



Development of Neurometrics for Selective Attention Evaluation in ATM

Dr **Martina Ragosta** & Stefano Bonelli
Dissemination & Project Manager

SESAR Innovation Days 2017
Belgrade, Serbia, 28 November 2017



Founding Members



Future ATM scenarios



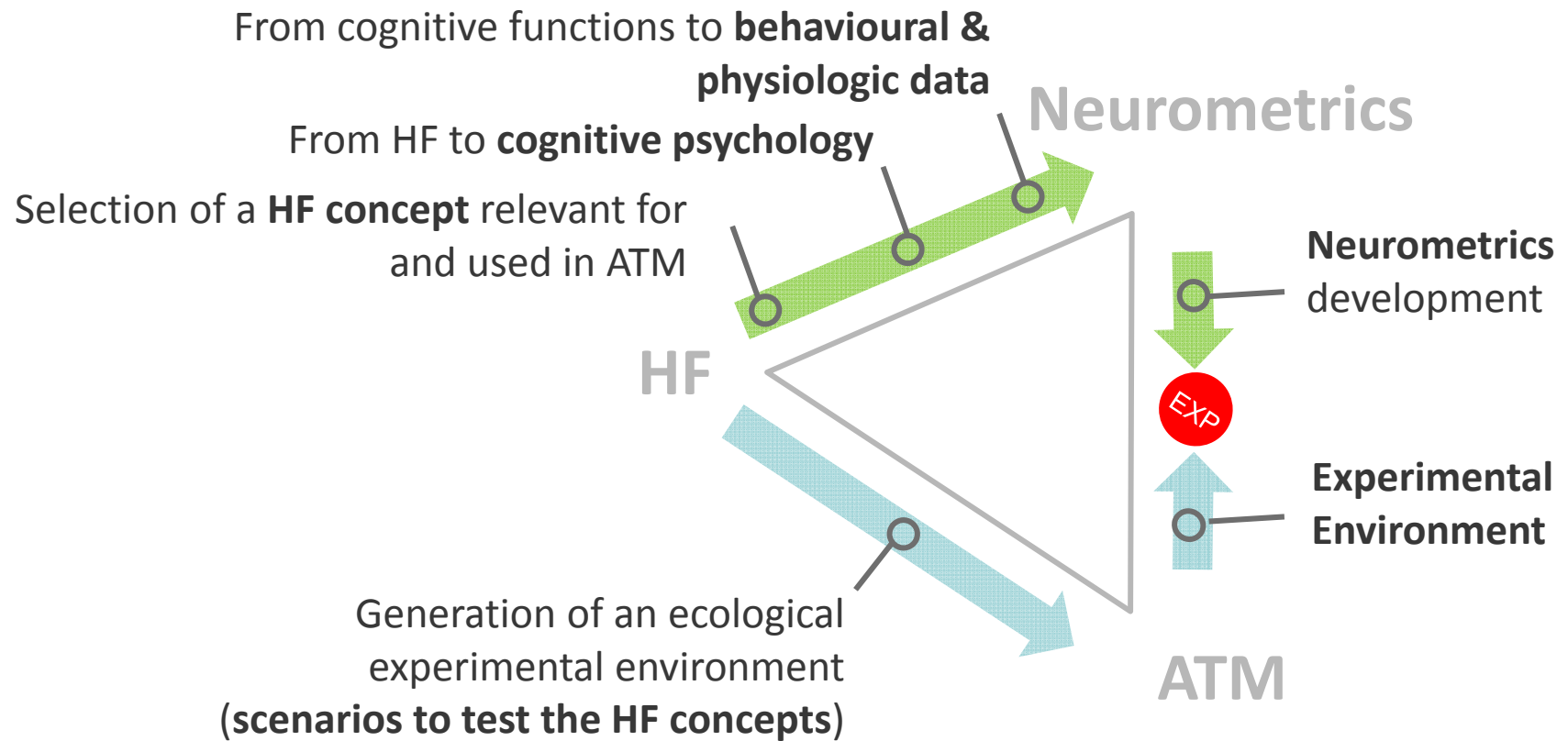
Automation is not seen to replace operators but to **empower** them
and to **improve** the **overall performance of ATM**

(HALA! SESAR Research Network, 2012)



It is needed to **support the transition** to higher automation levels
by *addressing, analysing* and *mitigating* its impact on
the **Human Performance (HP)** aspects

APPROACH



From Laboratory experiments...



