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Fatigue Risk Management
Solutions for Safety Teams

PREDICTIVE TOOLS IN APPROPRIATE FRM & FRMS
-The scientific and practical approach

February 2025 - Madrid

Predictions Are Based on Prior Measurements.

Fatigue can be measured in multiple ways.

Subjective Alertness Scales

Karolinska Sleepiness Scale (KSS)	
1	Extremely alert
2	Very alert
3	Alert
4	Fairly alert
5	Neither alert nor sleepy
6	Some signs of sleepiness
7	Sleepy
8	Very sleepy
9	Extremely sleepy

Samn Perelli Fatigue Scale	
1	Fully alert, wide awake
2	Very alert but not at peak
3	Okay
4	A little tired
5	Moderately tired
6	Extremely tired
7	Exhausted

Psychomotor Vigilance Task (PVT)

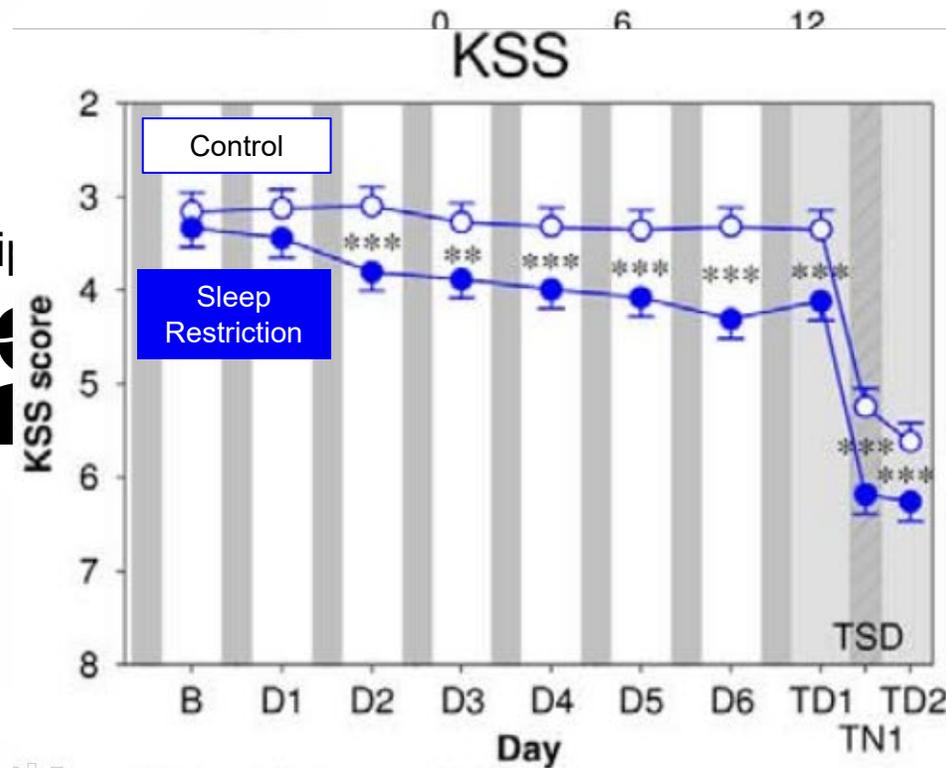
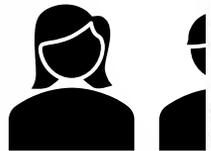


Sleep Loss Drives Fatigue.

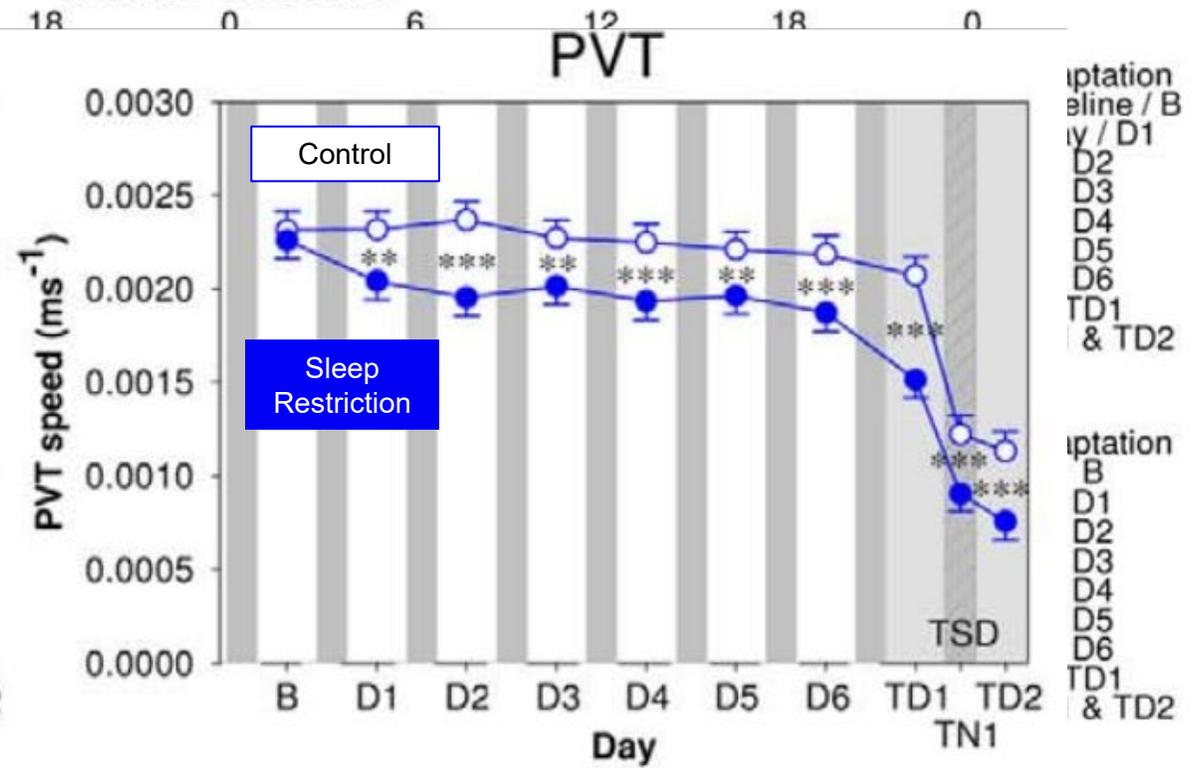
KSS and PVT are both good at tracking fatigue.

