	Understanding	If you don't	Criticality analysis of	Develop and validate

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
Capabilities	interoperability requirements to the interdependencies (sensitivity considerations)?	criticality will provide basis for understanding impact of any future trades.	understand the relative importance, the risk is that you may trade away the wrong things.	system interdependencies within the SoS.	"criticality analysis" with stakeholders to understand the criticality and priority of various interdependent functions.
Technical	What constraints on the system are imposed by the SoS context for the system? Have these been considered in selecting the system solution? This includes: ▪ Physical requirements (e.g. size, weight, cooling, power limits) ▪ Electronic requirements (e.g. signature, interference, etc.) ▪ Information exchange/management (e.g. network, bandwidth, information needs, etc.) ▪ Safety, Security / information assurance.	Understanding constraints is key to developing effective solutions. Understanding these early can contribute to selection of a sound solution.	If the SoS constraints and resulting requirements are not recognized, the risk is that the resulting system may not operate as expected in the SoS user environment or may incur unexpected addition time or budget for rework.	Results of early engineering analysis highlight the constraints placed on the solutions; these constraints were addressed in analysis of solution options and are considered in the selected solution.	Documentation of the constraints of the SoS context on alternative system solutions and the way the selected system solution addresses these constraints.
Technical/ Management	What are the dependencies and interfaces for the system?	Dependencies can be key to a system success in meeting	If the dependencies and interfaces are	A representation of the SoS architecture(s) with clear identification	Employ the description of how the users will conduct

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	Describe how these dependencies and interfaces are identified, defined, and controlled?)[e.g. how tightly coupled are the interdependent systems]? How will the interfaces be managed across the different systems?	user needs so understanding these clearly, early in acquisition provides a sound basis for selection of the most appropriate solution.	not identified when assessing alternatives or identifying preferred option(s), the risk is that the resulting system may not factor these into requirements, design, etc., and hence may not perform as needed in the SoS operational environment.	of interfaces and dependencies to the solution options, inclusion of these in the analysis of options and in the definition of the preferred solution.	the operation and mission threads as well as some representation of the end-to-end SoS architecture(s), to define the role of the proposed system solution(s) with respect to other systems, in terms of interfaces (see item above) and other physical and logical functions. Include these as factors in the assessment of system solution options.
Technical/ Management	Are there any other (complementary) systems critical to the success of the proposed system? Who is responsible for these systems and do they acknowledge the dependency? Are there impacts on these systems that need to be addressed to meet the capability needs once the	Identifying where other systems are key to a system success and making early contact can provide the basis for successful collaboration throughout development.	If the expectations of other systems (things they need to change or things they need to continue to do) are not clearly understood, the risk is that the selected system solution option alone will be insufficient to	Identification of the owners of the external systems and recognition of their roles in the system's mission.	Development of a functional allocation across systems for the preferred solution will allow for identification of external dependencies to be addressed as part of the selection of the preferred system solution.

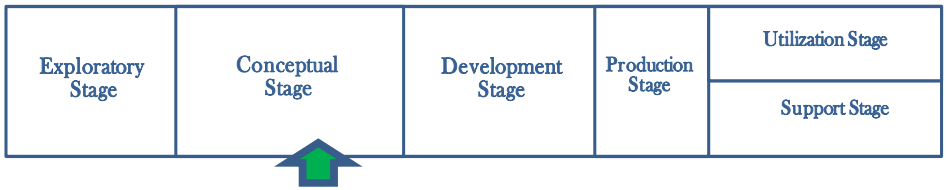
Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	new system or system upgrade is implemented?		meet user needs.		
Management	If the system will support one or more acknowledged or directed SoS, what organization (if any) is responsible for the SoS(s) which this acquisition program supports? What management arrangement has been established between the program and the SoS? Have these been formalized ? Do these arrangements address schedule and budget? Have these arrangements been implemented? [Initial Review]	Identifying and working with an established SoS level organization right from the start can provide the system development team with ready access to key information and existing arrangements to ensure the system development is aligned with the larger SoS.	If the role of the proposed system solution is not understood in the context of an acknowledged or directed SoS as the program develops, the risk is that the system solution may not be compatible with or operationally suitable for the current and future direction of the SoS or it may incur added costs and time for necessary rework.	Management arrangements with the SoS, and cooperative action plan including how you will work together over time (over lifecycle) that provide insight into the role of the system in the SoS and enable the development of system requirements, implementation, test, etc.	Arrange to work with the organizations responsible for the SoS(s). Engage with the manager(s) or systems engineer(s) for the SoS, to ensure that plans for the system and SoS are aligned. Revisit as needed to assure continued alignment. Identify software and hardware lifecycles of other systems within the SoS.
Management	If there is no acknowledged SoS management, then what management arrangements have been made with other	Establishing arrangements with other systems early in development can	If the role of the proposed system solution is not understood in the	Management arrangements with the relevant systems and cooperative action	Engage with the managers or systems engineers of the relevant systems, to

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	systems which impact this system (including when a systems participates in multiple SoS)? Have these arrangements been implemented?	provide a key foundation of collaborative efforts throughout the system development.	context of an SoS as the system develops, the risk is that the system solution will not be compatible with the current and future direction of the SoS , and will not be operationally suitable or will incur added costs and time for necessary rework.	plan including how you will work together over time (over lifecycle) to support the development of system requirements, implementation, test, etc.; this may include data sharing agreements.	ensure that plans for the system in question align with those of the other relevant systems.

SoS Supporting Technical Base

- Analysis conducted to understand end-to-end capability objectives, performance metrics and current performance data, systems supporting those objectives, technical baseline, gaps, etc. to provide needed context. *[Initial Review]*
- An understanding of how systems currently support the capability (including functionality, performance, interfaces, data exchanges etc.) as well as the current concept of operations – how the systems are employed by users in an operational setting to deliver the capability objectives. This could be described in the form of an architecture or a model. *[Initial Review]*

Table 3: Requirements Review



Review Point **Requirements Review**

State of Program at this Review Point

The preferred solution has been selected, in-depth review of user needs has been conducted, and system requirements have been documented. The purpose of this review is to validate the requirements. The next activity will be to solicit system designs.

