SAFTE-FAST as a Supporting Tool for Fatigue Investigation

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Introduction

Biomathematical models are widely used in the aviation, rail, and shiftwork industries to assess fatigue risk during operations. While the goal is to avoid safety hazards, work-related incidents do happen. When a work-related incident occurs, a safety investigation can help determine which factors contributed to the event so that action may be taken to correct or avoid its occurrence in the future. One of these potential contributing factors is operator fatigue. In the context of a safety investigation, biomathematical modeling software like SAFTE-FAST can be used to provide a picture of fatigue risk at the time of the incident as a function of work schedule data, time of day, and sleep history.

This white paper describes, in general terms, the process of using SAFTE-FAST to estimate fatigue risk during the time of a work-related incident to determine whether fatigue should be considered a contributing factor during a safety investigation. Regulatory requirements regarding safety investigations vary by industry and region, so it is important to check with your organization's FRMS or regulatory board to ensure compliance.

Recognizing Fatigue

Fatigue is a general term used to describe low alertness, feelings of tiredness, or reduced cognitive ability. Fatigued individuals are less alert, have reduced ability to process information, and have slower reaction times than usual, which can lead to operator errors and procedural violations which can ultimately result in costly damage to people and property (Gaines, Morris et al. 2020). Fatigue is heavily related to prior sleep duration. Healthy adults are recommended to get 7-9 hours of sleep per night (Hirshkowitz, Whiton et al. 2015, Panel, Watson et al. 2015). Sleeping less than 7 hours per night is associated with impaired performance, increased errors, and greater risk of accidents for the average person (Panel, Watson et al. 2015). While some people may need more or less sleep than others, a worker who is routinely sleeping less than 5 hours per night or who has slept less than 3 hours in the 24-hour period leading up to the incident can reasonably be considered impaired due to fatigue (Belenky, Wesensten et al. 2003). While these levels of sleep deprivation are positive indicators of potential fatigue risk, getting more than these amounts but less than the average amount could still be a factor in an incident, especially when combined with other factors, such as the time-of-day factor. When investigating an incident, it is important to gather as much information as possible about the person's sleep during the three days leading up to the incident.

The time-of-day factor relates to a person's 24-hour cycle (circadian rhythm) of alertness. Reduced cognitive ability is greatest during the windows of circadian low (WOCL). The primary WOCL occurs at night when physiological sleepiness is greatest and performance capabilities are lowest, roughly between the hours of 0200 to 0600 (Dinges, Graeber et al. 1996). The reduction in alertness during the WOCL can be exaggerated by inadequate prior sleep (FAA 2010). Operators may also experience low alertness, reduced cognitive ability, or grogginess upon waking from sleep. This phenomenon is known as sleep inertia (Wertz, Ronda et al. 2006).

Fatigue can also be measured subjectively using self-report scales like the Karolinska Sleepiness Scale (KSS), the Epworth Sleepiness Scale (ESS) or the Samn-Perelli Scale (Gawron 2016). Fatigue may also be observable by in-cab monitoring systems, verbal complaints, or interactions with coworkers. Any corroborating evidence of operator fatigue can be helpful during a safety investigation even though it cannot be used as input data for SAFTE-FAST modeling. Fatigue reporting is recommended in order to identify fatigue risks in daily operations. Routinely using a standardized reporting form, like the Aviation Flight Safety Fatigue Report form provided in Appendix A, can help investigators track sources of fatigue in relation to incidents or near misses. A well-organized fatigue report form can be a substantial piece of collaborating evidence during an investigation.

Examples of SAFTE-FAST Use in Investigations

SAFTE-FAST can be used to support a large-scale analysis of incidence occurrence over multiple schedules. The Federal Railroad Administration (FRA) sponsored a study to demonstrate the ability of SAFTE-FAST to predict the likelihood of human factors accidents relative to nonhuman factors accidents under conditions of fatigue (Hursh, Raslear et al. 2006). The study collected 30-day work histories of locomotive crews prior to 400 human factors incidents and 1,000 nonhuman factors incidents. More than 1 million 30-minute work intervals, covering over 57,000 work starts, were evaluated for Effectiveness in SAFTE-FAST. The chi square ($\chi 2$) statistic was used to compare the distributions of human factors and nonhuman factors accidents to demonstrate significantly different distributions of risk. SAFTE-FAST estimates of Effectiveness were significantly correlated with human factors accident risk ($r = -0.93$, $p < 0.01$). Nonhuman factors accident risk was not correlated with Effectiveness ($r = -0.14$, $p > 0.05$). The analysis of freight railroad accident risk found a reliable relationship between reduced Effectiveness and increased risk of human factors accidents, indicating that work schedule-related fatigue likely contributed to an elevated risk of accidents (Hursh, Raslear et al. 2006).

