Operator Qualification Differences between Manned and Unmanned Aerial System (UAS)

Jennifer Pagan
Randy Astwood
Henry Phillips
Naval Air Warfare Center Training Systems Division (NAWCTSD)
Orlando, FL
jennifer.pagan1@navy.mil, randy.astwood@navy.mil henry.phillips@navy.mil

ABSTRACT

Currently, no empirically validated qualification standard exists for selecting Naval Unmanned Aerial System (UAS) operators (Howse, 2011). Some UAS platforms (e.g., Triton, Fire Scout, and Predator) require their operators be winged aviators. This involves a $1 million investment per pilot and years of pilot training, in addition to mandatory, UAS platform-specific training (Cohn, 2012). The Shadow UAS program, on the other hand, uses junior to mid-grade enlisted personnel with no aviation experience. The training program for Shadow pilots is 10 weeks long and approximately a third of the investment (about $347,000) of manned aviators (Cohn, 2012). While adapting a Shadow-like selection/training model could yield significant cost avoidance, thorough research is necessary to develop qualification and training standards that support identification of the most qualified people to operate UAS and who will be most likely to succeed in training and operations (i.e., select the right individuals capable of acquiring these UAS specific skill sets). These differences in standards may be driven more by the relative size and cost of different UAS platforms rather than by empirical comparison of the Knowledge, Skills, Abilities, and Other personal characteristics (KSAOs) underlying performance in each (Howse, 2011). This paper describes differences between KSAOs required to operate manned and unmanned platforms, possible reasons underlying those observed differences, and implications of the observed trends for selection criteria, training requirements, and system design.

ABOUT THE AUTHORS

Ms. Jennifer Pagan is a Research Psychologist at the Naval Air Warfare Center Training Systems Division (NAWCTSD), Orlando FL. She currently manages a research and development effort devoted to investigating automated performance and physiological measures. Additionally, she is the principle investigator on multiple efforts investigating selection concerns for unmanned systems. She currently supports several research and development efforts focused on instructional system capabilities and Live, Virtual, and Constructive training. Her research interests include performance assessment and measurement, personnel selection, test validation, and training effectiveness evaluation. She holds an M.S. degree in Industrial/Organizational (I/O) Psychology from the University of Central Florida.

Dr. Randy Astwood is a Senior Research Psychologist in the Human Performance Science and Technology Branch at NAWCTSD. He has almost 14 years of experience providing cognitive and behavior research to improving training and human performance and is the Co-PI on an effort to validate personnel selection tools for unmanned systems. In addition, he is the Emerging Technology Research point of contact for the Human Performance Science and Technology Branch. Dr. Astwood holds a Doctorate of Philosophy in I/O Psychology from the University of Central Florida.

Commander Henry Phillips IV, MSC, USN earned his doctorate in Industrial/Organizational Psychology from the University of Houston in 2001, and was winged as a Naval Aerospace Experimental Psychologist in 2002. He currently serves as the NAWCTSD Military Deputy for Research and Technology, and has over 25 publications and presentations in the areas of personnel selection, personality assessment, training design, psychomotor assessment, and item-response theory.

Authors' Note. The views expressed herein are those of the authors and do not necessarily reflect the official position of the organizations with which they are affiliated.

Operator Qualification Differences between Manned and Unmanned Aerial System (UAS)

Jennifer Pagan
Randy Astwood
Henry Phillips
Naval Air Warfare Center Training Systems Division (NAWCTSD)
Orlando, FL
jennifer.pagan1@navy.mil, randy.astwood@navy.mil, henry.phillips@navy.mil

INTRODUCTION

Currently, there is no standardized method in use by the Navy for selecting Unmanned Aerial System (UAS) operators. Existing methods in use by the Naval services rely on non-validated assumptions regarding requisite Knowledge, Skills, Abilities, and Other personal characteristics (KSAOs) required for success in UAS operations. While larger platforms (Group IV and V) currently select operators based on existing or prior aviation designators (e.g., prior H-60 pilots fly Fire Scouts; P-3 & P-8 pilots will fly Triton) and smaller platforms (Groups I through III) utilize enlisted personnel, neither method is based on validated KSAOs specific to unmanned operators.

