USAARL-TECH-CR--2021-02

UNITED STATES ARMY AEROMEDICAL RESEARCH LABORATORY

Future Vertical Lift Cognitive Workload Risk Mitigation Study - Executive Summary

Katie Ernst, Laura Militello, Emilie Roth, Christen Sushereba, & Scott Scheff

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
28-10-2020

2. REPORT TYPE
Contract Report

3. DATES COVERED *(From - To)*
05/01/2020 - 09/30/2020

4. TITLE AND SUBTITLE
Future Vertical Lift Cognitive Workload Risk Mitigation Study - Executive Summary

5a. CONTRACT NUMBER
NNA13AB88C AS19-01059 Mod2

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

6. AUTHOR(S)
Katie Ernst, Applied Decision Science
Laura Militello, Applied Decision Science
Emilie Roth, Roth Cognitive Engineering
Christen Sushereba, Applied Decision Science
Scott Scheff, HF Designworks

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Applied Decision Science, LLC
1776 Mentor Avenue
Suite 424
Cincinnati, Ohio 45112

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Aeromedical Research Laboratory
P.O. Box 620577
Fort Rucker, AL 36362

10. SPONSOR/MONITOR'S ACRONYM(S)
USAARL

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
USAARL-TECH-CR--2021-02

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

13. SUPPLEMENTARY NOTES
This study was performed under contract and funded by USAARL.

14. ABSTRACT
This document is an executive summary from a detailed report of a Future Vertical Lift (FVL) Cognitive Workload Risk Mitigation study that addresses the question of whether the Future Attack Reconnaissance Aircraft (FARA) and Future Long Range Assault Aircraft (FLRAA) will be able to be flown and fought in the Joint All-Domain Operations environment without excessive cognitive workload on the aircrew that will compromise mission effectiveness. Applied Decision Science (ADS) analyzed projected workload for FARA and FLRAA aircrew, and reviewed science and technology (S&T) and research development test and evaluation (RDT&E) programs to understand not just whether, but how the Army will mitigate the risk of cognitive overload. The full report is also available as USAARL-TECH-CR-2021-03.

15. SUBJECT TERMS
Future Vertical Lift, FVL, Future Attack Reconnaissance Aircraft, FARA, Future Long Range Assault Aircraft, FLRAA, cognitive workload, helicopter workload

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER *(Include area code)*
UNCLAS	UNCLAS	UNCLAS	SAR	5	Loraine St. Onge, PhD / 334-255-6906

Future Vertical Lift
Cognitive Workload Risk Mitigation Study
Executive Summary

September 30, 2020

AUTHORS
Katie Ernst, Applied Decision Science
Laura Militello, Applied Decision Science
Emilie Roth, Roth Cognitive Engineering
Christen Sushereba, Applied Decision Science
Scott Scheff, HF Designworks

APPLIEDDECISIONSCIENCE

Roth Cognitive Engineering

EXECUTIVE SUMMARY: FUTURE VERTICAL LIFT COGNITIVE WORKLOAD RISK MITIGATION STUDY REPORT

About Applied Decision Science

Applied Decision Science, LLC (ADS) is a research and development company focused on supporting human cognition in environments that are characterized by high stakes, high time-pressure and/or high complexity. Led by Senior Scientist and Chief Executive Officer, Laura Militello, ADS applies Naturalistic Decision Making methods and models to support human performance in complex environments. Our emphasis is on studying how decision makers operate in the real world to articulate cognitive challenges and the skills and strategies that experienced operators employ to manage complexity. We rely on a suite of cognitive task analysis methods that drive the design of decision support tools, training programs, and work-process redesign services to support and to improve decision-making. The company primarily provides its services in military and health care environments.

