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2006 CCRTS:
The State of the Art and the State of the Practice

Title: Assessing C2 Program Capabilities

Topics: C2 Programs, Net-centric Metrics, Policy

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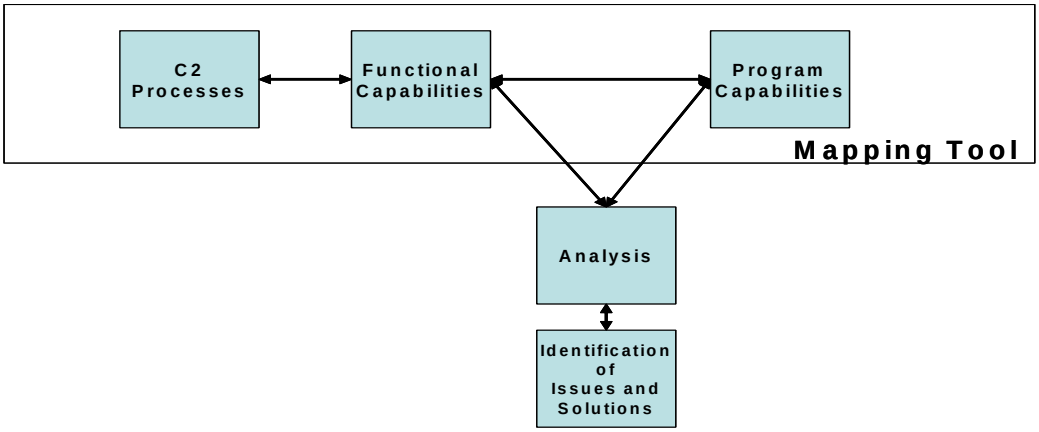
I. Abstract

The Assistant Secretary of Defense (Networks & Information Integration) (ASD(NII)) C2 Programs Directorate is responsible for the overall strategy and plan to support program direction and decisions; relating to development, integration, convergence and synchronization of Command and Control (C2) Programs across the Services, Agencies and Combatant Commands.

In fiscal year 2005, MITRE developed a methodology to identify potential capability gaps and overlaps in C2 programs. We adapted the Matrix Mapping Tool (MMT) (used in MITRE's support of the Under Secretary of Defense for Acquisition, Technology, and Logistics) to determine its utility in comparing C2 program capabilities to fundamental C2 processes. Modification of the tool allows mapping of the C2 and Net-Centric Environment Joint Functional Concepts (JFCs) to program capabilities embodied in their respective Capabilities Development Documents (CDD). The methodology operates under the hypothesis that C2 capabilities supporting the same functionality are potentially similar. MITRE used the methodology to identify areas of possible overlap between two DoD C2 Programs, referred throughout as Program A and Program B. This effort is a first step in developing a common and consistent basis for providing program oversight and guidance, for C2 programs, on an enterprise-wide basis, in support of the C2 Programs Directorate mission.

II. Overview of Methodology

Exhibit A presents the components of the methodology and describes, at a high level, the activities undertaken for the effort presented in this paper.



- Development of conceptual C2 definition based in **C2 Processes**
  - Evaluated Universal Joint Task List (UJTL) and Joint Integrated Activity Set (JIAS) as the candidate bases for C2 definition
- Development of **Functional Capabilities** vision
  - Used C2 and Net-Centric Environment JFCs as the basis for a C2 Functional Vision
- Mapping of **Program Capabilities** to Functional Capabilities
  - Assembled relevant program capabilities data from authoritatively confirmed documentation - Focused foremost on CDD capabilities
- Conduct **Analysis** to identify potential gaps and overlaps
  - Used mapping tool to identify CDD-capability discrepancies
  - Analyzed discrepancies outside the model

Exhibit A

Given the numerous programs under purview of ASD(NII) and the numerous capabilities within each program, an automated tool to identify gaps and overlaps is paramount. The sheer volume of CDD-capabilities makes the process difficult. To arrive at a tenable solution, we identified an established fixed metrology against which we measured each program. Specifically, two C2 Programs were selected to evaluate the utility of this approach.