Information Available at this Review Point

- At this point there will be more detailed versions of the information that was available at Alternatives Review, ultimately enabling a full System Requirements Review. As such, the program should have more complete versions of the following available:
  - Description of how the users will conduct the operation and how the system will be used in this context.
  - Definition of the threat and physical/operational environment.
  - Functional and Systems requirements:
    - The required characteristics, attributes, and functional and performance requirements for a product solution are specified.
    - Constraints that will affect the architectural design of a system are defined and the means to realize it is specified.
    - The integrity and traceability of system requirements to stakeholder requirements is achieved.
    - A basis for verifying that the system requirements are satisfied is defined.
  - System Architecture – particularly focused on consistency and completeness of interface, functional interaction, and standards information and the implications on performance as well as data exchanges.
  - Plans for systems engineering for the acquisition.
  - Test & Evaluation strategy including metrics consistent with those used to define the need.

- In addition, at this point there will be initial versions of:
  - Risk Assessment -- assessment of risks and opportunities associated with the preferred solution; risks should include financial and non-financial considerations.
  - Source selection plan – this includes an approach for procuring and/or developing the proposed system, whether through an off-the-shelf system, a modification of an existing system, a fully developed approach, or a mix. Because systems today are rarely

standalone or fully provided through one vendor, this also needs to include consideration of partnerships (at the programmatic and technical levels) needed to fully deliver the necessary capability.

- System safety and security plans – the program should be able to characterize the safety and security challenges this system will face, and begin to deal with them very early in the program lifecycle. This prevents the postponement of dealing with safety and security challenges to the deployment phase, and increases the odds that the program will be developing a system that is fundamentally safe and securable. This includes consideration of all possible adversary threats, risks, vulnerabilities and resiliency, and is an analysis that must be performed with knowledgeable individuals as well as involving the user community and management. The results should be included in system requirements and design considerations.
- Test and evaluation plan – the strategy should be decomposed into an actual approach for testing the program, including the certifications and accreditations required to deploy, implement, and operate this system.
- Supportability strategy – at this point there is enough known about the candidate system approaches to be able to start recording a strategy for supporting the system once deployed. This can include elements of contractor and government support, as well as support provided at home, in transit, and abroad. Sustainment and continuation challenges should be noted and dealt with, to include not just consideration of how to handle a given system problem, but how to provide enhancements to capability during the system life.
- Technology readiness assessment – as a logical progression from the technology development strategy, now that more is known about the technical challenges and their potential mitigation, the program can more formally assess the integration of the system and its readiness to be developed and ready for use. There are many methodologies for looking at this, and there are specific challenges in the areas of hardware, integration, and software that should be considered.
- Acquisition strategy – In preparation for fulfilling the plans for selecting a supplier or developer, the contractual and programmatic aspects of the program should be fully understood in order to actually procure the system. This includes consideration of industrial base challenges that may create shortages or other procurement limitations, including government policy and process limitations if applicable. Where needed, agreements need to be formalized and implemented at this stage; this includes data sharing agreements.
- Interim baseline review, affordability (budget) assessment, and integrated master schedule – The program should be able to start to flow activities to deliver this program through time and understand their dependencies and relationships. This requires review and assessment in an ongoing fashion, and identification of costs and budget.
- A detailed laydown of the information to be shared by the system with other systems - Aspects of information interoperability can be among the toughest technical and programmatic challenges to address. Pursuing these challenges deliberately and completely, early in the program, is a best practice, particularly for complex distributed systems. This information should be recorded and explored using an appropriate framework of rigor and discipline to ensure that the requisite information, which will fuel the fulfillment of relevant interface control documents, is recorded and evaluated.
- System requirements and specifications – a deliberate process of recording and evaluating requirements needs to be initiated and continued at this stage, ensuring wide participation and substantial rigor. It is necessary at this stage to have bidirectional traceability from a.) the user plans to operationally use the system, through b.) the highest-level system requirements and architecture, to c.) lower-level requirements and specifications.

- Other considerations - Environmental, Safety, Health, Human System Interfaces, Anti-Tamper, Training, Personnel Readiness, System/mission assurance, user work-load analysis, and other issues need to be considered and explored at this stage.

System Issues at this Review Point

Questions

- Can the system requirements, as disclosed, satisfy the user needs?
- Are the system requirements sufficiently detailed and understood to enable system functional definition, functional decomposition, test and evaluation?
- Are there conflicting requirements? Have they been prioritized?
- Have Human Systems Integration and sustainment requirements been reviewed and included in the overall system requirements?
- Can the requirements be met given the technology maturity achieved?
- Is there evidence that the requirements are technically feasible from a material and manufacturing perspective?
- Is there an approved system performance specification?
- Are adequate processes and metrics in place for the program to succeed?
- Have end-to-end metrics been defined to characterize each external interface to ensure the capability being developed satisfies mission objectives?
- Are the risks known and manageable for development?
- Is the program properly staffed?
- Is the program executable within the existing budget?
- Are the preliminary software development estimates established with effort, schedule, and cost analysis?
- Did the completed effort to date sufficiently mature all system elements to enable low risk entry into development?
- Have security requirements, applicable standards (including programming languages and architectures), and operational and support concepts been identified?
- Have retirement and dismantling considerations been addressed?
- Is there a complete and credible assumptions and dependencies list?

