ARL-TN-1248 ● APR 2025

Cognitive Workload Considerations for Human–Machine Integrated Formations

by Craig J. Johnson and Amar R. Marathe

NOTICES

Disclaimers

ARL-TN-1248 ● APR 2025

Cognitive Workload Considerations for Human–Machine Integrated Formations

Craig J. Johnson and Amar R. Marathe
DEVCOM Army Research Laboratory

REPORT DOCUMENTATION PAGE

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED: START DATE	END DATE
April 2025	Technical Note	12/05/2024	2/21/2025

4. TITLE AND SUBTITLE
Cognitive Workload Considerations for Human–Machine Integrated Formations

5a. CONTRACT NUMBER	5b. GRANT NUMBER	5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER	5e. TASK NUMBER	5f. WORK UNIT NUMBER

6. AUTHOR(S)
Craig J. Johnson and Amar R. Marathe

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
DEVCOM Army Research Laboratory
ATTN: FCDD-RLA-FD
Aberdeen Proving Ground, MD 21005

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-TN-1248

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.

13. SUPPLEMENTARY NOTES
ORCIDs: Craig J. Johnson, 0000-0003-3739-9679; Amar R. Marathe, 0000-0002-6253-6105

14. ABSTRACT
This report summarizes the cognitive workload challenges related to human–machine integrated formation (HMIF) drawing from scientific literature. It specifically addresses four key issues: 1) Individual cognitive load related to user interfaces and human–automation interactions. 2) Team-level impacts of cognitive load that extend beyond the individual operator. 3) Challenges to scaling cognitive demands with multiple autonomous systems. 4) The variability and evolution of cognitive workload and task demands over time in complex environments. Areas for further consideration and specific recommendations are provided for HMIF development—including additional language necessary for requirements documents, measures necessary in professional military education to prepare Soldiers for cognitive overload, and updates to policy (including DoDI 5000.95).

15. SUBJECT TERMS
cognitive workload, human factors, robotics, human–autonomy teaming, human–machine integration, swarms, unmanned vehicles, Humans in Complex Systems

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	C. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UU	22

19a. NAME OF RESPONSIBLE PERSON	19b. PHONE NUMBER *(Include area code)*
Amar R. Marathe	(520) 691-6291

STANDARD FORM 298 (REV. 5/2020)
Prescribed by ANSI Std. Z39.18

Contents

1. Introduction **1**

1.1 Summary 1

1.2 Background 1

2. Cognitive Load Considerations **3**

2.1 Human-Centered Design Is Essential 3

2.2 Cognitive Overload Extends to Teams and Formations 5

2.3 Scaling Cognitive Demands with Multiple Systems 6

2.4 Cognitive Workload Dynamics and Flexibility 7

3. References **9**

Appendix. Recommendations for Human–Machine Integrated Formation (HMIF) Development **12**

List of Symbols, Abbreviations, and Acronyms **16**

Distribution List **17**

1. Introduction

1.1 Summary

Managing cognitive load within Army systems is a critical area of research due to the high-stakes environments in which military personnel operate. Over recent decades, research in this area has primarily focused on interface design issues to mitigate cognitive load. However, when dealing with the integration of human and autonomous systems into human–machine integrated formations (HMIFs), it is more critical to purposefully design the means in which humans and all forms of autonomous systems—to include physical embodied systems and non-embodied systems such as decision support tools and aided target recognition systems—are expected to interact across the breadth of Mission, Enemy, Terrain and weather, Troops and support available, Time available, and Civil considerations (METT-TC) within operational settings across missions. This report specifically addresses four critical cognitive workload issues relevant to HMIFs and concludes with specific recommendations for development:

1) **Individual Operator Load:** User interfaces (UIs) and human–machine interactions must be designed to deal with information overload when interacting with HMIF systems.
2) **Team-/Unit-Level Impacts of Cognitive Load:** The Army must consider the impacts of cognitive workloads that extend beyond the individual operator.
3) **Scaling Cognitive Demands with Multiple Autonomous Systems:** Systems and formations must be designed to account for how cognitive demands scale when interacting with multiple interdependent HMIF systems, including autonomy and people.
4) **Cognitive Workload Dynamics and Flexibility:** Cognitive demands will vary and evolve over time in complex environments. HMIF must be flexible enough to account for changes in tasking, operational environment, adversary capabilities, and team structure/configuration.

