NATO Flight Surgeons Conference,
Garmisch, 24 Mar 22

ROYAL AIR FORCE

RAF AIRCREW FATIGUE:
Assessment, Management, Research

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Disclosure

Clearance number 187

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- I may discuss specific products, but that does not confer endorsement
- I have no financial interest in this material
- I self-funded to be at this Conference.

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Scope

- Introduction
- Assessment
  - What is fatigue
- Management
  - Modelling, Aeromedical advice
- Research
  - Current and future research
- Other technologies

What is fatigue

- **Fatigue**:
  "A physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety related duties" [ICAO]

Introduction

- Familiar with the hazards of fatigue
- Military risks:
  - Disturbed sleep
  - Circadian disruption – deployment
  - Circadian mismatch – night VULs
    - Greater with advent of steath.

Introduction (2)

- Fatigue reduction – force preserver
- Active fatigue mitigation:
  - Higher performance
  - Increased productivity
  - Fewer errors, incidents and accidents.

Introduction (3)

- Effective and safe flight scheduling
  - Fatigue avoidance guidance
  - Assurance with validated tools

Introduction (4) – Despite this….

- Reports of fatigue in D-ASORs
- Adverse comments about fatigue:
  - Types of flying / platforms
  - Operational locations
- **Almost all experienced aircrew report falling asleep on duty**
- Comd(s) interest in fatigue.

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Introduction (5)

- ICAO SARPs support 2 distinct approaches to fatigue management:
  - **Prescriptive**
    - **Flight and duty time limits – Regulator defined**
  - Performance-based
    - Operator develops and implements Fatigue Risk Management System (FRMS), approved by the Regulator.

Introduction (6)

- Key points from FRMS:
  - Need to assess (measure) fatigue, and
  - Safety Performance Indicators:
    - Metrics from: Roster, Fatigue Reporting, Subjective Fatigue Survey, Subjective Alertness/Sleepiness Assessment, Subjective Sleep/Wake Diary, Objective Performance, Objective Sleep, Fatigue Model.
- **No RA requirement to assess, or report SPIs**
- Therefore, Military rules are prescriptive.

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Fatigue guidance sources

- MAA RA2345 [link] – Management of aircrew fatigue
- MAA RA3207 [link] – Controller fatigue management
  - AP8000 [link] – RAF Safety Management Policy
    - Lflt 8213 [link] – Fatigue Management
- Group Air Staff Orders (GASOs) – Various
- ICAO [link] – Suite of Fatigue Management Manuals
- EWTD, EASA FTL
- HSE FRI [link] and calculator v2.3 [link]
- DSTL Sleep Education on DLE [link]

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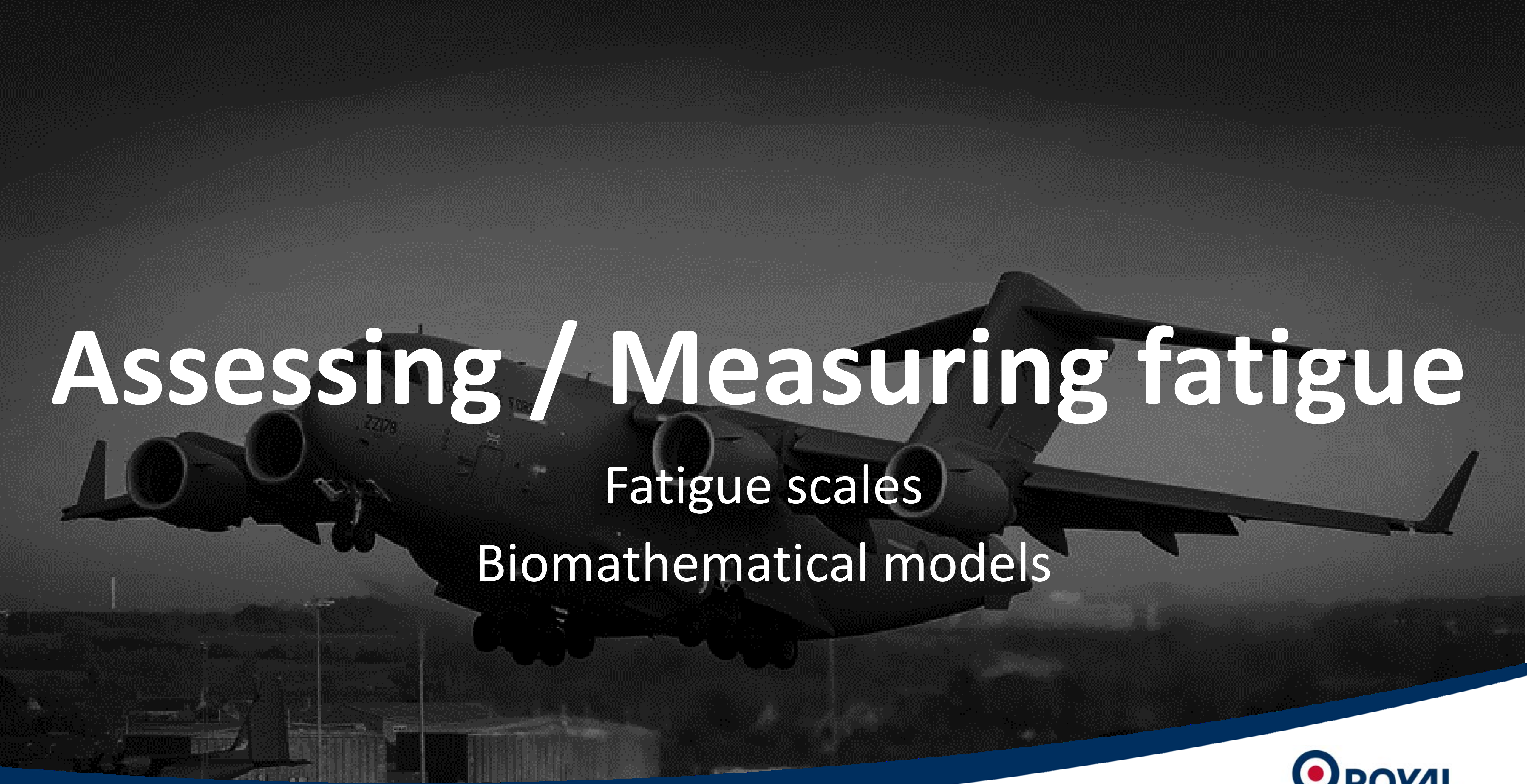

Assessing / Measuring fatigue

Fatigue scales

Biomathematical models

Evaluating fatigue [IATA]: Common Protocol for Minimum Data Collective Variables

Level	Measure
1	Background Questionnaire, or Subjective survey assessment about operations
2	Sleepiness or alertness ratings, e.g. KSS or Samn-Perelli Fatigue Scale
3	Sleep/activity and duty logs
4	Actigraphy
5	Objective Performance Testing

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Subjective Fatigue Assessment:
Samn-Perelli Scale (SPS)

Level	Measure
1	Fully alert, wide awake
2	Very lively, responsive, but not at peak
3	OK, somewhat fresh
4	A little tired, less than fresh
5	Moderately tired, let down
6	Extremely tired, very difficult to concentrate
7	Completely exhausted, unable to function effectively

Subjective Fatigue Assessment: Karolinska Sleepiness Scale (KSS)[1]

Level	Measure
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 effort to keep awake
8	Sleepy, but some effort to keep awake
9	Very sleepy, great effort to keep awake, fighting sleep
10	Extremely sleepy, can’t keep awake

1 Akerstedt T, Gillberg M. (1990). Subjective and objective sleepiness in the active individual. International Journal of Neuroscience, 52, 29–37

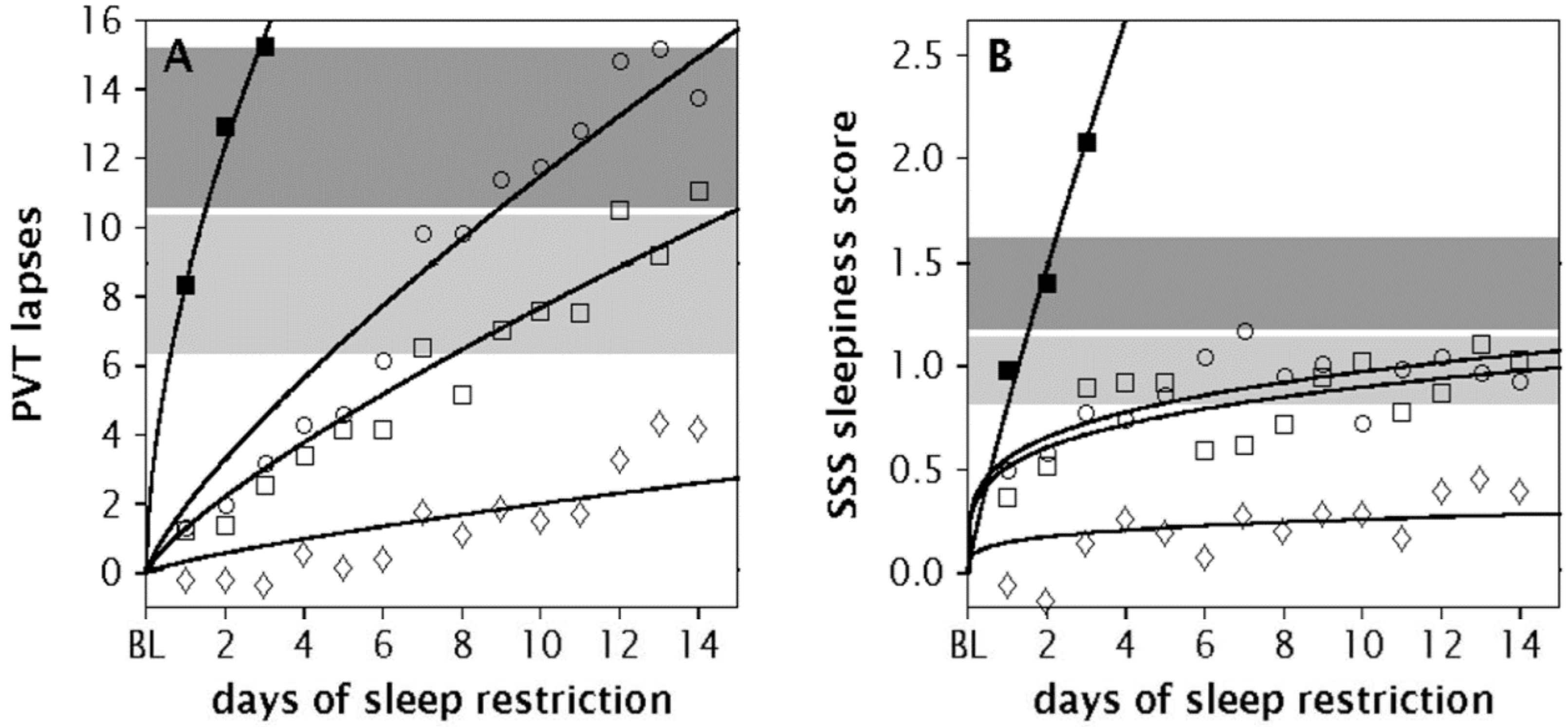

Figure 1—Neurobehavioral responses to varying doses of daily sleep. Four different neurobehavioral assays served to measure cognitive performance capability and subjective sleepiness. Each panel displays group averages for subjects in the 8 h (◊), 6 h (□), and 4 h (○) chronic sleep period conditions across 14 days, and in the 0 h (■) sleep condition across 3 days. Subjects were tested every 2 h each day; data points represent the daily average (07:30–23:30) expressed relative to baseline (BL). Panel A shows psychomotor vigilance task (PVT) performance lapses; panel B shows Stanford Sleepiness Scale (SSS) self-ratings; panel C shows digit symbol substitution task (DSST) correct responses; and panel D shows serial addition/subtraction task (SAST) correct responses per min. Upward corresponds to worse performance on the PVT and greater sleepiness on the SSS, and to better performance on the DSST and the SAST. The curves through the data points represent statistical non-linear model-based best-fitting profiles of the response to sleep deprivation (equation (1)) for subjects in each of the four experimental conditions. The mean ± s.e. ranges of neurobehavioral functions for 1 and 2 days of 0 h sleep (total sleep deprivation) are shown as light and dark gray bands, respectively, allowing comparison of the 3-day total sleep deprivation condition and the 14-day chronic sleep restriction conditions. For the DSST and SAST, these gray bands are curved parallel to the practice effect displayed by the subjects in the 8 h sleep period condition, to compensate for different amounts of practice on these tasks.

Why we cannot use subjective self-ratings to determine fatigue.

