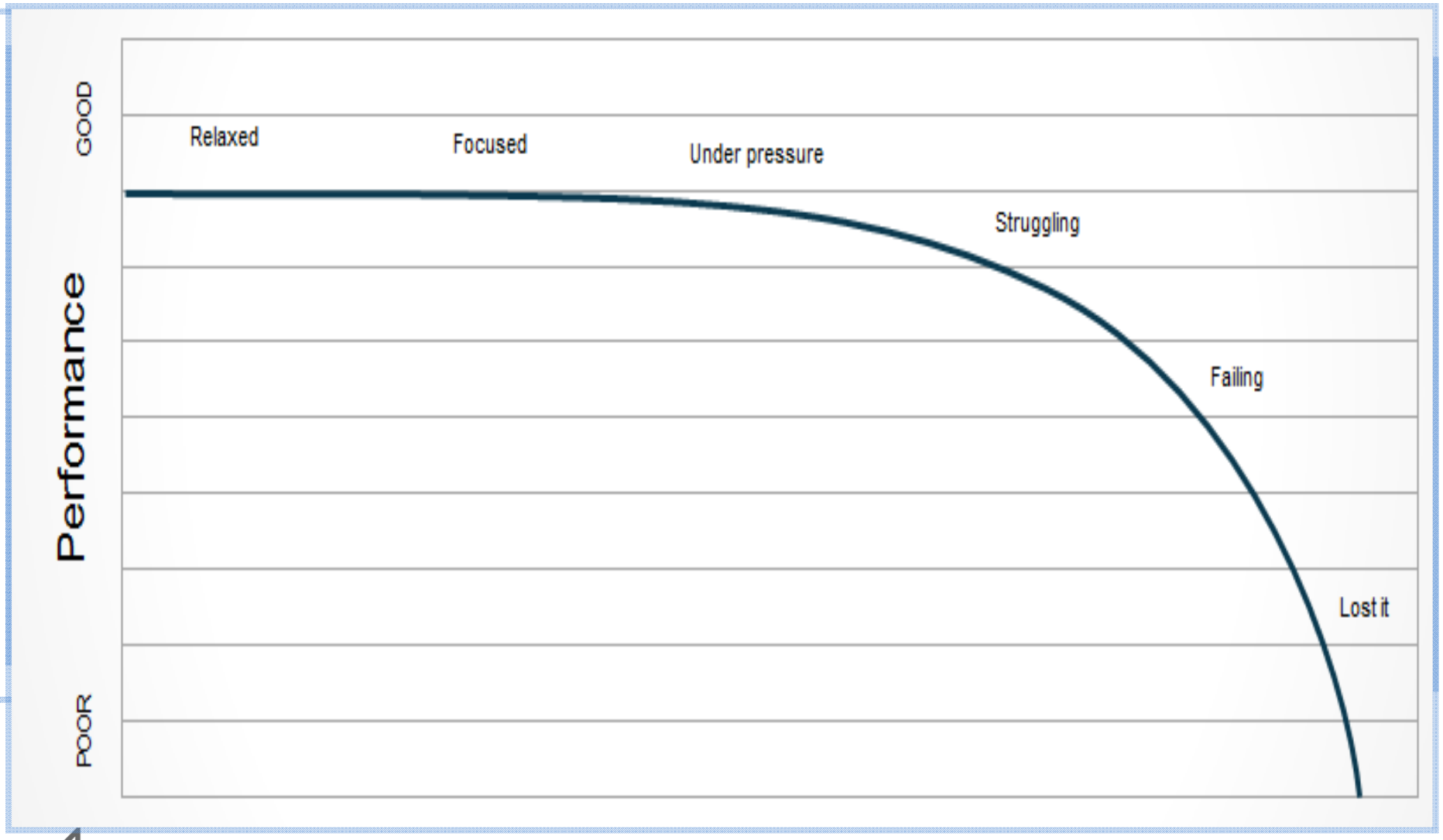
How eye tracking data can enhance human performance in tomorrow's cockpit.
Results from a flight simulation study in FUTURE SKY SAFETY.

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

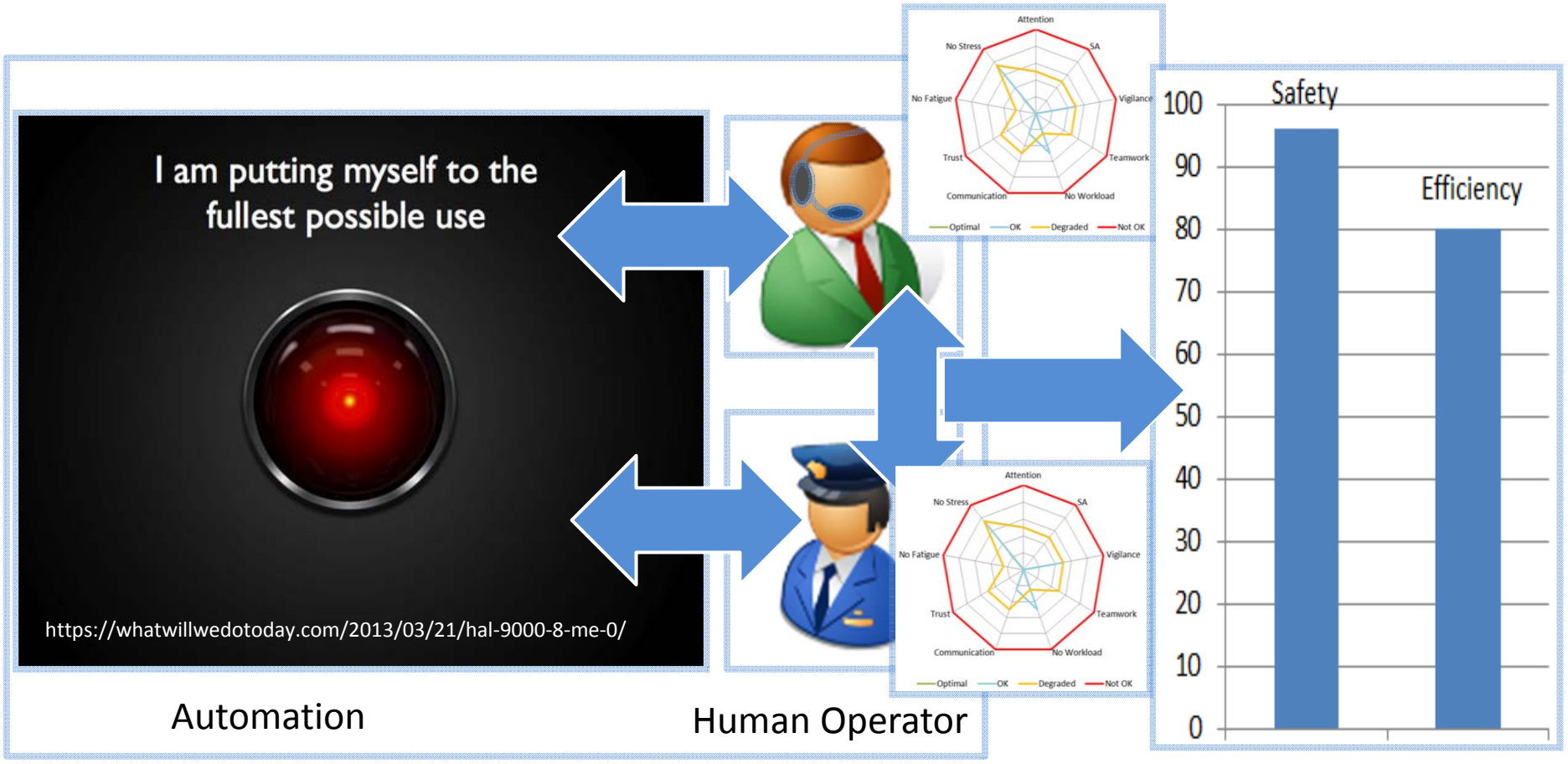
RAeS Flight Simulation Conference
2017-11-15