Research on UAS mishaps has begun to uncover the inherent issues associated with utilizing a selection protocol that is not directly related to operator KSAOs. Specifically, platforms that employ winged aviators as operators (i.e., Predator) have significantly more human factors related mishaps than those that select enlisted personnel (i.e., Shadow) (Williams, 2004). Further investigation of Predator mishaps indicates issues with instrumentation, sensory feedback systems, and channelized attention; in contrast, Shadow human factors mishaps were found to be associated with procedural guidance and publications, training issues, overconfidence and crew resource management (Thompson, Tvaryanas, & Constable, 2005). A potential cause of these findings may be attributed to negative training transfer from manned to unmanned platforms. In regards to the performance contexts of each UAS, operators work in significantly more controlled environments than manned aviators. For example, unmanned aviators are required to monitor multiple sources of incoming data including: sensor video feeds, input from multiple audio channels, and communications (i.e., email, chat, radios, and telephone); their shifts may be much longer due to the endurance of the aircraft and may require rotating and/or overnight shifts (Paullin, Ingerick, Trippe, & Wasko, 2011; Tvaryanas, Platte, Swigart, Colebank, & Miller, 2008). Shifts typically consist of long periods of inactivity while the aircraft is transiting to its destination or loitering to provide surveillance while on-station, followed by short bursts of intense activity. Maintaining vigilance during these periods of inactivity is a significant challenge for UAS operators. This challenge may be exacerbated for winged aviators operating UASs, as they are trained to rely heavily on sensory inputs or “seat of the pants” cues from the aircraft (i.e., visual information, kinesthetic/vestibular input, sound) to provide situation awareness and keep them engaged and attentive (Thompson, et al., 2005). This segregation of aircraft and pilot puts winged aviators in a situation in which they are unable to utilize the psychomotor skills that have been trained into automaticity (Grier et al., 2003), suggesting that winged aviators may not necessarily have the right KSAOs to operate a UAS.

In search of an alternative selection population to winged aviators, McKinley, McIntire, and Funke (2009) investigated the feasibility of utilizing video game players as UAS operators. The results from this study indicated video game players performed equally as well or significantly better than winged aviators in a series of operational relevant cognitive tasks (i.e., simulated Predator landing task, warship commander task, perception and processing task). While these findings suggest that video game players may be a viable alternative selection population based on performance alone, the KSAOs associated with this performance were not investigated.

Triplett (2008), conducted a follow-on research effort to investigate skill differences amongst video game players, UAS operators, and manned aviators. Interviews with fighter pilots, UAS operators, and video game players indicated that frequent video game players have the consistent ability and confidence to obtain new skills and retain existing ones related to operating the Predator UAS in a two-dimensional environment. Video game players were also found not to rely on the same visual and non-visual cues that fighter pilots use. Finally, this study found that there are several fighter pilot skills that go unused when operating a UAS including:

- Ability to determine the changes in aircraft performance while aboard the aircraft based on direct feedback
- Ability to control the aircraft by sensing abnormal environmental changes

- Ability to assess landing performance by using visual cues (e.g., peripheral vision)

These studies coupled with higher mishap rates for UAS platforms that employ winged aviators suggest that winged aviators may not be the best suited individuals to fly UASs. However, further research must be conducted to make the determination of exactly what individuals have the capabilities to acquire UAS specific skills and will succeed in training. In order to identify these individuals, it is important to understand the differences and similarities in KSAOs across candidate selection populations. Additionally we need a better understanding as to which of these KSAOs are most important to select for, and train to, while considering the empirical performance differences across populations. As such, the Optimizing Performance of Trainees for UAS Manpower, Interface and Selection (OPTUMIS) effort consists of three phases: 1) KSAO Comparison, 2) KSAO Classification and Tool Development, and 3) Performance Differences. Thus, this paper describes preliminary results from the first phase of a research effort seeking to bridge this research gap by identifying a selection pool for Navy UAS operators based on validated KSAOs and performance data, the OPTUMIS effort.

