Update on Test and Evaluation Issues for Systems of Systems

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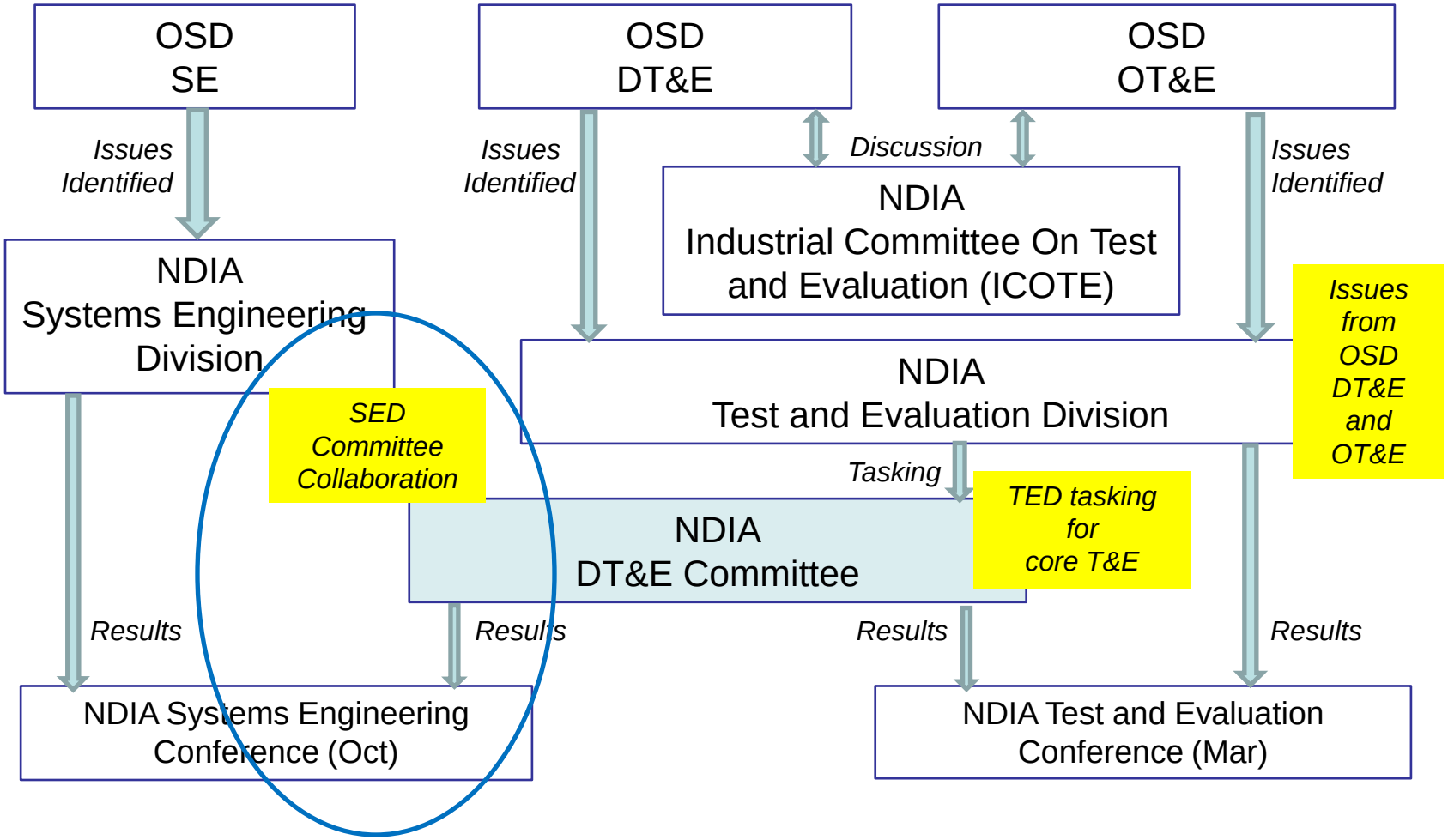
Topics

- NDIA DT&E Committee Overview
- T&E for SoS Issues Identified
- T&E for SoS Strategic Initiatives
- Summary

