Preparing rail industry guidance on bio-mathematical fatigue models

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Viravanh SOMVANG
Philippe CABON

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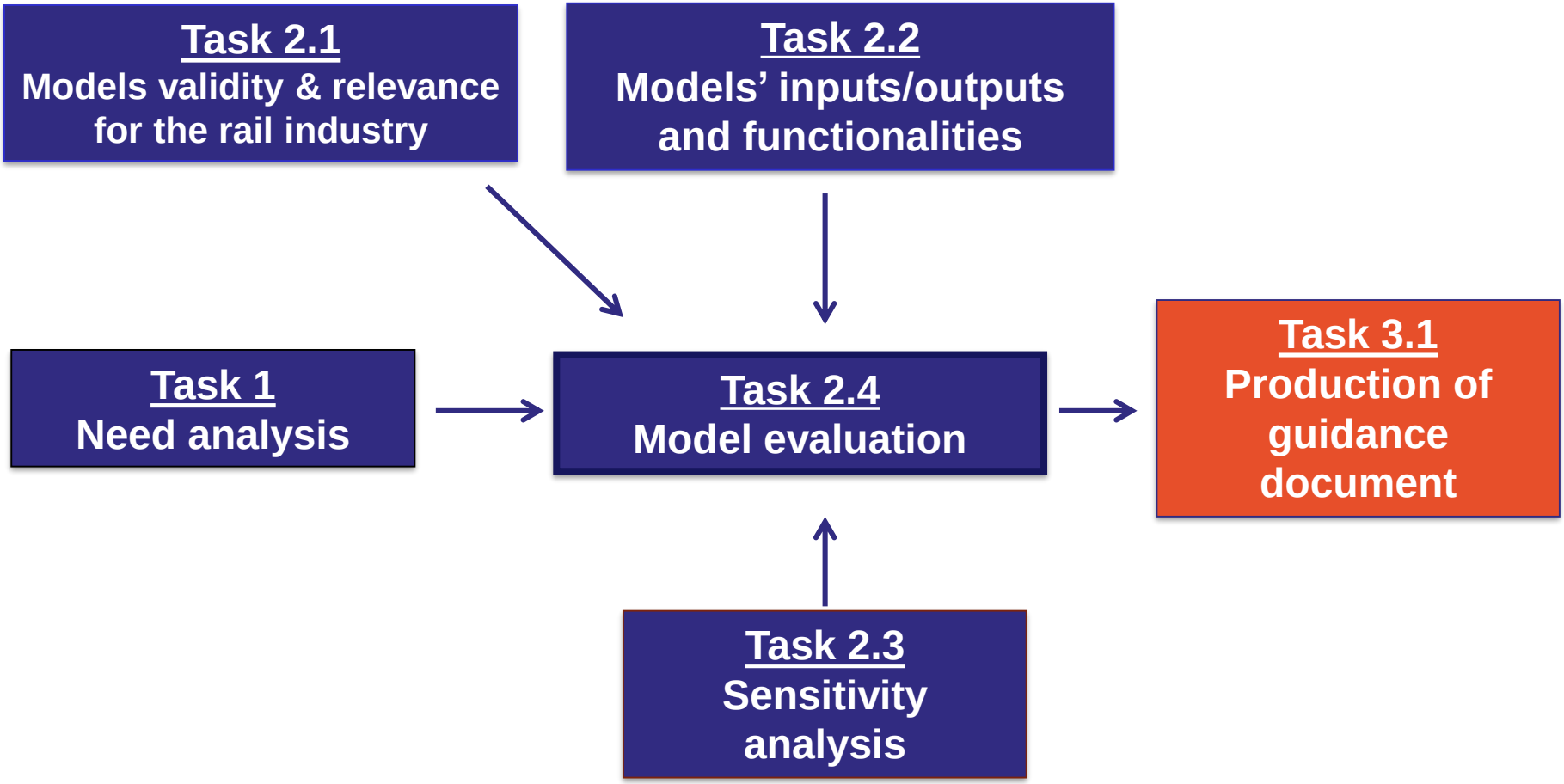
Scope & Objectives

