Enterprise Capability Assessment and Prioritization

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Abstract. The Idaho National Laboratory (INL) is a science-based, applied engineering national laboratory dedicated to supporting the U.S. Department of Energy's missions in nuclear and energy research, science, and national security. This paper describes the development of a qualitative approach (and tool) for assessing and prioritizing capability gaps of an enterprise (i.e., based on similar effort for a U.S. Army Brigade Combat Team) along with the assessment of potential solutions for reducing or closing those gaps. It discusses the effort to create a common information model (i.e., within a qualitative process and toolset) that can assist an enterprise to capture and visualize relationships between its mission(s), required capabilities, performance objectives, gaps and potential solutions. Key to this effort was the establishment of an analysis framework containing unique (i.e., mostly independent) capabilities organized within a hierarchy which allows for appropriate visibility into problem areas while eliminating redundancy that would bias assessment results. Finally, the paper presents the tool developed to manage and display relationships between multiple required capabilities, their gaps, and the solutions proposed for gap closure, such that the enterprise can better fulfill its mission(s).

Introduction and Background

Introduction. An enterprise, which can be an organization or undertaking, especially one of some scope, complication, and risk (American Heritage, 1993), will possess many capabilities that it must employ to successfully accomplish a mission or set of missions. In this context, a capability can be thought of as a complex collection of elements (i.e., ways and means) which typically includes physical resources (e.g., facilities, equipment, hardware and/or software), skilled personnel, and associated organizational knowledge in the form of, for example, policies, tactics and procedures. These collections of elements are used within organizational processes to perform a necessary repeated task or function that, either directly or indirectly, creates value for the enterprise. A "required" capability, therefore, represents a key core competency that is inextricably tied to the success of the enterprise in the performance of one or more of its missions. An enterprise's many capabilities need to be effectively integrated for it to be more successful. This integration of capabilities across the enterprise, some of which can be performed independently, can be thought of as constituting a system of systems (SoS).

Thus, factors such as evolving markets, changing business environments, technological innovation, personnel turnover, aging infrastructure/equipment or emerging opportunities (or threats) can create a need for an enterprise to identify and measure its capability gaps (i.e., either missing capabilities or shortfalls in the necessary or desired level of performance). Implementing such a process involves developing a structured approach for assessing the current (or baseline) set of capabilities against an identified set of *required capabilities* (RCs) that support either a current or future mission. The complete picture of baseline capability gaps with respect to a defined mission can provide a means for the enterprise to focus finite resources (e.g., labor and/or investment capital) on resolving capability gaps expected to have the greatest impact on mission performance. However, because the integrated set of RCs can behave as a SoS, the approach used for assessing a potential solution's ability to reduce or close capability gaps must also be able to account for adverse impacts to other affected capabilities.

Background. In 2006, a U.S. Army Current Force (CF) Fleet Management and Modernization (FMM) Initiative was launched to focus on technology insertion with the purpose of maximizing brigade and platform effectiveness specific to future force (FF) capability needs. The goal of the initiative was to support development of modernization plans, which serve as input to the Program Objective Memorandum (POM) cycle to modernize the CF Brigade Combat Teams (BCTs) with requisite capabilities that enable them to complete specific missions. Toward this end, it was recognized that impact on BCT-level SoS performance would be an important criterion in deciding which solutions to include in the modernization plans. The INL, a member of the Future Force Integrated Support Team (FIST)[1] already conducting other Army analyses, was engaged to support the qualitative assessment of BCT baseline and enhanced performance as part of a six-step process (see Figure 1)[2]. The INL support provided the impetus for developing a qualitative capability gap assessment approach and tool appropriate for use at an enterprise or SoS level. It should be noted that, in the context of this work, the Army solutions were materiel technologies (hardware/software) being considered for closing or reducing the size of BCT capability gaps either by enhancing an existing program of record or by replacing it. This paper extrapolates the approach developed for general application by enterprises with the Army CF BCT modernization effort referenced where applicable as a case study.

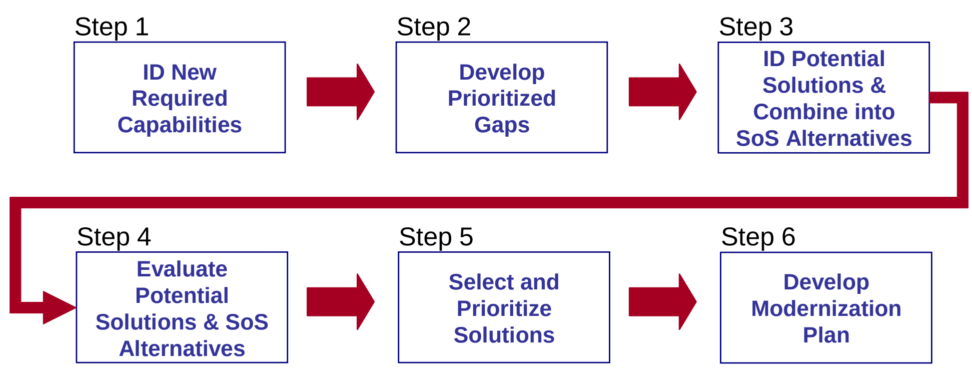

Figure 1. Systematic Six-Step Process Used by the CF FMM Initiative

[1] FIST is a consortium of Department of Energy laboratories including INL, Oak Ridge National Laboratory, and Sandia National Laboratories originally formed to provide systems engineering integration and SoS analysis support to the U.S. Army's Future Combat Systems (FCS) Program.

[2] This six-step process differs from the process proposed in this paper for general enterprise application.

Problem Statement

Enterprise Application. Enterprises need to have the ability to identify and measure capability gaps with respect to their current capability states and specific missions in order to more effectively adapt to changing conditions and improve performance toward successful mission completion. Finite resources, including labor and investment capital, often make it impractical for enterprises to correct every capability deficiency. Thus the enterprise must be able to prioritize among their various capability gaps to establish appropriate levels of effort and investment for gap closure. Likewise, when solutions are proposed for reducing or closing capability gaps, the enterprise must be capable of measuring each solution's SoS affects. For example, a solution introduced to reduce one gap could cause an increase in the size of one or more other gaps—detracting from the merit of the solution. If there are many proposed solutions, some or all of which affect multiple capabilities, the enterprise needs to have the ability to link those solutions with the appropriate capabilities, assess their impact relative to each capability and finally, rank the solutions relative to each other within the mission context. The ranking of potential solutions can then support decisions about which ones to fund and implement first.

