

Optimizing Operational and Engineering Models with Dynamic Visualizations for today's Warfighter

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ABSTRACT

The communications complexities in today's battlespace continue to increase at an exponential rate. The demand for fielding new technologies that operate as intended is critical to mission success. Our Joint Force is anticipating and entering an era where our tactical and operational dominance is in question and considers the environment where the potential enemy can interrupt and impede our military operations. So often, the warfighter is left out of the initial planning phase for new technology and capabilities, ultimately leading to mission failure. A common theme found between the acquisition and operational communities centers on the lack of actionable dynamic visualization capabilities that provide systems, data, requirements, and operational factors in a cohesive and dynamic format. The core focus of this paper will be examining how, by utilizing dynamic visualizations and dashboarding systems developers, acquisition decision makers, and operational users can produce results that set forth the foundational requirements for any organization. We have quantitative evidence that this process provides needed results and demonstrates the ability to streamline the developmental production with a critical ability to close operational imperative gaps. The differentiator between our approach and other similar efforts hinges on the success we have had in utilizing a suite of tools that fully integrate analytical rigor and warfighters with detailed dynamic visualizations that pave the way for the two to "co-exist" within technological development. By operationalizing Microsoft's Power Bi Dashboarding into a wholistic, system engineering, testing, and warfighting integration, we have been able to integrate old, new, and future capabilities that identify the operational "so what," providing end-users with a clear operational picture and increased systems engineering and operational efficiency. This paper will explore our methodology that modernizes the way decision makers, warfighters, and engineers see the battlefield through detailed analysis, graphics, and the powerful capability of dynamic data visualizations that build an optimal Course of Action within multiple Joint Mission threads. Augmenting such software combines Mean Operating Scores (Data & Modeling), Quality of Service (Operator Expertise), and an operationally informed Model Based Systems Engineering process to enhance new technology turnaround times and product leveraging across the community of interest. Additionally, it will also save considerable funding through the creation of a more streamlined and accurate systems acquisition process in support of Testing & Evaluation, Simulation Exercises and optimized platform-system configurations. Finally, the paper presents a full operational picture with detailed proven analytics, dynamic mission threads, and operational benefit for Warfighters & Engineers. The overarching components outlined in the paper will offer the community an essential and effective approach to bridging engineering solutions to successful operational outcomes.

ABOUT THE AUTHORS

Herb Honaker CDR USN (Ret), is a former Surface Warfare officer Operations Limited Duty Officer, and graduate of the Naval War College, specializing in National Security and Strategy. Mr. Honaker's 28-year Naval career encompassed Frigates, Cruisers, Destroyers, Carriers, Carrier Strike Group and numbered Fleet Command Operational Staff assignments as Joint Operations Center Director. Mr. Honaker is currently with Compendium Federal Technology serving as the Technical Director-Team Lead and Program Manager for the USAF Mission Capabilities Analysis Team supporting Air Combat Command Joint Base Langley Eustis.

CPT Logan Rash currently serves in the Virginia Army National Guard as a Military Intelligence Officer. He is an Intelligence Surveillance & Reconnaissance (ISR) Subject Matter Expert, proficient in conducting Intelligence Preparation of the Battlefield. Mr. Rash currently serves as a Data Manager and Intelligence Analyst for Compendium Federal Technology, designing executable missions' architecture and end-to-end mission analysis in support of USAF missions' communications solutions. Additionally, he implemented Microsoft's Power BI Dashboarding platform to create various analytical dashboards that depict critical gaps within COAs, communication transport layers, and fuses operational expertise with analytical data backed by various modeling programs.

Optimizing Dynamic Visualizations, Operational and Engineering Models for today's Warfighter

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INTRODUCTION

The development of new military systems consistently faces the challenge of requiring an improved, data-informed, and operationally influenced systems engineering process with a systems acquisition architecture developmental framework. Another issue is the inability of systems development engineers and warfighters to clearly visualize how new capabilities will translate into warfighting improvements. The lack of an actionable architecture, operationally informed systems development and acquisition capabilities, or solution sets all too often generates systems that fall short of the operational requirement, resulting in a stovepipe-disconnected end-to-end development process.

A common theme found between the acquisition and operational communities centers on the lack of actionable dynamic visualization capabilities that provide systems, data, requirements, and operational factors in a cohesive and dynamic format. The core focus of this paper will be examining how, through the utilization of dynamic visualizations and dashboarding coupled with integrated systems engineering and warfighters' participation, systems developers, acquisition decision-makers, and operational users can produce results that set forth the foundational requirements for any organization. We have quantitative evidence that this process provides needed results and demonstrates the ability to streamline the developmental process with a critical ability to close or find a higher degree of mitigation of operational imperative gaps. The paper will examine the process success we obtained in looking at a notional, ubiquitous Beyond Line-of-Sight (BLOS) tactical voice networking system design, development, and modeling with operational participation testing.

