

Biomathematical MOdelling

Practical Approaches



Martin Hughes



PROFESSIONAL EXPERIENCE:

- Seventeen years' experience in Aviation, including Cabin Crew fleeted across A320/1, A330, A300, B757. Crewing Officer & FRMS at easyJet Since 2011.
- BA in Airline & Airport Management from Buckinghamshire New University.
- Presently: easyJet FRMS Analysis & Development Manager; Department of Safety, Security & Compliance.
- Focus area: Fatigue Reporting, Biomathematical Modelling, Fatigue Research and Artificial Intelligence.

OTHER INFORMATION

easyJet Research Lead during 2013, 2015, 2018 studies.

Developer of easyJet Bespoke Biomathematical Model (FRAM).

Lead Co-Investigator on NASA Alertness & Performance Research



THE Biomathematical Toolbox

> Multiple models can give you different information based on their strengths and weaknesses.

Model A

Strengths

- Long Haul
- Circadian Rhythm
- Flight Crew

Weakness

- Short Haul
- Sleep Periods
- Workload

Model B

Strengths

- Workload

Weakness

- Sleep Quality

Model C

Strengths

- Sleep Quantity
- Sleep Quality
- General Shift work

Weakness

- Workload
- Circadian alignment



Is one enough?

> Short Answer : No.

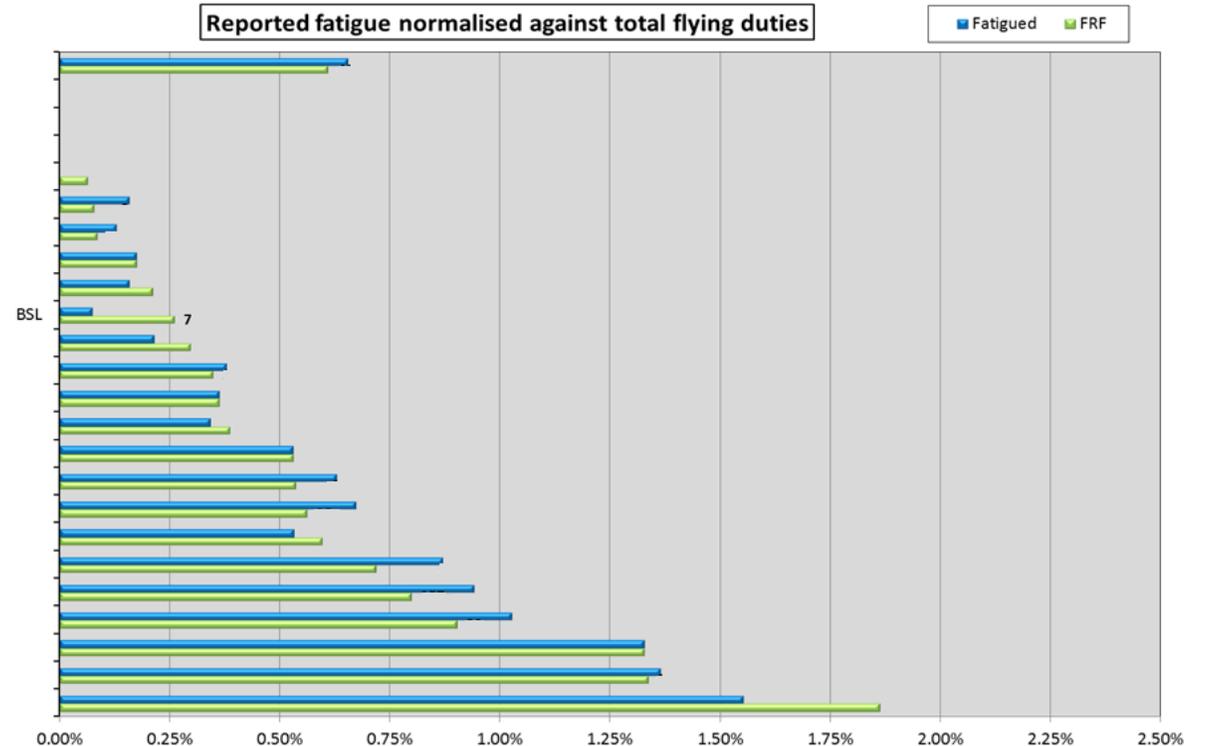
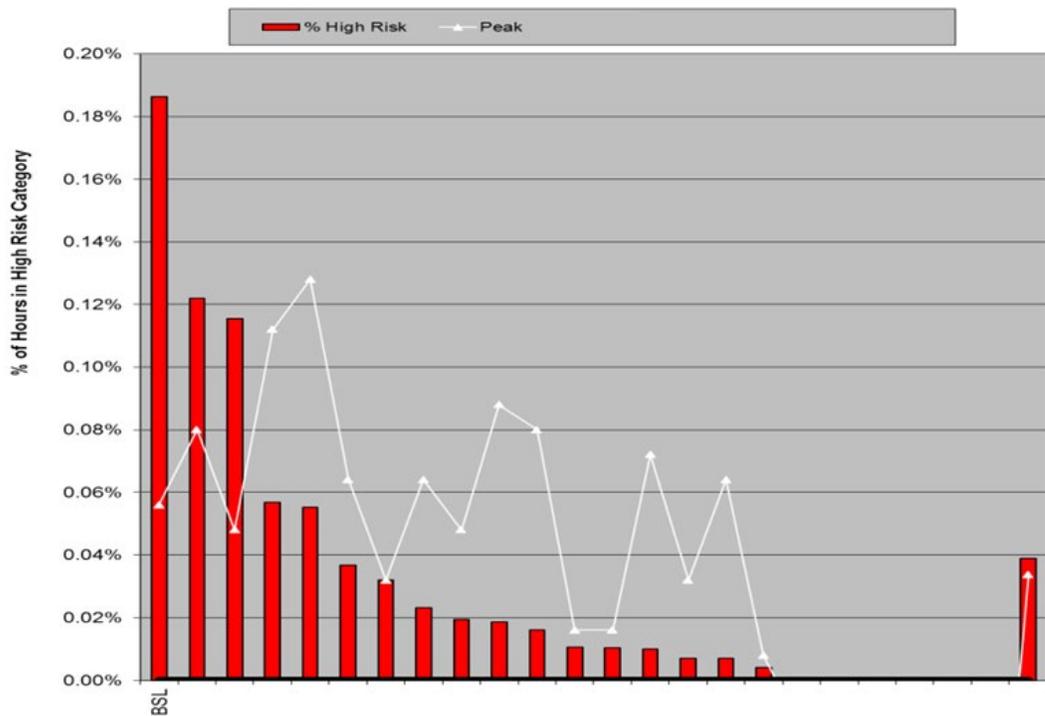
> Depending on:

- FRMS Maturity
- Schedule
- Operational Limitations
- Decision Making Capacity
- SME Resource
- Research Plans
- Operational Capability



Science Fact or Science Fiction

- > Data does not always match the science.
- > Generic Data can challenge practical application



- > Bespoke biomathematical modelling can help solve this.



Bespoke Challenges?

> Data

- Research
- Reporting
- Realism

> People

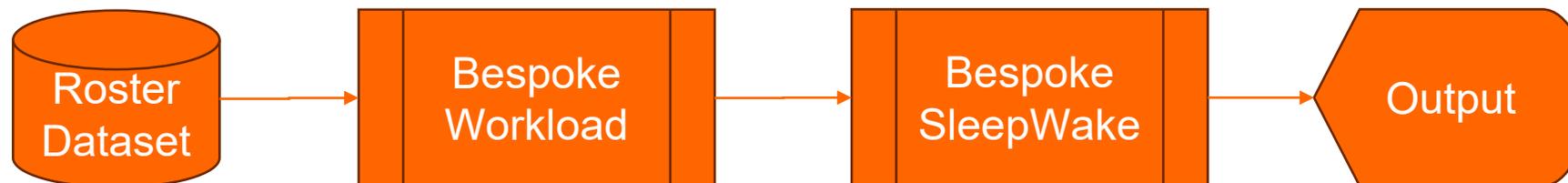
- Subject Matter Experts
- Computer Modellers
- Independent Support

> Technology

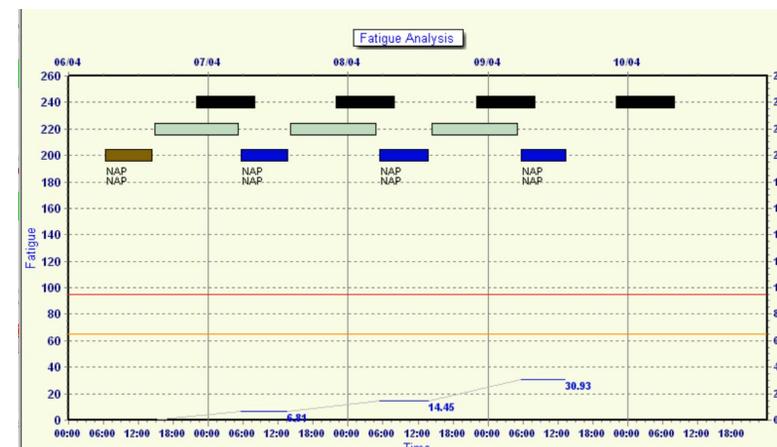
- Artificial Intelligence
- Analytical Tools
- Modelling Platforms