NDIA DT&E Committee Work with SE and T&E Divisions



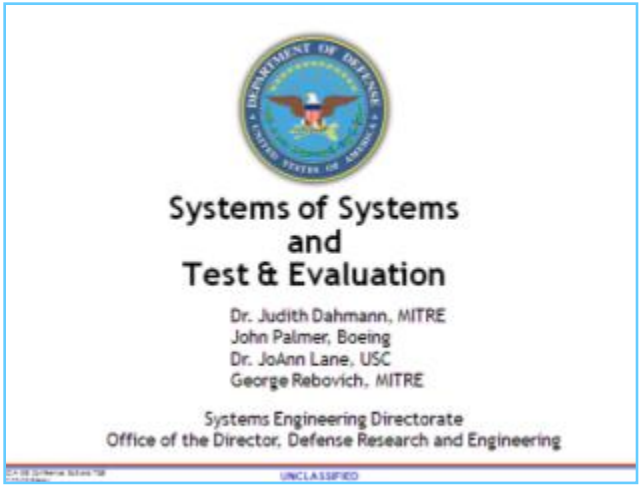
Focus of this Effort: DT&E Collaboration with SoS

2009

Sleepless Nights: Test and Evaluation for SoS

- **SoS Committee Developed "Sleepless Nights" List**
  - Systems of Systems topics discussed by NDIA SoS Committee
  - Compiled list of "**What keeps me awake at night**" topics for SoS
- **T&E for SoS topped the "Sleepless Nights" list**
- **NDIA SoS and DT&E Committees Joint Effort**
  - Identified key T&E challenges for SoS
  - White paper described 5 top issues
  - Presented at 2009 NDIA SE Conference

Backup (2009): White Paper Issues



2009 Effort: Problem Space

White Paper: T&E Challenges for SoS

1) **Future T&E:** If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?
2) **Requirements:** If 'requirements' are not clearly specified up front for a SoS, what is the basis for T&E of an SoS?
3) **Metrics:** What is the relationship between SoS metrics and T&E objectives?
4) **Systems Changes:** Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?
5) **End to End Testing:** How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results? What if systems all implemented to their specification, but the overall SoS expected changes cannot be verified?

White Paper was Starting Point

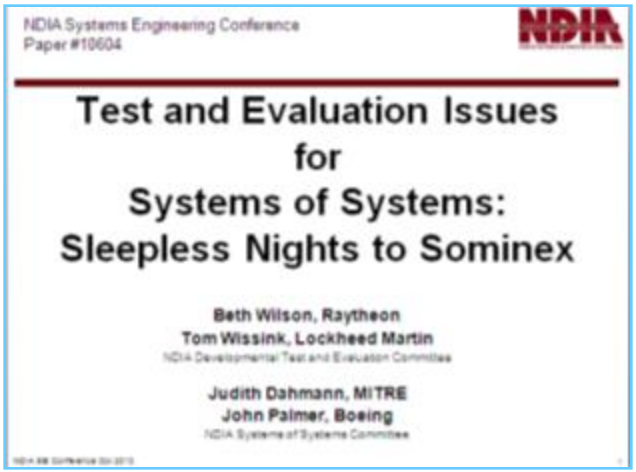
2010

Sominex: Test and Evaluation for SoS

- **Now What?**
  - List of things that keep us awake at night
  - Continued discussion of approaches, but in context of issues identified
  - Question asked early in 2010: **Where's the Sominex?**

Backup (2010): Discussion and Approaches

- **Joint Workshop on August 17, 2010:**
  - Evaluate challenges and underlying issues
  - Transition specific issues into strategic initiatives
  - Presented at 2010 NDIA SE Conference


NDIA Systems Engineering Conference
Paper #10604

Test and Evaluation Issues for Systems of Systems: Sleepless Nights to Sominex

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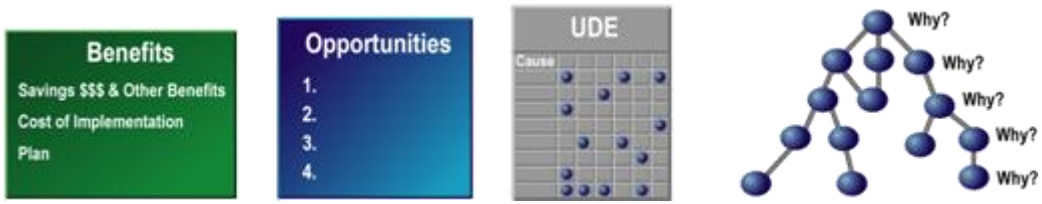
2010 Effort: Transition to Solution Space

Facilitated Workshop Technique
Translate Issues into Initiatives

Data Collection:
SoS White Paper
SE Conference Papers



Potential Problem Areas

1) Future T&E for Systems brought together as SoS
2) Requirements
3) Metrics
4) Systems Changes
5) End to End Testing with systems not yet available