SAFTE-FAST can also be used to investigate a single incident like the crash of Comair Flight 5191 (Pruchnicki, Wu et al. 2011). In brief, on August 27th, 2006, the flight crew of Comair Flight 5191 inadvertently attempted to take off from a runway that was too short for their aircraft at Bluegrass Airport in Lexington, Kentucky. The aircraft crashed, killing 49 of the 50 people on board. SAFTE-FAST was retrospectively used to estimate circadian phase and sleep/wake histories for the Captain, First Officer, and Air Traffic Controller (ATC) at the time of the incident (06:06 Eastern Daylight Time) using the U.S. National Transportation Safety Board (NTSB) reports for the 4 days preceding the accident. The investigators also examined the NTSB accident report and the cockpit voice recorder (CVR) transcript for the 30 m prior to and immediately after the crash for behavioral evidence of fatigue to correlate to the SAFTE-FAST Effectiveness predictions. SAFTE-FAST estimated that the ATC had an Effectiveness score of 71% at the time of the accident, a level roughly equivalent to 21 hour of wakefulness, a 40% increase in reaction time, and more than a quadrupling of the likelihood of a lapse in attention. There were also records of fatigue-related behavior or minor errors on the part of the ATC, Captain, and First Officer on the morning of the crash. The investigators in this report emphasized that although they could not make a direct, causal link between fatigue and the accident, but concluded that fatigue contributed at least in part to the human errors leading up to the crash (Pruchnicki, Wu et al. 2011).

Both of these cases serve as just two examples of the proper use and limitations of SAFTE-FAST for safety investigations. The next sections describe in general terms the requirements for modeling fatigue risk in SAFTE-FAST for the purposes of safety investigations. Each investigation is unique, and thus, proper modeling of fatigue risk through SAFTE-FAST should be handled on a case-by-case basis.

Modeling Fatigue Risk in SAFTE-FAST

SAFTE-FAST models the ability of the average person to perform effectively as a function of the three processes described above (sleep duration, time of day, and sleep inertia) in relation to work schedule data. The metric used to estimate cognitive performance in SAFTE-FAST is called Effectiveness. Effectiveness scores are based on reaction time speed on the Psychomotor Vigilance Task (PVT) (Dinges and Powell 1985, Hursh 2007). Effectiveness is expressed as a percentage of individual optimum performance (e.g., 100); lower Effectiveness scores indicate slower cognitive reaction times and speed of cognitive processing.

For reference, an Effectiveness score of 77% is equivalent to being awake for 18.5 hours continuously while an Effectiveness score of 70% is equivalent to 21 hours of continued wakefulness (Dean, Fletcher et al. 2007). Acceptable levels of fatigue risk as measured by Effectiveness scores are determined internally by the organization or set by regulatory bodies. As an example, the Federal Aviation Administration (FAA) used a target minimum predicted effectiveness of 77% to guide flight and duty time regulations (Huerta 2012)[1] while the Federal Rail Administration (FRA) considers a schedule with more than 20% of the schedule below 70% effectiveness to constitute a fatigue risk (Szabo 2011). It is important to consult your organization's fatigue risk management system (FRMS) or regional regulatory body regarding threshold of acceptable risk based on sleep duration or Effectiveness scores when conducting a safety investigation. SAFTE-FAST can provide estimates of prior sleep history and circadian misalignment that may help inform a safety investigation. SAFTE-FAST fatigue metrics that can aid in an investigation are summarized in Table 1 below.

[1] Part 117 Final Rule, Federal Register / Vol. 77, No. 2 / Wednesday, January 4, 2012: "An effectiveness level of 77 is approximately equivalent to the effectiveness of someone with a blood alcohol concentration of 0.05." page 372; "SAFTE/FAST model have been evaluated sufficiently to provide useful information to the agency in making policy decisions on how best to balance the needs of carriers to maximize their operations while still providing sufficient and meaningful rest opportunities to mitigate the risk of fatigue to those operations," page 390.

Table 1. SAFTE-FAST Performance and Fatigue Metrics

Domain	Metric	Definition	Recommended Use for Safety Investigations
Performance	Effectiveness	Effectiveness represents speed of performance on the Psychomotor Vigilance Test, scaled as a percent of a fully rested person's normal best performance. Effectiveness corresponds to the speed of cognitive performance, is highly sensitive to fatigue, and correlated with many other cognitive performance metrics. The higher the score the lower the fatigue risk.	The metric may be used as supporting evidence in safety investigations provided that the appropriate criterion levels have been verified against industry-specific and regional regulations.
	Mean Cognition	Average cognitive throughput based on a battery of cognitive tests scaled as a percent relative to the fully rested person's normal best performance.	The metric may be used as supporting evidence in safety investigations.
	Lapse Index	The Lapse Index score represents the likelihood of a lapse in attention relative to a well-rested person. The higher the score the higher the risk of lapses. Where 1 is relative to being rested, a 3.41 indicates the rate of the person experiencing a lapse would be increased by almost three and a half times, relative to them being rested	The metric may be used as supporting evidence in safety investigations.
	Reaction Time	The Reaction Time score represents reaction time, expressed as a percent of the average reaction time of a well-rested person. The higher the score the slower the reaction speed.	The metric may be used as supporting evidence in safety investigations.

