SYSTEMS ENGINEERING
Research Center

Modular Reconfigurable Architecture for Tailored Rapid SE Artifact Generation and Dissemination

Technical Report SERC-2010-TR-011-1

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1 Purpose/Scope

As projects become increasingly complex, the need for good systems engineering is paramount. Part of systems engineering is documentation of past events, current activities, and future plans of software, hardware, and technical management. Documentation of the program's technical plans can require significant effort to keep current and to keep the content synchronized in an environment where change is constant. Add to this issue the fact that many documents have overlapping information and you have additional complications. This often results in the documents becoming obsolete relative to fast moving development activities and can create inconsistencies across the project. The objective of this research was to investigate the ability to align systems engineering (SE) documents such that the program documents track and complement one another, are easier to produce and update, support agile environments, and move towards a data centric rather than document centric focus. The documents that were evaluated for this task were the Systems Engineering Plan (SEP), Test and Evaluation Master Plan (TEMP), and the Information Support Plan (ISP). The tool utilized to assist in this research work was the Systems Engineering Toolkit (SET) developed by the Rotorcraft Systems Engineering and Simulation Center (RSESC) at the University of Alabama – Huntsville.

2 Applicable Documents

The following were the documents or guidance that were used or referenced as a part of this research:

- Department of Defense Instruction (DODI) Number 4630.8, Procedures for Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS), June 30, 2004.
- Defense Acquisition Guidebook (DAG), Traditional Information Support Plan, Defense Acquisition University.
- Department of Defense (DoD) Enhanced Information Support Plan (EISP) Guidebook Version 2.0, November 16, 2009.
- Department of Defense Systems Engineering Plan Preparation Guide Version 2.01, April 2008.
- Defense Acquisition Guidebook Annex, Test and Evaluation Master Plan.

3 SET Tool Background

The SET was originally created to assist in the development of SEPs. The hope was to create a tool that assisted programs in building their technical planning documents so that more time could be spent planning verses creating a document. The tool takes the administrative work such as the creation of table of contents, formatting, building of acronym lists, and the numbering tables and figures out of the writers' hands thus allowing concentration on the information required by the document. The beta version of the tool was released in June of 2007 with version 1.0 being released in March of 2008. An updated version is anticipated in early 2011.

Additional research is ongoing to further develop the tool and capabilities to create a family of systems engineering documents with funding from NAVAIR, DoD, and NASA Marshall Space Flight Center.

3.1 SET Tool Overview

The University of Alabama in Huntsville/Rotorcraft Systems Engineering and Simulation Center developed a web-based systems engineering plan generation tool. It is part of an overall systems engineering toolkit. This tool was designed to assist a program's technical planning. The output product is a systems engineering plan (SEP) which documents the systems engineering processes of a program per guidelines established by the Office of the Under Secretary of Defense. The SET allows technical experts to document the systems engineering tasks in their area of expertise simultaneously thus increasing the overall productivity and effectiveness of the planning process.

The tool is a web-based systems tool with data fields that present content pertinent to the type of program and the phase of the program generated from a database. Tight configuration management is maintained by the fact that data may only be modified from within the web-based tool and all changes to data fields are captured in a change log associated with the project. SET does not require any installations on the user's computer thus allowing access in many environments. The SET compiles user input into systems engineering documents such as the SEP. These outputs are presented as compiled PDF documents that may be reviewed by the project team members, upper management or the appropriate approving authority outside the SET to support existing document review processes. The SET also provides an integrated review process that to track all comments submitted and to allow reviewers to know the status of the plan at any point. The tool automatically generates the table of contents and many of the tables within the document that can be time consuming for the writers.

The web-based feature enables different personnel to work on the document in their specialized areas without worrying about latest versions, formatting issues, configuration management or having the bottleneck of one sole figure that is responsible for incorporating all the sections and variations. Avoiding this bottleneck allows the document preparation process to be more efficient. The modularity of the tool allows it to be tailored to many types of documents and projects. Multiple users may access the tool to write or review the documents at the same time. The managers and reviewers may also know at any point the status of the document by utilizing the status indicators.

The tool enhances the communication process which is a crucial role in systems engineering. Messages may be sent from within the tool and are displayed within and outside of the tool for writers in preparation of the document as well as reviewers and approvers in overseeing the document. Another communication enhancement is the capability to log into the SEP at any time to see the present status and items that have been modified within the documents.

Some of the key features of the web-based tool are as follows:

1. Configuration management with global access
2. Multiple users on different sections at any given time
3. Secured and controlled access (account required)
4. Modular based software designed to meet different program office's needs
5. Internal mapping capabilities to assist users when moving from milestone to milestone or if there are updates to the guidance
6. Integrated creation and review process available to speed the planning process and documentation creation time
7. Can create consistency across numerous documents
8. Integrated communications tools
9. Foundation for metrics and statistical analysis
10. Ability to upload images and appendices
11. Up to date dynamic knowledge on the status of the program's systems engineering documentation by any of the teammates
12. Ability to cross program lines when dealing with systems of systems or family of systems SEPs
13. Ability to create multiple types of documents containing the same or dependent content using SET's mapping capabilities to increase consistency and efficiency
14. Preset tailoring of the SEP depending on program ACAT level or program phase
15. Tailorable tool
16. Conformity to the guide therefore creating a simpler review process
17. Ensures the entire lifecycle is addressed therefore it can be more thorough
18. Instant feedback to the writers and reviewers
19. Reference and example data fields

Future enhancements to the toolkit include research into linkages to other programmatic and acquisition type documents. This may include such things as acquisition strategies, Test and Evaluation Master Plans, Interface Control Documents, Capability Production Documents, and team charters, eliminating redundant efforts and ensuring that the information in the documents agree and are consistent with one another.

Other linkages may be created with the Systems Engineering Management Plan (SEMP) that is developed by the prime contractor and possibly the work breakdown structure (WBS) and request for proposal (RFP) generation.

As seen from this research there are many ways for growth in making the technical planning for a program more efficient. It also begins to open the door for developing complex systems, SoS and FoS programs. This is one of the many ways to improve the overall aspects of the technical planning of a program and move the documentation process along into the generation of platforms.

Figures 3-1 to 3-5 are screen captures of the user interface and various features that the SET offers. Further details on the tool can be found in the SET Quick Start Guide located in the appendix of this document.

