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Redesigning the Army Continuum of Analysis Database

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Author Note: Luke McCurdy, Kyle Brett, Joshua Kim, and Prescott Da Vitoria Lobo are First Class (senior) Cadets at the United States Military Academy at West Point. COL Matthew Dabkowski serves as their advisor. In May 2023, these Cadets will commission into the United States Military as Second Lieutenants in the Air Force Special Warfare, and the Army's Infantry, Transportation, and Field Artillery branches, respectively. The authors would like to express their gratitude to Dr. Brian Wade for supporting this project, as well as the many leaders and specialists in the Army Analytical Community (AAC) that provided such insightful and valuable contributions. The views expressed herein are those of the authors and do not reflect the position of the United States Military Academy, the Department of the Army, or the Department of Defense.

Abstract: The mission of the United States Army is to fight and win our Nation's wars. Confronted with dynamic threats and limited resources, Army Senior Leaders (ASLs) make difficult decisions about manning, training, and equipping formations for success on the future battlefield. To assist them, the Army Analytical Community (AAC) conducts research and analysis to support these decisions. Partnering with The Research and Analysis Center (TRAC), a United States Military Academy senior capstone design team developed a comprehensive analysis of the functions and applications of the Army Continuum of Analysis (ACA) database using the Systems Decision Process, a value-focused, systems engineering decision process used to support fact-based decision making. The team's fundamental objective was to facilitate better communication between organizations within the AAC and ASLs by providing an easily accessible, centralized repository of analyses. This paper discusses their findings, recommends modifications to the ACA database, and makes suggestions for future research.

Keywords: Army Senior Leaders, Army Analytical Community, The Research and Analysis Center, Army Continuum of Analysis, Systems Decision Process

1. Background

To help Army Senior Leaders (ASLs) make better informed decisions, the Army Analytical Community (AAC) conducts studies on enduring questions related to deep futures (i.e., trend understanding), force design, force development, force employment, and Program Objective Memorandum (POM) build (AFC, 2022). To effectively use the results of these studies, they are compiled into a single repository, known as the Army Continuum of Analysis (ACA) database, which is maintained and operated by the AAC (ACA, 2022). Conceptually, the ACA is a mechanism that facilitates the synchronization of the organizations in the AAC such as Army Futures Command, TRAC, the Center for Army Analysis, and many more (ACA, 2022). However, the current structure of ACA database does not convey sufficient information to aid the decision making of ASLs. A new database, or an enhanced version of the current one, will better facilitate coordination between the AAC and ASLs by providing an easily accessible, centralized repository of past, ongoing, and future analyses.

In this project, the Systems Decision Process (SDP) was used as a framework to holistically analyze the problem. Shown in Figure 1, the SDP is a collaborative, iterative, and value-based decision process that can be applied in any stage of the system life cycle (Parnell et. al, 2011).

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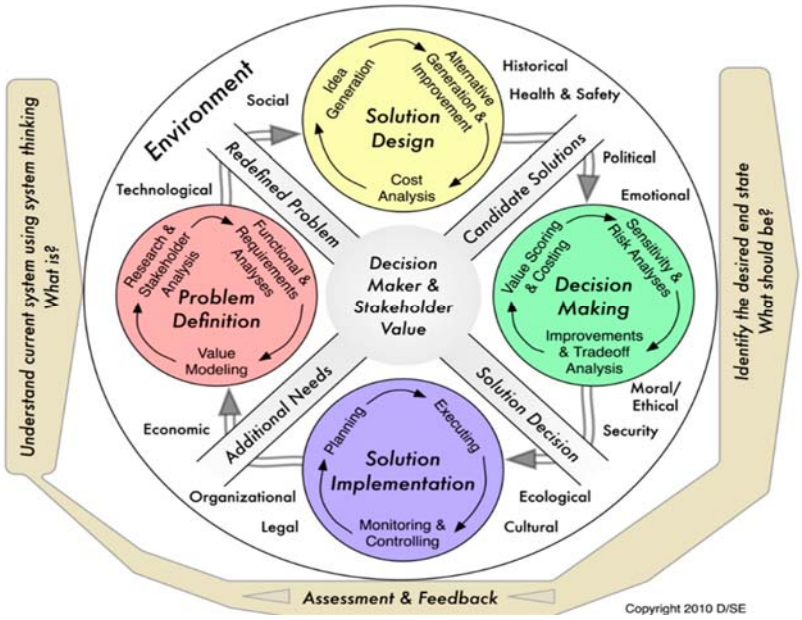

