15th ICCRTS

The Evolution of C2

Paper Title: *Program Element Analysis*

Topics: 1: Concepts, Theory, and Policy
Alternate: 5-Experimentation and Analysis & 8-C2 Assessment Metrics and Tools

Authors:
1. Mr. James Porter,   U.S. joint Forces Command (USJFCOM),
   Joint Systems Integration Center (JSIC),
   Deputy Director, C2 Analysis (C2A)
2. Ms. Laura Byrd,   USJFCOM, JSIC, C2A
3. Mr. David Perretta,   Booz Allen Hamilton, USJFCOM, JSIC, C2A
4. Mr. Jason Shreve,   Booz Allen Hamilton, USJFCOM, JSIC, C2A

James R. Porter **Laura T. Byrd** Joint Systems Integration Center 116B Lake View Parkway, Suffolk, VA 23435 Phone (757) 203-4035 Fax (757) 203-4102 James.poerter@jsic.jfcom.mil & Laura.byrd@jsic.jfcom.mil	**David A. Perretta *POC** **Jason B. Shreve** Booz | Allen | Hamilton 5800 Lake Wright Drive, Norfolk, VA 23502 Phone (757) 893-6100 Fax (757) 893-6150 Perretta_David@bah.com Shreve_Jason@bah.com

Point of Contact: Mr. David Perretta
U.S. Joint Forces Command - Joint Systems Integration Center
116B Lake View Parkway
Suffolk, VA 23435
(757) 203-4580
david.perretta.ctr@jsic.jfcom.mil

1. REPORT DATE **JUN 2010**	2. REPORT TYPE	3. DATES COVERED **00-00-2010 to 00-00-2010**	
4. TITLE AND SUBTITLE **Program Element Analysis**		5a. CONTRACT NUMBER	
		5b. GRANT NUMBER	
		5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)		5d. PROJECT NUMBER	
		5e. TASK NUMBER	
		5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Joint Forces Command,Joint Systems Integration Center,116B Lake View Parkway,Suffolk,VA,23435**		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)	
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)	

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Proceedings of the 15th International Command and Control Research and Technology Symposium (ICCRTS '10), Santa Monica, CA, June 22-24, 2010

14. ABSTRACT

The successful management of large portfolios of C2 systems and applications requires an understanding of programmatic data. The ability to extract and clarify programmatic data related to specific C2 systems or groups of C2 systems and codified as Program Elements (PEs) is complementary to any functional or capabilities-based C2 analysis. PEs are the basic components or building blocks of the Future Years Defense Plan (FYDP) containing all funding documentation. Analyzing PEs through repeatable analytic methods allows resource managers to better focus attention toward essential programs and associated funding lines. Further methodologies that can help develop fundamental programmatic baselines and accurately apply a tangible measurement of the alignment of PEs to specific focus areas provide critical assistance when making programmatic recommendations for Periodic Review (PR) and Program Objective Memorandum (POM) cycles. This paper discusses the general application of the PE analysis methodology as well as the specific application of the methodology to a test case. It covers several successful applications of the methodology as well as the challenges encountered and refinements to the original alignment processes. Methodology strengths and weaknesses are discussed, as well as possible venues for improvement before concluding with a proposed way ahead.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**13**	

ABSTRACT

The successful management of large portfolios of C2 systems and applications requires an understanding of programmatic data. The ability to extract and clarify programmatic data, related to specific C2 systems or groups of C2 systems and codified as Program Elements (PEs), is complementary to any functional or capabilities-based C2 analysis. PEs are the basic components or building blocks of the Future Years Defense Plan (FYDP) containing all funding documentation. Analyzing PEs through repeatable analytic methods allows resource managers to better focus attention toward essential programs and associated funding lines. Further, methodologies that can help develop fundamental programmatic baselines and accurately apply a tangible measurement of the alignment of PEs to specific focus areas provide critical assistance when making programmatic recommendations for Periodic Review (PR) and Program Objective Memorandum (POM) cycles. This paper discusses the general application of the PE analysis methodology as well as the specific application of the methodology to a test case. It covers several successful applications of the methodology as well as the challenges encountered and refinements to the original alignment processes. Methodology strengths and weaknesses are discussed, as well as possible venues for improvement before concluding with a proposed way ahead.