METHOD

The first phase of the OPTUMIS effort is focused on identification of similarities and differences between KSAOs required for manned and unmanned platforms. While Triplett (2008) identified differences amongst Air Force fighter pilots and Predator operators, it is important to understand these differences for Navy relevant platforms. Thus, a comparative analysis of utilizing Naval relevant KSAOs for unmanned aviation to determine the degree to which they overlap with relevant KSAOs for manned aviation was conducted. To accomplish this, a comprehensive list of KSAOs for both manned and unmanned platforms was developed. Existing Job Task Analyses (JTAs) with relevant competencies were analyzed and redundant KSAOs removed. While multiple JTAs were used to develop a comprehensive list of unmanned KSAOs, many JTAs did not provide the KSAO importance ratings needed to conduct the analysis (e.g., Damos, 2011; Howse, 2011). Thus, it was determined that only the Analysis of Cross-Platform Naval Unmanned Aircraft System Task and Competency Requirements (Mangos, Vincenzi, Shrader, Williams, & Arnold, 2012) would be used for the first round of analyses due to the cross platform nature of the JTA and the fact that all other JTAs identified, while extremely thorough and informative, did not provide the specific data needed for these analyses. The Analysis of Cross-Platform Naval Unmanned Aircraft System Task and Competency Requirements (Mangos et al., 2012) JTA was funded by the Naval Air Systems Command and the Navy Aviation Training Systems Program Office (PMA-205). This JTA focused on all major UAS systems actively used by the U.S. Navy and Marine Corps. This integrated JTA identified 256 general and system-specific operator (i.e., crew member, by position) task requirements, 20 task groups, and 67 requisite KSAOs across platforms. However, the focus of this task analysis was UAS operator performance - not training requirements.

Additionally, the Analysis of Work of Naval Aviation Training Pipelines (Mangos et al., 2005) funded by the Naval Aerospace Medical Institute, Operational Psychology Department was selected as the optimal manned JTA for comparison because of its cross-platform focus. Specifically, this JTA focused on all Naval Manned Aviation training pipelines for naval aviators and naval flight officers in support of the revision and validation of the Navy and Marine Corps Aviation Selection Test Battery (ASTB). This JTA identified 372 tasks grouped into 26 task groups, and 89 KSAOs organized according to phase of flight. KSAO importance and whether the KSAO was necessary upon entering the training pipeline were also assessed. It is also important to note that because this JTA was used in support of selection test validation, knowledge constructs necessary for operational performance were intentionally left out. The rationale being that aviation specific knowledge is acquired during training and the ASTB is not to predict job knowledge, rather select those most likely to acquire the skills necessary to succeed in training.

While the UAS Cross Platform JTA provided data across crew positions, it was deemed necessary to focus the scope of this effort on the Air Vehicle Operator or "pilot" position for UAS operators to support a more direct comparison to manned KSAOs. Likewise, the Student Naval Flight Officer data yielded by the manned JTA was also intentionally left out of this analysis.

A total of 67 KSAs were identified for unmanned Air Vehicle Operators (AVOs)/pilot that were derived from the Analysis of Cross-Platform Naval Unmanned Aircraft System Task and Competency Requirements (Mangos et al., 2012) JTA. Out of those 67 KSAOs, 42 were rated as important (means > 4.00) by AVO/pilot SMEs across all relevant platforms (see table 1). Importance ratings were given using a 5-point scale, where 1.0 is "Not important" and 5.0 is "Extremely important." This provided a comprehensive set of UAS KSAOs for comparison with manned KSAOs.

Table 1. UAS AVO Important KSAOs

Rank	KSAO	AVO Mean Importance Rating
1	Dependability	4.74
2	Oral Comprehension	4.72
3	Accountability	4.72
4	Self-Discipline	4.70
5	Oral Expression	4.67
6	Rule Abiding	4.67
7	Decision Making Skills	4.57
8	Handling Crisis/Emergency Situations	4.57
9	Adaptability	4.54
10	Deliberation	4.50
11	Written Comprehension	4.48
12	Attention to Detail	4.46
13	Task Prioritization	4.43
14	Safety Consciousness	4.41
15	Critical Thinking Skills	4.41
16	Learning Ability	4.41
17	Assertiveness	4.35
18	Concentration/Selective Attention	4.35
19	Systems Comprehension	4.33
20	Listening Skills	4.33
21	Map Reading	4.33
22	Problem Solving Skills	4.33
23	Confidence	4.30
24	Stress Tolerance	4.28
25	Attention Allocation and Control	4.28
26	Teamwork Skills	4.28
27	Initiative	4.26
28	Reasoning Skills	4.24
29	Leadership Skills	4.22
30	Emotional Control/Stability	4.20
31	Working Memory	4.20
32	Long-term Memory	4.15
33	Written Expression	4.15
34	Work Motivation	4.13
35	Disengagement	4.11
36	Time Management Skills	4.11
37	Planning Skills	4.11
38	Reaction Time	4.07
39	Interpersonal Skills	4.07
40	Organization Skills	4.04
41	Technical Troubleshooting	4.04
42	Information Management Skills	4.02

A total of 89 KSAOs were identified for manned aviation utilizing the KSAOs derived from the Analysis of Work of Naval Aviation Training Pipelines (Mangos et al., 2005) JTA. Out of those 89 KSAOs, Naval Aviation Training SMEs consistently rated 67 KSAOs as important (means > 4.00 on the same 5-point scale as above) across the Student Naval Aviator Primary Training Phase. Data from the Primary training phase was selected due to the non-platform specific nature of the training (i.e., all trainees train using the T-45). These KSAOs provided the basis for our comparative analysis.