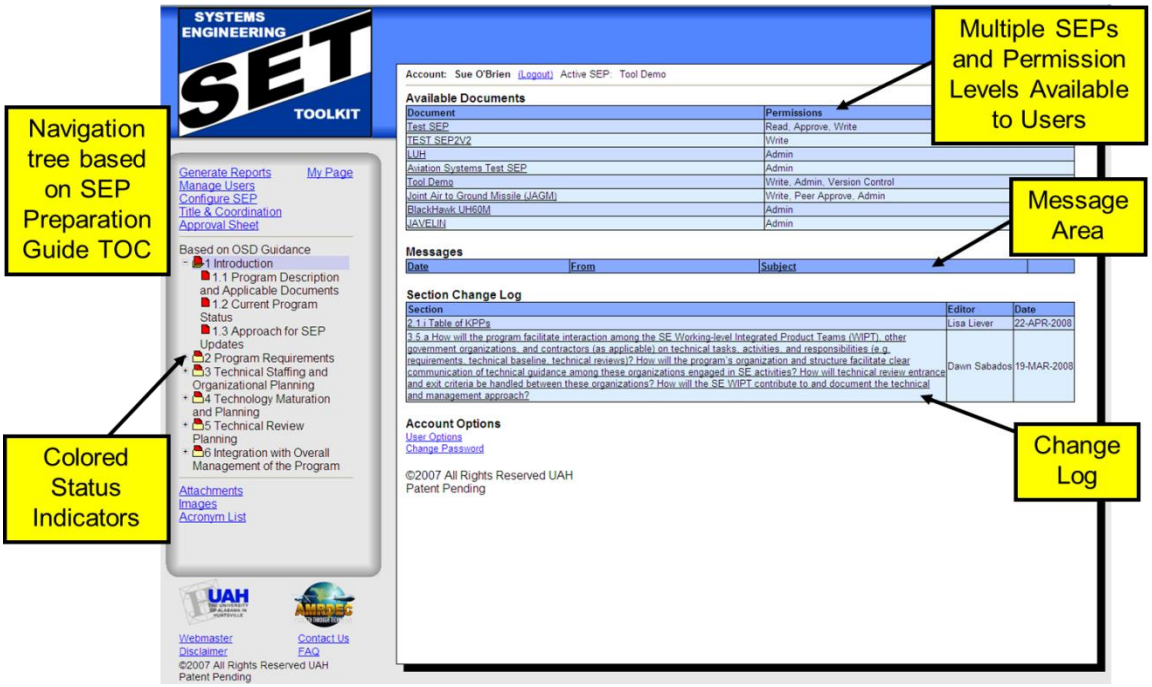

Figure 3-1. SET Navigation Screen

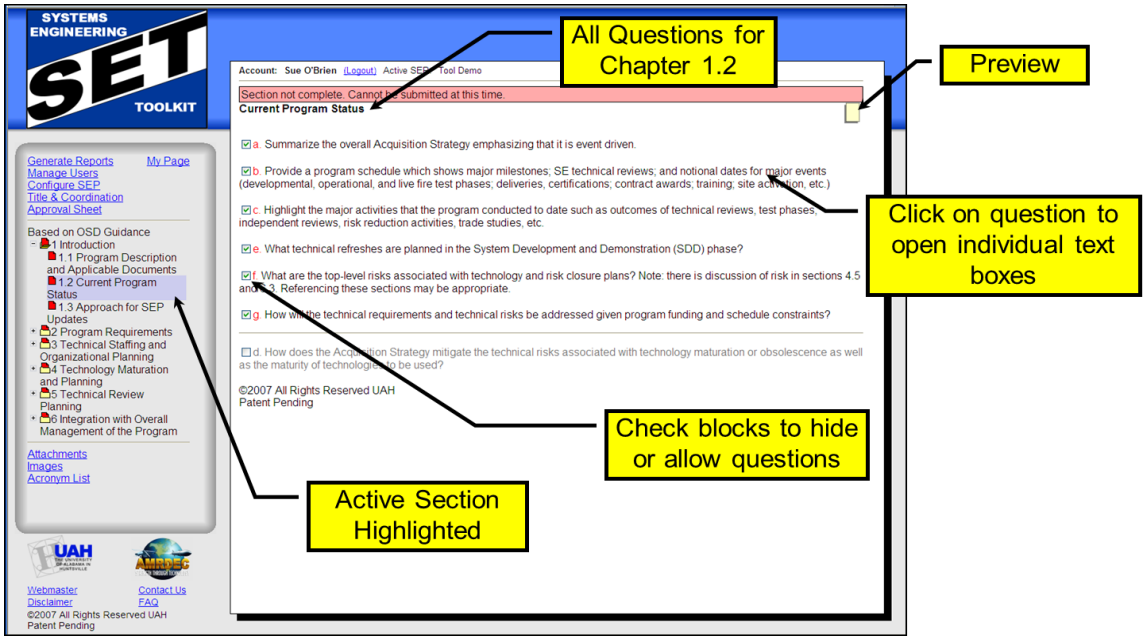

Figure 3-2. Project Information Entry by Section

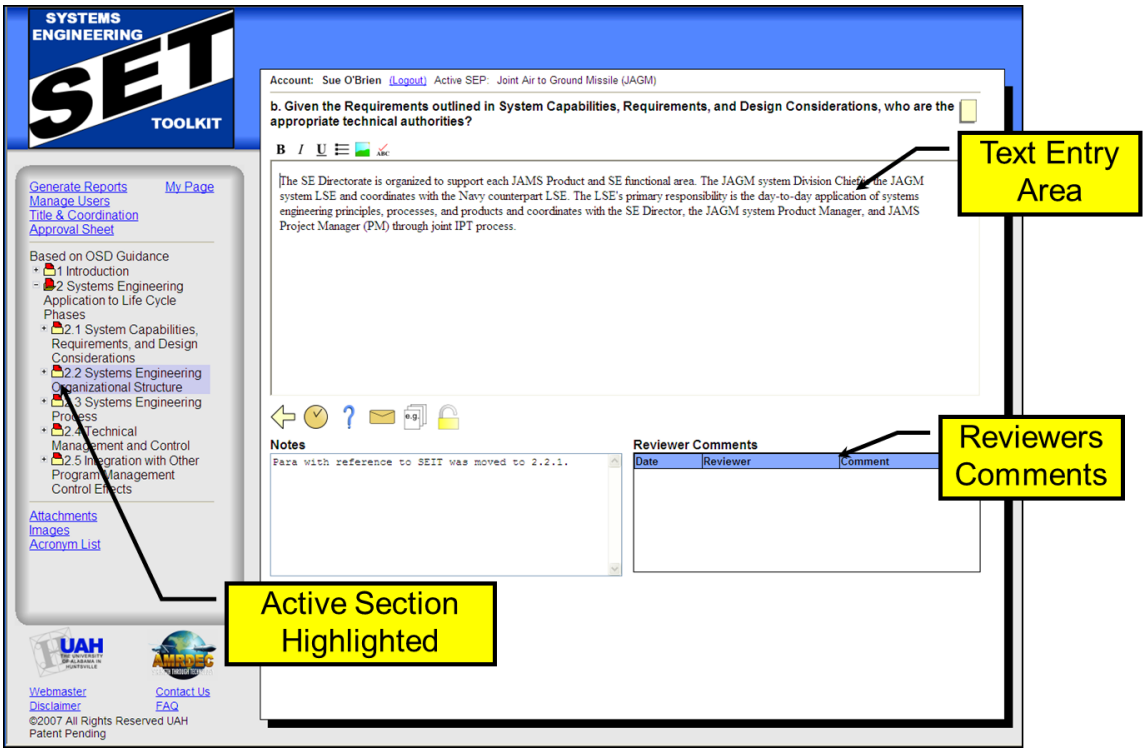

Figure 3-3. Individual Question View

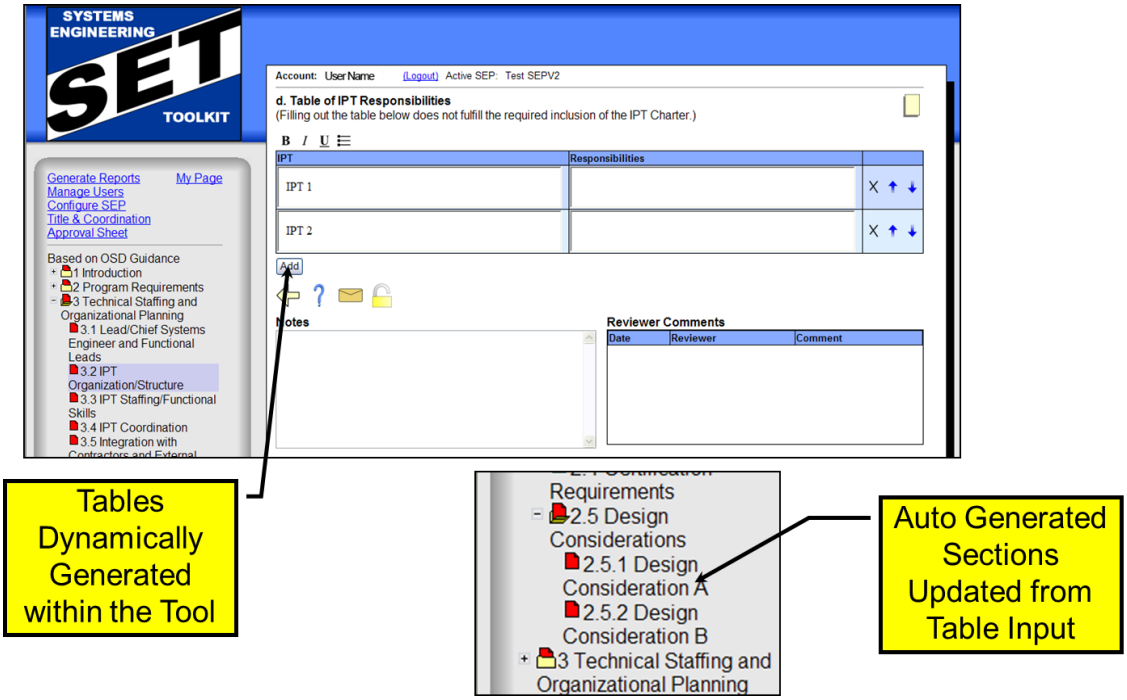

Figure 3-4. Dynamic Table Entry

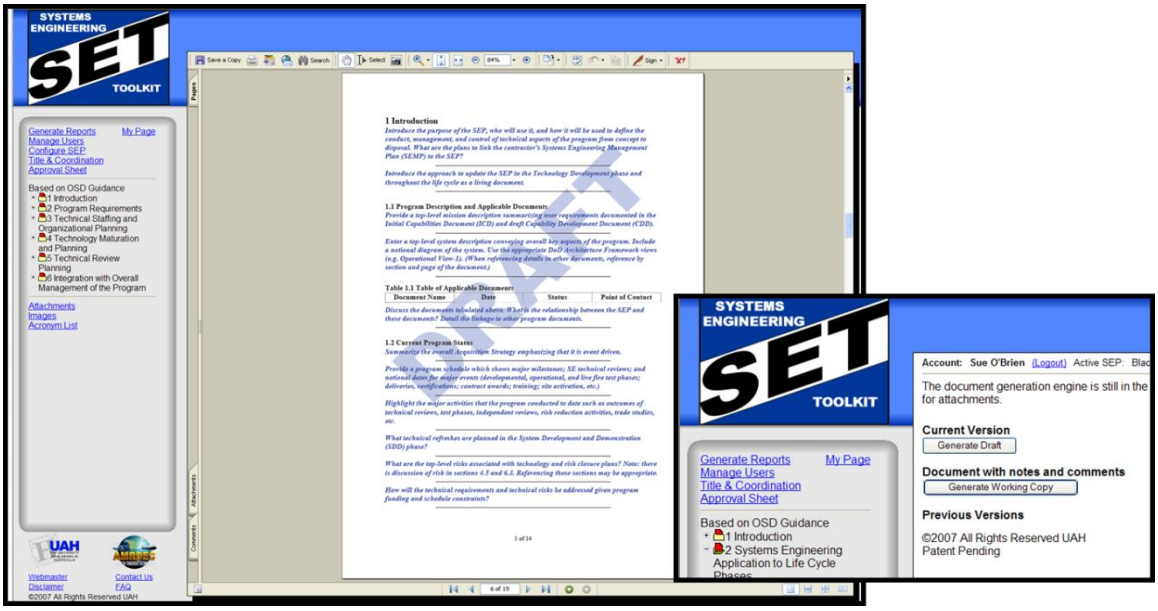

Figure 3-5. Generation of Draft or Working Copy of Report

SET provides eight types of users allowing customized document generation and review process that works for your organization. Users may be assigned multiple roles to allow greater flexibility within the tool. Available user roles are as follows:

- Reader – Lowest level of permissions, only able to generate document
- Writer – User populates the document
- Reviewer – Reviews the document at an inquiry level
- Peer Reviewer – Reviews the document at an inquiry level (Note: Peer roles do not effect document processing, inputs are merely advise).
- Approver – Approves the document at the section level
- Peer Approver**Error! Bookmark not defined.** – Approves the document at the section level
- Version Controller – Final approver of the document, one person
- Administrator – Sets up user roles, document type, etc.