Army CF FMM Initiative. In this particular effort, three Army organizations had performed important work that could be leveraged to support decisions and funding requests for BCT modernization and performance improvement:

1. The Army Capability Integration Center (ARCIC) had produced an Army-wide Capability Needs Assessment (CNA) that included descriptions of RCs and gaps in the context of the Joint Functional Concepts .
2. Capability managers and combat developers in the Army's Training and Doctrine Command (TRADOC) had drafted or produced updated operational requirements documents or capability description documents representing user requirements for the platforms to be modernized.
3. Program managers within the Army's Program Executive Office – Ground Combat Systems (PEO-GCS) had produced lists of near-term technology solutions for each platform to be prioritized and agreed upon with appropriate TRADOC Capability Managers (TCMs) toward satisfying the updated requirements and, ultimately, inclusion in the POM. A decision framework had been established that included BCT SoS effectiveness as one of the criteria for prioritizing the technology solutions. A good means for measuring the BCT SoS effectiveness, however, was not available.

An analysis framework (i.e., model of interrelated data) was needed for organizing and representing the problem set (i.e., as a common denominator or common "language") through which these separate work products could be integrated and used to more fully describe the problem/solution space while retaining the separate organizations' views of their respective data.

Development of a System of Systems Approach

Gap Terminology. The ability to comparably evaluate capability gaps across the enterprise requires the capabilities to be defined in a manner that minimizes any functional overlaps. This will help to avoid counting the individual gaps more than once. Once that has been done, a SoS approach must also have a "measuring stick" for determining the relative size of each capability gap. Conveniently, utility theory provides a means for measuring performance gap size by allowing a benchmark to be defined for the desired, or objective, level of capability performance. This benchmark represents "full utility" and is illustrated by the blue line on the right hand side of Figure 2. The utility provided by the baseline capability's performance can then be assessed relative to the benchmark, thereby creating a basis for scaling the "size" of the baseline capability (shown as a green bar). The initial capability gap, therefore, is the difference between the utility of the baseline capability and that of "full utility." The initial capability gap is depicted by the span of the red bracket. Potential solutions for closing the initial capability gap can be evaluated against the same benchmark based on their expected affect on capability performance toward achieving the desired level. Solution effectiveness is illustrated by the yellow bar. Any remaining performance gap is termed "residual gap" and is represented by the span of the blue bracket.

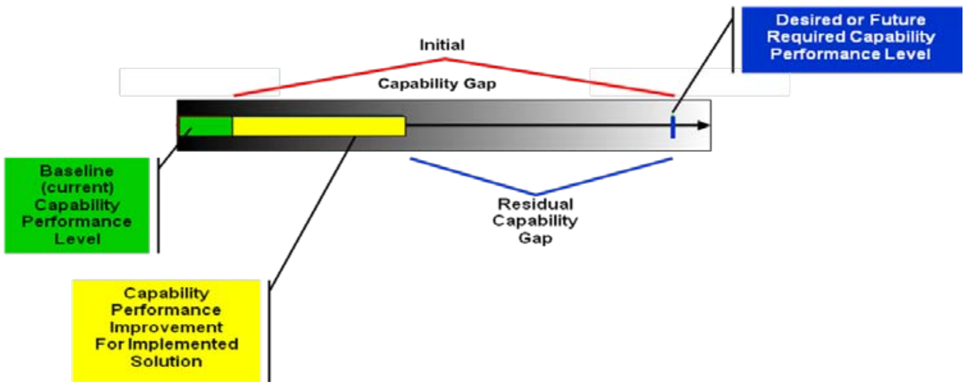

Figure 2. Notional Depiction of Gap Terminology

Enterprise Application. The authors propose the following seven-step approach (see Figure 3) for SoS capability gap assessment based on experience gained from the Army CF FMM Initiative. This approach is sequential, but may be iterated for addressing additional measures of effectiveness (MOE) or additional missions within a larger decision-making framework.

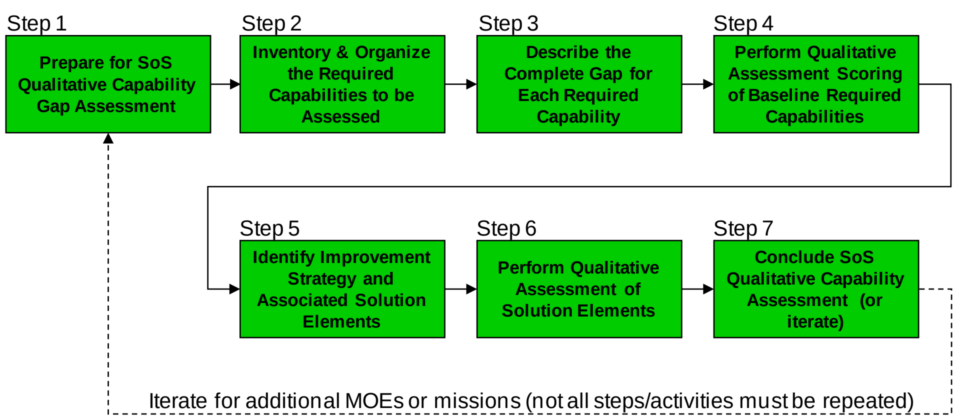

Figure 3. Suggested approach for SoS Qualitative Capability Gap Assessment

Figure 4 depicts a notional context for some of the key data elements of an enterprise-level capability gap assessment. The left hand side of the figure depicts the functional decomposition of the functions an enterprise performs relative to a mission. Unique (i.e., non-overlapping) RCs associated with these functions are shown in the center (green and grey boxes). The lighter green boxes below the required capability depict the various physical and informational components that comprise the capability in the baseline state. The analysis framework (purple box) depicts the organization of the RCs in a hierarchical structure used to interpret performance with respect to a selected MOE. The dark blue box represents a statement of the desired level of performance for the required capability which may be documented in capability performance requirements. The defined baseline capability and the desired level of performance provide the necessary basis for stating the capability gap or problem statement (red box). Solution elements developed within the context of a solution strategy are shown in yellow boxes in the upper right of the figure.