Core functional capabilities were used as the yardstick from which gaps and overlaps could be garnered. To place programs on equal footing, we mapped program CDD-capabilities against this yardstick. Thus programs can be readily compared to a common C2 definition basis. This common C2 definition consists of two primary functional classes: 1) the Joint C2 Functional Concept and 2) the Net-Centric Environment (NCE) Joint Functional Concept (JFC). For brevity we refer to these collectively as "JFCs".

The first set of JFCs composes 43 JROC-approved C2 capabilities, dated February 2004, and encompasses the full Range of Military Operations (ROMO) out to the year 2015. These are further broken down into two subsets: 1) "Basic C2 Capabilities" - of which are seven, and 2) "Collaborative Capabilities" - of which are eight. Within each subset, a fourth level of indenture composes detailed specifics. In all, there are a total of 43 detailed capabilities at this 4th level of indenture, as defined in the document.

The second set, NCE JFC, came from the net-centric community and ASD(NII), dated April 7, 2005. This capability set encompasses ROMO and Operational Levels of War (OLW), and extends into other general C2 domains (e.g. Operations Other Than Warfare - OOTW) out to the year 2020. This set composes of 82 capabilities bifurcated into two classes: 1) "Knowledge Area Capabilities" - of which are seven, and 2) Technical Area Capabilities - of which are 14. Within each subset, a fourth level of indenture composes detailed specifics. In all, there are 82 detailed capabilities for this class.

Thus, 125 core functional capabilities make up the yardstick or fixed C2 definition standard. The CDD capabilities can then be mapped into one or many of the 125 functional capabilities to reveal, upon analysis, areas of potential gaps/overlaps. The key word here is "potential" since some overlap may be necessary and appropriate; such as in keeping with net-centric functionality. Proof for gap/overlap lies within the CDD paragraph contents. An existing tool was selected to aid in this mapping, pointing the way to CDD paragraphs and topic areas that appear to overlap but require greater detailed investigation.

III. Matrix Mapping Tool (MMT)

The tool selected was developed by the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (OUSD (AT&L)) and is a mapping-tool whose purpose is similar insofar as addressing OUSD (AT&L) program overlaps. "The Matrix Mapping Tool" is hereafter referred to as 'MMT'. MMT is a spiral development effort. Fiscal year 2005 is devoted to spiral three pilot applications. This analysis was one of these pilots. The purpose of the pilots is to apply MMT to real problems of interest to the DOD, and use lessons learned from use of the tool to review and enhance MMT capabilities.

MMT Background (Dahmann et.al., 2005)

The MMT project was initiated May 2004, and sponsored by DOD OUSD (AT&L) and the Joint Staff (J8). Its purpose is to facilitate cross organization collaboration and reuse, in support of capabilities-based planning, analysis, and acquisition. MMT is a database with supporting software that documents relationships between warfighting activities, the UJTL, systems, ACTDs, roadmaps, and capability areas. It allows for a common set of reusable data to support portfolio management (functional, operational), analysis of capability gaps, and other studies where it is necessary to understand the relationships across the dimensions listed above.

Beginning with the 2001 Quadrennial Defense Review, the Department of Defense (DOD) has been moving to a Capabilities-Based Acquisition (CBA) approach for planning and requirements definition (Davis, 2002). With the advent of CBA, there is an increased need for analysis of cross-cutting capability needs and solutions as a step in the systems engineering process. CBA calls for an integrated assessment of current capabilities in light of future concepts. The concept for MMT grew out of collaborative efforts between the Joint Staff (JS) J8 and OUSD(AT&L) Defense Systems (DS) in the implementation of the new Joint Capabilities Integration and Development System (JCIDS - CJCSI 3170), the replacement for the traditional military requirements system. As a cooperative effort between J8 and AT&L Defense Systems, and in response to the common data recommendation, MMT supports data sharing and cross

Functional Control Board (FCB) analysis. MMT is intended to be a cross-referencing tool to be used by both users and providers to facilitate collaboration across multiple communities.