SoS Issues Impacting the System

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
Capabilities	Is the SoS context clearly defined in the updated description of how the users will conduct the operation and how the system will be used in this context and in the user statement of need? Has this changed since the last review? *[Initial and Alternative Reviews]*	A clear, early understanding of the system's context and its potential impact on system requirements and dependencies will provide a solid basis for development of a system which will meet user needs.	If there is no description of how the users will conduct the operation as context for system use, the risk is that the requirements and dependencies may be missed, potentially leading to: • an ineffective system; • unexpected higher costs; • schedule slips; • too narrow a description of how the users will conduct the operation and how the system will be used in this context to cover the full requirement or to enable emergent behavior.	Written system description of how the users will conduct the operation with a clear delineation of how the new system will work in context of other systems and SoS operational context.	Develop and validate how users expect to use the new system, clearly identifying the key elements external to the proposed system and their impact on system attributes and functionality, as well as impacts of the system on these external factors. Ensure compatibility with description of how the users will conduct the operation overall, including the other systems supporting the operation.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
Capabilities	Have the roles in different SoS been identified and prioritized? Has this changed since the last review? *[Alternative Review]*	Understanding the variety of roles a system will play will provide a strong foundation for system requirements.	If a system has roles in several SoS, and if the capability development information and associated requirements are not identified early, the risk is that the system will not meet full set of user objectives.	Identification of the suppliers of SoS interfaces information and their responsibilities. Development of interoperability requirements. Identification of technical working groups / forums tasked with management and approval of changes to applicable protocols.	Interoperability requirements can be identified or developed in order of priority within resource constraints. Driving interfaces along with protocols and standards can be identified.
Capabilities	How critical are the interoperability requirements to the interdependencies (sensitivity considerations)? Has this changed since last review? *[Alterative Review]*	Understanding the relative criticality of interoperability requirements will provide the basis for understanding impact of any future trades.	If you don't understand the relative importance, the risk is that you may trade away the wrong things.	Criticality analysis of requirements and priorities.	Develop and validate "criticality analysis" with stakeholders to understand the criticality and priority of various interdependent functions.
Technical	What added (implied) requirements on the system are imposed by the SoS context for the	Constraints are key to effective solutions. Understanding these early can contribute to a sound	If the SoS constraints and resulting requirements are not	Results of early engineering analysis highlight the constraints placed on	Document the constraints of the SoS context on alternative system

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	system? What is the significance of these requirements? This includes: ▪ Physical requirements (e.g. Size, weight, cooling, power limits) ▪ Electronic requirements (e.g. signature, interference, etc.) ▪ Information exchange/management (e.g. network, bandwidth, information needs, etc.) ▪ Protocols and standards Has this changed since the last review? *[Alternatives Review]*	solution selection.	recognized, the risk is that the resulting system will not operate in the user environment or will incur unexpected additional time or budget for rework.	the system solutions. These constraints were addressed in analysis of solution options and are considered in the selected system solution.	solutions and the way the selected system solution addresses these constraints.
Technical/ Management	What are the dependencies and interfaces for the system? Describe how these dependencies and interfaces are identified, defined, and controlled.	Dependencies can be key to a system success in meeting user needs so understanding these clearly, early in acquisition provides a sound basis for solution selection.	If the dependencies and interfaces are not identified when assessing system alternatives or identifying preferred option(s), the risk is that the resulting	A representation of the SoS architecture with clear identification of interfaces and dependencies to the solution options, inclusion of these in	Employ the description of how the users will conduct the operation and mission threads as well as some representation of the end-to-end SoS

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	Has this changed since the last review? This includes both dependencies from a development perspective as well as operational dependencies. *[Alternatives Review]*		system may not factor these into requirements, design, etc., and hence may not perform or function as needed in the operational environment.	the system analysis of options and in the definition of the preferred solution.	architecture(s), to define the role of the proposed system solution(s) with respect to other systems, in terms of interfaces (see item above) and other physical and logical functions. Include these as factors in the assessment of system solution options.
Technical/ Management	Are there any (complementary) systems critical to the success of the proposed system? Who is responsible for these systems and do they acknowledge the dependency? Are there impacts on these systems that need to be addressed to meet the capability needs once the new system or system upgrade is implemented? How are these addressed?	Identifying where other systems are key to a system success and establishing early commitments for cooperation can provide the basis for successful collaboration throughout development	If the expectations of other systems (things they need to change or things they need to continue to do) are not clearly understood and considered, the risk is that the selected solution option alone will be insufficient to meet user needs.	• Description of how the users will conduct the operation and how the system will be used in this context and architecture. • Identification of the role of external systems to the achievement of capability or mission objectives. • Identification of the owners of the external systems	Develop a functional allocation across systems for the preferred solution will allow for identification of external dependencies to be addressed as part of the selection of the preferred system solution.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	Has this changed since the last review? *[Alternatives Review]*			and recognition on their parts of their role(s) in the mission.	
Technical	What analysis has been done of the system in the context of the larger SoS to identify constraints, coherence (including reuse and evolution considerations), systems attributes, interfaces or other design considerations for the system? How have these been documented? How have these been captured in the system requirements?	Clearly identifying and documenting the externally imposed considerations into system requirements ensures that they can be considered in the systems design.	If explicit analysis of impact of external factors on systems is not conducted, the risk is that these may not be identified, documented, and reflected in system requirements and as a result the system may not address them and, when delivered, it may not be operationally suitable or support the user capability needs which motivated its development.	Clear documentation and traceability of system requirements to factors associated with the system context, validated by the right stakeholders representing external systems or factors.	Using the description of how the users will conduct the operation and mission threads as well as some representation of the end-to-end SoS architecture(s), assess the key elements of the context in terms of how these will impact the system and as such need to be addressed as considerations in the system design, and review the system requirements top ensure these have been addressed.
Technical	How are SoS-derived technical requirements used in technical planning?	If you have a clear approach to addressing these external considerations in the system technical plans, they can most effectively be addressed as an integral part of the	If these external factors are not considered early in the development process, working in conjunction with the owners of the	Technical plans include explicit arrangements to address these derived requirements with the right plans supported by formal	Review the SE plans to identify ways these plans could be adjusted so they explicitly address the SoS-derived technical

