Check Tables HSI

The "default tradeoff" of acquisition

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Most acquisition professionals would readily chastise the groupthink that led to the *Challenger* tragedy or shake their heads at the gross neglect that led to Chernobyl, but do they look at their own omission of the user as integral to the systems that they acquire? Omitting the user could result in mission failure or severe injury or death of operators, maintainers, and support personnel. At the very least, ignoring the "human-ware" as an equal partner with software (SW) and hardware (HW) can often lead to cost overruns, schedule slippages, and performance degradation.

Human systems integration (HSI) uses interdisciplinary technical and management processes to consider the human users within and across all system elements to enable the systems engineering (SE) process.[1] Its goal is to optimize total system performance (HW, SW, and humans) as defined by operational effectiveness, suitability, survivability, safety, and affordability.[2] The human, as part of the weapon system, must perform within the battlefield environment, which usually means heavy stressors like fatigue, night operations, temperature extremes, protection against nuclear/chemical/biological threat, noise, precipitation, crowding, rough terrain, and the fog of war. As system users are coping with many of these stressors, they must also face increasingly complicated HW and SW that not only must be operated on but also troubleshot and maintained. Moreover, the battlefield has become full of available information so that ultimately decision making for the military user is often characterized by a high cognitive workload of sifting through information uncertainty and exacerbated by ever-present time pressure. Warfighters do not have time to struggle with HW, SW, or systems that were partially developed because humans, the very core of the systems, were forgotten or ignored during acquisition.[3]

How can Marines, the customers of our defense acquisition, be seemingly easily swept aside? Studies have shown that there is a tension of expediency versus effectiveness that affects a full integration of people, technology, and organization. Constrained budgets, workforce manpower, schedules, technology maturity, industrial limitations, among other issues work continually against the battlespace mission needs. The program manager (PM) must continually sift through competing requirements, whether documented or implied, to find a way to field a system that meets cost, schedule, and performance standards. The SE process' focus is all three, and somehow in the fray of acquisition, the warfighter is often either lost or forgotten. Moreover, top-level acquisition leadership supporting HSI is paramount; otherwise, mid-level acquisition leaders are prone to view HSI as an obstacle that can easily be traded off as they give in to the misguided hope that *Marines will figure it out*. Doing so, however, simply transfers risk from the program office to the individual Marine.

This article introduces the need for integrating HSI within acquisition in terms of its benefits, processes, and ways ahead. Many DOD professionals have dedicated their life's work on this topic; there is a plethora of studies and guidance for the dedicated reader to find. Hopefully, the points made here persuade us to not only consider the Marine user more purposely but more importantly affect change to enable effectively equipped warfighters.

First, to define HSI more clearly, it includes seven domains: manpower, personnel, training, environmental safety and occupational health (ESOH), human factors engineering (HFE), survivability, and habitability. Table 1 (on following page) offers definitions for each of these domains as well as examples of their measures. HSI is concerned with all facets of the human user: physically, mentally, and socially.

While all important, the seven domains have varying emphases in the HSI acquisition process. Manpower, personnel, and training are usually listed as the largest HSI-related cost drivers

HSI Domain	Definition	Examples of Measures
Manpower	number and mix of personnel required to carry out tasks	job tasks; operation/maintenance rates; workloads; operational conditions
Personnel	aptitudes, knowledge, skills, abilities, and experience levels that are needed to perform tasks	job task requirements; certifications; security clearance levels; concepts of operations requirements; workload drivers
Training	learning process by which personnel individually or collectively acquire knowledge, skills, abilities	job task difficulty, criticality, and frequency; curricula gaps; concepts of operation requirements; available learning tools
HFE	designing human-machine interfaces consistent with the physical, cognitive, and sensory abilities of the user population	interfaces include functional, informational, environmental, cooperation, organization, operational, cognitive, and physical
ESOH	physical conditions in and around the system, design features and operating characteristics of a system that serve to minimize the potential for human or machine errors or failure that cause injurious accidents, risk of injury, acute or chronic illness, or disability	temperature, humidity, noise, vibration, radiation, shock, air quality, soil integrity, warning signs/labels, hazards, lift requirements, chemical safety, and human factors issues that can create chronic disease and discomfort
Survivability	system design features that reduce the risk of fratricide, detection, and the probability of being attacked	detectability from system noise and light emission; ease of emergency egress; system volatility; system error tolerance
Habitability	living and working conditions that are necessary to sustain the morale, safety, health, and comfort of the user population	lighting, space, ventilation, sanitation; noise and temperature control, religious, medical, and food services availability; berthing, bathing, and personal hygiene