Potential Causes

If we could only fix one thing, it would be _____

Improvement Areas:
Strategic Initiatives
Collaborative Go-Do

		Cable	Tasks	Setup	Testing	Security
Facility	Signal cables wrong length or incorrect	X		X		
	Power/Cooling connections	X		X		
	Safety interconnect	X				
	Test equipment			X		
	Equipment in NFR	X		X		X
Schedule Dependencies	Signal cable delivery	X	X			
	REX/NBDC/SDP availability		X		X	
	REX array availability		X		X	
	Test results prior to string integration				X	
	Detailed tasks for integration/prep	X	X	X	X	
Security	Classified shipment					X
	Classified workstations					X
	Classified field returns					X
Integration Test Conduct	Procedures incomplete or incorrect		X	X	X	
	SDP emulator				X	
	Work-arounds required	X	X	X	X	X

Leverage Matrix
Map Causes to problem areas

Raytheon Six Sigma Tool: Business Diagnostic

Workshop Results

	Initiative Title	Action Plan	Initiative Vision Statement
Strategic Initiatives	Best Practices Model for SoS T&E	Define a best practices model	SoS T&E as a continuous improvement process supporting capabilities and limitations information for end users and feedback to SoS and System SE teams toward evolution of the SoS
	SoS Governance	Define characteristics of successful SoS T&E	Indentify the process by which we can change and influence the governance of SoS. Mature and improve templates to define a minimum set of characteristics that are required to govern SoS T&E efforts
	Radical Approach to SoS T&E	Define SoS capability test approach	Rethink T&E of systems in an operational context and systems interoperability away from system testing toward integrated capability SoS testing
Go-Do	SoS SE Policy and Guidance	Recognize and employ SoS guidance	Ensure that guidance or SoS SE (DoD SoS SE Guide) is recognized and employed on growing number of SoS

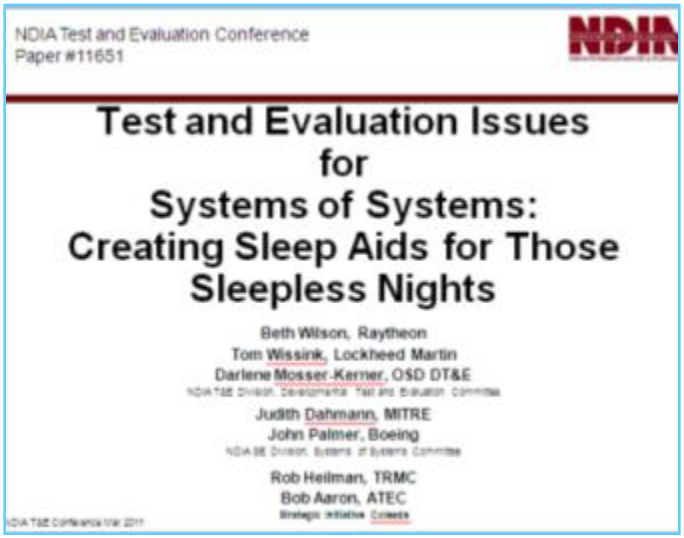
5 Issues (Problem Space)
Translated into 3 Initiatives (Solution Space)

Initiatives Identified with Action Plans

Sleep Aids: Working the Initiatives

- **Start Work on 2 Initiatives**
  - #1: Best Practices Model for SoS T&E
  - #3: Define Characteristics of Successful SoS T&E

- **Plan to Use Results for 3rd Initiative**
  - #2: Define SoS Capability Test Approach
  - Need results from other initiatives as inputs
  - Presented at 2011 NDIA T&E Conference


NDIA Test and Evaluation Conference
Paper #11651

Test and Evaluation Issues for Systems of Systems: Creating Sleep Aids for Those Sleepless Nights

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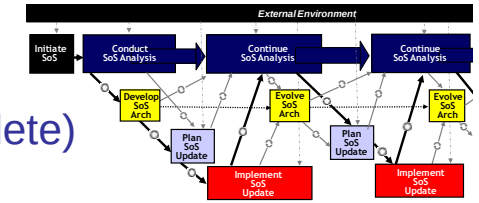
Transition Discussion from Challenges to Solutions