An illustration of the document development and internal review process capabilities can be found in the Figure 3-6.

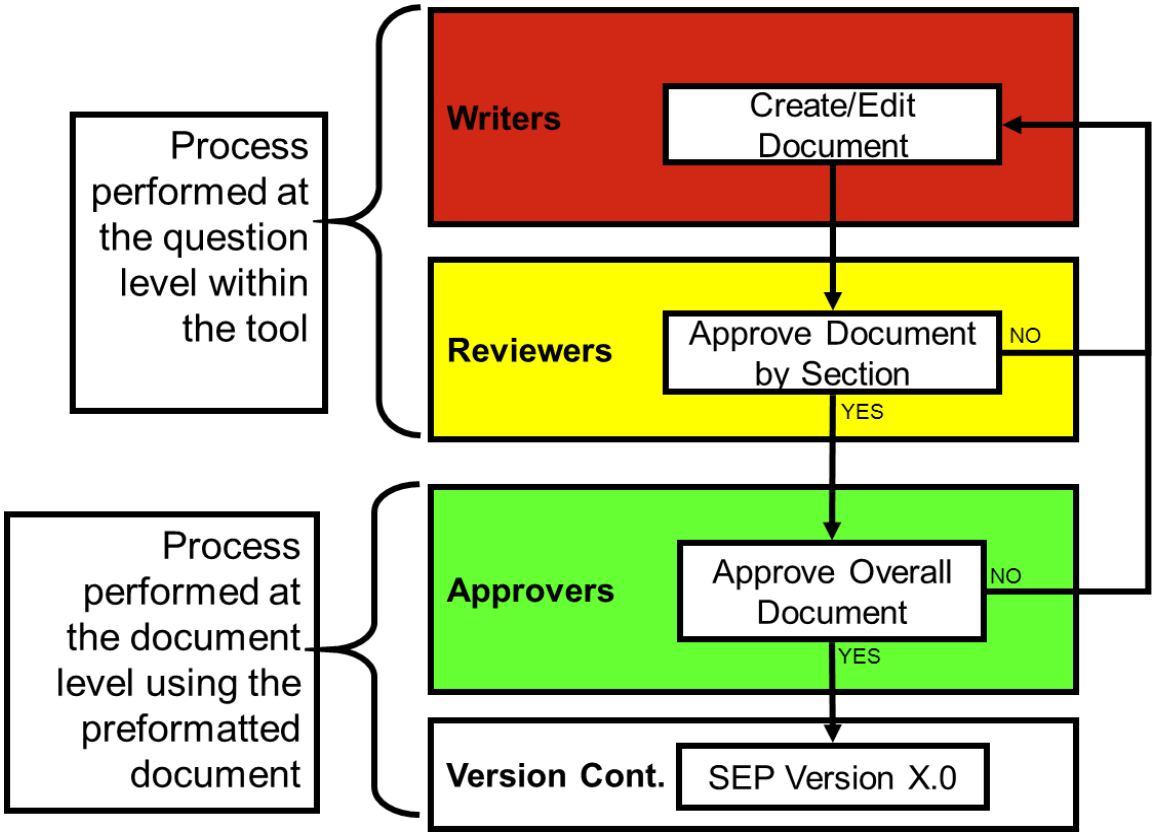

Figure 3-6. Document Development and Internal Review Process Capability

An additional feature of the tool that is hidden to users is the mapping and tailoring aspect. As guidance is updated, the tool's internal mapping process can update a user's document to a newer set of guidelines automatically to ensure that the program's documents reflect the latest guidance or policy. Figure 3-7 is an illustration of how complex this process can be for a user. By having the tool automatically update the documents, it saves time for the planners such that their time is used for planning verse modifying a document or trying to figure out the changes. The tool maintains the older versions of guidance at all times in cases where an organization is not ready to move to the new guidance or is not required to update the document. This mapping capability is also used as a program progresses through the lifecycle, when a program moves between milestones, the contents within the documents are automatically updated to reflect the next Milestone, and pertinent text is flowed forward as shown in Figure 3-8 when desired.

