Improving Trade Visibility and Fidelity in Defense Requirements Management:

A Formative Study of the Joint Capabilities Integration and Development System (JCIDS) using Enterprise Strategic Analysis and Semantic Architecture Engineering

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by

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ABSTRACT

In 2003, the Department of Defense (DoD) requirements process migrated from a bottom-up, threat-based force-planning method to a capability-based, top-down approach with the introduction of the Joint Capabilities Integration and Development System (JCIDS). The primary objective of the JCIDS process is to ensure the capabilities required by the joint warfighter are identified, assessed, validated, and prioritized in a transparent process that allows for a balanced and informed decision. Although JCIDS continues to evolve, criticisms remain: solution development and delivery are not timely; the process is complex; and it lacks mechanisms to focus the review across portfolios; to name a few. It is imperative to address these fundamental issues as the DoD is now forced to operate within a severely constrained fiscal environment – the DoD must gain better insight and visibility across its defense requirements portfolio.

This thesis seeks to address these issues through the application of Systems Engineering techniques, specifically an Enterprise Strategic Analysis and Semantic Architecture review, to the JCIDS process. The Enterprise Strategic Analysis reveals the critical stakeholder interactions as well as nuances of the landscape in which JCIDS functions. This is followed by a detailed Semantic Architecture review of sample documents within the JCIDS process to inform a knowledge base. The result of these steps is a formative ontology which reveals basic relationships and patterns with the ability to assist decision makers manage the complexity inherent in the management of joint capabilities.

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1. INTRODUCTION

The United States Air Force (USAF) National Defense Fellows Program places a small number of senior officers at distinguished civilian institutions. The goals of the program include solidifying the USAF's relationship with academic communities, as well as broadening and deepening the Fellow's competencies: absorbing new techniques and processes; learning what is 'state of the art'; and bringing these skills and experiences back to the Services. One might say the ultimate objective of a Fellow is to be the disruptor, to bring change to the military. It is this spirit that inspired the research to support this formative study of the defense requirements process. But that's not the only reason. During my studies at M.I.T. something interesting was happening, it was called Sequestration.

As a result of the Budget Control Act (BCA) of 2011, on 1 March 2013, approximately $1 trillion in automatic budget cuts, spanning ten years, were put into motion across the entire of the U.S. Government. However, what many did not understand was that the BCA directed to "allocate half of the total reduction calculated ($500 billion)…to discretionary and appropriations and direct spending accounts within function 050 (defense function) and half to accounts in all other functions (nondefense functions)"; the Department of Defense (DoD) was directed to reduce its budget by $50 billion (approximately 10%) every year for the next ten years [1, p. 18]. These cuts are in addition to $400 billion of voluntary budget reductions the DoD negotiated in 2011 over the same ten year span. It was clear that within the DoD things would have to change, it was no longer 'business as usual'. Although successive legislation has somewhat decreased these reductions, the severity of their impact remains (Figure 1) [2] .

Military budgets are divided into six sections: procurement; research and development; operations and maintenance; military personnel; defense health; and military construction. Of these, operations and maintenance (the flying of airplanes, sailing of ships and driving of tanks), military personnel, defense health and military construction are difficult areas to grossly adjust which leaves only procurement and research and development (R&D) to absorb the brunt of the cuts. From these two, procurement and R&D, the procurement budget exceeds R&D, in fact by close to 30 per cent at times [3, p. 64]. Therefore, the DoD has channeled its costs savings efforts towards procurement. The challenge, though, is where to focus the efforts within this domain?

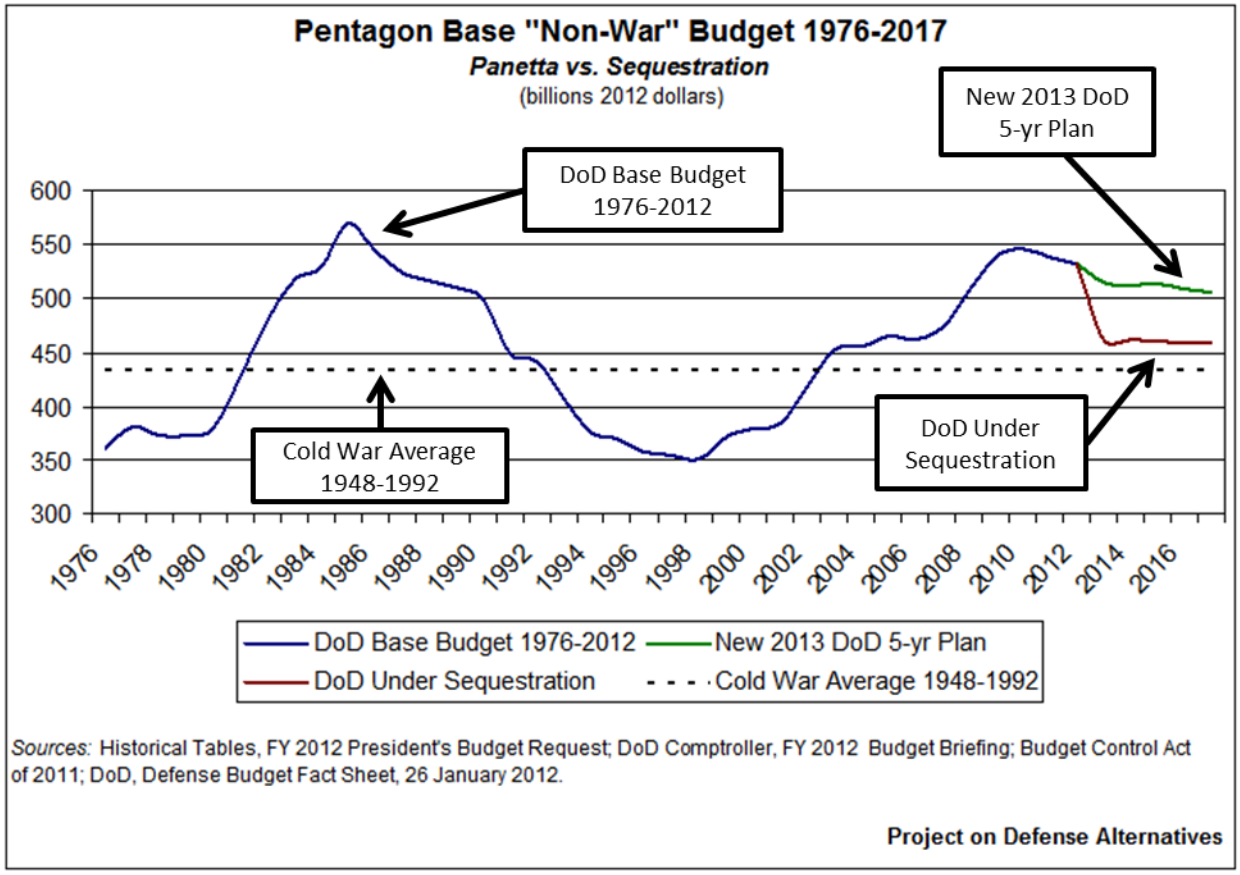


Figure 1: Pentagon Base "Non-War" Budget 1976 – 2017.
(Project on Defense Alternatives)

As noted by Frank Kendall, Under Secretary of Defense for Acquisition, Logistics and Technology, in an e-mail dated December 6, 2013 to members of the acquisition workforce detailing an interim Department of Defense Instruction 5000.02 "Operation of the Defense Acquisition System":

> *The Basic structure of the "acquisition system" is unchanged with minor exceptions. The things that have to be done in defense acquisition never change. They include: identifying a need or desire for a new product, reducing technical risk to an acceptable level, developing and testing the product, and fielding and sustaining it over time.* [4]

While the basic acquisition framework remains unchanged, within this context, there are new processes and approaches that can be implemented, three of which include tight integration of requirements and acquisition communities, "should cost", [1] and affordability analysis [4]. It is

[1] "Should Cost" is defined as a regulatory tool designed to proactively target cost reduction and drive productivity improvements into programs. It applies to programs in all acquisition categories, in all phases of the product's life cycle, and to all elements of program cost.

two of these three areas that this formative study can assist. This study applies an enterprise analysis to the defense requirements process to identify and investigate the stakeholders and processes, to include their incentives, interactions and dynamics, to better inform those within the requirements and acquisition communities – hopefully to assist with the integration of these two communities. Next, it continues with the capture of sample data from the requirements process to inform an ontology that can be leveraged to reveal relationships and patterns for decision makers – hopefully to assist with affordability analysis.

While some might see the current austere fiscal conditions as a grave threat to the DoD community, others, like Jack Mohney, a professor of requirements at the Defense Acquisition University, see a challenge – we have a "prime opportunity to address long-standing process disconnects, thus improving the materiel solutions our warfighters use in battle while giving ourselves – the taxpayers – a needed cost break" [5]. In the same article, Dr. Ashton Carter, previous Deputy Secretary of Defense, and then serving Under Secretary of Defense for Acquisition, Technology and Logistics notes "the alternative is broken programs, canceled programs, budgetary turbulence, the kind of unpredictability and uncertainty that are bad for industry; the erosion of taxpayers' confidence that they're getting value for their money;.… It's now time for a DoD-wide behavioral shift."

1.1. REQUIREMENTS PROCESS

Solving the problem is the easy part; the hard part is understanding what the problems is. Understanding the problem – the real problem – is the role of the requirements process [6]. Both IBM and the Volere Requirements Technique detail a similar nine step Requirements Management Process (Table 1) [6] [7]. Of these nine steps, the first two, can be the most daunting. They encompass the organization and rationale of the project.

Process Step	***IBM***	***Volere***
1	Create an overview of the project	Project blastoff
2	Analyze the problem and gather stakeholder needs	Trawl for requirements
3	Document features in a vision document	Prototype the requirements
4	Develop requirement details	Write the requirements
5	Create traceability between requirements	Quality gateway
6	Prioritize requirements	Design and build
7	Assign requirements	Review the requirements
8	Add detail to requirements	Requirements reuse
9	Manage changes to requirements	Product use and evolution

Table 1: Requirements Process

A system architecture approach can be quite helpful to capture, frame and organize the effort. System architecture is defined as "an abstract description of the entities of a system and the relationships between those entities" [8]. This is usually a deliberate approach when applied to "familiar products of industry (cars, aircraft, computers)" and often follows a "process of decomposition, in which a top-level concept of the system's required functions is broken down into subfunctions" [8]. Within the architecting process, several types of architectures are involved: functional; physical; technical and operational [9]. The functional architecture in turn identifies the non-functional architecture which includes the life cycle aspects of the system, the "ilities" (Process Step 4). It is specifically these "ilities", such as durability, adaptability, and affordability that tend to affect life-cycle value [8]. The insight that the architecture affords into these areas provides valuable information for decision makers as they assess the viability of their system in today's fiscal environment.

As the architecture decomposes the system's functions a natural hierarchy of logical groupings/categories tends to arise (a taxonomy in the biological sense). These categories, referred to as 'views' in the military, could be as simple as a mono-wing, bi-wing, or tri-wing configuration for an aircraft or data structures, organizational forms, or knowledge representations that support an intellectual framework [8]. Regardless of the exact category, these break-outs, including the relationships and interactions amongst themselves, are instrumental to understanding the system's behavior. The existing system can be mapped "as-is" against the hierarchical categorization to reveal where something is missing – a "gap". It is this gap that the requirements process tries to identify and 'fill'.

1.2. DEFENSE REQUIREMENTS PROCESS

The DoD manages its requirement process via the Joint Capability Integration Development System (JCIDS) implemented by the Joint Staff under the direction of the Chairman, Joint Chiefs of Staff. JCIDS focuses on advancing capability analysis, improving operational requirements development, and promoting joint solutions to wartime problems – a capability-based, top-down approach. Experience with this approach is still fairly limited as JCIDS was introduced in 2003, but not fully implement until 2009. Historically the DoD utilized a bottom-up, threat-based force-planning method to develop forces based upon specific threats and scenarios (Figure 2) [10]. This fostered an environment where requirements were often

developed, validated, and approved as stand-alone unique solutions to counter specific threats or scenarios, not as participating integrated elements in an overarching system of systems.

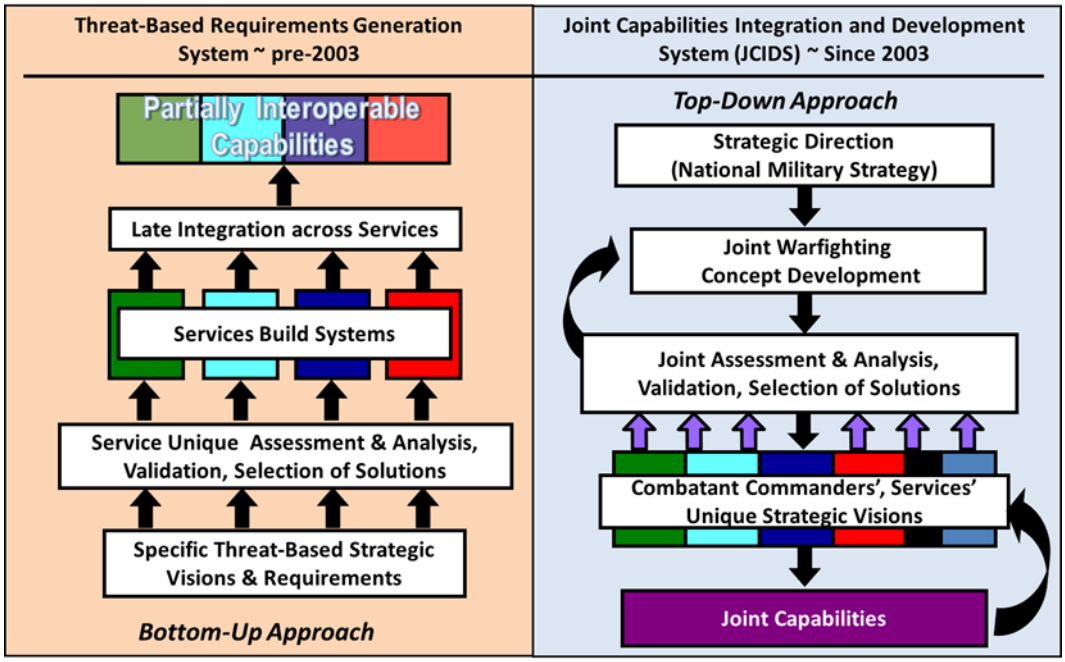


Figure 2: The Evolution of DoD Requirements Generation Process
(Defense Acquisition University, 2012)

The primary objective of the JCIDS process is to ensure the capabilities required by the joint warfighter are identified, assessed, validated, and prioritized in a transparent process that allows for a balanced and informed decision. This process is similar to the trade visibility process in the corporate sector which "offers a transaction-centric outlook coordinating multiple functional modules while enabling event management of business processes" [11]. JCIDS' intent is to employ a synchronized, collaborative, and integrated approach that links strategy to capability. JCIDS consists of two major phases: document build and document review. The document build portion includes the analysis phase which is captured in a Capabilities Based Assessment (CBA), whose objective is to validate capability gaps. The CBA is the starting point in identifying the DoD's needs and recommending solutions.

The CBA provides recommendations to pursue either a materiel or non-material solution. If a non-materiel solution is proposed it is documented in a Doctrine, Organization, Training, materiel[2], Leadership, Personnel, Facilities, Policy (DOTmLPF-P) Change Recommendation

[2] Materiel in DOTMLPF-P is 'small' materiel -- all the "stuff" necessary to equip forces that DOES NOT require a new development effort (weapons, spares, test sets, etc that are "off the shelf" both commercially and within the government) [61]

(DCR)[3]. If a Material solution is recommended it is documented in one of three capability documents, based upon the maturity of the solution (Figure 3):

- Initial Capability Document (ICD) – documents the need for a materiel solution;
- Capability Development Document (CDD) – specifies the operational requirements for the system;
- Capability Production Document (CPD) – specifies the information required for production, testing and deployment.

The resulting capability document (CD) is processed by a Joint Staff 'Gatekeeper' and forwarded within JCIDS for further review by the appropriate Functional Capabilities Board (FCB). The FCB reviews, prioritizes and makes recommendations to the final approval authority, the Joint Requirement Oversight Council (JROC). Upon JROC approval, the CD exits JCIDS as a validated, prioritized joint military requirement ready to enter into the DoD Acquisition Process.

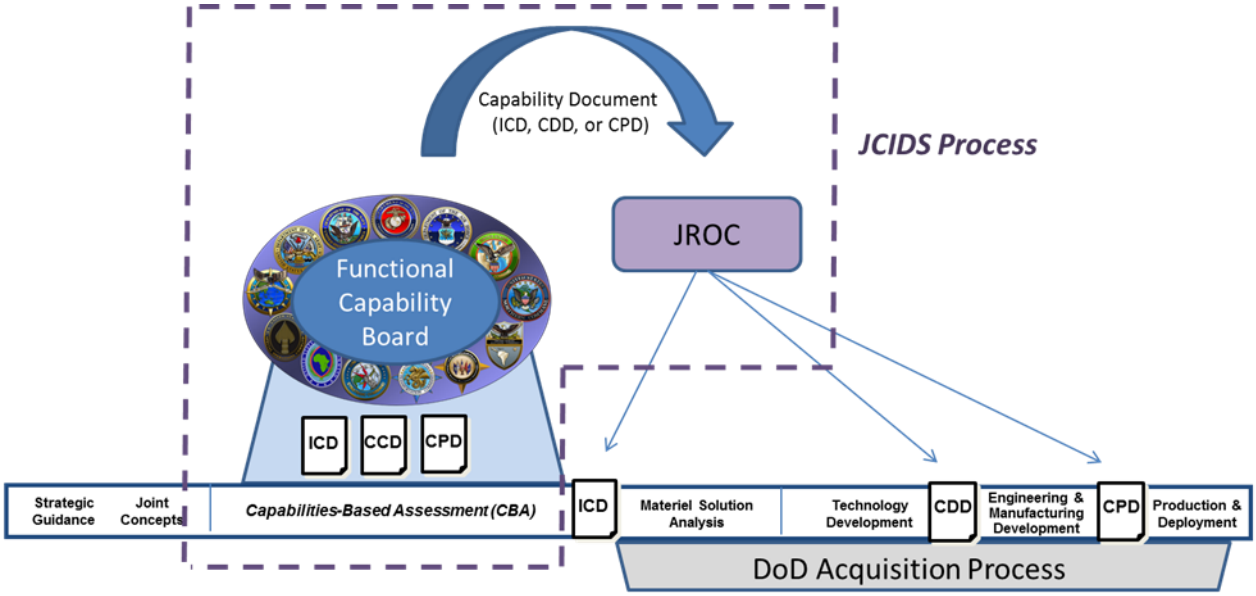


Figure 3: Capability Progression through JCIDS

Concurrent to the introduction of JCIDS, in 2004 the Joint Defense Capabilities Study, also referred to as the Aldridge Study, proposed the addition of Joint Capability Areas (JCA). The study called for dividing the DoD's capabilities into manageable capability categories (later called areas) as an essential early step to implementing a capabilities-based approach [11]. The JCAs were the first step to providing a common language to discuss and describe issues across

[3] For the purpose of this study, the assumption is that a material solution is proposed; therefore the resulting document is a capability document.

all of DoD requirements. For the next few years the number of JCAs fluctuated at approximately 22 Tier 1 and 200 Tier 2 elements. In 2008, the Deputy's Advisory Working Group recommended, and the Deputy Secretary of Defense approved a final list of nine Tier 1 JCAs and their functional decomposition down to the Tier 3 level, as well as codifying JCAs as the DoD's capability management language and framework. Currently there nine Tier 1 JCAs: force support; battlespace awareness; force application; logistics; command and control; net-centric; protection; building partnerships; and corporate management and support. As of April 8, 2011 there were 37 Tier 2 elements and 117 Tier 3 elements [12].

In 2008, Department of Defense Directive 7045.20, dated September 25, 2008, introduced the concept of Capability Portfolio Management (CPM). It directed:

> *The use of capability portfolio management to advise the Deputy Secretary of Defense and the Heads of the DoD Components on how to optimize capability investments across the defense enterprise (both materiel and non-materiel) and minimize risk in meeting the Department's capability needs in support of strategy.* [13]

Building upon DOD capabilities-based planning (CBP) and management efforts to facilitate strategic choices and improve the ability to make capability tradeoffs, FCBs and capability portfolio managers are instructed to collaborate with each other's processes to ensure awareness of cross-portfolio interdependencies and provide appropriate context to requirements and acquisition decision making [14, p. 188].

It is interesting to note that the United Kingdom's Ministry of Defense (MOD) utilizes a similar capability based requirements process which is captured in their MOD Architecture Framework (MODAF). The MODAF process is based upon the US Department of Defense Architecture Framework (DODAF) [15]. In particular, the MODAF affords a strategic view (StV) which captures capability policy/concepts, decomposing this into a capability taxonomy supported by appropriate measures of effectiveness that can be used for capability audit and gap/overlay analysis [16]. This view is then time-shifted and applied across phases, known as epochs [17].

1.3. SCOPE OF EFFORT

This thesis fits into a larger research effort regarding the utility of a semantic architecture framework in support of defense requirements. The focus of this thesis is the application of

Systems Engineering to the JCIDS process to improve trade visibility and fidelity[4] in the management of defense requirements. The study seeks to investigate the feasibility of a common ontology for the use in the analysis of JCIDS documents to support analytics needed for the complexity inherent in the management of joint capabilities. An approach was implemented to frame enterprise issues through a systematic review of the current JCIDS process using an enterprise strategic analysis method. This was followed by an empirical review of JCIDS documents to capture sample data to inform an ontology that can be leveraged to reveal relationships and patterns for decision makers.

1.4. THESIS ORGANIZATION

The remainder of this thesis is organized as follows:

- Section 2 presents results from an Enterprise Strategic Analysis that was conducted utilizing the MIT Enterprise Strategic Analysis for Transformation (ESAT) methodology. The objective of this section is to identify and frame the enterprise level issues facing the defense requirements process.
- Section 3 presents results from an empirical review of over 86 sample JCIDS documents to gain a perspective on semantics as used versus as instructed. The objective of this section is to distil a capability document to its core, to determine if the basic elements exist to support an ontology.
- Section 4 introduces a basic ontology based upon the results from Sections 2 and 3. The objective of this section is to present a basic ontology that could be used to assist decision makers with identifying capability gaps and solutions through cross-capability analysis.
- Section 5 presents a case study which documents the interoperability challenges the US Air Force F-35 fighter aircraft encountered as part of the defense requirements process. The objective of this section is present a scenario where an ontology could provide utility.
- Section 6 presents conclusions and recommendations, to include a discussion how this study can be applied to areas other than the DoD.

[4] Although this phrase has multiple meanings within the DoD, for this study it is defined as clarifying the complex relationships and providing requirements traceability and alternatives while improving the accuracy and precision of the accompanying information, to include cost. The end result is offering Senior DoD Leadership improved data to better inform their decisions.

2. ENTERPRISE STRATEGIC ANALYSIS

The MIT Systems Engineering Advancement Research Initiative identifies Enterprise Perspective as one of four key aspects when dealing with engineering systems[5] [18]. The importance of an enterprise perspective cannot be overstated. "In order to successfully design and develop large-scale complex engineering systems, engineers must take all of the enterprise issues into account" [19]. As discussed earlier, an enterprise perspective will help to better inform the requirements and acquisition communities of the challenges and issues each face. **The goal of the Enterprise Strategic Analysis is to frame the enterprise level issues facing the defense requirements process.** As was succinctly stated by one Senior Leader Stakeholder, "Affordability is not a JCIDS (requirements) question, nor is it a budget (acquisition) question. The solution is that the (communities) must work together…" For this thesis, the MIT Lean Advancement Initiative's (LAI) Enterprise Strategic Analysis Transformation (ESAT) methodology was applied to the JCIDS process. LAI's ESAT (from here forward referred to as ESAT) is an integrated, analytical framework for diagnosing and improving overall enterprise performance (Figure 4).

ESAT methodology is designed to optimize the enterprise value stream as a critical element in formulating a strategic business plan and transforming to a lean enterprise [20]. This systematic review allows us to: [21]

- Develop an understanding at the total enterprise level.
- Identify sources of waste in the enterprise as well as obstacles of value delivery.
- Gather stakeholder values/needs.
- Conduct analysis to connect stakeholder values, strategic objectives, enterprise processes, and metrics.
- Identify barriers to the creation/delivery of value to each stakeholder.
- Develop a vision for the enterprise based on a lean implementation program.

