USAARL Report No. 2015-11

Manned-Unmanned Teaming: Expanding the Envelope of UAS Operational Employment (Reprint)

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April 2015

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*: 17-04-2015

2. REPORT TYPE: Final

3. DATES COVERED *(From - To)*:

4. TITLE AND SUBTITLE
Manned-Unmanned Teaming: Expanding the Envelope of UAS Operational Employment

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Gaydos, Steven J.
Curry, Ian P.

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Aeromedical Research Laboratory
P.O. Box 620577
Fort Rucker, AL 36362

8. PERFORMING ORGANIZATION REPORT NUMBER
USAARL 2015-11

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Medical Research and Materiel Command
504 Scott Street
Fort Detrick, MD 21702

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

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

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

13. SUPPLEMENTARY NOTES
Aviation, Space, and Environmental Medicine, volume 85, number 12, pages 1231-1232, November 2014

14. ABSTRACT
None

15. SUBJECT TERMS
unmanned aerial systems, UAS, situation awareness, spatial disorientation

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
UNCLAS	UNCLAS	UNCLAS	SAR	4	Loraine St. Onge, PhD
					19b. TELEPHONE NUMBER *(Include area code)* 334-255-6906

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Manned-Unmanned Teaming: Expanding the Envelope of UAS Operational Employment

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The employment of unmanned aerial systems (UAS) has become ubiquitous, not only within modern multinational militaries, but also among the civilian and commercial aviation communities. Although the concept of UAS application dates much farther back than most realize (unmanned balloons were used during the American Civil War for ordnance delivery with limited success, for example), most trace the origins of contemporary apposite UAS application to the Israelis and Americans in the 1970s and 1980s (11). Over the past few decades, there has been rapid expansion of UAS technology, capability, and employment strategies on many fronts.

One of these important developments includes interoperability of manned and unmanned aerial platforms to enhance mission command and complement combat power. Titled "Manned-Unmanned Teaming" (MUM-T), this entails the synchronized employment of manned and unmanned air (and ground) vehicles, sensors, and weapons systems. The concept has existed for decades, but relatively recent advances in technology and doctrine have spearheaded the movement from concept to real-world application. And as development continues to swiftly mature, the aerospace medical community at large would do well to pay attention. Many of these applications, while no doubt providing enhanced capability, may pose aeromedical and human factors challenges to which we should remain vigilant. These may include (but are not limited to) visual overload, increased workload and task saturation, distraction and diminished flight situation awareness (SA), motion sickness, and spatial disorientation (SD).

In its roadmap to articulate vision and strategy for the future of unmanned systems technology, the Department of Defense (DoD) defines the concept of MUM-T "…to combine the inherent strengths of manned platforms with the strengths of UAS, with product synergy not seen in single platforms. MUM-T combines robotics, sensors, manned/unmanned vehicles, and dismounted soldiers to achieve enhanced situational awareness, greater lethality, improved survivability, and sustainment. Properly designed, MUM-T extends sensor coverage in time and space and provides additional capability to acquire and engage targets" (5). Doctrinally, there are five MUM-T Levels of Interoperability (LOI) corresponding with increasing levels of coordination and control (2,8):

- LOI 1: Indirect receipt of UAS payload data.
- LOI 2: Direct receipt of UAS steaming video and other sensor information in the cockpit.
- LOI 3: Receipt of UAS video and pilot remote control of UAS sensors/payload.
- LOI 4: Video sharing, sensor control, and manipulation of UAS flight path.
- LOI 5: Full UAS control from takeoff through landing.

The advantages are extraordinary: extending sensor range far beyond the manned platform, capitalizing on system-specific efficiencies (e.g., the UAS is quieter with greater loiter time, but the manned system carries more firepower), enhanced survivability, target engagements at longer standoff ranges, greater information with actionable intelligence to commanders and pilots, and many others. This is not the realm of science fiction or 'over the horizon' thinkers. In fact, in May of this year, the first successful Hellfire missile strike in Afghanistan was conducted with team employment of the AH-64E Apache attack helicopter and the MQ-1C (Predator-like) Gray Eagle (8). Recognizing increased interoperability as the direction of the future, AH-64E aviators now receive UAS theory, basic tactics, and simulation training as early as the aircraft transition course.

