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## **Findings from the FAA Fatigue Working Group (2018-2021)**

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## **List of Abbreviations**

<b>ATC</b>	Air Traffic Control
<b>CAMI</b>	Civil Aerospace Medical Institute
<b>DoD</b>	Department of Defense
<b>FAA</b>	Federal Aviation Administration
<b>FDP</b>	Flight Duty Period
<b>FRMP</b>	Fatigue Risk Management Program
<b>FRMS</b>	Fatigue Risk Management System
<b>MX</b>	Maintenance
<b>NASA</b>	National Aeronautics and Space Administration
<b>REDAC</b>	FAA Research, Engineering, and Development Advisory Committee
<b>R&amp;D</b>	Research and Development
<b>SAS</b>	Subcommittee on Aircraft Safety
<b>SMS</b>	Safety Management System
<b>TRACON</b>	Terminal Radar Approach Control Facilities
<b>UAS</b>	Unmanned Aircraft Systems
<b>WOCL</b>	Window of Circadian Low

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# Introduction

## Summary

In 2017, the Federal Aviation Administration (FAA) Research, Engineering, and Development Advisory Committee (REDAC) Subcommittee on Aircraft Safety (SAS) identified a lack of coordination between different FAA fatigue research programs. This resulted in the formation of a fatigue working group composed of FAA, industry, and labor stakeholders. The current report documents the increased collaboration between FAA fatigue research areas and stakeholders, and includes fatigue-related issues and priorities identified by members through multiple 2018-2021 FAA Fatigue Working Group meetings.

## Background

In the fall of 2017, the SAS REDAC released the following recommendation after a ‘deep dive’ into fatigue management research, which was provided by FAA Civil Aerospace Medical Institute (CAMI) researchers:

*Issue:* Fatigue Mitigation... The committee feels that this report... identified an effective plan for moving forward which involved among other things, identifying research initiatives from around the industry, gaps in knowledge, and the establishment of fatigue working group with members from industry, research, and regulators to continue the necessary follow-up work needed to ensure required research is performed. The report stated that this working group will need a sponsor from the regulatory community to provide guidance and tasking for the working group.

*Recommendation:* The FAA establish a Fatigue Working Group, identify an FAA working group lead who will best represent fatigue across the agency, execute the FAA plan that was presented as the path forward for identifying and addressing fatigue research issues, and properly implementing research results.

Following the Committee’s recommendation, an FAA lead was identified to guide the formation of the group. Goals for the FAA Fatigue Working Group were developed and included:

- Formalizing communication across types of operations with consideration of stakeholder concerns and priorities
- Prioritizing fatigue research recommendations
- Capitalizing on overlapping opportunities, in-house resources, pooling of resources, and industry collaboration
- Hosting annual meetings with all stakeholders to re-assess priorities and gaps

The data and findings of the working group were not expected to result in funded research, rather it would provide critical information to policy offices for research prioritization decisions, synergy across operations, resource pooling, and collaboration.

## **2018-2021 FAA Fatigue Working Group Activities**

### **2018-2020 meetings**

Initially, a small core FAA group met in early 2018 to identify appropriate internal and potential external members and develop working group plans and an invitation for participation. These internal FAA members held an initial meeting in July to discuss working group plans, identify external group members, and develop a short survey requesting feedback from all members about their respective operations' the top five fatigue concerns. Individual working group members independently provided priorities which were then assessed, quantitatively combined as appropriate, and discussed interactively as a group.

This model of collecting, synthesizing, and documenting pre-meeting priorities for the group was replicated at each annual meeting. The expanded FAA Fatigue Working Group first met in January 2019, which included FAA researchers, policyholders, industry stakeholders, and labor to represent fatigue-related interests across various operations. Each of the six subgroups conducted follow-up meetings that occurred throughout the summer and were completed in the fall of 2019. These meetings aimed to identify and document fatigue-related priorities across each of the specific operations, and to learn about the common elements for potential collaboration, pooling of resources, and synergy among the subgroups. Initial subgroup operations included aeromedical, air traffic control and technical operations, flight attendants, maintenance, and pilots. Each year, additional membership or stakeholder groups are reviewed for inclusion to improve communication and collaboration. As a result, helicopter/rotorcraft operations were added, as well as cargo operations that were separated between ground/loading personnel and pilots.

