



Opturion Roster Analysis for Sample Company
Sample Roster
December 20, 2022



OPTURION
Intelligent Decision Support



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1 Overview

This document provides a summary of the Opturion Roster Analyser as well as a detailed analysis of the roster which has been examined for *Sample Company*.

2 Introduction

The fatigue and risk analysis tool used by Opturion to conduct this examination is based on research conducted as part of an HSE [1] investigation into the effects of sleepiness on shift workers. During this research numerous contributing factors were identified and a modelling tool was produced which predicts sleepiness and risk based on these factors.

2.1 Fatigue Index

During the research, the following factors were identified as contributing to fatigue.

1. **Cumulative Fatigue**
2. **Recovery Provided by Breaks**
3. **Duration Before Meal Break**
4. **Time of Day**
5. **Duration of Shift**
6. **Recovery After Long Sequences of Work**
7. **Intensity of Shift**
8. **Direction and Speed of Rotation**

The model uses these factors to estimate the average level of fatigue of the worker during the shift. This number, referred to as the *fatigue index* or *FI* is a value between 0 and 100 which gives the probability of the worker having a high level of sleepiness. Specifically, this is the percentage likelihood of achieving a score of 8 or 9 on the Karolinska Sleepiness Scale (*KSS*).

2.1.1 The Karolinska Sleepiness Scale

The KSS is a 9 point scale often used when conducting studies involving self-reported, subjective assessment of an individual's level of sleepiness at the time. The scores are defined as

1. Extremely alert.
2. Very alert.
3. Alert.
4. Rather alert.
5. Neither alert nor sleepy.
6. Some signs of sleepiness.
7. Sleepy, but no difficulty remaining awake.
8. Sleepy, some difficulty remaining awake.
9. Extremely sleepy, fighting sleep.



2.2 Risk Index

The output from the *risk index* or *RI* represents the average relative risk of the occurrence of an incident on a particular shift. This index is normalised with respect to a “typical” two day, two night four off schedule:

- Shift changes occur at 07:00 and 19:00.
- Typical commute of 40 minutes.
- Work is moderately demanding and requires continuous attention sometimes.
- 15 minute break every 2 hours.
- 30 minute meal break after 4 hours.

If this schedule is repeated over 21 consecutive cycles (24 weeks) then the average value of the RI is 1.00. Therefore, a shift pattern that has a RI of 2.00 represents a doubling of the risk.

2.3 Notes on the Indices

It should be noted that there are some large differences in the output from the two indices, and a shift with a high value on one index is not always assigned a high value on the other. This is an inevitable consequence of the different information from which the two indices have been constructed and, in particular, of the differential effect of time of day. Whereas both fatigue and risk are highest on the night shift, the risk of an incident occurring on the afternoon shift is higher than on the morning shift. This contrasts with fatigue which tends to be higher on a morning than on an afternoon shift.

2.4 Industry Best Practice

According to Bell [2], the following scores represent industry best practice:

| | Day | | Night | |
|---------------|----------|---------|----------|---------|
| | Moderate | Maximum | Moderate | Maximum |
| Fatigue Index | 30 | 35 | 40 | 45 |
| Risk Index | 1.4 | 1.6 | 1.4 | 1.6 |

Table 1: Industry Best Practice.



2.5 Potential Repercussions of Fatigue

Fatigue has significant consequences for society and several studies have showed that fatigue sustained for extended periods is an accurate predictor for future morbidity and mortality [5] and a reduction in quality of life [9]. Fatigue can also result in declines in worker productivity [6] with Lin et al. [7], showing that fatigue led to an annual decline in earnings of \$8,554 among households studied. Reynolds, K.J et al. [8] also showed that fatigue accounts for a loss of \$9.1 billion in earnings each year in the United States.

In a study comparing the effects of fatigue on performance to blood alcohol concentration [10] performance deficits equivalent to 0.05% BAC were seen after 17 to 19 hours of sleep deprivation levels equivalent to 0.10% BAC were predicted to occur after 18 to 20 of wakefulness. The implication of this research is that a worker driving home after extended duties, such as a night shift, may have their driving impaired to a equivalent level as someone who is driving over the legal BAC.

These examples illustrate that fatigue is an outstanding public health issue that requires the implementation of effective interventions to help employers manage their fatigue exposure.

2.6 Alertness Rules

The Opturion Roster Analyser can be configured to analyse the roster for unfavourable shift patterns.

The Alertness rules used in this analysis are:

1. **Maximum Consecutive Shifts:**

This is limit on the number of shifts the worker can perform without a day off. The recommended limit is no more than 6 consecutive shifts.

2. **Maximum Consecutive Early Shifts:**

This is limit on the number of early shifts the worker can perform without a day off.

3. **Maximum Consecutive Nights:**

This is limit on the number of night shifts the worker can perform without a day off. The recommended limit is no more than 4 consecutive night shifts [12].

4. **Night-Day Rotation:**

Following a period of night shifts, it is desirable to have the following day off before returning to duties.

