A Scientific Approach for the Fatigue Risk Management in the Brazilian Civil Aviation

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In partnership with:

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Outline

1) Overview of the SAFTE-FAST model

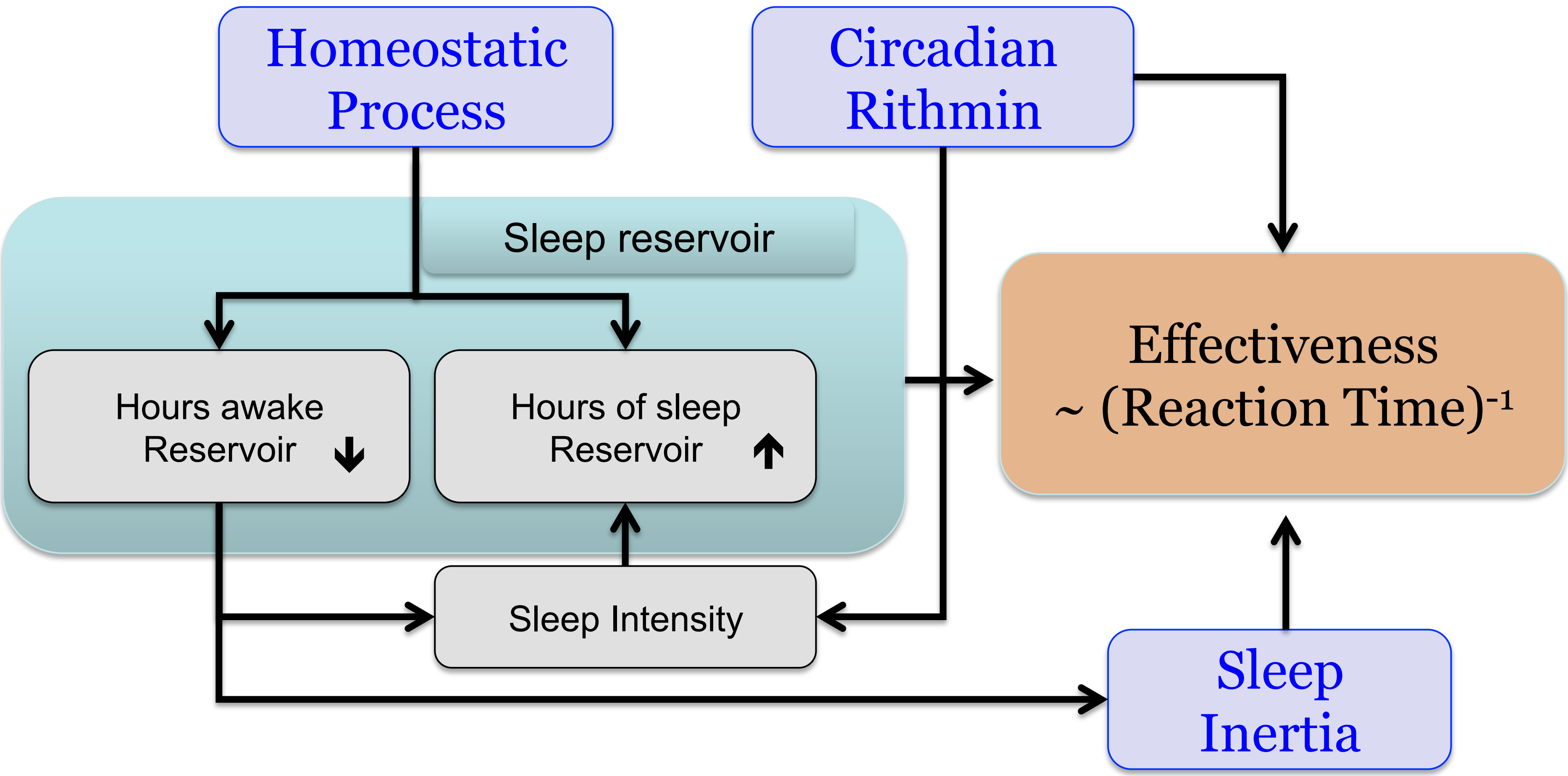
2) Results:

- Pilot fatigue in Brazil
- Risk analyses: scenarios, fatigue risk & risk exposure
- FDT Limits: a science based proposal for minimum crew

3) Conclusions

4) Future plans

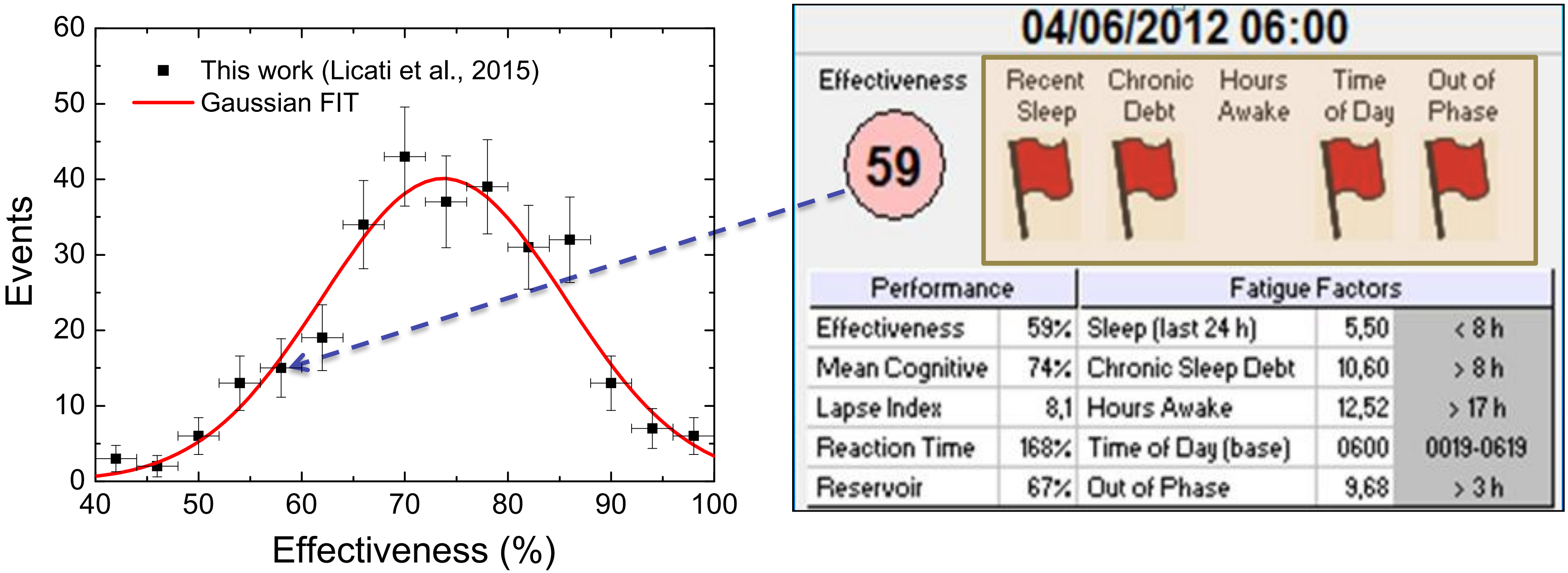
Overview of the SAFTE-FAST model*



(*) Adapted from S. Hursh *et al.*, Aviat Space Environ Med 2004; 75(3 Suppl): A44-53

