European Commission

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FUTURE SKY SAFETY

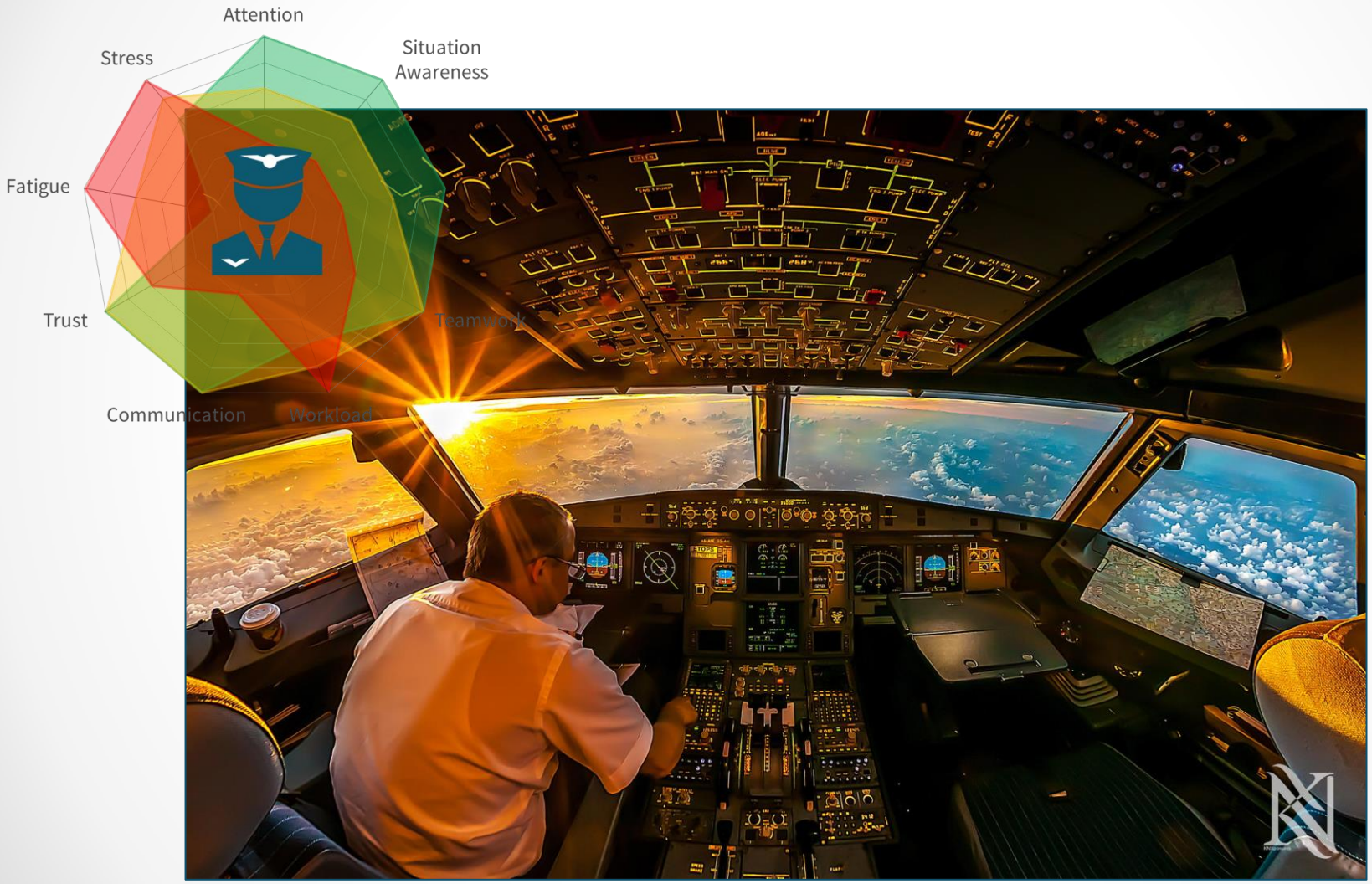
THE FUTURE PILOT FOR THE FUTURE SKY

Frederik Mohrmann, NLR

HPE IN OPERATIONS

Project #6
HUMAN
PERFORMANCE
ENVELOPE

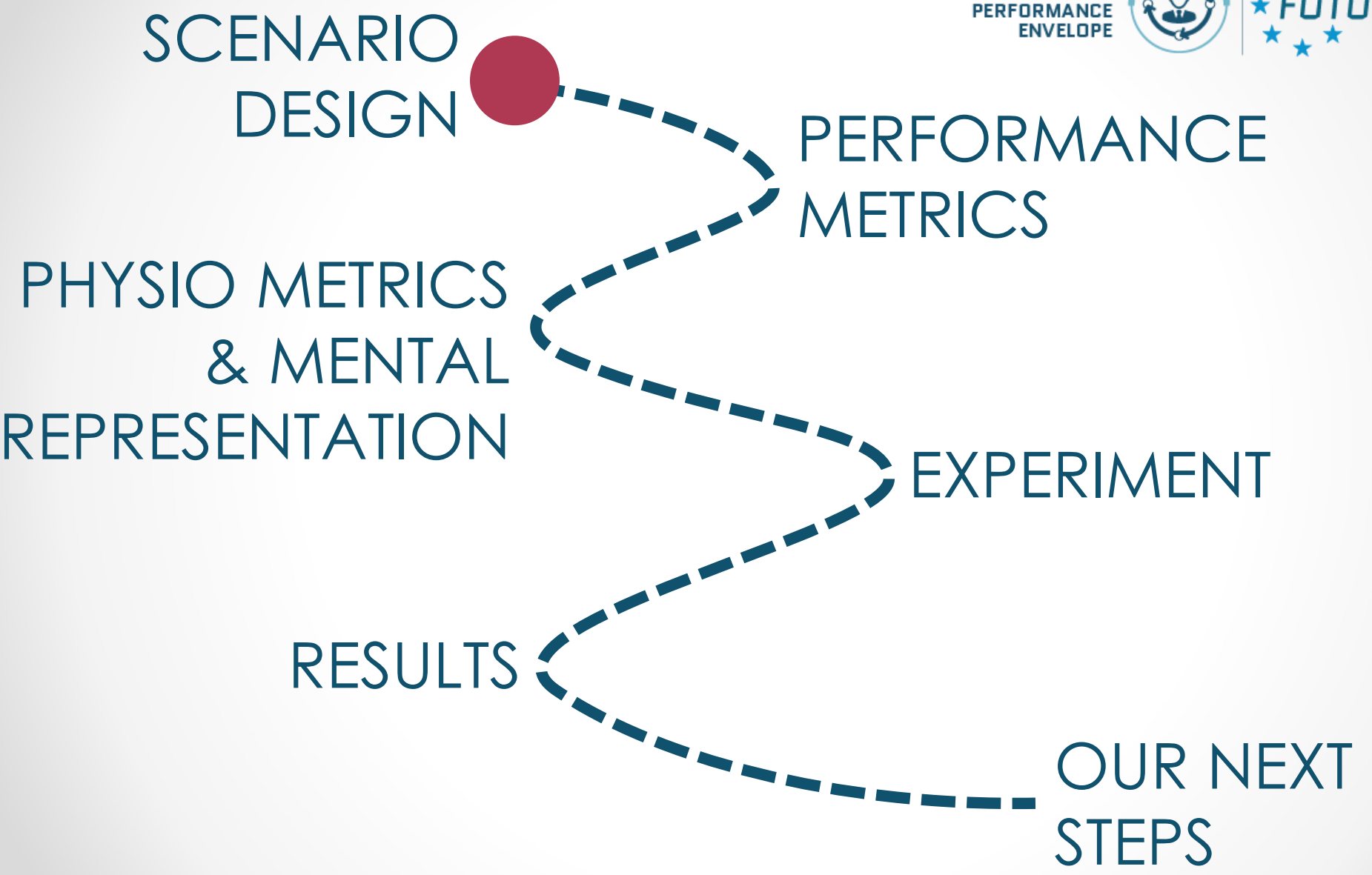
FUTURE SKY
SAFETY



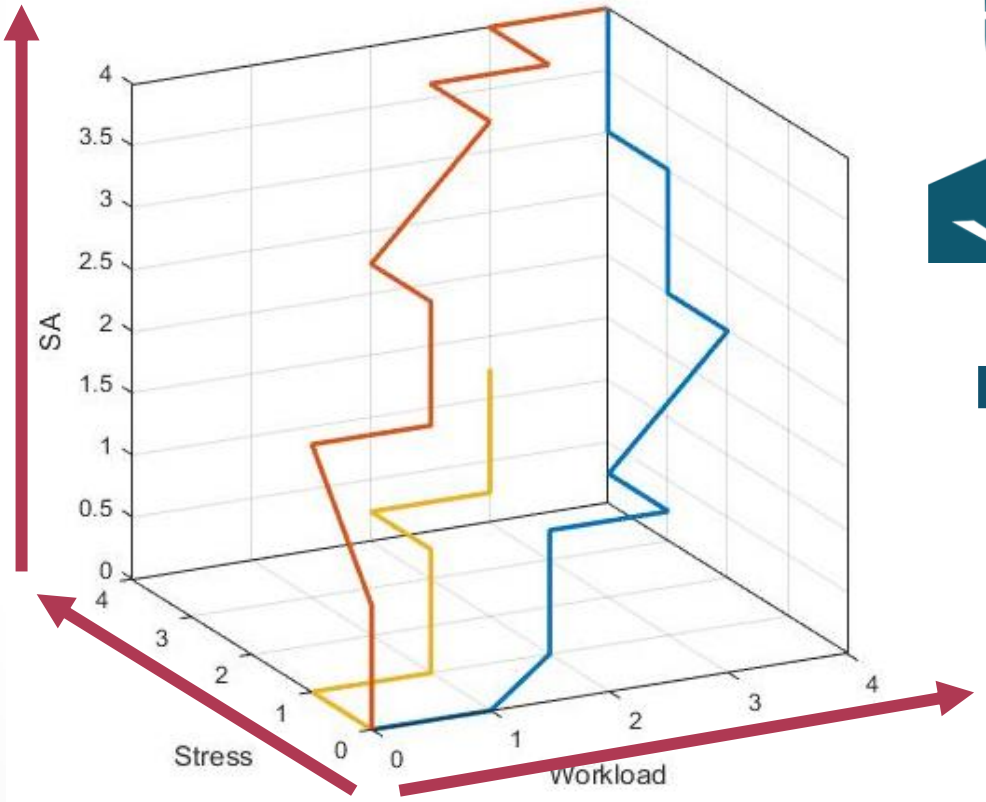
HOW DOES THE HPE CONCEPT WORK IN AN OPERATIONAL SCENARIO?

WHERE ARE THE PERFORMANCE LIMITS OF THE HPE MODEL?

HOW CAN WE SUPPORT THE HPE EFFECTIVELY?

