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User-in-the-Loop or User-Out-of-the-Loop: Acquisition Strategies as Indicators of Human Factors Practices in Software-Centric Defense Programs

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User-in-the-Loop or User-Out-of-the-Loop: Acquisition Strategies as Indicators of Human Factors Practices in Software-Centric Defense Programs

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Abstract

Human factors (HF), including human-centered design, user experience, and human systems integration, play a crucial role in the operational effectiveness of defense software and digital systems. HF practices involve user focused activities such as user interviews, product design, usability testing, training, safety assessments, and early prototyping. Some Army acquisition programs have applied "soldier-centered design" to address HF in defense systems, but these approaches are inconsistently embedded due to limited early involvement of HF specialists and the frequent omission of HF requirements in DoD contract solicitations. This lack of emphasis in contracts leads contractors to deprioritize HF to remain competitive on price, limiting the routine integration of HF practices in defense systems. This study aims to investigate how acquisition strategies influence the prioritization of HF in software-centric programs, recognizing that certain contract and acquisition methods may better support HF practices such as user touchpoints and soldier-centered design. Additionally, it explores whether acquisition methods commonly used by traditional primes versus "defense tech" vendors correspond to differing levels of HF integration. A mixed sample of major software-centric defense programs, spanning traditional primes and commercial dual-use/"defense tech" vendors, is analyzed by constructing an HF score based on proxy criteria derived from contract characteristics, acquisition pathways, and indicators of iterative development or user interaction. External sources, including DOT&E reports, GAO assessments, and program press releases, are then used to validate whether programs with higher proxy HF scores experience fewer human-factors deficiencies, better usability outcomes, or reduced rework. By establishing a data-driven method to infer HF activity from acquisition data, this study provides a replicable analytical framework for evaluating user-centered development across defense programs, supporting a systematic understanding of where and how warfighter-centered design is occurring within DoD acquisition.

Introduction

Software-centric defense capabilities increasingly determine operational effectiveness, yet usability and human-performance shortfalls persist across many Department of Defense (DoD)[1] programs. While the Department has established Human Systems Integration (HSI) policy and guidance, evidence suggests that these requirements are unevenly translated into program execution, particularly in contracts, incentives, and delivery models that shape how software is built and fielded. This paper examines whether acquisition pathways, contracting mechanisms, and contractor archetypes systematically enable or constrain human factors integration (HFI), and whether stronger HFI is associated with better downstream program and user outcomes. To do so, it evaluates 10 DoD software programs using a multidimensional scoring framework that infers HFI activity from acquisition characteristics and observable indicators of iterative development and user engagement.

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[1] This study was proposed prior to the 2025 renaming transition from the Department of Defense (DoD) to the Department of War (DoW). For consistency with the study's abstract, source material, and the Department's legal designation, the term DoD is used throughout.

Background

Software in Modern Warfare and the Role of Human Factors

In modern warfare, software has become a critical enabler of military operations as warfare grows increasingly digital, interconnected, and information-intensive. Concepts such as multi-domain operations, enhanced interoperability, and data-rich operational environments place software at the center of mission execution. Even traditionally hardware-centric platforms, such as the F-35 Lightning II and the Patriot missile defense system, are now increasingly software-defined, with software performance often acting as the decisive factor between mission success and failure (Soare et al., 2023).

As defense software systems grow more complex, their effectiveness is rarely limited by technological shortcomings, but by the human factor: how systems are designed, integrated, and ultimately used by warfighters (Martin et al., 2017). The human factor (HF) becomes the decisive constraint, especially in environments where split-second decisions determine tactical outcomes. Systems that impose excessive cognitive load or conflict with human cognition directly degrade warfighter effectiveness and can result in catastrophic errors.

HF has long been recognized as essential to operational performance, supporting effective decision-making, situational awareness, and cognitive workload management across both hardware and software systems. Since World War II when human factors took shape as a modern discipline, HF research and practices have informed how complex systems should be designed around human capabilities and limitations (Human Factors and Ergonomics Society, 2026). Related disciplines, human-centered design, user experience (UX), human computer interaction, and human-in-the-loop approaches, share the same premise that usability is a functional requirement in both academia and industry (National Institute of Standards and Technology, 2021).

