

How eye tracking data can enhance human performance in tomorrow's cockpit.

Results from a flight simulation study in FUTURE SKY SAFETY.

**Marcus Biella ¹, Matthias Wies ¹, Rebecca Charles ², Nicolas Maille ³,
Bruno Berberian ³ & Jim Nixon ²**

¹ DLR (German Aerospace Center), Institute of Flight Guidance, Braunschweig, Germany

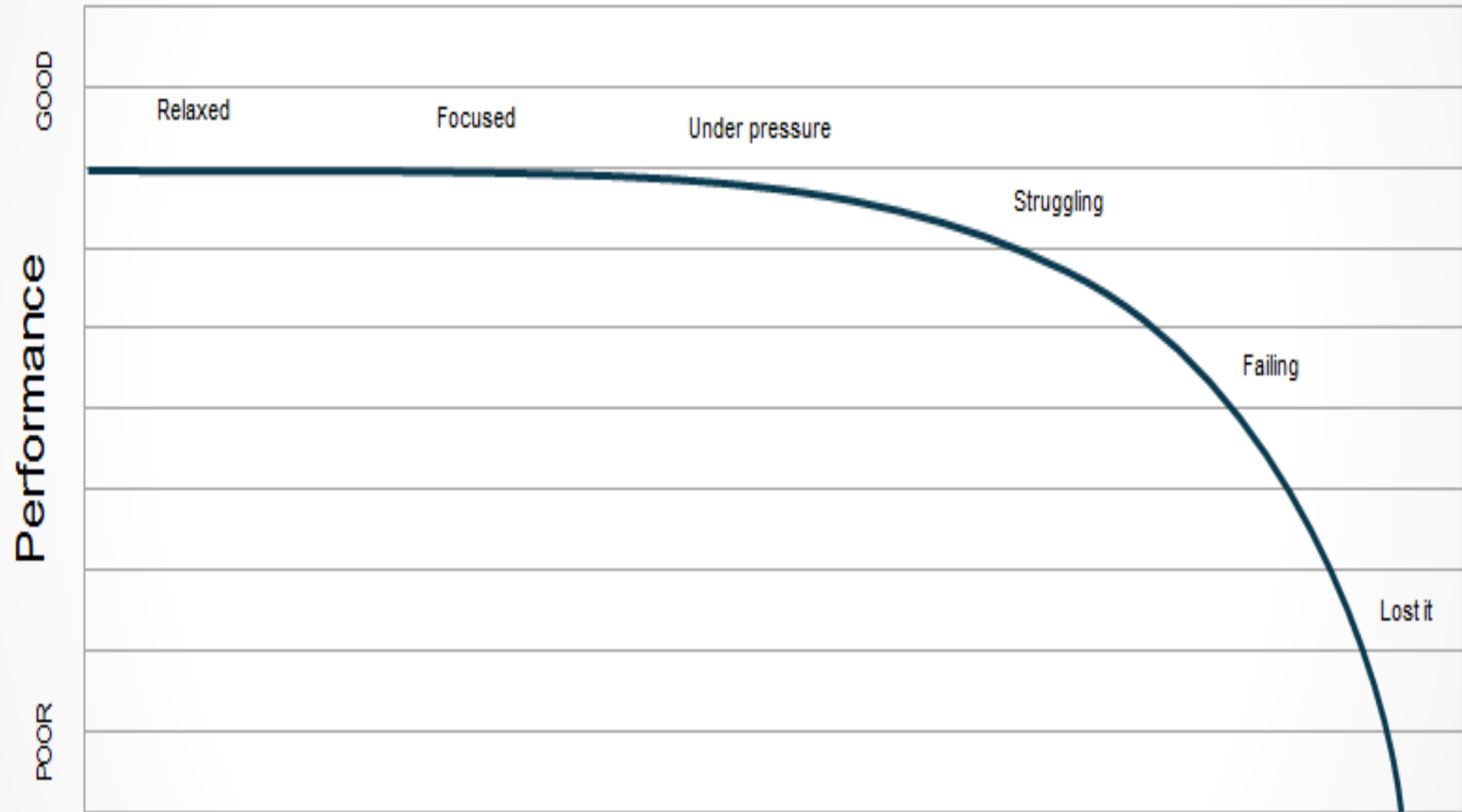
² Cranfield University, Centre for Safety & Accident Investigation, Cranfield, UK

³ ONERA Systems Control and Flight Dynamics Department, Salon de Provence, France