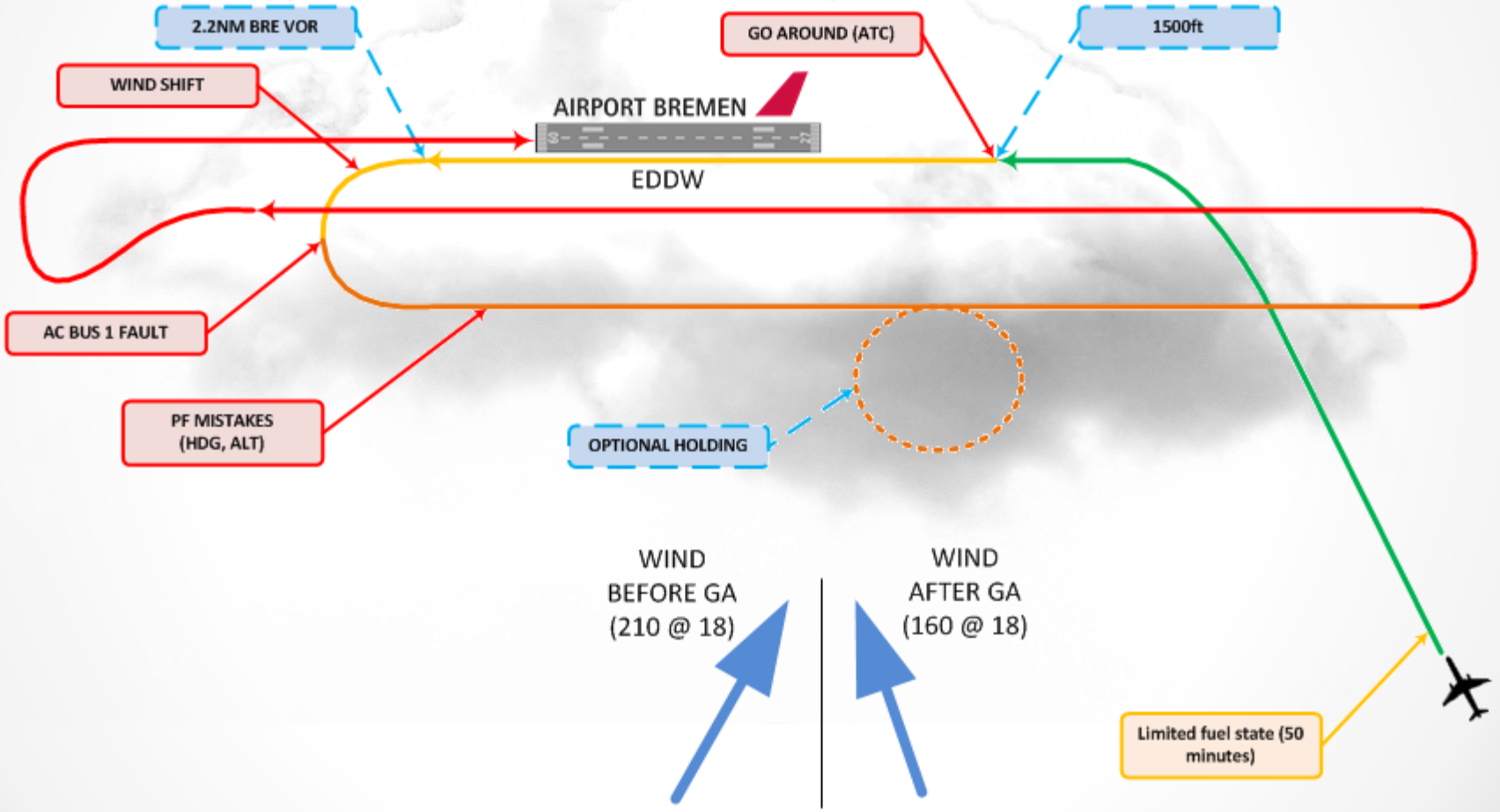

SCENARIO DESIGN
PERFORMANCE METRICS
PHYSIO METRICS & MENTAL REPRESENTATION
EXPERIMENT
RESULTS
OUR NEXT STEPS

WL	ST	SA
0	0	0
0	0	1
0	0	1
0	0	1
0	0	1
0	0	2
0	0	2
0	1	2
1	0	3
1	0	3
1	0	3
1	0	2
1	0	3
1	0	3
0.5	0	1.5
0.5	1	2.5
1.5	1	2.5
1.5	1	1.5
1.5	1	1.5
1.5	1	1.5
1.5	1	1.5
2.5	2	2.5
2.5	1	2.5
2.5	1	2.5
2.5	1	2.5
3.5	1	3.5
3.5	1	3.5
2.5	1	2.5
2.5	2	3.5
3.5	2	3.5
3.5	2	3.5
3.5	2	3.5
3.5	2	4.5
3.5	3	4.5
3.5	3	4.5
3.5	3	4.5
3.5	3	4.5
3.5	3	4.5
3.5	3	4.5
3.5	3	4.5
3.5	3	4.5
3.5	3	4.5
3.5	3	4.5
3.5	3	4.5
4.5	4	4.5
4.5	4	4.5
4.5	5	5.5
4.5	4	5.5
4.5	4	5.5
4.5	4	5.5
4.5	4	5.5



PILOT FLYING

PILOT MONITORING


2.2NM BRE VOR
WIND SHIFT
GO AROUND (ATC)
1500ft
AIRPORT BREMEN
EDDW
AC BUS 1 FAULT
PF MISTAKES
(HDG, ALT)
OPTIONAL HOLDING
WIND
BEFORE GA
(210 @ 18)
WIND
AFTER GA
(160 @ 18)
Limited fuel state (50 minutes)

ELEC AC BUS 1 FAULT

AC BUS 1 normally supplies the AC ESS BUS and, through TR1, the DC ESS BUS. In case of an AC BUS 1 FAULT both the AC and DC ESS BUS will be lost and therefore the AC ESS BUS FAULT and the DC ESS BUS FAULT will be displayed on the ECAM. However, both AC and DC ESS BUS can be recovered by switching the AC ESS FEED pushbutton to ALTN as displayed in the AC ESS BUS FAULT ECAM procedure.

– BLOWER . . . . . OVRD
The avionics ventilation system is in the closed circuit configuration.
Air conditioning is added to the ventilation air.

WHEEL N.W. STEER FAULT

VENT EXTRACT FAULT

– EXTRACT . . . . . OVRD

ENG 1 EPR MODE FAULT

Refer to associated procedure

Affected systems
* AVNCS VENT
* HYD
* FUEL
* F/CTL

ELEC AC BUS 1 FAULT (CONT'D)

STATUS

– LDG DIST PROC . . . . . APPLY
Refer to the QRH Part 2, or to the FCOM 3.02.80.
CAB ZONE AT FIXED TEMP
Due to the loss of the galley fan, the Pack 1 controller, and the primary zone controller channel. (See associated procedures).
[illegible]
CAT 2 ONLY

INOP SYS
See below

INOP SYS displayed on ECAM

BLUE HYD	L+R TK PUMP 1	MAIN GALLEY
SPLR 3	CTR TK PUMP 1	B ELEC PUMP
ADR 3	VENT BLOWER	BSCU CH 1
RA 1	GALLEY FAN	DMC 3
CAPT TAT	CRG VENT ◁	GPWS
L WSHLD HEAT	GND COOL ◁	LAV DET
L WNDW HEAT	N.W. STEER	PACK 1 REGUL
CAT 3	REVERSER 1	

Other inoperative systems

Left cabin fan	Engine 1 ignition B	Zone controller prim channel
Radar 1	EVMU eng 1 and eng 2	Hydraulic quantity indication
Stby Pitot/AOA		Partial galley
ACARS ◁	Printer	PVI ◁
Brake fans 5, 6, 7 and 8 ◁	MCDU 3 ◁	TCAS ◁
HUD ◁		

Note : The warning may be caused by a sub BUS failure. Consequently, only a part of the above-listed systems may be lost.

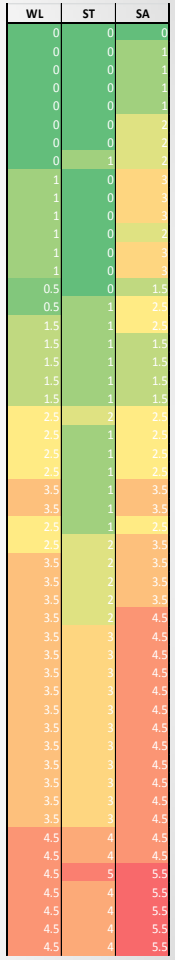
INITIAL APPROACH

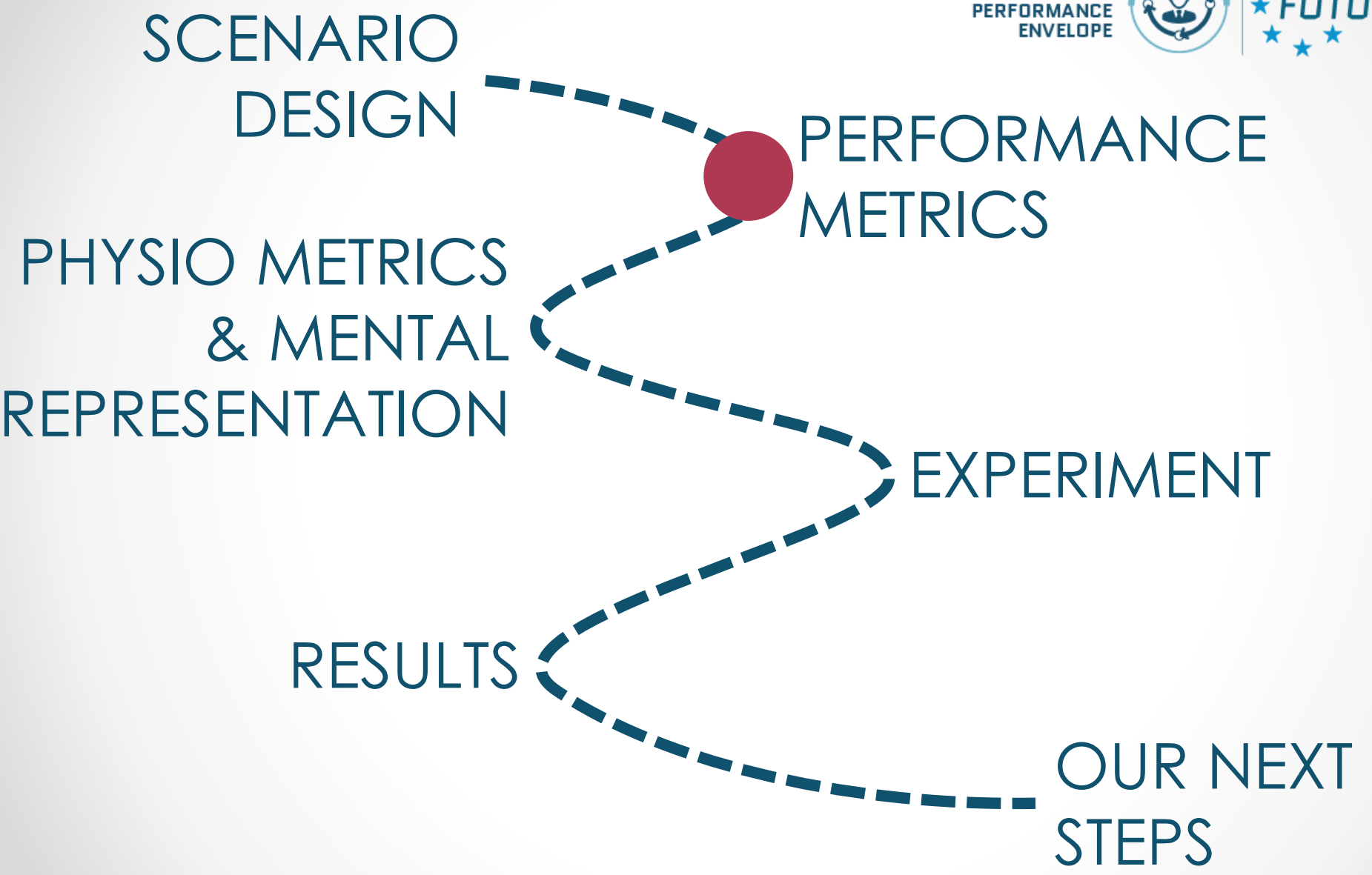
GO AROUND WITH LIMITED FUEL

AC BUS 1 FAILURE & PF MISTAKES

SECOND GO AROUND (WIND SHIFT)

