Unclassified: Dist A. Approved for Public Release

2016 NDIA GROUND VEHICLE SYSTEMS ENGINEERING AND TECHNOLOGY SYMPOSIUM
SYSTEMS ENGINEERING (SE) MINI-SYMPOSIUM
AUGUST 2-4, 2014 – NOVI, MICHIGAN

THE RDECOM INTEGRATED SYSTEMS ENGINEERING FRAMEWORK (ISEF) AND ITS USE IN SUPPORT OF THE COMBAT VEHICLE PROTOTYPE (CVP)

Edward Umpfenbach, PhD
Chief Architect – PM ISEF
US Army-TARDEC
Edward.L.Umpfenbach.Civ@Mail.Mil

John Blasky
Chief Engineer – PM CVP
US Army-TARDEC
John.P.Blasky.Civ@Mail.Mil

Abstract

The Integrated Systems Engineering Framework (ISEF) is an RDECOM solution to capture, leverage, and preserve/reuse Systems Engineering (SE) knowledge generated throughout a system's lifecycle. The framework is a system of tools designed to support decision making with confidence through embedded SE process management, high quality data visualizations, and system lifecycle information traceability. A web based tool architecture supports near zero IT footprint and allows real time collaboration between team members.

The Combat Vehicle Prototype program is a large S&T effort within the Army community to create a virtual demonstrator to influence the next Future Fighting Vehicle program of record. The program is made up of "leap-ahead" technology development efforts pursuing TRL 6 demonstrations. These technologies are being coordinated with the CVP central program office to ensure an effective system level concept is transitioned at the end of the program.

This paper will begin by providing an overview of current capabilities within ISEF as well as in-development and funded efforts to come in the near future. Next, it will discuss the implementation of the ISEF toolset on the CVP program, success stories, and areas for improvement through continued development.

1. Introduction (ISEF)

1.1 What is ISEF?

The Army Research Development and Engineering Command (RDECOM) Integrated Systems Engineering Framework (ISEF) is a collection of government and commercial SE tools. ISEF tools can be applied to all levels of systems, subsystems, and systems-of-systems. ISEF provides DoD engineers with common tools and processes, while minimizing knowledge loss that is inherent in document-artifact based systems engineering processes. The mission of ISEF is to provide a collaborative, integrated environment for the practice and management of systems engineering knowledge. ISEF tools have been adopted (to various degrees) by organizations across all 4 DoD services as well as the Department of Homeland Security.

1.2 Why Build an ISEF?

A voluminous list of publications could be assembled that discuss the problems of the defense acquisition process over the last 50 years. Neches (2011) states that the struggles within the Department of Defense to manage an exponential explosion in product complexity through acquisition process reform have been unsuccessful. While acquisition process reform is a part of solution, it needs to be combined with improved tools capability, increased collaboration and information sharing, and continued continuous improvement efforts. The OSD Better Buying Power Initiative (Kendall, 2016) advocates principles of (among others):

1) Continuous improvement over radical change.

2) Data-driven policies.

3) Strong critical thinking in the face of complex challenges.

4) Defense acquisition is a team sport.

These principles can be explicitly mapped to ISEF objectives to improve SE practice within the DoD through the creation of a collaborative, decision-driven SE framework.

The ISEF value proposition can be broadly broken down into five aspects:

1) A framework connecting disparate SE tools that are used throughout the product lifecycle by a diverse set of users enables lifecycle traceability that would not otherwise be capable through document-based Systems Engineering. *Example:* Program risks are a consequence of choosing an alternative in a decision. A risk could have been avoided by choosing a different alternative. Tracing this relationship is important to effective risk management.

2) Government-owned tools can have a significant cost advantage to commercial counterparts, especially for tool in domains with broad applicability. Detailed cost data will not be discussed in this paper.

3) A "cloud-based" infrastructure is ideal for government tools to reduce IT costs, improve application security, and promote application accessibility. *Example:* Security updates pushed to a server application do not need to be pushed to the desktop computers that connect to it through a web-browser.