RAeS Flight Simulation Conference
2017-11-15

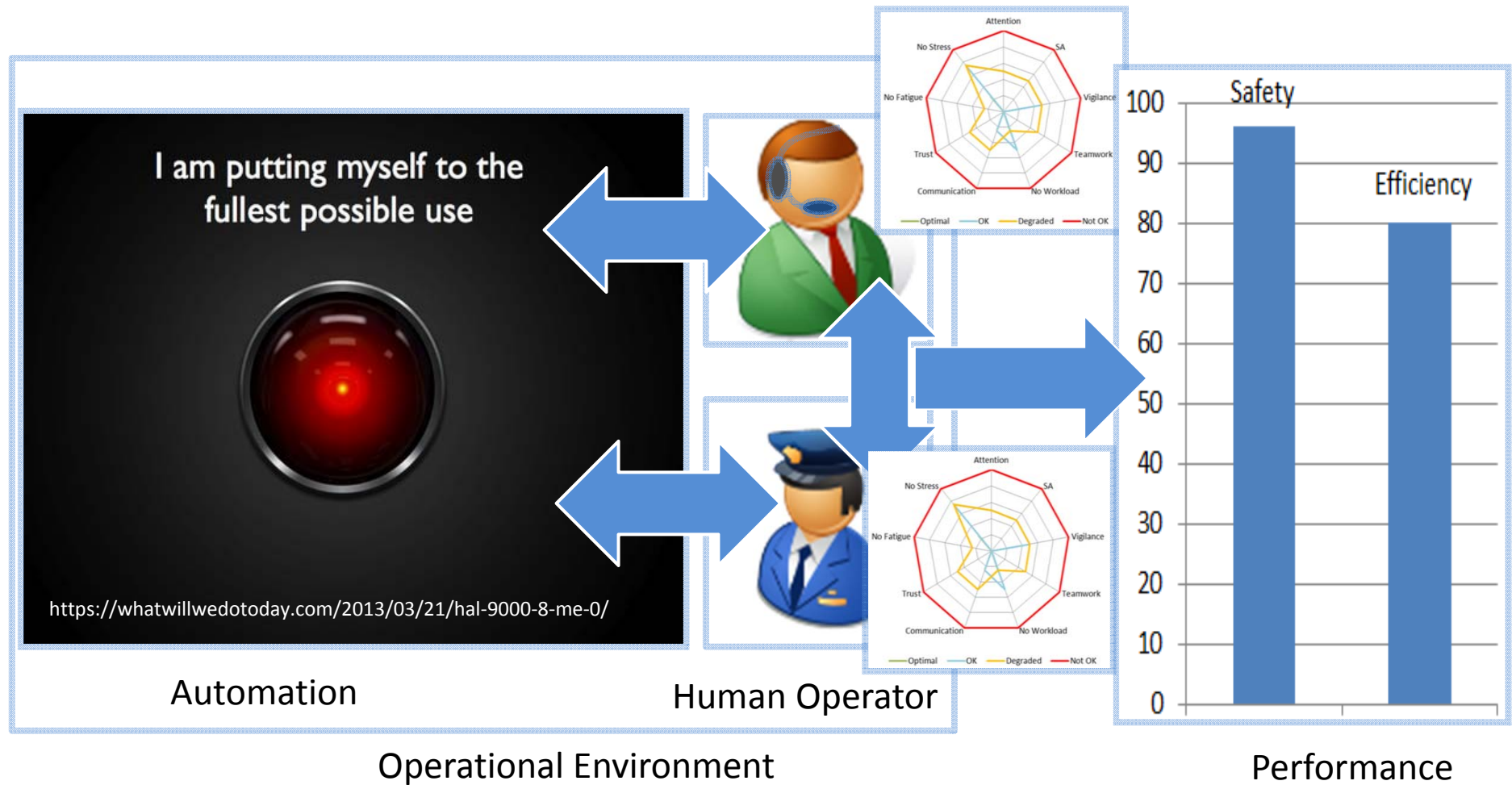


Decline in performance: it happens gracefully, not abrupt

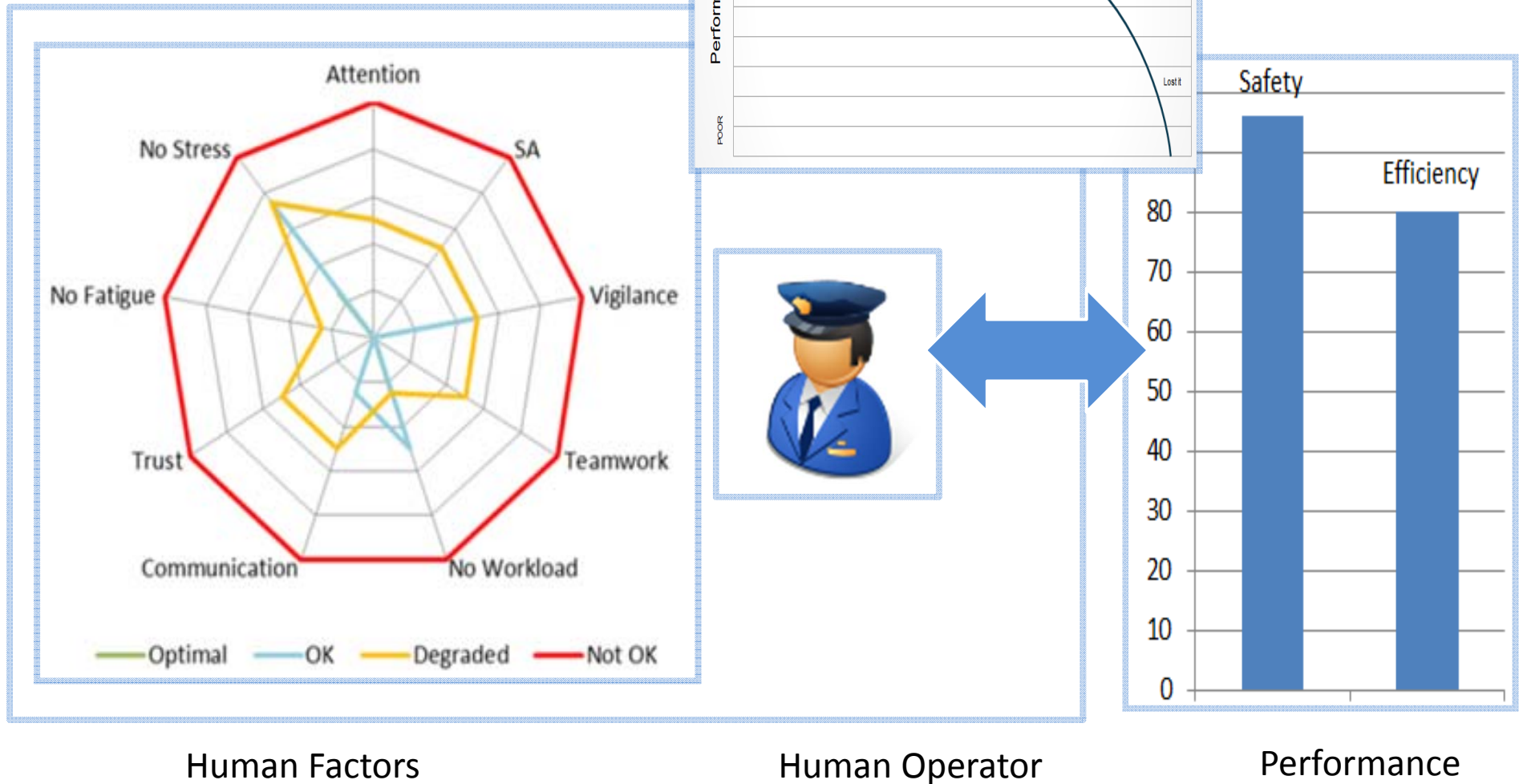


How to automate now? Human Centered!

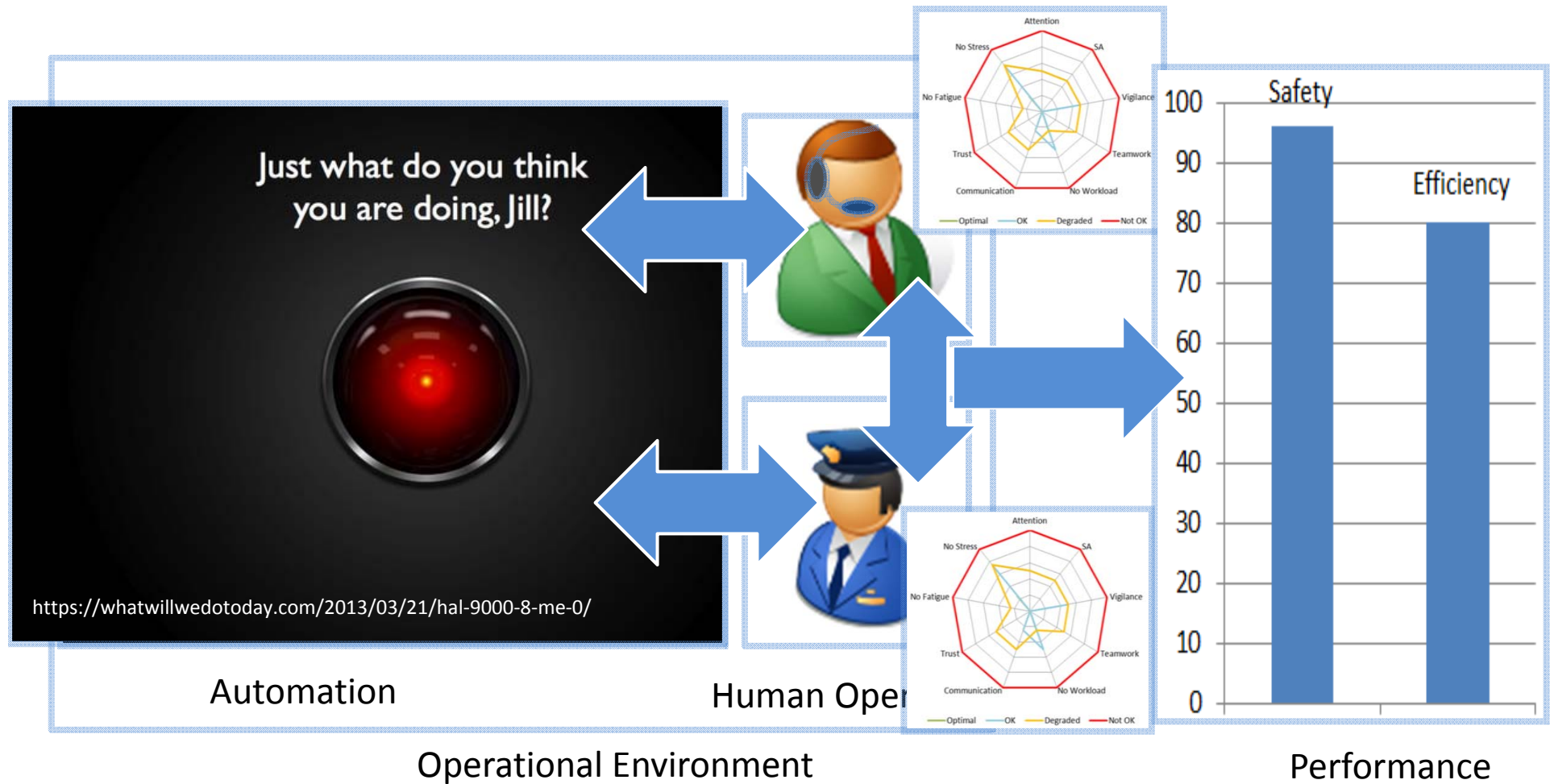
... enabled by Human Performance Envelope



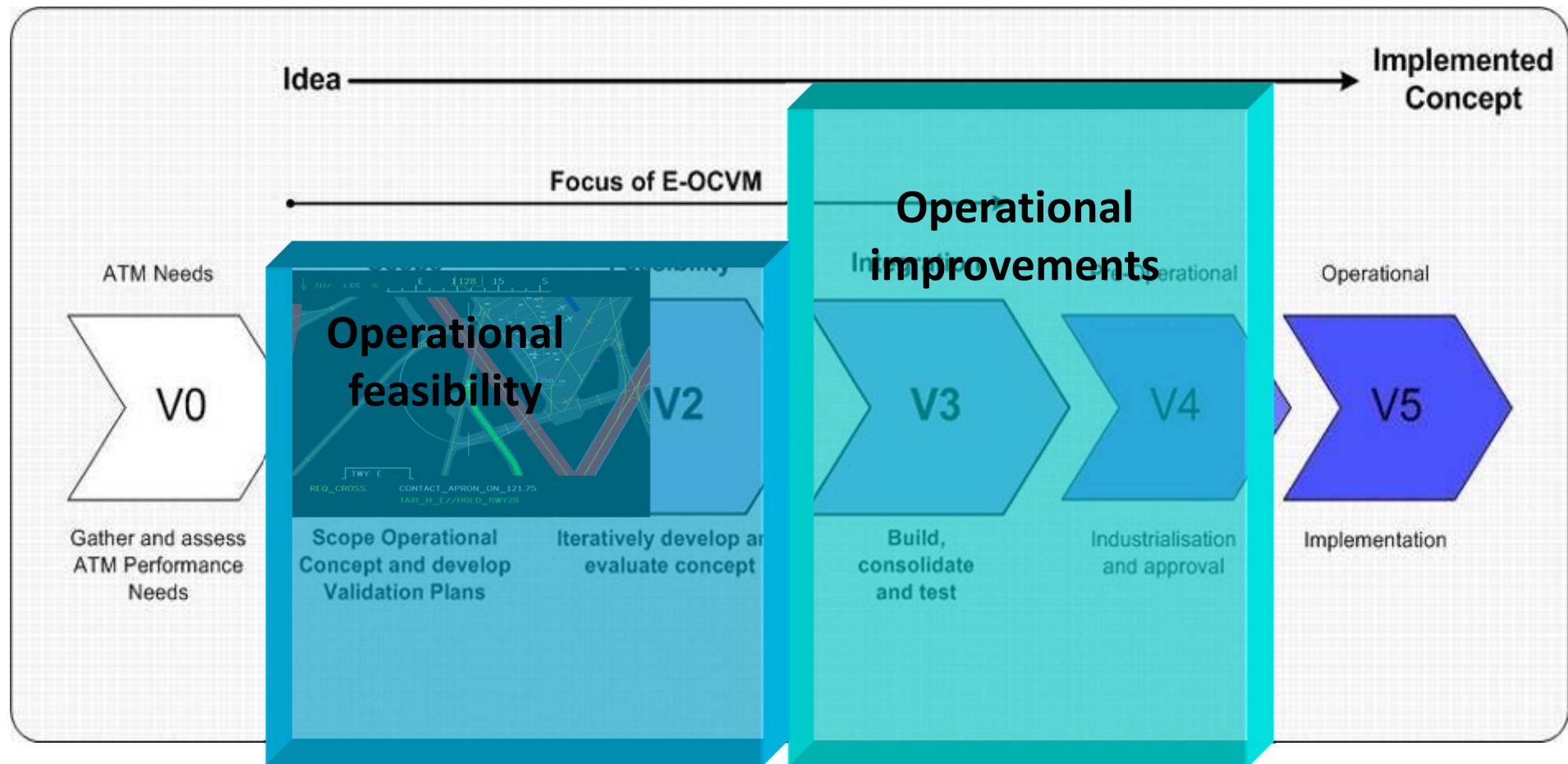
a. Detect operator's state on time



b. Develop automation which is capable to adapt to the state of the operator



Reaching HIGHER Levels of Maturity



According to "European Operational Concept Validation Methodology"

