DoD Systems Engineering Standardization Initiative

NDIA 17th Annual Systems Engineering Conference

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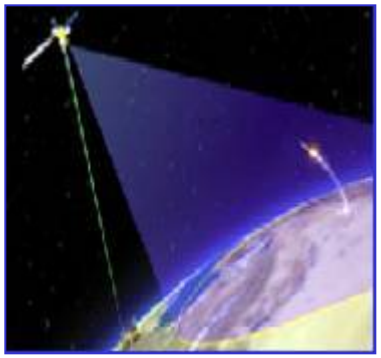
October 30, 2014

Track 3
briefing 17103

U.S. AIR FORCE

SMC Space Missions

WE DEVELOP, ACQUIRE, FIELD AND SUSTAIN SYSTEMS IN FOUR MAJOR MISSION AREAS



Space Superiority

Space Situation Awareness
- SBSS
- Space Fence

Defensive Counter Space
Offensive Counter Space

Space Support

Launch Systems
Spacelift Range
Sat Control & Network

Force Application

Conventional Missiles
Prompt Global Strike

Space Force Enhancement

Milstar/AEHF/EPS(Comm)
DSCS/GBS/WGS(Comm)
GPS (Navigation)
DSP/SBIRS (Surveillance)
DMSP/DWSS (Weather)
NUDET (Nuclear Detection)

Developing, Delivering, and Supporting Military Space and Missile Capabilities to Preserve Peace and Win Conflicts

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Space System Development

Titan IV-A A-20

- **Launch is a "one-strike-and-you're-out" business**
- **Spacecraft must work by remote control for 15 years**
  - Hostile environment
  - "Small" failures can cripple or end mission

Delta III

No "flight Testing" and No Service Calls in Space
Mandates Unique, High-Confidence Mission Assurance Culture

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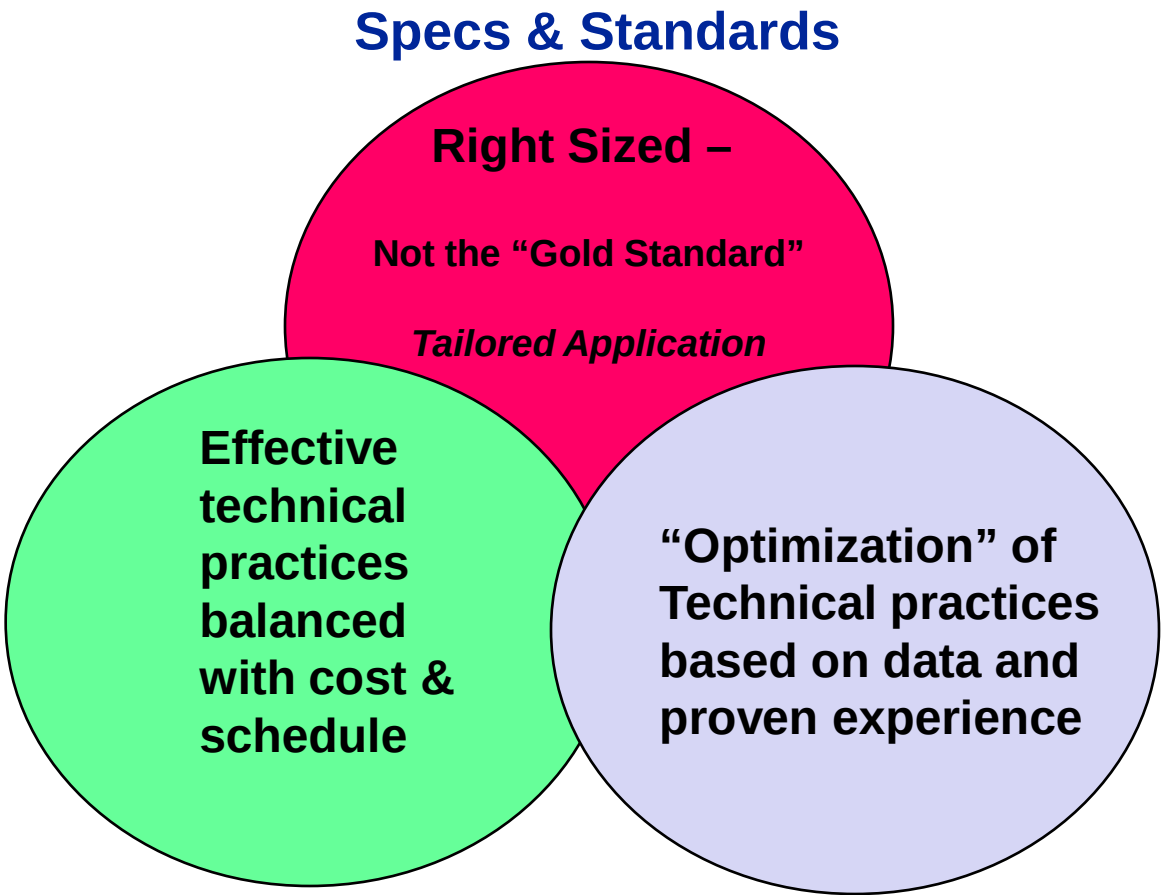
Balanced Technical Practices



Include commercial data/practices where available and applicable

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Functional Areas of SMC Standards

STANDARD PRACTICES

- Program/Subcontract Management
- Systems Engineering
  - Architecture Development
- Design Reviews
- Configuration Management
  - Quality Assurance
- Logistics
- Manufacturing /Production Management
  - Parts Management (non-space)
- Parts Management (space)
  - Risk Management
- System Safety
  - Occupational Safety and Health
- Reliability/Availability

Subsystem/Component Standards

  - Electrical Power, Batteries
  - Electrical Power, Solar Cells/Panels
- Electromagnetic Interference & Control
  - Environmental Engineering; Cleanliness
  - Human Systems Integration
- Interoperability
- Maintainability
  - Mass Properties
  - Moving Mechanical Assemblies
  - Ordnance
  - Pressurized Systems & Components
- Information Assurance/Program Protection
  - Software Development
  - Structures
- Survivability
- Test, Space & Ground

