An Operational Analysis of Human Factors in an Unmanned Air System

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Previous research has highlighted Human Factors (HF) issues associated with operating Unmanned Air Systems (UAS). This research has examined the human-machine interface, error types found in UAS mishaps, and examined specific factors such as workload or situation awareness. Fewer studies have examined the HF issues experienced during live military UAS operations in a conflict zone. Accordingly, a HF analysis was undertaken of a UK UAS unit operating in Afghanistan. The analysis was conducted using the Operational Events Analysis (OEA) approach, which is a structured, qualitative method of identifying flight safety HF issues. The OEA included UAS operators and maintenance personnel. HF issues were identified that included the aviation culture, characteristics of the task, fatigue and shift management, and the work environment.

Accident and incident rates for UAS are generally higher than for manned aircraft. Analysis of accident and incident data has shown that Human Factors (HF) are involved in up to 68% of UAS incidents (Williams, 2004; Tvaryanas, Thompson and Constable, 2006). Accordingly, researchers have sought to understand and address the HF issues associated with UAS operations.

HF studies of UAS operations have examined the human-machine interface, error types found in UAS mishaps, and explored specific factors such as workload or situation awareness. For instance, Thompson, Lopez, Hickey, DaLuz, Caldwell and Tvaryanas (2006) examined the effects of shift work and sustained operations on UAS operators and found subjective boredom amongst operators and decrements in vigilance over the course of a shift. UAS aircrew have also been found to report decreased mood and increased fatigue levels relative to traditional aircrew (Tvaryanas and Thompson, 2006). A number of studies have examined the nature of personnel who are recruited to fly and maintain UAS. McCarley and Wickens (2004) highlighted that there was a lack of consistency in the standards for UAS pilot selection across the US military for the extent to which the pilots had previous aviation experience. The impact of personnel background on culture was identified by Hobbs and Herwitz (2005), identifying a potential negative impact for maintenance personnel who had not come from a mainstream aviation background.

The wide range of factors considered reflects the novel field of UAS HF research, and the varied ways in which UAS are operated. For instance, Thompson et al.’s (2006) study analysed personnel involved in UASF MQ-1 Predator missions in support to operations where personnel were based at Nellis Air Force Base rather than the conflict zone itself. In the UK, the Hermes 450 (H450) UAS has provided operational Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) capability while being controlled by operators situated within the conflict zone.

In 2011, the Royal Air Force Centre of Aviation Medicine (RAF CAM) identified a number of HF issues associated with operating the H450 whilst deployed at Camp Bastion, Afghanistan. These issues included the aviation culture, training, supervision, procedures and working environment in which H450 was operated. Five months after this work was conducted, a H450 accident occurred and the subsequent inquiry found that many of the issues identified in the RAF CAM analysis had contributed to the accident (MAA, 2012). Since the accident inquiry, changes were implemented by the unit and a follow-up HF review was requested in 2013 to provide a ‘health check’ for H450 operations. The aim of the follow-up HF review was to identify what HF issues were influencing the work of the team so that awareness of those issues could be raised and action taken to address.

Method

A HF review was undertaken of the British Army H450 unit operating at Camp Bastion, Afghanistan in summer 2013 using the Operational Events Analysis (OEA) approach. The OEA is a structured and proactive method of identifying HF issues that have the potential to influence flight safety (Harris, 2011). The OEA is based on the Accident Route Matrix (ARM) (Harris, 2011) which is a framework used as part of UK military HF air accident investigations.

The OEA is a mixed methods qualitative design which uses a combination of semi-structured interviews and observations. The OEA conducted for H450 in 2013 followed the first six stages outlined by Revell, Harris and Cutler (2014). The first three of these stages were associated with setting up the OEA and stage four was the OEA visit; stages five (analysis) and six (output) are described in the results section.

OEA Set Up

The requirement for the OEA was specified as being to conduct a HF 'health check' of H450 operations. The scope of the OEA was agreed to include H450 operations in Afghanistan and use of the Hermes 450 simulator in the UK. The HF specialist established a point of contact in both the UK and Afghanistan and familiarised themselves with the previous OEA that had been conducted and the subsequent accident investigation (MAA, 2012). A number of logistical considerations also were made to enable the HF specialist to integrate with the H450 team during the visit. H450 personnel were provided with key information in advance of the visit to allow personnel enough time to understand the OEA and decide whether to participate.

OEA Visit

The OEA visit took place over a six day period during summer 2013. At the time of the OEA visit the majority of personnel had been deployed for approximately four months and the Rest and Recuperation (R&R) cycle was in progress, as such, some personnel had recently returned from R&R while others, were due to go. H450 crew, however, had only recently deployed and the majority had not been in Afghanistan longer than a month.