1.2 Background

The safety and effectiveness of Soldiers on the modern battlefield requires balance between the cognitive demands of their tasks (e.g., target acquisition, navigation, communication) and their capacity to meet those demands. Cognitive workload describes the relationship between an operator's finite cognitive resources—such as attention and working memory—and the demands of their tasks; and how this balance impacts key performance outcomes like safety, speed, and accuracy (Gopher and Donchin 1986; Hancock and Meshkati 1988; Wickens and Tsang 2015; Young et al. 2015). When demands exceed an operator's available cognitive resources, they experience cognitive "overload" where performance deteriorates, potentially resulting in reduced accuracy, slower decision-making, task shedding, or ineffective coordination (Grier et al. 2008; Wickens and Tsang 2015; Young et al. 2015). Within HMIFs, such failures can disrupt critical functions like target identification, communication across echelons, or synchronization between Soldiers and robotic assets. These disruptions can cascade, jeopardizing not only individual Soldiers but also entire formations and mission success.

An important consideration when incorporating automation into complex human systems is to enhance overall performance capabilities and safety while maintaining manageable levels of operator workload. However, automation requires its own set of cognitive demands and fundamentally alters task workflows and system interdependencies (Woods and Hollnagel 2006; Woods 2018), which can lead to unintended consequences. Poorly integrated or inadequately designed automation may fail to deliver the desired performance benefits and increase cognitive demands on operators (Strauch 2017). In HMIFs, this can erode trust, reduce utilization, negatively impact situation awareness (SA), and ultimately degrade performance (Endsley 2023). Conversely, properly integrated systems improve performance while reducing operator workload, leading to increased capabilities for the HMIF.

Managing cognitive workload is a ubiquitous challenge on the battlefield. Integrating humans and autonomous systems in HMIFs creates new sources of cognitive load (Barnes et al. 2019), resulting in overload if not appropriately managed. For instance, Soldiers may face information overload because of the unprecedented data collection capabilities of robotics and autonomous systems (RASs), which can ultimately impair decision-making and SA despite access to more data. This issue is compounded by the expectation that human–machine integrated (HMI) units will coordinate, supervise, and control multiple autonomous systems that operate in changing conditions over time. These systems are anticipated to be highly interconnected and interdependent with Soldier tasks and thus may have widespread impacts on workload and performance.

There exists a broad research literature relevant to cognitive overload in HMIFs. This report focuses on four pressing issues specific to HMIF:

1) UI and human–automation interaction design related to information overload in individual Soldiers,
2) Wider team-/unit-level impacts of cognitive workload that extend beyond the individual operator,

3) How cognitive demands scale with multiple autonomous systems, and
4) The dynamics of how demands can rapidly evolve over time and when teams reconfigure.

This report concludes with specific recommendations on how the Army addresses these issues, and potential updates to policy (including DoDI 5000.95) in the Appendix.

2. Cognitive Load Considerations

2.1 Human-Centered Design Is Essential

HMI systems must be designed to effectively interface with Soldiers, regardless of their autonomous capability. This includes collecting data from the operational environment, sharing it appropriately across interconnected systems, and timely presentation of data to operators. However, presenting all available data to every user is neither necessary nor efficient. Overloading Soldiers with irrelevant data creates visual or auditory clutter, increases cognitive load, reduces SA, and delays access to the information needed for their tasks (Wickens et al. 2022). One goal of any HMI system should be to deliver the right data to the right person at the right time and place. Importantly, this information management imperative must be balanced with providing sufficient data to maintain SA.

In addition to the raw volume of data, the form in which data is presented to a user has a significant impact on cognitive workload and performance. Data should be integrated into meaningful *information* in a way that helps users understand its significance and anticipate how events and data are likely to evolve over time (Flach and Bennett 2011; Endsley and Jones 2024). A well-designed UI can present large quantities of potentially relevant information in a digestible format that highlights critical components of the work domain while simultaneously allowing details to be investigated, resulting in reduced cognitive workload, enhanced SA, and improved decision-making capabilities. Determining *what, when,* and *how* to present information requires adherence to user-centered interface design principles that consider human cognitive capabilities, limitations, and dynamics; and are grounded in users' goals, tasks, and mental models (Tidwell et al. 2020; Wickens et al. 2021).

The way that users can interact with the system is as important as the data itself. Different modalities (e.g., visual, auditory, tactile) are suited for different contexts and conflicts between modalities and attentional resources—such as requiring a vehicle operator to communicate exclusively over a text medium—can also cause cognitive overload (Wickens 2008). Interaction designs must also be intuitive and require minimal cognitive effort to achieve operator goals. HMIF systems should not be clumsy, wherein they interrupt or add additional demands to human operators during periods of high demand.