Despite this broad consensus, HF practices are inconsistently embedded in defense product development, particularly in software development. Both warfighters and HF practitioners agree that the Department of Defense (DoD) has a software UX problem (Hunt, 2025; Savage-Knepshield, 2021). In fact, some warfighters have reported using commercial tools alongside official platforms because of better user experience with commercial products (Savage-Knepshield, 2021). This raises a fundamental question: is this design gap a reflection of deficient engineering execution or does it originate earlier in the development life cycle? HF literature suggests the latter plays a decisive role: measures such as error rate, training burden, and task efficiency are shaped in large part by upstream design choices in interfaces, procedures, and training requirements (Federal Aviation Administration, 2016). In practice, this implies many usability and human-performance risks can be mitigated when identified during requirements definition and early design, rather than deferred until after production or deployment, when fixes often require costly updates, retrofits, retraining, continued reliance on error-prone workflows, and dissatisfied users (Martin et al., 2017).

Table 1. Definitions of Key HF-Related Terms Used Throughout the Paper, Providing a Quick Reference for Later Sections

Term	Definition
Human Factors (HF)	The discipline of how humans interact with systems, tools, environments, and the application of that knowledge to design systems that fit human capabilities and improve performance, safety, and usability.
Human Factors Integration (HFI)	The degree to which human performance, usability, and user-centered design are systematically embedded across the full arc of a program or product, from initial requirements and contracting through development methodology and product delivery, such that the human is treated as a primary design constraint and continuous stakeholder rather than a compliance checkbox or late-stage consideration.
Human Systems Integration (HSI)	DoD term defined as the systems engineering process and program management effort that provides integrated and comprehensive analysis, design, and assessment of requirements, concepts, and resources for human factors engineering, manpower, personnel, training, safety and occupational health, force protection and survivability, and habitability (DoDI 5000.95, 2022).
Human Factors Core Concepts (HFCC)	Core principles used throughout the discipline such as task analysis to understand real-world user activities, continuous user involvement throughout design and development, compatibility between system design and human capabilities and limitations, clear and timely user feedback, consistency across design elements to reduce cognitive load, error tolerance to minimize mistakes and mitigate performance impacts, designing systems for users rather than forcing users to adapt, and accessibility to ensure usability for all users.

Human Factors in Defense Acquisition

Given that the DoD's software usability and human factors challenges are widely recognized, the Department has formally sought to address them through implementing Human Systems Integration (HSI) governance and standards in the acquisition process. Some of the documents relevant to HSI in acquisition policy are DoDD 5000.01 Defense Acquisition System, DoDD 1100.4 Guidance for Manpower Management, DoDD 5000.02 Adaptive Acquisition Framework, DoDI 5000.95 HSI in Defense Acquisition, DoDI 5000.88 Engineering of Defense Systems, HSI Guidebook, DoD HCI Style Guide, JCIDS Manual, AR 602-2 Army HSI in System Acquisition, AP 602-2 Army HSI Acquisition Guide, USAF HSI Handbook, and NAVSEAINST 3900.8A HSI Policy in Acquisition. These policies and standards are longstanding and explicitly require that HSI be considered throughout the design and development of defense systems.

Yet the continued prevalence of documented usability issues suggests that formal policy requirements have not been translated into consistent practice across programs, pointing to a gap between governance and execution (Savage-Knepshield, 2021). Three mechanisms likely responsible for this gap are summarized below.

Table 2. Structural Mechanisms Likely Resulting in the HSI Implementation Gap

Mechanism	Description
Contractual	When HFI is not explicitly included in RFP requirements or source-selection criteria, contractors have little incentive to incorporate it into their bids. In price-competitive procurements, UX / HFI design practices are often omitted to reduce cost, particularly when designs are prefabricated, prototyped, or based on commercial solutions (Savage-Knepshield, 2021). Furthermore, there often are no stated requirements for HSI to a be a key performance parameter (KPP) or key system attribute (KSA) which are used as critical metrics to develop military capabilities, essentially making HSI and optional design tool (Gomez, 2016).
Temporal	Depending on acquisition frameworks used, HSI engagement can be tied to infrequent milestone reviews, resulting in user feedback cycles that are too slow, spread out, and overall incompatible with agile, iterative software development. MANPRINT, the Army's formal HSI implementor, is only involved in some programs and resources (Martin et al., 2017).
Organizational	In traditional defense primes, HF engineering is typically positioned as a compliance function within systems or safety organizations, limiting its influence on design (Savage-Knepshield, 2021), unlike commercial software development, where UX is a core differentiator and designers work continuously alongside developers (Mehta, 2025; Root, 2024).