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
		system engineering process.	external systems or areas, the risk is that the system requirements will not capture their impact and the system will fail to meet user needs.	agreements and engagement plans.	requirements, particularly in terms of agreements with external organizations technical plans for implementation of the agreements.
Technical	How are SoS-derived technical requirements used to define interfaces and data sharing agreements?	If the derived technical requirements are directly tied to interface definitions these will be addressed as a part of the system development process.	Key elements of any system requirements are the requirements associated with how that system fits into an end-to-end capability (e.g. mission thread). If this is not considered in developing requirements for the system, the risk is that it may not meet user needs or may incur unexpected time and budget to make changes to meet these needs.	Clear interface definitions and implementation plans agreed to by all players involved and supported by formal agreements, charter, or data sharing agreements and engagement plans.	Review requirements to ensure that they adequately address the key system interfaces and interdependencies.
Technical Management	For considerations which involve interactions with other	If aspects of a system which are directly related to other systems are addressed early	A key area of engagement with external systems is	Clear interface definitions, data sharing agreements	Engage with the managers or systems engineers of the

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	systems (e.g. interfaces, new or changed functionality in other systems), how are the specifications negotiated with the others involved?	with the related parties, the design is more likely to be robust and meet user needs.	definition of interfaces with those systems as well as any functionality changes or enhancements which are key to the new system meeting the end-to-end user capability needs; if these are not identified early and completely and addressed when system requirements are specified, the risk is that the system will fail to meet user capability needs.	and implementation plans agreed to by all players involved and supported by formal agreements, engagement plans, and configuration management plans.	relevant systems, to ensure that the technical specifications and plans for the system in question align with those of the other relevant systems.
Management	If the system will support an acknowledged or directed SoS, what organization (if any) is responsible for the SoS(s) which this acquisition program supports? What management arrangement has been established between	Identifying and working with an established SoS-level organization right from the start can provide the system development team ready access to key information and existing arrangements to ensure the system development is aligned with the larger SoS.	If the role of the proposed system solution in the context of a recognized (‘acknowledged’ or ’directed’) SoS is not understood as the program develops, the risk is that the system solution will not be compatible with the current and	Management arrangements with the SoS in a formal agreement, charter, or data sharing agreements and cooperative action plan to support the development of system requirements, implementation, test, etc.	Arrange to work with the organizations responsible for the SoS(s). Engage with the SoS manager(s) or systems engineer(s), to ensure that plans for the system and SoS are aligned. Revisit as needed to assure continued alignment.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	the program and the SoS? Have these been formalized in some for of written agreement? Have these arrangements been implemented? *[Initial Review and Alternatives Review]*		future direction of the SoS, and will not be operationally suitable or will incur added costs and time for necessary rework.		Identify software and hardware lifecycles of other systems within the SoS.
Management	If there is no acknowledged SoS management, then what management arrangements have been made with other systems which impact this system (including when a systems participates in multiple SoS)? Have these arrangements been implemented? *[Alternatives Review]*	Establishing arrangements with other systems early in development can provide a key foundation of collaborative efforts throughout the system development.	If the role of the proposed system solution in the context of a SoS is not understood as the program develops, regardless of whether the SoS is formally acknowledged and managed as such, the risk is that the system solution will not be compatible with the current and future direction of the SoS, and will not be operationally suitable or will incur added costs and	Management arrangements with the relevant systems either in the form of a forma agreement, charter, or data sharing agreements and cooperative action plan to support the development of system requirements, implementation, test, etc.	Engage with the managers or systems engineers of the relevant systems, to ensure that plans for the system in question align with those of the other relevant systems.

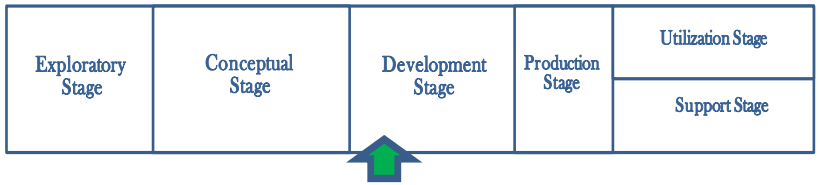
Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
			time for necessary rework.		
Cost	Have the SoS-related systems costs, including integration, been identified and included in cost estimates? This includes costs of added requirements not identified when system costing was initially estimated (e.g. costs to ingrate a new system onto a platform).	If full costs of a new system are planned for upfront, adequate resources are more likely to be available to meet development needs.	If costs of SoS-related requirements are not included in cost estimates (and budgets), the risk is that these requirements will not be addressed and the actual costs for the system will be higher than expected.	Costs related to external systems are clearly reflected in cost drivers, cost and budget estimates.	Engage with the managers or systems engineers of the relevant systems, to ensure that plans for the system in question align with those of the other relevant systems.
Cost	Have costs associated with external systems, including integration, been identified and included in cost estimates for these external systems? Does this include costs to upgrade, planning costs, and costs of integration and test?	If changes are needed on other systems, planning for these resources will ensure that these changes will be implemented.	If costs associated with external systems (including the time for these systems to work on planning) are not included in cost estimate (and budgets), the risk is that these requirements will not be addressed or the actual costs for the system will be	Costs related to external systems are clearly reflected in cost drivers, cost and budget estimates.	Engage with the managers or systems engineers of the relevant systems, to ensure that plans for the system in question align with those of the other relevant systems, and that funding has been planned,

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
			higher than expected.		
Cost Management	Have mechanisms been implemented to monitor progress in the areas of cross-system dependencies for prompt identification of changes or delays which could mean added costs? Have plans been formulated to accommodate additional costs, if necessary?	If a good monitoring process is put into place, when inevitable changes occur they can be quickly identified and addressed.	If there is no plan in place for monitoring progress related to external systems including the impact of delays and changes on costs, this area is likely to be neglected and the risk is that there will be unexpected technical or testing issues adding to cost and schedule.	Implementation/oversight plans explicitly track execution of external engagement activities, with clear milestones (interface specification, development, test, protocols/standards, etc.), to identify risks/issues promptly.	Engage with the managers or systems engineers of the relevant systems, to ensure that plans for the system in question align with those of the other relevant systems, particularly for regular reviews of progress in areas of shared interest and implications of changes.
Schedule	Have the SoS-related systems' schedules been identified and included in planning estimates? This includes the sequence of events and associated dependencies.	If the full schedule for a new system is planned upfront, including all the associated activities potentially affecting it, adequate time is more likely to be available to meet development needs.	If schedules of SoS-related modifications are not accommodated in system plans, the risk is that the schedule requirements will not be addressed or the actual costs for the system will be higher than expected.	Schedules related to external systems are clearly reflected in system schedules and budget estimates.	Engage with the managers or systems engineers of the relevant systems, to ensure that plans for the system in question align with those of the other relevant systems, particularly the schedules of elements of shared interest.

