

# Bundeswehrkrankenhaus HAMBURG



## Fatal Monotony – Increased Daytime Sleepiness in the Deployed Setting

Dr. Reinhard Stark, Lieutenant Colonel, Medical Corps



# Monotony intolerance



DRIVECAM



FG +0.0

SG +0.0

Time -10.00

Rear View

# Elbphilharmonie



The **Elbphilharmonie** is one of the largest and acoustically most advanced concert halls in the world.

According *Wikipedia*

(77 → 866 m €)





# *Elbphilharmonie*



# The harber



# The harbor



# Falling asleep at the wheel



25% of all fatal accidents on motorways are attributed to drivers falling asleep at the wheel.





# Truck drivers

- Some 43% of truck drivers fall asleep while driving during the last 12 months



# Truck drivers



And this in spite of fully air-conditioned cabs, comfortable beds, tachographs, and police checks





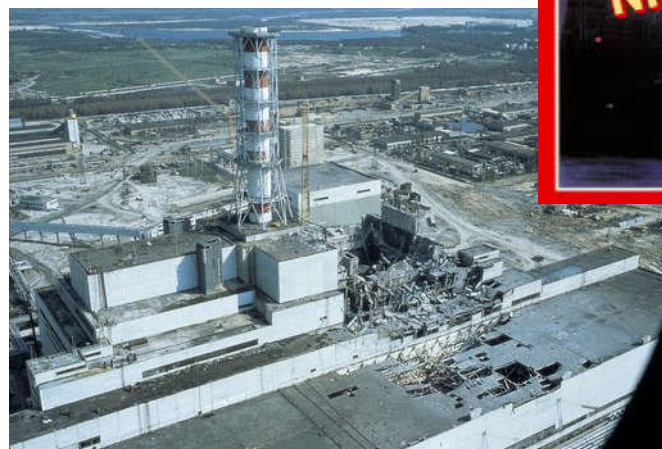
- More than 50% of pilots have fallen asleep in the cockpit
- A total of 29% of them stated that the second pilot was sleeping when they awoke



# Sleepiness on the job

Sleepiness on the job is the cause of numerous disasters

- the Chernobyl nuclear accident
- the Three Mile Island accident
- the Bhopal industrial disaster
- the Exxon Valdez oil spill
- the capsizing of the Herald of Free Enterprise







- In the maritime sector too, reduced performance as a result of fatigue carries serious risks.
- Excessive fatigue is estimated to account for 25% of maritime accidents.





- 32% of the crew members of an U.S. Navy aircraft carrier (N = 767) were affected by daytime sleepiness (!)



# Crew fatigue as contributing factor for collisions



In 2017, the 7th US Navy suffered three collisions and a grounding with a total of 17 dead. Crew fatigue was identified as contributing factor.