Acquisition Reform and Defense Industry Shifts as Levers for Human Factors Integration

The governance-to-practice gap described above is largely an acquisition problem: even strong HSI policy has limited impact if not translated into enforceable requirements, contract incentives, resourcing, and delivery timelines. This may reflect both the acquisition structures used to procure software and the ways contractors translate requirements into execution.

Prior to the Acquisition Transformation Strategy of 2025, software-intensive defense programs were largely shaped by legacy Defense Acquisition System (DAS) and JCIDS processes that emphasized front-loaded requirements definition and milestone-based governance. JCIDS functioned as the DoD's primary mechanism for validating capability requirements and translating them into acquisition programs (Neenan, 2024). Within this structure, programs progressed through formal milestone decision reviews, such as Milestones A, B, and C, which often served as discrete approval points rather than user-focused continuous feedback mechanisms (National Research Council, 2024). These processes tended to treat HFI considerations as documentation inputs evaluated at review events or afterthoughts, rather than as design constraints embedded throughout development (Drillings, 2008). As a result, user engagement, interface evaluation, and iterative usability refinement were often episodic, limiting the degree to which HFI could meaningfully shape system design as software evolved (Gomez, 2016; Martin et al., 2017).

In 2020, the Adaptive Acquisition Framework brought a deliberate shift away from one-size-fits-all acquisition governance toward a set of tailored pathways intended to better match oversight mechanisms to program characteristics (Defense Acquisition University, 2024). Within this framework, the Software Acquisition Pathway formally recognized software as distinct from hardware-centric acquisition and emphasized iterative delivery, continuous user engagement, and performance metrics tied to meeting user need (DoD, 2020). In parallel, the increased use of Commercial Solutions Openings (CSOs) and Other Transaction Authority (OTA) mechanisms was framed as a way to reduce procedural rigidity and enable faster prototyping and experimentation with operational users (Defense Innovation Unit, 2025). Additionally, the Acquisition Transformation Strategy of 2025 pushed to reorganize traditional Program Executive Officers (PEOs) with Portfolio Acquisition Executives (PAEs), centralizing oversight and orienting management around delivering capabilities faster (Marino, 2026). Collectively, these reforms created acquisition conditions more compatible with HFCC by shortening feedback cycles, enabling earlier user involvement, and allowing design decisions to be revisited as systems evolved rather than frozen at early milestones. This raises the question of whether particular acquisition structures are associated with higher levels of HFI and more human-centered software outcomes.

Even when acquisition structures create the conditions for HFI, the practical bottleneck often comes down to the project manager. Project managers can be the end determinant of whether HFI is prioritized and built into execution or treated as optional. As acquisition reforms created more room for iteration, Soldier-Centered Agile (SCA) emerged within the Army as an improved approach for project managers to implement HFI (Savage-Knepshield et al., 2021). SCA was used during software modernization efforts of Advanced Field Artillery Tactical Data System (AFATDS) 7.0 and Precision Fires Dismounted Block 2. It responds to the HFI gap by merging ideas from agile development and human-centered design, positioning user feedback as an input to ongoing design tradeoffs rather than a post-development validation step (Savage-Knepshield et al., 2021). By integrating soldier touchpoint events into recurring development cycles, this approach aligns HFCC with software development, allowing usability, workload, and training burden considerations to shape system evolution in near real time. In doing so, SCA reflected a shift from compliance-oriented HFI practices toward HFI as a driver of design quality and operational effectiveness (Savage-Knepshield et al., 2014).

Alongside formal acquisition reform, the defense industrial landscape has evolved with the emergence of a new class of venture-backed, software-forward “defense tech” companies. Many of these companies were founded by leaders steeped in Silicon Valley product development culture, emphasizing rapid iteration, a product-first approach, and dual-use commercialization. These companies are often characterized as faster-moving and more software-centric than traditional primes, introducing culture and development practices that contrast with primes (Siu, 2025). These “defense tech” companies likely import UX and rapid user-feedback cycle practices from the commercial technology sector, where such capabilities are not discretionary enhancements but prerequisites for competitive survival. Because these companies often do not fit neatly into traditional defense contracting models, the DoD has increasingly relied on commercially aligned mechanisms, such as CSOs, to acquire from non-traditional vendors (Defense Innovation Unit, 2025). Taken together, this raises another central question for this study: do software-centric programs built by “defense tech” companies, and acquired through mechanisms designed for speed and iteration, tend to exhibit stronger HFI?