5. **Quick Returns:**

A quick return occurs when the time between shifts is less than a given amount. It is recommended that quick returns are avoided. If this is not possible, it is recommended that they occur on the last day before time off.

For a description of the values used during this analysis please consult Section 6.



2.7 Warnings and Violations

The Opturion Roster Analyser checks the roster against the various rules described above. If a rule has been broken, the analyser will output a *warning* or *violation*, depending on the severity.

2.7.1 Fatigue Risk Index

Assume we are using a moderate and high fatigue index of 30 and 35 respectively. Figure 1 shows an example of warnings and violations for the fatigue index.

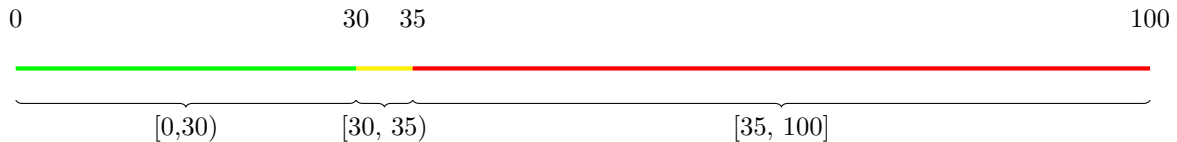


Figure 1: FRI Warnings Vs Violations.

This can also be represented by the following table

| Range | Colour | Type |
|-----------|--------|-----------|
| [0,30) | Green | None |
| [30, 35) | Amber | Warning |
| [35, 100] | Red | Violation |

Table 2: Fatigue Ranges.

Example:

| Day | Fatigue Index | Type | Explanation |
|-----|---------------|-----------|------------------------------------------------------------------------------|
| 1 | 28 | None | Less than the moderate level of 30. |
| 2 | 30 | Warning | Equal to, but not exceeding, the moderate level of 30. |
| 3 | 32 | Warning | Greater than the moderate level of 30 but less than the maximum level of 35. |
| 4 | 35 | Violation | Equal to, but not exceeding, the maximum level of 35. |
| 5 | 40 | Violation | Greater than the maximum level of 35. |

Table 3: Fatigue Example.

2.7.2 Alertness

For the various Alertness rules, the *warnings* are usual triggered when the value is equal to the set limit, and a *violation* when it exceeds it.

Example:

Say we have a *maximum shift limit* of 6.

| Consecutive Shifts | Colour | Type | Explanation |
|--------------------|--------|-----------|--------------------------|
| <6 | Green | None | Less than limit of 6. |
| 6 | Amber | Warning | Equal to limit of 6. |
| >6 | Red | Violation | Greater than limit of 6. |

Table 4: Consecutive Shift Warnings.



3 Staff Summaries

3.1 Staff: Dorris Flowers

The staff member *Dorris Flowers* worked a total of 9 shifts over 12 days. During this time they worked 1 shift type and 1 role type. Following the fatigue and risk analysis, the staff member had no fatigue warnings and no fatigue violations. They also had no risk warnings and no risk violations.

After conducting the fatigue management analysis on the roster, it was found that the staff member had no *consecutive shift violations*, as well as no *consecutive night violations*. There were also no *consecutive earlies violations*, as well as no *night day rotation violations*. Additionally, there were no *quick return warnings* and no *quick return violations*.

3.1.1 Roster

| | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 |
|---------|-------|-------|-------|-------|-------|-------|-------|
| Shift | D | D | D | D | | | |
| Role | R | R | R | R | | | |
| Mean SS | 1.00 | 0.55 | 0.32 | 0.23 | | | |
| Max SS | 4.41 | 3.63 | 3.19 | 3.01 | | | |
| FI | 10.00 | 11.00 | 14.00 | 18.00 | | | |
| RI | 1.08 | 1.15 | 1.21 | 1.27 | | | |

Table 5: Dorris Flowers: Days 3 - 9.

| | Day 10 | Day 11 | Day 12 | Day 13 | Day 14 |
|---------|--------|--------|--------|--------|--------|
| Shift | D | D | D | D | D |
| Role | R | R | R | R | R |
| Mean SS | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| Max SS | 2.89 | 2.87 | 2.87 | 2.86 | 2.86 |
| FI | 10.00 | 13.00 | 16.00 | 19.00 | 22.00 |
| RI | 1.09 | 1.15 | 1.22 | 1.28 | 1.34 |

Table 6: Dorris Flowers: Days 10 - 14.



3.1.2 Work Summary

| | | Roles | | | |
|--------|---|-------|--------------------|------------------|-----------------|
| | | R | | | |
| Shifts | | Count | Fatigue Violations | Fatigue Warnings | Risk Violations |
| | | | | | Risk Warnings |
| | D | 9 | 0 | 0 | 0 |

Table 7: Dorris Flowers Shift and Role Summary.