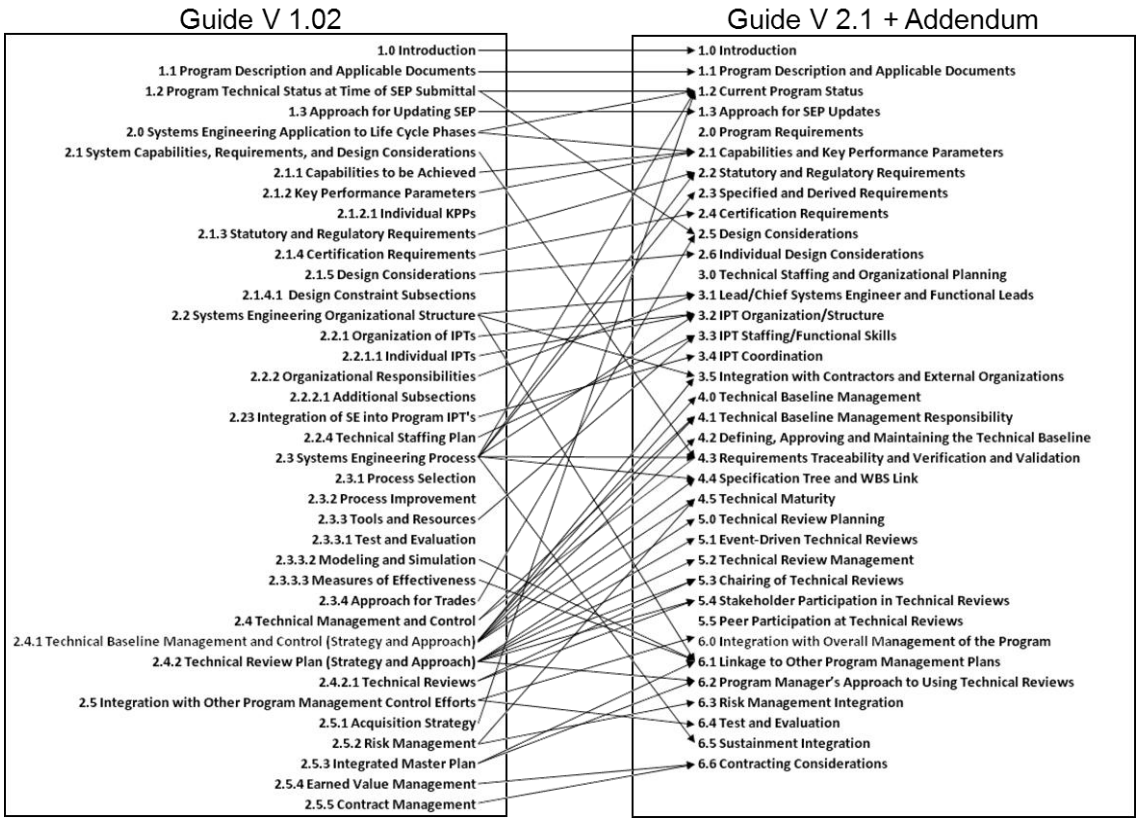

Figure 3-7. Guidance Updates

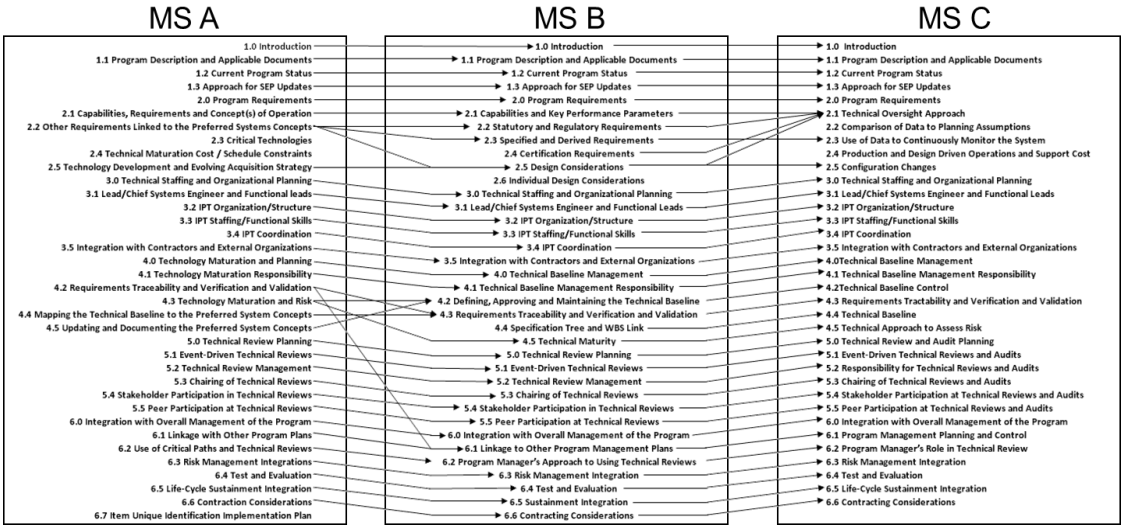

Figure 3-8. Milestone Mapping

4 Research Methodology

The following definitions will assist in understanding the research methodology:

- Correlated Information - Duplicate topic information found in more than one document with only one governing entity. A governing entity can be a document or role filled by personnel as clarified below.
  - Governing Document - Topic areas are dependent on specific documents such as the SEP, TEMP, ISP, etc., not necessarily a particular role or SME. The governing document controls the content and changes to that content for a subject area. (Generic roles: reader, writer, reviewer, approver, version controller)
  - Governing Role - Independent topic areas and not governed by a specific document. This information would be changed by preapproved individual roles. Changes to the information are not governed by the document. (Specific Roles: PM, LSE, SMEs, Logisticians, etc.)
- Dependent Information
  - Level 1: High level details about a topic area. An overview on how processes will be handled. Should be consistent with Level 2 information.
  - Level 2: Lower level more specific information that falls in line with the Level 1 information but has much more detail specifics.

Three documents were identified for this research: SEP, TEMP, and ISP. The first step was to understand the information that each document required by creating a modular architecture for each one. From this, high level topic areas were generated for each document from the guidance or policy. Then a commonality matrix was created between the topic areas to understand common themes. Further analysis was then performed on the high level topic areas to determine whether the topic area information was dependent or correlated information. The next step was to classify the dependent information as Level 1 or Level 2.

A commonality table of contents was generated that merged these modular architectures where possible in order to investigate the linkages and dependencies across the documentation. Each document topic area was mapped to the new table of contents noting what sections or topic areas were not mapped. The topics in the commonality table of contents assisted in determining the governing document as well as the governing role. Based on the governing document, the dependent information was evaluated as to which document contained the level 1 information while which document had the level 2 information. Once completed, a methodology for utilizing the results in the most effective manner was developed to allow better change management, maintain consistency, and leverage the modularity. The final product was built on existing capabilities of the SET developed by RSESC.

5 Results/Discussion

The research began by reviewing the guidance for each of three key SE documents: SEP, TEMP, and ISP (as listed under applicable documents). Based on the topics presented in each of the documents, a new table of contents (commonality table of contents) was developed that encompassed areas of overlap between 2 or more documents. The analysis was performed from two complimentary directions. One way in which the data was investigated was by looking at the topic areas noting the amount each document that overlapped with another document. The second approach was to assess each document's table of contents how they mapped into the topic areas. An example of a topic area would be Mission Need or Previous Testing. In regards to the Mission Need, it was identified as a topic area located in all three documents while Previous Testing was common to only the TEMP and SEP. The final analysis showed the section titles, topic areas and mappings of the documents to different topic areas. An example is presented in Table 5-1. The results were that a large portion of each document mapped into the commonality table of contents. There were seventy-six topic areas that were in common between at least two of the three documents. For example, the SEP had fifty-two topic areas that were in common with another document or sixty-eight percent of the document was in common with another document. Note: Commonality means the information was either correlated information or dependent information. A break-out of each document is presented in Table 5-2. When examining the table of contents for each of the three documents, greater than 55% had commonality as presented in Table 5-3. Number of orphan sections refers to the sections that were specific to a document. For instance, live fire test and evaluation approach or TEMP updates is only discussed in the TEMP, therefore these sections would be considered orphans. The results for the ISP were more difficult to evaluate because there was more than one document that guides the development of an ISP. A rough table of contents was developed based on the guidance and an example ISP that was provided.