Building Bespoke



Flight	DEP	ARR	STD	STA	Dep Date	Trip Day	(E)stim/(A)ctual	Tail #	AC	Block Hours	FDP Begin	FDP End	Acclim FDP Begin	Acclim FDP End	allowable FDP	Duty Begin	Duty End
EJU4107	NAP	CTA	0635	0740	Fri107Apr	1	A0635 A0733	OE-INO	320	0:58	5:35	5:35				5:35	
EJU4108	CTA	NAP	0815	0920			A0816 A0932	OE-INO	320	1:16							
EJU4129	NAP	CTA	1015	1120			A1017 A1115	OE-INO	320	0:58							
EJU4130	CTA	NAP	1155	1300			A1158 A1307	OE-INO	320	1:09	13:07	13:07					13:37
15:48 Rest										4:21 NAP B 7:32		9:00		8:02			
EJU4131	NAP	MXF	0625	0755	Sat08Apr	2	A0620 A0746	OE-IVH	319	1:26	5:25	5:25				5:25	
EJU4132	MXF	NAP	0825	0950			A0832 A0959	OE-LQI	319	1:27							
EJU4255	NAP	DBV	1025	1125			A1037 A1135	OE-LQI	319	0:58							
EJU4256	DBV	NAP	1205	1300			A1206 A1324	OE-LQI	319	1:18	13:24	13:24					13:54
15:46 Rest										5:09 NAP B 7:59		9:00		8:29			
EJU4263	NAP	MLA	0640	0755	Sun09Apr	3	A0633 A0747	OE-LQI	319	1:14	5:40	5:40				5:40	
EJU4264	MLA	NAP	0835	0950			A0824 A0931	OE-LQI	319	1:07							
EJU4129	NAP	CTA	1025	1130			A1015 A1119	OE-LQI	319	1:04							
EJU4130	CTA	NAP	1205	1310			A1155 A1255	OE-LQI	319	1:00	12:55	12:55					13:25
FTGD	NAP				Mon10Apr	4											
D/O	NAP				Tue11Apr	5											
										4:25 NAP B 7:15		9:00		7:45			



Red Line / Orange Line Upper / Lower limits for fatigue assessments



Workload model

Night Contribution

- Day In Block
- Duty Period End Time (Local)
- Night Finish

Simple Transition Contribution

- Duty Period Start Time (Local)
- Duty Period End Time (Local)
- Morning Start
- Evening Finish

Backward Circadian Contribution

- Day In Block
- Duty Period Start Time (Local)
- Morning Start
- Night Finish

Duty Length Contribution

- Day In Block
- Duties In Block
- Duty Period Length
- Morning Start
- Elongated Duty Period
- Consecutive Elongated Duty

Complex Transition Contribution

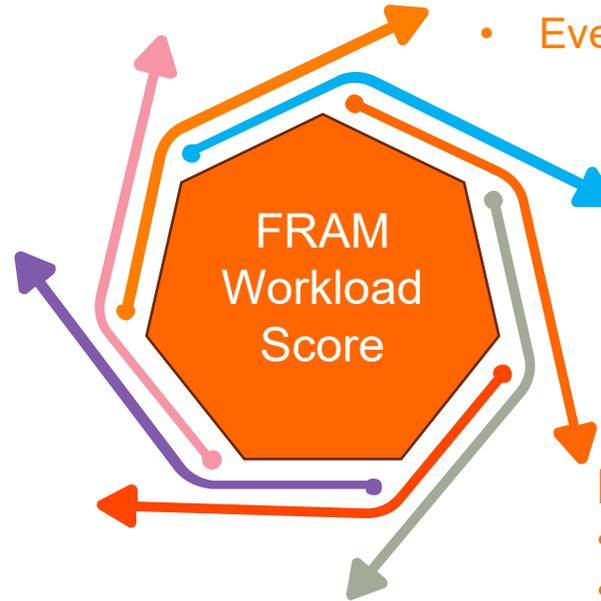
- Day In Block
- Duty Period End Time (Local)
- Morning Start
- Night Finish

Sector Contribution

- Day In Block
- Sector Count
- High Sector Duty Period
- Consecutive High Sector Duty

Rest Contribution

- Day In Block
- Duties In Block
- Duty Period Length
- Duty Period Start Time (Local)
- Duty Period End Time (Local)
- Duty Period Home Standby
- Sector Count