3.1.3 KPIs

| Parameter | Value |
|---------------------|--------|
| Total Hours | 126:00 |
| Total Shifts | 9 |
| Hours Per Shift | 14:00 |
| Average Fatigue | 14.78 |
| Maximum Fatigue | 22.00 |
| Average Risk | 1.20 |
| Maximum Risk | 1.34 |
| Average Sleep Score | 1.37 |
| Maximum Sleep Score | 4.90 |
| Total Sleep | 83:01 |
| Average Daily Sleep | 06:55 |

Table 8: Dorris Flowers KPI Summary¹.

¹See [KPI Tables](#) for explanation.

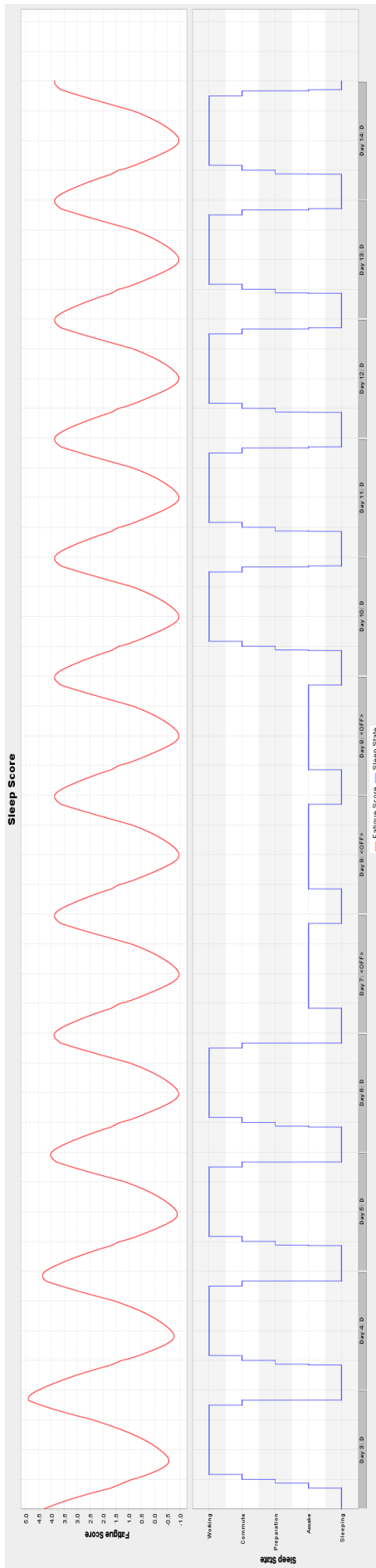


Figure 2: Dorris Flowers: Days 3 to 14.



3.2 Staff: Tom Warner

The staff member *Tom Warner* worked a total of 9 shifts over 14 days. During this time they worked 2 shift types and 1 role type. Following the fatigue and risk analysis, the staff member had 3 fatigue warnings and 3 fatigue violations. They also had no risk warnings and no risk violations.

After conducting the fatigue management analysis on the roster, it was found that the staff member had no *consecutive shift violations*, as well as no *consecutive night violations*. There were also no *consecutive earlies violations*, as well as no *night day rotation violations*. Additionally, there were no *quick return warnings* and no *quick return violations*.

3.2.1 Roster

| | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 |
|---------|-------|-------|-------|-------|-------|-------|-------|
| Shift | D | D | | | | N | N |
| Role | R | R | | | | R | R |
| Mean SS | 1.00 | 0.55 | | | | 4.36 | 6.21 |
| Max SS | 4.41 | 3.63 | | | | 4.84 | 6.69 |
| FI | 10.00 | 11.00 | | | | 39.00 | 41.00 |
| RI | 1.08 | 1.15 | | | | 0.92 | 1.03 |

Table 9: Tom Warner: Days 1 - 7.

| | Day 8 | Day 9 | Day 10 | Day 11 | Day 12 | Day 13 | Day 14 |
|---------|-------|-------|--------|--------|--------|--------|--------|
| Shift | N | | N | N | N | | N |
| Role | R | | R | R | R | | R |
| Mean SS | 5.44 | | 4.07 | 4.64 | 4.27 | | 2.98 |
| Max SS | 6.09 | | 4.89 | 5.59 | 5.57 | | 4.72 |
| FI | 45.00 | | 42.00 | 46.00 | 48.00 | | 44.00 |
| RI | 1.14 | | 1.14 | 1.25 | 1.35 | | 1.35 |

Table 10: Tom Warner: Days 8 - 14.



3.2.2 Fatigue Risk Index Violations

| Day | Shift | Role | Type | Level | Score | Limit | Difference |
|-----|-------|------|---------|--------|-------|-------|------------|
| 7 | N | R | Fatigue | Yellow | 41.00 | 40.00 | 1.00 |
| 8 | N | R | Fatigue | Red | 45.00 | 45.00 | 0.00 |
| 10 | N | R | Fatigue | Yellow | 42.00 | 40.00 | 2.00 |
| 11 | N | R | Fatigue | Red | 46.00 | 45.00 | 1.00 |
| 12 | N | R | Fatigue | Red | 48.00 | 45.00 | 3.00 |
| 14 | N | R | Fatigue | Yellow | 44.00 | 40.00 | 4.00 |

Table 11: Tom Warner Fatigue Risk Summary.