LANDING WITH LOW FUEL, WINDSHEILD FROZEN




SCENARIO DESIGN
PERFORMANCE METRICS
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OUR NEXT STEPS

Project #6
HUMAN
PERFORMANCE
ENVELOPE

FUTURE SKY
SAFETY

ICAO DOC 9995
EVIDENCE BASED TRAINING
(COMPETENCY BASED TRAINING)

Situational Awareness

Problem Solving & Decision Making

Application of Procedures

HPE-sensitive

Single-pilot

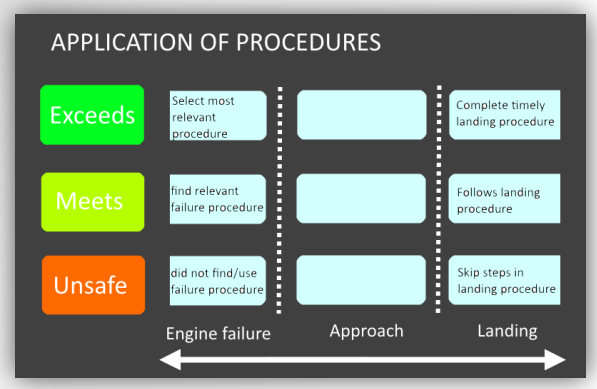
PM relevant

Observable

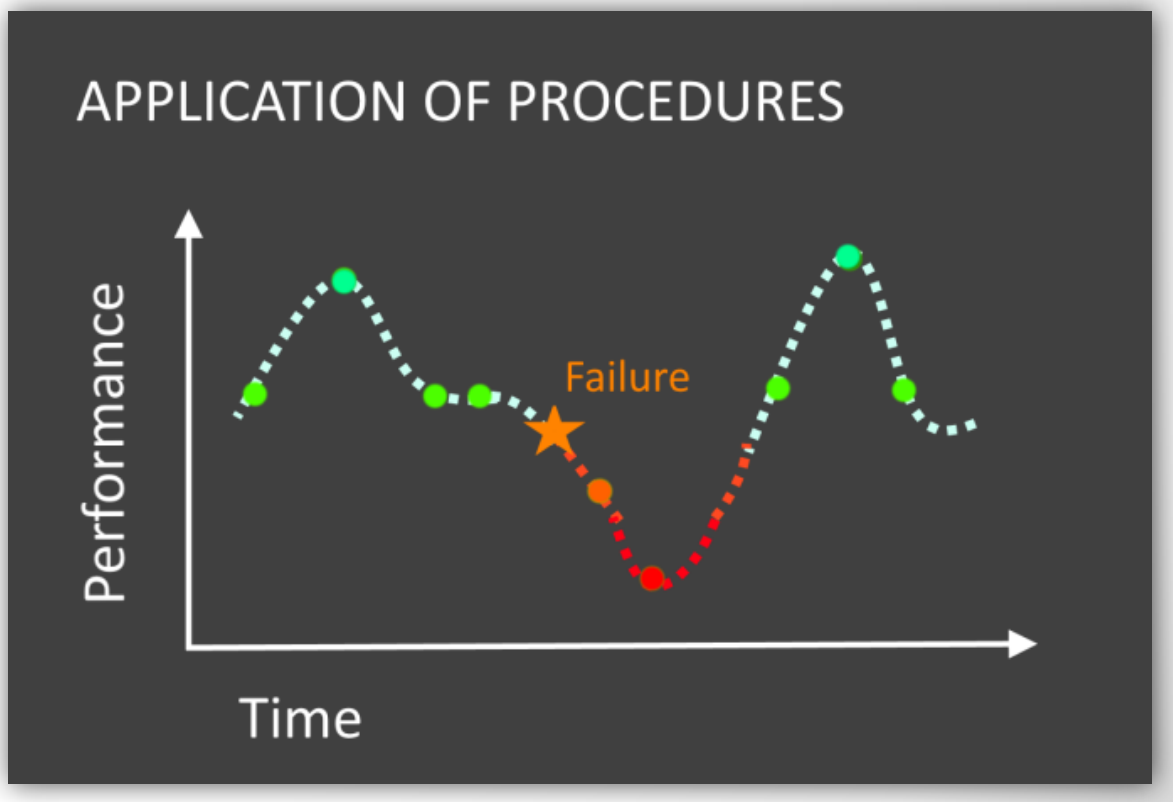
			General	Descent & Approach 27	Go around	AC BUS FAULT	Second LAPA calc (RWY)	Approach
Situational Awareness	Identifies and assesses accurately the state of the aircraft(systems), aircraft position, environment, and of people involved and anticipates on what could happen in the future.	1 Exceeds	Develops 'what if' scenarios and plans for contingencies, including further anticipation of the far future.	Interprets and what-if scenarios, options, updates throughout the descent	Notices fuel status, wind shift and PF errors. Interprets and what-if scenarios, suggests courses of action	[illegible] with AC fault,verbalises landing distance, realises it is a OM-B inop problem and its consequences	[illegible] weather (wind)observations in flight progress, combines with technical status of the aircraft. QRH awareness (extra checklist) Mentions CAT1 landing	[illegible] that can evolve as a result of condition (Mentions extra space in front of the runway, and potential nose wheel steering issues), e.g. runway overrun and subsequent evacuation
		2 Meets	Has an awareness of the aircraft state in its environment (including people); projects to near future and anticipates changes.	Mentions fuel/endurance in minutes	Notices fuel status, wind shift and PF errors.	Verbalises consequences for Landing dist.	Accepts additional inputs from ATC without actively seeking new information. QRH awareness, Mentions CAT1 landing	Acknowledges runway state, fuel state, weather. Mentions potential nose wheel steering problem
		3 Below	Spends time searching for irrelevant information, incomplete assessment of the situation.	Mentions fuel/endurance in kilos/tons	Does not notice one of the three events	Does not mention fuel, and/or landing dist	Slow in accepting new information. Misses QRH and/or CAT1 issue.	Requires extra time to complete the picture of the situation
		4 Unacceptable	Does not or incorrectly identify the state (changes), does not seek updates.	No mention of fuel status	Does not notice two of three events, or all	Misses two of the three issues or all	Ignores new information	Misses urgency of the situation

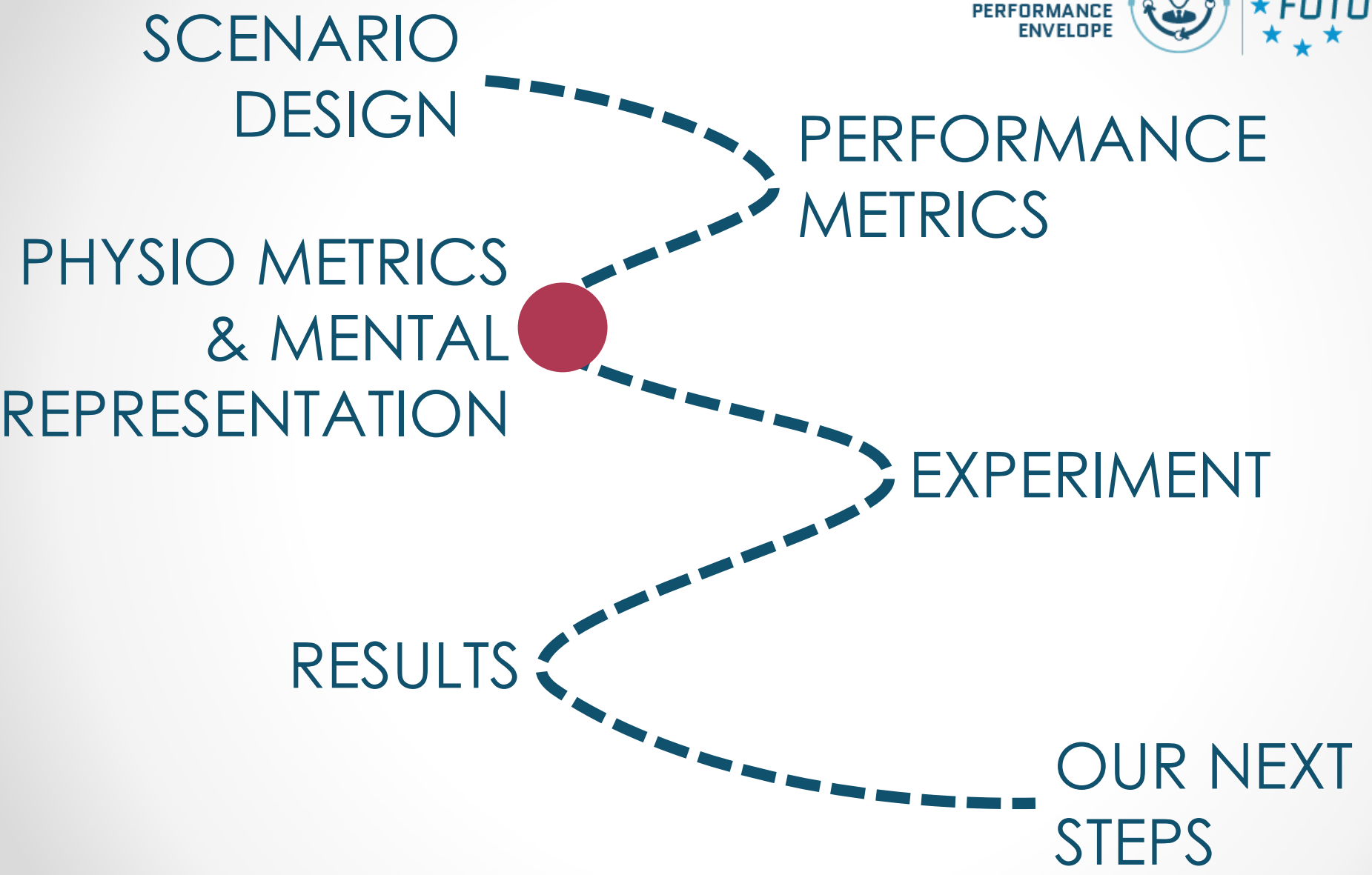
			General	Descent & Approach 27	Go around	AC BUS FAULT	Second LAPA calc (RWY)	Approach
Decision making	Identifies the problem and diagnoses, identifies risks, generates options, decides, resolves problems, monitors, and evaluates.	1 Exceeds	Anticipates future states, effects and risks, is pro-active.			Demonstrates knowledge (Realises it is a OM-B inop issue) of AC BUS fault consequences	Anticipated possible weather deterioration in relation with landing runway	Prepares for potential contingencies. Requests full help of emergency vehicles, prepares cabin, dedicates for landing etc.
		2 Meets	Evaluates (potential) problems, identifies risk, considers alternatives and selects the best course of action. Continuously reviews progress and adjust plans.			Understands the consequences once read from ECAM/OM. Realises it is a OM-B inop issue	Combines technical failure with changes weather situation, decided on landing 09	Accepts information and identifies the criticality of the situation: low fuel, relatively short runway, bad weather
		3 Below	Evaluates the problem poorly. Makes decisions based on incomplete information.			Does not combine the consequence with operational status (landing dist, 27 potentially too short with tailwind, 09 longer flying time considering low fuel)	Passive in decision making, leaves the decision to ATC or PF	Misses elements, e.g. briefs go-around i.s.o. dedicating to landing
		4 Unacceptable	Does not identify there is a problem. Does not indicate what must be done. Does not adjust plan where necessary.			Proposes course of action not taking into account both anomalies	Does not decide on runway 09 as best option for landing	Suggests wrong actions, e.g. not using maximum stopping performance, possibly making a go-around

