ICAO UNITING AVIATION

FMAS2016

Fatigue.
Risk.
Assessment.

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Fatigue Management Approaches Symposium

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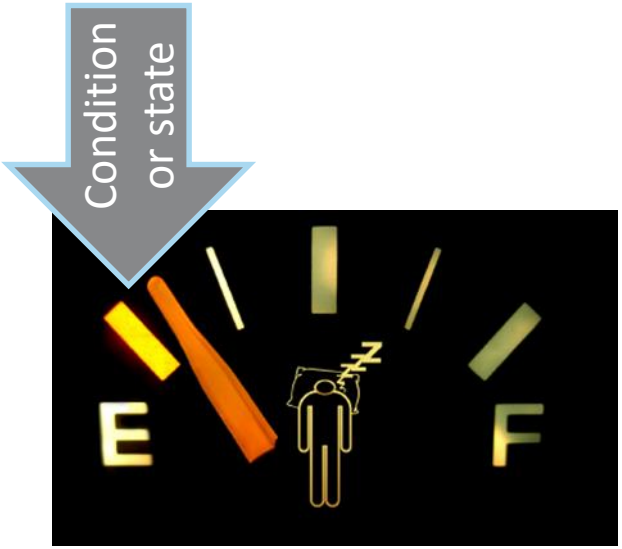
Is Human Fatigue a Risk?

Risk primarily depends on:
What you are doing
or intend to do
(task)

Is Human Fatigue a Risk?



Fatigue by itself is a regular state, experienced every day.
To make fatigue a hazard, we need a safety related task.

Fatigue. Risk. Assessment.

- Challenges to assess the risks associated with “fatigue”
- Fatigue Risk Assessment using a Risk Matrix
- Fatigue Specific Severity Classifications
- Fatigue Factor Assessment Table
- Summary & Conclusion

ICAO Definition of Fatigue

Human fatigue can be defined as:

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 person's alertness and ability to perform safety related operational duties.

Key Characteristics of Fatigue: Each Contains a Hazard

Human fatigue can be defined as:

A physiological state of reduced mental or physical performance capability

Reduced Performance Capability

resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity)

