

About FRI^{PRO}

To understand FRI^{PRO}, we must begin with Fatigue Risk Index (FRI). Lets explore the FRI range of models.

What is Fatigue Risk Index(FRI)?

Fatigue models consider sleep disturbance and mental workload, although some just consider sleep disturbance and so should be avoided for occupations that require significant mental workload and job attention.

The development of the HSE Fatigue Index (FI) arose from the requirement to assess the risks from fatigue associated with rotating shift patterns and the requirement to provide guidance in support of the Railway (Safety Critical Work) Regulations. The output of this research was a report in 1999 that described the research with some basic calculations that managers of shift workers could make to identify the levels of alertness within their workforce.

The programme was developed further by incorporating the calculations into a spreadsheet, which was not ideal as the calculations were designed for manual operation.

In 2006, after the FI had been in use for some time, HSE approached the original research team, now in QinetiQ (formerly DERA), and requested further developments to the research base, including the addition of a calculation for likely risk and for the calculations to be incorporated into a spreadsheet for hosting on their website.

Since the development of the original version in 1999, the FI had been widely used by the rail sector and was increasingly being used in other areas, e.g., by the police and by the nuclear and chemical industries. However, by 2006, several issues had arisen associated with its use, and various shortcomings had been identified. This created the motivation to revise the index.

At that time, it was recognised that a considerable quantity of new information on fatigue and risk had become available since the previous version was constructed. Moreover, the timing of the revised Index also coincided with the new Railway and Other Guided Transport Systems (Safety) Regulations (ROGS) 2006. Consequently, the new Index was intended to be used in the update of guidance to accompany these regulations.

Specifically, the aims of the 2006 project were to:

- review current users of the FI spreadsheet to identify problems and uncertainties that must be addressed;
- bring the Index up to date in terms of the published literature on fatigue and risk;
- update the spreadsheet on which the index is presented, together with the accompanying user instructions;
- investigate the feasibility of developing a second index designed to assess patterns involving a high proportion of night working, especially permanent night working.

Fatigue Index (FI) and FRI

HSE had developed a method for assessing the risk arising from fatigue associated with work patterns for safety critical workers. The methodology involved the calculation of a 'Fatigue Index', and it was intended that the index could be used to provide an assessment of changes in work patterns and to determine whether any particular aspect of the work pattern was likely to increase levels of fatigue.

This initial Fatigue Index included six factors associated with the development of fatigue, namely: the length of the shift, the interval between shifts, the number of rest days, the quality of the rest breaks, the variability of the shifts, and the time of day. Each of the six factors was scored independently, and the composite score was used to provide an overall index of fatigue.

The HSE commissioned QinetiQ (then known as the Defence Evaluation and Research Agency) to carry out an assessment of this initial version of the Fatigue Index to identify its strengths and weaknesses. It was concluded that, whilst it contained many of the important factors which relate to fatigue, the method of calculation was in many cases difficult to apply, and the individual factors did not always reflect current knowledge concerning the development of fatigue. Subsequently, based on information from various studies of shift workers, the FI was revised. The revised version retained five of the original six factors (time of day, shift duration, rest periods, breaks, and cumulative fatigue), the scores from each of which were summed to provide an overall index for the pattern of work. One feature of the index was that, like its predecessor, it was designed for manual calculation. This inevitably restricted the extent to which it was able to represent the full complexity of the issues related to fatigue.

Subsequently, further work was commissioned after additional studies of shift workers to update the FI model and convert the index into a spreadsheet format. The use of a spreadsheet permitted more complex calculations which could therefore reflect the interaction between the various factors influencing fatigue more accurately. This version has been used widely throughout British industry to assess and compare patterns of working.

The further development reflected trends in risk related to shift work. This called for the construction of a new index; as it was proposed to investigate the extent to which the output

of the index could be expressed in terms of the relative risk associated with different patterns of work, this new model was called the Fatigue Risk Index (FRI).

