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Naval Undersea Warfare Center Division Newport Annual SE Assessment Process

NDIA SE conference track
Systems Engineering Effectiveness

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Contents

- Overview
- System Engineering Governance
- Assessment facts
- Assessment Process
- Results
- Recommendations
- Conclusion

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Overview

- System engineering (SE) project assessment, when applied to multiple projects, provides the Naval Undersea Warfare Center Division Newport (NUWCDIVNPT) with critical insight as to the effectiveness of the engineering processes across the division.
- The annual SE assessment is a tool used to standardize and further refine those processes to maximize success.
- The purpose and objective of the annual assessment is to ensure that systems engineering processes are applied across all project phases.

System Engineering Governance

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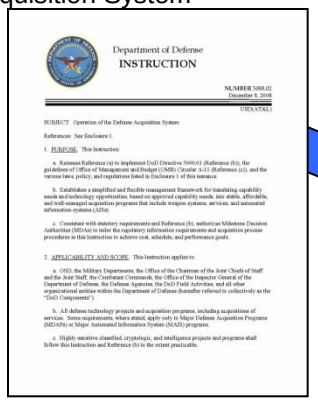
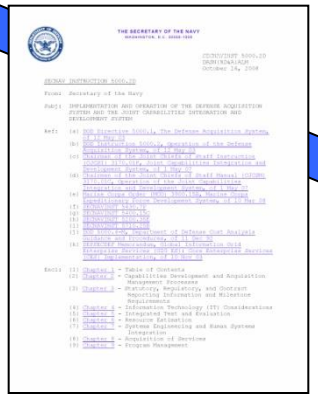
DoDI 5000.02, 2 DEC 08
Defense Acquisition System
(enc: 12)

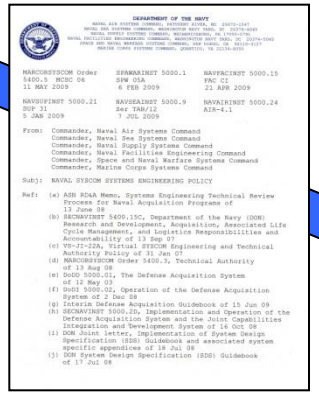

Department of Defense
INSTRUCTION

NUMBER 5000.02
December 8, 2008
USD(AT&L)

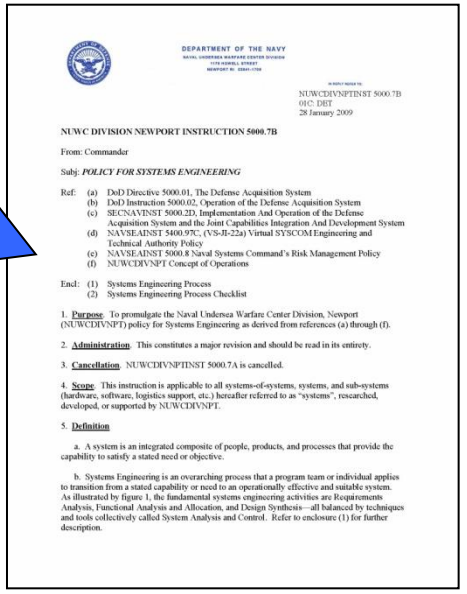
SECNAVINST 5000.2D 16 OCT 08
Implementation and Operation of the Defense Acquisition System and the Joint Capabilities Integration and Development System (ch 7)



- DoD and NAVSEA policy require System Engineering Practices
- NUWCDIVNPT Instruction 5000.7B requires an annual assessment of DIVNPT projects


