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# The Use of Aviation Safety Practices in UAS Operations: A Review

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Unmanned Aerial Systems, UAS, have rapidly become a part of the US National Airspace System (NAS) with more than 1.6 million registered between 2015 and 2020. As the number of UAS has increased so has the number of sightings by manned aircraft and airport operators. This increase in sightings has raised concerns about the safety of UAS operations, a concern validated by the experiences of the US military. Following high accident/incident rates during UAS operation the US military discovered that UAS, despite having no pilot onboard, are subject to human error. The research and methods to minimize human error are mature, widely integrated, and successful in manned aviation. This paper presents a literature review of three aviation safety practices and their use in UAS operations. Science Direct and the Web of Science Core Collection databases were reviewed for articles with the keywords "Crew Resource Management", "Safety Management Systems", or "Standard Operating Procedures" and "Unmanned Aerial System" or "Unmanned Aerial Vehicle." One hundred and sixteen articles containing these keywords were published between 2000-2020. Each of the discovered articles were downloaded and reviewed by two researchers. This review discovered that six articles discuss the use of either CRM, SMS, or SOPs in UAS operations, which suggests a need for a greater body of UAS research in these areas. This void in research mirrors the early integration approach taken by the US military, and the consequence of the knowledge gap was an increased accident rate. Additional research must be conducted to understand the effect of human error on civilian UAS operations to allow for the safe operation of UAS in the US NAS.

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The unprecedented growth of Unmanned Aerial Systems (UAS) in the United States has seen over 1.6 million UAS enter the National Airspace System (NAS) between 2015 and 2020 (FAA, 2020a; Valavanis, 2008). Due to the dramatic increase of UAS in the NAS, concerns have been raised regarding the risk associated with UAS operations (Dalamagkidis, Valavanis, & Piegl, 2008). Of large concern is the risk of mid-air collisions between manned and unmanned aircraft (O'Donnell, 2017; Russell, 2010; Zhang et al., 2018). Showcasing the potential danger are the numerous reports of UAS sightings near manned aircraft or airports, over 100 per month, and the two confirmed mid-air collisions between manned and unmanned aircraft (FAA, 2020b; NTSB, 2017, 2019). One well researched solution to the dramatic potential of manned-unmanned mid-air collisions is the development of “sense and avoid” technology for UAS (Haessig, Ogan, & Olive, 2016; Karhoff, Limb, Oravsky, & Shephard, 2006; Stark, Stevenson, & Chen, 2013). While on-board airborne collision avoidance systems (ACAS) are vital to safe air traffic management, they do not entirely prevent mid-air collisions (Brooker, 2005). Human error in the cockpit has been responsible for aircraft accidents, including midair collisions, even with robust technological solutions that may have prevented the accident (German Federal Bureau of Aircraft Accidents Investigation, 2004; Papadimitriou et al., 2020).

Human error, active and latent, plays a major role in aviation accidents and incidents (C.-C. Chen, Chen, & Lin, 2009; Chiu & Hsieh, 2016; McFadden & Towell, 1999). While human error cannot be completely eliminated from a system, it can be anticipated and mitigated (Tullo, 2019). Manned aviation provides a significant history regarding methods to reduce the negative impact of human error. Multiple complimentary and overlapping processes or systems have been implemented in traditional manned aviation aimed at mitigating human error in the cockpit (Salas, Maurino, & Curtis, 2010). Crew Resource Management (CRM) reduces error by allowing a cockpit crew to function as a multi-person unit taking advantage of the skills, knowledge, and capabilities of all members of the crew (Ginnett, 2019). Safety Management Systems (SMS) are a formal method by which organizations define how they will mitigate risk within their operations that is followed by all levels of the organization (Roughton, Crutchfield, & Waite, 2019). Standard Operating Procedures (SOPs) ensure that all flight crews reliably complete tasks in the correct manner (FAA, 2017). These three systems have reduced human error and increased safety in manned aviation (Davies & Delaney, 2017).

Early UAS integration into the US military relied on software modification, instead of a robust system of traditional aviation safety practices, to “reduce human-error induced losses to near zero” (DOD, 2001, p. 54). The need for these aviation safety practices can be seen in the Predator program (A. Tvaryanas, Thompson, & Constable, 2005). While not the first UAS used by the US Military, the Predator was the first to be widely integrated in military service (Nullmeyer, Herz, & Montijo, 2009). During this integration it became clear that removing the pilot from within the aircraft does not eliminate human error as the Predator’s mishap rate was 10 to 100 times higher than manned aviation, with 68% involving human error (DOD, 2001; A. P. Tvaryanas, Thompson, & Constable, 2006). It was also discovered that in some cases an increase of automation proved detrimental. For example the RQ-4 Global Hawk, the US Air

Force's High Altitude Long Endurance (HALE) platform, complex mission planning processes led to taxi speed of 155 knots into a turn causing major damage to the aircraft (Williams, 2004). The human factors challenge with UAS can in part be explained by the rapid deployment of the technology which outpaced the research and development of SOPs, CRM training, and adequate SMS for operations (Johnson, 2009; Moorkamp, Kramer, van Gulijk, & Ale, 2014b). Given the current safety expectations of the aviation industry, UAS safety processes and support systems cannot take years to develop or rely upon lessons learned strictly from UAS accidents and mishaps. Human factors guidelines must instead be developed from early operational experiences with UAS and the lessons learned in manned aviation and adopt a greater proactive approach to safety (Hobbs & Shively, 2013).