Decline in performance:
it happens gracefully, not abrupt

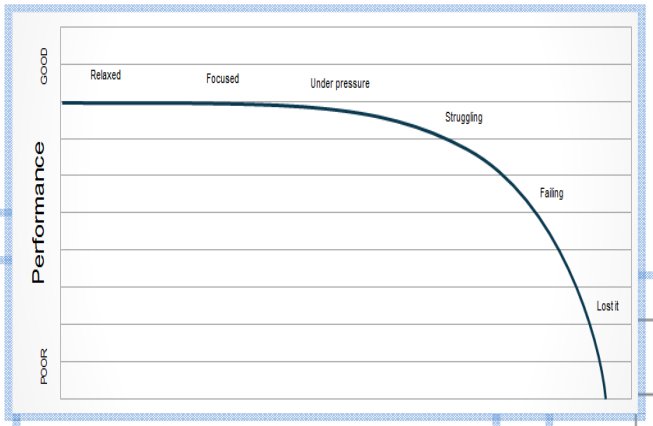


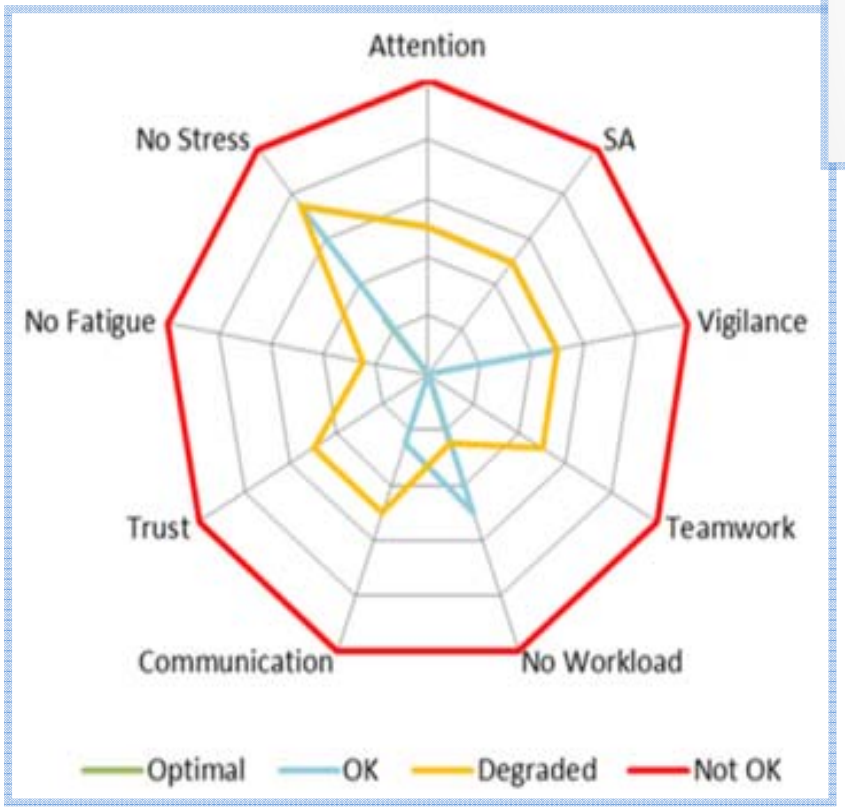
DLR

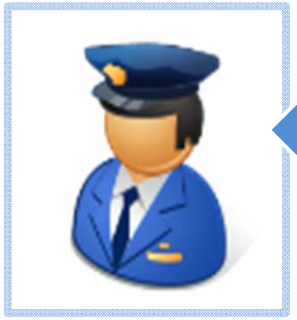
How to automate now? Human Centered!
… enabled by Human Performance Envelope