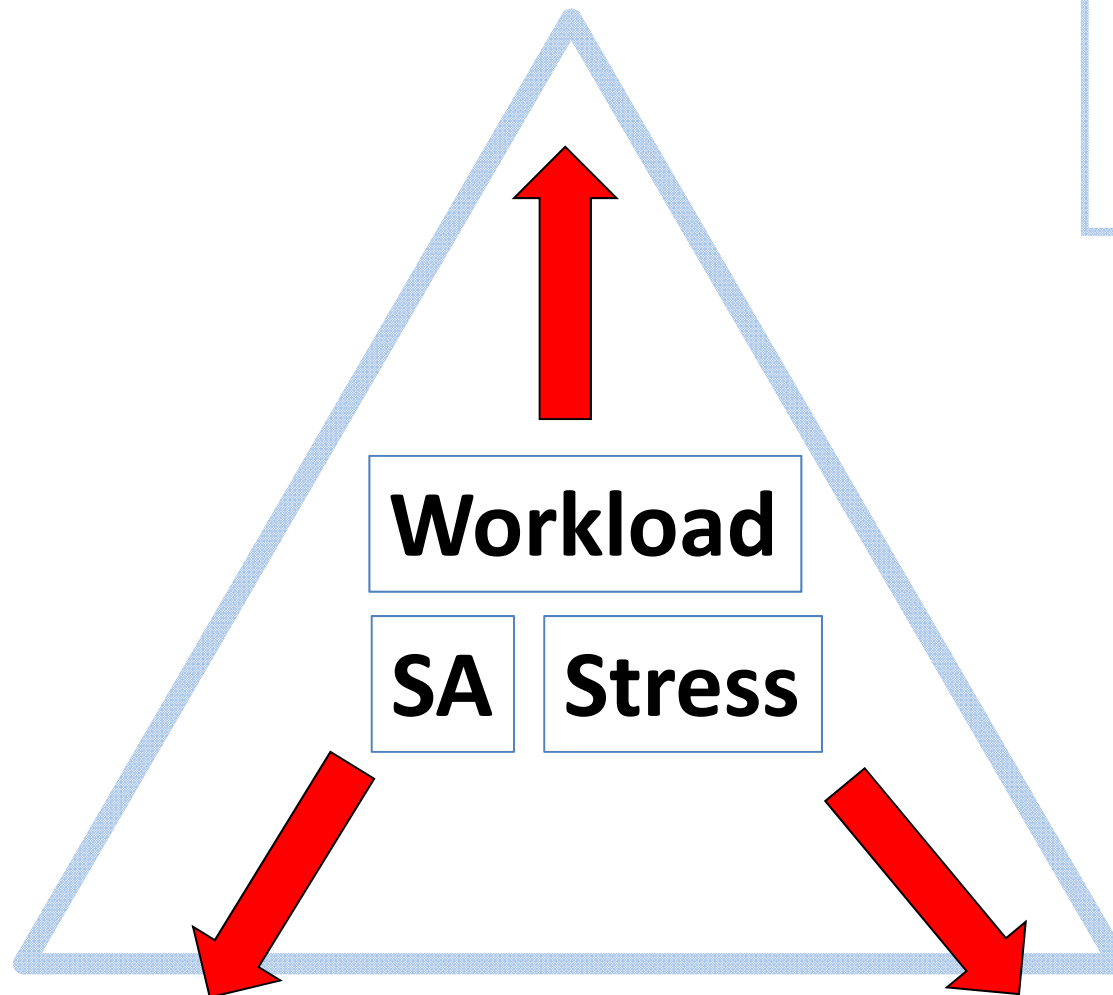
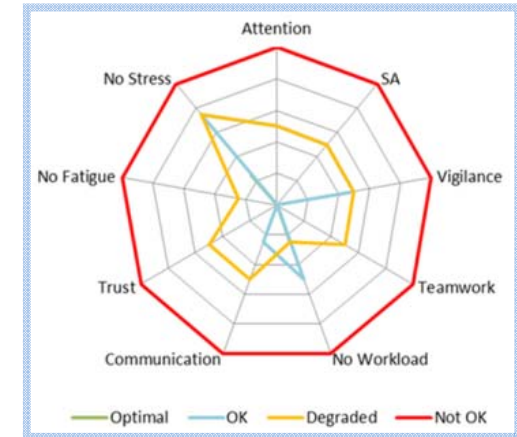


Project: Human Performance Envelope

January 2015 - March 2018



Moving toward the edges of the envelope



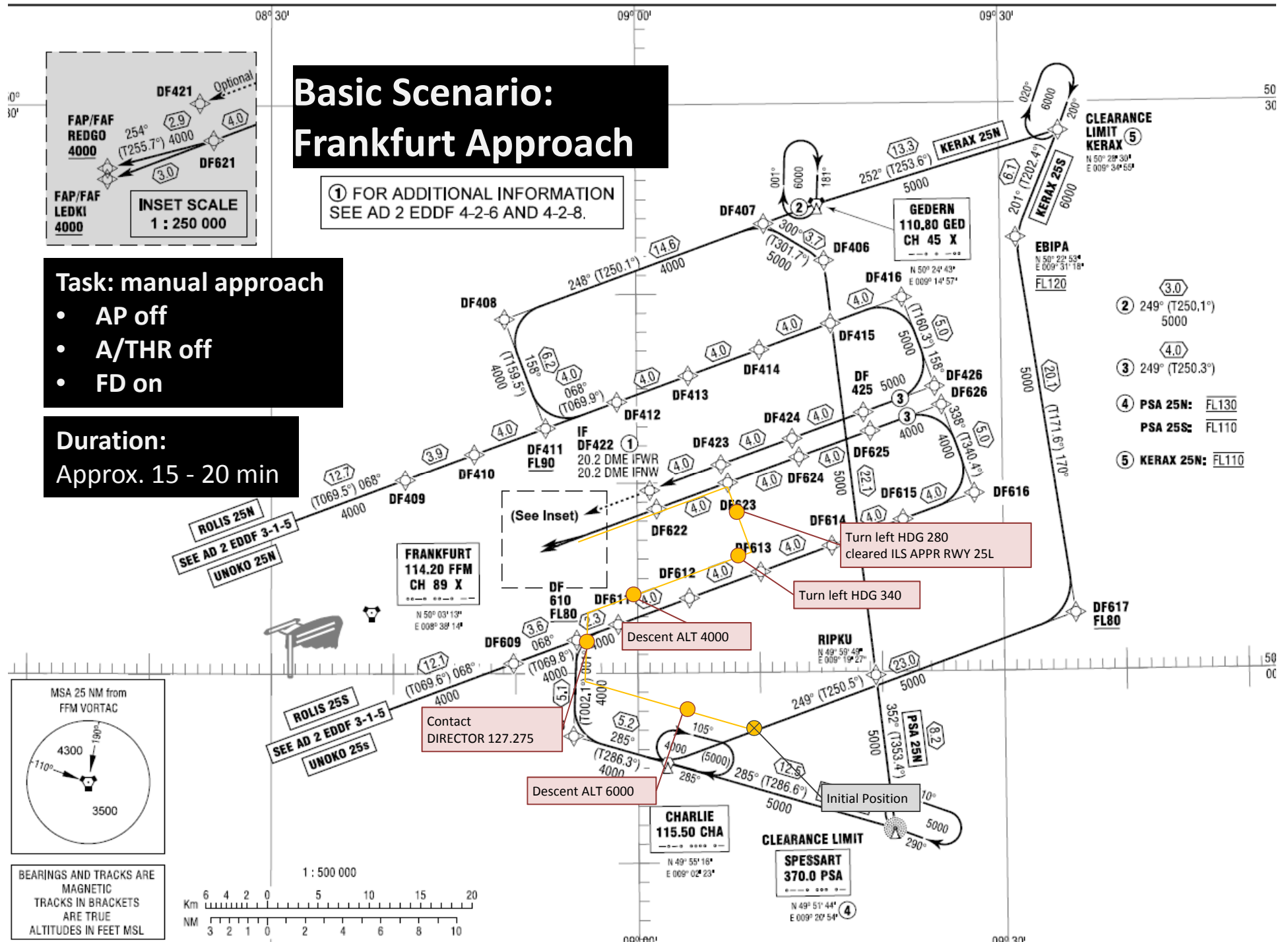
By events



① FOR ADDITIONAL INFORMATION
SEE AD 2 EDDF 4-2-6 AND 4-2-8.