Together, these acquisition reforms, execution models, and contractor shifts suggest that “user-in-the-loop” conditions are not simply a matter of intent, they are shaped by structural choices that determine whether feedback is frequent, usable insights are acted on, and usability is treated as a performance driver. The remainder of this paper tests that proposition by translating these upstream signals into a set of research questions and observable indicators.

Research Questions

Given the landscape described above about HFI gaps in DoD software, acquisition reform, and the evolving defense industrial base, several research questions are produced surrounding HFI and its role in these areas.

- RQ1 (Acquisition Strategies): Does the acquisition pathway and contract type structurally enable or constrain HFI?
- RQ2 (“Defense Tech” Companies): Do contractor archetypes differ systematically in their degree of HFI?

- RQ3 (Combined): Do programs with stronger acquisition and practice indicators (RQ1-RQ2) also exhibit better independent outcome evidence?

These research questions probe a single problem: whether HF is actually integrated into software acquisition and contracting. The table below operationalizes this idea by organizing HFI into three layers: process integration, practice integration, and product integration.

Table 3. Three-Layer HFI Construct

Layer	Description	Evidence / Observable Indicators
RQ1: Process Integration	HFI/HSI is structurally required and contractually enforced from requirements through milestone reviews. The acquisition pathway and contract type encourage HFI practices.	HSI used in contract language; CDD includes human performance KPPs/KSAs; acquisition pathway and contract type reflect HFCC
RQ2: Practice Integration	The development team and contractor actively use user-centered methods during design and build such as SCD or SCA where real users are involved and feedback is structurally integrated.	Documented user touchpoints and user feedback events; SCD or SCA methodology; HF practitioners and designers embedded in dev. sprints; iterative prototyping with users; participatory design evidence.
RQ3: Product Integration	The delivered software reflects HF principles: usable, lowers cognitive burden, requires minimal workarounds, and operators adopt it willingly.	Report findings such as DOT&E (positive/deficient) and GAO program outcome assessments; media reports on user satisfaction, adoption rates, training burden, program restructuring or cancellations tied to usability failures.

Methodology

To address these research questions, this study examines a mixed sample of 10 DoD software programs: TITAN, SMBC/IVAS, KRADOS, ABMS, HADES, Forge, AFTADS, CPCE, JBC-P, DCGS-A. The sample was selected to capture variation in contractor archetypes, mission applications, and program scales. All programs include a core software component, with some also incorporating hardware. Some efforts are established programs of record, while others are pilot-oriented initiatives. Each program was evaluated using a multidimensional scoring framework that defines the three research questions and the three-layer HFI construct into observable criteria. The framework is divided into five dimensions with each dimension weighed the same in the final composite score.