Effects of Sleep Restriction and Total Sleep Deprivation on Alertness

36 participants



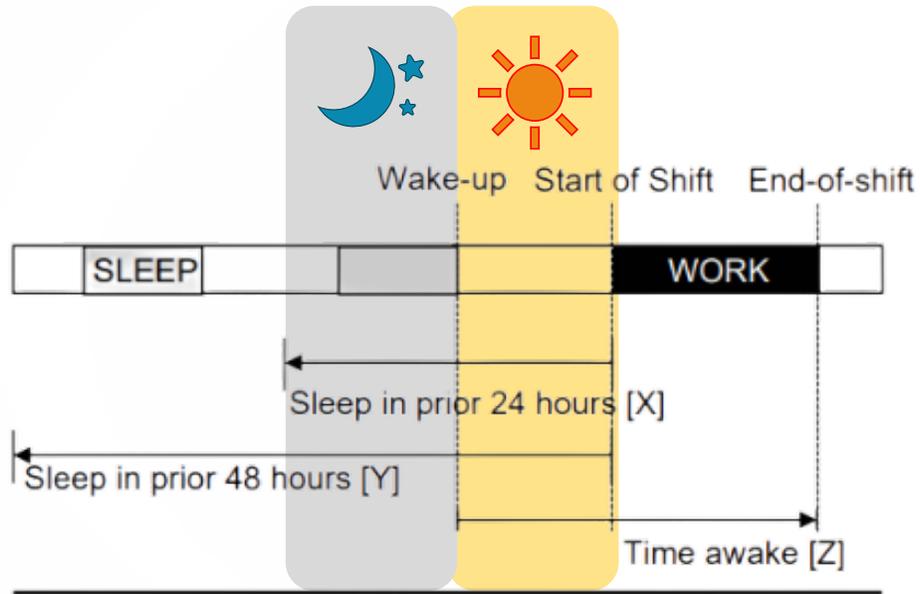
Results



Sleep Loss Drives Fatigue.

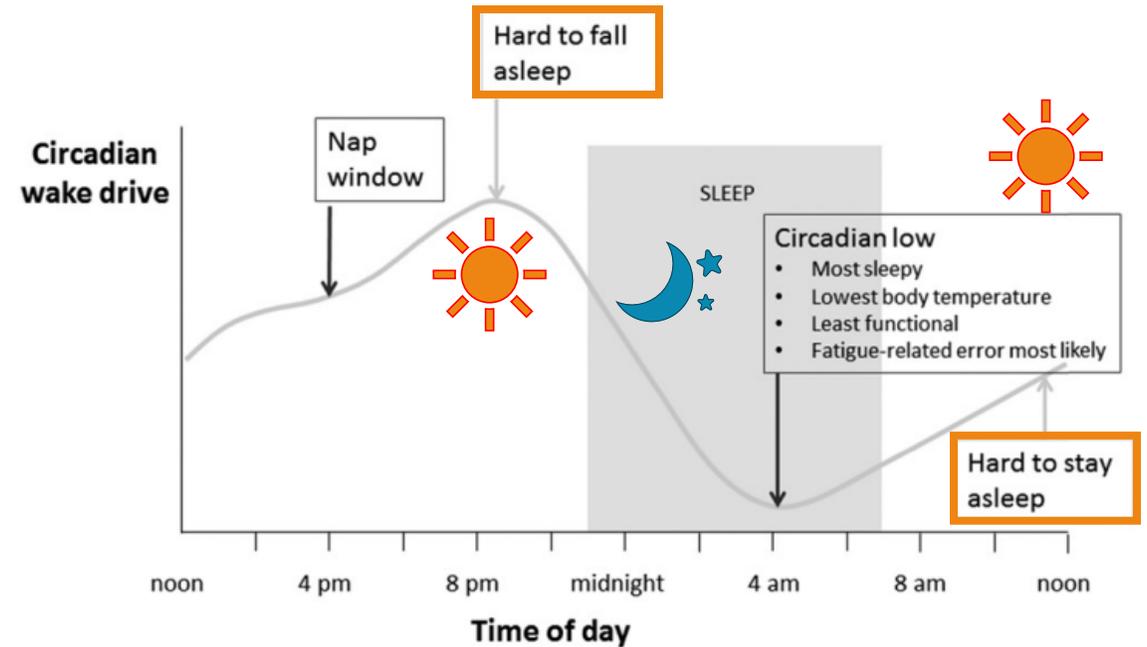
Not all sleep opportunities are equal.