- **AP off**
- **A/THR off**
- **FD on**

Duration:
Approx. 15 - 20 min

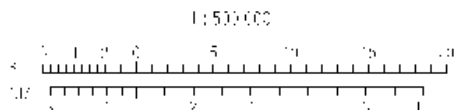


bio-TRANSITION BECOMES OUR FUTURE. WE CAN
 LIVE WITH THE CONSEQUENCES OF CLIMATE CHANGE,
 OR WE CAN PREVENT THEM. THAT'S
 THE CHOICE WE'VE MADE. WE'VE CHOSEN LIFE.

INSET SCALE
1 : 250 000

No events

Abstract



CLEARANCE LIMIT
SPEC: SART
370.0 PSA

SPE: SART
370.0 PSA
4

50
51

11

Load Scenario

① FOR ADDITIONAL INFORMATION
SEE AD 2 EDDE 4-2-6 AND 4-2-8.

Medium

FAP:FAF
REDGO
4000

DF421

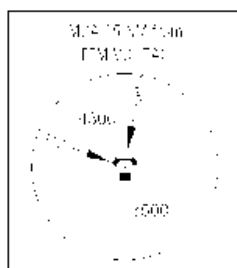
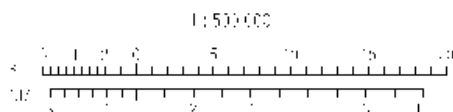
DF621

FAP:FAF
LEDKI
4000

INSET SCALE
1 : 250 000

Medium turbulence whole scenario

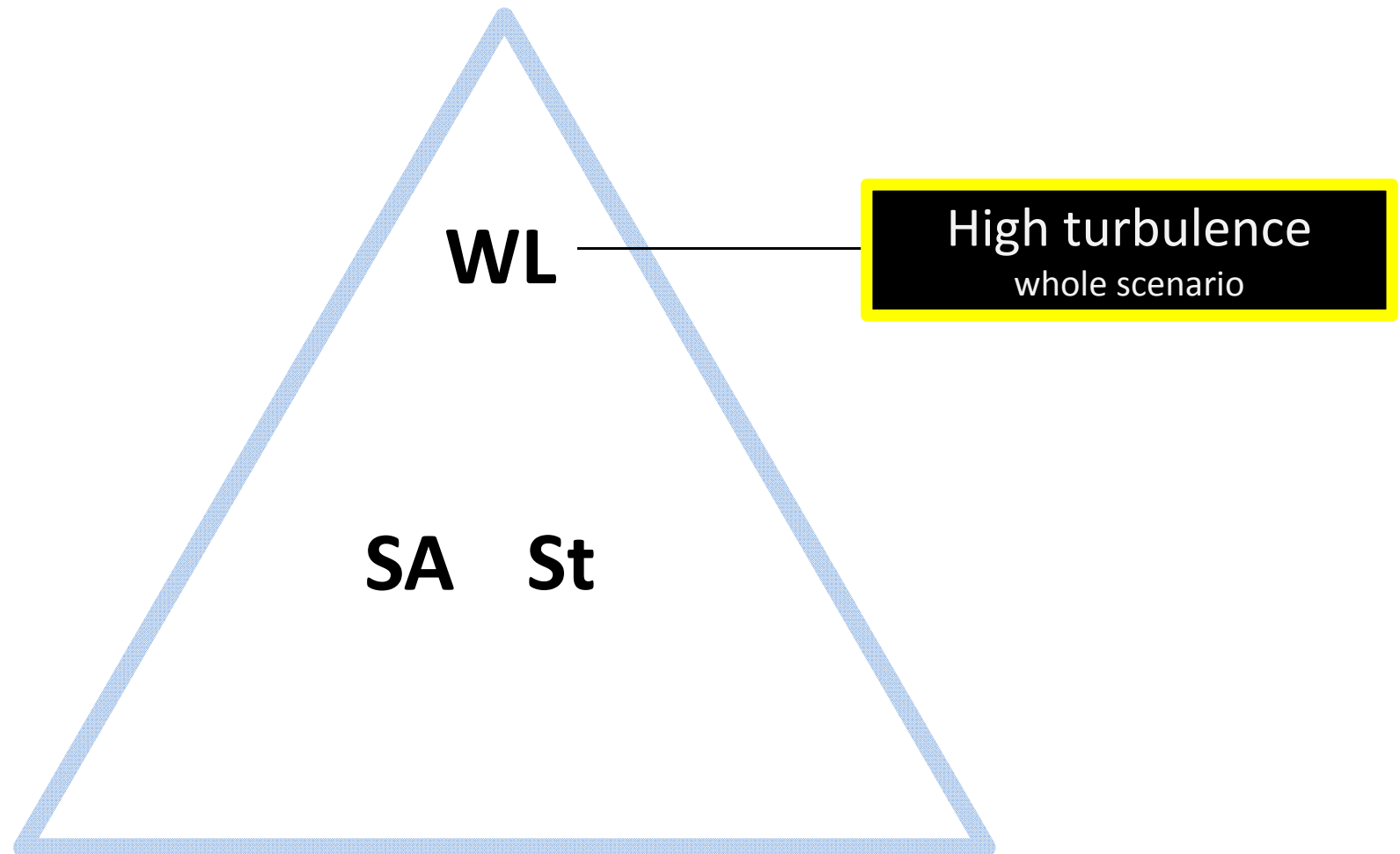
SA St

[illegible]