### **2021 meeting**

With the onset of the COVID-19 pandemic in early 2020, the Annual FAA Fatigue Working Group meeting was canceled. All subgroup operations had been affected by the pandemic and fatigue issues remained. Further, constraints on in-person data collection and significant changes in aviation operations paused many fatigue-related data collection efforts. Quasi-normalization to aviation operations and changes in in-person data collection protocols began stabilizing in May of 2021. The next annual meeting occurred in August 2021 to resume formalized communications, discuss pandemic implications for operations and fatigue, and reassess fatigue-related priorities across the various work group operations.

With the acknowledgment that the pandemic significantly impacted the aviation industry, working group members were asked to reassess their top three priorities within respective

operations in advance of the meeting. For this meeting, the working group membership and scope expanded to include representation of unmanned aircraft systems (UAS) operations in addition to the previous operational specialization areas of aeromedical, air traffic control and technical operations (Tech Ops), flight attendants, maintenance, pilots, cargo ground/loading personnel, and helicopter/rotorcraft operations.

## **General Findings**

### **Group Demographics**

Overall engagement in the working group has been consistent, with 78% of the original invited members still active in the group. An additional seven working group members joined as of 2021 including 14 (44%) FAA employees, 10 (31%) industry representatives, 7 (22%) laborers, and 1 (3%) employee from the National Aeronautics and Space Administration (NASA). These members represent a range of fatigue-related operational interest groups, including pilots (25%), air traffic control (19%), cargo pilots and operations (19%), flight attendants (12%), maintenance (MX) operations (12%), aeromedical (6%), and UAS fatigue (6%). For detailed member affiliations, see Appendix A.

### **Subgroup Priorities 2019**

The various subgroups identified and discussed a number of crosscutting fatigue-related issues. The priorities listed below represent a qualitative and quantitative assessment of the overlapping themes between groups. The number of subgroups that expressed each theme as a priority is shown in parenthesis.

- Methods to assess and self-evaluate fatigue-related effects (6)
- Measuring the effectiveness of fatigue mitigations (5)
- Fatigue-related issues unique to different operations (5)
- Workload and scheduling issues related to fatigue (4)
- Interest in evaluating or creating new bio-mathematical models of fatigue (3)
- Evaluating controlled rest (2)

### **Subgroup Priorities 2021**

Several cross-cutting fatigue-related issues were synthesized from individual operational subgroup priorities and discussed during a single work group meeting. The number of subgroups increased by one, for a total of seven represented, following the addition of UAS operations. The top crosscutting fatigue-related issues are listed below. The number of subgroups that expressed each theme as a priority is shown in parenthesis.

- Pandemic-related effects on schedules and fatigue (7)



- Lack of fatigue data in varying operations including cargo pilots, short-haul flights, part 137 industry, and UAS (7)
- Continuous improvement of fatigue management strategies for day-to-day operations (5)
- Fatigue effects from increasing automation and new technologies (4)
- Focus on ongoing fatigue education/awareness (3)
- Evaluating controlled rest (2)

More detailed results and specific priorities are documented below by individual operational subgroup.<sup>1</sup>

## **Findings by Operational Subgroup**

### **Aeromedical Subgroup**

#### ***2019 Working Group Priorities***

In preparation for the 2019 work group meeting, representatives for the aeromedical operational subgroup reported the following fatigue-related priorities and potential research topics:

- Identifying biomarkers to detect performance impairment relative to aerospace operations.
- Discovering candidate biomarkers that will allow real-time measurement of performance impairment during sleep loss/mistimed sleep and other relevant fatigue-related conditions.
- Identifying key performance metrics and optimal performance assay to assess aerospace-relevant performance.
- Validating candidate biomarkers across a broad population with diverse demographics in conjunction with applicable performance assay results.
- Identifying and developing optimal biomarker sample source (i.e., RNA vs protein and blood vs urine/saliva/tears/etc.) as well as collection method (venipuncture vs finger stick, etc.).
- Assessing the performance of biomarkers in the presence of countermeasures, including pharmaceutical measures such as caffeine and potentially others (e.g., blue light exposure).

