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"A Method to Analyze Network-Centric Capabilities for Agile C2 for Force Sustainment Soldiers in Southwest Asia"

Topic:
C2 Assessment Tools and Metrics

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The U.S. Army Chief Information Officer (CIO/G6) recognized potential communication and collaboration issues in performing C2 for Force Sustainment Soldiers working at Forward Operating Bases in Southwest Asia. The G6 commissioned a study to determine what network enabled capabilities would improve Logistics tasks in this area of operations. This paper outlines the methodology employed to identify and prioritize those gaps based on their impact on the efficacy of Transportation operations. This unique methodology is based on mapping operationally significant and doctrinally defined tasks to C2 concepts as defined in the Network Centric Operational Environment Joint Integrating Concept. It brought together the usually isolated Signal Community and Logistics Community with ways that they can assist each other in the transition to net-centric communications. The recommendations of this study included integrated solution packages that will significantly improve Transportation operations by increasing their ability to access net-centric domains while minimizing operational risk and cost. This approach can be applied across the acquisition process and, more importantly, inform requirements documents and early systems engineering efforts for agile C2 outside the traditional realm of Combat Arms.

1. INTRODUCTION

1.1 PROBLEM OVERVIEW

If Soldiers were polled in World War II, they would have said that their most important piece of personal equipment was their weapon. Today, in Southwest Asia, Soldiers say that their cell phone or internet connection is the most important. This is as expected because instead of a single bullet or single weapons systems, the most critical thing on the battlefield today is information. To support information sharing, Soldiers are finding that information technology (IT) is the key to success whether they are an Infantry Soldier (e.g. downloading maps and current intelligence to their PDA) or a Logistician (e.g. getting real-time visibility of shipments on the Main Supply Routes). To fulfill these IT requirements, the Army Signal Corps has the mission of responding to critical voice, data, and video requirements for the battlefield and then fielding systems that can provide that service at the appropriate time in the appropriate place.

During the past decade, the US Army has designed and fielded numerous systems geared toward the Soldier in combat. These include Blue Force Tracker, Smart Ballistics, and Improved Body Armor. Millions of dollars have been spent, years of research have been completed, and hundreds of organizations have participated – all to improve the odds of success for the Combat Arms Soldier. But what about the rest of the Army? The other branches of service seem to be behind in receiving updated IT. The investment has been in enabling Information Age C2 for front-line defenders at the expense of the logisticians. That is, there has been little attention paid to network-centric logistics or C2 for Force Sustainment Soldiers. Recent studies, including the June 2007 Tactical Networks for Ground Forces, anecdotal evidence obtained from Joint Urgent Operational Needs (JUONs), combatant commander's integrated priority lists (IPL), and lessons learned from theater support the need for the smooth integration of the individual sustainment Soldier into the government-provided network. The current practice of turning a blind eye to Soldiers purchasing non-supported COTS devices to be used in the field introduces security issues, raises spectrum use problems, and reduces agility.

Therefore, in January 2008 the Army CIO/G6 Office tasked TRAC-Monterey to conduct a Capabilities Based Assessment (CBA) on the network enabled capability gaps faced by Transportation Soldiers in Southwest Asia working on a Forward Operating Base (FOB). This represents a more narrowly bounded subset of the entire logistics and combat support problem. Only transportation tasks were considered and only in the context of FOBs in Southwest Asia. The idea was to 1) determine what Transportation Tasks Soldiers and Civilians have a difficulty performing to standard, 2) prioritize these task gaps based on their risk to the overall mission and 3) identify the application of network enabled capabilities to reduce the mission risk. TRAC-Monterey partnered with the Naval Postgraduate School in executing this study and this paper summarizes that effort. In order to discuss these efforts in the following sections, an overview of the CBA methodology is given under the Joint Capabilities Integration and Development System (JCIDS) Overview.

1.2 JOINT CAPABILITIES INTEGRATION AND DEVELOPMENT SYSTEM (JCIDS) OVERVIEW

Prior to the introduction of the JCIDS process in June 2003, DoD employed a threat-based force-planning construct (left side of Figure 1) to develop forces, systems, and platforms. This methodology was based on specific threats and scenarios. Additionally, requirements were often developed, validated, and approved as stand-alone solutions that never took into account the overarching DoD system of systems design. This mentality created a "bottom up, stove-piped" approach to acquisition decisions that routinely created solutions that were not interoperable, not linked to the National Military Strategy, not coordinated between military services, and routinely failed to consider non-material solutions.

In contrast, the JCIDS process is a capabilities-based process that, as shown on the right of the below figure, facilitates force planning in an uncertain environment and identifies the broad set of capabilities that will be required to address the challenges of the 21st century. According to the Defense Acquisition University, the purpose of the JCIDS process is to "identify capability gaps and redundancies, determine the attributes of a capability or combination of capabilities that would resolve the gaps, identify materiel and non-materiel approaches for implementation and roughly assess the cost and operational effectiveness of the joint force for each of the identified approaches." (Defense Acquisition University, https://acc.dau.mil) The purpose is to accurately describe needed capabilities that are explicitly connected to doctrinally-defined concepts and communicate those to the acquisition community.

The key to the JCIDS process is a three-step methodology collectively termed "Capabilities-Based Assessment" (CBA). The three steps are Functional Area Analysis (FAA), Functional Needs Analysis (FNA), and Functional Solutions Analysis (FSA).