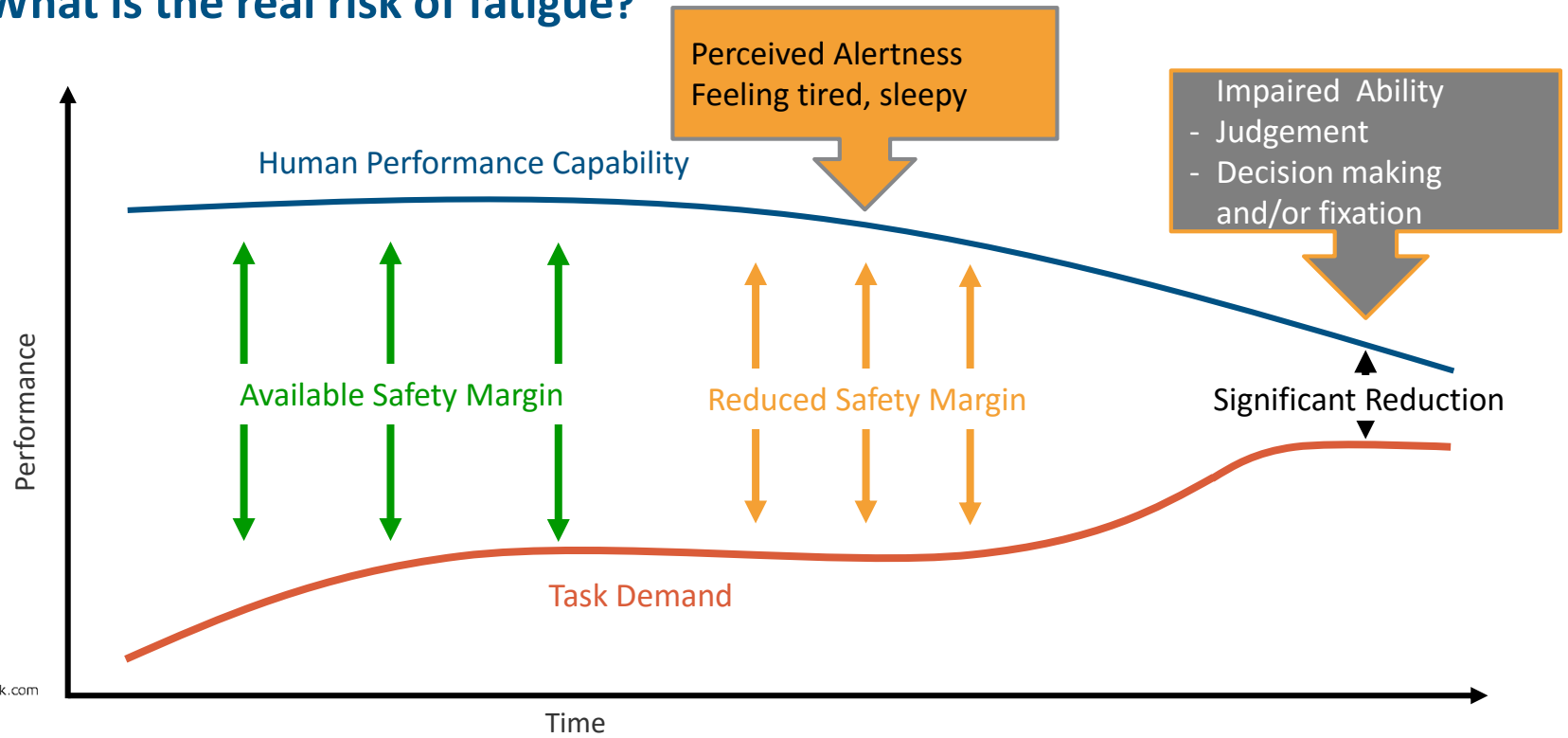
Impairment

that can impair a person's alertness and ability to perform safety related operational duties.

Consequences

Task Demand

What is the real risk of fatigue?



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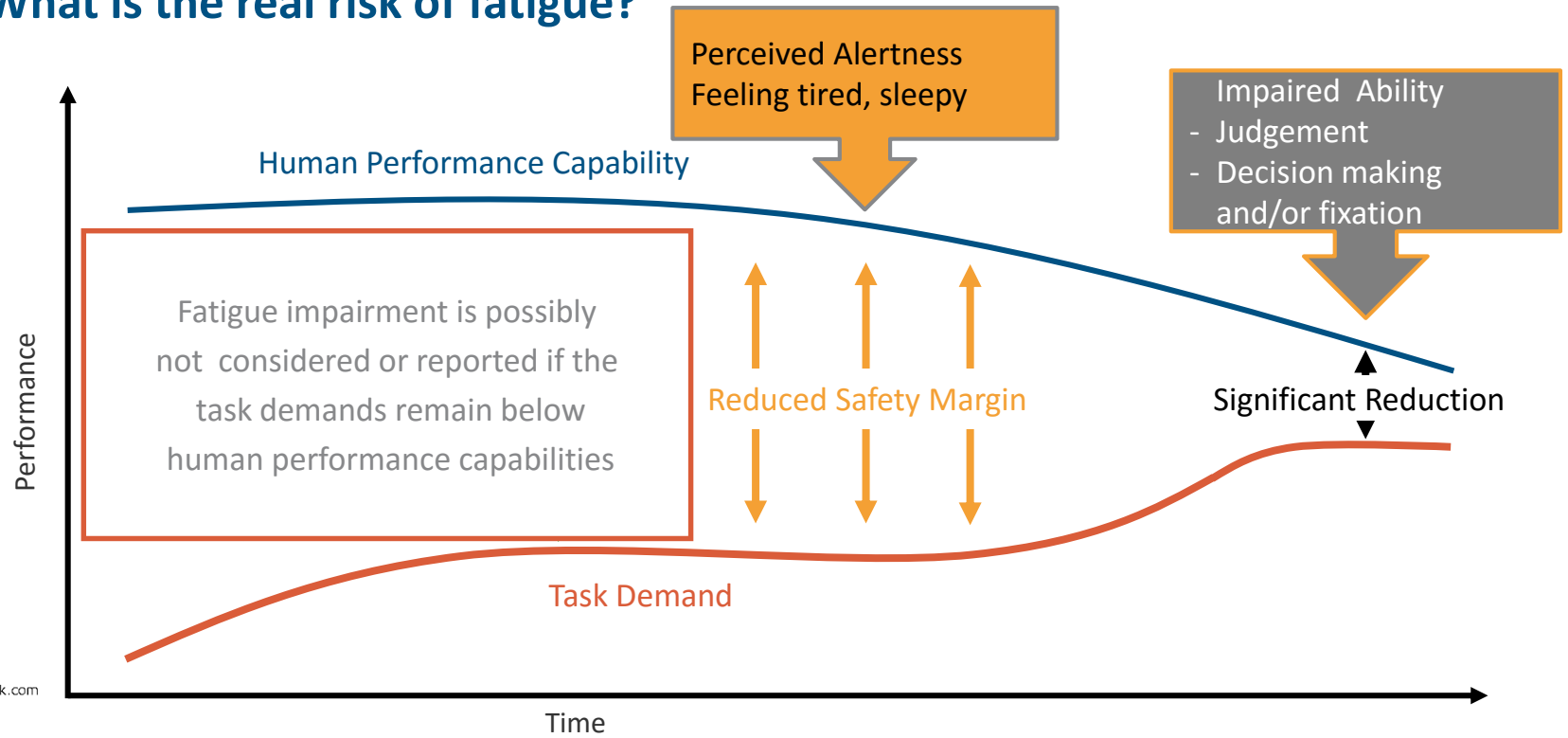