Strategic Initiative: Best Practices Model

Complete
In Process
Planned

1. **Form core team (Complete)**
   - Core team will implement activities
   - Share results for feedback from SoS and DT&E committee
2. **Define scope (Complete)**
   - Focus on Acknowledged SoS *(SoS objectives, management, funding and authority; however systems retain their own management, funding and authority in parallel with the SoS)*
   - Investigating potential for Directed SoS *(SoS objectives, management, funding and authority; systems are subordinated to SoS)*
3. **Develop a draft description of the proposed model**
   - Review the workshop discussions (Complete)
   - Review current SoS SE guidance on T&E (Complete)
   - Framework for model and implementation approaches (Complete)
   - Draft model description and circulate for review (In Process)



4. **Review use cases to support and/or adapt the model**
5. **Update the model based on use cases**
6. **Review and assess state and utility of the model**

Identifying T&E inserts into SoS Wave Model
Soliciting Use Case Recommendations

Strategic Initiative: Governance

Complete
In Process
Planned

1. **Form core team (Complete)**
2. **Define scope (Complete)**
   - Purpose: to provide an integrated governance perspective for SOS development, deployment, and life cycle
   - Scope: Governance for overall acquisition, including T&E as a holistic/comprehensive view *(focus on Directed and Acknowledged SoS)*
3. **Identify Governance As-Is State (Complete)**
   - Fundamental Governance Concepts
   - Architecture Concepts & DODAF for managing complexity
4. **Develop Governance To-Be Fundamental Concepts (In Process)**
   - Organizations that produce reference models, reference architectures, and data engineering components including T&E considerations for measuring performance
   - Synchronized and aligned organizations (structures), policy, tools, technical approaches, and resources that support the selected option.
5. **Draft Recommendations to Achieve To-Be State**

Reference Architecture As Framework to Discuss Governance

Starting Point: Acknowledged SoS

- Focus on 'Acknowledged' SoS
- Investigating potential for addressing 'Directed' SoS

- **Directed**
  - SoS objectives, management, funding and authority; systems are subordinated to SoS
- **Acknowledged**
  - SoS objectives, management, funding and authority; however systems retain their own management, funding and authority in parallel with the SoS
- **Collaborative**
  - No objectives, management, authority, responsibility, or funding at the SoS level; Systems voluntarily work together to address shared or common interest
- **Virtual**
  - Like collaborative, but systems don't know about each other

Comparison of Systems and Acknowledged SoS

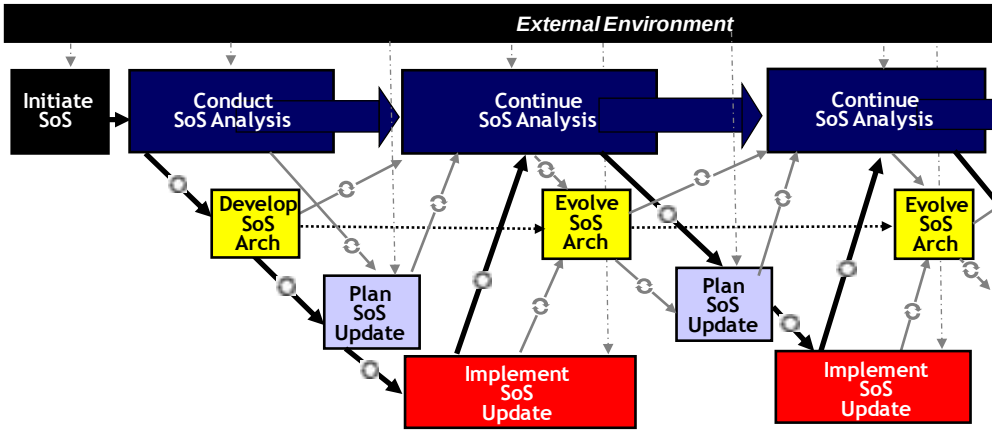
Aspect [1]	System [1]	Acknowledged System of Systems [1]	SoS T&E Implications
Management & Oversight			
Stakeholder Involvement	Clearer set of stakeholders and aligned objectives	Stakeholders at both system level and SoS levels (including the system owners), with competing interests and priorities; in some cases, the system stakeholder has no vested interest in the SoS; all stakeholders may not be recognized.	Validation criteria more difficult to establish
Governance	Aligned PM and funding	Added levels of complexity due to management and funding for both the SoS and individual systems; SoS does not have authority over all the systems.	Can not explicitly impose SoS conditions on system T&E
Operational Environment			
Operational Focus	Designed and developed to meet operational objectives	Called upon to meet a set of operational objectives using systems whose objectives may or may not align with the SoS objectives.	System level operational objectives may not have clear analog in SoS conditions that need T&E
Implementation			
Acquisition	Aligned to ACAT Milestones, documented requirements, SE	Added complexity due to multiple system lifecycles across acquisition programs, involving legacy systems, systems under development, new developments, and technology insertion; Typically have stated capability objectives upfront which may need to be translated into formal requirements.	Depends on testing of constituent systems to SoS requirements as well as SoS level testing
Test & Evaluation	Test and evaluation of the system is generally possible	Testing is more challenging due to the difficulty of synchronizing across multiple systems' life cycles; given the complexity of all the moving parts and potential for unintended consequences	Difficult to bring multiple systems together for T&E in synchrony with capability evolution.
Engineering & Design Considerations			
Boundaries and Interfaces	Focuses on boundaries and interfaces for the single system	Focus on identifying the systems that contribute to the SoS objectives and enabling the flow of data, control and functionality across the SoS while balancing needs of the systems.	Additional test points needed to confirm behavior
Performance & Behavior	Performance of the system to meet specified objectives	Performance across the SoS that satisfies SoS user capability needs while balancing needs of the systems	Increased subjectivity in assessing behavior, given challenges of system alignment.

