

FAA Aviation Mx Human Factors Quarterly



June 2021
Vol 9, Issue 2

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If you would like to subscribe, please click on the following link [Subscribe](#).

The views and opinions expressed in this quarterly forum are those of the authors and do not necessarily reflect the official policy or position of the FAA, editor, or quarterly forum staff.

Upcoming Events

Do you know of an event that you would like us to share?

Send information to Janine King at janine.ctr.king@faa.gov.

Editor's Note: These events may have been cancelled or postponed due to the COVID-19 pandemic. Please consult the event website for confirmation before planning to attend these events.

Aero-Engines Europe

[Stavanger, Norway \(September 15-16, 2021\)](#)

Aero-Engines Asia-Pacific

(In conjunction with MRO Asia-Pacific)

[Singapore \(September 22-23, 2021\)](#)

MRO Europe

[Amsterdam, the Netherlands \(October 19-21, 2021\)](#)

66th Air Safety Forum, 2021

[Washington Hilton Hotel, \(October 25-28, 2021\)](#)



We're Taking Submissions	Author Appreciation
Want to share an article or experience in an issue of the FAA Aviation Mx HF Quarterly? The Mx HF Quarterly is published every 3 months, beginning at the end of March. We welcome your articles related to aviation maintenance. Our great editorial team will review submissions to ensure that content and format meet the needs of our readers. Editorial feedback is subject to author approval prior to the publication. <u>Please include the following with your submission</u> • Short author biography (50-150 words) • Photo of yourself for biography • One-sentence summary of your article • Images and/or graphics (with captions) • Call-out quote(s) • Takeaway message (what you hope the readers takeaway) from your article (not to exceed 100 words) Send your submissions to Janine King at <u>janine.ctr.king@faa.gov</u>.	We, the editorial team, extend our gratitude to our readers and contributors for their continued support of this quarterly publication. Our contributors and authors are not primarily responsible for writing articles for this quarterly newsletter; however, their vast knowledge and understanding of issues impacting and relating to aviation maintenance substantially improve this publication. If you are interested in providing suggestions or feedback concerning this publication, or would like to submit an article or notify us of an upcoming event, please email Janine King at <u>janine.ctr.king@faa.gov</u> or Kylie Key at <u>kylie.n.key@faa.gov</u>. We look forward to not only new article submissions but to reviews and feedback from our readers. We appreciate your input!

Keeping Current Regarding Human Factors and Aviation Safety

Bill Johnson

Background

As many readers likely know, I recently retired from my tenure as the FAA Chief Scientific and Technical Advisor for Human Factors in Aircraft Maintenance Systems. Since retirement, I've given a lot of consideration about how to remain current on the rapid change and innovation going on in the aviation industry and how it will affect safety and human factors. I have always relied on aviation news sources and selected attendance at industry meetings, so a change in aviation jobs did not disconnect me from current information. The fact that many aviation conferences are capitalizing on virtual-live meetings and conferences also helps ensure access to professional networks. My experience so far is that it's actually easier to remain current on safety and human factors issues without the trappings and overhead of full time employment. For me, a change in positions meant that I am on the phone less and, certainly, have diminished attendance in FAA meetings. In that way, retirement afforded me additional time to access many sources of information.

This short article provides a description of my favorite aviation safety information sources, mostly free or low cost. My hope is that readers can use these sources to remain current on updates in the aviation safety and human factors community. For a list of my favorite sources, you need look no further than the [table included on the right](#).

Characterizing Information Sources

Daily Information:

The easiest characterization is frequency of delivery. Some sources are a "push" that is published as quickly as news is available, or at least once per day. I like [The Flight Safety Information Newsletter](#) because it offers a broad view of aviation, comprehensive real-time news coverage, and it's free. They include selected general aviation stories, though the predominance of the Newsletter is airlines and MRO.