A comprehensive, detailed eight step ESAT analysis of the JCIDS process was conducted as a group project in support of MIT ESD 61 – Integrating the Lean Enterprise Course [22]. For this thesis, the focus is limited to the first three steps: define the enterprise; collect data; and construct current state perspectives. These steps generate a current state perspective through the study of stakeholder analysis, processes and interactions, along with a review of current

[5] The other three are: broad interdisciplinary perspective; intensified incorporation of system properties; and complex synthesis of stakeholder perspectives.

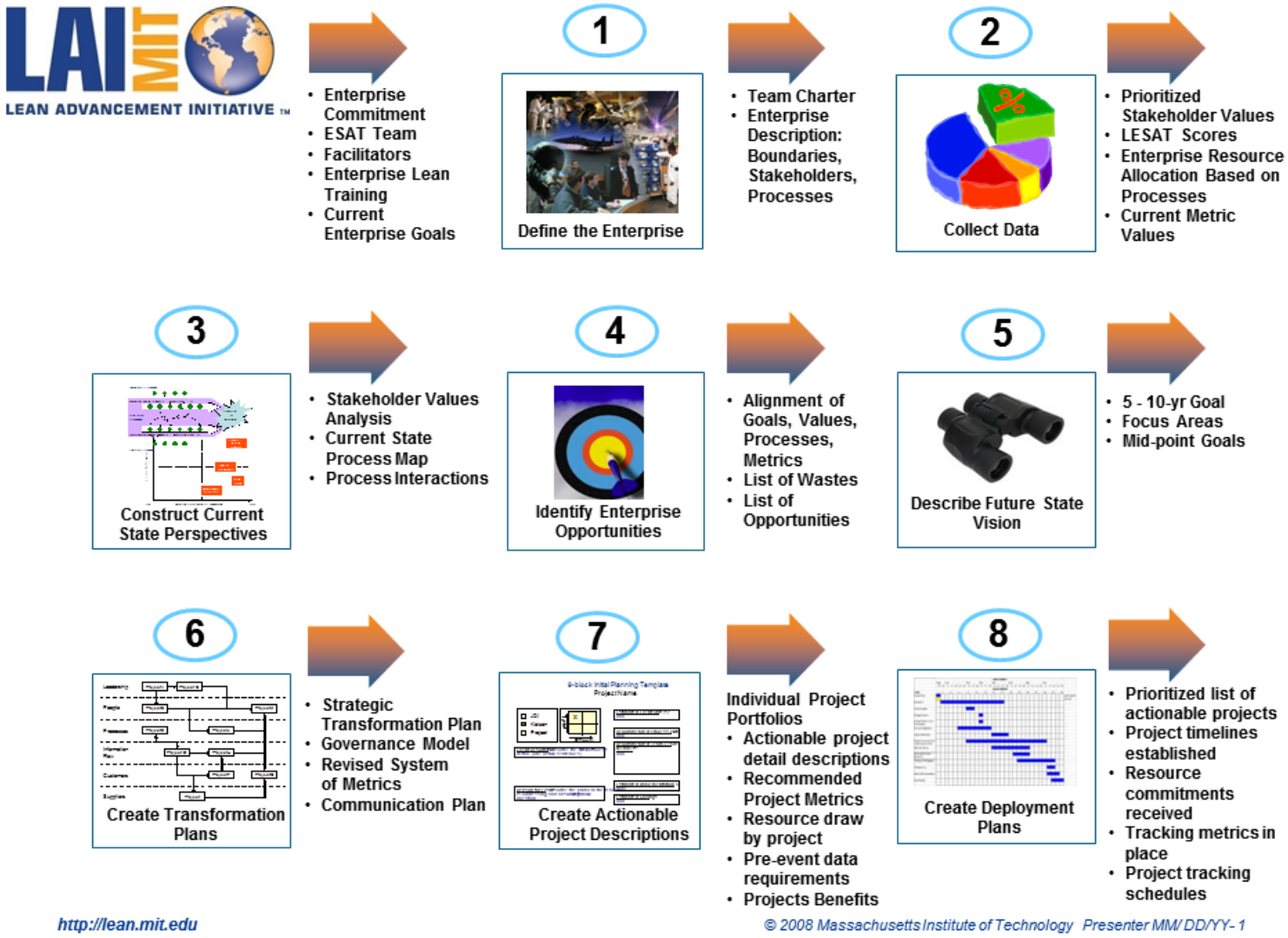


Figure 4: MIT LAI Enterprise Transformation Roadmap
(LAI MIT, 2013)

performance measurements (metrics). This information provides insight regarding stakeholders' perspectives, what they perceive as the "value proposition" delivered by the system which ultimately informs the 'Enterprise Value'.

2.1. ESAT STEP 1: DEFINE THE ENTERPRISE

The first step in the ESAT process is enterprise definition. This includes the scope of effort, the goals, challenges and issues associated with the process, as well as clearly identifying the stakeholders.

2.1.1. SCOPE OF EFFORT

The current version of the JCIDS process is regulated by Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3170.01H dated 10 January 2012. As noted earlier, JCIDS was introduced in 2003; however it was not fully implemented until 2009. Access to 2012 data sets was limited at the time of the assessment therefore the scope was set to the 2009 edition of JCIDs.

In particular, the ESAT evaluation focusses on the process that a typical, large Joint program would follow in the JCIDS process (Figure 5) [23]. The first phase is Document Build, which consists of: JCIDS analysis; document creation; entry into knowledge database (KM/DS[2]); and gatekeeper review. The second phase is Document Review, which consists of: Joint Staff Review; FCB review; and JROC approval.

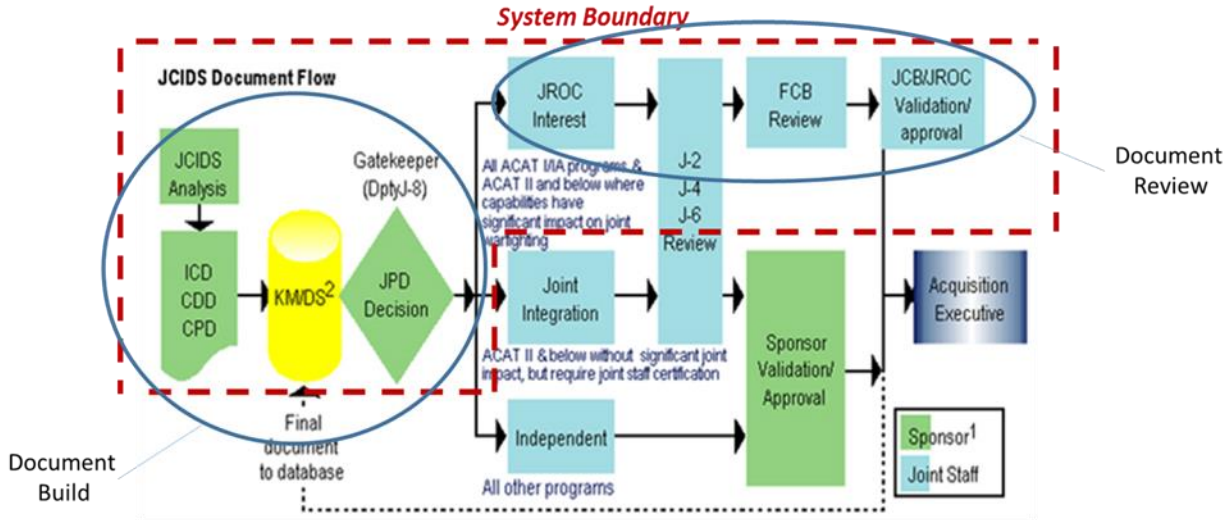


Figure 5: JCIDS process flow for 'typical' large, Joint Program
(Weinberger, 2008)

2.1.2. STRATEGIC GOALS, OBJECTIVES, ISSUES AND CHALLENGES

To assist with the enterprise definition, it is critical to understand JCIDS' operating environment, to include challenges and issues. The JROC assists the Chairman of the Joint Chief of Staff (CJCS) in "assessing, prioritizing, and approving joint military requirements" [14]. The JROC takes into consideration cost, schedule, and performance trades to ultimately shape the force of today into the force of tomorrow.

Requirements are vetted and approved using JCIDS. Nine strategic objectives were identified for the JCIDS process (Table 2), of which the primary objectives are to ensure the capabilities required by the joint warfighter are identified, assessed, validated, and prioritized in a transparent process that allows for a balanced and informed decision. It is interesting to note that the JCIDS process (Table 2) follows a similar strategy as described previously in the Requirements Management Process (Table 1). The JCIDS process first two primary objectives; Identify and Assess Joint Military Capabilities, organize and scope the rationale of the project, as directed in the Requirements Management Process. Furthermore, JCIDS calls for the Prioritization of Military Capability Requirements (Table 2, objective 4), as does the Requirements Management Process (table 1, process step 6).

	Objective	***Primary***
1	Identify Joint Military Capability Requirements	X
2	Assess Joint Military Capability Requirements	X
3	Validate Joint Military Capability Requirements	X
4	Prioritize Joint Military Capability Requirements	X
5	Balance Joint Equities	
6	Assist with Informed Decisions	
7	Facilitate Doctrine, Organization, Training, Materiel, Leadership Policy and Education, Personnel, Facilities, and Policy (DOTmLPF-P)	
8	Drive Defense Acquisition System	
9	Inform Planning, Programming, Budgeting, and Execution Processes	

Table 2: JCIDS Strategic Objectives

The intent of the JCIDS process is to employ a synchronized, collaborative, and integrated approach that links strategy to capability. However, JCIDS remains a 'work in progress'. Despite the 2012 revision, criticism of JCIDS remains: [10]

- solution development and delivery are not timely;
- decisions are made late to need or with poorly scoped information;
- the process is complex, cumbersome and too document-centric;
- it lacks mechanisms to focus review across portfolios;

- it does not control “requirements creep”;
- it does not include key customers in the decision process;
- it does not have tracking mechanisms to trace developments from gap identification through solution fielding.

These criticisms fall into three categories: affordability, stability and tough decision making early.

2.1.2.1 AFFORDABILITY

Affordability is a key challenge facing JCIDS. Since 1995, the Army alone has cancelled “22 major programs, at an estimated cost of $32 billion, for equipment that was never built or fielded” [5]. Upfront, JCIDS has to determine affordability. “The key is doing those engineering trades right at the beginning and then sticking with them.… You don’t buy the car that you fantasize about. You first check how much money you have before you buy a car. And we need to start doing that” [5]. Other penalties from an ‘over commitment’ of resources can include constantly shifting insufficient funds from one program to another which can lead to increased costs and programs delays resulting in a lower quality product .

The goal of the updated JCIDS process is to achieve better affordability through:

- Up front analytical rigor.
- Greater fidelity in cost, schedule, and estimates enabling better performance trade-offs.
- Incorporation of affordability as a firm requirement in all programs like other “ilities”.
- Making the tough decisions up front and throughout the lifecycle.

2.1.2.2 REQUIREMENTS INSTABILITY

Requirement instability results in costly schedule delays and performance issues later in a program’s life. Starting with the Warfighter’s capability analysis, the hard work must be done up front and remain stable throughout a program. To improve stability, JCIDS must ensure requirements are captured up front in the process and eliminate requirement creep by establishing mechanisms such as configuration steering boards to limit future changes. Requirements form the basis of any program and JCIDS is the mechanism by which those requirements achieve stability. Without stable requirements, programs will never achieve their intended purpose and this is not an option in today’s environment. Stability is a must.

2.1.2.3 TOUGH DECISION MAKING EARLY

Additional JCIDS challenges include the inability to prioritize requirements and lack of rigor required to eliminate wasteful programs. At the confirmation hearing of General Dempsey, Chairman of the Joint Chiefs of Staff, a congressional question for the record asked, "General Dempsey, what's the remedy for Admiral Mullen's (former CJCS) belief that DoD has 'lost the ability to prioritize, to make hard decisions, to do tough analysis, to make trades'?" In response, General Dempsey stated "Over the last decade in an era of relatively unconstrained resources, the Department of Defense has not had to make difficult decisions about budgetary tradeoffs. While we may have lost some of the "muscle memory" for such decision-making, I am confident we can adapt to a changing security and fiscal environment. If confirmed, I will build on current efforts to strengthen the analytical processes needed for making hard choices. More importantly, I will reinforce a culture of cost discipline that will ensure we remain good stewards of our national resources" [24]. Also, multiple sources, to include the Defense Science Board and the Government Accountability Office, criticized the JCIDS process as "not making the hard decisions up front regarding cost, schedule, and performance" [25]. To tackle these issues, time needs to be invested up front in the JCIDS process to ensure the proper discussions occur and analysis is done. JCIDS intends to achieve these objectives through:

- Limiting the decision audience (cut through bureaucracy).
- Balancing cost vs. capability vs. risk.
- Making the tough decisions early.
- Debating critical items such as portfolio analysis.
- Reviewing the entire (all classification levels) DoD portfolio to determine if a solution exists prior to creating one.
- Being solution-centric, not document/process-centric.

JCIDS no longer has the luxury of being a bureaucratic, document-centric process. Enterprise level issues such as failing to consider affordability, not making the tough decisions early, and constantly changing/altering requirements has resulted in drastic measures throughout the DoD. JCIDS is the methodology that will shape the future joint force and thus must become a leaner, more agile process in order to deliver requirements and capability is an efficient and effective manner.

The Joint Staff, which manages the JCIDS process, is well aware of these outstanding issues. In fact, in the recent 2012 revision, they tackled the issue of timeliness drastically

reducing the amount of time required to process the CDs. The issue of timeliness resided completely within the Joint Staff's domain, making it one of the easier issues to resolve. With regards to the larger issues, another revision is underway to support a 2014 update.

2.1.3. Stakeholders

The final piece of the enterprise definition is a clear accounting of the stakeholders. Six stakeholder categories were identified (Table 3). While these stakeholder categories could further be sub-divided into their constituent parts, for the purpose of this effort it was deemed satisfactory to remain at this higher level.

JCIDS Stakeholders	
Type	Stakeholder
End User	Warfighters -- Service Members
	Americans
Customers	Service Acquisition Authorities
	Defense Contractors
	Military Program Offices
Suppliers	American Citizens
Partners	Military Services (ARMY, NAVY, US Air Force, US Marine Corps)
Employees	DoD Joint Staff
	FCB
	JROC
Strategic Leadership	President of the United States
	US Congress
	US Secretary of Defense
	Joint Chiefs of Staff
	Combatant Commanders

Table 3: JCIDs Stakeholder Categories

The main *End Users* of the JCIDS process are the Warfighters. These are the service members (from the Army, Air Force, Navy, Marines) that will be actually using/operating the weapon system (or capability) that is being considered in the JCIDS process. Another ultimate set of End Users are the American people, as the recipients of the national defense being provided.

The *Customers* of JCIDS are the Service Acquisition Authorities. These are the direct customers of the requirements process. They input requirements into the process (gathered from End Users) and act upon the output (create a program office, develop a weapon system). Other important customers of the JCIDS process are defense contractors and program offices. They

need the product created by JCIDS (approved Capabilities Documents) in order to do their jobs…create and manage a weapon system.

The *Suppliers* of the JCIDS are the U.S. taxpayers without whom the DoD would not exist. Although their funding is critical, it is actually allocated by Congress who acts on their behalf.

The military services are *Partners* in JCIDS. They are codependent in the requirements process.

The *Employees* of the JCIDS enterprise are the members of the Joint Staff organization (J8) that "runs" the JCIDS process, staffing, etc. The other employees include the members of the Functional Capabilities Boards (FCB) and Joint Requirements Oversight Council (JROC) since they are part of the JCIDS execution and the key decision-making bodies.

The *Strategic Leadership* for the JCIDS enterprise comes from The President, Congress, Secretary of Defense, Joint Chiefs of Staff, and the Combatant Commanders. They all have a large hand in the strategic direction for JCIDS and allocate the resources required to make it run.

2.2. ESAT STEP 2: COLLECT DATA

The second step in the ESAT process is data collection. JCIDS afford two types of data, quantitative and qualitative. Quantitative data was harvested from the CDs, whilst qualitative data was received via feedback from JCIDS stakeholders.

2.2.1. QUANTITATIVE -- PROCESS TIME & ENTERPRISE COST

The quantitative data set consisted of 25 documents (8 ICDs, 8 CDDs, and 9 CPDs) spanning a number of programs types, from large acquisition efforts to smaller IT programs, across all the military services[6]. Each capability document had a configuration control page which tracked document revisions/updates providing insight into the time and effort spent to process the document.

Process Time

Figure 6 is the JCIDS process value stream map. It reflects the quantitative nature of the process (time & money), noting that it consists mostly of staffing. As discussed earlier, the process time has been reduced and is now envisioned to take no longer than 83 days versus "taking on average up to 10 months" [26].

[6] At the time of this report, JCIDS processed approximately 60 – 75 documents per year.

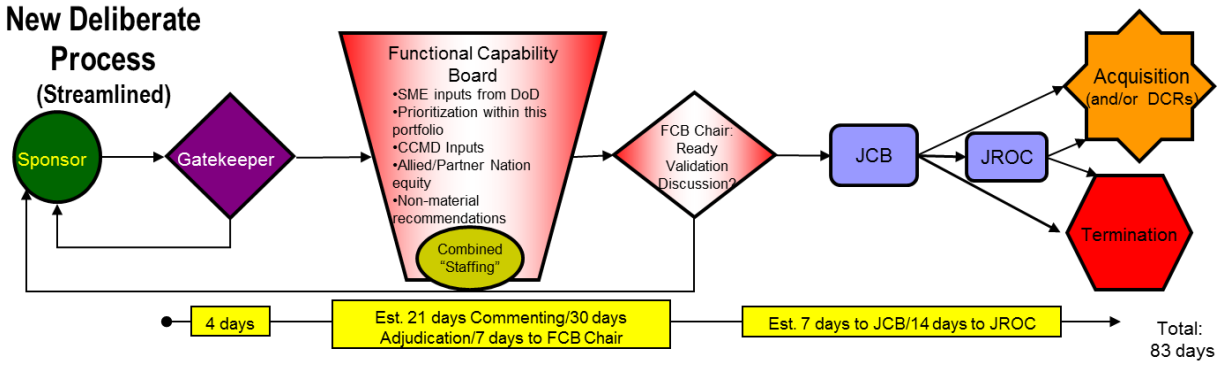


Figure 6: JCIDS Process
(CJCSI 3170.01H Jan 12)

Entry into the formal JCIDS process occurs once the Sponsor provides the CD to the Joint Staff Gatekeeper. The Gatekeeper performs an initial review/assessment of the CD before it can move forward. Upon 'release' from the Gatekeeper, the CD proceeds to the FCB which is composed of three distinct phases: FCB Working Group commenting (includes assessment of capabilities, tasks, attributes, metrics, and risk areas); Adjudication (includes recommendation of prioritized CDs across the FCB portfolio); and finally FCB Chair approval (includes coordination with other relevant FCBs as required). From there the CD proceeds to the JROC for final review at which point the JROC convenes and then issues results. (See Figure 7 below for a detailed breakout of the timeline)

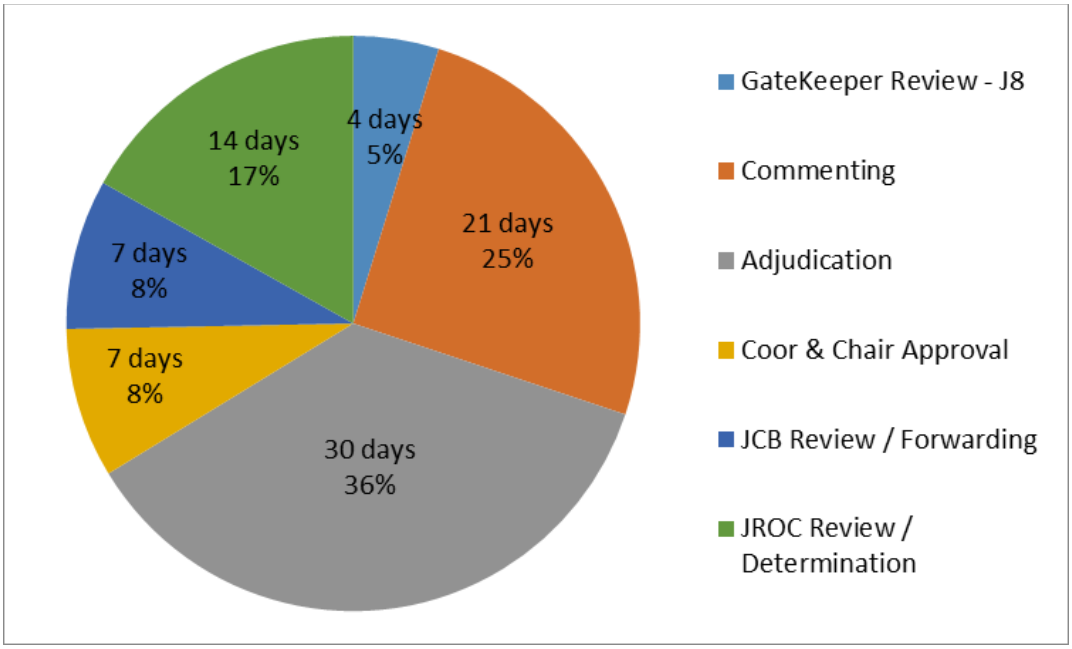


Figure 7: JCIDS Process Steps Timeline

Enterprise Costs

Cost in this process is a function of time and size of the JCIDS staffs. The average Joint Staff officer working on this process through the Gatekeeper, Functional Capabilities Board, and Joint Capabilities Board phases is an O-6 (Colonel/Navy Captain). Even though there are flag officers (General/Admiral) leading the efforts, an aggregate was taken that averaged the grade of the personnel that actually staff/analyze the documents and process. The Joint Requirements Oversight Council process involves a mix of O-6s and O-10s (4-star flag officers). An average hourly pay was applied based on the 2013 pay tables for an O-6 with 24 years and an O-10 with 35 years (the average time in service for the four Service Vice-Chiefs and the Joint Chiefs of Staff Vice-Chairman). The costs of each hour of effort are approximate but applied consistently across the enterprise; these approximations are adequate for the purpose of measuring affects proportionally. Table 4 provides an excerpt of select individual process step as well the correlated staffing costs per document.

Process Step	***Hours***	***Avg. Rank***	***Cost***	***% process time***	***% process cost***
Gatekeeper	32	O-6	$2,477.10	4.8%	4.6%
FCB	464	O-6	$35,917.88	69.9%	66.0%
JCB	56	O-6	$4,334.92	8.4%	8.0%
JROC (Staff)	52	O-6	$4,025.28	7.8%	7.4%
JROC (Board)	60	O-10	$7,632.90	9.0%	14.0%
TOTAL	***664***		***$54,388.08***		

Table 4: JCIDS Process Costs per Document

The facilities, overhead, and materials used in JCIDS were researched, and while it was found that their minimization could generate some efficiency, taken on the whole their effects across the enterprise were considered negligible.

Figure 8 depicts individual process times and costs as a percentage of the JCIDS effort. After having done the time/dollar calculations for the JCIDS steps, it became apparent that this small portion of the enterprise wasn't the source of inefficiencies in the system. As confirmed by the stakeholder surveys, the qualitative elements of JCIDS (not the time/money) are the driving forces in the enterprise.