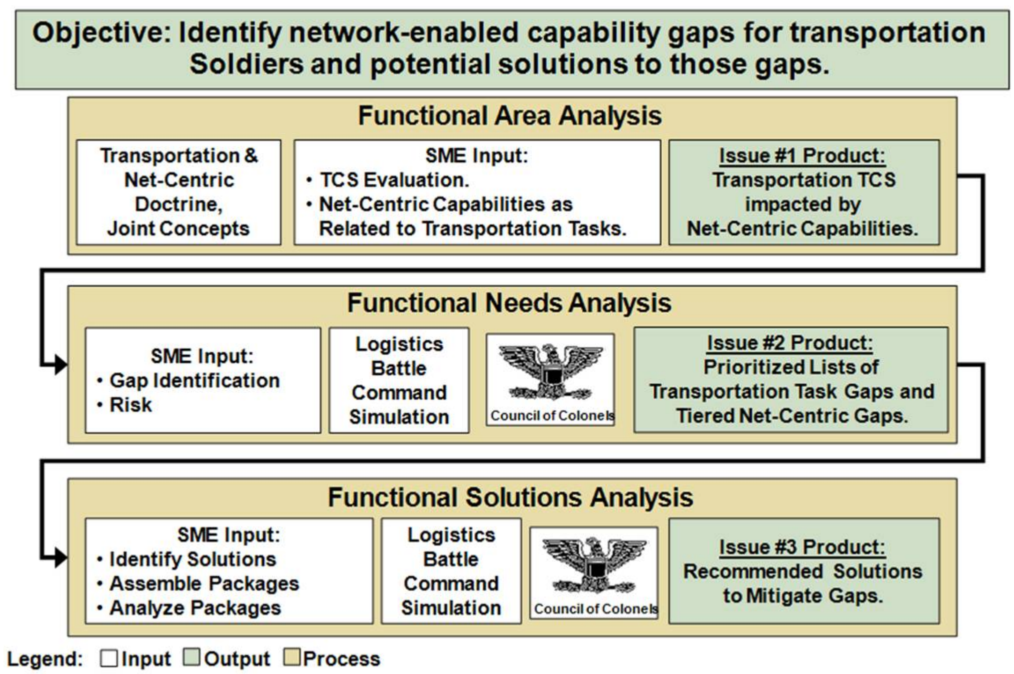

FIGURE 1. CBA Process for this study

The FAA "identifies the mission area or military problem to be assessed, the concepts to be examined, the timeframe in which the problem is being assessed, and the scope of the assessment." (CJCSM 3170.01C) The FAA answers the question "What are we trying to accomplish and how do we measure it?" The FAA examines the desired objectives, the required effects, and links capabilities back to defense strategy. The output for this study is the Transportation Tasks (along with their updated conditions and standards) that net-centricity could positively influence.

The FNA is designed to "assesses the capabilities of the current and programmed force to meet the relevant military objectives of the scenarios chosen in the Functional Area Analysis (FAA) using doctrinal approaches."(CJCSM 3170.01C) The FNA answers the question "How good are we at doing it with today's programmed forces and systems?" Namely, the FNA looks to identify if capability gaps do exist and to also find any overlaps or redundancies in the current operating set. The output is a prioritized listing of the net-centric capability gaps facing the individual Transportation Soldier and the associated operational risk assessment.

The FSA is a "joint assessment of potential DOTMLPF (Doctrine, Organization, Training, Materiel, Leadership & Education, Personnel and Facilities) and policy approaches to solving, or at least mitigating, one or more of the capability gaps identified in the FNA."(CJCSM 3170.01C) The FSA answers the question "What should we do about it?" The output of the FSA for this study is the optimal combination of DOTMLPF solutions to achieve the required capabilities for the warfighter.

1.2 OUTLINE OF PAPER

An overview of the paper outline is given in this section. In this paper, Section 2.0 will discuss in detail the methodology carried out, with various subsections discussing the execution and analysis of the Functional Area Analysis (FAA), the Functional Needs Analysis (FNA), and the Functional Solutions Analysis (FSA). Section 3.0 will discuss overall results of the CBA, followed up with conclusions in Section 4.0.

2.0 METHODOLOGY

This section discusses in detail the overall methodology executed in the CBA study. Details of the FAA, FNA, and FSA are discussed.

2.1 FUNCTIONAL AREA ANALYSIS (FAA) METHODOLOGY

For the FAA, the research focused on the tasks that an individual Transportation Soldier would be expected to perform in a deployed location. The overall FAA methodology carried out in this study can be seen in Figure 2.

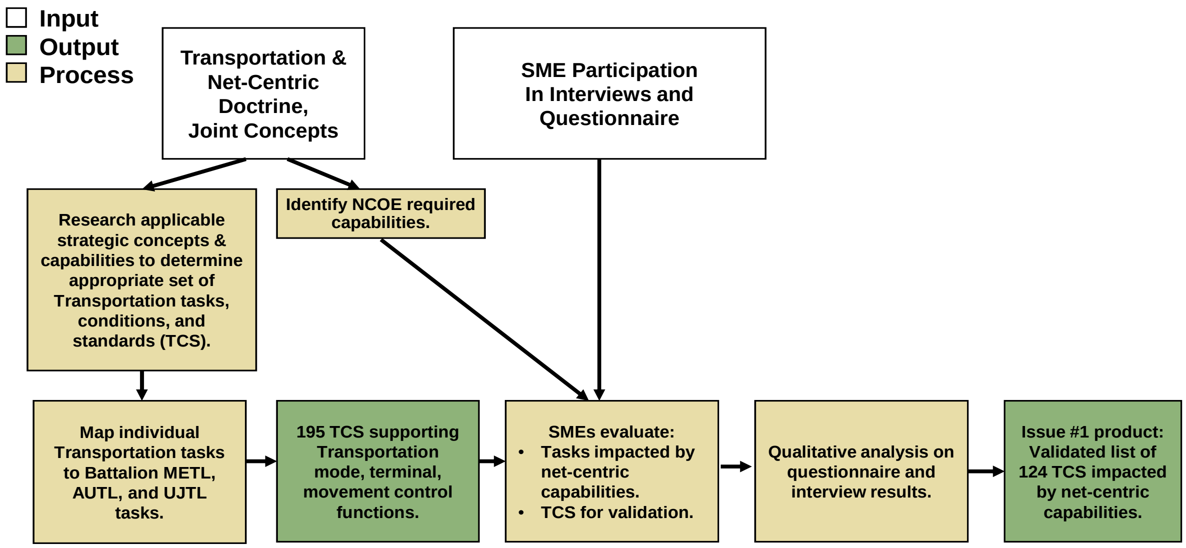

FIGURE 2. FAA Methodology

First, we captured the "As Is" situation: the existing Transportation system of systems that is not entirely satisfactory. As in any systems engineering effort, understanding the shortcomings of the predecessor system is key to requirements analysis (Kossiakof & Sweet). This was done by 1) examining the DoD operating concepts for both net-centricity and transportation and 2) discussions with personnel performing those tasks in the field. Additionally, we created operational vignettes depicting scenarios in which these Transportation tasks are not accomplished to standard.