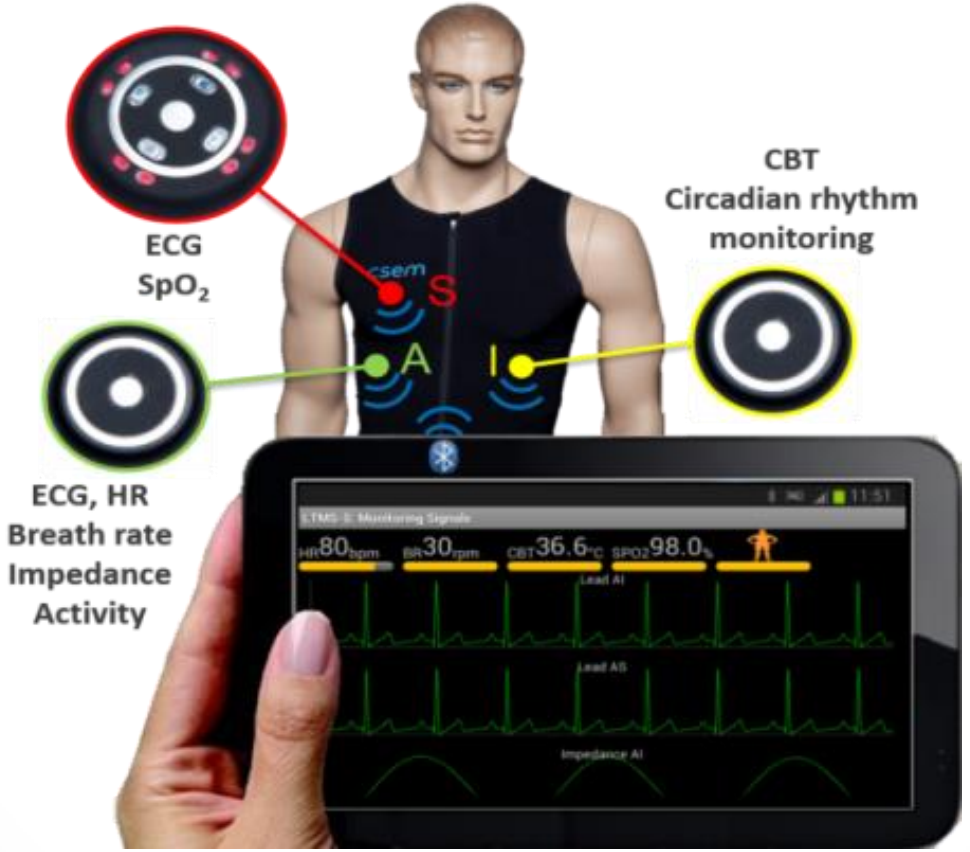
			General	Descent & Approach 27	Go around	AC BUS FAULT	Second LAPA calc (RWY)	Approach
Application of procedures	Identifies and applies accurately procedures in accordance with published operating instructions and applicable regulations, using the appropriate knowledge. Only if a higher degree of safety is achieved, deviation from standard procedures might be necessary.	1 Exceeds	Identifies and applies at the correct moment the procedures according to published operating instructions.	Mentions threats and errors, defines mitigating measures		Demonstrates knowledge of AC BUS fault procedure, anticipates time available vs procedure length	Correctly calculates LAPA at an early stage, identifies consequences early. Uses Mayday call	Mentions threats and errors, defines mitigating measures. All preparations and checklists completed well in time
		2 Meets	Execute the prescribed procedures and operate the systems during normal and abnormal circumstances.	Briefing, approach preparation incl landing dist calc, approach checklist	Performs actions and call-outs (gear, flaps, ATC comms)	call for ECAM actions	Correctly calculates landing distance. After discussion identifies consequences. Uses Mayday call	Briefing, approach preparation, approach checklist. Time management in relation with time pressure
		3 Below	Applies in general the procedures according to published operating instructions. Unnecessarily skips procedure steps.	Misses steps, caught by approach checklist	Slow in actions, gear, flaps, ATC comms	Slow in call for ECAM actions	Calculates LAPA, but initially with some errors that are corrected	Misses steps, caught by checklist or ECAM Status. Takes extra time to complete the procedure
		4 Unacceptable	Follows the wrong procedure. Skips important procedure steps. Or follows the procedure in such a way that the result is influenced negatively.	Misses essential threats (RWY length, weather, fuel)		Forgets to fly the aircraft, misses procedure steps (status page, OM ref)	Incorrect calculation, wrong result	Misses essential threats (runway length, runway state, fuel status, weather) in the briefing

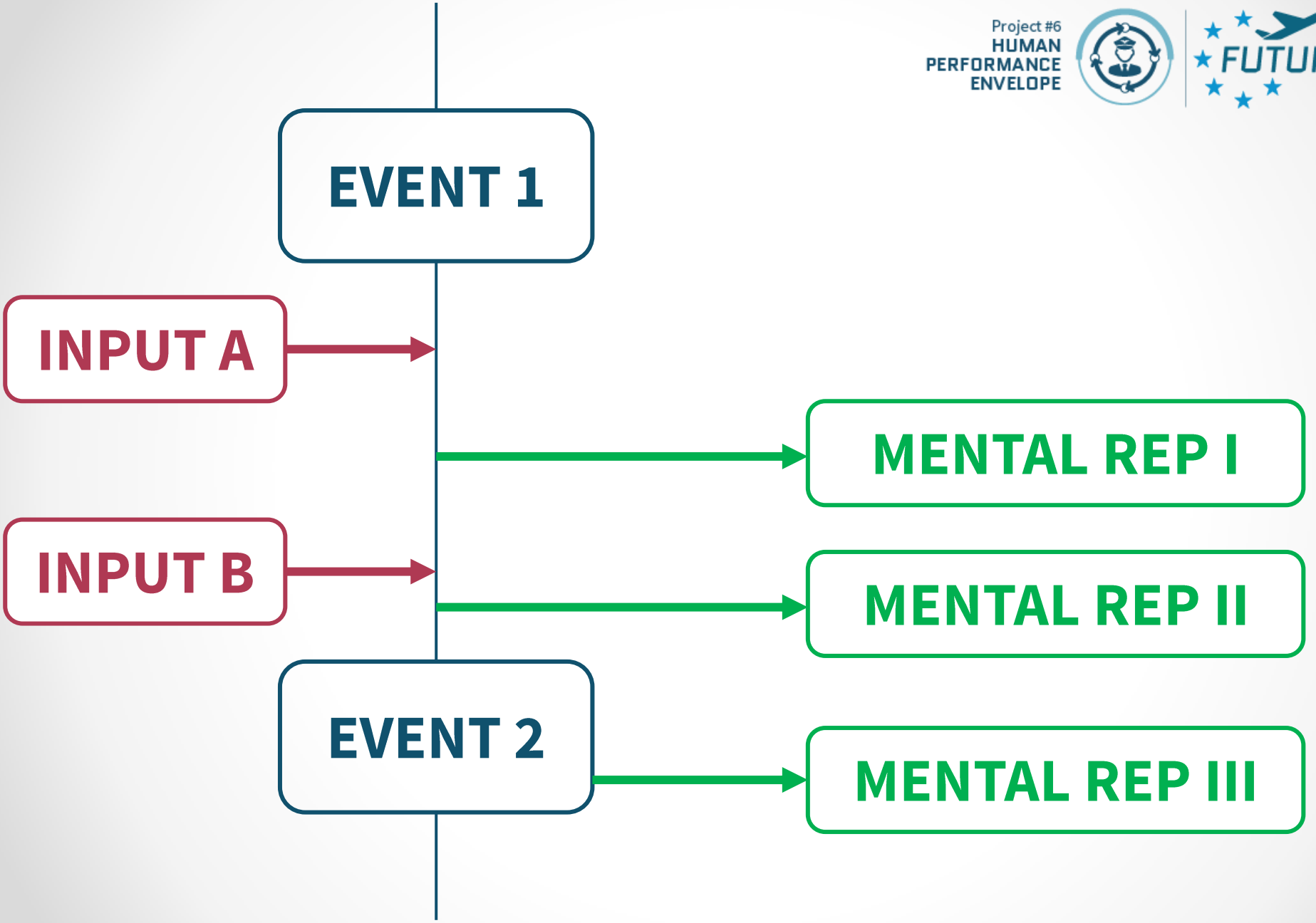

APPLICATION OF PROCEDURES
Exceeds
Meets
Unsafe
Select most relevant procedure
find relevant failure procedure
did not find/use failure procedure
Complete timely landing procedure
Follows landing procedure
Skip steps in landing procedure
Engine failure
Approach
Landing