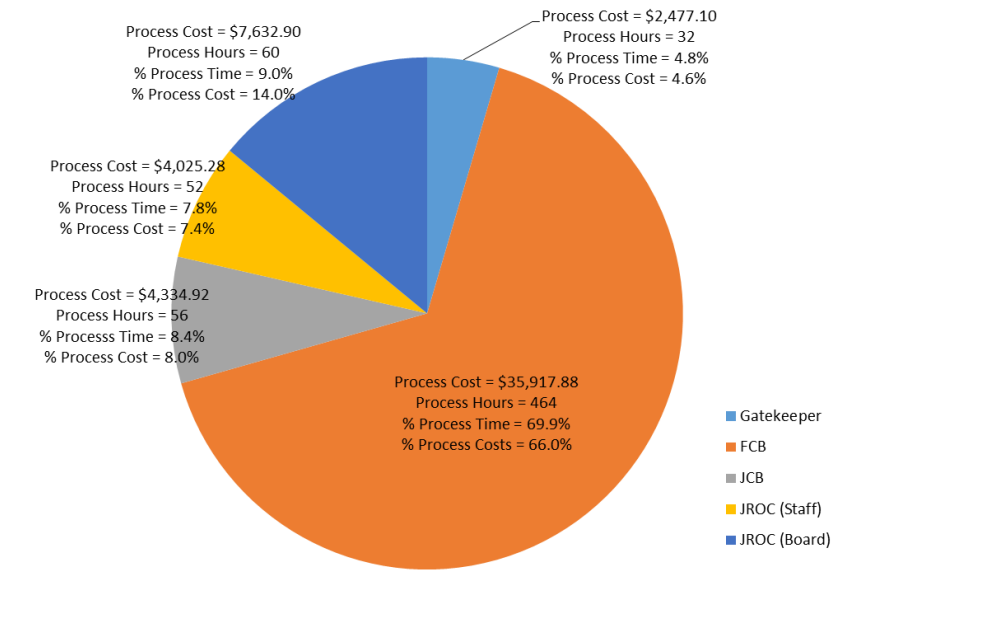


Figure 8: JCIDS Individual Steps and Correlated Costs

2.2.2. QUALITATIVE -- SURVEYS & INTERVIEWS

Although a number of specific metrics within JCIDS track 'quality', these metrics are not currently recorded (this is addressed more fully in Section 2.3.3). Lacking this data, surveys were conducted of applicable stakeholders. Surveys were e-mailed to various former and current stakeholders to include End Users, Customers, Partners, Employees, and Leadership[7]. Respondents were asked to assess their personal opinion on the relative importance and performance of 20 different aspects of JCIDS. Respondents were also given an opportunity to give additional feedback on those 20 aspects and the survey included an open section, which the respondent could fill out with anything that he/she chose to write. A blank copy of the survey is included as Appendix A.

After compiling the initial survey data, an additional round consisting of follow-on interviews, and a final set of more detailed, focused surveys (Appendix B) was conducted with a small, select number of strategically positioned stakeholders to elicit additional data and further details in specific areas. Samples from the survey and interview questions are presented below:

- What functions should JCIDS include that it does not already perform?
- How stable are the identified requirements after approval?

[7] Surveys were not sent to Suppliers, rather team members, as American Citizens, provided inputs for this stakeholder category.

- Rate the Relative Importance of Transparent Process.
- Rate the Relative Performance of JCIDS ability to deliver Coordinated Requirements.
- How do you regard the JCIDS process, is it a one-time (static) process?

Interview and survey data derived from explicit questions, such as those above, as well as information extracted from free-narrative responses were instrumental for identifying 21 key stakeholder values (See Appendix C for the full stakeholder value exchange) as well as provided great insights into the stakeholder experiences with JCIDS.

Key Stakeholder Values																					
Stakeholder	Effective Capabilities	Effective Contribution to National Defense	Defined Requirements	Accurate Requirements	Vetted Requirements	Coordinated Requirements	Prioritized Requirements	Thorough, Complete Capability Documents	Affordable Requirements	Actionable Requirements	Efficient us of Taxes	Validated Capabilities and Gaps	Robust Process	Responsive Process	Flexible Process	Transparent Process	Documented Process	Articulate Capability Documents	Coordinated Assessments	Effective Military Force	Efficient Use of Budget
End User	X																				
Customers		X	X	X	X	X	X	X	X	X											
Suppliers											X										
Partners								X				X	X	X	X						
Employees						X										X	X	X	X		
Strategic Leadership		X	X	X			X	X			X	X		X		X				X	X

Table 5: Key Stakeholder Values

2.3. ESAT STEP 3: CONSTRUCT CURRENT STATE PERSPECTIVES

The third step in the ESAT process is to build the current state perspective. This perspective is based on analysis of stakeholder values, enterprise processes and their interactions, and high-level metrics within the enterprise. The resulting data is captured in an "X-Matrix" which details these interdependencies providing an enterprise level mapping of the system.

2.3.1. VALUE EXCHANGE ASSESSMENTS

Over 30 requests for information were submitted, with 14 survey results from the Joint Staff, Combatant Commands (CCMD), the Office of the Undersecretary of Defense (OUSD) for Intelligence, Service Acquisition Executives, US Air Force, US Navy and Military Program

Offices. Overall, the relative importance vs. performance comparisons indicated that the requirements values of "Prioritization" and "Affordability" were underperforming in relation to the relative importance, whereas validation and effectiveness of "Capability" was performing quite well.

2.3.1.1 PRIORITIZATION

In regards to prioritization, one respondent noted that JCIDS needs to "prioritize requirements in addition to validate them…At issue is there are more requirements than resources to execute, and the acquisition arm needs to know, in a resource-constrained environment, which ones it should work on before others." Another respondent noted that the acquisitions authorities will currently make that determination, which means that those who submit requirements into JCIDS may have no say in their priority. The solution may be, as one respondent posited, to have each Functional Capabilities Board prioritize all requirements across its mission space, and to have the Joint Capabilities Board integrate "those requirements together and [prioritize] then across the department," after which the compilation of prioritize requirements would be "sent to the JROC and Chairman of the Joint Chiefs of Staff for approval."

2.3.1.2 AFFORDABILITY

For affordability, one respondent nailed the crux of the issue: "You can't cost requirements – you can only cost solutions." The majority of respondents noted there seems to be confusion regarding the definition of affordability as it is often confused with "program costs (something JCIDS tracks very well) but cost and affordability are two different things". As remarked by one senior executive within the requirements community, "Affordability is what (the customer) can afford, not how much a program is estimated to cost". Remarkably, neither the JCIDS Instruction nor Manual prescribes a definition for affordability. What the JCIDS Manual does offer is that the "affordability determination is made as part of the cost assessment in the (supporting) analysis" [14, pp. B-36]. As was commented, "affordability is not always 'established'". Rather it should be used "as a tool to promote responsible and sustainable investment decisions". Several respondents also felt that the real cause of affordability creep was

in the acquisitions process. Figure 9 provides an executive level summary of a select portion of the quantitative results from the surveys[8].

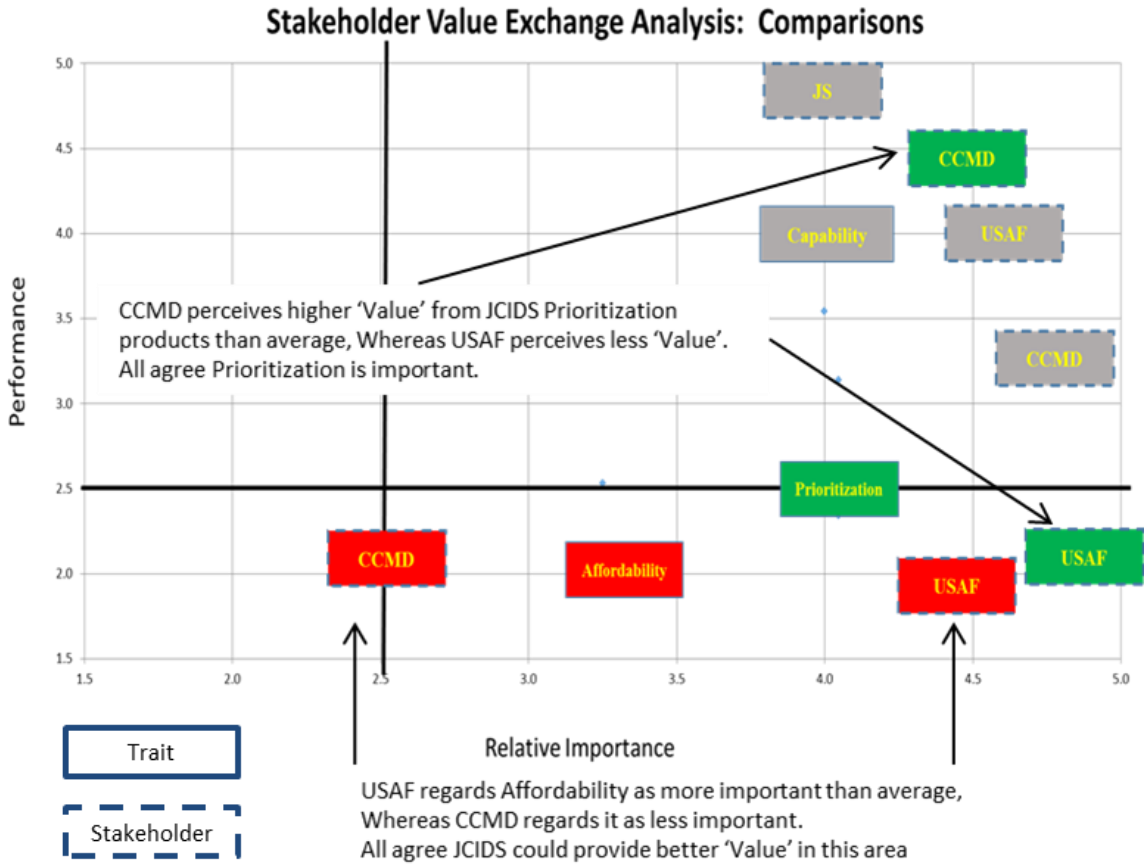


Figure 9: Overall Relative Importance vs. Performance

Analyzing the results by stakeholder group reveals some interesting characteristics. The horizontal axis represents the Relative Importance of each trait, whereas the vertical axis depicts the how well each trait delivers that characteristic, Performance. For example, the trait of 'Effective Capability' is rated by all stakeholders as being very important (average Relative Importance score of 4.0). Furthermore, all stakeholders agree that the JCIDS process delivers this trait very well (average Performance score of 4.0). Amongst the six stakeholders, it is interesting to note that three of them, Partners (US Air Force in particular), Employees (DoD Joint Staff, in particular), and Strategic Leadership (Combatant Commanders, in particular) each regarded the utility of Effective Capability differently. The CCMDs viewed Effective Capability as the utmost important giving it a much higher Relative Importance score than the average. The

[8] A nominal/average score is set at 2.5(out of 5.0) for both Relative Importance and Performance.

DoD Joint Staff presumes that the JCIDS process fully delivers Effective Capability giving it a much higher Performance rating than the average. With regards to Affordability, all stakeholder groups agree that JCIDS was lacking in its ability to provide affordable requirements (average Performance score of 2.0), however for the CCMDs this was far less important than to the US Air Force (Relative Importance score from the CCMDs was 2.5 versus close to 4.5 for the US Air Force). Similarly, all stakeholder groups agree that prioritized requirements, Prioritization, are important (average Relative Importance score of 4.0), however JCIDS was lacking in its ability to deliver these products (average Performance score of 2.5).

2.3.2. ENTERPRISE PROCESS PERFORMANCE AND INTERACTIONS

As discussed earlier, the only quantifiable measures of the JCIDS process are the time and money required for a capability document to advance through the system. The other measures of the JCIDS success are qualities like stability, affordability, and prioritization of capabilities. In addition to the physical documentation process there are several other leadership, lifecycle, and enabling processes that have a more significant impact on the quality of the JCIDS process and their ability to be successful.

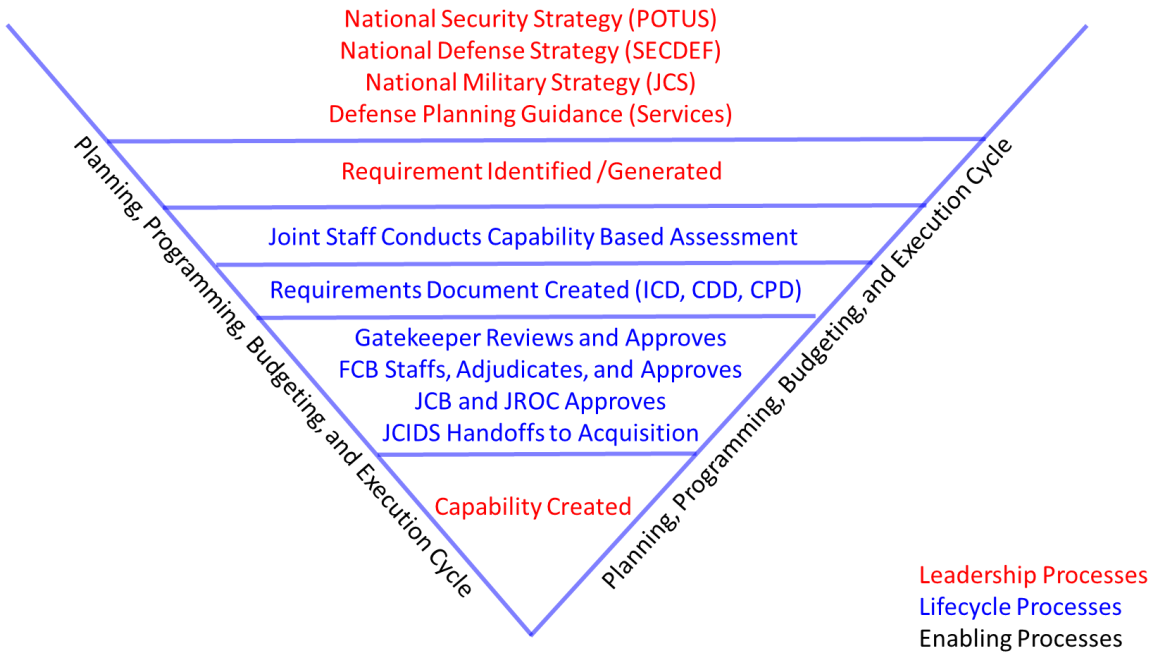


Figure 10: JCIDS Processes
(reproduced from Integrating the Lean Enterprise – Team Project: The Department of Defense Joint Staff Joint Capabilities Integration and Development System – Final Report, 2013)

The processes above (Figure 10) are the significant leadership, lifecycle and enabling processes that include, and interact with the JCIDS process. The biggest quality complaints about the current JCIDS process (that it lacks stability, affordability, and priority) are directly related to the Capability Based Assessment, the Program Objective Memorandum (part of the Planning, Programming, Budgeting, and Execution Cycle process), and the Strategic Guidance processes. These processes are discussed more in detail below.

2.3.2.1 CAPABILITIES-BASED ASSESSMENTS

This is the longest part of the JCIDS process and occurs up front. The CBA is a rigorous analytical process that validates the capability gap identified by the warfighter and explores possible solutions. It can take up to 6 months to complete after a requirement is identified. The CBA provides recommendations to pursue a materiel (new weapon system) or non-materiel solution (like a new tactic or new application of an existing system) to fill an identified capability gap that meets an established capability need. Part of the outcome of the CBA is to prioritize the gaps in capabilities. This is potentially where the "prioritization" failure in the current JCIDS process comes from. Either it is not being done well enough during the CBA or it somehow is not being communicated correctly to the FCB and JROC by the time they receive it. The CBA also has a potential role in the "stability" quality of the JCIDS requirements process. Warfighters, contractors, and program offices alike complain that requirements are constantly changing throughout the JCIDS and acquisitions processes. Part of this instability is an unavoidable part of the program manager's tradeoffs between cost, schedule, and performance. The rest, though, is a result of directed changes based on national budget challenges, 'piling-on' of requirements in order to meet new/emerging needs, and 'gold-plating' by contractors. The output of the CBA should be considered the baseline requirement from which stability can be measured.

2.3.2.2 PLANNING, PROGRAMMING, BUDGETING AND EXECUTION (PPBE)

The PPBE process is essentially the DoD's budget building process. It is a five-year plan detailing how the DoD intends to allocate resources in accordance with the Defense Planning Guide (DPG). When JCIDS stakeholders complain about a lack of "affordability" in the JROC decision-making, they are speaking about how the decisions play into (or are bound by) the PPBE process. While funding varies from year to year and short-term realities impact long-term

plans, there is enough predictability in the budget that the JROC should know what their maximum funding levels are going to be. Since there are always more needs than resources, programs need to be accurately prioritized and estimated (affordable) in order for the DoD to make the most efficient use of their limited dollars. Money is wasted on low-priority programs that slip through the cracks or programs that are approved based on one set of cost estimates only to see cost grow several times over. It is the role of JCIDS to prevent that from happening.

2.3.2.3 STRATEGIC GUIDANCE

Strategic Guidance is provided to the JCIDS process by the National Security Strategy, the National Defense Strategy, and the National Military Strategy. These strategies are issued by the President, the Secretary of Defense, and the Joint Chiefs of Staff respectively. The defense budget and resource planning get their roots from these documents. The three strategies are used to develop the DPG, which provides goals, priorities, and fiscal constraints to the Services. The JCIDS process must consider the DPG when prioritizing capability development programs. Even if there is a legitimate capability gap identified through the CBA, if it does not support the nation's strategic aims, it should not be approved or funded to begin development. This again speaks to the "prioritization" quality of the JCIDS process. Currently the FCB is supposed to prioritize any capability gaps into a joint priority list within their functional area which is then integrated by the JROC. At this point, it is unclear if this product is being used effectively.[9]

2.3.2.4 PROCESS INTERACTIONS

The true benefits of the JCIDS process can only be realized when all elements work in concert. When performed in isolation, the JCIDS process is merely a rubber-stamping of capability documents and requirement wish lists. The process interaction map below (Figure 11) shows the many interfaces and influences between processes. Even though it is built as a serial process, there are many formal and informal feedback loops throughout.

[9] This discrepancy has been highlighted to the Joint Staff and it is believed that the 2014 revision of JCIDS will address this issue.

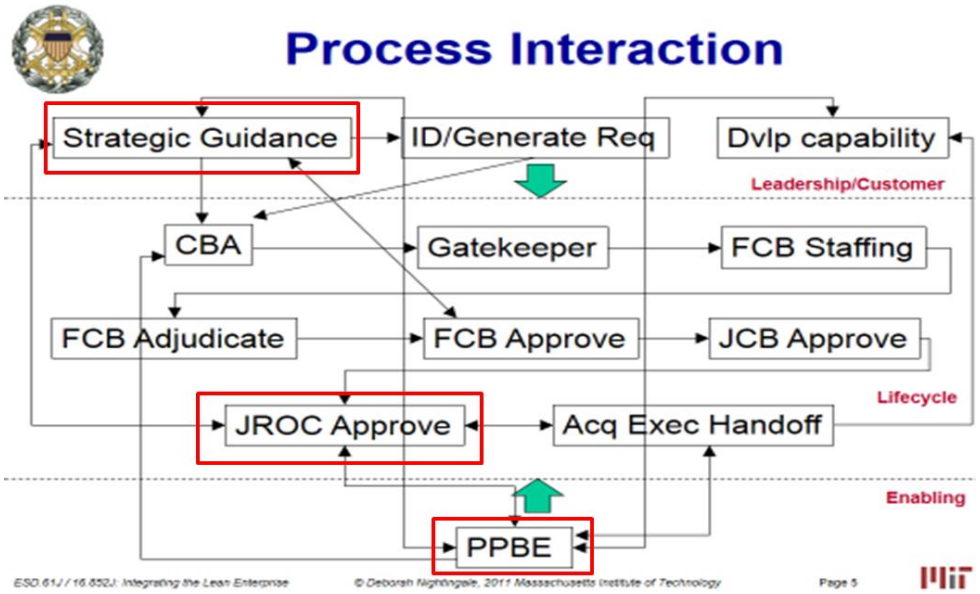


Figure 11: JCIDS Process Interactions
(reproduced from Integrating the Lean Enterprise – Team Project: The Department of Defense Joint Staff Joint Capabilities Integration and Development System – Final Report, 2013)

2.3.2.5 PPBE AND STRATEGIC GUIDANCE

These two processes have the most interactions with the other processes in JCIDS. They are also critical in respect to the JCIDS issues of "prioritization" and "affordability." In addition to how they provide enabling guidelines/leadership to the system, the results of JCIDS also feed back into the PPBE and strategy to help develop the next round of Defense Planning Guidance and the next budget cycle. The process by which capability gaps are analyzed and prioritized by the CBA, FCB, and JROC influences what weapon system programs get funded by the budget which in turn informs our national strategic priorities. This is formalized in the Chairman's Program Recommendation, the Chairman's Program Assessment, and the Chairman's Risk Assessment. Those three products from the Chairman of the Joint Chiefs of Staff deliberately use the FCB/JROC priority lists to inform and influence the PPBE and DPG.

2.3.2.6 JROC APPROVAL AND ACQUISITION EXECUTIVE HANDOFF

After the JROC approves a capability requirement, responsibility moves to the sponsoring Service Acquisition Executive to initiate the acquisition process to develop that capability through a program office. The oversight by the JROC continues, in the form of tripwires that require the program to be re-evaluated. If the program strays too far from its originally intended cost, schedule, or quantity, it must return to the JROC for revalidation [14].

This helps the JROC control affordability and promotes requirements stability. If a program has to return to the JROC for revalidation, it usually means there was a failure in affordability or requirements stability in the original approval process. This feedback loop helps the JROC and JCIDS process get iteratively better. It's not quite "continuous improvement" because of the infrequent nature of these revalidations, but it's a form of lean processing nonetheless.

In most enterprises, process interactions are the "seams" of the system and a natural weak point. The interactions are where information gets lost in translation or can get stuck in the queue waiting for the next process to start. In JCIDS, the process interactions appear to be well-connected and rigorously defined. There are numerous directives, instructions, and manuals that control the interactions and have created formal and informal feedback loops. There do not appear to be any processes that exist in a bubble; they all have connections to at least two other processes as inputs and/or outputs.

These processes and interactions give rise to 14 key JCIDS processes:

JCIDS Key Processes	
1	Capability Document (CD) Generation
2	CD data entry into Knowledge Database
3	CD Initial Gatekeeper Review
4	Functional Capability Board (FCB) Working Group Commenting
5	FCB Adjudication
6	FCB Coordination/Approval
7	Joint Capability Board Review/Recommendation
8	Joint Requirements Oversight Council (JROC) Initial Review
9	JROC Convenes/Issues Results
10	JROC Decision Memorandum published to the field
11	Joint Urgent Operational Need Expedited Process
12	DoD Component Urgent Operational Need Expedited Process
13	Joint Emergent Operational Need Expedited Process
14	Classified/SIPRNET 'black' process[10]

Table 6: JCIDS Key Processes

As with any business, it is important to have a clear understanding of these key processes as they define the success of the JCIDS process. The measurements of success are supplied by the enterprise metrics.

[10] This process is listed for reference only so the reader is aware another parallel process exists – no further discussion is provided.

2.3.3. ENTERPRISE METRICS

JCIDS doctrine prescribes ten explicit enterprise metrics across two categories. However, the only metrics tracked are the six that deal with time elapsed (Table 7). As noted earlier, two of JCIDS challenges include time and quality of documents. The Joint Staff has made the explicit decision to resolves these two issues in a serial manner, attacking timeliness of the process first while deferring quality.[11]

Category	*Metric*	*Measurement Type*	*Tracked*
Gatekeeper	Percentage of documents initially accepted/rejected by Gatekeeper	Quality	
	Percentage of documents utilizing Knowledge Database	Policy Compliance, Collaboration, Leverage legacy efforts	
	Elapsed time from submission to Gatekeeper staffing	Compliance, Efficiency	X
Deliberate Staffing/Validation	Elapsed time for FCB Working Group review	Compliance, Efficiency	X
	Elapsed time for comments/adjudication	Compliance, Efficiency	x
	Elapsed time for FCB Chair review/validation/recommendation	Compliance, Efficiency	x
	Percentage of documents receiving positive/negative FCB validation	Quality of comments/ adjudication, Significance of capability requirements	
	Elapsed time from FCB to JCB or JROC	Compliance, Efficiency	x
	Percentage of documents validated/non-validated by JROC	Quality, Prioritization, Effective	
	Elapsed time from approval to JROC approval memo available in Knowledge Database	Efficiency	x

Table 7: JCIDS Enterprise Metrics

2.3.4. X-MATRIX ANALYSIS

The conclusion of ESAT steps 1, 2 and 3, is an assessment regarding the alignment of goals, values, processes and metrics (Figure 4, Step 4) commonly referred to as an X-Matrix analysis. An X-Matrix is an analysis tool that generates a representation of the system at the enterprise level. It provides a graphical, one-page executive-level view of the system that can

[11] It is believed that the 2014 revision of JCIDS will begin to address the quality metrics.

assist in communicating the system's interactions and behaviors at a specific point in time. An X-Matrix analysis (Figure 12) was conducted on the JCIDS system to review interactions between:

- Strategic Objectives (Section 2.1.2, Table 2);
- Stakeholder Values (Section 2.2.2, Table 5);
- Key Processes (Section 2.3.2, Table 6);
- Enterprise Metrics (Section 2.3.3, Table 7).