Results/pilot fatigue in Brazil

Pilot Effectiveness*

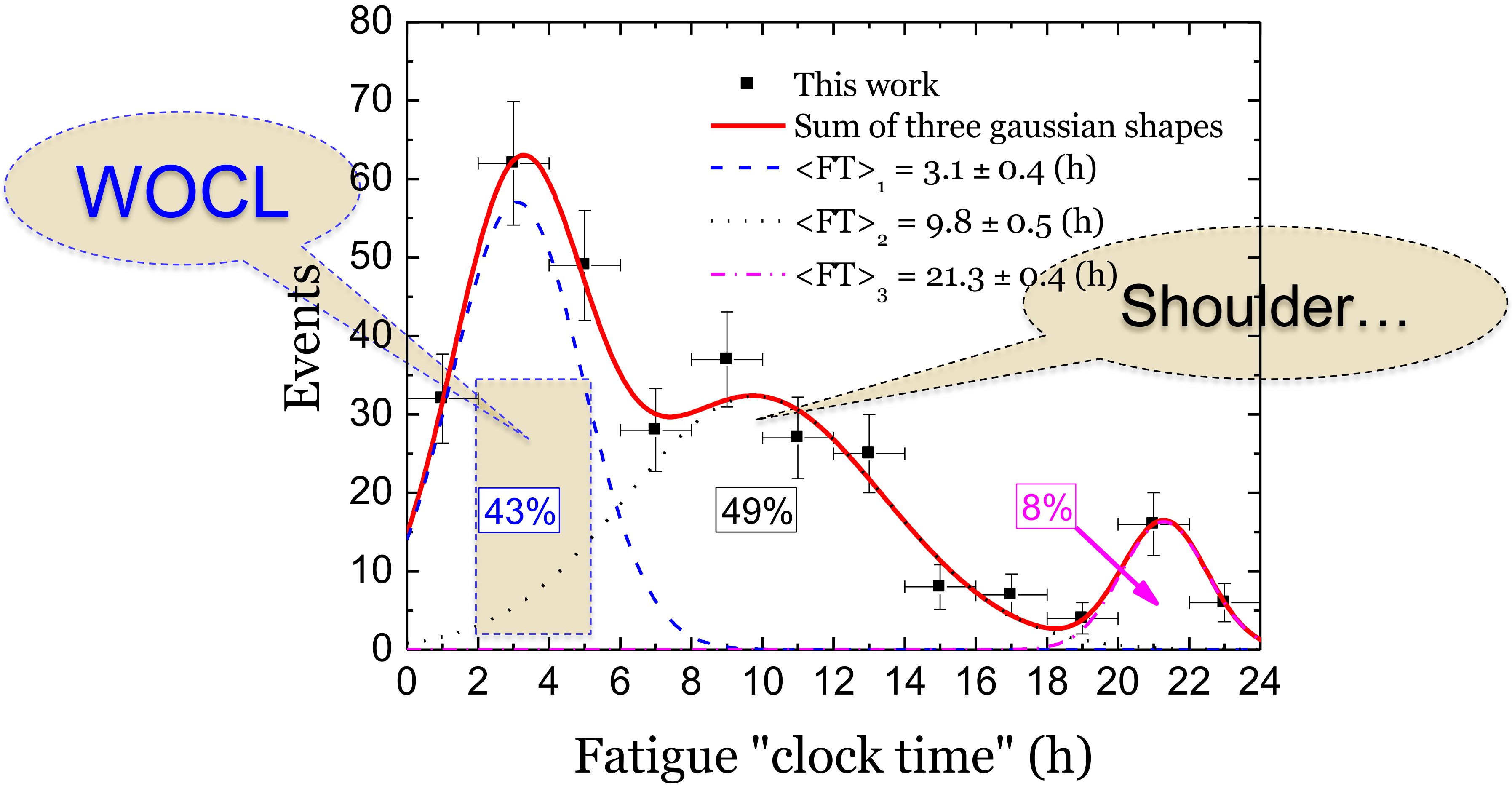


Average effectiveness: 73.8 ± 0.8% (E = 77.5% → BAC ≈ 0.05%)

(*) Licati, PR; Rodrigues, TE; Wey, D; Fischer, FM; Menna-Barreto, L. (2015) *Conexão Sipaer*, Vol. 6, No. 1, pp. 7-17.