DEPARTMENT OF THE NAVY

NAVSEAINST 5000.9
7 JUL 09
Naval SYSCOM
Systems Engineering Policy

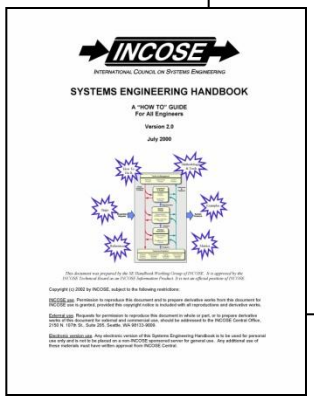

DEPARTMENT OF THE NAVY

NUWCDIVNPTINST 5000.7B
01C, DBT
28 January 2009

NUWC DIVISION NEWPORT INSTRUCTION 5000.7B

From: Commander

Subj: *POLICY FOR SYSTEMS ENGINEERING*

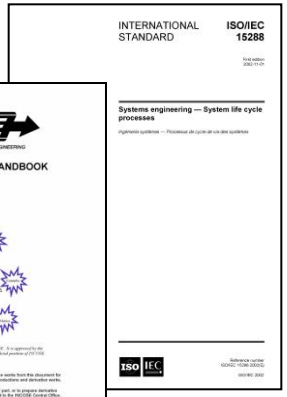

INCOSE
INTERNATIONAL COUNCIL ON SYSTEMS ENGINEERING

SYSTEMS ENGINEERING HANDBOOK

A "HOW TO" GUIDE
For All Engineers

Version 2.0

July 2000


INTERNATIONAL STANDARD ISO/IEC 15288

Systems engineering — System life cycle processes

ISO/IEC 15288

INCOSE Handbook

Informs

NUWCDIVNPT INST 5000.7B
28 JAN 09
Policy for Systems Engineering

NUWCDIVNPT Policy Aligns with Navy and DoD policy

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Assessment facts

- The assessment measures the execution of DIVNPT tasks, not the sponsor's program execution
- The assessment is part of the process reported in the NAVSEA Performance and Compliance Inspection. The process ensures:
  - Systems requirements are accurate, documented, quantifiable, and testable.
  - Systems meet top-level requirements, specifications, and Fleet needs.
  - Comprehensive risk assessment, mitigation, and reporting.
  - Best value solutions are delivered in a timely manner to meet Navy needs.
  - Robust participation of external organizations, as required, to support development, modification, and Verification and Validation activities.
  - Systems engineering processes are applied across all project phases.
  - Systems engineering decisions are documented and based on sound systems analysis and life cycle considerations.
  - Process inputs and outputs are well understood.
- Results are used to:
  - Adjust DIVNPT training plans
  - Identify projects for Technical Reviews
  - Identify need for Department and Division level corrective actions
  - Identify good practices
  - Support workforce development in system engineering
  - Support development of task books

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Assessment Process Schedule

- Fall
  - Process and Scoring Criteria adjusted (from previous years)
  - Projects are selected for review. Department CHENGS may choose to combine projects if there is a common sponsor and Technical Project Manager.
- Jan – Mar
  - Project Team and Department CHENG develop assessment ratings
  - Project team develops responses to questions, updates assessment and performs immediate and rapid response actions.
- Mar
  - Department CHENG assigns final rating and consolidates results.
- Apr – Jun
  - CHENG Council conducts Division-wide review of all data.
- Jun
  - Final report and brief developed. Provided to senior leadership.

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Assessment Process

- The SE assessment tool identifies eleven criteria which are assessed by each project. These criteria are:
    1. Decision Analysis
    2. Technical Planning
    3. Technical Assessment
    4. Requirements Development & Management
    5. Risk Management
    6. Configuration Management
    7. Design Solution
    8. Interface Management
    9. Development and Production
    10. Integration Plan
    11. Verification and Validation
- Each criterion is broken into a varying number of component elements.

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Assessment Process

- First: the individual projects are evaluated by the TPM
- Second: a TPM/Dept CHENG evaluation meeting is held and the scoring sheet shows both the TPM score and the CHENG score
- Third and final: a cross departmental roll-up of system engineering effectiveness scoring is developed which defines the state of system engineering across NUWC division Newport, along with any identified limitations and forward recommendations

Decision Analysis Criteria Scoring sheet

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NUWC SE Policy Checklist		**Program: Program Name Goes Here**	
TPM: Name Goes Here **SE: Name Goes Here**		**Status or Event at Evaluation: Event/Review Name Goes Here**	**Comment: Summary of program goes here**
Program Data Repository Location :	**What location is used to hold all program documentation and make it available to the team members? Generally where the Objective Quantitative Evidence (OQE) will be found.**	**Project Team Assessment**	**Department CHENG Assessment**