Prior Sleep Wake Model



Dawson and McCulloch. "Managing fatigue: it's about sleep."
Sleep medicine reviews 9.5 (2005).

Circadian Effects on Ability to Sleep



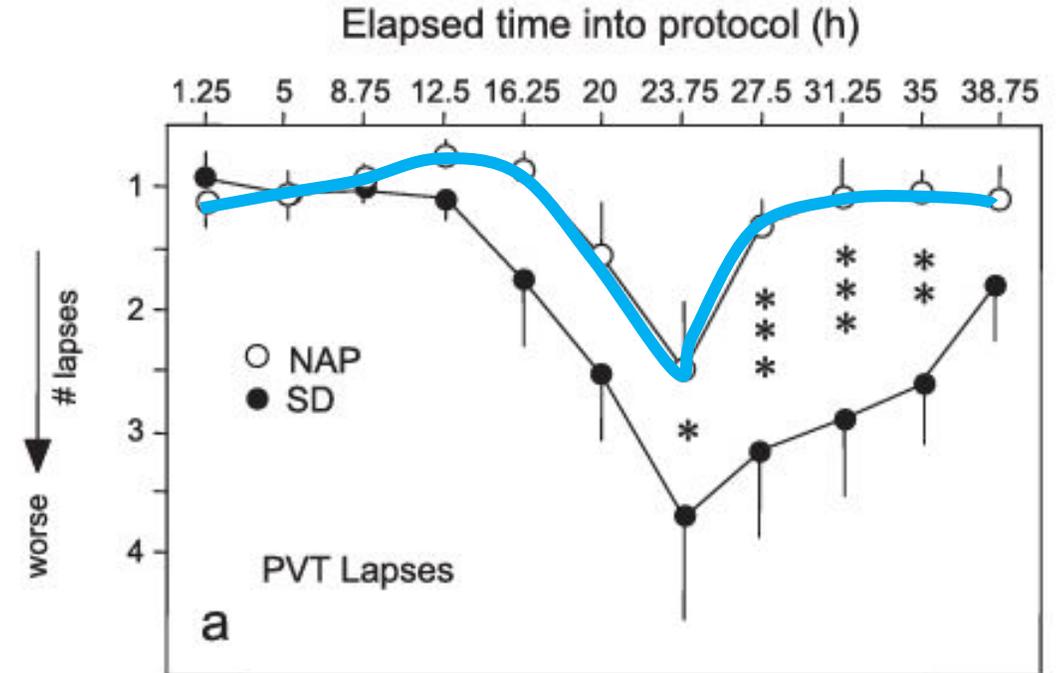
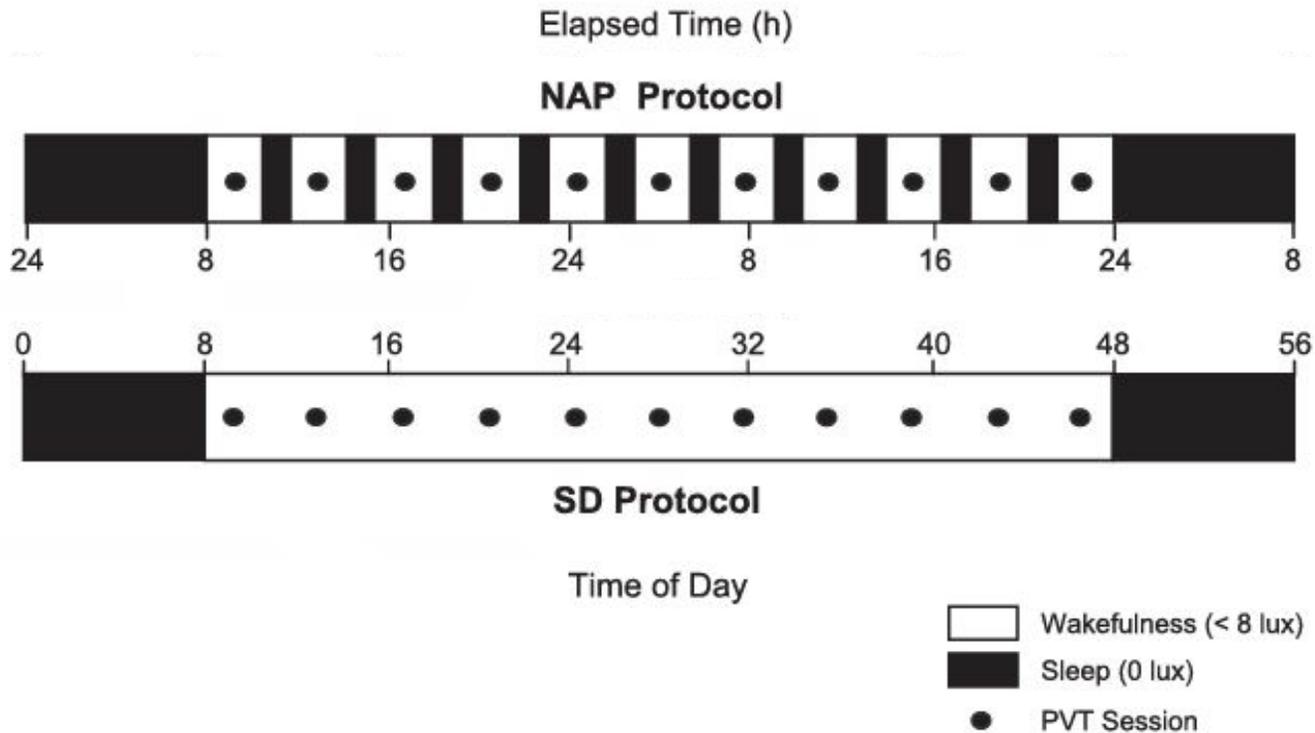
Gander, et al. "Preparing safety cases for operating outside prescriptive
fatigue risk management regulations." *Aerospace Medicine and Human
Performance* 88.7 (2017).