The combined Fatigue Risk Index (FRI) version 2.0 was delivered in a report to HSE in June 2006. Small changes to the hosting platform, with associated version changes from version 2.0 through to version 2.3, were made between 2006 and 2016, particularly to make it perform better with the ongoing changes in Microsoft's Excel architecture.

Fatigue Index Calculator											
Read the manual before using! Go to http://www.hse.gov.uk/RESEARCH/rpdf/m448g.pdf											
Company							Assessor				
Location							☐ Display schedule ☐ Display charts				
Shift ID							© Crown Copyright 2005 Version 2.3				
Date							About				
Mode	Fatigue	Defaults	Reset Index	Calculate Index							
Day	On Duty	Off Duty	Job type / breaks	Commuting Time	Duty Length	Rest Length	Average duty per day	Cumulative component	Duty timing component	Job type / Breaks component	Risk Index
01/01/2023	06:00	18:00	Default	Default							
02/01/2023	06:00	18:00	Default	Default							

FRI⁺

The science team at FRMSc developed FI, and subsequently FRI, whilst employed by QinetiQ and its constituent companies. FRMSc was created in 2010, and learning that FRI was no longer supported, the directors acquired the licence rights to use and develop FRI.

In 2017, FRMSc incorporated the FRI algorithms within their Predictive Fatigue Model hosting platform on the Microsoft Azure Cloud that hosted their more advanced aviation models. This version became known as FRI⁺ because the algorithms used, and the inputs and outputs available, remained essentially the same as the latest version of the FRI model. However, the new platform permitted better scalability, security and resilience. Moreover, the displays were improved for a better user experience, the users were able to access the model from any internet connected device wherever they were, and FRI⁺ could be connected to a user's employee scheduling system through a two-way API for automatic population of employee work datasets. Further, the whole system was maintained and supported by FRMSc's science and mathematics team and IT group.

The good modelling features provided in FRI⁺ are useful for managers to explore changes in the input data to find the best solution for any particularly fatiguing duty.

The original algorithm library provided to HSE is no longer supported by FRMSc and at the time of writing, is no longer available from the HSE website.

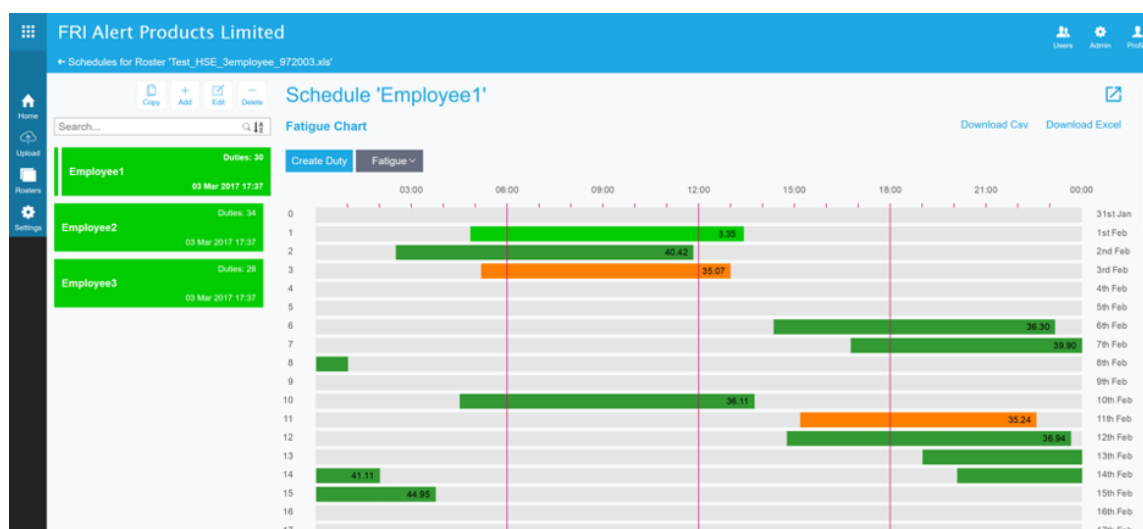
Users who are licenced to use our aviation models that are held on the same platform are now able to switch easily from the FRMSc aviation models, which comprise the SAFE model for pilots, the CARE model for cabin crew, and the HARVEST analytics package for overall

fatigue management of an enterprise, to the FRI+ model for use with aviation ground crew including maintenance engineers, Air Traffic Controllers and airport workers.