The second step of the FAA was to determine the necessary objectives in the "To Be" situation. Namely, what should the end state system be able to perform? This information came from not only the official tasker from the sponsor, but also from numerous discussions with them and other Signal Corps leaders. Also taken into consideration was the opinion of experienced Transportation leaders on the ground on what they feel success would look like and how it should be measured.

Once the "As Is" and 'To Be" situations were defined, we mapped the military's sustainment tasks down to the individual Soldier level. They were then reduced to the tasks that could be affected by the application of a net-centric capability. The resulting task list served as the input into the FNA, thereby focusing the rest of the study on the sub-set of Transportation tasks most likely to be impacted by net-centric principles.

2.1.1. Transportation task cross-walk

For this research, we needed to scope the entire Transportation mission down to the key capabilities that are required within a deployed environment. We began with the three core transportation capabilities as outlined in the Transportation FAA conducted by United States Army Combined Arms Support Command (CASCOM) in May 2005. Further confirmation of these three key capabilities came from the 6th Transportation Battalion stationed at Fort Eustis, Virginia. This battalion provided first-hand information about the Transportation mission in Southwest Asia and shared their Battalion Mission Essential Task List (METL). METLs are the essential tasks that a unit must be proficient on in order to accomplish their wartime mission.

According to the Joint Chiefs of Staff CBA Guide, the FAA must "determine, develop, and document enabling tasks supporting required capabilities". (JCS J-8, CBA User Guide) Upon the identification of the core Transportation capabilities, they must be mapped to individual tasks in order to facilitate analysis. Multiple Army Transportation training manuals were studied to gain insights on critical collective/team tasks. Once collective tasks were defined and mapped to the core Transportation capabilities, then the collective tasks could be broken down into individual tasks by additionally referencing the Military Skills and Qualification (MQS) manuals for task title, conditions, and standards. Both officer and enlisted individual tasks were found to support the identified collective tasks.

Additionally, we validated current conditions and standards that the individual tasks are to be conducted in. Starting with the conditions listed in the MQS, the tasks' condition statements were updated to capture the joint aspect to operations currently being conducted within theater. These were tailored to the three METL tasks and patterned after the verbiage used in the Transportation FAA. Also, key attributes from the Joint Logistics Joint Integrating Concept (capacity, visibility, reliability, velocity, and precision) were added to the tasks' standards in order to measure success for this study.

Following this methodology, 195 individual transportation tasks were identified that support the core Transportation capabilities conducted on FOBs. For example, one of these tasks is "Process unit for unit movement" which falls under the key Transportation capability of Movement Control Operations. The entire list of tasks can be found in TRAC-Monterey ISWTN FAA Report.

2.1.2. Net-Centric Capabilities

The Network Centric Operational Environment (NCOE) Joint Functional Concept identified 21 capabilities within the framework of net-centricity. The NCOE Joint Integrating Concept took these 21 capabilities and refined them into 16 capabilities based on war games and analysis. The NCOE Joint Capabilities Document further refined the 16 into 13 capabilities. Finally, during the FAA process, it was determined that only 10 of the 13 capabilities were relevant to the Transportation community. Those ten relevant capabilities are: Continuous Knowledge, Skills & Attributes (KSA), Decisions & Planning, Relationships, Situational Understanding, Collaboration, Create & Produce Information, Exchange Information, Interoperability, Process Data, and Network Infrastructure.

2.1.3. Data collection

At this point, we had assembled a list of doctrinally-defined transportation tasks along with their conditions and standards for accomplishment. And, we had the "official" definitions of network centric capabilities. The next step was to determine any relationships between those lists. A web-based questionnaire asked Transportation Soldiers to link the Transportation tasks to the net-centric capabilities and validate the metrics and standards for the tasks. The questionnaire had three parts. The first part of the questionnaire collected demographic data such as rank, MOS, education level, and duration of experience in a combat zone. This information tailored the remaining parts of the questionnaire to their experiences.

The second part of the questionnaire explored the links between the transportation tasks and net-centric capabilities. The participant was given the sub-set of Transportation tasks within their expertise (based on provided demographic data). These were the tasks that are either in their primary MOS or in an MOS with which they had supervisory experience. The following question was posed:

> *For each task below, select which Net-Centric capabilities have any impact (good or bad) on your ability to complete the task.*

The respondent then could choose as many of the previously defined net-centric principles that applied.

The third part of the questionnaire contained an evaluation of the standards and conditions of the tasks. Participants were presented two different scenarios for each of their tasks. They were asked to evaluate the proposed standard as if they had all the required net-centric capabilities, and then they were asked to evaluate it under the current conditions within theater.

This first questionnaire was posted for 3 weeks and received 49 responses from individuals in operational units (both CONUS and SWA) and individuals at the Transportation Schoolhouse (Advanced Non-Commissioned Officer Course, Basic Non-Commissioned Officer Course, and Captains Career Course.

Multiple focus group discussions were conducted to gain further insights into the processing of cargo and personnel into, around, and out of theater. Participants consisted of Officers, Motor Transport Operators, Cargo Specialists, and Transportation Management Coordinators who were deployed or recently deployed. They discussed their personal experiences regarding transportation tasks and how additional communications could impact their mission accomplishment rate. Special attention was paid to the processes and technologies which enable in-transit visibility (ITV) and how different units handle frustrated cargo.

Now, this was a unique approach. We were asking senior enlisted personnel and junior officers with training and experience in transportation operations about network centricity. Of course, some time was dedicated to simplifying and communicating these concepts to the participants. However, it was well worth it because it provided results that were directly connected to mission accomplishment rather than C2 theory.

2.1.4. Analysis

The data collected during the FAA was then analyzed in order to identify the Transportation tasks that could be affected by the application of a net-centric capability. If a task could not be improved by executing it within the NCOE, then it was dropped from the investigation. For example, the Transportation task of "Conduct preventive maintenance on a HMMWV" was dropped. Enabling a

Soldier with enhanced communications or information flow would not help him/her verify that the HMMWV was not leaking oil.

The primary metric used for this decision was the number of participants who agreed that the Transportation task was impacted by a specific net-centric capability. If >50% of the participants agreed that a link existed between a task and at least one net-centric capability, then the task was retained for further investigation in the FNA and FSA. This decision rule yielded 103 Transportation tasks. However, to ensure that critical tasks were not missed, if a task had less than seven participants respond to it, it was kept. This increased the number of Transportation tasks to 119. Additionally, during the focus group discussions, five "new" Transportation tasks were identified that participants claimed were in need of net-centric capabilities. These tasks were "new" as they were not captured in the questionnaire.