Sources

Daily Resources

- 1 [Flight Safety Information Newsletter](#)
- 2 [FlightGlobal](#)
- 3 [Aviation Week Network](#)
- 4 [Aerospace Digest*](#)
- 5 [Air Transport Digest*](#)
- 6 [BCA Digest*](#)

Magazines

- 7 [AviationPros](#)
- 8 [Aviation Week Network](#)
- 9 [Flight International](#)
- 10 [Civil Aviation Training](#)
- 11 [Airport Business*](#)
- 12 [Flight Safety Australia*](#)

Professional Networks

- 13 [Human Factors and Ergonomics Society](#)
- 14 [International Federation of Airworthiness](#)
- 15 [Flight Safety Foundation](#)
- 16 [Aviation Technicians Education Council](#)
- 17 [Professional Aviation Maintenance Association](#)
- 18 [Aircraft Owners and Pilots Association](#)
- 19 [Airlines for America*](#)

Websites

- 20 [FAA Maintenance Human Factors Website \(humanfactorsinfo.com\)](#)
- 21 [FAASafety.gov*](#)

1. Sources noted with an asterisk (*), are not described in the current article but are frequently utilized by the author.

They also include industry and academic conference announcements, selected summary of accident and events occurrences, and references to other relevant information sources.

[FlightGlobal](#) and [Aviation Week Network](#) are two of the largest aviation news publishers in the world, offering daily pushes. [Flight Global](#) generally has a broader international perspective than [Aviation Week Network](#). Both of these provided a limited free scope of news to non-subscribers, with additional content available to subscribers.

From the Magazines:

Magazines push a lot of free high-value information, usually on a weekly basis. One excellent example is AviationPros.com. They publish in four aviation areas including Airports, Aircraft Maintenance, Ground Support, and E-Military. I like their content because it's authored by industry leaders, usually written in plain language. The content is available via the online [archives](#).

I am a long-time subscriber to [Aviation Week Network](#) and [Flight International](#), my two favorite magazine publishers. The subscriptions are a bit costly, but in my view, are very reasonable for the comprehensive aviation news coverage.

Much of aviation safety and human factors hinges on quality training. One excellent source of aviation training information is the [Civil Aviation Training](#) magazine, supplemented by newsletters and a series of large international training conferences.

Professional Networks:

There are many magazines and newsletters published by professional societies. Examples are the

[Human Factors and Ergonomics Society](#), the [International Federation of Airworthiness](#), the [Flight Safety Foundation](#), the [Aviation Technicians Education Council](#), the [Professional Aviation Maintenance Association](#), the [Aircraft Owners and Pilots Association](#), and more.

Websites:

I have numerous favorite websites from government and industry that could be another full article. However, I would be remiss not to mention the site from which you are likely reading this article. That is the [FAA Maintenance Human Factors Website](#), found at www.humanfactorsinfo.com. This website describes research on aviation maintenance human factors and provides 1) links to reports and publications, 2) resources for fatigue risk management, 3) procedures and tools to evaluate HF interventions, and 4) resources for proactive approaches to risk management.

Human Factors in Aviation Maintenance

Library and Current Research

Videos

Fatigue Risk Management

Line Operations Safety Assessments (LOSA)

Training and Tools

Key Contacts

FAA Home > About FAA > Programs & Initiatives > Human Factors in Aviation Maintenance

Human Factors in Aviation Maintenance

What We Do

The overall goal of Aviation Maintenance human factors research is to identify and optimize the factors that affect human performance in maintenance and inspection.

Research attention to personnel includes:

Resources

- Newsletters
- Library
- Training & Tools

Key Takeaways

We all want to remain fully informed of local, national, and international safety and human factors issues. This article provided readers with a description of some of my favorite information sources, categorized into daily pushes and newsletters, magazines, professional network publications, and websites. Join me in relying on these sources to stay current on aviation safety and human factors.

Dr. Bill Johnson, a frequent contributor to this newsletter, is the former FAA Chief Scientific and Technical Advisor for Human Factors in Aircraft Maintenance Systems. His comments are based on nearly 50 years of combined experience as a pilot, mechanic, airline engineering and MRO consultant, a professor, an FAA scientific executive, and now President and Chief Scientist for Drbillj.com LLC.



Feasibility of Maintenance Instructions Displayed in Augmented Reality

Kylie Key and Ashley Awwad

Can Augmented Reality (AR) instructions be helpful in aviation maintenance operations? This article will explore the potential benefits of using AR in aviation maintenance, and describe a new FAA CAMI research study aiming to determine the feasibility of AR instructions in aviation maintenance. Our study, in partnership with a major manufacturer and air carrier, will compare traditional and AR instructions to determine whether AR instructions are feasible in aviation maintenance. We expect based on similar research studies that AR instructions will confer performance advantages over traditional instruction, but there may be ergonomic and other constraints.