INTRODUCTION

U.S. Joint Forces Command's (USJFCOM) Joint Capability Development Directorate (J8) identifies near-and far-term joint, multinational, and interagency capability gaps and works with other combatant commands, the services, coalition partners, and agencies to fill those shortfalls with integrated capabilities. As the Joint Capability Developer (JCD), USJFCOM J8 advances warfighter effectiveness and improves combat capability by leading the development and transition of joint capabilities, architectures and technologies. USJFCOM has been assigned the Command and Control (C2) portfolio management responsibilities with USJFCOM J8 delegated the responsibility for day-to-day management of the C2 portfolio. Department of Defense Directive (DoDD) 7045.20 of 25 September 2008 established policy and assigned responsibilities for the use of Capability Portfolio Management (CPM). Assigned as the C2 Capability Portfolio Manager, USJFCOM J8 established a C2 CPM program satisfying the intent of the 2006 Quadrennial Defense Review (QDR) which stated that the DoD should strive to deliver integrated Joint C2 (JC2) capabilities, improve interoperability, identify and capture efficiencies, reduce capability redundancies and gaps, and increase Joint operational effectiveness. To maximize operational effectiveness in the Joint environment, the JCD synchronizes C2 portfolio management with the Combatant Commands (COCOMs), the Services, and applicable Agencies (C/S/A).

There are nine CPM areas which directly correspond to the nine tier one Joint Capability Areas (JCAs): Force Application, Command and Control, Battlespace Awareness, Net-Centric, Building Partnerships, Protection, Logistics, Force Support, and Corporate Management and Support. Complete JCA terminology is provided in two DoDDs (CJCS 2009a, CJCS 2009b) that

fully describe each capability portfolio. CPM areas are assigned to and managed by a variety of military and civilian agencies. JSIC's PE analysis provides alignment across all CPM areas and JCAs

In support of the JCD, the Joint Systems Integration Center (JSIC) conducts unbiased assessments of systems with existing and emerging C2 capabilities. Specifically, JSIC supports the JCD CPM responsibilities for C2 requirements, resourcing, and acquisition processes. JSIC assessments, which integrate programmatic data, include analysis of Program Elements (PEs), the basic building blocks of the Future Years Defense Plan (FYDP). Each line item in the defense budget is associated with a PE and PE number (PEN) and each PE falls into one of three broad categories: Research, Development, & Testing (RDT&E); Procurement; and Operations and Maintenance (O&M). In addition, each PE may be further divided into projects to provide more detailed insight into specific systems and applications. Developing methodologies which accurately locate and correctly interpret critical programmatic data contained within PEs is essential to JSIC's assessment and analysis roles in support of the JCD.

PE analysis provides mission-essential support to C2 CPM by helping to maintain an understanding of C2 systems and applications in the context of programmatic funding. Primary recipients of JSIC's PE analysis are the C2 CPM Focus Integration Teams (FITs), collaborative teams composed of C/S/A representatives. FITs are typically tasked with resolving capability gaps, synchronizing capabilities and programs, and mitigating portfolio risks. PE analysis can provide FITs with a clear vision of system specific program data, enabling them to make informed recommendations designed to mitigate functional overlap and capability gaps. In addition to use by C2 CPM FITs, PE analysis can benefit other Department of Defense (DoD) organizations that seek perspective on PE alignment to systems and across all CPM areas and JCAs.

To produce an informative and accurate analysis of publicly available PE data, JSIC has developed a rigorous, structured, and repeatable methodology. The methodology allows analysts to extract small numbers of PEs that relate to a specific system or application from large DoD and public access databases. Analysts then assess systems and applications contained within the selected PEs in the context of programmatic data and their alignment across CPM areas and JCAs. This paper describes the methodology in detail and discusses its successes and limitations as applied to the C2 On-the-Move (C2OTM) focus area and to USJFCOM J89 C2 CPM base-lining efforts. The paper concludes with a discussion of possible methodology improvements and a proposed outline for future support of additional CPM areas.

METHODOLOGY

JSIC's PE analysis methodology addresses three needs:

1. Identification of PEs and associated funding that are relevant to a particular CPM focus area

2. Identification of CPM focus area related funding within PEs

3. Alignment of CPM focus area related PEs across CPM areas and JCAs

PEs are, by their very nature and composition, extremely complex documents that represent all aspects of an immense DoD budget. There are over 6000 active PEs which contain tens of thousands of text pages. JSIC's methodology is designed to quickly isolate specific data within this database using a three-step mapping and analysis process. The steps are as follows:

1. Isolate small numbers of PEs which are directly related to a given focus area.

2. Examine funding within the selected PEs.

3. Clarify the PEs to determine their alignment across CPM areas and JCAs.

This process enables organizations responsible for CPM to focus analytical efforts on a meaningful subset of the overall data by providing an effective and repeatable method for identifying, dissecting, and understanding smaller units of programmatic data that relate to specific focus areas.