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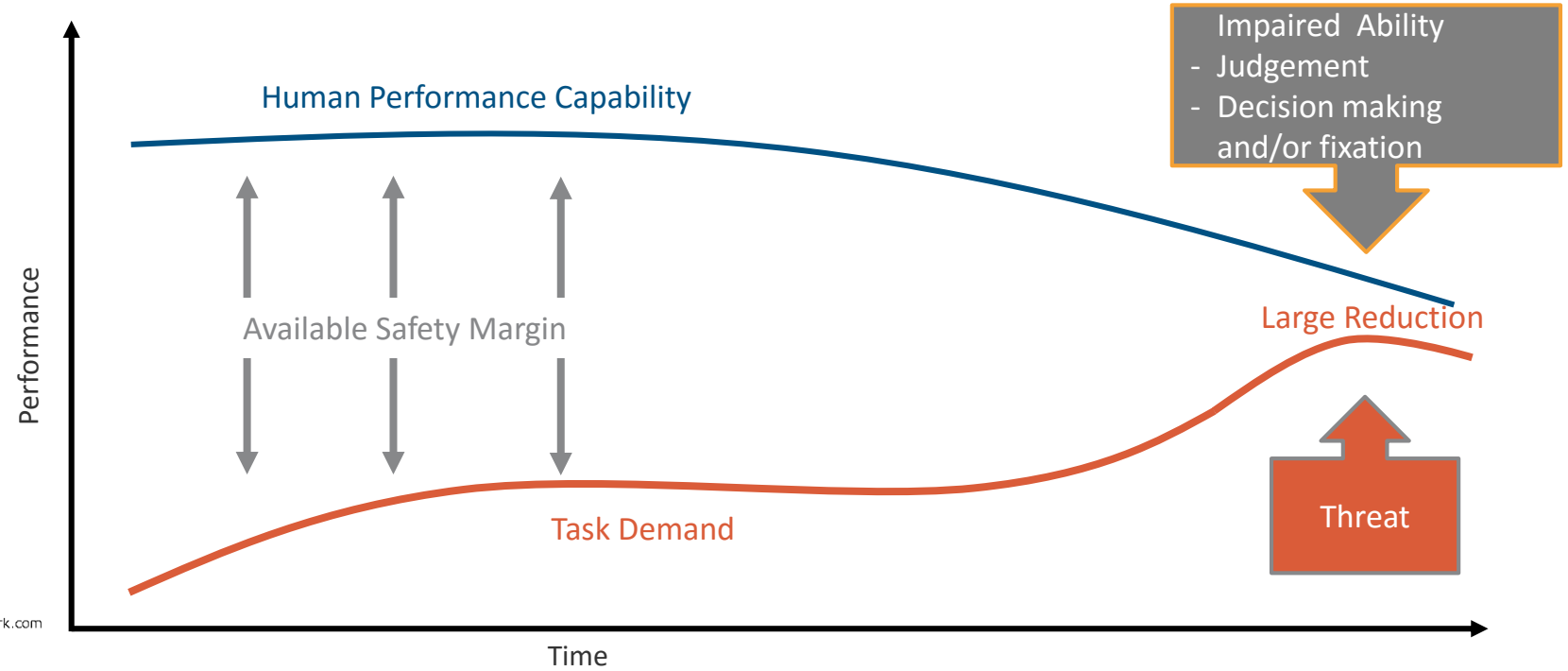