The result of the FAA was the identification and validation of Transportation Soldier tasks, conditions, and standards that could be impacted by network-enabled capabilities. The FAA process culminated in 124 Transportation Soldier tasks deemed impacted by net-centric capabilities, which were inputted into the FNA. The FNA Methodology is discussed in the next subsection.

2.2 FUNCTIONAL NEEDS ANALYSIS (FNA) METHODOLOGY

For the FNA, the research focused on the Individual Transportation Soldier's ability to accomplish required tasks to standard as identified in the FAA. The overall FNA Methodology can be seen in Figure 4. The scenarios used in the FNA examined the Transportation Soldier as part of a Transportation unit and as part of a Combat Arms unit. These scenarios were all based on the current year, located in Southwest Asia, with the unit's current MTO&E (Modified Task Organization and Equipment), and on and around a FOB. Those tasks that could not be accomplished to standard were assessed for risk and then mapped into the applicable NCOE capability gaps. A risk assessment prioritized the capability gaps. The prioritized listing served as an input into the FSA, thereby focusing the study on the most important gaps. As resources to fix gaps are limited, prioritizing critical task gaps is necessary.

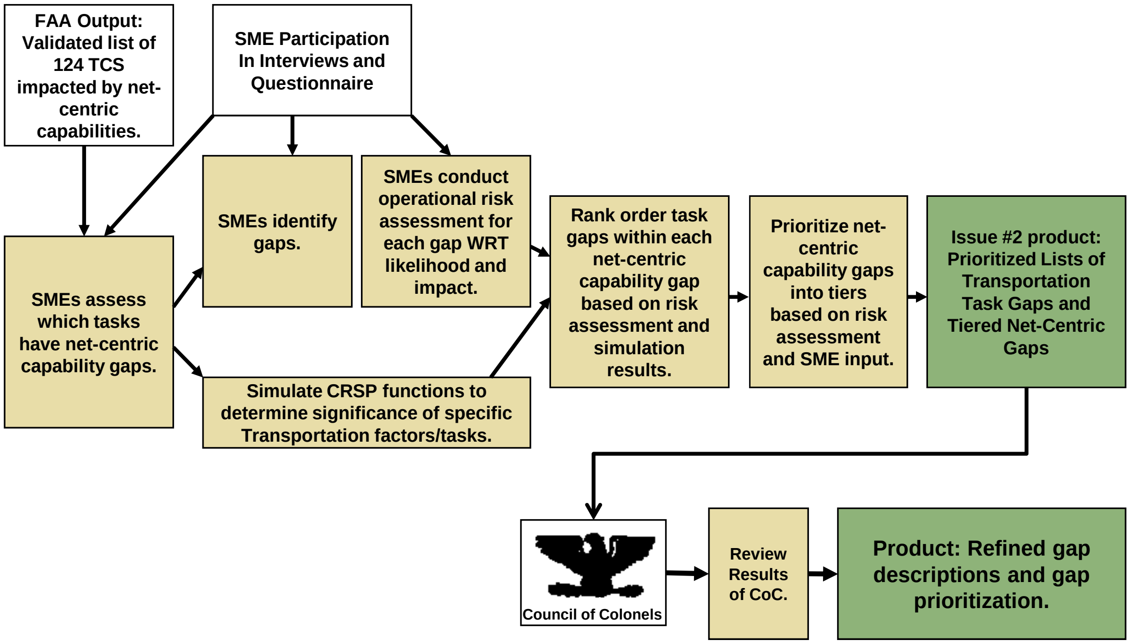

FIGURE 3. FNA Methodology

2.2.1. Identify Transportation Task Gaps

The first step in the FNA process was to identify the critical Transportation Task gaps. Explicitly, to take the 124 Transportation tasks from the FAA and reduce the number of potential tasks to be evaluated in detail. This step started by merging similar tasks and eliminating those tasks that would not occur within the confines of the FOB, resulting in 60 Transportation Tasks.

One of the key tenets of the CBA process is to evaluate and analyze tasks against operational scenarios. Therefore, the team binned the 60 Transportation tasks into eight operational scenarios in which questionnaire participants would be asked to perform or supervise the specified task. These scenarios were designed to cover the three types of Transportation Missions (Mode, Terminal, and Movement Control) in the different locations across Southwest Asia. These scenarios also included a "stressor" event in order to capture which tasks became increasingly difficult when mission tempo was high.

Some of these 60 tasks fell into more than one scenario, which resulted in 121 Transportation Task instances across the eight scenarios. The team was interested in seeing the level of success of the same task in different locations in order to determine if a specific type of location had "cracked the code" on how to accomplish the task successfully. Evaluating varying circumstances for failure enabled detailed assessment of reasons for failure, leading to well-defined gaps.

Another web-based questionnaire (FNA Q#1) asked participants to assess whether the 121 tasks could be performed to standard within the various scenarios. If not, the questionnaire asked about the consequence to the overall mission. The questionnaire had three distinct parts. Part one was the core questions that would be presented to each of the respondents. This consisted of 5 scenarios that placed the participant in the role of a senior NCO or junior Officer. These scenarios were chosen based on previous interviews, lessons learned research, and sponsor guidance to key problems within the community. The rationale behind the questions on the core scenarios was to ensure that the team gathered the most information possible (had the largest sample size possible) about these tasks from participants. Part two was the "Choose your own adventure" section. Each participant was asked to choose one of the eight scenarios to answer questions about. Each task had two questions within the scenarios:

Assume you have no cell phones or hand-held radios/PDAs/scanners, can you successfully perform this task in the scenario?

☐ *Yes* ☐ *No* ☐ *Not Applicable*

If you answered "No", what would be the consequence to the mission?
(Choose "Not Applicable" below if you chose "Yes" or "Not Applicable" on the previous question)

☐ *Catastrophic* ☐ *Critical* ☐ *Marginal* ☐ *Negligible*
☐ *None* ☐ *Not Applicable*

The third part of the questionnaire was the demographic data. This questionnaire was posted for 2 weeks and received 116 responses from the same groups responding to the first.

Lastly, focus group discussions were used to collect data. Multiple focus group discussions were conducted to gain further insights to FNA Q#1 topics. Participants consisted of the same kinds of personnel who had previously participated.