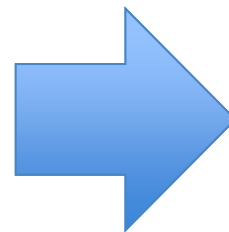
HF concept

ATTENTION

STRESS

COGNITIVE
CONTROL

MENTAL WL



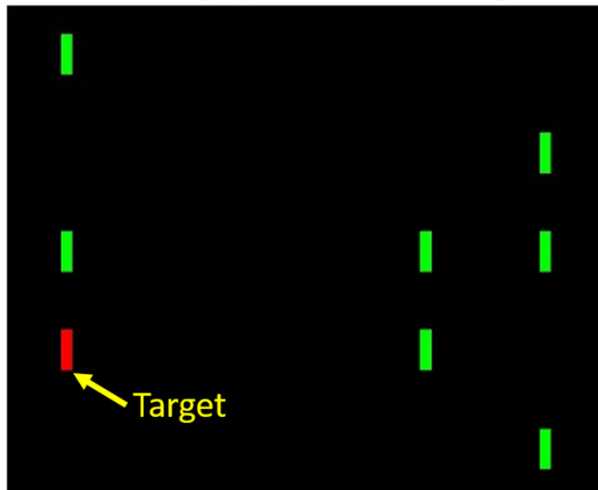
Neurophysiological indexes

The Conjunction Visual Search Task

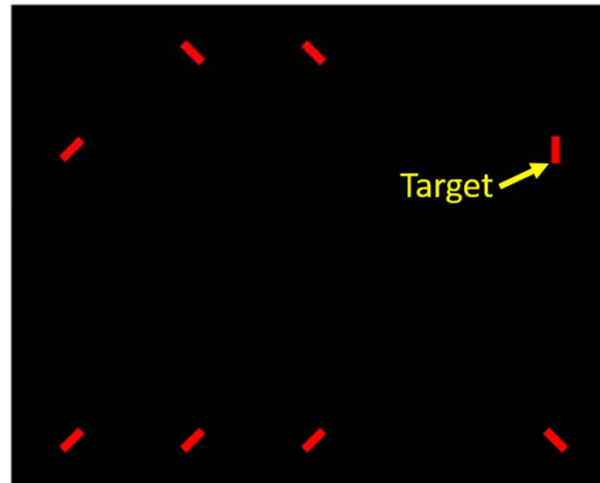


The **Conjunction Visual Search Task** (CNJ) consists in presenting **visual** stimuli on a screen and finding out the **target** among *distractors*, and reacting as fast as possible by pressing the space bar on the keyboard

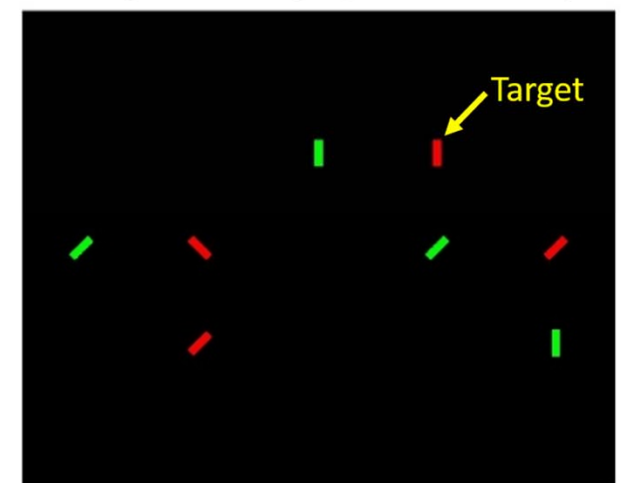
Easy (Low Attention)