Table 1. SAFTE-FAST Performance and Fatigue Metrics (continued)

Domain	Metric	Definition	Recommended Use for Safety Investigations
Sleep	Reservoir	The Reservoir score represents the current level of the sleep reservoir expressed as a percent of the full capacity. The color warning is driven by the Reservoir Palette (->75% Yellow). The reservoir threshold is 80% and correlates to a Sleep Debt of 6.4 hours and 19 hours of wakefulness. It is flagged as a fatigue factor when the Reservoir is at or below 75%, correlating to 8 hours of sleep debt and 24 hours awake.	The metric may be used as supporting evidence in safety investigations.
	Sleep 24 hours	The estimated amount of sleep obtained in the previous 24-hour period. The average person is recommended to get 8 hours of sleep each day.	The metric is considered a fatigue factor by the NTSB and may be used to inform safety investigations.
	Sleep Debt	The cumulative number of hours of sleep that have been missed since the Sleep Reservoir was last at full capacity. This fatigue factor is flagged as an outlier when there is 8 hours or more of sleep loss, either in a single day or accumulating over a series of days. Eight (8) hours of sleep debt is approximately 75% on one's Sleep Reservoir.	The metric is considered a fatigue factor by the NTSB and may be used to inform safety investigations.
	Hours Awake	The number of continuous hours of wakefulness since the last period of sleep. This fatigue factor is flagged as an outlier when staying awake longer than the average person's typical 16-hour wakefulness period. The severity increases the longer the time a person remains awake. Seventeen (17) or more hours awake is considered a fatigue factor.	The metric is considered a fatigue factor by the NTSB and may be used to inform safety investigations.

Table 1. SAFTE-FAST Performance and Fatigue Metrics (continued)

Domain	Metric	Definition	Recommended Use for Safety Investigations
Circadian	Time of Day	This fatigue factor will become an outlier when a person is working when the average person would normally be asleep in the early morning hours through the Window of Circadian Low (WOCL). This evaluation of vulnerability to error is based on the person's own adjusting circadian rhythm. For a person with a normal bedtime of 11pm, maximum vulnerability is considered to be between 12am-6am. Times are shown in Base time zone but are always adjusted to the person's own rhythm.	The metric is considered a fatigue factor by the NTSB and may be used to inform safety investigations.
		The difference between the environmentally driven circadian phase based on sleep pattern in the local time zone (Goal Phase) and the person's current physiological circadian phase (Current Phase). A positive value reflects a phase delay (westward travel), and a negative value reflects a phase advance (eastward travel). This fatigue factor is flagged as an outlier when a person leaves the place, they are acclimated to by crossing sixty degrees of longitude or more than three time zones. It is also possible for someone to become out-of-phase without traveling. This occurs where someone works night shifts and as such, often carry-on sleep/wake habits which are considered back-of-clock to where they live. More than 3 hours is a fatigue factor.	The metric is considered a fatigue factor by the NTSB and may be used to inform safety investigations.

SAFTE-FAST also provides estimates of KSS and Samn-Perelli scores for interpretive reasons (Gawron 2016). Importantly, SAFTE-FAST estimates of KSS or Samn-Perelli scores have not been robustly calibrated against actual records of self-reported fatigue. Therefore, it is not recommended to rely on SAFTE-FAST estimates of subjective fatigue (KSS, Samn-Perelli) during a safety investigation.

SAFTE-FAST can be used to model fatigue risk at the time of a singular work-related incident or to examine risk across multiple schedules with incidents provided that the investigators have the following information:

1. Time and date of the incident(s)
2. A minimum of three days of work schedule data leading up to the incident(s)
3. If possible, objective sleep data or self-report sleep data from the operator(s) in question

Data can be compiled in a csv or xml file, as shown in Figure 1A. Table 2 below demonstrates the recommended column headers and format for data to be uploaded. Work, sleep, and incident data can be uploaded as a single file using the Load function or as separate files using the Load>Merge function in SAFTE-FAST. For further instructions on how to upload data into SAFTE-FAST, see the SAFTE-FAST user manual or contact the SAFTE-FAST commercial services team at info@saftefast.com.