Figure 1. The Systems Decision Process (Parnell et al., 2011)

2. Problem Definition

The SDP is broken down into four sequential phases: problem definition, solution design, decision making, and solution implementation. The problem definition phase entails three major tasks including research and stakeholder analysis, functional and requirements analysis, and value modeling. In the first task of research and stakeholder analysis, the capstone design team conducted literature reviews on the AAC, the ACA, prototyping, and databases. Among the key findings was the current usage of the ACA and AAC to inform ASLs with key information on complex problems. The literature reviews also gave the team information on prototyping and databases. The team researched good database qualities, how to make databases more effective, four strategies to prototype a database (horizontal, vertical, task-oriented, and scenario-based (Beaudouin-Lafon & Mackay, 2011, p. 1013)), and database types (Roy-Hubara, 2019). Prototyping, which has been a trusted technique by many system designers, will be used once a solution decision is generated (Camburn, 2017). The technical report gave the team the necessary background knowledge of the ACA, AAC, prototyping, and databases to provide TRAC with a viable solution to the initial problem.

To conduct stakeholder analysis, the team reached out to the ACA point-of-contact Dr. Brian Wade, a principal analyst and data scientist at TRAC, and received the contact information of twelve analysts in different organizations of the AAC (Wade, 2022). The team then conceived a twelve-question survey to send to each contact in hopes of gaining deeper insight from different points of view. Each stakeholder had a unique, narrow lens on the ACA and its database, and the variety of perspectives and vested interest in the database made each response invaluable. With the feedback received from each contact, a Findings-Conclusions-Recommendations (FCR) matrix was generated. The findings from the stakeholder responses were narrowed down to conclusions which were further distilled into a short list of recommendations for the new database. Some of these recommendations included: studies should be searchable, database search functions should be intuitive, studies should provide a "sponsor's" contact information, and the mission statement and current practices of the ACA database need to be realigned with higher leadership's intent. Combining the recommendations from the FCR matrix, the fundamental objective of the new ACA database was authored: facilitate better communication between organizations within the AAC and ASLs by providing an easily accessible, centralized repository of past, ongoing, and future analyses.

The next task of the problem definition phase was functional and requirements analysis. This task required the team to identify and organize the system functions, arrange them into processes, and identify the system's inputs, outputs, and requirements. The primary output of the functional analysis was a functional hierarchy for the ACA database (seen in Figure 2), which provides a clear understanding of the system's functions and a foundation for candidate solutions. Furthermore, it provides a guide for concept design and helps identify the system's performance measures. From top to bottom, the functional

hierarchy contains the fundamental objective (orange), functions (yellow), and subfunctions (blue/green) (Parnell et al., 2011, p. 317).

The team used the information gathered during research and stakeholder, functional, and requirements analysis to create objectives and their associated value measures, which are scales used to assess how well the system objectives are met. Nested under the top-level functions of the functional hierarchy, these are given in Figure 3. For example, when studies are uploaded to the ACA database (Function 1.0), a good alternative will minimize the effort required to upload them (Objective 1.1), as measured by the intuitiveness of the database's upload functionality (Value Measure 1.1.1). Taken together, the functions, objectives, and value measures seen in Figure 3 set the conditions for the redesigning of the ACA database and delivering value to the client.