Sleepwake model

Cumulative Effects

- Day In Block
- Duties In Block
- Sleep Deprivation When Operating
- Alertness Changes When Operating

Sleep Deprivation When Operating

- Duty Period Start Time (Local)
- Duty Period End Time (Local)
- Optimal Sleep Duration (8h)

Alertness Changes When Operating

- Duty Period Start Time (Local)
- Duty Period End Time (Local)

Alertness Level Before/After Duty

- Duty Period Start Time (Local)
- Duty Period End Time (Local)

Sleep & Wake Times Prediction

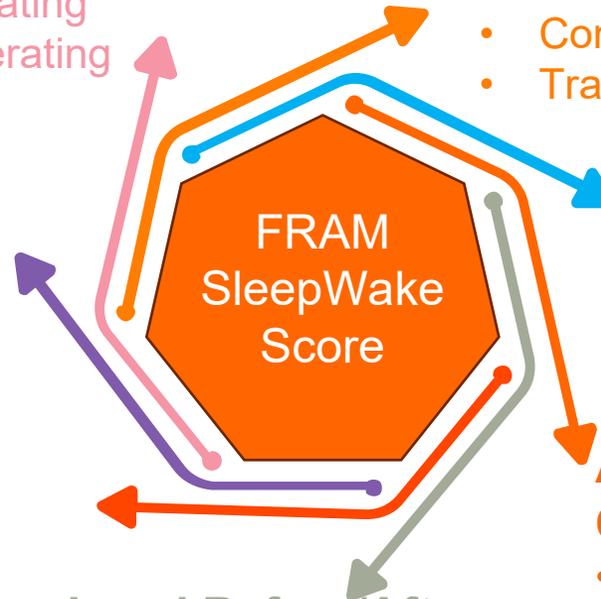
- Duty Period Start Time (Local)
- Duty Period End Time (Local)
- Duty Period Standby / Contactable
- Commute Time
- Transitions

Alertness Evaluation

- Duties In Block
- Duty Period Start Time (Local)
- Duty Period End Time (Local)
- Homeostasis Component (Steady State of Body)
- Circadian Component (Over 24h)