➢ *Industry consensus standards developed or adopted for use on SMC contracts*

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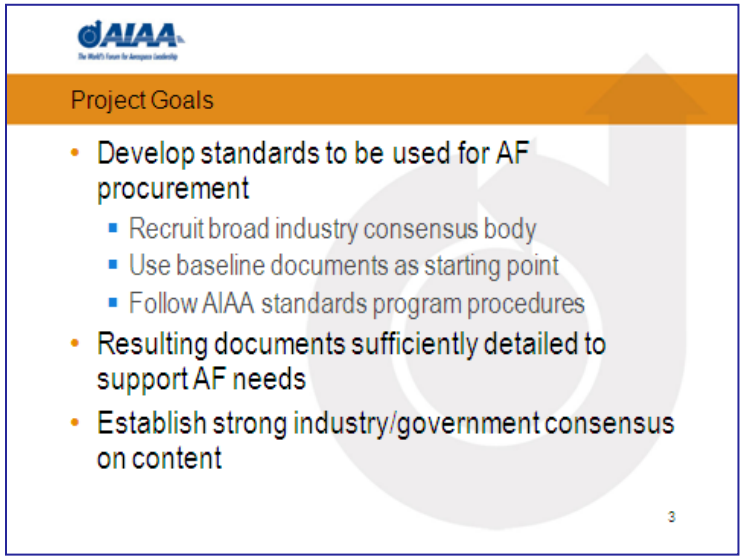
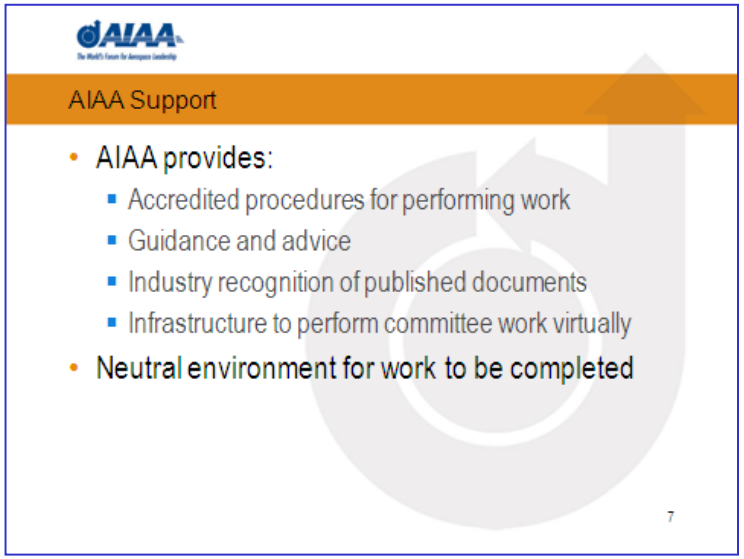
Government-Industry Partnership

- **Mutual-benefit stipulations:**
  - **Must meet both party's needs and objectives**
  - **Potential teaming partners must have existing experience with subject matter of document and existing infrastructure for publishing standards**
  - **Content of documents must be consistent with government needs**

Example from prior SMC effort





Source: AIAA Standardization Activity Kick-off Meeting, 24 March 2009

Successful partnership REQUIRES commitment from both parties

Why Standards are Important

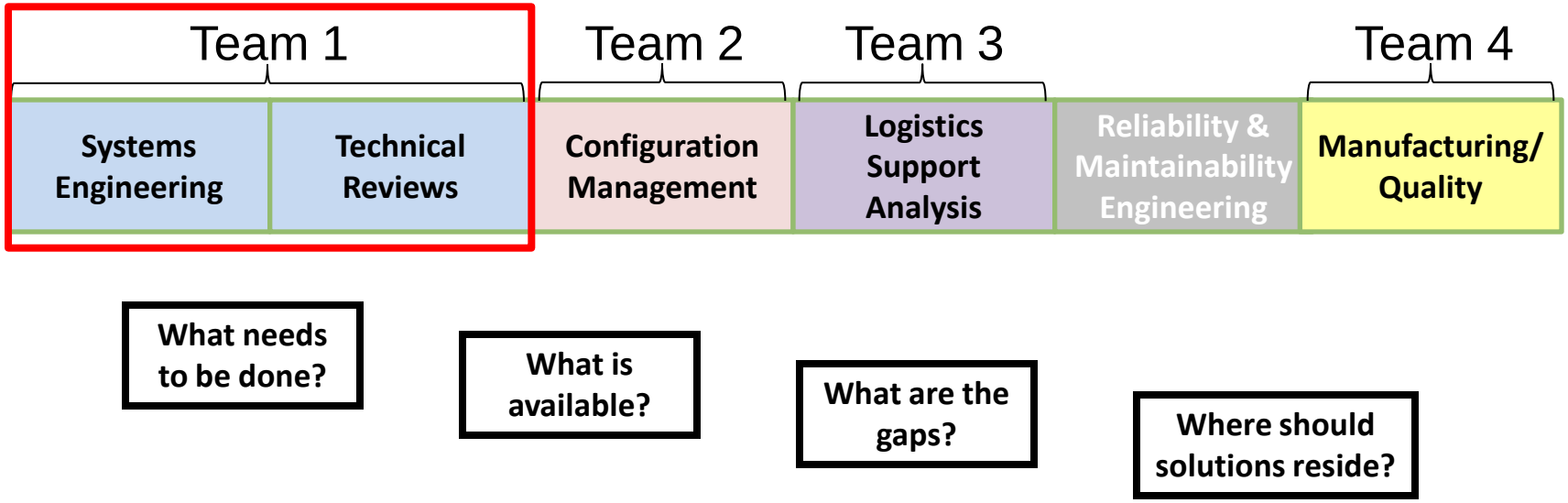
"Technical standards provide the *corporate process memory* needed for a disciplined systems engineering approach and help ensure that the government and its contractors *understand the critical processes and practices* necessary to take a system from design to production, and through sustainment."

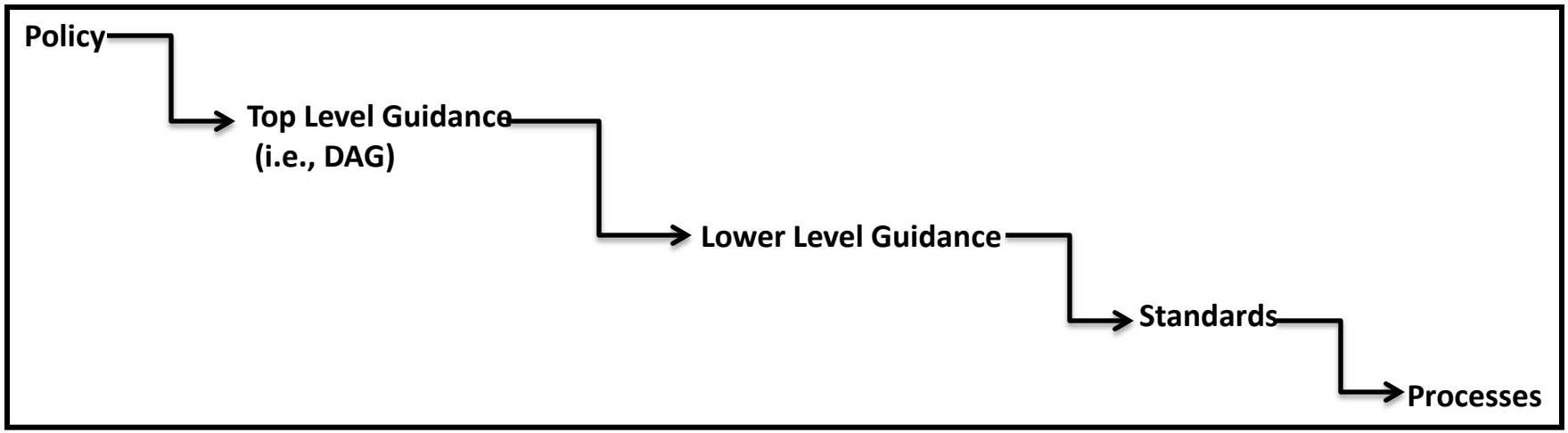
Mr. Stephen Welby

United States Deputy Assistant Secretary of Defense for Systems Engineering

(Modeling & Simulation Journal, Spring 2013)