From "Systems of Systems T&E Challenges" IEEE SoSE 2010

SoS Wave Model Framework for Description

SoS Wave Model

- Describe key activities at each stage as they relate to T&E of the SoS
  - Conduct (and Continue) SoS analysis
  - Develop and evolve SoS architecture
  - Plan SoS Updates
  - Implement SoS Updated



- What actions are taken at each step to support the model of SoS T&E as

  "Continuous improvement process supporting capabilities and limitations information for end users and feedback to the SoS and system SE teams toward evolution of the SoS"

- Why are these important?
- What value to they add?
- How do they contribute to the larger SoS SE and T&E outcomes?
- How do they address the challenges?
- What methods or tools apply?

Strategic Initiatives: Capability Testing

Complete
In Process
Planned

1. **Assess inputs from Strategic Initiatives**
   - Best Practices Model
   - Characteristics of Successful T&E for SoS
2. **Form core team**
3. **Define scope**
4. **Define SoS T&E As-Is State**
   - Build up of systems testing in operational context
   - Build up of systems interoperability
5. **Define SoS Capability T&E To-Be State**
   - Define gaps in implementation as integrated capability SoS
   - Identify barriers responsible for these gaps
6. **Draft Recommendations to Achieve Capability SoS T&E**

Rethink T&E of SoS in Operational Context

Summary

- **Successful Effort with SoS and T&E Practitioners**

- **Top 5 T&E Issues for SoS:**
  1. Future T&E for SoS programs not currently program of record
  2. Requirements that become the basis of T&E for SoS
  3. SoS Metrics that relate to T&E objectives
  4. System changes that impact SoS performance and T&E objectives
  5. End to End Testing of SoS elements

- **Initiatives to Develop T&E Solutions for SoS**:
  1. Define a best practices model
  2. Define SoS capability test
  3. Define characteristics of successful SoS T&E
  – Recognize and employ existing guidance for SoS (DoD SoS SE Guide)

Successful Collaboration Between DT&E and SoS Committees

BACKUP

Details on SoS T&E White Paper Issues 2009

SoS T&E Issues Raised in the White Paper

1) If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?
2) If ‘requirements’ are not clearly specified up front for a SoS, what is the basis for T&E of an SoS?
3) What is the relationship between SoS metrics and T&E objectives?
4) Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?
5) How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results?

   What if systems all implemented to their specification, but the overall SoS expected changes cannot be verified?

SoS T&E Issue (1)

- Relationship between SoS and acquisition
  - Many SoS are not acquisition programs, but rather are ‘umbrella’ programs which incorporate multiple systems at different stages of development each with their own T&E requirements
  - The constituent systems are operationally and managerially independent from the SoS and are on asynchronous development schedules
  - Scope and complexity of SoS

If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?

Issue Discussion (1)

If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?