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<sup>1</sup> *Note.* The priorities summarized within the findings of this report are paraphrased from original responses by working group members. Individual priorities were rephrased or edited for clarity, and similar priorities within a subgroup have been combined.

- Assessing the performance of biomarkers in postmortem samples and developing key post-mortem biomarkers of conditions (e.g., hypoxia) not easily assessed by toxicological methods.
- Determining the robustness of biomarkers in postmortem measurements.
- Validating biomarkers across the broad population in conjunction with performance assay metrics.
- Identifying the key performance impairment metrics relevant to operational performance in the aerospace transportation industry, including baseline metrics applicable across fields and those tailored for specialized areas.

### ***2021 Working Group Priorities***

In preparation for the 2021 work group meeting, aeromedical subgroup representatives reported the following fatigue-related priorities and potential research topics:

- Discovering candidate biomarkers that will allow real-time measurement of performance impairment during sleep loss/mistimed sleep and other relevant fatigue-related conditions.
  - What genetic biological indicators (i.e., biomarkers) can be used to measure *impairment* from insufficient sleep?
- Validating candidate biomarkers as correlates of fatiguing conditions in aviation accident autopsy specimens.
  - What genetic biomarkers can be used to measure *impairment* from insufficient sleep?
- Assessing the performance of biomarkers in the presence of countermeasures, including pharmaceutical measures and potentially others (e.g., blue light exposure).
  - What genetic biomarkers can be used to measure *impairment* from insufficient sleep?

### **Air Traffic Control and Technical Operations Subgroup**

#### ***2019 Working Group Priorities***

In preparation for the 2019 working group meeting, representatives for the Air Traffic Control (ATC) and Technical Operations subgroup reported the following fatigue-related priorities and potential research topics:

- Contribution of mental workload and time on task to rate of fatigue accumulation
- Recovery times needed after working longer than normal hours
- Comparison of the strengths and limitations of different models of fatigue on assessing alertness and fitness for duty

- Are there behavioral indicators of fatigue that could be derived from voice communications or system interactions and leveraged for research purposes (and maybe eventual operational use)?
- Non-traditional methods to treat lack of sleep
- ATC
  - What are the top fatigue mitigation techniques for nontraditional schedules?
  - What is the impact of 6-day workweeks on fatigue:
    - Aside from self-reported fatigue, is there a measurable decrease in performance in comparison to other schedules?
    - What is the impact on the rate of fatigue accumulation?
  - How do we protect a controller's sleep opportunity during shift rotations, to reduce fatigue and improve alertness on the night shift? Knowing that an individual controller is required to cover the night shift, what can be done to reduce fatigue and improve alertness?
  - What improvements could be made to controller shift schedules to address potential fatigue issues but that also are acceptable to the workforce (e.g., work-life balance, childcare and senior care, 2-shiftworker families)?
  - Are there technologies (e.g., wearable Fitbit-like device) that could be employed to monitor fatigue levels that would be technically accurate and meaningful, have no operational impact (distraction, workload), and be deemed as acceptable to the controller workforce?
- Tech Ops
  - Impact of unpredictability of time outside of shift on performance and fatigue
  - Fatigue symptoms, behavioral indicators, and warning signs
  - Contribution of physical workload to the rate of fatigue accumulation
  - Effects of fatigue on cognitive processes
  - Utility of recuperative breaks on the rate of fatigue (happens in ATC but not in Tech Ops)

### ***2021 Working Group Priorities***

In preparation for the 2021 working group meeting, ATC and Tech Ops subgroup representatives reported the following fatigue-related priorities and potential research topics:

- ATC
  - Fatigue-Related to Reduced Controller-Pilot Interaction
    - The amount of interaction that controllers have with pilots is decreasing. Workload is reduced, but it comes at a price. This price typically is usually talked about in terms of reduced situation awareness (less interaction, less awareness). Other potential costs include increased boredom, reduced engagement and alertness, loss of vigilance, inattention, and fatigue.