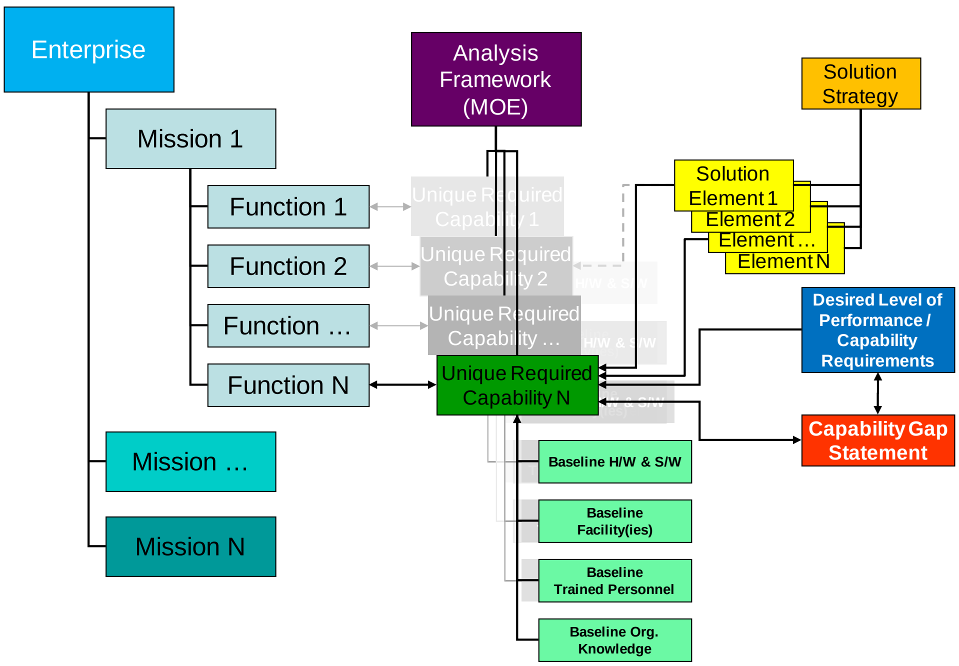

Figure 4. Notional Context for Enterprise Capability Gap Assessment

Army CF FMM Initiative. As discussed previously in the Background section above, PEO-GCS endorsed a six-step plan of action (see Figure 1) which largely represented a generic systems engineering approach. The six-step plan of action was supported by both qualitative and quantitative (i.e., SoS modeling and simulation) analyses and sought to leverage existing work and available analysis tools where possible. This combination supported a set of formal, repeatable analyses for creating a strong basis to prioritize the solution elements underpinning BCT modernization by aiding the understanding of where the greatest gaps in capability existed and which technology solutions would best fill those gaps. Thus, the greatest performance improvement could be provided in the most cost efficient manner. This approach differs somewhat from that being proposed for general enterprise application (see Figure 2). Primarily, the differences can be attributed to the starting point for the Army effort. As noted above in the Problem Statement section, an Army-wide CNA had already been performed. In leveraging this work, the CF FMM Initiative team did not need to perform the Step 2 (general case) RC identification activity from the beginning. However, there was some necessary reinterpretation and reformulation of the CNA RCs (and associated materiel gap statements) into unique capabilities (and unique simplified gaps) due to the change in perspective (Army-wide to BCT) and to eliminate the redundancy of RCs and gaps across the Joint Functional Concepts (JFC) chapters (i.e., many capabilities are reused across the functional concepts). In general, the mapping of the proposed enterprise application process relates to the Army CF FMM Initiative as follows: enterprise steps 1, 2, and 3 map to Army step 1; enterprise step 4 maps to Army step 2; enterprise step 5 maps to Army step 3; enterprise step 6 maps to Army step 4; and enterprise step 7 maps to Army step 5. No equivalent to the Army's modernization plan is being proposed for the enterprise application case. Due to funding and schedule limitations, the scope of the CF FMM Initiative was limited to analyzing the Heavy and Stryker BCT capability gaps. Likewise, only the CNA material gaps were used as a basis for identifying new RCs since PEO-GCS only acquires and integrates materiel solutions.

Qualitative Assessment

The following paragraphs describe in some detail the proposed qualitative approach proposed for enterprise capability gap and solution effectiveness assessment (see Figure 3). Graphics from the CF FMM Initiative are included where appropriate to provide examples and illustrate results.

Step 1. The first step involves laying the groundwork for the qualitative capability gap assessment. These activities include:

- Deciding on an overall MOE for the qualitative capability gap assessment (e.g., mission effectiveness, service quality, or energy efficiency).
- Identifying and documenting the mission context for the qualitative capability gap assessment.
- Defining criteria for rating the unique RC's performance level against the MOE selected. See Figure 5 for CF FMM Initiative example.
- Defining criteria for determining a unique RC's importance (i.e., weighting) within the mission context. See Figure 5 for CF FMM Initiative example.
- Defining the shape of the MOE utility function to convert RC performance level scores to utility values (0 to 1). See Figure 6 for CF FMM Initiative example.