RESULTS

Comparison of the relevant unmanned and manned KSAOs identified above specifies 38 common KSAOs, indicating about 57% of overlap in important competencies for manned aviation, relative to a possible maximum of 63% (i.e., 42 / 67), and a 90% overlap in important competencies for unmanned aviation (i.e., 38/42). The common KSAOs identified as important overlapped in a number of general KSAO categories.

Table 2. Student Naval Aviator Important KSAOs

Rank	KSAO	Manned Mean Importance Rating
1	Handling Crisis/Emergency Situations	4.92
2	Work Motivation	4.88
3	Stress Tolerance	4.84
4	Task Prioritization	4.76
5	Integrity	4.72
6	Oral Comprehension	4.68
7	Spatial Orientation	4.68
8	Accountability	4.68
9	Dependability	4.68
10	Coping with Stress & Emergencies - Overall	4.67
11	Motivation - Overall	4.65
12	Concentration/ Selective Attention	4.64
13	Decision Making Skills	4.64
14	Adaptability	4.64
15	Emotional Control/Stability	4.64
16	Multi-tasking & Attention Skills - Overall	4.6
17	Rule Abiding	4.6
18	Self-discipline	4.6
19	Conscientiousness - Overall	4.58
20	Oral Expression	4.56
21	Problem Solving Skills	4.56
22	Working Memory	4.56
23	Initiative	4.56
24	Learning Ability	4.52
25	Achievement Motivation	4.52
26	Listening Skills	4.52
27	Attention to Detail	4.48
28	Safety Consciousness	4.48
29	Hand-eye Coordination	4.48
30	Time Management Skills	4.44
31	Depth Perception	4.44
32	Reaction Time	4.44
33	Learning & Memory Skills - Overall	4.41
34	Attention Allocation & Control	4.4
35	Confidence	4.4
36	Control Precision	4.4
37	Manual Dexterity	4.4
38	Multilimb Coordination	4.4
39	Visual Acuity	4.4
40	Physical & Perceptual Abilities - Overall	4.4
41	Spatial Visualization	4.36
42	Mastery Orientation	4.36
43	Developmental Skills – Overall	4.33
44	Disengagement	4.32
45	Planning & Organizing Skills - Overall	4.3
46	Communication Skills - Overall	4.29
47	Assertiveness	4.28

Table 2. Student Naval Aviator Important KSAOs (continued)

Rank	KSAO	Manned Mean Importance Rating
48	Teamwork Skills	4.28
49	Problem Solving & Reasoning Skills – Overall	4.27
50	Spatial & Navigational Skills - Overall	4.26
51	Critical Thinking Skills	4.24
52	Goal Setting	4.24
53	Information Management Skills	4.2
54	Systems Comprehension	4.2
55	Deliberation	4.2
56	Long-term Memory	4.16
57	Navigation Skills	4.16
58	Reasoning Skills	4.16
59	Leadership Skills	4.16
60	Planning Skills	4.12
61	Perceptual Speed & Accuracy	4.09
62	Map Reading	4.08
63	Written Comprehension	4.08
64	Response Selection	4.08
65	Perceptual & Psychomotor Abilities – Overall	4.06
66	Color Discrimination	4.04
67	Mental Rotation	4.0

Table 3 lists specific KSAOs identified as important in the NAVAIR Analysis of Work of Naval Aviation Training Pipelines study that were also identified as important in the UAS Cross Platform JTA. Representative elements from this table include spatial abilities, information processing, and navigational skills, task prioritization, and non-cognitive attributes related to time management, stress tolerance, and big-five personality traits and trait facets (Campbell, Castaneda, & Pulos, 2010) including dependability, adaptability, assertiveness, and self-discipline.