Additional focus will center on gaining an understanding of the operational speed, precision, and agility dependence on the ability to move information to the point of need, then developing that information into understanding, then translating that understanding into meaningful action from an end-to-end system concept, design, testing, acquisition, and integration with an operationally informed integration throughout the process. To guide the discussion, this paper is constructed to provide the reader with an understanding of and proposed solutions to address four specific areas:

- Relevant, actionable data informed architectures to guide system development and the acquisition process, coupled with an understanding or ability to articulate, with analytical rigor, the “operational impact – so what” of a new system(s)
- Operational integration and understanding throughout the concept, design, development, testing, and integration phases of the acquisition process
- Significantly enhance and enable systems engineers, acquisition decision makers, and the warfighter to have the ability to dynamically visualize and understand what a collection of capabilities will offer to influence and conduct successful operations
- The key to resolving a problem is first to understand what the problem is

OVERVIEW

Problem Statement

In general, the Joint services approach is a disconnected stovepipe with an acquisition structure that all too often is platform-centric, which hinders the rapid development of mission capabilities and enterprise solutions. The Department of Defense (DoD) leadership recognizes the benefits resulting from data valuation and the ability to assess trends based on the aggregate of data being produced. In addition, the service components across the DoD recognize the challenge of connecting tactical sensing to large-scale data analytics and cloud infrastructure. Like with any other machine-driven analytics, if the data being entered into the analytic process is flawed, then the outcome of the machine-driven analysis is also likely to be flawed. A requirement lacking an integrated developmental solution often ends in chaos. In **Figure 1**, we created a prime example of the problem set that developers and warfighters want to avoid. Even with a wide aperture of data, the core problem remains centered on two primary issues: the ability to understand the data from a value proposition perspective and the ability to visualize meaningful dynamic data with operational outcomes. A prime example of the data's value and visualization problem is gaining an understanding of how various communications technological improvements affect operational mission effect chains, which is crucial for the current Joint force structure to be fully successful in 2030 and beyond, given expected and emerging improvements in adversary capability to disrupt tactical and operational communications capability. The problem set is further complicated by the lack of a common touch point, creating a disconnect between the acquisition, engineering development, and operational warfighting communities. Our analysis experience and findings have consistently demonstrated the disconnect between the acquisition and operational communities. It was only through the development of dynamic dashboarding visualizations that we began to see a path forward to achieving success. It is our goal to explore our developed process within a demonstration use-case that is designed to address the problem set and solutions provided by an integrated developmental process that utilizes dynamic dashboarding visualizations as the centerpiece touchpoint.

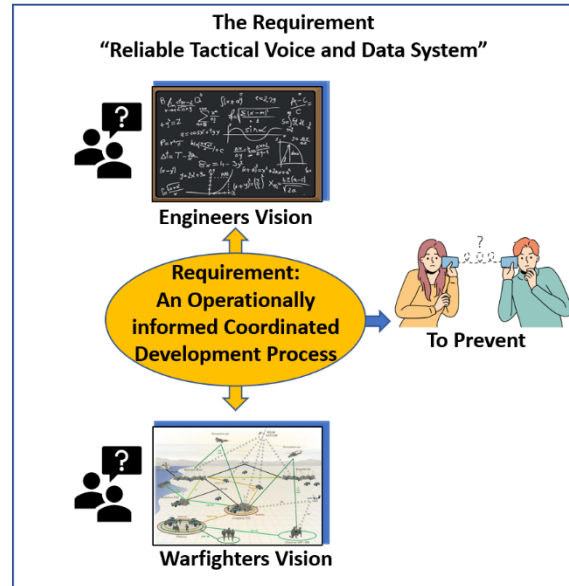


Figure 1: The Requirement Paradox

Background

The early 21st century presents new stressors for the integrated coordination requirements process. The era in which a warfighter had the comfort of conflict within a dominated Area of Operations (AO) has since passed. Modern-day warfighters face near-peer capabilities, relying on the best requirements process to maintain a tactical advantage in any AO. The absence of this overwhelming need for a fused requirement process has resulted in a growing tangle of new requirements, none of which holds the same lasting primacy. Simultaneously, the resources available to the warfighter to deal with current and new requirements continue to decline. The need to better visualize operational outcomes and synchronize platform interoperability is abundantly clear. A program of record that should be highly synergistic is instead published in a highly competitive market, which in turn creates stovepipes. This will become increasingly important as the complexity of national security continues to change. Few issues appear to have the luxury of time to be addressed and resolved.

Synergistic or fused development principles would make more efficient use of asset capabilities throughout the developmental process. The efficiencies gained would avoid duplication, introduce warfighter feedback, provide a more collaborative testing environment, and finally result in a seamless implementation plan. We believe there is a consensus that platforms are intentionally more effective when they operate together. However, historically, this approach has resulted in dysfunctional systems that fail to meet the intended requirements.

It's critical to understand the uphill battle of maintaining innovation for the warfighter, and it starts with the development of new capabilities. Today's military faces a significant inflection point that demands fundamental change or risks mission degradation or failure against near-peer threats. Similar to previous wars, some of the answers to the Joint Force's growing challenges lie in preexisting ideas already developed, tested, and proven by

different elements across the domains. They could simply lack the analytical testimony to lay old methods to rest and shift focus with a clear synergistic operational picture.

Communications are an essential component of virtually every aspect of our daily lives. This becomes even more crucial during the planning and execution of military operations. Designing, integrating, and operating with continued capability evolution is essential in defeating the adversary's ability to impact critical communications. It is well documented that National and Defense senior leaders, Combatant Commanders (CCDRs), and Joint Forces at all echelons require robust, multi-layer (subsurface and surface naval, ground, air, space, and cyberspace), high-capacity communications networks at all security levels to employ military capability across the range of military operations (ROMO) in support of national security objectives. Current operations highlight a number of capacity and joint interoperability gaps within and among aerial, space, and surface communications networks.