Effectiveness Score Guidance	Importance Score Guidance
5. The ability to perform or provide the unique capability meets objective requirements.**	5. Unique capability is CRITICAL to BCT's mission effectiveness; mission cannot be successfully accomplished without the capability.
4. The ability to perform or provide the unique capability meets threshold requirements** Materiel solutions employed within the BCT need only evolutionary improvement or broader fielding to fill remaining gap.	4. Unique capability is VITAL to BCT's mission effectiveness; BCT's mission still can be accomplished, however, its effectiveness in doing so is severely degraded without the capability.
3. The ability to perform or provide the unique capability does not meet threshold requirements**- Supplementary materiel solutions are needed to satisfy the desired threshold level of performance. These supplementary materiel solutions exist, but require integration into the BCT.	3. Unique capability is IMPORTANT to mission effectiveness; BCT's mission can be accomplished, however, its effectiveness in doing so is significantly degraded without the capability.
2. The ability to perform or provide the unique capability does not meet requirements** and cannot be adequately improved or supplemented. A revolutionary materiel solution change is needed to replace the current materiel solution.	2. Unique capability SUPPORTS mission effectiveness; BCT's mission can be accomplished, however, its effectiveness in doing so is noticeably or moderately degraded without the capability.
1. There are no materiel solutions present to perform this unique capability. A new materiel solution must be developed and incorporated.	1. Unique capability FACILITATES or ENHANCES mission accomplishment; BCT's mission can be accomplished, however, its effectiveness in doing so is slightly or somewhat degraded without the capability.
	0. Unique capability is NOT APPLICABLE to BCT's mission

**The term "requirements" as used here refers to the future set of requirements (as envisioned) that must be met for the Current Force BCTs to be interoperable with and fight along side the FCS BCT in the year 2015.

Figure 5. Example Criteria for Scoring Capability Effectiveness and Importance

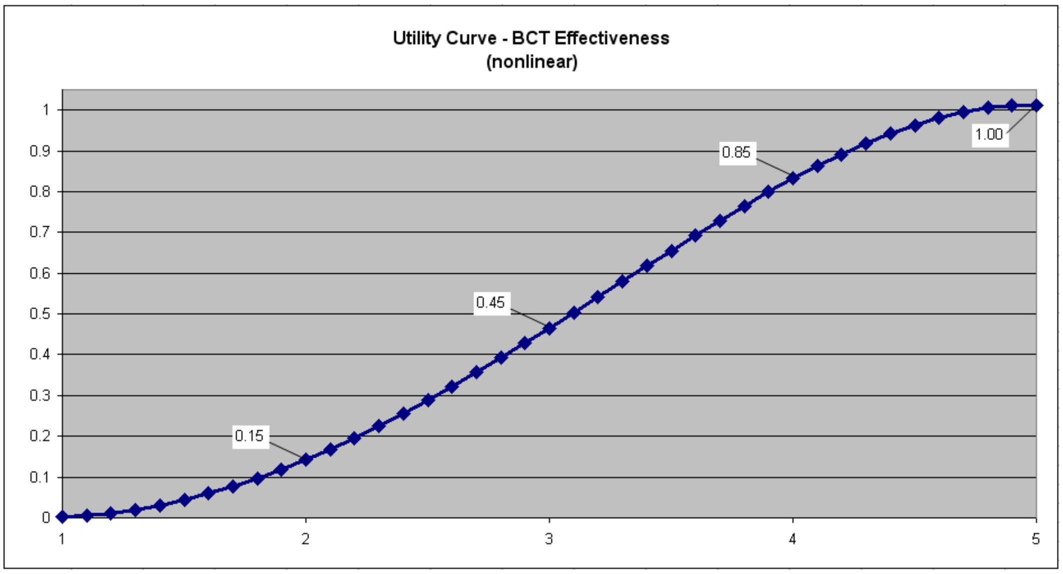

Figure 6. Utility Function (nonlinear)

Step 2. This step involves identifying and organizing the list of unique RCs to be assessed as well as describing their baseline state for qualitative assessment. Suggested activities include:

- Identifying and defining the full set of unique RCs through, e.g., a capability needs analysis, mission analysis, concept of operations (CONOPS) review, functional analysis & decomposition, or risk/opportunity analysis.
- Organizing the unique RCs into a hierarchy (or analysis framework) that provides a rollup by areas of interest, similarity, or other logical groupings. All unique RCs need to be at the same level of the hierarchy. See Figure 7 for CF FMM Initiative example.
- Linking the unique RCs to supporting information that provides necessary definition in terms of mission context, baseline RC constituents, and level of performance (e.g., to capability requirements or description documents that describe the "to be" state).

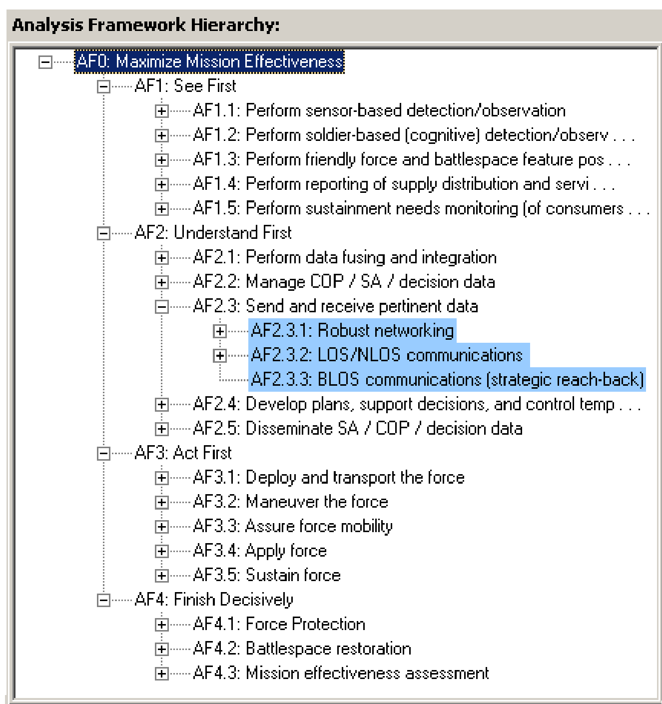

Figure 7. Analysis Framework (partially opened) showing and example BCT Capabilities

- Documenting constraints associated with the RC baseline elements (e.g., size, weight, and power constraints) that might affect the potential integration of various solution elements.

Step 3. Once the list of unique RCs has been identified and organized, the enterprise must determine whether these capabilities are deficient in any way or missing altogether. The proposed activities include:

- Defining the capability gap (i.e., full problem statement), if any, for each unique RC. RC performance level expectations should be set according to the desired, or "to be", state.
- Linking the capability gap statement to its unique RC in the analysis framework.
- Linking the capability gap statement to supporting information that helps to define the source, breadth, depth, timing or impact of the capability gap. See Figure 8 for CF FMM Initiative example.