The data collected during this step of the process was then analyzed in order to identify the Transportation Task gaps. The primary metrics for finding the Transportation Tasks included percentage of participants that could not complete the task and the mission consequence. Tasks that could be completed to standard or that had a low consequence to the mission were removed from further investigation (low risk).

The top three tasks from each scenario (to gather breadth) were selected for continuation and the remainder of tasks were chosen based on high "risk" values (to gather depth). This resulted in 33 Transportation Task Gaps. Additionally, the team added 4 "new" Transportation Tasks based on interview and discussion group results: Manage Contractors at the APOD (Aerial Port of Debarkation), Manage Contractors at the SPOD (Sea Port of Debarkation), Manage Contractors at the CRSP (Central Receiving & Shipping Point), and Communicate with Subordinates in a Marshalling Yard.

2.2.2. Associate Task Gaps with Net-centric Capabilities

The second step in the FNA process was to associate the 37 Transportation Task Gaps identified as "high risk" to net-centric Capabilities. In order to accomplish this step, the 10 relevant NCOE capabilities were mapped to their attributes and then to their supporting measures in accordance with published references. This was a bottoms-up approach to the association. This mapping yielded 10-15 possible measures for a capability. Therefore, transcripts from previous interviews were reviewed along with the results of FNA Q#1. This data enabled the selection of the most relevant and meaningful net-centric measures to the Transportation mission. These measures became the "reasons" in the resulting FNA questionnaires, interviews, and discussions. These reasons were critical to the process as this research is only interested in the net-centric reasons why tasks tend to fail. For example, the team was not particularly concerned that forklift operators want to reduce the number of safety features in their equipment in order to gain more functionality, but with their lack of communications within their cab to interact with supervisors.

Three modes of data collection were used for this step: a web-based questionnaire (FNA Questionnaire #2 with 18 respondents), telephone interviews (from the previous phase), and focus group discussions (10 sessions).

FNA Q#2 had three goals. The first was to ascertain the reasons why tasks failed to be accomplished to standard. The second goal was to gain a typical frequency of failure for each of the 37 tasks based on the number of times a month a task was done. This would be necessary to conduct the risk assessment for the prioritization step of the process. The third purpose was to gain insight on the level of risk if the gap was not closed 100%. This questionnaire was intended to be completed by Officers and mid-grade Non-Commissioned Officers. It presented the participants with the definitions of the consequences and then the definitions of the possible net-centric reasons why the task could not be performed to standard. An example of a net-centric reason is shown below.

Availability: I cannot access the data or information services required to accomplish this task.

FNA Q#2 then requested that participants choose one of the six scenarios with which they were most comfortable or had the most experience accomplishing its subordinate tasks. In the body of the questionnaire, each task was presented to the participant with the complete standard and then they were asked:

I found it difficult to meet the standard because of the following reasons:

The participants were then given the list of net-centric reasons to rank. At the end of the scenario, the participant was asked to rank the tasks (from 1 to n) based on difficulty and on performance.

Rank them in order of their ***difficulty*** *to perform to standard (1 being the hardest of the group, 2 being second hardest, etc).*

Rank them in order of their ***consequence*** *to the mission when they are not done to standard (1 being the most severe consequence of the group, 2 being second severe, etc).*

Focus Group Discussions were conducted with approximately 50 Transportation and Signal community subject matter experts (SMEs) to gain insights into the specific reasons that the identified Transportation tasks were not being completed to standard. The study team conducted these sessions in person at Fort Gordon, GA and Fort Lee, VA.

FNA Q#2 yielded quality data even with a low response rate. The participants ranged in rank from E7 to O4 and many took the time to write extensive comments about why tasks are difficult in a deployed environment.

In addition to information gathered about the Transportation Tasks, comments from participants resulted in an additional capability being added to the analysis. It was entitled 'Basis of Issue' in order to highlight difficulties facing Transportation Soldiers because equipment is available, however not to the correct people in the correct amount. This resulted into 11 NCOE capability gaps that would be used in the remainder of the research.

Once data retrieval was complete, each task was associated with the appropriate NCOE capabilities based on the net-centric reason for not being completed to standard. The key was to only capture the first order net-centric capability gap in the associations. For example, the questionnaire data indicated that the task,

'Coordinate onward movement of personnel and cargo'

was difficult to complete to standard in the MCT scenario due to '*accuracy*' and '*timeliness*' reasons. Interview data confirmed these reasons with comments such as,

> *"Planning onward movement of people and cargo requires up-to-date, accurate information about transportation routes and carriers. Currently, there is no one system to provide planners with the situational understanding of neither what assets are available nor what assets are currently on the road/air/sea."*

'Accuracy' and 'timeliness' are attributes of the net-centric capability 'Situational Understanding'. These attributes, combined with interview data, led to the association of 'Coordinate onward movement of personnel and cargo' to the net-centric capability 'Situational Understanding'.

This analysis continued for all the 37 Transportation tasks/scenario pairs. Twenty-seven were found to generate NCOE capability gaps. The remaining 10 tasks would not result in gap closure through the introduction of network-enabled. Additionally, it should be noted that 13 of the 37 tasks were placed in multiple NCOE capabilities. Therefore, there were 44 Task/Capability instances to be prioritized in the next steps.

2.2.3. Prioritize Transportation Task Gaps within NCOE Capabilities

The third step in the FNA process was to prioritize the Transportation Tasks within each NCOE Capability Gap through the examination of risk. These results were then combined under the principle of risk adverseness into the final ranking.

The first data set was generated by a group of participants (Transportation Soldiers and Leaders) who took FNA Questionnaire #3 (FNA Q#3). FNA Q#3 was similar to the other questionnaires as it was scenario based. However, this time all participants completed each scenario and the target audience was only senior NCOs and Officers.

In this questionnaire, participants were given the 44 tasks (with their specific net-centric gap) binned into the 6 scenarios. Each task was given with its standard and a short statement on the net-centric reason that there was a gap. The participants were asked the following two questions per task in each gap:

What is the consequence of this gap to the mission?

☐ *Catastrophic* ☐ *Critical* ☐ *Marginal* ☐ *Negligible*

☐ *None* ☐ *No Answer*

What percentage of time does this gap cause the task NOT to be accomplished to standard?