“THE MAIN ISSUE IS HOW UNDERSTANDABLE AND ACCESSIBLE THE CONTENT IS FOR AIRCRAFT MAINTENANCE TECHNICIANS (AMTs).”

Study Purpose

It is well-known that traditional (paper-based) maintenance instructions can be challenging to use. The main issue is how understandable and accessible the content is for Aircraft Maintenance Technicians (AMTs). AMTs can get lost in the large number of safety messages (warnings/cautions), linked-references and other details, and can miss important safety-critical information (Avers et al., 2011). For example, a written instruction or illustration may be missing in the manual, or may be inaccurate/out of date. In fact, **data indicate that 43% of technical manuals have not been updated in a decade or more (Ricci, 2003).**

To enhance the usability of maintenance instructions, industry has introduced digital instructions such as iPads, or taken it a step further by displaying instructions in AR. In AR, virtual information (e.g., images, text, animation) and objects are overlaid on the real world. This means users are not visually removed from their actual environment, and can still interact and see what is going on in front of them. The AR can be shown via head-worn displays similar to a pair of sunglasses. Two well-known brands are Microsoft HoloLens and Google Glass.

Potential Benefits of AR

AR has been identified as a potentially feasible technology for displaying maintenance instructions because it gives users real time access to procedures, 3D visualization of airframe and components, and interconnectivity of maintenance information systems. AR allows the instant visualization of critical data directly into the viewpoint of the AMT at each stage of a maintenance/repair/servicing task. AR technologies and 3D visualization have the potential to simplify maintenance work instructions by reducing the quantity of text content AMTs have to refer to. Easy status tracking and completion verification



1. Image of AMT using AR to perform landing gear lubrication task (image was taken and provided by the author of this article)

may also help improve accuracy and efficiency in following procedures.

Scientific Research on AR

Although AR is becoming an industry trend, the feasibility of this technology for displaying real-time work instructions has not been thoroughly investigated by FAA. These technologies are beginning to appear in the research literature, both to support maintenance training (Bowling et al., 2008) and improved operational performance (De Crescenzo et al., 2011; Henderson & Feiner, 2007, 2011; Jo et al., 2014). An abundance of literature indicates AR training incurs benefits like reduced preparatory and repair time for certain tasks (Jo et al., 2014), improved user satisfaction (De Crescenzo et al., 2011), reduced AMT learning curve for troubleshooting an aircraft, and faster task performance when compared to electronic instructions (Pozzi, 2016).

There are fewer studies about the feasibility of AR as a display medium for real-time work instruction, but the available data seem promising. In one recent study, the display of maintenance instructions via a head-worn display were shown to decrease task completion time, mental and temporal workload, compared to paper instructions (Brady et al., 2019). This study used novice participants completing a simple maintenance task on a spacecraft. Research studies in industrial settings have shown AR might improve task performance, depending on the task complexity and the expertise of the user (e.g., see Henderson & Feiner, 2009; 2011; Wiedenmaier et al., 2003). **However, participants in these studies also identified usability and comfortability limitations of the head-worn display** (e.g., weight, limited window of view, eyestrain; see also Keesling, 2019). Further work is needed to resolve potential roadblocks to the implementation of AR and to ensure that the applications are dedicated to tasks in a way that maximizes return on investment.

“GIVEN THE LACK OF SCIENTIFIC RESEARCH ON AR IN AVIATION MAINTENANCE SPECIFICALLY, FURTHER INVESTIGATION IS NEEDED TO DETERMINE HOW AR TECHNOLOGY CAN BE FEASIBLY USED TO DISPLAY MAINTENANCE INSTRUCTIONS IN REAL AVIATION MAINTENANCE SETTINGS.”

These studies clearly demonstrate some potential benefits, but also some potential challenges with displaying AR instructions on a head-worn device. But critically for our study purpose, most of these studies were conducted in other industrial settings, not aviation maintenance. To our knowledge, there are only a few scientific studies investigating the feasibility of AR instructions specifically in the aviation maintenance environment. Recently, Eschen et al. (2018) identified viable use cases for augmented and virtual reality in the aviation inspection and maintenance domain, such as virtual inspection and ground testing. Keesling (2019) conducted interviews to determine whether AR can overcome shortfalls in the maintenance community (e.g., personnel shortages) and what challenges must be addressed prior to implementation. Finally, De Crescenzo et al. (2011) tested a prototype AR display and found improved user satisfaction. But, we are unaware of any studies determining whether AR improves operational performance, and whether it can be safely and feasibly integrated into the maintenance environment. Given the lack of scientific research on AR in aviation maintenance specifically, further investigation is needed to determine how AR technology can be feasibly used to display maintenance instructions in real aviation maintenance settings. That is the purpose of FAA CAMI’s research study.