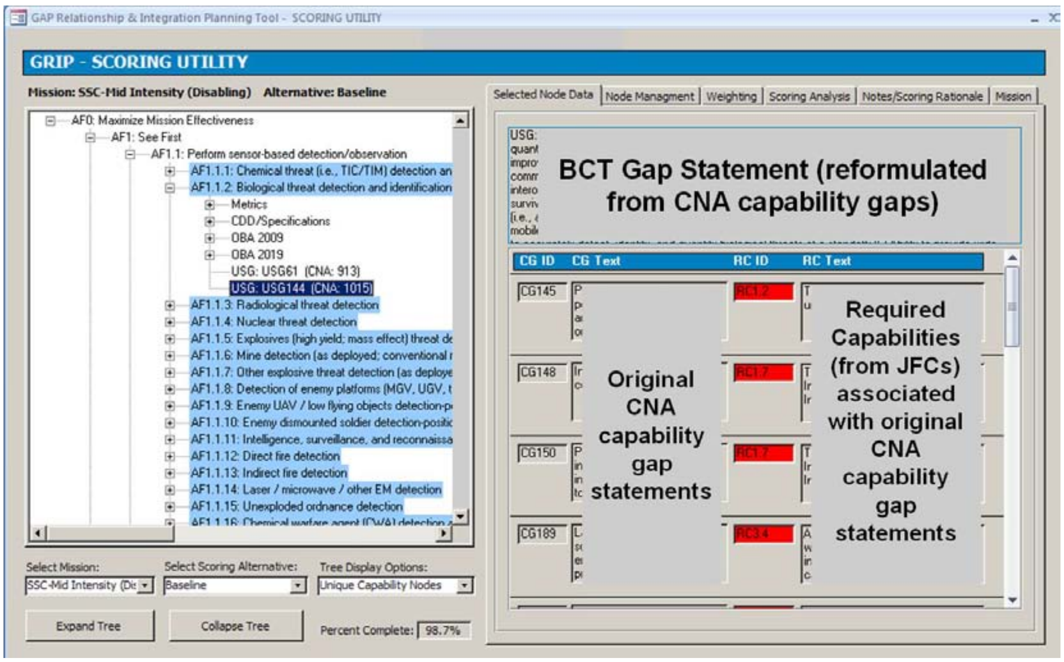

Figure 8. Gap Statement Association and Traceability back to CNA

Step 4. The importance weighting and performance levels for each unique RC can then be scored to create the qualitative assessment baseline. The scoring is based on the documented mission, baseline RC constituents, and gap statements. The output of this step is a comparative measure of the size of the capability and gap (opportunity for improvement) in terms of weighted utility. Specific activities include (see Figure 9 for CF FMM Initiative example):

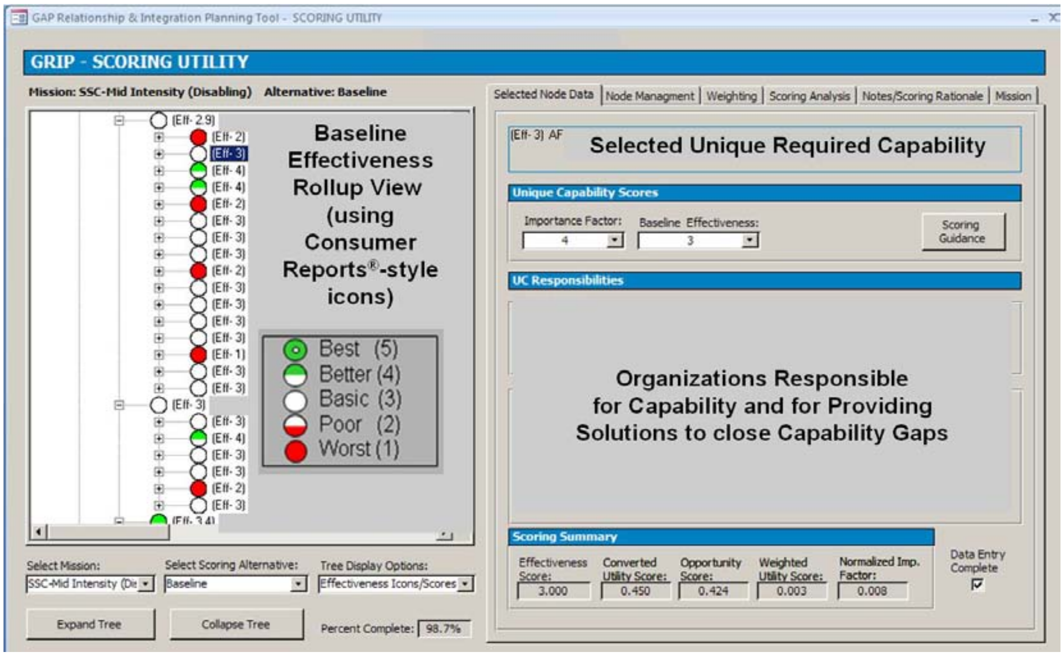

Figure 9. Baseline Results with Rollup Icons

- Using subject matter expert (SME) professional judgment and previously developed importance criteria to assign an importance factor to each unique RC. The question asked in this activity is "How important is each RC to the enterprise in providing or supporting mission success as measured by the selected MOE."
- Normalization of the importance factors across the full set of unique RCs.
- Using SME professional judgment and previously developed MOE performance criteria to assign a performance level score to each unique RC. The question asked here is "To what degree does the baseline capability satisfy the desired performance expectations set by the enterprise as measured by the selected MOE and within the identified mission context."
- Converting unique RC assigned performance scores to utility values using the utility function defined in Step 1.
- Calculating the weighted capability (i.e., utility) scores and gap size for each unique RC.
- Sorting the unique RCs by capability gap size.
- Calculating the rollup values for upper hierarchy levels (for both baseline weighted capability and gap scores).