Other industrial users such as those in healthcare, rail, construction, energy, manufacturing etc. will only require access to the FRI+ model.

Users should be aware that the aviation models SAFE and CARE have a different architecture from FRI as their working environment is more challenging. Both aviation models apply to aircrew whose sleep may be disturbed through rapid trans-meridian travel and who have inconsistent duty start and end times. Shift workers mainly do not travel rapidly through time zones and indeed mostly stay completely within the same time zone (with certain exceptions such as in the energy industry) with set duty start times as they rotate through their early, late, and overnight shifts. Accordingly, the model architecture is different as the target occupations have different challenges, hazard characteristics and consequent fatigue profiles.

For those users with employees that work shifts but may travel across time zones, please contact info@frmssc.com for further information to accommodate their specific requirement.



FRI+ uses similar algorithms to those that were developed for all original FRI versions from v. 2.0 through v 2.3 but has higher performance because of the move to the Azure platform. The main advantages of this move to the Azure Cloud are as follows:

1. Improved Security

Security is massively increased as it is provided by Microsoft as an inherent part of the Azure system. This is enhanced by FRMSc with independent monthly checks and annual penetration testing that are carried out on the hosting platform and all the models within it, by specialist contractors to FRMSc.

2. Improved Resilience

Resilience is improved with recovery times as low as less than one minute if required. Clients must request this premium recovery option if required.

3. Improved Scalability

FRI+ has a much higher capacity to analyse much larger datasets than FRI. FRI+ uses the powerful features of Azure to achieve improved speed of processing, scalability, resilience, and security. As FRI+ is much more powerful than the previous simple spreadsheet, it is necessary to put limits on the performance of FRI-PLUS to contain the negative effects of any errors in data upload. This is particularly important for users of the API who drive data directly from their rostering programmes.

With the FRI+ architecture, an overload of data will cause more processors to be added to handle the load. This means that clients will consequentially be overwhelmed by the amount of data provided by FRI+ and Microsoft will issue a very large invoice for processing services.

FRI^{PRO}

FRI was developed as a separate work package specifically for HSE in parallel to the ongoing work in the separate project that developed the more complex aviation models. These aviation models have been developed further with many very useful features that could, with hindsight, be very useful for users of FRI+. Unfortunately, as both models are built with different architecture, they are incompatible, making it impossible to use the aviation features within FRI+.

Consequently, the FRI+ algorithm library has been recast in the same architecture as the aviation models for use as FRI^{PRO}. Consequently, all the appropriate advanced features of these aviation models are now available for those who wish for higher performance from FRI.

FRI^{PRO} is designed for the overall management team of any user of FRI as it contains powerful modelling features, much more granularity on how fatigue builds up during the duty and tools to explore ways to change schedule design to minimise fatigue.

An API is available to connect FRI^{PRO} with any employee scheduling software package for automatic population of the model. The API is a two-way API that sends data to FRI^{PRO} and receives the results of the analysis in return for populating the scheduling software displays. This is a very productive way to use the models and indeed the scheduling software which may now consider fatigue as schedules are built.

FRI^{PRO} is also useful for post-incident analysis as all sleep periods can be altered to reflect the actual sleep of the employee and the workload changed to cater for any unexpected environmental issues.

Finally, FRI^{PRO} will connect with the HARVEST analytics package to provide management charts and reports to identify the trends of fatigue levels and to identify issues in the design

of schedules that may contain perhaps too many consecutive early starts or late finishes etc. HARVEST has a POWER BI version which is a data warehouse that can drive the client's licenced POWER BI application. This may suit larger companies who wish to create their own charts and reports.