Table 2. Recommended Formatting of Input Data

Schedule ID	Event ID	Event Type	Start Location	End Location	Start	End	Time Reference
ID1	1	sleep	DCA	DCA	1/27/2024 23:00	1/28/2024 5:00	Base
ID1	2	**crewing**	DCA	LHR	1/28/2024 7:00	1/28/2024 15:00	Base
ID1	3	sleep	LHR	LHR	1/28/2024 23:00	1/29/2024 5:00	Base
ID1	4	**crewing**	LHR	DCA	1/29/2024 7:00	1/30/2024 19:00	Base
ID1	5	sleep	DCA	DCA	1/30/2024 2:00	1/30/2024 5:00	Base
ID1	6	**crewing**	DCA	LAX	1/30/2024 22:00	1/30/2024 2:00	Base
ID1	7	marker	DCA	LAX	1/30/2024 23:06	1/30/2024 23:08	Base

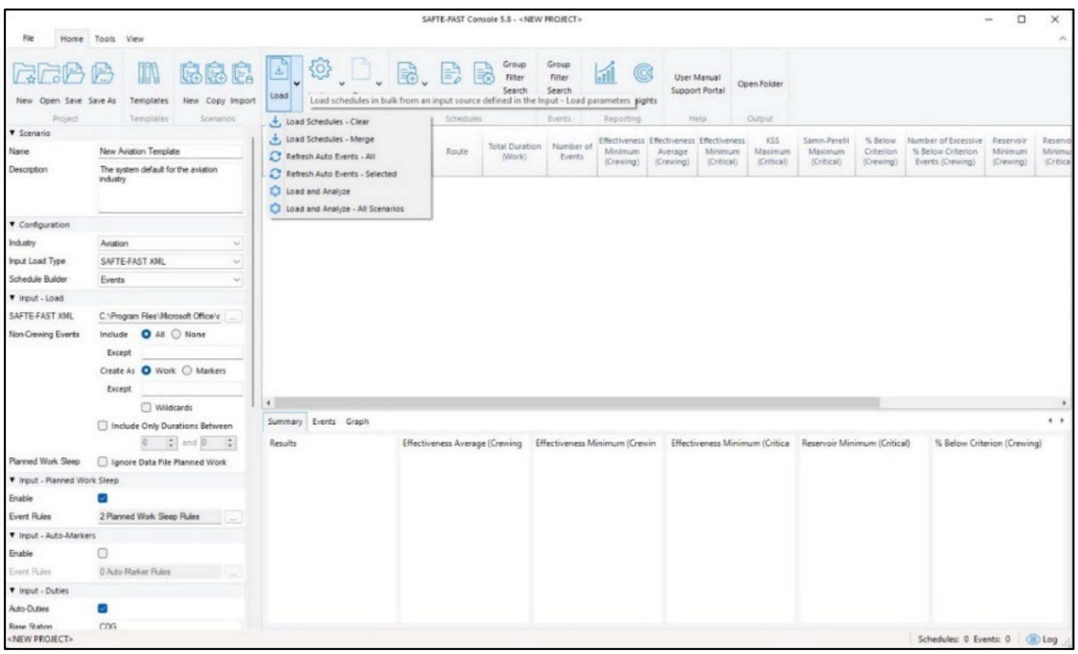
Table 2. An example layout of necessary input data when using SAFTE-FAST for safety investigations. Schedule ID can be any number, name, or code to link work data to incident and/or sleep data. Event ID is a chronological number assigned to a specific event for a given ID. Any available objective or self-report sleep data should be given the Event Type distinction of 'sleep', shown in blue. Schedule data can be given the Event Type distinction of 'crewing', 'non-crewing' or 'work', shown in bold black. Incidents can be given the Event Type distinction of "marker", shown in purple, to indicate the time, date, and duration of an incident in the SAFTE-FAST analysis.

Start Location, End Location, and Time Reference indicate how SAFTE-FAST should interpret the timing of events. If the investigation does not involve travel across time zones, the Start Location and End Location columns can be replaced with a single Location column, with Time Reference set to Local or Base. The Start and End columns should be formatted as numerical dates with 24-hour time. Time Reference can be set to Base, Local, or UTC depending on how the time data in the Start and End columns was collected.