Van Dongen et al. The Cumulative Cost of Additional Wakefulness: Dose-Response Effects on Neurobehavioral Functions and Sleep Physiology From Chronic Sleep Restriction and Total Sleep Deprivation. Sleep. Vol 26(2); 2003.

Subjective Fatigue Assessment: Models (1)

- **System for Aircrew Fatigue Evaluation (SAFE)**
  - Output is KSS
- **Fatigue Assessment Tool by InterDynamics (FAID)**
  - Output is KSS
- **Boeing Alertness Model (BAM)** aka Jeppesen Crew Alert®
  - Output is KSS

Objective Fatigue Assessment: Model

- **Sleep, Activity, Fatigue, and Task Effectiveness model** and **Fatigue Avoidance Scheduling Tool (SAFTE-FAST)**
  - Output is a numerical value (0-100)
  - Correlates with PVT
  - High values = less fatigue
  - Value at 70, and below = perform as well on PVT as someone who has BAC 80 mg%
  - Statistically significant increased chance of road, rail transportation safety accident (≤ 70)

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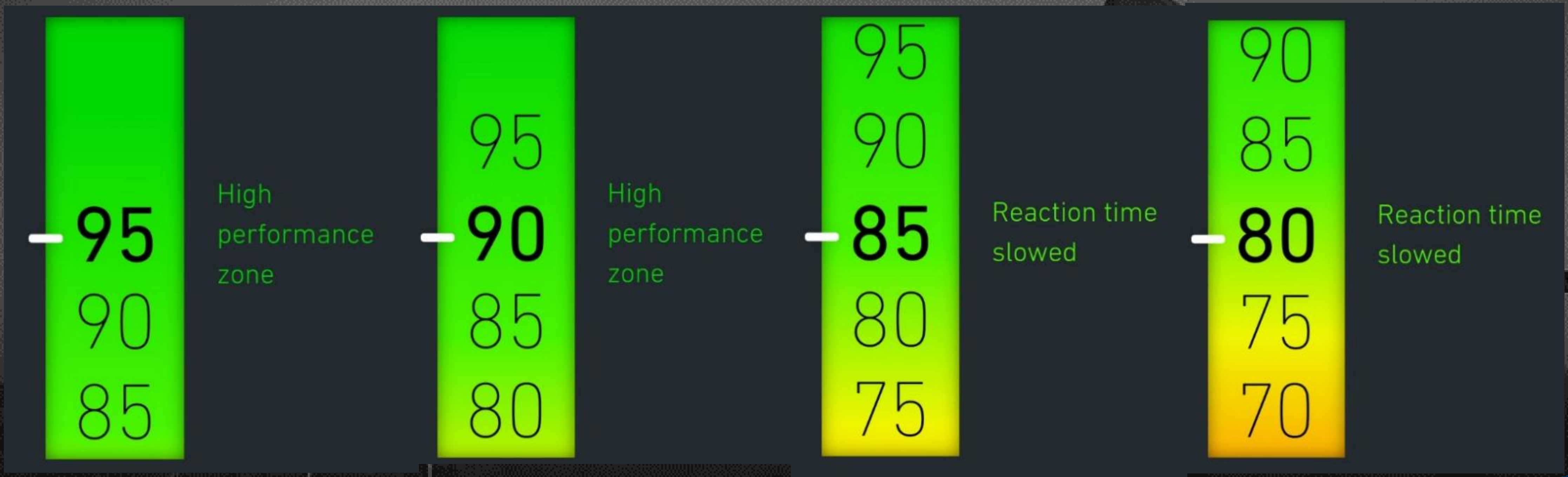
Objective Fatigue Assessment: FAST

Sleep time equivalence (sustained)

8 hrs | 7 hrs | 6½ hrs | 5½ hrs



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Objective Fatigue Assessment: FAST

Sleep time equivalence (sustained)

5½ hrs **5 hrs** **4½ hrs** **4 hrs**

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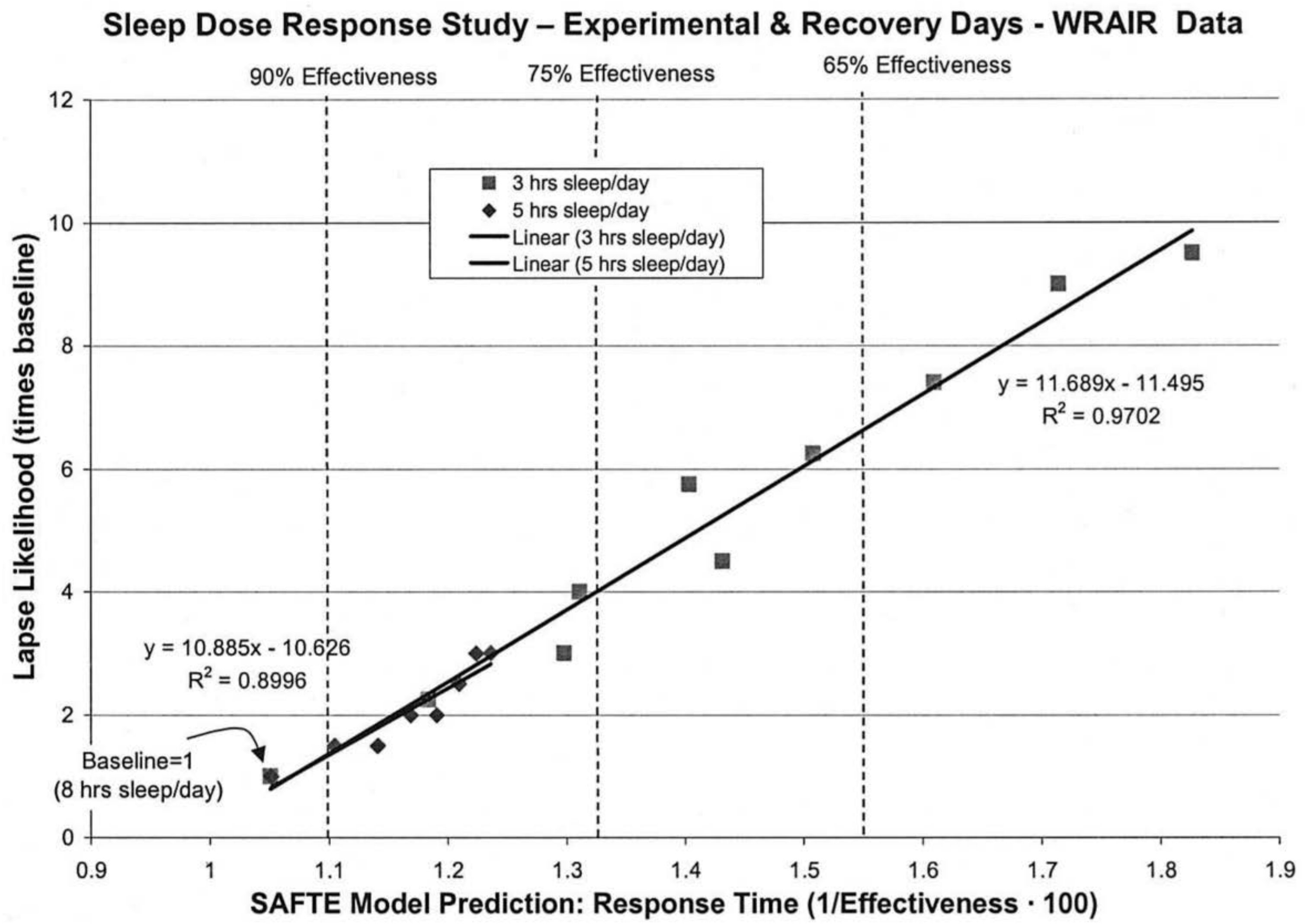

Fig. 7. Likelihood of lapses on the PVT is a linear function of the inverse of effectiveness predicted by the SAFTE Model optimized for PVT speed. These data are based on the results of the sleep dose response study (6).

Hursh et al. Fatigue Models for Applied Research in Warfighting. Aviation, Space, and Environmental Medicine March 2004;75(Supplement 1): A44-A53.

Managing fatigue

Modelling / Aeromedical Advice

Fatigue Modelling product

C-17 BZZ–MSP–BOI–MSF–BZZ

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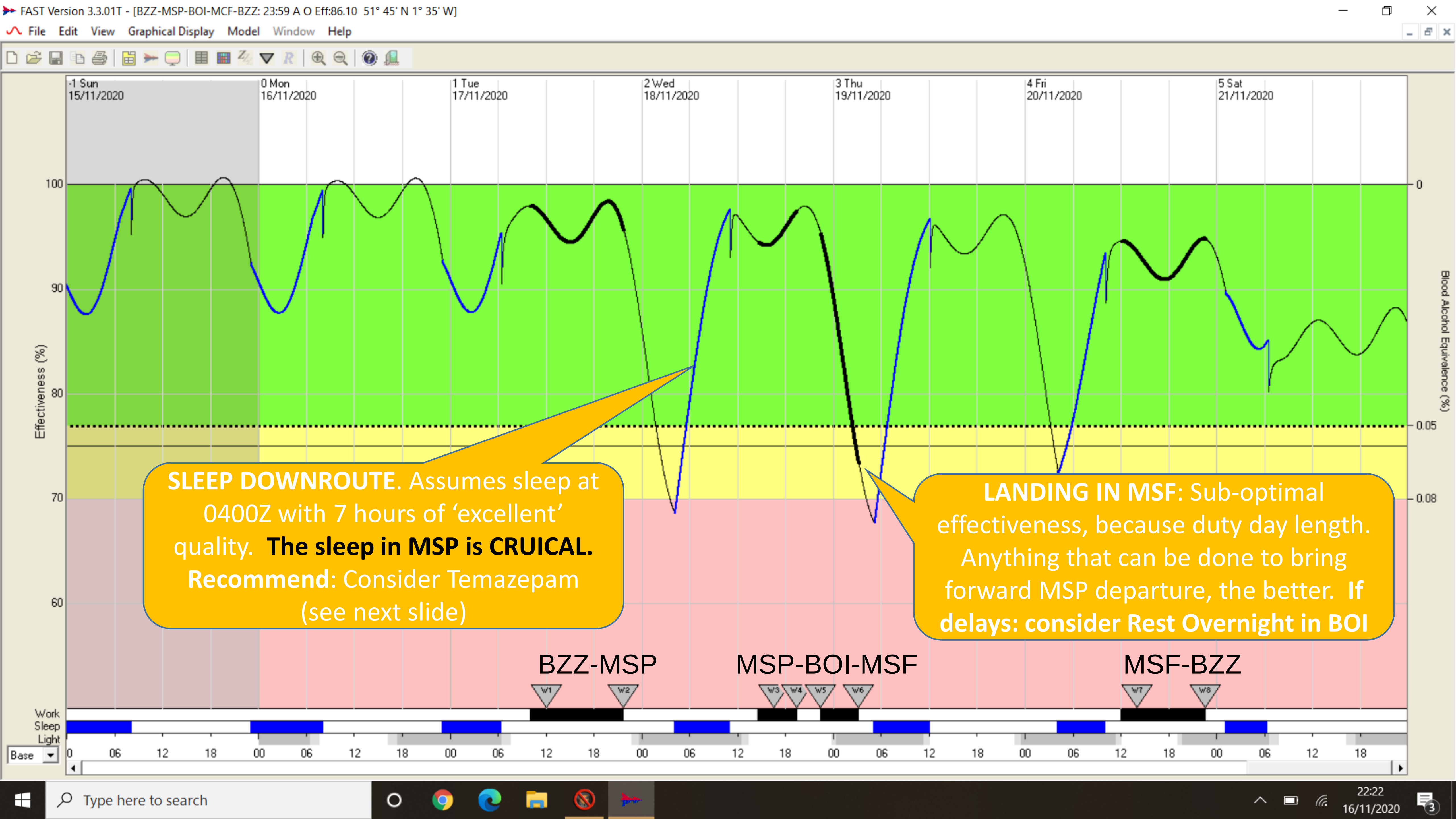
Aviation Medicine Matters