DISCUSSION

While a 90% overlap in important manned to unmanned Naval KSAOs certainly suggests that manned aviators may be good candidates for recruitment as UAS air vehicle operators, it is critical to address the differences in KSAOs that emerged. As with the work conducted by Triplett (2008), this analysis indicated that there are core manned aviator skills that go unused when piloting a UAS. Specifically, psychomotor skills aviators rely most heavily on to control aircraft performance and provide situational awareness were not found to be important for unmanned AVOs. This is no surprise as aviators are segregated from the aircraft when flying UASs and thus deprived of the sensory cues that prompt those psychomotor responses (McCarley & Wickens, 2007).

Additionally, these results may be attributed to the shift from stick and throttle control interfaces to point and click interfaces for unmanned vehicle control. Table 4 lists 18 entries representing the unique aspects of the 25 KSAOs identified as relevant to manned aviation that were not classified as important entries in the UAS Cross-Platform JTA. These are organized into four categories, including: Cognitive/Spatial, Physical/Perceptual, Non-cognitive/Motivational, and Non-cognitive/Trait-Based.

Another set of core manned aviator attributes that may go unused for unmanned operators are the personality characteristics associated with high motivation. Manned aviators, fighter pilots in particular, work in high risk and dangerous environments requiring a high level of achievement motivation to complete a goal or mission (Picano, Williams, & Roland, 2006). UAS operators on the other hand, are not in the same type of environment. The challenges of their environments require far more vigilance and tolerance for long periods of relatively low activity (Tvaryanas et al., 2008) than do their manned counterparts in most pipelines.

Table 3. Overlapping Manned and Unmanned KSAOs

KSAO	Importance Ratings	
Cognitive Abilities	UAS	Manned
Attention Allocation & Control	4.28	4.4
Concentration/Selective Attention	4.35	4.64
Critical Thinking Skills	4.41	4.24
Decision Making Skills	4.57	4.64
Information Management Skills	4.02	4.2
Learning Ability	4.41	4.52
Long-term Memory	4.15	4.16
Map Reading	4.33	4.08
Oral Expression	4.67	4.68
Problem Solving Skills	4.33	4.56
Reasoning Skills	4.24	4.16
Systems Comprehension	4.33	4.2
Task Prioritization	4.43	4.76
Working Memory	4.20	4.56
Written Comprehension	4.48	4.08
Non-cognitive Abilities		
Accountability	4.72	4.68
Adaptability	4.54	4.64
Assertiveness	4.35	4.28
Attention to Detail	4.46	4.48
Confidence	4.30	4.4
Deliberation	4.50	4.2
Dependability	4.74	4.68
Disengagement	4.11	4.32
Emotional Control/Stability	4.20	4.64
Handling Crisis/Emergency Situations	4.57	4.92
Initiative	4.26	4.56
Leadership Skills	4.22	4.16
Listening Skills	4.33	4.52
Oral Comprehension	4.72	4.65
Planning Skills	4.11	4.12
Rule Abiding	4.67	4.6
Safety Consciousness	4.41	4.48
Self-Discipline	4.70	4.6
Stress Tolerance	4.28	4.84
Teamwork Skills	4.28	4.28
Time Management Skills	4.11	4.44
Work Motivation	4.13	4.88
Physical/Perceptual Abilities		
Reaction Time	4.07	4.44

Another critical difference is in the duration of their separation from their families. Predator operators tasked with UAS operations remotely over Afghanistan for single shifts before returning home to their families at night have experienced significant adjustment difficulties not encountered by their counterparts separated from familial obligations for the duration of an extended deployment (Ouma, Chappelle, & Salinas, 2011), suggesting that resilience may play a greater role in UAS operator performance than does achievement motivation. UAS operation is not as glamorous a profession as is manned aviation, particularly tactical aviation, and as such, it calls for different types of characteristics among successful practitioners (Paullin et al., 2011).

More surprising, however, is the finding that spatial and navigational skills were not rated as important unmanned KSAOs. These KSAOs have historically been thought to be important for performance in both domains. However, these results show otherwise. This may be attributed to unmanned aviators utilizing more two-dimensional spatial abilities (e.g., map/sensor displays) rather than utilizing three-dimensional cues within the aircraft and live airspace. Similarly, the type of navigation conducted by manned aviators requires use of more environmental and sensory cues than navigation conducted when operating a UAS.