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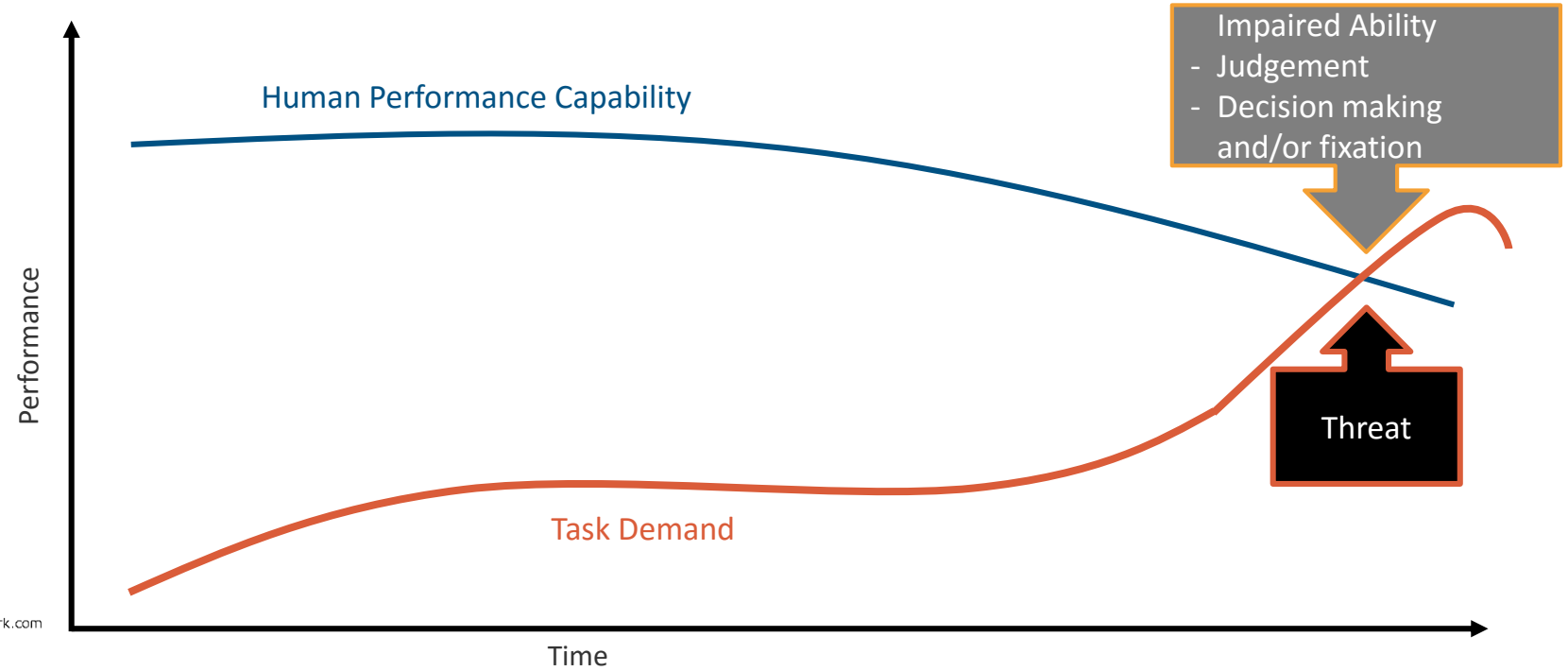