Table 5-1. Mapping Results

Topic Areas	Level	Governing Entity	TEMP Section	SEP Section	Milestone	ISP (DODI/DAG)	ISP Example
Mission Need	1	Role Based/SME	1.2	2	A, B, and C	2.1	2.1
Supported Capability	2	Role Based/SME				2.2	2.2
OV-1 Showing the operational environment	1	Role Based/SME	1.2	1.1	A, B, and C	1.1	1.1
Organizations which the system will be integrated (if applicable	1	Role Based/SME	1.2	3.5	A, B, and C	1.1	1.1.1
Role Definitions	2	Role Based/SME				1.3	1.3
Business Case	1	Role Based/SME	1.2	1.1	A, B, and C		
System Description and Configuration	1	Role Based/SME	1.3	1.1	A, B, and C	1.1	1.1
Key features	2	Role Based/SME	1.3	1.1	A, B, and C	1.1	1.1
Required Capabilities	2	Role Based/SME				2.4	2.4
Threat Environment	1	Role Based/SME	1.3.1	1.1	A, B, and C	1.1	1.1
Analysis of Alternatives	1	Role Based/SME	1.3.2	4.4	A	Appendix A refers to it	Touches on this in 1.1.1 and 1.3.2.1 but no big discussion

Table 5-2. Commonality Mapping

Document	Topic Areas with Commonality	Percent Commonality
SEP	52	68%
TEMP	49	64%
ISP (DODI/DAG)	21	28%
ISP (Example)	24	32%

Table 5-3. Table of Contents Mapping

Document	Total Number of Sections	Number of Orphan Sections	Number of Sections with Common Information	Percent Common
SEP MS A	29	10	19	65.5%
SEP MS B	29	11	18	62.1%
SEP MS C	29	13	16	55.2%
TEMP	57	26	14	56.1%
ISP (DODI/DAG)	23	9	14	60.8%

Figure 5-1 is an illustration of the mapping between the TEMP and SEP. This is an example just between two but it was completed on all three documents.

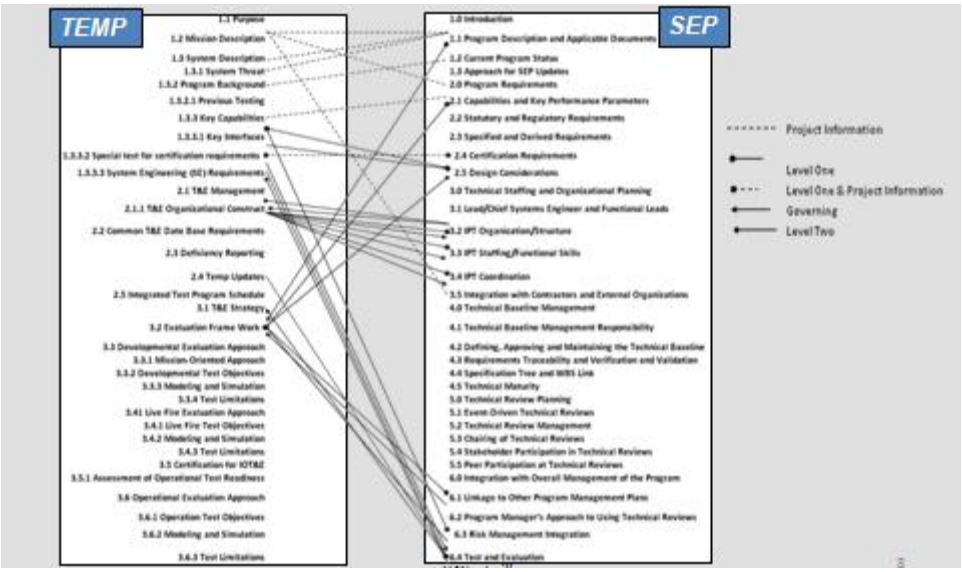

Figure 5-1: Document Mapping Example

As this mapping progressed, a preliminary determination was made to answer such questions as which document governs this information, is this information governed by a role such as project manager, or how detailed does your document need to be in relation to other documents that discuss the same information. A sample of the results is presented in Table 5-1.

As part of the research task a project based system was developed for managing the data as discussed for the three documents. A semantic data model was developed that allowed the creation of project schemas in terms of concepts and their relationships. After the creation of a schema, the system allows for the creation of a project that conforms to a particular project schema. In order to map the data into a form that matches the format of the SEP, TEMP, and ISP, a modular, node-based presentation system was developed for specifying transformations of projects into a document like format. A role-based permission system was implemented that allowed for tailorable sets of permissions that could be selected based on the user's organizational needs. Permission assignment was implemented at both the project schema level and the presentation node level. A web-based AJAX user interface was developed that allowed the user to edit the project's underlying data using the document-like format produced by the presentation system.

As the team began to discuss these results, questions arose about how to make the modular database function effectively. Migrating to a modular database could increase efficiency, synchronization, and consistency across multiple documents. How can a program become data centric rather than document centric? The answer that came out was to be more role based. Evidence showed various subject matter experts are needed within a project and can vary between milestones (chief engineer, lead system engineer, project manager, test lead,

logisticians, etc.). Research on these three documents showed topic areas that SMEs govern and are co-located in multiple documents. The method for utilizing this information is to develop a set of topics that are specific to each SME. Principal writers or SMEs are selected for the predetermined topic areas. Each SME would access the SET and be able to select a meta document which is tailored to their area of expertise. This governing information is then made available to the pertinent documents that have been mapped to the information. (This information could be pulled from already written documents within the tool, require newly developed information or a combination of the two.). An example is presented in Figure 5-2. The results would be that if a user were to access the tool to write a TEMP, they would pull the TEMP template and any information that has already been written by the principal writers or SMEs would already be populated into the document. The only topics to be answered are the areas that are specific to that particular document. A schematic is presented in Figure 5-3. Some of the benefits from this methodology are:

- Reduces the time necessary to complete a document
- Ensures that common information between documents is consistent
- As information is updated by principals or SMEs, all documents are updated
- The review process could go faster because much of the information has been supplied by principals or SMEs who are often also a reviewer to large sections of the document
- Documents can be frozen and version controlled at each milestone