Communication nodes have insufficient diversity by both location and type to provide a resilient and agile level of protection, allowing for continuity of operations as other communication paths are lost, denied, or unavailable and to fill gaps in capability. Closely related to this discussion are questions of "what" and "how much" to develop and procure in an environment of technological risk and fiscal constraint. Quantity, quality, and understanding of "data" are at the heart of the issue. Modeling and Simulation is certainly not a new concept, nor is the production of data; both remain a centerpiece of answering core requirement questions while influencing the acquisition process. The gap that exists, though, is understanding "so-what" of the system(s) or capabilities being analyzed. As we enter 2023, we find computing power, data lakes, data clouds, and graphical capabilities have significantly surged during the past five years. We are realizing we are on the precipice of meaningful Artificial Intelligence implementation geared toward a dramatic innovation explosion. The perceived innovation is exciting and is sure to bring about world changing future capabilities, which is what the "but" here centers on. We will have large amounts of data, but how does that translate into a meaningful application to the end user commercially or to the operational warfighter.

Given the wide breadth and aperture of technological improvements and innovation, one could logically conclude that the operational value-added question would be readily attainable. However, we find that this is not necessarily the case. Take, for instance, the advances in data visualizations, simply having great visuals with no context or understanding with no direct correlation to answering a specific question becomes more of a hindrance than a solution. Enter into the equation the application of data visualizations coupled with dynamic dashboarding. Data visualizations with interactive dashboards continue to improve and are found useful in multiple application areas, especially for commercial and data centric users. Interactive dashboards with unique visualization experienced significant growth during the COVID-19 global pandemic. These dashboards were prevalent at the global, national, state, and local level. It was during this period that we began to theorize the applicability of dashboarding to our specific problem sets of systems and capabilities development processes with the ability to influence the outcomes in a meaningful way for the end user. We quickly discovered that simply throwing a bunch of data on graphs, tables, and graphics on a page wouldn't achieve the desired end results; what is needed are meaningful data visualizations.

The need for meaningful data visualization was summed up nicely in the Data Visualization paper published by Anthony Unwin, "there are great opportunities for future research in data visualization. Principles are needed on how to decide which of many possible graphics to draw. It is not a matter of drawing a single, 'optimal' graphic, if such a thing even existed; it is a matter of choosing a group of graphics that will provide more information. It is like taking photographs of a complicated object, a single one would not be enough, and taking pictures from every possible angle and distance would be far too many". (Unwin, 2020)

APPROACH

The main approach to identifying the operational "so-what" centers on finding the operational value added of new capabilities, which requires a multi-component process approach. The multi-components consist of transforming static architectures to executable architectures, generation of systems capabilities, and creation and implementation of dynamic visualizations, all of which are required to reach and understand the value added of a new collection of capabilities' impact on operational outcomes. An operational mission use-case will be explored in order to gain a better understanding of the process while demonstrating how impactful generating systems and operational data informed dynamic visualizations can be.

OPERATIONAL MISSION TO FINDINGS USE CASE

Background

The US Air Force's Agile communications development process involves various research efforts focused on future complex communications technologies and systems. Given the complexity and rapid developmental speed of future communications technology and capabilities, it is also apparent that success will also greatly depend on developing and implementing a rapid, more robust modeling, simulation, and analysis (MS&A) process and activity is required in order to provide the desired results that are efficient and relevant. The intent and purpose of conducting operation analysis is to provide quantitative data for the various proposed communications and networking solutions with results that are focused on the operational effectiveness and benefit to the warfighter, to include Tactical, Operational and Strategic level of warfare planning and execution. The analysis has to address Measures of Effectiveness (MoE) and Measures of Performance (MoP) in order to provide a credible basis for subsequent cost-benefit analyses and advocacy of potential solutions. The goal is to help the warfighter understand what's happening within the data, so that they have the ability to make confident decisions based on the M&S analytics.

Central to achieving the core objective of dashboarding is providing architecting structured data linkages to leverage mission analysis data findings and generating visual analytics to enable the decision-maker and users to compare data across time, function, and tasks in order to ascertain effects, outcomes, communications, and networking improvements to make a difference by measure. This is where integrating a dynamic approach to data analytics and visualization is best utilized. Our team conducted a tool-set meta-analysis and found that Microsoft's PowerBI software offered an incredibly beneficial technological tool with the ability to transform various types of data into usable, network-enhancing solutions; by collecting, assessing, and analyzing data through dynamic visuals. Applying a dynamic visualization, the warfighter is able to make meaningful decisions about future practices, monitor critical data, and identify intelligence gaps throughout the interactive visualization. These fully customized and detailed visuals will compare and contrast operational mission processes, communications, and networking data across multiple Strategic, Operational, and Tactical execution components. Additionally, they can be combined with on-premises and cloud-based data in single-view visualizations across multiple domains.

Effects-Based Assessment

Operational Need for Data Fusion: The Tactical Voice Networking Effects-Based Assessment use-case demonstrates how significant an operational benefit is obtainable through the implementation of data fusion. Data is useful and more attainable when combined with information generated by all devices and systems, not just at a single site but across all sites. Filtering the data with different criteria and clearly visualizing the obtained information makes it possible to utilize the information in decision-making in a new way. At the same time, the data generated by modeling and simulation (M&S) can be used to automate processes and make operational and strategic reporting information available to the organization in the required format for various uses.

The use-case will employ developed dynamic visualization processes and methodologies to move beyond the static data and encompass a more dynamic approach. The focus will be on the ability to effectively assess the new capabilities being designed and presented to the warfighter, which requires a multi-step process informed by numerous inputs and a doctrinally sound operational scenario to serve as the backdrop for the overall analytical effort.

Pushing data along the track without knowing or understanding the value proposition of the data is striking and often a fact in many analytical projects. To move beyond just pushing data around, we have found significant success in adopting commercial dashboarding capabilities into the overall analysis process. This proposition was that through a better visualization process, the engineers, the requirements generators, and the operational user would all find a means in which to see the information in a meaningful format.