- Effects of Room Lighting on Fatigue and Standards
  - Most facilities are moving away from the pitch-black Terminal Radar Approach Control Facilities (TRACON), however, there are no national requirements for room lighting. This makes the workspace and user interface design problem more challenging and causes issues (i.e., dark adaptation, circadian effects). The facilities attempt to address room lighting issues on a case-by-case basis. Some offer quasi-office lighting and some offer dim lights. Data are needed to determine the room lighting levels that disrupt circadian rhythms and sleep quality.
- Chronic fatigue
  - Follow up measure of effectiveness of prior mitigations for long-term fatigue caused by factors such as:
    - Accumulated sleep debt due to rotating work schedules that disrupt circadian rhythm
    - Sleep interruption such as those experienced working from home during the pandemic
    - Longer work hours (e.g., mandatory or voluntary overtime)
    - Increased job difficulty associated with on the job training
- Acute fatigue
  - Need to characterize and assess the effect of fatigue on performance if experienced after peak traffic load surges (aka “pushes”) due to flight scheduling and the hub-and-spoke business operations model
- Recuperative breaks
  - Need definitive research data to support recommendations on how often breaks are needed and how long they should be to effectively restore performance.
- The effect of the pandemic on schedule changes
- If possible, identify any new scheduling practices that can comply with all current laws, rules and regulations that may have a positive impact on mitigating fatigue in Shiftwork
- Continuous improvement of fatigue management strategies
- Greater understanding of fatigue-relevant factors/effects on fatigue
  - Pandemic influences on work-life changes, workload, and scheduling, for example.
- Focus on ongoing fatigue education/awareness
  - Identify and educate ATC on fatigue-based modifications that could improve quality of life
- Fatigue factors related to COVID-19 changes include:
  - Overload, change in work factors, needing schedule limits to be re-oriented, etc.
  - How the pandemic has impacted culture and the way operators/managers perceive, manage, and address fatigue

## **Cargo Operations Subgroup**

### ***2019 Working Group Priorities***

In preparation for the 2019 working group meeting, representatives for the Cargo Operations subgroup reported the following fatigue-related priorities and potential research topics:

- How do you properly diagnose cognitive impairment due to fatigue before duty?
- What are factors that could be considered as evidence of fatigue in loading personnel?
- What is the impact or potential role of medication on fatigue?
- How do you properly assess safety enhancements and other Fatigue Risk Management Plan improvements?
- Does controlled rest play a role? How does the military's use of controlled rest measure any enhancements to safety?
- Are there any models that can accurately predict fatigue by looking at schedule and proposing specific sleep you need between flights, for flight mechanics, loadmasters, loading personnel and flight crew?

### ***2021 Working Group Priorities***

2021 priorities for the Cargo Operations subgroup were not represented.

## **Flight Attendants Subgroup**

### ***2019 Working Group Priorities***

In preparation for the 2019 working group meeting, representatives for the Flight Attendant operational subgroup reported the following fatigue-related priorities and potential research topics:

- Scheduling issues creating or impacting fatigue
  - Examples of scheduling practices include reserves being on call for 24 hours, blended trips that include continuous overnight duty, long scheduled sits in airports without a hotel, and cabin door closures occurring only moments before reaching legal or contractual limits.
- Staffing Levels
  - Flight attendant roles, responsibilities, and job stress have increased due to high load factors, a greater density of seats in the cabin, and expanded security duties. However, the minimum staffing levels have remained constant. There is a need to describe and measure the impacts of these changes on fatigue.
- Safe limitations on monthly flying by type of operation
- Current aviation challenges, such as stress
- Operational issues that exacerbate fatigue such as extended tarmac delays, weather/maintenance delays, lack of opportunities for proper hydration or nutrition, and changing sleep wake cycles/time zones.