Step 5. This step involves identifying one or more strategies for reducing or closing the capability gaps having the greatest impact on enterprise performance with respect to the selected MOE and mission. The proposed activities include:

- Identifying a strategy (e.g., procedural changes) for unique RC performance improvement through gap reduction or closure.[3]
- Using SME input to identify and define an integrated set of solution elements that fit within the improvement strategy (e.g., revise procedure X, provide training on procedures X and Y).
- Using SME input to link solution elements to specific unique RCs, as appropriate, based on the expectation for positive or negative impacts to the assessed gap if the solution were to be implemented. See Figure 10 for CF FMM Initiative example.
- Using SME input to identify and link predecessor or enabler relationships that may exist between solution elements.
- Linking solution elements to supporting information that helps to define the solution's scope or impact on unique RC performance. The linked information should also include cost and uncertainty (risk) estimates for solution element implementation.

Step 6. Once the solution elements have been linked with the unique RCs, which by their implementation will cause some change in the associated gap size, the amount and direction of impact can be assessed. This is accomplished by:

- Using SME professional judgment and previously developed MOE performance criteria to assign (estimate) a performance level "delta" impact score (i.e., from the baseline score) to each solution-to-unique RC linkage (created in Step 5). See Figure 10 for CF FMM Initiative example.

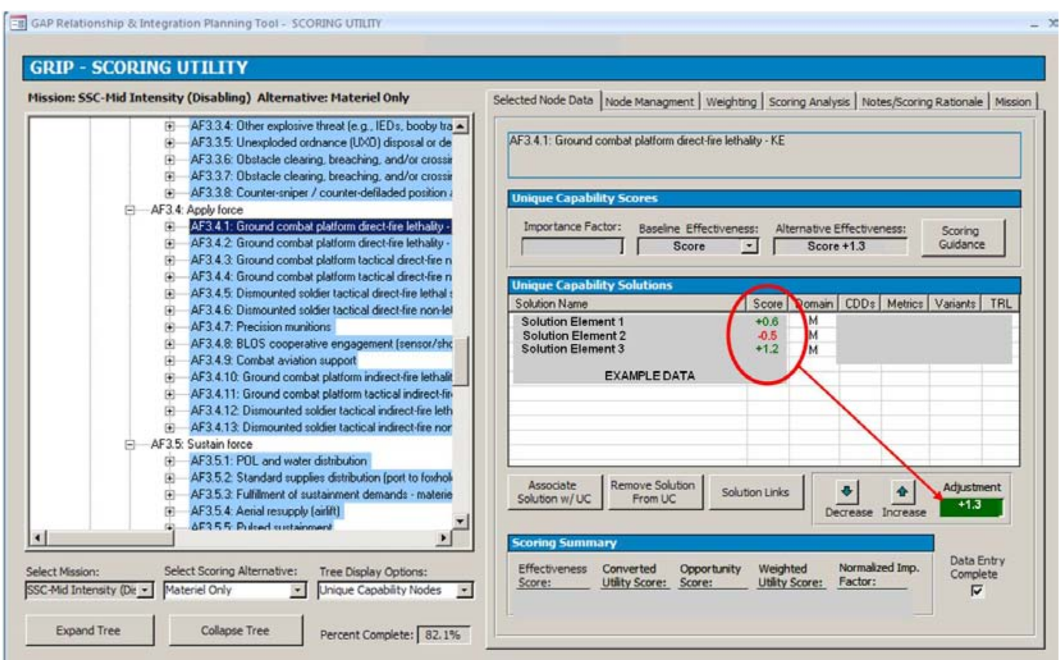

Figure 10. Solution Element Association and Scoring of Impact on Capability

[3] The Department of Defense now requires, as part the JCIDS process, that solutions be considered from the doctrine, organization, training, leadership, personnel and facilities (DOT_LPF) domain areas prior to consideration and use of solutions from the materiel domain.

- Converting the “enhanced” performance score to a utility value and calculating the unique RC gap closure (or increase) amounts due to anticipated solution element implementation. These amounts are measured in weighted utility and reflect the change from baseline due to all of the connected solution elements.
- Calculating the residual gaps, if any, for unique RCs after assumed implementation of the connected solution elements.
- Calculating overall gap closure impact brought by each solution element by summing its pro-rata share of gap closure impact across the full set of unique RCs. This summation of effects across the RCs allows comparisons to be made between the solution elements of a strategy.
- Calculating rollup values for the upper hierarchy levels (for both “enhanced” weighted capability and residual gap scores).
- Sorting solution elements by overall contribution to gap closure and accounting for precedence/enabler relationships. See Figure 11 for CF FMM example.

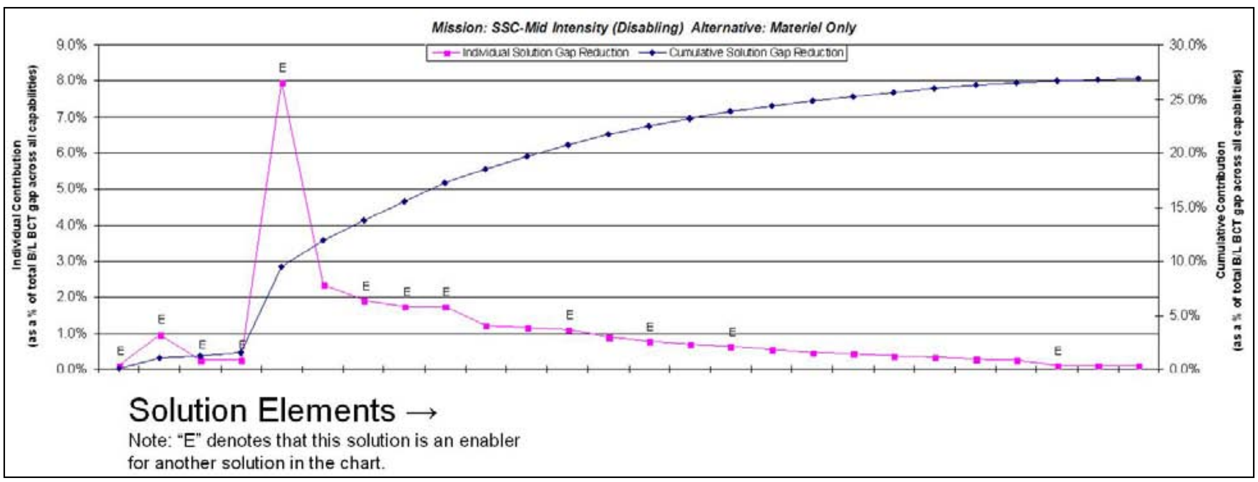

Figure 11. Solution Ranking Accounting for Precedence Relationships

Step 7. In the final step, various analyses such as bang-for-buck, bang-for-risk, optimization, etc., can be performed and the results are documented. The activities suggested for this step include:

- Performing additional analyses, as appropriate, to support decision making:
- Bang-for-buck or Bang-for-risk analyses
- Optimization within size, weight, and power constraints
- Cost as an independent variable analysis
- Documenting qualitative capability gap assessment results and providing these as inputs to the decision-making model, if applicable.
- Iterating the approach for different MOEs and/or different missions by returning to Step 1 and repeating subsequent steps/activities, as appropriate, for each additional MOE

and/or mission. Results can be weighted by importance for input to a larger decision-making model, if applicable.