ADS leads a strong coalition of small businesses in this cognitive workload risk mitigation study. Roth Cognitive Engineering, founded by Dr. Emilie Roth, is a small company that conducts research and application in the areas of human factors and cognitive engineering. HF Designworks, Inc., founded by Scott Scheff, is a human factors, user interface research and design company focused on system end users. For the past two years, ADS has led this coalition in several efforts related to Future Vertical Lift including the U.S. Army's Optimally Crewed Vehicle program that developed the Integrated Cognitive Analyses for Human-Machine Teaming (ICA-HMT) strategy for determining optimal crewing configurations.

www.applieddecisionscience.com

Acknowledgements

This material is based on work supported by the U.S. Army under agreement NNA13AB88C AS19-01059 Mod2. The authors would like to thank the U.S. Army Aeromedical Research Laboratory, and Combat Capabilities Development Command - Aviation and Missile Center - Technology Development Directorate for their sponsorship of this work. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the U.S. Army. The authors would also like to thank Julie DiIulio, of Applied Decision Science, for her support in this study.

EXECUTIVE SUMMARY

This Future Vertical Lift (FVL) Cognitive Workload Risk Mitigation study addresses the question of whether the Future Attack Reconnaissance Aircraft (FARA) and Future Long Range Assault Aircraft (FLRAA) will be able to be flown and fought in the Joint All-Domain Operations environment without excessive cognitive workload on the aircrew that will compromise mission effectiveness. Applied Decision Science (ADS) analyzed projected workload for FARA and FLRAA aircrew, and reviewed science and technology (S&T) and research development test and evaluation (RDT&E) programs to understand not just whether, but *how* the Army will mitigate the risk of cognitive overload. *Our analysis indicates that the Army is on track to deliver FARA and FLRAA aircraft that will mitigate the risk of cognitive overload that would compromise mission effectiveness.*

What is cognitive workload? Cognitive workload refers to the demands placed on a person's limited cognitive resources. Automation is an important strategy for cognitive offloading. A commonly held belief is that handing tasks over to automation directly reduces the human's cognitive workload by the exact amount of workload associated with the tasks. In reality, while some workload is handed off, new, often hidden, cognitive workload is imposed on humans as they manage the automation. Managing automation includes monitoring the automation to keep track of what it is doing, monitoring its mode of operation and health status, and anticipating what it will do next. These are important workload drivers that must be considered in automation, human-machine interface, crewing, and training design.

What will be the key contributors to cognitive workload? Prior Army Aviation studies assess the workload effect of technologies designed to reduce risk of cognitive overload. These include: automation and advanced human-machine interfaces to support flight controls, communications, navigation, manned-unmanned teaming, and attack planning. Workload studies highlight the strengths and limitations of existing technologies in different contexts. Looking forward at the requirements and operational concepts for FARA and FLRAA, we identified seven key performance attributes of FARA and FLRAA operations that are new or substantively altered as compared with current operations. These seven attributes will likely influence workload. They are: 1) Advanced teaming with air launched effects; 2) Increased agility in all modes of flight including degraded visual environments; 3) Sending and receiving an increased volume of situation awareness data to maintain a common operating picture; 4) Fusing sensor data from many sources and new types of sensors; 5) Increased survivability in complex threat environments; 6) Increased operations tempo; and 7) Managing multiple levels of supervised autonomy. Each of these attributes will impose specific cognitive demands on the FARA and FLRAA aircrew. Looking across these attributes and their associated cognitive demands, a set of overarching cognitive requirements emerged. These include calibrating trust, integrating and interpreting information from multiple sources, anticipating second and third order effects, managing interruptions, and managing workload spikes. These overarching cognitive requirements are applicable across the range of FARA and FLRAA systems.

How will the Army mitigate the risk of cognitive overload in FARA and FLRAA? Our analysis indicates that the Army is on track to deliver FARA and FLRAA aircraft that will mitigate the risk of cognitive overload that would compromise mission effectiveness. Although there is risk that new capabilities and anticipated threats may contribute to crew member cognitive overload, our analyses indicate that adaptation of TTPs, combined with expected outcomes of ongoing and planned S&T and RDT&E programs will mitigate this risk. Specific cognitive overload risk mitigation strategies will evolve over time as FARA and FLRAA platforms incorporate emerging technologies to meet the threat.