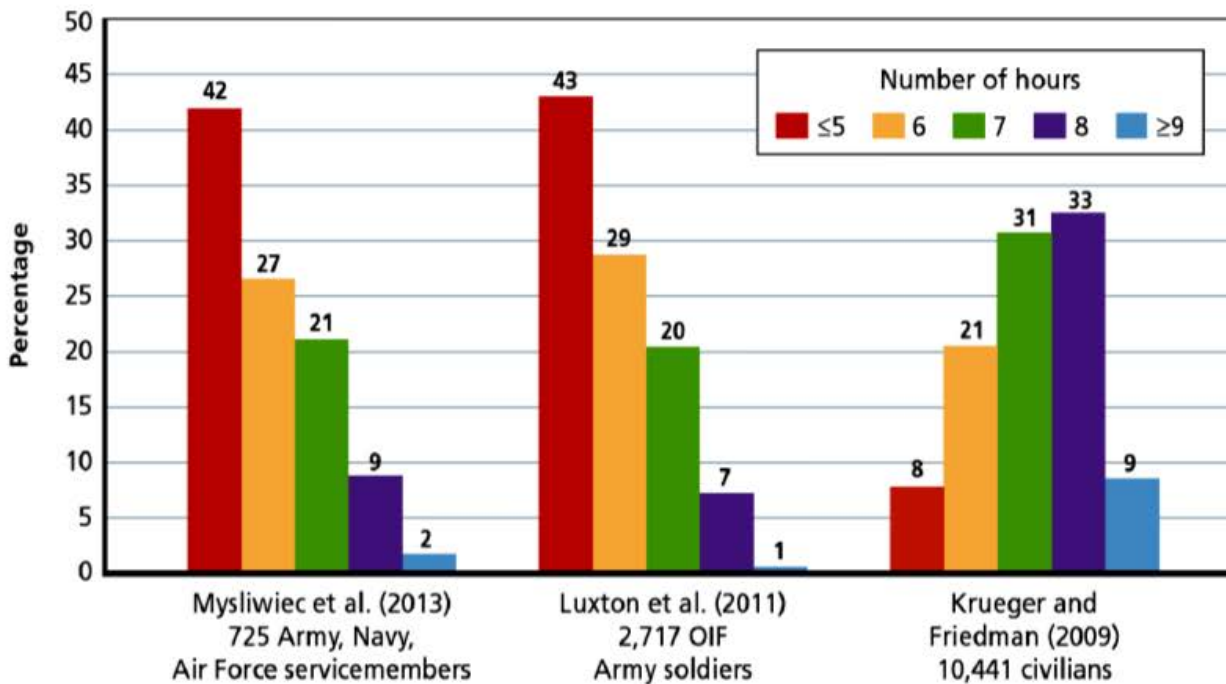
USS Fitzgerald



USS John S McCain

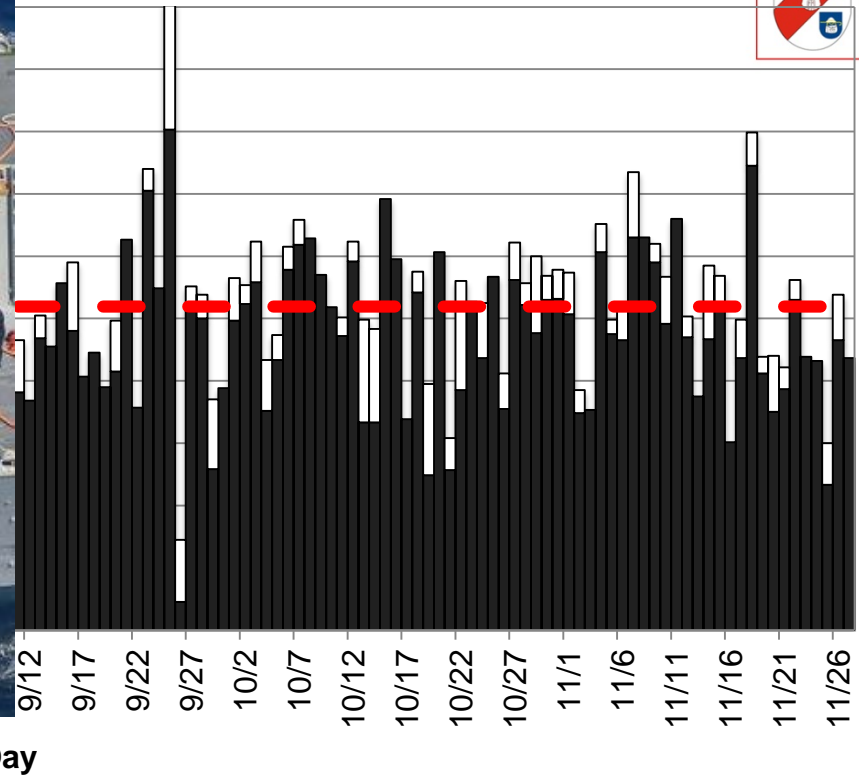


# Fatigue Management





# Actigraphy of an USN Commanding Officer

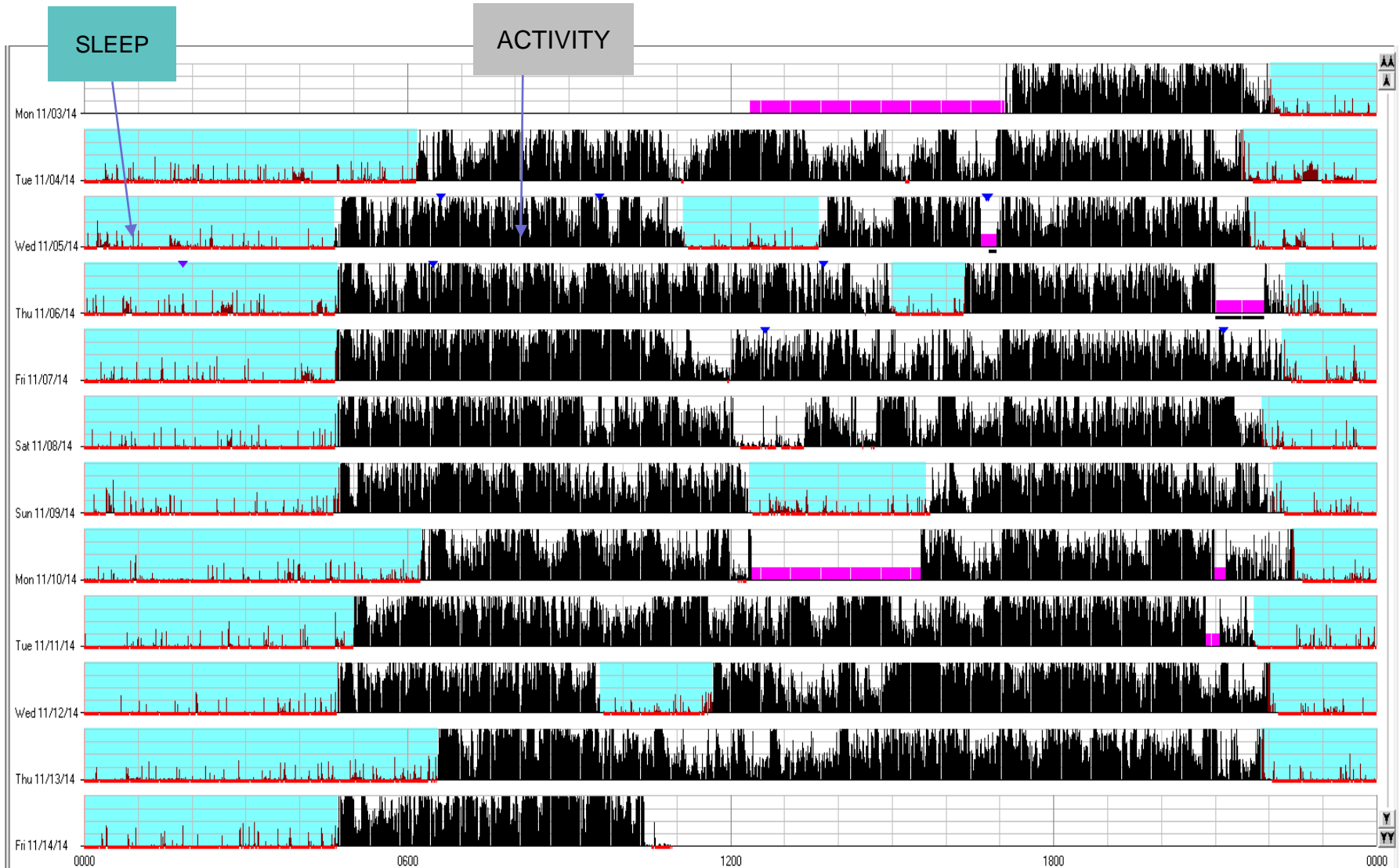


■ Major Night Sleep    □ Naps    — Average daily sleep

**Average daily sleep time of about 5 hours**

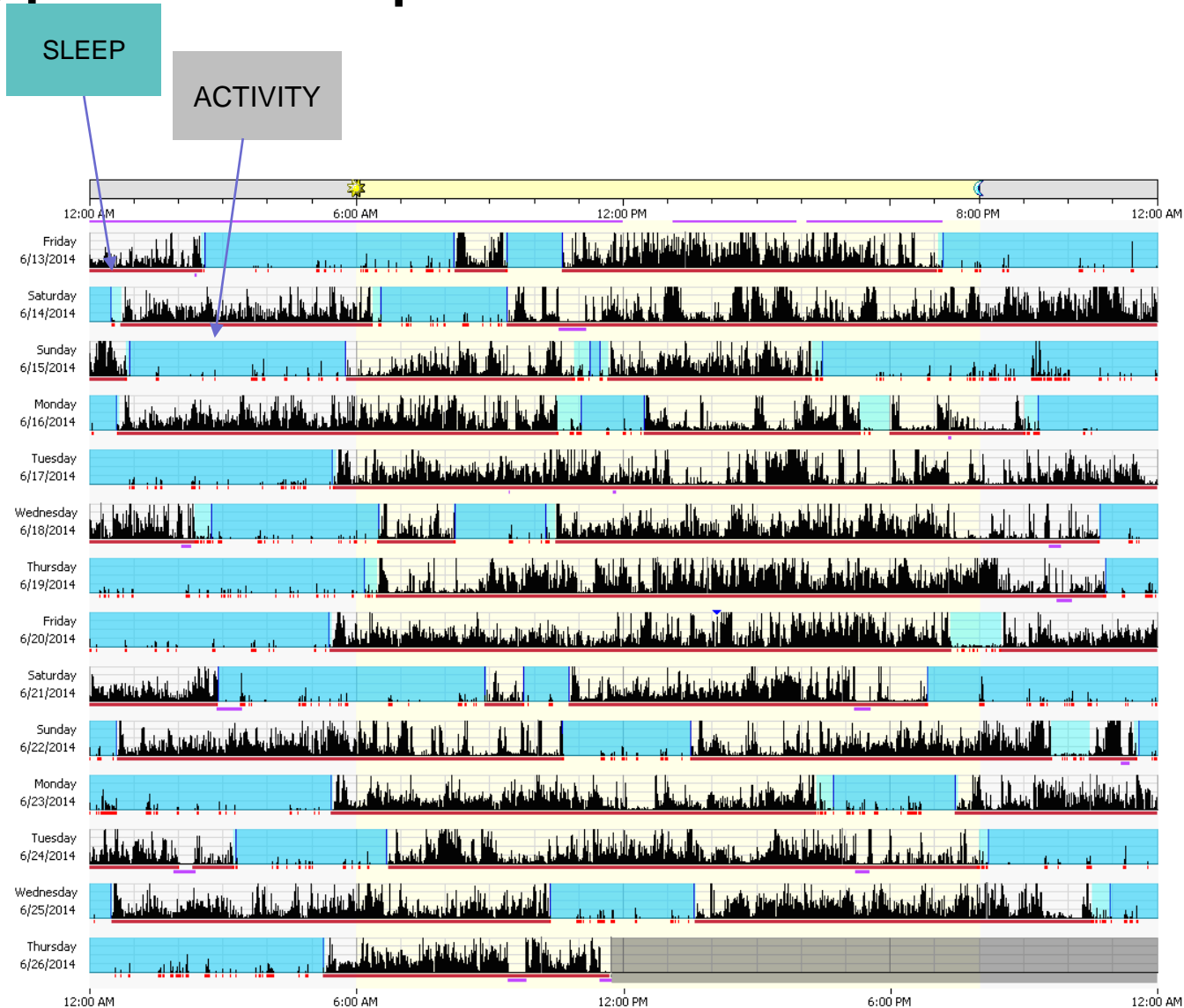
Taken from: Matsangas and Shattuck (2018). Fatigue in the wild