Following a familiarisation tour of the unit, the HF specialist commenced an iterative process of interviews and observations to gather information regarding any HF issues that were present on the unit.

Interviews. 24 one-to-one interviews and multiple informal discussions were held with personnel. The interviews included nine H450 crew, seven maintainers, three management personnel and five people who were in operational support roles. Interviews were conducted across the spectrum of job roles, and across the rank structure. Participants were recruited voluntarily and on an anonymous basis. A semi-structured interview was used for the one-to-one interviews. These interviews took up to one hour and used the same interview form as used in HF accident investigations (Harris, 2011). Accordingly, the interview included questions on a wide range of HF issues including organisational factors, supervision, tasks, equipment, environment, behaviours and actions, and operator conditions.

Observations. Observations were undertaken of: flight planning, briefing, and debriefing; personnel operating H450 from the Ground Control Station (GCS) and from next to the runway; engineering tasks, including aircraft launch and recoveries; team meetings; and the H450 simulator used in the UK.

Results

Thematic analysis was used to review the data collected based on the six phases detailed by Braun and Clark (2006) applied as described by Revell et al. (2014). The output of the OEA was provided in a formal written report to the unit, which described the HF issues identified and the role of these issues in potential hazard sequences. Positive factors were also highlighted and a set of recommendations made to address the HF issues identified. In this section, some of the key findings from OEA are described. These findings are highlighted due to their applicability to a range of UAS operations, rather than being specific to characteristics of the H450 operation in Afghanistan.

Aviation Culture

Personnel felt that aviation culture and practices had improved since the introduction of H450, however, a particular challenge to maintaining that culture related to the fact that live flying of H450 in UK airspace was not permitted. Therefore, some personnel felt there was a lack of aviation focus, particularly when not deployed. H450 crew were drawn from a non-aviation, Army background and reported that when not deployed they returned to more typical 'Army' tasks and performed few aviation related duties. Operators then had to re-build their aviation experience and be re-immersed in aviation culture in preparation for their next deployment.

Task Characteristics

H450 sorties lasted up to fourteen hours and each flight was operated by two separate crews, with one crew responsible for the aircraft launch and first half of the mission and the second continuing the mission before recovering the aircraft. Therefore, crews were operating H450 for an extended period of time. The tasks to operate the aircraft during this time were perceived as being simple and non-demanding, linked to the high level of automation offered by the system. The tasks personnel performed were largely supervisory in nature, monitoring systems and responding to issues and changes that occurred. As a result, personnel perceived that operating H450 was mundane with little mental stimulation, and difficulties were reported in maintaining vigilance and alertness. Indeed, when operating the H450 simulator, crews were observed to appear bored and have difficulty maintaining attention to the displays.

Maintenance personnel also stated that they found working on H450 simple and monotonous, and that H450 was less technically challenging than other aircraft they had worked on (typically helicopters, as maintenance personnel were drawn from the Army aircraft engineering cadre).

Working Environment

The majority of H450 crew stated that the GCS was a cold environment to work in. The GCS had a large number of computer systems that required constant air conditioning to maintain performance. As a result, crews were instructed not to touch the temperature controls and mitigated the cold temperature by wearing extra layers including hats, scarves and gloves during winter periods. Operating the H450 involved sitting for long periods of time with little movement, which decreased the perceived temperature even further.

Maintenance tasks were often performed outside, and so could be undertaken in a wide temperature range. A particular issue was heat in the summer where personnel could be working without shade for an extended period of time, although personnel also reported that temperatures could get very low during winter periods. Extended periods of time working outside was particularly common for aircraft launch and recovery tasks where personnel would be on the runway either waiting for ATC and the GCS to release the aircraft or waiting for the H450 to land.

Accommodation

H450 operators and maintainers were accommodated in tents at Camp Bastion which, at the time of the OEA, was a major military base located within a conflict zone. Therefore, there could be a high level of noise from military equipment and personnel, including other aircraft. Personnel reported having disturbed sleep and rest due to noise. Sleep disruption was also linked with unreliable air conditioning inside the tents. Although a few reported that they became accustomed to the noise and heat, reduced sleep quality increases the risk of both acute and cumulative fatigue. Indeed, a number of personnel reported observing others being tired including those operating and working on aircraft.