In Step 1, analysts perform searches across all PEs for systems, terminology, and comparative text that relate to a CPM focus area. To perform searches, JSIC analysts use a "Term Query" search engine function and to examine paragraphs of text relevant to the focus area of interest, a "Similar Text Query" function is used. Comparative Document Navigator (CDN) is one example of an internally created JSIC search tool commonly used by JSIC analysts. However, any moderately sophisticated search engine can be employed with the methodology. Verification of search results, or "hits", requires subjective human analysis to ensure accuracy and proper context. For some search results, especially results from contextual type searches, analysts must thoroughly examine individual PEs to determine the true context and validity of the hit. Once verification is complete, JSIC develops an initial list of PEs relevant to the given CPM focus area. In most cases, this list includes less than one percent of the total PE database.

In Step 2, analysts examine each valid hit within the smaller subset of PEs. Whenever possible, the analyst determines a complete quantification of each hit in terms of actual funding and then compares these figures with the overall funding value of the PE. Due to the internal complexity of most PEs, it is not always possible to determine an exact allocated funding amount. As in Step 1, subjective analysis is often required. Based on perceived confidence, analysts assign each hit a relevance score of 100, 50, or 25 percent. For example, a hit is assigned a relevance score of 100 if it is a system or includes terminology that is known, with a high level of confidence, to be closely related to a particular CPM focus area. Hits that are less clearly related to a particular CPM focus area may be assigned a relevance factor of 50 or 25 percent. Ultimately, the relevance scores are used as multipliers when quantifying each hit within a PE. Step 2 provides data that can be manipulated in a variety of ways to detail and quantify CPM focus area related funding contained in each PE. Figure 1 shows notional results of Steps 1 and 2 of the methodology.

PE XXXX782A - System X	
Total Program Element (PE) Funding	$1,413,926,780
Total All Focus Area (FA) Funding	$1,093,196,900
Total % of FA Funding in this PE	77.32%

C2 CPM Focus Areas	System / Terminology Hit Description (Associated Project Title)	Identified Funding	Rel Factor	Rel Value	Funding Value
C2 OTM	System X Increment 2 – Initial Networking-on-the-move (367)	$83,259,420	1	1	$83,259,420
	System X Increment 3 – Full Networking-on-the-move (372)	$1,009,937,480	1	1	$1,009,937,480

PE:		FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
TOTAL FY DOLLARS		$0.00	$0.00	$302,480,610.00	$272,543,310.00	$253,699,820.00	$214,629,490.00	$49,843,670.00
C2OTM	System X Increment 2 – Initial Networking-on-the move (367)	$0.00	$0.00	$61,260,870.00	$14,134,260.00	$7,864,290.00	$0.00	$0.00
	System X Increment 3 – Full Networking-on-the-move (372)	$0.00	$0.00	$241,219,740.00	$258,409,050.00	$245,835,530.00	$214,629,490.00	$49,843,670.00

Figure 1. PE XXXX782A (System X) Funding Related to C2OTM

The C2OTM FIT identified System X as a C2 system that is directly related to C2OTM. In the example shown in Figure 1, a search for "System X" resulted in multiple hits within PE XXXX782A. After verification and examination, analysts determined that two projects within the PE contained significant C2OTM related funding for System X. The top portion of the spreadsheet shows the title of the associated PE along with its total funding, the total amount of C2OTM related funding, and the percentage of C2OTM related funding to total PE funding. Next, the two hits are listed with their funding amounts. Each is assigned a relevance factor of "1" because analysts determined that the identified funding amounts were completely and directly associated with System X. On the lower half of the spreadsheet, each funding hit is broken out by Fiscal Year (FY) for greater detail. The spreadsheet provides the C2OTM FIT with a basic summary of C2OTM funding data contained within a PE. Complete results would include additional spreadsheets for each of the related PEs identified in a search.

In Step 3, analysts further examine the subset of PEs produced in Steps 1 and 2 by searching for CPM area JCA related systems, terminology, and comparative text in order to determine the relationship of PEs the full range of CPM areas and JCAs. The purpose of this step is twofold: to validate PE assignment to CPM areas and JCAs and to help portfolio managers identify possible cross portfolio implications. This is important because system functionality often crosses portfolios and recommendations for funding actions from one capability portfolio manager can affect the equities of other CPM areas.

Related system data can be derived from multiple sources. For example, for C2 related systems, sources include PEs identified as C2 by their sponsor services in the DoD Cost Assessment and Program Evaluation (CAPE) database, systems reviewed for the U.S. Central Command (USCENTCOM) Best of Breed (BoB) study, and systems of interest to the USJFCOM and Service analysts supporting CPM sponsored issues for the Periodic Review (PR) 09, Program Objective Memorandum (POM) 10, PR 11, and POM 12 budget cycles.

