Application of Shift Work Scheduling Principles and Tools for Optimizing Console Based Operations

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ABSTRACT

Modern command and control has created the novel paradox whereby units "deployed" at their home base are tasked to conduct wartime operations and face wartime stresses while simultaneously juggling peacetime administrative duties, manpower intensive base support duties and social stresses not typically faced by deployed personnel. This often results in units trying to cope by using rapidly shifting, haphazard work schedules that overstress their personnel and result in chronic unit fatigue, decreased morale and social problems. Applying nine principle-based shift work scheduling techniques along with the human performance modeling capability such as the Fatigue Avoidance Scheduling Tool (FAST) gives personnel of console based units the tools needed to mitigate chronic fatigue, reduce mishap risk and increase mission effectiveness.

1.0 INTRODUCTION

For the past 100 years the endurance of manned aircraft has been limited by their human operators. That dynamic is now changing with the introduction of remotely piloted aircraft (RPA); high loiter unmanned aircraft are now routinely operated by rotating ground-based aircrew, often from control sites thousands of kilometers from the area of operation, thus enabling units to be "deployed" while still at their home base.

These units are tasked to conduct wartime operations and face wartime stresses while simultaneously juggling peacetime administrative duties, manpower intensive base support duties and social stresses not typically faced by deployed personnel.

This duality often results in units trying to cope by using rapidly shifting, haphazard work schedules that overstress their personnel and result in chronic unit fatigue.

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2.0 FATIGUE

Fatigue can be categorized into five different types:

- Physical Fatigue - degraded physical task performance
- Circadian Effects - normal circadian rhythm degradation of task performance (primarily mental)
- Acute Mental Fatigue - prolonged wakefulness (≥ 16 hours) that occurs between two major sleep periods
- Cumulative Mental Fatigue - disturbed or shortened major sleep periods between two or more successive major waking, duty or work periods
- Chronic Fatigue - At least 1 month of multiple periods of prolonged wakefulness, excessive work hours, disturbed or shortened major sleep periods, unresolved conflicts, or prolonged frustration

3.0 OPERATIONAL ISSUES

High operations tempo console-based operations merge the worlds of acute mental fatigue traditionally found in the military flight environment with the chronic fatigue found with rapidly changing shift work schedules.

Acute and chronic fatigue can be mitigated by the application of a good shift work schedule. Optimal shift schedules should be based on principles capable of being scientifically validated using existing circadian prediction models.

A predictable schedule can immediately affect unit morale as it enables personnel to plan their lives and gives them a sense of control.

4.0 SHIFT WORK SCHEDULING

Effective shift work scheduling can be achieved through the application of shift work scheduling principles validated using effectiveness models.

Principle based shift work scheduling uses nine principle addressing five major areas:

- Circadian stability – principle one
- Hildebrandt’s five principles of chronohygiene and applications to calendar arithmetic – principles two through six
- Shift worker satisfaction – principles seven through nine

In order to assure the schedule developed using these principles will effectively reduce fatigue shift schedules can be validated using circadian performance effectiveness models. An example of such a model is the Fatigue Avoidance Scheduling Tool (FAST™).

4.1 Nine Principles

The nine shift work principles are:

- P1. Maintain circadian entrainment to the 24-h cycle – in keeping with the human circadian cycle
- P2. Shift length ≤ 8 hours, with exceptions – While shift length can, and often does, exceed 8 hours error rates increase dramatically; “…risk increased in an approximately exponential fashion with time

on shift such that in the twelfth hour it was more than double that during the first 8 h." (Folkard & Tucker, 2003).

- P3. Minimize the number of consecutive night shifts – Because humans are diurnal night shift work is a "crime against nature" and should therefore be minimized.
- P4. Night shift followed by 24 hours off – Because night shift work is upsetting to our normal circadian sufficient recovery time is necessary to get back on cycle.
- P5. Maximum number of free days on weekends – Weekends have significant social value. A schedule that provides free days on weekends, even if only one or two a month, can greatly improve morale.
- P6. At least 104 days off per 364-d year – As with weekends, the number of days off is important. This allows for sufficient rest and recovery and increases its social value by enabling personal time.
- P7. Equity – One of the fastest ways to degrade unit morale is for shift work to even appear unequal. A proper shift work schedule equally exposes everyone to the same numbers of day, evening and night shifts and provides the same number of days off.
- P8. Predictability – A well constructed shift schedule not only provides predictability but practically runs itself.
- P9. Good quality time off (at least 4 contiguous days) – While not always possible to give four days off (often implies 12 hour shifts), contiguous time off (minimum of two days) is necessary for proper recovery and morale.

CAUTION: It is not possible to invoke all 9 shift work principles at once!

4.2 Example Shift Schedule

Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
1	D	D	S	S	N	N	N
2	–	–	D	D	S	S	S
3	N	N	–	–	D	D	D
4	S	S	N	N	–	–	–

Table 1: Continental rota alignment

The Continental rota (table 1) was developed in Europe and shows the types of weekends created by the selected shift alignment.

It is important to note that days off (dashes) should always occur after night shift days to allow for recovery (on their own time).