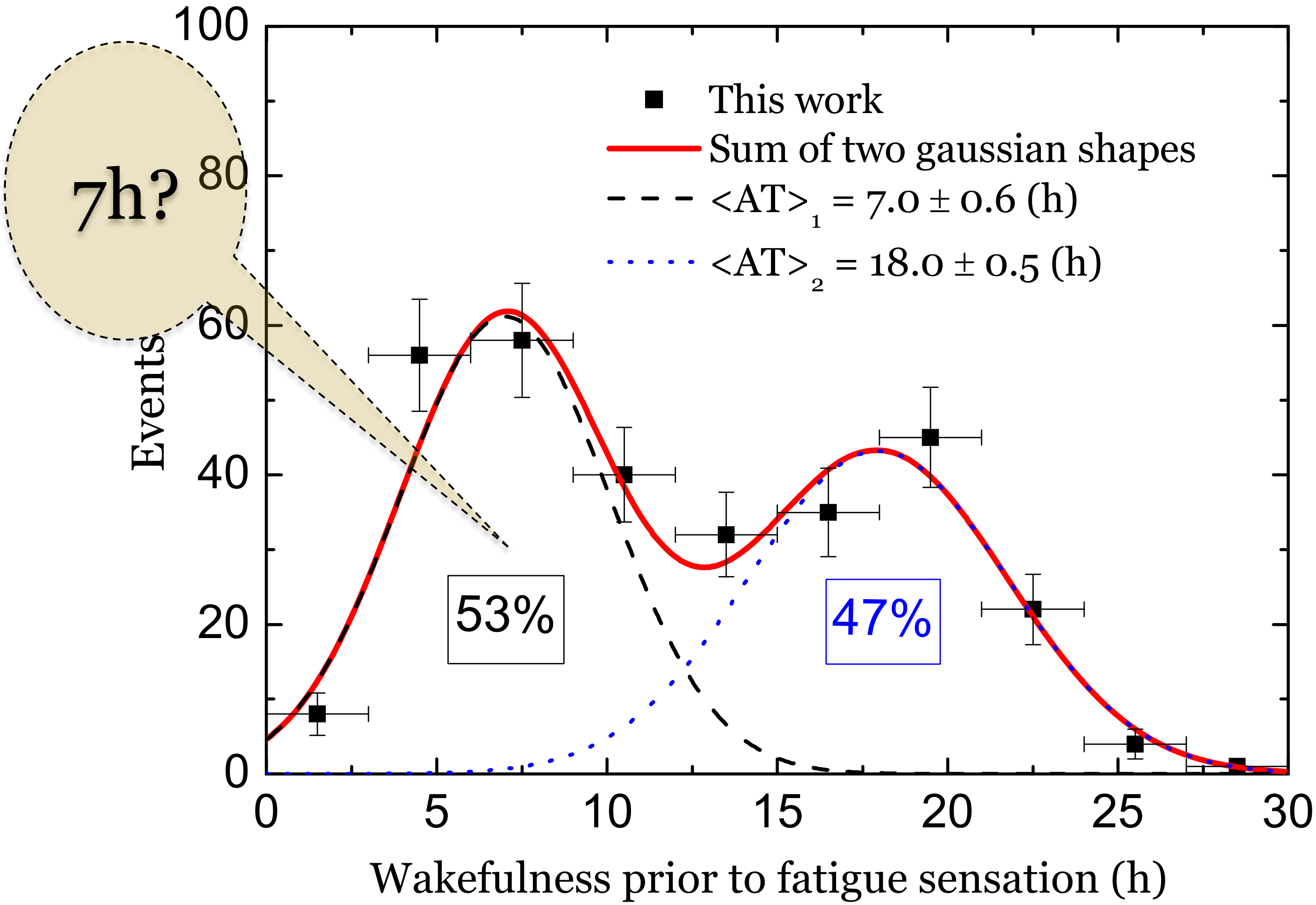
Pilot fatigue in Brazil

Fatigue clock time - FT



Pilot fatigue in Brazil

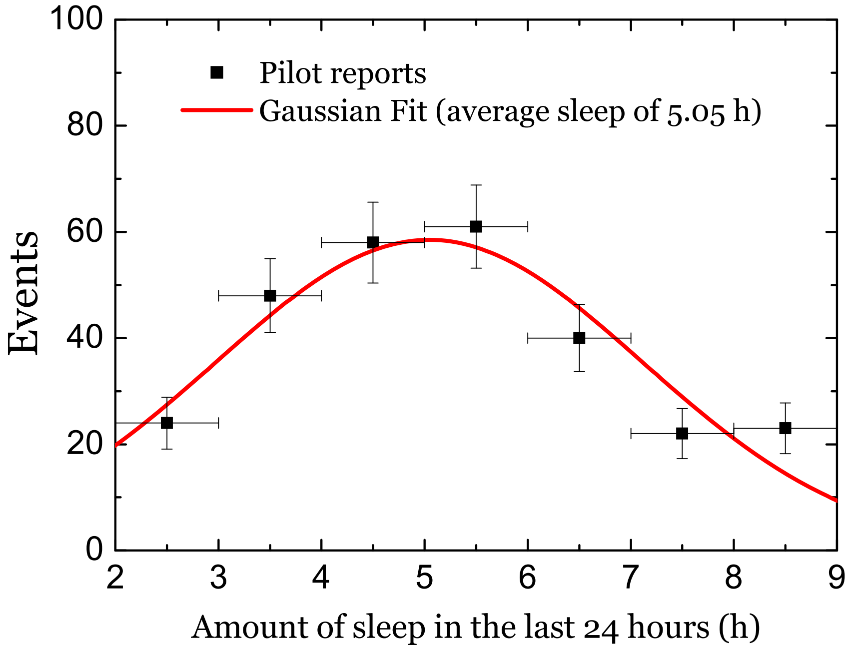
Wakefulness - AT

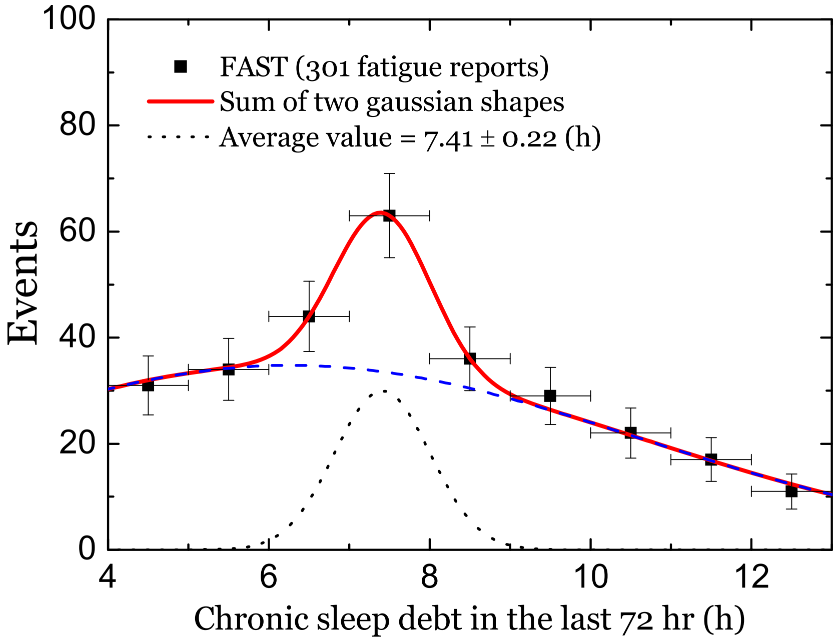


53% of the pilots manifested fatigue after only 7 hours of wakefulness

Pilot fatigue in Brazil

Sleep history





- Insufficient sleep in the last 24 hours (5.05 h) and
- chronic sleep debt in the last 72 hours (7.4 h)