**Use of Safety Standards in Scientific Research Literature**

In order to understand the current state of literature concerning the use of human factors practices in UAS operations, predominantly using UAS as scientific data collection tool, a scoping literature review was performed, using the ISI Web of Science core collection and Science Direct. The first article to mention UAS in either database appeared in 1988 (Draper, 1988) and increased rapidly to 126 in the 1990s, 2,075 in the 2000s, and 20,732 in the 2010s. This exponential rise in UAS related publications leaves no doubt that technology is being rapidly adopted in many fields and adapted to many uses. This literature was reviewed using the methods described by (Arksey & O'Malley, 2005) with the goal of determining the current state of UAS literature regarding human factors practices. Human factors in aviation is an extensive field of study that bridges into many other fields; such as psychology, computer science, and engineering (FAA, 2008). Given the broad nature of aviation human factors research the scope had to be set so that a large portion of human factors based research would be discovered, but limited enough that it could be completed in a reasonable timeframe. In order to accomplish this FAA regulations, 14 CFR and Advisory Circulars, were reviewed to determine the practices required for operation. In parallel the application of aviation human factors practices to other industries was reviewed to determine which practices were the most used outside of aviation; with the idea that these would be the most likely to be used without aviation knowledge as our focus is the use of UAS as a scientific data collection tool. These two lists were compared and the three practices chosen were CRM, SOPs, and SMS. Each database, ISI Web of Science core collection and Science Direct, were queried in the following way ("Unmanned Aerial System" OR "Unmanned Aerial Vehicle") AND ("Crew Resource Management") with "Crew Resource Management" being changed for each human factors practice, Table 1. The first article that contained the required verbiage appeared in the year 2000 and this year was chosen as the start year for the literature review with 2020 set as the end year. Each returned article was retrieved and reviewed by two separate reviewers who each recorded: year, author, title, primary topic, role of UAS, role of the human factors practice, and the relevance of human factors to UAS operations within the article. Articles were marked if human factors practices were applied in operation and the effect of the practice was discussed, or if the effect of human factors practices applied to UAS operations in general were discussed. Once each article had been independently reviewed, the reviewers convened and compared their assessments. During this comparison there were articles where the reviewers disagreed. Where there was a disagreement the articles were re-reviewed against the inclusion criteria. The initial search of Science Direct and the ISI Web of Science core collection returned 116 sources containing relevant text based upon database queries, table 1. All 116 sources were retrieved and reviewed by two reviewers. Of these 116 sources only six were found to discuss the use of human factors practices within UAS operations. While each of the three human factors practices is represented safety management systems had the most relevant articles, followed by crew resource management, Table 2.

Table 1.
*Count of articles containing both "Unmanned Aerial Systems" OR "Unmanned Aerial Vehicles) and one of the human factors terms*

| Year | Crew Resource Management | Standard operating Procedures |
|---|---|---|
| 2000-2010 | 5 | 6 |
| 2010-2020 | 15 | 56 |
| | Safety Management System | Total Articles |
| 2000-2010 | 3 | 14 |
| 2010-2020 | 31 | 102 |

Table 2.
*Articles found during the literature review which positively discussed the use of one of the three human factors practices within UAS operations.*

| Citation | Title | CRM | SMS | SOP |
|---|---|---|---|---|
| (Ren, Cheng, & Huang, 2015) | Exploration of Crew Resource Management Concept Based on UAV System | x | | |
| (O'Connor, Hahn, Nullmeyer, & Montijo, 2019) | Chapter 19 The Military Perspective | x | | |
| (Moorkamp, Kramer, van Gulijk, & Ale, 2014a) | Safety management theory and the expeditionary organization: A critical theoretical reflection | | x | |
| (Moorkamp, Wybo, & Kramer, 2016) | Pioneering with UAVs at the battlefield: The influence of organizational design on self-organization and the emergence of safety | | x | |
| (Clothier, Williams, & Hayhurst, 2018) | Modelling the risks remotely piloted aircraft pose to people on the ground | | x | |
| (Zmarz et al., 2018) | Application of UAV BVLOS remote sensing data for multi-faceted analysis of Antarctic ecosystem | | | x |