HMIF systems should be observable, predictable, and directable (Johnson et al. 2014). Soldiers must understand how their own inputs are interpreted by these autonomous systems (i.e., bidirectional interactions) through a tight coupling of user inputs and feedback. Continuous interaction and feedback mechanisms are important for supporting the trusting process in HMIF systems (Chiou and Lee 2023). Misaligned communication interfaces or poorly designed systems can exacerbate the problem of cognitive load by increasing ambiguity and task difficulty. Thus, for each system included within an HMIF, balancing task distribution between humans and machines, ensuring intuitive system design, and fostering trust are critical to reducing cognitive load and enhancing overall performance.

Establishing and maintaining appropriate trust will become increasingly critical for the management of cognitive workload in HMIF systems. Soldiers will be required to interpret, gather, and synthesize information originating from spatially and temporally distributed and heterogenous sources to establish SA and make decisions. An operator's willingness to use this information therefore becomes a determining factor in their ultimate effectiveness, and this hinges on operators having an appropriate level of trust in the systems. If trust is too low, operators may retain tasks they could offload or invest additional cognitive resources to verify the system's reasoning, reducing efficiency and performance. However, over-trust in systems can lead to over-reliance, a lack of human oversight, and unanticipated behaviors. Proper design can encourage appropriate trust and therefore more effective performance by enhancing transparency (Chen and Barnes 2022) and calibrating expectations of behavior (Lee and See 2004; Mercado et al. 2016; Johnson et al. 2023).

Many of these cognitive workload issues can be informed by the fields of human–computer interaction, human factors/ergonomics, and user experience; thus, it is recommended that such expertise be included as part of an interdisciplinary team when developing and evaluating any HMIF technology. However, cognitive workload challenges extend beyond the individual operator level in HMIFs, suggesting a need to adopt a team-oriented, multisystem perspective on cognitive overload.

2.2 Cognitive Overload Extends to Teams and Formations

Because HMIFs are expected to include various autonomous systems working with many Soldiers, the Army must consider how the combination of all these systems will collectively impact the cognitive load of the Soldiers. Thus, designing each individual system to manage cognitive load is not sufficient.

HMIFs integrate people and technology, leveraging diverse individual capacities to enable joint activities that exceed what either can achieve alone. Human cognitive resources vary in quality (e.g., skills) and quantity (e.g., working memory capacity), while AI systems also possess cognitive (computational) resources, albeit with significantly greater variability across systems and decidedly different forms than human cognition. Effective HMIF system design should not simply substitute human cognition but combine the complementary cognitive attributes of humans (e.g., flexibility) and AI (e.g., speed); thus, enabling collaborative cognitive work that capitalizes on their respective strengths and mitigates their weaknesses in the context of the mission (Dellermann et al. 2019).

However, even when all necessary skills and resources are present in a formation, coordination problems can still hinder performance. RAS may increase demands by altering coordination given the differing speed at which RASs operate from humans. Cognitive overload or delays for one individual or technology can create information-processing bottlenecks, disrupting the flow of critical information and causing performance losses across the formation, regardless of whether individual members are directly overloaded. Optimizing workload for an individual Soldier operating an HMI tool does not equate to optimizing workload for the broader unit within an HMIF; thus, the intersection of cognitive workload and team coordination must be considered.

Coordination and communication require cognitive resources that can lead to conflicts when multitasking between coordination and individual tasks (Crawford and LePine 2013). HMIF communication and coordination tools should be designed to minimize additional burdens from these resource conflicts. HMIF systems can also directly support coordination processes and reduce associated demands and wider impacts of bottlenecks by providing relevant information about the coordination itself. This includes details such as which communication channels are currently available (or expected to be available), the timeliness (or staleness) of updates and communications, the operational stages of interdependent components, and their availability for interruption or re-tasking.

2.3 Scaling Cognitive Demands with Multiple Systems

The ability of RAS to execute their mission-essential tasks independently will depend on the complexity of the environment, enemy, and other factors encompassed in METT-TC. This level of potential independence will drive the nature of the interactions that are possible between humans and robots with HMIF. In some cases, RAS will be able to act independently, whereas in more complex situations Soldiers will need to directly teleoperate these platforms. Therefore, the Army must account for the fact that the combined impact of including multiple autonomous systems in formations, regardless of how well each individual system is designed, is likely to overload Soldiers without careful consideration as to the means in which the Soldiers and systems are expected to interact across the breadth of METT-TC.