- Effectiveness of the rest environment
- Appropriate methods to self-evaluate individual fatigue level and fitness to fly
- Workplace injuries and fatigue

### ***2021 Working Group Priorities***

In preparation for the 2021 working group meeting, Flight Attendant subgroup representatives reported the following fatigue-related priorities and potential research topics:

- How do extended periods of wakefulness, restricted sleep, cumulative fatigue, and improper diet can affect individual performance in flight attendants?
- What are the effects of pandemic-related policies/procedures on fatigue and rest?
- How do duty/rest schedules affect flight attendant fatigue and performance? For example, variations with flight segment ranges, circadian rhythm disruptions, back of the clock flying, number of rest hours “behind the door”, split crews).
- Are flight attendant Fatigue Risk Management Programs (FRMPs) achieving safety goals?
  - Are they driving changes to practices and procedures or assuring “fitness to fly”? Do they increase understanding of the root causes of fatigue and ensure effective corrective actions?
  - Is FRMP data being used for anything?
- How does inadequate hydration/nutrition on duty impact flight attendant fatigue?

### **Maintenance Operations Subgroup**

#### ***2019 Working Group Priorities***

In preparation for the 2019 working group meeting, representatives for the Maintenance Operations subgroup reported the following fatigue-related priorities and potential research topics:

- Real-time fatigue assessment and new technologies in MX operations
  - New and emerging technologies/products (non-scientific, or scientific) (e.g., wearables such as Fitbit, Apple watch, Garmin for real-time fatigue assessment, breathalyzer paradigm)
  - Technologies monitoring driving behaviors in automobiles (e.g., Optalert<sup>®</sup> system used in the Australian mining industry)
- Increase guidance and process-tools for locally controlled Fatigue Risk Management Systems (FRMSs) to assess individual schedules, work tasks, and physiological factors that contribute to fatigue risks.
- What are some measureable physiological factors that contribute to fatigue risk? How can an overall understanding of risk be transformed with new technologies and tools?
- Measuring the impact of FRMS in terms of reports, events, and costs saved

- Potential resource: A Federal Railroad Administration Technical Report on costs associated with human factors and incidents/accidents in the rail industry showed that higher levels of fatigue were associated with greater damage and higher injuries.<sup>2</sup>
- Potential resource: The FRMS Team is gathering fatigue-related reports in the Technical Operations Safety Action Program and reviewing them to categorize the severity of the fatigue hazard identified, and then analyze associated safety risks in order to recommend appropriate mitigations as may be required. Fatigue reporting is an important part of a non-punitive voluntary safety reporting approach and critical to maintaining a solid safety culture for MX operations as well.
- Potential resource: The FAA Air Traffic Organization is developing a consolidated human performance taxonomy.
- Understanding the cost of fatigue-related error, as cost data prioritizes issue and mitigation decisions.
- Root Cause Analysis tools for fatigue
  - The MX Fatigue web pages developed earlier by the FAA should be updated and reintroduced.

### ***2021 Working Group Priorities***

In preparation for the 2021 working group meeting, Maintenance Operations subgroup representatives reported the following fatigue-related priorities and potential research topics:

- How time awake, time on duty, time of day, and workload affect performance related to following maintenance instructions
- How time awake, time on duty, time on task, and workload affect the use of virtual/augmented reality headsets for accomplishing tasks (i.e., whether maintenance instructions are completely read and understood, usage under various lighting and ground clutter “walking around” conditions).
- Difficulty implementing FRMS in aviation maintenance (e.g., paucity of guidance for industry)
- Lack of guidance, tools, and training for FAA aviation safety inspectors’ surveillance of fatigue risk
- Fatigue risks associated with operational impacts of the pandemic

### **Pilots Subgroup**

#### ***2019 Working Group Priorities***

In preparation for the 2019 working group meeting, representatives for the Pilots operational subgroup, which included both passenger and cargo pilots, reported the following fatigue-related priorities and potential research topics:

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<sup>2</sup> See Raslear, Gertler, and DiFiore (2013).