☐ *0% to 20%* ☐ *21% to 40%* ☐ *41% to 60%* ☐ *61% to 80%* ☐ *81% to 100%*

Participant responses were then used to assess risk based on consequence and frequency.

The second data set was from senior leaders and analysts within CASCOM. The Transportation Tasks to NCOE Capability Gaps mapping was presented to representatives from CASCOM's Concepts division, Futures division, and DPMO (Deployment Process Modernization Office). An in-depth discussion was held on the nature of the gaps and the reasons behind the tasks not being able to be performed to standard. CASCOM then provided an independent evaluation and ranking of Transportation task prioritization.

The third data set was pulled from FNA Q#1. This data was predominantly used to resolve discrepancies between the first two data sets. Each task was assigned a ranking based on the consequence and the percentage of participants that felt the task was difficult to accomplish to standard.

The analysis portion of this step started with the first data set (FNA Q#3). However, this analysis was not straightforward as the relationship between the consequence levels is not strictly linear. The associated consequence value and average frequency value were used to graph each task (within a NCOE capability) on a risk assessment chart. This data enabled a loose ranking to be determined amongst the tasks within the capability. This ranking was then compared to the CASCOM provided rankings of the tasks within the NCOE capabilities (Data Set #2).

For most tasks, both data sets were fairly similar and the final ranking of tasks was straightforward. The final prioritization of the Transportation Task gaps within the NCOE capability gaps can be found in the official TRAC-Monterey ISTWN FNA Report.

2.2.4. Capability Gap Prioritization

The final step in the FNA process was to prioritize the 11 net-centric capability gaps, having already prioritized the tasks themselves. This prioritization was performed using four different data sets. These results were then combined under the principle of risk adverseness. The capabilities were binned into three tiers based on accuracy and fidelity of data. All capabilities within a tier were assumed to be of equal importance. Tiers helped alleviate any false precision in the results as there is always some uncertainty when combining qualitative assessments.

The first data set was the information from FNA Q#3. The second data set was from the Concepts division of CASCOM. The third data set was from the Futures division of CASCOM. The final data set was the information from FNA Q#1 and Q#2 which was only used in case of significant disagreement of the first three sets about a capability.

The concept of risk aversion was used during the binning of the net-centric capability gaps. Therefore, the five high level tasks from the FNA Q#3 analysis automatically made the Tier 1 category. Interesting enough, three of those five tasks were also high according to the CASCOM participants. Then the remaining capabilities were analyzed to determine binning.

2.2.5. Council of Colonels

In accordance with the CBA process, a Council of Colonels (CoC) was convened to review the results of the FNA. The council consisted of eight O6 Signal Officers, one O5 Signal Officer, one former O6 Transportation Officer (currently GS-15 at the Transportation School), one O6 Transportation Officer, one Army Reserve O6 Transportation Officer, and a GS-15 Operations Research Analyst. The members of the council had multiple years of deployed experience within Southwest Asia.

The consensus of the group was positive about how the FNA process was conducted and the results found. Additionally, the feedback led to a re-structuring of the net-centric capability gaps into two tiers due to the fidelity of the data provided. Table 1 provides a summary of the final prioritized results incorporating the feedback from the Council of Colonel.

	Final Ranking
Collaborate	1
Continuous KSA	1
Create & Produce Information	1
Decisions and Planning	1
Relationships	1
Situational Understanding	1
Basis of Issue	2
Exchange Information	2
Fuse	2
Interoperability	2
Network Infrastructure	2

Green corresponds to Tier 1
Yellow corresponds to Tier 2

TABLE 1. FNA Results

This research found that the operational risk to the mission from an Individual Transportation Soldier not being able to accomplish their assigned tasks is High based on the sub-set of tasks analyzed in this study. The TRAC-Monterey ISWTN FNA report has a complete listing of the eleven net-centric capabilities and their definitions. Additionally, the subordinate Transportation tasks are discussed in depth to include the reasoning behind the mappings. Overall, the output of the FNA is prioritized capability gaps, which are the input into the FSA. The FSA Methodology is discussed in the next subsection.

2.3 FUNCTIONAL SOLUTIONS ANALYSIS (FSA) METHODOLOGY

For the FSA, the research focused on possible solutions for the Individual Transportation Soldier to overcome their Transportation task deficiencies (as identified in the FNA) through net-centric capabilities. The overall FSA Methodology can be seen in Figure 5. This began with SME discussions to develop potential net-centric solutions for Individual Transportation tasks. These solutions were merged into several packages in order to cover the priority Transportation tasks. Using multi-attribute decision theory methods, the 336 packages were analyzed against each other based on their estimated performance and required resources. Therefore, we identified the "best" package to fix the most prominent problems while maximizing effectiveness and minimizing required resources. The output of the FSA was recommended packages to be implemented within the Transportation and Signal Communities in order to mitigate the net-centric capability gaps facing Transportation Soldiers in a deployed environment.