Overall Gap Analysis Process





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SE & TR&A Standards Background

- OSD formed Gap Analysis Working Groups (summer 2011) to evaluate standardization gaps and potential solutions in several functional areas, including Systems Engineering and Tech Reviews and Audits
- Recommendation for SE and TR&A standards was briefed in November 2011 to Defense Standardization Council (DSC)
  - Need based on WG findings
- DSC agreed with recommendations
  - OSD clarified direction in March 2012: All teams are to develop commercial standards
- OSD issued direction to establish a Se and TR&A Working Group (Dec 2012)
- In Jun 2013, OSD selected IEEE to develop the SE and TR&A standards (each standard was individually evaluated and selected)
- DSC and DSE Direction:
  - Concurred with findings and recommendations
  - Non-government standards (NGS) are preferred approach
  - AF will lead multi-service working groups
  - Develop standards that apply to contractors

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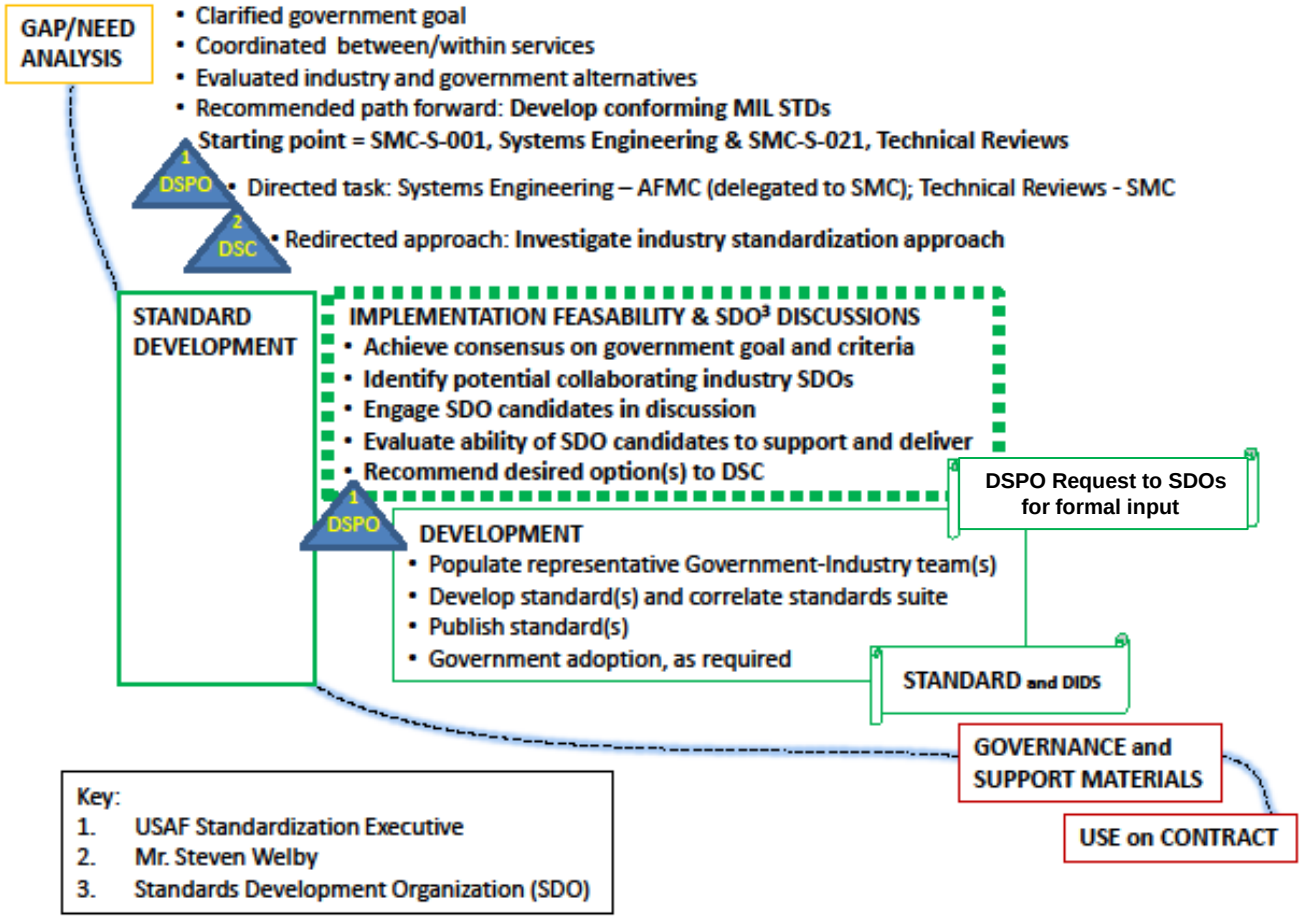
DOD SE/TRA Standards Process

Standard Development Phases



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IEEE Joint Systems Engineering WG

- **DoD-IEEE Standards Working Group established**
  - Kickoff meetings 15 & 22 Aug 2013
  - Leadership Team
    - WG Chair, Garry Roedler, Lockheed Martin
    - WG Vice-chair, Dave Davis, USAF SMC
    - WG Secretary, Brian Shaw, The Aerospace Corp.
  - Technical Editors
    - SE Standard, Bill Bearden, Los Alamos National Labs
    - TR&A Standard, Mark Henley, L-3 Com
  - DoD & Industry broadly represented (next chart)
    - Same WG members for SE and TR&A teams
- **Two IEEE projects**
  - 15288.1 Defense Systems Engineering: DoD addendum to 15288
    - Leverage 15288 process language; specify work products and attributes
  - 15288.2 TR&A Standard: stand-alone document
    - No equivalent industry standard)
    - Hook reviews/audits to 15288 process

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IEEE Joint Systems Engineering WG

Industry

- BAE Systems
- Ball Aerospace
- Boeing
- General Dynamics
- Harris
- Lockheed Martin
- Northrop Grumman
- Raytheon
- SAIC/Leidos
- United Technologies
- Ingalls Shipbuilding

Associations

- AIA
- IEEE-CS/SA
- INCOSE
- ISO/IEC
- NDIA
- SAE Intl

Defense

- Air Force
- Army
- Navy
- OSD – DASD (SE)
- DAU
- DSPO
- DOD SERC Universities – Systems Engineering Research Center

Leadership Team

Chair, Garry Roedler, Lockheed Martin

Vice-chair, Dave Davis, USAF SMC

Secretary, Brian Shaw, The Aerospace Corp.