- Update the **CASA report** for the GB rail industry
- Provide **rail industry guidance** on bio-mathematical fatigue models
  - Determine **how the models compare** in their assessment of fatigue from different roster patterns
  - **Raise awareness** of potential users on model usage and their limitations

Project overview – T1083



Selected biomathematical models

- **Five biomathematical models** have been selected for the study :
  - The Circadian Alertness Simulator (**CAS**);
  - The Fatigue Assessment Tool by InterDynamics (**FAID**);
  - The Fatigue and Risk Index (**FRI**);
  - The Sleep, Activity and Task Effectiveness Model and associated Fatigue Avoidance Scheduling Tool (**SAFTE-FAST**);
  - The Sleep Wake Predictor (**SWP**).

Methodology

Four analyses carried out

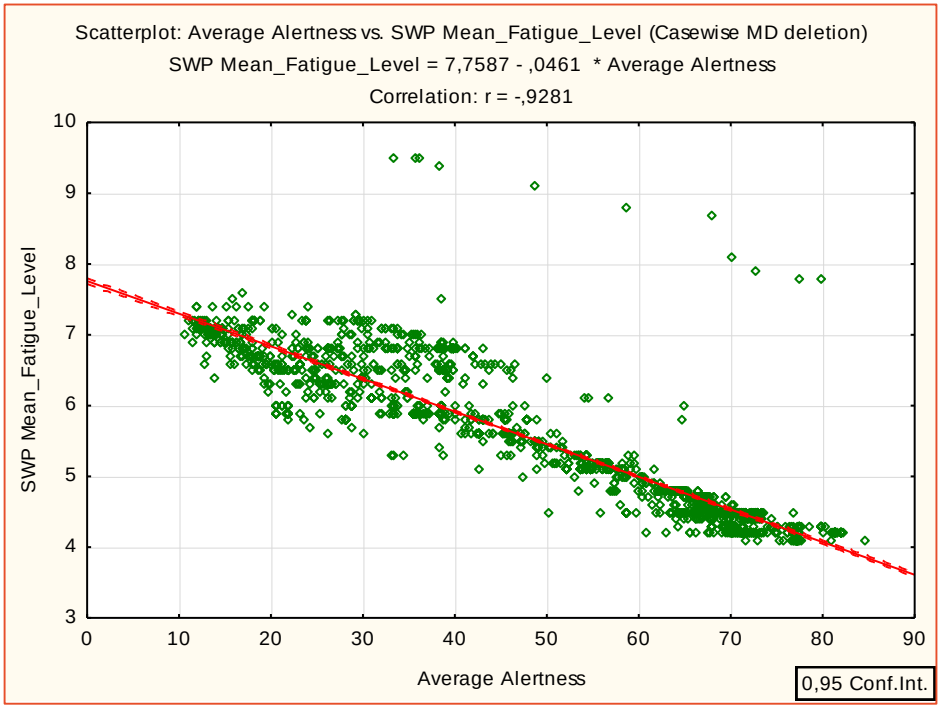
1) General correlation between the fatigue models
2) Analysis on fatigue factors
3) Individual parameters variations
4) Default thresholds