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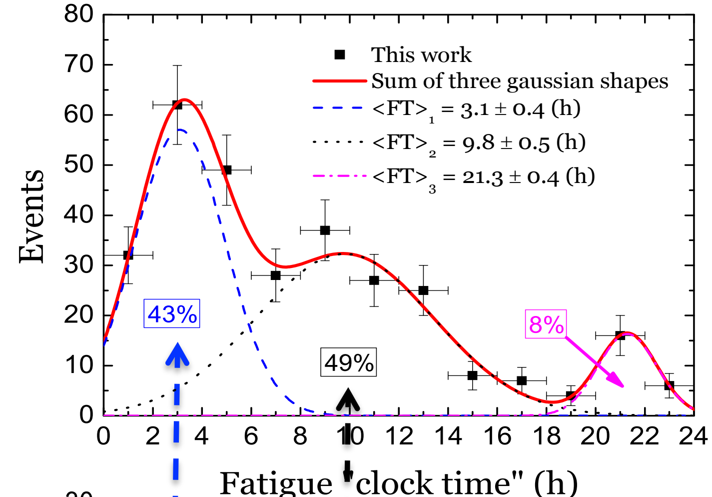
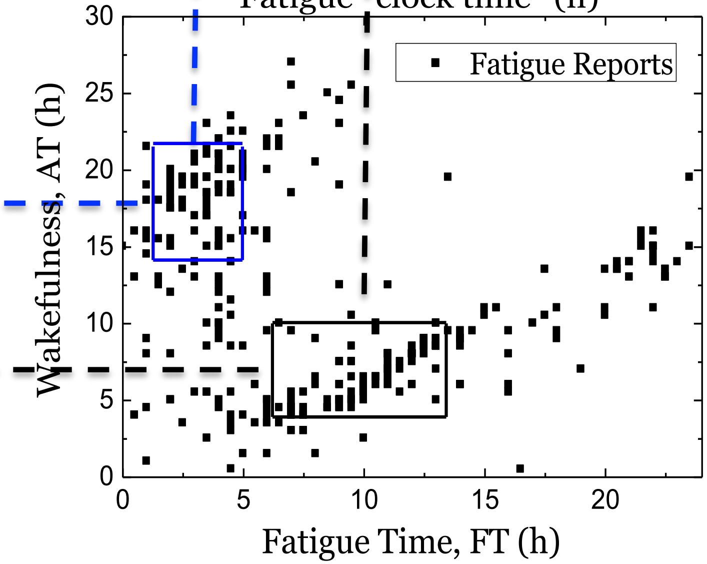
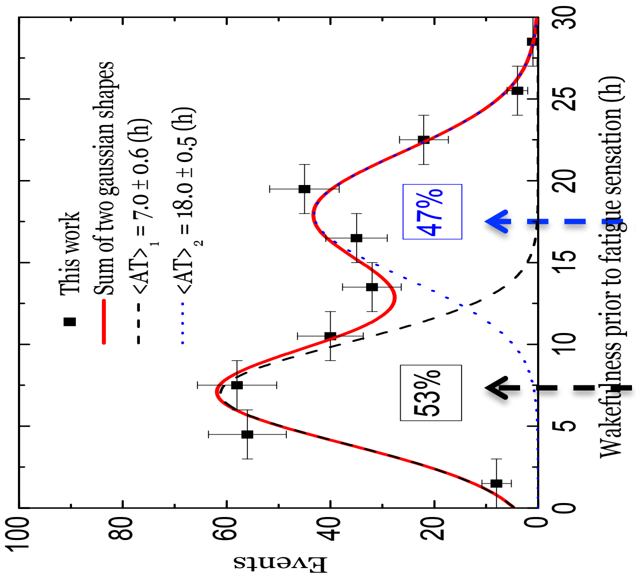
Pilot fatigue in Brazil

Fatigue time x wakefulness

Mean values (h)	
Wakefulness	Fatigue Time
18.0 ± 0.5	3.1 ± 0.4
7.0 ± 0.6	9.8 ± 0.5

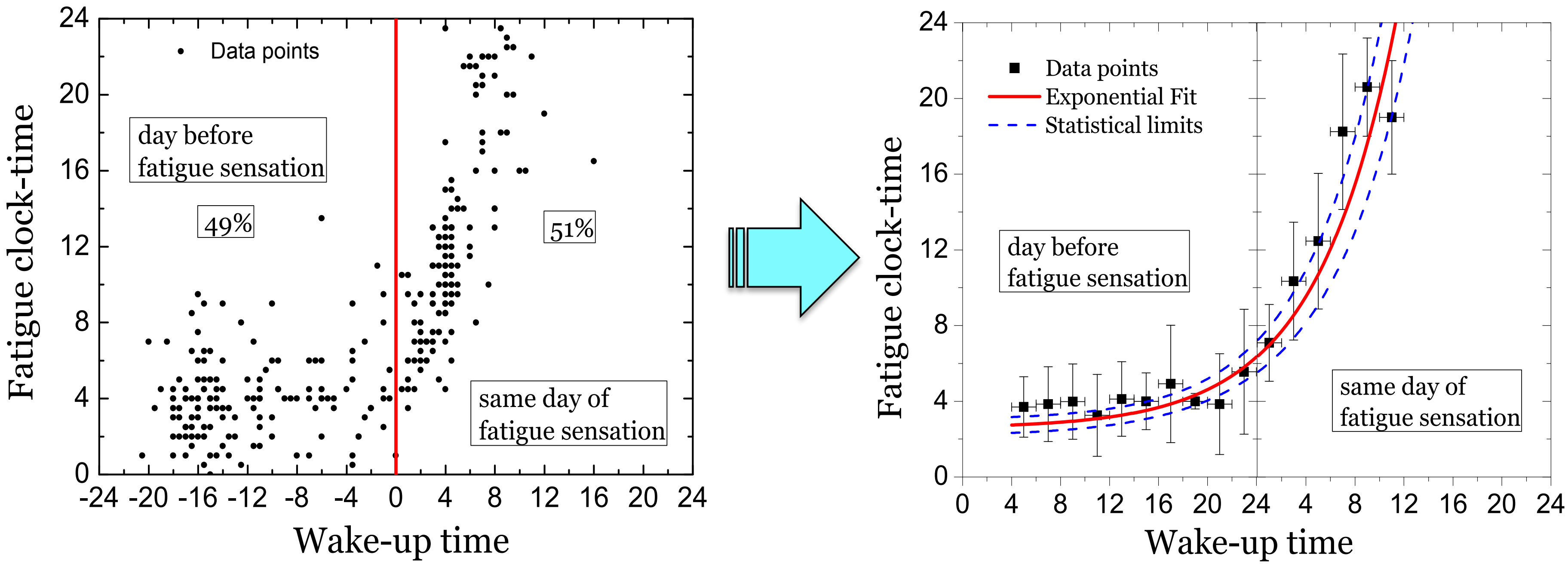






Pilot fatigue in Brazil

Fatigue time x awake time



Exponential relationship between FT and AT

Risk Analyses

Scenario 1: first *late night duty**

Scenario 1: Crew member checks in fully recovered				
Check-in (h)	Δ = 2h	Δ = 3h	Duty time (h)	# results
02:00	M1	M3	10	2
04:30	M5	M7	10	2
05:30	M9	M11	12	2
12:30	M13	M15	13	2
14:30	M17	M19	12	2
15:00	M21	M23	12	2
15:30	M25	M27	11	2
19:30	M29	M31	12	2
22:30	M33	M35	11	2
23:30	M37	M39	10	2

Δ: elapsed time between wake-up and check-in

(*) "*late night duty*" indicates that any fraction of the duty can elapse between 0000 and 0600

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Risk Analyses

Scenario 2: second *late night duty*

Scenario 2: Crew member starts the second work day after completing the scenario 1 in the first day				
Check-in (h)	Δ = 2h	Δ = 3h	Duty period (h)	# results
02:00	M2	M4	10	2
04:30	M6	M8	10	2
05:30	M10	M12	12	2
12:30	M14	M16	13	2
14:30	M18	M20	12	2
15:00	M22	M24	12	2
15:30	M26	M28	11	2
19:30	M30	M32	12	2
22:30	M34	M36	11	2
23:30	M38	M40	10	2