J8 combined multiple JFCs across multiple FCBs into a single coherent set, known as the Joint Integrated Activity Set (JIAS) in March 2004. This list was expanded in September 2004 to include Net-Centric activities based on input from the Net-Centric FCB. The JIAS were chosen over other potential task/activity sets, such as the Universal Joint Task List (UJTL), as the core dimension for mappings between systems and other dimensions because they are: 1) less closely tied to current doctrine, 2) focus on long-term functional concepts, and 3) enable analysts to explore the connections between data dimensions with fewer constraints.

Mappings between JIAS and OUSD(AT&L) systems were done by a small team of contractor Subject Matter Experts (SMEs). Guidance for mapping an activity to a system was to err on the side of making the mappings too loose rather than too precise.

The UJTL was added to MMT and mapped to the JIAS to enable analysts to use the tool to explore a broader range of capabilities-related issues, including potential gaps and overlaps in doctrine and training. Initial UJTL numbering and definitions were developed as part of the JIAS database development activity under the Joint Staff J8. UJTL numbers and definitions are version 4.2 (CJCSM 3500.04C dated 1 July 2002).

MMT includes a "User Workspace" component which allows a user to define their own specific areas of interest in terms of "studies" (specific users' investigations) and categories (user-defined topics of interest). The initial release of the tool provides the capacity to associate these categories to the operational activities as represented in the tool (specifically the JIAS's). Once these associations are made, the tool generates the counterpart UJTL tasks and systems that have been identified as potential contributors to these activities.

Exhibits B.1 and B.2 depict Venn diagram set relationships as initial interpretation for: 1) entering JFCs into the MMT 'User Workspace', 2) associating to JIAS's, and 3) showing

effective outcome from the 'Run Comparables' algorithm. The Venn diagrams ease the complexity of the depiction and explanation. Arrows pointed left-to-right refers to manual associations using the tool. Arrows pointed right-to-left refer to outcomes, whether implied, embedded or extracted, as a result of using MMT.

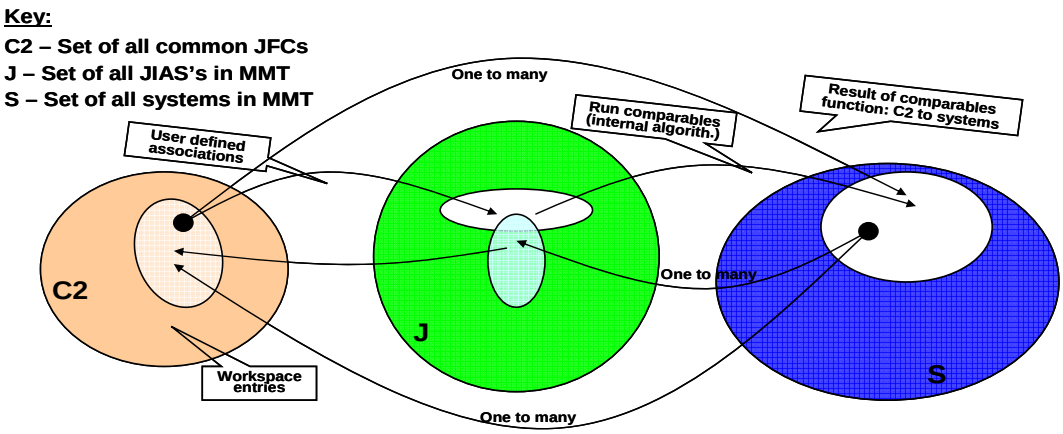


Exhibit B.1

Exhibit B.2 shows the embedded UJTL relationship within MMT. Here, UJTLs are internally mapped to JIAS's, i.e. user has no ability to modify. Internally within MMT, UJTLs mapped to systems is implied. The MMT "Run Comparables" algorithm uses JIAS's to explicitly cluster like-systems that can be extracted in a generated Microsoft Excel output file.