3.2.3 Work Summary

| | | Roles | | | | |
|--------|---|-------|--------------------|------------------|-----------------|---------------|
| | | R | | | | |
| | | Count | Fatigue Violations | Fatigue Warnings | Risk Violations | Risk Warnings |
| Shifts | D | 2 | 0 | 0 | 0 | 0 |
| | N | 7 | 3 | 3 | 0 | 0 |

Table 12: Tom Warner Shift and Role Summary.

3.2.4 KPIs

| Parameter | Value |
|---------------------|--------|
| Total Hours | 98:00 |
| Total Shifts | 9 |
| Hours Per Shift | 10:53 |
| Average Fatigue | 36.22 |
| Maximum Fatigue | 48.00 |
| Fatigue % | 67.00% |
| Fatigue Warnings | 3 |
| Fatigue Violations | 3 |
| Average Risk | 1.16 |
| Maximum Risk | 1.35 |
| Average Sleep Score | 2.30 |
| Maximum Sleep Score | 6.69 |
| Total Sleep | 86:24 |
| Average Daily Sleep | 05:45 |

Table 13: Tom Warner KPI Summary².

²See [KPI Tables](#) for explanation.

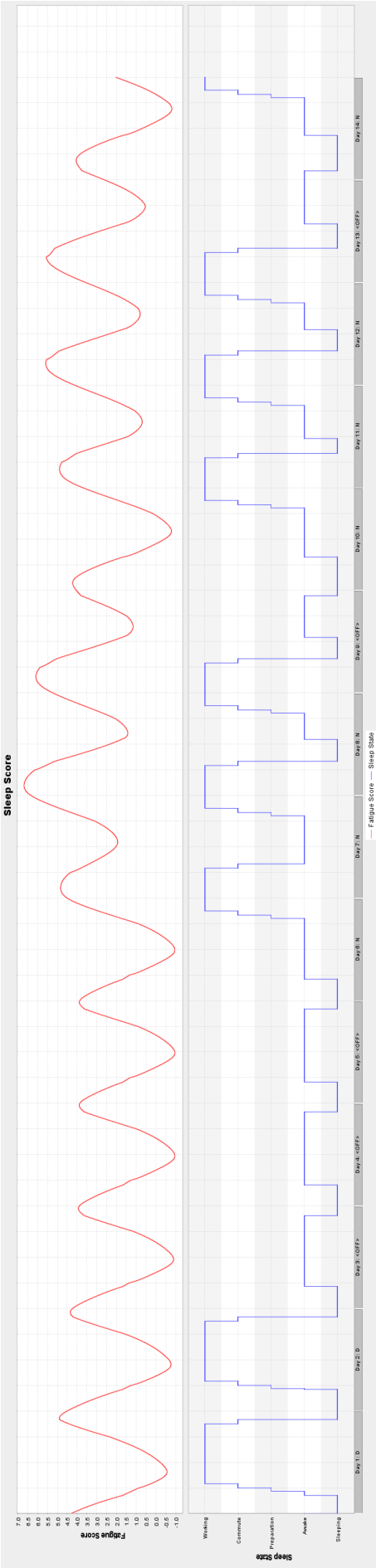


Figure 3: Tom Warner: Days 1 to 14.

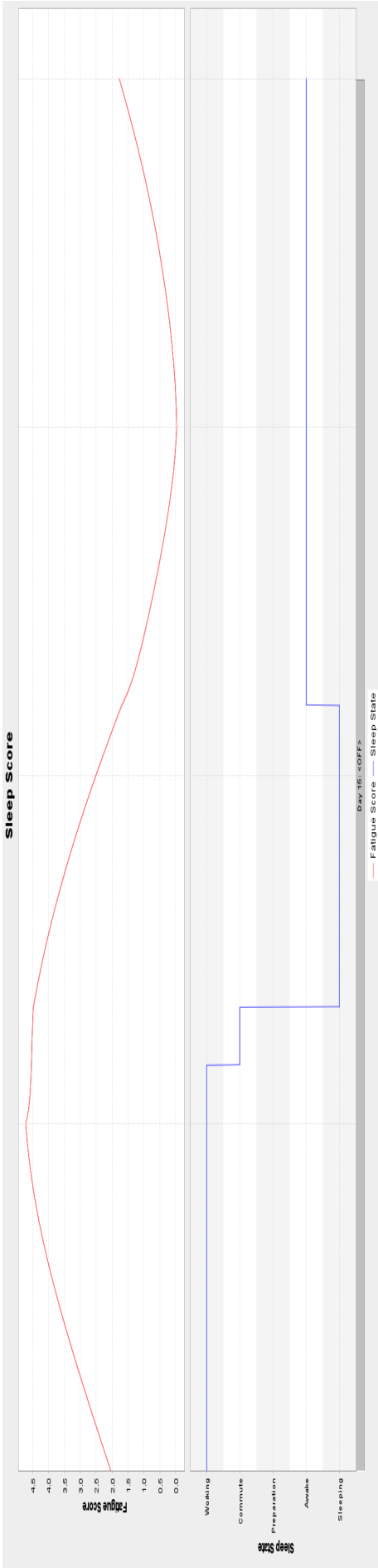


Figure 4: Tom Warner: Days 15 to 15.