Table 4. Important KSAOs for Manned Aviation Not Included for Unmanned

Cognitive: Spatial	Physical/Perceptual	Non-cognitive: Motivation	Non-cognitive: Trait
Spatial Orientation	Hand-eye Coordination	Achievement Motivation	Conscientiousness
Spatial Visualization	Depth Perception	Mastery Orientation	Integrity
Navigation Skills	Control Precision	Goal Setting	
Mental Rotation	Manual Dexterity		
	Multilimb Coordination		
	Visual Acuity		
	Perceptual Speed & Accuracy		
	Response Selection		
	Color Discrimination		

Implications for Selection

These preliminary findings coincide with findings discussed previously, suggesting that manned aircraft aviators may not be the best suited to fly UAS. Specifically, because of the rigors and challenges associated with the flight environment, manned aviators are selected based on stringent physical health and requirements, as these attributes are critical for safe operation in such a physiologically austere environment. Because much of the challenges associated with operation in this environment, such as g-forces, spatial disorientation, and hypoxia are not experienced by UAS operators, these selection criterion may not be relevant. Many candidates who fail to meet the physical and physiological standards for manned aviation may be perfectly suited to UAS operations, assuming they possess the requisite cognitive and non-cognitive attributes.

Finally, the lack of importance of spatial and navigational skills for UAS operators may suggest that those populations that have better two-dimensional spatial reasoning (e.g., video game players) may be a more suitable UAS operator selection pool. This aligns with the findings from Triplett (2008) and McKinley et al. (2009) that video game players have the aptitude to perform just as well as existing UAS operators.

Implications for Training

The implication that manned aviators may not be the best candidates to operate UAS also suggests that training will be impacted. The current Student Naval Aviation training pipeline consists of three phases:

1) Primary: All trainees participate in 22 week curriculum that teaches Aircraft Familiarization, Basic Instruments, Precision Aerobatics, Formation, Night FAM, and Radio Instruments in the T-6A Texan aircraft.
2) Intermediate: Trainees enter aircraft specific training pipeline for a 17 week training covering multi-engine aircraft ground training, flight support, and flight training. All training is conducted in the T-45.
3) Advanced: Twenty-seven week phase of training in which trainees will master Aircraft Familiarization, Out-of-Control Flight, Basic Instruments, Radio Instruments, Airways Navigation, Formation, Night Familiarization, and Carrier Qualifications for their specific aircraft variant. Additionally, strike aircraft pilots are trained in platform-specific tactics and weaponry.

In addition to this 66-week training pipeline, unmanned aviators must complete UAS specific training that ranges in duration per platform and by service, costing up to $1 million per aviator (Cohn, 2012). However, the preliminary findings of this analysis suggest that UAS operators may not need such extensive training in areas that focus on building physical/perceptual skill automaticity (see Table 4). Curriculum topics such as formation flight, aircraft familiarization, intermediate flight training, out-of-control flight, and carrier qualification as currently structured are not likely to be as critical to UAS operator performance.

A specific example of complex physical/perceptual skill training that does not appear useful to UAS operator performance can be seen in carrier qualification training. Carrier qualification is a requirement for all strike pipeline aviators to achieve proficiency in prior to completion of the Advanced training phase to become winged pilots. This task is extremely complex and dangerous, and requires a significant amount of physical/perceptual skill to accomplish. Aviators must react to sensory inputs to adjust aircraft performance almost instantly, requiring large training investment to train these skills to automaticity. However, these skills are not utilized when flying an UAS. While there are carrier-based UAS platforms, it seems clear that UAS operators may be better served to "train as they fight" and learn the task of carrier landing utilizing a UAS rather than a manned aircraft.

While this is one example of complex skill training that would benefit from UAS specific training, tailoring the Naval Aviation training pipeline to include a UAS specific pipeline would allow all KSAOs and tasks to be trained in the operational environment in which operators will fly. A UAS specific pipeline would also allow for the tailoring of the curriculum to focus more heavily on interpersonal skill training such as teamwork and Crew Resource Management as these skills were found to be more important to UAS operators than manned aviators.
Similarly, in manned aviation, aviators are trained to respond almost instantaneously to in-flight problems by following clearly documented emergency procedures methodically and without interruption, by following checklists. In UASs, remediation of many emergencies is handled by automated systems rather than by the operator or other crew members (Grier et al., 2003). The role of the operator, as indicated by results of the present study, may include far more technical troubleshooting and diagnostic work than does the role of the aviator in a manned platform. The operator is removed from the situation, can have access to a much broader array of information about the system in question, and may be able to communicate more readily with other crewmembers and stakeholders, who may be in the same room with the operator, than could his or her counterpart in a manned aircraft.

This removal from the cramped confines and physiological conditions of the aviation environment, as well as the difference in pace of operations between manned and unmanned environments, may also serve to explain why written communications are more important for unmanned operations than in a manned environment. A UAS operator waiting on a platform to move from one waypoint to another may have far more available time to respond to chat-based taskers or requests for information.