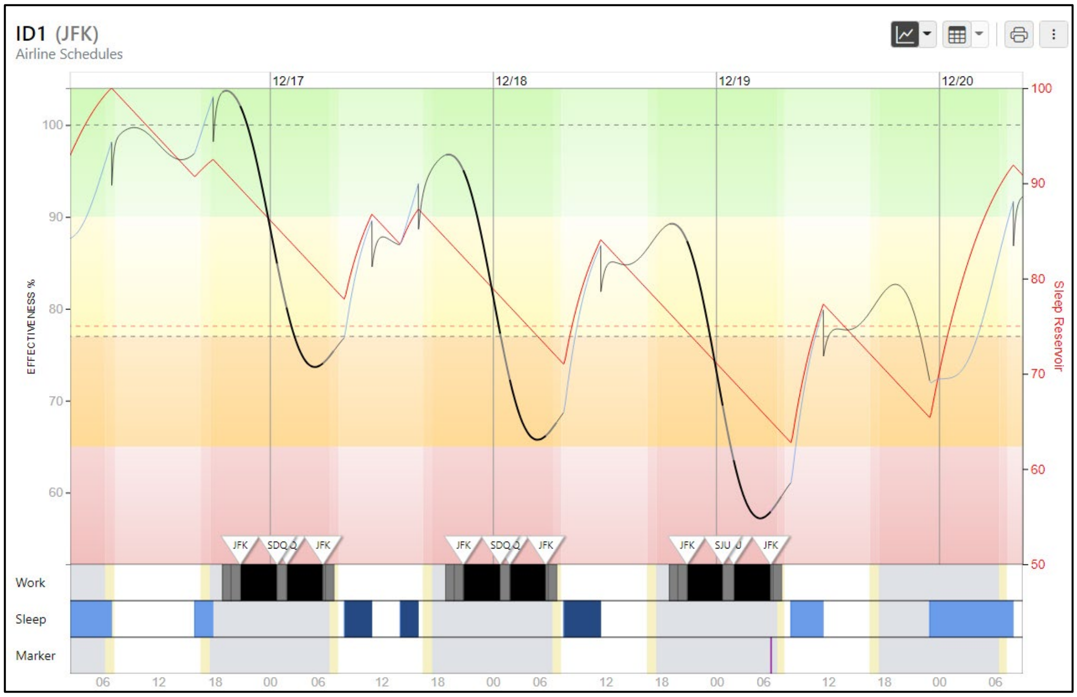
Once the available data has been uploaded into a SAFTE-FAST project file using the most appropriate templates and settings, the investigators can click the Analyze button (Figure 1A). There are two types of data in a SAFTE-FAST project file; Schedule and Event level. Schedule level data is data on the schedule as a whole, while Event level data is data on events that make up the schedule. The Events Table displays Event level data. To view events for a specific schedule, click on it in the Modeling Results Table. A graph will appear in a separate window that depicts performance over time as shown in Figure 1B. The graph will show Effectiveness over the entire schedule by default. The time scale of the graph can be changed using the Zoom bar at the bottom of the graph. The display can be changed to show either a table or both a table and graph using the View function at the top right of the graph. Fatigue factors and performance metrics can also be viewed in the graph dashboard at any point within a schedule by clicking at that point within the graph, as shown in Figure 1C.

Figure 1. SAFTE-FAST Project File and Graph

A.



B.


ID1 (JFK)
Airline Schedules
12/17
12/18
12/19
12/20
EFFECTIVENESS %
Sleep Reservoir
JFK
SDQ
SJU
Work
Sleep
Marker
06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06

C.

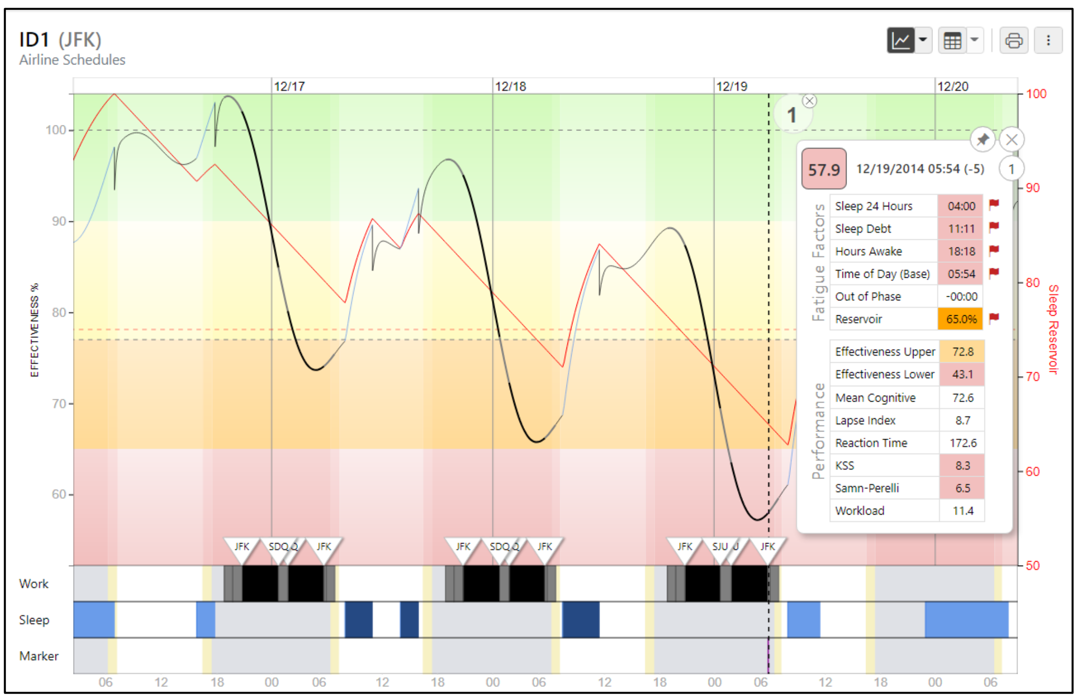

ID1 (JFK)
Airline Schedules
12/17
12/18
12/19
12/20
EFFECTIVENESS %
Sleep Reservoir
57.9
12/19/2014 05:54 (-5)
Fatigue Factors
Sleep 24 Hours 04:00
Sleep Debt 11:11
Hours Awake 18:18
Time of Day (Base) 05:54
Out of Phase -00:00
Reservoir 65.0%
Performance
Effectiveness Upper 72.8
Effectiveness Lower 43.1
Mean Cognitive 72.6
Lapse Index 8.7
Reaction Time 172.6
KSS 8.3
Samn-Perelli 6.5
Workload 11.4
JFK
SDQ
SJU
Work
Sleep
Marker
06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06