16 Nov 2020 v1



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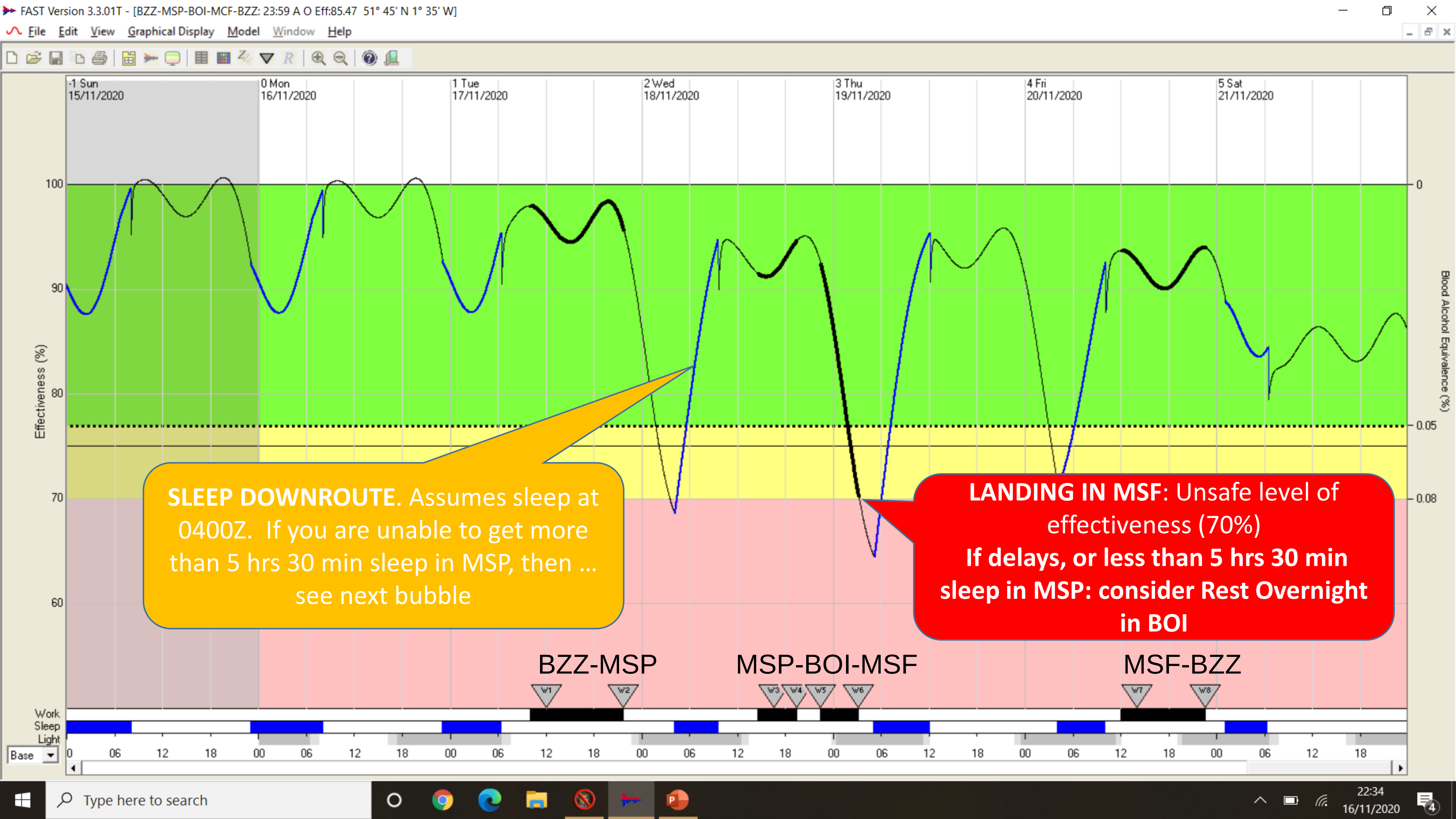
File Edit View Graphical Display Model Window Help
-1 Sun 15/11/2020
0 Mon 16/11/2020
1 Tue 17/11/2020
2 Wed 18/11/2020
3 Thu 19/11/2020
4 Fri 20/11/2020
5 Sat 21/11/2020
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
SLEEP DOWNROUTE. Assumes sleep at 0400Z with 7 hours of 'excellent' quality. The sleep in MSP is CRUICAL. Recommend: Consider Temazepam (see next slide)
LANDING IN MSF: Sub-optimal effectiveness, because duty day length. Anything that can be done to bring forward MSP departure, the better. If delays: consider Rest Overnight in BOI
BZZ-MSP
MSP-BOI-MSF
MSF-BZZ
W1 W2 W3 W4 W5 W6 W7 W8
Work
Sleep
Light
Base
0 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18
Type here to search
22:22
16/11/2020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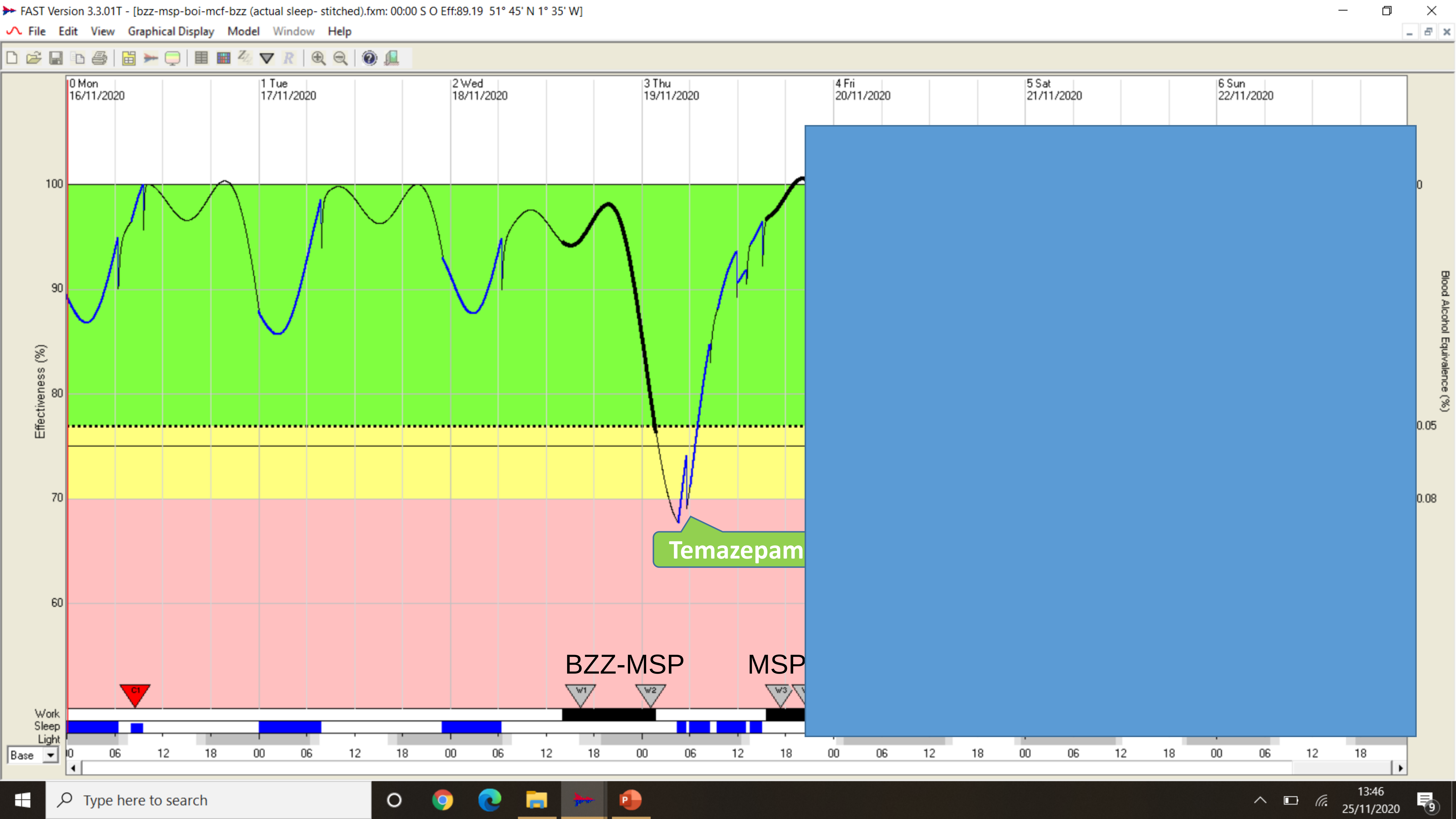
0 Mon 16/11/2020
1 Tue 17/11/2020
2 Wed 18/11/2020
3 Thu 19/11/2020
4 Fri 20/11/2020
5 Sat 21/11/2020
Effectiveness (%)
Blood Alcohol Equivalence (%)
100
90
80
70
60
0
0.05
0.08
SLEEP DOWNROUTE. Assumes sleep at 0400Z. If you are unable to get more than 5 hrs 30 min sleep in MSP, then … see next bubble
LANDING IN MSF: Unsafe level of effectiveness (70%)
If delays, or less than 5 hrs 30 min sleep in MSP: consider Rest Overnight in BOI
BZZ-MSP
MSP-BOI-MSF
MSF-BZZ
W1
W2
W3
W4
W5
W6
W7
W8
Work
Sleep
Light
Base
0 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18
Type here to search
22:34
16/11/2020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File Edit View Graphical Display Model Window Help
0 Mon 16/11/2020
1 Tue 17/11/2020
2 Wed 18/11/2020
3 Thu 19/11/2020
4 Fri 20/11/2020
5 Sat 21/11/2020
6 Sun 22/11/2020
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
Temazepam
BZZ-MSP
MSP
C1
W1
W2
W3
Work
Sleep
Light
Base
00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18
Type here to search
13:46
25/11/2020

Proposed C-17 Op TORAL Current Schedule (Crew 1 & 2) v4

Provided on behalf of RAFCAM by:
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22 Apr 21 v4.0

Aviation Medicine Matters

Current Schedule

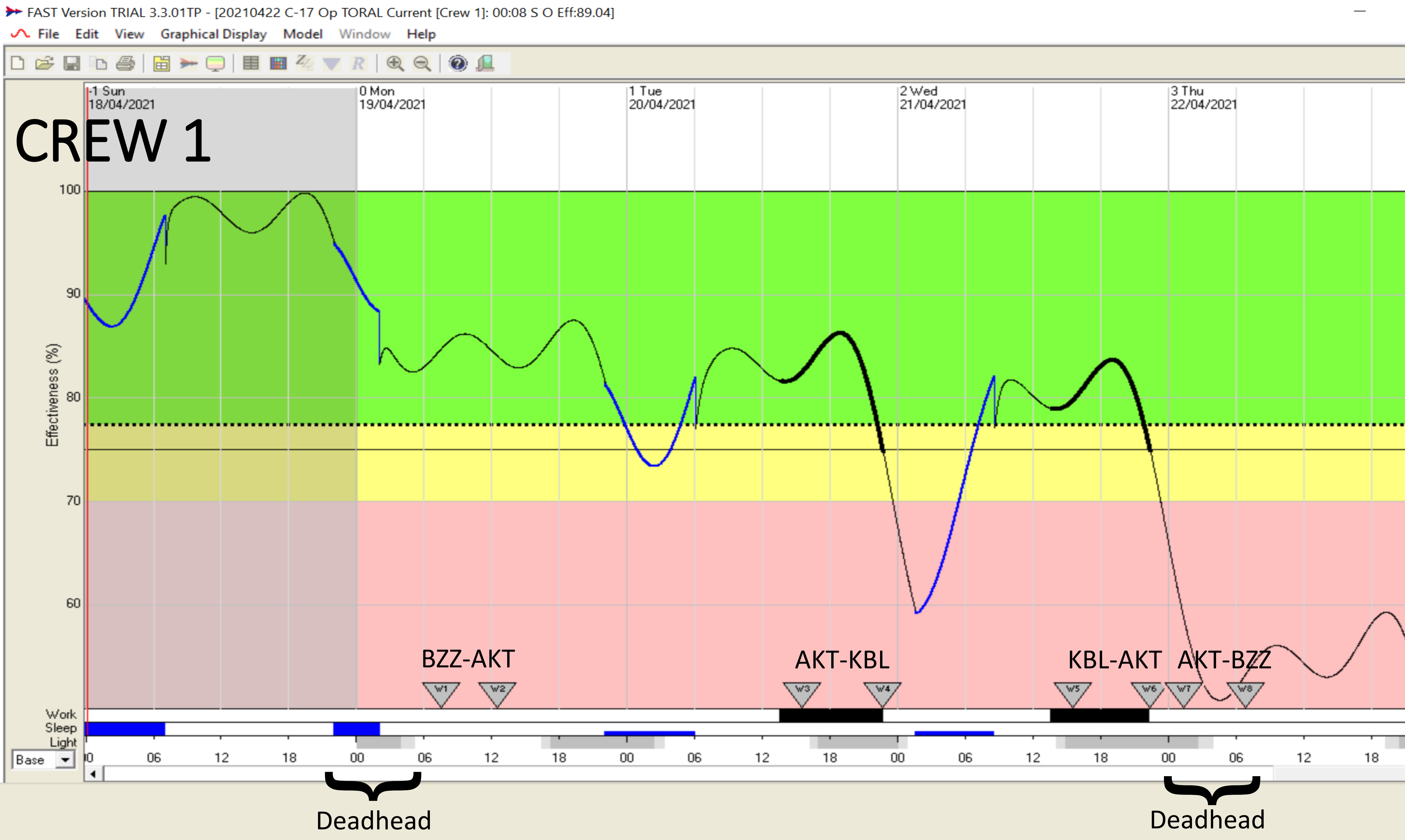
Arr			Dep	
L	Z		Z	L
		BZZ	0730	0830
1530	1230	AKT	1530	1830
0310	2240	KBL	1530	2000
0120	2220	AKT	0120	0420
0750	0650	BZZ		