SoS Supporting Technical Base

- Analysis has been conducted to understand end-to-end capability objectives, performance metrics and current performance data, systems supporting those objectives, technical baseline, gaps, etc. to provide needed context. *[Initial and Alternatives Review]*
- An understanding of how systems currently support the capability (including functionality, performance, interfaces, data exchanges etc.) as well as the current concept of operations – how the systems are employed by users in an operational setting to deliver the capability objectives. This could be described in the form of an architecture or a model. *[Initial and Alternatives Review]*

Table 4: Design Review



Review Point: Design Review(s)

State of Program at this Review Point

Designs (preliminary or detailed) have been completed. There would be a natural unfolding of design detail before and through this review point, from system requirements, through functional allocation, levels of specifications, preliminary design, and final design. Purpose of this review is to technically validate the design so the program can proceed to development.

Information Available at this Review Point

- An established system allocated baseline
- Allocated design captured in subsystem product specifications for each configuration item (hardware and software) in the system and an initial product baseline
- Subsystem specifications for hardware and software, along with associated internal and external interface control documents, along with detailed design of subsystems.
- Configuration items consisting of hardware and software elements, and include items such as structures, avionics/electronics, weapons, crew systems, engines, trainers/training, etc.
- A risk assessment (including schedule, cost, and technical performance, supportability, safety, environment, reputation, compliance and security).
- For parts and systems that may be difficult to procure or require substantial lead-time, long-lead planning should be done and the risk of that analyzed. This is particularly critical where this system may have challenging materials requirements (e.g., titanium) or interfaces with (or even requires) legacy components that may not be indefinitely supportable.
    - This risk analysis and assessment should therefore include an update on the industrial base and analysis of diminishing manufacturing sources, so contingency and workarounds can be implemented as needed.
- An updated document containing cost analysis requirements descriptions, based on the system allocated baseline

- An updated program schedule including system and software critical path drivers and status, tracked continuously and linked to program risk if necessary
- Plans for non-material supporting activities (e.g. doctrine, personnel, training)
- A plan for life-cycle support/sustainment including sustainment development efforts and schedules
- Plans for security, program protection, anti-tamper, safety, and analysis of failure modes and effects criticality should be done. The context of this analysis can begin to set the development methodologies and process maturity needed at this stage. By this point you should have understood the security and supply chain threats and factored these into your design and development process.
- Initial contract structure and contract content should be available at this stage, for systems requiring contracted development and implementation. Following from this, management plans and business rhythm should be set and reviewed to ensure that all aspects of contract and subcontractor management are achieved.
- Updated information on certification and accreditation should be available at this stage, including test and certification events that may be required, particularly if those events require external participation and coordination. This is particularly important for complex distributed systems entailing systems and subsystems (and user communities) from different areas and technical focuses. The concept and execution of a given cross-system certification may need to be carefully set, scheduled, budgeted, articulated, contracted, and verified. Where there is risk in achieving this (perhaps due to, for example, differences in expectations or definitions), program-level risk should be defined and managed.
- At this stage, the grounds of user acceptance should begin to be defined, whether that operates in a more informal checklist fashion or a formally contracted and certified fashion. Requirements for managing this process should be obtained and scheduled at this time.
    - This may entail an independent quality assurance process (in hardware, manufacturing, software, and other areas) and associated metrics. This process should be understood at this time and its initiation and interfaces properly managed.

System Issues at this Review Point

Questions

- Does the status of the technical effort and design indicate that if effectively implemented, it would achieve operational test and evaluation success (operationally effective and suitable) [e.g., does the design address the requirements]?
- Can the design, as disclosed, satisfy the technical requirements?
- Is the strategy to validate the design sound?
- Has the system allocated baseline been established and documented to enable hardware fabrication and software coding to proceed with proper configuration management?
- Are adequate processes and metrics in place for the program to succeed?
- Have sustainment and human integration design factors been reviewed and included, where needed, in the overall system design?

- Have support issues been considered? (Is the system being designed so as to reduce ownership cost over the life-cycle? To reduce total LCC? To reduce the logistic footprint?)
- Is there a strategy for support? (Which organization will do what? Which levels of service are required or proposed?)
- Have security consideration been addressed?
- Are the risks known and manageable for integration testing and Developmental, Engineering/Qualification, and Operational Test & Evaluation (DT&E, ET&E, and OT&E)?
- Is the program schedule executable (technical & cost risks)?
- Are all critical safety items identified?
- Has the program‘s cost estimate been updated?
- Is the program executable within the existing budget and with the approved system allocated baseline?
- Is the system level design producible within the production budget?
- Is the updated cost estimate consistent with the approved allocated baseline?
- Have the manufacturing processes been defined and characterized?
- Are manufacturing approaches documented?
- Has a production cost model been constructed?
- Can the industrial base support production of development articles?
- Have long-lead and key supply chain elements been identified?
- Is the software functionality in the approved product baseline consistent with the updated software metrics and resource-loaded schedule? Has the program established a robust integration and test process to ensure program success, especially when multiple software applications are operating with common data sets?
- Have key product characteristics having the most impact on system performance, assembly, cost, reliability, sustainment, and safety been identified?
- Have the critical manufacturing processes that affect the key characteristics been identified and their capability to meet design tolerances determined?
- Have process control plans been developed for critical manufacturing processes?
- Have manufacturing processes been demonstrated in a production representative environment?
- Are detailed trade studies and system producibility assessments underway?