In a Massachusetts Institute of Technology (MIT) Research study, "Dashboarding Pays Off," published in January 2022, it was found that companies that are highly effective at dashboarding outperform. The research highlighted several reasons for the effectiveness of dashboarding, with one of the most crucial being the visibility it provides to all stakeholders, enabling them to gauge performance against agreed-upon metrics and collaboratively implement course corrections when necessary. Drawing from these commercial dashboarding principles and tools, a compelling

opportunity emerges to apply them within DoD's system requirements, design, testing, integration, and full operational deployment capabilities. By adopting such an approach, the DoD can benefit from enhanced insights and collaborative decision-making, thus bolstering the efficiency and effectiveness of military operations.

In applying the commercial dashboarding principles, the overarching process will consist of utilizing operational and analytical visualization dashboarding techniques to compare and contrast operational mission processes, communications, and networking data across multiple Strategic, Operational, and Tactical execution components. The core focus of the analytics and dynamic dashboards will be to enable:

1. Focus on operational outcomes and creating a scalable analytical environment
2. Provide meaningful data that has been evaluated for its value rather than just pushing data along the track without knowing or understanding the value proposition of the data
3. The warfighters' ability to make meaningful decisions about future practices, monitor critical data, and identify intelligence gaps throughout the interactive visualization
4. Utilize dynamic dashboard visualizations as the primary interface that presents metric information, graphical representations, and recommended actions for optimization for the various courses of action under analysis

DEMONSTRATION USE-CASE

Overview

The USAF Agile communications process is involved in various research efforts focused on future complex communications technologies and systems. Our demonstration use-case, BLOS Tactical Voice Networking Experiment battle simulation specifically examines success achieved in the employment of our process with dynamic visualizations – dashboarding representing the centerpiece of the analysis. To support the communications development effort, engineering, live operator participation, and an operational benefit analysis were conducted to provide an operational assessment and benefit analysis of new technologies being garnered through Agile Communications. The experiment was designed and conducted with two main objective components:

1. Ascertain the ability of the new BLOS transport layer capabilities to close the voice links via a secure means coupled with cognitive routing
2. Determine the acceptable voice quality at an operationally executable level of each of the capabilities under analysis. The experiment additionally looked at variances for various forms of interference and the associated impacts.

To support the objectives, the analysis team generated several key operational components supporting the communications experiment, including:

- Command and Control (C2) vision, Information Exchange Requirements (generation/refinement)
- Operational Measures of Effectiveness (MoE) to include supporting Measures of Performance (MoP)
- Execution of operational analysis in support of the BLOS Tactical Voice Network Experiment (BLOS TVNE) and Operator Experiment culmination event in the "2030+ To-Be" operational environment, providing a high-level assessment and operational impact

Analysis Intent

The intent of conducting operational analysis is to provide quantitative data for the various proposed communications and networking solutions with results that are focused on the operational effectiveness and benefit to the warfighter, including tactical, operational, and strategic levels of warfare planning and execution. Operational analysis by trade is a method of examining the current performance of an operational (or steady state) investment and measuring that performance against an established set of cost, schedule, and performance parameters. The critical element is to identify specific objectives or goals that an organization or individual seeks to achieve through data analysis. By aligning the analysis intent with the dashboarding capabilities, organizations can develop

dashboards that are tailored to the specific needs and objectives of the users, and that enable them to visualize and analyze data in a more efficient, effective, and meaningful way. This sets the foundation for the objective of dashboarding operational analysis. Here are some examples of how analysis intent can be aligned with dashboarding capabilities:

- Real-time monitoring: If the analysis is to monitor Key Performance Indicators (KPIs) in real-time, the dashboarding capabilities should include features such as data streaming, automatic data refresh, and real-time alerts.
- Customizable features: The dashboarding capabilities should include options for users to choose the metrics they want to see, adjust filters and parameters, and customize the layout and design of the dashboard.
- Interactive data exploration: If the intent of the analysis is to enable users to explore and analyze data in a more interactive and dynamic way, the dashboarding capabilities should include features such as drill-down, filtering, and sorting options, interactive charts and graphs, and data visualization tools.
- Comparative analysis: If the intent of the analysis is to compare different sets of data or metrics, the dashboarding capabilities should include features such as side-by-side comparisons, trend analysis, and historical data tracking.
- Collaborative analysis: In order to facilitate collaboration and teamwork among users, the dashboarding capabilities should include features such as data sharing, commenting, and annotation, as well as the ability to assign tasks and track progress.

Objective

What sets this process apart from the many others that harness the potential of dashboards? As previously mentioned, the fundamental objective here is to enable warfighters to grasp the dynamics of the data, empowering them to make well-founded decisions based on that comprehension. Dashboards serve as comprehensive snapshots of performance. Given their dynamic nature, users can delve deeper by clicking on specific performance areas to access more intricate details. At its core, a dashboard functions to deliver dependable outcomes by aggregating and extracting value from the entire pool of collected data, commonly referred to as Key Performance Indicators (KPIs). By presenting visual information in manageable segments, it facilitates the identification of areas warranting enhancement. Dashboards prove instrumental in making informed decisions that wield a substantial influence on performance, a critical aspect in this context that directly impacts operational outcomes.

However, what truly distinguishes the process adopted in this use-case is its deliberate focus on integrating warfighters and engineers, eschewing a multi-perspective approach in favor of a synergistic alignment with a single perspective. The uniqueness lies in the precision of this alignment, creating a cohesive synergy between the expertise of warfighters and engineers. This synchronization streamlines decision-making, ensuring a unified understanding of the data's implications. Additionally, the process places emphasis on not just data visualization, but data interpretation. By fostering a more intimate connection between those who execute missions and those who design the capabilities, it catalyzes a more effective transformation of data into actionable insights. This collaborative approach minimizes misinterpretation, ensuring that decisions are rooted in a holistic understanding of operational requirements.