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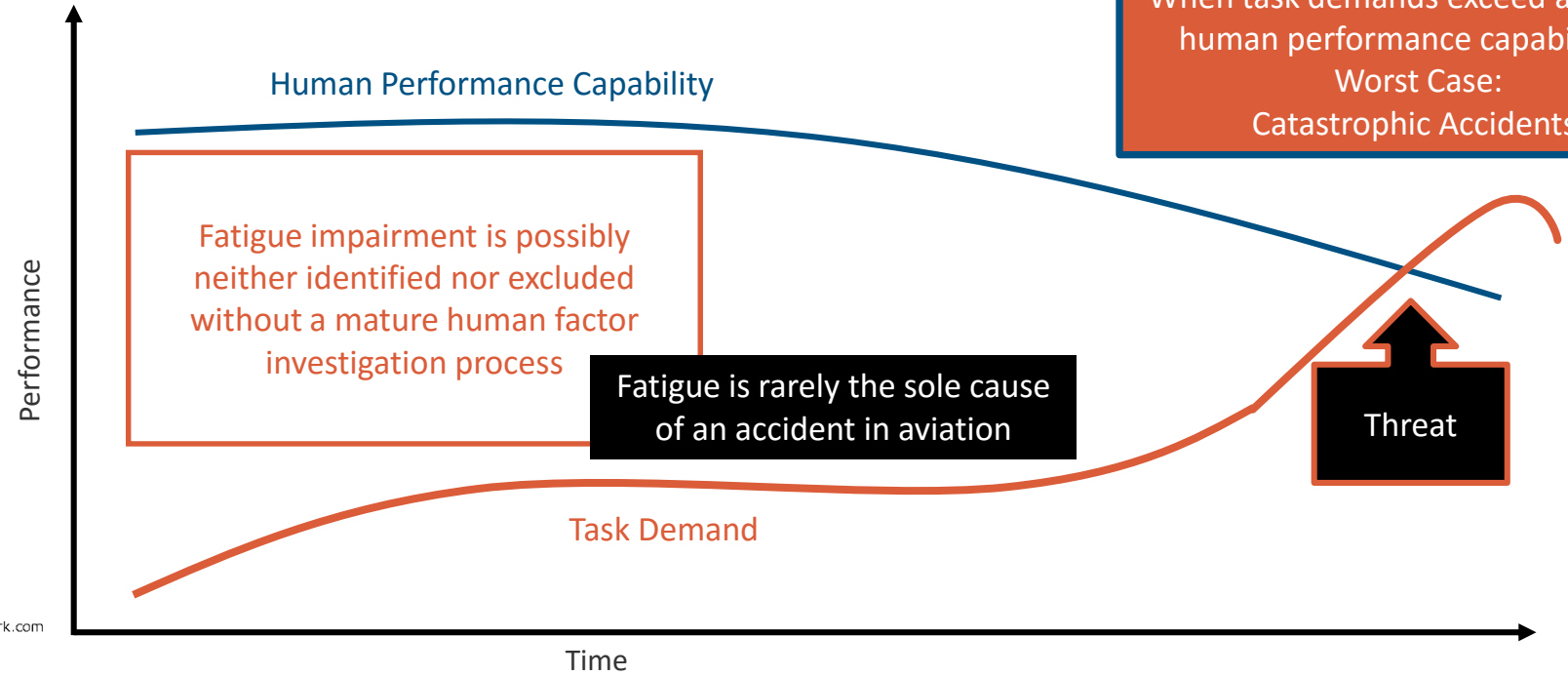

Fatigue. Risk. Assessment.

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Severity Classification related to ICAO Definition of Fatigue

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Safety Risk Assessments typically take the worst consequence as severity into account:

Consequences

Safety Risk Severity [ICAO SMM Doc 9859 Figure 2-12]		
Severity	**Meaning**	**Value**
Catastrophic	- Multiple deaths - Equipment destroyed	A
Hazardous	- A large reduction in safety margins, physical distress or a workload such that crewmembers cannot be relied upon to perform their tasks accurately or completely - Serious injury - Major equipment damage	B
Major	- A significant reduction in safety margins, a reduction in the ability of crewmembers to cope with adverse operating conditions as a result of increase in workload, or as a result of conditions impairing their efficiency - Serious incident - Injury to persons	C
Minor	- Nuisance - Operating limitations - Use of emergency procedures - Minor incident	D
Negligible	- Little consequences	E

Severity Classifications based on ICAO Definition of Fatigue

Human fatigue can be defined as:

A physiological state of reduced mental or physical performance capability

Safety Margin

resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity)

that can impair a person's alertness and ability to perform safety related operational duties.