Technical Editor, Bill Bearden, Los Alamos Nat. Lab.

* Although any individual was welcome to participate in the working group, individuals from the organizations above were requested to ensure a good cross section of the industry stakeholders. Names and affiliations of *individuals* rather than organizations will be used for identification of working group membership as individuals sign up for the group.

IEEE Standard for Application of SE on Defense Programs

- Summary of Project Authorization Request for Systems Engineering
  - Identifier of Standard – IEEE Std 15288.1
  - Title: Standard for Application of Systems Engineering on Defense Programs
    - Scope:
      - System life cycle processes, activities, and tasks of ISO/IEC/IEEE 15288 for use on any defense system across the life cycle
    - Purpose:
      - This standard implements ISO/IEC/IEEE 15288 for use by United States Department of Defense (DoD) organizations and other defense agencies in acquiring systems or systems engineering support.
    - Need:
      - Provide the defense specific language and terminology for the standard to ensure the correct application of acquirer-supplier requirements for a defense prgm.
    - Technical Approach:
      - Addendum to ISO/IEC/IEEE 15288 and will:
        - Not repeat processes and information in 15288
        - Include defense specific language and terminology
        - Include necessary tailoring or changes to existing elements
        - Include any additional explanation or guidance

IEEE Standard for Application of Technical Reviews & Audits

- Summary of Project Authorization Request for Technical Reviews & Audits
  - Identifier of Standard – IEEE Std 15288.2
  - Title: Standard for Application of Technical Reviews and Audits on Defense Programs

  – Scope:
    - Establishes the requirements for technical reviews and audits to be performed throughout the acquisition lifecycle for the U.S. Department of Defense (DoD) and other defense agencies.

  – Purpose:
    - Amplify ISO/IEC/IEEE 15288 Clause 6.3.2.3.a for selection, negotiation, agreement, and performance of the necessary technical reviews and audits, while allowing tailoring flexibility for the variety of acquisition situations/ environments when the technical reviews or audits are conducted.

  – Need:
    - Provide the defense specific language and terminology for the standard to ensure the correct application of acquirer-supplier requirements for a defense program.

  – Technical Approach:
    - Standard will be in the form of a full standard that has links to ISO/IEC/IEEE 15288 and will:
      – Elaborate on the activities and tasks related to TR&A
      – Include defense specific language and terminology needed for the standard
      – Include the criteria for reviews & audits
      – Include the expected/required outcomes/ products of reviews & audits
      – Include any additional explanation or guidance

Example SE Addendum (15288.1)

Baseline: ISO/IEC/IEEE 15288:2014 (FDIS)	Tailoring Needed for Defense Programs
6.3.1 Project planning process	6.3.1 Project Planning Process
6.3.1.1 Purpose The purpose of the Project Planning Process is to produce and coordinate effective and workable plans. This process determines the scope of the project management and technical activities, identifies process outputs, tasks and deliverables, establishes schedules for task conduct, including achievement criteria, and required resources to accomplish tasks. This is an on-going process that continues throughout a project, with regular revisions to plans.	**6.3.1.1 Purpose** ISO/IEC/IEEE 15288:201x 6.3.1.1 "Purpose" applies as stated.
6.3.1.2 Outcomes An implementation of the Project Planning Process shall achieve the following outcomes: a) Objectives and plans are defined and recorded. b) Roles, responsibilities, accountabilities, authorities are defined. c) Resources and services necessary to achieve the objectives are formally requested and committed. d) Plans for the execution of the project are activated and maintained.	**6.3.1.2 Outcomes** ISO/IEC/IEEE 15288:201x 6.3.1.2 "Outcomes" shall apply in accordance with the acquirer-supplier agreement:
6.3.1.3 Activities and tasks The project shall implement the following activities and tasks in accordance with applicable organization policies and procedures with respect to the Project Planning Process. a) **Define the project.** This activity consists of the following tasks: 1) Identify the project objectives and constraints. 2) Define the project scope as established in the agreement. 3) Define and maintain a life cycle model that is comprised of stages Establish a work breakdown structure based on the evolving system architecture. 4) Define and maintain the processes that will be applied on the project.	**6.3.1.3 Activities and Tasks** ISO/IEC/IEEE 15288:201x 6.3.1.3 "Activities and Tasks" shall apply: Add: The supplier shall plan, execute, and control the engineering efforts. In addition, the supplier **shall** ensure appropriate flowdown of requirements and technical management of subcontractors and vendors.

- **Purpose**
- **Outcomes**
- **Activities and Tasks**

- **Identifies applicable parts of 15288**
- **Defines any deltas**
- **Outputs (added)**

Resulting IEEE Standard - DoD Addendum: IEEE 15288.1 - Standard for Application of SE on Defense Programs

6.3.1.4 Project Planning Process Outputs

The following Technical Process outputs shall be provided in accordance with the acquirer-supplier agreement.

a) Systems Engineering Management Plan (SEMP) with the following attributes:

1) Identifies the technical assessment and control of the project, including required technical reviews and audits and their completion criteria, technical measurement, quality assurance, baseline management, and change control.

2) Provides a description, or reference to, the life cycle model and systems engineering processes or process model description for the technical effort, including an overview of the methods, tools and techniques which are applicable across the project.

3) Identifies any specific infrastructure needs to support the technical effort.

4) Describes or points to the Work Breakdown Structure (WBS), project schedule, and project budget.

5) Identifies any project constraints that may limit or restrict the project or system solution.

6) Identifies supporting plans.

b) Contract Work Breakdown Structure (CWBS)

1) Is consistent with the evolving physical hierarchy and is maintained and applied to plan and monitor all work carried out under the project.

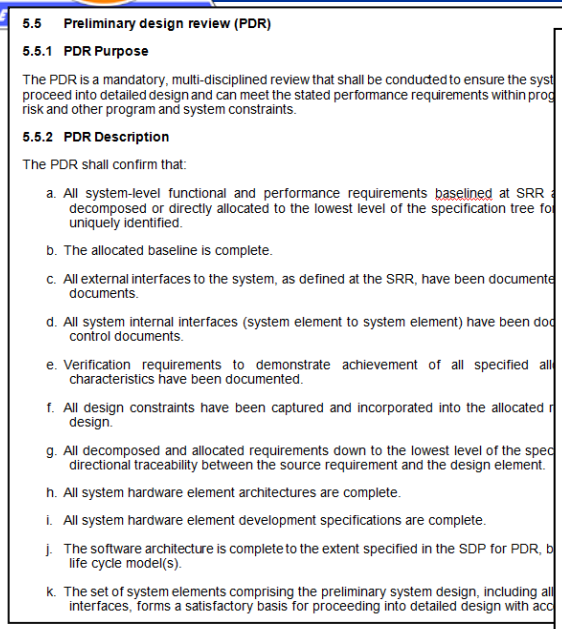
c) The systems engineering accomplishments, accomplishment criteria, and narrative in the integrated master plan (IMP); tasks in the integrated master schedule (IMS); and work packages in the earned value management system (EVM) and other specific plans (such as tradeoff plans)

Tailorable

Document structure is aligned with ISO/IEC/IEEE 15288 and INCOSE SE Handbook

15

Example: Technical Review (15288.2)



5.5 Preliminary design review (PDR)

5.5.1 PDR Purpose

The PDR is a mandatory, multi-disciplined review that shall be conducted to ensure the syst proceed into detailed design and can meet the stated performance requirements within prog risk and other program and system constraints.