## Discussion of Literature Review Human Factor Practices

Current literature is sparse, but what has been published describes the benefits of human factors practices in UAS operations. "The Military Perspective", the nineteenth chapter of *Crew Resource Management (Third Edition)*, O'Connor, Hahn, Nullmeyer, & Montijo (2019) describe the use of CRM in global military training programs and explicitly discuss the implications of human error in UAS programs, as well as the positive impact of CRM training on mishap rates. "Exploration of Crew Resource Management Concept Based on UAS System" focuses on the use of CRM training to decrease UAS mishap rates within UAS operations and presents multiple suggestions for implementation (Ren, Cheng, & Huang, 2015). Moorkamp reports on the experience of Task Force Uruzgan, describing the challenges and considerations that must be taken when implementing SMS in a rapidly changing and unpredictable environment, such as a combat zone (Moorkamp et al., 2014a; Moorkamp et al., 2016). While UAS may require a specialized SMS when operating in unpredictable environments a proactive SMS allows the operator to recognize factors that endanger flight and lead to an accident (Clothier, Williams, & Hayhurst, 2018). In *Application of UAV BVLOS remote sensing data for multi-faceted analysis of Antarctic ecosystem* Zmarz et al describe the steps taken to create SOPs for regular data collection flights in a hostile environment, and how those SOPs were integrated into a living handbook for UAS operations. The use of aviation based human factors practices when UAS are used as a scientific data collection tool are still in their infancy (Lercel & Hupy, 2020). Developing and integrating human factors practice for UAS operations will require an assessment of how these practices are integrated into manned aviation. The following sections describe how each of the discussed human factors practices, CRM, SMS, and SOPs are currently used in manned aviation and the effect they have had on flight safety.

## Crew Resource Management

Crew Resource Management is the process by which an aircraft crew makes “effective use of all available resources: human resources, hardware, and information” (FAA, 2004, p. 2). The concept of CRM was developed during a 1979 NASA workshop in the wake of multiple fatal aircraft accidents resulting from pilot error, most notably the collision of two 747 airliners at the Tenerife airport (Cooper, White, & Lauber, 1980; Helmreich & Foushee, 2010; Netherland Aviation Safety Board, 1978). Early CRM programs were focused on increasing the managerial effectiveness of pilots, and providing general information on interpersonal interactions in the cockpit (Helmreich, Merritt, & Wilhelm, 1999). Unfortunately, this information provided little in the way of specific guidance and the cockpit became a group of highly skilled individuals working simultaneously towards the same goal, instead of a cohesive team (Ginnett, 1987). A second CRM workshop was held in 1986, focusing on methods to improve team interactions and synergy; with Line Oriented Flight Training (LOFT) proving effective (Hamman, 2010; Orlady & Foushee, 1987). The improvement of aircraft simulators has allowed LOFT to include realistic scenarios and evaluate the performance of the flight crew instead of an individual crewmember (Koteskey, Hagan, & Lish, 2019). Simulator based LOFT has been credited with the near miraculous survivable crash landing of United Airlines Flight 232 (Brookes, 1992). After losing hydraulic power to the aircraft’s control surfaces the flight crew was able to use differential engine power to guide the aircraft to the Sioux City airport. This method of control required complex crew coordination and simulator based reenactments determined that the crew “greatly exceeded reasonable expectations” (National Transportation Safety Board, 1989, p. 76)

Crew Resource Management (CRM) is credited as an essential factor in reducing aviation accidents and increasing the safe return of critically damaged aircraft (Ford, Henderson, & O'Hare, 2014; Wakeman & Langham, 2018). These high-profile successes have drawn the attention of high consequence industries looking to emulate aviation's safety successes (Malcom, Pate, & Rowe, 2020). Medicine is one such industry taking notes from aviation's successes with a focus on CRM and simulation-based training (Hughes et al., 2016; Schulz, Endsley, Kochs, Gelb, & Wagner, 2013). Introducing CRM into trauma care has had "an overwhelmingly positive impact on confidence, preparedness, and teamwork in trauma personnel," (Ashcroft, Wilkinson, & Khan, 2020, p. 17) In addition to increasing the confidence of trauma, personnel CRM was found to enhance their non-technical skills and reduce surgical mortality rates (Neily et al., 2010; Wakeman & Langham, 2018). The benefits of CRM have been recognized throughout manned aviation and other high consequence industries, such as the medical industry. Despite their similarities additional research will be required to adequately adapt CRM practices from manned to unmanned aviation (Lim et al., 2018).