5.0 VALIDATION

5.1 SAFTE Model

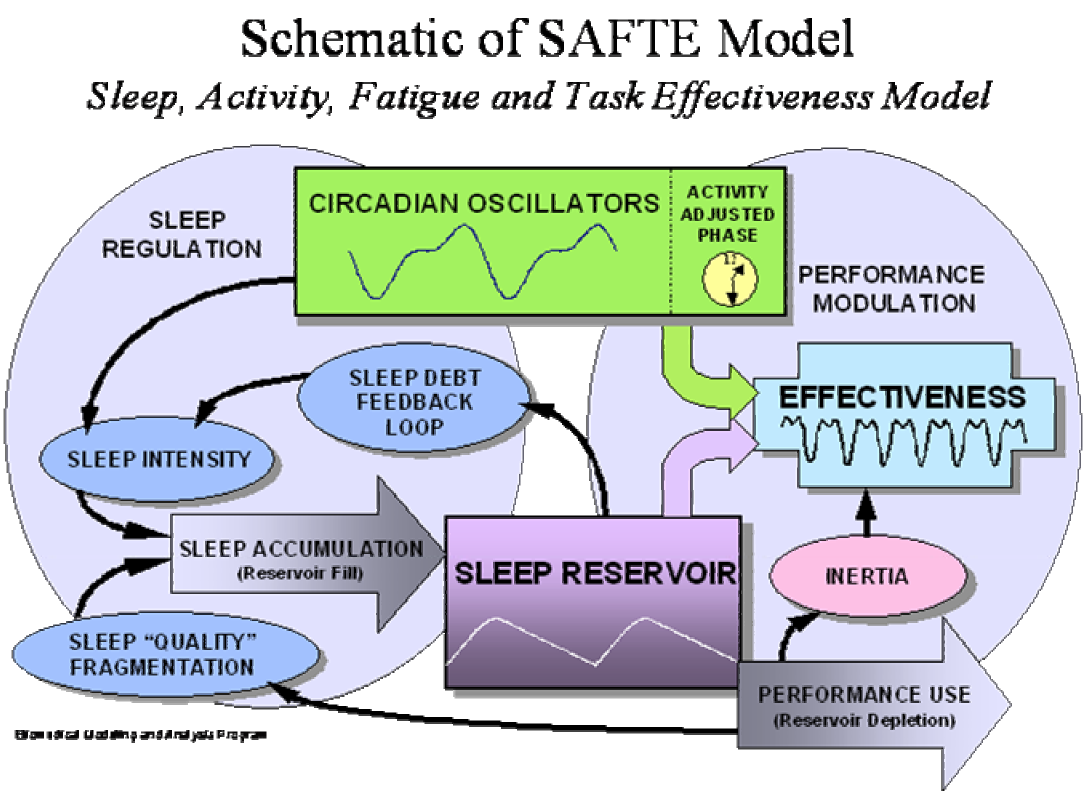

Figure 1: SAFTE Model

Validation of shift work schedules can be done using a mathematical model of circadian rhythm.

The circadian model adopted by the US Department of Defense is the Sleep, Activity, Fatigue and Task Effectiveness (SAFTE) Model developed by Dr. Steven Hursh.

The SAFTE model provides a prediction of cognitive performance based upon circadian oscillators coupled with sleep recovery called the "sleep reservoir."

5.1.1 SAFTE Validation

The SAFTE model has itself been validated using over twenty years of sleep and circadian data.