5.5.2 PDR Description

The PDR shall confirm that:

a. All system-level functional and performance requirements baselined at SRR a decomposed or directly allocated to the lowest level of the specification tree fo uniquely identified.

b. The allocated baseline is complete.

c. All external interfaces to the system, as defined at the SRR, have been documente documents.

d. All system internal interfaces (system element to system element) have been doc control documents.

e. Verification requirements to demonstrate achievement of all specified all characteristics have been documented.

f. All design constraints have been captured and incorporated into the allocated r design.

g. All decomposed and allocated requirements down to the lowest level of the spec directional traceability between the source requirement and the design element.

h. All system hardware element architectures are complete.

i. All system hardware element development specifications are complete.

j. The software architecture is complete to the extent specified in the SDP for PDR, b life cycle model(s).

k. The set of system elements comprising the preliminary system design, including all interfaces, forms a satisfactory basis for proceeding into detailed design with acc

5 Requirements

- .1 Purpose
- .2 Description
- .3 Timing
- .4 Entry Criteria
- .5 Content
  - .5.1 Product
  - .5.2 Conduct
  - .5.3 Outputs
- .6 Exit Criteria

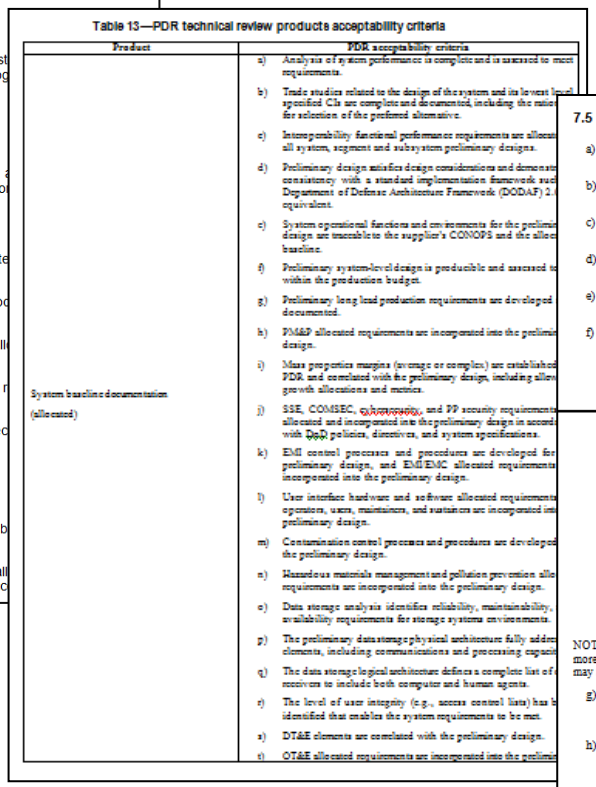
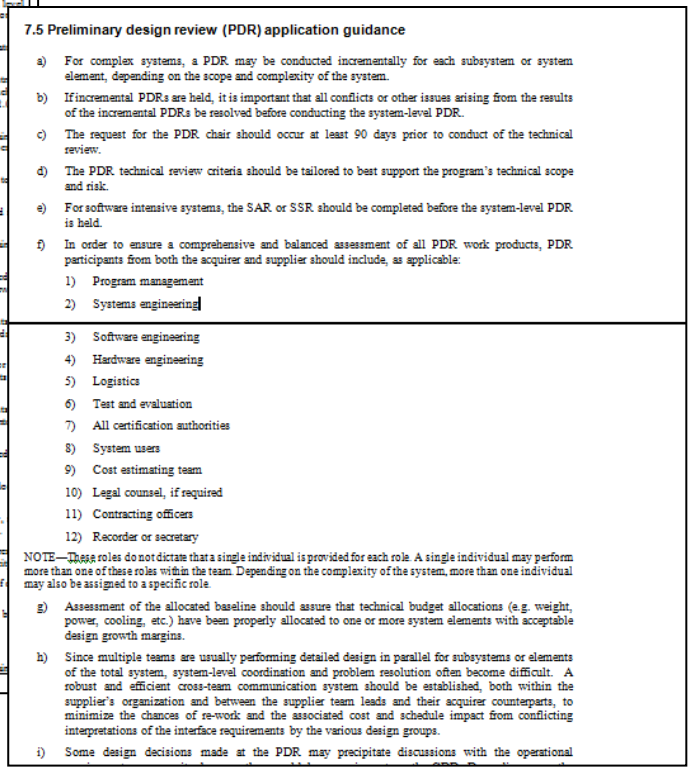


Table 13—PDR technical review products acceptability criteria

Product	PDR acceptability criteria
System baseline documentation (allocated)	a) Analysis of system performance is complete and is assessed to meet requirements. b) Trade studies related to the design of the system and its lowest level specified CIs are complete and documented, including the rati for selection of the preferred alternative. c) Interoperability functional performance requirements are allocat all system, segment and subsystem preliminary designs. d) Preliminary design satisfies design considerations and demonstr consistency with a standard implementation framework such Department of Defense Architecture Framework (DODAF) 2. equivalent. e) System operational functions and environments for the prelimin design are traceable to the supplier's CONOPS and the allo baseline. f) Preliminary system-level design is producible and assessed t within the production budget. g) Preliminary long lead production requirements are developed documented. h) PM&P allocated requirements are incorporated into the prelimi design. i) Mass properties margins (average or complex) are establishe PDR and correlated with the preliminary design, including allow growth allocations and metrics. j) SSE, COMSEC, cybersecurity, and PP security requirement allocated and incorporated into the preliminary design in accord with DoD policies, directives, and system specifications. k) EMI control processes and procedures are developed for preliminary design, and EMI/EMC allocated requirements incorporated into the preliminary design. l) User interface hardware and software allocated requirements operators, users, maintainers, and sustainers are incorporated int preliminary design. m) Contamination control processes and procedures are develope the preliminary design. n) Hazardous materials management and pollution prevention allo requirements are incorporated into the preliminary design. o) Data storage analysis identifies reliability, maintainability, availability requirements for storage systems environments. p) The preliminary data storage physical architecture fully addres elements, including communications and processing capabi q) The data storage logical architecture defines a complete list of receivers to include both computer and human agents. r) The level of user integrity (e.g., access control lists) has b identified that enables the system requirements to be met. s) DT&E elements are correlated with the preliminary design. t) OT&E allocated requirements are incorporated into the prelimi