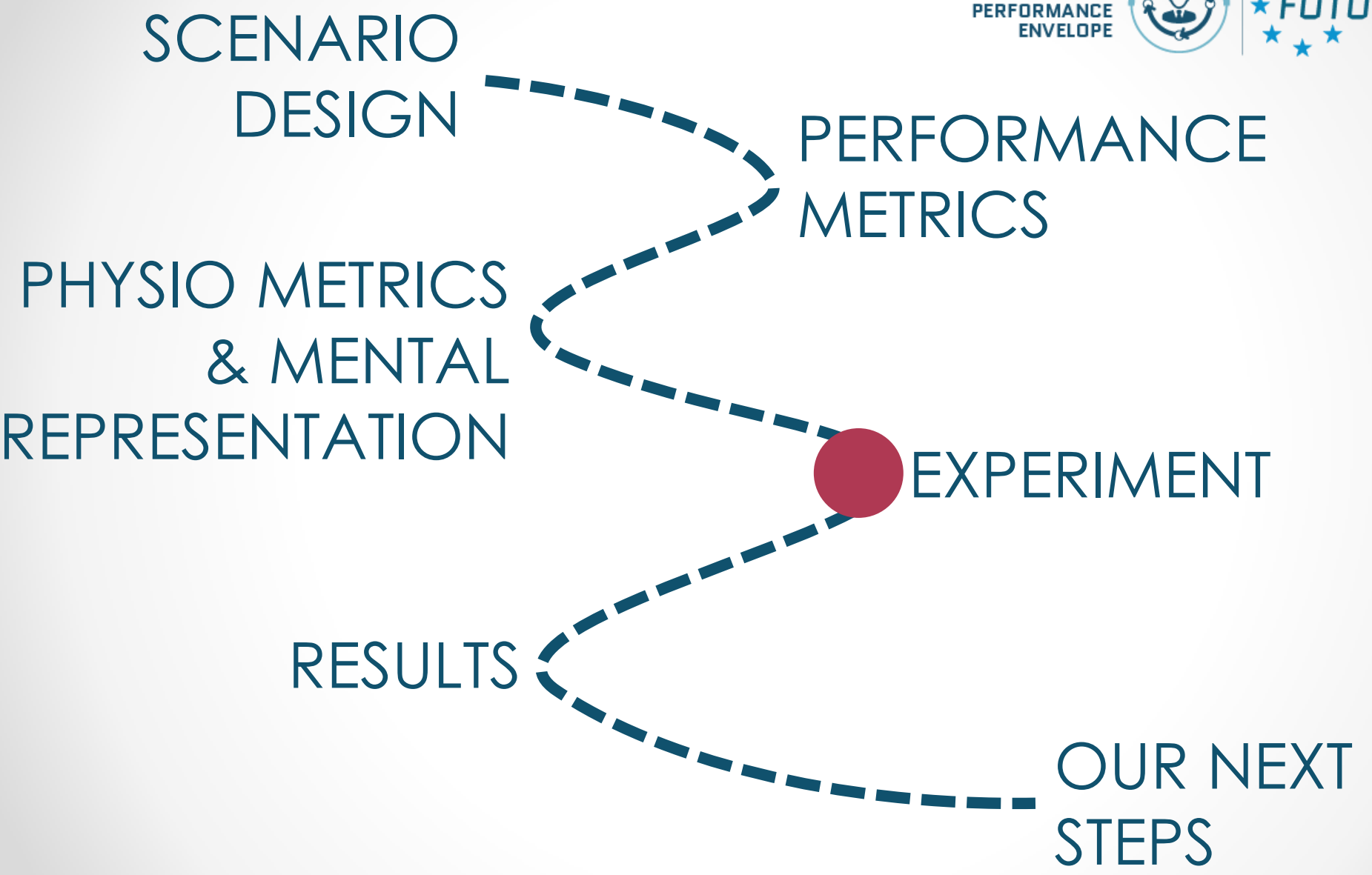
ONLINE TOOL


APPLICATION OF PROCEDURES
Performance
Failure
Time


SCENARIO DESIGN
PERFORMANCE METRICS
PHYSIO METRICS & MENTAL REPRESENTATION
EXPERIMENT
RESULTS
OUR NEXT STEPS


ECG
SpO2
CBT
Circadian rhythm
monitoring
ECG, HR
Breath rate
Impedance
Activity
S
A
I
HR 80 bpm
BR 30 rpm
CBT 36.6 °C
SPO2 98.0 %
Lead AI
Lead AS
Impedance AI


EVENT 1
INPUT A
INPUT B
MENTAL REP I
MENTAL REP II
EVENT 2
MENTAL REP III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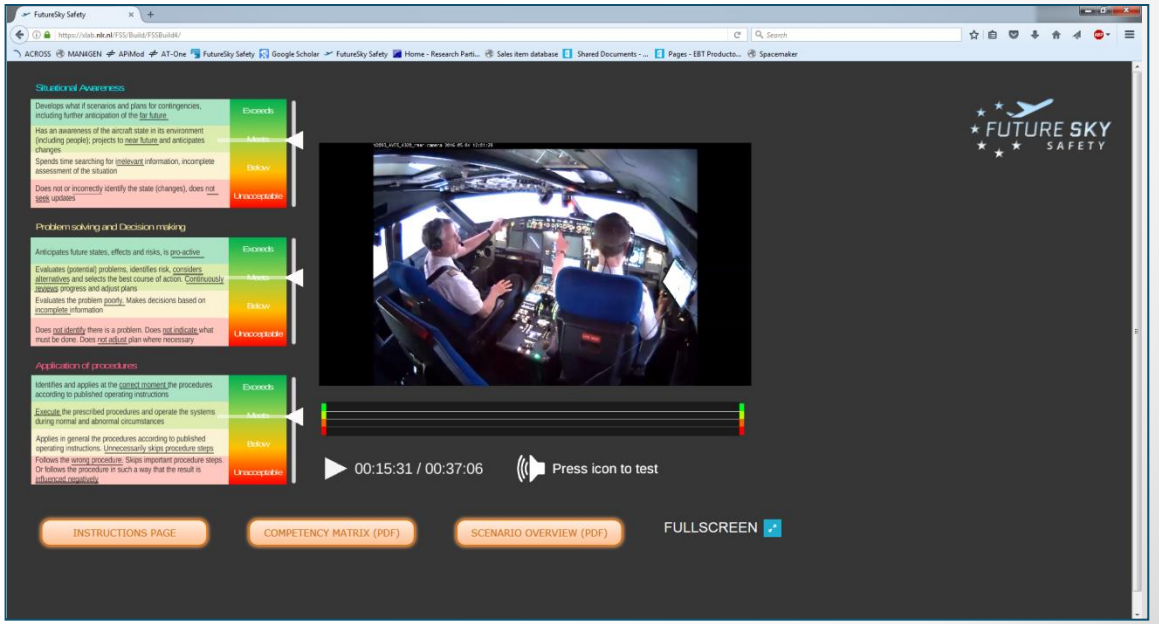
AVES SIMULATOR @ DLR

ONLINE ASSESSMENT @ NLR



@ DLR

Project #6
HUMAN
PERFORMANCE
ENVELOPE

FUTURE SKY
SAFETY

PILOT FLYING
(CAPTAIN)

SCRIPTED ROLE

PILOT MONITORING
(FIRST OFFICER)

CANDIDATE PILOT

@ NLR

Project #6
HUMAN PERFORMANCE ENVELOPE

FUTURE SKY SAFETY

Three competencies

Flight Scenario Video

Track your ratings

Situational Awareness

Develops what if scenarios and plans for contingencies, including further anticipation of the far future	Exceeds
Has an awareness of the aircraft state in its environment (including people); projects to near future and anticipates	Meets
Spends time searching for irrelevant information, incomplete assessment of the situation	Below
Does not or incorrectly identify the state (changes), does not seek updates	Unacceptable

Problem solving and Decision making

Anticipates future states, effects and risks, is pro-active	Exceeds
Evaluates (potential) problems, identifies risk, considers alternatives and selects the best course of action. Continuously reviews progress and adjust plans	Meets
Evaluates the problem poorly. Makes decisions based on incomplete information	Below
Does not identify there is a problem. Does not indicate what must be done. Does not adjust plan where necessary	Unacceptable

Application of procedures

Identifies and applies at the correct moment the procedures according to published operating instructions	Exceeds
Execute the prescribed procedures and operate the systems during normal and abnormal circumstances	Meets
Applies in general the procedures according to published operating instructions. Unnecessarily skips procedure steps	Below
Follows the wrong procedure. Skips important procedure steps. Or follows the procedure in such a way that the result is influenced negatively	Unacceptable

00:20:48 / 00:42:54

Press icon to test

Play and Pause only

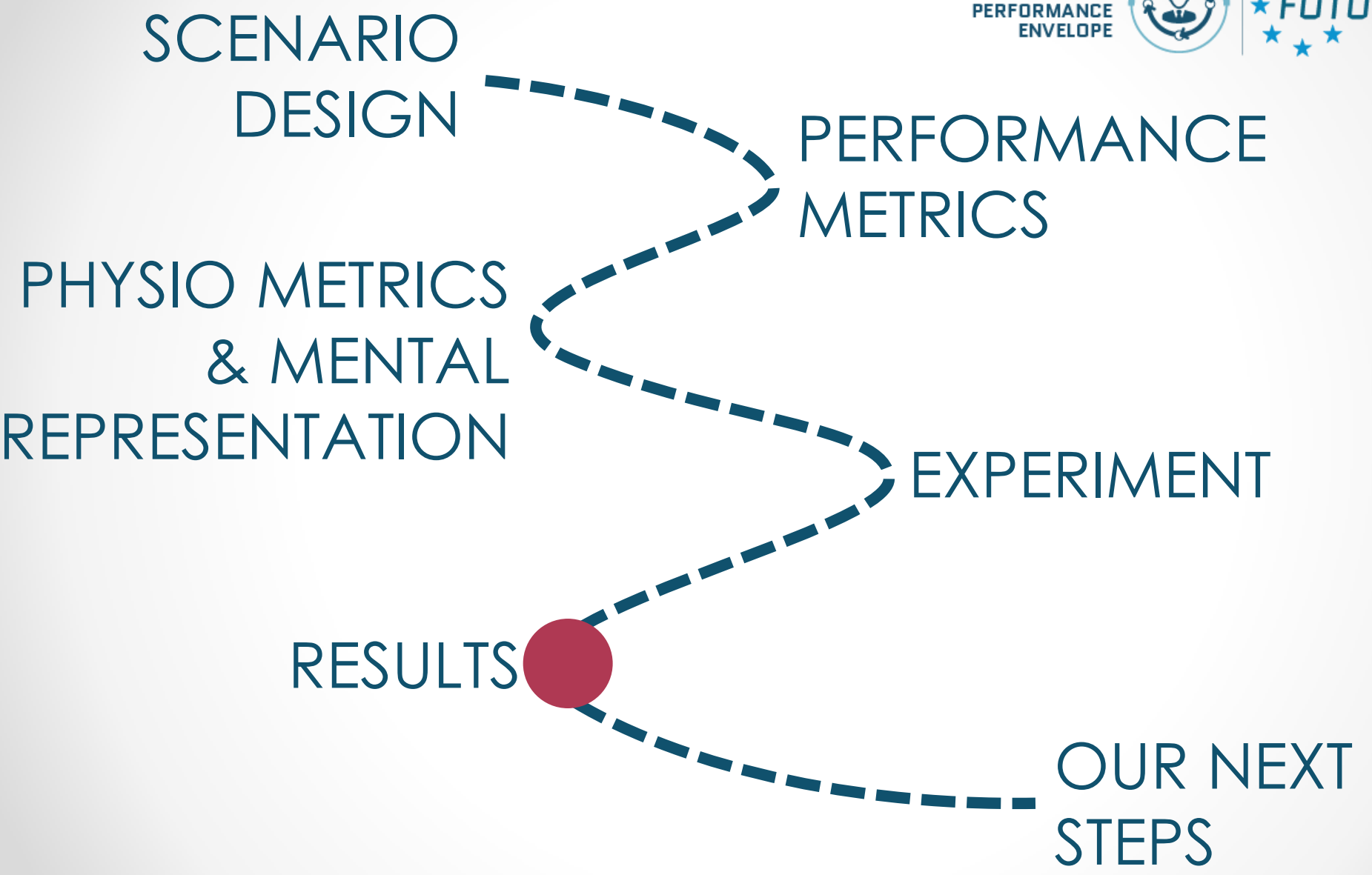
Test your sound (!)