The FAA CAMI Study

This research study will compare traditional instruction to AR on a head-worn device to determine whether AR is a feasible technology in the aviation maintenance environment. In particular, we're interested in questions like:

- Is the AR head-worn device comfortable to wear?
- Are users satisfied with the AR device?
- Are there any safety concerns with using AR?
- What types of maintenance tasks can AR instruction support?
- What changes (if any) to the AR design are needed to ensure this is feasible technology in the aviation maintenance environment?

The Task

The maintenance task selected for the study is lubrication of the main landing gear on B777-200 aircraft. This task is routinely scheduled, and each B777 main landing gear side (left and right) takes about 4 hours to complete. The associated task card traditionally comes with a table of the locations (more than 160 lubrication points per gear) to be lubricated and subsequent numerous diagrams to pictorially display where the fittings are located on the gear.

While performing this task, a pair of AMTs work their way across the gear to systematically lubricate each fitting one by one, using the required type of grease, and then check off each fitting as completed.

The AR Instructions

The AR display will highlight the lubrication fitting locations and make task information readily available to the AMTs including: work card information and steps, number of fittings, type of grease to use, cautions and warnings, and a 3D landing gear model.

With the AR capability, the Main Landing Gear (MLG) will be holographically 3D imaged to reflect *all* of the fitting locations via fly around or fly through technology, which is expected to be an improvement over the 2D graphics where hidden locations are described via flagnotes (not actually shown in the 2D graphics). Fittings are also depicted in different colors to reflect their status. For example, completed fittings could be displayed in green, versus not-yet-completed fittings in red.

What Next?

To determine the feasibility of AR instructions in the aviation maintenance environment, we are measuring many different variables of interest, like: efficiency, usability and workload, user satisfaction and comfortability of wearing the device, and potential workplace safety concerns related to wearing AR. We will also measure experience with the task, technology enthusiasm and familiarity, because we know these things may shape users' perceptions of the technology. The data collected will only be used in aggregate and will not disclose performance at an individual or company level.

The information collected during this study will be used in several ways including: to further develop AR applications, flesh out realistic maintenance use cases, and inform the overall feasibility and human factors considerations for the use of AR applications in the maintenance environment.



2. Photo of CAMI research team (image was taken and provided by the author of this article)

Data collection is unfortunately delayed due to COVID-19, but we expect to continue the research as soon as it is deemed safe.

References

- Avers, K. E., Johnson, W. B., Banks, J. O., & Nei, D. (2011). *Prioritizing Mx human factors challenges and solutions: Workshop proceedings*. (Report No. DOT/FAA/AM-11/11). Washington, DC: Federal Aviation Administration Office of Aerospace Medicine.
- Bowling, S. R., Khasawneh, M. T., Kaewkuekool, S., Jiang, X., & Gramopadhye, A. K. (2008). Evaluating the effects of virtual training in an aircraft maintenance task. *The International Journal of Aviation Psychology*, 18(1), 104-116.
- Braly, A. M., Nuernberger, B., & Kim, S. Y. (2019). Augmented reality improves procedural work on an International Space Station science instrument. *Human Factors*, 61(6), 866-878.
- De Crescenzo, F., Fantini, M., Persiani, F., Di Stefano, L., Azzari, P., & Salti, S. (2011). Augmented reality for aircraft maintenance training and operations support. *IEEE Computer Graphics and Applications*, 31(1), 96-101. <https://doi.org/10.1109/MCG.2011.4>
- Eschen, H., Kötter, T., Rodeck, R., Harnisch, M., & Schüppstuhl, T. (2018). Augmented and virtual reality for inspection and maintenance processes in the aviation industry. *Procedia manufacturing*, 19, 156-163.
- Henderson, S., & Feiner, S. (2007). *Augmented Reality for Maintenance and Repair (ARMAR)* (Report No. AFRL-RH-WP-TR-2007-0112). Wright-Patterson AFB.
- Henderson, S. J., & Feiner, S. (2009). Evaluating the benefits of augmented reality for task localization in maintenance of an armored personnel carrier turret. In *Proceedings of the 8th IEEE International Symposium on Mixed and Augmented Reality* (pp. 135–144). New York, NY: IEEE.
- Henderson, S. J., & Feiner, S. (2011). Augmented reality in the psychomotor phase of a procedural task. In *Proceedings of the 10th IEEE International Symposium on Mixed and Augmented Reality* (pp. 191–200). New York, NY: IEEE.
- Jo, G-S., Oh, K-J., Ha, I., Lee, K-S., Hong, M-D, Neumann, U., & You, S. (2014). A unified framework for augmented reality and knowledge-based systems in maintaining aircraft. *Proceedings of the Twenty-Sixth Annual Conference on Innovative Applications of Artificial Intelligence*, 2990-2997.
- Keesling, R. (2019). Exploratory analysis of the potential use of augmented reality in aircraft maintenance. Master's thesis, Air Force Institute of Technology. Retrieved from <https://scholar.afit.edu/etd/2305>
- Ricci, K. (2003). Human factors issues in Mx publications design. In *DOD Mx Symposium & Exhibition*. King of Prussia, PA: SAE International.
- Wiedenmaier, S., Oehme, O., Schmidt, L., & Luczak, H. (2003). Augmented reality (AR) for assembly processes design and experimental evaluation. *International Journal of Human-Computer Interaction*, 16, 497–514. doi:10.1207/S15327590IJHC1603_7