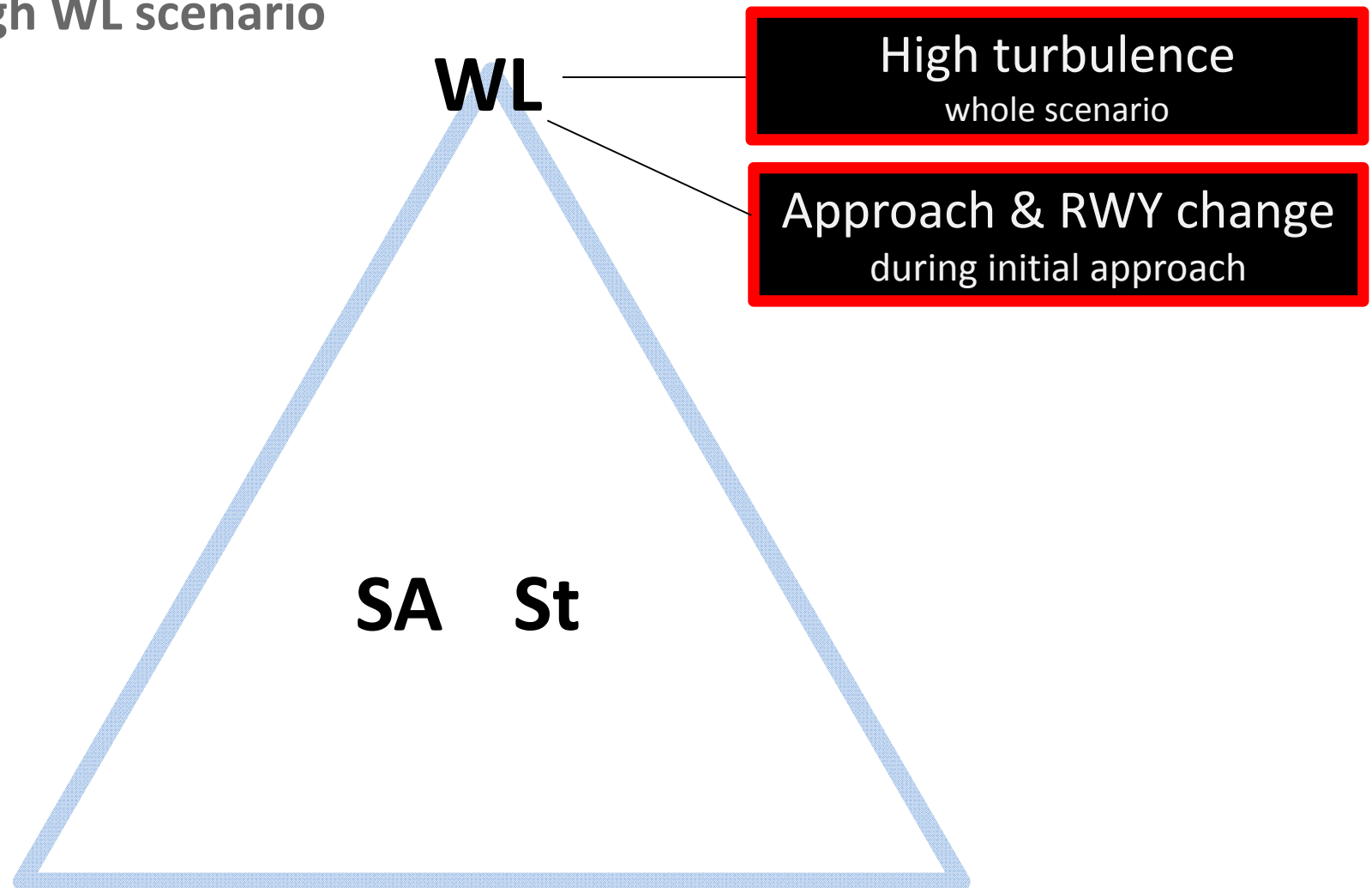
CHARLIE
115.50 CHA

CLEARANCE LIMIT
SPECSART
370.0 PSA

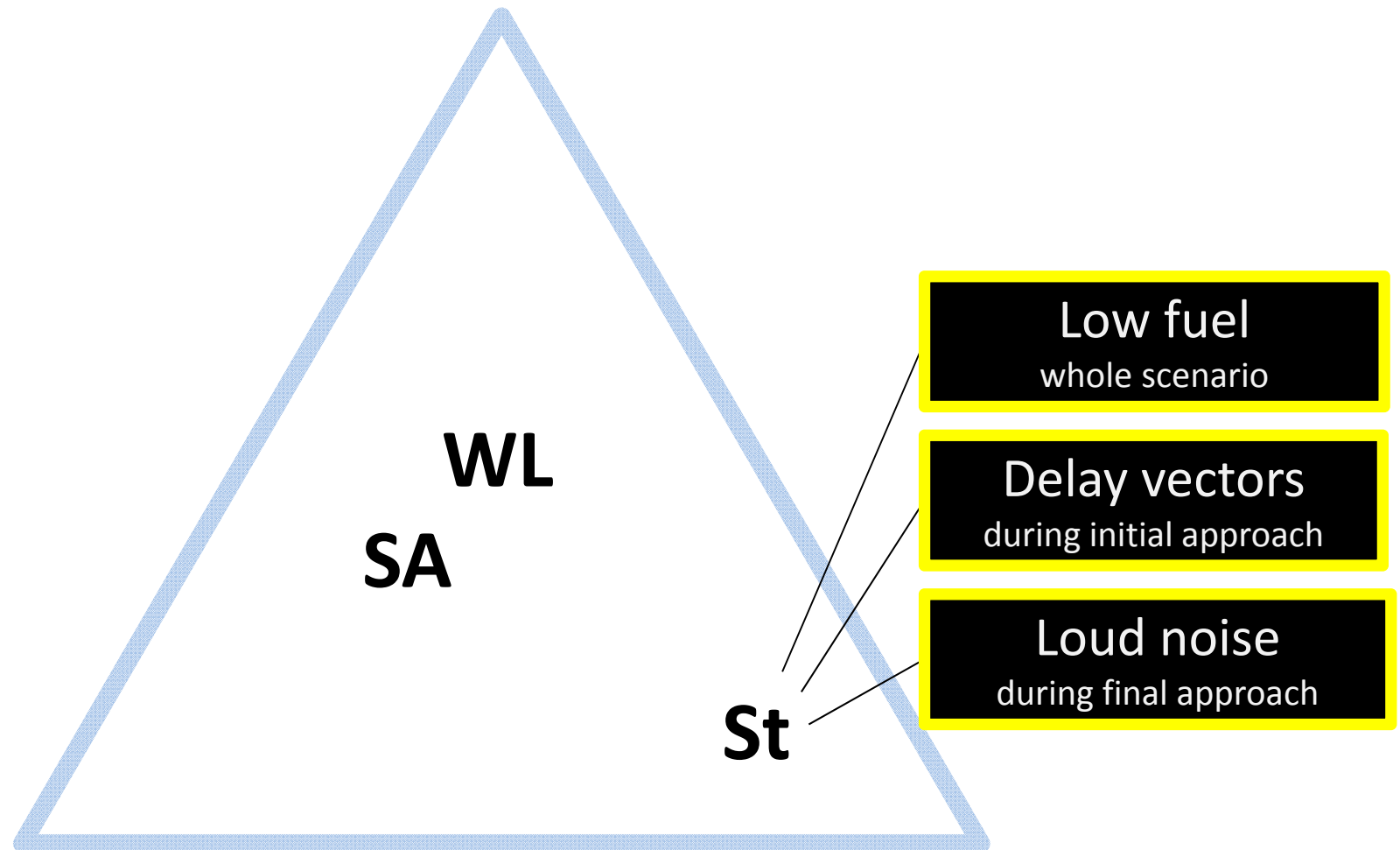
High WL scenario



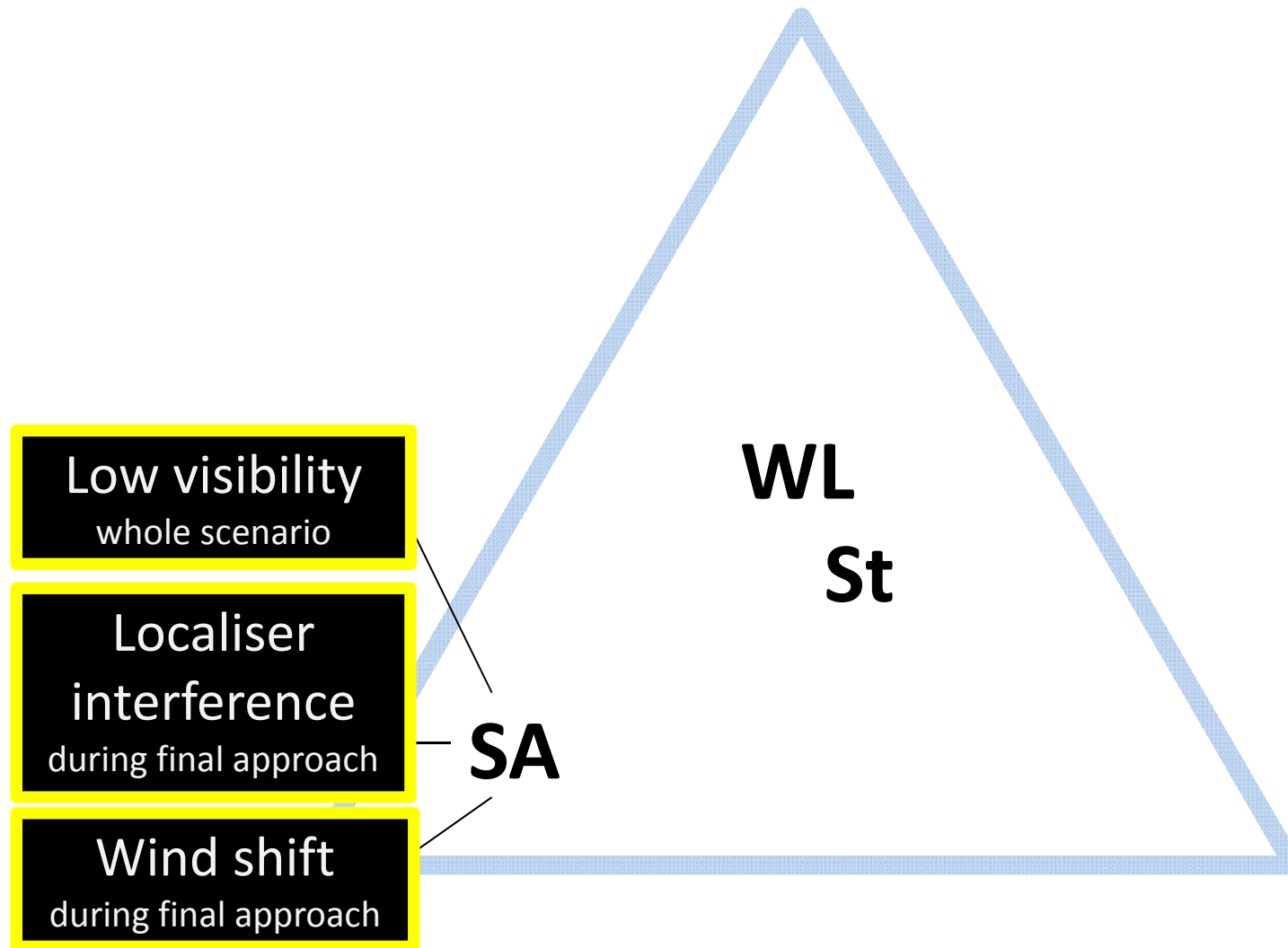
Very high WL scenario



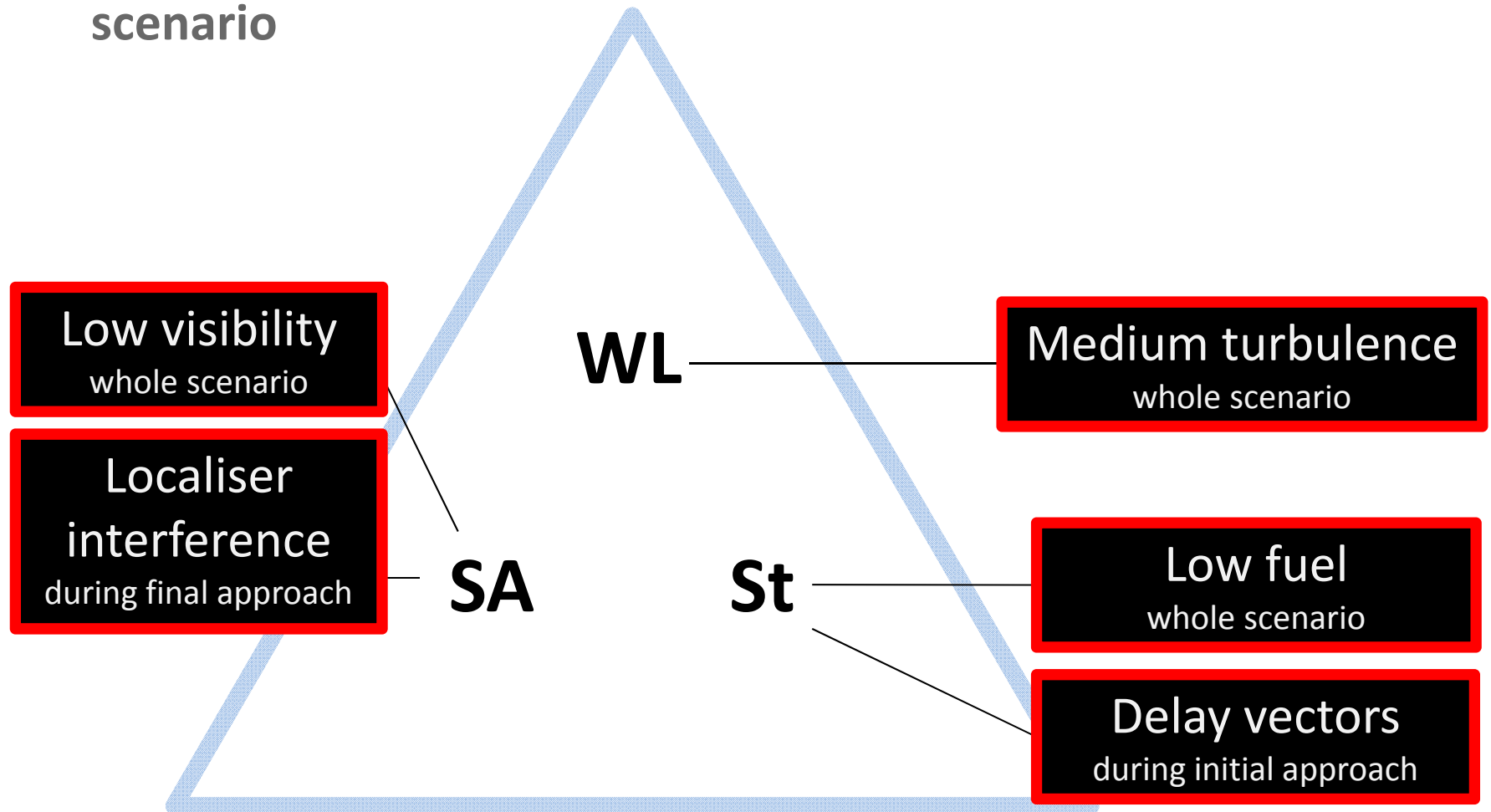
High stress scenario



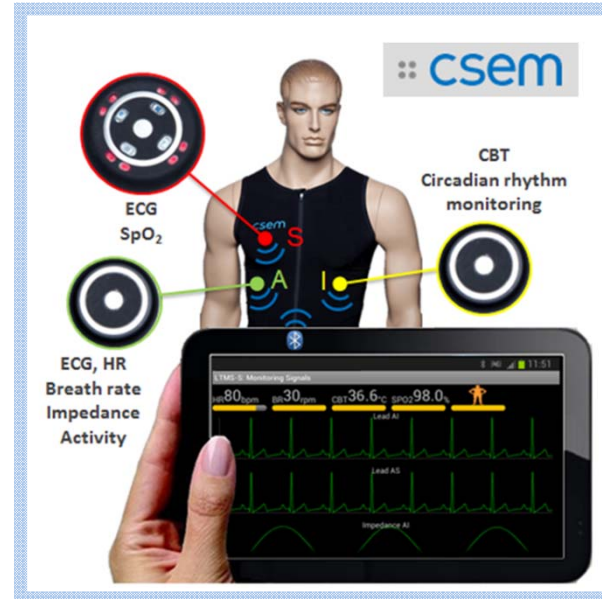
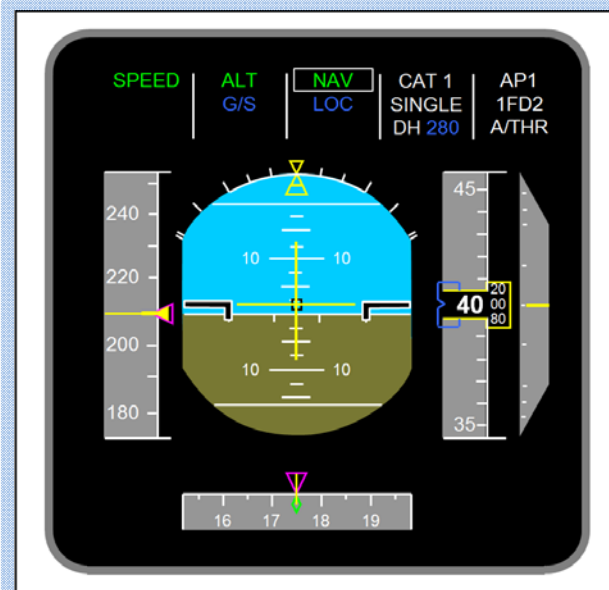
Highly decreased SA



Medium workload, medium stress, medium reduced SA scenario



Measurements



Instantaneous Self-Assessment (ISA)
(Scenario 1)

Pilot ID: _____
Run No.: _____
Time (start): _____ (stop): _____

t	2 m	4 m	6 m	8 m	10 m	12 m	14 m	16 m
Level 1								
2								
3								
4								