Finally, a UAS specific pipeline may support the reduction of total ownership costs and increase the life of high value assets, be they fighter aircraft or Group IV or V UASs, through the introduction of lower-cost UAS platforms early in the undergraduate aviation training continuum prior to platform assignment, in contrast to the current model which requires completion of the entire manned training pipeline prior to transition to UAS platforms.

Limitations and Recommendations for Future Research

The current analysis utilized only two JTAs due to limited availability of KSAO importance ratings in other JTAs. While the two JTAs used for this analysis are believed to provide a good preliminary pilot to pilot comparison, it is important to note that Naval Flight Officer data and other UAS position data (e.g., sensor operators) were not included. Additionally, a qualitative analysis of existing JTAs indicates an additional 42 KSAOs that are applicable for UAS operators. However, because of limited availability to importance ratings these data were not included this analysis. The OPTUMIS effort is currently in process of collecting important ratings on these additional 42 KSAOs to gain a more comprehensive picture of the qualifications UAS operators need to succeed in training and performance.

Another important limitation that must be acknowledged is that this study examined the primary training phase of manned flight only for purposes of comparison with UAS KSAOs. In the Naval services (c.f. Carretta, 2013), there is no single-site or single-platform UAS training center that provides a true comparative baseline to this phase of training. The manned-unmanned differences discussed herein must be interpreted carefully, as differences in KSAOs may be partially attributable to the prior training and experience of the operators and aviators expected to demonstrate the KSAOs in question.

Additionally, these findings do not include comparisons of other potential UAS operator selection populations, such as Air Traffic Controllers (ATCs). Although important ATC KSAOs were identified, limited importance data availability precluded inclusion of ATCs in this analysis. Commonly identified important ATC KSAOs include (Morath, Quartetti, Bayless, & Archambault, 2001):

- Selective Attention/Concentration
- Timesharing/Multitasking
- Visualization
- Mathetmatical/Probablistic Reasoning
- Scanning
- Situation Monitoring/Awareness

Further analysis is warranted to understand the degree of importance and overlap to UAS KSAOs. The OPTUMIS effort is currently investigating these aspects.

Next, it is also important to note these findings utilized an aggregate importance rating for AVOs across UAS platforms. Individual UAS platform KSAO ratings were not analyzed. This is a crucial area for future research as smaller UAS platforms may have different KSAO requirements than the larger group IV and V category of UAS. However, research is necessary to understand the degree to which these KSAOs differ and if the differences are significant enough to impact selection and training decisions.

The next Phases of the OPTUMIS effort will take these preliminary findings a step further by classifying the comprehensive set of 109 UAS KSAOs into selection, training, and design criteria. This data will extend the understanding of the minimum qualifications for UAS operator selection, those KSAOs most important to include in training curricula, and KSAOs mapped to tasks that have the highest workload that should be taken into account during system design. The final phase of this effort will focus on providing empirical performance differences between manned, unmanned, and other candidate selection populations to support for the qualitative analysis described in this paper. Qualitative findings that UAS operator KSAOs differ from manned aviators in extremely critical skill areas (e.g., physical/psychomotor skills not to be found not important for unmanned operations but critical for manned pilots), coupled KSAO classifications and empirical performance data indicate that expansion of qualitative results will provide foundational data for who the right candidates to for UAS operators are and their training needs.

CONCLUSION

While the Navy currently employs manned aviators to operate UASs, findings from this analysis suggest that they may not be the best suited candidates for the job. Specifically, this analysis indicates that while there is a significant amount of overlap among manned and unmanned KSAOs, core manned skills appear to go unused during UAS operations. The lack of employment of these core skills may negatively impact operator performance through errors or in severe cases cause mishaps. Although this analysis does not provide the complete picture regarding UAS selection and training criteria, it does provide a foundation for further research. Additionally, these findings emphasize the need for selection criteria and training be validated on UAS relevant KSAOs.

REFERENCES

Campbell, J.S., Castaneda, M., & Pulos, S. (2010). Meta-analysis of personality assessments as predictors of military aviation training success. *International Journal of Aviation Psychology, 20,* 92-109.

Carretta, T. R. (2013). Predictive validity of pilot selection instruments for remotely piloted aircraft training outcome. *Aviation, Space, and Environmental Medicine, 84*, 1-7.