Crew 1:
Day 1- Deadhead Voyager from BZZ to AKT
Day 2- Crews C-17 from AKT to KBL
Day 3- Crews C-17 from KBL to AKT
Day 4- Deadhead C-17 from AKT to BZZ

Crew 2:
Day 1- Crews C-17 from BZZ to AKT
Day 2- Rest
Day 3- Rest
Day 4- Crews C-17 from AKT to BZZ

V.3 Adjustments:

1. **90 minute check-in**
2. **Sleep quality improved from Poor to Fair (AKT ONLY)**
3. **1&2 Combined**
4. **Deadhead flight times corrected**



FAST Version TRIAL 3.3.01TP - [20210422 C-17 Op TORAL Current [Crew 1]: 00:08 S O Eff:89.04]
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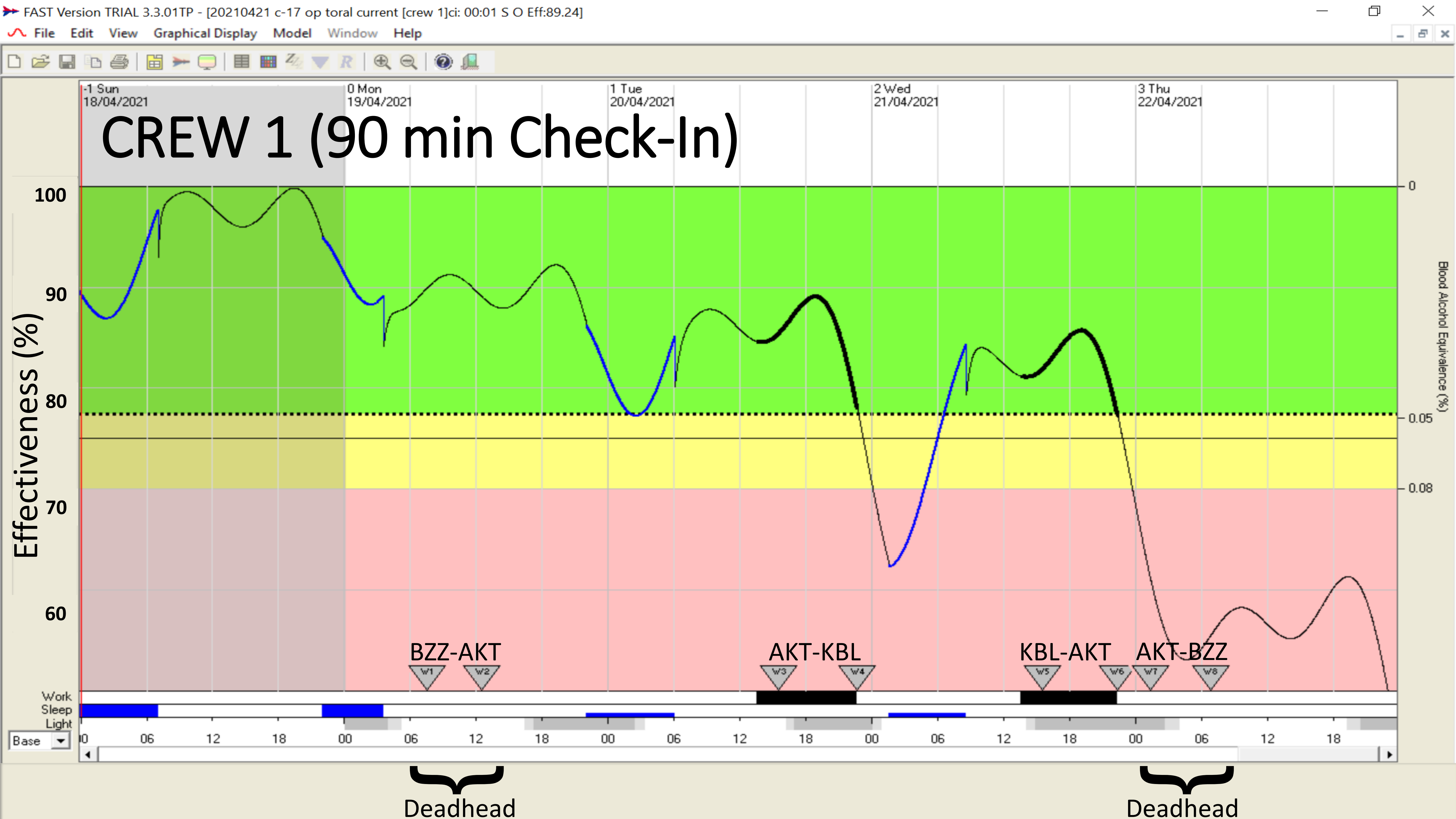
CREW 1
-1 Sun 18/04/2021
0 Mon 19/04/2021
1 Tue 20/04/2021
2 Wed 21/04/2021
3 Thu 22/04/2021
Effectiveness (%)
100
90
80
70
60
BZZ-AKT
AKT-KBL
KBL-AKT
AKT-BZZ
W1
W2
W3
W4
W5
W6
W7
W8
Work
Sleep
Light
Base
00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18
Deadhead
Deadhead


FAST Version 3.3.01T - [20210419 C-17 Op TORAL current [CREW 2].fxm: 08:23z A O Eff:85.30 34° 35' N 32° 59' E]
File Edit View Graphical Display Model Window Help
CREW 2
Mon 19/04/2021z
Tue 20/04/2021z
Wed 21/04/2021z
Thu 22/04/2021z
Fri 23/04/2021z
It will be difficult for crews to sleep at this time, because of the body's natural rhythm. Likely to have to use temazepam
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
BZZ-AKT
AKT-BZZ
W1
W2
W3
W4
Work
Sleep
Light
Zulu
18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12

Effect of reducing check-in time to 90 min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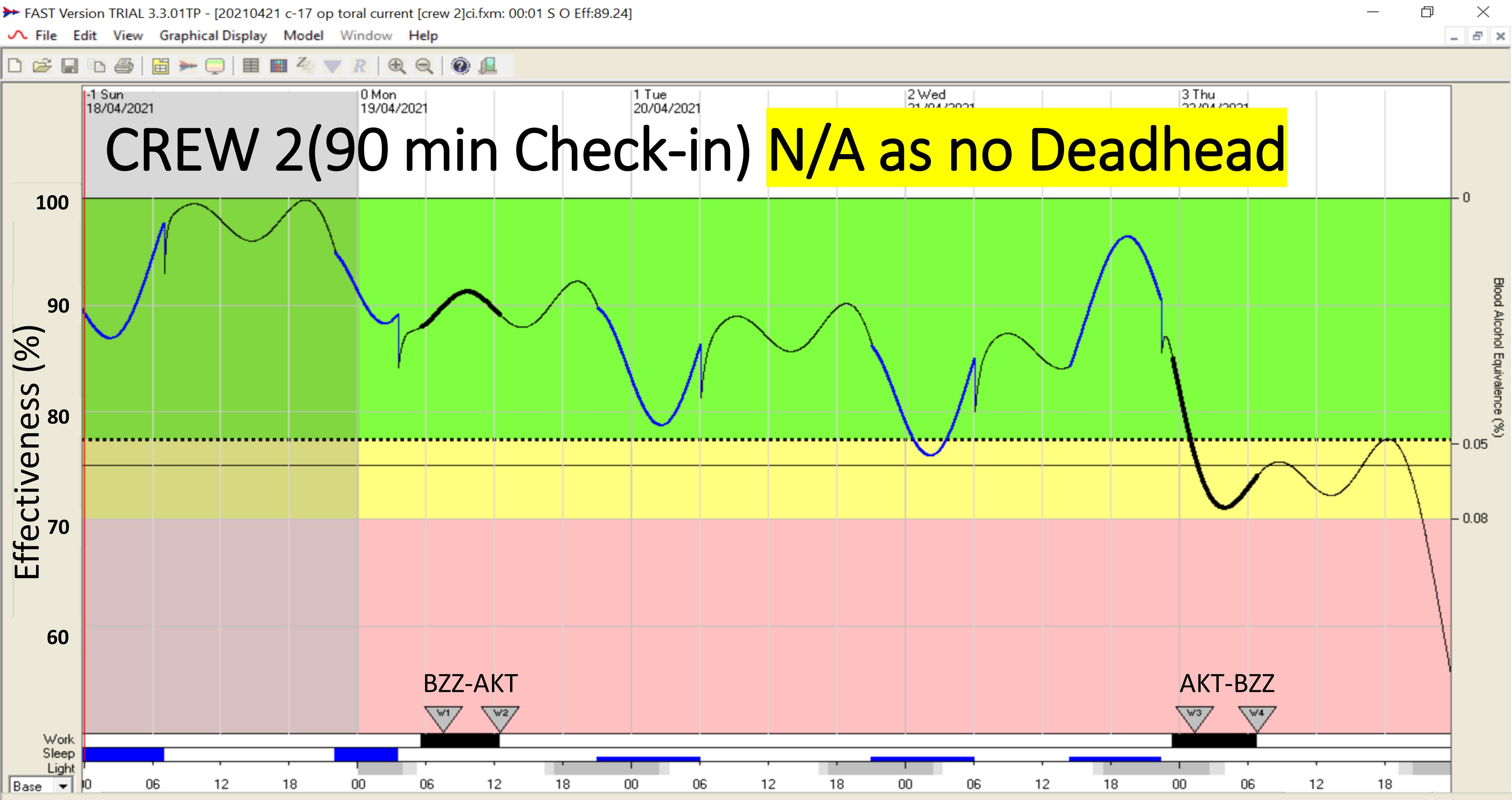
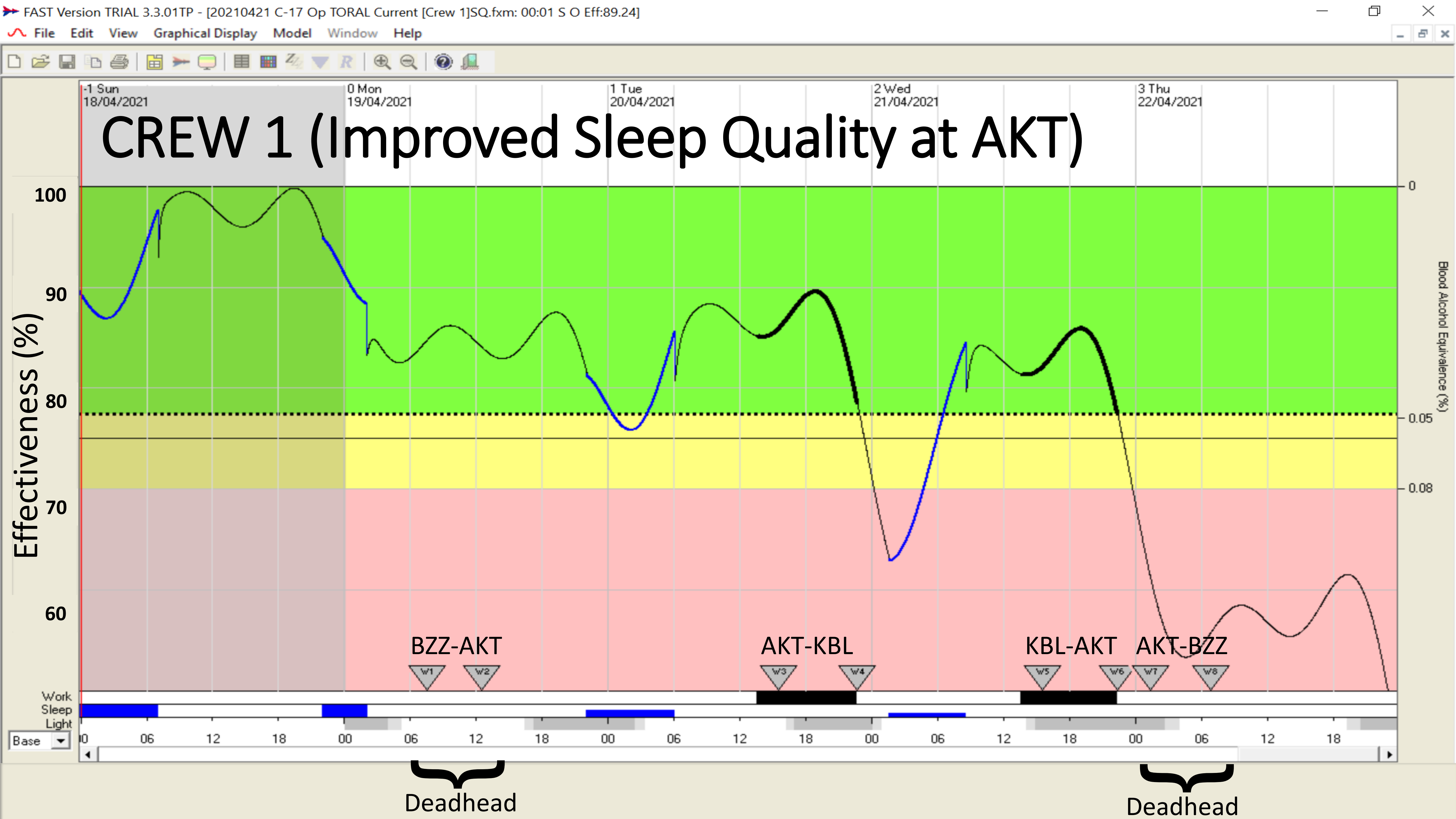
File Edit View Graphical Display Model Window Help
CREW 1 (90 min Check-In)
-1 Sun 18/04/2021
0 Mon 19/04/2021
1 Tue 20/04/2021
2 Wed 21/04/2021
3 Thu 22/04/2021
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
BZZ-AKT
AKT-KBL
KBL-AKT
AKT-BZZ
W1
W2
W3
W4
W5
W6
W7
W8
Work
Sleep
Light
Base
00
06
12
18
Deadhead
Deadhead