- Are materials and tooling available to meet pilot line schedule?
- Are long lead procurement plans in place and has the supply chain been assessed?
- Can the risks associated with Environment, Safety, and Occupational Health (ESOH) hazards be mitigated to an acceptable risk level within the existing budget?
- Is there a test plan, including plans for test resources in place?

SoS Issues Impacting the System

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
Capabilities	Is the SoS context clearly defined in the updated description of how the users will conduct the operation, how they expect to use the new system in this context, and in the user statement of need? Has this changed since the last review? *[Requirements Reviews]*	A clear, early understanding of the systems context and its potential impact on system requirements and dependencies will provide a solid basis for development of a system which will meet user needs.	Without an understanding of how the users will conduct the operation and how they expect to use the new system within the SoS context, the risk is that requirements and dependencies may be missed, leading to an ineffective system or unexpected higher costs.	Written description of how the users will conduct the operation with clear delineation of how the new system will work within the context of other systems and the operational context.	Develop and validate description of how the system users will conduct the operation with SoS users.
Technical	How are constraints on the system imposed by the SoS context addressed in the design? This includes:	Constraints are key to effective solutions. Understanding these early can contribute to a sound system design.	If the SoS constraints and resulting requirements are not adequately addressed in the system, the risk is that the resulting	Results of early engineering analysis highlighting the constraints placed on the solutions and that these constraints were	Clear documentation of the system requirements driven by the SoS context and traceability to the system design.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	▪ Physical requirements (e.g. size, weight, cooling, power limits) ▪ Electronic requirements (e.g. signature, interference, etc.) ▪ Information exchange/ management (e.g. security, network, bandwidth, information needs, security, etc.)		system will not operate in the user environment or will incur unexpected addition time or budget for rework.	addressed in analysis of solution options and are considered in the selected solution. It is equally important that the constraints placed on the solutions are adequately addressed in the design of the system.	Modeling/simulation as a way to understand how the SoS might perform, and hence to explore the effect of possible choices as part of system development.
Technical	How are SoS-derived technical requirements and resulting interfaces addressed in the system design?	If you have a clear approach to addressing these external considerations in the system technical plans they can most effectively be addressed as an integral part of the system engineering process.	A key component of any system is the ability to work in the end-to-end capability (e.g. Mission thread). If this is not considered in developing the system design, the risk is that it may not meet user needs or may incur unexpected time and budget to make changes to meet these needs.	Clear interface design and implementation plans agreed to by all players involved supported by formal agreements and engagement plans.	Conduct an analysis of the end-to-end systems of systems flow in supporting the user capability to provide the basis for identifying how the system fits into the larger SoS, the impacts on the system and other external systems to effectively support the capability. Include the interfacing systems in the interface design review.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
Technical/ Management	For considerations which involve interactions with other systems (e.g. interfaces, new or changed functionality in other systems), how are the design features negotiated with the others involved? Are there internal interfaces which may need to be exposed in the future to support evolving SoS needs?	If aspects of a system which are directly related to other systems are addressed early with the related parties, the design is more likely to be robust and meet user needs.	A key area of engagement with external systems is design of interfaces with those systems as well as any design for functionality changes or enhancements which are key to the new systems meeting the end-to-end user capability needs. If these design elements are not reviewed and supported by all the systems involved, the risk is that the system will fail to meet user capability needs.	Clear interface and functional designs agreed to by all players involved, supported by MOA/MOUs and engagement plans. Standards-based Interfaces.	Include explicit plans for coordinated review of designs as well as development and test of interfaces and cross system functionality in the system development plan.
Technical	When technical tradeoffs need to be made for this system, how are the impacts on the SoS/mission thread or system coherence with the broader system (enterprise) considered?	By ensuring impacts on mission and SoS are considered in trades, you reduce the risk that you unintentionally lose mission effectiveness in the design tradeoff process.	As development and detailed design proceeds, inevitably issues will arise and changes in design may need to be made. if these changes impact the way the systems will work with other systems and the impact of the change on these other systems is not considered, the risk is	Clear plans with the dependent and related systems to review design and development work at key points to identify any changes and resolve any issues.	Developing an ongoing working relationship with dependent and related systems with planned regular interaction throughout development.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
			that the resulting system may not work as intended and may not meet user needs without added unanticipated budget and schedule.		
Management	If the system will support a recognized SoS, what organization (if any) is responsible for the SoS which this acquisition program supports? What management arrangement has been established between the program and the SoS? Have these been formalized (e.g. MOUs, MOAs)? Have these arrangements been implemented? Does the planned development/upgrade timing match SoS	Identifying and working with an established SoS level organization right from the start can provide the system development team with ready access to key information and existing arrangements to ensure the system development is aligned with the larger SoS.	If you don't understand the role of the proposed system solution in the context of one or more recognized ('acknowledged') systems of systems and arrange to work with the SoS as the program develops, the risk is that the system solution will not be compatible with the current and future direction of the SoS, and will not be operationally suitable or will incur added costs and time for necessary rework.	Management arrangements with the SoS either in the form of an MOA or MOU and cooperative action plan to support the development of system requirements, implementation, test, etc.	Engage with the SoS manager(s) or systems engineer(s), to ensure that plans for the system align with those of the SoS.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	needs? Do the arrangements address system and SoS configuration management? *[Requirements Review]*				
Management	If there is no acknowledged SoS management, then what management arrangements have been made with other systems which impact this system? Have these arrangements been implemented? *[Alternatives Review and Requirements Review]*	Establishing arrangements with other systems early in development can provide a key foundation of collaborative efforts throughout the system development.	If you do not arrange to work with other relevant systems managers as members of a system of systems community, the risk is that the system solution will not be compatible with the current and future direction of the SoS, and will not be operationally suitable or will incur added costs and time for necessary rework.	Management arrangements with the relevant systems in the form of formal agreement, and a cooperative action plan to support the development of system requirements, implementation, test, etc.	Engage with the managers or systems engineers of the relevant systems, to ensure that plans for the system in question align with those of the other constituent systems.
Cost	Have the SoS-related systems costs been identified and included in cost estimates? This includes costs of requirements identified and added	If full costs of a new system are planned for at the earliest possible point in the program, and as soon as they are identified, adequate resources are more	If costs of SoS-related requirements are not included in cost estimates (and budgets), the risk is that these requirements will not be addressed or the actual costs for the	Costs related to external systems are clearly reflected in cost drivers, cost and budget estimates.	By ensuring requirements associated with external systems are clearly reflected in systems requirements, these will naturally be reflected in cost estimates.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	since system costing was initially estimated (e.g. costs to ingrate a new system onto a platform). *[Requirements Review]*	likely to be available to meet development needs.	system will be higher than expected due to rework requirements.		
Cost	Have costs associated with external systems been identified and included in cost estimates for these external systems? Does this include costs to upgrade, planning costs, and costs of integration and test? *[Requirements Review]*	If changes are needed on other systems, planning for these resources will ensure that these changes will be implemented.	If associated with external systems (including the time for these systems to work on planning) are not included in cost estimates (and budgets), the risk is that these requirements will not be addressed or the actual costs for the system will be higher than expected.	Costs related to external systems are clearly reflected in cost drivers, cost and budget estimates.	By ensuring requirements associated with external systems are clearly reflected in systems requirements, these will naturally be reflected in cost estimates, and also potentially cost-shared amongst the SoS (leading to a more affordable design).
Cost/ Management	Have mechanisms been implemented to monitor progress in the areas of cross-system dependencies for early identification of changes or delays which could mean added costs? Have	If a good monitoring process is put into place, when inevitable changes occur they can be quickly identified and addressed.	If there is no plan in place for monitoring progress related to external systems including costs, the risk is that this area is likely to be neglected, and unexpected technical issues will not be acted	Implementation/oversight plans explicitly track execution of external engagement activities, with clear milestones (interface specification, development, test, etc.), to identify risks/issues	Ensure that there are clear, agreed plans and arrangements with external systems, and they are tracked like other aspects of the program.