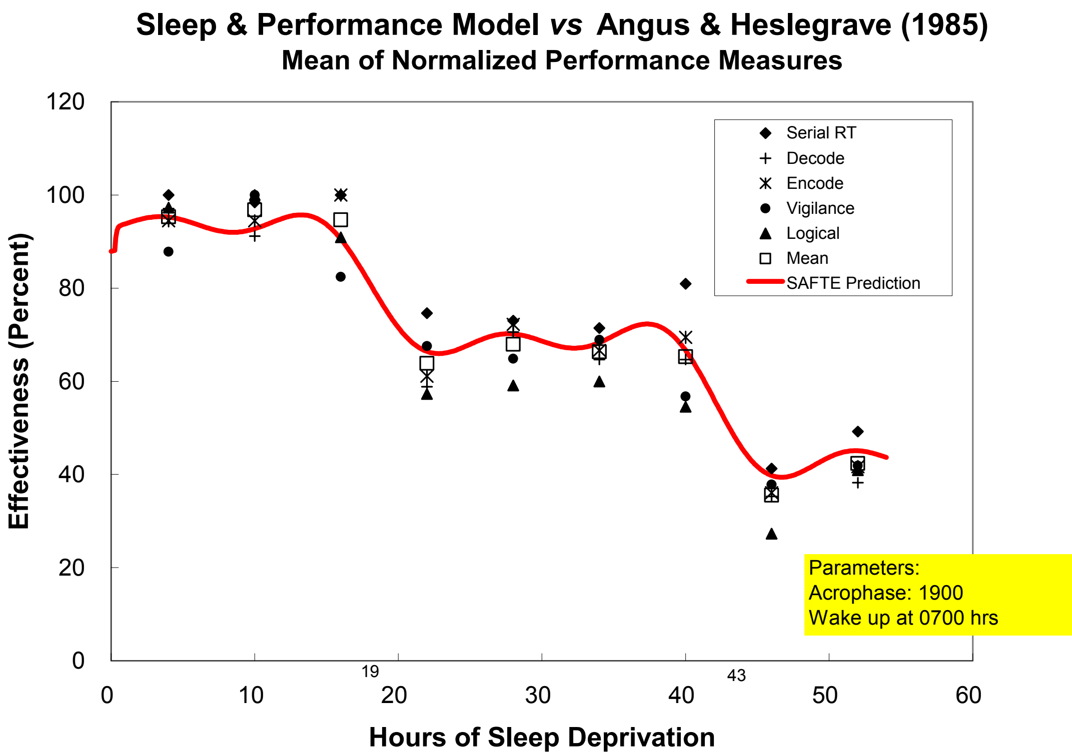

Figure 2: SAFTE Validation. Courtesy of Dr. Steven Hursh, SAIC

5.2 FAST™ Software

The SAFTE model has been integrated into a software package known at the Fatigue Avoidance Scheduling Tool (FAST™).

Once a shift schedule is input into FAST™ it will general a prediction of cognitive performance.

If done properly, a good shift schedule will allow workers to maintain their cognitive performance at or above a minimal level of performance.

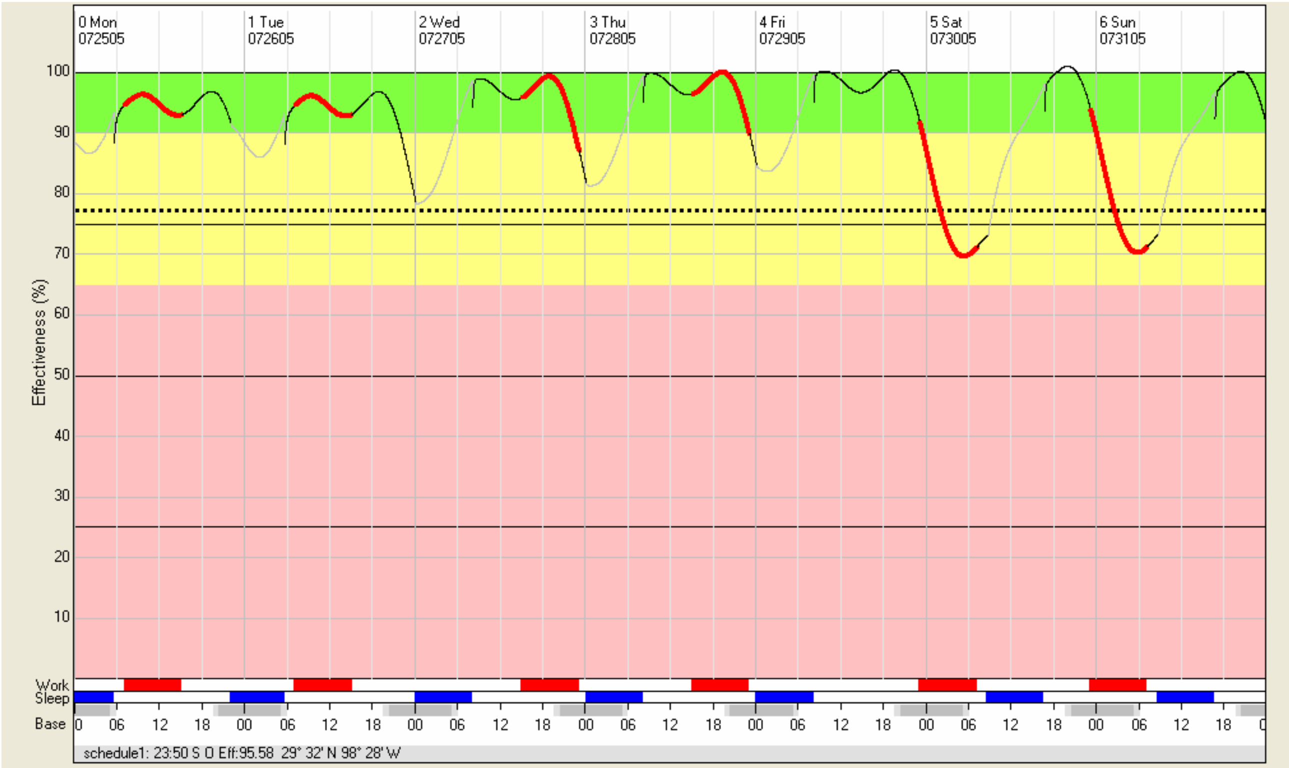

Figure 3: FAST™ Graphical Output

6.0 CONCLUSION

Providing a predictable work schedule based on sound fatigue science and validation (e.g. FAST) provides the tools needed to mitigate chronic fatigue, reduce mishap risk and increase mission effectiveness for cognitively demanding console operations.

7.0 REFERENCES

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