6 Detailed Criteria

- .1 Products Acceptability Criteria
- .2 Preparation
- .3 Conduct
- .4 Closure



7.5 Preliminary design review (PDR) application guidance

a) For complex systems, a PDR may be conducted incrementally for each subsystem or system element, depending on the scope and complexity of the system.

b) If incremental PDRs are held, it is important that all conflicts or other issues arising from the results of the incremental PDRs be resolved before conducting the system-level PDR.

c) The request for the PDR chair should occur at least 90 days prior to conduct of the technical review.

d) The PDR technical review criteria should be tailored to best support the program's technical scope and risk.

e) For software intensive systems, the SAR or SSR should be completed before the system-level PDR is held.

f) In order to ensure a comprehensive and balanced assessment of all PDR work products, PDR participants from both the acquirer and supplier should include, as applicable:

1) Program management
2) Systems engineering
3) Software engineering
4) Hardware engineering
5) Logistics
6) Test and evaluation
7) All certification authorities
8) System users
9) Cost estimating team
10) Legal counsel, if required
11) Contracting officers
12) Recorder or secretary

NOTE—These roles do not dictate that a single individual is provided for each role. A single individual may perform more than one of these roles within the team. Depending on the complexity of the system, more than one individual may also be assigned to a specific role.

g) Assessment of the allocated baseline should assure that technical budget allocations (e.g. weight, power, cooling, etc.) have been properly allocated to one or more system elements with acceptable design growth margins.

h) Since multiple teams are usually performing detailed design in parallel for subsystems or elements of the total system, system-level coordination and problem resolution often become difficult. A robust and efficient cross-team communication system should be established, both within the supplier's organization and between the supplier team leads and their acquirer counterparts, to minimize the chances of re-work and the associated cost and schedule impact from conflicting interpretations of the interface requirements by the various design groups.

i) Some design decisions made at the PDR may precipitate discussions with the operational

7. Application Guidance

Tailorable

Normative Reviews/Audits (10): ASR; SRR; SFR; PDR; CDR; TRR; FCA; SVR; PRR; PCA
Example domain-specific reviews in annexes that "may find useful" (4): SAR; SSR; IRR; FRR

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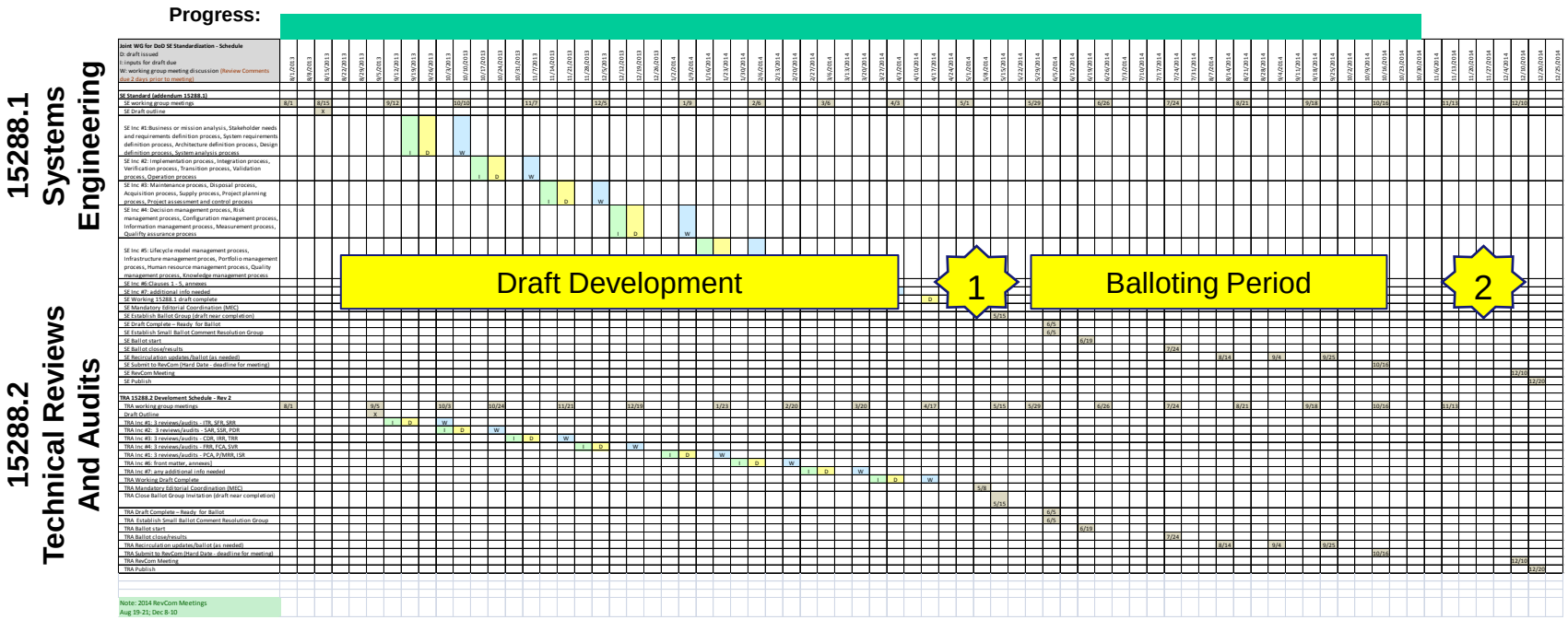
IEEE 15288.1 and 15288.2 Schedule

- **Bi-weekly meetings and document development is on-schedule**
  - **Working draft review by organizations: May 10, 2014** (1)
  - **Formal ballot period: June 12 to July 17, 2014; recirculation as required**
    - **Completed with 100% approval by ballot committee**
  - **Publication: January 2015** (2)



How DoD will implement

- **These standards:**
  - Will be adopted by DoD as soon as published
  - Will start to be listed as requirements on RFPs
  - Should influence the SOW
- **Application to contracts**
  - Expect to see on new contracts
  - Possibly on follow-on contracts
  - No change expected at this time for existing contracts
- **Impact to current processes**
  - Many industry organizations use 15288 as a source for their process documentation

Transition Initiative

- **Initiated by NDIA/AIA Workshop**
  - Workshop conducted in SEP 2015
  - Consensus reached on what is needed
- **NDIA SE Division to establish transition assets, including**
  - Tailoring Guidance
    - Both Acquisition perspective and Supplier perspective
  - RFP Language
    - To be published as an NDIA Report
    - Results to be considered for DoD publication
  - Compliance Mapping
    - Several methods possible
    - Level of mapping to be determined

SAE G-23 Manufacturing Management Committee

AS6500 Manufacturing Management Standard

Background

- **OSD formed Gap Analysis Working Groups (summer 2011) to evaluate standardization gaps and potential solutions in several functional areas, including Manufacturing**

- **Recommendation for a manufacturing standard was briefed in November 2011 to Defense Standardization Council (DSC)**
  - **Need based on Mfg/QA root causes of problems in weapon system acquisition**
  - **Quality area was deemed to have sufficient coverage by commercial standards**