Table 1. Navy/Marine Corps HSI domains definitions and measures.[4]

for a system's entire lifecycle, whereas ESOH, HFE, habitability, and survivability costs are more pronounced during the system's acquisition portion of its lifecycle. This is not to say that they have no associated costs after fielding, such as poor human interfaces could incur direct and indirect costs for system effectiveness and efficiency; however, manning a system with the right types, number, and trained users is a continual cost for the life of the system, even through disposal.[5] That said, the PM should consider focusing on four main areas for a system: task allocation and workloads in terms of man versus machine, training implications for the human users, workspace design and anthropometric considerations including the design of displays, and social issues and team performance.[6]

Besides cost-related considerations as well as DOD guidance specifically directing the PM to integrate HSI into all acquisition efforts, HSI carries compelling benefits. The list runs long but can be distilled to the following main points:

- HSI ensures that the system's purpose is kept in focus during the otherwise complicated acquisition process. Requirements creep is always a threat and usually spells disaster for human users.
- HSI ensures that the system's demands align with the user's capabilities. Technology-focused acquisition results in "manning the equipment" rather than "equipping the man," which often means overwhelmed users and diminished system effectiveness.
- HSI ensures that previous designs, operations, and user feedback are integrated into the system's development/selection. The users are the subject-matter experts who know the strengths and weaknesses of legacy systems so that new systems have the potential for enhanced effectiveness.
- HSI helps to control lifecycle costs by using operational data to plan manpower, skill demands, and training early in the acquisition process. The earlier this planning starts, the more optimized the system that is developed or selected.
- HSI is critical for risk mitigation when developing and/or selecting the optimized solution for the warfighter. Acquisition centers on risk reduction. When the three-legged acquisition stool of systems engineering, program management, and HSI is missing the HSI leg, the stool loses its stability and strength. There is nothing *but* risk because the user ends up supporting the system instead of the system becoming a force multiplier.[7]

Every acquisition PM operates within a risk reduction framework. Every decision is weighed in light of the cost, schedule, or performance risks it may carry. Acquisition guidance, both DOD and Service-related, continually remind the PM that every step must include risk assessment and, whenever possible, reduction. What has exacerbated the risk potential is the DOD's increasing dependence on commercial off-the-shelf (COTS) and non-developmental item (NDI) systems. The PM has little or even typically no influence on materiel design and little influence on requirements specification for COTS and NDI systems. Therefore, the product is often purchased as a "black box" that may not have the required functionality and/or effectively integrate with current systems. They can end up with modifications of current systems into which the new system must integrate myriad training fixes as workarounds.[8]

The COTS's purpose is to ultimately save time and money and to do so usually results in compromises.

Finding a solution that industry has already devised to meet another requirement seems much cheaper and more expedient than starting from scratch. However, the solution's initial targeted requirement is rarely exactly what the DOD needs for its warfighters. Even if the materiel is somewhat modified to meet more of the DOD's requirements, and thus segues from COTS to NDI, it still will invariably have shortcomings, especially because as NDI it now has had little to no market scrutiny.[9] The extent that a sub-optimal solution will meet a requirement is the foundational question. Generally, PMs are "satisfiers, not optimizers."[10] A seasoned PM once stated, "'Good enough' is the only concept you can truly build consensus on. All your trade space revolves around keeping it just good enough. Anything more than 'good' is trade bait." The question remains as to what the definition of "good" is.

The COTS/NDI dilemma of expediency versus effectiveness creates a focus on bending the requirements to fit the chosen system with little consideration of the human who ultimately ends up with a system that marginally meets his functional needs in an operational environment.[11] Indeed, the DOD warns about such acquisition mindsets as it calls for optimizing "total system performance and total ownership costs while ensuring that the system is designed, operated, and maintained to effectively provide the user with the ability to complete their mission."[12]

Clearly, military contexts are much more demanding than commercial ones for which COTS products were originally designed, and various impacts result from the mismatch (e.g., physical handling and usability; quality of graphic and physical interfaces; reliability levels in austere environments; integration issues with other hardware, software, and systems; continual training as a result of military manning cycles; space limitations; software upgrade cycles; and incomplete or inadequate glue code to integrate COTS software into existing software).[13] Contrary to what most program teams would believe, COTS-related systems can involve *additional* activities because of integration and compatibility issues with legacy systems, most borne out of mismatched original requirements under which the systems were designed and developed.