# Good Sleep Pattern



Taken from: Matsungas and Shattuck (2018). Fatigue in the wild

# Typical Sleep Pattern of USN Sailor



Taken from: Matsangas and Shattuck (2018). Fatigue in the wild

# Sleep deprivation makes you drunk



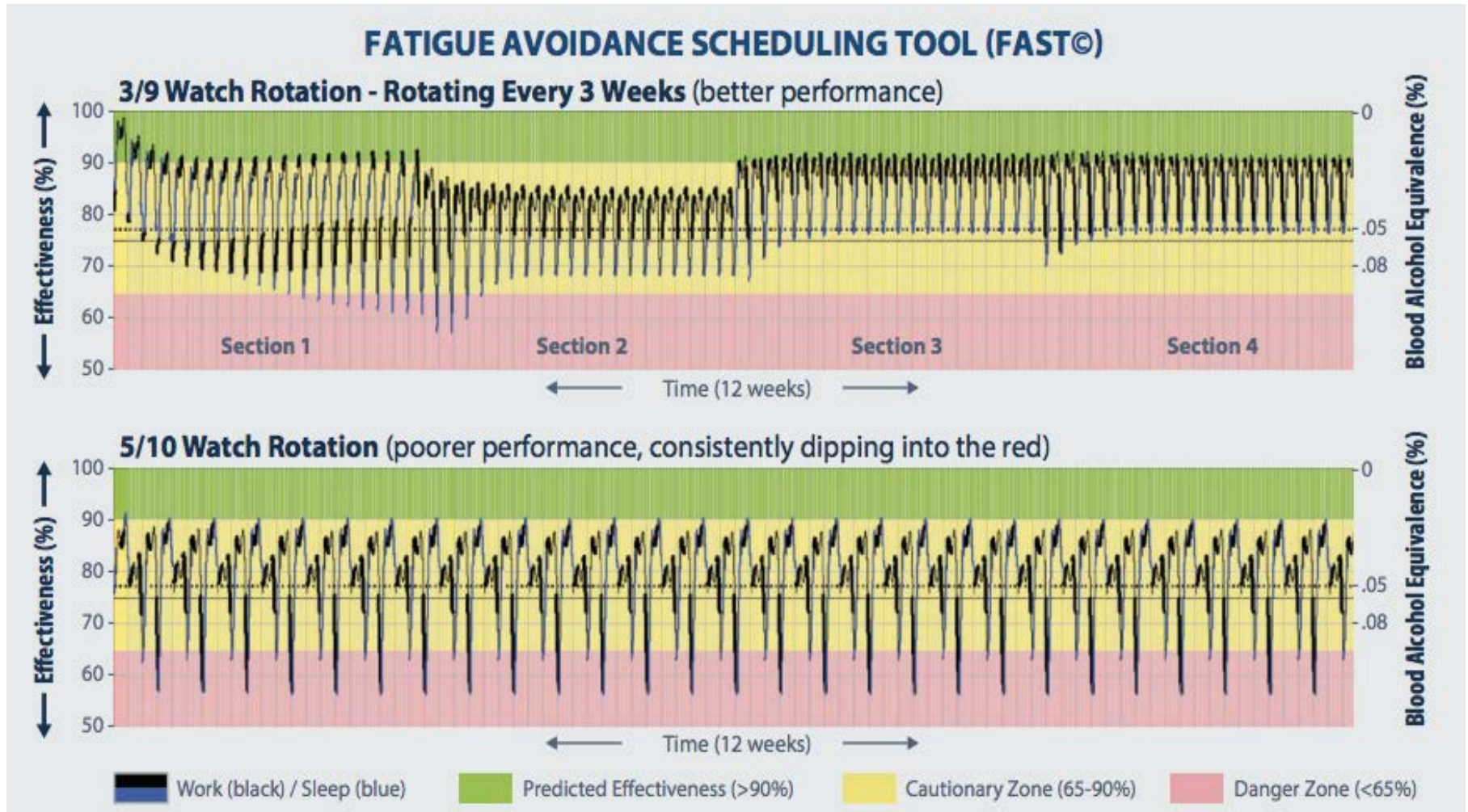
Seventeen hours of vigilance without sleeping breaks inhibits a person's abilities and is comparable to a blood alcohol concentration of 0.5‰, 24 hours corresponds to 1‰



Dawson D, Reid K: Fatigue alcohol et performans Impairment. Nature. 1997 Juli 17.; 388-6639): 235



# Fatigue depending on Schedule model



NPS Crew Endurance Resource Website

<http://nps.edu/crewendurance>

Taken from: Matsangas and Shattuck (2018). Fatigue in the wild



- Operations abroad include highly monotonous activities, e.g.
  - the work performed by bridge personnel on ships
  - surveillance personnel
  - drivers
- There are no tachographs.



- We have an unphysiological shift system
  - The German Navy, for example, has rotating shifts of up to every 4 hours
- Rest periods can sometimes not be planned.
- There are many factors such as heat, noise, insects and personal worries which adversely affect sleep.
- **Reliable data are difficult to collect**



## Prior to deployment

We must filter out personnel who are adversely affected by monotonous activities:

*The tendency to increased daytime sleepiness ranges from 4 to 9% among the general population*

→ An objective approach to diagnosis  
hypersomnia is required

**BUT: We do not have a gold standard to detect hypersomnia**





- The **German Sleep Society** recommends a series of tests to detect hypersomnia.
- This recommendation was also incorporated into the evaluation **guidelines on driver fitness**:  
*„Several components of daytime sleepiness from the areas of central nervous system activation and attention functions were to be tested“*

Components daytime sleepiness	Recommended tests by German Sleep Society
Tonic activation of the central nervous system	Multipler Schlaflatenz-Test (MSLT) Multipler Wachbleibe-Test (MWT) LZ-EEG (mit und ohne Verhaltensprotokoll) Pupillographischer Schläfrigkeitstest (PST) Psychomotorischer Vigilanztest (PVT) Alpha Attenuation Test (ATT) Osler Test (OT) Andere Reaktionszeitmessungen, z. B. Testbatterie zur Aufmerksamkeitsprüfung (TAP), Wiener Testsystem (WT)
Phasic activation of the central nervous system	Reaktionszeitmessungen mit Warnreiz, z. B. TAP EKP, z. B. CNV, SN
Selective attention function	z. B. Arbeitsleistungsserie, Test Selektive Aufmerksamkeit der TAP Reaktionszeitmessungen mit hoher zeitlicher Anforderung, z. B. FCRT
Shared attention function	Wiener Determinationsgerät Test Geteilte Aufmerksamkeit der TAP
vigilance	z. B. Test Vigilanz des WT oder der TAP, Vigimar





person's ability to focus their attention on relevant environmental stimuli and ignore others (Weeß et al., 2000).