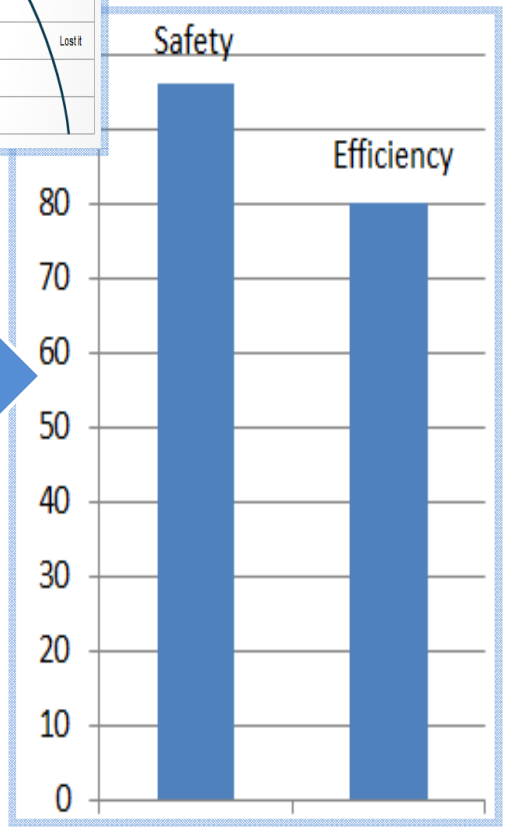


a. Detect operator‘s state on time









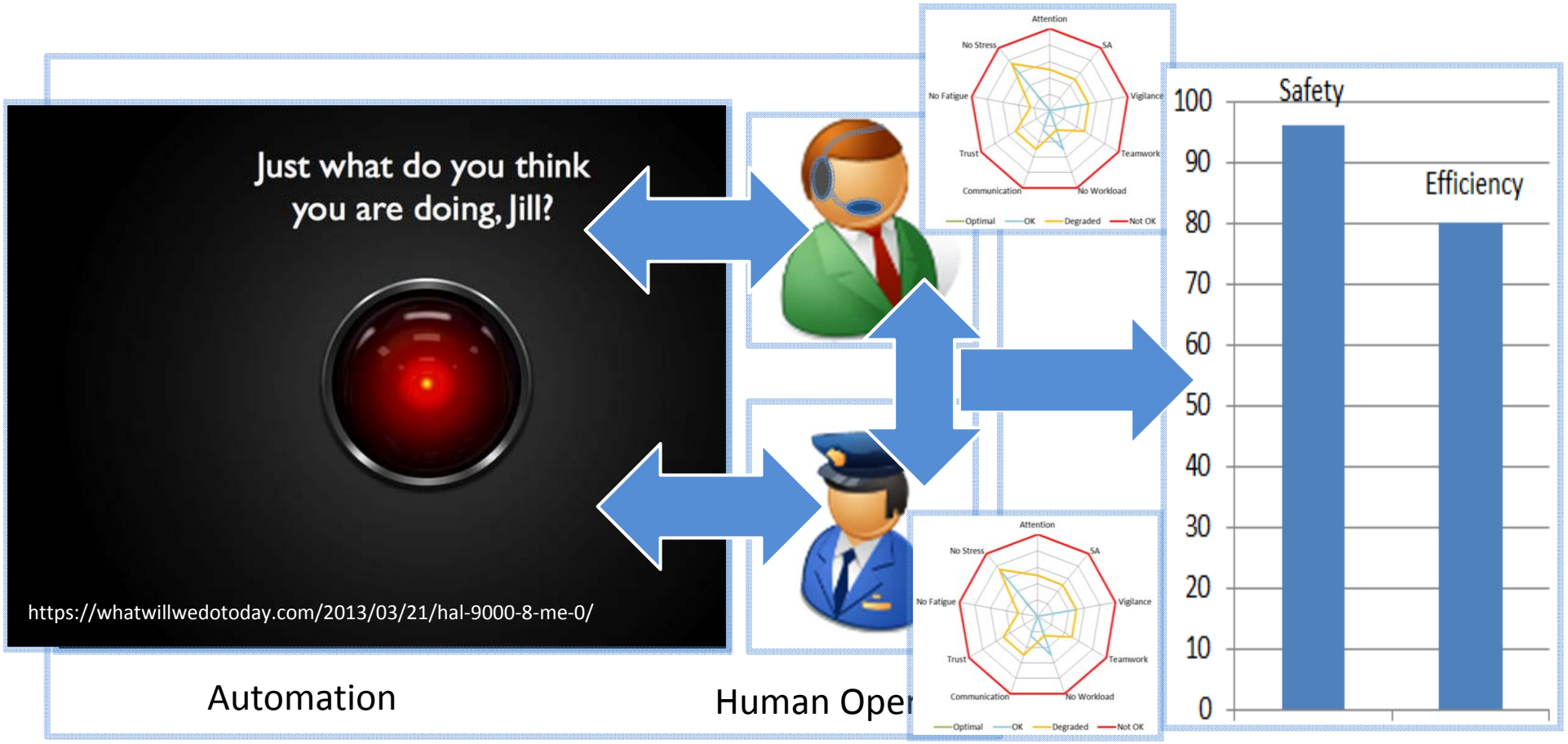
Human Factors

Human Operator

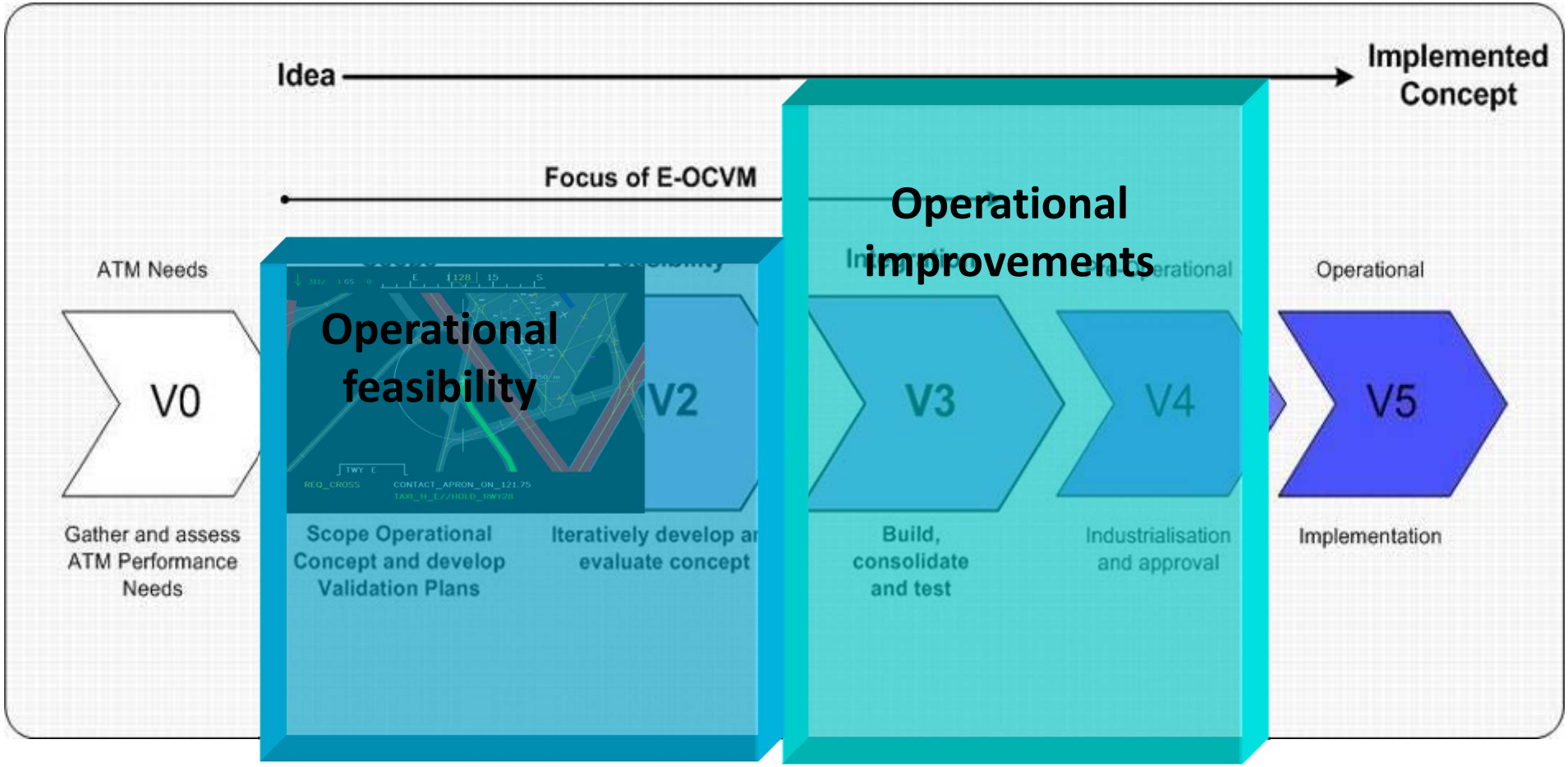
Performance

DLR

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"