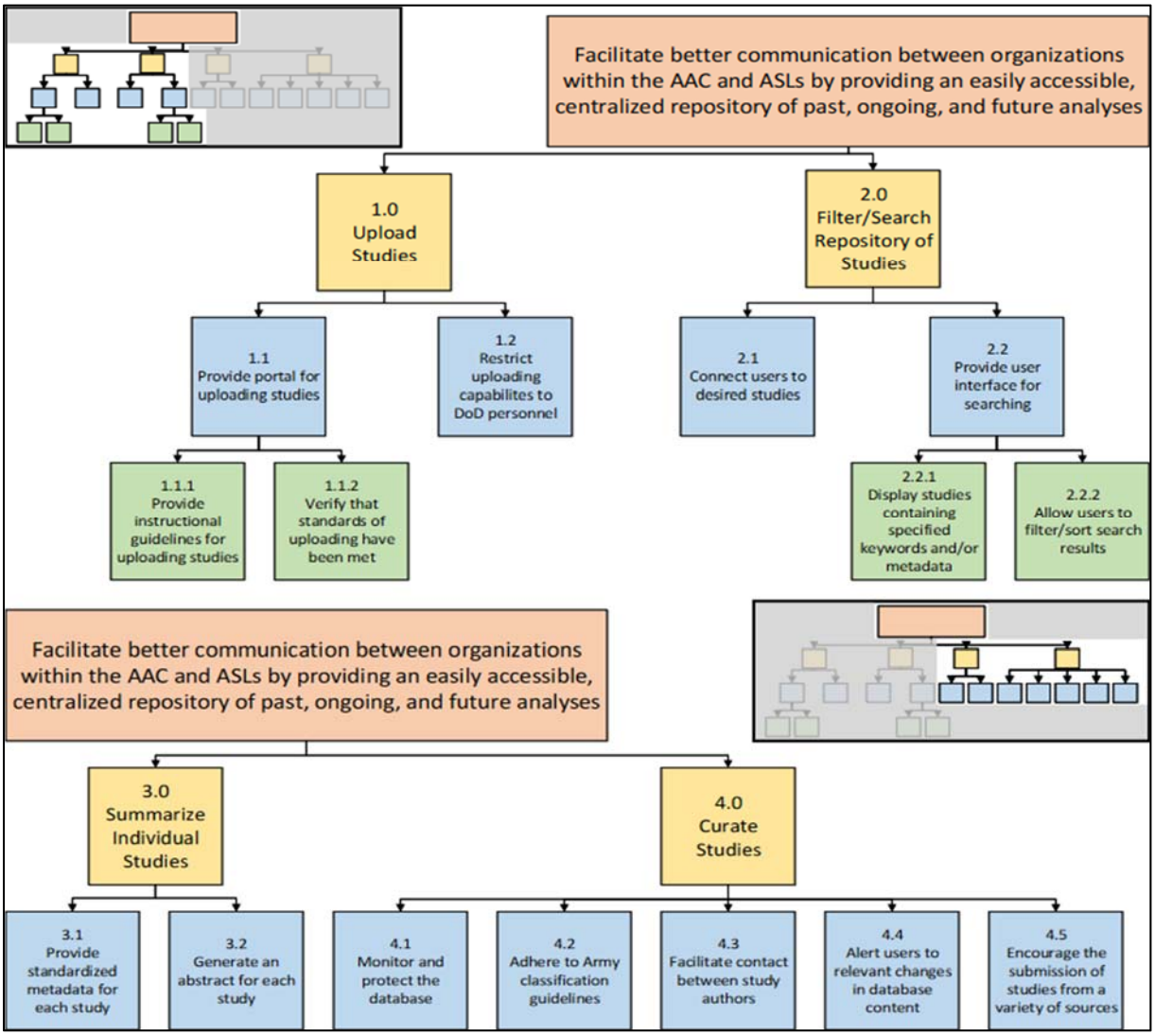

Figure 2. Functional Hierarchy

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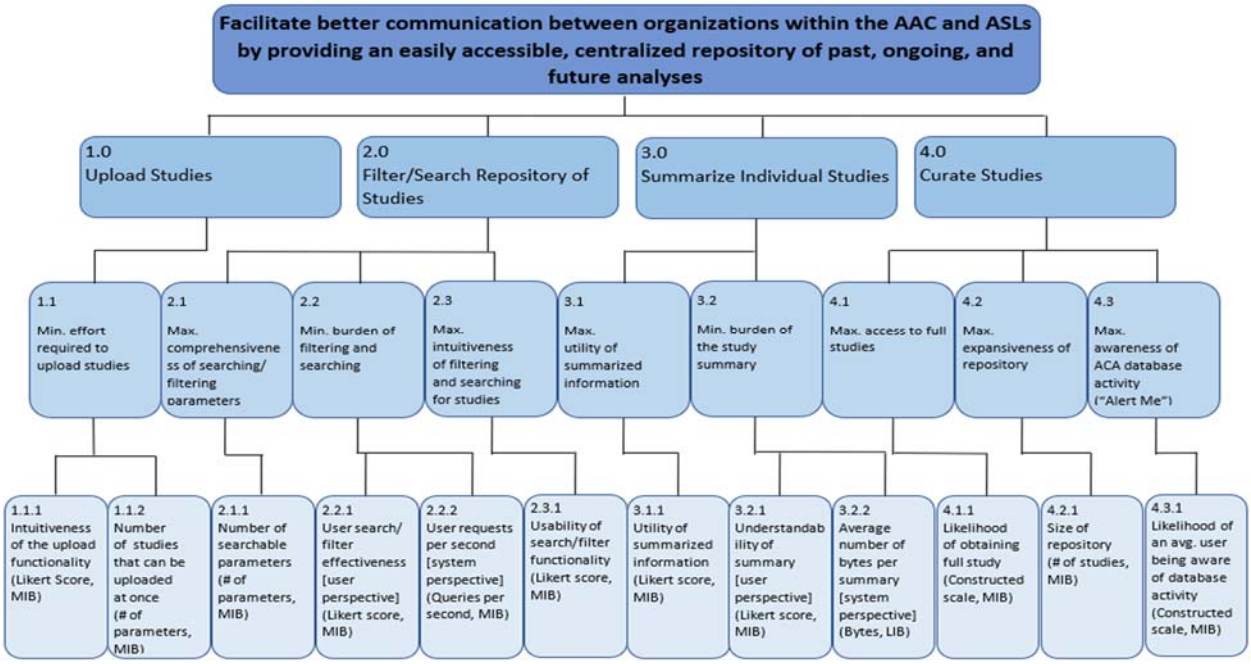