Using the same search tools and techniques described for Step 1, analysts verify search hits within each PE and then quantify validated hits, whenever possible, by associated funding. Similar to Step 2, valid search results are assigned relevance factors. However, in Step 3,

analysts identify all CPM areas and JCAs that are related to a hit. The analyst assigns each hit a relevance factor that indicates its percentage of alignment to each related CPM area and JCA. For example, a hit might be 10 percent aligned to the Battlespace Awareness (BA) JCA, 30 percent aligned to the C2 JCA, and 60 percent aligned to the Net-Centric (NC) JCA.

For system hits, analysts can assign alignment percentages by referencing existing mapping. Specifically, JSIC has mapped over 200 C2 systems to JCAs utilizing the Capability Mapping Framework (CMF) (Marlowe, Shreve, Byrd & Cooper, 2008a). The CMF maps systems to corresponding functions contained within the Joint Common System Function List (JCSFL) and those functions are then mapped to tasks contained within the Universal Joint Task List (UJTL). Tasks are then mapped to JCAs thereby completing the path from systems to JCAs. Utilizing CMF, C2 systems contained in the JSIC database are assigned percentage alignment to applicable JCAs. In other words, a particular C2 system found within a PE can be described as 25 percent C2, 30 percent Battlespace Awareness and 45 percent Net Centric based on existing mapping. Determining alignment percentages for non-system hits often requires subjective analysis. Figure 2 shows notional results of Step 3 of the process.

PE XXXX782A - System X

Total Program Element (PE) Funding	$1,413,926,780
Total All Portfolio (CPM) Funding	$1,413,926,780
Total C2 CPM Funding	$226,228,285
Total % of CPM Funding in this PE	100.00%

C2 CPM Portfolios	C2 System / JCA Terminology Hit Description (Associated Project Title)	Identified Funding	Rel Factor	Funding Value	Total Funding per CPM	% Total CPM Funding per CPM	% Total CPM Funding per PE
Force Support	System X - Dem/Val	$320,729,880	0.04	$12,829,195	$56,557,071	4.00%	4.00%
	System X Increment 2 - Initial Networking - on-the-move	$83,259,420	0.04	$3,330,377	$0	0.00%	0.00%
	System X Increment 3 - Full Networking - On-the-move	$1,009,937,480	0.04	$40,397,499	$0	0.00%	0.00%
Battlespace Awareness	System X - Dem/Val	$320,729,880	0.08	$25,658,390	$113,114,142	8.00%	8.00%
	System X Increment 2 - Initial Networking - on-the-move	$83,259,420	0.08	$6,660,754	$ -	0.00%	0.00%
	System X Increment 3 - Full Networking - On-the-move	$1,009,937,480	0.08	$80,794,998	$ -	0.00%	0.00%
Force Application	System X - Dem/Val	$320,729,880	0.02	$6,414,598	$28,278,536	2.00%	2.00%
	System X Increment 2 - Initial Networking - on-the-move	$83,259,420	0.02	$1,665,188	0	0.00%	0.00%
	System X Increment 3 - Full Networking - On-the-move	$1,009,937,480	0.02	$20,198,750	0	0.00%	0.00%
Logistics	System X - Dem/Val	$320,729,880	0.04	$12,829,195	$56,557,071	4.00%	4.00%
	System X Increment 2 - Initial Networking - on-the-move	$83,259,420	0.04	$3,330,377	0	0.00%	0.00%
	System X Increment 3 - Full Networking - On-the-move	$1,009,937,480	0.04	$40,397,499	0	0.00%	0.00%
Command & Control	System X - Dem/Val	$320,729,880	0.16	$51,316,781	$226,228,285	16.00%	16.00%
	System X Increment 2 - Initial Networking - on-the-move	$83,259,420	0.16	$13,321,507	0	0.00%	0.00%
	System X Increment 3 - Full Networking - On-the-move	$1,009,937,480	0.16	$161,589,997	0	0.00%	0.00%
Net-Centric	System X - Dem/Val	$320,729,880	0.66	$211,681,721	$933,191,675	66.00%	66.00%
	System X Increment 2 - Initial Networking - on-the-move	$83,259,420	0.66	$54,951,217	0	0.00%	0.00%
	System X Increment 3 - Full Networking - On-the-move	$1,009,937,480	0.66	$666,558,737	0	0.00%	0.00%