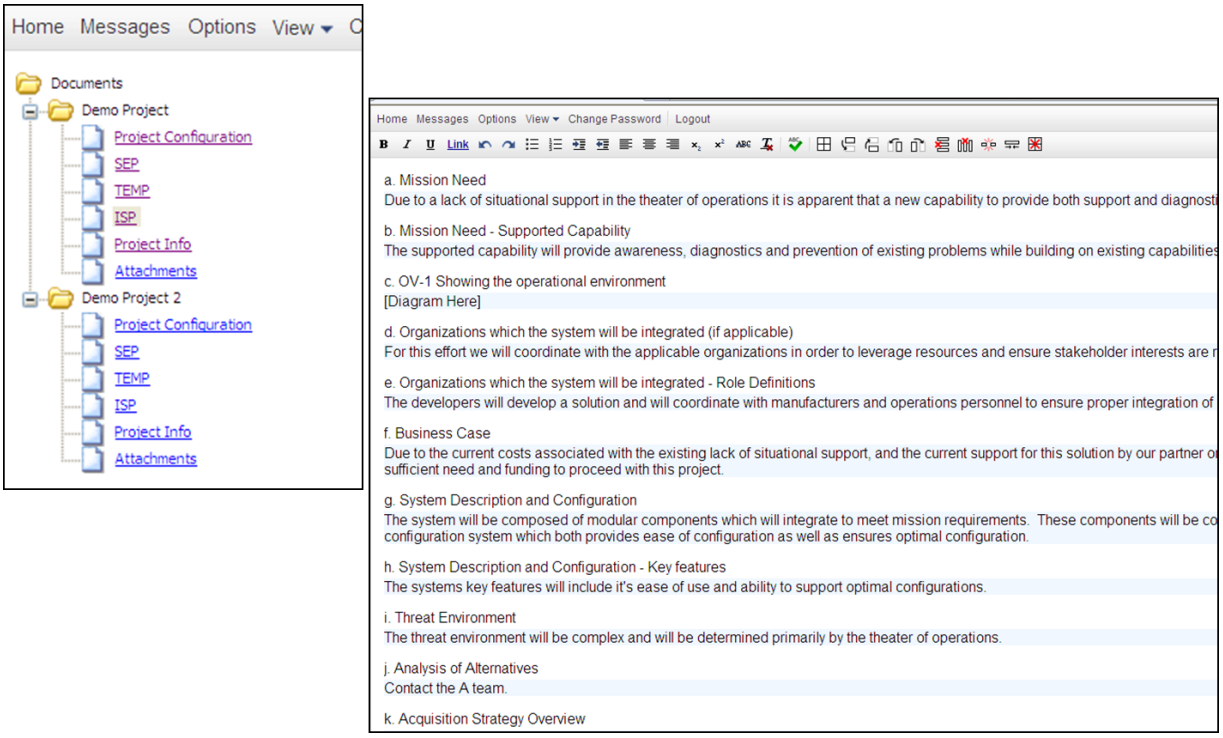

Figure 5-2. Example SME Information Request

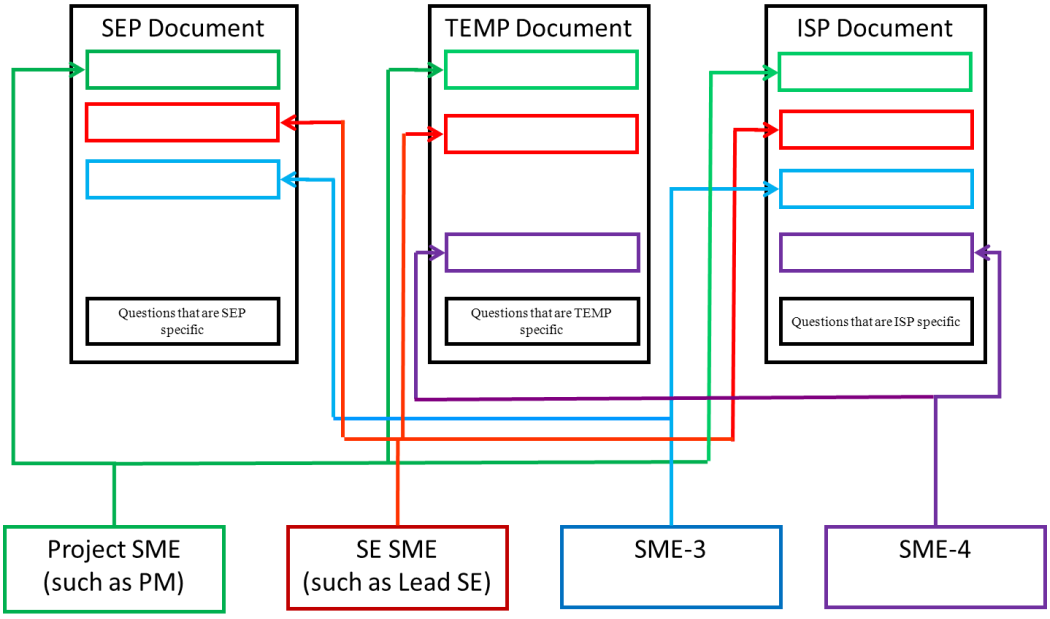

Figure 5-3. Role Based Data Entry

There are disadvantages to this methodology in that different people have different writing styles. This can be very evident when evaluating the completed document. Also, it can make the final document not read as smoothly as when a single person is the writer. Both of these issues could be handled by using a technical writer that could assist in creating a more readable document. Precautions would need to be taken so the technical writer did not alter core information supplied by the principals/SMEs. Also, it would take a little time to get all users involved comfortable in their roles and understanding the process. The thought is that the advantages outweigh these issues.

6 Conclusions

The research presented showed that using a data-centric modular database for creating program documentation is feasible and could be beneficial. Evidence was found that there are dependencies and correlations between the three documents. The automated mapping function, database capabilities, statistical and data collection methods designed within the SET tool allow both role based and document based planning. It also provides both a testbed environment and implementation tool for users.

7 Future work

Based on these results, there are several topics for future. Determining a higher fidelity of the topic areas and information requests would be one area while further defining and finalizing the level 1 and 2 mappings. Advancing the documentation process as well as determining roles and governing entities would take this research to the next level.