3.3 Staff: Harry Flynn

The staff member *Harry Flynn* worked a total of 8 shifts over 12 days. During this time they worked 2 shift types and 1 role type. Following the fatigue and risk analysis, the staff member had 3 fatigue warnings and a single fatigue violation. They also had no risk warnings and no risk violations.

After conducting the fatigue management analysis on the roster, it was found that the staff member had no *consecutive shift violations*, as well as no *consecutive night violations*. There were also no *consecutive earlies violations*, as well as no *night day rotation violations*. Additionally, there were no *quick return warnings* and no *quick return violations*.

3.3.1 Roster

| | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 |
|---------|-------|-------|-------|-------|-------|-------|-------|
| Shift | N | N | | N | N | N | |
| Role | R | R | | R | R | R | |
| Mean SS | 4.85 | 6.01 | | 4.55 | 6.25 | 5.50 | |
| Max SS | 5.28 | 6.45 | | 5.01 | 6.72 | 6.12 | |
| FI | 39.00 | 41.00 | | 40.00 | 44.00 | 47.00 | |
| RI | 0.91 | 1.02 | | 1.02 | 1.13 | 1.24 | |

Table 14: Harry Flynn: Days 1 - 7.

| | Day 8 | Day 9 | Day 10 | Day 11 | Day 12 |
|---------|-------|-------|--------|--------|--------|
| Shift | | | D | D | D |
| Role | | | R | R | R |
| Mean SS | | | 0.60 | 0.47 | 0.31 |
| Max SS | | | 2.76 | 2.90 | 2.89 |
| FI | | | 12.00 | 15.00 | 18.00 |
| RI | | | 1.13 | 1.19 | 1.25 |

Table 15: Harry Flynn: Days 8 - 12.



3.3.2 Fatigue Risk Index Violations

| Day | Shift | Role | Type | Level | Score | Limit | Difference |
|-----|-------|------|---------|--------|-------|-------|------------|
| 2 | N | R | Fatigue | Yellow | 41.00 | 40.00 | 1.00 |
| 4 | N | R | Fatigue | Yellow | 40.00 | 40.00 | 0.00 |
| 5 | N | R | Fatigue | Yellow | 44.00 | 40.00 | 4.00 |
| 6 | N | R | Fatigue | Red | 47.00 | 45.00 | 2.00 |

Table 16: Harry Flynn Fatigue Risk Summary.

3.3.3 Work Summary

| | | Roles | | | |
|--------|---|-------|--------------------|------------------|-----------------|
| Shifts | | R | | | |
| | | Count | Fatigue Violations | Fatigue Warnings | Risk Violations |
| | | | | | Risk Warnings |
| | D | 3 | 0 | 0 | 0 |
| | N | 5 | 3 | 1 | 0 |

Table 17: Harry Flynn Shift and Role Summary.

3.3.4 KPIs

| Parameter | Value |
|---------------------|--------|
| Total Hours | 92:00 |
| Total Shifts | 8 |
| Hours Per Shift | 11:30 |
| Average Fatigue | 32.00 |
| Maximum Fatigue | 47.00 |
| Fatigue % | 50.00% |
| Fatigue Warnings | 3 |
| Fatigue Violations | 1 |
| Average Risk | 1.11 |
| Maximum Risk | 1.25 |
| Average Sleep Score | 2.54 |
| Maximum Sleep Score | 6.72 |
| Total Sleep | 67:05 |
| Average Daily Sleep | 05:35 |

Table 18: Harry Flynn KPI Summary³.

³See **KPI Tables** for explanation.