PE:		FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
TOTAL FY DOLLARS		$87,080,240.00	$233,648,647.20	$302,480,610.00	$272,543,310.00	$253,699,820.00	$214,629,490.00	$49,843,670.00
Force Support	System X - Dem/Val	$3,483,209.60	$9,345,868.80	$0.00	$0.00	$0.00	$0.00	$0.00
	System X Increment 2 - Initial Networking - on-the-move	$0.00	$0.00	$2,450,434.80	$565,370.40	$314,571.60	$0.00	$0.00
	System X Increment 3 - Full Networking - On-the-move	$0.00	$0.00	$9,648,789.60	$10,336,362.00	$9,833,421.20	$8,585,179.60	$1,993,746.80
Battlespace Awareness	System X - Dem/Val	$6,966,419.20	$18,691,737.60	$0.00	$0.00	$0.00	$0.00	$0.00
	System X Increment 2 - Initial Networking - on-the-move	$0.00	$0.00	$4,900,869.60	$1,130,740.80	$629,143.20	$0.00	$0.00
	System X Increment 3 - Full Networking - On-the-move	$0.00	$0.00	$19,297,579.20	$20,672,724.00	$19,666,842.40	$17,170,359.20	$3,987,493.60
Force Application	System X - Dem/Val	$1,741,604.80	$4,672,934.40	$0.00	$0.00	$0.00	$0.00	$0.00
	System X Increment 2 - Initial Networking - on-the-move	$0.00	$0.00	$1,225,217.40	$282,685.20	$157,285.80	$0.00	$0.00
	System X Increment 3 - Full Networking - On-the-move	$0.00	$0.00	$4,824,394.80	$5,168,181.00	$4,916,710.60	$4,292,589.80	$996,873.40
Logistics	System X - Dem/Val	$3,483,209.60	$9,345,868.80	$0.00	$0.00	$0.00	$0.00	$0.00
	System X Increment 2 - Initial Networking - on-the-move	$0.00	$0.00	$2,450,434.80	$565,370.40	$314,571.60	$0.00	$0.00
	System X Increment 3 - Full Networking - On-the-move	$0.00	$0.00	$9,648,789.60	$10,336,362.00	$9,833,421.20	$8,585,179.60	$1,993,746.80
Command & Control	System X - Dem/Val	$13,932,838.40	$37,383,475.20	$0.00	$0.00	$0.00	$0.00	$0.00
	System X Increment 2 - Initial Networking - on-the-move	$0.00	$0.00	$9,801,739.20	$2,261,481.60	$1,258,286.40	$0.00	$0.00
	System X Increment 3 - Full Networking - On-the-move	$0.00	$0.00	$38,595,158.40	$41,345,448.00	$39,333,684.80	$34,340,718.40	$7,974,987.20
Net-Centric	System X - Dem/Val	$57,472,958.40	$154,208,762.40	$0.00	$0.00	$0.00	$0.00	$0.00
	System X Increment 2 - Initial Networking - on-the-move	$0.00	$0.00	$40,432,174.20	$9,328,611.60	$5,190,431.40	$0.00	$0.00
	System X Increment 3 - Full Networking - On-the-move	$0.00	$0.00	$159,205,028.40	$170,549,973.00	$162,251,449.80	$141,655,463.40	$32,896,822.20

Figure 2. PE XXXX782A (System X) Alignment to CPMs/JCAs

In the example shown in Figure 2, PE XXXX782A was examined to determine alignment to CPM areas and JCAs. The PE contains three projects, each of which contains CPM area and JCA related terminology. System X was the prevailing hit within each of the three projects, so analysts were able to generate JCA alignment percentages using JSIC's JCA-UJTL-JCSFL-System mapping (Marlowe, Shreve, Byrd & Cooper, 2008a). Figure 2 shows that the PE's overall alignment is 2 percent Force Application, 4 percent Force Support and Logistics, 8 percent BA, 16 percent C2, and 66 percent NC.

This particular example serves to illustrate the importance of identifying PE alignment to JCAs. Although a large proportion of the funding for this PE is C2 CPM area related (identified in Steps 1 and 2), understanding that it is also heavily aligned to the NC CPM area may be critical to coordination of programmatic recommendations across all applicable CPM areas.

JSIC's PE analysis methodology is designed with enough flexibility to be applied to a variety of requirements. A full application of the methodology is appropriate when a requirement includes all three needs addressed within the process and when sufficient data and documentation are available. However, portions or slightly modified versions of the methodology can be applied to meet different need sets as required. The *Methodology Application* section of this paper discusses several cases in which the JSIC team has successfully applied the methodology either in its entirety or in part.

METHODOLOGY APPLICATION

Command and Control On-The-Move (C2OTM)

C2 CPM POM 12 focus areas include Joint Task Force Headquarters (JTFHQ), Joint Personnel Recovery (JPR), C2OTM, and other areas of CPM interest. JSIC chose the C2OTM focus area as the initial test case for its methodology based on an established relationship with the C2OTM FIT. JSIC's work with C2OTM and Deployable C2 (DC2) provided well-defined data such as mapped systems and authoritative documentation. As defined in the draft Initial Capabilities Document (ICD), C2OTM represents the capability to maintain Situational Awareness (SA) and make timely and informed decisions while non-stationary (i.e., moving from place to place).