DLR

Project: Human Performance Envelope

January 2015 - March 2018

European Commission

FUTURE SKY SAFETY

Funded by the European Commission

Deutsches Zentrum für Luft- und Raumfahrt

THALES

Bordeaux INP ENSC

NLR

Lufthansa

Cranfield UNIVERSITY

ONERA THE FRENCH AEROSPACE LAB

AIRBUS DEFENCE & SPACE

csem

AIRBUS

DEEPBLUE consulting&research

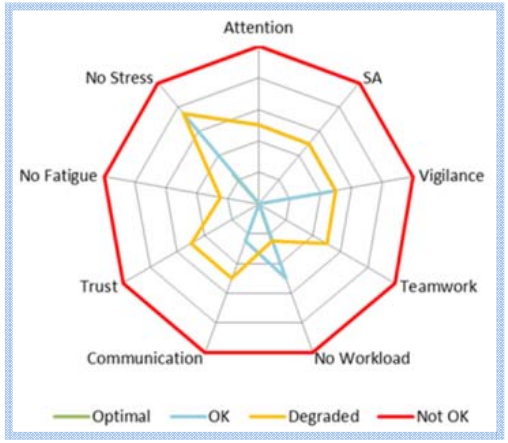
CIRA

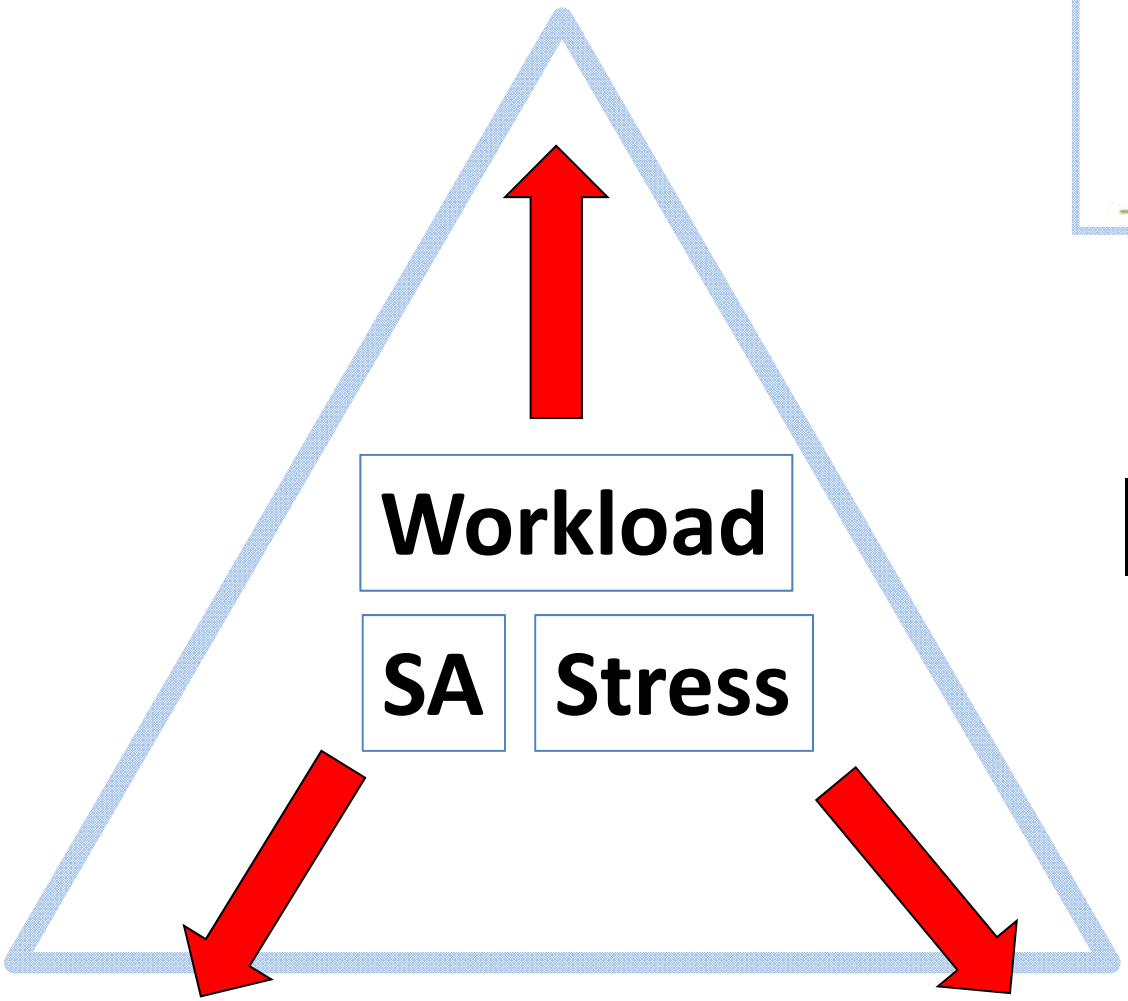
BOEING

EUROCONTROL

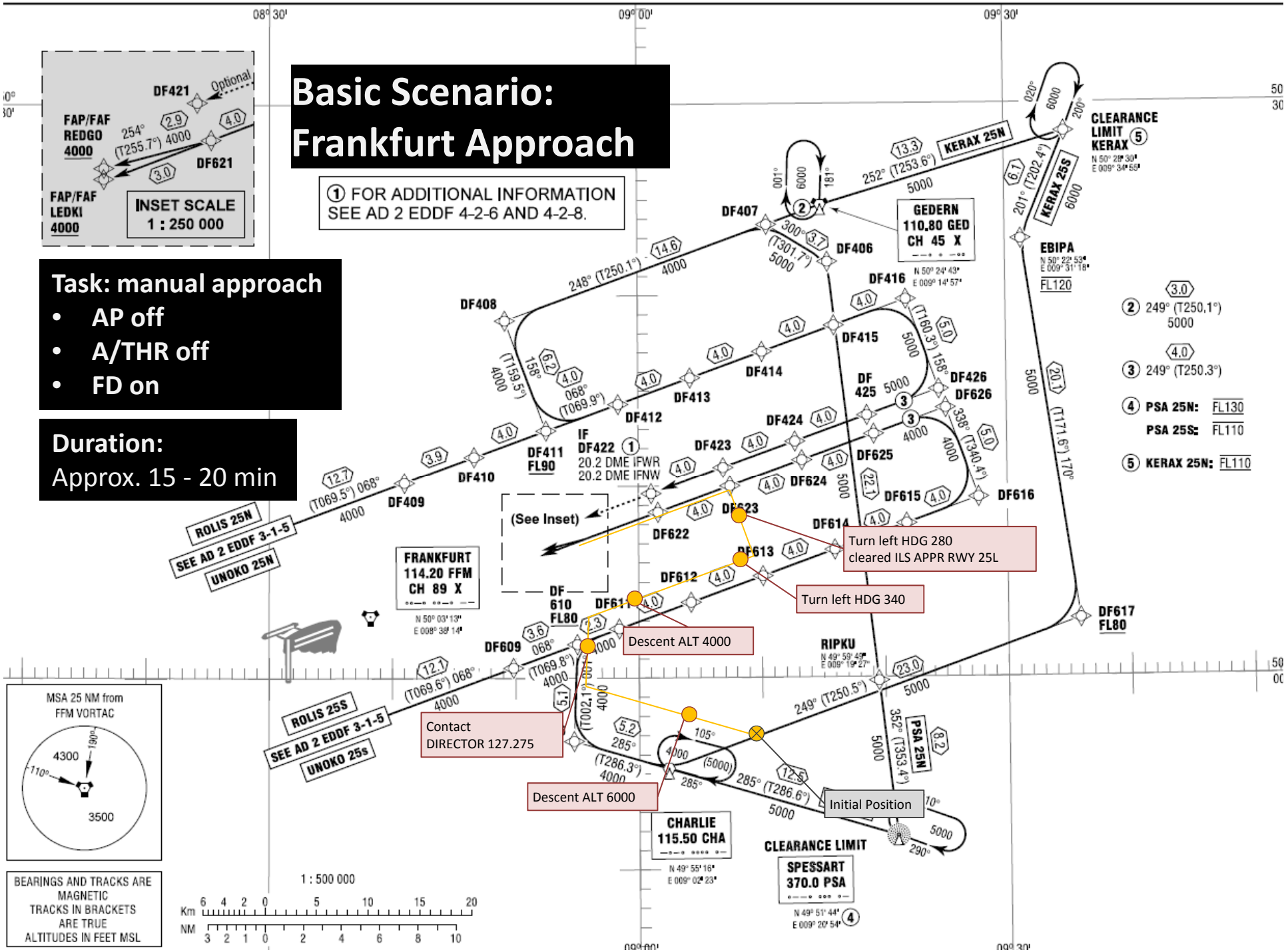
DLR

Moving toward the edges of the envelope

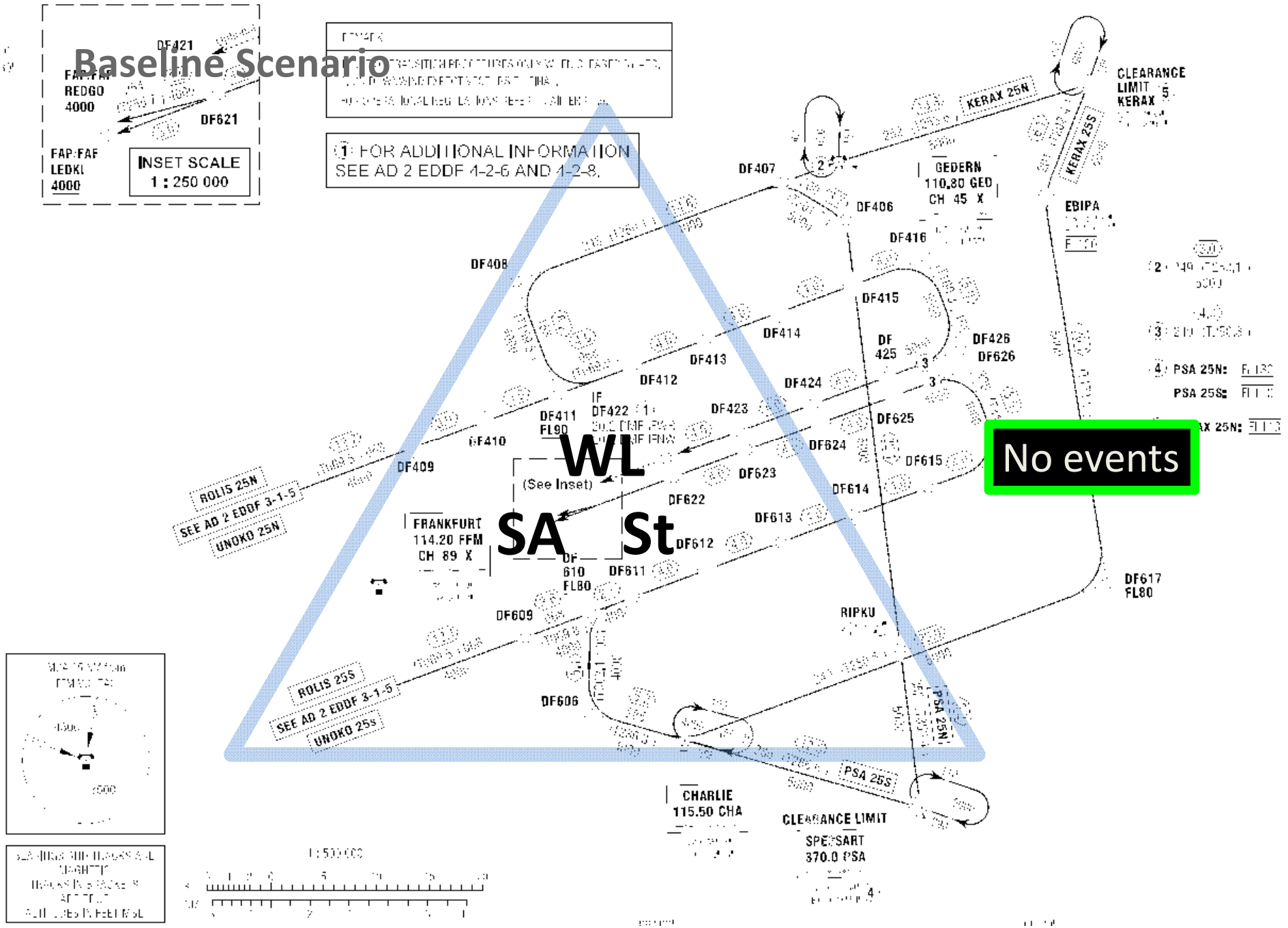




By events

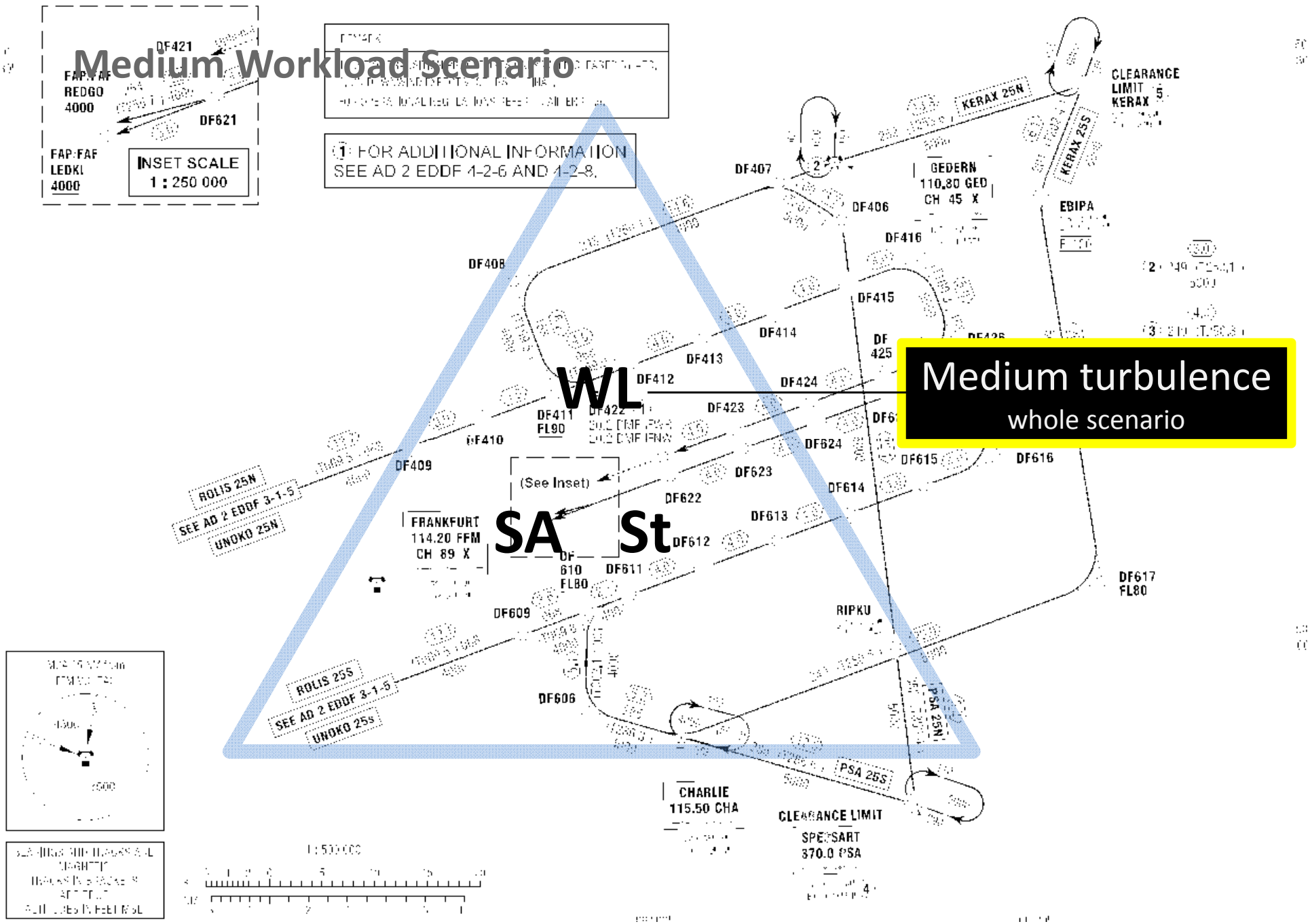

Basic Scenario:
Frankfurt Approach
Task: manual approach
• AP off
• A/THR off
• FD on
Duration:
Approx. 15 - 20 min
① FOR ADDITIONAL INFORMATION SEE AD 2 EDDF 4-2-6 AND 4-2-8.
INSET SCALE 1 : 250 000
FAP/FAF REDGO 4000
FAP/FAF LEDKI 4000
DF421
DF621
Optional
GEDERN 110.80 GED CH 45 X
FRANKFURT 114.20 FFM CH 89 X
CHARLIE 115.50 CHA
SPESSART 370.0 PSA
EBIPA
FL120
CLEARANCE LIMIT KERAX
KERAX 25N
KERAX 25S
ROLIS 25N
ROLIS 25S
UNOKO 25N
UNOKO 25s
SEE AD 2 EDDF 3-1-5
IF DF422 ①
20.2 DME IFWR
20.2 DME IFNW
DF411 FL90
DF610 FL80
DF617 FL80
RIPKU
PSA 25N
(See Inset)
Turn left HDG 280
cleared ILS APPR RWY 25L
Turn left HDG 340
Descent ALT 4000
Contact
DIRECTOR 127.275
Descent ALT 6000
Initial Position
② 249° (T250,1°) 5000
③ 249° (T250.3°)
④ PSA 25N: FL130
PSA 25S: FL110
⑤ KERAX 25N: FL110
MSA 25 NM from FFM VORTAC
4300
3500
BEARINGS AND TRACKS ARE MAGNETIC
TRACKS IN BRACKETS ARE TRUE
ALTITUDES IN FEET MSL
1 : 500 000
Km 6 4 2 0 5 10 15 20
NM 3 2 1 0 2 4 6 8 10