Time of Day Affects Fatigue.

Performance will be worse during the night even when individuals are well-rested.

Study Design

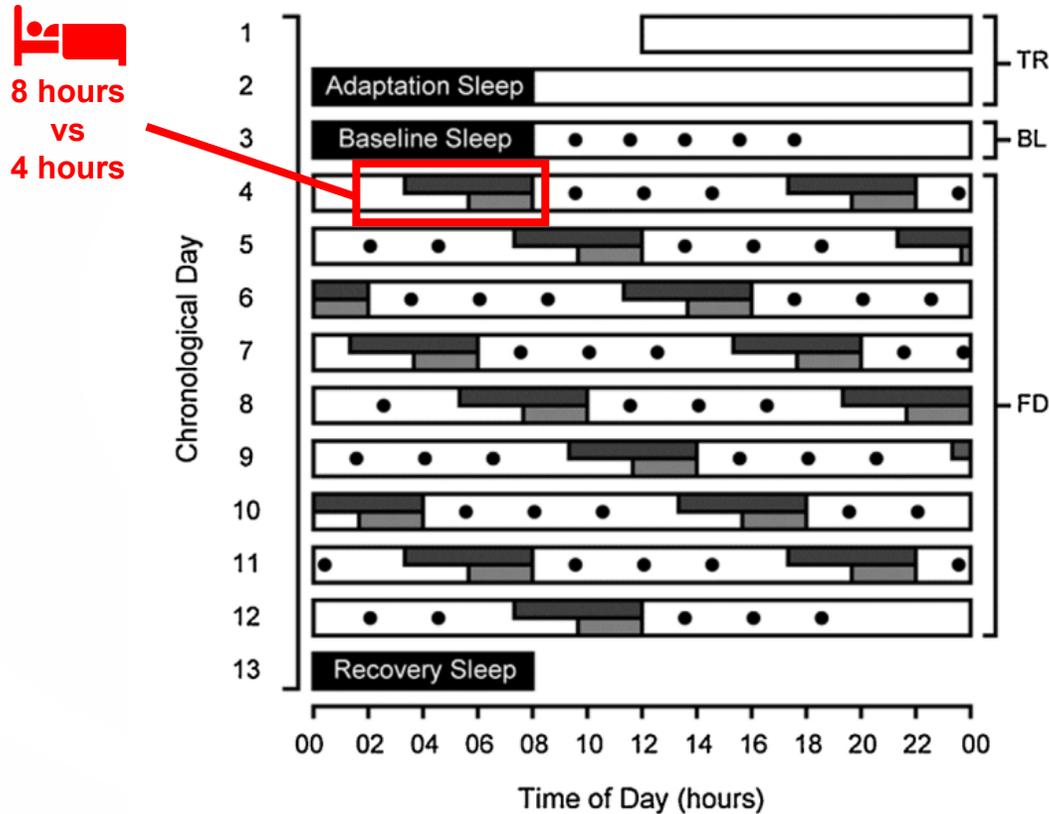
Results



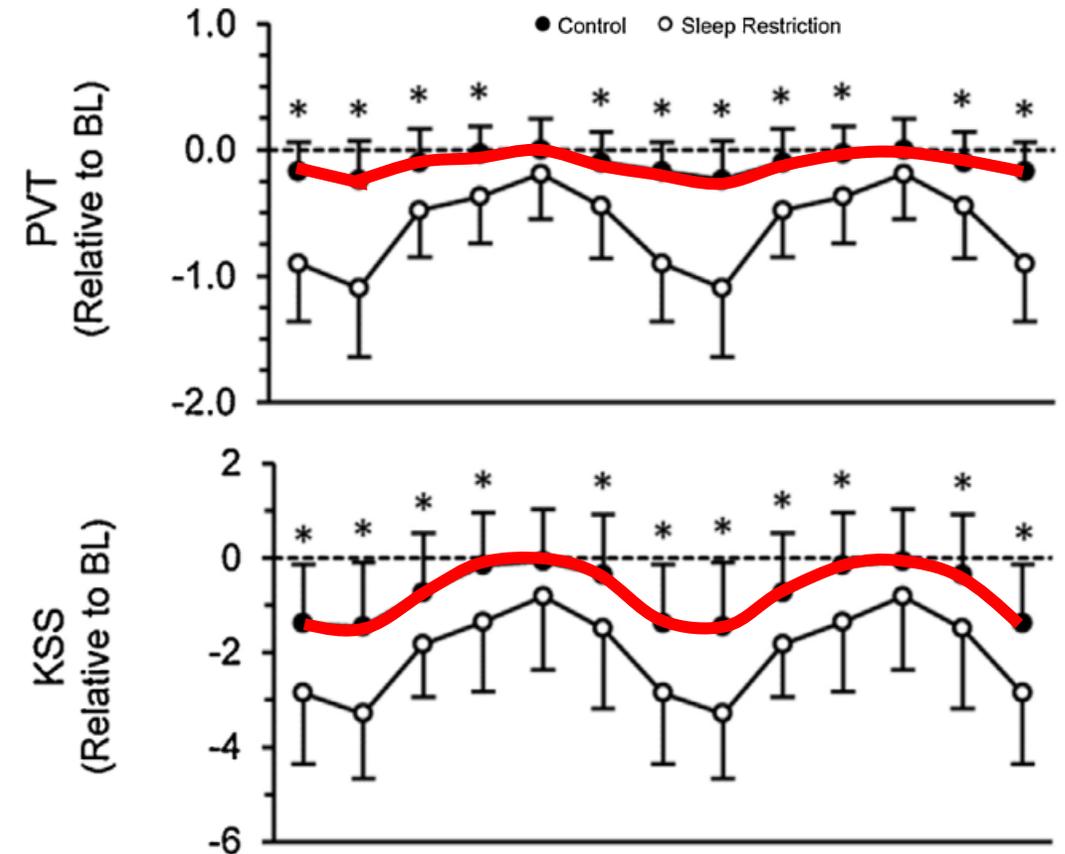
Jet Lag Affects Fatigue.

Performance will be worse when individuals experience circadian misalignment.

Study Design



Results



Kosmadopoulos, et al. "The efficacy of objective and subjective predictors of driving performance during sleep restriction and circadian misalignment."

Accident Analysis & Prevention (2017).

Predicting Fatigue

Things to consider:



Sleep will always be important.



Time of day affects sleep and performance capability.



Jet lag affects sleep and performance capability.

EASA Flight and Duty Time Limitations and Rest Requirements

EASA regulations consider impact of sleep loss, time of day, and circadian misalignment.