## Safety Management Systems

Safety Management is the "systematic control over worker performance, machine performance, and the physical environment," and a safety management system (SMS) is an organized collection of all used safety management practices within an organization (Heinrich, Petersen, Roos, Brown, & Hazlett, 1980, p. 4; Li & Guldenmund, 2018). SMS began integration into aviation after a series of aircraft accidents were attributed to latent failures (McDonald, Corrigan, Daly, & Cromie, 2000). Latent failures are a failure in an organizations structure, and are frequently revealed by active failures (Maurino, Reason, Johnston, & Lee, 2017). Active failures are discreet events in the human-machine interface with unintended and often un-desired consequences (Reason, 1998). SMS not only allows an organization to account for active and latent errors, but can assist in the development of a safety culture within the organization (Rundmo & Hale, 2003). While safety culture has many definitions (International Nuclear Safety Advisory, 1991; Turner, Pidgeon, Blockley, & Toft, 1989; Uttal, 1983) the goal is to create a culture which values safety and adopts practices which reduce accidents (Cooper Ph.D, 2000). As a safety culture is developed SMS programs further mature and become more effective which in turn strengthens the organization's safety culture (Cooper Ph.D, 2000; Hurst, Young, Donald, Gibson, & Muyselaar, 1996; Patankar & Sabin, 2010).

## Standard Operating Procedures

Standard Operating Procedures (SOPs) are a series of written procedures containing important information regarding task completion that each member of an organization follows (Bains, Bhandari, & Hanson, 2009). In aviation, SOPs are required for all stages of flight to ensure correct task completion throughout the flight, increasing the safety of flight operations (Moriarty, 2015). SOPs are an important part of increasing the safety and reliability of task completion, but increase in effectiveness when checklists are implemented in parallel (C. Chen, Kan, Li, Qiu, & Gui, 2016). Checklists developed in the wake of the Boing B-17 test flight crash and came to prominence after their integration proved effective in improving flight safety for that aircraft (O'Connor, Gordon, & Mendenhall, 2013; Schamel, 2012). Since this successful demonstration, checklists have become one of the core methods of standardization within aviation operations (Degani & Wiener, 1993). Deviation from SOPs in a high consequence and high complexity industry has potentially dire consequences; between 2001 and 2010 the National Transportation Safety Board (NTSB) identified 86 accidents, amounting to 149 fatalities, involving lack of adherence to or lack of adequate SOPs or checklists (Sumwalt, 2013).

While UAS operations are a lower consequence endeavor, in terms of potential fatalities, when compared to manned flight, there are many parallels in operation. In a 2013 presentation Robert Sumwalt of the NTSB gave a presentation concerning SOPs; the presentation contained the following quote concerning an aircraft crash in Atlanta, Georgia on September 14, 2007:

> When asked about the flight department's standard operating procedures (SOPs), the chief pilot advised that they did not have any… the flight department had started out as just one pilot and one airplane, and that they now had five pilots and two airplanes…(Sumwalt, 2013, p. 10)

While this quote is describing a corporate flight department it could easily be describing a UAS department. Small departments with little to no aviation experience are very prevalent in emergency response, where most UAS operations are undertaken by individuals as a collateral duty (Todd, Werner, & Hollingshead, 2019).

## Conclusions

With an average of 876 UAS registered per day since 2015 (FAA, 2020a) it would be impossible to remove UAS from the NAS. The meteoric rise of UAS in the United States has outpaced the development of traditional aviation safety practices within the UAS industry, just as it did in the US Military. When reviewing the experiences of the US military, in regards to UAS integration, the effect of rapid integration is easily seen in an accident rate 10 to 100 times higher than manned operations (DOD, 2001). In spite of the high accident rate UAS were used extensively in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) with the Army flying 867,566.6 hours between October 7$^{th}$, 2001 and December 2009, an average of 288 hours per day (Dempsey & Rasmussen, 2010). During this operational period, multiple articles and assessments were written by the US military to decrease the accident rate to acceptable levels.

Integration of consumer UAS into the NAS has the benefit of hindsight, through both manned aviation and the integration experiences of the US military. However, a review of the literature does not provide compelling evidence that these lessons are being applied. Of the 22,934 UAS based articles reviewed, 116 mention UAS and one of the three discussed human factors practices in the same article, and six discuss the use of the practices within UAS operations. Of these six: three discuss SMS, two discuss CRM, and one discusses SOPs. Two of the SMS related articles discuss the experiences of a Dutch Expeditionary Force operating a UAS in a complex environment, and the third states that a robust SMS can assist in early detection of errors. While one of the CRM articles focuses entirely on the use of CRM in UAS operations it appears poorly translated and contains few sources. The second CRM article highlights the challenges faced by the US military when first integrating and operating UAS platforms. This single article concerning SOPs discusses the experiences of an Antarctic research team and the steps they took to safely operate a UAS for wildlife monitoring.