Baseline Scenario



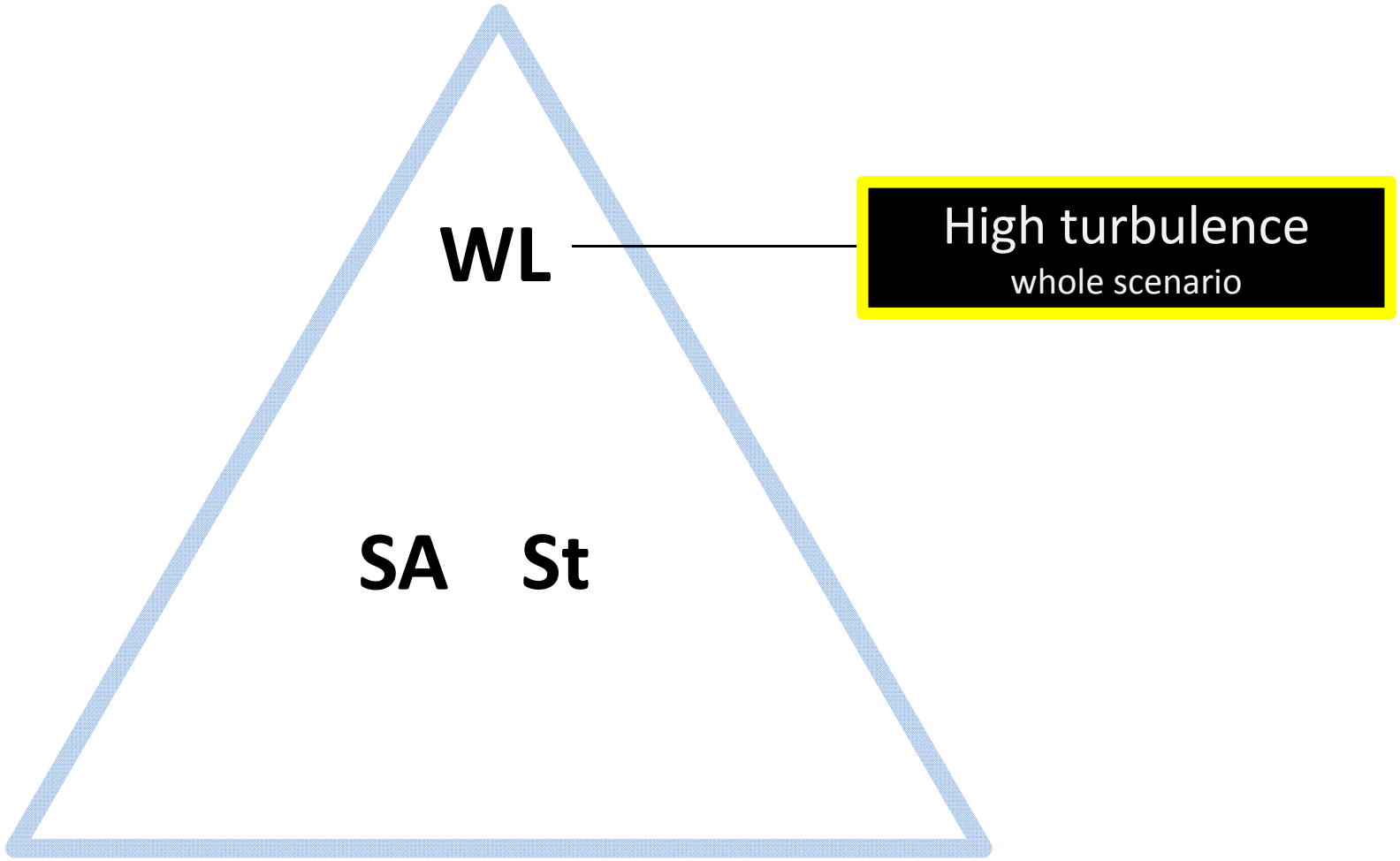
No events

Medium Workload Scenario

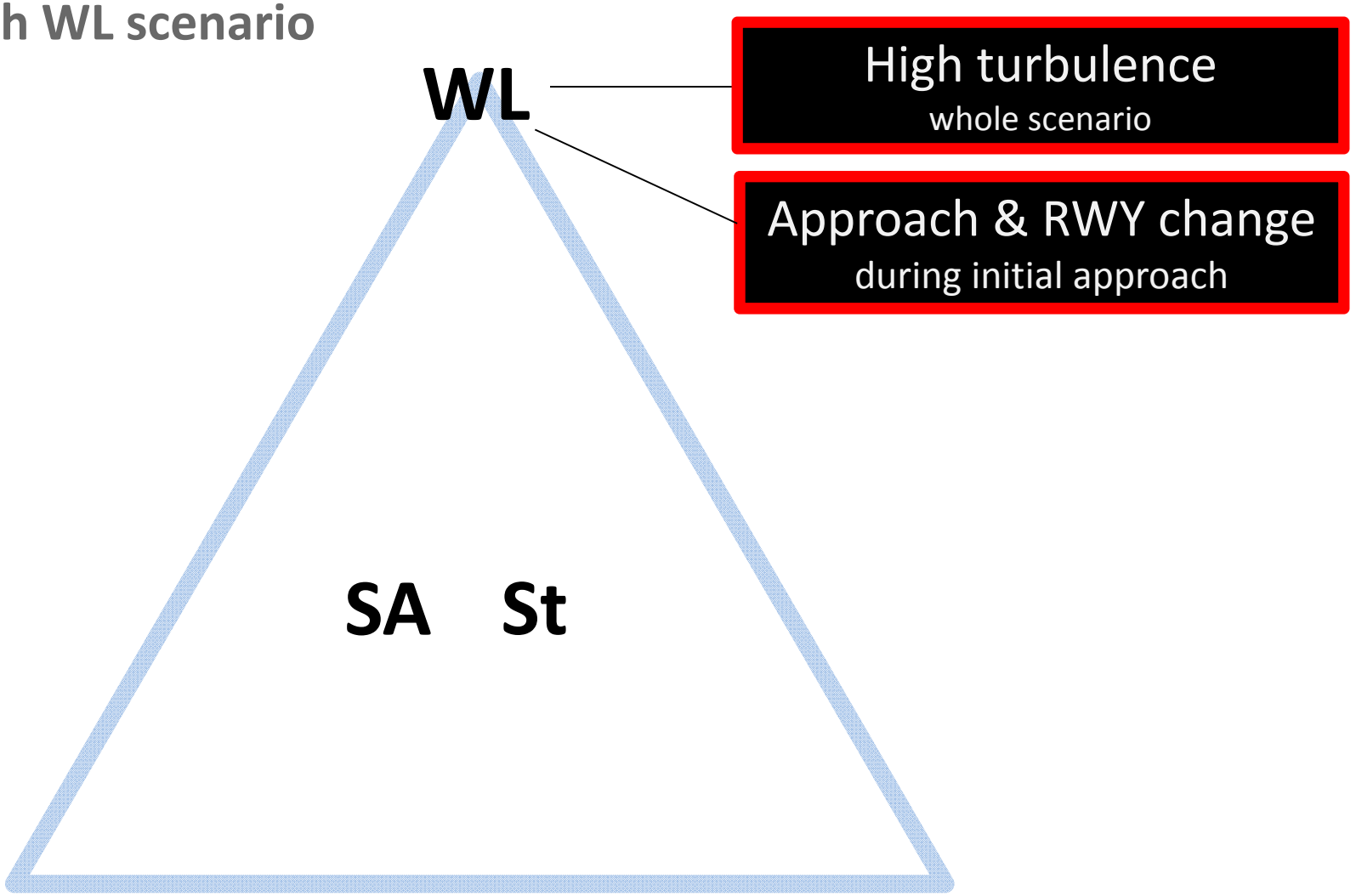


Medium turbulence
whole scenario

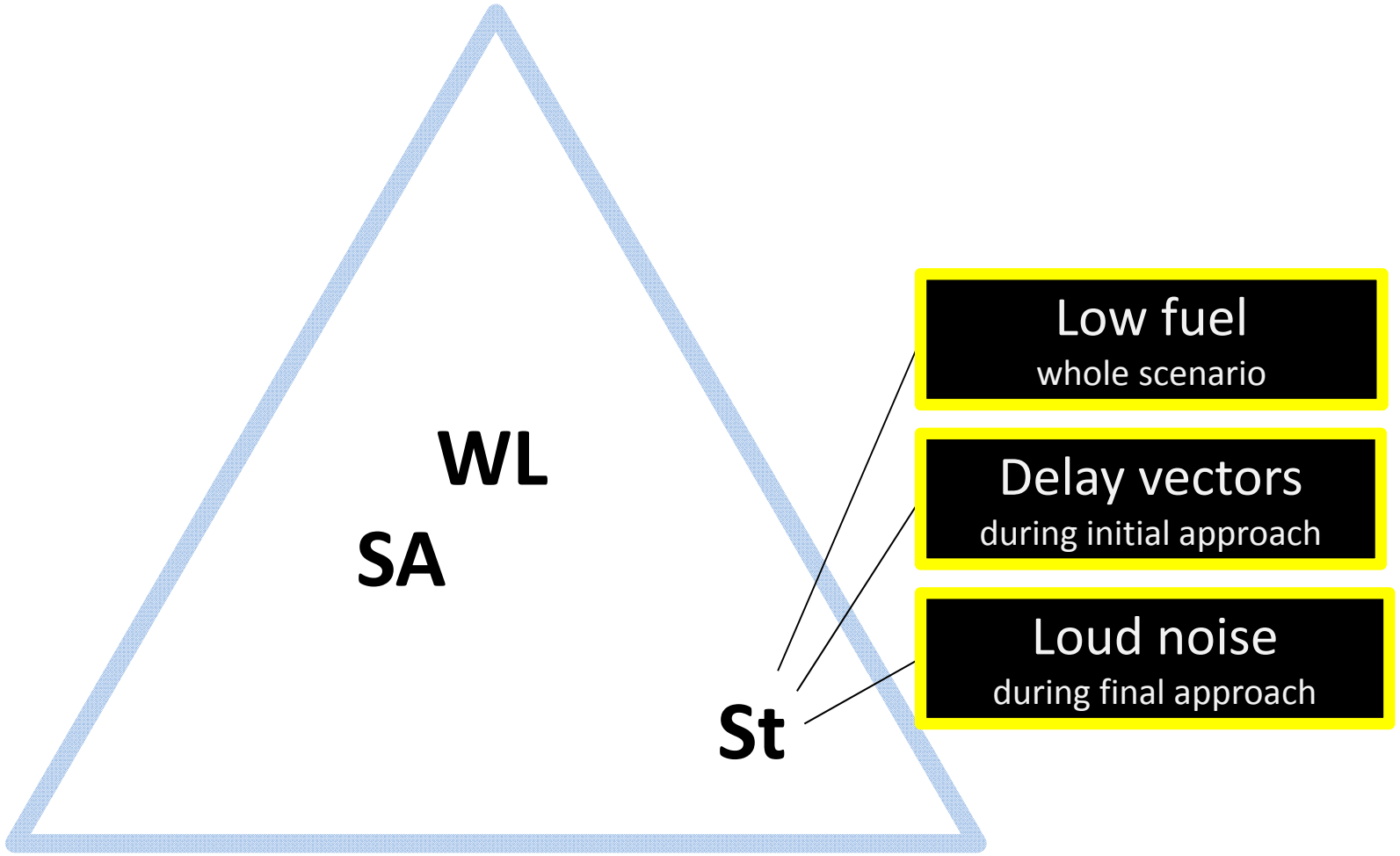
High WL scenario



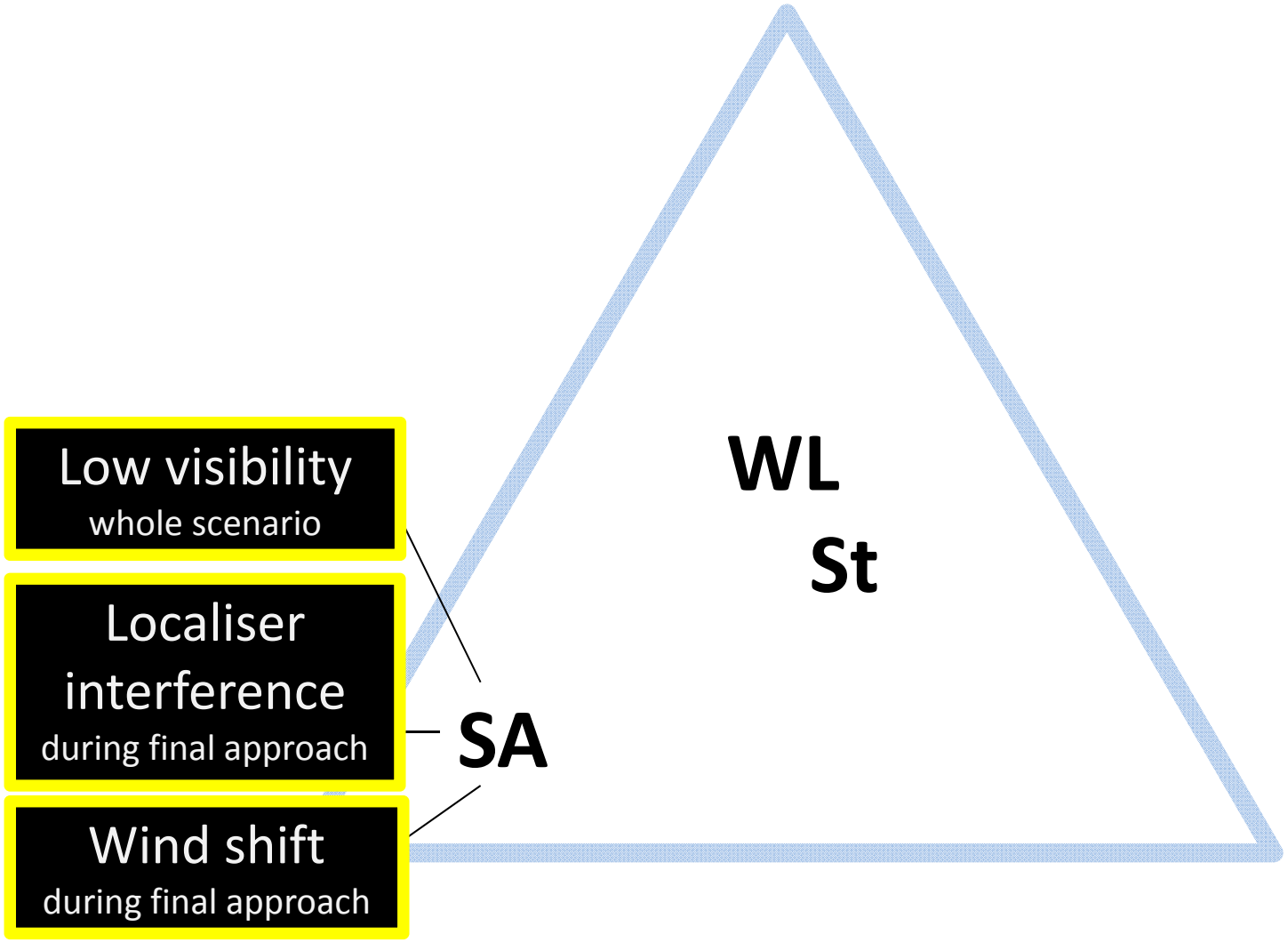
Very high WL scenario



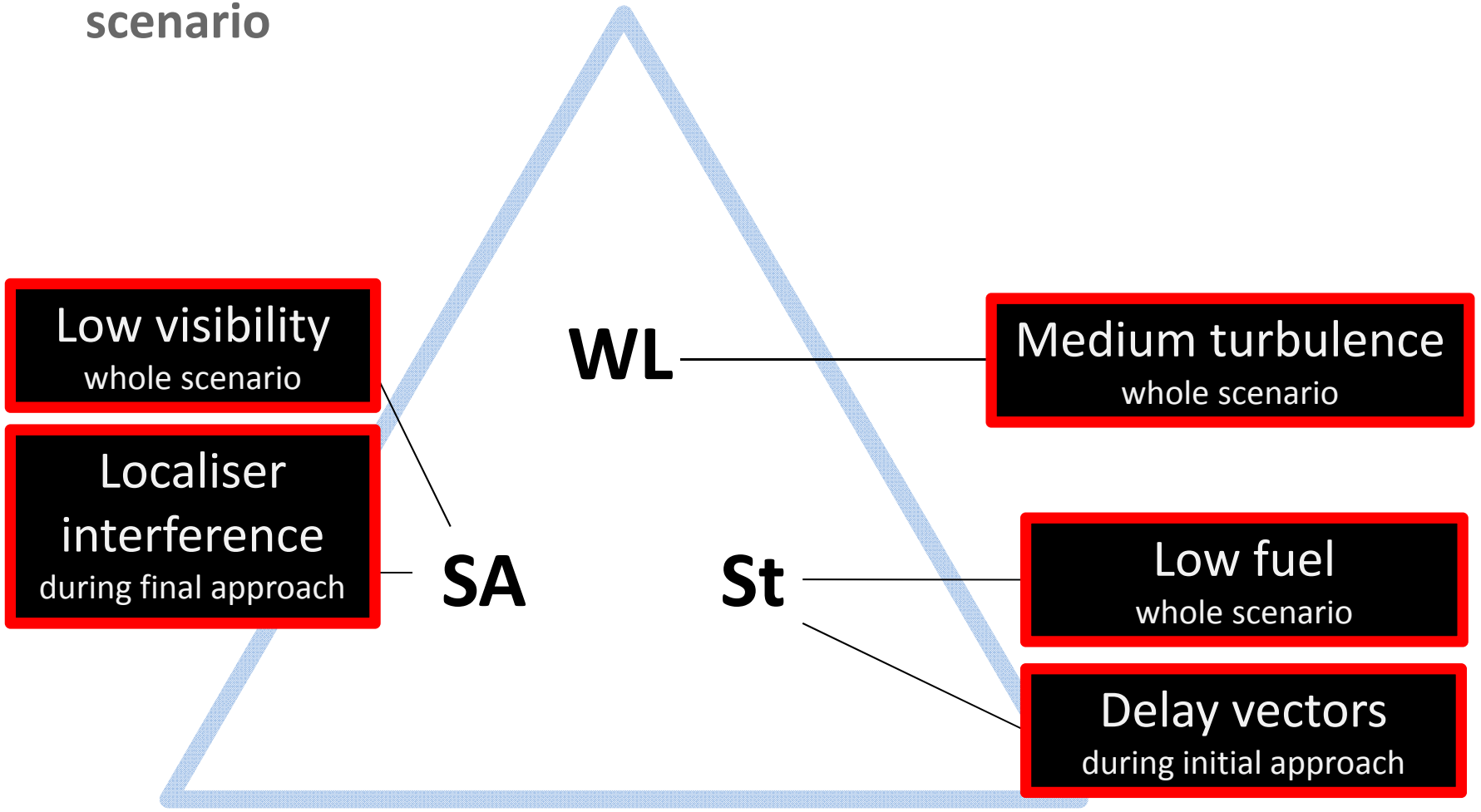
High stress scenario



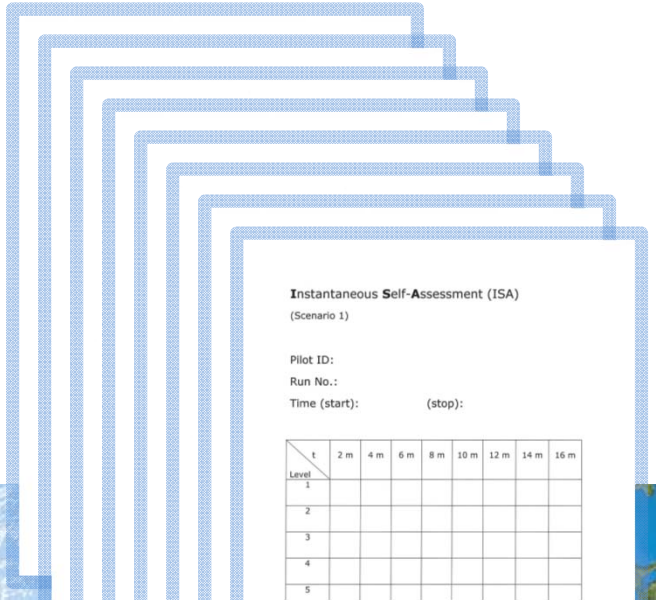
Highly decreased SA



Medium workload, medium stress, medium reduced SA scenario



Measurements