Tonic activation of the central nervous system	Multipler Schlaflatenz-Test (MSLT) Multipler Wachbleibe-Test (MWT) LZ-EEG (mit und ohne Verhaltensprotokoll) Pupillographischer Schläfrigkeitstest (PST) Psychomotorischer Vigilanztest (PVT) Alpha Attenuation Test (ATT) Osler Test (OT) Andere Reaktionszeitmessungen, z. B. Testbatterie zur Aufmerksamkeitsprüfung (TAP), Wiener Testsystem (WT)
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vigilance	z. B. Test Vigilanz des WT oder der TAP, Vigimar





capacity for automatic, quick and controlled processing of **simultaneous** information.

e.g. driving a car while carrying on a conversation with a passenger, paying attention to other cars and pedestrians, controlling hand movements

Tonic activation of the central nervous system	Multipler Schlafatenz-Test (MSLT) Multipler Wachbleibe-Test (MWT) LZ-EEG (mit und ohne Verhaltensprotokoll) Pupillographischer Schläfrigkeitstest (PST) Psychomotorischer Vigilanztest (PVT) Alpha Attenuation Test (ATT) Osler Test (OT) Andere Reaktionszeitmessungen, z. B. Testbatterie zur Aufmerksamkeitsprüfung (TAP), Wiener Testsystem (WT)
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Capacity to maintain a high level of attention over prolonged periods of time while stimuli occur rarely or randomly (Weeß, 2004).

Test > 30 minutes

➤ Important e.g. for surveillance personnel

Tonic activation of the central nervous system	Multipler Schlaflatenz-Test (MSLT) Multipler Wachbleibe-Test (MWT) LZ-EEG (mit und ohne Verhaltensprotokoll) Pupillographischer Schläfrigkeitstest (PST) Psychomotorischer Vigilanztest (PVT) Alpha Attenuation Test (ATT) Osler Test (OT) Andere Reaktionszeitmessungen, z. B. Testbatterie zur Aufmerksamkeitsprüfung (TAP), Wiener Testsystem (WT)
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## German Sleep Society:

*“As each test only covers some aspects of daytime sleepiness, it has not been possible to establish one test method that can be used as a gold standard for validating other methods”*

Aufmerksamkeitskomponente	Geeignete Testverfahren
Tonische Aktivierung	Multipler Schlaflatenz-Test (MSLT) Multipler Wachbleibe-Test (MWT) LZ-EEG (mit und ohne Verhaltensprotokoll) Pupillographischer Schläfrigkeitstest (PST) Psychomotorischer Vigilanztest (PVT) Alpha Attenuation Test (ATT) Osler Test (OT) Andere Reaktionszeitmessungen, z. B. Testbatterie zur Aufmerksamkeitsprüfung (TAP), Wiener Testsystem (WT)
Phasische Aktivierung	Reaktionszeitmessungen mit Warnreiz, z. B. TAP EKP, z. B. CNV, SN
Selektive Aufmerksamkeit	z. B. Arbeitsleistungsserie, Test Selektive Aufmerksamkeit der TAP Reaktionszeitmessungen mit hoher zeitlicher Anforderung, z. B. FCRT
Geteilte Aufmerksamkeit	Wiener Determinationsgerät Test Geteilte Aufmerksamkeit der TAP
Vigilanz	z. B. Test Vigilanz des WT oder der TAP, Vigimar



## Aim:

- to find **one test** which indicates hypersomnia specifically
- which is **mobile** and so suitable for testing on **operations abroad**
- could be operated by **untrained staff**





- 5 sleepiness tests recommended by the German Sleep Society were compared
- 30 staff members of the Bundeswehr Hospital in Hamburg.
- Tests were carried out before and after their night shifts: 19:30 o'clock and 06:30 o'clock
- Each set of tests lasted 90 minutes
- The co-author of the study was the head of the Vigilance Working Group of the German Sleep Society

# Pupillography...



Tonic activation of the central nervous system

Phasic activation of the central nervous system

Selective attention function

Shared attention function

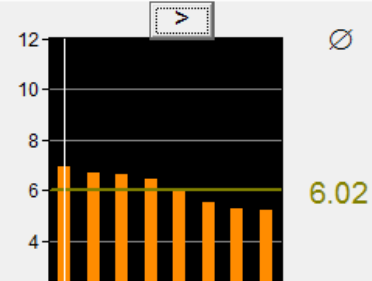
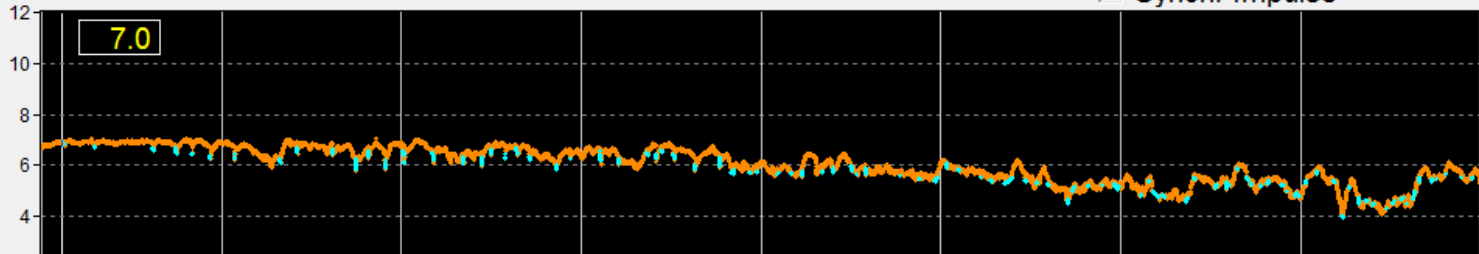
vigilance





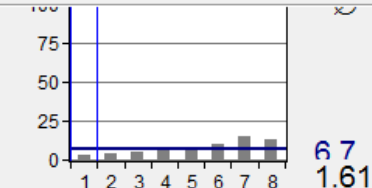
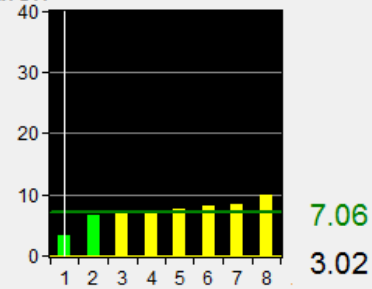
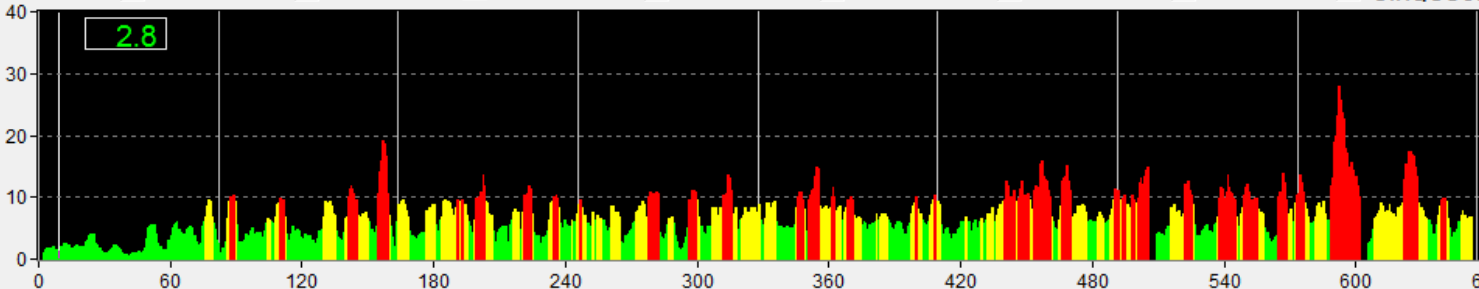
# Pupillendurchmesser

Synch.-Impulse

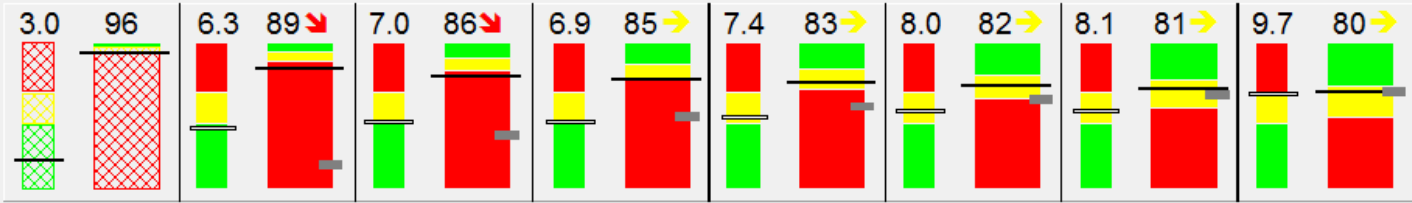


# rPUI PUI®

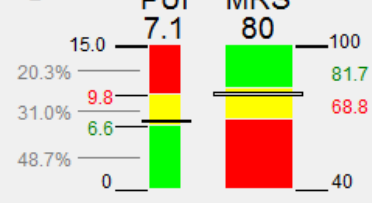
eingeschlafen



# PUI® / MRS®



# Ergebn







Neue Suche
Messung starten
Pause

Y-Zeit
X-Achse

Bild
Profil

Schießen
Abbruch

Puzzle
Ausgrenz.