FAST Version TRIAL 3.3.01TP - [20210421 c-17 op toral current [crew 2]ci.fxm: 00:01 S O Eff:89.24]
File Edit View Graphical Display Model Window Help
-1 Sun 18/04/2021
0 Mon 19/04/2021
1 Tue 20/04/2021
2 Wed
3 Thu
CREW 2(90 min Check-in) N/A as no Deadhead
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
BZZ-AKT
AKT-BZZ
W1
W2
W3
W4
Work
Sleep
Light
Base
06
12
18
00

Effect of improving accommodation in AKT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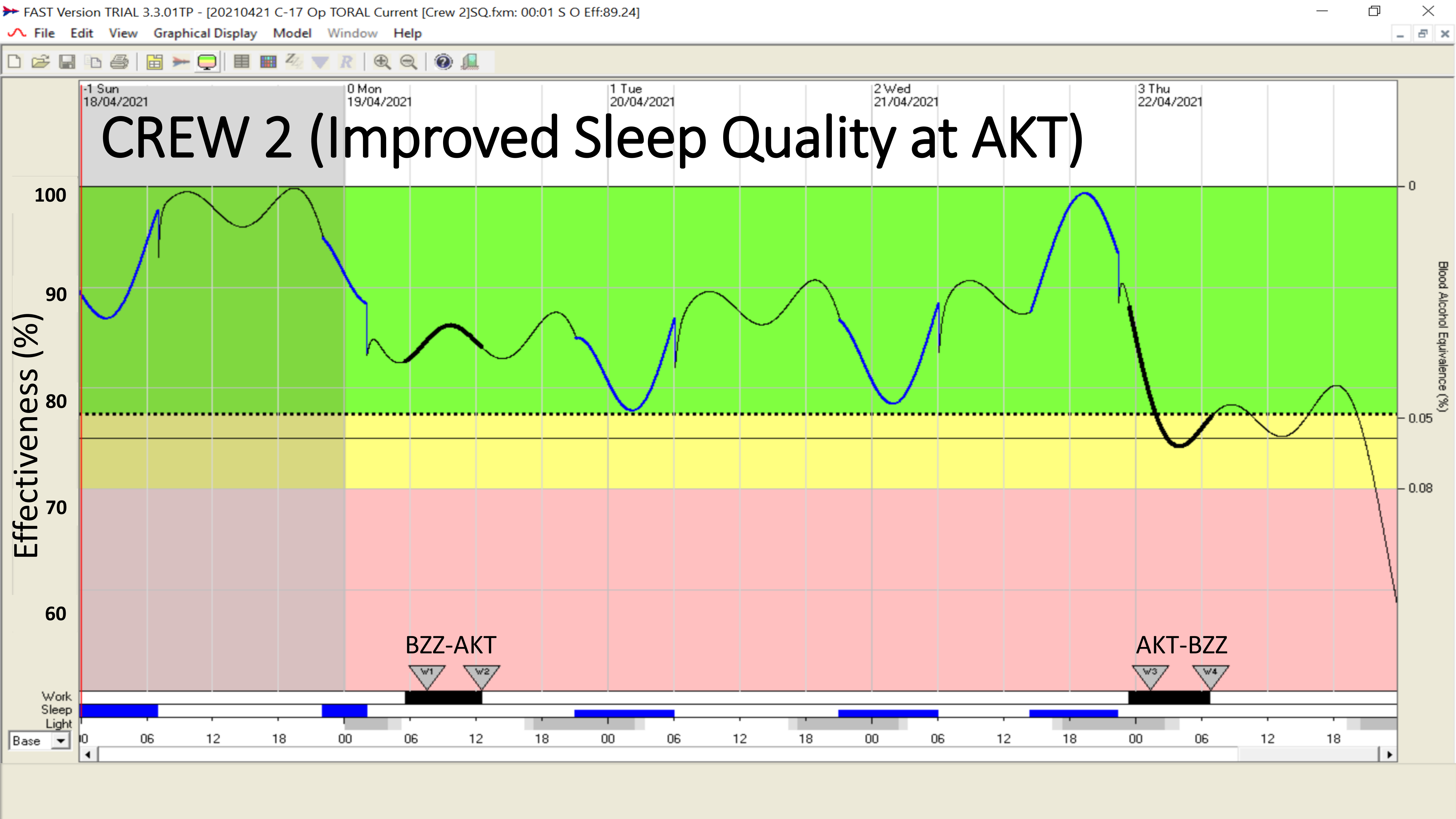
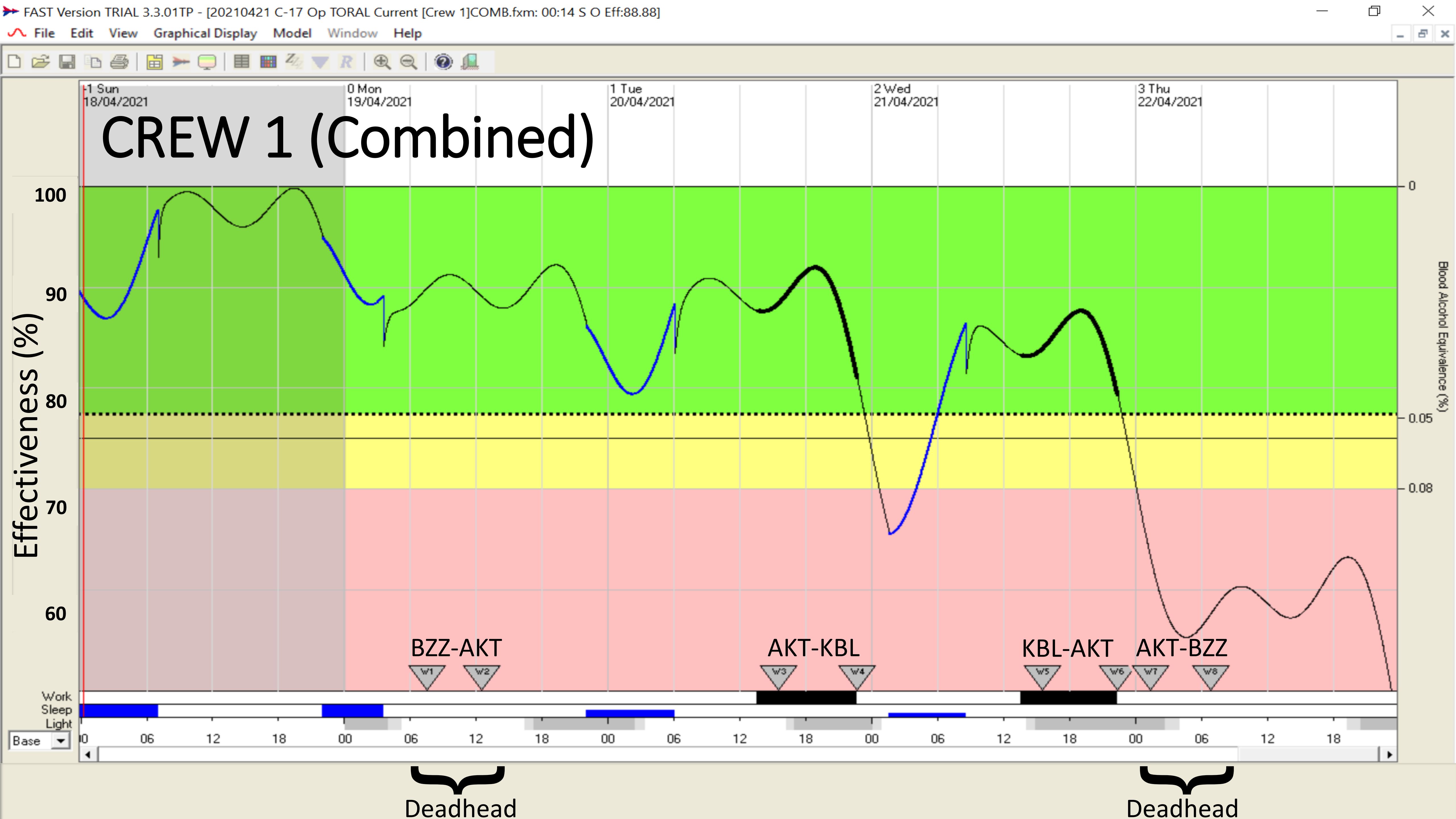
File Edit View Graphical Display Model Window Help
CREW 1 (Improved Sleep Quality at AKT)
-1 Sun 18/04/2021
0 Mon 19/04/2021
1 Tue 20/04/2021
2 Wed 21/04/2021
3 Thu 22/04/2021
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
BZZ-AKT
AKT-KBL
KBL-AKT
AKT-BZZ
W1
W2
W3
W4
W5
W6
W7
W8
Work
Sleep
Light
Base
00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18
Deadhead
Deadhead



FAST Version TRIAL 3.3.01TP - [20210421 C-17 Op TORAL Current [Crew 2]SQ.fxm: 00:01 S O Eff:89.24]
File Edit View Graphical Display Model Window Help
CREW 2 (Improved Sleep Quality at AKT)
-1 Sun 18/04/2021
0 Mon 19/04/2021
1 Tue 20/04/2021
2 Wed 21/04/2021
3 Thu 22/04/2021
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
BZZ-AKT
AKT-BZZ
W1
W2
W3
W4
Work
Sleep
Light
Base
00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18

Effect of 90 min check-in for deadheading crews, and improving accommodation in AKT