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

Measurements

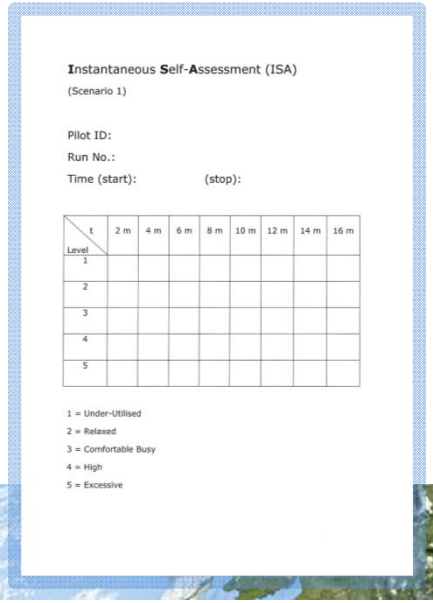
Performance Data

- 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):

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

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

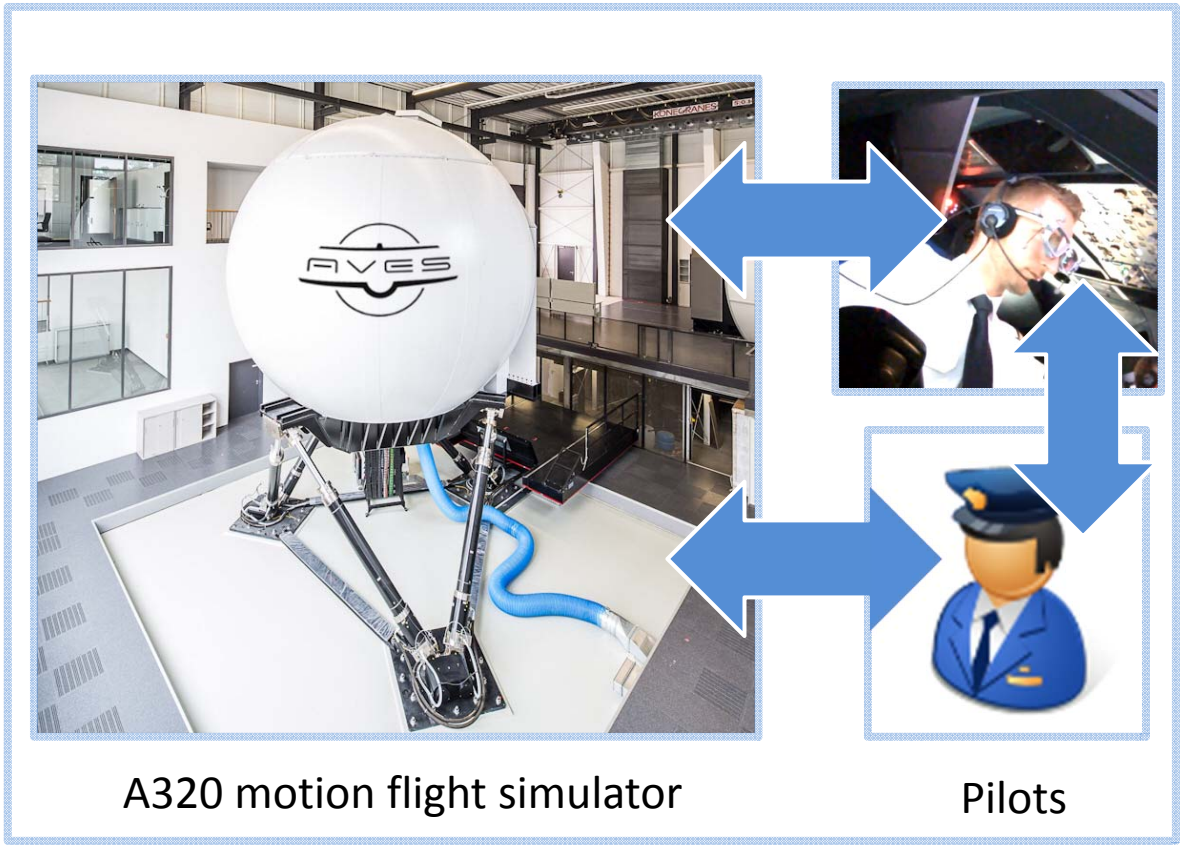
Simulator

A320 motion flight simulator

Pilots

Operational Environment

Participants



A320 motion flight simulator

Pilots

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