- The underlying driver for T&E regulations is the objective of assuring the user that the capability they need is provided by the systems.
  - This driver exists whether or not a systems (or SoS) is a program of record
  - Furthermore, all changes made to the constituent systems should be verified to confirm they have been implemented correctly, and end to end T&E supports the need to show that SoS changes have not inadvertently diminished other necessary capability
  - T&E provides a mechanism to understand the impact of changes on desired results, so an informed fielding decision can be made
- The following recommendations on SOS T&E approaches are made based on this assumed importance of T&E

SoS T&E Issue (2)

- Translating capability objectives into high level SoS requirements
  - In this element, the capability context for the SoS is established, which grounds assessment of the current SoS performance.
  - In many cases, SoS don't have 'requirements' per se, but capability objectives or goals that provide the starting point for specific requirements for increments of SoS evolution

If 'requirements' are not clearly specified up front for a SoS, what is the basis for T&E of an SoS?

Issue Discussion (2)

If 'requirements' are not clearly specified up front for a SoS, what is the basis for T&E of an SoS?

- SoS typically have broad capability objectives versus specific performance requirements as defined for other systems; these provide a foundation for
  - identifying systems supporting an SoS
  - development of an SoS architecture
  - recommended changes or additions to the systems in the SoS to address the capabilities
- This suggests that it is necessary to generate metrics defining the end-to-end SoS capabilities that provide an ongoing 'benchmark' for SoS development.
- In some SoS circumstances, the capability objectives can be effectively modeled in simulation environments which can be used to identify appropriate changes at the system levels.
  - The fidelity of the simulation provides for validation of the system changes needed to enable SoS-level capability.
  - In those cases in which the system changes are driven by SoS-level simulation, the fidelity of the simulation can provide for the SoS evaluation.
- In cases where simulation is not practical, other analytical approaches must be used for T&E.
  - Test conditions that validate the analysis must be carefully chosen to balance test preparation and logistics constraints against the need to demonstrate the objective capability under realistic operational conditions

SoS T&E Issue (3)

- Assessing Extent to Which SoS Performance Meets Capability Objectives over Time
  - This element provides the capability measures for the SoS which, as described in the guide, may be collected from a variety of settings as input on performance under particular condition and new issues facing the SoS from an operational perspective.
  - Hence, assessing SoS performance is an ongoing activity, which goes beyond assessment of specific changes in elements of the SoS (e.g. changes in constituent systems to meet SoS needs, and system changes driven by factors unrelated to the SoS).

What is the relationship between SoS metrics and T&E objectives?

Issue Discussion (3)

What is the relationship between SoS metrics and T&E objectives?

- Typically T&E objectives, particularly key performance parameters, are used as the basis for making a fielding decision
- SoS metrics on the other hand (as discussed above) provide an ongoing 'benchmark' for SoS development which when assessed over time show an improvement in meeting user capability objectives
- Because SoS are typically comprised of a mix of fielded systems new developments
  - There may not be a discrete 'SoS' fielding decision
  - Instead the various systems are deployed as they are made ready, at some point reaching the threshold that enables the new SoS capability

SoS T&E Issue (4)

- Addressing requirements and solution options
  - Increments of SoS improvement are planned by the SoS and systems managers and systems engineers
  - For each increment there may be specific expectations for changes in systems and an anticipated overall effect on the SoS performance
  - While it may be possible to define specifications for the system changes, it is more difficult to do this for the SoS, which is in effect the cumulative effect of the changes in the systems

Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

Issue Discussion (4)

Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

- SoS increments are based on changes in constituent systems which cumulate in improvements in the SoS overall
  - In most cases, changes in systems can be specified and tested.
- However, in SoS which are implemented in a variety of environments and are dependent on networks for end to end performance,
  - Impact of the system changes on SoS end-to-end capabilities can be estimated with less certainty.
- This uncertainty must be considered when assessing the SoS against its performance objectives

SoS T&E Issues (5)

- Orchestrating Upgrades to SoS
  - Systems may make changes as part of their development increment that will be ready to field once they have been successfully tested and evaluated.
  - However, given the asynchronous nature of system development paths, other systems in the SoS increment may not be ready to test with the early delivering systems, thwarting the concept of end to end test.

What if systems all implemented to their specification, but the overall SoS expected changes cannot be verified?

How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results?

Issue Discussion (5)

What if systems all implemented to their specification, but the overall SoS expected changes cannot be verified?

How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results?

- SoS increments are based on changes in constituent systems which cumulate in improvements in the SoS overall
  - In most cases, changes in systems can be specified and tested
- However, in SoS which are implemented in a variety of different environments and are dependent on networks for end to end performance
  - Impact of the system changes on SoS end-to-end capabilities can be estimated with less certainty
- This uncertainty must be considered when assessing the SoS against its performance objectives

BACKUP

Details on SoS T&E
Issue Discussions and Approaches
2010

Issue 1 If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?