4) Leveraging an object-oriented SE approach in which classes of SE data are organized and stored within a database improves the knowledge preservation of the technical data gained from a DoD program and enables continuous improvement of SE artifacts through traditional and pattern learning. *Example:* Explicitly capturing decision-maker priorities in a tradestudy allows

the decision to be better understood years later if leadership changes.

5) Providing a common look-and-feel to various SE tools reduces the learning curve to move from tools targeted at one SE domain to another. *Example:* A requirements manager may need to give input into a risk mitigation plan. Commonality between the requirements and risk tools being used by a program will allow that person to use the risk tool with minimal training as compared to a dissimilar tool.

1.3 What is CVP?

In 2014, senior Army acquisition executives decided to cancel the Ground Combat Vehicle (GCV) program of record, an effort to produce the next Army Infantry Fighting Vehicle (IFV). It was determined that the GCV requirements with respect to cost, weight, survivability, and other objectives were not achievable given the current state of ground vehicle technologies. These senior decision makers “rolled-back” the program to a science and technology (S&T) effort to utilize the portfolio of technologies to mature into a CVP integrated concept. The initially identified 43 technologies were targeted to demonstrate their increased leap ahead performance, flexibility, and modularity while making the vehicle lighter. These technologies would demonstrate a technology readiness level of 6 for the subsystems by the end of fiscal year 2019. This mature set of technologies will be passed on to industry partners and the future vehicle programs and influence the Army’s IFV requirements. The CVP program is a TARDEC led program that coordinates these technologies to integrate in the CVP concept through systems engineering practices.

2 Current ISEF Capabilities

ISEF Desktop (All Tools): Set up data schema (specific attributes to associate with SE data types). Capture document attachments, discussion threads, and history.

Project Recon: Capture risks, issues, and opportunities. Define risk mitigation plans and action steps. Auto-generate reports for leadership.

Decision Management & Analysis: Create a decision breakdown structure. Capture and trace decision criteria, alternatives, and consequences. Score alternatives and chart performance. Document decision status. Perform “what-if” analysis. Roll decision alternatives and consequences up from component to subsystem to system.

Requirements Management: Create requirements. Trace to needs (CNAs, WFOs, etc). Execute functional decomposition. Live push/pull data from IBM DOORS®.

Dashboarding: See summary views of cost/schedule/performance data. Create stoplight charts. Search across datasets for keywords. Subscribe to data and be notified immediately of changes.

Compliance Evaluation: Overlay compliance and test data on top of requirements data. Roll compliance up from system to source requirements (i.e., from P-spec to CDD). Chart requirements compliance and test data trends.

Roadmapping: Lay decisions or projects out over time. Identify capability gaps between warfighter needs and current or predicted technology performance. Display technology dependency relationships.

Architecture: Capture a hierarchical breakdown of physical or logical architectures. Allocate requirements to architecture objects. Read SysML XMI architecture exports.

Common Pattern Tool: Understand patterns (decision patterns, requirements patterns, etc) and facilitate pattern learning by displaying changes that users make to pattern instances.

Voice of the Customer: Capture PM 1-N needs lists. Capture warfighter discussions and lessons learned at soldier feedback sessions.

N-Squared Interactions: Capture interaction relationships between ISEF objects. Classify interactions by type (electrical, mechanical, etc). Generate interface documents.

3 ISEF Use on CVP

3.1 CVP Requirements

Figure 1 shows the structure of the CVP requirements modules and the traces between the different requirement sets. Source requirements from the GCV and Bradley programs were imported into the ISEF Requirements Tool. A copy of the GCV P-spec served as the starting point for the CVP System Requirements but modified to accommodate for 18 high-level needs that originated with Army executive leadership. The CVP program needs were allocated to tech area needs and the CVP System Requirements were allocated to Tech Area P-Specs. Additionally, the CVP System Requirements were allocated to a CVP Logical System Architecture represented within ISEF. Change requests were used as a tool to configuration manage the CVP needs and requirements. Given the size of CVP, changes to these modules required a formal adjudication process.