5								



Measurements



Eye Tracking Data

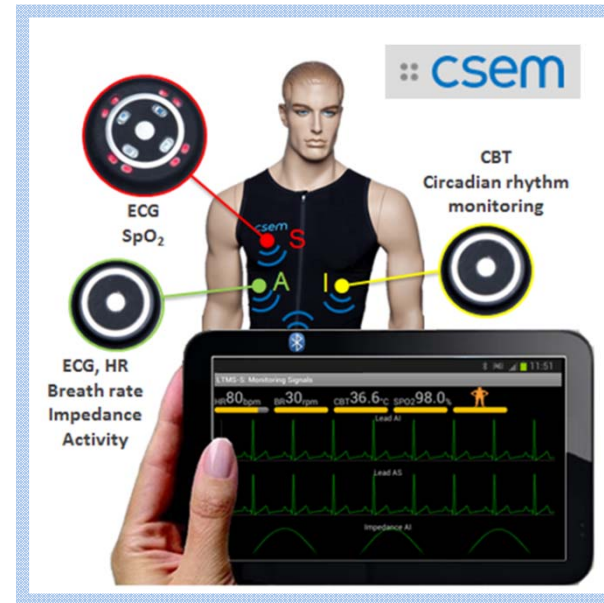
- Point of Gaze
- Blink Rate
- Areas of Interest
- Pupil Diameter



Measurements

Physiological Data

- Heart Rate (HR)
- HR Variability (HRV)
 - RR Intervals
 - Breath Rate
- Perfusion Index



Performance Data

- Speed
- Heading
- Altitude
- Vertical speed
- Localiser glideslope deviations
- Point of touchdown

Measurements

Subjective Data

- Self assessed performance
 - ISA
 - NASA-TLX
 - SACL
 - SART
- Samn-Perelli



Instantaneous Self-Assessment (ISA)
(Scenario 1)

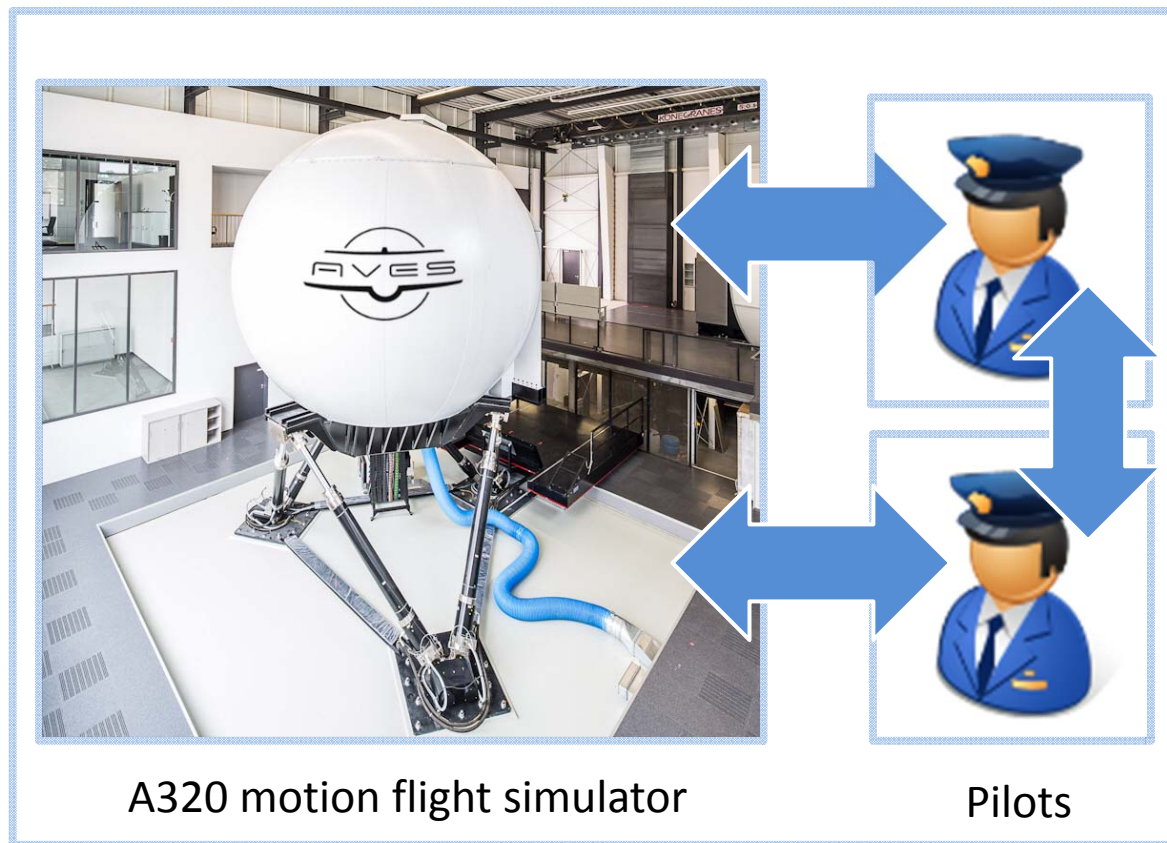
Pilot ID: _____
Run No.: _____
Time (start): _____ (stop): _____