Figure 1. A) Project scenarios include templates for aviation, rail, maritime and shiftwork operations. Templates can be adjusted under Configuration (left column panel). Data can be uploaded as XML or CSV files under Input- Load (left column panel). Clicking the Load button (paper with arrow icon) on the top toolbar will load data while the Analyze button (gear icon) will generate Effectiveness scores and fatigue estimations. B) Graph for example ID1 showing effectiveness on the X axis against time on the Y axis. Crewing events are indicated back black bars, objective records of sleep are indicated by dark blue bars, Auto-Sleep is indicated by light blue bars, and the incident event marker is indicated in purple at the bottom of the graph. C) Dashboard with Fatigue Factors and Performance estimation at the time of the incident.

The NTSB considers the five fatigue factors indicated on the dashboard (Sleep in 24 hours; Sleep Debt; Hours Awake; Time of Day; Reservoir) when investigating incidents/accidents (Marcus and Rosekind 2017). If any of the five factors present themselves to be critical outliers, the factor value will appear in red, and a flag will be associated to such factor(s). The Performance factors will also appear color coded for the Effectiveness and Reservoir scores based on the SAFTE-FAST parameter settings being used. Refer to Table 1 for detailed definitions of each performance and fatigue factor. SAFTE-FAST estimations of performance, sleep history, and circadian rhythmicity across work events can be exported as a summary or detailed CSV file using the Output function in the left column panel.

Statistical Testing

Statistical tests are mathematical tools for analyzing quantitative data, or data that can be measured numerically. The purpose of a statistical test is to determine whether there is enough evidence to accept or reject a hypothesis (Parab and Bhalerao 2010). Investigators may want to utilize statistical analysis during a safety investigation to support their hypothesis about whether fatigue was a contributing factor to the incident(s). Statistical testing cannot always be applied during the investigational process, however. Statistics requires multiple data points with numerical data, such as hours worked, prior sleep duration, or time of day. This means that a statistical test cannot determine the significance of fatigue for a single incident or in cases where the data is qualitative, or descriptive, such as may be seen in a written fatigue report or eye-witness testimony. Investigators should always consult with a statistician to determine whether statistical testing is appropriate given the specific circumstances of an incident or series of incidents.

SAFTE-FAST software does not include statistical testing tools. Quantitative data exported from SAFTE-FAST as a CSV file can be imported into statistics software applications in cases where investigators are analyzing data from multiple schedules or incidents. Statistical tests can either be used to determine if there is a difference between groups (for example, schedules during which safety incidents occurred versus schedule with no incidents) or to determine if there is a correlation between variables (for example, if operators' prior sleep history is related to the occurrence of an incident). Statistical tests can be most helpful for investigations if there is a variety of schedule data, not just data from schedules with similar incidents.

Common statistical tests that can support a safety investigation include, but are not limited to: descriptive statistics, power analysis, difference testing, correlations, and odds ratios (Parab and Bhalerao 2010, Lakens 2022). Descriptive statistics summarize the features of a data set in terms of average values and range of values. Descriptive statistics can be used to evaluate the characteristics of the data and can be used for qualitative analysis during an investigation.

Descriptive statistics (means, standard deviation, range, etc.) can be used to determine whether Effectiveness at the time of an incident was more than a standard deviation lower than the average Effectiveness score for the entire schedule. For example, say that the average Effectiveness across an entire schedule was 89% with a standard deviation of +/- 5% and a range of 77% to 101% Effectiveness. Effectiveness was estimated to be 77% at the time of the incident. An Effectiveness score of 77% in isolation may not be considered high fatigue risk, but the Effectiveness is greater than one standard deviation below the average (Lower limit: 89%-5%= 84%). The range indicates that 77% was in fact the lowest predicted Effectiveness score for the schedule. In other words, the operator was expected to be more fatigued at the time of the incident relative to the schedule as a whole. Taking the descriptive statistics into context may provide investigators with additional insight about fatigue risk relative to the operational circumstances.