The four quadrants of the X-Matrix represent potential interdependencies between each of these areas (a full page view of the X-Matrix is provided in Appendix D). Progressing counter-clockwise through the matrix allows for a comprehensive review of pair-wise relationships with a relative assessment: 'strong' (blue); 'weak' (yellow); or 'none' (white). The X-Matrix helps to reveal an enterprise level topology, interfaces and disconnects that often dominate enterprise pathologies [27]. In addition, the X-Matrix provides a 'score card' for each pair-wise assessment affording further insight regarding their characteristics. Scoring is a simple point system. One point is assigned each time an intersection is marked either strong (blue) or weak (yellow), with strong (blue) points having a greater relative 'weight' than weak (yellow). The 'score' allows for a quantitative assessment of inherently qualitative areas.

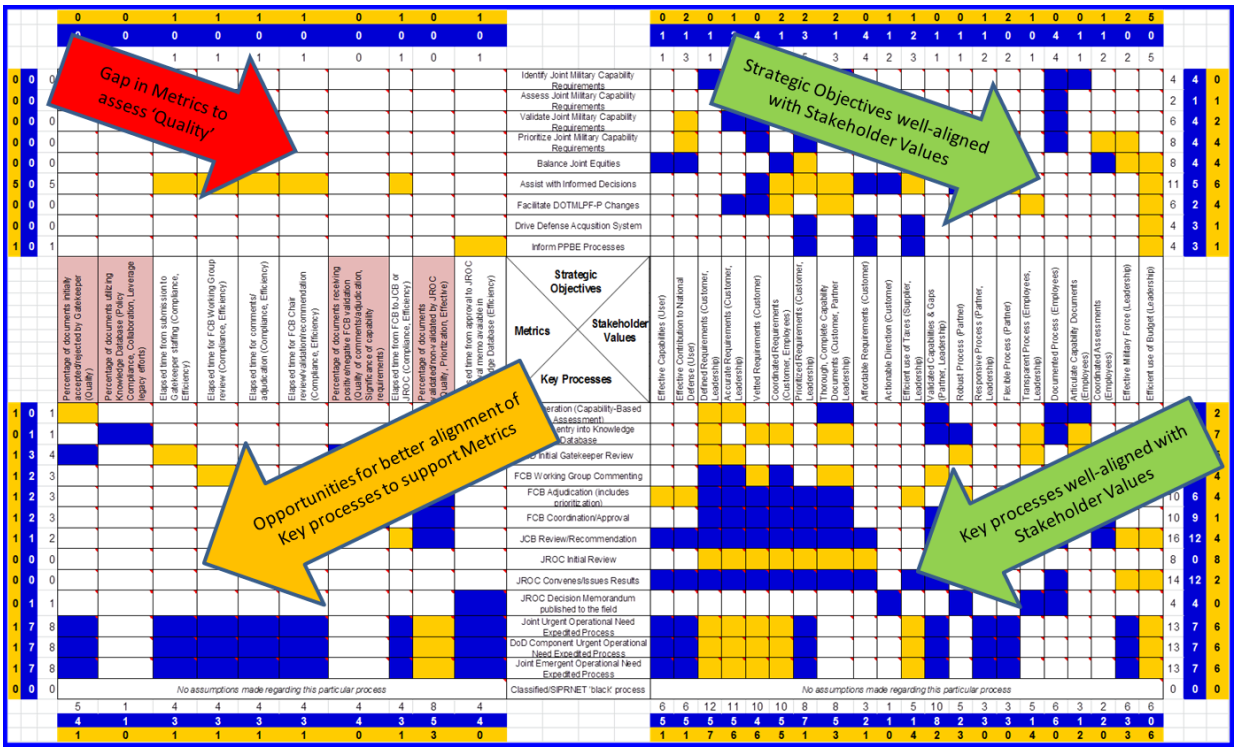


Figure 12: JCIDS Current State X-Matrix

2.3.4.1 ENTERPRISE METRIC ALIGNMENT WITH STRATEGIC OBJECTIVES

The current Metrics do not adequately measure the Strategic Objectives (upper left quadrant). This is not surprising given the nature of the measurements, which concentrate on efficiency (time) of the process rather than the 'quality' of the documents. However, some thought has been given to the quality of the products, and while it is difficult to directly measure quality, the JCIDS system implements an indirect measure via its document percentage approval/validation metric. The intent of these metrics is that 'good' documents will progress through the system while 'bad' documents will not, and the measure of this acceptance percentage effectively tracks the 'goodness' of documents[12].

2.3.4.2 STRATEGIC OBJECTIVES ALIGNMENT WITH STAKEHOLDER VALUES

The Strategic Objectives seem to be relatively well aligned with Stakeholder Values (upper right quadrant). In fact, all of the Stakeholder Values are represented by the Strategic Objectives, although the need for a Transparent Process is only reflected once. One glaring issue does present itself: the need for Efficient Use of Budget as well as an Effective Military Force. These values are not well aligned with the Strategic Objectives. This misalignment may be due to the inherent difficulty with quantifying these noble, altruistic values. When a 'scoring' template is applied across the Strategic Objectives (see Table 8 below) is it revealed that the Assisting with Informed Decisions and Balance Joint Equities are the most significant.

Strategic Objectives			Tot
Identify Joint Military Capability Requirements	6	2	8
Assess Joint Military Capability Requirements	3	3	6
Validate Joint Military Capability Requirements	5	4	9
Prioritize Joint Military Capability Requirements	4	6	10
Balance Joint Equities	4	7	11
Assist with Informed Decisions	6	8	14
Facilitate DOTMLPF-P Changes	3	4	7
Drive Defense Acqusition System	3	1	4
Inform PPBE Processes	3	2	5

Table 8: Strategic Objectives Relative Assessment

(reproduced from Integrating the Lean Enterprise – Team Project: The Department of Defense Joint Staff Joint Capabilities Integration and Development System – Final Report, 2013)

[12] As noted above, these four particular metrics (shaded mauve in Figure 12) although prescribed, are not currently tracked.

2.3.4.3 STAKEHOLDER VALUES ALIGNMENT WITH KEY PROCESSES

The Stakeholder Values are well aligned with the Key Processes (lower right quadrant). It is clear that the two most important processes are the senior level review/recommendation processes (JCB/JROC). However, what is not clearly reflected is that the 'real work' (key analysis, coordination) occurs one-level below at the FCB. While a quick glance at the X-Matrix alludes to this fact, it would be easy to overlook. Once more, as previously discussed, the value of Efficient Use of Budget is not strongly delivered by the Key Processes. When a 'scoring' template is applied across the 21 Stakeholder Values (see Table 9 below) is it revealed that Prioritized, Vetted and Accurate Requirements are 'valued' as the most significant. What is also significant is that Affordability, which comes up quite often as a major imperative, is not 'valued' as high as expected in the assessment.

Stakeholder Values			Tot
Effective Capabilities (User)	6	1	7
Effective Contribution to National Defense (User)	6	3	9
Defined Requirements (Customer, Leadership)	6	5	11
Accurate Requirements (Customer, Leadership)	7	6	13
Vetted Requirements (Customer)	8	5	13
Coordinated Requirements (Customer, Employees)	6	6	12
Prioritized Requirements (Customer, Leadership)	10	3	13
Thorough, Complete Capability Documents (Customer, Partner Leadership)	5	4	9
Affordable Requirements (Customer)	6	1	7
Actionable Direction (Customer)	2	1	3
Efficient use of Taxes (Supplier, Leadership)	3	5	8
Validated Capabilities & Gaps (Partner, Leadership)	7	2	9
Robust Process (Partner)	2	3	5
Responsive Process (Partner, Leadership)	4	1	5
Flexible Process (Partner)	3	2	5
Transparent Process (Employees, Leadership)	1	4	5
Documented Process (Employees)	8	0	8
Articulate Capability Documents (Employees)	1	1	2
Coordinated Assessments (Employees)	3	1	4
Effective Military Force (Leadership)	3	5	8
Efficient use of Budget (Leadership)	0	10	10

Table 9: Stakeholder Values Relative Assessment
(reproduced from Integrating the Lean Enterprise – Team Project: The Department of Defense Joint Staff Joint Capabilities Integration and Development System – Final Report, 2013)

2.3.4.4 KEY PROCESSES ALIGNMENT WITH ENTERPRISE METRICS

Finally, the Key Processes are not well aligned with the Enterprise Metrics (lower left quadrant). The core JROC processes do not align well with the existing Enterprise Metrics. Furthermore, the working level reviews which generate the 'quality' (FCB) are not adequately measured.

2.4. ESAT SUMMARY

In response to the question posed at the beginning of this section – to frame the enterprise level issues facing the defense requirements process -- the ESAT methodology identified four key issues that affect the successfulness of JCIDS:

1. inadequate metric data;
2. lack of requirement stability;
3. lack of requirement affordability;
4. and lack of requirement prioritization.

Overall, the relative importance vs. performance comparisons indicated that the values "Prioritized Requirements" and "Affordable Requirements" were underperforming in relation to the relative importance. In regards to prioritization, one respondent noted that JCIDS needs to "prioritize requirements in addition to validate them…" For affordability, one respondent nailed the crux of the issue: "You can't cost requirements – you can only cost solutions."

The only quantifiable measure of the JCIDS process is the time it takes a capability document to get through the system; the other measures of the JCIDS success are qualities like stability, affordability, and prioritization. Furthermore, the enterprise analysis revealed that there are several other leadership, lifecycle, and enabling processes such as the Capability Based Assessment and Strategic Guidance that have a more significant impact on the quality of the JCIDS process and their ability to be successful. **This results in a process that currently provides limited visibility and low fidelity regarding key cost-benefit issues that are required in today's fiscally constrained environment.**

The results of this Enterprise Analysis have been communicated to Senior DoD Leadership. They have had an inclination that these issues existed, however until now, have not had an empirical assessment which documents these issues. In response, they understand these shortcomings and are now in the early stages of adjusting to meet this challenge. The recent 2012 JCIDS revision was designed to "prepare for the significant reductions in military spending

(by) facilitat(ing) the discussions required to adapt to the new fiscal realities" [28]. Furthermore, the proposed 2014 JCIDS revision provides for 26 major updates, to include clarification and better alignment of Affordability and Capability requirements documents [29]. While no one questions our military readiness, limited budgets and resources mean we must be more efficient (*Efficient Use of Budget)* along the path we choose to arrive at that end state.

> *Although the current processes have produced the best armed forces in the world, they do not optimize our investment in joint capabilities to meet current and future security challenges.* [11]

3. SEMANTIC ENTERPRISE ARCHITECTURE

The enterprise evaluation of JCIDS reveals a sufficient system, capable of maturing into a great system capable of delivering critical insights into key areas for decision maker[13]. The ESAT assessment also offered a glimpse into the unique and varied perspectives of each stakeholder – to include the complex interactions amongst each other. Recall from Figure 9, the disparity between the US Air Force and the CCMD regarding the 'value' each assigned to the need for Prioritized Requirements. These unique, diverse perspectives from multiple stakeholders often give rise to what some describe as a 'wicked problem':

> *One that is almost impossible to solve because of the dynamic, contradictory, interrelated, piecemeal decision factors within an environment with inconsistent requirements – and within DoD – sometimes unspoken requirements*. [29]

Given the complex nature of wicked problems, there often is not one unique solution or 'right answer', rather "reasonable multiple solutions" [29]. In some cases the community may not realize that the solution already exists, as it is part of a completely different solution set.

So the question then, is how to approach these complex inter related, dynamic problems so they can be effectively managed? One answer is to "break the problem or decision down into more discrete pieces…these 'bite-size' pieces then can be prioritized" [29]. However, when resolving these problems down to their 'core', the challenge is to avoid the trap of solving these discrete pieces while ignoring the larger system. "The slogan should be: Define small and resolve big" [29].

In following this advice to 'define small and resolve big', a semantic review of the JCIDS documents was conducted. The intent was to break these documents down into their constituent parts to see how these relate to the existing JCIDS taxonomies. **The goal was to distil each document to its core, revealing the basic elements to create a knowledge base.**

To start, a broad review of the data set was conducted. The intent was to build familiarity, identify gross patterns and trends as well as understand the 'ground truth', how the documents overall tended to be written. The data set consisted of 86 documents spanning the entire range of capability documents from a Clinical and Rehabilitative Medicine ICD to an M109 (self-propelled artillery unit) Family of Vehicles CDD. The documents were formatted

[13] This statement is in no way meant to diminish the significant improvement JCIDS offers versus its predecessor, rather to inform the reader of the enormous potential for JCIDS.

either as MS Word or PDF, and ranged in size from 306Kb to 19Mb. Some were as few as 20 pages with others eclipsing well over 100 pages. This macro analysis revealed several inconsistencies across the documents: not all referenced JCAs as required; some that did reference JCAs referenced those that were outdated; and some referenced JFCs rather than JCAs. Furthermore, there were instances were basic terminology varied across the documents. Sometimes this was due to the various equities of the Sponsor, or in some cases, just a basic difference in definition of terms[14]. At a global level this revealed that the JCIDS process relies on very experienced and knowledgeable Subject Matter Experts (SMEs) who can infer and make sense of the documents despite gaps and other inconsistencies. Having gained this understanding of JCIDS along with a familiarity with the data set, the next step was to choose three documents (Table 11) and conduct a deep dive on each (See Figure 13):

- what *should* be in the document -- as instructed;
- what *was* in the document -- as used;
- what is *essentia*l in the document -- as revealed.

3.1. SEMANTICS – AS INSTRUCTED

Knowing 'what is supposed to be included' and 'what is actually included' are often two separate things. Therefore, the first step in the semantic review was to determine what data *should be included* in each of the CDs.

Each JCIDS document is championed by a document Sponsor. In the majority of cases the Sponsor is one of the military services. The Sponsor retains ownership of the document throughout its life in the JCIDS process. However, there are a number of unique instances where this is not the case. In some cases the document Sponsor is not a military service, rather another government agency, such as the Department of Homeland Defense. Furthermore, there are instances when the document Sponsor does not have delegated acquisition authority and therefore cedes development and fielding authority to another agency. Lastly, there are instances where the document Sponsor will change as the program proceeds through its lifecycle. Given the diverse group of potential Sponsors as well as the potential for wide variation across the capability documents JCIDS Manual, 19 Jan 2012, Enclosure B, provides detailed guidelines to assist authors with the construction of each particular document. Specifically:

[14] The US Air Force is fully cognizant of this issue and has recently introduced the concept of "Doctrine Next". In addition to moving all US Air Force doctrine to the web, "for the first time ever, terms and concepts are defined the same way wherever they appear in doctrine" [60].

Enclosure B outlines the different JCIDS documents which are used to articulate capability requirements and associated capability gaps for initial review and validation, as well as to provide more refined capability requirements related to specific materiel and non-materiel capability solutions for review and validation. [14]

Table 10 captures the key information for each CD as prescribed by the JCIDS Manual.

	ICD		**CDD**		**CPD**
	7 Sections and Appendix A (shall be no longer than 10 pages)		16 Sections and Appendix A (shall be no longer than 45 pages)		16 Sections and Appendix A (shall be no longer than 40 pages)
Section		Section		Section	
1	CONOPS Summary	1	Capability Discussion	1	Capability Discussion
2	JCAs	2	Analysis Summary	2	Analysis Summary
3	Capability Requirements	3	CONOPS Summary	3	CONOPS Summary
4	Capability Gaps & Overlaps/Redundancies	4	Threat Sumary	4	Threat Sumary
5	Threat & Operational Environment	5	Program Summary	5	Program Summary
6	Assessment of Non-Material Approachs	6	Development KPPs, KSAs, and additional performance criteria	6	Production KPPs, KSAs, and additional performance criteria
7	Final Recommendations	7	System of Systems Synchronization	7	System of Systems Synchronization
		8	Spectrum Requirements	8	Spectrum Requirements
		9	Intelligence Supportability	9	Intelligence Supportability
		10	Weapon Safety Assurance	10	Weapon Safety Assurance
		11	Technology Readiness Assessment	11	Technology Readiness Assessment
		12	Assets Necessary to Achieve IOC	12	Assets Necessary to Achieve IOC
		13	IOC and FOC Schedule Definition	13	IOC and FOC Schedule Definition
		14	DOTmLPF-P Considerations	14	DOTmLPF-P Considerations
		15	Other System Attributes	15	Other System Attributes
		16	Program Affordability	16	Program Affordability
Appendix		Appendix		Appendix	
A	Architecture Data	A	Net Ready KPP Architecture Data	A	Net Ready KPP Architecture Data
B	References	B	References	B	References
C	Acronym List	C	Acronym List	C	Acronym List
D	Glossary	D	Glossary	D	Glossary

Table 10: Capability Document Sections as Prescribed by JCIDS Manual

The definition of each capability document from the Defense Acquisition University Acquipedia is provided below: [30]

- *The Initial Capabilities Document (ICD) documents the DoD need for a materiel approach (or an approach that combines materiel and non-materiel solution sets) to satisfy specific capability gap(s). The ICD essentially summarizes the capability analysis (using a Capabilities-Based Assessment or other method...) and defines the gaps in terms of the functional area; the relevant range of military operations; desired effects; timeframe; and recommendations.*
- *The Capability Development Document (CDD) captures the information necessary to develop a proposed program(s). The CDD outlines an affordable increment of militarily useful, logistically supportable, and technically mature capability. It may define multiple increments if there is sufficient definition of the performance attributes (key performance parameters (KPPs), key system attributes (KSAs), and other attributes) to allow approval of multiple increments.*

- *The Capability Production Document (CPD) addresses the operational performance attributes and at a system level and production elements specific to a single increment of an acquisition program. The refinement of performance attributes and Key Performance Parameters (KPPs) is the most significant difference between the Capability Development Document (CDD) and CPD.*

3.2. SEMANTICS – AS USED

Having a thorough understanding of what should be in the documents, the next step was to determine exactly what information *was* included in the documents. To accomplish this, a detailed review of three CDs was undertaken. One document from each of the three requirements phases was picked (Table 11).

Capability Document	***Program***	***Description***	***Capability Area***
Initial Capability Document (**ICD**)	Joint Future Theater Lift (**JFTL**)	Airframe to move cavalry with armor 	Logistics
Capability Description Document (**CDD**)	Joint Air-to-Ground Missile (**JAGM**)	Replace existing air to ground missiles 	Force Application
Capability Production Document (**CPD**)	Extended Range Unmanned Aerial System (**ER UAS**)	Dedicated UAS support to combat division 	Battlespace Awareness

Table 11: Capability Documents reviewed

These three particular documents were selected as they detail large, joint weapon systems. Each system is unique, represents a different capability area, and is therefore handled by separate FCBs within the JCIDS process. Although each is processed through JCIDS independently, they

share a commonality -- they all operate in the air domain[15]. It is interesting to note that this shared domain would later reveal itself, as discussed in Section 4. In addition, enough time has passed since the publication of each of these documents that there is additional post-JROC validation data presented by the United States Government Accountability Offices (GAO) on each of these programs. These GAO reports provide interesting 'forensic' data regarding the current 'state-of-health' of the programs. The use of this GAO data for hindsight into the validation of the documents is also presented in Section 4.

The result of each deep dive was a detailed extraction of data from each document against the prescribed requisites. In one particular instance an entire section was omitted, but this was due to the nature of the weapon system and where it was in the requirements and life-cycle timeline. Otherwise, the documents were well written with the supplied information mapping well against the requested information. However it was interesting to note that all three documents shared one common infraction, their page count was above the allowed limits: JFTL over by 24 pages (~240%); JAGM over by 5 pages (~11%); ER UAS over by 359 pages (~900%)![16]

Having a thorough understanding of the information included in each document, the next step was to discern which parts were 'valuable'. The value of each piece of data was a subjective decision based upon the "value proposition" as revealed by the JCIDS ESAT assessment, as well as a personal assessment regarding relevance, and importance of the information. The intent was to create a distilled version of the document which captured the essence, and essential/critical factors from the original CD. Examples of such items include:

- citation of strategic documents, publications, engagements, and manuals;
- unique terms/concepts;
- capabilities and performance attributes;
- key phrases and nomenclature;
- scenarios and threats;
- timeframes/timespans;
- the discussion of any excluded items.

[15] The author's extensive experience with the air domain also influenced the selection of these particular systems.
[16] As discussed earlier, to address community concerns with the amount of time required to process a document, JCIDS instituted strict page limits, to include the number of Appendixes that can be included. In all three cases these limits were completely ignored.

3.3. SEMANTICS – AS REVEALED

Having separated the wheat from the chaff, the final step was to resolve the document to its bare minimum, leaving only the essential information (See Figure 13). Again, this was a subjective, personalized process. Each document was viewed through the lens of a 'greybeard'[17] -- if I were a SME, sitting on the FCB, what are the critical, essential bits of information I would require? One final pass through the document, asking this particular question at each juncture, resulted in a core document composed of only the critical elements.

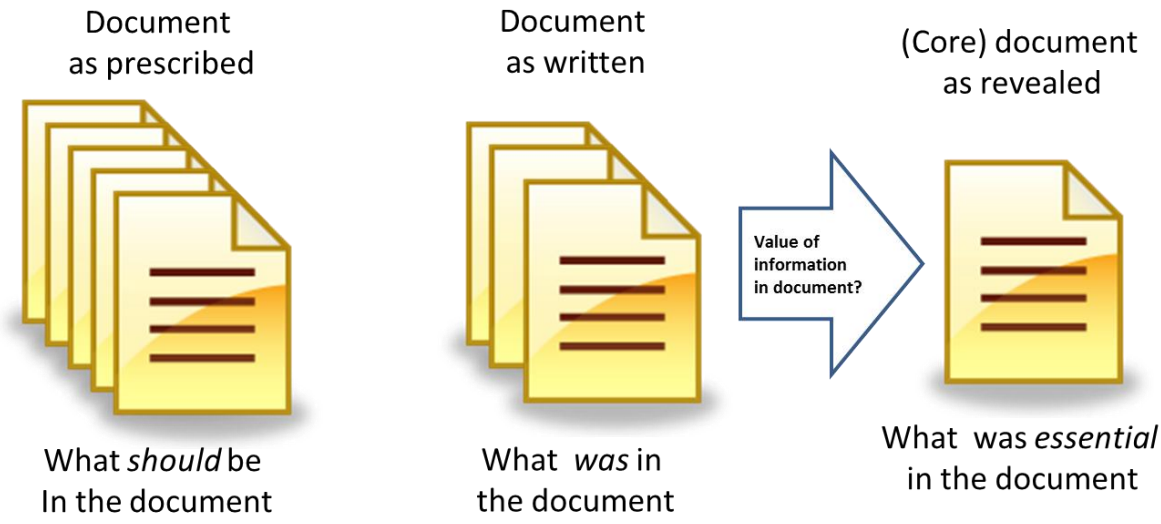


Figure 13: Capability Document deep dive process

3.3.1. SEMANTICS DEEP DIVE – EXAMPLE

Utilizing the process just described, a mock scenario is presented as an example. In this scenario the military has identified a capability gap providing adequate water to soldiers in the field – they need better water bottles. Having identified this gap an Initial Concept Document is created. As detailed in Table 10 an ICD consists of seven sections.

3.3.1.1 SECTION ONE – CONCEPT OF OPERATIONS

Section one must describe the relevant parts of the Joint Concepts, CONOPS, and/or Unified Command Plan-assigned mission to which the capability requirements identified in the ICD contribute; what operational outcomes they provide; what effects they must produce to achieve those outcomes; how they complement the integrated joint/multinational warfighting

[17] In this context graybeard is meant to suggest a sage, senior person with copious amounts of experience and background in a particular area.

force; and what enabling capabilities are required to achieve the desired operational outcomes. For our water bottle example, we might hypothesize the following list of details as supporting material for this section:

- Capstone Concept for Joint Operations.
- freedom of movement.
- all-weather operations.

From this list the need for all-weather operations is the essential element.

3.3.1.2 SECTION TWO – JOINT CAPABILITY AREAS

Section two of the ICD must cite the applicable Tier I and II JCAs and the range of military options being addressed. Identify timeframe for Initial Operational Capability. For our this example, we might hypothesize the following list of details as supporting material for this section:

- Force Application Joint Functional Concept.
- Focused Logistics Joint Functional Concept.
- Range of Military Operations – combat employment and sustainment, support of special operations, support of irregular warfare, noncombatant evacuation operations, recovery operations, and homeland defense.

From this list all items are essential elements.

3.3.1.3 SECTION THREE – CAPABILITY REQUIREMENTS

Section three of the ICD must describe the capability requirements as identified during the CBA or other study. Discussion should relate required capabilities to the Concept or assigned mission. Address compliance with DOD, joint, national, and international policies and regulations. Capability requirements should be general enough not to prejudice decisions. For this example, we might hypothesize the following list of details as supporting material for this section:

- Water bottle must have performance and structural capabilities to store, transport and discharge a minimum of 20 ounces of hot and cold liquids.
- Water bottle materials must meet OSHA and NATO standards for health and safety.
- Associated Tier 1, Tier 2, and Tier 3 JCAs:
    - (Tier 1) Force Application.
        - (Tier 2) Maneuver.
            - (Tier 3) Maneuver to Engage.