Appendix A: Topic Areas

1. Mission Need
    a. Support Capability
2. OV-1 showing the operational environment
3. Organizations which the system will be integrated (if applicable)
    a. Role Definitions
4. Business Case
5. System Description and Configuration
    a. Key features
    b. Required capabilities
6. Threat Environment
7. Analysis of Alternatives
8. Acquisition Strategy Overview
9. Previous Testing
10. KPPs, KSAs
11. Key Interfaces
    a. System interfaces
    b. External interfaces
    c. Risk interfaces
    d. Interface control agreements
12. System Architectures that are required for mission accomplishment
    a. Inconsistencies
13. Certification Requirements
14. Unique System Characteristics
    a. Special tests
15. SE Requirements
    a. Relative to Test and Evaluation
16. Test and Evaluation Responsibilities
    a. Initial Operational Test and Evaluation
17. IPTs and WIPTs
    a. Technical authority
    b. Structure
    c. Staffing
    d. Coordination
    e. Integration with contractor and external organizations
    f. ISE IPT details if there is an ISP IPT or WIPT
18. Modeling and Simulation
    a. SEP Specific
        i. Tools
        ii. SE

        iii. Analysis
        iv. V&V
        v. Requirements
        vi. T&E
        vii. Life cycle
    b. TEMP Specific
    c. ISP Specific
19. Method for Collecting, Validating, and Sharing Data
    a. SE Specific
    b. TEMP Specific
    c. ISP Specific
20. Data/Information Flow
    a. TEMP Deficiency Reporting
    b. Data Quality Requirements
    c. System Data Exchange
    d. Data Timeliness
    e. Information Access
21. Integrated Project Schedule
    a. Funding Summary
22. Correlation Matrix Between KPP/KSA, MOE, MOS, CTPs
    a. MOES and MOS
    b. Traceability
23. Approach for Evaluating System Process and Maturity
24. Risks
    a. System
    b. Process
25. Critical Technical Parameters
26. Logistics
    a. Resources
    b. Special Requirements
27. Sustainment
28. T&E Strategy
29. Evaluation Framework
30. Interoperability Requirements
    a. Supporting Systems
31. Configuration Differences between Current System and System to be Fielded

Appendix B: SEP Orphan Topics and Common Themes

Milestone	Section	Title
A	1.3	Approach for SEP Updates
	2.5	Technology Development and Evolving Acquisition Strategy
	4.1	Technology Maturation Responsibility
	5.1	Event-Driven Technical Reviews
	5.2	Technical Review Management
	5.3	Chairing of Technical Reviews
	5.4	Stakeholder Participation in Technical Reviews
	5.5	Peer Participation at Technical Reviews
	6.2	Use of Critical Paths and Technical Reviews
	6.6	Contracting Considerations
B	1.3	Approach for SEP Updates
	2.2	Statutory and Regulatory Requirements
	4.1	Technical Baseline Management Responsibility
	4.4	Specification Tree and WBS Link
	5.1	Event -Driven Technical Reviews
	5.2	Technical Review Management
	5.3	Chairing of Technical Reviews
	5.4	Stakeholder Participation in Technical Reviews
	5.5	Peer participation at Technical Reviews
	6.2	Program Manager's Approach to Using Technical Reviews
	6.6	Contracting Considerations
C	1.3	Approach for SEP Updates
	2.2	Comparison of Data to Planning Assumptions
	2.4	Production and Design Driven Operations & Support Costs
	3.1	Lead/Chief Systems Engineer and Functional Leads
	4.1	Technical Baseline Management Responsibility
	4.4	Technical Baseline

Common Themes	Milestone and Section
SEP Updates	1.3 of A, B, and C
Roles and Responsibilities	4.1A and B and C
Reviews	5.1 - 5.5A and B and C
Contracting	6.2 B and C 6.6A and B and C

Appendix C: TEMP Orphan Topics

Section	Title	Description
1.1	Purpose	
2.4	TEMP Updates	
3.3.1	Mission-Oriented Approach	Evaluate mission performance in a mission context (focuses on how the system will be employed)
3.3.2	Developmental Test Objectives	Summarize the planned objectives and stat the methodology to test the system attributes defined by the appicable capability requirement document
3.3.4	Test Limitations	
3.4	Live Fire Test and Evaluation Approach	
3.4.1	Live Fire Test Objectives	
3.4.2	Modeling & Simulation	in terms of life fire
3.4.3	Test Limitations	
3.6	Operational Evaluation Approach	Independent evaluation of the system
3.6.3	Test Limitations	
3.7	Other Certifications	
3.8	Reliability growth	
4.1.1	Test Articles	Actual number and timing
4.1.2	Test Sites and Instrumentation	
4.1.3	Test Support Equipment	
4.1.4	Threat Representation	
4.1.5	Test Targets and Expendables	
4.1.6	Operational Force Test Support	
4.1.7	Models, Simulations, and Testbeds	
4.1.8	Joint Mission Environment	Live, virtual, or constructive components for an acceptable environment
4.2	Federal, State, and Local Requirements	environmental regs

Appendix D: ISP Orphan Topics

Chapter 1: Introduction	Project Info
2.3 Step 3: Determine the operational users and notional suppliers of the information needed.	
2.9 Step 9: Discuss RF Spectrum needs.	
2.10 Step 10: Perform a Net-Centric Assessment	
2.12 Step 12: Discuss the program's Information Assurance strategy and reference the Program Protection Plan.	IAS
2.13 Step 13: Identify information support needs to support development, testing and training.	
Chapter 3 - Issues	
Appendix D. - Acronym List	ISP

Appendix E: ISP Example Orphan Topics

(U) EXECUTIVE SUMMARY		
1	(U) INTRODUCTION	
1.1.2	(U) Relationship to Other Programs	
1.1.3	(U) Relationship to Relevant Joint Functional Concepts (JFCs), Joint	
1.1.3.1	(U) Joint Functional Concepts	
1.1.3.2	(U) Associated Integrated Architectures	
1.1.3.3	(U) JCIDS	
1.2	(U) PROGRAM DATA	Current MS and Acquistion Status Integrated Master Schedule Increment I schedule Increment II schedule
1.2.1	(U) Milestone and Acquisition Status	
1.2.2	(U) Spiral Evolution Strategy	
1.2.3	(U) Program Points of Contact	
1.3.1	(U) Information Integrity	
1.3.2	(U) DoD PKI System Architecture	
1.3.2.1	(U) DoD PKI Certificate Management Components	
1.3.3	(U) Role Definitions	
1.3.4	(U) PKI System Interface Overview	
1.4	(U) ISP DOCUMENT STRUCTURE	
2	(U) ANALYSIS	
2.3	(U) STEP 3 - DETERMINE OPERATIONAL USERS AND NOTIONAL SUPPLIERS	OV-4 Organizational Relationship Role Overview
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2.10.7	(U) Step 10-G Net-Ready Key Performance Parameter (NR-KPP) Statement
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