- **DSC agreed with recommendations**
  - **OSD clarified direction in March 2012: All teams are to develop commercial standards**

- **OSD issued direction to establish a Manufacturing Standard Working Group (Dec 2012)**

- **In Sep 2013, OSD selected SAE International to develop the manufacturing management standard**

Purpose

- **The goal of the standard is to encourage the use of best manufacturing management practices aimed at promoting the timely development, production, modification, fielding, and sustainment of affordable products**

- **The standard is primarily intended for use in the defense industry, but may be applicable to other commercial industries**

- **The standard is intended for use as a contractual requirement, to be included in Requests for Proposals and Statements of Work**

- **The requirements of the standard are readily tailorable to each program's unique situation**

SAE G-23 Manufacturing Management Committee Membership

Chair: David Karr (US Air Force)

Vice-Chair: Mark Gordon (NCAT)

Secretary: Hamid Akhbari (US Air Force)

SAE Technical Project Specialist: Becky DeGutis

Organizations represented:

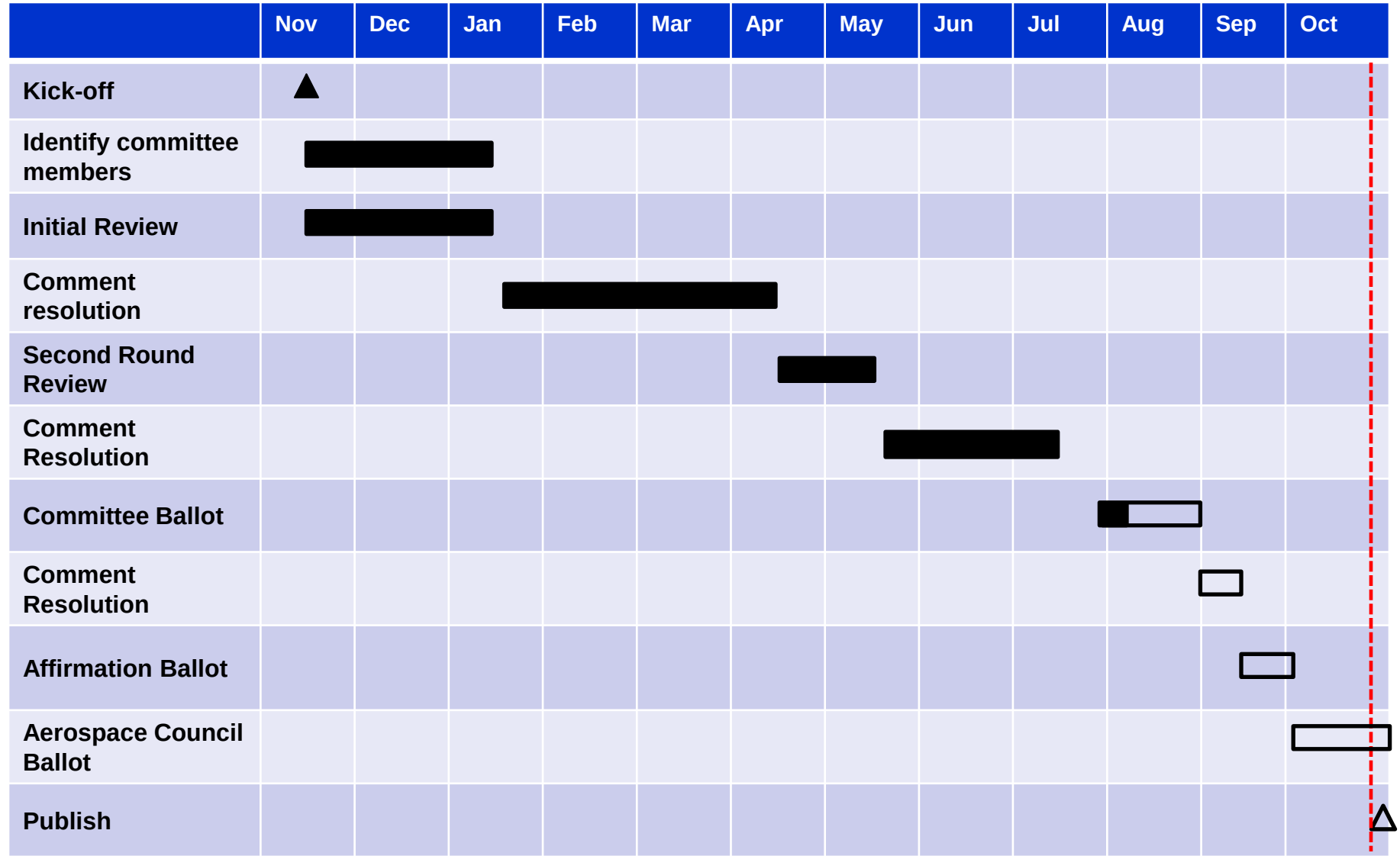
DoD Members

- Army
- Navy
- Air Force
- OSD
- DCMA
- DAU

Industry Members

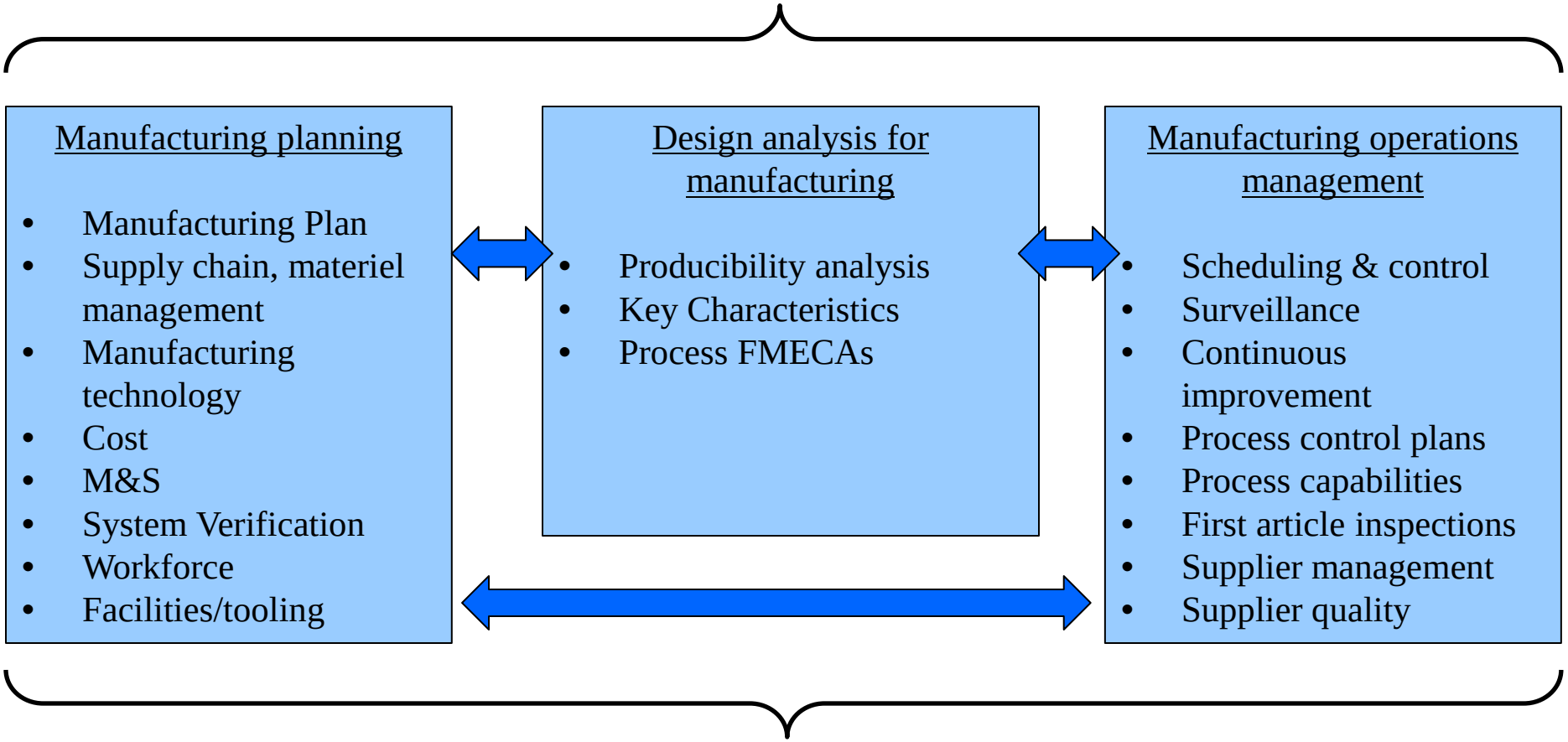
- Boeing
- Lockheed Martin
- BAE
- Raytheon
- Northrop Grumman
- GE Aviation