The C2OTM focus area includes collaboration, communication, and monitoring joint/multinational /combined/interagency operations through strategic arrangement of personnel, equipment, communications, and procedures in a highly decentralized environment over extended ranges and in complex terrain (urban, rural, and mountainous). C2OTM provides leaders with the ability to plan, direct, coordinate, assess, and control forces and operations while moving anywhere within the operational environment (USJFCOM, 2009b). The intent of JSIC's initial application of the PE Analysis methodology to the C2OTM focus area was to identify related PEs, identify C2OTM programmatic data within the related PEs, and align the related PEs with CPMs/JCAs.

Before beginning its PE analysis, JSIC analysts collaborated with the C2OTM FIT to identify an accurate list of systems most important to the focus area. In addition, JSIC analysts examined authoritative C2OTM documentation such as the C2OTM Study Plan, C2OTM Concept of Operations (CONOPS), and C2 OTM ICD to identify terminology that best described the focus area. Once the team agreed upon accurate search lists, analysts applied the methodology by first identifying C2OTM related documents and then working with the FIT to extract pertinent data from those documents.

The bulk of data of interest to the C2OTM FIT was publically available in RDT&E documents. Due to this fact and due to restricted access to the CAPE database, JSIC's initial searches were confined to the public Research and Development Description Summaries (RDDS) database of RDT&E PEs. Out of approximately 800 searchable PEs, initial results identified twelve PEs related to C2OTM. Figures 1 and 2 depict partial results from this first test case.

JSIC tailored its presentation of the data to focus on the specific needs of the C2OTM FIT. For example, budget data was calculated as a total for all recorded years rather than on a yearly basis. For several PEs, analysts identified detailed funding lines for systems of interest to C2OTM - data that the C2OTM FIT could use to support its future PR/POM recommendations. Finally, analysts generated reports to show how C2OTM related systems and, ultimately, the twelve C2OTM related PEs, aligned to the CPM/JCA. The source for alignment percentages was JSIC's JCA-UJTL-JCSFL-System mappings as described in *System Functional Analysis in a Capability Mapping Framework* (Marlowe, et al., 2008a).

The analysis results showed that most C2OTM aligned PEs were also heavily aligned with the NC portfolio. This information was important to the C2OTM FIT because it indicated a possible necessity to coordinate with the NC portfolio when developing future programmatic recommendations. JSIC's PE analysis is one of several analysis products that will support the C2OTM FIT's final POM 12 C2OTM issue papers and recommendations.

Follow-on work with the C2OTM FIT provided an opportunity to apply portions of the methodology to a broader PE database. While drafting a CONOPs and an ICD, the C2OTM FIT developed a list of approximately 27 C2OTM systems as part of their efforts to bound the C2OTM portfolio. JSIC's C2OTM functional analysis, along with additional analysis internal to the FIT, provided some quantification of the capability redundancies and gaps associated with the 27 core C2OTM systems. In order to assist the C2OTM FIT with potential PR/POM recommendations, JSIC applied its methodology to identify funding lines for the systems within RDT&E, Procurement, and O&M PEs within available budget documentation.

Analysts searched the IHS Inc. Jane's PE database, which includes publicly available RDT&E, Procurement, and O&M funding documentation, along with the Research and Development Descriptive Summaries (RDDS) database, which contains only RDT&E PEs. Whenever possible, system names were searched to identify related PEs and associated funding. Analysts examined each search result for validity and proper context before detailing any associated funding. Notional results from this partial application of the methodology are shown in Figure 3.