Managing workload related risks. It will be critical to fully fund ongoing and planned S&T and RDT&E programs to increase the likelihood that the technologies needed to fill these gaps and mitigate cognitive workload are filled. There are four areas of emphasis we encourage the Army to maintain over the life of the FVL program to manage cognitive workload related risks. They include 1) develop an integrated crewstation with frequent and iterative simulation and flight testing; 2) include a human machine teaming and interface plan for each technology with human roles clearly articulated; 3) integrate robust and reliable automation support; and 4) deliver training to support rapidly evolving tactics, techniques, and procedures with joint partners.

Conclusion. Sophisticated automation alone is not sufficient to overmatch against the envisioned threat. Deliberate strategies to mitigate the easily overlooked aspects of cognitive complexity and associated cognitive workload are already underway. Strategies for mitigating the cognitive workload of FARA and FLRAA aircrews and achieving mission effects in a Joint All-Domain Operations environment will evolve as increasingly advanced technologies to support flight and mission tasks, human machine interfaces, and human system integration become available.

About the Authors

Katie Ernst is a human factors engineer with Applied Decision Science. Katie leverages her experience in military operations with methods from human factors and cognitive systems engineering to analyze and design for both military and healthcare applications. Prior to joining Applied Decision Science, she served 13 years in the U.S. Air Force in both active and reserve capacities. Katie served in a mix of intelligence and engineering assignments including an MQ-1 Predator reconnaissance squadron, the National Security Agency, Headquarters Air Force, and the Air Force Research Laboratory. She received her M.S. in Industrial Engineering from Purdue University.

Laura G. Militello is co-founder and Chief Executive Officer at Applied Decision Science, LLC, a research and development company that studies decision making in complex environments. She is a recognized leader in the cognitive engineering and naturalistic decision making community. Ms. Militello contributed to the development of early cognitive task analysis methods, and coauthored a text-book on the topic (Hoffman & Militello 2009). She has applied cognitive task analysis methods to the design of technologies and training to support combat search and rescue piloting, air campaign planning, weapons directing, critical care nursing, and many other complex systems. She received her M.A. in Experimental Psychology and Human Factors from the University of Dayton.

Emilie M. Roth is owner and principal scientist of Roth Cognitive Engineering. Dr. Roth is a cognitive psychologist by training and has over 30 years of experience in cognitive analysis and design across a broad range of domains including military command control, intelligence analysis, healthcare, and transportation. She has supported design of first-of-a-kind systems including next-generation nuclear power plant control rooms; and work-centered support systems for airlift planning and monitoring for USTRANSCOM and the Air Mobility Command. She is a fellow of the Human Factors and Ergonomics Society and currently serves as a member of the Board on Human-Systems Integration at the National Academies.

Christen E. Sushereba is a research associate at Applied Decision Science, LLC. For the past ten years, Ms. Sushereba has applied cognitive engineering and human factors methods to a variety of domains including military pararescue, emergency response, cyber security, electronic health record design, emergency medicine training, air traffic control, workload, and human-automation teaming. She received her M.S. in Human Factors and Industrial/Organizational Psychology from Wright State University in Dayton, Ohio.

Scott Scheff is CEO and Principal Human Factors Engineer at HF Designworks, Inc., a user experience research and design company with deep roots in supporting the Department of Defense in situational awareness, unmanned aircraft command and control, and human performance modeling and simulation. With fielded systems in Iraq, Afghanistan, and CONUS (in use by the Department of Homeland Security), Mr. Scheff has applied his 20+ years' experience in human factors to a variety of systems including big data visualization for military intelligence; blue force tracking; and command, control, and maintainability of unmanned ground and air platforms. He received his M.A. in Human Factors and Applied Experimental Psychology from California State University, Northridge.

Cover photo | U.S. Army Aeromedical Research Laboratory photo by Scott Childress

U.S. Army Aeromedical Research Laboratory
Fort Rucker, Alabama

All of USAARL's science and technical information documents are available for download from the Defense Technical Information Center.

https://discover.dtic.mil/results/?q=USAARL

Army Futures Command
U.S. Army Medical Research and Development Command