In the same timeframe, 2000-2020, over 3,000 articles mentioning CRM/SMS/SOPs and Aviation/Airline were published concerning manned aviation; many of which were included as citations in this paper. The dramatic difference in published literature suggests a severe knowledge gap in the management of human error in UAS operations. This knowledge gap is particularly concerning as human error has been reported as the leading cause of aircraft accidents, both manned and unmanned (Harris & Li, 2011; A. P. Tvaryanas et al., 2006). Over the last 20 years research concerning human error and human factors has made up 3% of all research discussing manned aviation, in contrast human factors makes up 0.026% of all research discussing UAS. The current state of literature suggests that there is a lack of research being performed on the human factors component of UAS operations. This knowledge gap exists in opposition to an industry where safety is the highest desired competency and the proven problematic results from military integration (Lercel & Hupy, 2020; A. P. Tvaryanas et al., 2006). Civilian UAS integration must learn from these experiences, as decades of incidents and accidents are no longer tolerated (Hobbs & Shively, 2013).

References

Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International journal of social research methodology, 8*(1), 19-32.

Ashcroft, J., Wilkinson, A., & Khan, M. (2020). A Systematic Review of Trauma Crew Resource Management Training: What Can the United States and the United Kingdom Learn From Each Other? *Journal of Surgical Education*. doi:https://doi.org/10.1016/j.jsurg.2020.07.001

Bains, S., Bhandari, M., & Hanson, B. (2009). Standard Operating Procedures: The Devil Is in the Details. *19*(3), 195-199. doi:10.1615/JLongTermEffMedImplants.v19.i3.40

Brooker, P. (2005). Reducing mid-air collision risk in controlled airspace: Lessons from hazardous incidents. *Safety Science, 43*(9), 715-738. doi:https://doi.org/10.1016/j.ssci.2005.02.006

Brookes, A. J. (1992). *Disaster in the Air*: Ian Allen.

Chen, C., Kan, T., Li, S., Qiu, C., & Gui, L. (2016). Use and implementation of standard operating procedures and checklists in prehospital emergency medicine: a literature review. *The American Journal of Emergency Medicine, 34*(12), 2432-2439. doi:https://doi.org/10.1016/j.ajem.2016.09.057

Chen, C.-C., Chen, J., & Lin, P.-C. (2009). Identification of significant threats and errors affecting aviation safety in Taiwan using the analytical hierarchy process. *Journal of Air Transport Management, 15*(5), 261-263. doi:https://doi.org/10.1016/j.jairtraman.2009.01.002

Chiu, M.-C., & Hsieh, M.-C. (2016). Latent human error analysis and efficient improvement strategies by fuzzy TOPSIS in aviation maintenance tasks. *Applied Ergonomics, 54*, 136-147. doi:https://doi.org/10.1016/j.apergo.2015.11.017

Clothier, R. A., Williams, B. P., & Hayhurst, K. J. (2018). Modelling the risks remotely piloted aircraft pose to people on the ground. *Safety Science, 101*, 33-47. doi:https://doi.org/10.1016/j.ssci.2017.08.008

Cooper, G. E., White, M. D., & Lauber, J. K. (1980). Resource management on the flightdeck: Proceedings of a NASA/Industry workshop (NASA CP-2120). *Moffett Field, CA: NASA-Ames Research Center*.

Cooper Ph.D, M. D. (2000). Towards a model of safety culture. *Safety Science, 36*(2), 111-136. doi:https://doi.org/10.1016/S0925-7535(00)00035-7

Dalamagkidis, K., Valavanis, K. P., & Piegl, L. A. (2008, 25-27 June 2008). *Evaluating the risk of unmanned aircraft ground impacts.* Paper presented at the 2008 16th Mediterranean Conference on Control and Automation.

Davies, J. M., & Delaney, G. (2017). Can the Aviation Industry be Useful in Teaching Oncology about Safety? *Clinical Oncology, 29*(10), 669-675. doi:https://doi.org/10.1016/j.clon.2017.06.007

Degani, A., & Wiener, E. L. (1993). Cockpit Checklists: Concepts, Design, and Use. *Human Factors, 35*(2), 345-359. doi:10.1177/001872089303500209

Dempsey, M. E., & Rasmussen, S. (2010). Eyes of the army–US Army roadmap for unmanned aircraft systems 2010–2035. *US Army UAS Center of Excellence, Ft. Rucker, Alabma, 9*.