- Controlled rest for pilots
- Fatigue in part 137 industry
  - Need fatigue management programs for agriculture operations
- How fast and effective can a sleep opportunity be after a Flight Duty Period (FDP)?
  - How much sleep is possible and how much of that is restorative? How can a standard metric be created for models so that they all use the same criteria?
- How should cognitive impairment due to fatigue be diagnosed before flight? For example, when flight crew pilots are required to do some of the loadings.
- Average duration of sleep in the daytime hours after a window of circadian low (WOCL) incursion
- Lack of specific pilot fatigue and performance data for both men and women in the age cadre of 40-65
  - Recent research is dividing out even smaller windows of age groups as well as gender comparisons. Recommendations include capitalizing on the existing data collection opportunities and future opportunities to collaborate with the industry.
- Scheduling practices to help reduce fatigue (e.g., looking at back side of the clock operations, trip sequences, extended international operations)
- General value of actual napping duration before a WOCL incursion
- Standardized values/metrics of fatigue when using bio-mathematical fatigue models
- Effects of AM / PM / AM / PM switching in shift work on fatigue

## **Passenger Pilot Subgroup**

### ***2021 Working Group Priorities***

For the 2021 working group meeting, priorities for passenger pilots and cargo pilots were separated into two subgroups to better reflect the unique fatigue-related issues associated with each operation. In preparation for the 2021 working group meeting, representatives for the Passenger Pilot operational subgroup reported the following fatigue-related priorities and potential research topics:

- Loss of experience due to the pandemic
  - Pilots may have to develop new strategies to cope with flying new trips that they have never done before, and many senior captains have retired and have taken their strategies for managing fatigue with them.
- Changing bases due to the pandemic
  - Pilots who did not previously commute may now have a significant commute; others may have different/more challenging commutes.
- Strategies to improve monitoring of autonomous systems
- Fatigue in part 137 industry
  - Need fatigue management programs for agriculture operations



- Fatigue management strategies
- Fatigue in the UAS industry
- Measuring the effectiveness of Part 117 limits on mitigating fatigue in short-haul flying
- Develop/implement additional mitigations for short and long haul flying (i.e., controlled rest)
- Mature the use of Safety Management System (SMS) processes to manage and mitigate fatigue during day-to-day operations

## **Cargo Pilot Subgroup**

### ***2021 Working Group Priorities***

For the 2021 working group meeting, representatives from the Cargo Pilot operational subgroup reported the following fatigue-related priorities and potential research topics:

- Improved performance data for backside of the clock operations.
  - There are no science-based regulations that address the WOCL, fatigue risk of repeated operations at night, or the constant swapping of AM/PM scheduling and forced daytime sleep (i.e., regional/domestic schedules).
- How much fatigue is too much?
  - Create a valid model that correlates fatigue levels with performance degradation.
- The dangers and misinformation on the use of controlled rest in the cockpit
  - It was noted that multiple other agencies have rules on using controlled rest. However, it might become a scheduling tool to further extend the duty of a pilot with the premise of inflight napping, which causes other fatigue threats (e.g., reaction times, sleep inertia, no reporting of actual fatigue).
- Lack of specific pilot fatigue and performance data for both men and women in the age cadre of 40-65
  - Recent research is dividing out smaller age group ranges as well sex type for comparisons. Additional research is required on circadian dysrhythmia that includes all ages, but particularly for ages 40 to 65 in both men and women.

## **Rotorcraft Subgroup**

Neither 2019 nor 2021 priorities for the Rotorcraft operational subgroup were represented.

## **UAS Operators Subgroup**

### ***2019 Working Group Priorities***

2019 priorities for the UAS Operators subgroup were not represented.