FOUR FLIGHT INSTRUCTORS

OVER THE SUMMER

ALL CREWS RATED

(4/10 MULTI-RATED)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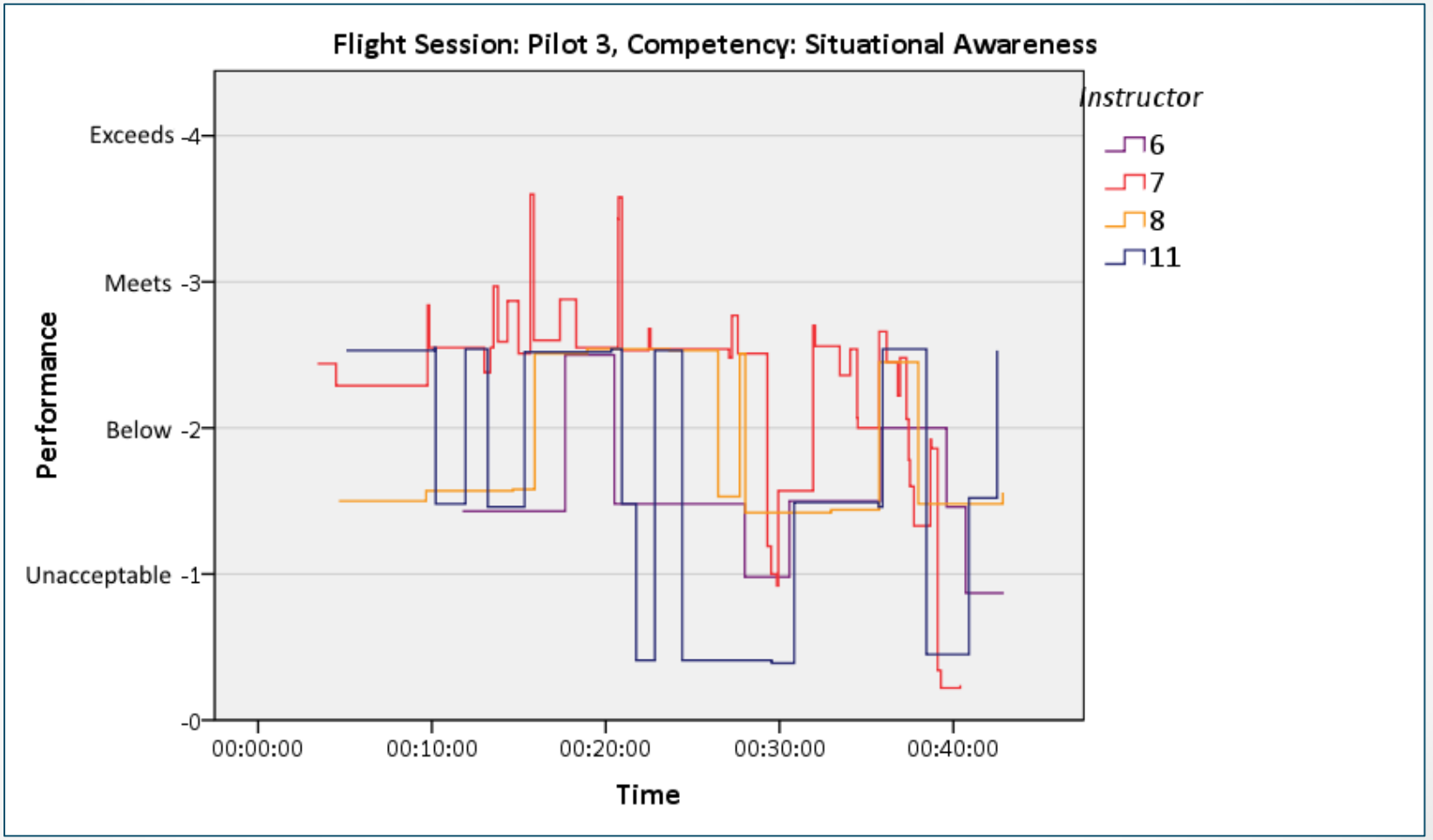