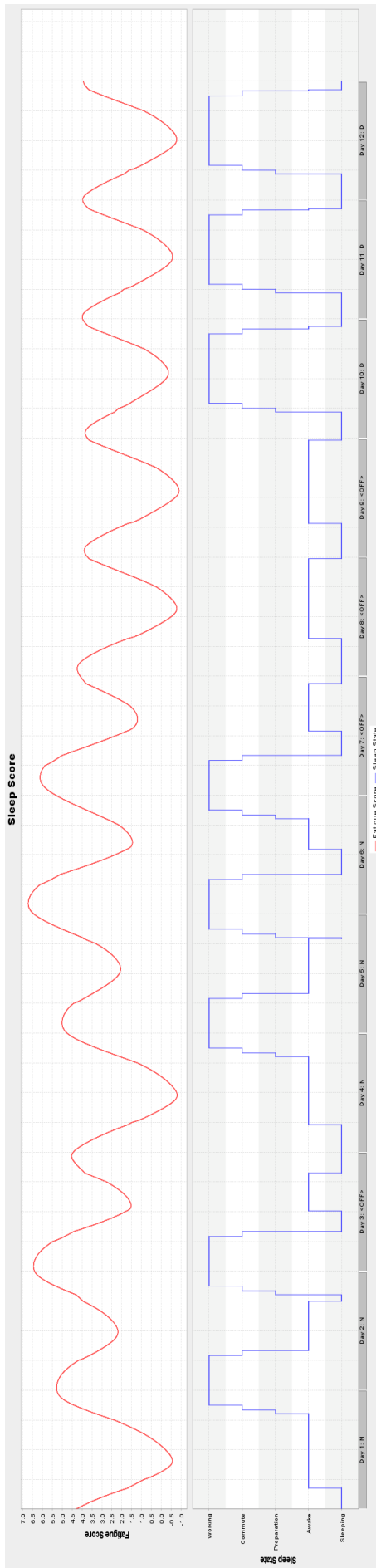


Figure 5: Harry Flynn: Days 1 to 12.



4 Roster Summary

This section contains the KPIs for the entire roster and includes all staff members across all days.

| Staff | Hours | Shifts | Mean Hours | Mean Fatigue | Max Fatigue | Mean Risk | Max Risk |
|----------------|--------|--------|------------|--------------|-------------|-----------|----------|
| Dorris Flowers | 126:00 | 9 | 14:00 | 14.78 | 22.00 | 1.20 | 1.34 |
| Tom Warner | 98:00 | 9 | 10:53 | 36.22 | 48.00 | 1.16 | 1.35 |
| Harry Flynn | 92:00 | 8 | 11:30 | 32.00 | 47.00 | 1.11 | 1.25 |

Table 19: Staff Summary⁴.

| Staff | Fatigue Warnings | Fatigue Violations |
|-------------|------------------|--------------------|
| Tom Warner | 3 | 3 |
| Harry Flynn | 3 | 1 |

Table 20: Fatigue Summary

| Staff | Days | Average Sleep | Total Sleep | Mean Sleep Score | Max Sleep Score |
|----------------|------|---------------|-------------|------------------|-----------------|
| Dorris Flowers | 12 | 06:55 | 83:01 | 1.37 | 4.90 |
| Tom Warner | 14 | 05:45 | 86:24 | 2.30 | 6.69 |
| Harry Flynn | 12 | 05:35 | 67:05 | 2.54 | 6.72 |

Table 21: AlertSafe Summary

| Parameter | Value |
|---------------------|--------|
| Total Hours | 316:00 |
| Total Shifts | 26 |
| Hours Per Shift | 12:09 |
| Average Fatigue | 27.50 |
| Maximum Fatigue | 48.00 |
| Fatigue % | 38.00% |
| Fatigue Warnings | 6 |
| Fatigue Violations | 4 |
| Average Risk | 1.16 |
| Maximum Risk | 1.35 |
| Risk % | 15.00% |
| Average Sleep Score | 2.09 |
| Maximum Sleep Score | 6.72 |

Table 22: Roster KPI Summary⁵.

⁴See [KPI Tables](#) for explanation.

⁵See [KPI Tables](#) for explanation.



5 Day Summary

This section contains the KPIs for each day of the roster and includes all staff members.

| KPI | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 |
|--------------------------------|-------|--------|-------|--------|--------|--------|---------|
| Total Hours | 24:00 | 24:00 | 14:00 | 24:00 | 24:00 | 34:00 | 10:00 |
| Total Shift | 2 | 2 | 1 | 2 | 2 | 3 | 1 |
| Hours Per Shift | 12:00 | 12:00 | 14:00 | 12:00 | 12:00 | 11:20 | 10:00 |
| Average Fatigue | 24.50 | 26.00 | 10.00 | 25.50 | 29.00 | 34.67 | 41.00 |
| Maximum Fatigue | 39.00 | 41.00 | 10.00 | 40.00 | 44.00 | 47.00 | 41.00 |
| Fatigue Warnings | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| Fatigue Violations | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Fatigue % | 0.00% | 50.00% | 0.00% | 50.00% | 50.00% | 33.00% | 100.00% |
| Average Risk | 1.00 | 1.09 | 1.08 | 1.09 | 1.17 | 1.14 | 1.03 |
| Maximum Risk | 1.08 | 1.15 | 1.08 | 1.15 | 1.21 | 1.27 | 1.03 |
| Risk Warnings | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Risk Violations | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Risk % | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Consecutive Shift Warnings | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Consecutive Shift Violations | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Consecutive Night Warnings | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Consecutive Night Violations | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Consecutive Earlies Warnings | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Consecutive Earlies Violations | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Quick Return Warnings | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Quick Return Violations | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night Day Rotation Violations | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 23: Days 1 - 7 Summary⁶.