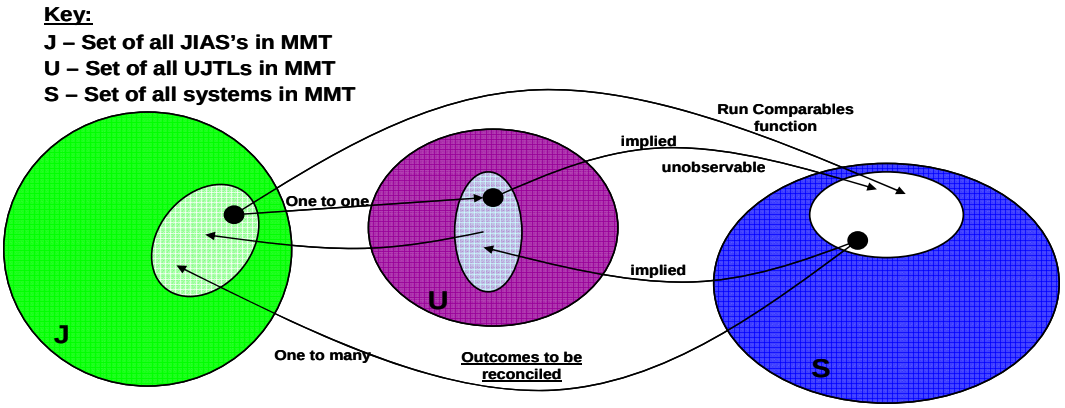


Exhibit B.2

JBMC2 Capabilities Mapping Environment (JCME)

Our team also considered the JCME tool for this analysis. This tool parses CONOPS and ORD material along with architectural elements, and provides detail on how systems and tasks fit into the joint architecture. It incorporates fewer C2 programs than MMT and requires a CITRIX licensing fee. Moreover, the CDD capabilities are not captured in this tool and thus require significantly more effort to employ. These factors degrade timely modifications on an as needed basis. Exhibit C was used to support our decision to use MMT over JCME.

	MMT	JCME
PROs	UJTL and JIAS are incorporated and mapped. Ties to top-level JCS constructs (e.g., Joint Functional Areas, links to FCBs); JCAs to be added.	UJTL is incorporated. Ties to many doctrinal sources (e.g., CJCSM 3500.05A - Joint Task Force Master Training Guide, Joint Task Force Standard Operating Procedure (SOP))
	Most C2 portfolio programs are represented.	Several C2 portfolio programs are represented. Two C2 programs have been addressed in detail. JC2 CDD and DJC2 ORD have been parsed.
	Provides context for tasks and systems (e.g., functional areas, roadmaps, etc.).	Provides detail on how systems and tasks fit into the joint architecture.
	Has hot links to A+ database, roadmaps (e.g., JBMC2, IAMS) and S&T/ACTD activities	Provides linkage to operational context (e.g., JMTs such as JCAS) for associated programs. Provides a vehicle for building integrated architectures (DODAF framework) and doing requirements traceability
	MMT can be used without licensing cost. The database can be augmented (User Workspace) to include other constructs such as C2 and Net-Centric FCAs and perhaps detailed JCME data on JC2 and DJC2. The basic database (aside from User Workspace) is maintained by contractor for the government.	
CONs	Mapping of programs to JIAS was done by SMEs and is not tied to specific system capabilities (e.g., CDD).	Fewer portfolio systems are represented than in MMT. Parsing program capabilities for other portfolio programs at the CDD level would require significant effort.
	Portfolio Strategic programs are not included, although STRATCOM is using MMT	Focus is on JTF operations. No strategic programs yet, but STRATCOM has begun use of JCME.
	Adding elements to core MMT dimensions (e.g. systems, activities) cannot be done by user, but must be done as part of the configuration managed database	Uses CITRIX and there is a $9-10K licensing fee for the JCME SLATE software.
	Programs are represented by system/program names, a top-level system description, and applicable ACAT, Functional Areas and Roadmaps. No detailed system capabilities are resident in the database.	

Exhibit C

In summary, MMT was selected for its appearance of potentially exposing capability-discrepancies among C2 programs. Some issues lingered, including the rigor for mapping JFCs to JIAS's and potentially unwanted side-effects. Since MMT is intended to be a broadly useable tool it includes many non-C2 programs. An added feature which would have allowed us to use tool features with only the C2 subset of programs may have been very useful. The following describes somewhat chronologically the effort and means by which difficulties were overcame. Analysis will be discussed, pertaining to the effectiveness/efficiency of the methodology for two C2 programs, Programs A and B. Recommendations and conclusions will summarize the findings of the two programs analyzed. Lastly, findings about our methodology are summarized.