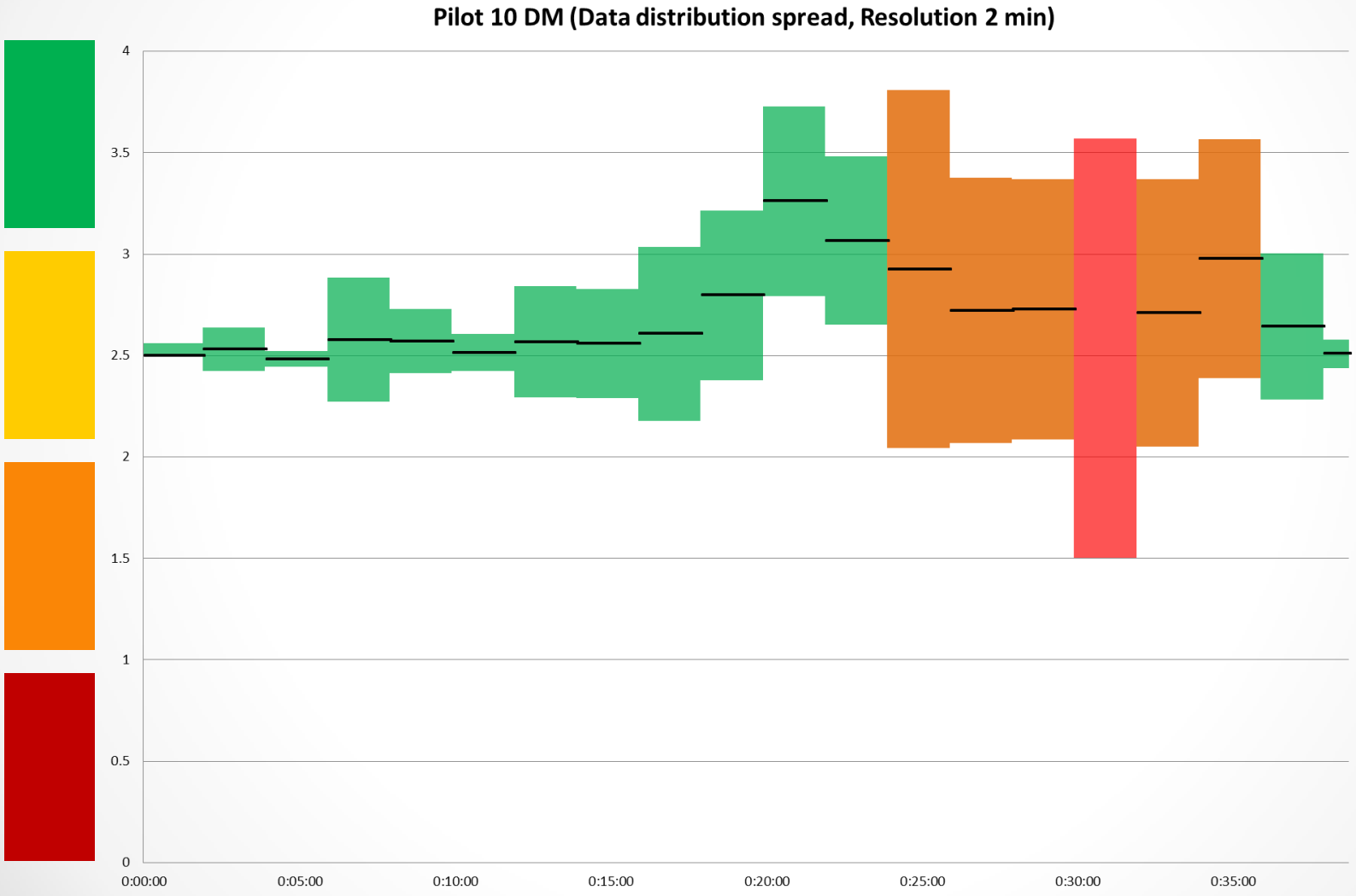
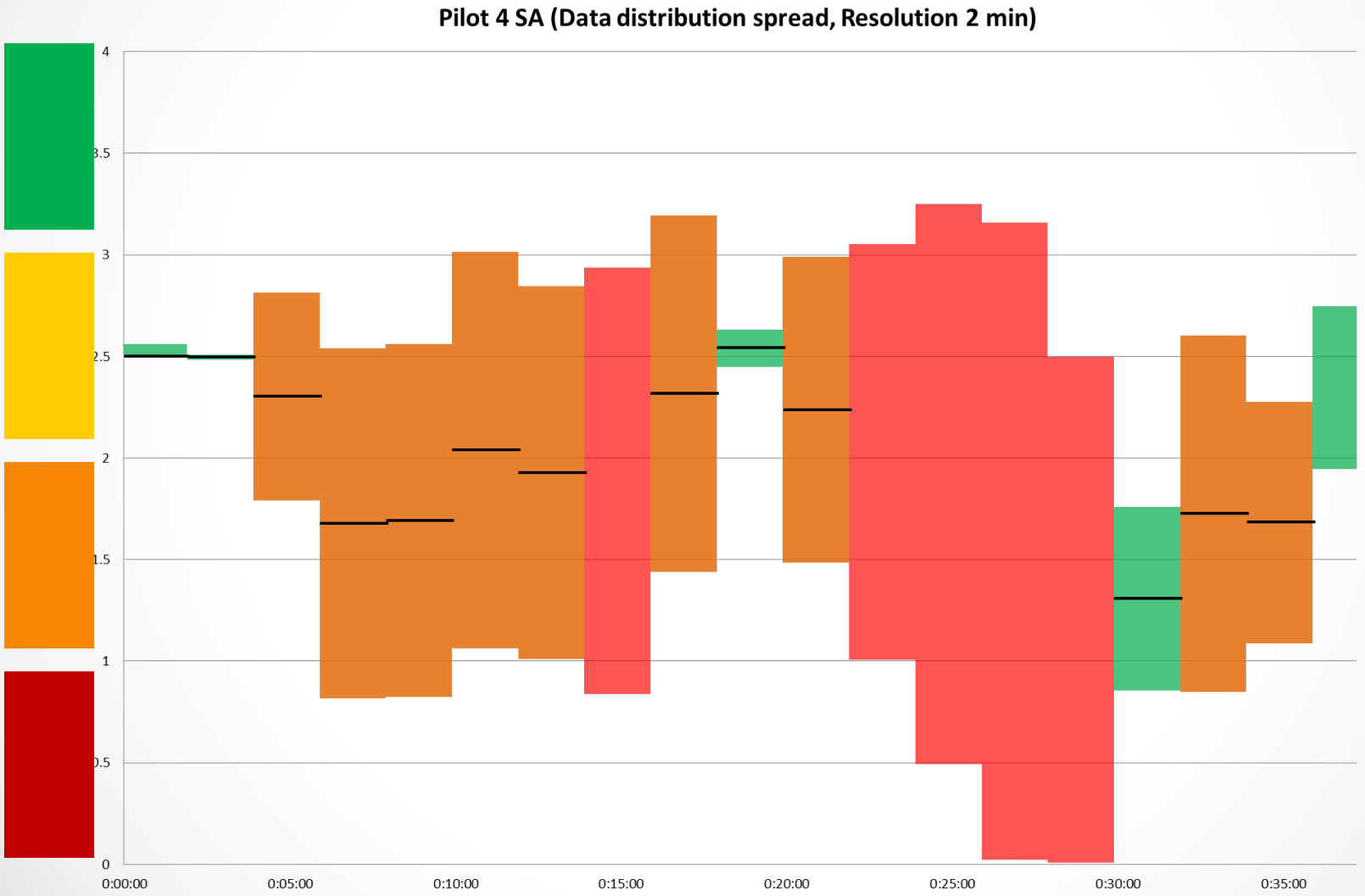
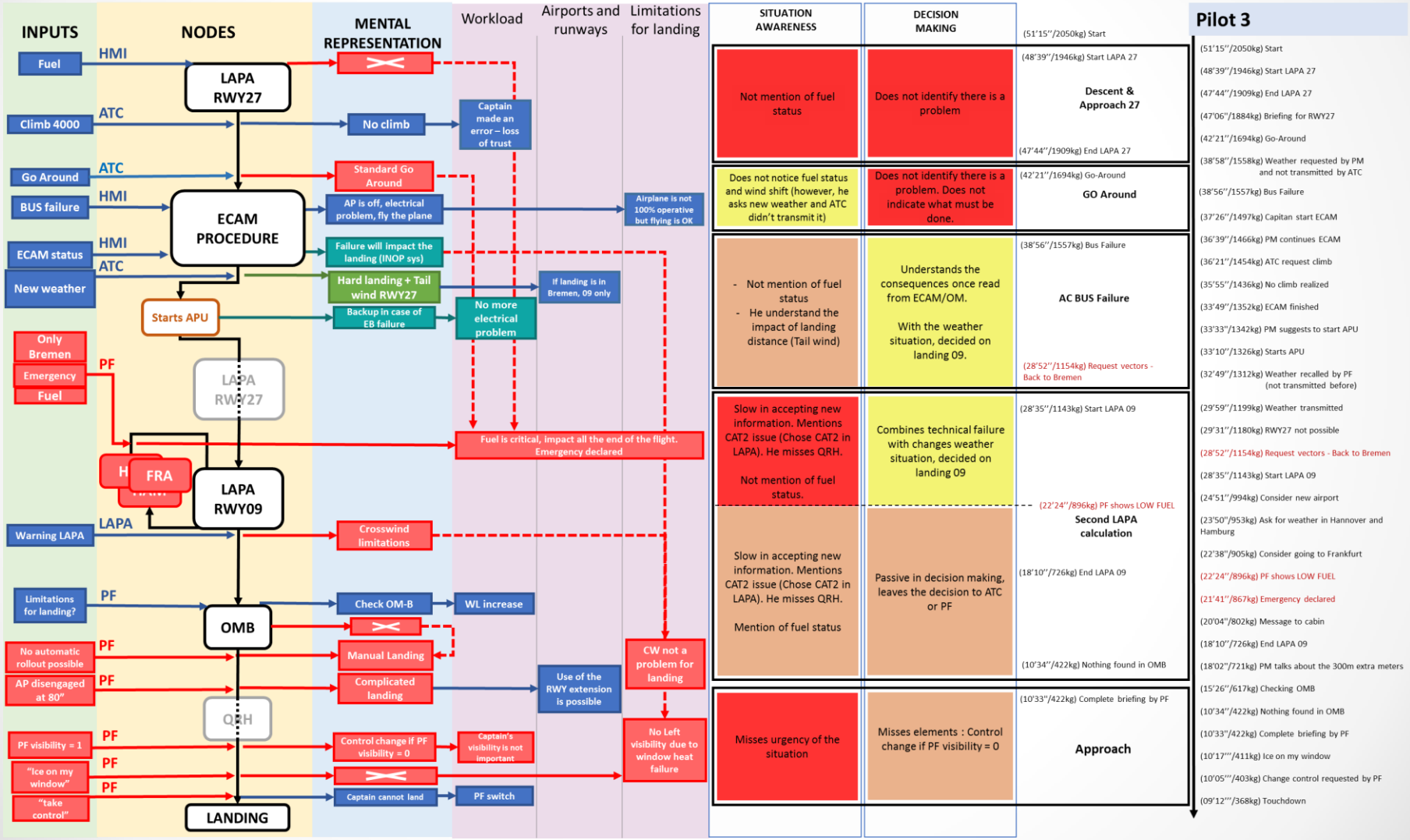
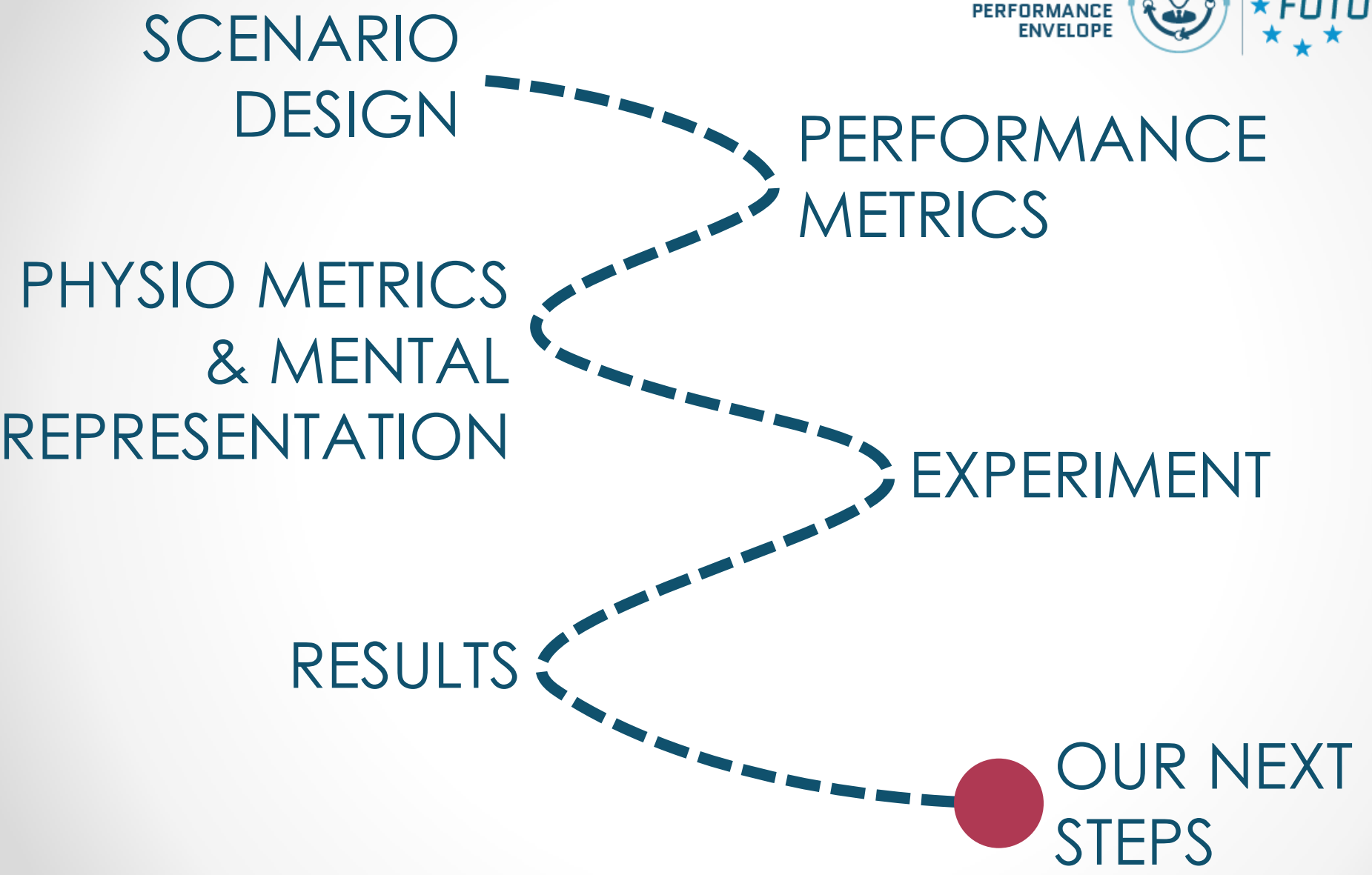