            - (Tier 3) Maneuver to Insert.
    - (Tier 1) Logistics.
        - (Tier 2) Deployment and Distribution.
            - (Tier 3) Move the Force.
            - (Tier 3) Sustain the Force.
            - (Tier 3) Operate the Joint Deployment Distribution Enterprise.

From this list the water bottle performance, materials, Force Application – Maneuver to Engage, and Logistics – Operate the Joint Deployment Distribution Enterprise are the essential elements.

3.3.1.4 SECTION FOUR – CAPABILITY GAPS

Section four of the ICD describes the capability gaps or overlaps in terms of the difference between the capability requirements enumerated in the previous section and the performance levels of current and projected force capabilities. For this example, we might hypothesize the following list of details as supporting material for this section:

- Current devices do not store a minimum of 20 ounces.
- Existing devices are not all-weather.
- Existing devices are not constructed from OSHA or NATO approved materials.
- Lifetime of current devices too short – they degrade too rapidly.
- Current devices are not interoperable with other services.
    - different mouthpieces.
    - different delivery devices.
- Cleaning takes too long and requires unique devices.

From this list the lack capacity and interoperability are the essential elements.

3.3.1.5 SECTION FIVE – THREATS

Section five of the ICD summarizes current and projected threat capabilities (lethal and non-lethal) to be countered. For this example, we might hypothesize the following list of details as supporting material for this section:

- Material hazards.
- Inadequate hydration of soldiers directly affects battlefield performance.

From this list all items are essential elements.

3.3.1.6 SECTION SIX – CHANGES TO EXISTING PROCEDURES

Section six of the ICD summarizes the changes to existing procedures processes or other analysis that would satisfy the capability gaps in part or whole. Include consideration of capabilities in Allied/partner nations, the interagency, and other DoD Components. For this example, we might hypothesize the following list of details as supporting material for this section:

- Two alternative CONOPS were examined, access through pre-positioned hydration and access through on-demand off-site hydration.
- Concluded that neither CONOPs mitigate the identified capability gaps nor enable the Joint force as required
- DOTmLPF-P assessment concluded:
    - Doctrine: The requirement for mobile hydration is actually driven by changes in joint doctrine. Alternate CONOPs were considered.
    - Organization: reviewed, no
    - Training: reviewed, no
    - Leadership and Education: reviewed, no
    - Personnel: reviewed, no
    - Facilities: reviewed, no.

From this list the notation that joint doctrine drives this requirement is the essential element.

3.3.1.7 SECTION SEVEN – RECOMMENDATION

Section seven of the ICD identifies material and non-material solutions. For this example, we might hypothesize the following list of details as supporting material for this section:

- Assessment of Joint Operating Environment points to a requirement for development of a mobile, lightweight, all-weather, delivery device.
- Backpack-like water device appears viable in terms of payload, range, access and interoperability with the Joint force.

From this list the notation of a backpack-like device is the essential element.

3.3.1.8 EXAMPLE – DOCUMENT AS REVEALED

In summary, Table 12 presents the (core) document as revealed.

Section		Essential Elements
1	Concept of Operations	• all-weather operations
2	Joint Capability Areas	• Force Application Joint Functional Concept • Focused Logistics Joint Functional Concept • Range of Military Operations – combat employment and sustainment, support of special operations, support of irregular warfare, noncombatant evacuation operations, recovery operations, and homeland defense.
3	Capability Requirements	• Water bottle must have performance and structural capabilities to store, transport and discharge a minimum of 20 ounces of hot and cold liquids • Water bottle materials must meet OSHA and NATO standards for health and safety • Force Application – Maneuver to Engage • Logistics – Operate the Joint Deployment Distribution Enterprise
4	Capability Gaps	• Current devices do not store a minimum of 20 ounces. • Current devices are not interoperable with other services
5	Threats	• Material hazards • Inadequate hydration of soldiers directly affects battlefield performance
6	Changes to Existing Process	• Doctrine: The requirement for mobile hydration is actually driven by changes in joint doctrine.
7	Recommendation	• Backpack-like device

Table 12: Water Bottle Essential Elements

3.4. SEMANTICS – MAPPING

Having reduced each of the three documents to their core, the next step was to find a mechanism to represent the essential features and to correlate the information. Interestingly enough, the Joint Staff is developing a concept that can assist with this correlation, a Capability-Mission Lattice (CML) [31, pp. A-2]. The CML (Figure 14) is a proposed example of an integrating construct to ensure traceability to strategic guidance, missions of the Joint force, and other departmental activities – both in the identification of capability requirements and their associated gaps, and in the review and assessment of capability requirement portfolios [32]. The CML incorporates existing JCIDS taxonomies, such as the JCAs, as well as extending into other pertinent areas of the requirements domain.

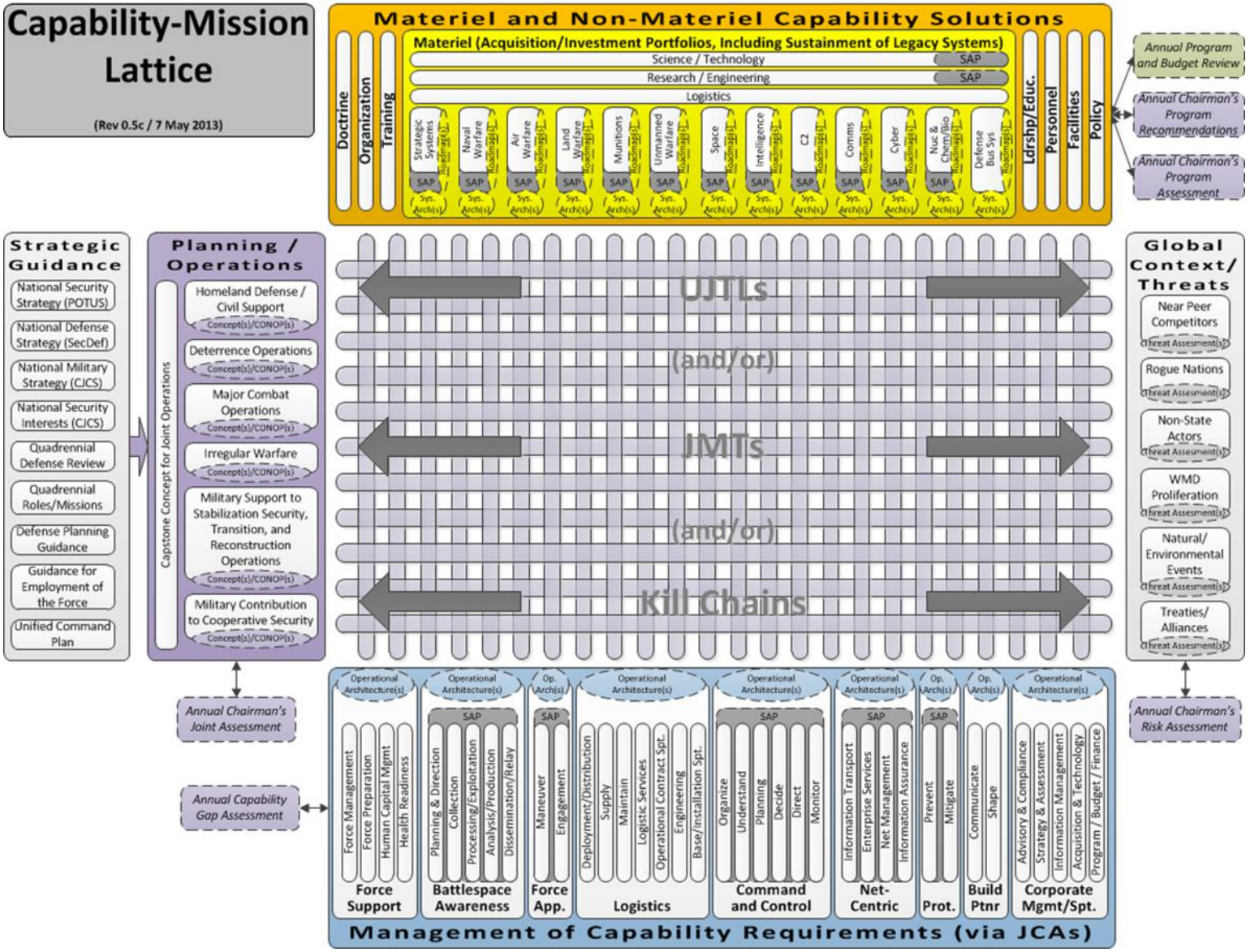


Figure 14: JCIDS proposed Capability-Mission Lattice
(Joint Staff, 2014- DRAFT pre-release)

The CML is composed of five basic areas:

- Top: Materiel and Non-Materiel Capability Solution. This is the form the solution will take – a new airplane, a new software load to an existing system, or training a new way, as examples.
- Right: Global Context/Threats. These are the exogenous factors that influence the requirements space – weapons of mass destructions or natural events, as examples.
- Lower: Management of Capability Requirements. This is how the forces and capabilities are governed – force application or net-centric, as examples.
- Left: Guidance and Planning. These are the endogenous national and military strategic and planning documents that influence and bound the requirements space -- Quadrennial Defense Review or Irregular Warfare, as examples.
- Center: Uniform Joint Tasks. These is how the forces and capabilities are implemented, Deploy and Employ Mounted Forces or Support Vertical Maneuver, as examples.

The CML provides a good representation of the requirements domain as well as documenting the connections across other influencing elements. Therefore it was adopted as the initial framework for this study. Next, parts of each of the core documents were mapped to the CML (Figure 15) (a full page view of each of the CMLs is provided in Appendix E, F and G). Approximately 15 'classes' (as described later) were selected for each of the three systems[18]. These classes provided a holistic look across the documents, as is represented by their dispersal throughout the CML.

Similar information within each of the core documents was clustered together, creating 'classes' (the mauve boxes in Figure 15) and 'subclasses' of information. For example, within the JAGM CDD one class of information was the *Uniform Joint Task* the system would have to perform, with a specific subclass of *Navy Tactical Task List* (Figure 16 and Table 14). These classes were then mapped to the CML. The resulting map of each core document to the CML shows that the CML does in fact provide a good framework representing the defense requirements process. Interestingly enough, it illuminates the fact that while the JCIDS manual (*as instructed*) treats the requirements process as a sequential, linear progression, explicitly prescribing the exact location for each discrete piece of information, this is not in fact how the documents are constructed (*as revealed*). Rather, there are instances when the same piece of information shows up multiple times. The fact that information shows up multiple times is not in itself a negative trait. It reflects that each document has a unique author, and in some cases

[18] For reference, the JFTL ICD had approximately 50 classes; the JAGM CDD had approximately 75 classes; and the ER UAS CPD well over 85 classes to choose from when selecting particular items to map to the CML.

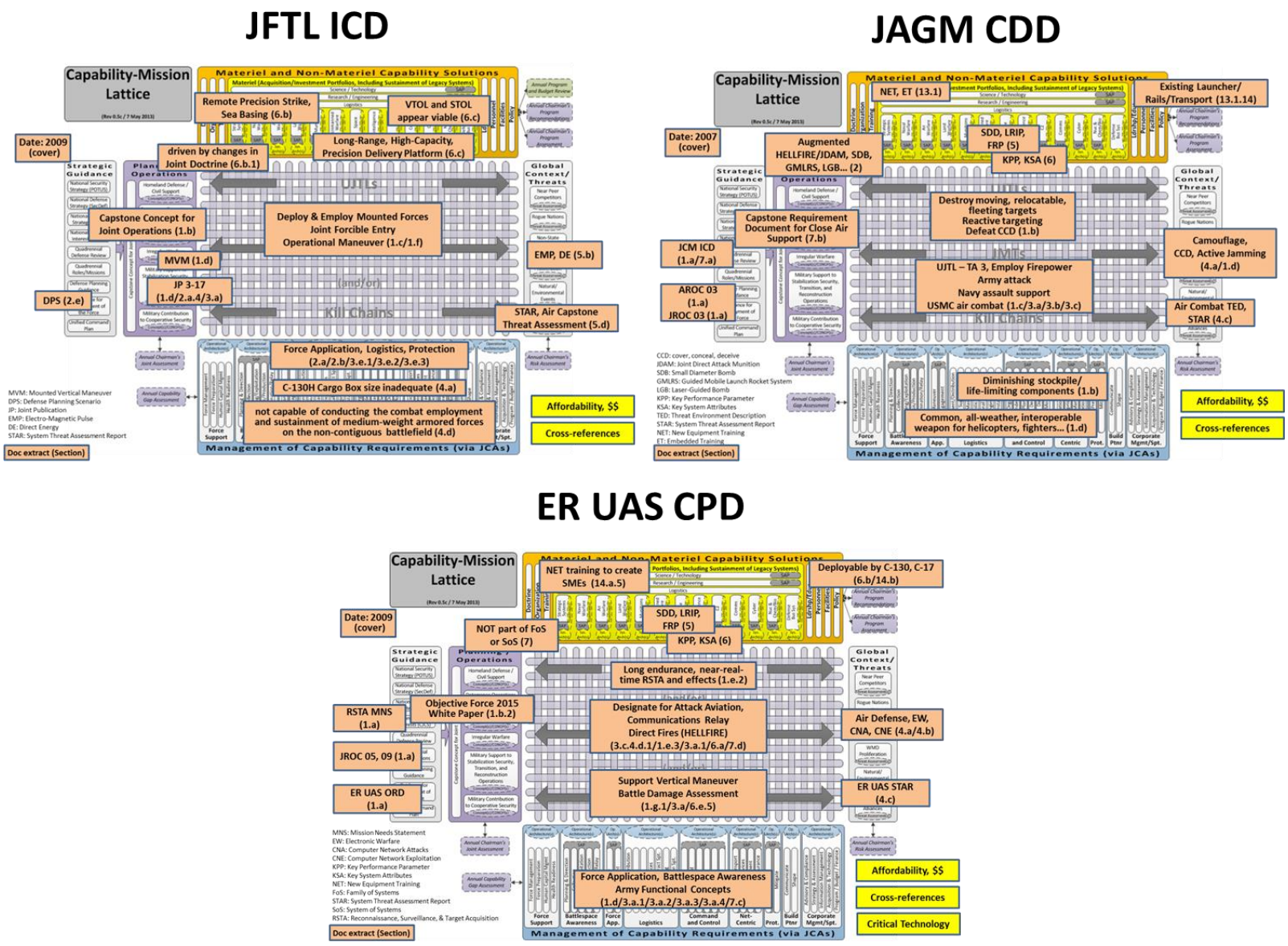


Figure 15: Capability Documents mapped to CML

multiple authors. As noted, this is where the current process relies on the expertise of the Greybeard, Subject Matter Expert, to discern the relationships and core elements of each document. These 'duplications' occurred most commonly in the center and lower portions of the CML. For example, the ER UAS CPD mapping illustrates that the Uniform Joint Task of Direct Fire (the act of shooting a missile from the UAS at a target) shows up in Sections 1 (Capability Discussion), 3 (CONOPs summary), 6 (Production KPPs) and 7 (System of System Synchronization) of the CPD. Furthermore the JCAs of Force Application and Battlespace Awareness similarly show up in multiple sections.

While this revelation is not very striking, in fact it seems intuitive that critical pieces of information would recur within the CD in different sections, what is important is that the author consciously structured the CD in this particular manner. It is crucial that the author's 'domain view' be understood as it directly affects the knowledge base, which in turn will influence the development of a supporting ontology, as discussed in the next Section.

What is also interesting is that the mapping of each CD to the CML revealed classes that are not currently captured by the CML: Cross-References (link to other CDs), Critical Technology (assessment of the technical risk with associated critical technologies) and in particular, Affordability. As indicted, the CML is an initial attempt to provide a framework and its lack of an Affordability space reflects the intrinsic difficulty and challenge the DoD is having with this particular issue – closing the "Affordability Gap" [33] as the ESAT assessment reflected.

Recalling that the goal of this section was to distil each document to its core, it has been shown during this process that the **basic elements do exist to create a knowledge base.** These resulting elements are the building block for the development of an ontology. It is important to note that these elements originated from a process that was grounded in the established CJCS directives and manuals that govern and assist the JCIDS process. One common origin for an ontology is the use of existing industry standards: "it may be possible to start with an existing industry standard and use that as the ontology starting point" [34].

4. CREATION OF A BASIC ONTOLOGY

Having reduced the capability documents down into their constituent parts, the basic elements are available to create an ontology. What is an ontology? It is the explicit formal specifications of the terms in the domain and relations among them [35]. Or simply put "it defines a common vocabulary to share information in a domain" [34]. It is important to understand that "the potential applications of the ontology and the designer's understanding and view of the domain will undoubtedly affect ontology design choices" [34]. Therefore those elements which have the potential to influence the domain, such as the previously accomplished JCIDS ESAT assessment and the semantics review, are vital to the creation of a relevant, educated ontology. In addition to including descriptions and relationships across multiple taxonomies and data sets, an ontology allows for the incorporation of those revealed by the influencing factors – the ESAT assessment and semantic review. In addition, the ontology will enable the display of information in a common form so that JCIDS documents are comparable irrespective of language, standards or date created. However, the true power of an ontology is its ability to support inferences and 'reveal' links beyond the explicit data. For the decision makers, this is critical; **the goal of the ontology is to assist decision makers with identifying capability gaps and solutions through cross-capability analysis.**

"There is no one 'correct' way or methodology for developing ontologies" [36]. However, as discussed earlier, the end use of most ontologies is to inform the knowledge base. To achieve this there are generally four steps to accomplish: defining classes in the ontology; arranging the classes in a taxonomic (subclass–superclass) hierarchy; defining slots and describing allowed values for these slots; and filling in the values for slots for instances [36]. Lastly, ontologies are iterative; their development is a process that starts with a first 'rough-cut' to establish the knowledge base. Understanding that "the best solution almost always depends on the application that you have in mind and the extensions that you anticipate" [36] as the knowledge base matures, the ontology is revised and refined to evolve alongside.

4.1. DOD COMMON VOCABULARY

As discussed in Section 1.2, the DoD utilizes JCAs as a common language to discuss and describe issues across all of DoD requirements. A sample of three of the nine JCAs, with their associated Tier 2 and Tier 3 elements is shown in Table 13 below.

JCA Tiers 1 – 3					
Force Support		Battlespace Awareness		Force Application	
Tier 2	Tier 3	Tier 2	Tier 3	Tier 2	Tier 3
Force Management		Intel, Surveil, & Recon		Maneuver	
• Global Force Management		• ISR Planning & Direction		• Maneuver to Escape	
• Force Configuration		• Collection		• Maneuver to Insert	
• Global Posture Execution		• Processing/Exploitation		• Maneuver to Influence	
		• Analysis & Production		• Maneuver to Secure	
		• ISR Dissemination			
Force Preparation		Environment		Engagement	
• Training		• Collect		• Kinetic means	
• Exercising		• Analyze		• Non-Kinetic means	
• Educating		• Predict			
• Doctrine		• Exploit			
• Lessons Learned					
• Concepts					
• Experimentation					

Table 13: Sample JCA Tiers 1-3

The JCAs are collections of like DOD capabilities functionally grouped to support capability analysis, strategy development, investment decision making, capability portfolio management, and capabilities-based force development and operational planning [37]. Furthermore, the JCA taxonomy provides the foundation of a basic structure to facilitate linking joint warfighting requirements with joint/Service resources [38]. Joint warfighting requirements are communicated via the Uniform Joint Task List (UJTL). The UJTL assigns either joint or agency specific tasks which are managed within one of the nine JCAs. Between the UJTL and JCAs we have the cornerstones for our ontology, an anchor which we define as a 'class' and a taxonomy, respectively.

4.2. CLASSES AND SLOTS

Classes are the first step and the main focus for an ontology. Understanding that "Ontology design is a creative process and no two ontologies designed by different people would be the same" [36], means the initial determination of classes is subjective. For example, a class may be automobiles, with subclasses defined as pick-up trucks, or sedans. Alternatively the subclasses could be defined as vehicles with four-wheel drive, and those without. Slots describe properties of the classes and instances. Automobile manufacturers Ford or Toyota might each be

a slot. Returning to the notion that an ontology is greatly influenced by its architect, the assumption is that these initial classifications of class, subclass, slot and instance are derived/influenced from an fundamental understanding of the system resulting in an educated initial classification.

Having extracted classes of information and instances of their appearance from the documents (See Figure 16 and Table 14), we have the basic building blocks for our ontology. It is understood that this first attempt to create classes and slots is crude and basic, however for the purposes of this thesis it is considered adequate. As discussed earlier, the entirety of the JCIDS enterprise, the perspectives of the document authors as well as those of the SMEs involved in the process was taken into account when making the subjective assessments as is required when creating the initial ontology.

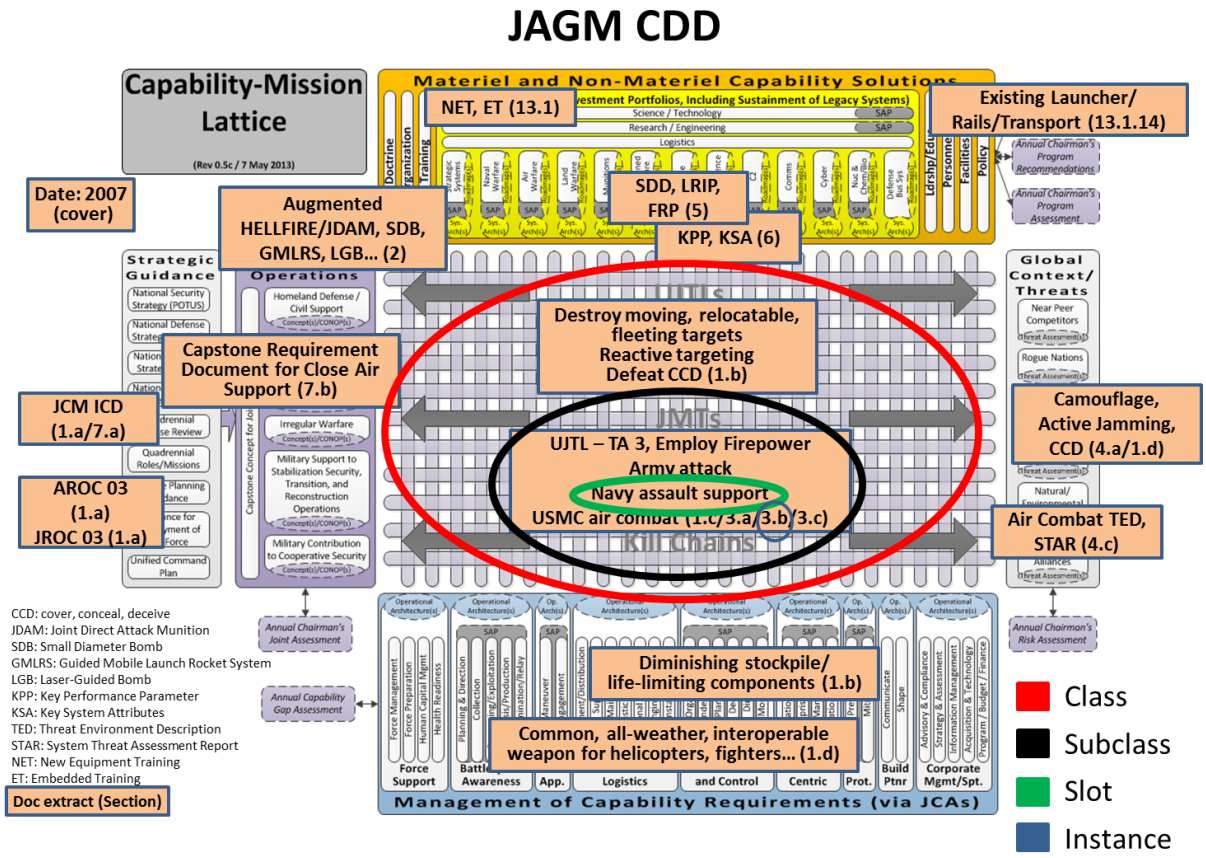


Figure 16: JCIDS Ontology Elements

Document	*Class*	*Subclass*	*Slot*	*Instance*
JFTL ICD	Capability Solution	Strategic Systems	Sea Basing	Section 6b: Analysis Summary & Final Recommendations
JAGM CDD	Uniform Joint Task	Employ Firepower	Navy assault support	Section 3b: Concept of Operations Summary – Navy Aviation
ER USA CPD	Threat Environment	Active threats	Computer Network Attacks	Section 4b: Threat Summary – Projected Threat Environment

Table 14: Sample JCIDS Ontology Elements

In addition to the basic ontology presented, additional classes should include: Cross-References; Critical Technologies; and Affordability; as previously discussed in Section 3.4.