Cohn, J. (2012). *DoD TAG 67 Special Session On Unmanned Aerial Systems Selection Approaches, Training Technologies, & Interface Design: A Human Systems View.* Presentation given the 67th Annual Department of Defense Human Factors & Engineering Technical Advisory Group, Dayton, OH.

Damos, D. (2011). *KSAOs for military pilot selection: A review of the literature* (AFCAPS-FR-2011-0003). Randolph AFB, TX: HQ AFPC/DSYX Strategic Research and Assessment Branch.

Grier, R. A., Warm, J. S., Dember, W. N., Matthews, G., Galinsky, T. L., Szalma, J. L., et al. (2003). The vigilance decrement reflects limitations in effortful attention, not mindlessness. *Human Factors, 45*, 349-359.

Howse, W. R. (2011). *Knowledge, skills, abilities, and other characteristics for remotely piloted aircraft pilots and operators* (Report No. AFCAPS-FR-2011-0006). Randolph Air Force Base, TX: Air Force Personnel Center.

Mangos, P., Vincenzi, D., Shrader, D., Williams, H., & Arnold, R. (2012). *Analysis of cross-platform naval unmanned aircraft system task and competency requirements*. Unpublished technical report, Naval Air Systems Command (NAVAIR), Patuxent River, MD.

Mangos, P., Arnold, R. D., Mead, A., Merket, D., Littrell, L., Credo, K., Young, R., Tollentino, A., & Kessler, S. (2005). *Technical report: Analysis of work of Naval aviation training pipelines.* Unpublished technical report, Naval Aerospace Medical Institute Operational Psychology Department: Pensacola, FL.

McCarley, J. S., & Wickens, C. D. (2007). *Human factors implications of UAVs in the national airspace* (Report No. AHFD-05-05/FAA-05-01). Atlantic City, NJ: Federal Aviation Administration.

McKinley, A. R., McIntire, L. K., & Funke, M. A. (2009). *Operator selection for unmanned aerial vehicle operators: A comparison of video game players and manned aircraft pilots* (Report No. AFRL-RH-WP-TR-2010-0057). Wright-Patterson Air Force Base, OH. Air Force Research Laboratory.

Morath, R. A., Quartetti, D., Bayless, A., & Archambault, C. (2001). Air traffic controller job analysis. *Documentation of Validity for the AT-SAT Computerized Test Battery, 1*, 7-18.

Ouma, J.A., Chappelle, W. A., & Salinas, A. (2011). *Facets of occupationalburnout among U.S. Air Force active duty and National Guard/Reserve MQ-1 Predator and MQ-9 Reaper operators.* (Report AFRL-SA-WP-TR-2011-0003) Air Force Research Laboratory, 711th Human Performance Wing, School of Aerospace Medicine, Wright-Patterson AFB.

Paullin, C., Ingerick, M., Trippe, M. D., & Wasko, L. (2011). *Identifying best bet entry-level selection measures for US Air Force remotely piloted aircraft (RPA) pilot and sensor operator (SO) occupation* (Report No. AFCAPS-FR-2011-0013). Human Resources Research Organization (HumRRO), Alexandria, VA.

Picano, J. J., Williams, T. J., & Roland, R. R. (2006). Assessment and selection of high-risk operational personnel. In C. H. Kennedy & E. A. Zillmer (Eds.), *Military psychology* (pp. 353-370). New York, NY: Guilford.

Thompson, W. T., Tvaryanas, A. P., & Constable, S. H. (2005). *U.S. military unmanned aerial vehicle mishaps: Assessment of the role of human factors using human factors analysis and classification system (HFACS)* (Report No. HSW-PE-BR-TR-2005-0001). Brooks City-Base, TX: United States Air Force 311th Human Systems Wing.

Triplett, J. E. (2008). *The effect of commercial video game playing: a comparison of skills and abilities for the Predator UAV* (Report No. AFIT/GIR/ENV/08-M22). Wright Patterson Air Force Base, OH: Air Force Institute of Technology.

Tvaryanas, A.P., Platte, W., Swigart, C., Colebank, J., & Miller, N. L. (2008). *A resurvey of shift work-related fatigue in MQ-1 Predator unmanned aircraft system crewmembers.* (Report No. NPS-OR-08-001). Report prepared for the 311th Performance Enhancement Directorate.

Williams, K.W. (2004). *A summary of unmanned aircraft accident/incident data: Human factors implications* (Report No. DOT/FAA/AM-04/25). Washington, DC: Office of Aerospace Medicine.