Tool Development

Tool Purpose & Overview. A relational database application was developed to support the PEO-GCS process discussed above. This program has been named the Gap Relationship and Interface Planning (GRIP) Tool. The GRIP tool was programmed in Visual Basic for Applications (VBA) which provides a graphical user interface for working with the Microsoft Access® database as well as the necessary data capture and management for conducting the utility theory-based assessment. The GRIP tool was designed for use by INL FIST team members to facilitate the data capture from SMEs during workshop sessions and to provide rapid feedback on results—often within the same session.

The original data schema (see Figure 12) on which the tool is based was developed in Rational Requisite Pro® which was used initially to manage the many data element types and their interrelationships. This beginning accounts for the underlying data structure now present in the GRIP tool. At present, GRIP effectively manages relationships between multiple data element types including: RCs, RC gap statements, future force gaps, unique capabilities (i.e., the independent and non-redundant functional areas distilled from RC gap statements), unique/simplified gaps (i.e., the reconstituted functional and performance attribute deficiencies for the unique capabilities), BCT (enterprise) elements, and potential technology solutions for gap closure. The tool has the ability to display these mapped relationships (using a hierarchical tree structure) including the data traceability back to multiple Army source documents. The tool also includes the ability for the user to look up or down the tree from a selected node of interest.

The GRIP application automates all of the mathematical calculations associated with performing the SoS capability gap qualitative assessment including normalization of importance weights, effectiveness score conversion to utility values, gap size calculations, and the scoring results rollup. It also provides the ability to store multiple assessments; each in the context of an associated mission.

The GRIP tool also provides built-in functionality for charting and reporting results. Specifically, GRIP:

- Has multiple output charts for displaying results including baseline capability, initial capability gaps, capability organizational responsibility/ownership, enhanced capability performance assuming solution element implementation, solution element comparative effectiveness, and residual gaps.
- Single data element attribute reports as well as multiple element mapping reports.
- Displays assessment rollup results for the various levels within the analysis framework using Consumer Reports®-style icons for easy comparison and identification of problem areas.

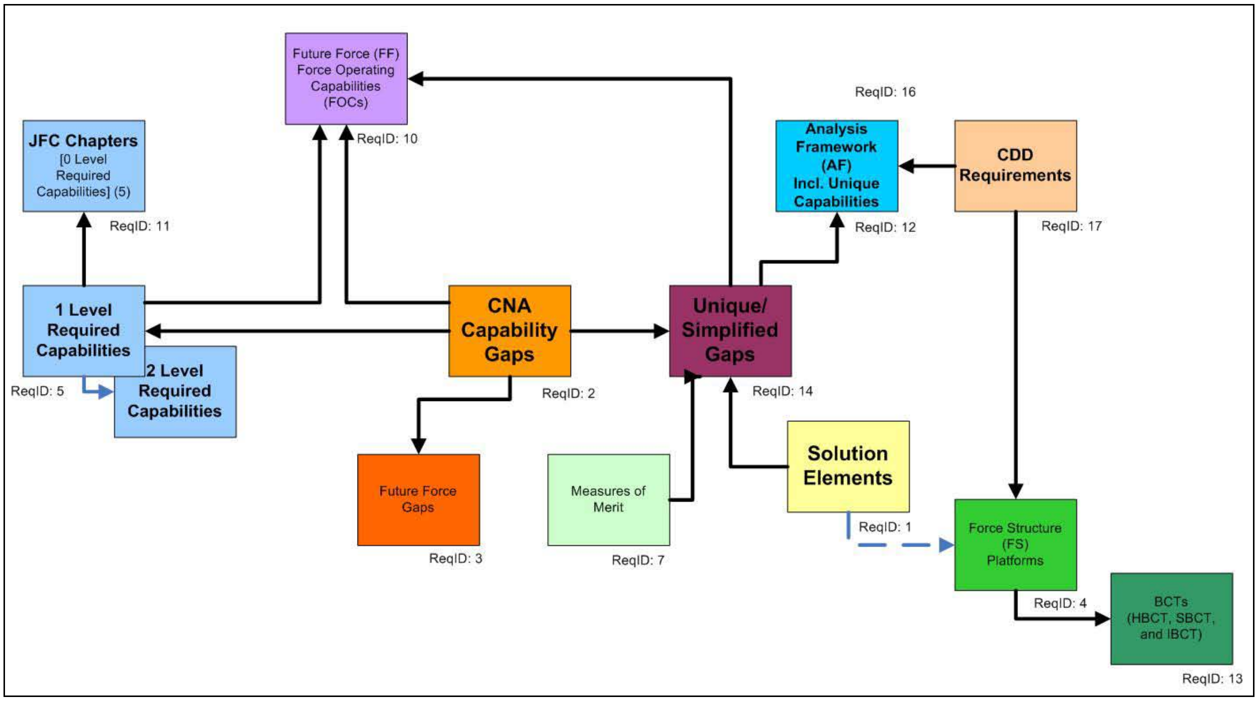

Figure 12. Partial GRIP Data Relationship Schema

Lessons Learned

The following lessons learned were documented in relation to the use of the tool and approach on the Army CF FMM Initiative.

Required Support. The GRIP tool was very effective at handling a large number of capabilities and the associated data relationships. However, with a large number of capabilities, two missions and multiple solution elements to assess, it was sometimes difficult to sequester the right SMEs for the duration of the assessment.