Alertness Deviation On Sleep When Operating

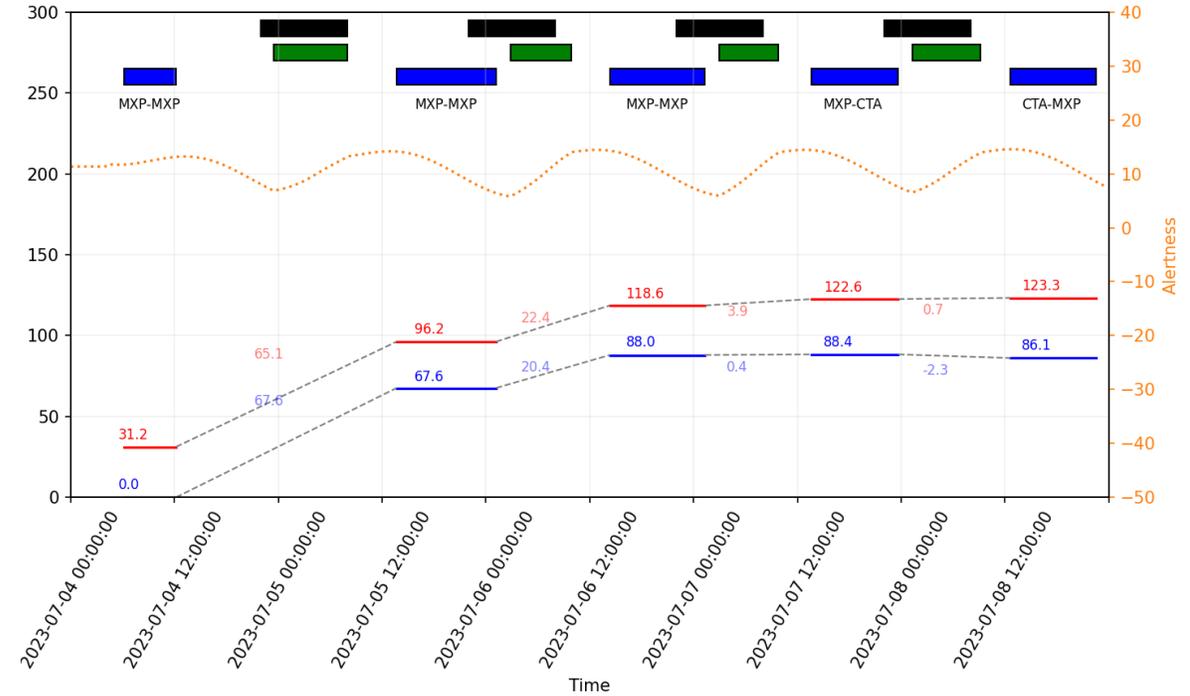
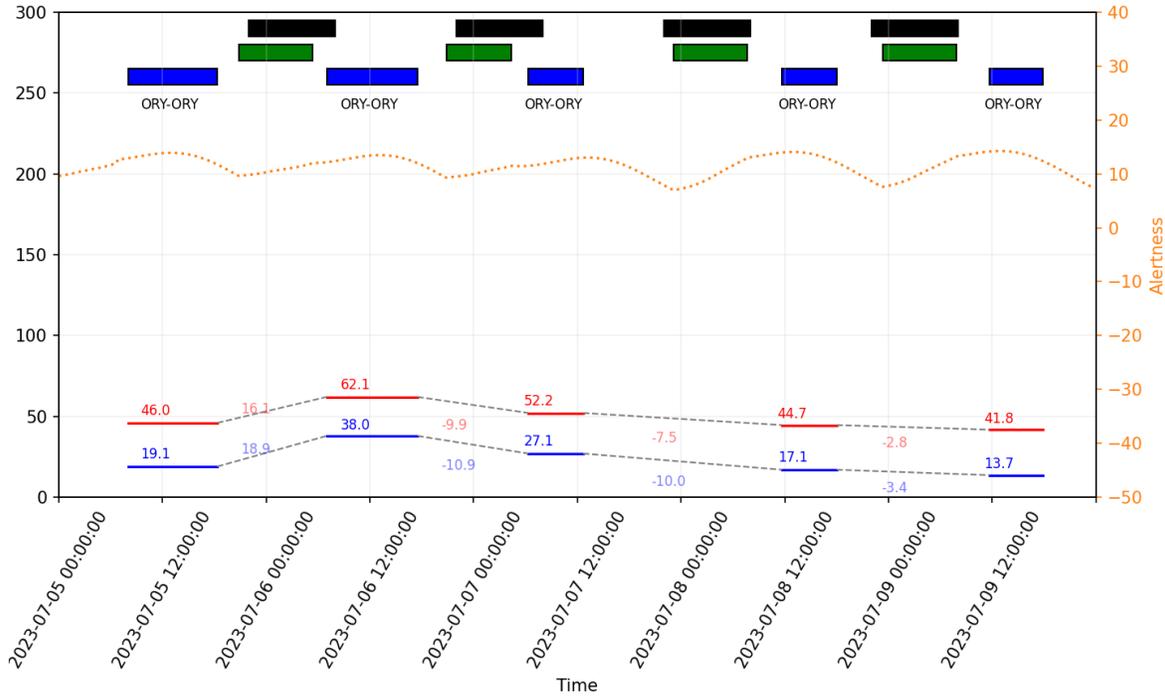
- Duty Period Start Time (Local)
- Duty Period End Time (Local)
- Predicted Sleep Times (Local)



Model Assessments

StartDate	StartTime	StartLocation	EndDate	EndTime	EndLocation	SectorCount
2023-07-05	08:00:00	ORY	2023-07-05	18:16:00	ORY	4
2023-07-06	07:00:00	ORY	2023-07-06	17:27:00	ORY	4
2023-07-07	06:20:00	ORY	2023-07-07	12:34:00	ORY	2
2023-07-08	11:35:00	ORY	2023-07-08	17:59:00	ORY	2
2023-07-09	11:35:00	ORY	2023-07-09	17:41:00	ORY	2

StartDate	StartTime	StartLocation	EndDate	EndTime	EndLocation	SectorCount
2023-07-04	06:05:00	MXP	2023-07-04	12:04:00	MXP	2
2023-07-05	13:35:00	MXP	2023-07-06	01:05:00	MXP	4
2023-07-06	14:15:00	MXP	2023-07-07	01:15:00	MXP	4
2023-07-07	13:35:00	MXP	2023-07-07	23:40:00	CTA	3
2023-07-08	12:35:00	CTA	2023-07-08	22:24:00	MXP	3



The Future

- > Applying biomathematical modelling principles across all human factor data sets.
- > Development of Generative Artificial Intelligence for fatigue research analysis and reporting.
- > Creation of neural network using information from internal data structures.
- > Learning from physics to determine applicability across different structural components in the sleep phase and workload balance.
- > Utilising internal research to further hone differences between generic modelling and
- > Adaptable biomathematical modelling for individualised factors. (Commute, Chronotype, Psychosocial Issues, Resilience).



Thank You & Any Questions