Marken (Rück)


Eingeschalen


Marken (Trop)

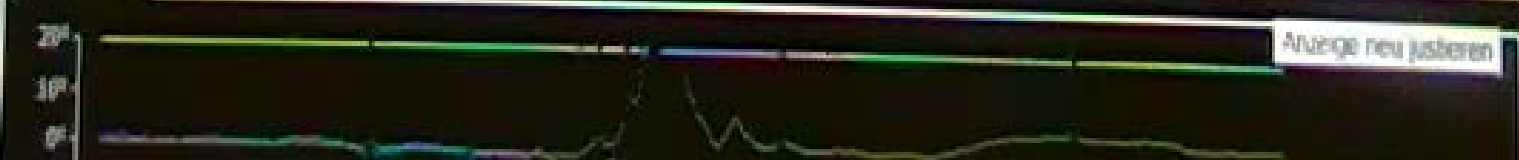
Eingeschalen

PUI

Messung







Anzeige neu justieren

# Awake subject

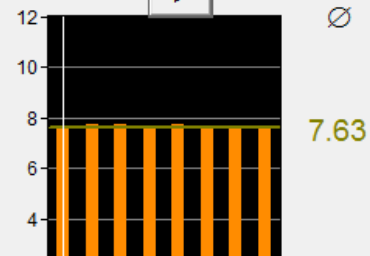
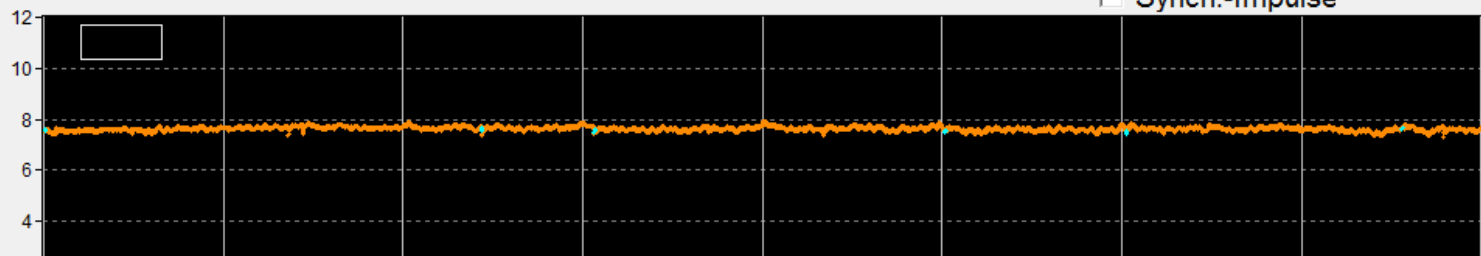


## Pupillendurchmesser

Synch.-Impulse

>

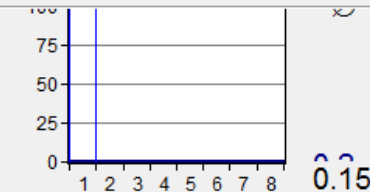
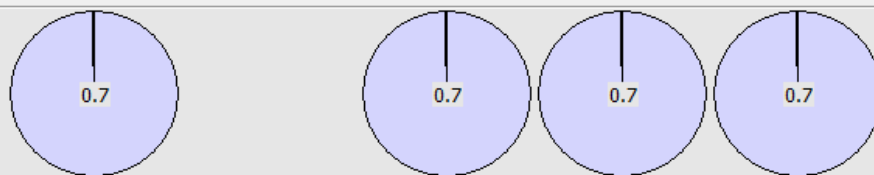
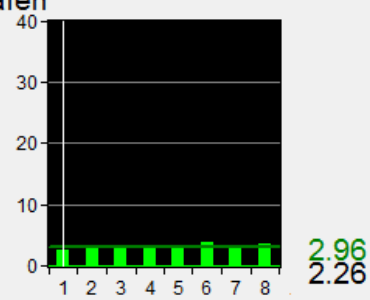
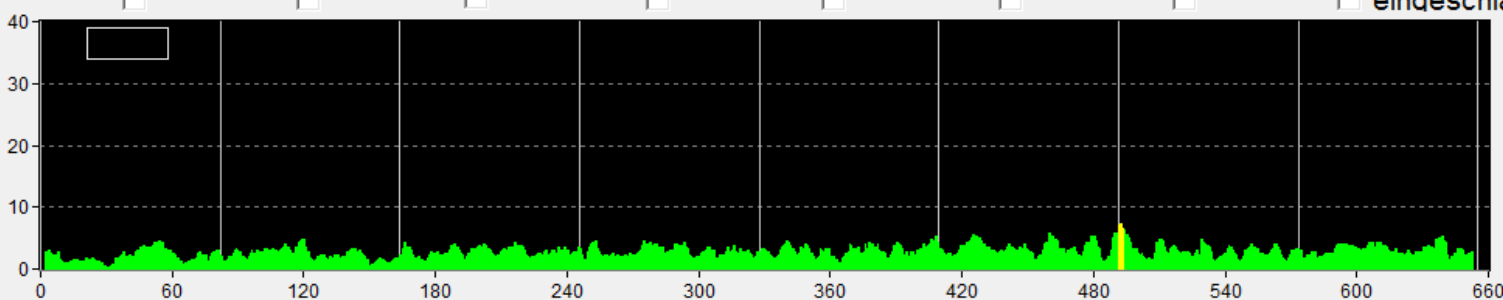
∅



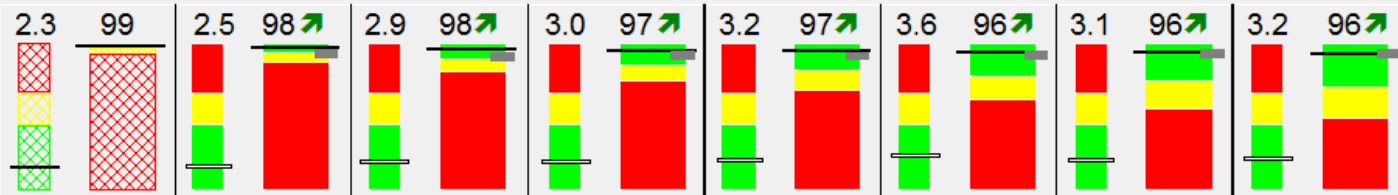
## rPUI PUI®

eingeschlafen

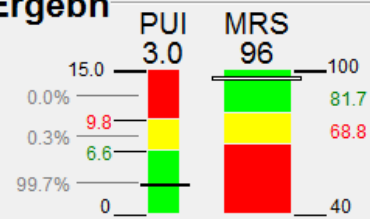
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## PUI® / MRS®