In essence, this process merges the art of decision-making with the science of data analysis, creating a bridge between the two that is fortified by the seamless integration of warfighter and engineer perspectives. This tailored alignment significantly enhances the precision, relevance, and impact of the decisions made, ultimately elevating operational outcomes to a new echelon.

Figure 2 illustrates how the use-case scenario incorporated an operator's Quality of Service (QoS). Once fused with engineering data, it produced a clear single page canvas of operational findings. During the conduct of the use-case, the sheer number of voice transactions between the assigned platforms coupled with the technical communications Measure of Suitability (MoS) standards under analysis made it nearly impossible to produce a visual MoP for the decision authority without a capable visualization toolkit. When comparing dashboards to reports, reports are text-based, whereas dashboards are visual. Simply put, the information in a dashboard is easier to consume than a report because, as viewers, it's easier to understand information presented to us through visuals more quickly than through a page of text or PowerPoint. Central to achieving the core objective is articulating structured data linkages that leverage mission analysis findings and generate visual analytics, allowing decision-makers and users to compare

data across time, function, and tasks in order to ascertain effects, outcomes, communications, and networking improvements that make a difference by measure. This level of meta-analysis can only be achieved by introducing an integrated, dynamic approach to data analytics and visualization, utilizing a dashboarding toolkit.

By harnessing the power of visualizations, the warfighter gains the capability to make informed and impactful decisions regarding future practices, while also being able to monitor critical data points and identify intelligence gaps. The interactive visualization facilitates detailed comparative analysis, empowering the warfighter with essential insights crucial for strategic, operational, and tactical success.

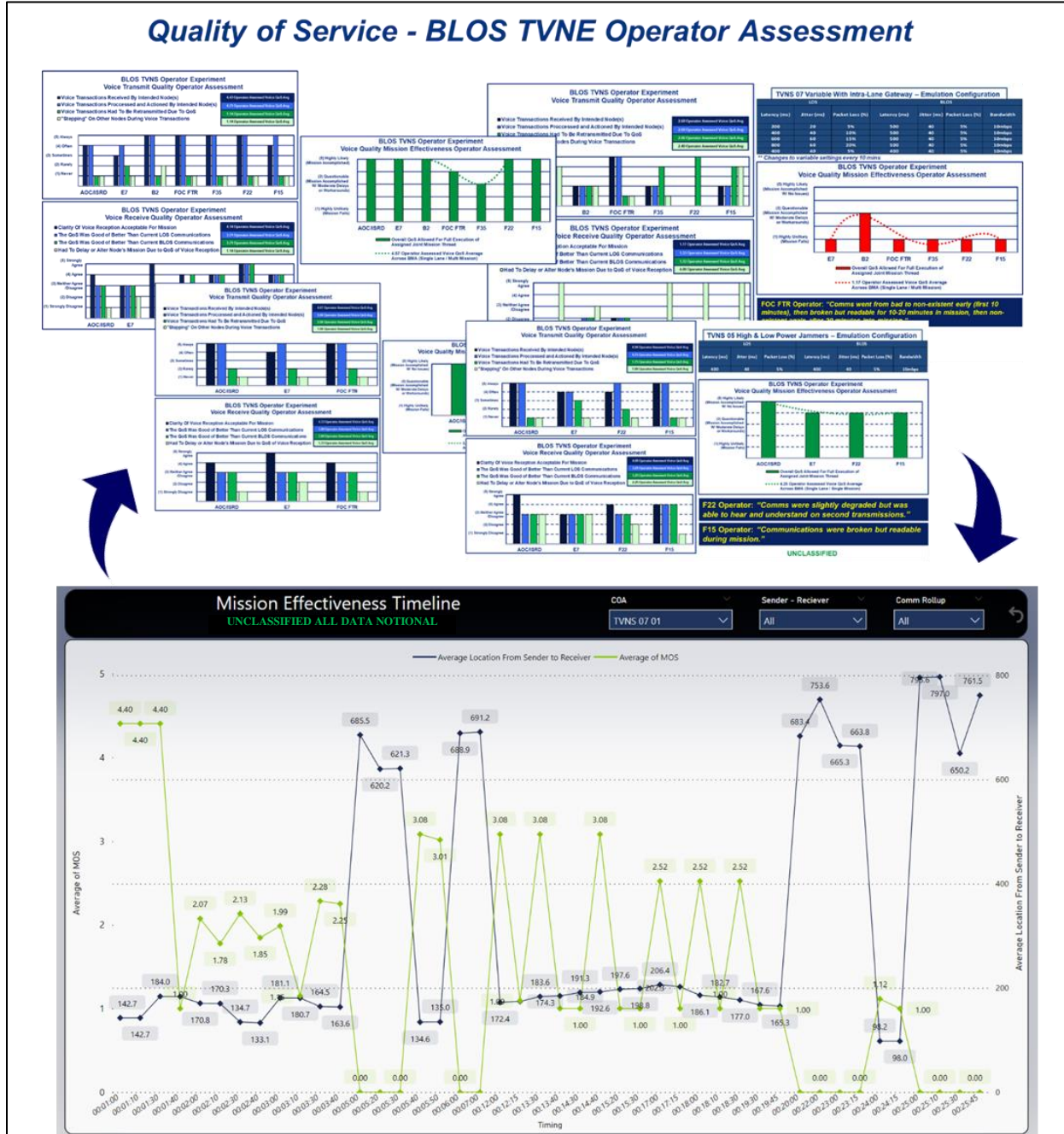


Figure 2: Fusion of QoS / MoS

Use-Case Operational Benefits

Figure 3 provides an example of the effective use of the dynamic dashboards to articulate the use-case COA effectiveness and mission-effective timeline dashboards, which were generated from over ~750,000 data elements, capturing the culmination of nine detailed operational effectiveness scenarios, supporting multiple Joint Mission Threads under analysis and testing.