4.2.1. BASIC ONTOLOGY - JAGM CDD

In the particular example of the JAGM, the Military Task to Accomplish (the Uniform Joint Task) has been classified as the Slot, whereas the specific Employment of Firepower is the Subclass. Within the SubClass, the Navy specific Assault Support is the Slot, versus the Army Attack or US Marine Corps Air Combat. An Instance of this Slot is in the Concept of Operations Summary, Section 3B of the CDD, which details the Navy Aviation support.

4.3. UTILIZATION

Having created a basic ontology, what can we do with it? Some uses for a structured ontology include: consistency checking; provide completion; interoperability support; support validation and verification testing; encode entire test suites; configuration support; support structured, comparative, and customized searches; and exploit generalization/specialization information [34]. For this thesis, two are relevant to assist with the goal of identifying capability gaps and solutions through cross-capability analysis: to provide completion and to provide interoperability support.

4.3.1. COMPLETION

Completion is when a small amount of information is provided and the ontology is able to expand the data to include ‘expected’ information [34]. An example of completion is found in

the JFTL ICD. The document calls for Aeromedical Evacuation (AE). From this the ontology can expand the medical treatment that is to be expected. This can be accomplished simply by applying the standard definition of AE: "provides time-sensitive en route care of regulated casualties to and between medical treatment facilities using organic and/or contracted aircraft with medical aircrew trained explicitly for that mission" [39]. This application results in new expectations: the aircraft will have the ability to travel to/from medical treatment facilities and the aircrew will include medical personnel – qualities that are not apparent with the ICD.

Similarly completion can be utilized to discern what information should be excluded. For example, if a male hospital patient is completing a medical form, completion would discern that the patient not be asked any questions relating to pregnancy. Relating this back to the AE example, completion would inform us that there should be no permanent structures within the airframe (such as large vertical pylons) that would limit the use of "Big Bertha", a roll-on, roll-off transformer required to convert aircraft-generated electricity to a usable voltage and frequency for medical equipment [40]. If there were an obstacle preventing the use of "Big Bertha", the AE mission would effectively be compromised.

4.3.2. INTEROPERABILITY SUPPORT

Interoperability support affords the ability to compare "operational definitions for how one term relates to another term and thus using equality axioms or mapping to express one term precisely in terms of another and thereby support more 'intelligent' interoperability" [34]. As mentioned earlier, although each of these three systems is unique and handled separately in the JCIDS process, they all operate within the air domain, something the ontology registers. When we take each of the three individual CML mappings and overlay them, the "intelligent interoperability" of the ontology reveals interdependencies among the systems (Figure 17).

There are three interdependencies: a common airframe replacement (C-130/C-17); the ability to conduct Mounted-Vertical-Maneuver (MVM); and the employment of the AGM-114 HELLFIRE Air to Surface Missile. The JFTL is the airframe set to replace the existing C-130 mid-size and C-17 large-size cargo aircraft. Both the JAGM and ER UAS are to be transportable via the existing C-130 and C-17 fleet. The interdependency revealed is that the C-130/C-17 replacement, the JFTL, must be sized properly to transport both of these items, something not included in the JFTL ICD. This means, for example, if the ER UAS, which is further along in

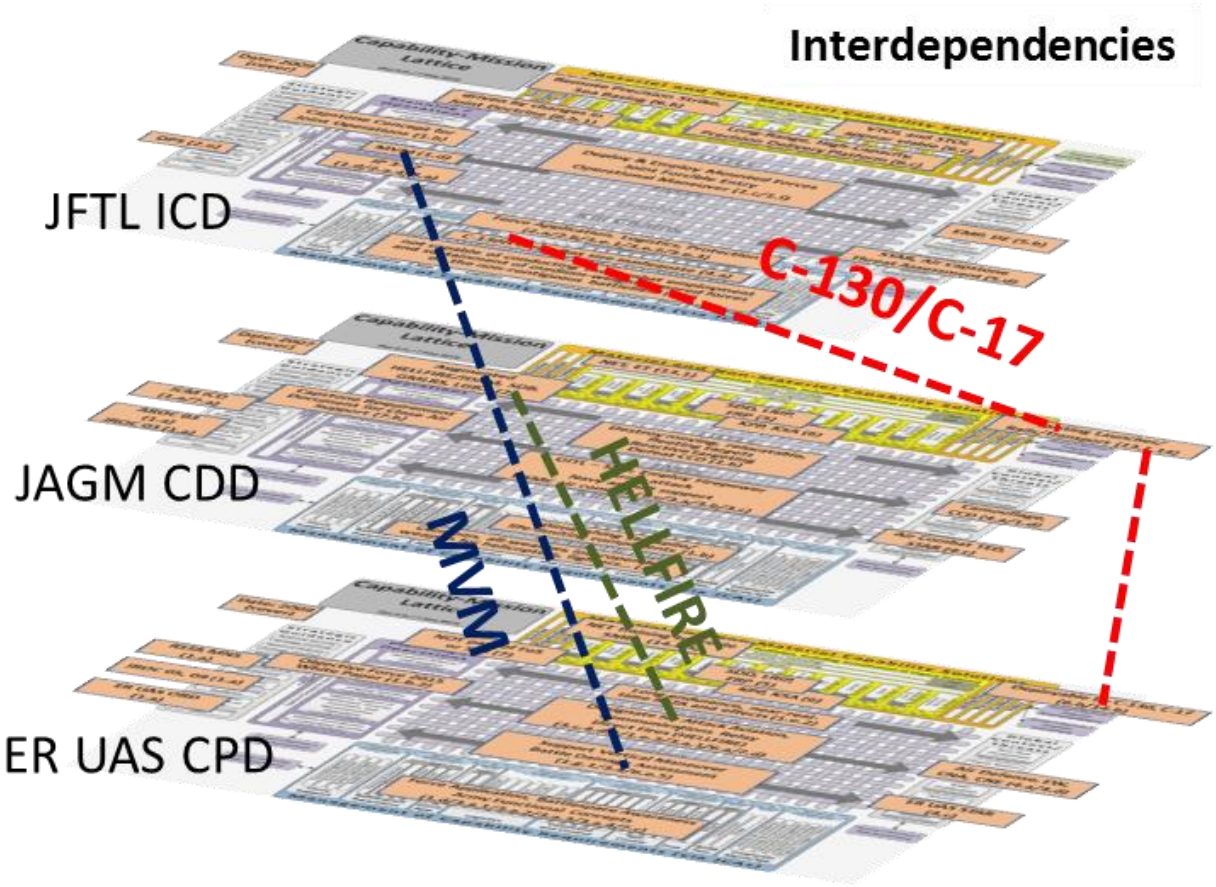


Figure 17: JCIDS "Intelligent" Interoperability

the requirements cycle (it is in the production phase) were to undergo a design change, perhaps larger wings for greater lift and endurance, its new footprint would be larger than currently planned. The fact that the ER UAS would not fit into the existing C-130/C-17 bays is less important than the fact that it would not fit into the future replacement aircraft, the JFTL[19]. Now would be the time to communicate this information. The JFTL team is in the Initial Concept phase, therefore their ability to redesign the bay size to accommodate a potential ER UAS design change would be easier as this point versus later as the JFTL design matures. A classic example of this is the US Army's Stryker armored combat vehicle (Figure 18).

[19] As is often the case in the military, an operational 'work-around' of some type would be reached to transport the ER UAS aboard the C-130/C-17. However the intent would be for it to be temporary until the JFTL was introduced.

Figure 18: US Army Armored Stryker
(US Army)

With the addition of removable armor the Stryker will not fit inside the C-130 [35]. It is interesting to note that this dilemma is addressed within the JFTL ICD[20]:

> *…transport of Stryker vehicles…is limited by the capabilities resident in the intratheater airlift fleet. The C-130H/J cargo box size is inadequate to load these vehicles and aircraft performance is insufficient to transport these payloads to/from landing zones.*

Another similar interdependency occurs with the ER UAS and the JAGM. The ER UAS is designed to carry the AGM-114 HELLFIRE missile. If the HELLFIRE missile replacement, the JAGM, undergoes a radical physical design change -- size and shape, the ER UAS may not be able to carry or employ the weapon.

Lastly while the JFTL has a direct role supporting MVM: a form of maneuver requiring insertion/extraction of medium weight armored forces to objectives without the need for fixed airports, airfields, or prepared airheads [41]; the ER UAS has a supporting role which must be in concert with the JFTL.

4.4. RELEVANCE

As mentioned earlier, the JFTL, JAGM and ER UAS programs are significant defense procurements. As such they have been followed closely by the GAO since their JROC-validations. The GAO is a "nonpartisan agency that works for Congress" that reports on how

[20] Although the armor can be removed (it is unclear how long this process takes) the specification calls for transport of the full Stryker vehicle (which includes armor).

well "government programs and policies are meeting their objectives" [42]. Given GAO's unique position they are often called upon to audit and assess key issues within the DoD. JFTL, JAGM and the ER UAS have all undergone either detailed GAO audits, or have been included multiple times in their comprehensive year-end weapon systems reviews. The GAO reports identify a current number of key issues and challenges for each program. Returning to our previous discussion, the power of an ontology is its ability to support inferences and 'reveal' links beyond the explicit data. Would our basic ontology have inferred or identified these links, GAO critiques, as each of the program's documents progressed through JCIDS?

4.4.1. PROGRAM CRITIQUES

Regarding JFTL, GAO critiques of the program include an ongoing discrepancy between the Army and US Air Force on the basic airlift mission requirements, "The Army and Air Force must also resolve fundamental differences in operating requirements and employment strategy" [43, p. Executive Summary], as well as the level of "technology invention" [43, p. 15]. While the report commends the DoD for adopting Capability Portfolio Management, stating it "offers opportunities to better manage airlift investments" [43, p. 18] it notes that there are still risks as it is unknown "whether adequate resources are available to complete programs within cost and schedule estimates" [43, p. 19].

The GAO reports that "technology… maturity" and "affordability" remain concerns on the JAGM program, noting in particular that "Army officials have stated that the service might not be able to afford JAGM, despite having a validated requirement for it" [44, p. 89], even though a 2011 review "indicated that JAGM is the most cost-effective solution to address warfighter needs" [44, p. 90]. This strikes at the dilemma of the Affordability issue. Even though JAGM is stated as the most cost-effective solution, the Army may not have the funds available to support the effort.

The GAO cites ongoing technology and maturity issues for the ER UAS. In 2011 the ER UAS program suffered a flight test accident in California, the result of faulty flight control software. As a result, the program "is undergoing design changes and has yet to demonstrate the maturity of its production process" having "experienced a 67 percent increase in design drawings over the past year (2012)" [45, p. 102]. The program "cost and schedule remain at risk" [45, p. 102].

4.4.2. ONTOLOGY PREDICATION

The basic ontology presented captures the areas of affordability and critical technologies, areas cited by GAO in all three programs. At this point, the ontology only captures them at a very broad level, identifying them both as a "class" within the ontology, with no further detail regarding the deeper sub-class, slot or instance levels. Although the level of detail provided by the basic ontology is minimal, its ability to forecast these key areas is significant.

A basic ontology has been constructed and applied to the defense requirements process. The ontology was grounded in the established existing JCIDS standard, leveraged the semantic knowledge base, and reflected the values of key stakeholders. As a result, it successfully revealed interdependencies across the three capability documents reviewed. The goal of the ontology was met – to provide information **to assist decision makers with identifying capability gaps and solutions through cross-capability analysis.**

5. CASE STUDY

The following case study documents the challenges the US Air Force F-35 aircraft faced during the defense requirements process, specifically its ability to inter-operate with the F-22 aircraft. Although both aircraft are operated by the same service, the US Air Force, and manufactured by the same company, Lockheed Martin, a detailed lack of understanding existed between the two weapon systems. Neither program understood the information exchange or data link requirements of the other.

The details of the case are pulled from discussions with a number of subject matter experts with first-hand knowledge of the events. Although the author did not have direct access to the capability documents, or other associated requirements documents, for either aircraft, the specifics of the case make it apparent that the architecture and processes in place were lacking. This leads one to ask, had an ontology been in place, might it have mitigated some of these issues?

5.1. BACKGROUND

The F-22 Raptor is the U.S. Air Force's air dominance fighter aircraft. It is a dual engine, Mach 2 class, U.S. only (not for export) fighter aircraft design primarily for air-to-air missions with secondary air-to-ground capability. The Raptor's first flight was September 1997, with the first production aircraft delivered January 2003. Original plans called for a fleet of 648 aircraft, however due to budget constraints and political issues, only 188 were produced [46]. The last F-22 Raptor was delivered May 2012. The F-35 Lightning II is the U.S. Air Force's premier multi-role fighter aircraft. It is a single engine, Mach 1.6, exportable aircraft optimized for both air-to-air and air-to-ground missions. The Lightning II's first flight was December 2006 with the first production aircraft delivered May 2011. Lightning II deliveries are scheduled to continue well into 2035 with an estimated 3,100 aircraft being produced for the U.S Military and International Partners [47]. The Raptor and Lightning II are both fifth generation aircraft which incorporate the most advanced technologies and stealth characteristics (See Figure 19). Both aircraft are manufactured by Lockheed Martin.

Figure 19: Lockheed Martin F-35 (left) and F-22 (right) aircraft
(reproduced from http://aviationintel.com)

Both the F-35 and F-22 are products of the defense requirements process prior the JCIDS. They fell under the legacy bottom-up, threat-base force-planning methodology.

5.2. F-22 AND F-35 DATA LINK SYSTEMS

The F-22 is designed to penetrate anti-access airspace, while finding, tracking and targeting enemy air and ground-based threats. Its unique combination of advanced stealth, supercruise, advanced maneuverability and integrated avionics will allow it to "kick down the door," and then follow up with 24-hour stealth operations and freedom of movement for all follow-on forces [48]. The Raptor employs a new data fusion engine which constructs unique message structures, formats and waveforms dissimilar to existing data link formats. Coupled with the hostile environment in which the Raptor is designed to operate, it employs a proprietary stealth-qualified (Low Probability of Intercept and Detection), narrow beam Intra-Flight Data Link (IFDL) to communicate with other aircraft and military assets [49].

Recall that the F-22 fleet was forecasted at well over 600 aircraft. The intent was for the F-22 to conduct 'autonomous' operations (flying only with other F-22's) with little integration or support from other aircraft. A notional F-22 ICD utilizing the basic ontology presented earlier is provided below (Figure 20). Given the F-22's original intent to operate autonomously, note that there is no 'requirement' for Net-Centric or Building Partnership Capability Areas.

Understanding the independence of the F-22, the F-35 was designed to follow the F-22 once the 'door was down' and dominate the tactical environment. Although the F-35 would have some capability to penetrate contested airspace, it would be limited when compared to the F-22. When implemented in conjunction with the Raptor, the Lightning II is to be a force multiplier

[50]. Understanding this relationship it was important that both aircraft have the ability to communicate and pass data.

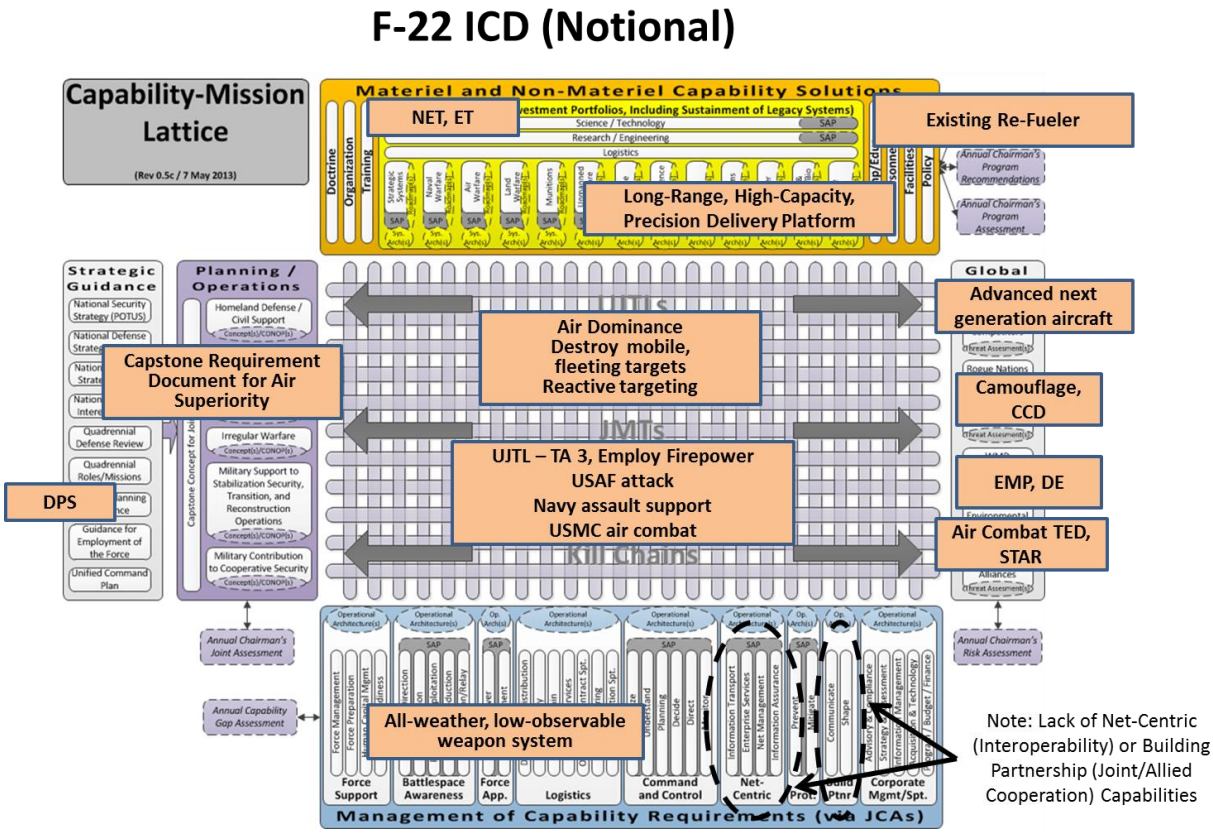


Figure 20: Notional F-22 ICD utilizing basic ontology

As the number of F-22's decreased, from 648 to 338 and finally 188, its mission profile was adjusted accordingly. Still 'responsible' for accomplishing the same tasks and mission sets, with only 188 aircraft in the fleet, the Raptor would have to partner much more closely with other aircraft. What was once an important capability, information exchange, was now critical.

In addition, the F-35 is touted as a "global aircraft" being purchased by a number of North Atlantic Treaty Organization (NATO) and coalition partners, meaning it will have to communicate with a number of global military assets as well [51]. Therefore, interoperability is key for the F-35. However, it is interesting to note that the F-22 community did not feel as strongly about this need for interoperability between the two aircraft as did the F-35. Similar to the F-22, a notional F-35 ICD utilizing the basic ontology presented earlier is provided below (Figure 21).

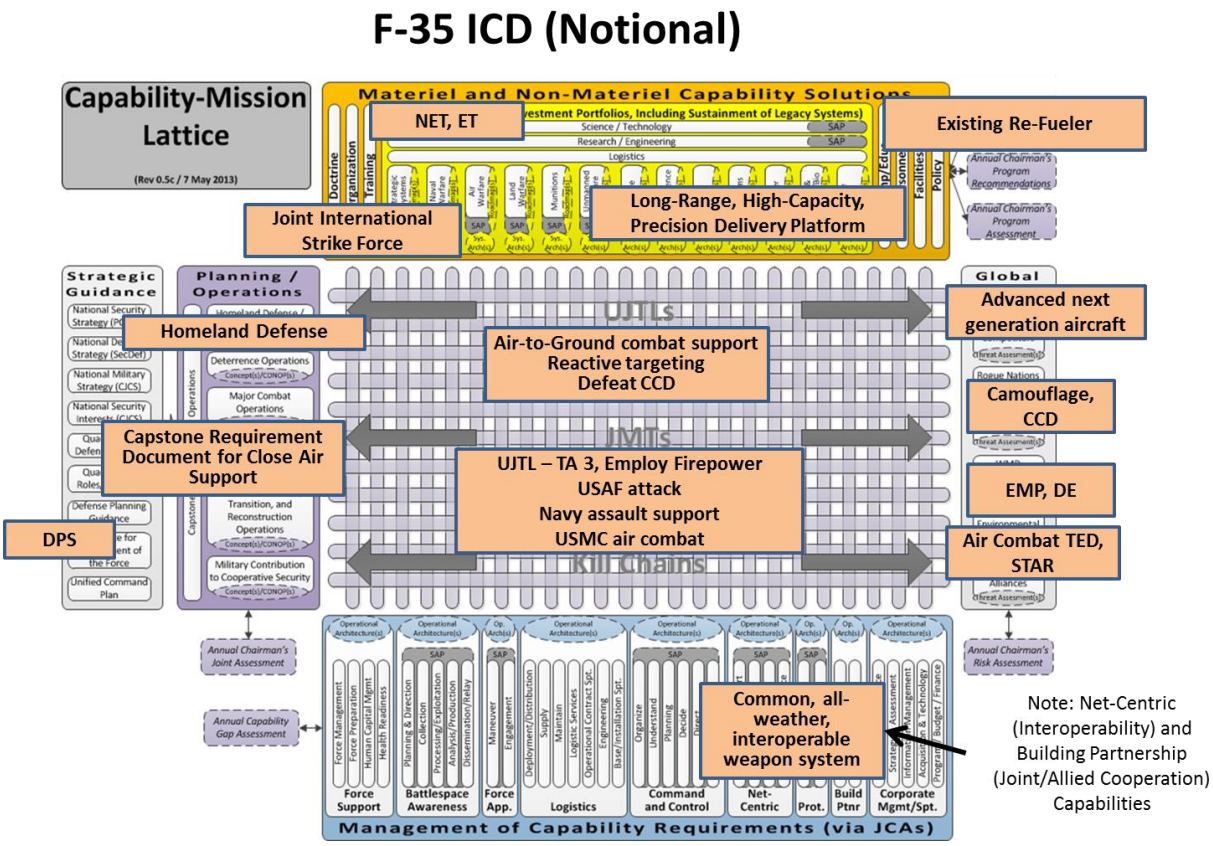


Figure 21: Notional F-35 ICD utilizing basic ontology

Simultaneous to the employment of IFDL on the Raptor, the U.S. Air Force continued its efforts for developing a small, compact terminal to support the existing NATO Tactical Digital Information Links (TADIL J) system, more commonly referred to as Link-16 in the United States [52, p. 108]. Link 16 is an encrypted, jam-resistant, nodeless tactical digital data link network established by JTIDS-compatible communication terminals that transmit and receive data messages in the TADIL J message catalog [52, p. 108]. It is the DoD's primary tactical data link for command, control, and intelligence, providing critical joint interpretability and situation awareness information [53]. Although Link 16 provides a secure, jam-resistant data link, there were concerns within the F-22 community that it would not provide an appropriate level of security – leading to the development of IFDL. Link-16 was being developed 'for the masses' which led some to question its integrity; there was a concern regarding a 'lack of emission control'. Given that the primary airframe the F-35 would partner with was the F-22, the F-35 program initially focused on the incorporation of IFDL onto the Lightning II while simultaneously supporting interoperability with existing legacy aircraft that did not utilize IFDL.

5.3. F-22 AND F-35 INTEROPERABILITY CHALLENGES

In 1995, as development efforts for the F-35 were underway, the Joint Strike Fighter Program Office (JPO) first addressed the issue of data links and interoperability for the F-35. A quick assessment revealed some interesting points. Dissimilar from the F-22, the F-35's primary role would include air-to-ground missions which in-turn would require higher bandwidth due to the larger amounts of data. To accommodate this enormous amount of data the F-35 would employ an advanced fusion engine, similar in logic but different to the F-22's fusion engine. Additionally, the F-35 would routinely fly with international partners. For many of those international partners the F-35 is to be their primary aircraft. As such, the F-35 must be able to communicate across a much wider array of platforms as compared to the F-22. For these reasons, amongst others, it was soon discovered that F-22 IFDL system would not be the optimal choice for the F-35. Now that it was clear that the Lightning II would not employ IFDL, the question arose – what system should it incorporate?