## Ergebn

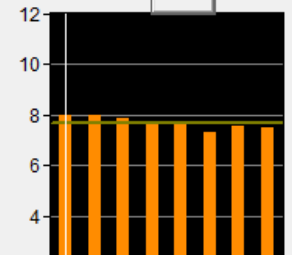
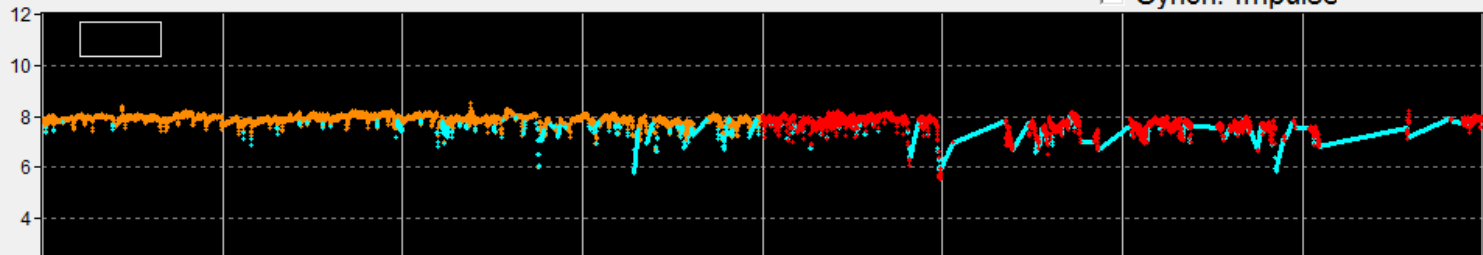


# Tired subject

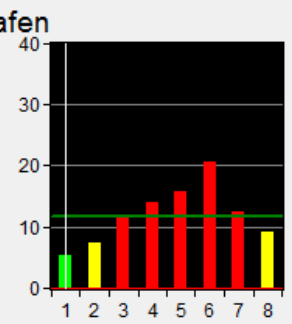
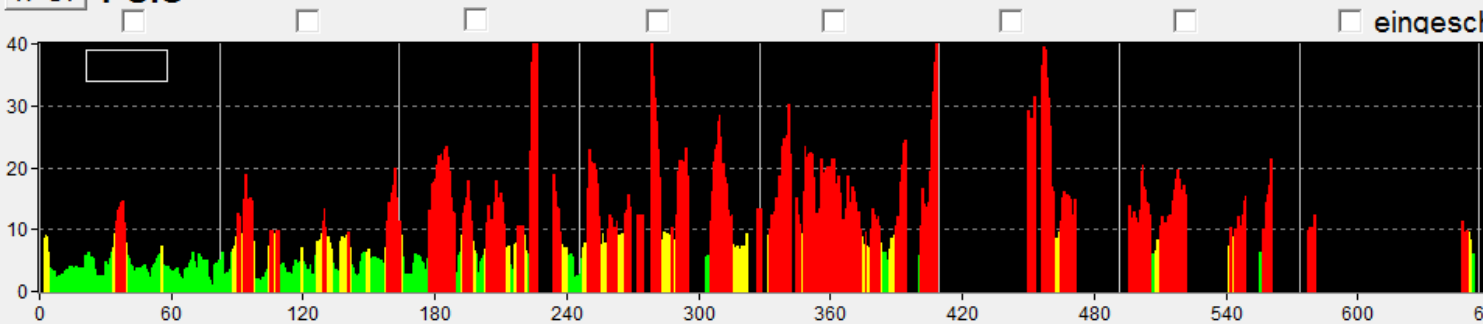


## Pupillendurchmesser

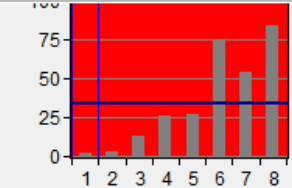
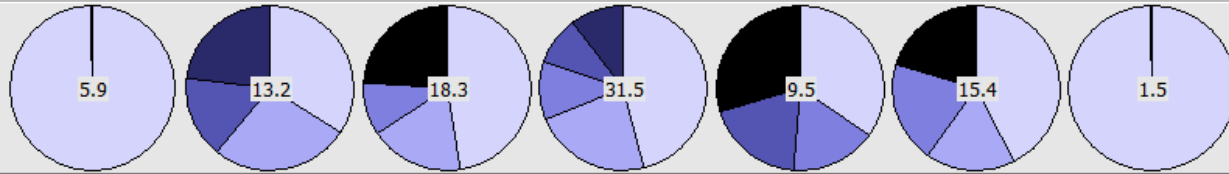
Synchron-Impulse



## rPUI PUI®

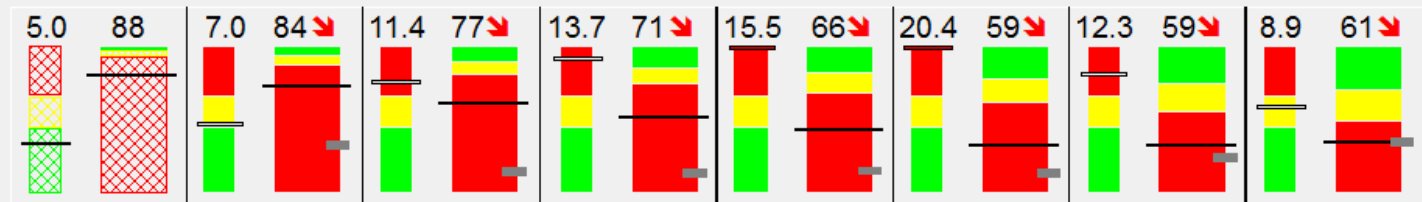


eingeschlafen

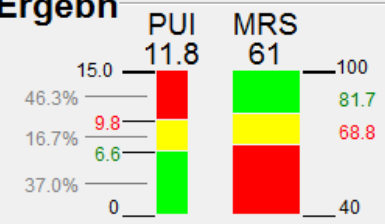


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## PUI® / MRS®



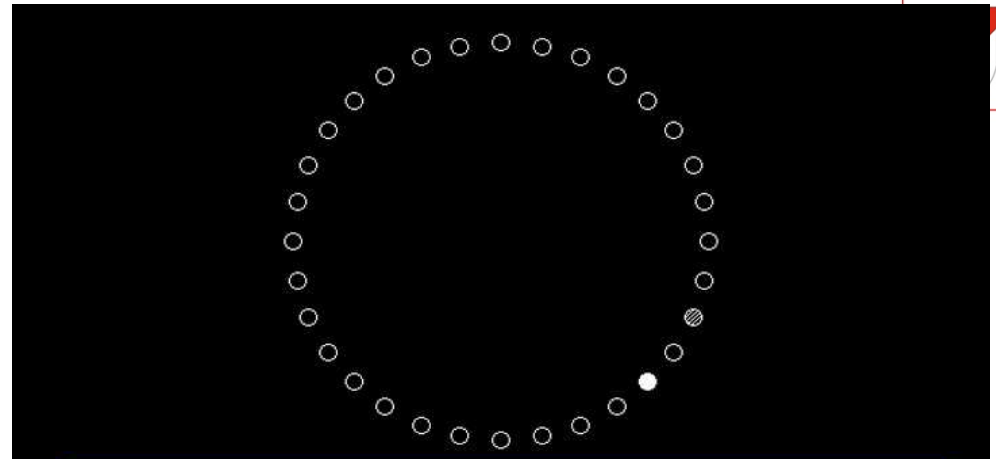
## Ergebn





Pupillography established  
proof of sleepiness with a  
**specificity of 100%**  
**(sensitivity only 37%)**

# Quatember-Maly psychometric vigilance test



Tonic activation of the central nervous system

Phasic activation of the central nervous system

Selective attention function

Shared attention function

vigilance







The Quatember-Maly  
vigilance test established  
proof of sleepiness with a  
**sensitivity of 96%** and a  
**specificity of 89%**.