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Ashley Awwad is a Program Analyst for the FAA's Civil Aerospace Medical Institute (CAMI) Flight Deck Human Factors Research Lab (AAM-510). Ashley began flying as a teenager and went on to become a flight instructor at Embry-Riddle Aeronautical University. Shortly after earning a Master's Degree in Human Factors, Ashley began working with the FAA on research and development initiatives. She is currently supporting FAA research in the area of Aviation Maintenance Human Factors.



Maintenance Fatigue: a Glimpse of Past, Present, and Future

Katrina Avers

Another decade has passed, and fatigue is back on the NTSB's Top 10 Most Wanted List for aviation maintenance.

Although this may be disheartening, at first glance, as so much work has been done in the aviation industry to reduce fatigue related risk; I think this is an opportunity to reflect on what has been done, celebrate our accomplishments, and roll up our sleeves to make the next big improvement. Fatigue is a tough issue, and our industry has all of the risk factors for fatigue. Specifically, duty days are long, the operations are often 24/7, overtime is plentiful, and sleep is short.

“THIS IS AN OPPORTUNITY TO REFLECT ON WHAT HAS BEEN DONE, CELEBRATE OUR ACCOMPLISHMENTS, AND ROLL UP OUR SLEEVES TO MAKE THE NEXT BIG IMPROVEMENT.”

So what has been done to reduce fatigue risk in aviation maintenance?

Over the past decade...

- A fatigue countermeasures workgroup representing operators, academia, labor, and regulators was established to identify practical, science-based solutions for fatigue risk management. This superstar team prioritized low-hanging fruit for immediate impact, while always looking to the future and long-term needs (Avers et al., 2009).
- An awareness campaign for fatigue and fatigue risk was deployed nationally and internationally with posters, calendars, and the “Grounded” video to improve industry awareness of the risks, the mitigations that are available, and the reminder that change has to start with “you”. These materials are still freely available at https://www.faa.gov/about/initiatives/maintenance_hf/fatigue/ and used today by the FAA Safety Team and Safety Directors around the world.
- A fatigue countermeasure-training program was developed, evaluated, and deployed to more than 250,000 aviators via a collaboration with the FAA Safety Team Program. Studies showed that following the training, people had a better understanding of fatigue, got more sleep, used more effective fatigue countermeasures, and used less ineffective fatigue countermeasures (see Banks et al., 2013; Hauck et al., 2011). The training was also made freely available to the industry and adopted by many companies within and outside of the aviation maintenance industry as part of corporate learning management systems. While this training program demonstrated the change that each individual can make for themselves, it also revealed that there are organizational/industry constraints that must be changed as well. In other words, you can only do what you can do as an individual; the responsibility starts there but it doesn't end there. Each company has to set their organization up for success when it comes to fatigue risk management as there truly is a shared responsibility.
- A fatigue risk index was developed and published on www.humanfactorsinfo.com. That index was recently translated to Spanish, see Hidalgo's article on page 17.
- A science-based fatigue assessment supplement form was developed and deployed to get beyond a fatigue checkbox on incident/accident forms. Research tells us that people are poor judges of their own fatigue when they are performing tasks. Instead, researchers developed 10 behaviorally anchored fatigue questions associated with a maintenance incident or accident. Questions were simple and easy to answer,