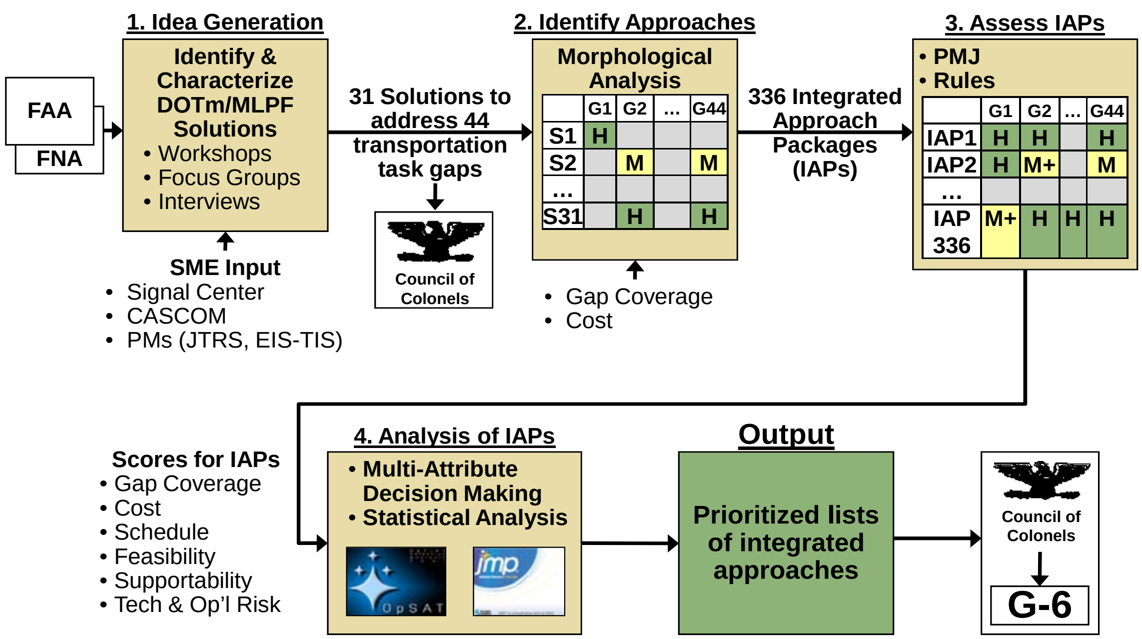

FIGURE 4. FSA Methodology

2.3.1. Idea Generation

Purely materiel solutions are not always the best answer. Many times, a process change or re-alignment of personnel can solve the problem. Therefore, the first step in the FSA process is to identify and characterize potential solutions across the DOTMLPF spectrum. This was accomplished through individual interviews and focus group discussions. These were conducted with SMEs from the Signal Center, CASCOM, and various acquisition program management offices. Additionally, the civilian sector was researched to determine insights from their best business practices, especially in the areas of in-transit visibility and handling frustrated cargo. Finally, a brainstorming workshop was conducted with SMEs in late August. Over the course of two days, 104 solutions across the DOTMLPF domain were discussed.

Upon the review of the 104 proposed solutions, it was found that some of them would typically be performed together. Additionally, many of the solutions were very specific and could be combined into a more generalized solution (as is appropriate for an FSA). This step was necessary not only to reduce the number of possibilities that SMEs would be asked to evaluate but also to simplify the complexity of the analysis phase as independent solutions would be required. Ultimately, 31 solution sets were created during this process.

The attributes for evaluating the potential solutions were chosen based on professional military judgment (PMJ), the FNA Council of Colonels' recommendations, and U.S. Army Capabilities Integration Center (ARCIC) guidance. ARCIC's guidance is that all solutions must be 1) strategically responsive, 2) feasible, and 3) realizable. Therefore, to ensure that the solutions were meeting the guidance, the following attributes were chosen to be evaluated:

- Transportation Task Gap Closure
- Time to Implement (Schedule)
- Affordability (Cost)
- Supportability
- Feasibility
- Technological Risk
- Operational Risk

Leaders from CASCOM, Signal Center, and various other Signal Officers used their PMJ to evaluate the proposed solution sets against six of the attributes. ARCIC guidance and professional military judgment was used to determine rough evaluations of cost.

2.3.2. Identify Approaches/Portfolios of Solutions

The goal of the FSA was to find solutions that mitigate the Individual Transportation Soldier net-centric capability gaps. However, NCOE is a fully integrated spectrum of inter-dependent concepts and the recommended solutions needed to span the environment. Additionally, all 31 solution sets have second and third order effects on the environment. Even considering those effects, not a single one of the solutions sets covered all 11 net-centric capability gaps, let alone just the 26 Tier 1 gaps. Therefore, a grouping of the solution sets was implemented in order to ensure effective coverage of the Tier I net-centric capability gaps (as defined by FNA). These groupings are termed Integrated Approach Packages (IAPs) which included both material and non-material solutions. The creation of these packages was the second step of the FSA process.

A morphological analysis approach was used to create the IAPs. The IAPs were created under two distinct sets of rules. The first set was based on gap coverage. Gap coverage was chosen as it is the main impetus from the sponsor – to effectively cover the gaps. IAPs were created by combining the solution sets to achieve at least moderate coverage of the tasks in the Tier 1 and to minimize redundancy of task coverage.

The second set of IAPs were created based on cost. Cost was chosen as it is an important factor for decision makers when considering new programs of record. IAPs were then created by combining the solution sets to achieve coverage of at least 75% of the tasks in the Tier 1 by only using low cost solution sets. Like the task coverage IAPs, the cost IAPs were also created to minimize redundancy.

The end state of this FSA step is 336 IAPs consisting of five to twelve component solution sets.

2.3.3. Integrated Approach Packages (IAP) Assessment

In order to make a decision between IAPs, there needed to be measurable performance attributes to compare. However, to ask SMEs to evaluate 336 IAPs on numerous attributes would be too difficult. Therefore, the information already collected from the SMEs on the attributes of the individual solution sets was used to determine attribute values for each IAP. This was the third step of the FSA process.

We explored the emergent behavior of the IAPS to determine their attribute values. Since all of the IAPs are specific combinations of the solution sets, their interactions needed to be examined in order to determine their effectiveness. Conceptually, the IAP is a System of Systems construct with the solution sets as subordinate systems. After studying the IAPs' behavior, three basic methods were established to determine attribute values.

The first method relied heavily on professional military judgment (PMJ) and was used for the task coverage attribute. There are two possible cases. If, for a specific task, the IAP only has one component solution improving the task gap, then the IAP took on that value for that task. Otherwise, if an IAP had more than one component solution improving a specific task gap, then PMJ was used to qualify the emergent behavior of the IAP on the task. Then the solutions were examined to determine if:

1) Solutions work on same aspect of the task gap
2) Solutions complement each other
3) Solutions degrade each other's effectiveness

The answers to these questions were used to determine if the IAP value remained at the maximum rating of the components or if it received a '+' or a '-' based on its interactions.

The second method was the maximal rule and was used for the schedule attribute. As all of the solution sets were constructed to be able to be executed independently of each other, the maximum time it takes to execute a component is the time it takes to execute the entire IAP.

The third method was the additive rule and was used on the remaining five attributes. This rule will be explained through the exploration of the cost attribute although it was similarly executed for the other four attributes. FSA guidance does not require a complete life-cycle cost analysis to be completed for each IAP because this is beyond the scope of a CBA. Instead we used a qualitative assessment based on the experience of personnel in the acquisition community in which they assigned values of High, Medium, and Low to the individual solutions. These values were combined within each IAP to create a cost score. The remaining attributes were determined similarly based on SME input, ARCIC guidance, and statistical analysis. End state of this step was the assignment of an estimated value for each of the seven attributers for all IAPs.