DOD, D. o. D. (2001). *Unmanned aerial vehicles roadmap 2000-2025*. Retrieved from https://apps.dtic.mil/dtic/tr/fulltext/u2/a391358.pdf

Draper, J. S. (1988). Military Information Processing. In M. C. Yovits (Ed.), *Advances in Computers* (Vol. 27, pp. 1-67): Elsevier.
FAA. (2004). *AC 120-51E - Crew Resource Management Training*.
FAA. (2008). Chapter 14 Human Factors. In *Aviation maintenance technician handbook—General* (FAA-H-8083-30A ed.): Federal Aviation Administration.
FAA. (2017). *Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck Crewmembers, (Advisory Circular 120-71B)*. Washington D.C
FAA. (2020a). UAS by the Numbers. Retrieved from https://www.faa.gov/uas/resources/by_the_numbers/
FAA. (2020b). UAS Sightings Report. Retrieved from https://www.faa.gov/uas/resources/public_records/uas_sightings_report/
Ford, J., Henderson, R., & O'Hare, D. (2014). The effects of Crew Resource Management (CRM) training on flight attendants' safety attitudes. *Journal of Safety Research, 48*, 49-56. doi:https://doi.org/10.1016/j.jsr.2013.11.003
German Federal Bureau of Aircraft Accidents Investigation. (2004). *Investigation Report no AX001-1-2/02*. Retrieved from http://www.bfu-web.de/EN/Publications/Investigation%20Report/2002/Report_02_AX001-1-2_Ueberlingen_Report.pdf?__blob=publicationFile:
Ginnett, R. C. (1987). *First encounters of the close kind: The formation process of airline flight crews*. Retrieved from
Ginnett, R. C. (2019). Chapter 3 - Crews as Groups: Their Formation and Their Leadership. In B. G. Kanki, J. Anca, & T. R. Chidester (Eds.), *Crew Resource Management (Third Edition)* (pp. 73-102): Academic Press.
Haessig, D. A., Ogan, R. T., & Olive, M. (2016, 30 March-3 April 2016). *"Sense and Avoid" - What's required for aircraft safety?* Paper presented at the SoutheastCon 2016.
Hamman, W. R. (2010). Chapter 8 - Line Oriented Flight Training (LOFT).: The Intersection of Technical and Human Factor Crew Resource Management (CRM) Team Skills. In B. G. Kanki, R. L. Helmreich, & J. Anca (Eds.), *Crew Resource Management (Second Edition)* (pp. 233-263). San Diego: Academic Press.
Harris, D., & Li, W. C. (2011). An extension of the Human Factors Analysis and Classification System for use in open systems. *Theoretical Issues in Ergonomics Science, 12*(2), 108-128. doi:10.1080/14639220903536559
Heinrich, H. W., Petersen, D., Roos, N. R., Brown, J., & Hazlett, S. (1980). *Industrial accident prevention: A safety management approach*. New York: McGraw-Hill.
Helmreich, R. L., & Foushee, H. C. (2010). Chapter 1 - Why CRM? Empirical and Theoretical Bases of Human Factors Training. In B. G. Kanki, R. L. Helmreich, & J. Anca (Eds.), *Crew Resource Management (Second Edition)* (pp. 3-57). San Diego: Academic Press.
Helmreich, R. L., Merritt, A. C., & Wilhelm, J. A. (1999). The evolution of crew resource management training in commercial aviation. *The international journal of aviation psychology, 9*(1), 19-32.
Hobbs, A., & Shively, R. J. (2013). Human factors guidelines for UAS in the national airspace system. *Proceedings of the Association for Unmanned Vehicle Systems International (AUVSI), Washington, DC*, 12-15.
Hughes, A. M., Gregory, M. E., Joseph, D. L., Sonesh, S. C., Marlow, S. L., Lacerenza, C. N., . . . Salas, E. (2016). Saving Lives: A Meta-Analysis of Team Training in Healthcare. *Journal of Applied Psychology, 101*(9), 1266-1304. doi:10.1037/apl0000120

Hurst, N. W., Young, S., Donald, I., Gibson, H., & Muyselaar, A. (1996). Measures of safety management performance and attitudes to safety at major hazard sites. *Journal of Loss Prevention in the Process Industries, 9*(2), 161-172. doi:https://doi.org/10.1016/0950-4230(96)00005-8

International Nuclear Safety Advisory, G. (1991). *Safety culture: a report*: International Atomic Energy Agency.

Johnson, C. W. (2009, 2009). *The safety research challenges for the air traffic management of unmanned aerial systems (UAS).* Paper presented at the Proceedings of the 6th EUROCONTROL Experimental Centre Safety Research and Development Workshop, Munich, Germany.

Karhoff, B. C., Limb, J. I., Oravsky, S. W., & Shephard, A. D. (2006, 28-28 April 2006). *Eyes in the Domestic Sky: An Assessment of Sense and Avoid Technology for the Army's "Warrior" Unmanned Aerial Vehicle.* Paper presented at the 2006 IEEE Systems and Information Engineering Design Symposium.

Koteskey, R. W., Hagan, C., & Lish, E. T. (2019). Chapter 10 - Line Oriented Flight Training: A Practical Guide for Developers. In B. G. Kanki, J. Anca, & T. R. Chidester (Eds.), *Crew Resource Management (Third Edition)* (pp. 283-322): Academic Press.