IV. Approach to Developing the Methodology

Our activity began with incorporating JFCs into the MMT "User Workspace' area followed by associating the JFCs to JIAS's. Afterwards, a 'Show Comparables' MMT-function was executed resulting in a listing of DoD programs/systems, most of which did not pertain to C2. 'Show Comparables' is a weighting algorithm to score programs on the basis of closely related JIAS's, then comparing that score to an internal pre-set closeness-threshold. Unfortunately there was no direct mapping or relationship to the JFCs. Furthermore it was unclear how program CDD-capabilities could be entered into MMT. This resulted in initial proposed customization to MMT. Exhibit D.1 depicts the proposed customization in replacing the program/systems, within the MMT database, with CDD-capabilities of selected programs. This promising direction presupposes a small number of programs under consideration, to analyze for their capability overlaps. This too was found to be not easily implementable given MMT's internal structure. Therefore it was abandoned in favor of changes amenable to the MMT core database infrastructure.

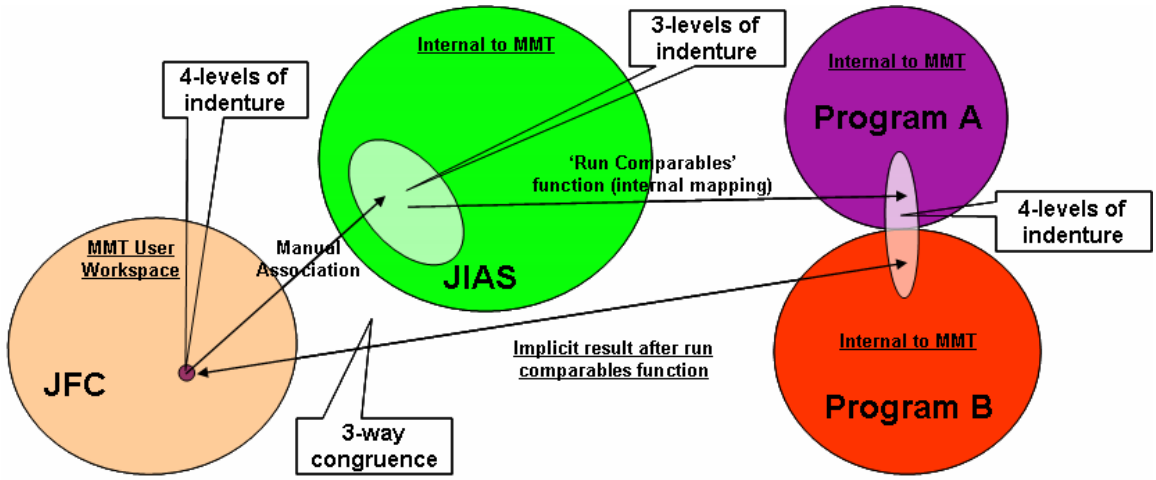


Exhibit D.1

Our final customization, seen in Exhibit D.2, combined both JFCs and program CDD capabilities into the MMT 'User Workspace', followed by manual linking to JIASs. From this larger database 'cross referencing' pivot tables were generated. These cross-reference tables gave, among other things, a tabular Microsoft Excel output tying together program CDD paragraph numbers directly to JFCs. JFC entries pointed to specific CDD paragraph numbers useful for discerning overlaps. Customized MMT points to potential overlaps, but proving/disproving a bona-fide overlap is ultimately grounded in a more detailed investigation of each program's capabilities. Thus the customized MMT served to screen for non-applicable paragraphs, and only identify candidate paragraphs that could be assessed for program overlap.