2.3.4. Analysis of Integrated Approach Packages (IAPs)

The fourth step in the FSA methodology was the analysis of the 336 IAPs using multi-attribute decision theory in order to determine the "best" IAP to implement. The Option Selection and Analysis Tool (OpSAT), developed by Sonalysts, Inc for DoD use in multi-attribute decision making (MADM), was used to support this analysis.

This research began with examining gap coverage, schedule, and cost as the ranking criteria and the remainder as selection criteria. In addition, the analysis was completed with different weighting schemes when comparing the ranking attributes. Scheme A examined the effectiveness of IAPs when the Gap Coverage was the most important attribute. This is a valid strategy because the purpose of this FSA is to select the best IAP to implement that will effectively cover the gaps while minimizing resources required. Scheme B examined the effectiveness of IAPs when the Cost was the most important attribute. This strategy was studied as cost tends to be a large driving factor for decision makers whether it is a quick policy change or a new program of record. Finally, scheme C examined the effectiveness of IAPs when the Schedule was the most important attribute. This strategy comes from the study constraints – namely, that the IAPs need to be able to be implemented in the near term (2010 time frame) to ensure that they are focused on getting solutions quickly into the hands of the Soldiers in combat environments.

The results of all the weight schemes were analyzed to determine how the various IAPs behaved and which weight schemes matched the best with the decision-makers' experience and directions. The IAP "top contenders" for each of the above schemes are shown in the results section. The TRAC-Monetary ISTWN FNA Report includes information about additional analysis runs, simulation construction and results, insights gained from the data, and trade-offs incurred by the IAPs when evaluated against more than three of the criteria.

3.0 RESULTS

Contrary to commercial technology marketing campaigns, it is not always a gadget that can best enable you to more effectively perform your mission. The analysis conducted during the FSA clearly shows that a complete solution is composed of process changes, standardized policy, software interactions, new training initiatives, and some materiel solutions can be more effective than just giving the latest gadgets to the workforce. The below table summarizes the primary analysis conducted in the previous section. Namely, it shows the "top contenders" of Scheme A, B and C organized in columns.

Coverage Most Important	Cost Most Important	Schedule Most Important
A-20	A-21	A-21
A-21	A-20	A-20
B-20	B-21	B-21
B-21	B-20	B-20
C-20	C-21	A-68
C-21	C-20	A-31
D-20	A-31	A-67
D-21	A-67	A-29
		B-68

TABLE 2. "Top Contender" IAPs

The Reader will note that information in Table 2 does not adequately explain the nature of these IAPs. The entire description of these solution packages is beyond the scope of this paper but can be found in the TRAC-Monterey ISWTN FSA Report. However, it can be noted that there are four IAPs that appear in the top tier no matter the weight scheme. That indicates that those IAPs provide acceptable gap coverage, satisfy cost constraints, and can be fielded within an acceptable time frame.

Within these four "top contender" IAPs, there are many common themes. Namely, they all consist of the following individual solutions:

- Field a radio with basic encryption at individual Soldier level
- Authorize more communications devices at unit level to support rotational, attached personnel
- Ensure policy supports contractors collaborating electronically
- Develop TTPs that create a method for sharing information horizontally between units and vertically between units and headquarters to facilitate tracer actions
- Improve tracking and reporting capabilities to determine movement asset location (trucks, etc) and cargo contained in assets, by integrating multiple systems into a single tool for complete ITV
- Allocate and utilize current Army asset-tracking capabilities to other military services and non-military organizations (contractors, etc)
- Modify Movement Control Battalion TOE so that in times of deployment, appropriate Air Force (AF) personnel are assigned to the unit. Develop habitual training relationships with supporting AF units.
- Train individuals on automated tracking & reporting
- Provide MOS-independent training focused on reliable and accurate cargo documentation and consequences of incorrect data; training should be accessible from any location
- Ensure Unit Movement Officers complete sustainment training
- Make SMEs available to provide guidance to unit level Commanders on movement tasks
- Train Port Support Activity personnel on C2 organization and relationships at the SPOD

- Establish training for senior and mid-grade Officers & NCOs for relationships w/contractors, and contractor roles & responsibilities

Also noted is that there are only two items that are a purely material solution within these IAPs. In fact, the In-Transit Visibility solution consists of integrating the current systems into a single device and does not call for a new material solution.

4.0 CONCLUSIONS

During this research, we confirmed the existence of Transportation tasks conducted in a deployed environment that are not easily performed to standard in which elements of net-centricity could help. Then we further quantified the tasks, their conditions, and the specific net-centric capabilities that are missing. This was followed by a prioritization of the gaps. Finally, over 300 solution packages (with component solutions from both the Signal and Transportation communities) were analyzed against the decision-makers' criteria to result in several "top contender" packages. It is expected that these packages, when executed, will mitigate the operational and security risks associated with the ad hoc acquisition of COTS tools and will address the wide range of net-centric requirements that Transportation Soldiers face.

This research was challenging because it assesses the intersection of two communities: the Signal Corps and the Transportation Corps. That is, the study was commissioned by the G-6 but the tasks involved are under the cognizance of the G-4. While research and experimentation in the area of network-centricity almost always revolves around command and control for combat operations, there have been few studies examining what network-centricity means in force sustainment operations. While the originators of network-centric warfare say their principles are applicable in any business domain, little work has been done to map the capabilities of network-centricity (as defined in the NCOE JIC, JOC and JFC) to specific tasks. This study did just that: breaking new ground by mapping doctrinally-defined every-day Transportation Soldier tasks to network-centric principles. It helps answer the question "what can network-centricity do for me?" and can serve as a starting point for aligning required capabilities between the G-6 and G-4. This new ground also proved to be most challenging because the measures for network-centricity do not match the measures of effectiveness for transportation. It is believed that the overall methodology of this study in identifying the highest-risk domain-specific tasks with their associated measures and then mapping their reasons for not being performed to standard to network centric capabilities is the correct approach. It brings together those usually concerned with C2 (and associated systems) and those concerned with other activities. This study confirmed that those groups tasked with defining requirements for C2 cannot operate independently of the communities that they support in today's environment. However, network-centricity cannot be a solution for all issues and this approach can help identify the ways in which they can. Systems should exist to support Soldiers doing their jobs, and justification for those systems or non-materiel changes must be rooted in the effect desired, on and off the battlefield.

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