Modern society’s 24/7 demands create significant physiological challenges for the humans responsible for safe and effective operations. Around-the-clock requirements create sleep and circadian disruptions that lead to reduced performance, alertness, safety, and health. Decades of scientific research and an extensive scientific literature clearly demonstrate that fatigue (created by sleep and circadian disruption) is a significant risk factor across diverse operational settings, including aviation and all other modes of transportation (1, 2, 3). The humans involved in EMS flight operations confront these same, well-documented physiological challenges and safety risks related to fatigue.

Acknowledging these fatigue-related safety risks, the National EMS Pilot Association (NEMSPA) requested a brief, summary examination of the challenges and opportunities related to managing fatigue in EMS flight operations. In response to this NEMSPA request, the following addresses four critical areas that represent the most significant challenges and opportunities related to fatigue in current EMS flight operations.

1. **Sleep is the most important factor to promote performance, alertness and safety.**

   It is an absolute: sleep loss will reduce alertness and performance. Extensive research, over many decades, in laboratories and field operations all over the world has shown that sleep loss will degrade diverse aspects of performance, impair alertness and create the risk for errors, incidents, and accidents (4, 5, 6, 7). All humans (100%) are susceptible to the negative effects of sleep loss. Sleep loss can take many forms (e.g., acute vs. cumulative) and be created by many different and complex factors (e.g., 14 factors related to work schedules) (1). While this extensive scientific research clearly demonstrates the many negative and serious consequences of sleep loss, it also establishes that the most important factor to promote performance, alertness, and safety is optimal sleep.

   This basic physiological requirement is established by extensive scientific findings and reflected in many, diverse applications in operational settings. Hours of Service policies, practices, and federal regulations include minimum off-duty periods to provide a sleep opportunity prior to subsequent work. Strategic naps are used in aviation, rail, healthcare, public safety and other work environments to promote alertness and performance during operations (8, 9, 10). On-board sleep facilities for long haul and ultra-long range aircraft are central to operational efforts to address fatigue-related safety risks. In trucking, sleeper berths are a critical and established mechanism for obtaining sleep. The physiological and operational importance of optimal sleep is well established and reflected in policies, practices, and activities across many different 24/7 operational settings.
The EMS flight operations that provide worksite sleep facilities acknowledge that sleep is a critical and foundational factor to promote performance, alertness, and safety. These EMS operations should be commended for addressing a fundamental physiological factor essential to managing fatigue. However, there is an opportunity to increase the effectiveness and use of these worksite sleep facilities. First, education about sleep, sleep loss, sleep disorders, circadian rhythms, alertness strategies and other relevant information is an important basis for the effective use of any fatigue management strategy or activity. Second, building on this educational foundation, scenarios specific to EMS flight operations should be identified and tailored guidance provided to address these situations. Just because the worksite sleep facility is provided does not mean that the operators will have knowledge or training on the most effective strategies to use the facility for optimal sleep.

One concrete example to support the development of scenario-specific guidance involves common EMS schedules that require transitions between day and night work periods. Night work requires day sleep, and studies show that due to circadian factors day sleep is significantly shortened and sometimes disrupted (11). Therefore, night work can result in acute sleep loss, creation of a cumulative sleep debt, and circadian disruption. Since the circadian clock does not physiologically adjust to night work (11), then having a sleep opportunity (e.g., at night in a worksite sleep facility) is a critical strategy to address a well-documented safety risk. Providing specific guidance on managing these day/night transitions would maximize the use and effectiveness of the worksite sleep facilities.

While there is an opportunity to enhance the use and effectiveness of worksite sleep facilities, it should be clear that eliminating existing facilities creates a significant and well-established safety risk related to sleep loss and fatigue. Such an action puts 100% of personnel (and subsequently their colleagues and patients) at risk and contradicts the extensive physiological, scientific, and operational findings that demonstrate sleep is the most important factor required for optimal performance, alertness, and safety.

2. What specific factors will reduce fatigue-related risks in EMS flight operations?
There has been justified concern that recent EMS flight operations accidents have occurred at night. There is the assumption that these were fatigue related because they occurred at night. There also is an assumption that the specific fatigue-related factors that were contributory or causal in these accidents are known and can be addressed directly. However, until there is a thorough and appropriate investigation of relevant fatigue factors in these accidents, it is not possible to determine whether fatigue was contributory or causal and what specific fatigue factors had a role in these accidents.