Consequences

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Typical Risk Matrix

Risk Assessments serve to focus efforts and resources on those hazards posing high(est) risk

Likelihood		Fatigue Severity					
		Catastrophic A		Hazardous B	Large safety reduction	Major C	Significant safety reduction	Mine D	
Frequent	5	5A	Accident	5B		5C		5D	5E
Occasional	4	4A		4B		4C		4D	4E
Remote	3	3A		3B		3C		3D	3E
Improbable	2	2A		2B		2C		2D	2E
Extremely Improbable	1	1A		1B		1C		1D	1E

Incident

Accident

highlighted

highlighted

Fatigue Specific Risk Assessments

- Existing SMS risk assessment methodologies may be sufficient within prescribed limits
- Using an FRMS requires more effort on fatigue-specific risk assessment

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Fatigue Specific Risk Assessment

- To assess different types of fatigue risks using a matrix, different severity classifications are needed
- Likelihood classifications depend on the severity classification

Severity Classifications based on ICAO Definition of Fatigue

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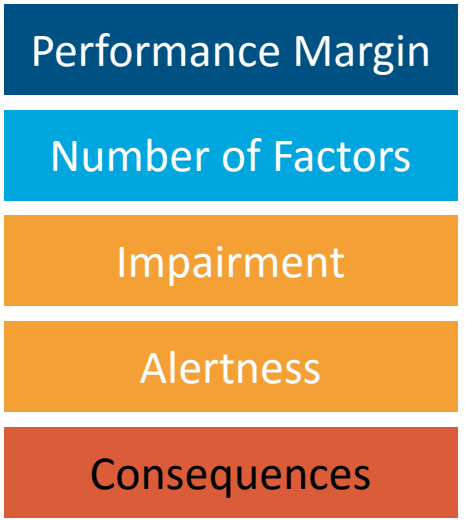

Severity Classifications based on ICAO Definition of Fatigue

ICAO SMM Severity Classification incl. “Safety Margin” (reports)	Performance Margin
Fatigue Factor Assessment and Mitigation Table (duties)	Number of Factors
Samn-Perelli (fatigue reports, surveys)	Impairment
Bio-Mathematical Thresholds, e.g. KSS (rosters, duties)	Alertness
ICAO SMM Severity Classification (general safety assessment)	Consequences

Severity Classifications related to ICAO Definition of Fatigue

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Impairment

Perceived Impairment (Fatigue Reports & Surveys)

Example: Samn-Perelli Check Fatigue Risk Severity		
S-P	**Meaning**	**Value**
7	- Completely exhausted, unable to function effectively	A
6	- Moderately tired, very difficult to concentrate	B
5	- Moderately tired, let down	C
4	- A little tired	D
3-1	- Okay, somewhat fresh (3) - Very lively, responsive, not at peak (2) - Fully alert, wide awake (1)	E

Severity Classifications related to ICAO Definition of Fatigue

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Alertness

Predicted Alertness by Bio-Mathematical Models

Example: KSS Fatigue Risk Severity		
KSS	**Meaning**	**Value**
9-8	- extremely sleepy, fighting sleep	A
8-7	- sleepy	B
7-6	- sleepy, but no difficulty remaining awake	C
6-5	- neither sleepy nor alert	D
4-3 2-1	- Alert - Extremly alert	E

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Number of Factors

Fatigue Factor Assessment and Mitigation Table

- Practicable approach for the assessment of a duty
- This example is based on relevant scientific research and operational FRMS experience of this operator
- Customisation is required for any other operator
- It needs to be related to a safety relevant task