Figure 3. Value Hierarchy

3. Solution Design

As mentioned earlier, the second phase of the SDP is solution design. The three major tasks in this phase are idea generation, alternative generation and improvement, and cost analysis. The framework the team used for idea generation was Zwicky's morphological box (see Figure 4). The first step in populating this framework was to brainstorm the design parameters that must be addressed when creating alternatives. For example, the first design decision for building an enhanced ACA database was selecting the technology platform. The options for the technology platform were the Shiny App (R), Microsoft Access, Office SharePoint, Microsoft Teams, and a custom commercial solution. The options were selected in accordance with the value measures. For example, a custom commercial solution would be best suited for a high volume of database traffic but may not be the most secure option. The addition of a plus sign in certain cells of the following figure below denote that the attribute fulfills what is specified as well as all inferior attributes. For example, the cell marked "Top Secret+" refers to Top Secret classifications, secret classifications, CUI, and Unclassified information.

Zwicky's Morphological Box							
Technology Platform	**Repository Permissions**	**Entry Contents**	**Provide POC Information**	**Study Sourcing**	**Notifications**	**Search/Filter Space**	**Classification Level**
Shiny App (R)	Open Source (like Wikipedia)	Full Study +	Yes	External/ Referenced Products +	Periodic Newsletter	References Within Studies +	Top Secret +
Microsoft Access	DoD Login ISO Uploading	Abstract +	No	DoD Studies +	Interest-Specific Alerts	Full Text +	Secret +
SharePoint	Request Form ISO Uploading	Metadata Only		AAC Studies Only	Global (every change)	Abstracts +	CUI +
Teams	AAC Admins				User-Specified Alerts	Metadata Only	Unclassified Only
Custom Commercial Solution	Study POCs Only				None		

Figure 4. Zwicky's Morphological Box

The next task in the solution design phase is alternative generation. In this task, the team generated six alternative candidate solutions by selecting an option from each parameter in Zwicky's morphological box and combining them. Each alternative has a theme. For example, the first alternative, nicknamed "Napoleon's Corporal," is an alternative designed to promote intuitiveness and usefulness by all parties. Derived from Napoleon's practice of ensuring his plans could be understood at the lowest level, this alternative features attributes that are centered around effectiveness through simplicity. Based in

Microsoft Teams, "Napoleon's Corporal" is a repository with a basic search function for metadata such as author, date published, title keywords or phrases, etc. A wide range of studies from a CUI (controlled unclassified information) classification and below are published with full text, but there is no point of contact for follow-up inquiries. Studies are sourced from a variety of places in the DoD, allowing access to a broader wealth of information. The repository is edited and maintained by AAC administrators exclusively. To keep stakeholders, clients, and other interested parties informed on the activity of the database, users will have the option to sign up for email notifications of new studies and updates to current studies within a specified field of interest. Within the six alternatives, an "ideal" solution was also conceived. It is important to note that the ideal solution is typically impossible to implement as the solution decision. The generated alternatives are shown in Figure 5.