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Risk Analyses

Scenarios 3, 4 & 5: early-starts

Scenario 3: Crew member checks-in fully recovered					
Check-in (h)	Δ = 2h	Δ = 3h	Δ = 4h	Duty period (h)	# results
06:30	M41	M43	--	13	2
07:30	M45	M47	--	14	2
09:30	M49	M51	M53	14	3

1st day

Scenario 4: Crew member in the third consecutive day after the completion of two successive early-starts					
Check-in (h)	Δ = 2h	Δ = 3h	Δ = 4h	Duty time (h)	# results
06:30	M42A	M44A	--	13	2
07:30	M46A	M48A	--	14	2
09:30	M50A	M52A	M54A	14	3

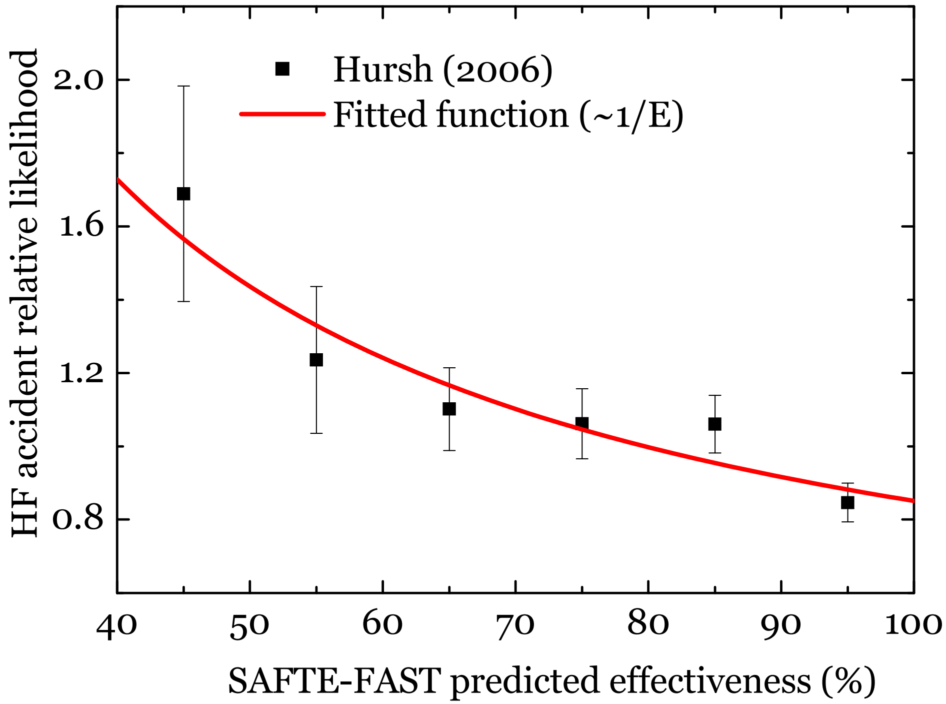
3rd day

Scenario 5: Crew member in the sixth consecutive day after the completion of five successive early-starts					
Check-in (h)	Δ = 2h	Δ = 3h	Δ = 4h	Duty time (h)	# results
06:30	M42	M44	--	13	2
07:30	M46	M48	--	10	2
09:30	M50	M52	M54	12	3

6th day

Risk Analyses

Fatigue risk versus Effectiveness

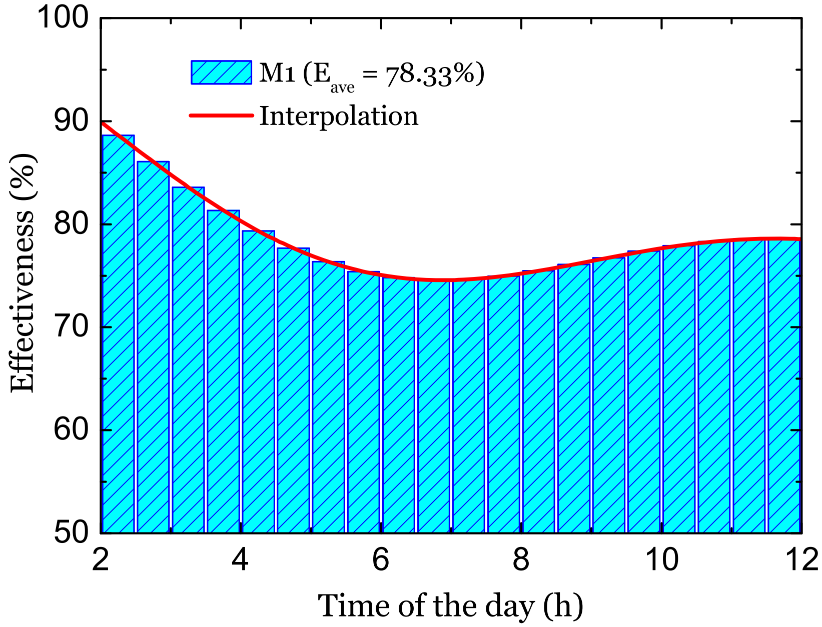


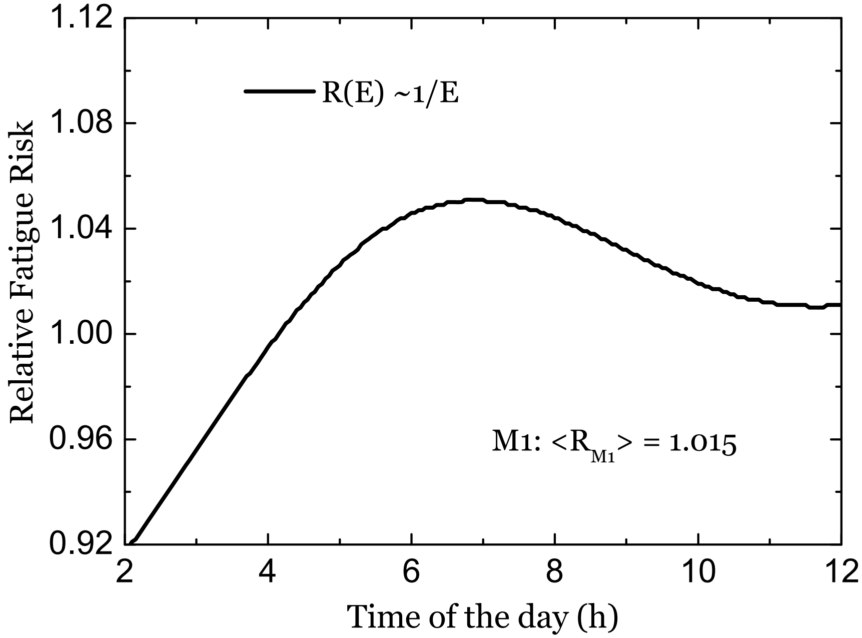
Data points: S. Hursh, T. Raslear, A. Kaye and J. Fanzone, Jr. (2006). Validation and Calibration of a Fatigue Assessment Tool for Railroad Work Schedules, Summary Report. (Report No. DOT/FRA/ORD-06/21). Washington, DC: U.S. Department of Transportation.