Lercel, D. J., & Hupy, J. P. (2020). Developing a Competency Learning Model for Students of Unmanned Aerial Systems. *The Collegiate Aviation Review International, 38*(2).

Li, Y., & Guldenmund, F. W. (2018). Safety management systems: A broad overview of the literature. *Safety Science, 103*, 94-123. doi:https://doi.org/10.1016/j.ssci.2017.11.016

Lim, Y., Gardi, A., Sabatini, R., Ramasamy, S., Kistan, T., Ezer, N., . . . Bolia, R. (2018). Avionics Human-Machine Interfaces and Interactions for Manned and Unmanned Aircraft. *Progress in Aerospace Sciences, 102*, 1-46. doi:https://doi.org/10.1016/j.paerosci.2018.05.002

Malcom, D. R., Pate, A. N., & Rowe, A. S. (2020). Applying safety lessons from aviation to pre-licensure health professions education: A narrative critical review. *Currents in Pharmacy Teaching and Learning, 12*(8), 1028-1035. doi:https://doi.org/10.1016/j.cptl.2020.04.015

Maurino, D. E., Reason, J., Johnston, N., & Lee, R. B. (2017). *Beyond aviation human factors: Safety in high technology systems*: Routledge.

McDonald, N., Corrigan, S., Daly, C., & Cromie, S. (2000). Safety management systems and safety culture in aircraft maintenance organisations. *Safety Science, 34*(1), 151-176. doi:https://doi.org/10.1016/S0925-7535(00)00011-4

McFadden, K. L., & Towell, E. R. (1999). Aviation human factors: a framework for the new millennium. *Journal of Air Transport Management, 5*(4), 177-184. doi:https://doi.org/10.1016/S0969-6997(99)00011-3

Moorkamp, M., Kramer, E.-H., van Gulijk, C., & Ale, B. (2014a). Safety management theory and the expeditionary organization: A critical theoretical reflection. *Safety Science, 69*, 71-81. doi:https://doi.org/10.1016/j.ssci.2014.05.014

Moorkamp, M., Kramer, E.-H., van Gulijk, C., & Ale, B. (2014b). Safety Management within Task Force Uruzgan: a report on working with Unmanned Aerial Vehicles. In.

Moorkamp, M., Wybo, J.-L., & Kramer, E.-H. (2016). Pioneering with UAVs at the battlefield: The influence of organizational design on self-organization and the emergence of safety. *Safety Science, 88*, 251-260. doi:https://doi.org/10.1016/j.ssci.2015.09.029

Moriarty, D. (2015). 3 - Error management and standard operating procedures for pilots. In D. Moriarty (Ed.), *Practical Human Factors for Pilots* (pp. 77-117). San Diego: Academic Press.
National Transportation Safety Board. (1989). *Aircraft Accident Report--United Airlines Flight 232*.
Neily, J., Mills, P. D., Young-Xu, Y., Carney, B. T., West, P., Berger, D. H., . . . Bagian, J. P. (2010). Association Between Implementation of a Medical Team Training Program and Surgical Mortality. *JAMA, 304*(15), 1693-1700. doi:10.1001/jama.2010.1506
Netherland Aviation Safety Board. (1978). *Final report of the investigation into the accident with the collision of KLM flight 4805 and Pan American flight 1736 at Tenerife airport*.
NTSB, N. T. S. B. (2017). *National Transportation Safety Board Aviation Incident Final Report*. Retrieved from https://app.ntsb.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20170922X54600&AKey=1&RType=HTML&IType=IA%EF%BB%BF
NTSB, N. T. S. B. (2019). *National Transportation Safety Board Aviation Incident Final Report*. Retrieved from https://app.ntsb.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20191205X95005&AKey=1&RType=Final&IType=IA
Nullmeyer, R., Herz, R., & Montijo, G. (2009). *Training interventions to reduce air force predator mishaps*. Retrieved from
O'Connor, B. B., Gordon, S., & Mendenhall, P. (2013). *Beyond the Checklist: What Else Health Care Can Learn from Aviation Teamwork and Safety*: Cornell University Press.
O'Donnell, M. (2017). *Investigation of UAS Accidents and Incidents*. Retrieved from FAA Office of Accident Investigation and Prevention:
Orlady, H. W., & Foushee, H. C. (1987, 1987). *COCKPIT RESOURCE MANAGEMENT; TRAINING*.
O’Connor, P., Hahn, R. G., Nullmeyer, R., & Montijo, G. (2019). Chapter 19 - The Military Perspective. In B. G. Kanki, J. Anca, & T. R. Chidester (Eds.), *Crew Resource Management (Third Edition)* (pp. 515-538): Academic Press.
Papadimitriou, E., Schneider, C., Aguinaga Tello, J., Damen, W., Lomba Vrouenraets, M., & ten Broeke, A. (2020). Transport safety and human factors in the era of automation: What can transport modes learn from each other? *Accident Analysis & Prevention, 144*, 105656. doi:https://doi.org/10.1016/j.aap.2020.105656
Patankar, M. S., & Sabin, E. J. (2010). Chapter 4 - The Safety Culture Perspective. In E. Salas & D. Maurino (Eds.), *Human Factors in Aviation (Second Edition)* (pp. 95-122). San Diego: Academic Press.
Reason, J. (1998). Achieving a safe culture: Theory and practice. *Work & Stress, 12*(3), 293-306. doi:10.1080/02678379808256868
Ren, Z. Q., Cheng, H. F., & Huang, G. L. (2015). *Exploration of Crew Resource Management Concept Based on UAV System*.
Roughton, J., Crutchfield, N., & Waite, M. (2019). Chapter 5 - Overview of Basic Safety Management Systems. In J. Roughton, N. Crutchfield, & M. Waite (Eds.), *Safety Culture (Second Edition)* (pp. 95-108): Butterworth-Heinemann.
Rundmo, T., & Hale, A. R. (2003). Managers’ attitudes towards safety and accident prevention. *Safety Science, 41*(7), 557-574. doi:https://doi.org/10.1016/S0925-7535(01)00091-1