Alternatives	Technology Platform	Repository Permissions	Entry Contents	Provide POC Information	Study Sourcing	Notifications	Search/Filter Space	Classification Level
Baseline (current)	Shiny App (R)	AAC Admins	Metadata Only	Yes	AAC Studies Only	None	Metadata Only	Unclassified Only
ALT 1 - Napoleon's Corporal	Teams	AAC Admins	Full Study +	No	DoD Studies +	Interest Specific Alerts	Metadata Only	CUI +
ALT 2 - ASL Oriented	Sharepoint	DoD Login	Abstract +	Yes	AAC Studies Only	User Specified Alerts	Abstracts +	Top Secret +
ALT 3 - Fort Knox	Shiny App (R)	Study POCs Only	Metadata Only	No	AAC Studies Only	None	Metadata Only	Top Secret +
ALT 4 - Rush Hour	Microsoft Access	Open Source	Full Study +	Yes	External/ Referenced Products +	Periodic Newsletter	References Within Studies +	Unclassified Only
ALT 5 - Kitchen Sink	Custom Commerical Solution	Request Form ISO Uploading	Full Study +	Yes	External/ Referenced Products +	Global (every change)	References Within Studies +	Top Secret +
Ideal (perfect solution)	Custom Commerical Solution	Open Source	Full Study +	Yes	External/ Referenced Products +	User Specified Alerts	References Within Studies +	Top Secret +

Figure 5. Alternatives for an Enhanced ACA Database

The last task of solution design, cost analysis, is ongoing, and it will allow the team to assess the alternatives' value to the AAC and ASLs relative to the resources required to implement them.

4. Decision Making

During the next phase of the SDP, decision making, the team analyzed which alternative best accomplished the client's fundamental objective and the goals of the AAC. Specifically, the team built value functions for each of the value measures in Figure 3, and the alternatives' raw scores for the value functions were obtained from a stakeholder survey and research. Additionally, Dr. Wade provided swing and global weights for each value measure to provide a comprehensive determination of their importance to the overall performance of the alternatives. As seen in Figure 6, our most highly weighted value measures, and therefore the measures that have the greatest overall effect on the value of our alternatives, are user/search effectiveness, usability of search/filter functionality, and understandability of summaries and abstracts. Our least significant value measures are the average number of bytes per summary, the number of user requests per second, and the likelihood of an average user being aware of database activity (Wade, 2023).

The global weights, value functions, and raw scores were combined using an additive value model, and the most valuable alternative was the "Kitchen Sink." Next, the team conducted sensitivity analysis on the swing weights by increasing and decreasing their values by 10% and recalculating the final value scores. The final value scores of the alternatives remained in the same order, implying the value model is insensitive to minor discrepancies in the global weights. This is likely due to the large number of value measures in our model.

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Value Measure	Swing Weight	Global Weight
1.1.1 – Intuitiveness of the upload functionality	20	0.037
1.1.2 – Number of studies that can be uploaded at once	20	0.037
2.1.1 – Number of searchable parameters	50	0.092
2.2.1 – User search/filter effectiveness	100	0.183
2.2.2 – User requests per second	10	0.018
2.3.1 – Usability of search/filter functionality	100	0.183
3.1.1 – Utility of summarized information	90	0.165
3.2.1 – Understandability of summary	100	0.183
3.2.2 - Average number of bytes per summary	5	0.009
4.1.1 - Likelihood of obtaining full study	20	0.037
4.2.1 - Size of repository	20	0.037
4.3.1 - Likelihood of an avg. user being aware of database activity	10	0.018
	Total	1

Figure 6. Swing and Global Alternative Weights from Client

5. Conclusion

ASLs face uncertain environments when making decisions to fight and win our Nation's wars. That is why it is critical to supervise and refine the ACA database to equip the AAC with the capabilities necessary to assist ASLs in their decision making. Given the current state of the ACA database, the team traversed through the phases of the SDP, using functional analysis and value modeling to create a redefined problem statement and generate alternatives for our TRAC counterpart. That said, the study has various limitations that must be considered when presenting the team's final recommendations to the decision maker. For example, due to the nature of the stakeholders the team sent the ACA database survey to, its perspective is somewhat limited. These members of the AAC conduct studies and upload them to the database, meaning the information received from the survey was restricted to analysts, as opposed to ASLs or those who rely on the database to make informed decisions. Future research efforts will revolve around assessing the cost of the alternatives, incorporating uncertainty into the value measures' raw scores and assessing the impact via Monte Carlo simulation, and presenting a recommended solution to the client.

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