Leveraging the distributed interactive simulation and dynamic operational battlespace modeling capability resident in Advanced Simulation Combat Operations Trainer (ASCOT) and the BLOS / LOS voice capability rendered within a use-case next generation capability, leveraging the Subject Matter Expertise (SME) to provide operator assessments for each COA mission run conducted during the OE. Utilizing the operator assessment and analytic example, the use-case end-to-end Air Tasking Order (ATO) Joint Mission Thread scenarios provided each operator the ability to provide voice transmission quality, voice reception quality, and overall mission assessment of the BLOS and LOS voice QoS. Furthermore, post-mission “hot wash” debriefs were conducted on station to allow operators to articulate real-time feedback and recommendations for the data



Figure 3: Use-Case Course of Action Effectiveness Dashboard

collection process and operational analysis. Typically, presentations would be utilized to display the information backed by analytical data elements spread over multiple spreadsheets or similar artifact databases, making it difficult to visualize the comparative findings. However, the dashboard visuals developed for the BLOS TVNS use-case provided the development engineers and operational warfighters the ability to see multiple data MoPs, which included QoS, in comparison to range and sender-receiver pairings. The comparative analysis also included the multiple test configuration results, providing significant insight into the overall effects of the application of various capabilities. Observing the visualization on the dashboard offered a substantial level of comprehension, which was significantly enhanced by the seamless ability to slice the data and observe its impacts without the need to navigate between multiple slides or Excel worksheets.

Employing the highest caliber of Joint and USAF Strategy, Operational, and Tactical SMEs was the cornerstone of mission success during this use-case initiative. From the proficient pilot in the cockpit display to monitoring the successful exchange of Information Exchange Requirements (IERS) in the Joint Operations Center or Joint Interface

Control Cell, the collective experts representing the warfighter in the use-case emulation environment were crucial to the end-to-end development and flawless execution of the analysis. With the warfighter integrated and terabytes of meta-data from running the simultaneous modeling capabilities, it was time to “data whisper”.

Once more, dashboards were employed to quickly make data-driven decisions that drive strategic Agile Communications requirements strategies, specifically targeting the “what” and the “how,” two extremely critical components of the requirements process. Utilizing dashboarding tools, we were able to collect, analyze, process, disseminate, and visually display the use-case results rapidly to decision-makers, feeding the Agile Communications decision-making cycle. The analysis findings concluded that through the implementation of solutions as presented in the use-case communications initiative, along with these findings and recommendations generated in the report, the USAF warfighter can realize substantial increases across the USAF Enterprise domain. It also indicates that the investment in Agile Communications is beneficial to overall mission success, but still requires further and more complex analysis. These benefits include:

- Agile Communication as the Operational with Battle Management C2 and at the Tactical Edge to support information sharing and combat effectiveness
- Assured – Time-Sensitive information to the Tactical Edge
- Providing valuable insights for long-term strategic planning and resource allocation.
- Developing a strategy at the USAF Enterprise level will promote a greater increase in connectivity between air and ground networking tiers, increase interoperability between Service and Joint Forces, and provide significant improvements to operational mission effectiveness in the contested environment. Maximum benefit requires a coordinated implementation strategy at the USAF Enterprise level to ensure interoperability amongst air and ground platforms.

The analysis shows significant operational benefit is achievable through the implementation of an enterprise-wide capability integration effort as represented in Agile Communications. The dashboard visualizations were instrumental in highlighting the ability to achieve the greatest operational benefit and relevance. The process we utilized for the use-case provided significant insight and established a framework within, which we progressed to the next phase of assessing a larger and more complex campaign level use-case scenario. The campaign level use-case produced tera bytes of data elements making it extremely difficult to visualize and understand the engineering or operational outcomes’ impacts. When examining **Figure 4**, we can see how it demonstrates the value of processing large quantities of data, as would be expected from a campaign level use-case scenario. The data displayed in Figure 4 articulates a *process decomposition diagram (decomps)*, depicting the breakdown of processes and relationships among IERs within different configurations. The purpose is to show all the processes and identify relationships and dependencies among them. Decomps play a critical role in the “what” or the operational “so-what” phase by addressing the five “W’s”. The decomposition functions by creating detailed relationships among “parent nodes,” in this case, “communication configurations,” highlighting how each configuration produces different outcomes for the data. Users are able to move through the data and identify critical gaps, as well as perform on-demand comparative analysis of different communication configurations.

In large-scale campaign-level analysis efforts, maintaining a clear operational picture can be challenging. By utilizing decompositions to analyze nearly 17,000 IERs across 22 Joint Mission threads and six different communication configurations, decision-makers of all types can effectively organize and access data. The true power of the decomposition tree lies in its ability to focus on the mission outcome, which is derived from the selected capabilities. The mission outcomes have several input requirements: capability package, mission under test, categorization of information exchange requirements, specific transport layer element, capability characterization assessment of the transport layer element, threat (environmental impacts), risk to the mission, and finally the mission success outcome. The power of the dashboard lies in its capacity to slice multiple transport layer elements and see the mission outcome coupled with roll ups of specific data artifacts such as the percentage of Catastrophic, or Critical information exchanges being impacted. The mission analysis data can be informative to both the engineer and the operational planners. Development engineers can ascertain the impact or benefit of various capabilities under development, while operational planners can select platforms with optimal systems to attain the maximum operational benefits.