	1	2 m	4 m	6 m	8 m	10 m	12 m	14 m	16 m
Level 1									
2									
3									
4									
5									

1 = Under-Utilised
2 = Relaxed
3 = Comfortable Busy
4 = High
5 = Excessive



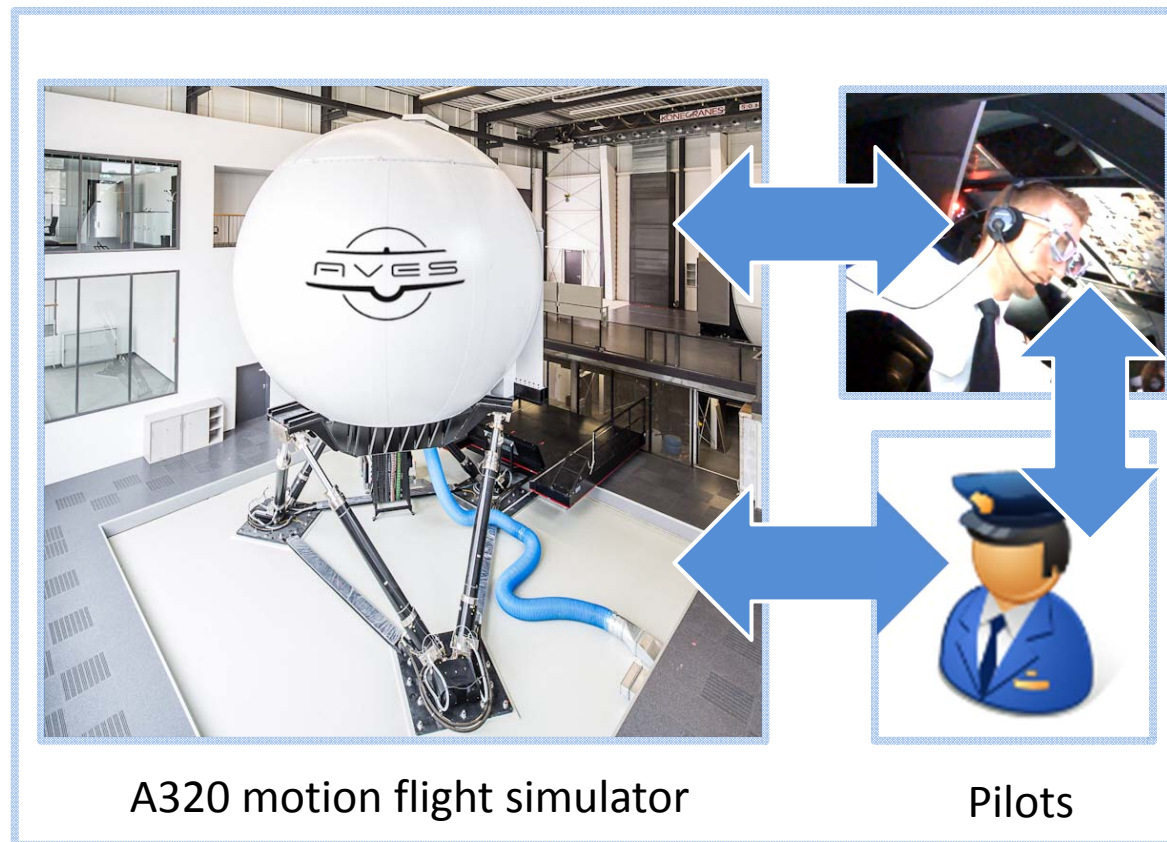
Simulator



Operational Environment



Participants



Operational Environment

- **N=10 first officers**
 - major European airline
 - A320 type rated
- **Age**
 - $M = 31$
 - $SD = 3.28$
- **Experience (total flight hours)**
 - $M = 4045$
 - $SD = 1569$
- **Captain**
 - from same airline
 - complemented crew



Results Workload



High WL



Baseline WL

With WL increase,

Pupil diameter
significantly
increases



Results Stress



With Stress
increase,

Pupil diameter
significantly
increases

Baseline St

High St



Results Situation Awareness



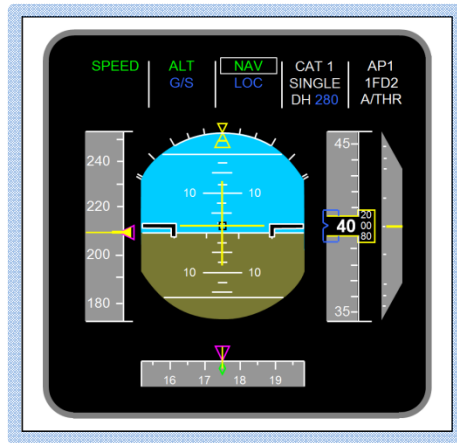
Pupil diameter
significantly
increases
not significantly

Baseline SA

impaired SA



Results Situation Awareness



Baseline SA



impaired SA

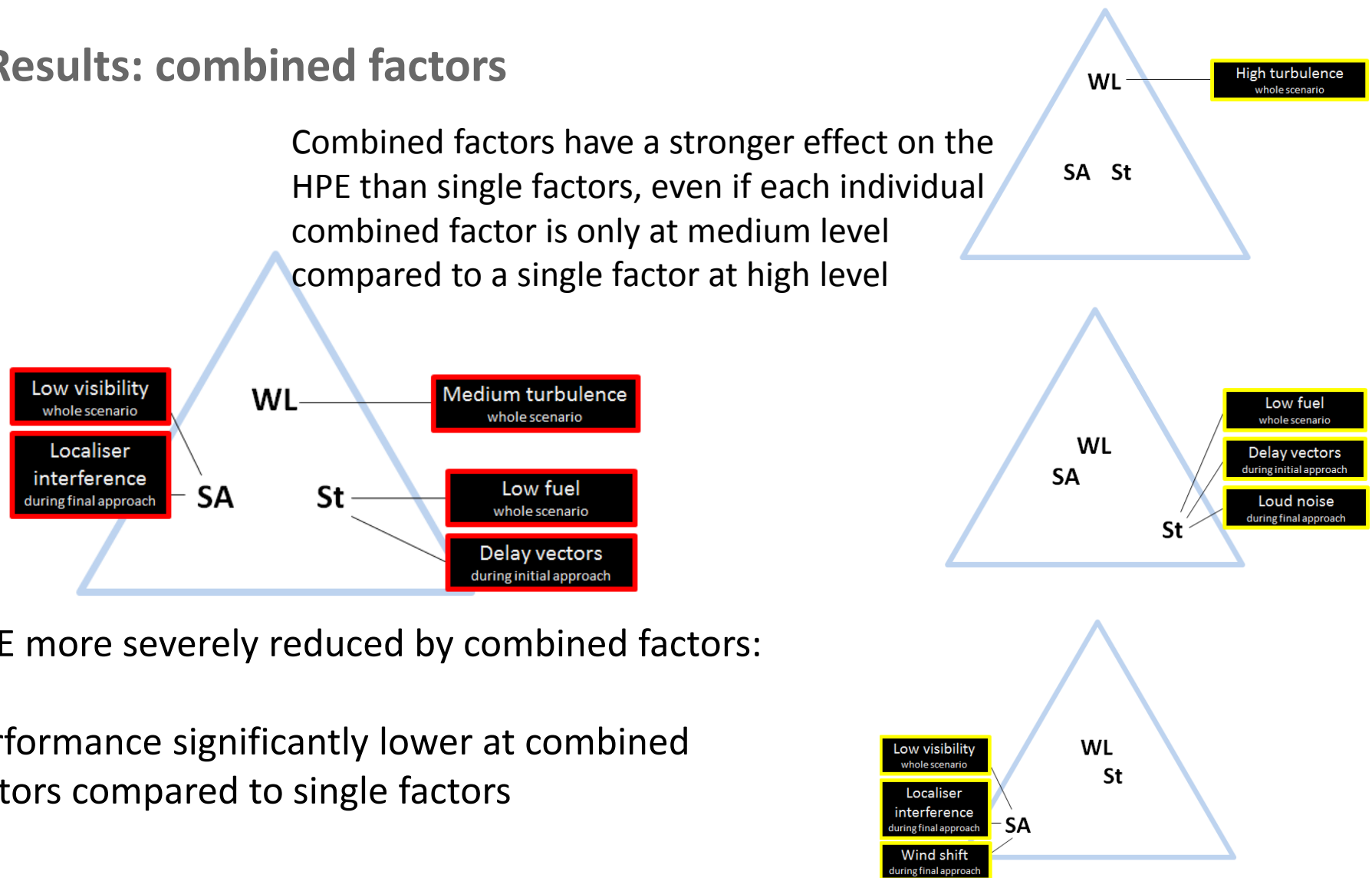
deviation of
localiser and
glide-slope
significantly
increases

and is **higher**
compared to
workload and
stress
scenarios



Results: combined factors

Combined factors have a stronger effect on the HPE than single factors, even if each individual combined factor is only at medium level compared to a single factor at high level