Human factors and aeromedical challenges have existed hand-in-hand with aircraft design and vehicle development, expanding performance capacity, and novel spheres of employment throughout aviation's history, sometimes at great human cost. With respect to the rapidly developing capabilities afforded with MUM-T, the aviation medicine community must engage to provide input, guidance, and expertise. It is with ease that one can envision the aviator sliding off to the right of the Yerkes-Dodson performance curve. Consider the increased workload, which may include cognitive, physical, sensory, temporal, and psychological demands. At present, aviators already devote significant capacity to flying highly sophisticated aircraft in congested (and sometimes contested) airspace with complex and evolving missions while simultaneously controlling their own complex sensors and weapons platforms. Task saturation and excessive workload may become important (Human Factors Analysis and Classification System) preconditions with the additional responsibilities of UAS vehicle control, payload operation, or target handovers. Commenting on training, one combat training center Observer-Coach/Trainer made the observation that junior aviators, while enthusiastic, "…quickly became task saturated with the addition of UAS video while still learning to employ the aircraft's existing sensors" (8).

With respect to situation awareness, Endsley formally defines it as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (6). It encompasses perception of critical factors in the environment (Level 1), understanding what they mean (a holistic picture) within the context of goals (Level 2), and accurately projecting what will happen with the system in the near future (Level 3) (10). Many contemporary MUM-T articles mention 'increased situational awareness' as an enhanced capability of the doctrine. To be sure, 'battlefield' or 'target' SA may be dramatically increased with respect to 'fighting' the aircraft (e.g., projecting the aircrew's sensor reach out to additional range by teaming with a UAS sensor), but can this result in concomitant decreased 'flying' SA as a penalty? To use Endsley's taxonomy, enhanced "tactical" SA must not come at the expense of reduced geographical, spatial/temporal, system, or environmental SA (6).

SD may be of concern as well. In their excellent review article, Gibb and colleagues note that "…it is apparent that aviation's extreme demands on pilots exceed human sensory-perceptual-cognitive capabilities, even with new technology" (7). SD represents an enduring and substantial risk to safe aircraft operations, often manifesting with disproportionately higher accident severity. With respect to helicopters, for example, Braithwaite concluded that "the 'typical' picture of rotary-wing SD is less one of a classical vestibular or visual illusion giving the pilot vertigo, but more one of hard-pressed aircrew flying a systems intensive aircraft using NVDs failing to detect a dangerous flight path" (4). Task saturation, workload, distraction, fatigue, and other unintended consequences of increased UAS interoperability in the cockpit may increase the risk of SD. Motion sickness, that perennial aeromedical problem commonly thought only to plague the ab initio in training, may be a factor as well. Processing conflicting sensory information between aerial platform motion cues and UAS orientation may very well provide the antecedent conditions for both SD and motion sickness, and deserves further investigation (1,3).

This column is coordinated and edited by William D. Fraser, M.Sc. These articles are not peer-reviewed. The AsMA Science and Technology Committee provides the Watch as a forum to introduce and discuss a variety of topics involving all aspects of civil and military aerospace medicine. Please send your submissions and comments via email to: fraserwdf@gmail.com. Watch columns are available at www.asma.org through the "Read the Journal" link.

DOI: 10.3357/ASEM.4164.2014

To be sure, the interrelated aeromedical concerns raised here are not insurmountable, nor do the solutions lie solely within the domain of the aeromedical community. There are many lines of scientific investigation among multiple consortia of research entities focusing on some these issues, including critical skill task identification and training, collaborative autonomy, cognitive automation, and others (9,12,13). The developments and capabilities of MUM-T are exciting and most certainly afford the warfighter expanded operational capabilities and enhanced lethality. And as the technology and optimal employment practices mature, this construct may extend to non-DoD UAS enterprises as well, including law enforcement, border patrol, environmental sensing, maritime surveillance, disaster management, commercial imagery, and others. It serves us well to remember, however, that the extant aviation community is already at a state whereby 70-80% of our accidents are attributed to human factors (14,15). With respect to novel developments, we must remain engaged with our contemporaries to recognize and mitigate the potential for performance degradation, error, and accidents from human factors and aeromedical threats.

ACKNOWLEDGEMENTS

The authors wish to thank Lieutenant Colonel Fernando Guadalupe, Jr., Chief, Doctrine Division, U.S. Army Aviation Center of Excellence at Ft. Rucker, AL, for his technical expertise and assistance with preparation of this manuscript.

The views, opinions, and/or findings contained in this document are those of the authors and should not be construed as an official Department of the Army, Department of Defense, or U.K. Ministry of Defence position, policy, or decision, unless so designated by other official documentation.

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