Overall, adeptly navigating operational dashboarding decompositions can reveal invaluable insights that foster informed decision-making. The identification of pertinent dimensions and metrics, the application of appropriate filters, and the execution of insightful data exploration collectively facilitate the extraction of actionable information.

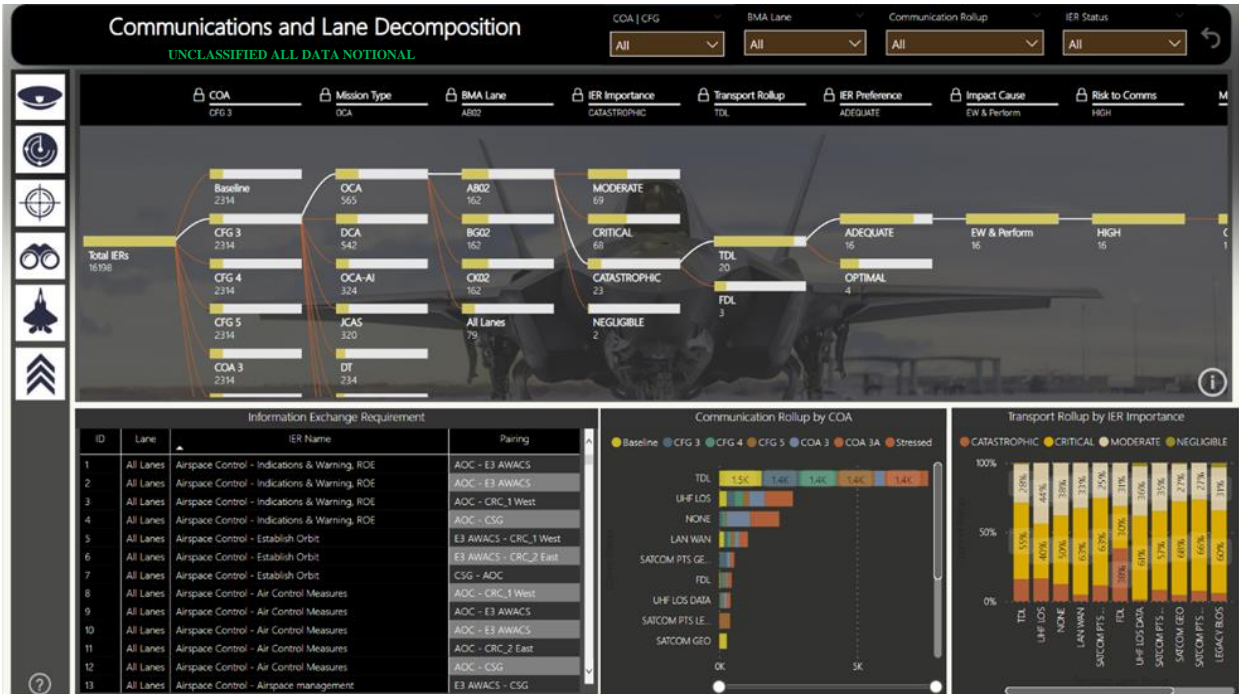


Figure 4: Use-case Campaign Scenario Decomposition Diagram

Research conducted by MIT Center for Information Systems Research (CISR), published on January 2022 stated that “In an analysis of recent MIT CISR survey data to explore the impacts of dashboarding, we found that

companies with top quartile dashboard effectiveness significantly outperformed bottom quartile companies on five internal and five external measures of performance (Figure 5).” When it comes to displaying and conveying large quantities of meta-data, it’s abundantly clear that dashboarding is the current best option for achieving overall effectiveness. There are many reasons why dashboarding is so effective, but perhaps among the most important is the ability to clearly and accurately conduct comparative analysis within a decomposition diagram.

MEASURES OF PERFORMANCE	BOTTOM QUARTILE DASHBOARD EFFECTIVENESS	TOP QUARTILE DASHBOARD EFFECTIVENESS
INTERNAL		
Percent complete on transformation	39%	63%
Percent effectiveness of the future-ready drivers	40%	78%
Effectiveness of leaders in moving orientation from Command and Control to Coach and Communicate	35%	78%
Effectiveness of leaders at holding people accountable	40%	75%
Employee experience, compared to industry	51%	65%
EXTERNAL		
Net profit margin, compared to industry1	-9.4 pp	8.4 pp
Revenue growth, compared to industry1	-13.4 pp	11.0 pp
Percentage of revenues from innovations introduced in the last three years	22%	49%
Percentage of revenues from cross-selling	20%	46%
Customer experience, compared to industry	51%	66%

Figure 5: MIT CISR (Jan2022) Dashboarding MoP Analysis Findings

As dashboards move closer to sharing real-time data into business and operational segments, it will become more effective and useful in any meaningful decision-making process and ease course correction moving forward. COA Mission Effectiveness, though much of the data is static M&S meta-data, the dashboard filter panel displays the

source of the data being examined and options to drill down on geography, scope, over effectiveness and much more.