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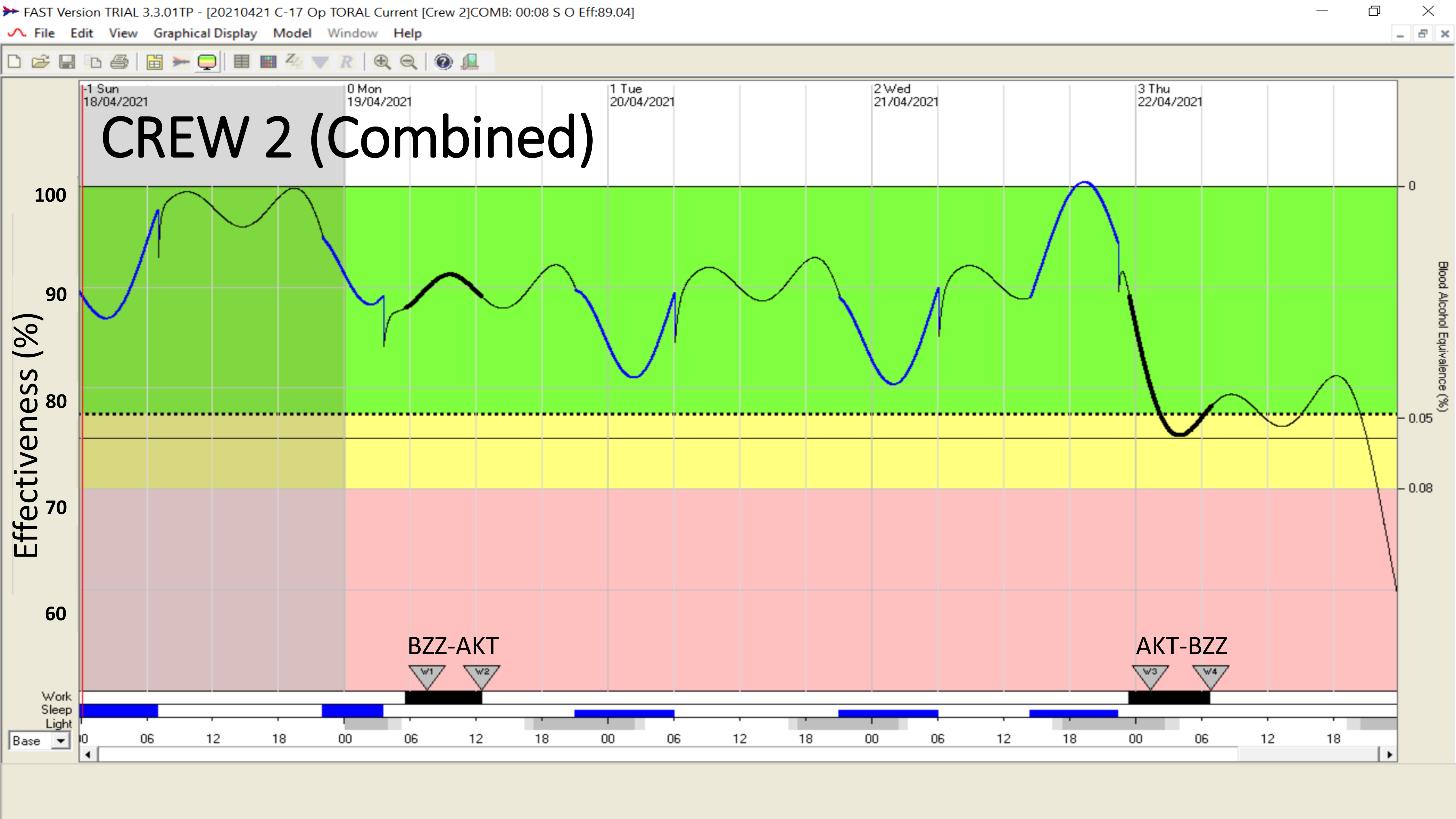
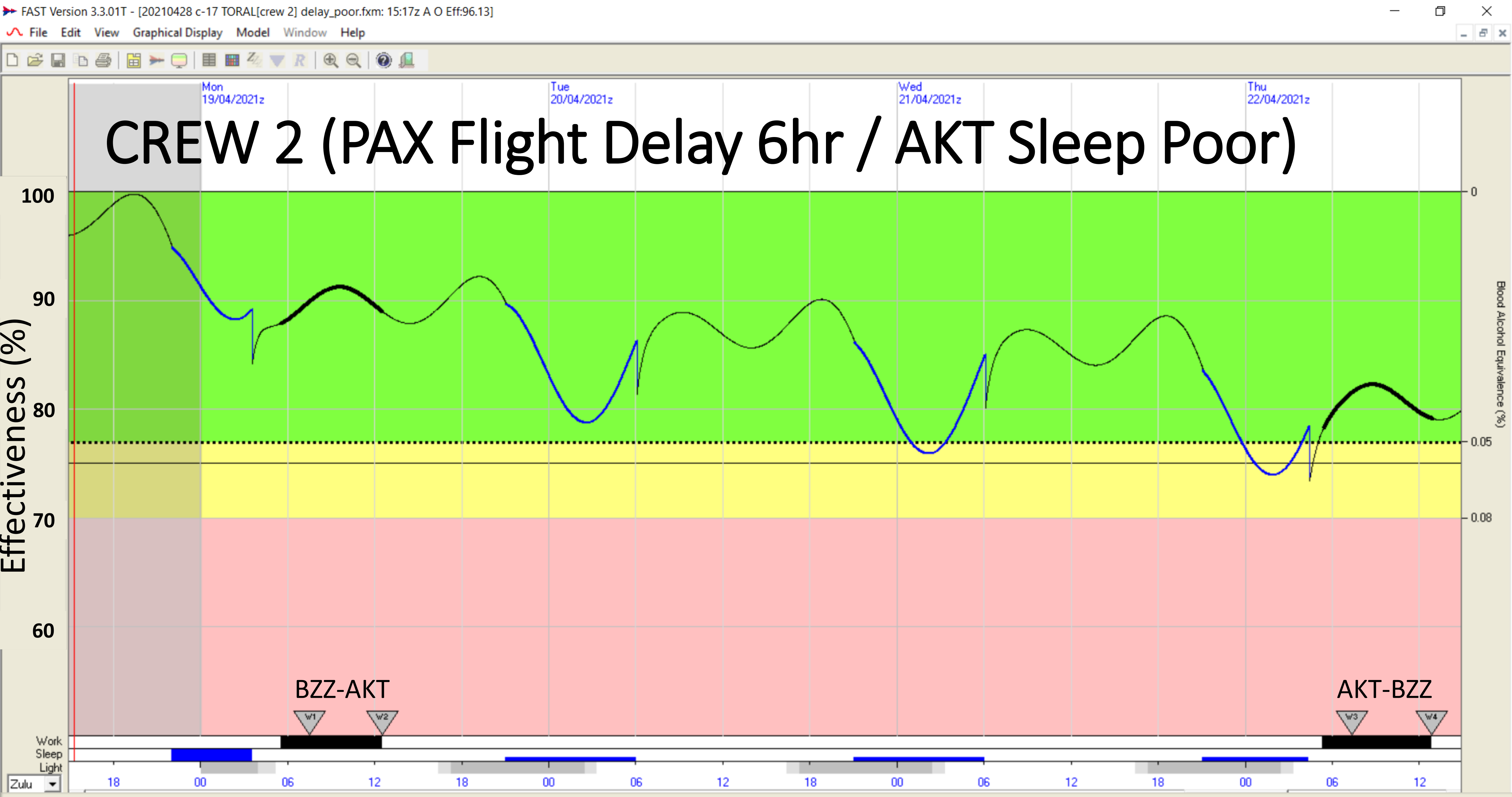
CREW 1 (Combined)
-1 Sun 18/04/2021
0 Mon 19/04/2021
1 Tue 20/04/2021
2 Wed 21/04/2021
3 Thu 22/04/2021
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
BZZ-AKT
AKT-KBL
KBL-AKT
AKT-BZZ
W1
W2
W3
W4
W5
W6
W7
W8
Work
Sleep
Light
Base
00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18
Deadhead
Deadhead



FAST Version TRIAL 3.3.01TP - [20210421 C-17 Op TORAL Current [Crew 2]COMB: 00:08 S O Eff:89.04]
File Edit View Graphical Display Model Window Help
CREW 2 (Combined)
-1 Sun 18/04/2021
0 Mon 19/04/2021
1 Tue 20/04/2021
2 Wed 21/04/2021
3 Thu 22/04/2021
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
BZZ-AKT
AKT-BZZ
W1
W2
W3
W4
Work
Sleep
Light
Base
00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18

Effect of delaying AKT – BZZ departure



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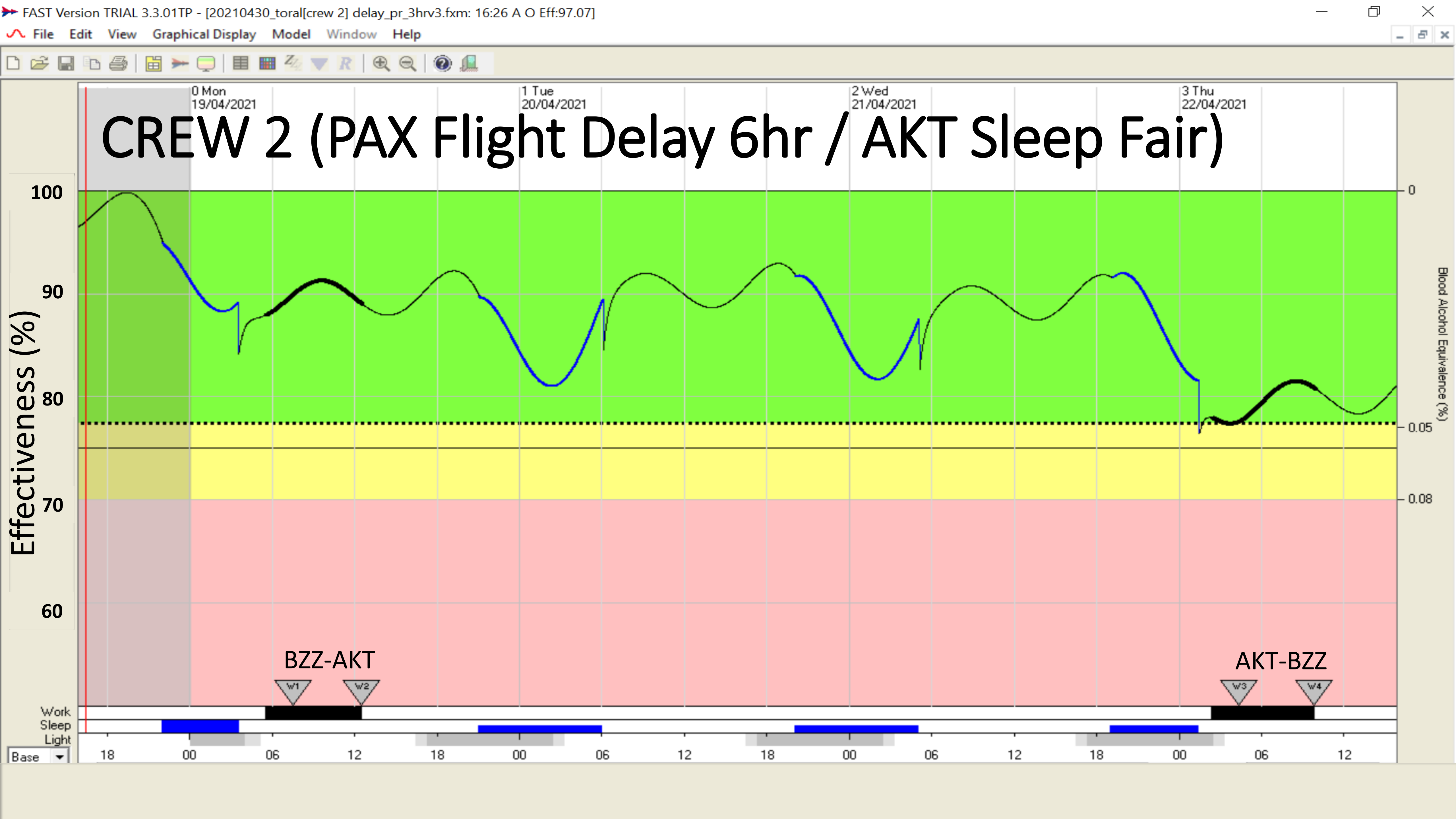
CREW 2 (PAX Flight Delay 6hr / AKT Sleep Poor)
Mon 19/04/2021z
Tue 20/04/2021z
Wed 21/04/2021z
Thu 22/04/2021z
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
BZZ-AKT
AKT-BZZ
W1
W2
W3
W4
Work
Sleep
Light
Zulu
18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12



FAST Version TRIAL 3.3.01TP - [20210430_toral[crew 2] delay_pr_3hrv3.fxm: 16:26 A O Eff:97.07]
File Edit View Graphical Display Model Window Help
CREW 2 (PAX Flight Delay 6hr / AKT Sleep Fair)
0 Mon 19/04/2021
1 Tue 20/04/2021
2 Wed 21/04/2021
3 Thu 22/04/2021
Effectiveness (%)
100
90
80
70
60
Blood Alcohol Equivalence (%)
0
0.05
0.08
BZZ-AKT
AKT-BZZ
W1
W2
W3
W4
Work
Sleep
Light
Base
18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12

Research

Overview

C-17 Fatigue project, and

Future Research

AOC 2Gp Fatigue research

- **[AOC 2Gp]**: Objective measurement of fatigue:
  - Quantify RtL in air and ground crew:
    - C-17 – Data collection complete; in analysis (wait FDM data)
    - A330 – Being designed
    - C-130
    - BAe-146
    - A400M – Being designed
    - Support personnel incl AGE, Movs, Ops

C-17 Fatigue Project

Measurement of fatigue in C-17 pilots: Assessment of Operational Risk Matrix efficacy and relationship to Flight Data Monitoring parameters

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Introduction

- Fatigue is the number 1 air safety risk on the C-17 platform
- Permissive Crew Duty regulations
- Proscriptive Rules
- Trans-meridian travel

Methods (1)

- **Data collected: 27 Feb – 7 Jun 21**
- This longitudinal study objectively measured fatigue in RAF C-17 pilots by actigraphy
- It analysed its' relationship with:
  - The existing Squadron ORM
  - A separate, study ORM
  - Samn-Perelli Scale at Top of Descent
  - Specified Flight Data Monitoring (FDM) parameters

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Methods (2)

- **Primary aims:**
  - 1. Are C-17 pilots fatigued, as measured using actigraphy and the SAFTE-FAST model?
    - a. Measure effectiveness by asking participants to wear an actigraphy device continuously during the study.
    - b. Calculate effectiveness during flying duties and describe the data.