A power analysis calculates the minimum sample size needed to accurately test for a significant difference. To conduct a power analysis, the investigator will need to determine the desired significance level, expected mean difference, and the effect size. Significance level, sometimes called alpha or the p-vale, describes the likelihood that the findings are due to random chance. A significance level of 0.05 indicates a 5% risk of concluding that a difference exists when there is no actual difference. Mean difference refers to the numerical difference in values between two groups. For example, if investigators suspect that average Effectiveness was 78% during schedules with no incidents but average Effectiveness was 70% during schedules with incidents, the expected mean difference in this case would be 8%. Effect size measures the strength of the relationship between two variables on a numeric scale between 0 to 1, which greater scores indicating greater strength of association (Cohen 1992). Power analysis should be conducted first in order to determine whether there is enough data to appropriately test for statistical differences. If data is ‘underpowered’ (i.e., there is not enough data to confidently support or reject a hypothesis through statistics), then is it not appropriate to conduct a statistical test. Underpowered statistics may result in inaccurate estimations of fatigue risk.

Difference testing refers to statistical tests that compare the average value of a variable between two or more groups. Student’s t-tests or analysis of variance (ANOVA) are two common formulas used to compare averages between groups. A correlational analysis is a statistical measure that expresses the extent to which two variables are positively or negatively related. For example, in SAFTE-FAST, Reservoir is positively correlated with Effectiveness, such that a higher Reservoir value is related to a higher Effectiveness score. Sleep debt is negatively related to Effectiveness such that greater sleep debt is associated with lower Effectiveness. Correlational analysis for safety investigations should not test for associations between SAFTE-FAST output metrics and input data; output metrics have been computed using the input data and are expected to be correlated. SAFTE-FAST metrics can be correlated to information that was not used to generate the project file, such as subjective report of fatigue or monetary value of damage during an incident.

An odds ratio (OR) analysis is a measure of association between a risk variable (e.g., fatigue) and an outcome (e.g., occurrence of an incident). The OR represents the odds that an outcome will occur given a particular exposure compared to the odds of the outcome occurring in the absence of that exposure (Szumilas 2010). OR analysis can be used to compare the risk of an incident occurring between schedules with elevated fatigue risk as estimated by SAFTE-FAST compared to schedules without elevated fatigue risk as an example. An OR greater than 1.0 indicates a greater than average risk of an outcome (e.g., safety incident) occurring based on exposure to a risk variable (e.g., fatigue).

Discussion

Determining the role of fatigue as a contributing factor during a safety investigation is a complex task. SAFTE-FAST can serve to support an investigation by quantifying fatigue risk in relation to schedule data, sleep history and time of day information. It is important to note, however, that the application of any biomathematical model to the identification and analysis of the role of fatigue as a contributing factor to safety incidents should be undertaken with caution. Biomathematical models have been developed using population-level data and may not accurately account for individual characteristics of an operator (citation). Some types of fatigue may not be predictable as a function of sleep opportunities, time of day, or workload. Therefore, it is possible that SAFTE-FAST may not be able to model the true impact of fatigue risk, particularly in instances with a limited amount of input data. Even with the assistance of biomathematical modeling, it is extremely difficult to prove a causal relationship between fatigue and incident occurrence (CASA 2014). Investigators should take care to use all the available information about a safety incident as well as industry-specific and regional guidance on the use of biomathematical models for the analysis for fatigue risk during investigations.

Take Aways

- Consult industry-specific and regional guidelines about the recommended use of biomathematical modeling in safety investigations.
- Model at least three (3) days of work schedule data from before/including the date of the incident(s).
- Analyze the modeling results in a manner that suits your specific investigation. Do not treat fatigue or performance metrics as absolute values but consider them in the context of all available information regarding the circumstances of the incident(s).
- Consult previous investigation reports, fatigue experts or a statistician if necessary.

Be aware that biomathematical models cannot account for individual differences in fatigue or alertness, such as the presence of sleep disorders, use of caffeine or other stimulants, or chronic sleep debt.

Resources

For more information about fatigue estimation using SAFTE-FAST or assistance using SAFTE-FAST to support an investigation, please refer to the SAFTE-FAST user manual, visit https://www.saftefast.com/, or contact info@saftefast.com.

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Appendix A: Aviation Flight Safety Fatigue Report

Name: ______________________ Rank: ________ Date of Birth (MM:DD:YYYY): __________

Home Base: _______________________Today's Date (MM:DD:YYYY): ____________________

1. This form is being prepared in relation to fatigue associated with (mark one):
   - ☐ A reported safety-related event that potentially involved fatigue
   - ☐ A non-reported safety-related event that potentially involved fatigue
   - ☐ A general concern regarding fatigue

2. When did the event or concern occur:

   Date (MM:DD:YYYY): ___________ Time (HH:MM) ____________Time Zone or UTC:

   How long had you been on duty? ________Hours ________Minutes

3. What were you doing at time of event or concern?
   - ☐ In flight
   - ☐ Driving to Work
   - ☐ Driving Home
   - ☐ Positioning
   - ☐ Other: __________________

4. If relevant, on what flight did the event occur?
   - ☐ Flight number:_________________
   - ☐ Route:________________________
   - ☐ Positioning:_______________
   - ☐ Other:___________________