	Assessment Questions		**Criteria**				**Linkage to OQE**		**Criteria**						**OGE Criteria**		
Decision Analysis		**R/Y/G ?**	**Completed or in use**	**Not complete or needs improvement**	**Not applied or planned**	**Not Applicable**	**OQE document names, locations, and/or links go here**	**R/Y/G ?**	**Completed or in use**	**Not complete or needs improvement**	**Not applied or planned**	**Not Applicable**	**Y/N/NA ?**	**Document presented to CHENG**	**Document NOT presented to CHENG**		**Not Applicable**
	Have alternative approaches been evaluated and documented (e.g. analysis of alternatives (AoA), trade-studies, experimental results, etc.)?	Green	comments go here					Green	comments go here				Green	comments go here			
	Are criteria for decisions (e.g. metrics, constraints, parameter limitations, etc.) well defined and documented?	Green						Green					Green				
	Has appropriate simulation, modeling or prototyping been accomplished to support a positive assessment of system feasibility with respect to top level requirements?	Green						Green					Green				
	Have methods for analysis been determined, including identification of data sources and collection methods?	Green						Green					Green				
	Have decisions been based on contribution to end-to-end capability?	Green						Green					Green				
			Rating:	100	% Answered:	100			Rating:	100	% Answered:	100		Rating:			

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Decision Analysis Rating Criteria guidance

Decision Analysis		Red	Yellow	Green	Not Applicable
	Have alternative approaches been evaluated and documented (e.g. analysis of alternatives (AoA), trade-studies, experimental results, etc.)?	No AoA, trade studies, experimental results or other option comparisons have been considered and documented. The system is a point design derived from external factors.	An AoA, trade study, experiment or other option comparison has been performed but the documentation of results is minimal or otherwise deficient.	An AoA, trade study, experiment or other option comparision has been performed and documentated according to standard conventions.	An AoA or other option study is not complete because the purpose of the system is to support such studies in the future. For example if the system is for exploratory or advanced development purposes, an AoA might be premature. Also if the system is a non-developmental item, i.e. it is just a reproduction of a previously proven system, an AoA might not be applicable.
	Are criteria for decisions (e.g. metrics, constraints, parameter limitations, etc.) well defined and documented?	Criteria for decisions (e.g. metrics, constraints, parameter limitations, etc.) have not been defined and documented.	Criteria for decisions (e.g. metrics, constraints, parameter limitations, etc.) have been defined but documentation is minimal or otherwise deficient.	Criteria for decisions (e.g. metrics, constraints, parameter limitations, etc.) have been defined and documented.	No criteria have been documented because no decision analysis will be performed due to one of the above applicability conditions.
	Has appropriate simulation, modeling or prototyping been accomplished to support a positive assessment of system feasibility with respect to top level requirements?	No simulation, modeling or prototyping was done to assess the feasibility of meeting top level requirements.	A limited amount of simulation, modeling or prototyping was done but not yet enough to properly to assess the feasibility of meeting top level requirements.	Sufficient simulation, modeling or prototyping was completed to properly assess the feasibility of meeting top level requirements.	No S&M or prototyping will be completed because no decision analysis will be performed due to one of the above applicability conditions.
	Have methods for analysis been determined, including identification of data sources and collection methods?	Methods for analysis have not been determined and/or documented.	Some assessment of analysis methods has been performed but documentation of results is minimal or otherwise deficient.	Methods for analysis have been derived and sufficiently documented.	No methods have been determined because no decision analysis will be performed due to one of the above applicability conditions.
	Have decisions been based on contribution to end-to-end capability?	No evidence exists indicating consideration of the end-to-end performance requirements during the AoA or other option studies.	Some evidence exists indicating consideration of the end-to-end performance requirements during the AoA or other option studies, but the evidence is poorly documented or otherwise unclear.	Sufficient evidence exists indicating consideration of the end-to-end performance requirements during the AoA or other option studies, and the documentation of evidence is adequate.	No end-to-end capability analysis has been completed because no decision analysis will be performed due to one of the above applicability conditions.