H450 Crew Shift Pattern

In order to launch the UAS within the system design constraints and support operations 24 hours a day, five H450 were launched per day with staggered take-off times and two crews to cover each flight. As a result, there were ten different start times for H450 crew. Crews operated on each start time for two days before moving to the next start time through the cycle. Many of the start times changed in small (one hour) increments but that at some points crews had a greater change in start time, up to a maximum of seven hours. H450 crew generally perceived their shift pattern to be okay, however, some found it difficult to adjust their body clock and acclimatise due to the constantly changing shifts. During the twenty-day shift cycle, crews' body clocks were likely to be continuously lagging behind, as there was not sufficient time given to enable their body clock to catch up. The constant changing of body clock could impact on alertness and fatigue. As a result, some crew reported feeling tired, particularly at the end of their shift.

Fatigue Management of Maintenance Personnel

Maintenance personnel were not subject to the same duty time regulations as aircrew and worked a "24 hours on, 24 hours off" shift pattern. Maintenance personnel were generally happy with this shift pattern as personnel were given a six hour rest period during the shift, had facilities to sleep at the work location, and after the shift had 24 hours off to recuperate. However, a number of potential issues were identified with this shift pattern that would increase the risk of a fatigue related error. These included extended time on task, as well as limited and disrupted rest periods.

Morale

When personnel had recently arrived in Afghanistan, morale was reported to be high. However, morale was found to decrease across the deployment. This was particularly noticeable when comparing the recently deployed H450 crew, to personnel who had been deployed for four months. There were a number of reasons given for the diminishing morale such as the task characteristics, being away from home for a number of months, and the pressures of working in the same team for an extended period of time.

Discussion

The OEA method was applied to identify the HF issues associated with the operation of H450 by the British Army in Afghanistan in summer 2013. The OEA identified a range of issues including aviation culture, task characteristics, fatigue and shift management, and aspects of the operational environment. Many of these issues reflect those identified in previous HF research undertaken into different types of UAS operations, but the H450 work has also identified additional factors which reflected the operational requirements and environment in which the H450 was flown.

Similar to Hobbs and Herwitz's (2005) findings, the aviation culture amongst H450 operators was influenced by the background of the personnel. However, the culture was found to have changed over time and was also influenced by other factors such as the nature of the task and the ability to operate H450 when not on operations.

Inline with Thompson et al.’s (2006) findings, the H450 operator’s task in the GCS was perceived to be boring, and there were reports and observations that attention was difficult to maintain. The present study also found that similar issues occurred amongst UAS maintenance personnel. The perceptions of the task were also contributing to low morale, along with a number of other factors that may be specific to personnel deployed away from home, who are working and living together within close proximity.

With regard to fatigue, although a comparison was not made between UAS aircrew and traditional aircrew, the findings of the present study indicate that the nature of H450 operations meant some H450 crew were struggling to adjust their body clock to the shift pattern resulting in fatigue, particularly at the end of their shift. Further, maintenance personnel were not subject to the same working hour regulations as aircrew, which increased the scope for shift patterns to increase the risk of fatigue related errors.

HF issues that were raised in the present study that had not been identified in previous UAS research were the temperature in the working environment, be it too hot or too cold, and issues with gaining adequate rest when flying from a major base in a conflict zone. Few studies had analysed UAS in a conflict zone and the application of the OEA approach in this environment has enabled different insights to be provided into the HF challenges that military UAS operators face.

Looking towards the future, UAS will continue to be utilised in UK military operations to provide ISTAR capability, however, the nature of military operations is set to change since the draw down of personnel from Afghanistan and a new UAS has been introduced. UAS operators will need to be adaptable to the new UAS and changing operational environment, which is likely to bring in new HF challenges. Therefore, the HF issues associated with operating military UAS will need to be continually assessed to ensure optimal performance is maintained. Further, it is recommended that research and design of UAS continues to consider factors such as fatigue and shift management of UAS personnel, aviation culture, environmental temperature, mental underload and perceived boredom of both UAS aircrew and maintainers, and develop methods to address these issues.

Conclusion

This paper presented the results from an OEA which was conducted on a UAS unit operating at Camp Bastion, Afghanistan. The HF challenges faced by military personnel operating UAS included the aviation culture, tasks characteristics, fatigue and shift management, and the characteristics of the working environment. The OEA has enabled the British Army to mitigate the HF identified, for example, reducing tour lengths from six to four months and making improvements to the shift cycle. In order to gain optimal performance from military UAS operators, the HF challenges of operating UAS in conflict zones will need to be continually assessed and actions taken to address in the changing military environment.

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This paper presents a summary of key findings from the OEA that was conducted on Hermes 450 in Camp Bastion, 2013. As such, it does not present the full findings of the HF analysis. The formal OEA report has been released internally to the organisation.