Figure 1: CVP Requirements and Traces

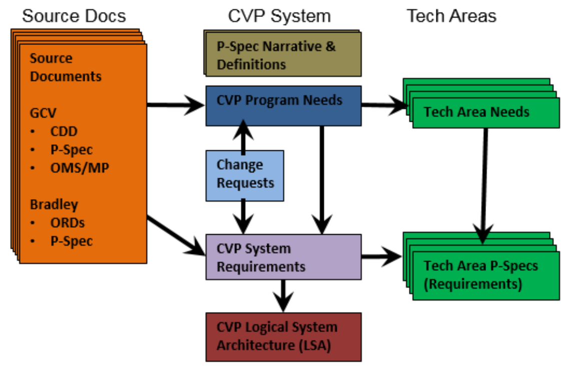


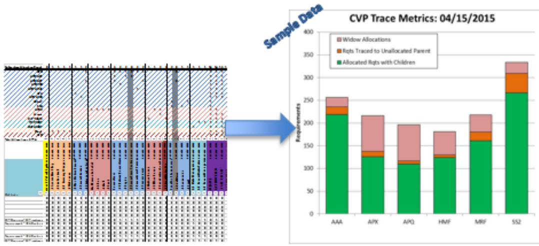
Figure 2 shows examples of both a metrics report generated by ISEF to capture the current status of a requirements set (number of allocation links, number of orphans, etc.) and a sample bar chart created by the CVP program from the ISEF generated metrics data. The bar chart was used to show the breakdown of:

1) Requirements allocated from CVP to a Tech Area Subsystem with a corresponding subsystem level requirement.

2) Tech Area Requirements that do not trace to a CVP system level requirement (potentially a requirement missing from the CVP P-spec).

3) CVP requirements that have been allocated to Tech Areas in need of a corresponding Tech Area subsystem level requirement.

Figure 2: CVP Requirements Metrics



3.2 CVP Architecture Allocations

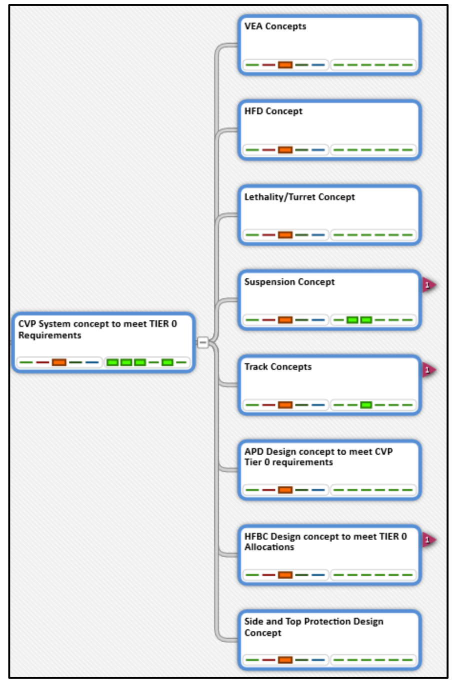
CVP's main architectural development efforts took place in a COTS Architecture tool. However, the architecture competency is still growing within TARDEC. CVP faced a problem in that it needed input on the allocation of requirements from its system level requirements to a logical system architecture that had been developed by architecture SMEs.

ISEF was able to help CVP overcome this gap by rendering a copy of the CVP Logical Architecture and allowing allocation links to be made to it. These allocation links were then translated back into the master architecture model within another tool. While some rework was necessary to move the data between tools, the alternative of capturing the allocation information in documents would have been far more painful.

3.3 CVP Decisions

Figure 3 shows the first level hierarchy of the CVP Decision Breakdown Structure.