For almost 15 years, the National Transportation Safety Board (NTSB) has used a structured, scientifically based approach to examining fatigue factors in accident investigations (12, 13). Using the NTSB approach allows determination of whether fatigue factors played a role or not in an accident, whether fatigue was contributory or causal, and the specific fatigue factors involved. Based on the findings of such an investigation, then recommendations can be made to address identified fatigue factors that can reduce safety related risks.
Without a specific examination of the fatigue factors that may have played a role in the recent EMS flight operations accidents, there is no justification to enact changes that are supposedly intended to address fatigue. Without this examination, there are no factual or accident-related findings that can justify efforts to address fatigue factors that have not been established as causal or contributory. However, this represents another significant opportunity for EMS flight operations to pursue. Conducting an appropriate examination of fatigue factors provides an opportunity to determine if fatigue was a relevant contributory or causal factor in these accidents. It also could identify specific areas of intervention that would reduce identified fatigue-related safety risks.

3. What is the role of sleep inertia in creating fatigue-related safety risks?
Sleep inertia is the term for the sleepiness, grogginess, and disorientation that can occur when an individual is awakened from deep NREM (non-rapid-eye-movement) sleep, stages 3 and 4 characterized by delta activity in brainwaves. Laboratory studies have demonstrated that sleep inertia can degrade alertness and performance for about 15 minutes after awakening.

Whether sleep inertia creates fatigue-related safety risks is completely unknown. There are no studies relating sleep inertia performance decrements to safety outcomes. There are no studies outside the laboratory to determine sleep inertia effects in actual operational settings. There are no real-world studies examining sleep inertia in emergency call-outs to duty. There are no studies, laboratory or operationally based, determining the effects of adrenaline on sleep inertia in an emergency call-out situation. Current laboratory studies do not justify the assumption that sleep inertia creates fatigue-related safety risks.

As a consequence of a primary sleep period or nap, sleep inertia is not an absolute. The occurrence of sleep inertia is related to a variety of factors, such as the length of the sleep period, prior sleep loss, and actual awakening from deep NREM sleep stages 3 and 4. Laboratory research on sleep inertia is minimal with no operationally based data. There is no basis to estimate the potential fatigue-related safety risk that sleep inertia creates, even in all of the best or worst circumstances. However, there are extensive scientific findings that clearly demonstrate sleep loss will degrade alertness and performance in all humans. The unknown potential role that sleep inertia may play in creating fatigue-related safety risks is no basis for reducing or eliminating sleep opportunities that are a well-established physiological foundation for performance, alertness, and safety.

4. More opportunities for the EMS flight operations community.
a) Education and alertness strategies. Virtually every industry activity that has examined fatigue issues identifies education as a fundamental requirement for any fatigue management effort (14). All personnel need a foundation of knowledge and common language to address fatigue issues effectively. Given the complexity and demands of 24/7 operations, sleep loss and circadian disruption are unlikely to be eliminated as safety risks. However, there are a number of effective, scientifically validated strategies that can successfully manage fatigue and enhance performance and alertness. Guidance on applying these strategies to specific EMS flight operations scenarios would enhance their utility and effectiveness.
b) Research opportunities. While every operational setting has certain unique requirements, the human operators share common physiological capabilities and limitations. Therefore, if the EMS flight operations community determines that industry specific fatigue research would be useful, it should consider several actions. First, identify relevant fatigue issues to be addressed, whether exploratory or specific. Second, apply the extensive scientific research findings that already exist; spend industry time, resources, and efforts on creating new, relevant data. Third, focus efforts on addressing a specific question or determining the effectiveness of a particular strategy. Conducting valid, meaningful research is time-consuming, can take years, and requires extensive financial commitments. It is important to ensure that these resources provide outcomes that will make a valuable contribution and a difference to safety in EMS flight operations.

c) Use a comprehensive, programmatic approach. Managing fatigue is a complex and often contentious endeavor. The diversity of operational requirements, individual differences, and physiological complexity ensure that no single or simple solution will eliminate fatigue from 24/7 operations. No “one-size-fits all” approach can effectively manage the complexity. Instead, an alertness or fatigue management approach uses a comprehensive program of activities to address the complexity of fatigue. At a minimum, an Alertness Management Program (AMP) involves education, alertness strategies, scheduling, healthy sleep (sleep disorders), scientific guidance and policy support (15). An AMP can increase relevant knowledge, increase operator sleep, and improve performance and alertness during operations. An AMP uses a comprehensive, programmatic approach to effectively manage the complexities of fatigue in real-world operational settings (16).

The classic approach to address fatigue is to apply an Hours of Service structure with minimums and maximums intended to eliminate the potential of sleep loss and circadian disruption. Hours of Service policies and practices are necessary but not sufficient to fully address the complexity of fatigue. Two examples clearly illustrate the limitations. First, while an Hours of Service policy may require a minimum off-duty period (intended to provide an adequate sleep opportunity), there is no control over what an individual does during that off-duty period. There are many different reasons that an individual may not obtain needed sleep during an off-duty period (controlled or uncontrolled by the individual). Thus, there is no guarantee that the individual has obtained appropriate sleep prior to commencing duty. Second, duty periods during circadian night are associated with reduced alertness and performance, increased errors, incidents, and accidents. There is no Hours of Service policy that can eliminate this physiological certainty.