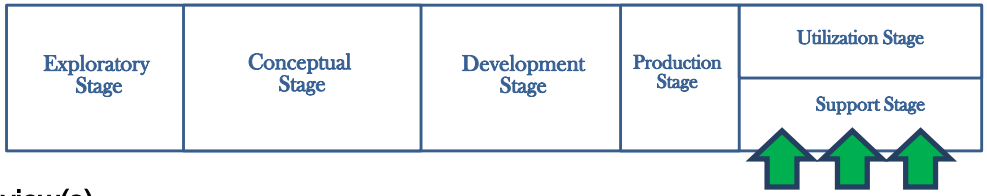
Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	plans been formulated to accommodate additional costs, if necessary? *[Requirements Review]*		upon promptly, thereby compounding the negative cost and schedule impact.	early.	
Schedule	Have the SoS-related systems' schedules been identified and included in planning estimates? Are the SoS drivers / dependencies and critical path for SoS outcomes included? *[Requirements Review]*	If the full schedule for a new system is planned upfront, including the inter-relationships with all external SoS-related systems' schedules, then adequate time is more likely to be available to meet development needs.	If schedules of SoS related modifications are not accommodated in system plans, the risk is that the actual schedule requirements will not be recognized and addressed and that the actual costs for the system will be higher than expected.	Schedules related to external systems are clearly reflected in system schedules and budget estimates.	By ensuring requirements associated with external systems are clearly reflected in systems requirements, these will naturally be reflected in system plans.
Schedule/ Management	Have mechanisms been implemented to monitor progress in the areas of cross-system schedule dependencies for early identification of changes or delays which could mean added costs? Is it clear who is responsible for doing	If a good monitoring process is put into place, when inevitable changes occur they can be quickly identified and addressed.	If there is no plan in place for monitoring progress related to external systems' schedules, the risk is that this area is likely to be neglected and that there will be unexpected technical or testing issues adding to cost and schedule.	Implementation/oversight plans explicitly track execution of external engagement activities, with clear milestones (interface specification, development, test, etc.), to identify risks/issues early.	Ensure that there are clear, agreed plans and arrangements with external systems, and they are tracked like other aspects of the program.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	the monitoring? Have plans been formulated to accommodate additional costs, if necessary?				

SoS Supporting Technical Base

- Analysis has been conducted to understand end-to-end SoS capability objectives, performance metrics and current performance data, systems supporting those objectives, technical baseline, gaps, etc. Models and simulations should verify assumptions about end-to-end performance, and architecture and preliminary design modeling should verify that interfaces are fully explained and covered in suitable artifacts.
- Architecture has been developed which provides the framework for understanding how constituent systems support the capability (including functionality, performance, interfaces, data exchanges etc.). The architecture should trace forward to all requirements and specification artifacts, and backwards from those artifacts to architecture. In this way, we can verify that architecture is truly driving design. To the extent that this traceability is not possible, it may highlight areas where the architecture is incomplete (and should therefore be updated), or a divergence in interpretation occurred (meaning it should be explained and re-traced).
- Interdependencies among systems and non-material aspects supporting capability should be fully evaluated and assessed. The architecture artifacts documenting this should be part of preliminary and formal reviews, and programmatic aspects of these dependencies should be recorded and explicitly worked. Such management should include the use of metrics and processes to evaluate the consistency, completeness and health of the interfaces, whether technical or management in nature.