Risk Analyses

Effectiveness* → Risk

$E_{ave} = 78.33\ \%$ → $\langle R \rangle = 1.015$

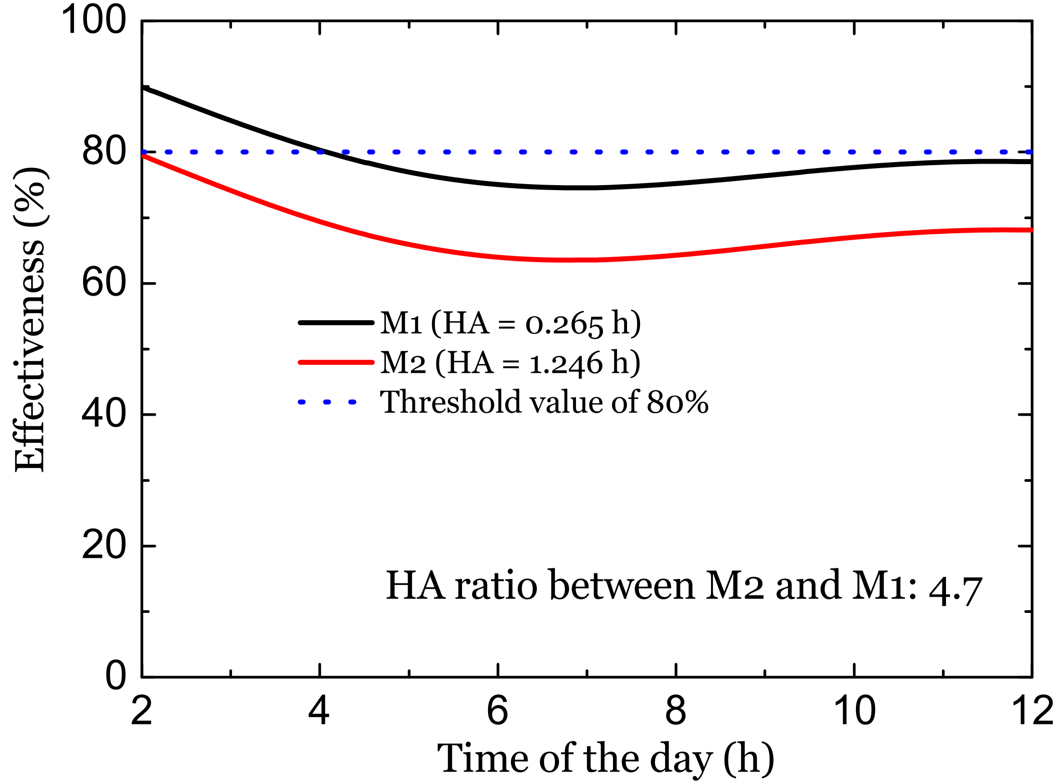




(*) SAFTE-FAST predicted Effectiveness were generously provided by Lauren Waggoner from IBR. The plots refer to the first night duty with check in at 02:00.

Risk Analyses

Effectiveness & Hazard Area (HA)

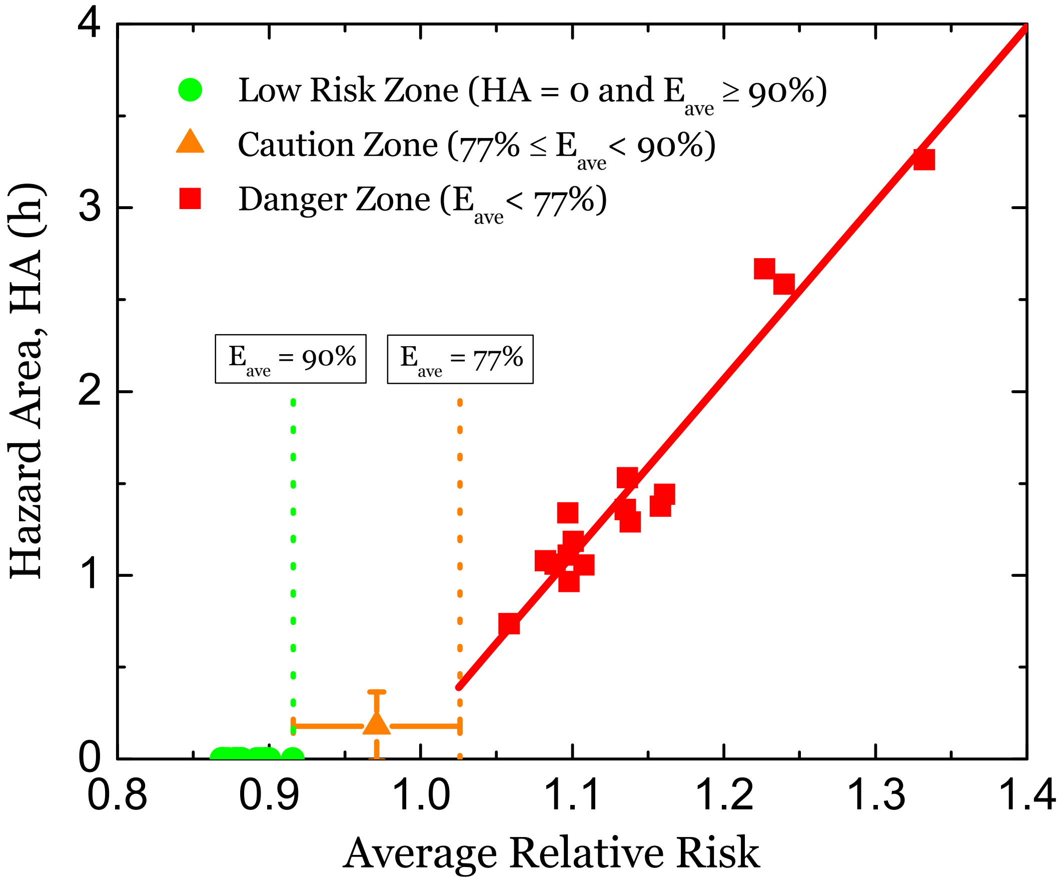


$$\frac{HA_{M2}}{HA_{M1}} \approx 5$$

The hazard areas (HA) were calculated by the fraction of the duty period with SAFTE-FAST Effectiveness below a threshold of 80%.