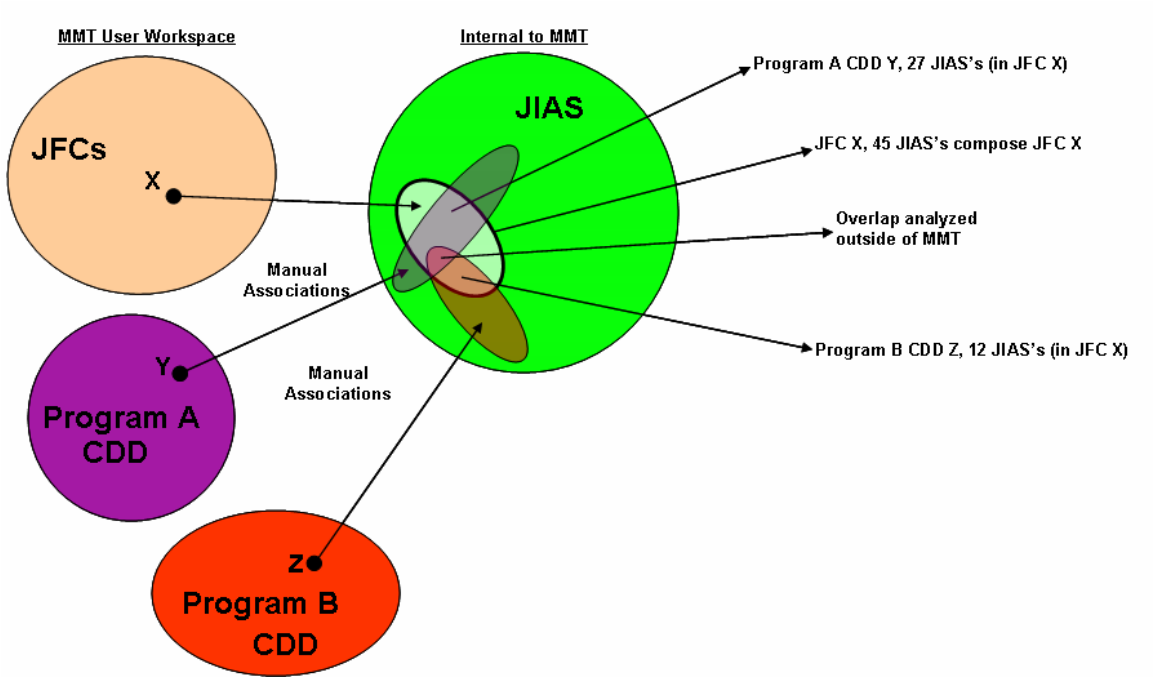


Exhibit D.2

While the customized MMT links paragraph numbers to JFC's, both entered into the 'User Workspace', the content in the paragraphs substantiates or disproves whether such overlaps exist. Consequently MMT itself cannot be held accountable to the analysis or conclusions regarding programmatic recommendations. The question is whether another mapping could better separate like-paragraphs for analysis. Note: no tool would be necessary if the number of program CDD capabilities were quite small among a few programs. The tool helps the person doing the analysis identify overlaps from a large database by focusing attention on areas to be analyzed. As a final note, all C2 programs would have to be analyzed collectively to assess for gaps.

V. Analysis of Programs A and B

Program A refers to multiple mission capability packages (MCPs), and Program B addresses a more singular specific mission. Both programs expect to share similar functionality, and it is this functionality-overlap that was sought after. Modified MMT bridges the analysis

effort by providing pointers to examine specific CDD-paragraphs in detail, having similar functional areas of interest.

At this juncture in the study, the translation and mapping of the functional and CDD capabilities to the JIAS, within MMT, does not appear to support identification of specific CDD paragraphs that should be analyzed. However, it does seem to yield general direction in identifying relevant C2 functional areas with potential overlap, requiring more detailed CDD examination and analysis. For example, MMT pointed to the C2 functional area of developing courses of action as an area to be examined based on the preponderance of CDD mappings, but not all relevant paragraphs were identified. Additionally, mission context was not addressed (Air Operations Center (AOC) Courses of Action (COA) vs. Antisubmarine Warfare (ASW) COA). Also, MMT identified a general area of overlap in the area of 'intelligence', but not its specific nature. In addition, a non-applicable paragraph relating 'Knowledge Management' was identified as disconnected with 'intelligence'. While these capabilities appear functionally similar, the ultimate capabilities will need to be tailored to mission and level of command.