DLR

Results Workload

High WL

Baseline WL

With WL increase,

Pupil diameter significantly increases

Results Stress

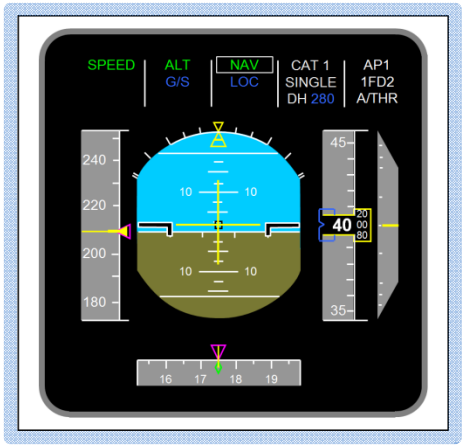
With Stress increase,

Pupil diameter significantly increases

Results Situation Awareness

Pupil diameter
significantly
increases
not significantly

Results Situation Awareness



Baseline SA

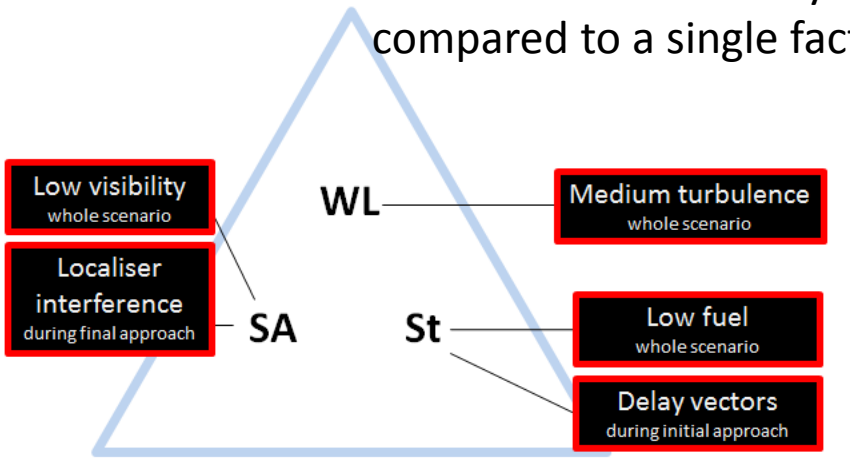
impaired SA

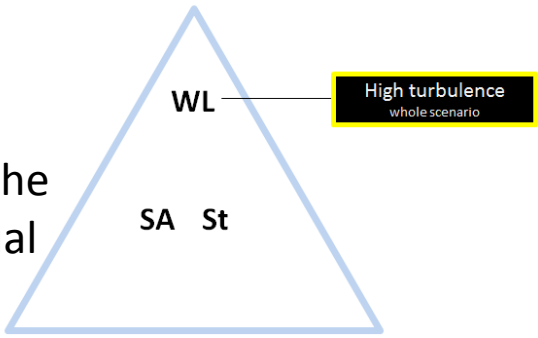
deviation of localiser and glide-slope significantly increases