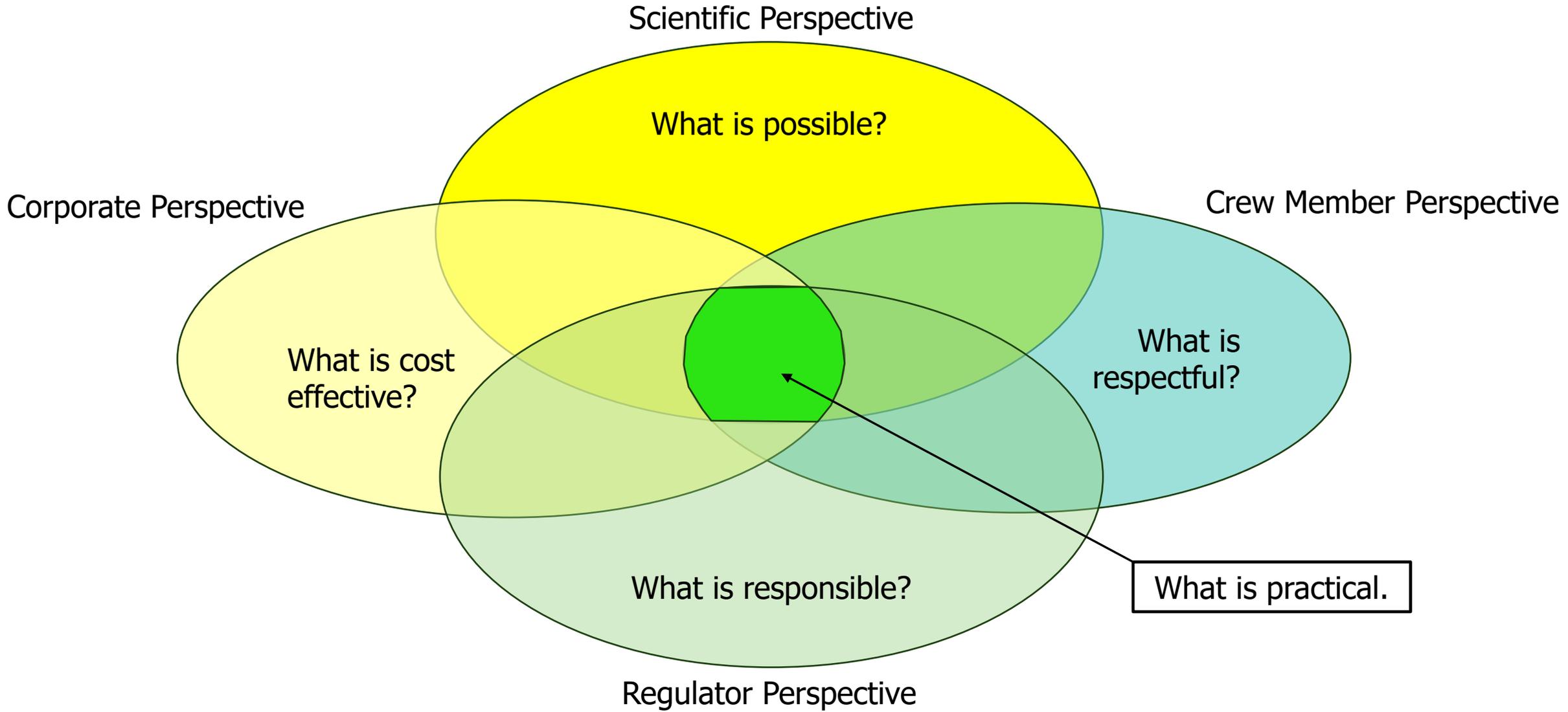
- Fatigue risk management principles for rostering of long night duties may include:
 - avoiding long night duties after extended recovery rest periods
 - progressively delaying the rostered ending time of the FDPs preceding long night duties;
 - starting a block of night duties with a shorter FDP
 - avoiding the sequence of early starts and long night duties

Time difference (h) between reference time and local time where the crew member starts the next duty	Time elapsed since reporting at reference time				
	< 48	48 – 71:59	72 – 95:59	96 – 119:59	≥ 120
< 4	B	D	D	D	D
≥ 4 and ≤ 6	B	X	D	D	D
> 6 and ≤ 9	B	X	X	D	D
> 9 and ≤ 12	B	X	X	X	D

Maximum extended FDP (hours)	Minimum in-flight rest (hours)		
	Class 1	Class 2	Class 3
Up to 14:30	1:30	1:30	1:30
14:31 – 15:00	1:45	2:00	2:20
15:01 – 15:30	2:00	2:20	2:40
15:31 – 16:00	2:15	2:40	3:00
16:01 – 16:30	2:35	3:00	Not allowed
16:31 – 17:00	3:00	3:25	
17:01 – 17:30	3:25	Not allowed	Not allowed
17:31 – 18:00	3:50		

Starting time of FDP	Sectors			
	1 – 2	3	4	5
06:15 - 06:29	13:15	12:45	12:15	11:45
06:30 - 06:44	13:30	13:00	12:30	12:00
06:45 - 06:59	13:45	13:15	12:45	12:15
07:00 - 13:29	14:00	13:30	13:00	12:30
13:30 - 13:59	13:45	13:15	12:45	Not allowed
14:00 - 14:29	13:30	13:00	12:30	
14:30 - 14:59	13:15	12:45	12:15	
15:00 - 15:29	13:00	12:30	12:00	
15:30 - 15:59	12:45	Not allowed		
16:00 - 16:29	12:30			
16:30 – 16:59	12:15	Not allowed		
17:00 – 17:29	12:00			
17:30 – 17:59	11:45	Not allowed		
18:00 – 18:29	11:30			
18:30 – 18:59	11:15			
19:00 – 06:14	Not allowed			

Different Perspectives on Fatigue Risk Management



EASA Key Performance Metrics

- EASA Night Duty Types
- Top of Descent

Work
Performance
Science

SAFTE-FAST EASA Night Duty Types

Identify flight duties that operate during one of three EASA Night Duty Types

Filter analysis results on the following EASA Night Duty Types:

- Type 1 - Flight time 0215 to 0444. Duty period starts at 0200 and ends at 0459.
- Type 2 - Flight time 0214 to 0544. Duty period starts at 0159 and ends at 0559.
- Type 3 - Flight time 0200 to 0545. Duty period starts at 0159 and ends at 0600.