like “What time did you go to sleep last night?” and “What time did the maintenance occur that produced the incident or accident?”, and are accurate for empowering improved accuracy in fatigue risk modeling and fatigue risk assessments. These questions were adopted by many companies and even incorporated into the Aviation Safety Action Program reporting system WBAT. A recent maintenance fatigue study of industry revealed that approximately 50% of incidents/accidents had the fatigue assessment supplement form data. Although there is much room for continued improvement, an increase from ZERO reports to 50% of reports having the information is HUGE!!!

- As the industry continued to advance with the application of Safety Management Systems, a science-based advisory circular (AC 120-115) was developed and published to provide guidance on the implementation of fatigue risk management in aviation operations. It focused on the causes of fatigue, the impact of fatigue, the benefits of fatigue risk management, and the shared responsibility in effectively managing fatigue risk. This was the first publication relating to rest and duty time limits that had been published in relation to aviation maintenance since 2001. It specifically outlined fatigue risk factors that an individual has responsibility for, as well as, the fatigue risk factors that the employing organization has responsibility for. Although some have argued a prescriptive rest and duty time rule is required for fatigue risk management, fatigue seems to be a perfect candidate for risk-based decision-making under 14 CFR Part 5.
- The AC provided a foundation for science-based discussion and recommended action but there were still many questions from maintenance operators on “How To” implement fatigue risk management. A team of researchers worked with a team of safety directors at Airlines for America to develop ATA Spec 116, Integrating Aircraft Maintenance Technician Fatigue into Safety Management Systems. This will be published in 2021 and is a resource that was developed in collaboration with the industry and for the industry. The collaboration itself speaks to the shared prioritization and investment across operators in fatigue risk management – this wasn’t happening a decade ago.

Fatigue is certainly a more common topic of interest by both employees and managers, as we see it referenced in ASAP and ASRS reports. We see increased discussion and understanding of the issue.

So what is the current state of fatigue risk in aviation maintenance?

This is really one of the first questions each company has to ask for themselves as they consider fatigue risk management from a risk-based decision-making perspective. We must KNOW our risk! In a recent FAA industry study of fatigue risk across four large operators, including 3 airlines and 1 MRO, we were able to collect 17.8 million aviation maintenance technician work hours over a 12-18 month data collection period. The study included data for 10,518 employees and 2,005 injuries/events. After eliminating poor quality data (either employee didn’t have timecard data to coincide with event or employee timecard was too inaccurate to fix), the study examined the data from 8,672 employees and 1,271 injuries/events. To date, it is the most extensive study of aviation maintenance schedule data as it relates to fatigue risk. A few key take-home points for the industry regarding our current state of fatigue risk based on this study:

“SHIFTS WITH AN ELEVATED FATIGUE LEVEL HAD AN 83% INCREASE IN INCIDENTS/ACCIDENTS PER 1000 SHIFTS WHEN COMPARED TO SHIFTS WITH A MODERATE OR LOW FATIGUE LEVEL.”

- 1) Across operations, in the aggregate, 238,235 work shifts (13.7%) were operating at elevated fatigue levels (performance comparable to individual's performance with a blood alcohol content of .05 and above). This is approximately 1 in 7 shifts and is nearly double what is typical in other 24/7 industries, indicating an elevated risk across the industry.
- 2) Shifts with an elevated fatigue level had an 83% increase in incidents/accidents per 1,000 shifts when compared to shifts with a moderate or low fatigue level. In other words, elevated fatigue levels do produce much high incident/accident rates.
- 3) There is significant variability across operators with regard to fatigue risk. One organization had a very low number of shifts (1.8%), operating with elevated fatigue levels, while another organization had 32.7% of its work shifts operating at elevated fatigue levels. **We interpret these data to mean: each maintenance organization is not the same – each organization needs to do their own fatigue risk assessment.**
- 4) Over the last 10 years, we have improved significantly in collecting incident/accident data and time on shift so we can actually make fatigue risk assessments. Almost 50% of incidents/accidents/non-compliance events included the critical information necessary to make fatigue assessments (this is a 50% improvement over the past decade). However, the converse of this improvement is that almost 50% of incidents/accidents/non-compliance events were not assessable for fatigue due to missing data. Specifically, many times the event reporters did not capture when the maintenance action was performed, rather the time data is only captured for when the incident/accident was discovered.
- 5) You can't know your operation's fatigue risk if you don't have clean work schedule data. **Each organization should be able to assess length of duty days (start and end times), number of consecutive duty days, and number of consecutive shifts. If safety directors or operational managers do not have access to this information, it is impossible to strategically assess or mitigate fatigue risk.**