Different control paradigms are likely needed for various HMIF systems and even within the same system, depending on the tasks being performed and the current METT-TC conditions (Metcalfe et al. 2021). When operators manage multiple unmanned vehicles (UVs), the way cognitive demands scale depends on how the systems are controlled and the capabilities of autonomy. Some tasks, such as approving targets or identifying casualties, are relatively independent; therefore, the time and cognitive resource demands increase roughly linearly as more UVs are added. However, these discrete tasks can be more easily distributed among multiple operators as needed. Other tasks, such as assigning UVs to a map region or coordinating group movement along a route, require a relatively fixed level of resources regardless of the number of UVs but are highly dependent on the ability of individual systems to perform such actions without direct intervention. However, tasks that require tightly coordinating UVs manually demand exponentially increasing resources and time as more UVs are added, making it impractical to control more than 1–3 UVs under such conditions (Hicks et al. 2023). It may therefore be necessary to either limit the manning of a system to match the highest level of manual coordination required during the most demanding tasks or implement flexible teaming structures that dynamically scale the number of operators based on the task demands of the UVs. In addition, autonomous systems, their interfaces and user interactions, along with the associated training paradigms will have to be designed for the entire range of control mechanisms to avoid inducing cognitive overload

2.4 Cognitive Workload Dynamics and Flexibility

The Army must also consider the impact of the variability inherent in the battlefield environment. Conditions will change, Blue Force (BLUFOR) units' capability will degrade and be replenished, and adversaries will adapt to BLUFOR tactics and capabilities. The dynamic nature of the Future Operational Environment means that Soldiers must be capable of interacting with systems through these changes while maintaining combat effectiveness. Thus, future HMIFs must account for how these units will adapt to changing demands without exacerbating the cognitive burden on the Soldiers.

Rapid workload transitions from low-demand vigilance tasks (e.g., conducting security) to high-demand situations (e.g., enemy contact; Huey and Wickens 1993) can lead to surprises, where cognitive resources are not effectively allocated to the situation, giving adversaries a potential advantage. This risk may be mitigated by predictive warning systems that help Soldiers anticipate and prepare for workload transitions in addition to flexible system designs that allow Soldiers to adjust system behaviors and reallocate assets to complete mission objectives.

In combat situations, organizational structures cannot remain static. Both attrition (of personnel and technology) and the use of flexible teaming paradigms (Gremillion et al. 2022, 2024a, 2024b) imply that components within HMIFs will need to dynamically reconfigure. When teams rapidly shift objectives, tasks, and roles among personnel and HMIF systems, these transitions can disrupt SA. Regaining SA requires cognitive effort (Endsley 1993), potentially leaving operators in a temporarily overloaded state. Systems that assist in reallocating human and technological resources or provide necessary handoff information and quickly orient operators to their new tasks or roles may help reduce the duration and severity of cognitive overload from team reconfigurations.

Dynamic team reconfigurations can lead to uneven cognitive demands, placing greater burden on certain roles. Mechanisms that provide insight into the demands faced by teammates or HMIF systems, as well as guidance on how best to assist with those demands, can help mitigate these effects by enabling backup behaviors. Additionally, these systems can support opportunistic assistance, where help is not essential but enhances accuracy or efficiency (Johnson et al. 2014). Finally, intelligent algorithms can be employed to facilitate these team reconfigurations in a manner that enhances mission performance (Gremillion et al. 2024a, 2024b).

Individuals and teams that effectively manage potential overload adjust their execution strategies by prioritizing tasks, using heuristics, or developing creative solutions as adaptive compensatory responses to maintain performance (Funke et al. 2012; Woods and Wreathall 2016). Beyond concerns about excluding humans from meaningful control and decision-making—such as loss of SA, automation surprise, skill degradation, and ethical issues (Parasuraman and Riley 1997)—fully offloading tasks to AI risks diminishing this innovative potential. Designing flexible and adaptive AI systems that keep humans in the loop is therefore critical to enabling innovative problem-solving while mitigating the risks of cognitive overload.

3. References

Barnes M, Elliott LR, Wright J, Scharine A, Chen J. Human-robot interaction design research: from teleoperations to human–agent teaming. Army Research Laboratory (US); 2019. Report No.: ARL-TR-8770.

Chen JY, Barnes MJ. Agent transparency for human-autonomy teaming. Human-Automation Interaction: Mobile Computing. Springer; 2022. p. 255–266.