Concluding comments
The EMS flight operations community has the opportunity to capitalize on the extensive scientific knowledge and operational experience that already exists related to fatigue and progress in an efficient and direct manner to solutions that will enhance safety. It will be important that future efforts build on existing strengths within the community and address known, relevant, and data based issues. This will be critical to ensure that efforts and resources move the community forward in an effective direction that will have tangible safety benefits for operators, colleagues, and patients.
References


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Dr. Mark Rosekind is internationally recognized as a leader in translating the complex science on sleep, circadian rhythms (the body clock), and alertness into practical and effective strategies that help individuals and organizations improve performance, safety, and health in our 24/7 global society. Over the past thirty years, Dr. Rosekind has conducted scientific research in major academic institutions, led the innovative advance of a groundbreaking NASA program, and run a scientific firm that helps to improve safety and performance in diverse work settings.

Dr. Rosekind began his scientific career while an undergraduate at Stanford University conducting research at the Stanford Sleep Disorders and Research Center. He graduated from Stanford with Honors, and then obtained his Ph.D. in clinical psychology and psychophysiology at Yale University. Dr. Rosekind completed his formal academic training with a postdoctoral fellowship in sleep and chronobiology at Brown University’s Sleep Laboratory.

Dr. Rosekind began his professional career as the Director of the Center for Human Sleep Research, a component program of the Stanford Sleep Disorders and Research Center. After Stanford, he went on to direct the NASA Fatigue Countermeasures Program in the Human Factors Division at NASA Ames Research Center. For a year and a half, he also served as Chief of the Aviation Operations Branch in the NASA Ames Flight Management and Human Factors Division. After seven years as a Principal Investigator at NASA, Dr. Rosekind founded Alertness Solutions, a scientific consulting firm, and has served as President and Chief Scientist since 1998.

Over the course of his career, Dr. Rosekind has conducted research and implemented programs in diverse work settings, including all transportation modes, healthcare, public safety, nuclear energy, military groups, and other 24/7 operational environments. These activities have included many groundbreaking efforts, such as the “NASA Nap” study showing the powerful benefits of a cockpit nap for pilots, a Hilton Hotel project enhancing the sleep environment of U.S. Olympic athletes, and developing innovative flight schedules for an industry-leading program at JetBlue Airways.
Dr. Rosekind’s expertise has been used by many government agencies to address safety and alertness-related policies. He has contributed directly to policy activities involving the Federal Aviation Administration, Federal Rail Administration, Federal Motor Carrier Safety Administration, Nuclear Energy Commission, NASA, and numerous corporations, as well as provided Congressional testimony. Over the years, Dr. Rosekind has worked extensively with the National Transportation Safety Board (NTSB), including as Co-Chair of the first symposium on fatigue in transportation organized by the NTSB and NASA. Dr. Rosekind led efforts to develop a structured approach to examining fatigue factors in accident investigations for use by NTSB investigators and teaches a course on this topic at the NTSB Academy.

Dr. Rosekind’s research and activities have been published in over 125 scientific and technical papers. He typically provides 30 presentations each year to diverse general, scientific, and operational audiences. His expertise has been used by national and local media, including pieces in print (e.g., New York Times, Wall Street Journal, Washington Post, Time Magazine, USA Today, Business Week, Los Angeles Times, Forbes, US News & World Report; as well as Oprah’s Magazine, Reader’s Digest, Glamour, McCall’s, Parent’s Magazine, Health Magazine), on television (e.g., 60 Minutes, CNN, CBS 48 Hours, ABC 20/20, NBC Dateline, Good Morning America, Early Show, MSNBC, Discovery Channel), radio (e.g., NPR) and online (e.g., WebMD, CNN.com, Fortune Magazine Online, ABC News Website). International media pieces have appeared in the United Kingdom, Canada, Hong Kong, and Australia. He was a member of the Board of Directors of the National Sleep Foundation and the Executive Council of the Harvard Medical School’s Division of Sleep Medicine.

Dr. Rosekind’s contributions and accomplishments have been acknowledged through numerous honors and awards. For example, he has received the NASA Exceptional Service Medal and five other NASA Awards. The Flight Safety Foundation has honored him with their Outstanding Achievement in Safety Leadership Award and their Business Aviation Meritorious Award. Dr. Rosekind is a Fellow of the World Economic Forum, and was the first to present information on alertness and sleep at the annual meeting in Davos, Switzerland in 1999 and returned to present at the 2000 meeting.