### ***2021 Working Group Priorities***

For the 2021 working group meeting, representatives from the UAS Operators subgroup reported the following fatigue-related priorities and potential research topics:

- The effects of long missions and monitoring tasks on fatigue:
  - UAS missions, especially those with new vehicle types, may be longer, more automated, and, frankly, more boring than many manned flights. The tasks and working environment of a UAS ground station operator, especially one using a ground station that is more like a computer workstation than a cockpit, may be subject to fatigue/loss of vigilance issues more akin to someone monitoring a power plant control room or building security.
  - How well do the lessons and guidance derived from pilot fatigue studies apply to such an environment? Does the Department of Defense (DoD) have data on this? Do researchers and working group members need to start connecting with colleagues in other domains who have more experience with these types of tasks and environments?

## **Discussion**

This technical report documents the history and collaborative progress made by the FAA Fatigue Working Group, which was recommended by the SAS REDAC subcommittee to increase communication across fatigue-related stakeholders. Overall, the working group was well received by stakeholders in the FAA, labor, and industry, and has succeeded in raising mutual awareness of fatigue issues throughout operational areas. Fatigue-related priorities and issues were identified separately by individual working group members, then quantitatively and qualitatively integrated for further analysis during group discussions. Results from these discussions were briefed to the REDAC SAS subcommittee.

### **Summary of Priorities**

For both 2019 and 2021 collections of fatigue-related priorities, several cross-cutting fatigue priorities were identified. The top cross-cutting fatigue-related issues identified between 2019 and 2021 largely cover similar topics. Examples include a general interest in assessing and advancing fatigue management strategies already in use and a shared interest in how new technologies or models may be useful in managing fatigue. Additionally, both samples highlight the importance of fatigue-related challenges that are unique to individual operations and note the lack of data for these unique challenges in current fatigue research. A continuing interest in evaluating controlled rest also is identified.

The 2021 list of priorities includes new fatigue-related research interests that are associated with the operational changes caused by the pandemic. Additional priorities unique to the 2021 sample include an interest in “fatigue effects from increasing automation” and a “focus on ongoing fatigue education/awareness.”

While cross-cutting issues offer new opportunities for pooling resources and minimizing overlapping research, the sharing of fatigue issues that are unique to individual operations is also an invaluable part of this collaborative effort. For example, lighting conditions for ATC workers cause unique fatigue risks that require tailored mitigations. Similarly, group members have expressed a need for specific fatigue management programs targeting part 137 agricultural operations. These specific operational risks deserve attention along with cross-cutting issues, and these topics could benefit from additional operational input from groups involved in future advancements in technology. For example, research on lighting conditions and fatigue effects in ATC workers may be informative for future working conditions in UAS operations.

### **Fatigue-Related Research**

To receive research funding for FAA research, an FAA-sponsoring organization develops a research requirement that undergoes a formal evaluation process before receiving funding allocated to the FAA for research and development by Congressional budgets. Details on the research prioritization and funding process may be found in the [Research and Development \(R&D\) Portfolio Development Process: Guidance Reference Document](#) or on the [REDAC website](#).

The fatigue-related priorities identified by working group members will not necessarily result in new fatigue-related research. However, several FAA sponsored research studies were initiated since the formation of the FAA Fatigue Working Group to address some of the identified priorities.

For example, across both 2019 and 2021 working group assessments, multi-segment short-haul flight operations have been identified as particularly fatiguing for pilots. A recent research project sponsored by Flight Standards is beginning to investigate which particular short-haul operations are particularly high risk for fatigue. Similarly, ongoing maintenance research at CAMI includes conducting focus groups to examine best practices for implementing fatigue risk management in MX operations, which should inform priorities identified within these operations for 2019 and 2021. Working group members have also identified relevant fatigue research being conducted within air traffic control and aeromedical operations by the FAA.

### **Limitations**

The current research-related priorities represent a small sample of trending research needs within each subgroup area. Subgroups vary in representation across working group demographics, and some subgroups are more active than others. Others do not seem well-connected with the research community or are involved in the research requirement process. It is expected that involvement in this workgroup will help identify these gaps and provide resources to those that could be involved in sponsorship and funding for critical fatigue investigation. At this point, the working group still requires more representation of rotorcraft and UAS fatigue areas.