Chiou EK, Lee JD. Trusting automation: designing for responsivity and resilience. Hum Fact. 2023;65(1):137–165.

Crawford ER, LePine JA. A configural theory of team processes: accounting for the structure of taskwork and teamwork. Acad Manage Rev. 2013;38(1):32–48.

Dellermann D, Ebel P, Söllner M, Leimeister JM. Hybrid intelligence. Bus Info Syst Eng. 2019;61(5):637–643.

Endsley MR. Situation awareness and workload: flip sides of the same coin. International Symposium on Aviation Psychology; 1993. Columbus, OH. p. 906–911.

Endsley MR. Ironies of artificial intelligence. Ergonomics. 2023;66(11):1656–1668.

Endsley MR, Jones DG. Situation awareness oriented design: review and future directions. Int J Hum – Comput Interact. 2024;40(7):1487–1504.

Flach JM, Bennett KB. Display and interface design: subtle science, exact art. CRC Press; 2011.

Funke GJ, Knott BA, Salas E, Pavlas D, Strang AJ. Conceptualization and measurement of team workload: a critical need. Hum Factors. 2012;54(1):36–51.

Gopher D, Donchin E. Workload: an examination of the concept. In: Boff KR, Kaufman L, Thomas JP, editors. Handbook of perception and human performance. John Wiley & Sons; c1986. p. 1–49 (Cognitive Processes and Performance; vol 2).

Gremillion GM et al. Preliminary assessment of manpower needs and task-sharing in the next generation combat vehicle. DEVCOM Army Research Laboratory (US); 2022. Report No.: ARL-TR-9408.

Gremillion GM et al. Technologies to cue and support team tasking and coordination in the next generation combat vehicle (Summary Technical Report, Oct 2021–Sep 2022). DEVCOM Army Research Laboratory (US); 2024a Sep. Report No.: ARL-TR-9963.

Gremillion GM et al. Technologies for automated dynamic resource allocation in the next generation combat vehicle. DEVCOM Army Research Laboratory (US); 2024b Nov. Report No.: ARL-TN-1234.

Grier R et al. The red-line of workload: theory, research, and design. Proc Hum Factors Ergon Soc Annu Meet. 2008;52(18):1204–1208.

Hancock PA, Meshkati N. Human mental workload. North-Holland Amsterdam; 1988.

Hicks J, Lewis M, Sycara K. Report on human factors issues likely to affect air launched effects/autonomous loitering effects (ALE). DEVCOM Analysis Center (US); 2023. Report No.: DEVCOM DAC-TR-2023-078.

Huey BM, Wickens CD. Workload transition: implications for individual and team performance. National Academy Press; 1993.

Johnson CJ et al. The impact of training on human–autonomy team communications and trust calibration. Hum Factors. 2023;65(7):1554–1570.

Johnson M et al. Coactive design: designing support for interdependence in joint activity. J Hum-Robot Interact. 2014;3(1):43–69.

Lee JD, See KA. Trust in automation: designing for appropriate reliance. Hum Factors. 2004;46(1):50–80.

Mercado JE et al. Intelligent agent transparency in human–agent teaming for multi-UxV management. Hum Factors. 2016;58(3):401–415.

Metcalfe JS, Perelman BS, Boothe DL, McDowell K. Systemic oversimplification limits the potential for human-AI partnership. IEEE Access. 2021;9:70242–70260.

Parasuraman R, Riley V. Humans and automation: use, misuse, disuse, abuse. Hum Factors. 1997;39(2):230–253.

Strauch, B. Ironies of automation: still unresolved after all these years. IEEE Trans Hum-Mach Syst. 2017;48(5):419–433.

Tidwell J, Brewer C, Valencia A. Designing interfaces: patterns for effective interaction design. 3rd ed. O’Reilly Media; 2020.

Wickens CD. Multiple resources and mental workload. Hum Factors. 2008;50(3):449–455.

Wickens CD, Helton WS, Hollands JG, Banbury S. Engineering psychology and human performance. Routledge; 2021.

Wickens CD, McCarley JS, Gutzwiller RS. Applied attention theory. CRC Press; 2022.

Wickens CD, Tsang PS. Workload. APA handbook of human systems integration. American Psychological Association; 2015. p. 277–292.

Woods DD. Decomposing automation: apparent simplicity, real complexity. Automation and human performance. CRC Press; 2018. p. 3–17.

Woods DD, Hollnagel E. Joint cognitive systems: patterns in cognitive systems engineering. CRC Press; 2006.