Initial analysis in conjunction with MMT was performed by examining individual JFCs to determine related CDD capabilities. While the initial assessment was in no way comprehensive, it pointed to the following four primary areas of functional overlap: 1) Intelligence, 2) Courses of Action (COA), 3) Situational Awareness (SA), and 4) Information Assurance (IA).

These four areas were then examined in detail using the most current CDDs, for Programs A and B, to identify specific overlaps. Although MMT did not specifically point to these CDD paragraphs, it did identify those functional areas that warranted further investigation.

Under the 'Intelligence' area, MMT identifies two subsets of overlap, they were: ISR Management and Intelligence Preparation of the Battlespace (IPB). Under ISR Management, the two CDD areas were strongly aligned to: 1) Produce an ISR Collection Plan, and 2) Dynamically Adjust Collection Plan Based on Mission Requirements. Program A called for capability to

create a multi-disciplined ISR collection plan, and Program B requires the capability to produce an integrated prioritized ISR plan incorporating National, theater, Service, and multinational/coalition sensors. Thus, adjusting the 'collection plan' in a changing requirements environment was judged to be a shared functionality.

Situational Awareness pertains to the Common Operating Picture (COP) for both C2 programs. The COP is the mechanism for delivery of Situational Awareness. Moreover, like-concepts specifically called out include: 4-D information, user tailorable displays, standardized symbology, and a common geospatial reference.

Information Assurance (IA) is straight-forward in its discussion regarding exchange of information across multiple security domains. The language and terms are identical for accommodation of systems operating at different levels of classification, and protecting/defending infrastructure by ensuring all elements of IA are in-place. IA elements are consistent across both programs; e.g. availability, integrity, authentication, confidentiality, and non-repudiation; as they should per accepted definition for IA.

VI. Conclusions and Lessons Learned

Exhibit F summarizes the pros and cons associated with our methodology. As far as the methodology is concerned, two key observations apply:

1) Going to too high a level of abstraction (indenture) does not yield enough specificity to engender gap/overlaps among programs (efficient but ineffective)
2) Going to a deeper level of indenture is more useful for pointing out areas of overlap, but the amount of data rapidly grows unwieldy as more than a few programs are introduced (effective but inefficient)

The tool also only deals in the capabilities-dimension, and other dimensions such as risk, cost and schedule also go into making actionable C2-program decisions. Clearly these dimensions are best served when linked, say in a common tool, or portable to a suite of interoperable tools.

Topic	Pro's	Con's
Gap/Overlap Identification	MMT focuses on general areas of potential overlap reducing the volume of data to be analyzed	To ensure quality of results, program SME involvement is needed to perform the mappings. MMT may not be capable of identifying all areas of overlap.
Gap/Overlap Validation	MMT as a tool is technically correct from an accounting standpoint	SME review and analysis of the identified functional areas is required
Net-centricity	MMT can support list of net-centric functions, associations to JIAS supported	Careful deliberation to V&V (CDD-capability) associations to net-centric functions needed
Scalable	MMT is effective for program comparison's, providing the MMT database can be manipulated	Level of complexity and adding programs quickly overwhelms database and analyst's ability to find gaps/overlaps
Automation	Opportunities to enhance tool development such as standardized file importing	MMT is heavy on user entry of CDD requirements and deliberating associations
P3I	MMT may be better structured to automate and select queries for gaps/overlaps, to include importing of CDD files	MMT not structured to handle multidimensional frameworks such as temporal-schedule and cost, or risk domains
Experience/User Friendly	MMT can be quickly learned	Significant tedious data entry

Exhibit F

The JFCs represent a reasonable depiction of top-level required C2 capabilities in both scope and level of detail. However, the ability of MMT to identify appropriate capabilities corresponding to a given set of JFCs is dependent in large part on the quality of their association to the JIAS's. Vague capabilities can result in large numbers of associations which defocus the results. Accuracy and consistent interpretation are important to achieving precise mappings, requiring SME input and data quality assurance measures. In general, we found the CDDs to be cumbersome in capturing required capabilities; both in terms of volume of data they present and the precision with which capabilities are described. For example, the Program B's CDD uses the term "Predictive Battlespace Awareness (PBA)" which was not present in the MTT instantiation of the Program A's CDD.