Risk Analyses

Risk exposure: average risk versus HA

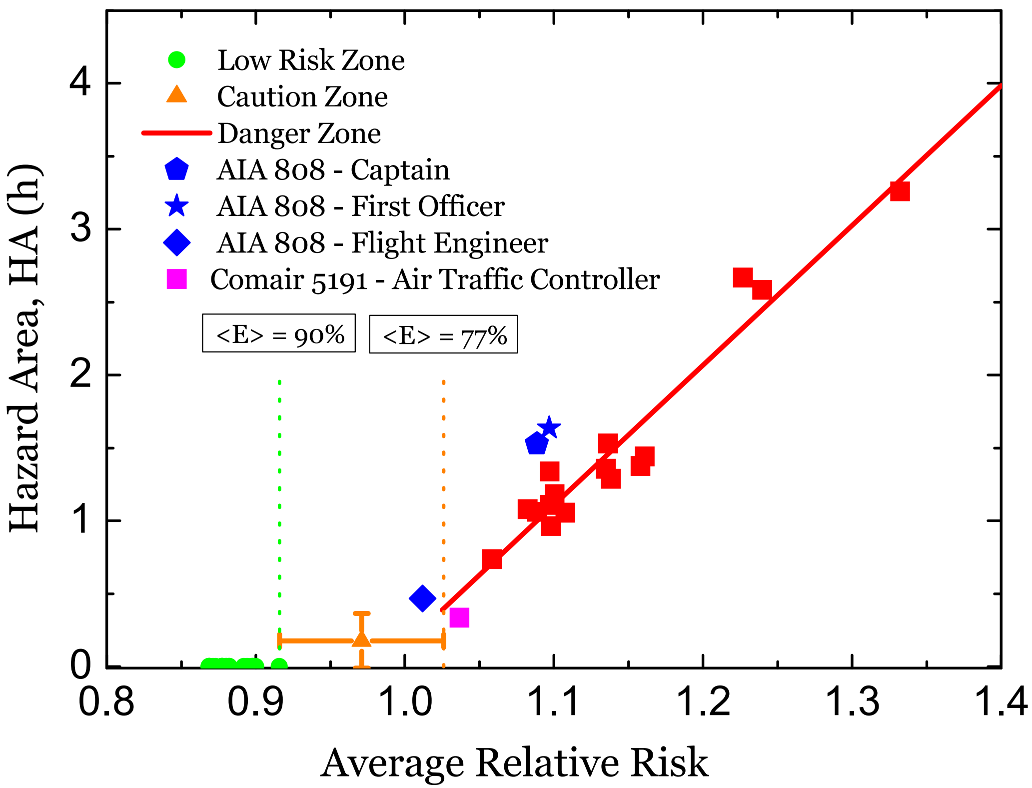


GREEN: LOW RISK

AMBER: CAUTION

RED: DANGER

Risk exposure: including real accidents [1,2]



SAFTE-FAST Effectiveness calculations:
(1) AIA 808 (Guantanamo Bay): Wesensten & Belenky (private comm.)
(2) Comair 5191: Pruchnicki, Wu & Belenky (2011)

FDT Limits

A science based proposal for minimum crew

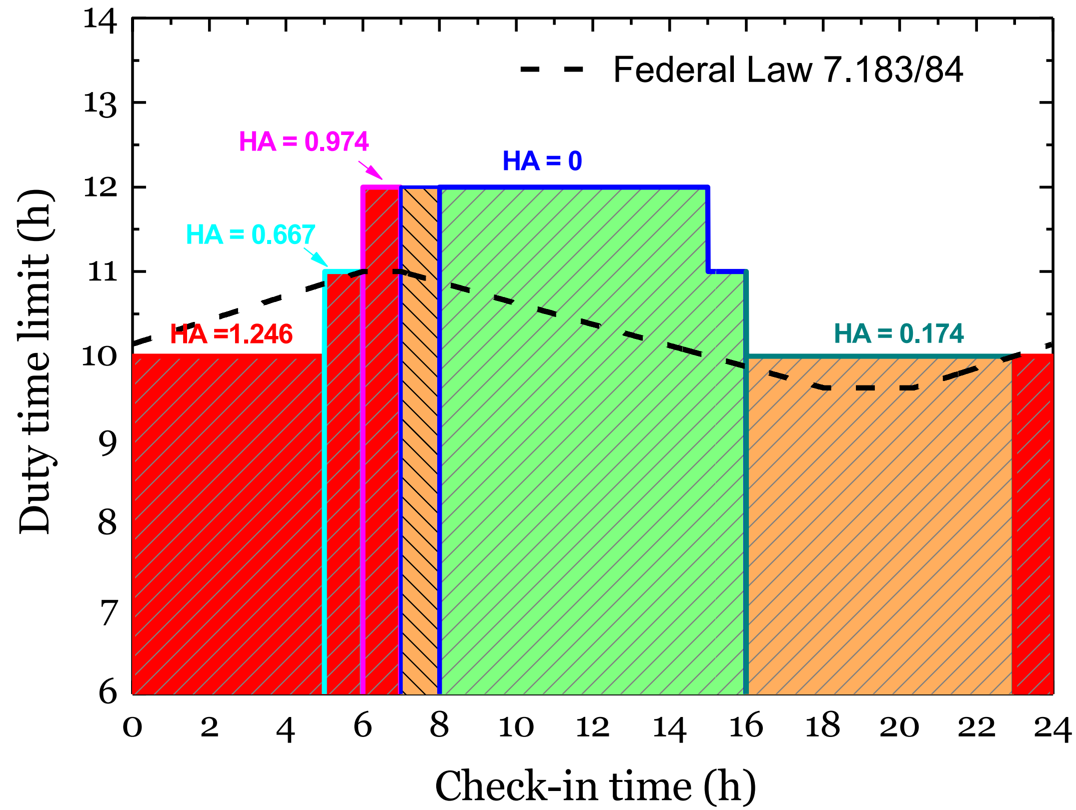
Start with CAO's-48 (scenarios 2 and 4), but limited to 12 hours*

Duty time limits (1 or 2 sectors) in scenarios 2 and 4* with Δ = 2 hours				
Check-in (h)	Initial condition label	Maximum duty time (h)	Average risk	Hazard area (h)
0500-0559	M10	11	1.059	0.667
0600-0659	M42A(*)	12	1.089	0.974
0700-0759	M46A(*)	**13 → 12**	0.973	0
0800-1059	M50A(*)	**14 → 12**	0.894	0
1100-1359	M14	**13 → 12**	0.871	0
1400-1459	M18	12	0.869	0
1500-1559	M26	11	0.869	0
1600-2259	M30	10	0.978	0.174
2300-0459	M2	10	1.135	1.246

(*) Details at http://www.asagol.com.br/files/_dirtecnica/FRMS/FRMS%20Report%20Part%20II.pdf

A science based proposal for minimum crew

Current (Federal Law 7.183/84) versus "future" limits (one or two sectors)