“BOTTOM-LINE, FATIGUE IS STILL A RISK IN AVIATION MAINTENANCE BUT EACH ORGANIZATION DOES NOT HAVE THE SAME RISK. EACH ORGANIZATION NEEDS TO DO AN INTERNAL ASSESSMENT OF THEIR WORK SCHEDULE DATA SO THEY CAN MANAGE THEIR OPERATIONAL FATIGUE RISK STRATEGICALLY.”

So what is next for fatigue risk management in aviation maintenance?

Much, if not all of the industry, recognizes fatigue is a risk in aviation maintenance. Many have implemented some type of fatigue countermeasure training but have struggled to move beyond that in terms of incorporating fatigue as a major safety hazard in the context of SMS that requires assessment and mitigation.

Although much work has been done to de-mystify the science of fatigue and fatigue risk management, it remains for many to be an overwhelming undertaking. There is significant variability across the industry in how fatigue risk is being managed and the maturity and robustness of fatigue risk assessment and mitigation. **Some operators have indicated they need help from inspectors in identifying fatigue risk.**

In response, researchers are currently working with inspectors and operators to develop a science-based, applied, step-by-step approach to fatigue risk management that is broken down into actionable efforts that can build into a mature organizational fatigue risk management strategy. Researchers are identifying questions that operators and inspectors should be asking that are easy indicators of fatigue risk, so that fatigue risk can be incorporated, as appropriate, on the safety management dashboard.

In conclusion, we have come a long way; we have seen significant improvements in our understanding and assessment of fatigue in aviation maintenance. We have many wins in terms of collaboration and shared investment in addressing the hazard of fatigue. However, it is a tough nut to crack! We still have work to do, and are continuing to pursue practical and applied research that will empower the industry and improve aviation safety!

“RESEARCHERS ARE CURRENTLY WORKING WITH INSPECTORS AND OPERATORS TO DEVELOP A SCIENCE-BASED, APPLIED, STEP-BY-STEP APPROACH TO FATIGUE RISK MANAGEMENT THAT IS BROKEN DOWN INTO ACTIONABLE EFFORTS THAT CAN BUILD INTO A MATURE ORGANIZATIONAL FATIGUE RISK MANAGEMENT STRATEGY.”

Key Takeaways

Much, if not all of the industry, recognizes fatigue is a risk in aviation maintenance. Many have implemented some type of fatigue countermeasures training and about half of incident/accident data include adequate fatigue-related information to empower risk assessment – a huge victory! However, many organizations have struggled to move beyond that in terms of assessment and mitigation of fatigue risk. A recent research study demonstrated the current level of fatigue risk (1 in 7 shifts operating at elevated fatigue risk) and the significant variability across organizations – necessitating that each organization perform their own fatigue risk assessment and targeted mitigations. The next step is to develop a science-based framework and guidance materials, comprised of actionable efforts that can build into a mature fatigue risk management strategy.

References

- Avers, K. E., Johnson, W. B., Banks, J. O., Nei, D., & Hensley, E. (2011). *Fatigue Solutions for Maintenance: From Science to Workplace Reality* (No. DOT/FAA/AM-11/19). United States. Federal Aviation Administration, Civil Aerospace Medical Institute.
- Banks, J. O., Wenzel, B. M., Avers, K. E., & Hauck, E. L. (2013). *An Evaluation of Aviation Maintenance Fatigue Countermeasures Training* (DOT/FAA/AM-13/9). Federal Aviation Administration, Civil Aerospace Medical Institute.
- Hauck, E. L., Avers, K. B., Banks, J. O., & Blackwell, L. V. (2011). *Evaluation of a Fatigue Countermeasures Training Program for Flight Attendants* (DOT/FAA/AM-11/18). Federal Aviation Administration, Civil Aerospace Medical Institute.