Dimension	Score	Archetype	Scoring Rationale
D1: Process Integration - Acquisition Pathway	1	Traditional MCA / ACAT Programs	Traditional pathways often rely on predetermined requirements, often brushing off HSI or treating it as a compliance check, with limited built-in feedback loops and HSI depth left for PM discretion
	2	MTA (Rapid Prototyping) / Hybrid pathways	MTA allows for more open-ended desired characteristics, enabling flexibility and rapid iteration; however, HSI can still be de-scoped in practice since MTA prioritizes speed and depends on PM priorities and contractor commitment
	3	SWP	SWP pathway structurally embeds continuous delivery and user engagement by requiring the collection and reporting of user-centric metrics, making user feedback and performance data formal deliverables, not optional activities
D2: Process Integration - Contract Mechanism	1	FAR-based FFP	FFPs do not often structurally promote iterative development, as the emphasis is on price risk allocation; if HSI is not explicitly required in contract language, HFI activities are typically minimal or absent in execution
	2	FAR-based CPFF	CPFFs do not inherently promote iterative development; however, by reducing pricing risk as requirements evolve across multiple cycles, they are more tolerant of exploratory and adaptive development than FFPs
	3	CSOs / OTAs	OTAs are structured to support iterative prototyping and continuous user feedback, with flexibility that encourages prioritization of UX considerations which enables HFI
D3: Practice Integration – Contractor / Company Behavior Type	1	Traditional Prime / Integrator	Traditional primes and systems integrators are often known for applying HFI within safety and certification contexts, with limited integration of HFI into broader system design and UX
	2	Augmented Traditional / In-House	Companies where HF practitioners, UX staff, and software-forward approaches exist, but are not core to culture; typical of services firms or traditional primes that have partnered with "defense tech" companies
	3	"Defense Tech"	Software-forward and iterative development are foundational to the company through commercial technology heritage or product-led culture
D4: Practice Integration - Development Process & User Engagement	1	Waterfall	Users consulted at formal test events after design is complete; user experience informed by PMs or contractors, not derived from field observation; HF practitioners review artifacts instead of co-design
	2	Agile with Limits	Agile sprints are employed with periodic or limited user feedback, while HF practitioner involvement is constrained or recommendations are largely advisory rather than embedded or enforceable
	3	SCD / SCA Integrated	User-centered design, implemented through agile development and supported by HF practitioners, embeds users throughout design and development and enables systematic tracking of usability metrics
D5: Product Integration – Program Outcomes	1	Critical Gaps	Evidence includes high-risk or canceled programs, documented user dissatisfaction, and performance deficiencies attributable to product-level design or integration issues
	2	Operational with Constraints	Program has been fielded and remains in use, but documented concerns persist, including deficiencies related to training, testing, and user adoption
	3	Mission Effective	Positive user feedback and independent assessment reports demonstrating high adoption, strong user satisfaction, and successful program outcomes

Figure 1. Multi-Dimensional Scoring Framework Used to Examine Software Programs

Data and Analysis

The 10 software programs were scored using publicly available sources (i.e., press releases, public reports, and independent articles). Results are limited by the availability and detail of open-source information, so some program findings and context may be missed.

The figure below summarizes each program's description, contractor(s), period of performance (PoP), contractor archetype (CA), acquisition pathway & contract type (PW), dimension scores, composite score (Comp.), and the rationale for those scores. Note that contractor archetype represents the type of contractor including traditional prime (TP), augmented traditional (AT), and "defense tech" (DT) and composite scores consists of all five-dimension scores summed. Majority of the programs evaluated are Army efforts which was not intentional, but reflect the Army's emphasis on software modernization as a distinct mission area, resulting in greater publicly available documentation on Army software programs.