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Systems Engineering Effectiveness at the Project Level Weakest Execution

Project	A	B	C	D	E	F	G	H
Decision Analysis	50	60	50	70	90	80	70	70
Technical Planning	38	63	83	88	75	88	63	88
Technical Assessment	50	60	40	80	80	50	70	80
Requirements Development and Management	67	33	67	67	75	83	83	67
Risk Management	50	40	70	100	100	90	90	100
Configuration Management	50	80	83	90	40	80	100	90
Design Solution	40	38	50	50	83	80	75	50
Interface Management	75	50	75	50	75	83	100	50
Development and Production	42	67	0	50	92	50	100	50
Integration Plan	33	100	83	100	N/A	100	83	100
Verification and Validation	63	50	100	63	83	100	83	63

The assessment tool has proven effective in identifying programs which are struggling with Systems Engineering. Weaknesses can be revealed across the development and in-service life cycle.

Division Assessment Summary Sample Output

- Strongest Categories
  - Configuration Management
  - Development and Production
- Weakest Categories
  - Technical Assessment
  - Decision Analysis
  - Design Solution
- Average differences are very subtle and numerically insignificant. Drill-down important to understand results

	Code A	Code B	Code C	Code D	Code E	Code F	Code G	Division Average
Decision Analysis	91	100	95	94	98	82	90	93
Technical Planning	89	96	95	94	99	85	88	92
Technical Assessment	93	97	95	91	99	83	86	92
Requirements Development and Management	91	93	96	86	98	87	92	92
Risk Management	90	97	98	96	99	84	89	93
Configuration Management	88	95	98	92	96	98	95	95
Design Solution	84	97	94	97	97	87	96	93
Interface Management	96	98	90	89	100	98	77	93
Development and Production	94	98	95	99	96	100	84	95
Integration Plan	93	94	97	89	100	93	86	93
Verification and Validation	92	93	98	95	94	100	83	94
# of Program Assessments	17	21	11	10	9	5	8	81

Best value of assessment is the discussion between Department CHENG and TPM on the approach to execution

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What do we do with the Results?

Example output from one year:

- Based on Rating Distribution Function values, two process areas were examined:
  - Decision Analysis
  - Design Solution
- Lean event held across the Division to develop better execution
  - Consolidated assessment responses reviewed to determine common themes contributing to the weaker assessments

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Decision Analysis Common Themes for Improvement

- Findings
  - Analytical Work to Support Decision Analysis:
    - Not performed or not well documented
    - Often limited in scope to a subset of the overall system or program
      - Lack consideration of “End-to-End” performance or Total Lifecycle Cost
    - Lack adequate resources provided
    - Impacted by non-technical factors
      - “Plus up” activities in advance of Programs of Record
      - Sponsor or stakeholder guidance
    - Affected by changing or poorly defined program requirements
      - Multiple examples where analytical work was not updated when requirements changed
    - Performed in response to issues in program execution rather then as proactive part of program planning
  - Architectural design data provided without analytical work to support results
  - Functional analysis of design solutions and alternatives performed but not well documented.
  - Lifecycle planning inadequately reflected in design solutions
  - Better responsiveness needed to changing requirements during program execution to review and update design analysis
  - Lifecycle issues with sustainment and production revealed later in program not adequately evaluated as part of total program considerations
  - For a very small number of programs functional analysis and architecture development not evident but judged necessary

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Objective Quality Evidence Common Themes for Improvement

- OQE assessment results widely variable:
  - Full disclosure of reference titles, applicable chapter and record's location
  - Partial disclosure of reference titles and location
  - Reference titles provided only
  - Program document repositories identified but specific records not cited
  - Program documents discussed but not linked
  - Policy, Guidance and Standards referenced rather than program artifacts demonstrating fulfillment
  - No disclosure
  - Shelfware vice usable material

CHENG Council to take a closer look at OQE and improve for next assessment

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General Observations
Value of SE assessment

- Assessment tool remains very effective in highlighting where programs are weak in Systems Engineering
- Improvement seen in assessment consistency across programs and departments
  - Keep focus on assessment of DIVNPT execution
  - Revised definitions and guidance improvements
- OQE remains an area for improvement in assessment method
- Assessment does not necessarily reflect program SE health when not a NUWC executed task
- Assessment process supported continued TPM awareness of NUWC SE Instruction and requirement to assess programs
- Best value of assessment is the discussion between Department CHENG and TPM on the approach to execution

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Examples of Department(s) SE Improvements Resulting from Annual SE Assessment