The JPO tasked their existing Interoperability division to manage this issue. The division consisted of U.S. military officers, government contractors, as well as representatives from some of the F-35 international partner countries, such as the United Kingdom, Italy and the Netherlands. Within the division there was a smaller four-man team dedicated to the specific issue of Information Exchange Requirements (IERs). It was this team that was tasked with answering the question – who would the F-35 need to talk to and what would they need to communicate?

5.4. F-35 INFORMATION EXCHANGE EFFORTS -- EXOGENOUS

The team started by reviewing existing program requirements documentation, to include the Mission Need Statement (MNS), Joint Operational Requirements Document (JORD), as well as higher level Office of the Secretary of Defense (OSD) Support Plans. It was quickly revealed that these documents did not provide the level of fidelity required to support a detailed interoperability discussion. Meanwhile, development of the F-35's data link architecture continued, and it was soon decided that the F-35 would field the Multifunction Advanced Data Link (MADL). MADL is a digital waveform that is designed for secure transmission of voice and data between F-35s, with the potential of linking F-35s to ground stations or other aircraft

[54]. MADL would be employed for 'internal' communications, within the F-35 fleet, while Link-16 would be used for 'external' communications, any data passed outside the F-35 fleet.

In 1997, the IER team set out to identify and quantify the F-35's communication architecture. OSD guidance was for programs to develop their own Command, Control, Communications, Computers and Intelligence Support Plan (C4ISP)[21]. However in the case of the F-35, development of the C4ISP lagged the requirements development process. By the time the C4ISP took shape, F-35 requirements were, for the most part, already defined. As a result, Interoperability requirements and IERs arrived late. Lacking an established C4ISP, the practice was that the Air Force at a global level would provide assistance with 'requirements oversight', whereas the Air Force's Air Combat Command (those who would fly and implement the F-35 weapon system) assisted with particular 'mission oriented' aspects. This resulted in very few, if any, interoperability issues that had been either studied or identified at the time. The team's first action then was to build the C4ISP. Furthermore, automated tools just weren't available so the only option was to "get (a) straight edge and pencil and start drawing out the communications architecture". The C4ISP would document specific mission characteristics, such as those attributes required to support Close Air Support (CAS) or the Destruction of Enemy Air Defenses (DEAD), along with the associated IERs.

The goal of the team was to 'try to envision 15 years out' what platforms the F-35 would need to interoperate with, both U.S. and internationally. To construct this vision, the team started as most Air Force missions start – with chair flying. Chair flying is a visualization technique where you mentally fly the flight walking through each step of the mission. This was the exact philosophy that the team implemented. They started at the beginning, 'flying' every type of mission, from aerial refueling, to include tanking from both U.S. and International airborne tankers, to strike missions with non-piloted airframes, similar to those tasks that are detailed in the UJTL. All these chair flight missions were based upon a projected timeframe of 2010. These missions leveraged Lockheed Martin's internal databases of record, iSMART and eSMART. eSMART was developed by Lockheed Martin UK to support the iSMART process, an internationally-accepted means of identifying interoperability challenges often arising during the development of information systems and communication media - including tactical data

[21] The C4ISP was the DoD's first attempt at an architectural framework. It would go through a number of revisions before being a major building block in the DoDAF released in 2003.

links. The process provides detailed analysis of interoperability across the whole communications domain, from strategic data to operational and "tactical edge" communications systems [55]. If a chair flight missions was not in the database it required 'a manual comparison'. This laborious, expensive and intensive process fed an evolving architecture which produced approximately 1000 unique IERs for the F-35.

5.5. F-22 AND F-35 INTEROPERABILITY CHALLENGES -- ENDOGENOUS

In addition to the chair flights, the team approached the F-22 program office to leverage their experiences. They immediately hit a wall, the wall of security clearances and program classifications. Although members of the team were able to access most classified documents, there were still areas which were extremely difficult to access, leading to the question – are there other systems, unknown to us, that we should be able to communicate with? Remember, the F-22's employment concept was such that it did not want to, or in many cases, need to talk to other non-F-22 aircraft. Also, there seemed to be little incentive 'driving to a joint solution', rather it seemed as if 'Fiefdoms' ruled the day. However, the F-22 program was a mature platform at the time and had invested heavily in IFDL. As was remarked, it can be very difficult trying to assimilate communication structures based upon funding availability as the lead platform usually has a significant advantage. This seemed odd as both aircraft are manufactured by the same company, Lockheed Martin. However, as is the often the case in an effort such as this, Lockheed Martin had erected their own internal firewall between the two programs. Additionally, at the time, the F-22 Program was in the midst of some political maneuvering. The program was under constant scrutiny. The final number of aircraft was consistently questioned, so much that the future of the program was in serious doubt. This unique environment made it much more of a challenge for the F-35 program resulting in very limited detailed information exchange between the two programs.

As this process continued, the team would attend JORD update meetings, Operator Advisory Group meetings, as well as warfighter simulation events to ensure they were accurately capturing the potential missions. During all these meeting the team constantly solicited feedback from the operators/customers on their IER database. Sporadically the team would receive feedback from the individual U.S. Military Services, however it was only at these senior meetings that they would receive feedback from all the Military Services as well as OSD. It was also at these meetings that the community would offer their final 'blessing' making the IERs

official, at which point they were documented and included in the JORD as Appendix F. This effort continued in earnest well into 2005 at which point the numbers of IERs had been reduced to approximately 132[22].

5.6. SUMMARY

It is clear that the F-35 program office faced a number of challenges when architecting their data link system. As discussed, the late nature of the C4ISP resulted in the lack of detail required. Lastly, the C4ISP documentation (DoD Architecture Framework) required 'too many architecture views' without offering 'basic templates' resulting in very little value added. Although the C4ISP was seen as a good process, forcing programs through a defined checklist and offering them a standard against which to document, it was seen as just that, a checklist, rather than a dynamic tool. The process in place was viewed as a pass-through, a gate to traverse rather than a system to assist. While some of these design challenges may have been foreseen, and possibly mitigated, the dramatic reduction in the number of F-22s presents a different challenge. As the number of F-22's decreased, the role of the F-35 increased. This role now includes more tasks to accomplish which directly translated into a greater number of IER's.

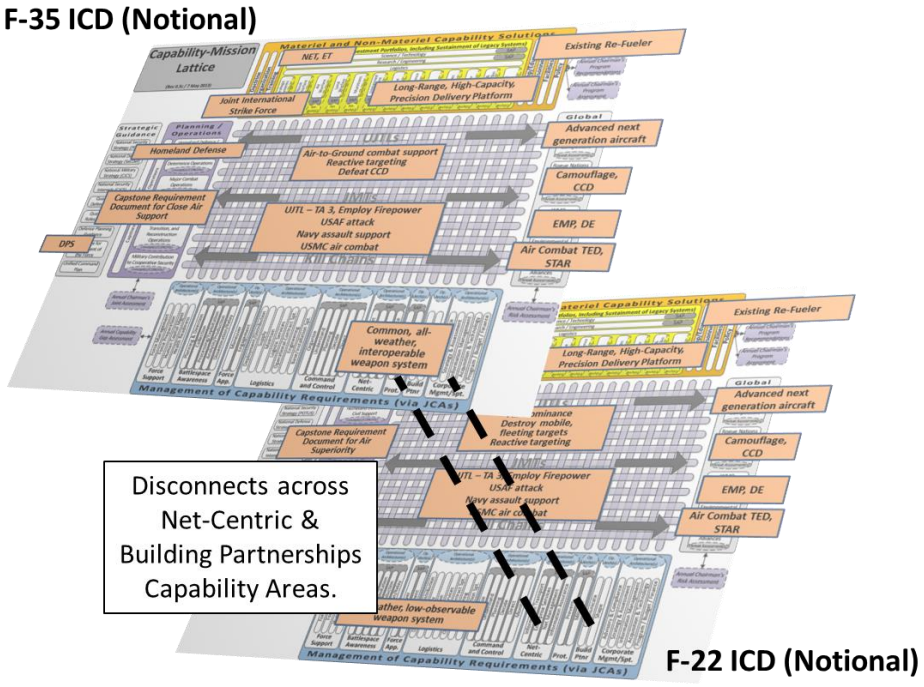


Figure 22: Potential F-35, F-22 "Intelligent" Interoperability and Interdependency

[22] Currently, the number is approximately 112.

Recalling that the objective of this section was to present a scenario where an ontology could provide utility, it could be surmised that had a basic ontology been in place, it might have revealed an evolving capability 'gap' created by the reduction in F-22's scope (Figure 22). The lower number of F-22's meant the aircraft would no longer be able to operate as autonomously as planned, and therefore require greater interoperability with other US forces, as well as allied and coalition forces. Would the "intelligent" interoperability of a mature ontology been able to surface these interdependencies? It is unclear. However, had a mature ontology been in place, it might have even been able to forecast, predicate, the emergence of the 'gap'.

6. CONCLUSIONS & RECOMMENDATIONS

The DoD finds itself in a precarious position. As US forces withdraw from large-scale operations in Iraq and Afghanistan it must manage a reduction in forces as well as a demand to reduce spending while balancing its ability to protect national interests and prosecute wars. Although the debate continues regarding the exact reduction in military spending, one thing is clear – given that the United States debt has surpassed $15 trillion, reduced defense spending is a reality. As the Secretary of Defense, Chuck Hagel stated, "as a consequence of large budget cuts, our future force will assume additional risk in certain areas" [56]. The challenge for the DoD is to manage this risk without sacrificing national security. In meeting this challenge, an opportunity exists to address deficiencies in the existing defense requirements process. As Professor Gordon Adams from American University states, "It is time to discipline defense", to add some rigor, and restore our ability to prioritize and make trades [57].

6.1. RESTATEMENT OF MOTIVATION & FINDINGS

This thesis applied Systems Engineering to the defense requirements process with the goal of improving trade visibility and fidelity. In particular, it investigated the feasibility of a common ontology for the use in the analysis of JCIDS documents. The investigation was comprised of two steps: the framing of JCIDS enterprise issues followed by selected data collection to validate an ontological approach.

6.1.1. ENTERPRISE STRATEGIC ANALYSIS

An Enterprise Strategic Analysis was utilized to frame enterprise level issues facing the defense requirements process. This analysis disclosed a number of issues at the enterprise level. Key among those was the challenges associated with managing affordability, effectively prioritizing requirements, and a lack of requirements stability.

6.1.2. SEMANTIC ENTERPRISE ARCHITECTURE

A semantic review of select JCIDS documents was conducted to determine if they could meaningfully be reduced into constituent parts, the first step to creating an ontology. This process mined the critical elements from each of the JCIDS documents producing the core document as revealed, versus as prescribed or written. The subsequent mapping of these

elements from each core document demonstrated that the basic elements are in place to support an ontology.

6.1.3. Creation of a Basic Ontology

From the elements revealed in the semantic review, a basic ontology was created. The goal of the ontology was to demonstrate its ability to identify capability gaps and solutions through cross-capability analysis. The ontology successfully spotlighted a number of critical interdependencies across a select number of programs.

6.1.4. Case Study

A case study examining the US Air Force F-35 combat aircraft discussed the potential utility of an ontology. The case helps to move this thesis from the theoretical to the practical.

6.2. Limitations & Future Research

This thesis was conducted as part of a larger research study for the Joint Staff regarding a JCIDS semantic architecture framework. The Joint Staff study is composed of three main branches: systems engineering; semantic architecture; and technology design and implementation. This thesis was the beachhead for the Joint Staff study. As such, the research was planar and limited. Although the results validate the premise, the resulting ontology is rudimentary with little value outside this academic effort. Clearly, more work is required to refine and extend the ontology before the technology design and implementation can occur.

6.3. Final Thoughts

As an active duty Air Force Colonel, I find myself in a unique position. Upon conclusion of my National Defense Fellowship I will be reassigned to the F-35 Joint Program Office as the Deputy Director, Requirements. I am being afforded the opportunity to put this thesis into action.

BIBLIOGRAPHY

[1] One Hundred Twelfth Congress of the United States of America, *Bill S. 365: Budget Control Act of 2011,* http://www.gpo.gov/fdsys/pkg/BILLS-112s365enr/pdf/BILLS-112s365enr.pdf, 2011.

[2] Project on Defense Alternatives, "Pentagon Base "Non-war" Budget 1976-2017 – Secretary Panetta vs. Sequestration," 13 February 2012. [Online]. Available: http://www.comw.org/pda/120213Dod-budget-history.gif. [Accessed 19 February 2014].

[3] F. Kendall, Interviewee, Under Secretary of Defense for Acquisition, Logistics and Technology. [Interview]. 6 December 2013.

[4] J. D. Mohney, "Requirements in the Affordability Crosshairs," *Defense AT&L : Better Buying Power,* pp. 19-24, September - October 2011.

[5] S. Robertson and J. Robertson, "Mastering the Requirements Process," Atlantic Systems Guild Ltd, [Online]. Available: http://www.volere.co.uk/masteringrequirementsprocess.htm. [Accessed 22 February 2014].

[6] IBM, "Managing and Composing Requirements: Requirements Management Process," IBM, [Online]. Available: http://pic.dhe.ibm.com/infocenter/reqpro/v7r1m0/index.jsp?topic=/com.ibm.reqpro.help/req_mgt_tour/c_reqmgt_proc.html. [Accessed 24 February 2014].

[7] E. Crawley, O. de Weck, S. Eppinger, C. Magee, J. Moses, W. Seering, J. Schnidall, D. Wallace and D. Whitney, "The Influence of Architecture in Engineering Systems," in *Engineering Systems Symposium -- Engineering Systems Monograph*, Cambridge, 2004.

[8] A. Levis, "Systems Architectures," in *Handbook of Systems Engineering and Management,* New York, John Wiley & Sons, 1999, pp. 427-454.

[9] Defense Acquisition University, "Requirements - Executive Overview Workshop," DAU, Fort Belvoir, VA, 2012.

[10] QuestaWeb, Inc, "Global Trade Visibility," 2013. [Online]. Available: http://www.questaweb.com/sln-internet-services_tt.aspx. [Accessed 28 April 2014].

[11] Department of Defense, "Joint Defense Capabilities Studies (Improving DOD Strategic Planning, Resourcing and Execution to Satisfy Joint Capabilities)," Department of Defense, Washington, DC, 2004.

[12] Joint Staff, "Future Joint Warfighter - Joint Capability Areas (JCAs) -- JCA Taxonomy," 8 April 2011. [Online]. Available: http://www.dtic.mil/futurejointwarfare/jca.htm. [Accessed 23 April 2014].

[13] G. England, *Capability Portfolio Management,* vol. 7045.20, Washington, DC: Department of Defense, 2008.

[14] Joint Staff, "Manual for the Operation of the Joint Capabilities Integration," *JCIDS Manual*, 19 Jan 2012.

[15] IBM, "Rational Systems Architecture 11.4.2, Designing and Managing, Creating MODAF products, MODAF overview," [Online]. Available: http://pic.dhe.ibm.com/infocenter/rsysarch/v11/index.jsp?topic=%2Fcom.ibm.sa.modaf.doc%2Ftopics%2Fc_MoDAF_Overview.html. [Accessed 26 April 2014].

[16] Gov.UK, "MOD Architecture Framework," Government Digital Service, 12 December 2012. [Online]. Available: https://www.gov.uk/mod-architecture-framework. [Accessed 25 February

2014].

[17] UK Ministry of Defence, "MOD Architectural Framework -- White Paper on Strategic View 1 (StV-1): Capability Vision," MODAF Partners, Abbey Wood, 2005.

[18] D. H. Rhodes, *Systems Engineering in the Enterprise,* Cambridge: Systems Engineering Advancement Research Initiative - MIT, 2008.

[19] T. Allen, D. Nightingale and E. and Murman, "Engineering Systems: An Enterprise Perspective," in *Engineering Systems Symposium -- Engineering Systems Monograph*, Cambridge, 2004.

[20] MIT, "Enterprise Strategic Analysis for Transformation (ESAT)," LAI MIT, 2013. [Online]. Available: http://lean.mit.edu/products/enterprise-strategic-analysis-for-tranformation-esat. [Accessed 27 February 2014].

[21] D. Nightingale, *ESD.61J / 16.852J: Integrating the Lean Enterprise -- Lecture 2 Lean Fundamentals,* Cambridge: Deborah Nightingale, 2013 Massachusetts Institute of Technology, 2013.

[22] S. Weinberger, "How to: Speak Pentagon," May 2008. [Online]. Available: www.wired.com. [Accessed 15 November 2013].

[23] G. M. Dempsey, Interviewee, *Confirmation Hearing.* [Interview]. 26 July 2011.

[24] Government Accountability Office, "Defense Acquisitions: DOD's Requirements Determination Process Has Not Been Effective in Prioritizing Joint Capabilities," 2008.

[25] United States Government Accountability Office, "DEFENSE ACQUISITIONS - DOD's Requirements Determination Process Has Not Been Effective in Prioritizing Joint Capabilities," GAO, Washington, DC, 2008.

[26] D. Nightingale, ESD.61J / 16.852J: Integrating the Lean Enterprise -- Lecture 8: Enterprise Interactions and Alignment, Cambridge: Deborah Nightingale, 2013 Massachusetts Institute of Technology, 2013.

[27] S. Maley, *JROC/ JCIDS Updated Processes,* Washington, DC: Force Support Division, Joint Staff, 2012.

[28] Joint Staff, "JCIDS Manual (Staffing Draft, pre-release)," Joint Staff, Washington DC, 2013.

[29] D. E. Hahn, "Predicting Program Success - Not Child's Play," *Defense AT&L,* pp. 45-47, January - February 2014.

[30] Defense Acquisition University, "Acquipedia -- JCIDS," Defense Acquisition University, 8 August 2013. [Online]. Available: https://dap.dau.mil/acquipedia/Pages/ArticleDetails.aspx?aid=12227505-ba29-41c0-88f0-682a219d5bbc. [Accessed 4 March 2014].

[31] Defense Acquisition University, *Requirements Webinar,* Fort Belvoir, VA: DAU, 2013, p. 18.

[32] J. Owens, J. Belanger, R. G. Bonesteele, A. T. Guillen and R. Duenas, "Defining Military Space Capability Requirements for Successful Development," *Crosslink Magazine,* vol. 14, no. 1, pp. 1-5, 2013.

[33] D. L. McGuinness, *Ontologies Come of Age,* D. Fensel, J. Hendler, H. Lieberman and W. Wahlster, Eds., Cambridge: MIT Press, 2003.

[34] T. R. Gruber, "A Translation Approach to Portable Ontology Specifications," *Knowledge Acquisition 5(2),* pp. 199-220, April 1993.

[35] N. F. Noy and D. L. McGuinness, "Ontology 101: A Guide to Creating Your First Ontology," Stanford Knowledge Systems Laboratory, Palo Alto, 2001.

[36] Joint Staff, "Future Joint Warfare - Joint Capability Areas," Joint Staff, 2007. [Online]. Available: http://www.dtic.mil/futurejointwarfare/jca.htm. [Accessed 1 April 2014].

[37] D. Crissman, "The Joint Force Capability Study and the Development of Joint Capability Areas,"

Joint Staff, Washington, DC, 2005.

[38] United States Air Force, USAF Doctrine Volume 4 - Operations, Maxwell Air Force Base: United States Air Force, 2013.

[39] W. W. Hurd and J. G. Jernigan, Aeromedical Evacuation, New York: Springer, 2003, pp. 88-111.

[40] United States Air Force, "Initial Capabilities Document for Joint Future Theater Lift," United States Air Force, Washington, DC, 2009.

[41] United States Government Accountability Office, "About GAO," GAO, [Online]. Available: http://www.gao.gov/about/index.html. [Accessed 16 March 2014].

[42] United States Government Accountability Office, DEFENSE ACQUISITIONS -- Strategic Airlift Gap Has Been Addressed, but Tactical Airlift Plans Are Evolving as Key Issues Have Not Been Resolved, Washington, DC: GAO, 2009.

[43] United States Government Accountability Office, DEFENSE ACQUISITIONS - Assessment of Selected Weapons Programs, Washington, DC: GAO, 2012.

[44] United States Government Accountability Office, DEFENSE ACQUISITIONS - Assessments of Selected Weapons Programs, Washington, DC: GAO, 2013.

[45] R. Vartabedian and W. J. Hennigan, "Los Angeles Times - F-22 program produces few planes, soaring costs," 16 June 2013. [Online]. Available: http://www.latimes.com/business/la-fi-advanced-fighter-woes-20130616-dto,0,7588480.htmlstory#axzz2xfEblAxP. [Accessed 1 April 2014].

[46] Joint Strike Fighter Program Office, Joint Strike Fighter Producion, Sustainment, and Follow-On Development Memorandum of Understanding, Washington, DC: Department of Defense, 2009.

[47] Lockheed Martin, "F-22 Raptor - Capabilities," Lockheed Martin, 2014. [Online]. Available: http://www.lockheedmartin.com/us/products/f22/f-22-capabilities.html. [Accessed 13 February 2014].

[48] Defense Update, "Raptor in the Net - Raptors, Vipers Share sensor data for the first time," Defense Update, 8 May 2008. [Online]. Available: http://defense-update.com/features/2008/may08/F22_datalink_gateway.htm. [Accessed 13 February 2014].

[49] R. Laird, "Why Air Force Needs Lots of F-35s: Gen. Hostage on The 'Combat Cloud'," 10 January 2013. [Online]. Available: http://breakingdefense.com/2013/01/why-the-air-force-needs-a-lot-of-f-35s-gen-hostage-on-the-com/. [Accessed 13 February 2014].

[50] Rand Corporation, "Interoperability - A Continuing Challenge in Coalition Air Operations," Rand Corporation, Washington, DC, 2000.

[51] J. Pike, "FAS - Tactical Digital Information Links (TADIL)," 23 April 2000. [Online]. Available: http://www.fas.org/irp/program/disseminate/tadil.htm. [Accessed 13 February 2014].

[52] A. Mehta, "New Data Link Enables Stealthy Comms for F-35," Lockheed Martin, 19 July 2013. [Online]. Available: http://www.airforcetimes.com/article/20130719/NEWS04/307190027/New-data-link-enables-stealthy-comms-F-35. [Accessed 13 February 2014].

[53] Lockheed Martin, "2010 Press Release - Lockheed Martin UK's eSmart Toolset Supports Ministry of Defence Project Guardian," Lockheed Martin, 18 November 2010. [Online]. Available: http://www.lockheedmartin.com/uk/news/press-releases/2010-press-releases/esmart-guardian.html. [Accessed 13 February 2014].

[54] T. Connor and J. Miklaszewski, "NBC News - Pentagon Set to Slash Military to Pre-World War II Levels," 24 February 2014. [Online]. Available: http://www.nbcnews.com/storyline/military-spending-cuts/pentagon-set-slash-military-pre-world-war-ii-levels-n37086. [Accessed 1 April 2014].

[55] G. Adams, "U.S. News & World Reports, News Opinion - Debate Club: It Is tIme for Discipline,

Defense," 28 November 2011. [Online]. Available: http://www.usnews.com/debate-club/are-cuts-to-the-defense-budget-necessary/it-is-time-for-discipline-defense. [Accessed 1 April 2014].

[56] P. Towell and A. Belasco, "Defense: FY2014 Authorization and Appropriations," Congressional Research Service, Washington, DC, 2014.

[57] L. N. Ahmed, G. Gleckel, C. Wadsworth and J. Williams, "Integrating the Lean Enterprise - Team Project: The Department of Defense Joint Staff Joint Capabilities Integration Integration and Development System -- Final Report," Cambridge, 2013.

[58] United States Government Accountability Office, "MILITARY TRANSFORMATION - Fielding of Army's Stryker Vehicles is Well Under Way, but Expectations for Their Transportability by C-130 Aircraft Need to Be Clarified," GAO, Washington, DC, 2004.

[59] J. T. Correll, "Doctrine Next - Air Force doctrine takes a greap leap into the digital age," *AIR FORCE Magazine*, pp. 53 - 57, December 2013.

[60] The White House, "Department of Defense FY12 Budget -- Funding Highlights," The White House, Washington, DC, 2011.

[61] Defense Acquisition University, "ACQuipedia -- DOTmLPF-P Analysis," Defense Acquisition University, 22 August 2013. [Online]. Available: https://dap.dau.mil/acquipedia/Pages/ArticleDetails.aspx?aid=d11b6afa-a16e-43cc-b3bb-ff8c9eb3e6f2. [Accessed 25 March 2014].