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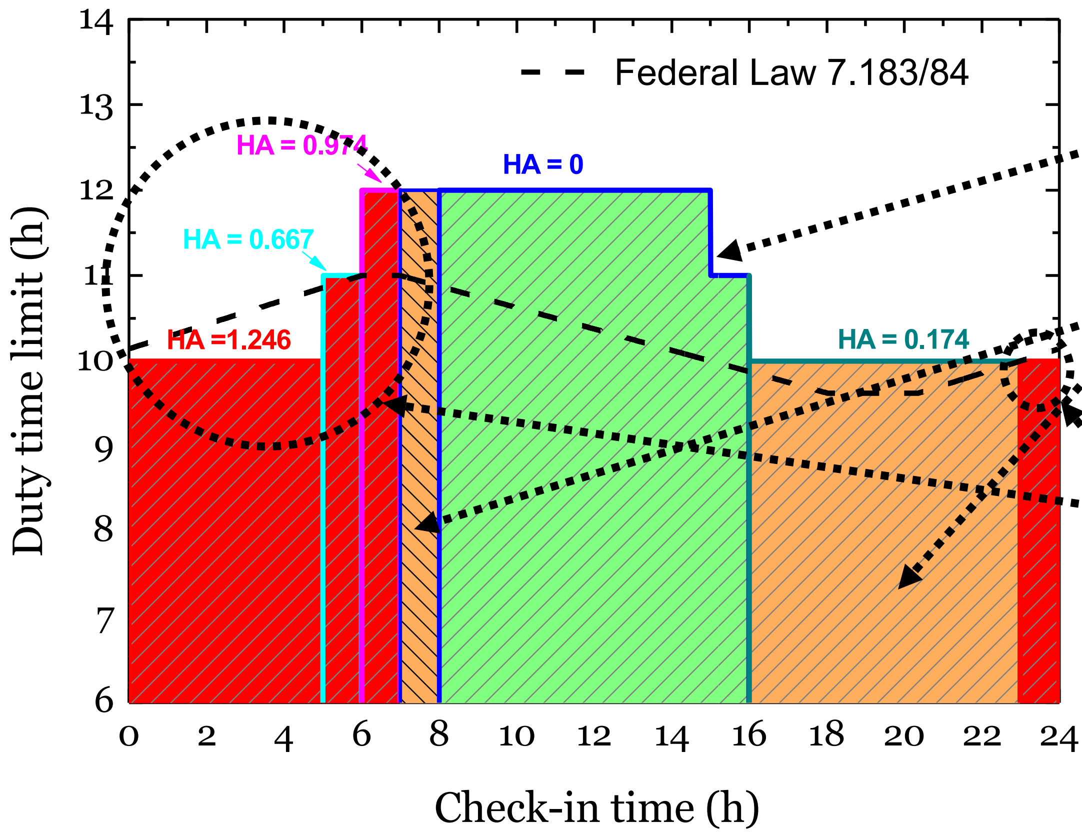
FDT Limits

A science based proposal for minimum crew

Safety x Productivity
Fatigue Risk As Low As Reasonably Practicable (ALARP)



Green zone:
FDT increased to 12 hours

Amber zone:
FDT maintained

Red zone:
FDT reduced by 1 hour

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FDT Limits

A science based proposal for minimum crew

Duty and flight time limitations					
Check-in (h)	Number of flight sectors				
	1-2	3-4	5	6	7+
0500-0559	10(9)	9(8)	9(8)	9(8)	9(8)
0600-0659	11(9)	10(9)	9(8)	9(8)	9(8)
0700-0759	12(9.5)	12(9)	11(9)	11(9)	10(8)
0800-1059	12(10)	12(9.5)	12(9)	11(9)	11(9)
1100-1359	12(9.5)	12(9)	11(9)	11(9)	10(8)
1400-1459	12(9)	11(9)	10(8)	10(8)	9(8)
1500-1559	12(9)	11(8)	11(8)	10(8)	10(8)
1600-2259	10(8)	9(8)	9(8)	9(8)	9(8)
2300-0459	9(8)	9(8)	9(8)	9(8)	9(8)

- ✓ **Limits in black: the same as CAO's-48, but limited to 12 hours**
- ✓ **Limits in red: one hour lower than CAO's-48**
- ✓ **Limits in blue: one hour higher than CAO's-48**

Conclusions

1. Licati *et al.* (2015) found a scenario of chronic fatigue in Brazil with an average effectiveness of 73.8 ± 0.8 %. Roma *et al.* (2012) found a much higher value of 87.9% in USA. Comparing these experiments, the average fatigue risk in Brazil is 14% higher than in the USA.

2. More than 50% of the pilots manifested fatigue after only 7 hours of wakefulness. This result was explained by an insufficient sleep in the last 24 hours (average of 5 h) and chronic sleep debt in the last 72 hours (average of 7.4 h).

3. Single days-off should be avoided as they do not allow for a complete recovery. If they are needed it is not recommended that the crew members show to work before 10:00 in the next day.

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Conclusions

4. The Hazard Areas (HA) in the second *late night duty* (CAO's-48 or FAR's-117 FDT limits) is roughly 5 times higher than in the first one;

5. The HA during the third successive early-start before 07:00 is similar to the one found in the second *late night duty*;

6. The daily averaged HA of FAR's-117 is 26% (9%) higher than CAO's-48 in scenarios 1 and 3 (2 and 5);

7. The relative human-factor accident risk increases by 45% (90%) as the time on duty increases from 10 (8) to 12 hours [(Goode, 2003), reanalysis]. Is it really necessary to go beyond 12 hours for minimum crew?

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Conclusions

Lessons learned

I. The importance of an effective participation of Crew Member Representatives in de decision making of the FSAG;

II. Review of Prescriptive Limits as they play a major role for the fatigue risk management (ICAO's Annex 6). A step back may be needed;

III. The State FRMS Regulations can not rely 100% in a "*copy and paste*" strategy.

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Future Plans

1. Member Institutions: SNA, ABRAPAC, ASAGOL and ATT

2. Objective: To monitor the alertness level of the Brazilian crew members during their duty periods, providing data analyses for the identification of potential hazards, as well as safety recommendations for risk mitigation

3. Partnerships with IFALPA (HUPER Committee), Universities, Research Centers, FRMS Specialists, etc...

4. When to start: hopefully by the end of 2016!

Acknowledgments

- **Crew Member National Union (SNA)**
- **Brazilian Civil Aviation Pilots Association (ABRAPAC)**
- **GOL Airline Crew Member Association (ASAGOL)**
- **TAM Airline Crew Member Association (ATT)**

In Partnership with:

- **University of São Paulo (USP)**
- **Institutes for Behaviour Resources, Inc**

Collaborating Stakeholders:

- **National Centre of Investigation and Prevention of Aeronautical Accidents (CENIPA)**
- **National Commission of Human Fatigue (CNFH)**

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Thank you!