Figure 3: CVP Decision Breakdown Structure



CVP uses the decision breakdown structure to track and manage the status of their open and closed decisions. Each node in the decision breakdown structure represents a tradestudy with its own criteria, alternatives, consequences (risks, derived requirements), and performance estimates. System level decisions can be broken down into subsystem level decisions with a human-in-the-loop to determine the appropriate amount of rigor required for each decision based on its complexity and importance. Decision (tradestudy) reports can be generated automatically for each decision node. Between the CVP System and Tech Area decision breakdown structures, 292 decisions are being managed.

The ISEF Decision Management tool suite will allow CVP to transition not only the technical data for the recommended technologies that emerge from the program at its eventual close-out, but to also put that decision in context against the other alternatives considered and the rationale behind final decisions. This capability will be extremely important to ensure minimal knowledge is lost between CVP and FFV.

3.4 CVP Risk Management

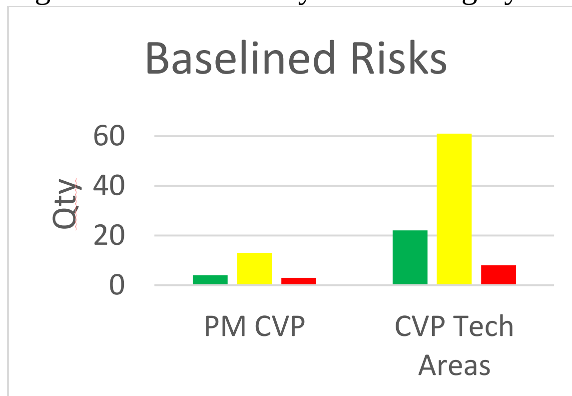
Having a formalized, standard approach to risk management has been incredibly helpful to PM CVP and the associated Tech Area programs. While S&T programs “push the envelope” with respect to technical performance and consequently assume more risk than programs of record, it is crucial that the programs formally understand, analyze, and mitigate risks that could prevent the program from transitioning. Embedded methodologies and workflows within the Project Recon tool suite helped to ensure a common approach to risk management, enabling analysis of overall CVP risk levels that would have been very difficult without a tool to guide the process.

Figure 4 shows a breakdown of the CVP System risks in accordance with standard DoD risk management policy. Figure 5 shows a summary of the total number of risks between the CVP System and Tech Areas.

Figure 4: CVP Risk Square

Likelihood					
Near Certainty (5)		1		1	
Highly Likely (4)			7	9	
Moderate (3)		4	36	14	1
Low (2)		5	13	14	1
Not Likely (1)	1	1	2		1
111	Negligible (1)	Marginal (2)	Moderate (3)	Critical (4)	Catastrophic (5)
	Consequence				

Figure 5: CVP Risks by Color Category



4 ISEF Opportunities for Improvement

While ISEF has been a successful tool in helping CVP to execute its strategy for Systems Engineering, there are opportunities where continued ISEF development could improve the tools capabilities for the remainder of CVP and other programs to follow:

Better integration with SysML Architecture Tools: ISEF is working to support more of the SysML standard in its data structures and to improve the ability for data to flow seamlessly from SysML models to and from ISEF. In the short term, this includes continuing to improve the ISEF support of SysML XMI interchange data through a more robust importer (read, write, update). In the longer term, PM ISEF intends to have a “live” integration to various SysML architecting tools vs. the current standards-based manual data transfer.

Improved application speed: It is no secret that military networks prioritize information security over speed. Operating a highly responsive Systems Engineering web tool in a military environment can be a challenge, especially for programs with large data sets. PM ISEF is continuing to optimize the ISEF codebase to get the application to function as close to instantaneous as possible.

5 References

Neches, R. *Engineered Resilient Systems (ERS) S&T Priority Description and Roadmap.* 2011.

Kendall, F. *Better Buying Power Principles – What Are They?* Defense AT&L. January-February 2016.