Data sample

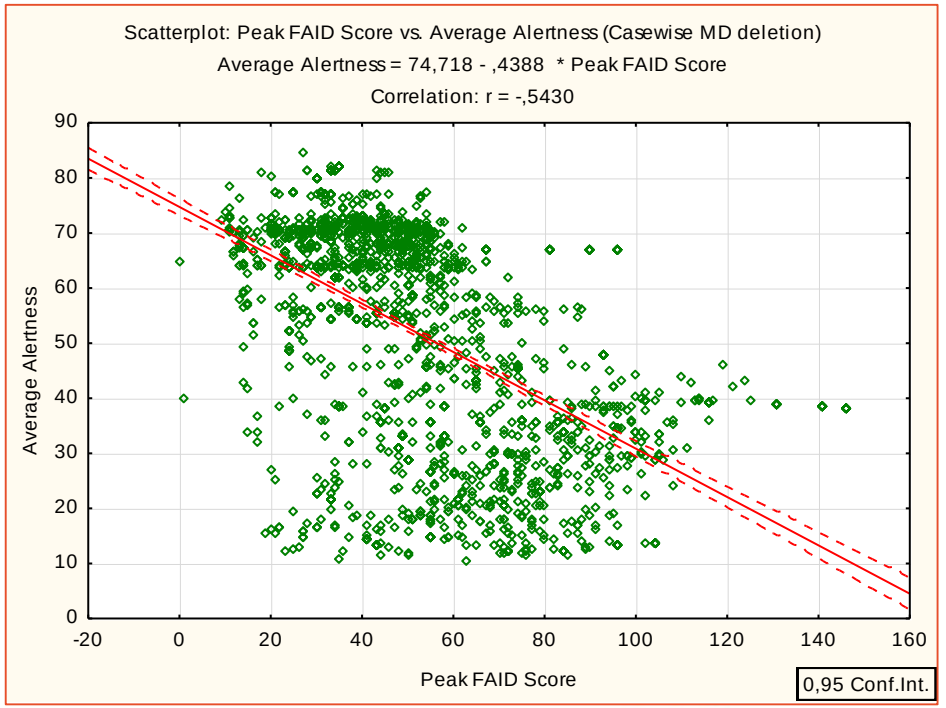
- 45 rosters from 8 different rail companies
- At least over a period of three months

1) General correlation between the models

- **Correlation analysis** on global behaviours of the five models (N=2568)
- All models tend to **evaluate fatigue in the same way**, **except for FAID and FRI** which seem to evaluate fatigue slightly differently.



CAS vs SWP (r=-.93)



CAS vs FAID (r=-.54)

2. Analysis on fatigue factors

Objective

Analyze the sensitivity of the fatigue models **against specific fatigue factors**

6 categories of fatigue factors

- Time of day
- Duty length
- Recovery time
- Rest time between consecutive duties
- Cumulative fatigue
- Circadian phase shift

2. Analysis of fatigue factors

- **Correlation analysis between the models on the fatigue factors**
  - **High** correlation between **FRI and FAID** (r=.81)
  - Low correlations between the other models: SAFTE-FAST, SWP and CAS.

FAID vs FRI

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2. Analysis of fatigue factors

	CAS	FAID	Fatigue Index (FRI)	SAFTE-FAST	SWP
Time of day	✓		✓	✓	✓
Duty Length			✓		
Recovery time		✓	✓		
Daily rest interval		✓	✓	✓	
Cumulative fatigue		✓			
Circadian phase shift					✓

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3. Individual Parameters Variations

Objective

Analyse the sensitivity of the fatigue models regarding **variations of individual parameters**

- **Three individual parameters**
  - Habitual sleep need
  - Commute time
  - Chronotype
- **Depending on the settings**, the model output may **vary greatly**
  - **SAFTE-FAST:** good sensitivity to **chronotype** compared to other models
  - **FRI:** good sensitivity to **commute time** compared to other models

4. Threshold analysis

- **Objective**

Compare the **default threshold** used by each model.

- Overall, **very few fatigue factors were actually detected** by the models based on their default thresholds.

- **Percentage of agreement on critical duties** between the fatigue models

	1 model	2 models	3 models	4 models
% of shifts where the models agree	54.3%	24.4%	15.2%	6.1%

Only 6.1% of "critical" duties are detected as critical by all four models

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Conclusion

- Overall, the five biomathematical fatigue models are **not sensitive to the same types of fatigue factors**
- The sensitivity of the models against **individual settings differs from one model to another.**
- The default thresholds provide **very variable results** depending on the models.
- No model clearly **stands out as the overall best or worst**.
- Development of **rail industry guidelines** on the use of biomathematical models based on the results of the research
- Guidance document and research report (**T1083**) available for download on : http://www.sparkrail.org

Contact

Viravanh Somvang
+33 (0)6 23 20 12 71

Philippe Cabon
+33 (0)6 20 34 73 08

207 rue de Bercy
75012 Paris
FRANCE

welbees.com

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