Table 5: In-Service Review(s)



Review Point In-Service Review(s)

State of Program at this Review Point

System has been fielded and is in operation and support. This review is conducted to provide feedback on how well the system is delivering the capability to the operational user with acceptable operational performance and how well the system is positioned to meet future operational scenarios. In addition, the feedback substantiates in-service support resource priorities. The in-service review (ISR) is typically conducted shortly after initial operational deployment and periodically until the system is retired. As a product of the review, in-service safety and readiness issues are grouped by priority to form an integrated picture of in-service health, operational system risk, system readiness, and future in-service support requirements which are used for planning future operations and support plans and resources.

Information Available at this Review Point

- Results of operational testing prior to transition to operations
- Feedback from users on performance of the system including lessons identified from exercises and operations
- Field and maintenance reports including defect and safety incident reports
- In-service operation and support costs
- Latest Defense plans and operational scenarios affecting future system context

System Issues at this Review Point

Questions

- Has the system performance in the field matched expectations based on operational testing?
- Is the system meeting reliability expectations?
- Are the costs of operation and support aligned with estimates?

- What is the state of operational readiness in terms of system problems (hardware, software, and production discrepancies)?
- What is the status of system problem (discrepancy) report inflow, resolution rate, trends, and updated metrics?
- Is the system safety as originally expected and are the hazards being mitigated to tolerable levels?
- What are the plans for system modifications, upgrades, product improvement, technology refresh, or technology insertion?
- Are these change plans aligned with those of other related systems and with the current and future system context?
- What are the assessments of current system operational risk and system readiness for the future operational scenarios?

SoS Issues Impacting the System

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
Capability	Has the current or future operational context for use of the system changed (including threat, environment, usage, etc.)? If so, do the changes impact the way the system needs to work with other systems supporting the user capability? *[Initial, Requirements Alternatives, and Design Reviews]*	A clear, early understanding of any changes in the system context and its potential impact on system requirements and dependencies will provide a solid basis for planning for upgrades or changes in a system to meet current and future user needs.	Without an understanding of changes (current and planned) in how the users conduct operations and support and how they use the system, there is a risk that required changes to the system may be missed, leading to a reduction in its effective capability.	Written description of how the users currently conduct the operations and support (sometimes documented in Concepts of Operation, Use and Support) with clear delineation of how system is expected to work in context of other systems in the current and planned operational context.	Validate and update descriptions of how the users currently conduct the operation with users. Concepts of Operation, Use and Support if available should be updated accordingly.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
Capability	Are the non-materiel aspects that contribute to capability (i.e. other lines of development such as Doctrine, Training, Logistics, etc.) mature and aligned so that the capability is being fully exploited as planned?	Understanding of whether any of the other (non-material) aspects of the capability are affecting the ability of the system to meet the user need.	Without an examination of the effectiveness of the non-material aspects (including any planned changes to these such as military doctrine, manning levels and skills, etc.) there is a risk that the system will not deliver the required capability.	Periodic Assessments of the maturity and effectiveness of the non-material aspects of the capability in which any planned changes (e.g. military manning or education levels) are taken into account.	Changes are made to the non-material aspects to improve capability (e.g. improved Training) or changes are made to the physical system to improve the effectiveness of the non-material aspects (e.g. changes made to the User Interface to improve Training effectiveness).
Technical	If there have been changes in the operational context of the system, how do these changes affect the system? This includes: ▪ Physical requirements (e.g. size, weight, cooling, power limits) ▪ Electronic requirements (e.g. signature, interference,	Understanding the effect of changes in the operational context is key to assessing whether these require changes in the system for it to provide continued effective capability for the user.	If the SoS context has changed and the impacts on the systems are not addressed, the risk is that the system will not operate effectively in the user environment to meet user needs.	On-going periodic assessments and documentation of the system impact of changes in the SoS operational context.	Clear documentation of changes in the operational context and the impact on the system, together with identification of candidate changes to the system or SoS required to address these.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	etc.) ▪ Environmental requirements (e.g. safety, environment, CBRN, etc.) ▪ Information exchange/ management (e.g. security, network, bandwidth, information needs, security, etc.)				
Technical Management	If one or more SoS has been recognized since this system was fielded which involve this system, have the SoS SE organizations for these SoS been consulted to ensure the needs of the SoS are consider in the planning for the system? Are there proposed	If one or more SoS depends on this system to address user capabilities, factoring the needs of these SoS into plans for the system will ensure an integrated approach to meeting user needs for all SoS capabilities.	If the needs of these SoS are not considered in in-service review planning, there is the risk that future upgrades to the system will not support these newly recognized SoS user capabilities.	On-going periodic in-service review assessments and documentation of the role of the system in fulfilling the operational capabilities of all related SoS, including newly recognized SoS.	Include engagement with the SoS SE teams to understand role of the system in the SoS and any shortfalls which need to be addressed to support SoS user capability objectives.

Area	Questions	Benefits	Risks	Evidence/Metrics	Potential Actions/Mitigations
	upgrades to other systems in the SoS which should be factored into upgrades to this system?				
Management	For user requirements which involve other systems (e.g. interfaces, new or changed functionality in other systems), have these other systems made changes or are they planning to make changes which impact this system (or vice versa)? Do these impact the ability of the SoS to support the user?	If aspects of a system which are directly related to other systems have changed since the system was fielded, or there are plans in place to make changes, these need to be examined at each in-service review to ensure the system changes are compatible with continued SoS user support.	If changes in the system are made which potentially impact the SoS (or vice versa), there is the risk that the SoS will no longer provide adequate support to the users.	On-going periodic in-service review assessments and documentation of system dependencies within the SoS, and review of the status of other systems which may impact the system and vice versa.	Include consideration of the status of the dependent systems in the in-service review assessments to ensure that plans for changes are aligned and user capability is maintained at both the system and SoS levels.

SoS Supporting Technical Base

- Ongoing SoS testing/analysis is available to identify shortfalls in user capability.
- Architecture has been updated to provide the framework for understanding how constituent systems support the SoS capability (including functionality, performance, interfaces, data exchanges etc.).
- Interdependencies among systems and non-material aspects supporting capability area evaluated and assessed across the SoS.