Fatigue Factor Assessment and Mitigation Table			
Type of Shift/Specific Duty:			
Fatigue Factor:	Worst Case:	Mitigated:	Comment:
Sleep debt	Previous night sleep ** reduced < 4h (night: 22-08LT)			
	Previous night sleep ** reduced > 4h			
	Reduced night sleep > 4h before previous night ***			
	Previous "night duty" ** (day sleep only)**			
Wakefulness	Time since awake prior duty start > 2h prior C/I*			
	Time since awake prior duty start > 6h prior C/I*			
	Time on task > 10h (FDT)			
	Time on task > 12h < 14h (FDT)			
Circadian Factors	Circadian disruption > 4h **			
	Flight after 2300LT or last landing during darkness			
	Flighttime <2h during WOCL (02-06LT)			
	Flighttime > 2 h during WOCL (02-06LT)			
Workload	3 or 4 consecutive flights/sectors			
	5 or 6 flights / or: 3 flights during night			
	Known hassles			
	Training flights			
Sum of fatigue factors			
Mark every line: 1 = relevant; 0 = actively avoided; --- = not present			
Assessment of fatigue factors: 0-3 relevant factors: accept 4-6 relevant factors: check 7-9 relevant factors: mitigate >10 relevant factors: not acceptable		* Crew member's responsibility ** Depending on preceding duty *** The night before 2 consecutive nights are relevant	
Factors are not fully weighted! Most important factors are sleep debt, wakefulness, circadian factors then workload in this order.			
Tritschler 2016; ICAO Fatigue Management Symposium 2016			

Sleep Debt

Wakefulness

Circadian Factors

Workload

About:

- All 4 causes of fatigue are taken into account
- Each line is based on a scientific statement / study
- Factors are not fully weighted

	Fatigue Factor Assessment and Mitigation Table			
	Type of Shift/Specific Duty:	CGN-TFS-CGN: Checkin 1600LT, Checkout 0300LT; FDT: 11:00h		
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Sleep debt	Previous night sleep ** reduced < 4h (night: 22-08LT)	1**		Not relevant if 1st duty day
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Sleep debt	Previous "night duty" ** (day sleep only)**	1**		
Wakefulness	Time since awake prior duty start > 2h prior C/I*	1		
Wakefulness	Time since awake prior duty start > 6h prior C/I*	1		
Wakefulness	Time on task > 10h (FDT)	1		FDT > 10h at night (!)
Wakefulness	Time on task > 12h < 14h (FDT)	--		
Circadian Factors	Circadian disruption > 4h **	1**		
Circadian Factors	Flight after 2300LT or last landing during darkness	1		
Circadian Factors	Flighttime <2h during WOCL (02-06LT)	1		
Circadian Factors	Flighttime > 2 h during WOCL (02-06LT)	--		
Workload	3 or 4 consecutive flights/sectors	--		
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	Factors are not fully weighted! Most important factors are sleep debt, wakefulness, circadian factors then workload in this order.			
	Tritschler 2016; ICAO Fatigue Management Symposium 2016			

Step 1: Worst Case

- Mark every line under existing conditions:

  1 = relevant; -- not present

Fatigue Factor Assessment and Mitigation Table

	Type of Shift/Specific Duty:	CGN-TFS-CGN: Checkin 1600LT, Checkout 0300LT; FDT: 11:00h		
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Wakefulness	Time on task > 12h < 14h (FDT)	--		
Circadian Factors	Circadian disruption > 4h **	1		"
Circadian Factors	Flight after 2300LT or last landing during darkness	1		
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Circadian Factors	Flighttime > 2 h during WOCL (02-06LT)	--		
Workload	3 or 4 consecutive flights/sectors	--		
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	Tritschler 2016; ICAO Fatigue Management Symposium 2016			

If sleep reduced > 4h mark both lines!

If time on task > 12h mark both lines!

If flight time > 2h in WOCL mark both lines!

If consecutive sectors > 4 mark both lines!