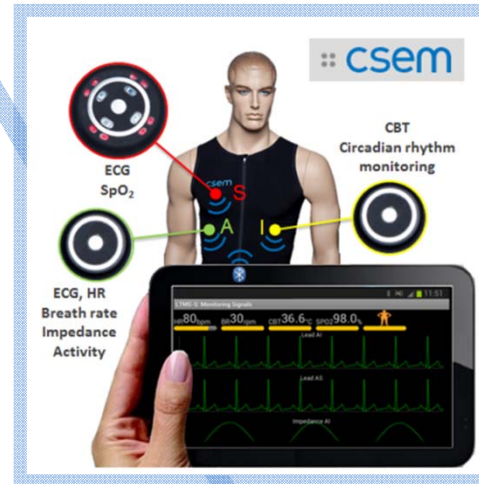
HPE more severely reduced by combined factors:

Performance significantly lower at combined factors compared to single factors

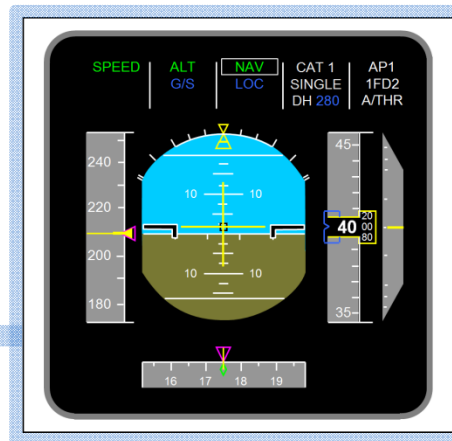


Results: combined factors

Pupil
diameter



LF of HRV



Localiser /
Glideslope
deviation



Stay tuned

- Paper in the Aeronautical Journal
 - *under preparation*



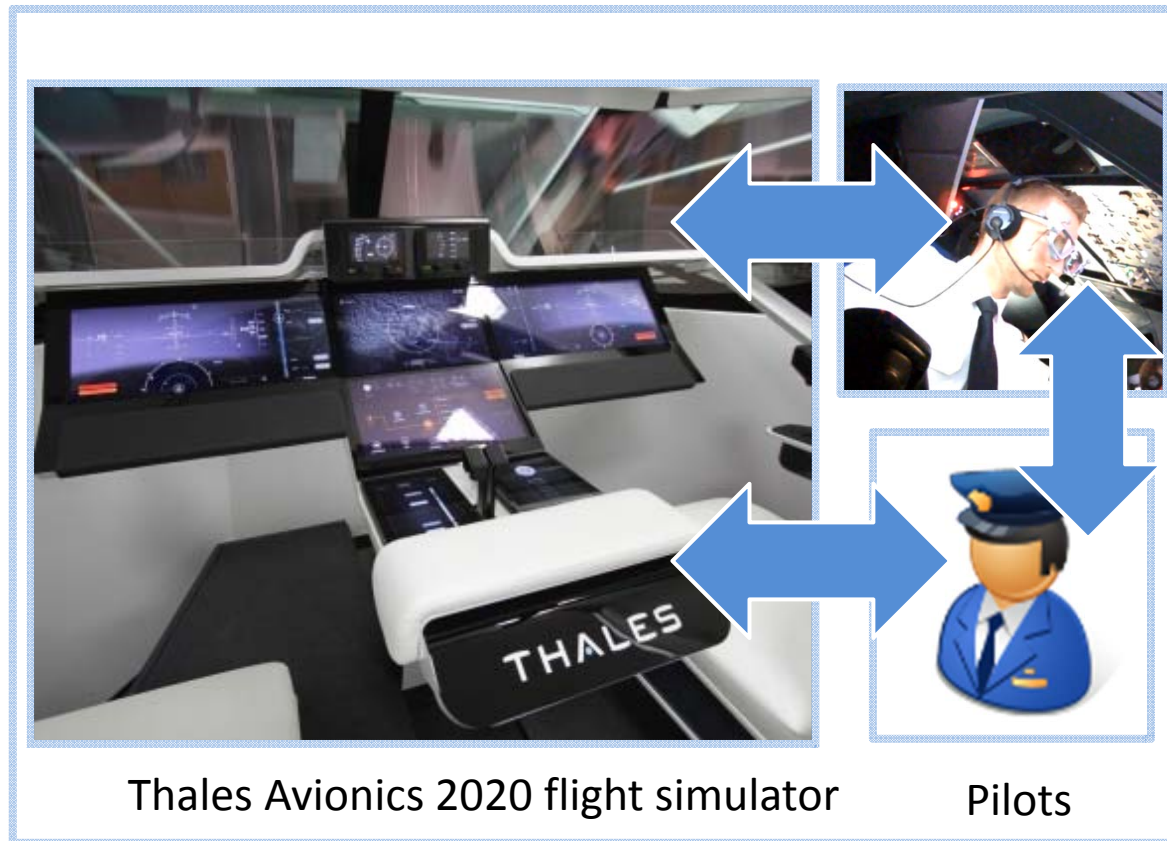
<http://www.futuresky-safety.eu>



- P6 „Human Performance Envelope“
 - D6.3
 - Results for a second set of scenarios
 - D6.4



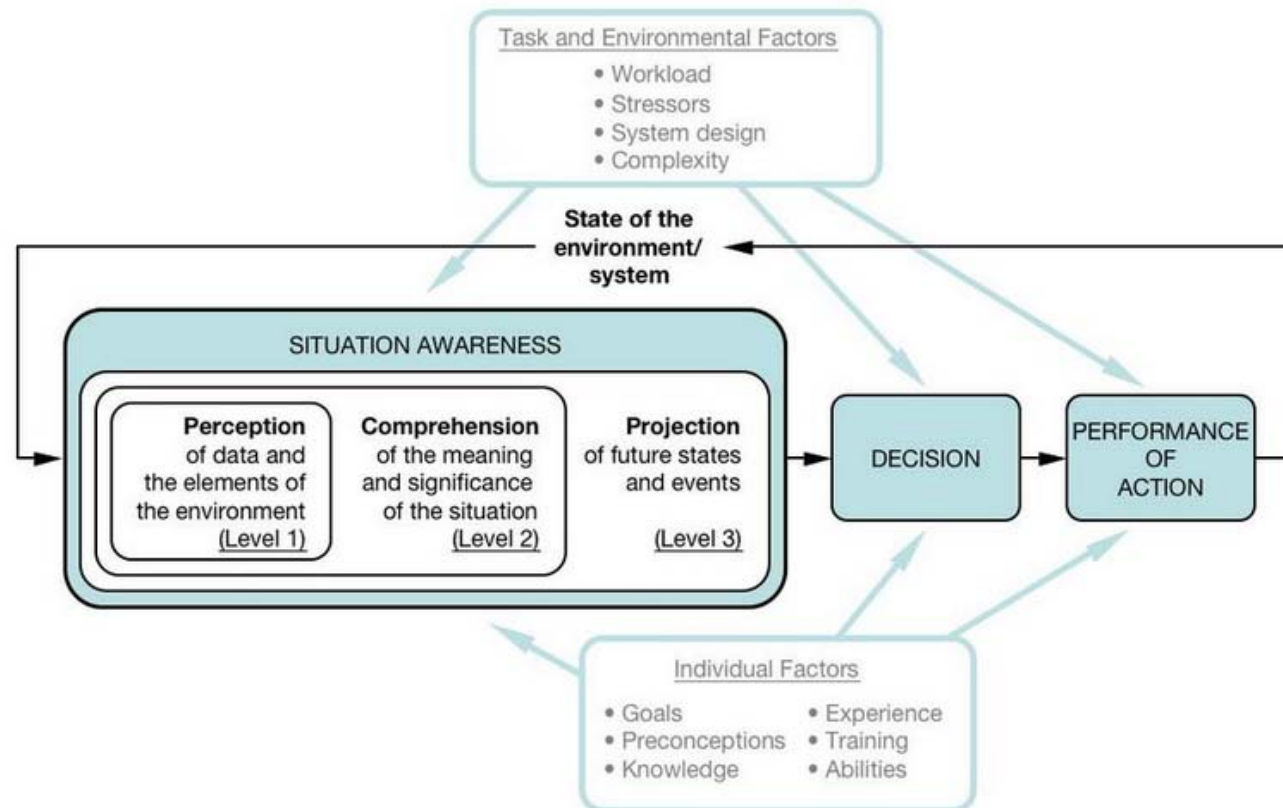
Outlook



Operational Environment



#4 How will eye tracking improve tomorrow's pilots' training and performance?



Endsley's model of SA. This is a synthesis of versions she has given in several sources, notably Endsley (1995a) and Endsley et al (2000). Drawn by Dr. Peter Lankton, May 2007.

https://en.wikipedia.org/wiki/Situation_awareness



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DSPACE

<https://dspace.org/>

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Biella, Marcus; Wies, Matthias; Charles, Rebecca; Maille, Nicolas; Berberian, Bruno ...

2017-12-31

Royal Aeronautical Society

<https://www.aerosociety.com/media/7616/marcus-biella.pdf>

Marcus Biella, Matthias Wies, Rebecca Charles et al. How eye tracking data can enhance human performance in tomorrow's cockpit. FAeS Flight Simulation Conference: Modelling and Simulation in Air Traffic Management, 14-15 November 2017, London, UK.