To assess a portfolio of programs for gaps, all programs inclusively need consideration and MMT can not scale to include more than a few programs. The comparison of both programs produced Microsoft Excel pivot charts with over 100,000 entries. On the other hand, overlap can be ascertained from pair-wise analysis of two programs, to which MMT is better suited. MMT points to areas of potential overlap, but requires a SME effort to distill overlap proof from the CDDs. In addition, creating and maintaining a database for a portfolio of systems would be extremely difficult. The bottom line is that the current customized version of the tool is useful for identifying potential functional areas of overlaps between programs, but is not able to handle a large portfolio of systems. As such, it could find limited use for evaluating a small number of small programs, but does not address the overall ASD(NII) C2 program needs.

VII. Recommendations

C2 and NCE JFCs

The C2 and NCE JFCs represent a reasonable depiction of top-level required C2 capabilities. We recommend that the ASD(NII) C2 Programs Directorate go on record, with the Joint Staff, that JFCs will be used by ASD(NII) as the authoritative set of required functional capabilities.

CDDs

The draft CDDs used in this analysis were difficult to use and interpret. We recommend that ASD(NII) influence JFCOM to focus less on making CDDs comprehensive, and more on developing a common understanding of user needs leaving little to interpretation.

The utility of describing required capabilities in terms of a common framework as part of the JCIDS process should also be investigated. This would significantly simplify the process of comparing capabilities across programs if not already addressed CBA process. Program A is using JCME to continue to parse and refine C2 capabilities, and should be investigated as a potential foundation for comparisons of capabilities being developed by other C2 programs and technology efforts.

MMT as a tool for ASD(NII)

MMT provided limited analytic support as shown by this analysis. However, as is typically the case, one tool will not meet the full set of organizational needs. MMT needs to be supplemented by other mechanisms to support the full range of the ASD (NII) C2 Programs Directorate mission. In particular, to the degree that C2 programs continue to include a large volume of detailed capabilities perspectives, an alternative approach to manage and track these may be warranted. Other mechanisms deserving further investigation and characterization include: 1) requirements for an integrated capabilities-based development schedule that could be used to identify opportunities to leverage capabilities across programs, and 2) an integrated management schedule useful to analyze Planning, Programming, Budgeting and Execution (PPBE) aspects.

Program Overlaps

Programs A and B need to start dialog on areas of potential synergism such as those identified in section V. The four areas identified serve as a point of departure for initiating dialogue to glean insight into commonality and opportunities for synergism.

We recommend that a specific apparent overlap (e.g., wargaming for COA analysis) be resolved. The objective of this effort would be to: 1) ensure coordination of the CDDs, 2) gain commitment from both programs on an agreed-to way ahead avoiding duplication, and 3) document the process for subsequent repetition. MMT would be updated and validated by both programs to support a more comprehensive examination of potential overlaps than what has been done to date.

VIII. **References and Cited Literature**

Dahmann, Judith, Kristen Baldwin, Dennis Bergin, Ajay Choudhary, Ana Dubon, Gary Eiserman, "Matrix Mapping Tool (MMT)" white paper OUSD AT&L/Defense Systems Washington DC 20301-3090, 2005.

Chairman of the Joint Chiefs: "Joint Capabilities Integration and Development System," CJCSI 3170.01E, 11 May 2005.

Chairman of the Joint Chiefs: "Universal Joint Task List," CJCSM 3500.04B, 1 July 2002.

Davis, Paul K: "Analytic Architecture for Capabilities-Based Planning, Mission-System Analysis, and Transformation," p. 74, Rand, Santa Monica, CA, 2002. Also available online: http://www.rand.org/publications/MR/MR1513/MR1513.pdf.

USD AT&L: "The Defense Acquisition System," Directive Number 5000.1, Department of Defense, May 2003.

USD AT&L: "Operation of the Defense Acquisition System," Instruction Number 5000.2, Department of Defense, May 2003.