⁶See [KPI Tables](#) for explanation.



| KPI | Day 8 | Day 9 | Day 10 | Day 11 | Day 12 | Day 13 | Day 14 |
|--------------------------------|---------|-------|--------|--------|--------|--------|--------|
| Total Hours | 10:00 | 00:00 | 38:00 | 38:00 | 38:00 | 14:00 | 24:00 |
| Total Shift | 1 | 0 | 3 | 3 | 3 | 1 | 2 |
| Hours Per Shift | 10:00 | 00:00 | 12:40 | 12:40 | 12:40 | 14:00 | 12:00 |
| Average Fatigue | 45.00 | | 21.33 | 24.67 | 27.33 | 19.00 | 33.00 |
| Maximum Fatigue | 45.00 | | 42.00 | 46.00 | 48.00 | 19.00 | 44.00 |
| Fatigue Warnings | 0 | | 1 | 0 | 0 | 0 | 1 |
| Fatigue Violations | 1 | | 0 | 1 | 1 | 0 | 0 |
| Fatigue % | 100.00% | | 33.00% | 33.00% | 33.00% | 0.00% | 50.00% |
| Average Risk | 1.14 | | 1.12 | 1.20 | 1.27 | 1.28 | 1.35 |
| Maximum Risk | 1.14 | | 1.14 | 1.25 | 1.35 | 1.28 | 1.35 |
| Risk Warnings | 0 | | 0 | 0 | 0 | 0 | 0 |
| Risk Violations | 0 | | 0 | 0 | 0 | 0 | 0 |
| Risk % | 0.00% | | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Consecutive Shift Warnings | 0 | | 0 | 0 | 0 | 0 | 0 |
| Consecutive Shift Violations | 0 | | 0 | 0 | 0 | 0 | 0 |
| Consecutive Night Warnings | 0 | | 0 | 0 | 0 | 0 | 0 |
| Consecutive Night Violations | 0 | | 0 | 0 | 0 | 0 | 0 |
| Consecutive Earlies Warnings | 0 | | 0 | 0 | 0 | 0 | 0 |
| Consecutive Earlies Violations | 0 | | 0 | 0 | 0 | 0 | 0 |
| Quick Return Warnings | 0 | | 0 | 0 | 0 | 0 | 0 |
| Quick Return Violations | 0 | | 0 | 0 | 0 | 0 | 0 |
| Night Day Rotation Violations | 0 | | 0 | 0 | 0 | 0 | 0 |

Table 24: Days 8 - 14 Summary⁷.

⁷See **KPI Tables** for explanation.



6 Analyser Settings

| Parameter | Value |
|----------------------------------|-------|
| Fatigue Analysis | True |
| Fatigue Analysis Warnings | True |
| Risk Analysis | True |
| Risk Analysis Warnings | True |
| Output Indices | True |
| Age Scaling | False |
| Max Consecutive Shifts | 5 |
| Max Consecutive Shifts Warnings | False |
| Max Consecutive Nights | 4 |
| Max Consecutive Nights Warnings | False |
| Max Consecutive Earlies | 5 |
| Max Consecutive Earlies Warnings | False |
| Min Night-Day Rotation | 3 |
| Min Night-Day Duration | 00:00 |
| Min Break Between Shifts | 10:00 |
| Quick Return Last Shift | False |
| Preferred Break Between Shifts | 10:00 |
| Max Shift Duration | 00:00 |
| Max Shift Duration Warnings | True |
| Rolling 1 Duration | 00:00 |
| Rolling 1 Warnings | True |
| Rolling 2 Duration | 00:00 |
| Rolling 2 Warnings | True |
| Backward Rotation Analysis | False |
| 24 Hour Limit Analysis | 00:00 |
| 24 Hour Limit Warnings | True |
| AlertSafe Analysis | True |

Table 25: Analyser Settings.



Appendices

A KPI Tables

A KPI table is generated for each **Staff Summary**, the **Day Summary** and the **Roster Summary**. This section describes the entries in this table.

1. **Total Hours:**
The total number of hours worked.
2. **Total Shifts:**
The total number of shifts worked.
3. **Hours Per Shift:**
The average shift length worked.
4. **Average Fatigue:**
The average fatigue score across all shifts.
5. **Maximum Fatigue:**
The maximum fatigue score across all shifts.
6. **Fatigue %:**
The percentage of shifts with a fatigue warning or violation.
7. **Fatigue Warnings:**
The number of shifts with a fatigue warning.
8. **Fatigue Violations:**
The number of shifts with a fatigue violation.
9. **Average Risk:**
The average risk score across all shifts.
10. **Maximum Risk:**
The maximum risk score across all shifts.
11. **Risk %:**
The percentage of shifts with a risk warning violation.
12. **Risk Warnings:**
The number of shifts with a risk warning.
13. **Risk Violations:**
The number of shifts with a risk violation.
14. **Consecutive Shift Violations:**
The number of shifts with a consecutive shift violation.
15. **Consecutive Night Warnings:**
The number of shifts with a consecutive night violation.
16. **Consecutive Shift Warnings:**
The number of shifts with a consecutive earlies violation.
17. **Quick Return Warnings:**
The number of shifts with a quick return warning.