[62] Lockheed Martin, "F-35 Lightning II," Lockheed Martin, 2014. [Online]. Available: http://www.lockheedmartin.com/us/products/f35.html. [Accessed 13 February 2014].

[63] A. Moulton, JCIDWS Semantic Architecture Framework Study -- Guidance on Manual Text Extraction Form & Process, Cambridge: M.I.T., 2014.

APPENDIX A – JCIDS STAKEHOLDER SURVEY

Joint Capabilities Integration and Development Stakeholder Survey

INTRODUCTION: The purpose of this survey is to collect data from groups and individuals who work within or are affected by the Joint Capabilities Integration and Development System (JCIDS). JCIDS is the United States Department of Defense's system of record that provides analysis for warfighter capabilities, develops and improves material operational requirements, and promotes joint (inter-service) solutions to wartime problems. The data collected will be used for a class project at the Massachusetts Institute of Technology. The goal of the project, conducted in Integrating the Lean Enterprise under the direction of Professor Deborah Nightingale by four Air Force and Army officers, is to analyze the JCIDS process using lean enterprise methodologies. Please fill out the survey in the context of your experiences with JCIDS. Thank you in advance for your support of this project.

PRIVACY STATEMENT: Although you cannot submit this survey anonymously, we will not use information that is personally identifiable in our interim and final reports. The personally identifiable information (PII) includes names, ranks, duty positions, email addresses, or experiences. If you are willing to discuss follow-up questions with the research team, please indicate so when you return the survey.
ACADEMIC STATEMENT: Although sponsored by the DoD J8 and conducted by active duty military officers, this survey is intended solely to fulfill academic requirements at the Massachusetts Institute of Technology. The final results will be shared with the sponsor.
NON-DISCLOSURE: This survey is not intended to collect or disseminate any information that is not unclassified or otherwise restricted. Please do not include any information that is not releasable to the general public.

1. What is/was your experience with JCIDS? Please include your organization, your position in the organization, and which parts of JCIDS you dealt with.

2. When (year) was this experience? (NOTE: JCIDS has been revised a number of times, this will help to correlate your experiences with the particular JCIDS revision at the time)

3. What was the outcome in terms of the JCIDS process for your program? (e.g. approved CDD, returned for further staffing, disapproved, etc)

4. What functions should JCIDS include that it does not already perform?

5. How consistent is the JCIDS process in terms of published timelines and review requirements?

6. Are requirements (as identified by capability documents) of similar complexity processed to the same standard?

7. How stable are the identified requirements after approval?

RELATIVE IMPORTANCE: Please rate on a scale of 1-5 on how IMPORTANT the following JCIDS priorities and functions are to you based on your professional opinion and experiences. Later you will be asked to judge how well they perform in these same areas. Scale: 1 = irrelevant, 2 = somewhat unimportant, 3 = neither important nor unimportant, 4 = important, 5 = very important, NA = no experience.
(For definitions of the terms below, please see the last page.)

JCIDS Outputs

1. Effective Capabilities for the Warfighter:	1	2	3	4	5
2. Effective Contribution to National Defense:	1	2	3	4	5
3. Efficient Use of Resources and Time:	1	2	3	4	5
4. Defined Requirements	1	2	3	4	5
5. Accurate Requirements	1	2	3	4	5
6. Vetted Requirements	1	2	3	4	5
7. Coordinated Requirements	1	2	3	4	5
8. Prioritized Requirements	1	2	3	4	5
9. Thorough, Complete Capability Documents	1	2	3	4	5
10. Affordable Requirements	1	2	3	4	5
11. Articulate Capability Documents	1	2	3	4	5
12. Actionable Direction as a Result of JCIDS Outputs	1	2	3	4	5
13. Validated Capabilities	1	2	3	4	5
14. Identified Capability Gaps	1	2	3	4	5
15. Validated Capability Gaps	1	2	3	4	5

System Characteristics

16. Robust Process	1	2	3	4	5
17. Responsive Process	1	2	3	4	5
18. Flexible Process	1	2	3	4	5
19. Transparent Process	1	2	3	4	5
20. Documented Process	1	2	3	4	5

PERFORMANCE: Please rate on a scale of 1-5 on the PERFORMANCE of each JCIDS priority and function based on your professional opinion and experience.
Scale: 1 = poor, 2 = fair, 3 = satisfactory, 4 = good, 5 = excellent, NA = no experience.
(For definitions of the terms below, please see the last page.)

JCIDS Outputs

1. Effective Capabilities for the Warfighter:	1	2	3	4	5
2. Effective Contribution to National Defense:	1	2	3	4	5
3. Efficient Use of Resources and Time:	1	2	3	4	5
4. Defined Requirements	1	2	3	4	5
5. Accurate Requirements	1	2	3	4	5
6. Vetted Requirements	1	2	3	4	5
7. Coordinated Requirements	1	2	3	4	5
8. Prioritized Requirements	1	2	3	4	5
9. Thorough, Complete Capability Documents	1	2	3	4	5
10. Affordable Requirements	1	2	3	4	5
11. Articulate Capability Documents	1	2	3	4	5
12. Actionable Direction as a Result of JCIDS Outputs	1	2	3	4	5
13. Validated Capabilities	1	2	3	4	5
14. Identified Capability Gaps	1	2	3	4	5
15. Validated Capability Gaps	1	2	3	4	5

System Characteristics

16. Robust Process	1	2	3	4	5
17. Responsive Process	1	2	3	4	5
18. Flexible Process	1	2	3	4	5
19. Transparent Process	1	2	3	4	5
20. Documented Process	1	2	3	4	5

OPTIONAL: Please provide any feedback on the items below as necessary. We are especially interested in your feedback if you had extensive experience in one of these areas or are a subject matter expert.

JCIDS Outputs

1. Effective Capabilities for the Warfighter:
2. Effective Contribution to National Defense:
3. Efficient Use of Resources and Time
4. Defined Requirements
5. Accurate Requirements
6. Vetted Requirements
7. Coordinated Requirements
8. Prioritized Requirements
9. Thorough, Complete Capability Documents
10. Affordable Requirements
11. Articulate Capability Documents
12. Actionable Direction as a Result of JCIDS Outputs
13. Validated Capabilities
14. Identified Capability Gaps
15. Validated Capability Gaps

System Characteristics

16. Robust Process
17. Responsive Process
18. Flexible Process
19. Transparent Process
20. Documented Process

OTHER: Please use this space to include comments on JCIDS relative to the study we are conducting that were not included above.

Definition of Terms Used in the Survey

JCIDS Outputs

1. Effective Capabilities for the Warfighter: JCIDS provides effective capabilities to warfighters across DoD.
2. Effective Contribution to National Defense: The output of JCIDS results in real advances to the capabilities of warfighters based on capability gaps.
3. Efficient Use of Resources and Time: The cost of the system (personnel effort, time) is worth the resources and time used.
4. Defined Requirements: JCIDS provides requirements that are easily identifiable as requirements.
5. Accurate Requirements: JCIDS requirements are accurate based on the capability gap assessment.
6. Vetted Requirements: JCIDS requirements are individually assessed by individual services and joint staff and feedback is given to the Vice Chairman of the Joint Chiefs of Staff.
7. Coordinated Requirements: JCIDS requirements are coordinated by the individual services and joint staff.
8. Prioritized Requirements: JCIDS requirements are prioritized by the individual services and joint staff.
9. Thorough, Complete Capability Documents: The Capability Documents provide all information that is necessary to continue the process.
10. Affordable Requirements: The projected cost of JCIDS requirements is accurate and affordable.
11. Articulate Capability Documents: The Capability Documents provide information in such a way that is easy to read and comprehend.
12. Actionable Direction as a Result of JCIDS Outputs: Individuals and staff components have all necessary information to start analysis as a result of JCIDS
13. Validated Capabilities: Capabilities identified are accurate and validated through the services and the joint staff.
14. Identified Capability Gaps: Identified Capability Gaps provide
15. Validated Capability Gaps: Capability Gaps are accurate and validated through the services and the joint staff.

System Characteristics

16. Robust Process: The whole system is self-sufficient; the number of "work-arounds" is minimal.
17. Responsive Process: The system responds to the actual and projected needs of the warfighter.
18. Flexible Process: There is sufficient flexibility within the system to account for changing conditions without undue costs.
19. Transparent Process: Information required by staff decision makers is readily available within the constraints of security requirements.
20. Documented Process: All interim processes and decisions are properly documented for further action.

APPENDIX B – JCIDS SENIOR STAKEHOLDER FOCUSED SURVEY

Senior Leader Stakeholder Survey

PURPOSE: The Massachusetts Institute of Technology is in the midst of a Joint Staff funded research effort to study the feasibility of a common ontology for use in analyzing JCIDS documents. Part of this process is reaching out to Subject Matter Experts for their comments and opinions regarding the JCIDS process. The questions are purposefully vague and open-ended, please respond as you fell appropriate.
PRIVACY STATEMENT: Although you cannot submit this survey anonymously, we will not use information that is personally identifiable in our interim and final reports. The personally identifiable information (PII) includes names, ranks, duty positions, email addresses, or experiences. If you are willing to discuss follow-up questions with the research team, please indicate so when you return the survey.
NON-DISCLOSURE: This survey is not intended to collect or disseminate any information that is not unclassified or otherwise restricted. Please do not include any information that is not releasable to the general public.

1. Background: What is your position and how do you interact with the JCIDS process?

2. What do you define as a quality product from JCIDS?

    a. How would you improve this quality?

3. How stable, in your perception, are the identified requirements (both during and after the approval process)?

4. Does JCIDS provide you adequate insight into ‘affordability’ to make cost-benefit tradeoffs?

    a. When (where) should affordability be established in JCIDS (when do you need the information)?

    b. Who should establish affordability within JCIDS?

5. Does JCIDS provide adequate information to make decisions and progress to the next phase of the defense acquisition system?

6. How do you regard JCIDS?

    a. Do you view it as a one-time (static) process?

    b. Do you view it as a repository that provides evolving insight across systems?

7. What functional expansion, if any, would you propose to JCIDS?

8. What stream-lining (efficiencies) would you propose to JCIDS?

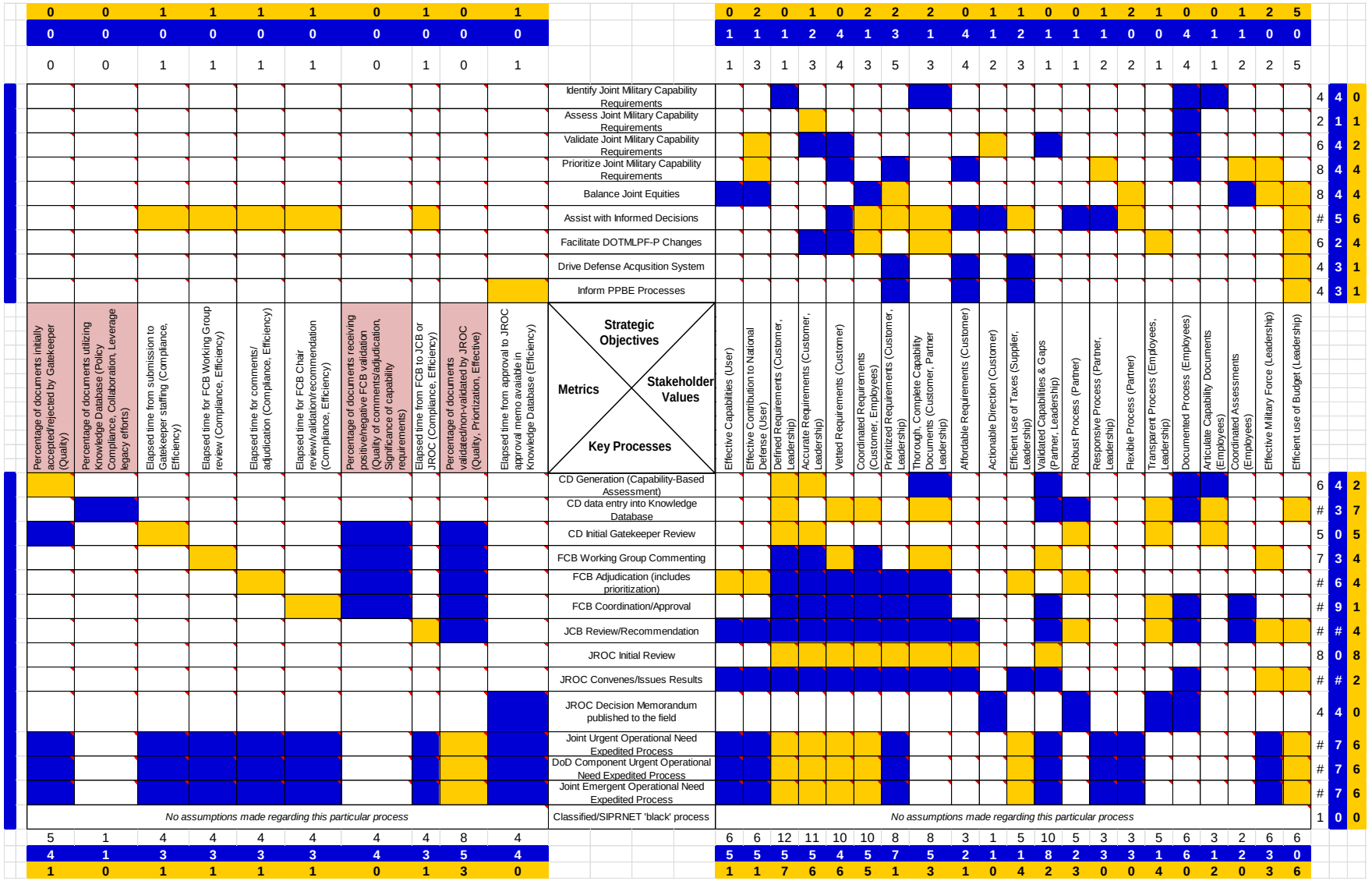
APPENDIX C – VALUE EXCHANGE ACROSS STAKEHOLDERS AND JCIDS

Value Expected from the Enterprise	Stakeholders	Value Contributed to the Enterprise
• Effective Capabilities	Warfighters	• Identify Capability Gap(s)
• Effective contribution to National Defense	Americans	• Personnel • Societal Support
• Defined requirements • Accurate requirements • Vetted requirements • Coordinated requirements • Prioritized requirements • Thorough, complete capability documents • Affordable requirements	Service Acquisition Authorities	• Provide JROC Advisors • Executive level process feedback • Lessons learned based upon experience • Ideas/Innovation
• Defined requirements • Accurate requirements • Prioritized requirements	Defense Contractors	• Process utility feedback • Affordability feedback • Capability limitations
• Defined requirements • Accurate requirements • Affordable requirements • Prioritized requirements • Thorough, complete capability documents • Actionable direction	Military Program Offices	• Direct feedback regarding utility of process documents
• Efficient use of taxes	U.S.A. Taxpayers	• Funding
• Validated Capabilities • Validated Capability Gap(s) • Thorough, complete capability documents • Robust process • Responsive process • Flexible process	Military Services	• Produce capability gap(s) assessments, documents • Coordinate, collaborate, and gain concurrence on assessment, documents • Provide feedback • Provide JROC Members • Provide FCB Members
• Coordinated requirements • Transparent process • Documented process	DoD Joint Staff	• Staff and support process • "Gatekeeper" controlling and assigning responsibilities across process • Initial review of documents
• Identified Capability Gaps • Articulate Capability Documents	FCB	• Assess Capability Documents • Formulate recommendations

• Coordinated assessments • FCB recommendations	JROC	• Determine and oversee process • Validated Capabilities • Validated Capability Gap(s) • Defined requirements • Accurate requirements • Vetted requirements • Coordinated requirements • Prioritized requirements
• Effective Military Force	President of the United States	• National Military Strategy • National support
• Efficient use of taxes • Transparent process	U.S. Congress	• Funding
• Validated Capabilities • Validated Capability Gap(s) • Defined requirements • Accurate requirements • Prioritized requirements • Thorough, complete capability documents • Efficient use of budget	U.S. Secretary of Defense	• Strategic guidance • Resources allocation • Executive level direction
• Process to support Chairman JCS to identify and assess joint military capability needs • Efficient use of budget	Joint Chiefs of Staff	• Strategic Guidance • Advocacy for process • Senior leadership
• Validated Capabilities • Validated Capability Gap(s) • Responsive process	Combatant Commanders	• Identify Capability Gaps • Advocate to JROC on all capabilities that fall within their scope • Coordinate on all documents within their scope • Review and assess other capabilities outside their scope

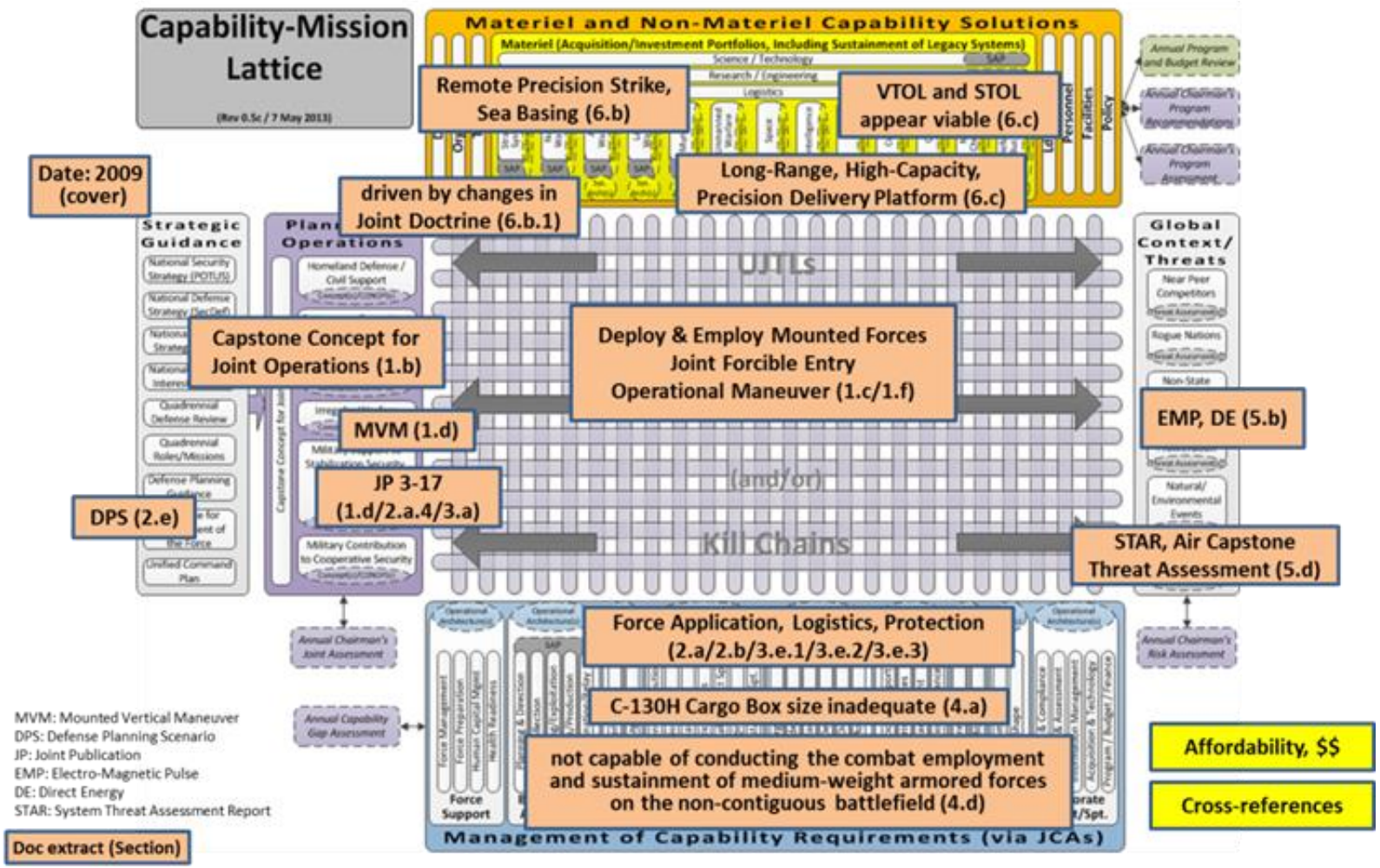
APPENDIX D – JCIDS CURRENT STATE X-MATRIX

(mauve blocks denote metrics that are prescribed but not collected)



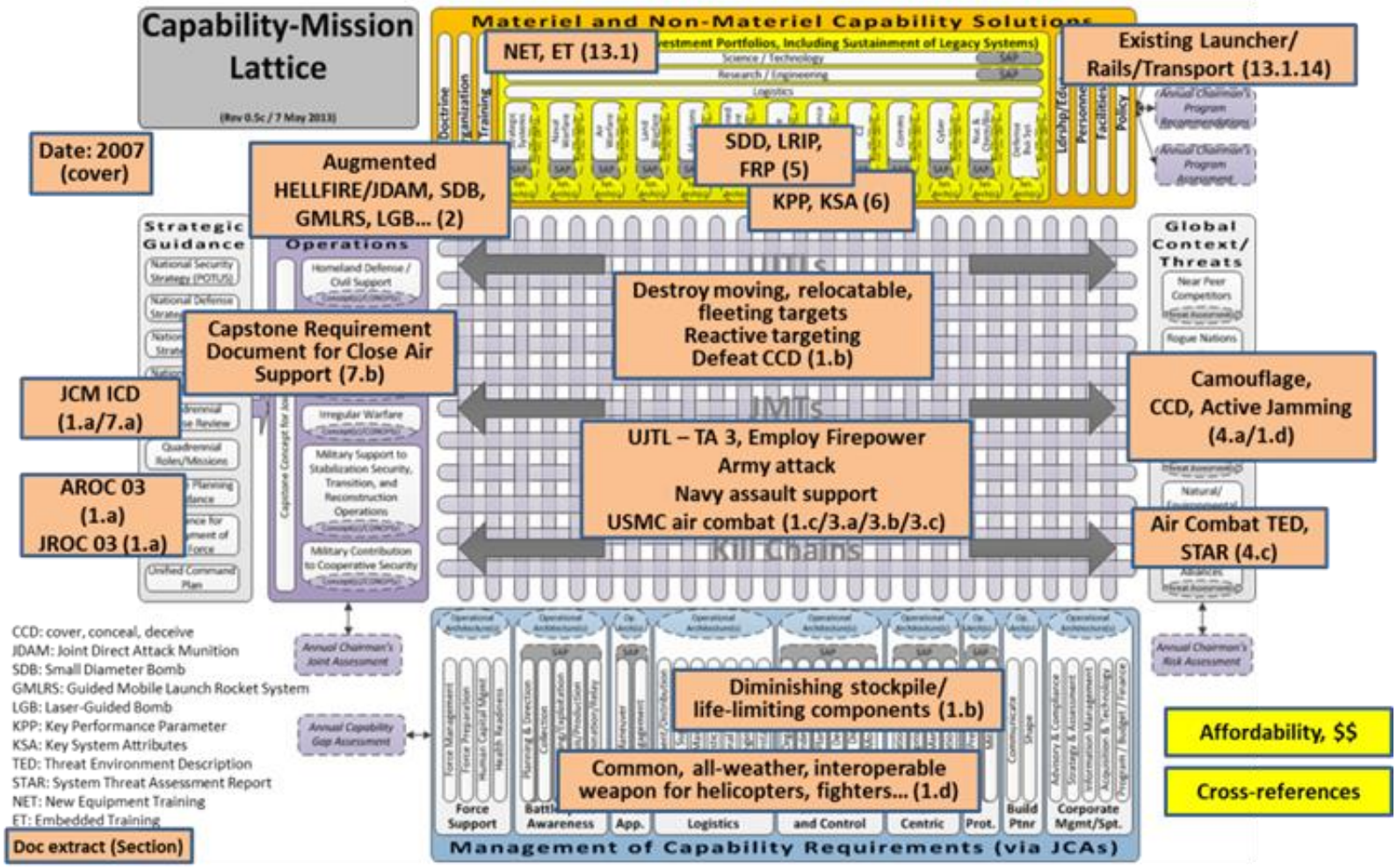
APPENDIX E – CAPABILITY DOCUMENTS MAPPED TO CML – JFTL ICD

JFTL ICD



APPENDIX F - CAPABILITY DOCUMENTS MAPPED TO CML – JAGM CDD

JAGM CDD



APPENDIX G - CAPABILITY DOCUMENTS MAPPED TO CML – ER UAS CPD

ER UAS CPD