Flight Session: Pilot 3, Competency: Situational Awareness
Instructor
6
7
8
11
Performance
Exceeds -4
Meets -3
Below -2
Unacceptable -1
-0
00:00:00
00:10:00
00:20:00
00:30:00
00:40:00
Time


Pilot 10 DM (Data distribution spread, Resolution 2 min)
4
3.5
3
2.5
2
1.5
1
0.5
0
0:00:00
0:05:00
0:10:00
0:15:00
0:20:00
0:25:00
0:30:00
0:35:00


Pilot 4 SA (Data distribution spread, Resolution 2 min)
4
3.5
3
2.5
2
1.5
1
0.5
0
0:00:00
0:05:00
0:10:00
0:15:00
0:20:00
0:25:00
0:30:00
0:35:00


INPUTS
NODES
MENTAL REPRESENTATION
Workload
Airports and runways
Limitations for landing
SITUATION AWARENESS
DECISION MAKING
Pilot 3
Fuel
HMI
LAPA RWY27
Climb 4000
ATC
No climb
Captain made an error – loss of trust
Go Around
ATC
Standard Go Around
BUS failure
HMI
ECAM PROCEDURE
AP is off, electrical problem, fly the plane
Airplane is not 100% operative but flying is OK
ECAM status
HMI
Failure will impact the landing (INOP sys)
New weather
ATC
Hard landing + Tail wind RWY27
If landing is in Bremen, 09 only
Starts APU
Backup in case of EB failure
No more electrical problem
Only Bremen
Emergency
Fuel
PF
LAPA RWY27
Fuel is critical, impact all the end of the flight. Emergency declared
FRA
LAPA RWY09
Warning LAPA
LAPA
Crosswind limitations
Limitations for landing?
PF
Check OM-B
WL increase
OMB
No automatic rollout possible
PF
Manual Landing
CW not a problem for landing
AP disengaged at 80"
PF
Complicated landing
Use of the RWY extension is possible
QRH
PF visibility = 1
PF
Control change if PF visibility = 0
Captain's visibility is not important
No Left visibility due to window heat failure
"Ice on my window"
PF
"take control"
PF
Captain cannot land
PF switch
LANDING
Not mention of fuel status
Does not identify there is a problem
Descent & Approach 27
Does not notice fuel status and wind shift (however, he asks new weather and ATC didn't transmit it)
Does not identify there is a problem. Does not indicate what must be done.
GO Around
- Not mention of fuel status
- He understand the impact of landing distance (Tail wind)
Understands the consequences once read from ECAM/OM.
With the weather situation, decided on landing 09.
AC BUS Failure
Slow in accepting new information. Mentions CAT2 issue (Chose CAT2 in LAPA). He misses QRH.
Not mention of fuel status.
Combines technical failure with changes weather situation, decided on landing 09
Second LAPA calculation
Slow in accepting new information. Mentions CAT2 issue (Chose CAT2 in LAPA). He misses QRH.
Mention of fuel status
Passive in decision making, leaves the decision to ATC or PF
Misses urgency of the situation
Misses elements : Control change if PF visibility = 0
Approach
(51'15''/2050kg) Start
(48'39''/1946kg) Start LAPA 27
(47'44''/1909kg) End LAPA 27
(42'21''/1694kg) Go-Around
(38'56''/1557kg) Bus Failure
(28'52''/1154kg) Request vectors - Back to Bremen
(28'35''/1143kg) Start LAPA 09
(22'24''/896kg) PF shows LOW FUEL
(18'10''/726kg) End LAPA 09
(10'34''/422kg) Nothing found in OMB
(10'33"/422kg) Complete briefing by PF
(51'15''/2050kg) Start
(48'39''/1946kg) Start LAPA 27
(47'44''/1909kg) End LAPA 27
(47'06"/1884kg) Briefing for RWY27
(42'21''/1694kg) Go-Around
(38'58''/1558kg) Weather requested by PM and not transmitted by ATC
(38'56''/1557kg) Bus Failure
(37'26''/1497kg) Capitan start ECAM
(36'39''/1466kg) PM continues ECAM
(36'21''/1454kg) ATC request climb
(35'55''/1436kg) No climb realized
(33'49''/1352kg) ECAM finished
(33'33''/1342kg) PM suggests to start APU
(33'10''/1326kg) Starts APU
(32'49''/1312kg) Weather recalled by PF (not transmitted before)
(29'59''/1199kg) Weather transmitted
(29'31''/1180kg) RWY27 not possible
(28'52''/1154kg) Request vectors - Back to Bremen
(28'35''/1143kg) Start LAPA 09
(24'51''/994kg) Consider new airport
(23'50"/953kg) Ask for weather in Hannover and Hamburg
(22'38"/905kg) Consider going to Frankfurt
(22'24''/896kg) PF shows LOW FUEL
(21'41''/867kg) Emergency declared
(20'04"/802kg) Message to cabin
(18'10''/726kg) End LAPA 09
(18'02"/721kg) PM talks about the 300m extra meters
(15'26''/617kg) Checking OMB
(10'34''/422kg) Nothing found in OMB
(10'33"/422kg) Complete briefing by PF
(10'17''''/411kg) Ice on my window
(10'05''''/403kg) Change control requested by PF
(09'12''''/368kg) Touchdown


SCENARIO DESIGN
PERFORMANCE METRICS
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SCENARIO 1

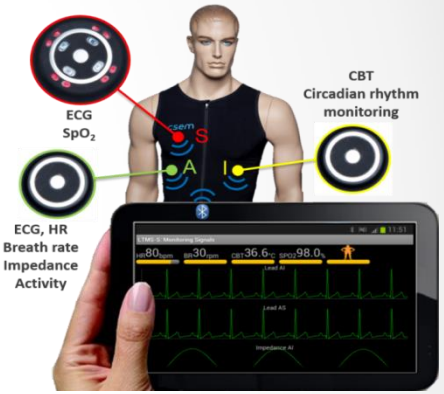
Project #6
HUMAN PERFORMANCE ENVELOPE

FUTURE SKY SAFETY

STRESS

WORKLOAD

SITUATIONAL AWARENESS



Performance =

.354 * (25.935 * **HR** + 41.075 * **EYE** - 61.495) + . 285 * (28.928 * **HR** + 44.242 * **EYE** - 68.747) + -.446 * (-42.2185 * **HR** + 31.697) + .313 * (25.935 * **HR** + 41.075 * **EYE** - 61.495)* (28.928 * **HR** + 44.242 * **EYE** - 68.747) * (-42.2185 * **HR** + 31.697)

SCENARIO 1

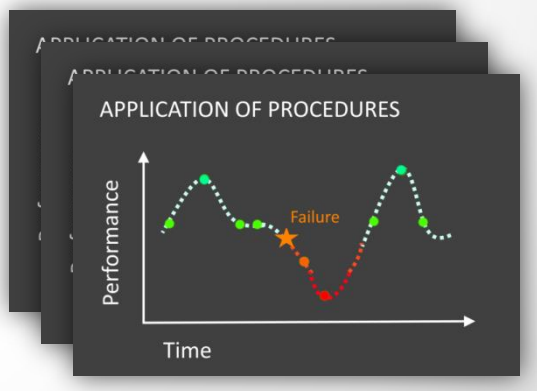
Performance =

SCENARIO 2

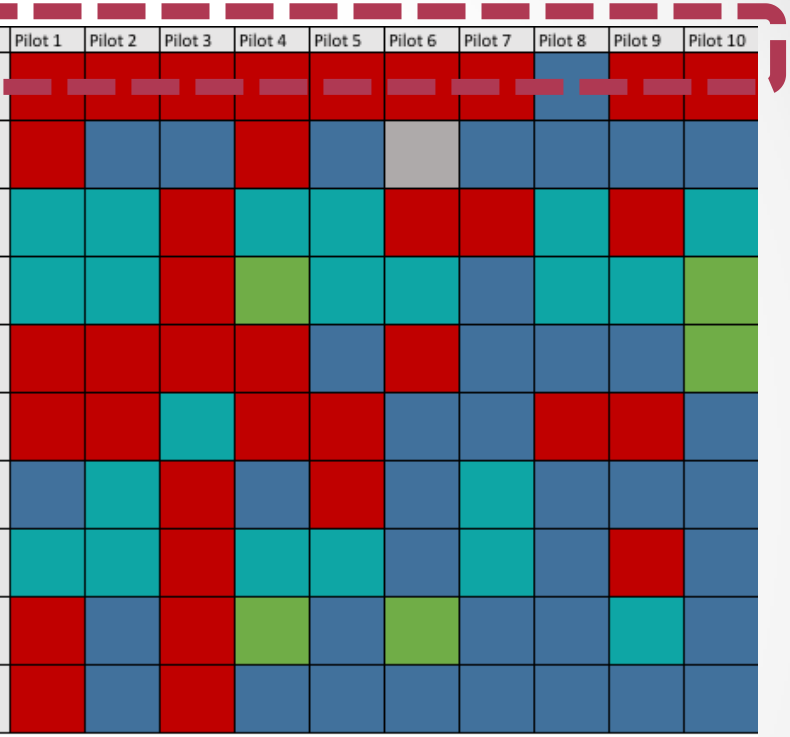
PREDICTED
PERFORMANCE

SCENARIO 2

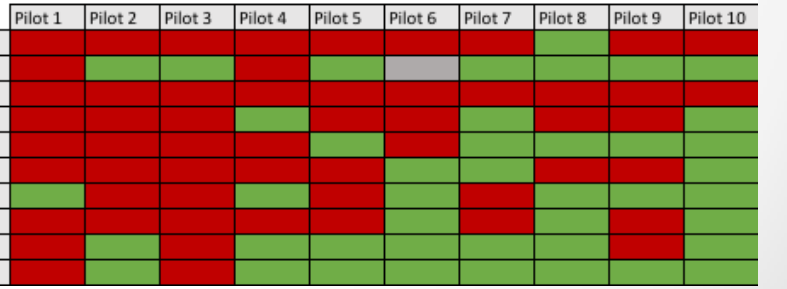
VALIDATE
HPE EQUATION

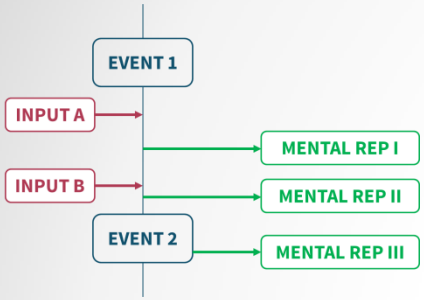


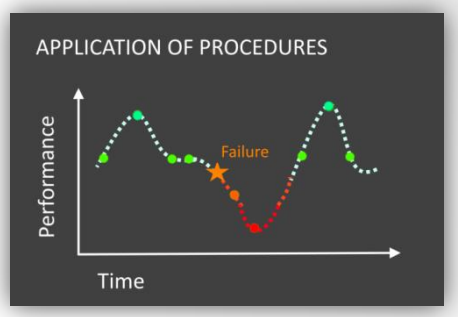
Inputs	Standad Phase	Notes
Fuel	Descent & Approach 27	LAPA RWY27
Fuel + Climb4000	GO Around	Climb4000
Fuel + GoAround		GO Around (Critical fuel)
Fuel + BUS Failure + ECAM stat	AC BUS Failure	ECAM PROCEDURE
Fuel + New weather + Airports status		CONSIDER NEW AIRPORT (FUEL)
Fuel + RWY27 not possible		RWY SHIFT (WIND)
Warning LAPA	Second LAPA calculation	LAPA RWY09 (Warning)
Limitations for landing? + No automatic rollout possible + AP disengaged at 80"	Approach	OMB (Knowledge about landing limitations)
PF visibility must be = 1		QRH (Awareness about PF visibility = 1)
"Ice on my window"		LANDING



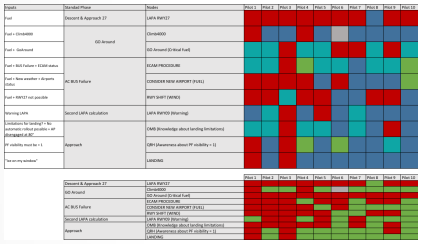
Descent & Approach 27	LAPA RWY27
GO Around	Climb4000
	GO Around (Critical fuel)
AC BUS Failure	ECAM PROCEDURE
	CONSIDER NEW AIRPORT (FUEL)
	RWY SHIFT (WIND)
Second LAPA calculation	LAPA RWY09 (Warning)
Approach	OMB (Knowledge about landing limitations)
	QRH (Awareness about PF visibility = 1)
	LANDING

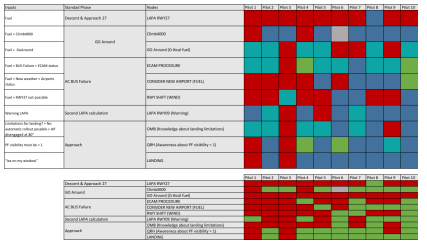






VALIDATED HMI DESIGN MATRIX





Inputs	Standard Phase	Nodes	Pilot 1	Pilot 2	Pilot 3	Pilot 4	Pilot 5	Pilot 6	Pilot 7	Pilot 8	Pilot 9	Pilot 10
Fuel	Descent & Approach 27	LAPA RWY27										
Fuel + Climb4000	GO Around	Climb4000										
Fuel + GoAround		GO Around (Critical Fuel)										
Fuel + BUS Failure + ECAM status	AC BUS Failure	ECAM PROCEDURE										
Fuel + New weather + Airports status		CONSIDER NEW AIRPORT (FUEL)										
Fuel + RWY27 not possible		RWY SHIFT (WIND)										
Warning LAPA	Second LAPA calculation	LAPA RWY09 (Warning)										
Limitations for landing? + No automatic rollout possible + AP disengaged at 80'	Approach	CMB (Knowledge about landing limitations)										
FF visibility must be < 1		QRH (Awareness about FF visibility < 1)										
"Eye on my window"		LANDING										


THE FUTURE PILOT
FOR THE FUTURE SKY....
FUTURE SKY
SAFETY