Discussion

- **Restatement of issue:**
  - How do we define, articulate, and enforce the relationship between the SoS and the constituent systems?
  - How does T&E support/help this?
- **Governance/Roles/Stakeholders**
  - Need a shepard (architect?) and support from users
  - Need to educate stakeholders
  - What are rules of governance?
  - What are the regulations, standards, and policies?
  - Need to obtain resources (funding, test assets, time)
  - SoS leadership focus: architecture views, who "owns"
  - Potential conflicts between SoS and constituents
  - Business case for PMs to do SoS
- **SoS T&E Focus**
  - SoS T&E operationally driven (vs. DT-ish)
  - SoS edge of the envelop
  - What is an AoA of SoS?
  - Emergent behaviors (good and bad)
  - SoS resource consumption (e.g. data pipeline)
  - Continual assessment (joint exercises, deployments)
  - How to define test strategies to efficiently continuously test?
  - How do we help the T&E process help the SoS work?
- **Understand SoS Capabilities**
  - What is the SoS expected to do?
  - Define and articulate relation between SoS and systems
  - Flexible composition
  - Artfully sub-optimize the systems in favor of the SoS
  - System performance bounds are not rigid in real operation
  - Candidate solution: SoS requirements document with annex for each constituent system (what is constituent contribution to SoS capability)

Issue 1 If SoS are not programs of record (and not subject to T&E regulations) why should we worry about this at all?

Approach to addressing issue

- Define a minimal set of SoS governance characteristics of a successful acknowledged SoS
  - Roles/resources
  - Rules/regs/standards/policies
  - Managing conflicts
  - Establishing cooperation of constituent systems
  - Includes responsibility to define SoS capabilities, architecture, and associated test strategy
  - Concept of continual change and test in operational and training environment
  - Lean management, taking advantage of available opportunities
  - Recognize the large number of SoS across the DoD, and the fact that many systems support multiple SoS.anf the potential impacts of governance

Issue #2 If "requirements" are not clearly up front from a SoS, what is basis for T&E of an SoS?

Discussion

- Requirements vs expectations; Mission objective vs. technical requirements
- Mission threads linked to capability strands as architecture model
- Who/what has responsibility for architecture/requirement- another DOD layer?
- Standards for participating or acceptance of each system into SoS
- Requirements model for architecture encompassing time, space changes
- SoS level requirement T&E at program or SoS level balance?
- T&E of aggregation of systems level requirements (SOS level TEMP)
- Integrated development environment/ reference architecture as model
- Need operations/architecture view of SoS that individual systems must plug into- need someone responsible for this
- Prioritization of SoS capabilities at high (OSD) level required to permit constituent PM to manage development and delivery. With funding at SoS
- Measure and baseline SoS capability thru T&E w/o requirements. Where do we get metrics?
- Must have an "enforcer" capability manager - carrots and sticks
- Measure SoS capabilities when changes to SoS Baseline
- CONOPs vs innovative use of systems in face of changing threat
- Move from paper to 4 dimensions to capture SoS capabilities requirements.
- Use of modeling tools of SoS components delivered with each component to communicate requirements
- Capability flow down to systems, demo meeting systems capability

Issue 2: If "requirements" are not clearly defined up front for a SoS, what is basis for T&E of an SoS?

Approach to addressing issue

- The DOD needs a top-down (architecture, requirements, context, expectation) flow-process to systems within the SoS
- Needs authority & funding to enforce capability fulfillment
- Needs to be flexible enough to meet changing needs and threats and CONOPS/operator innovation.
- Determine the right balance between system test to sos- test to SOS level test

Issue 3 What is the relationship between SoS metrics and T&E objectives?

Discussion

- SoS T&E is focused on continuous improvement of the SoS (as compared to system T&E which is focused on the field, fix, or don't field decision)
- Continuous SoS T&E requires
  - Stable/consistent metrics
  - Consistent approach to defining evolving baseline
  - A way to deal with emergent behavior (technical, organization, human) – positive or negative
  - Need to leverage wide range of opportunities for test environments
  - Continuous improvement means continuous testing ; Built in test instrumentation for feedback from field
- SoS metrics
  - Do not address discrete behaviors of systems (as do system metrics)
  - Do address end to end performance across systems in SoS toward capability objectives of the SoS
- What is objective of T&E for an SoS?
  - Development information on capabilities and limitations of SoS to inform end users and ongoing SoS evolution (as compared to system T&E which is assessment of whether system meets requirements)
- SoS T&E customers?
  - End user and SoS SE team (as compared to system T&E where aquisition community is the customer)
- SoS T&E should be risk driven: focus on areas of risk to SoS or systems

Issue 3 What is the relationship between SoS metrics and T&E objectives?