<input type="checkbox"/>	Name	Owner	Modified	Viewed ↓	Viewed By	Start Station	Base Station	Effectiveness Minimum (Crewing)	Effectiveness Minimum (Critical)	KSS Maximum (Critical)	Samn-Perelli Maximum (Critical)	Reservoir Minimum (Crewing)	Reservoir Minimum (Critical)	% Below Criterion (Crewing)	% Below Criterion (Critical)	Total FHA (Crewing)	Total FHA (Critical)	Number of EASA Night Type 1 Duties	Number of EASA Night Type 2 Duties	Number of EASA Night Type 3 Duties
<input type="checkbox"/>	751	Robert Mora	07/08/2024 14:14	07/10/2024 14:27	Robert Mora	CPH	CPH	55.2	55.2	8.4	6.5	64.7	64.7	34.5	23.0	88.1	36.7	1	0	6
<input type="checkbox"/>	331	Robert Mora	07/08/2024 14:18	07/08/2024 14:18	Robert Mora	MMX	MMX	79.3	79.3	6.6	5.2	82.8	82.8	0.0	0.0	0.0	0.0	2	1	1
<input type="checkbox"/>	828	Robert Mora	07/08/2024 14:17	07/08/2024 14:17	Robert Mora	CPH	CPH	70.0	70.0	7.6	6.0	78.2	78.2	0.0	0.0	0.0	0.0	5	3	1
<input type="checkbox"/>	796	Robert Mora	07/08/2024 14:17	07/08/2024 14:17	Robert Mora	KRN	KRN	83.1	83.1	6.0	4.8	83.0	83.0	0.0	0.0	0.0	0.0	4	0	0
<input type="checkbox"/>	725	Robert Mora	07/08/2024 14:16	07/08/2024 14:16	Robert Mora	MPL	MPL	61.1	61.1	8.2	6.4	66.8	66.8	2.7	3.2	9.1	9.1	1	9	7
<input type="checkbox"/>	775	Robert Mora	07/08/2024 14:15	07/08/2024 14:15	Robert Mora	ZRH	ZRH	69.5	69.5	7.7	6.0	77.2	77.2	0.5	0.6	0.0	0.0	5	2	2
<input type="checkbox"/>	738	Robert Mora	07/08/2024 14:14	07/08/2024 14:13		SDL	SDL	72.6	72.6	7.4	5.8	75.4	75.4	0.0	0.0	0.0	0.0	1	2	2
<input type="checkbox"/>	508	Robert Mora	07/08/2024 14:14	07/08/2024 14:13		CDG	CDG	77.8	77.8	6.8	5.4	80.8	80.8	0.0	0.0	0.0	0.0	0	0	0



SAFTE-FAST EASA Night Duty Types

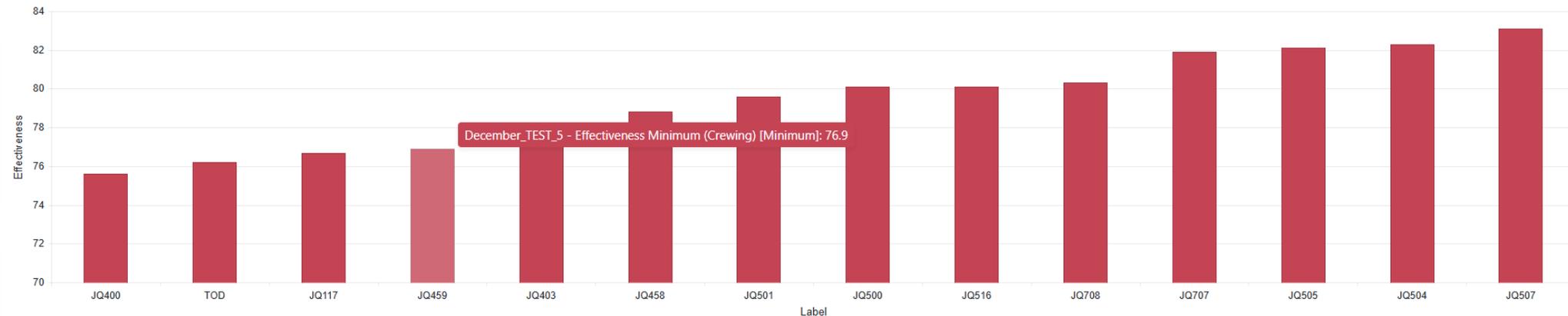
Identify flight duties that operate during one of three EASA Night Duty Types

Alertness levels during EASA Night Duty Types:

- Generate reports on Effectiveness during:
 - Type 1 - Flight time 0215 to 0444. Duty period starts at 0200 and ends at 0459.
 - Type 2 - Flight time 0214 to 0544. Duty period starts at 0159 and ends at 0559.
 - Type 3 - Flight time 0200 to 0545. Duty period starts at 0159 and ends at 0600.

Reports Dashboard \ Report View

EASA Night Type Effectiveness



December_TEST_5 - Effectiveness Minimum (Crewing) [Minimum]