AS6500 Schedule

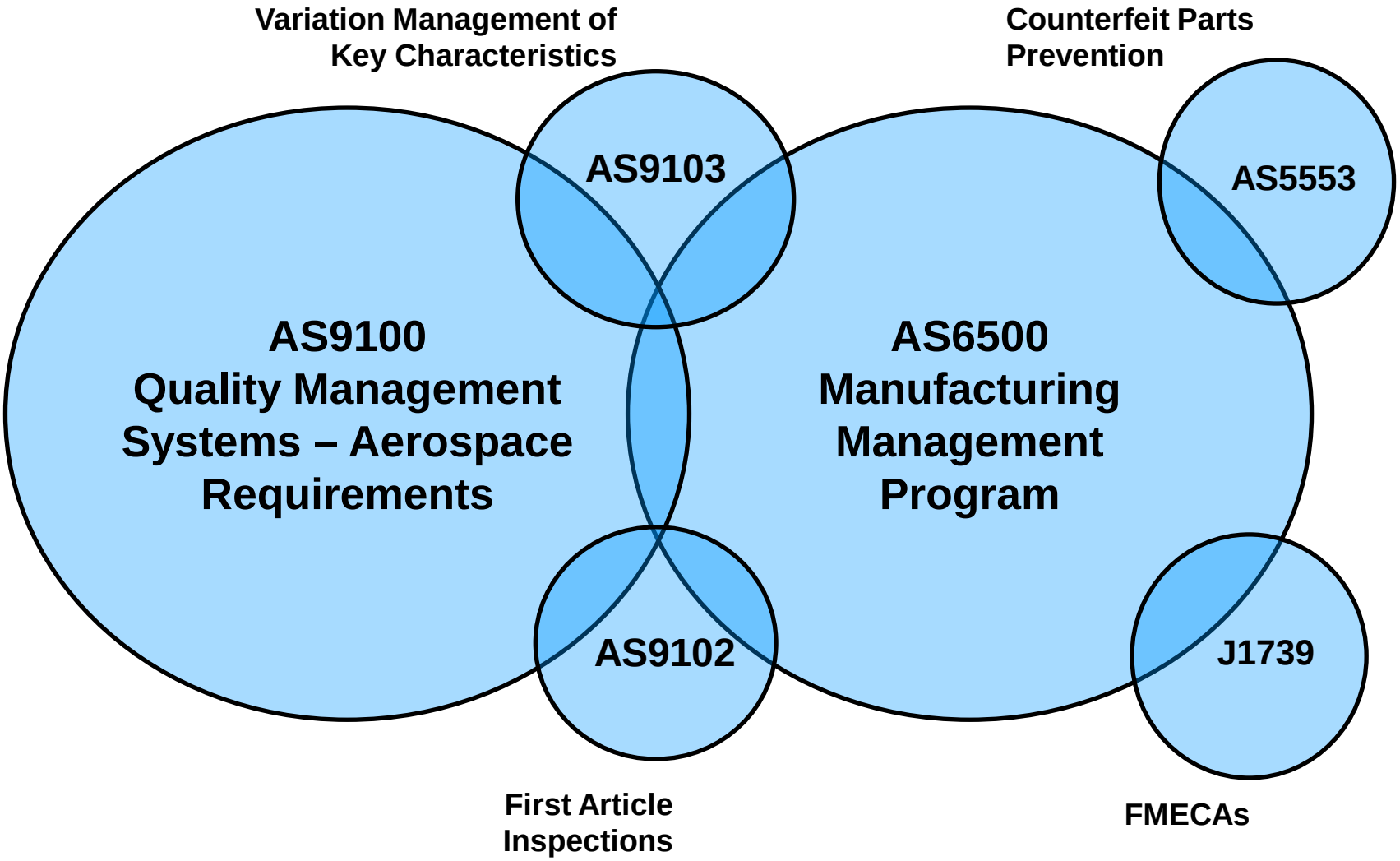


SAE AS6500 Overview of Content

Manufacturing Management System:
Program, Policies, Objectives



AS6500 Integration with Other SAE Standards



AS6500 Manufacturing Standard Status

- Committee ballot resulted in nearly unanimous approval
  - 93% approval
  - Dissenting vote related to implementation of the standard as opposed to the content of the standard
- Draft AS6500 standard forwarded to SAE's Aerospace Council
  - SAE's tech editor “clean-up” process
- Aerospace Council voting expected to commence NLT end of October for a 28 day ballot process
- Committee intent to develop guidance and training on implementation of the standard

Summary

- **Teaming with industry essential!**
  - For both technical and political reasons
  - Selection of industry partners critical
    - Willingness to publish standard consistent with government needs
    - Basis for military standard if no cooperative agreement with industry org established
- **Experience – *Industry collaboration can be done provided ground rules and working relationships are forged***
  - **SE, TR&A, Manufacturing Standards examples of excellent participation and support from industry**
- **Common recognition that awareness, training targeted at appropriate implementation critical**
  - **Objective of standards is to apply proven management and technical practices that will result in improved cost, schedule, and quality performance and more robust and reliable products for our customers**