Woods DD, Wreathall J. Stress-strain plots as a basis for assessing system resilience. CRC Press; 2016. p. 157–172 (Resilience Engineering Perspectives; vol 1).

Young MS, Brookhuis KA, Wickens CD, Hancock PA. State of science: mental workload in ergonomics. Ergonomics. 2015;58(1):1–17.

Appendix. Recommendations for Human–Machine Integrated Formation (HMIF) Development

A.1 General Lessons Learned and Best Practices to Manage and Mitigate Cognitive Overload

A.1.1 User Interface Design is Critical for HMIFs

- Provide the right data to the right place at the right time in a format meaningful to its operational context.
- Design interfaces that align with human cognitive capacities and limitations.
- Ensure interactions are intuitive, require minimal necessary effort, and include clear feedback to reduce cognitive burden.
- HMIF systems should not be *clumsy*, wherein they interrupt or add additional demands to human operators during high criticality or high demand periods.
- Present information that proactively explains machine reasoning, context, and impacts to support trust calibration.

A.1.2 Cognitive Overload Extends Beyond Individuals

- Individual workload optimization does not guarantee team-level optimization.
- Integrate human and AI strengths to create systems that complement, rather than replace, human cognition.
- Avoid bottlenecking coordination structures that are likely to propagate cognitive overload through the team.
- Design communication and coordination tools to reduce cognitive demands and highlight coordination affordances.

A.1.3 Scaling and Complexity of Autonomous Systems

- Recognize that cognitive demands vary based on how unmanned vehicles (UVs) are controlled.
- Match system manning to the highest expected coordination requirement for UV control.
- Implement flexible teaming structures that scale operators dynamically with task demands of UV control.

A.1.4 Cognitive Workload Dynamics and Flexibility

- Support teams in anticipating, preparing for, and adjusting to workload transitions to minimize overload during shifts.
- Share real-time information about teammates' cognitive demands and task statuses to help identify when and how to provide backup.
- Design autonomous systems for flexibility by considering the various ways the system will be used under different Mission, Enemy, Terrain and weather, Troops and support available, Time available, and Civil considerations (METT-TC) conditions. Interfaces must support flexibility as well.
- Maintain humans in the decision loop.

A.2 Additional Language Necessary for Requirements Documents (Army Futures and Concepts Center/Capability Development Integration Directorates)

- Include modes of interaction required for each autonomous system to enable more complete design of systems.
- Account for reasonable failure rates for systems.
- Design approaches for units to overcome system failures to meet mission objectives.

A.2.1 Measures Necessary in Primary Military Education to Prepare Soldiers for Cognitive Overload

- Introduce Soldiers to the concept of cognitive workload and overload in the context of HMIFs due to increases in data collection volumes, system speed, and the complexities of having multiple interconnected HMIF systems.
- Train Soldiers to recognize cognitive overload in themselves and their teammates.
- Train Soldiers on strategies to mitigate overload such as frontload in anticipation of workload peaks and transitions, team monitoring, backup behaviors, and strategy shifts.
- Train Soldiers on the key capabilities and limitations of AI and automation.
- Provide simulation-based or embedded training solutions that enable Soldiers to experiment with system capabilities prior to live use.

A.2.2 Recommended Updates to Policy (including DoDI 5000.95)

- Capabilities for flexibility and adaptation of HMIF units will enable changing system behaviors after test and evaluation procedures are complete. This violates current DoD policy but will be a critical need for effective HMIF utilization against intelligent adaptive adversaries in the Future Operational Environment.

- Approaches for human–system integration assessment (described in DoDI 5000.95) must be updated to deal with systems that adapt to environmental and adversarial conditions.
- Exhaustive testing of systems within all possible METT-TC conditions may not be feasible; alternative approaches will be needed to certify systems for fielding.

List of Symbols, Abbreviations, and Acronyms

AI	artificial intelligence
BLUFOR	Blue Force
DoD	Department of Defense
DoDI	Department of Defense Instruction
HMI	human–machine integrated
HMIF	human–machine integrated formation
METT-TC	Mission, Enemy, Terrain and weather, Troops and support available, Time available, and Civil considerations
RAS	robotics and autonomous system
SA	situation awareness
UI	user interface
UV	unmanned vehicle

1 (PDF)	DEFENSE TECHNICAL INFORMATION CTR DTIC OCA
1 (PDF)	DEVCOM ARL FCDD RLB CI TECH LIB