Hard (Medium Attention)



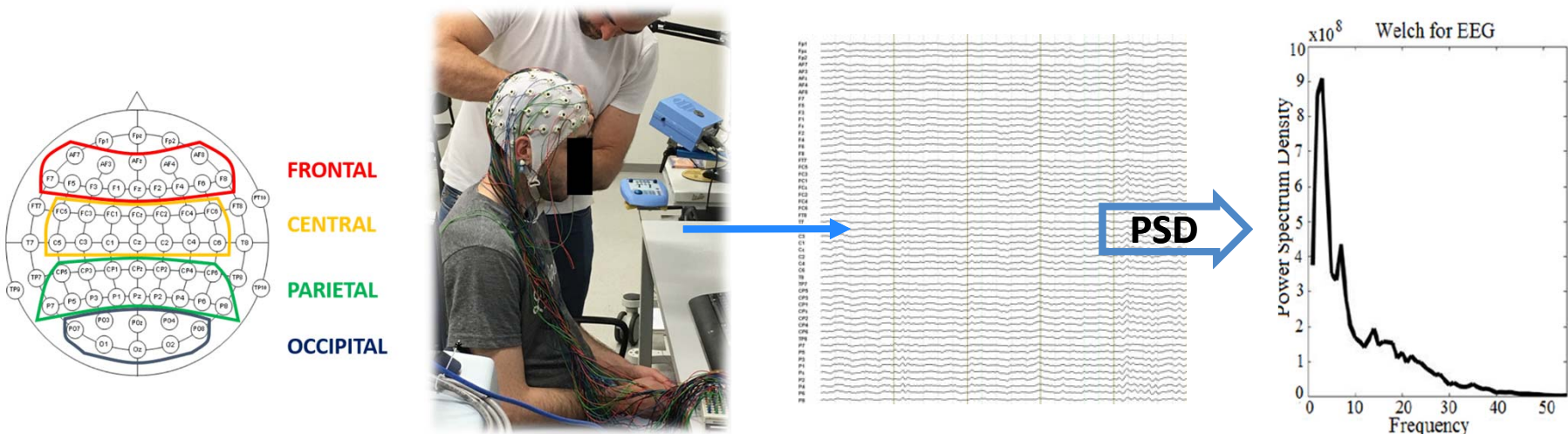
Conjunction (High Attention)



Neurophysiological signals recording and analysis - EEG

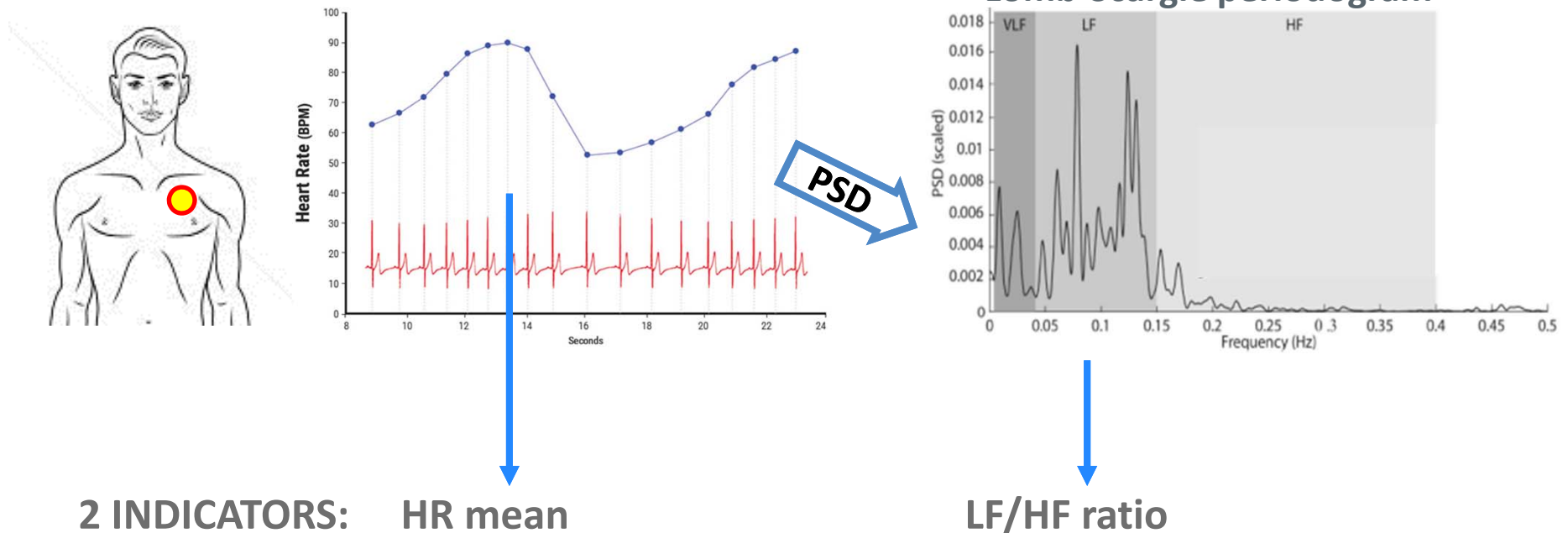
Electroencephalography (EEG) refers to the recording of the brain's spontaneous electrical activity over a period of time, as recorded from multiple electrodes placed on the scalp.