- This test is uncomplicated in terms of hardware and software and can be carried out by untrained staff.
- As a laptop-test, it has a high mobility and is also suitable for testing on operations abroad.

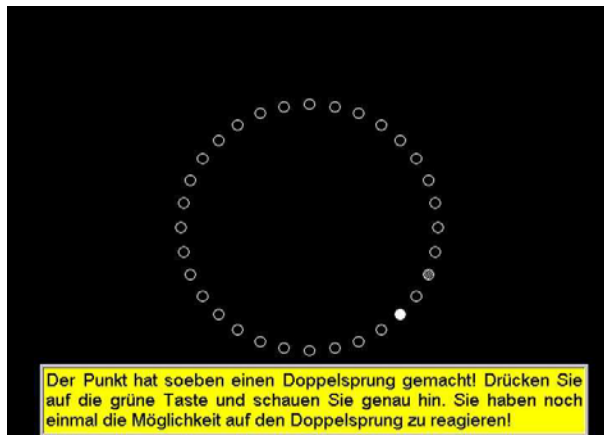


The following known fact was confirmed:  
*Self-assessments of sleepiness differed greatly from objective test results*

Two thirds of the subjects were much sleepier than they felt they were.

## outlook...

- three-minute test for identifying sleepiness is developed by the Department of Aviation and Space Psychology of the Cologne-based Institute of Aerospace Medicine
- It is performed on a portable handheld computer and therefore suitable for mobile measurements in a deployed setting





Dear 3 am,  
we have to stop meeting this way.  
I`d much rather sleep with you.





Any questions?  
Thank you very much for your attention!





## microsleep prevention programme:

- Soldiers should learn what sleepiness is, how to recognise it, and what they can do to prevent it.
- Sleepiness is not suddenly there. It develops over time.
- The various phases of this development must be recognised before microsleep occurs.
- In this way, soldiers can plan breaks or take power naps.



- Civilian airlines have integrated a fatigue risk management
- Also the civilian and US-Army maritime sector offers fatigue guidelines