C2OTM System	System Description	JCA/CPM Function Mapping	Funding Document	Funding Type	Document Date	Comments	Direct Funding Amount
System X	The System X mission equipment package integrates on UH-60L helicopters to provide commanders from brigade to theater level the ability to exercise C2 on joint battlefields. The System X also supports Corps, Division and Brigade commanders with an airborne tactical command post. This mission equipment package is hosted on a UH-60 Helicopter. It provides situational awareness and C2 through the application of the several systems and other Applications as required.	**C2 – 33.2% overall** 18.9% Primary 13.1% Secondary 1.2% Tertiary **BA – 24.1% overall** 11.9% Primary 08.9% Secondary 3.3% Tertiary **NC – 12.8% overall** 7.7% Primary 4.2% Secondary 0.9% Tertiary **FA – 12.6% overall** 0.7% Primary 6.5% Secondary 5.4% Tertiary	**PE - XXXX818A** Army Tactical Command & Control Hardware & Software (ATCSS) **Project C3A**	RDT&E	2009	PE XXXX818A is the overall RDT&E funding document for ATCSS. Project C3A, within PE XXXX818A, details funding for System X. The system was funded in FY 2007, however no funding was listed for subsequent years. Note: System X Project C3A does not appear in 2010 version of PE XXXX818A.	FY2007 - ▬
			PE - XXXX716A Army Evaluation Center	RDT&E	2009	Precise funding that can be attributed to the System X system is unclear in this PE. Broad accomplishments listed in this PE include evaluation strategy, design of technical and operational tests and evaluation of the test results to address the combat effectiveness, suitability, and survivability factors pertinent to the decision process for several programss to include System X.	N/A
			Army, Aircraft Procurement, Modification of Aircraft, Line 28 Airborne Avionics, AA0700	Procurement	2010	Precise funding that can be attributed to the System X system is unclear in this procurement funding document. FY10 base funding in the amount of $104.6 million will procure several systems and applications to include System X.	N/A
			Army, Other Procurement, Elect Equip – Tactical C2 Systems, Line 108 Life Cycle Software Support (LCSS), BD3955	Procurement	2010	Precise funding that can be attributed to the System X system is unclear in this procurement funding document. FY 10 Base procurement dollars procures critical C4ISR lab equipment: System X requires purchase of equipment to support, track and troubleshooting of software issues encountered by the warfighter and ensure System X systems can best protect our airborne fighters.	N/A

Figure 3. System X Related Funding and CPM Alignment

Figure 3 shows a portion of the results spreadsheet and how JSIC tailored the methodology to meet the C2OTM focus area's needs for System X. The complete spreadsheet provides

information pertinent to all 27 core systems identified for the C2OTM focus area. For each C2OTM system, a short description is provided in Column 2. Overall, primary, secondary, and tertiary CPM/JCA alignment data is shown in Column 3. As in previous analyses, the JSIC team generated alignment data using JCA-UJTL-JCSFL-System mapping (Marlowe, et al., 2008a). Subsequent columns detail funding information for System X. This data includes the document in which the hit was found, the funding type (RDT&E, Procurement, or O&M), the year the funding document was created, and the associated funding. The "Comments" column summarizes how the general funding document is related to the specified system.

Overall, the data produced by JSIC through the use of the PE analysis methodology proved useful to the C2OTM FIT. It is important to note that, in most cases, the methodology does not provide a complete or authoritative answer. Rather, it provides starting points and initial data, which should be interpreted as broad pointers toward a complete funding picture and/or programmatic understanding. The PE analysis methodology provides a structured, rigorous, and repeatable means to effectively isolate programmatic data related to a specific focus area or system from a large database.

USJFCOM C2 Portfolio Baseline

JSIC also recently applied the methodology to assist with populating spreadsheets contained within the USJFCOM J89 (Joint Architectures and Capability Engineering Division) C2 Portfolio Baseline. JSIC's task was to populate the "Relevant PEs" field included in each spreadsheet. The USJFCOM portal contains databases that store lists of C2 systems, support systems, and systems of interest. JSIC analysts applied portions of the methodology to search PE databases for system names, validated all hits, and documented relevant PEs. JSIC was able to identify relevant PEs for the majority of systems included in the USJFCOM C2 Portfolio Baseline.

LIMITATIONS

While JSIC's PE analysis can aid the C2 CPM in making informed PR/POM recommendations, it is important to discuss and understand the limitations of the methodology. Conclusions drawn from PE analysis should not be the sole criteria for making programmatic decisions. As previously discussed, PE analysis results are a first step toward complete understanding of the programmatic funding associated with a particular focus area or CPM/JCA. Additionally, as the PE analysis is expanded to other C2 focus areas and potentially other CPMs/JCAs, the methodology will be refined to meet future requirements. Challenges and limitations encountered during initial applications of the methodology are described below.

- **_Databases Access:_** Approved, publicly accessible databases that contain the entire depth and range of programmatic data and information are not available. Complete DoD funding data, both classified and unclassified, is available only through CAPE's DoD Resources Data Warehouse (DRDW). By obtaining proper authorization whenever possible, all searches will be performed in this complete and authoritative database to ensure the use of the most current and inclusive programmatic documentation. For most

- ***Complexity and Diversity of Program Element Documentation:*** The complexity of PEs can lead to misinterpretation of funding data. Most PE documents are structured to divide the overall PE into projects with identifiable funding. However, there is a lack of consistency in how PE data is documented by different services and agencies. Variations in format, level of detail in project descriptions, and terminology often make the information unclear to personnel not directly involved in the program. JSIC analysts can often overcome PE complexity by isolating and focusing on specific known funding lines and relating search results to the overall context of the PE.