- Dept. developed and distributed Systems Engineering Process Memorandum
  - Provides department personnel roles and responsibilities NUWDIVNPT SE Instruction
- Held SE Assessment Kick Off Meeting with TPMs
  - Reviewed last year's findings;
  - Identified the need for OQE with examples
- Identified several opportunities for individual project improvements
  - Improved Configuration Management practices
  - Need for project plan where SEP doesn't exist due to scale
  - Improved requirements management processes
- Department SE Policy issued to all hands and established Dept CHENG website with posting of SE resources
- Conducting independent SE assessment as part of program events (CDRs, PMRs, QPRs, DBMTs, Daily SITREPs, etc.)
- Developing SE Manual to provide SE guideline for improving sub-ACAT programs
- Requirements documents developed and formally submitted for concurrence from sponsors

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Conclusions

- Overall the goal is to successfully execute our technical projects and deliver our products meeting all requirements at or under budget and at or under schedule without excessive post-delivery risk.
- Applying systems engineering practices to systems development and maintenance has been identified as the most effective means to achieve this goal.
- The systems engineering annual assessment is the method whereby DIVNPT measures and evaluates how well we are executing systems engineering practices in our projects.
- The first year's execution of the system assessment resulted in a comprehensive education at the Technical Project Manager level of the DIVNPT systems engineering process.
- The second year of execution resulted in improved communication and system's engineering education of the workforce at the engineering level. In addition, data from the second annual assessment shows that DIVNPT has improved execution of the systems engineering **assessment** and systems engineering **execution**.
- Third year (just completed) we achieved a greater level of critical examination of the quality of OQE and quality of risk management execution. Next year's recommendations are to highlight the active elements of the SE process per project. Projects are in different phases every year so only those active phases should be reviewed and assessed.

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BACKUP

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Assessment Process Criteria Component questions

1. Decision Analysis

1. Have alternative approaches been evaluated and documented (e.g. analysis of alternatives (AoA), trade-studies, experimental results, etc.)?
2. Are criteria for decisions (e.g. metrics, constraints, parameter limitations, etc.) well defined and documented?
3. Has appropriate simulation, modeling or prototyping been accomplished to support a positive assessment of system feasibility with respect to top level requirements?
4. Have methods for analysis been determined, including identification of data sources and collection methods?
5. Have decisions been based on contribution to end-to-end capability?

2. Technical Planning

1. Is the appropriate level of the systems engineering planning completed and tailored to respective milestones and acquisition phases?
2. Have guidance and policy for scheduling, conducting and reporting the technical effort, including success criteria, through event-based technical reviews been defined?
3. Does the scope of the technical approach integrate technology development, requirements maturation, and overall project/program management planning and control efforts, such as integrated master planning and scheduling?
4. Has a methodology been developed to collect and analyze data to report on associated "-ilities" (reliability, safety, availability, composibility, …) in accordance with law, instructions, project/program requirements and system engineering principles across the life cycle and materiel availability requirements?
5. Is the appropriate level of system safety planning complete, documented and followed e.g. a published System Safety Management Plan or project plan?

Assessment Process Criteria Component questions

3. Technical Assessment

1. Are technical assessment metrics defined for the project/program at the appropriate level (e.g. component, subsystem and system) to effectively judge progress during the development, production and inservice portions of the system?
2. Have entrance and exit criteria for Systems Engineering Technical Reviews been defined and documented? Do these criteria reflect technical achievement in addition to milestones on design progress?
3. Are suitable methods of periodic technical assessment defined and documented?
4. Has the level of reviews and participation been incorporated into the project/program plan (including defined, agreed, and appropriate participation)?
5. Has the responsibility been assigned and methodology for conducting failure investigations been defined?
6. Has a methodology for conducting safety assessments been defined e.g. CDR Safety Assessment, SAR, HAR, PESCHE?

Assessment Process Criteria Component questions

4. Requirements Development & Management

1. Does the project have a formal Requirements Document which defines the system requirements, i.e. functional requirements and design constraints including requirements from systems of systems?
2. Have all operational and support needs for the system been considered, addressed and agreed to by the sponsor, user and stakeholders?
3. Have the system acquirer and other stakeholders accepted the requirements as necessary, sufficient and achievable within the program to allow the system to perform its intended function?
4. Have the acquirer's requirements and system technical requirements been analyzed and compared to determine traceability both upward and downward?
5. Have external mandates and constraints such as budget, schedule, technical standards, interface standards, environmental regulations, Navy policy, information assurance, or other factors which may impact the project/program execution been identified and documented for the project/program?
6. Is there a process for managing requirements change during development that includes description and rationale for change, whether the change is driven by technology, application or programmatics?