18. **Quick Return Violation:**

The number of shifts with a quick return warning.

19. **Night-Day Rotation Violations:**

The number of shifts with a night-day rotation violation.

20. **Average Sleep Score:**

The average sleep score across the roster period.

21. **Maximum Sleep Score:**

The maximum sleep score across the roster period.

22. **Total Sleep:**

The total duration of sleep predicted by the model.

23. **Average Daily Sleep:**

The average daily duration of sleep predicted by the model.

A.1 Example

These KPIs must be considered in the context of the table they appear in. For example, say we have the following table.

| Parameter | Value |
|------------------------------|--------|
| Total Hours | 644:00 |
| Total Shifts | 56 |
| Hours Per Shift | 11:30 |
| Average Fatigue | 19.7 |
| Maximum Fatigue | 45.0 |
| Fatigue % | 0.25 |
| Backward Rotation Violations | 4 |

Table 26: KPI Summary Example .

1. Staff Summary

- (a) **Total Hours:** Total hours the staff member worked during the roster.
- (b) **Total Shift:** Total number of shifts the staff member worked during the roster.
- (c) **Hours Per Shift:** The average duration of the staff's shifts.
- (d) **Average Fatigue:** The average fatigue score for the staff's shifts.
- (e) **Maximum Fatigue:** The maximum fatigue score for the staff's shifts.
- (f) **Fatigue %:** The percentage of the staff's shifts that incurred a *fatigue violation*.
- (g) **Backward Rotation Violations:** The number of the staff's shifts with a *backward rotation violation*.



2. Day Summary

- (a) **Total Hours:** Total hours worked by all staff on this day.
- (b) **Total Shift:** Total number of shifts worked by all staff on this day.
- (c) **Hours Per Shift:** The average duration of a shift on this day.
- (d) **Average Fatigue:** The average fatigue score of a shift on this day.
- (e) **Maximum Fatigue:** The maximum fatigue score of a shift on this day.
- (f) **Fatigue %:** The percentage of the shifts that incurred a *fatigue violation* on this day.
- (g) **Backward Rotation Violations:** The number of the shifts with a *backward rotation violation* on this day.

3. Roster Summary

- (a) **Total Hours:** Total hours worked in the roster.
- (b) **Total Shift:** Total number of shifts worked in the roster.
- (c) **Hours Per Shift:** The average duration of a shift in the roster.
- (d) **Average Fatigue:** The average fatigue score of a shift in the roster.
- (e) **Maximum Fatigue:** The maximum fatigue score of a shift in the roster.
- (f) **Fatigue %:** The percentage of the shifts that incurred a *fatigue violation*.
- (g) **Backward Rotation Violations:** The number of the shifts with a *backward rotation violation*.



References

- [1] Health and Safety Executive; *The Development of a Fatigue / Risk Index For Shiftworkers; Research Report 446*; **2006**.
- [2] Bell, Julie; *Evaluation of the UK Rail Sector Initial Fatigue & Risk Index Thresholds: Identifying Good Practice*; **2007**.
- [3] Folkard, Simon; Lombardi, David *Modeling the Impact of the Components of Long Work Hours on Injuries and "Accidents"*; **2006**.
- [4] Wei-Quan, Lin; et al. *Factors Associated with Fatigue among Men Aged 45 and Older: A Cross-Sectional Study*; **2015**.
- [5] Jason, L.A; et al. *Causes of death among patients with chronic fatigue syndrome; Health Care Women Int* pg 615-626; **2006**.
- [6] Kant, I.J; et al. *An epidemiological approach to study fatigue in the working population: The Maastricht Cohort Study; Occup. Environ. Med* pg i32-i39; **2003**.
- [7] Lin, J.M.; et al. *The economic impact of chronic fatigue syndrome in Georgia: Direct and indirect costs*; **2011**.
- [8] Reynolds, K.J; et al. *The economic impact of chronic fatigue syndrome*; **2004**.
- [9] Bollegala, D; et al. *Combined impact of concomitant arthritis and back problems on health status: Results from a nationally representative health survey; Arthritis Care Res* pg 1584-1591; **2011**.
- [10] Williamson, A; et al. *Development of Measures of Fatigue: Using an Alcohol Comparison to Validate the Effects of Fatigue on Performance; Road Safety Research Report CR 189*; **2000**.
- [11] *Alertness CRC* <http://alertnesscrc.com/>
- [12] Lockley; Steven W et al. *Associations between number of consecutive night shifts and impairment of neurobehavioral performance during a subsequent simulated night shift*; **2016**.