5. Factors that contributed to event or concern (mark all that apply):
   - ☐ Hotel rest issues
   - ☐ Home rest issues
   - ☐ Insufficient scheduled rest time
   - ☐ Roster disruption
   - ☐ Early or late transition
   - ☐ Early duty start time
   - ☐ Late duty end time
   - ☐ Time zone changes
   - ☐ Delays
   - ☐ Positioning
   - ☐ Commute
   - ☐ Disturbed sleep
   - ☐ Insufficient sleep
   - ☐ Early morning (midnight to 6 am) slump in alertness (duty during WOCL)
   - ☐ Long commute
   - ☐ Health or Illness
   - ☐ Long-term fatigue
   - ☐ Home issues
   - ☐ Don't know
   - ☐ Other, specify_____________

6. Physical Signs of fatigue in the two hours prior to the event (mark all that apply):
   - ☐ No physical signs were noted
   - ☐ Fidgeting
   - ☐ Rubbing eyes
   - ☐ Yawning
   - ☐ Frequent blinking
   - ☐ Staring blankly
   - ☐ Long blinks
   - ☐ Difficulty keeping eyes open
   - ☐ Head nodding
   - ☐ Impaired or slurred speech

- ☐ Other, specify________________

7. Cognitive signs of fatigue in the two hours prior to the event (mark all that apply):
   - ☐ No cognitive signs were noted
   - ☐ Increase in slips (minor mistakes)
   - ☐ Impaired flight control or precision
   - ☐ Increase in lapses (zone out, microsleep, failure to respond to stimulus, etc.)
   - ☐ Impaired attention (including missed signals, radio calls, etc.)
   - ☐ Impaired memory or memory lapse
   - ☐ Impaired situational awareness
   - ☐ Negative mood
   - ☐ Reduced motivation
   - ☐ Reduced communication
   - ☐ Impaired problem solving, mental processing
   - ☐ Increased risk taking
   - ☐ Impaired situational awareness
   - ☐ Other, specify:
8. Alertness rating prior to event of concern (mark one only):
   - ☐ Fully alert, wide awake
   - ☐ Very lively, somewhat responsive, but not at peak
   - ☐ OK, somewhat fresh
   - ☐ A little tired, less than fresh
   - ☐ Moderately tired, let down
   - ☐ Extremely tired, very difficult to concentrate
   - ☐ Completely exhausted
9. Day of duty details, report in format - Date: (MM:DD:YYYY) Time: (24 HR HH:MM)

   If you were on reserve status for any part of this day, specify the start and end date/time of reserve status and leave scheduled line blank, if appropriate.

Duty Day of Event	Start Date:	Start Time:	End Date:	End Time:	Time Zone or UTC	Flight Duty Y/N
Scheduled:						
Actual:						
Reserve Duty						Reserve status

   a. At time of event or concern, about how long had you been on duty? HH:MM ______
   b. At time of event or concern, how many segments had you flown? ___________
   c. Approximately how long had you been awake prior to reporting for duty? _______
   d. How many days has it been since you had a day without duty? _________________
   e. Did you commute to this duty location and if yes, how long was the commute and when did you arrive? (Y/N) Duration: HH:MM _______

   Arrival Date (MM:DD:YYYY): ____________Time (24 HR HH:MM): _______________

10. Augmented Crews:
    a. During this duty, did you operate as an augmented crew? (Y/N) ____________
    b. What classification of onboard rest facility was used? (Class 1, 2, or 3):____________
    a. What was the quality of your rest (Excellent, Good, Fair, or Poor) and how long was sleep? Rating: ____________________ Duration (HH:MM): __________________

11. Prior duties, SAME FORMAT AS ABOVE: Report all duty time and indicate flight duty Y/N.

Prior Duty	Start Date:	Start Time:	End Date:	End Time:	Time Zone or UTC	Flight Duty Y/N
1st prior:						
2nd prior:						

12. Do you normally operate through the nighttime hours (Between 0200 and 0600 local)? (Y/N)______

13. Sleep information related to event or concern (approximate), *excluding in-flight rest*:

Sleep Events	Start Date:	Start Time:	End Date:	End Time:	Time Zone or UTC	Domicile or Hotel (D/H)	Environment (Excellent, Good, Fair, Poor)
Day of event:							
Major Sleep							
Nap (if any)							
1 day prior:							
Major Sleep							
Nap (if any)							
2 day prior:							
Major Sleep							

a. On average, how many total hours of sleep do you try to get per day on a duty day?
b. On average, how many total hours of sleep do you try to get per day on a non-day day?
c. Define the sleep quality of your environment, Excellent – no sleep interruptions, Good – two 5-minute sleep interruptions per hour, Fair – four 5-minute sleep interruptions per hour, Poor – six 5-minute sleep interruptions per hour

14. Other pertinent information – report any conditions that contributed to your report of fatigue or information that clarifies the situation (add pages if necessary):