Assessment Process Criteria Component questions

5. Risk Management

1. Has a Risk Management plan been developed and approved for the project/program?
2. Has a risk management process been an integral part of the project/program since its inception and were early identified risks mitigated directly through tasks integrated into the project/program plan?
3. Are risk descriptions clearly articulated with descriptions of the potential impact to the project/program, i.e. If X occurs the impact will be Y?
4. Have risk mitigation steps that strive to reduce the risk level been identified for each risk area and incorporated into the project/program plan.
5. Are project/program and technical risks continually tracked, reassessed and closed out when complete across the lifecycle in accordance with NUWVDIVNPT Risk Management CONOPS? Are those risks regularly communicated with stakeholders?
6. Are hazards IAW MILSTD 882 identified and communicated to the program office and have hazard mitigation steps been identified for each safety risk?

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Assessment Process Criteria Component questions

6. **Configuration Management**

1. Have Configuration Items (CI) and products been clearly identified and base lined to an appropriate level?
2. Is a configuration management process used to identify and track CI documentation and software across the lifecycle, and are project personnel trained in this process?
3. Is an appropriate change control methodology in use?
4. Is an effective configuration audit system being utilized to ensure the functional and performance attributes of the CIs are achieved? Are Functional and Configuration Audits incorporated into the project/program plan?
5. Do project plans and schedules take CM requirements into account (documentation review and approval, audits, data base support, etc.)?

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Assessment Process Criteria Component questions

7. **Design Solution**
    1. Has a Functional Analysis been performed at the system level (Object Oriented Analysis for software; structured analysis for context/data flow diagrams)?
    2. Has the allocation of functions have been addressed explicitly throughout the design process?
    3. Has the architecture been defined and documented?
    4. Have Design Alternatives been analyzed and documented?
    5. Are Design Alternatives and implementation well defined considering impact on performance, cost, and schedule?
    6. Has lifecycle planning been evaluated and documented?

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Assessment Process Criteria Component questions

8. **Interface Management**

1. Are all interfaces identified for the product, components or system (including both internal and external interfaces) and documented such as in architecture or functional diagram?
2. Do interface designs exist and have the design documents been presented to appropriate personnel and organizations?
3. Have methods and verification events been established to ensure complete compliance for all interfaces?
4. Is a process in place for reviewing and processing interface changes across the lifecycle?

Assessment Process Criteria Component questions

9. **Development and Production**

1. Has the production representative system been built and evaluated to determine that it correctly and completely implements all system requirements?
2. Has production planning demonstrated acceptable level of risk for schedule, performance, cost, or other relevant criteria? Have long-lead items been identified and included in the production planning?
3. Have manufacturing processes, the Quality System, and production capabilities been reviewed as to provider's ability to deliver?
4. Have appropriate activities (monitoring, testing, etc.) to ensure production compliance with all requirements been established and agreed to?
5. Does system design incorporate unjustified sole-source, sunset or proprietary components?

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Assessment Process Criteria Component questions

10. Integration Plan

1. Does the integration approach address a reasonable progression from component level to system level integration events?
2. Does the integration approach address interoperability requirements with systems developed and maintained externally to the program?
3. Does tasking (including contracts) include requirements for integration tests and verification with external interfaces and subsystems?
4. Does the project integrated master plan accurately reflect the time and resources for integration events?

11. Verification and Validation

1. Does the project/ program have a documented test plan and strategy that reflect an appropriate level of V&V test events at the component, subsystem and system levels as well as formal DT and OT events or product acceptance tests?
2. For products or projects/programs using incremental builds, has a regression testing approach been developed to insure the baseline capability is maintained?
3. Have testing limitations been identified and evaluated relative to the operational modes or in-service conditions for the system?
4. Is a process in place to ensure that all acceptance and design verification testing are performed with calibrated measurement equipment and have the quality and pedigree of test tools been evaluated? If test tools or facilities require certifications are they complete and current?