Another limitation to note is the strong influence of the pandemic on responses gathered in 2021. Many of these identified research priorities related to the pandemic may not apply to non-pandemic operations or may be resolved naturally over time. A number of the concerns were noted before the pandemic, but the pandemic amplified the magnitude or prevalence of these situations.

## **Conclusion**

The FAA Fatigue Working Group has facilitated better collaboration and awareness of top fatigue-related issues since its development in 2018. The group has expanded in operational subgroup representation and has been well received by federal, industry, and labor members. The group plans to continue annual meetings and collections of updated fatigue priorities while raising issues and sharing updates on ongoing fatigue research. Identified fatigue-related priorities offer opportunities for cross-cutting collaborative research opportunities moving forward.

## References

Raslear, T. G., Gertler, J., & DiFiore, A. (2013). Work schedules, sleep, fatigue, and accidents in the US railroad industry. *Fatigue: Biomedicine, Health & Behavior*, 1-2, 99–115.

## Appendix A.

### Group Members

Member	Affiliation	Membership years	Interest areas
Kenneth Allendoerfer, Ph.D.	FAA, ANG-E25	2019-2021	ATC, UAS
Katrina Avers, Ph.D.*	FAA, AAM-500	2019-2021	Maintenance
Hannah Baumgartner, Ph.D.†	FAA, AAM-500	2021	Pilots
Brad Brugger	Labor	2019	Maintenance
David A. Buczek	FAA, AJI-155	2019	ATC
DK Deaderick	FAA, AFS-220	2019-2021	Flight Attendants
Jason Demagalski, Ph.D.	FAA, AJI-3420	2019-2021	ATC
Julie Frederick	Labor	2019	Flight Attendants
Brandon Fried	Industry	2019	Cargo
RB Haggerty	Industry	2019-2021	ATC
Francis C. Heil	Industry	2019-2021	Flight Attendants, Maintenance
Joseph Hemler	FAA, AFS-830	2019-2021	Pilots
Dan Herschler	FAA, ANG-C1	2019-2021	ATC
Rich Hughey	Labor	2019-2021	Cargo Pilots
Bob Ireland	Industry	2019-2021	Maintenance
Bill Johnson	FAA, AIR-600	2019	Maintenance
Aaron Katz	Labor	2019-2021	ATC
Kylie Key, Ph.D.	FAA, AAM-500	2021	Maintenance
Jim Mangie	Industry	2019-2021	Pilots
Doug Marchese	Labor	2021	Cargo Pilots
Paul McGraw	Industry	2019-2021	Pilots
Dinkar Mokadam	Labor	2019-2021	Flight Attendants
Thomas Nesthus, Ph.D.†	FAA, AAM-500	2019-2021	Pilots, UAS
Scott Nicholson, Ph.D.	FAA, AAM-600	2019-2021	Aeromedical
Brian Noyes	Labor	2019-2021	Cargo Pilots
George Paul	Industry	2019-2021	
Mark Phaneuf	Labor	2019-2021	Cargo Pilots
Adrienne K. Phillips	Industry	2021	Pilots
Chester Piolunck, Jr.	FAA, FS-220	2019-2021	Pilots
Nobuyo Reinsch	Industry	2021	
Yvette A. Rose	Industry	2019-2021	Cargo
Sheryl Stroup	Labor	2019-2021	Flight Attendants
Michael Tipton	Labor	2019	Flight Attendants
Hilary Uyhelji, Ph.D.	FAA, AAM-600	2019-2021	Aeromedical
Nancy J. Wesensten, Ph.D.	FAA, AJI-1550	2019	ATC
Patricia K. Williams	FAA, AFS-340	2019-2021	Cargo
Bill Whyte	Industry	2021	
Laura Wood	FAA, AJI-3420	2021	ATC
Erin Flynn-Evans, Ph.D.	Other, NASA	2019-2021	Pilots

\* Chair

† Co-facilitators