The Boeing Alertness Model

Technical Fact Sheet.

Scientific Basis

The Boeing Alertness Model is based on research published by Simon Folkard and Torbjörn Åkerstedt on the Three Process Model of Alertness – also known as the Sleep Wake Predictor.

Most relevant references include:

Åkerstedt, T., Axelsson, J. and Kecklund, G. *Individual validation of model predictions of sleepiness and sleep hours.* Somnologie, 2007, 11:169-74.

Åkerstedt, T., Ingre, M., Kecklund, G., Folkard, S. and Axelsson, J. *Accounting for partial sleep deprivation and cumulative sleepiness in the three-process model of alertness regulation.* Chronobiol. Int., 2008b, 25: 309-19

Åkerstedt, T., Connor, J., Gray, A. and Kecklund, G. *Predicting road crashes from a mathematical model of alertness regulation – The Sleep/Wake Predictor.* Accid. Analys. Prevent., 2008a, 40: 1480-5.

Åkerstedt, T., Folkard, S., & Portin, C. (2004). *Predictions from the three-process model of alertness.* Aviation, Space and Environmental Medicine, 75, A75-A83.

Folkard, S. and Åkerstedt, T. *A three process model of the regulation of alertness and sleepiness.* In: R. Ogilvie and R. Broughton (Eds), Sleep, Arousal and Performance: Problems and Promises. Birkhäuser, Boston, 1991: 11-26.

Axelsson, J., Kecklund, G., Åkerstedt, T., Donofrio, P., Lekander, M., & Ingre, M. (2008). *Sleepiness and performance in response to repeated sleep restriction and subsequent recovery during semi-laboratory conditions.* Chronobiology Int., 25(2), 297-308.

Ingre, M., Van Leeuwen, W., Klemets, T., Ullvetter, C., Hough, S., Kecklund, G., Karlsson, D., & Åkerstedt, T. (2014). *Validating and Extending the Three Process Model of Alertness in Airline Operations.* PLOS, DOI: 10.1371/journal.pone.0108679.

BAM Prediction Capability

Output	Sleepiness mapped to the Common Alertness Scale[1] ranging from 0 to 10,000.
Output mode	Continuous predictions + discrete mode per flight for optimization.
Sleep prediction	Open – fully visible start/end.
Individu-alization	Configurable diurnal type and habitual sleep length per chain.
Improvment method	Closed loop improvement from collected data. Self-tuning algorithm.

Applicability

Transfer time	BAM respects configurable transfer times allowing for modeling of commuting and variation in hotel locations.
Initial state pairing[2]	A start-state is customizable to ensure best rosterability.
Augmentation	Up to three in-flight rests.
Acclimatization	Time zone driven.
Sleep adjustment	Configurable to enable airline specific strategy – both in-flight and in turn-arounds.
Performance[3]	>250,000 flight predictions/ second, scaling further via multi-core execution.
Interface	Complies fully with proposed industry technology standard CAPI 2.0 for performance, connectivity & interchangeability.
Deployment	Available stand-alone as well as through CrewAlert (iOS), Concert (web service), and integrated in the Jeppesen Crew Management solutions.

Support and Training

Support	BAM is supported for mission-critical applications out of Denver, Gothenburg and Singapore. SLA is available on two levels: office hours or 24/7. Systematic regression testing and service pack process for new releases.
Architectures	RHEL4 and above (64bit), Windows, Solaris, HP-UX, and iOS
Training	Training courses are offered in Denver, Montreal, Gothenburg and Singapore.

Sales/Contact

BAM is sold and supported worldwide by Jeppesen. For more information please visit www.jeppesen.com/frm or contact us through frm@jeppesen.com.

1) A Boeing/Jeppesen proposed common scale for all fatigue models.
2) Pairing construction requires control over assumptions for the final roster context.
3) Single core performance measured on P9400 2.53GHz with chains averaging 70 legs.

Fatigue Model Comparison Matrix

Complements the CASA Guidance Document.

The CASA Biomathematical Fatigue Models Guidance Document (pdf) is an excellent start when selecting a fatigue model meant to add the predictive/proactive part of a Fatigue Risk Management System, but it leaves out a number of aspects critical for real-world application to crew management processes.

The Fatigue Model Comparison Matrix (pdf) complements the CASA document by addressing a number of additional aspects relevant to take into account.

For more information please contact us through frm@jeppesen.com.