Program	Description	Contractor	Pathway	D1	D2	D3	D4	D5	Comp.	Rationale
TITAN *Tactical Intel. Targeting Access Node*	Army's next-gen. SW defined ISR ground station	Palantir *(and others)*	**PoP:** ~2020 - Present **CA:** DT **PW:** MTA / SWP + OTA	3	3	3	2	2	13	• *Utilizes MTA Rapid Prototyping, SWP, and OTA with emphasis on Soldier Touch Points* • *Palantir is a well-known technology company employing a Forward Deployed Engineering model that embeds technical staff directly with end users*
SBMC *Soldier Borne Mission Command (Formerly IVAS)*	Army's mixed reality head-mounted soldier system	Anduril *(Formerly Microsoft before 2025)*	**PoP**: ~2018 - Present **CA:** DT **PW:** MTA + OTA	2	3	3	2	2	12	• *MTA Rapid Prototyping effort used with possible transition to SWP, leveraging Soldier Touch Points and quick iterations* • *Anduril is another well-known "defense tech" company, entering the landscape as a disruptor* • *Known performance and usability issues prior to Anduril takeover*
KRADOS *Kessel Run All Domain Ops. Suite*	Air Force's command-and-control SW for Air Ops. Centers	Air Force *(and Clarity Innovations, Raft, Omni Fed, & LMT as contributors)*	**PoP:** ~2021 - Present **CA:** AT **PW:** MTA / SWP + FFP	3	1	2	3	3	12	• *Unique program where majority of development was done in-house by USAF* • *FFP contractors used for integration, DevSecOps, and sustainment* • *Viewed as a major pilot for software with a positive reputation due to use of modern agile, DevSecOps, and user-centered design, significantly reducing development timelines and saving costs*
ABMS *Adv. Battle Management System*	Air Force's family of command-and-control SW for JADC2	Multi-Vendor *(Leidos as lead digital integrator as of 2024)*	**PoP:** ~2019 - Present **CA:** AT **PW:** MTA / SWP + Multi.	3	1	2	2	2	10	• *Program started out with industry consortium to develop digital infrastructure* • *Program components use different acquisition pathways (MTA and SWP)* • *Both FAR-based contracts via IDIQ vehicle and OTA contracts are used* • *DOT&E reports MVP-style releases enabling rapid iteration, but limited data on performance and user satisfaction*
HADES *High Accuracy Detection & Exploitation System*	Army's mission SW for deep-sensing ISR aboard business jets	Sierra Nevada Corp. *(and others)*	**PoP:** ~2023 - Present **CA:** TP **PW:** MTA + OTA	2	3	1	2	2	10	• *Part of the Multi-Domain Sensing System (MDSS) Family of Systems* • *Utilizes MTA Rapid Prototyping with frequent user feedback* • *Traditional contractors (SNC, L3Harris, etc.) used, but dev. practices unclear* • *Early-stage program, but ARTEMIS and ARES demonstrations showed promising operational results following rapid iteration*
The Forge *(worked on Virtualized Aegis Combat System)*	Navy's SW factory updating ship combat SW systems	Navy *(and others)*	**PoP:** ~2021 - Present **CA:** AT **PW:** Unk. + FFP	1	1	2	2	2	8	• *Not a formal program of record; modernizes legacy shipboard SW* • *Relies on traditional FAR-based contracting for IT dev. and sustainment* • *Applies modern SW dev. practices, including rapid testing and DevSecOps* • *Positively received by Navy leadership, credited for accelerating upgrades and modernization*
AFTADS *Adv. Field Artillery Tactical Data System*	Army and Marine Corp.'s fire support and command system	Raytheon *(with Leidos as SW integrator)*	**PoP**: ~1980 - Present **CA:** TP **PW:** MCA + CPFF / FFP	1	1	1	3	2	8	• *Long-standing program using MCA and FAR-based contracting* • *AFTADS 7.x represents the most recent major software modernization, applying Soldier-Centered Agile with support from ARL HF practitioners* • *MANPRINT directly engaged to address HSI and workload considerations*
CPCE *Command Post Computing Env. (Part of NGC2)*	Army's tactical command-post SW that NGC2 is built on	Leidos *(with General Dynamics and others as contributors)*	**PoP:** ~2018 - Present **CA:** AT + TP **PW:** ACAT II	1	1	2	1	1	6	• *One of the Army's six computing environments, built on legacy systems and developed incrementally using FAR-based contracting* • *Originally executed under a waterfall approach, may transition to agile* • *Strong C2 situational awareness, but data-sharing limitations created cumbersome and unreliable workflows*
JBC-P *Joint Battle Command Platform*	Army, Marine Corp., and SOF's battle command info. system	Multi-Vendor *(Army in-house dev. with integ. from others such as LMT and GD)*	**PoP:** ~2013 - Present **CA:** TP **PW:** MCA + FFP	1	1	1	1	1	5	• *Follow-on program of record to FBCB2 and Blue Force Tracking, executed under FAR-based contracting prior to AAF adoption* • *Incremental development with limited modern software or UCD practices* • *DOT&E assessed the system as operationally effective, but not operationally suitable or survivable*
DCGS-A *Distributed Common Ground System - Army*	Army's main tactical intel. system for ingesting ISR data	Northrop Grumman / Raytheon *(and others before Palantir switch in 2018)*	**PoP:** ~2005 - Present **CA:** TP **PW:** MCA + FFP	1	1	1	1	1	5	• *Evaluated for performance prior to Palantir lawsuit and assuming program* • *Users reportedly preferred Palantir's software but were required to use DCGS* • *Widely documented usability and performance issues, including training burden, sluggish performance, and complex interfaces, with GAO characterizing the program as troubled and ineffective in 2013*

Figure 2. Ten Software Programs Scored Across Multi-Dimensional framework

Main takeaways from scoring results:

- Higher composite scores are associated with more modern acquisition approaches: Top programs (TITAN, SBMC/IVAS, and KRADOS) use MTA/SWP and OTA structures and are executed by augmented traditional contractors or "defense tech" vendors. Note that SBMC/IVAS appears to be performing well now; however, prior to Anduril's takeover, its D5 score would likely have been lower.
- Programs with strong D3 and D4 scores stand out: Those led by tech-forward contractors and modern software development practices consistently score higher.
- D1 is a key differentiator: programs using MTA Rapid Prototyping tend to score higher, consistent with more iterative development cycles.
- D5 performance varies across programs: AFATDS is a notable case where despite using more traditional contractors, it scores well in D4 and D5, supported by HF involvement through SCA and MANPRINT.
- DCGS-A illustrates the operational risk of weak HFI: Usability deficiencies resulted in frustrated users and drove users to prefer commercial alternatives, contributing to a

"troubled" program narrative. Following a shift to more modern software development practices and a software-forward vendor that utilizes more HFI, these challenges are substantially addressed.

- Programs initiated before the 2020s generally scored lower, likely reflecting pre-Adaptive Acquisition Framework constraints, while recent programs show increased adoption of reformed acquisition and modern software development practices.
- Several programs are at different life cycle stages which may introduce scoring bias since mature programs have longer observation windows and richer reporting histories, increasing the likelihood that deficiencies are observed and documented, whereas newer efforts may score higher because of less public evidence and performance has yet to be scaled at the same magnitude.
- Overall, the scoring results suggest that modern acquisition pathways paired with contemporary software development practices tend to perform better, though not uniformly. Traditional primes and legacy pathways do not inherently produce poor outcomes, but they appear more frequently associated with lower-scoring programs in this sample.
- Note that this analysis aims to identify associations between HFI conditions and acquisition, contracting, and development structures rather than causal effects. D1–D4 do not necessarily determine D5, the ranking used may mask variation in performance, and unobserved factors may influence outcomes.

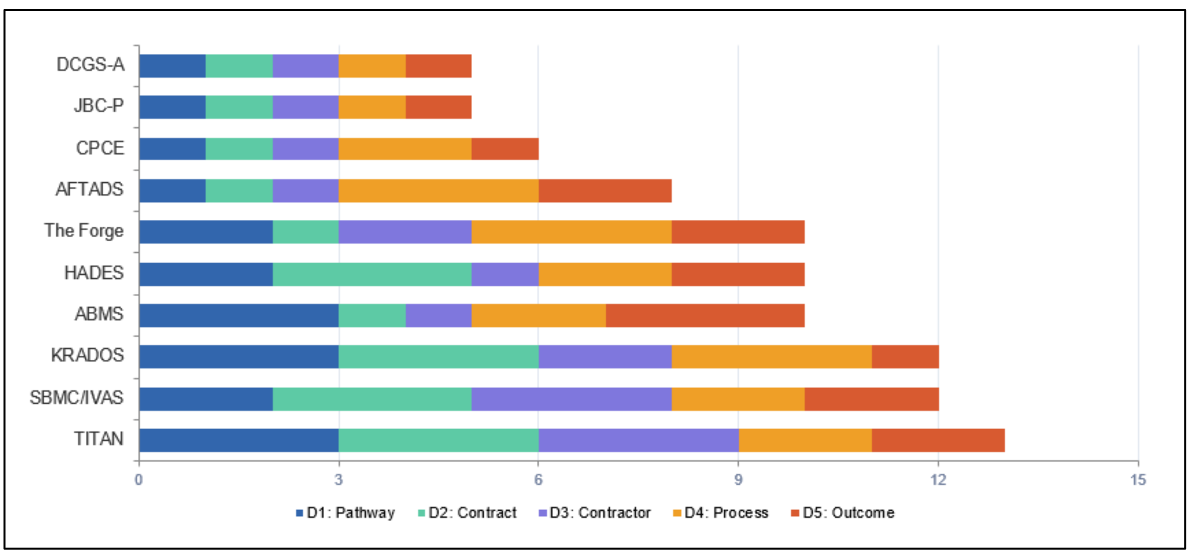

Figure 3 visualizes the Figure 2 results by decomposing each program's composite score into its constituent dimension scores, enabling comparison between higher-scoring programs (e.g., TITAN, KRADOS) and lower-scoring programs (e.g., DCGS-A, JBC-P).