Dr. Katrina Avers is a research psychologist in the Human Factors Research Lab at CAMI. Focal research activities include organizational assessment, fatigue education, fatigue reporting systems, and fatigue risk management programs for flight crew, cabin crew, and maintenance technicians.



Índice De Riesgo Por Fatiga: Fatigue Risk Index

Santiago Hidalgo

[Fatigue Risk Management](#) is a critical element to managing human factors risk in aviation maintenance. The FAA has sponsored research and development initiatives to implement evidence-based and proactive risk identification approaches to fatigue risk management among aviation personnel (including this newsletter). The FAA has developed various tools for identifying fatigue risk in the work environment. In particular, the Fatigue Risk Index (FRI) is a helpful tool for measuring quality of sleep, which is among the most important leading indicators of fatigue risk. To further promote the accessibility of the FRI, I recently translated the originally FAA published [Fatigue Risk Index](#) into Spanish. By doing so, I hope to make this tool available to groups that perform fatigue risk management in operations that include both English and/or Spanish speaking aviation personnel.

Fatigue Risk Index (English Version)

Step 1: Sleep in prior 24 hours						Step 4: Total points to determine your score									
Sleep	≤ 2 hr	3 hr	4hr	5+hrs											
Points	12	8	4	0											
Step 2: Sleep in prior 48 hours						<table><tr><th>Score</th><th>Action</th></tr><tr><td>1 - 4</td><td>Keep an eye on yourself</td></tr><tr><td>5 - 8</td><td>Have someone keep an eye on you</td></tr><tr><td>9+</td><td>Go to bed</td></tr></table>		Score	Action	1 - 4	Keep an eye on yourself	5 - 8	Have someone keep an eye on you	9+	Go to bed
Score	Action														
1 - 4	Keep an eye on yourself														
5 - 8	Have someone keep an eye on you														
9+	Go to bed														
Sleep	≤ 8hr	9hr	10hr	11hr	12+hr										
Points	8	6	4	2	0										
Step 3: Hours awake since last sleep															
If sleep in Step 2 is greater than hours awake, points = 0.															
If less, add 1 point per hour awake greater than sleep in Step 2.															
*Used by many in the transportation industry to address fatigue risk.															

Índice De Riesgo Por Fatiga (Spanish Translation)

Utilizado por muchas entidades en la industria del transporte para hacer frente al riesgo por fatiga

Paso 1: Horas de sueño en las últimas 24 horas					
Tiempo de sueño	2 horas <u>o menos</u>	3 horas	4 horas	5 horas <u>o más</u>	
Puntos	12	8	4	0	
Paso 2: Horas de sueño en las últimas 48 horas					
Tiempo de sueño	8 horas <u>o menos</u>	9 horas	10 horas	11 horas	12 horas <u>o más</u>
Puntos	8	6	4	2	0
Paso 3: Horas despierto desde el último período de sueño					
Tiempo despierto	Si el tiempo despierto es <u>menor</u> que las horas de sueño en las últimas 48 horas (tiempo del paso 2)				
Puntos	0				

Tiempo despierto	Si el tiempo despierto es <u>MAYOR</u> que las horas de sueño en las últimas 48 horas (tiempo del paso 2)
Puntos	Añada un punto (+1) por cada hora despierto en exceso de las horas de sueño en las últimas 48 horas (tiempo del paso 2)
De 1 a 4 puntos	Vigílese; cuide sus acciones
De 5 a 8 puntos	Que otra persona lo vigile; que cuiden sus acciones
9 puntos o más	Váyase a Dormir

Santiago Hidalgo is a recently retired aeronautical engineer and pilot who spent 53 years actively in the field of aviation. Throughout that time, he was a B-727 copilot and captain, F-100 captain, and A-320 captain for Mexicana Airlines. While flying, he also took time to teach a wide array of aeronautical topics, with human factors being a subject of focus. Santiago also has a passion for serving others, a trait he solidified through his work for the Mexican Government as a public servant.

Other HF Resources and Links

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Follow Procedures: The Buck Stops with Me



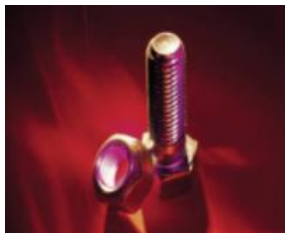
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