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Methods (3)

- 2. How does the current Squadron ORM and the study ORM correlate with the objective measure of fatigue?
  - a. Fatigue related questions from the current Sqn ORM will be evaluated with the calculated effectiveness score at the time of the ORM completion.
  - b. All questions on the proposed ORM will be evaluated with the calculated effectiveness score at the time of the ORM completion.

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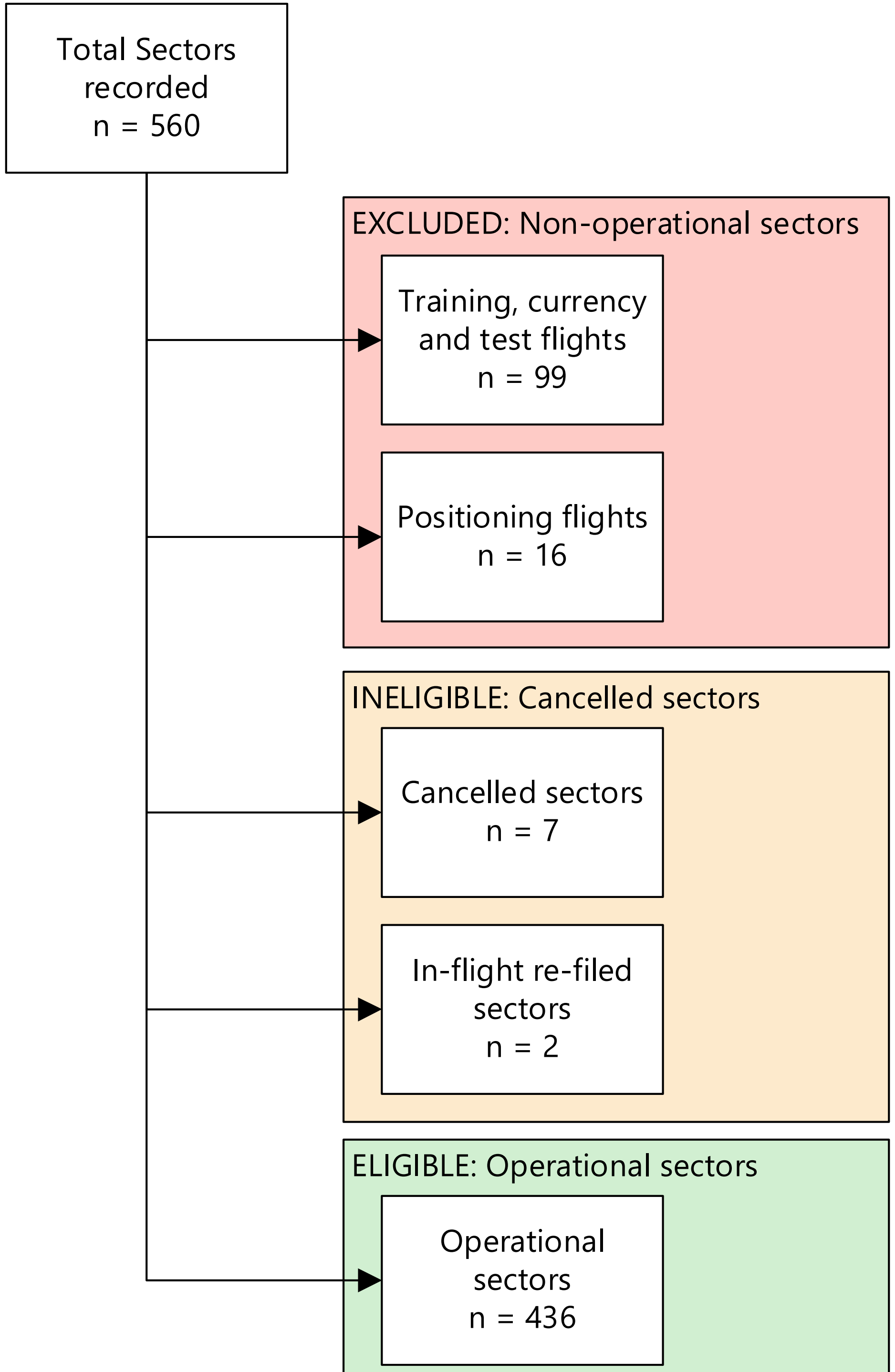
Methods (4)

- 3. Is there a valid relationship between objective measure of fatigue and FDM data?
  - a. Effectiveness at time of approach (landing) will be calculated and evaluated against specific FDM data points, including:
  - (1) Deviation from optimal landing speed.
  - (2) Vertical acceleration on touchdown.
  - (3) Depth of landing.
  - (4) Time taken to select reverse thrust.

Methods (5)



Total Sectors recorded n = 560
EXCLUDED: Non-operational sectors
Training, currency and test flights n = 99
Positioning flights n = 16
INELIGIBLE: Cancelled sectors
Cancelled sectors n = 7
In-flight re-filed sectors n = 2
ELIGIBLE: Operational sectors
Operational sectors n = 436

Results (1)

- Response rates:
  - Pilot participation: 29 / 42 (69%)
  - Sector participation: 261 / 436 (60%)

PILOT SECTOR PARTICIPATION	One/both	Both	One	None
Number of sectors	261 (59.9)	78 (17.9)	183 (42)	174 (40.1)

*All numbers presented as n(%).

ROYAL AIR FORCE

Results (2) – Demographic data

PARTICIPANTS	Participant
Male	28 (97)
Age, mean(sd)	36.4 (5.6)
Exec role	10 (34)
Live in	0 (0)
Small children at home	16 (55)
Service length (yrs), median(IQR)	13.5 (11.3-17.9)
Flight time (hrs), median(IQR)	
Flight time total	2900 (2100-3800)
Flight time military	2700 (2030-3800)
Flight time military multi-engine	2050 (900-3000)
Flight time on C-17	1300 (600-2000)

*All numbers presented as n(%) unless otherwise stated.

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Results (3) – Flight Rotations

FLIGHT ROTATIONS						
Base	UK	Europe	BME	USA	Africa	Total
BZZ	4 (3)	34 (21)	24 (15)	24 (15)	16 (10)	102 (64)
(for forward basing)	-	-	8 (5)	-	-	8 (5)
BZZ sub-total	4 (3)	34 (21)	32 (20)	24 (15)	16 (10)	110 (69)
Forward based						
DQM	-	-	46 (29)	-	-	46 (29)
NHD	-	-	3 (2)	-	-	3 (2)
Forward based sub-total		-	49 (31)	-	-	49 (31)
Total	4 (3)	34 (21)	81 (51)	24 (15)	16 (10)	159 (100)

*All numbers presented as n(%).

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Results (4) – Sectors flown per rotation

SECTORS FLOWN PER ROTATION						
Base	UK	Europe	BME	USA	Africa	Total
BZZ	3 (2 – 4)	2 (2 – 3)	4 (2 – 6)	3 (1 - 6)	3 (2 – 4)	3 (1 – 6)
Forward based						
DQM	-	-	2 (2 – 4)	-	-	2 (2 – 4)
NHD	-	-	2 (2 – 2)	-	-	2 (2 – 2)
Forward based sub-total		-	2 (2 – 4)	-	-	2 (2 – 4)
Total	3 (2 – 4)	2 (2 – 3)	3 (2 – 6)	3 (1 - 6)	3 (2 – 4)	3 (1 – 6)

*All numbers presented as mean(range).

Results (5) – Effectiveness at TOD and landing

EFFECTIVENESS AT TOP OF DESCENT AND LANDING						
(n=261)	UK	Europe	BME	USA	Africa	Total
Top of Descent (TOD)	78 (77 – 79)	88 (84 – 91)	85 (77 -91)	85 (77 – 91)	86 (80 – 85)	85 (77 – 91)
Landing	77 (76 – 79)	85 (76 – 90)	85 (76 – 90)	85 (76 – 90)	85 (76 – 90)	85 (76 – 90)

*All numbers presented as median(IQR).

Results (6) – No of landings and effectiveness

NUMBER OF LANDINGS AND EFFECTIVENESS ON LANDING						
(n=261)	UK	Europe	BME	USA	Africa	Total
Safe (>77%)	2 (1)	40 (15)	81 (31)	42 (16)	26 (10)	191 (73)
Sub-optimal (70 – 77%)	1 (0)	1 (0)	32 (12)	3 (1)	6 (2)	43 (16)
Unsafe (<70%)	0 (0)	0 (0)	21 (8)	4 (2)	2 (1)	27 (10)
Total	3 (1)	41 (16)	134 (51)	49 (19)	34 (13)	261 (100)

*All numbers presented as n(%)

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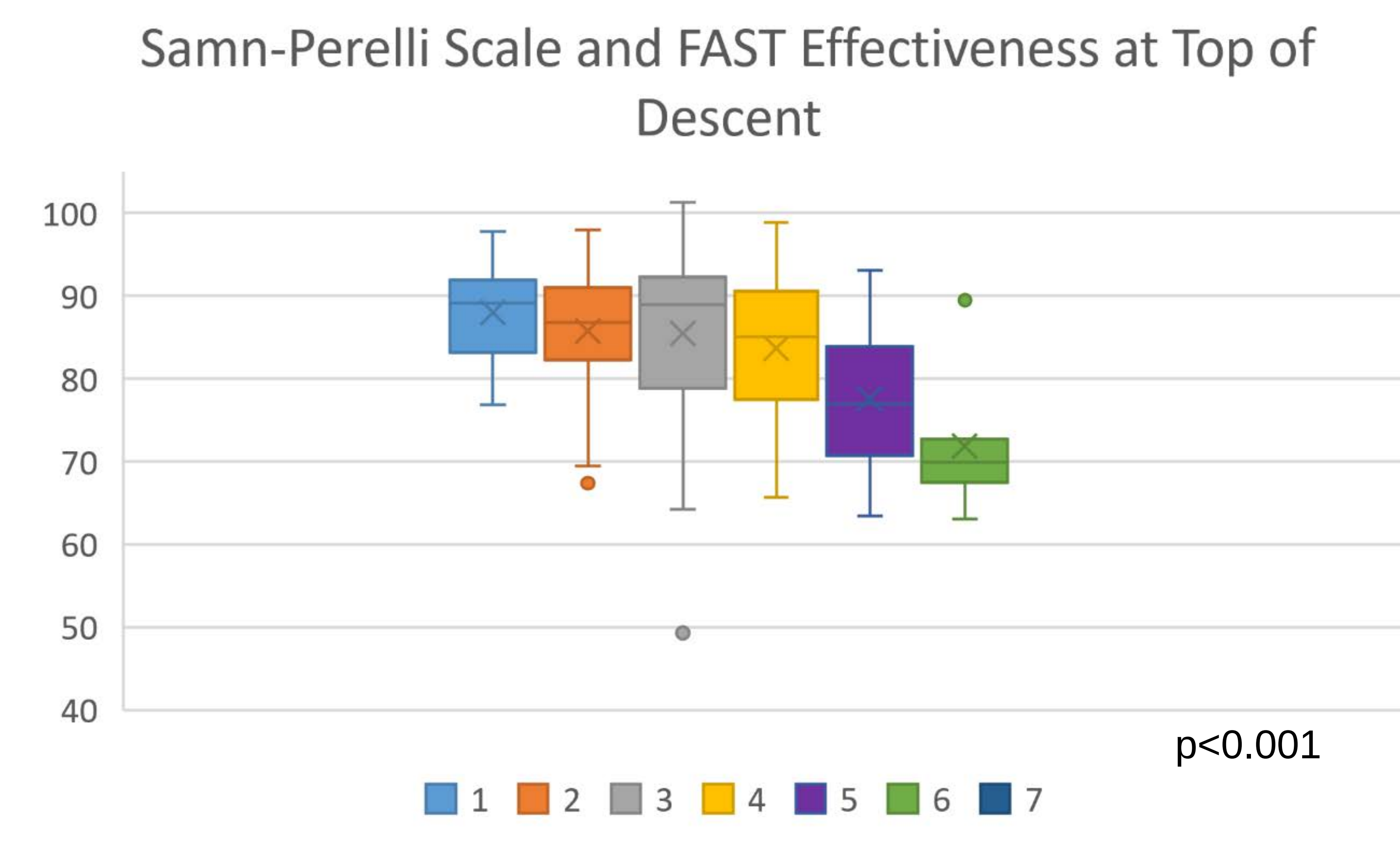
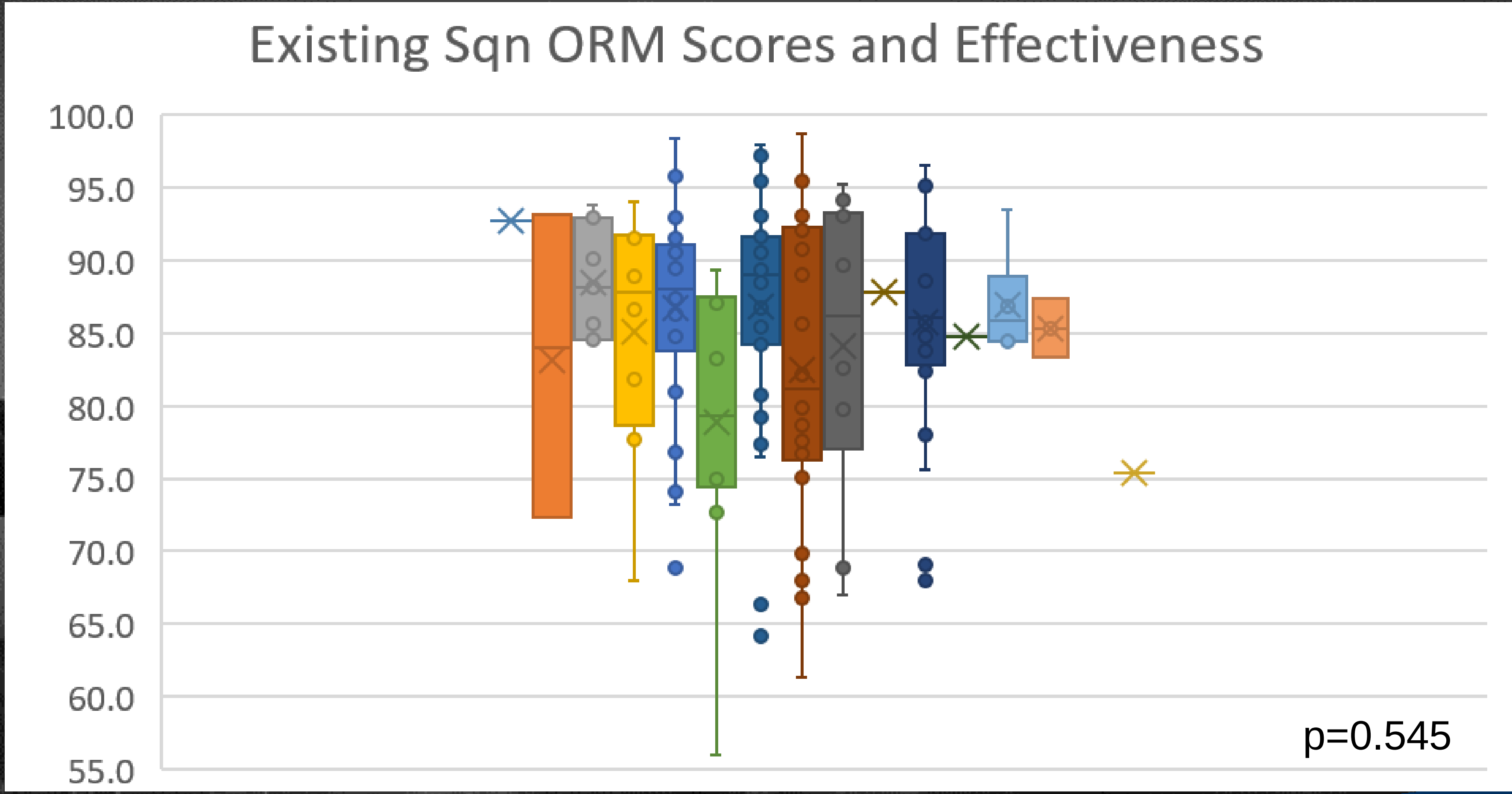
Results (7) – SPS at TOD