Russell, C. J. (2010). *Airspace command and control in the contemporary operating environment*. Retrieved from

Salas, E., Maurino, D., & Curtis, M. (2010). Chapter 1 - Human Factors in Aviation: An Overview. In E. Salas & D. Maurino (Eds.), *Human Factors in Aviation (Second Edition)* (pp. 3-19). San Diego: Academic Press.

Schamel, J. (2012). How the pilot's checklist came about. *Flight Service History*.

Schulz, C. M., Endsley, M. R., Kochs, E. F., Gelb, A. W., & Wagner, K. J. (2013). Situation Awareness in Anesthesia Concept and Research. *Anesthesiology, 118*(3), 729-742. doi:10.1097/ALN.0b013e318280a40f

Stark, B., Stevenson, B., & Chen, Y. (2013, 28-31 May 2013). *ADS-B for small Unmanned Aerial Systems: Case study and regulatory practices.* Paper presented at the 2013 International Conference on Unmanned Aircraft Systems (ICUAS).

Sumwalt, R. (2013). *Standard Operating Procedures:  The Backbone of Professional Flight Operations*. In.

Todd, C., Werner, C., & Hollingshead, J. (2019). *Public Safety UAS Flight Training and Operations*. Retrieved from Miami, FL: https://96aed291-76e8-4e1e-8460-cb6ce37417a2.filesusr.com/ugd/ef6978_19517dfe38b34fad94d29c2b0c908491.pdf

Tullo, F. J. (2019). Chapter 2 - Teamwork and Organizational Factors. In B. G. Kanki, J. Anca, & T. R. Chidester (Eds.), *Crew Resource Management (Third Edition)* (pp. 53-72): Academic Press.

Turner, B. A., Pidgeon, N., Blockley, D., & Toft, B. (1989). *Safety culture: its importance in future risk management*.

Tvaryanas, A., Thompson, W., & Constable, S. H. (2005). *The U . S . Military Unmanned Aerial Vehicle ( UAV ) Experience : Evidence-Based Human Systems Integration Lessons Learned*.

Tvaryanas, A. P., Thompson, W. T., & Constable, S. H. (2006). Human factors in remotely piloted aircraft operations: HFACS analysis of 221 mishaps over 10 years. *Aviation, space, and environmental medicine, 77*(7), 724-732.

Uttal, B. (1983). The corporate culture vultures. *Fortune, 108*(8), 66-72.

Valavanis, K. P. (2008). *Advances in unmanned aerial vehicles: state of the art and the road to autonomy* (Vol. 33): Springer Science & Business Media.

Wakeman, D., & Langham, M. R. (2018). Creating a safer operating room: Groups, team dynamics and crew resource management principles. *Seminars in Pediatric Surgery, 27*(2), 107-113. doi:https://doi.org/10.1053/j.sempedsurg.2018.02.008

Williams, K. W. (2004). *A summary of unmanned aircraft accident/incident data: Human factors implications*. Retrieved from

Zhang, X., Liu, Y., Zhang, Y., Guan, X., Delahaye, D., & Tang, L. (2018). Safety assessment and risk estimation for unmanned aerial vehicles operating in national airspace system. *Journal of Advanced Transportation, 2018*.

Zmarz, A., Rodzewicz, M., Dąbski, M., Karsznia, I., Korczak-Abshire, M., & Chwedorzewska, K. J. (2018). Application of UAV BVLOS remote sensing data for multi-faceted analysis of Antarctic ecosystem. *Remote Sensing of Environment, 217*, 375-388. doi:https://doi.org/10.1016/j.rse.2018.08.031