Figure 3. HFI Composite Scores by Dimension (D1–D5)

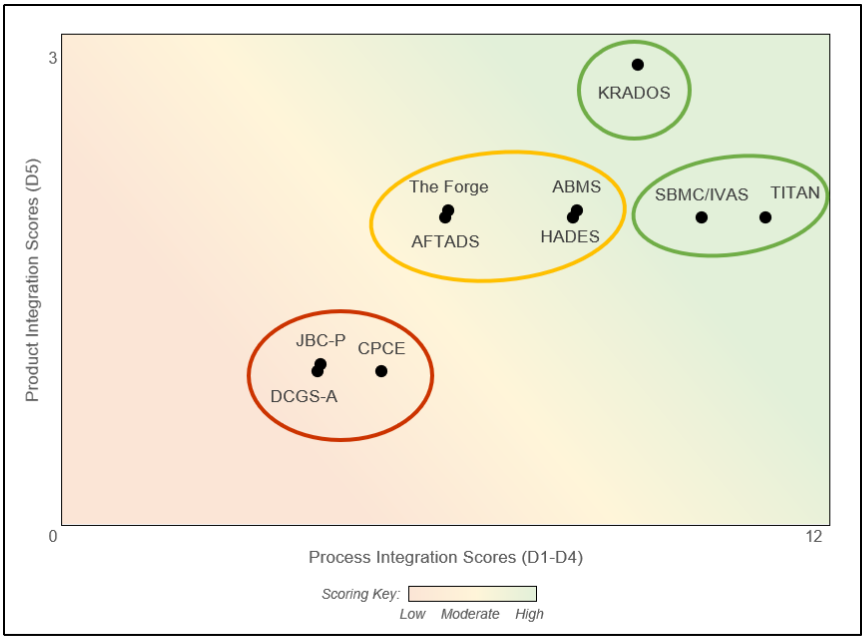

Figure 4 visualizes the Figure 2 results by plotting the D1–D4 scores associated with Process and Practice Integration (RQ1 and RQ2) versus D5 scores associated with Product Integration Scores (RQ3). The data shows a general positive trend that higher D1–D4 scores tend to be associated with better D5 outcome scores.

Figure 4. Process and Practice Integration Scores (D1–D4) vs. Product Integration Scores (D5)

Conclusions

This study was an exercise in inference: a practical attempt to estimate HFI activity in defense software programs using observable acquisition and execution signals. The proxy-scoring framework effectively distinguished programs structurally positioned for sustained user engagement and iterative refinement from those where such conditions are harder to maintain, offering a replicable way to assess “user-in-the-loop” tendencies in the DoD.

The results should not be read as a criticism of traditional primes or legacy acquisition structures. Strong HFI outcomes are achievable in those environments, such as through MANPRINT or when project managers account for it. However, the patterns in this study’s data suggest legacy structures more often create incentives that quietly discourage HFI: front-loaded requirements, long feedback cycles, and procurements that underweight usability tend to push HFI toward compliance rather than continuous practice. Modern pathways and software-forward contractors do not guarantee high quality outcomes, but they appear to naturally reinforce the operating rhythms HFI requires.

The broader direction of acquisition reform and the changing defense industrial base is encouraging. Adaptive acquisition reform, software-forward defense entrants and disruptors, and hybrid contractor models are shifting the ecosystem toward structures where HFI is easier to execute and sustain. If that momentum continues, and if HFI is translated into enforceable requirements rather than staying an aspirational policy goal, usability and human performance stand a real chance of becoming upstream design determinants rather than downstream fixes.

The value of early, sustained HFI is not confined to the programs scored in this study, as it shows up in other DoD efforts as well. ATAK (Android Team Awareness Kit), a smartphone-based situational awareness tool originally developed for Special Operations Forces, and Raven Sentry, an Army AI-enabled indications-and-warnings capability, were initiatives both built through agile, user-immersed development cycles emphasizing HFCC iterative design and human-in-the-loop validation. Both have been widely recognized as successes: ATAK has expanded well beyond its military origins to serve civilian groups including DHS, the National Guard, and first responders, while Raven Sentry has been cited as a model case for applying commercial software practices effectively within a defense context (Spahr, 2024).

Their success underscores a central point to this study: what drives effective defense software is not development for its own sake, nor the addition of surface-level capabilities, but the deliberate integration of HF from the outset. Treating users as foundational stakeholders, designing around users, simplifying high-stakes workflows, reducing cognitive burden, and supporting confident decision-making, consistently produces systems that humans actually adopt, trust, and use.

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