- ***Subjective Interpretation of the Documentation:*** Subjective interpretation of the language within the PE documentation is unavoidable. JSIC recognizes this limitation and minimizes its effects on results through designed analyst consensus.

- ***Labor Intensive Nature of Search Validation:*** Validation of search results involves reading and understanding the PE in order to verify accuracy and context. This process is the most labor-intensive part of the process and requires not only time, but also a base level of programmatic expertise. JSIC will provide analysts with some level of programmatic training to decrease the workload related to this part of the process.

- ***Search Engine Capability:*** While the use of CDN and other search engines greatly reduces the number of man-hours required during the search phase of the methodology, each search engine has limitations. These limitations include "Comparative Text" query accuracy, display functionality, and data exporting capability. JSIC will use more sophisticated search engines as they become available to increase the clarity and accuracy of its results. As PE analysis methodologies are refined, ontology-based approaches allowing for more sophisticated semantic searches may also provide more concise interpretation of data and increased consistency to the analysis.

CONCLUSIONS

JSIC's PE analysis methodology is a repeatable and effective process for identifying PEs relevant to a particular area of interest. It can assist in aligning PEs across CPMs/JCAs. The results of PE analysis do not conflict or compete with CAPE's authoritative assignment of PEs to CPMs/JCAs. Rather, the analysis presents an alternate or complementary view of the funding data. Specifically, JSIC applies the methodology to identify PEs that may be directly relevant to a specific system or focus area by applying simple searches to a large database and analyzing the results. FITs and other groups can use the analysis results to quickly narrow their programmatic focus as they seek to obtain an overall view of DoD funding that applies to their focus area. PE analysis has proven to be a beneficial and integral part of the overall programmatic efforts of the C2OTM FIT by providing analytical data required to develop POM issue papers and subsequent programmatic recommendations.

WAY AHEAD

JSIC will continue to work closely with the C2OTM FIT to complete and refine existing work. In order to assist the C2 CPM with the development of future PR/POM recommendations, JSIC's PE analysis should eventually be expanded to other CPM focus areas. JSIC will provide successful analyses in the future by collaborating with various CPM FITs to develop accurate and meaningful system lists, terminology, and descriptive text to define each focus area's programmatic boundary. Reaching out to other FITs at the beginning of the PR or POM budget cycle will ensure that critical programmatic analysis is available to meet ongoing needs.

As PE analysis is expanded to other focus areas, JSIC will continually refine the methodology to address changing requirements. To improve analysis products, JSIC personnel will take advantage of available programmatic training. Additionally, JSIC will pursue the incorporation of CAPE data from the PE Data Warehouse to improve analysis accuracy. Finally, in recognition that programmatic data is updated on at least a yearly basis, the PE analysis will be continually verified and modified to effectively support the C2 CPM's future PR and POM budget cycles.

REFERENCES

Chairman of the Joint Chiefs of Staff. (2008). *Command and Control Joint Capabilities Document* (Version 2.0, 13 September 2008). (unpublished manuscript).

Chairman of the Joint Chiefs of Staff. (2009a). Joint Capability Area Framework. Retrieved November 15, 2009, from http://www.dtic.mil/futurejointwarfare/strategic/jca_framework.xls

Chairman of the Joint Chiefs of Staff. (2009b). Joint Capability Area Framework with Definitions. Retrieved November 15, 2009, from http://www.dtic.mil/futurejointwarfare/strategic/jca_framework_defs.doc

Department of Defense. (2006). *Quadrennial Defense Review.* Retrieved November 10, 2009, from http://www.defenselink.mil/qdr/report/Report20060203.pdf

Marlowe, K. L., Shreve, J. B., Byrd, L. T., & Cooper, W. H. (2008a). 76th MORS Symposium: *Numerical Analysis of Systems in a Capability Mapping Framework.* New London, CT.

Marlowe, K. L., Shreve, J. B., Byrd, L. T., & Cooper, W. H. (2008b). 76th MORS Symposium: *System Functional Analysis in a Capability Mapping Framework.* New London, CT.

Marlowe, K. L., Shreve, J. B., Byrd, L. T., Easter, J. W., & Perretta, D. A. (2009). 77th MORS Symposium: *Practical Applications of the Capability Mapping Framework.* Fort Leavenworth, KS.

United States Joint Forces Command. (2009a). *Concept of Operations for Command and Control On-the-Move (C2OTM)* (Version 1.1, 14 July 2009). (unpublished manuscript).

United States Joint Forces Command. (2009b). *Initial Capabilities Document (ICD) for Command and Control On-the-Move (C2OTM)* (Version 2.0, 15 September 2009). (unpublished manuscript).