CONCLUSION

Applying an integrated approach to requirements, systems engineering, and operational warfighter participation with dynamic visualization enables engineers, acquisition decision-makers, and warfighters to clearly visualize how new capabilities will translate into warfighting improvements. The process will further be immensely beneficial in reducing developmental timelines, costs and mitigating the all too often redesign due to end products falling short of the warfighter's requirements. The findings consistently highlighted the importance and benefits of an integrated systems engineering and operational architecture. Applying a dynamic executable architecture proved to increase the benefits of the overall systems capabilities' development process. The game changer occurred when applying the dynamic visualizations as a core piece of the process, which provided the ability to access large volumes of completed communications and networking analysis in order for the warfighter and requirements developer to understand an individual or combination of capabilities that offer the impact analysis on the ability to conduct successfully operations. The capability to visualize what communications - networking capabilities are available on each platform and the impact of interaction in a warfighting scenario served as a core foundation and is enabled through multiple products, which also include requisite metadata generated from multisource analysis. Our multi-scope perspective provides a comprehensive evaluation of opportunities, prioritizes effective Joint Mission Threads, and designs roadmaps and outcomes that assess the progress of mission capability initiatives. The interactive products offered in this approach include:

- High-Level Assessments / Assets – Command and Control Apportionment / Operational Impact Assessments
- Communications – Networking Capabilities Decomposition

By utilizing this comprehensive and dynamic approach, military systems development can greatly enhance its capabilities, ensuring the successful execution of critical missions and operation. Several benefits were observed, including:

- Ability to articulate the operational needs, gaps, risks, and mission effects
- Format to provide the operational "*So What*" to new capabilities and technology maturation
- Provide a high-level process to measure communications, networks, and systems' effects or lack of effects on mission outcomes within varied environments (Permissive, Contested, Highly Contested)
- Generate a venue to confirm or derive requirements
- Identifies areas where detailed engineering analysis is / may be required

The innovative process we have developed offers a unique approach to understanding the value of "data" and provides traceability of how data or a collective set of data potentially influences the required mission effects and serves as a significant commercial application influencer. The importance of "data" from a commercialization perspective serves DoD and the commercial sector, which both share a demonstrated need to communicate effectively. Especially important to these effective communications is the ability to provide the right data to the right node at the right time. Civil emergency response is a prime example of the commercial value of the capabilities offered in this proposal. The "right data at the right time" need is significant and prevalent at all emergency response echelons, either in a localized, regional, or nationwide framework. The solutions presented in this paper offer the ability to construct requirements and solutions that are flexible, and supported by persistent, collaborative information-sharing capabilities, which are critical in meeting an efficient response to challenging emergency response events.

To provide a succinct overview and underscore the various advantages outlined in this paper:

- Dashboards are proven to provide real-time situational awareness updates on critical information such as troop movements, equipment status, logistics, intelligence data, and operational metrics. This process enhances overall situational awareness by offering a centralized view of essential information, enabling commanders to make informed decisions promptly.
- Military decision-making relies on accurate and timely information. Dashboards facilitate data-driven decision-making by presenting relevant data in a visually accessible format. Commanders can monitor

- mission-critical metrics, assess risks, and identify trends, allowing for more effective planning, resource allocation, and strategic decision-making.
- They streamline operational efficiency by presenting KPIs and metrics related to training, logistics, maintenance, and resource allocation. By visualizing this data, military leaders can identify bottlenecks, optimize resource allocation, and improve overall operational efficiency.
 - Dashboards assist in managing military resources effectively. They provide visibility into resource utilization, including personnel, equipment, fuel, and ammunition. By monitoring resource availability and consumption, military leaders can optimize logistics, avoid shortages, and ensure resources are allocated where they are needed most.
 - By utilizing dashboards, you can enable the evaluation of military operations and performance. By tracking metrics such as mission success rates, training performance, and operational readiness, commanders can assess the effectiveness of strategies, tactics, and training programs. This information can then be used to identify areas for improvement and implement corrective measures.
 - Capture and analyze data from past military operations, facilitating after-action reviews (AARs). By reviewing metrics and data visualizations from previous missions, commanders can identify lessons learned, identify areas for improvement, and develop more effective tactics and strategies for future operations.
 - Dynamic visualizations enhance communication and collaboration within military organizations. They provide a centralized platform for sharing information, disseminating orders, and coordinating activities across units and command levels. Shared dashboards promote transparency, align objectives, and facilitate effective teamwork.
 - Integrating intelligence data from various sources, including surveillance systems, reconnaissance assets, and information databases. By visualizing and analyzing this intelligence, military analysts can identify patterns, detect threats, and gain insights to support tactical and strategic decision-making.

In conclusion, the ability for the warfighter to understand what's happening in real-time is more valuable than ever. Furthermore, the ability to make confident decisions based on that understanding is essential for helping the warfighter adapt and thrive—even as circumstances change rapidly. Armed with this data, operational and acquisition decision-makers are afforded the opportunity to make informed decisions based on something more than a “gut” feeling. The overall intent was to provide a complete set of tools in which the greatest bang for the buck is realized, with the ultimate intent of increasing our forces' survivability, reducing fratricide, and markedly increasing the potential for overall mission success.

REFERENCES

Antony Unwin, January 31, 2020. Why is Data Visualization Important? What is Important in Data Visualization? HARVARD Data Science Review - MIT Press On-Line Issue 2.1, Winter 2020. from <https://hdsr.mitpress.mit.edu/pub/zok97i7p/release/4>

Weill and Woerner, January 20, 2022. Dashboarding Pays Off, MIT Center for Information Systems Research, NO. XXII-1. From https://cistr.mit.edu/publication/2022_0101_Dashboarding_WeillWoerner

Jerry “Marvin” Gay, Modernizing C2 of ISR – Part 2: Breaking ISR’s Industrial Age Chains, Over the Horizon Multi Domain Operations and Strategy, November 18, 2018 from <https://overthehorizonmdos.wpcomstaging.com/2018/11/23/modernizing-command-control-of-isr/>

Microsoft PowerBI Desktop Version: 2.115.663.0 64-bit (March 2023). <https://powerbi.microsoft.com/en-us/>