Fatigue Model Comparison Matrix

V1.0 Dec 2014

This comparison matrix complements the CASA Biomathematical Fatigue Models Guidance Document, by addressing a number of additional aspects relevant to take into account when selecting a fatigue model meant to add the predictive/proactive part of a Fatigue Risk Management System. The CASA document is an excellent start, but leaves out a number of aspects critical for real-world application to crew management processes. For feedback or further questions on this document please contact the authors over email frm@jeppesen.com.

Model Aspect	BAM	Model X
1. Validity / credibility		
- Peer-reviewed validation *Has the validation of the science in the model passed the quality assurance process (called peer-review) with other scientists scrutinizing both the method used as well as the results?*	Yes	
- Publication in well-renowned journal *Is the validation published in an international, scientific journal with good reputation (a receipt of peer-review being first class)?*	Yes	
- Validation on mixed-operation aviation data *Is the data used for validation specific to just one type of operation or a reasonably big cross section of operational conditions (in aviation)?*	Yes	
- Number of observations in the validation *What is the size of the validation data set?*	>8,000	
- Measurement of accuracy *Is the model accuracy measured to individual observations (or is the model just delivering an average, with unknown precision)?*	Yes	
- Openly published data set *Is the dataset used for validation openly published (of integrity reasons most certainly in de-identified form)?*	Yes	
- Openly published model (equations etc.) *Is the model openly published in its entirety with all equations, constants and mechanisms? Meaning; together with openly published data and validation methodology that anyone, with adequate competency, is able to scrutinize the model validation?*	Yes	
- Output of operational relevance *Is the model output something that can be directly compared to operational experience (like sleepiness) opposed to a more abstract property like "risk index" or "effectiveness" that cannot be observed (at least not easily)?*	Yes	
- Vendor-offered specific validation *Is the model vendor offering to measure and compare operational relevance of the model specifically for your operation?*	Yes. For free, subject certain conditions.	
2 Applicability		
2.1 Feature set		
- Continuous prediction *A prediction of model output at any point in time (also between duties) over a roster or trip.*	Yes	
- Open prediction of sleep/wake *Clearly stated timings for sleep onset and wake-up (to be compared with operational experience) for check of realism.*	Yes	
- Ability to predict also pairings (definable start-state) *Customization of the assumption for typical roster context of a pairing, as a function of the pairing itself. (A one-day pairing might typically end up with production prior vs. a long pairing have days off prior.)*	Yes	
- Per-chain control of habitual sleep length *Can habitual sleep length be set differently for each roster if needed?*	Yes	
- Per chain control of diurnal type *Can diurnal type be set differently for each roster if needed?*	Yes	
- Customizable prediction point *When representing holistic risk; can the prediction representing risk for an individual flight be customized to TOD, arrival, lowest point etc. to the wish of the airline?*	Yes	
- Acclimatization *Is acclimatization built-in and what is driving the gradual adaptation to local time?*	Yes. TZ-driven	
- Customization of tactical sleep patterns *Can typical sleep patterns in a certain turn-around be customized to operational experience if there is a disagreement with model prediction of sleep?*	Yes	
- Detailed control of transfer times *Use actual transport times (if available) to precisely model time between duty and sleep opportunity; for example making difference between airport hotel and downtown hotel.*	Yes	
- In-flight rest facility classification *Modelling of Class I, II, III rest facilities and corresponding recovery proration.*	EASA, FAA + net method	
- Max number of inflight sleep periods *Ability to model different in-flight sleep dispositions (once, twice etc. but also placement.)*	Yes, up to three per flight.	
- Mitigation strategies built-in *Is the model capable of proposing suitable fatigue mitigation strategies for a certain situation, taking prior sleep/wake, individual settings and work history into account?*	Yes	
- Local light conditions built-in *Can the model output also local light conditions for fast investigation of sleep prediction realism?*	Yes	
- X-percentile capability. *Is the model able of not only answering back with the average prediction, but also for a certain percentile (e.g. "what is the alertness level for the 90-percentile of crew?""*	Yes	
2.2 Connectivity		
- Loose integration over web-service *Is the model easily accessible also via a web-service "bolting on" to an existing solution for crew management requiring only a simple file transfer?*	Yes	
- Implementation time *What is the approximate implementation time needed in an existing solution (for a skilled programmer) to produce the file formats needed for the web service in case the current format is not already supported?*	2-4 days	

(Extract from the Fatigue Model Comparison Index. Download the pdf document here)

V2.3

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