Note:

Mark every relevant line means that two lines are relevant:

- If sleep reduced > 4h
- If time on task >12h
- If flight time during WOCL > 2h
- If more than 4 sectors

	Fatigue Factor Assessment and Mitigation Table			
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Circadian Factors	Flight after 2300LT or last landing during darkness	1		
Circadian Factors	Flighttime <2h during WOCL (02-06LT)	1		
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	Tritschler 2016; ICAO Fatigue Management Symposium 2016			

Step 1: Worst Case

- Mark every line under existing conditions:
- Sum relevant factors (fatigue factor score)

	Fatigue Factor Assessment and Mitigation Table			
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Wakefulness	Time since awake prior duty start > 2h prior C/I*	1		
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	Tritschler 2016; ICAO Fatigue Management S			

Step 1: Worst Case

- Mark every line under existing conditions:
- Sum relevant factors
- First Assessment

Assessment of Fatigue Factors under Existing Conditions (Column 1):		
Relevant factors	**Requirement**	**Action**
0-3	Accept	No mitigation required
4-6	Check	Identify mitigations to reduce relevant fatigue factors
7-9	Mitigate	Identify mitigations to reduce the remaining fatigue factors to the minimum
> 9	Not Acceptable	Identify mitigations to reduce the remaining fatigue factors to an acceptable minimum. If not possible this duty is not permissible

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Wakefulness	Time since awake prior duty start > 2h prior C/I*	1	1	
Wakefulness	Time since awake prior duty start > 6h prior C/I*	1	(1)	Recommend nap before duty
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	Tritschler 2016; ICAO Fatigue Management Symposium 2016			

Step 2: Mitigate!

- Identify avoidable factors:

  Mark every line:

  0 = actively avoided

  1 = remains relevant;

  -- = still not present

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	Tritschler 2016; ICAO Fatigue Management Symposium 2016			

Step 2: Mitigate!

- Identify avoidable factors:

  Mark every line:
- Sum relevant fatigue factors

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	Tritschler 2016; ICAO Fatigue Management Symposium 201			

Step 2: Mitigate!

- Identify avoidable factors:

  Mark every line:
- Sum relevant fatigue factors
- Second Assessment - acceptability

Acceptability of Fatigue Factors after Mitigating Actions (Column2)		
Relevant factors	**Fatigue Impairment**	**Acceptability**
0-3	Low	Acceptable, no further mitigation required
4-6	Increased	Acceptable, but keep remaining fatigue factors as low as reasonably practicable; monitor operation
7-9	Significant	Acceptable if remaining fatigue factors are kept at the minimum (all avoidable fatigue factors are avoided), number of this duty is limited per crewmember per time-period; monitoring of this work period required
> 9	High	Not acceptable

Conclusion after Step 2:

This duty is not permissible without these mitigations:

- May be rostered only in combination with “late duties”
- Previous duties shall be completed prior midnight
- Training flights not recommended
- Promote nap prior duty
- Fatigue impairment is expected to be increased
- Monitoring of this rotation required

Step 3: Assess Fatigue Risk

	Frequency of Exposure per Crewmember per Working Period (week)			
Relevant fatigue factors	May be scheduled every day	May be scheduled twice per week	May be scheduled once per week	Unexpected circumstances
1-3	low	low	low	low
4-6	moderate	moderate	low	low
7-9	high	moderate	moderate	moderate
> 9	high	high	high	high

FSAG would recommend, to assign this duty (under mitigations) only once per working period for any pilot

Fatigue. Risk. Assessment.

- Challenges to assess the risks associated with “fatigue”
- Fatigue Risk Assessment using a Risk Matrix
- Fatigue Specific Severity Classifications
- Fatigue Factor Assessment Table
- Summary & Conclusion

Summary

- Customisation required for any methodology, classification and risk tolerance thresholds
- 5 different severity classification for fatigue risk assessments
- Fatigue specific severity classes do not contain the task
- A safety relevant task is required for (fatigue) risk assessment
- ICAO basic risk matrix fulfils its objective for SMS
- Fatigue itself is a regular condition, occurring every day

Conclusion

- Current methodologies for assessing fatigue risks are all limited to some degree.
- With growing maturity of SMS and more operational FRMS experience, advances are continuing to be made in the way fatigue risks are assessed.

Further Guidance

- Fatigue Management Guides 2016
- Technical paper published at EASA FRM Workshop 2015
  "Tritschler 2015, Fatigue Risk Assessment Methodologies"
  Available at the EASA Website or
  http://www.smartshiftwork.com/sharing/publications/

Thank you