Information Updates. Managing the changes to supporting or source data over time for purposes of maintaining traceability proved to be a challenge. This potential for this situation to occur should be considered during the planning phase when there is ample time to incorporate mechanisms to facilitate data updates. For example, it may be appropriate to use a requirements management tool that automatically updates the requirements database when the source document entries are modified.

Nonlinear versus Linear Utility Function. Initially the capability effectiveness scores were converted to utility values using a linear utility function. However, after discussions with the TCMs, it was concluded that the value associated with a solution element that increases the capability performance level temporarily or marginally was not as great as a solution element that could subsequently be improved upon or that had a chance of attaining the threshold performance level. Based on these discussions then, the original linear utility function was replaced with the nonlinear utility curve shown in Figure. 6.

Accounting for Solution Precedence Relationships. The analysis approach must be capable of defining and managing any infrastructure improvements being suggested within the set of proposed solution elements. Also known as enablers, these solution elements place the enterprise's baseline capabilities in a position to implement other solutions which provide the most performance improvement. While the enablers don't always improve performance directly (and won't rank as high in a straight solution element comparison as a result), they nonetheless must be implemented prior to the other solutions they enable. In other words, an enabler must become a priority when any solution element requiring that enabler becomes a priority.

BCT SoS Results. Qualitative results were indeed useful to understand the BCT's priority gaps and reinforced the need to think of the BCT as a SoS. Continuing to focus on combat platform improvements could cause decision makers to overlook other larger opportunities for improving BCT mission effectiveness. Additionally, qualitative results (comparative) were obtained for all of the proposed solutions including some for which quantitative modeling results were neither available nor practical.

Teaming. The qualitative process, which relies on SME input, is enabled when needed participants are identified and become part of the analysis team. Otherwise, the lack of an established team with roles and responsibilities will create competing priorities for the SMEs. To formalize SME support when working with organizations like the U.S. Army, a formal task order is critical so requests for information can be satisfied within the timeframe needed.

Workshops. Workshops with SMEs are an effective way of not only capturing essential input, but facilitate communication across the enterprise both during the workshop as a result of the discussion and afterward due to the information that was uncovered. These workshops should be planned in detail, aggressive and facilitated to maximize the limited time most SMEs can afford to provide.

Use of Tools. Often tools are seen as the very thing that validates behavior when, in reality, tools only contain the knowledge programmed into them. Quantitative models can help with understanding these complex interactions if there is an understood correlation between the qualitative assessment and the quantitative models. A limited number of primary performance metrics should be identified that relate to overall enterprise mission effectiveness. In support of PEO-GCS, without a correlation map of the mission effectiveness to metrics to modeling results, it was difficult to use the quantitative results to directly impact the qualitative mission effectiveness scores. To better understand the relationship between the qualitative and quantitative analyses, it required facilitated interactions with the SMEs providing the qualitative scores to identify factors (metrics) that went into their assessment.

Defining the Mission. The mission must be well defined and documented such that it can ultimately be used to describe the environment, circumstances, and value space wherein the capabilities will be employed. A well defined mission will facilitate the decomposition of necessary functions that is needed for compiling the list of capabilities to be assessed.

Conclusion

An enterprise has capabilities it must perform at some minimum level of proficiency to successfully accomplish its mission. Assessment of these capabilities for the purpose of focusing improvement efforts where it will do the most good can be quite complex when the number of capabilities is large and their associated constituents represent a SoS. Implementing a process to prioritize capability gaps (i.e., shortfalls in performance), as well as potential solutions to fill those gaps, involves developing a structured approach for comparing the performance of baseline capabilities against that of the desired or future set of RCs (e.g., those needed for future missions). The complete picture of gaps, with respect to a mission or a particular MOE, when viewed across the enterprise's full complement of capabilities provides an effective means of identifying where improvement efforts will do the most good. Likewise, being able to assess solutions that have the to potential to affect the gaps of multiple capabilities while accounting for solution predecessor relationships allows the enterprise to focus on those that will provide the greatest overall benefit.

A qualitative process was developed and implemented in support of the CF FMM Initiative and focused on technology insertion that would maximize brigade and platform effectiveness specific to FF capability needs. By conducting the assessment at the SoS level rather than the platform level (i.e., stovepipe approach), capability gaps were identified and prioritized and then solutions evaluated for their effectiveness in closing those gaps for the BCT. This need for a SoS, brigade-level analysis aligns well with an enterprise approach.

To effectively manage all the relationships between multiple data elements, the GRIP tool was developed in VBA and using MS Access® as the relational database engine. Functionality based on utility theory was incorporated into the tool to perform gap measurement and prioritization for multiple missions. An extension of this functionality also provided the ability to perform a comparative analysis of materiel solutions relative to gap closure effectiveness. The final tool provided a means to create a common "language" between the various Army communities that define needed strategic capabilities, generate the user's requirements, and that instantiate those requirements through system acquisition. This common language does not always exist and until it is achieved, the largest gaps in capability can be missed or remain ill-defined resulting in technology and/or non-technology solutions not being evaluated to fill the highest priority gaps.

Future Applications or Application to Other Domains

To date, the approach and GRIP tool has been used for materiel solutions only. Because the tool has the flexibility to manage solution elements as part of larger solution strategies and to connect solution elements to capabilities as applicable, the authors believe that it would easily handle non-materiel solutions developed from the doctrine, organization, training, leadership, personnel and facility domains. Thus the tool could be used to fully support Army capability based assessments conducted as part of the JCIDS process.

By extension, the basis of the assessment could be shifted from qualitative to quantitative by associating each capability with one or more measurable performance metrics coupled with associated utility functions. Actual (baseline) and predicted performance (after enhancement) against these metrics would provide the scores to be converted into utility values. However, such a shift would only be recommended in cases where there are relatively few capabilities to assess due to the time involved in data collection and validation.

With minor modifications, the GRIP tool could be applied to other areas where an enterprise SoS evaluation is necessary. Adaptations of GRIP, for example, have already been initiated at the INL in the following applications:

- Technology risk assessment and response planning
- Infrastructure investment planning and prioritization
- SoS scenario-based performance evaluation and rollup.

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