$p<0.001$

Results (8) – Existing Sqn ORM efficacy



Callsign		Op/Ex		Transop	
Airfields				Dates	

Crew

CAP				
CO				
ALM				
GE				
SVC				

Risk Factors		0	1		Score
Mission					
1	Task complexity [1]	Low	Moderate	High	0
Timings					
2	Task crew-in time (Local) [2]	0500 – 1459L	1500-0459L		0
3	Consecutive operating days	< 5	5-6	> 7	0
4	Planned CDT within 1h of max CDT	No	Yes		0
5	Number of Op legs in crew day	< 3	3-4	> 5	0
6	Take-off or landing in WOCL [3]	No	Yes		0
Environment					
7	Threat assessment	Low/Moderate	Substantial	Severe	0
8	En-route location mission support [4]	Meets Requirement	Below Requirement		0
9	En-route language difficulties	No	Yes		1
10	Airfield complexity [5]	Low	Moderate	High	2
11	Night departures/arrivals in crew day	< 3	3-5	> 6	1
12	NVG take-off or landing	No	Yes		0
13	Bird/wildlife hazard	Low	Moderate	High	0
14	En-route complexity and risks [6]	Low	Moderate	High	0
Crew/Aircraft					
15	Number of LCR Crew Members [7]	0	1-2	> 3	1
16	Pilot Composition	CAP/CO	CAP/CAP		1
17	Aircraft Captain C-17 PIC hrs	≥ 500 hours	< 500 hours		0
18	Co-pilot C-17 hrs	≥ 500 hours	< 500 hours		1
19	ALM C-17 hrs	≥ 500 hours	< 500 hours		0
20	Sectors by Captain in last 31 days	≥ 4	< 4		0
21	Sectors by Co-pilot in last 31 days	≥ 4	< 4		0
22	Sectors by ALM in last 31 days	≥ 4	< 4		0
23	Pilot MCT currency (3 months)	Both	One	Neither	0
Theatre Task Recency					
24	Captain	≤ 90 days	> 90 days		0
25	Co-pilot	≤ 90 days	> 90 days		0
26	ALM	≤ 90 days	> 90 days		0
Worldwide AT					
27	Captain previous similar mission [8]	< 6 months	6-18 months	> 18 months	2
28	Co-pilot previous similar mission	< 6 months	6-18 months	> 18 months	2
				Total	11

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Discussion – Existing Sqn ORM efficacy

2	Task crew-in time (Local) [2]	0500 – 1459L	1500-0459L		
3	Consecutive operating days	< 5	5-6	> 7	
4	Planned CDT within 1h of max CDT	No	Yes		
5	Number of Op legs in crew day	< 3	3-4	> 5	
6	Take-off or landing in WOCL [3]	No	Yes		

$p<0.001$

Discussion – Existing Sqn ORM efficacy

Q	Q	p value
1	Task complexity	0.32
2	Task crew-in time	0.06
3	Consecutive operating days	1.00
4	Planned CDT within 1h of max CDT	0.001
5	Number of op legs in crew day	0.81
6	Take-off or landing in WOCL	0.003

$p<0.001$

Discussion - FDM

- Wait for AsMA presentation in Reno
  - Mon 23 Mar 22 1600 hrs
  - TUSCANY B
  - SLIDE: Fatigue in Military and Commercial Aviation

$p<0.001$

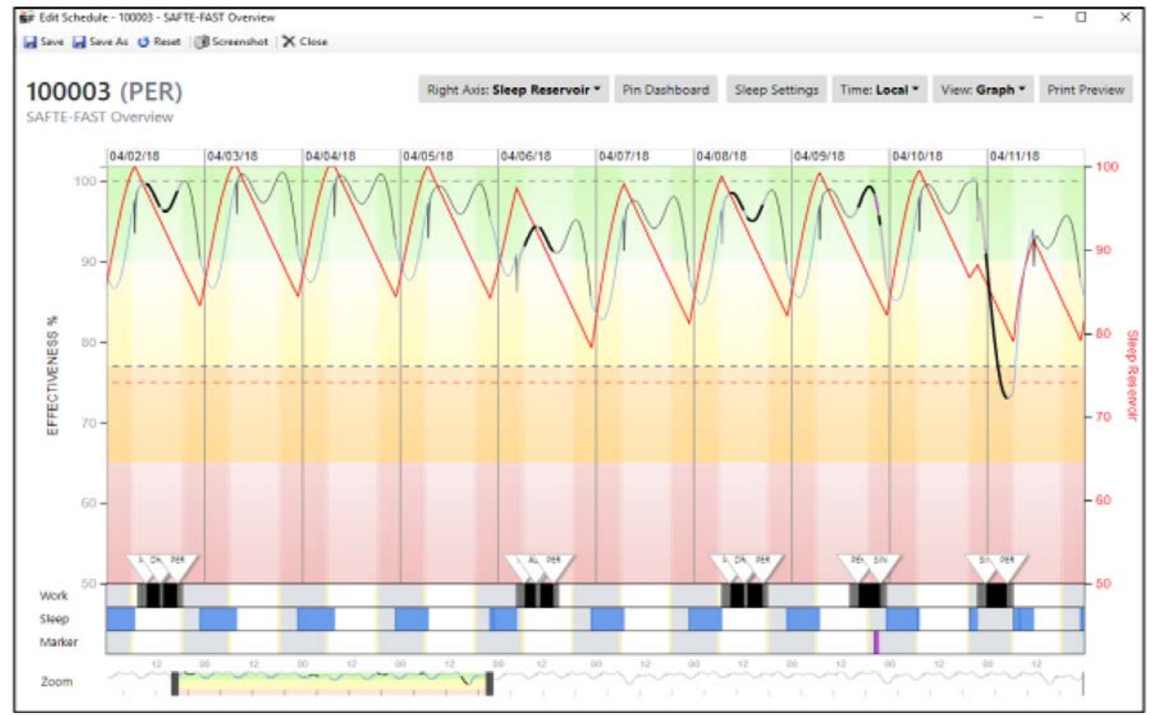
Discussion

- Effectiveness cut-offs are scientifically sound
- Re-purpose the existing Sqn ORM (questions and 'math')
  - Re-measure to assess efficacy
- Can we engineer out the problems, without restricting FTL
  - Worrying sectors e.g. WOCL departures / arrivals
  - Modelling as standard and modelling within BOCS?
  - MOG issues (foreign airfield constraints)
  - Move towards a FRMS
  - Improvements to sleep
    - Military accommodation, other aids

$p<0.001$

Recommendations

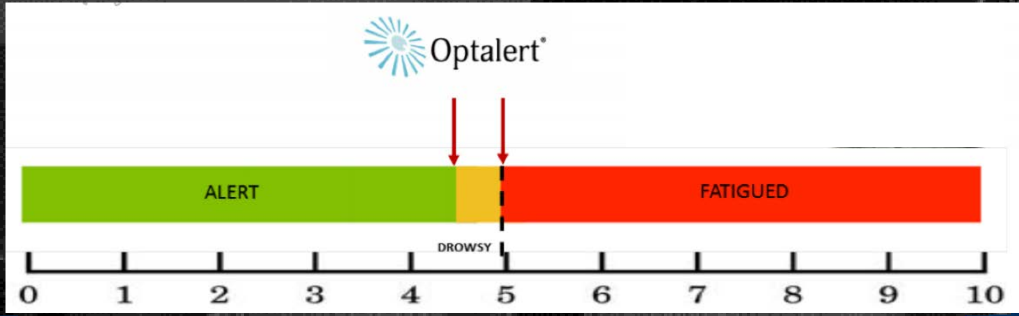
- Procure automated fatigue analysis system
  - DSCOM, 2Gp, BZZ ASC – reviewed 4 products.
  - Scalable (desktop // integrated into BOCS)
  - Coherence AtRS
  - Cost minimal
  - Confirm military 'real-world' by measurement



Future Projects and Research

Platform	Problem / Tool	Level
RPAS (Watchkeeper)	Operating shift length without break, total CDT – Optalert	MSc
A400M (Atlas)	Fatigue assessment, ORM efficacy (FAST/SAFTE-FAST)	
RPAS (Desert Hawk)	CDT require 6 hrs sleep pre-flight. Preliminary assessment – TBD	
Hawk T2	ATC -> Station-wide ORM. Have flight performance data (training) - FAST	
(pan platform)	Temazepam / Melatonin use	
RW	Fatigue assessment, ORM efficacy (FAST/SAFTE-FAST)	MSc
A330 MRTT (Voyager)	Fatigue assessment, ORM efficacy (FAST/SAFTE-FAST)	

- "Drowsy / fatigue detection system" (Optalert™)
- Glasses: blinks
  - Duration of, and
  - Amplitude-Velocity ratio
- Niche: ***Onset*** of fatigue



ROYAL AIR FORCE

Summary

- Introduction
- Assessment
  - What is fatigue
- Management
  - Modelling, Aeromedical advice
- Research
  - Current research, future projects and research

ROYAL AIR FORCE

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