SE Activities	HSI Activities	HSI Activities Relevant to COTS
Define required capability	Identify human issues implied by the capability.	Same (should be solution independent)
Identify and assess system options to provide it	1. Identify human issues associated with predecessor systems.	1. Identify human issues associated with COTS elements in current use, including user performance.
	2. Identify differences in context of use and predict impact on system options.	2. Same, informed by current use of COTS components. 2a. Seek evidence of compatibility of COTS equipment with intended target audience and operational tasks
	3. Assess human-related risks and requirements for each option.	3. Same
Define system options for comparison and selection	Ensure human parts of overall system (manpower, training, support, etc.) are adequately defined and costed.	1. Same 2. Identify and cost all additional equipment needed to make overall system work. 3. Identify and cost human interventions (selection, training, support, etc.) needed to make overall system work. 4. Identify and cost any performance shortfalls of overall system due to mismatch between equipment and people.
Select option	Take part in option trade-off across all system domains.	Inject the above into the option trade-off process. Focus on the total system, not just the COTS equipment.
Specify system requirements	1. Identify human-related system requirements.	1. Same, but focusing on any freedom within COTS components, on glue components (software code needed to integrate with legacy code), and on performance requirements for the overall system.
	2. Identify human-related risks still to be addressed.	2. Same
	3. Plan activity to mitigate human-related risks.	3. Same

Table 2. HSI Activities for COTS Compared to Non-COTS Systems within the SE Process.[14]
(Table created by author.)

Table 2 provides a general comparison of HSI activities for design/developmental systems versus activities for COTS-based systems within the SE process. Some activities are the same for each; however, others are scaled differently, involving a more holistic approach to evaluating the materiel solution in terms of its integration with current systems as well as how users will support, operate, and maintain the system.

What is the way ahead for PMs who wish to better integrate HSI into their acquisition? The SE technical review process is a powerful tool for PMs to monitor and ensure that their programs are optimally robust in terms of cost, schedule, and performance. Unfortunately, especially in a COTS/NDI environment, the belief is that the human plays a small part in the SE process given that "the system is what it is." Even for those programs that do acknowledge the human as part of the system, they usually know very little about the details of the principles and methods of HSI.[15] What often happens when programs do not address the human component is the human users end up becoming de facto architects for the system as they must manipulate it to meet their changing needs given the ever-changing mission environment. The users need to make on-the-spot decisions to address system shortcomings that should have been identified and addressed during the SE process.[16] Clearly, however, this should not be.

The PM who truly wants to *support the Marines* and *equip the Warfighter* (all mantras that Marine acquisition professionals are taught to repeat) will put down this article and immediately call in the systems engineer to account for how HSI is integrated into the PM's SE technical review process. In other words, how are the acquisition teams being held accountable for HSI and how can it be improved? Without leadership support, multiple research studies have shown that infusing HSI into the acquisition process will meet opposition at every turn due to lack of commitment.[17] In short, the culture will resist it or at best treat it as an obstacle to skirt around or leap over.

DOD acquisition is a large, complicated process beset by thousands of regulations. That much will not change. However, at the ground level of acquisition where DOD professionals partner with industry and the warfighter to define, develop, and deploy systems, there is a possibility of revolutionary change; what has been regarded as a default trade-off is actually a linchpin of success. The concept seems beautifully logical and simple: materiel systems are comprised indivisibly of HW, SW, and humans. Testing and evaluating a vehicle without attending to how humans will occupy and work with that vehicle makes no more sense than testing and evaluating a vehicle without making sure that it brakes and accelerates. Omitting HSI from acquisition obscures a whole view of the system for the program office, the vendor, and most importantly for the humans who must interact with and use the system.

The concept seems beautifully logical and simple: materiel systems are comprised indivisibly of HW, SW, and humans.

Notes

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