SAFTE-FAST EASA Night Duty Types

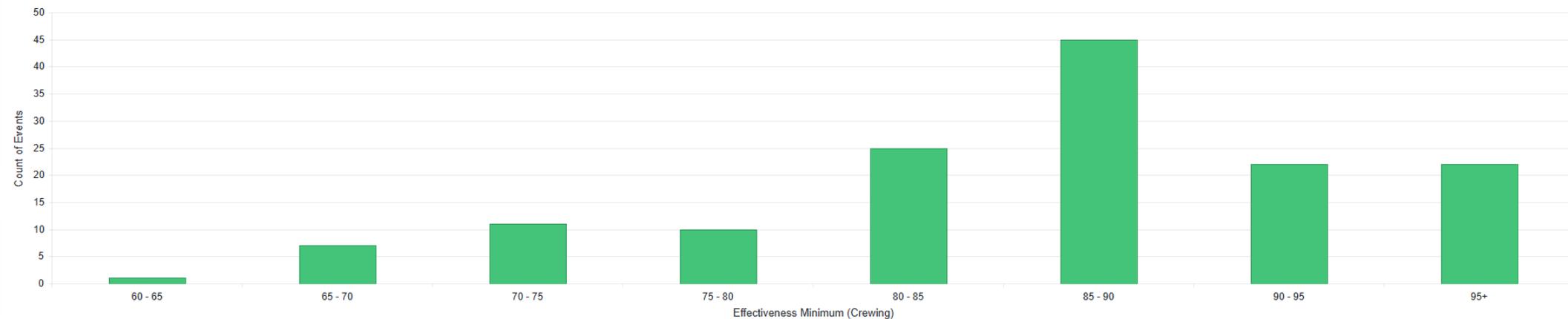
Identify flight duties that operate during one of three EASA Night Duty Types

Alertness levels at Top of Descent (TOD) during EASA Night Duty Types:

- Insert TOD on flight duties, TOD is configurable XX minutes prior to landing:
 - Alertness Level at TOD during Type 1 - Flight time 0215 to 0444. Duty period starts at 0200 and ends at 0459.
 - Alertness Level at TOD during Type 2 - Flight time 0214 to 0544. Duty period starts at 0159 and ends at 0559.
 - Alertness Level at TOD during Type 3 - Flight time 0200 to 0545. Duty period starts at 0159 and ends at 0600.

Reports Dashboard \ Report View

Effectiveness at TOD



December TEST 5 - Effectiveness Minimum (Crewing) (Count)

SAFTE-FAST Circadian Swap Duties

Identify the number of duty circadian swaps in a schedule period

Circadian Swaps are flagged if the following 3 condition occurs during schedule analysis:

1. A duty will be defined as a Duty Circadian Swap if the end of the previous duty is labeled as a Late End and the start of the next duty is labeled as an Early Start.
2. Or, if the start of the previous duty is labeled as an Early Start and the end of the next duty is labeled as a Late End.
3. Also, the prior rest between the duties must be less than 36 hours.

The definitions of an Early Start and Late End is configurable:

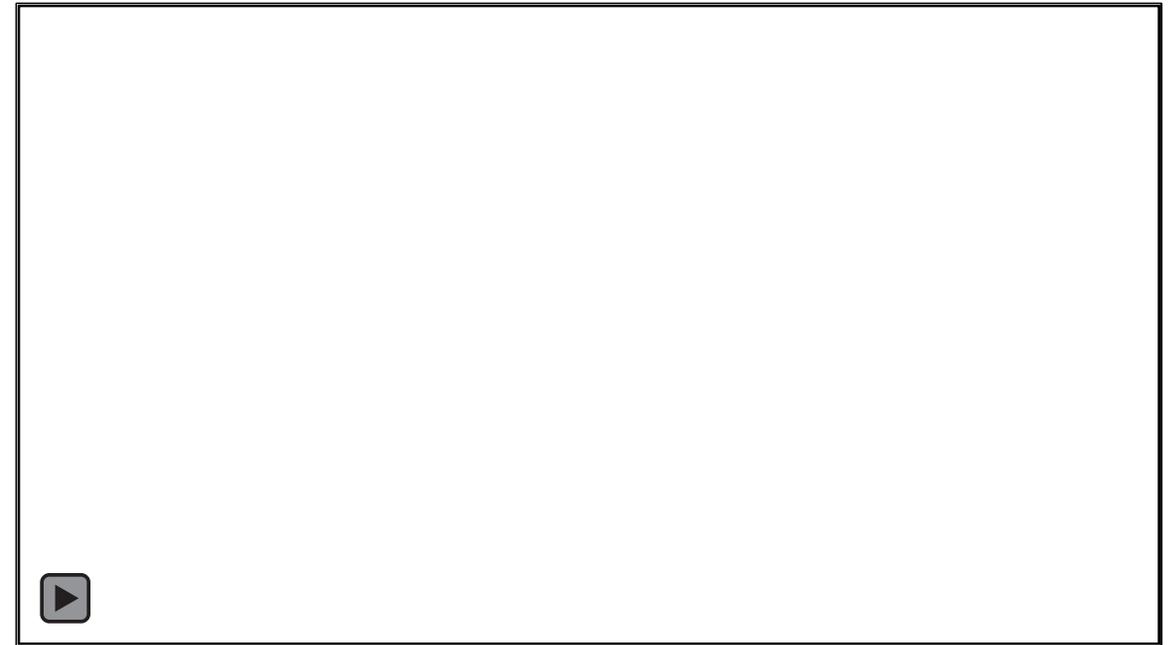
	Start	End	Time Reference
Early Start	03:00	07:00	Local
Late End	22:00	03:00	Local

SAFTE-FAST Reporting

Default & Custom Reports

Data Analytics

Immediate Drill-down



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