Approaches to addressing issue

- Characterize SoS T&E as continuous improvement, document the approach and share with the community
- Radically change how we look at testing given the growing prevalence of SoS
  - Concepts of DT and OT don't really fit
  - Inefficient to address systems in operational SoS environment on a system by system basis (OT today)
  - Continue to test individual systems to assess whether we have developed what we asked for
  - Create a new approach to OT, by cross systems support for testing capabilities

Issue 4 Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

Discussion

- To address these issues you need to fix
  - Define the SoS and its performance objectives
    - Constituent systems that are part of the SoS
    - Which parts of the constituents contribute to the SoS objectives
  - Describe the current and future state of the changing systems (Baselines)
  - Assign ownership of SoS performance objectives
  - Big challenge; leadership issue, etc
    - More collaborative approach for stakeholders of SoS
- Emergent behavior – interaction of systems, humans, system and organization along with constant change of the parts
- Bounds of human impact
  - Operator – leader – mission
  - The people side of systems
- Training and development of the evaluators (and the end users)
- Expensive to assess if capabilities are realized (hard to do)
  - Doing more with less?
  - Disconnect thinking and reality?
- Leadership understanding of SE and SoS
  - Is there competency to make decisions and know the impact and implications?
    - Trades without know the desired outcome can be achieved
  - Evaluation on an SoS basis vs individua;l systems and their acquisitions
  - Timing and who benefits (lack of rewards systems)
  - Accountability for SoS
- Continued improvement, assessment, and alignment because objectives have changed
  - More data from fielded systems
- Connections to fielded side of the house (doesn't deal well with change)
- "Measurement system' for system
  - Analysis of impacts
  - M&S?
  - Risks; "we are not sure but…" with some mitigation
  - Regression testing and configuration of SoS
  - Comparative analysis

Issue 4 Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

Approaches to addressing issue

- Influence assigning leadership responsibility and ownership of defined SoS capability and associate performance objectives
- Establish incentives of constituent systems to collaborate and achieve SoS performance objectives
- Map SoS capabilities and performance objectives to constituent systems (under configuration control)
- Continual assessment, improvement, and realignment is required (incremental approach) focused on end user)
- Create a guidance framework for emergent behaviors of changing to be measured and managed

Issue 5

Are expected cumulative impacts of systems changes on SoS performance the same as SoS performance objectives?

How do you test the contribution of a system to the end to end SoS performance in the absence of other SoS elements critical to the SoS results?

Discussion

- Trying to assemble all piece parts for T&E
- So many variables that can impact T&E outcome
- Reliance on other programs (e.g., JTRS) for capabilities that can slip in schedule or are never delivered
- Spanning "use-case" space with a reasonable set of resources and schedule
- Need defined set of requirements (but, of course, this is part of the problem space)
- What does a T&E strategy look like?
- How account for "the network" and stresses to it?
- DoD should require programs to share/ make transparent to other programs their development, DT and other data (obstacles: proprietary/security)
- Recommend ways to systems instrument to enable post-fielding collection of "test" data
- Operations, exercises, training
- DoD should develop a common approach to accounting for "the network" as a constituent of all SoSs for purposes of T&E
- DoD articulate purpose of SoS T&E
  - Is it a capability demo ("what do we have?")
  - Is it a classical check against requirements?
  - The real purpose of SoS T&E is to answer:
    - Is the new capability operationally useful (whether or not it "met" requirements); what are risks?
  - How can the new capability be used?
  - What further changes are required?

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Approach

- M&S of piece parts that are not yet ready to be tested (but issues between M&S for individual system performance versus effects-based M&S) – potential solution to issue #1.
- Architectures and synchronizing them an enabler of T&E (provides well-defined baseline; can measure deltas against the baseline)
- Combinatorial test & design (suggested as potential solution to issue #2).
- Model-test-model approach suggested for way to accommodate emergent behavior
- Field exercises – instrumentation to collect data
- Training as a T&E opportunity
- No SoS requirement => no TEMP for SoS capabilities => no SoS T&E funding. Therefore need a capability (SoS) focused, cross-system, integrated test schedule that builds to a graduation-level event. (some disagreement re. existence of such an event). Push SoS T&E to fleet/operators as proof of IOC (need fleet experimentation funding).