# Fatigue Risk Management System



## Lufthansa Flight Training

Cockpit Training

Cabin Training

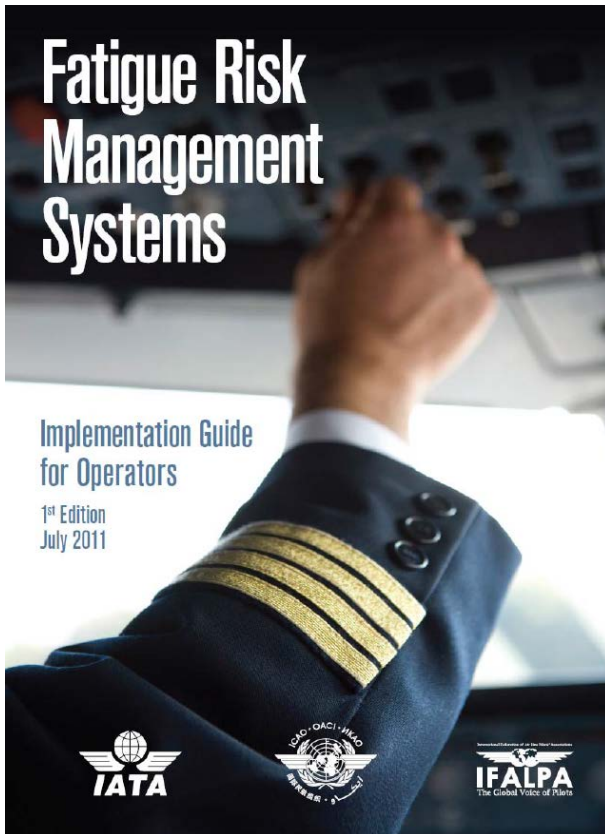
Pilotenausbildung

Trainingsgeräte

Business Training

Event & Erlebnis

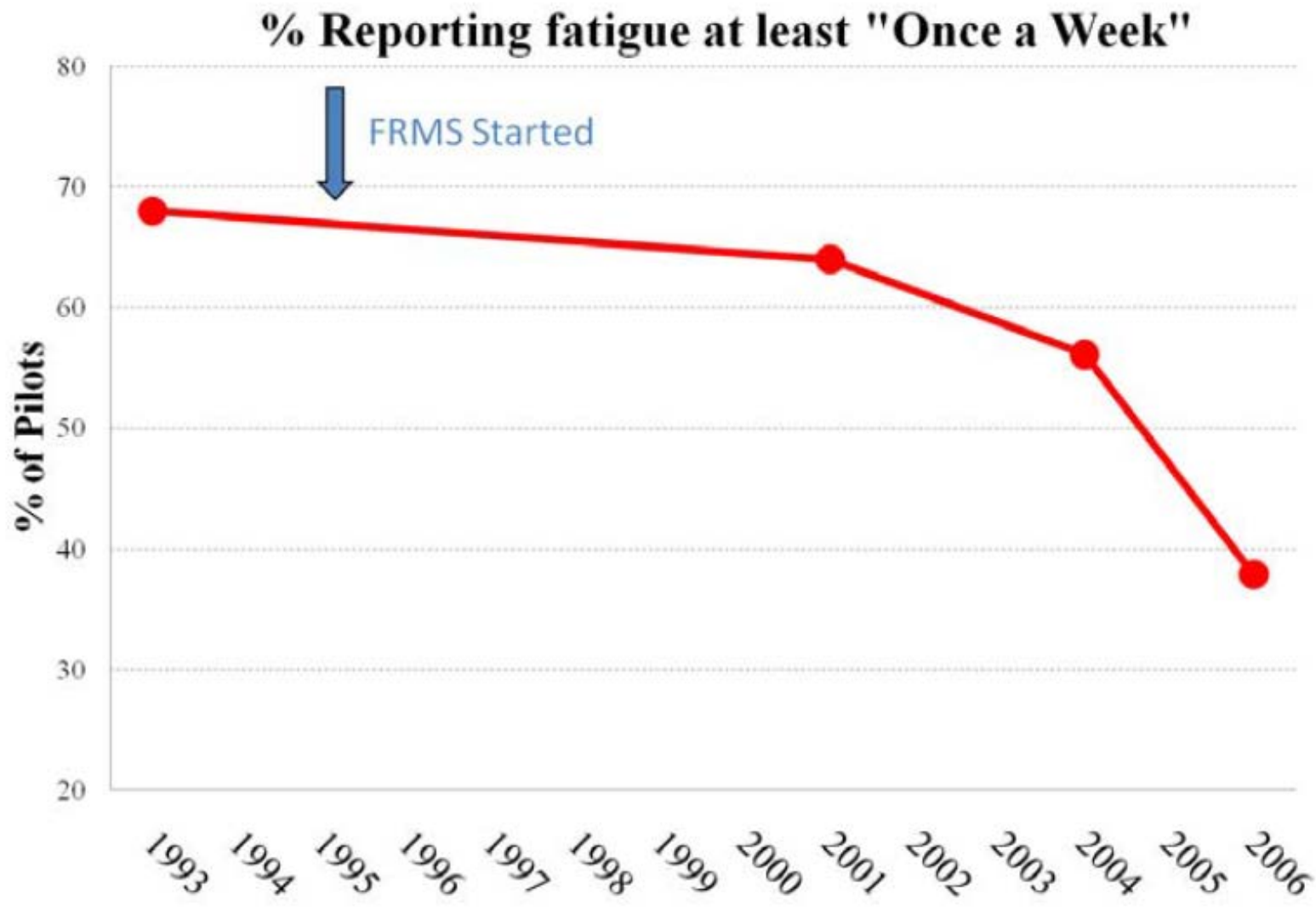
Unterricht



## Fatigue Risk Management beugt Gefahren vor



# Effectiveness of FRMS on pilots of Air New Zealand



# ROWDATA

## Abendtestung

Probandennr	SSS	PUI	Anzahl Richt	Anzahl Falsch	Mittelwert d	Anzahl Verp	Anzahl Falsch	Mittlere Rea	Mittlere RZ c	Mittlere Mo	Nicht reagier	Differenz mit	Differenz mit	Mittlere RZ r	Mittlere Mo	Nicht reagier
1	2	6,6	78	60	89	83	20	94	84	93	57	20	61	62	96	53
2	4	4,3	7	29	16	83	65	88	69	27	57	56	99	70	70	53
3	1	10,2	2	12	11	0	3	7	65	85	9	4	30	17	71	53
4	3	6,5	81	45	43	0	17	23	69	87	57	28	64	55	91	53
5	2	3	78	29	1	56	30	49	42	60	57	40	40	36	56	53
6	1	7,3	46	86	86	56	30	89	47	30	57	28	68	31	33	53
7	2	8,9	78	7	89	83	14	91	86	73	57	27	11	70	50	53
8	1	7,2	7	29	61	2	3	57	89	54	57	43	72	87	62	53
9	2	5,7	46	29	38	56	30	51	90	73	57	48	30	47	71	53
10	2	7,2	78	29	97	83	44	94	95	90	57	47	90	95	100	53
11	1	4,4	29	41	74	83	65	84	90	57	57	5	20	47	47	53
12	1	10,2	7	60	81	6	20	31	87	87	57	62	29	92	74	53
13	2	6,5	46	41	81	56	44	73	22	65	57	62	62	87	69	53
14	2	3,4	78	41	78	56	44	98	60	27	57	59	21	60	20	53
15	2	5,1	78	41	38	41	30	82	22	23	57	97	99	77	69	53
16	2	2	81	32	90	83	89	83	41	80	9	78	30	57	66	53
17	1	7,6	29	19	16	83	65	32	36	87	9	84	62	58	88	53
18	1	6,1	13	6	38	41	3	33	83	65	57	60	30	87	56	53
19	2	1,8	78	60	86	56	65	92	73	79	57	67	34	84	66	53
20	2	3,8	78	60	99	83	65	100	94	76	57	61	82	97	90	53
21	2	2,8	78	60	97	83	30	99	100	80	57	36	64	97	82	53
22	2	5,2	78	60	55	56	30	63	65	76	57	47	62	62	81	53
23	1	8,4	78	86	86	83	65	100	74	87	57	47	53	73	88	53
24	2	5,1	46	60	28	13	3	51	67	87	57	73	40	82	81	53
25	2	1,5	46	12	74	83	5	73	74	89	57	55	56	77	91	53
26	2	1,8	78	86	78	83	20	88	63	79	57	81	48	85	71	53
27	2	1,8	29	60	25	56	5	63	61	55	57	25	98	41	99	53
28	2	6,8	78	41	99	83	44	94	80	64	57	78	72	94	70	53
29	1	3,3	19	86	55	83	30	40	45	48	57	93	88	89	70	53
30	1	9,8	46	41	93	83	65	74	72	91	57	67	61	85	93	53
		1,8	5,9	53,1	44,9	63,4		59,9	34,8	69,9		68,2	69,1	52,2		53,0

Pupillograph Test VIGIL

Test WAFV (Vigilanz/Daueraufmerksam RT - Tonisch zentralnervöse Aktivierung

RT - Phasisch zentralnervöse Aktivierung

## Morgentestung

Probandennr	SSS	PUI	Anzahl Richt	Anzahl Falsch	Mittelwert d	Anzahl Verp	Anzahl Falsch	Mittlere Rea	Mittlere RZ c	Mittlere Mo	Nicht reagier	Differenz mit	Differenz mit	Mittlere RZ r	Mittlere Mo	Nicht reagier	Subj	KFZ-T		
1	4	8,5	3	19	74	3	19	74	45	91	57	90	48	77	91	53	3	3		
2	5	3,6	0	29	7	83	65	88	69	29	57	56	99	70	70	53	4	4		
3	2	12,6	0	7	1	0	1	10	43	60	2	68	76	50	70	4	4	4		
4	5	2,6	0	6	48	13	5	48	78	95	57	57	44	83	96	53	4	4		
5	3	3,5	7	19	8	6	5	13	12	49	57	9	14	4	38	53	4	4		
6	3	8,2	46	7	8	6	2	38	49	20	57	43	53	43	19	53	4	4		
7	5	8,9	0	0	21	56	2	92	85	67	57	30	40	71	56	53	4	4		
8	3	1,5	0	2	11	0	2	0	81	35	57	20	98	60	71	53	2	2		
9	3	6,5	19	19	25	52	19	20	69	60	57	83	90	70	70	53	3	3		
10	4	6,1	78	86	55	83	65	79	90	90	57	67	80	96	99	53	4	4		
11	4	14,6	7	41	50	4	5	64	63	47	57	33	43	50	48	53	2	2		
12	2	5,3	60	89	89	83	65	92	81	92	57	57	27	42	65	91	53	3		
13	3	6,8	13	41	55	56	11	57	43	85	57	57	27	42	65	91	53	3		
14	3	1,5	46	41	55	16	5	74	58	22	57	15	26	32	18	53	3	3		
15	4	1,5	14	12	25	9	11	23	22	38	57	93	92	59	63	53	3	3		
16	1	3,2	0	19	8	16	2	52	49	94	57	24	10	30	72	4	4	4		
17	2	6,7	11	86	6	29	2	20	56	85	57	8	50	25	83	53	2	2		
18	2	6,3	7	4	21	56	65	33	77	66	57	83	22	72	56	53	2	2		
19	5	2,4	19	60	86	56	65	96	55	82	57	80	40	76	71	53	4	4		
20	3	5,1	13	4	68	21	2	76	90	79	57	74	70	88	85	53	3	3		
21	4	2,8	46	41	86	56	5	88	91	63	57	40	90	89	91	53	4	4		
22	4	7,2	46	41	50	21	31	75	69	89	57	82	26	89	51	53	3	3		
23	3	10,6	2	29	81	0	2	75	47	43	57	73	90	59	66	53	3	3		
24	3	4,3	46	29	55	41	44	47	85	96	57	49	43	84	96	53	2	2		
25	3	1,5	9	3	3	17	3	66	42	85	57	78	53	82	91	53	4	4		
26	4	3,9	46	60	25	16	11	37	74	53	57	98	43	89	51	53	4	4		
27	4	2,3	46	86	61	83	44	99	74	85	57	61	59	82	86	53	3	3		
28	4	5,3	78	86	99	83	89	100	91	85	57	36	70	89	91	53	4	4		
29	3	3,4	3	5	11	21	14	33	67	74	57	1	26	37	60	53	4	4		
30	5	6,6	78	86	93	83	65	69	80	91	57	59	80	87	92	53	3	3		
		3,4	6,8	23,3	34,3	43,3		35,1	22,1	57,8		63,1	68,5	55,2		52,2	53,9	64,8	70,2	48,0

Pupillograph Test VIGIL

Test WAFV (Vigilanz/Daueraufmerksam RT - Tonisch zentralnervöse Aktivierung

RT - Phasisch zentralnervöse Aktivierung