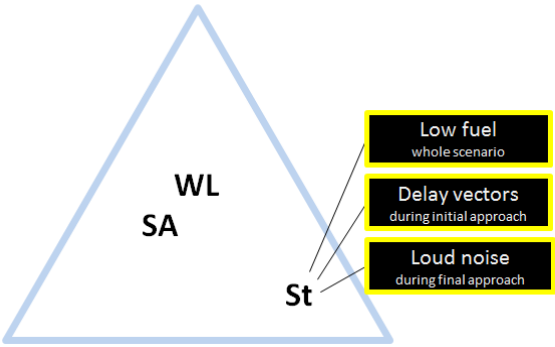
and is **higher** compared to workload and stress scenarios

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

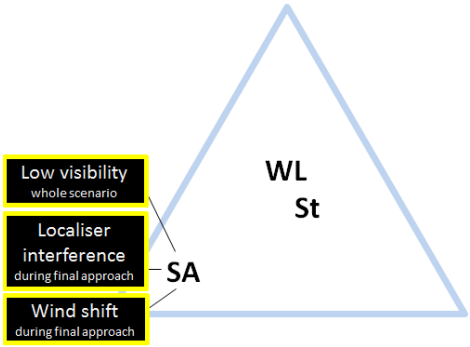






HPE more severely reduced by combined factors:

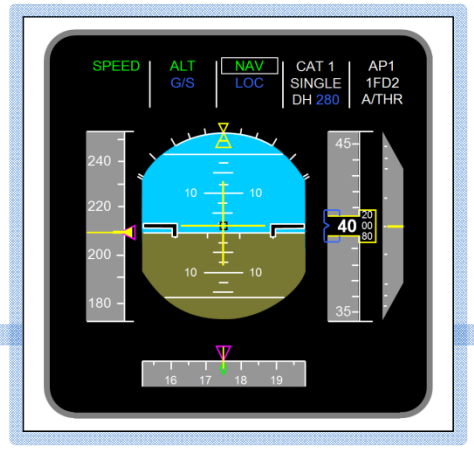
Performance significantly lower at combined factors compared to single factors



Results: combined factors

Pupil diameter

LF of HRV



Localiser / Glideslope deviation

Stay tuned

- Paper in the Aeronautical Journal
  - *under preparation*

ROYAL AERONAUTICAL SOCIETY

http://www.futuresky-safety.eu

FUTURE SKY SAFETY

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

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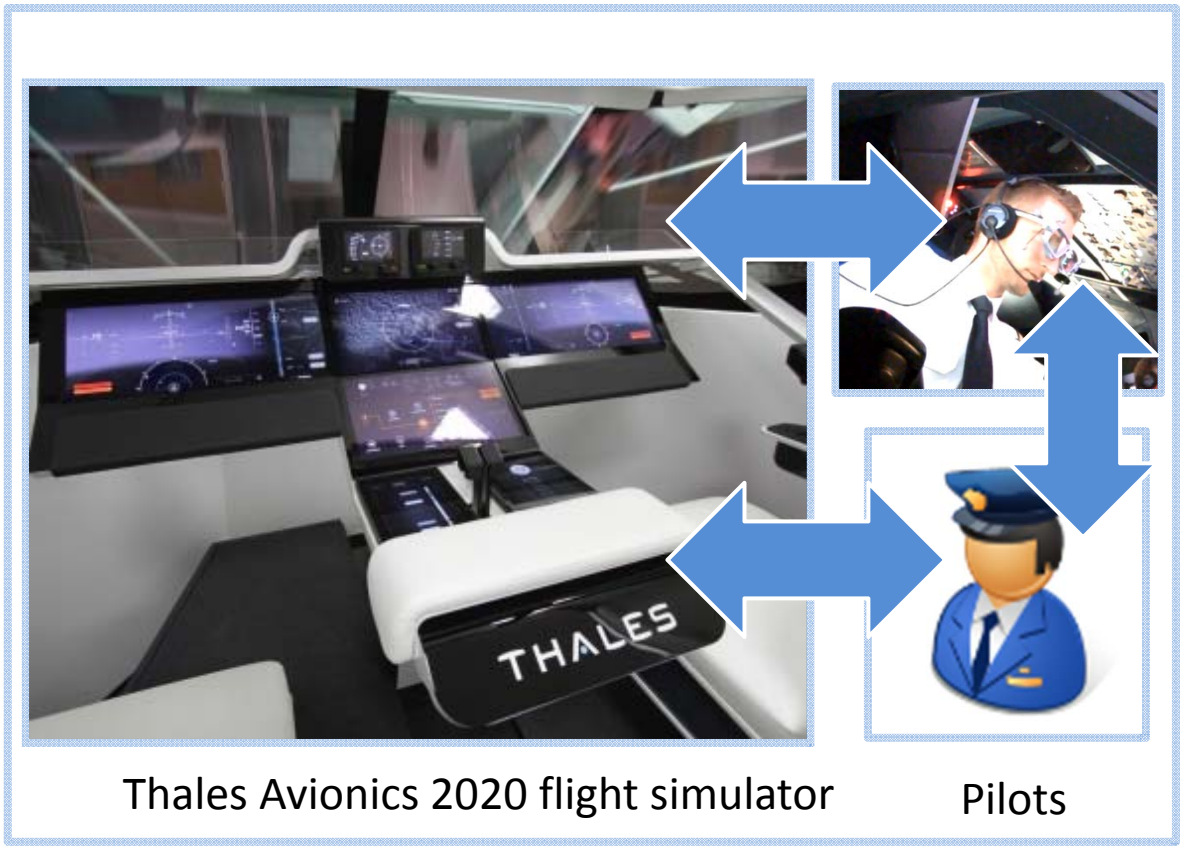
Outlook

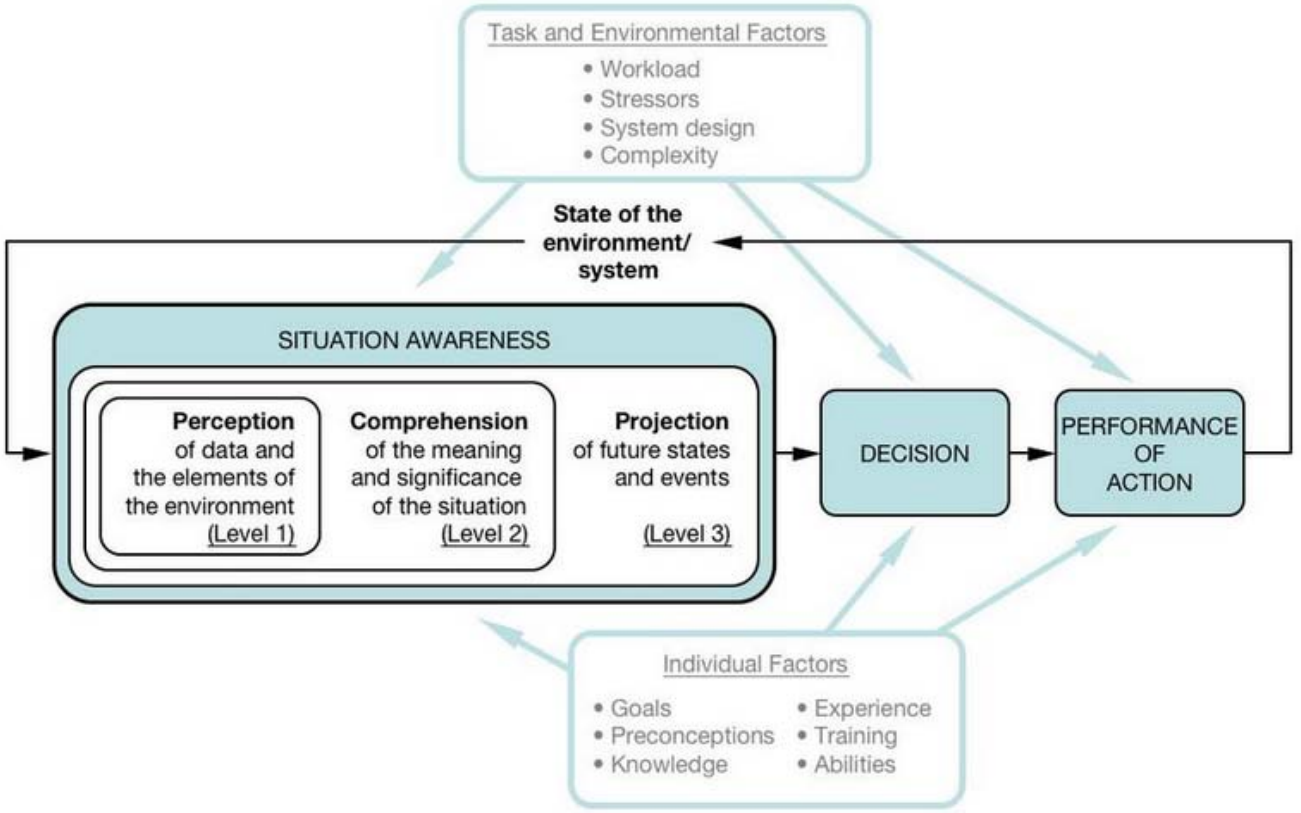


Thales Avionics 2020 flight simulator

Pilots

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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