Applications generally focus on the spectral content of EEG, that is, the type of neural oscillations (popularly called "brain waves or rhythms") that can be observed in EEG signals.



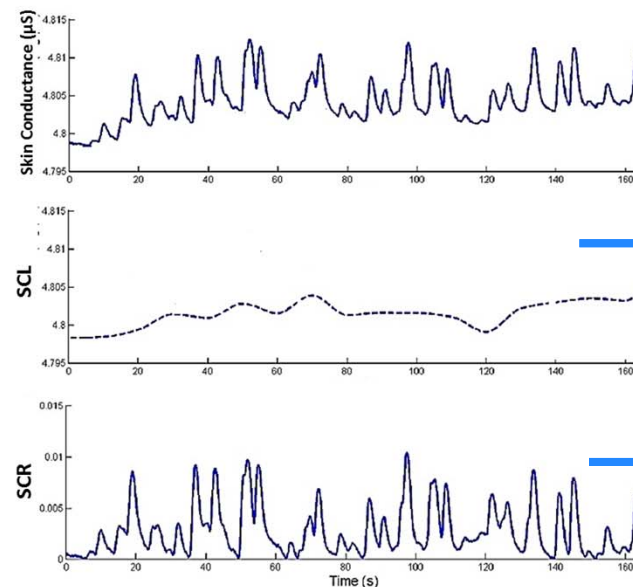
Neurophysiological signals recording and analysis - ECG

Electrocardiography (ECG) is the process of recording the **electrical activity of the heart**. The electrodes detect electrical changes on the skin that arise from the **heart muscle's electrophysiological pattern** of depolarizing and repolarizing during each heartbeat.



Neurophysiological signals recording and analysis - GSR

Galvanic Skin Response (GSR) is the electrical measurement of the **Skin Conductance (SC)**. Skin resistance varies with the state of sweat glands. Sweating is controlled by the sympathetic nervous system. If the sympathetic branch of the **autonomic nervous system is highly aroused**, then **sweat gland activity also increases**, which in turn **increases SC**.



2 INDICATORS:

SCL mean
Epidermis Sweat Diffusion
(Tonic – Slow)

SCR peaks amplitude
O/C Pores
(Phasic – Fast)

HF and neurophysiological signals

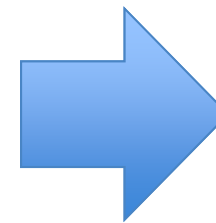


	EEG				ECG		GSR	
	Theta	Alpha	Beta	Gamma	HR	HRV	SCL	SCR
Stress			Left and Right Parietal		HR mean		SCL mean	
Attention	Occipital		Midline Frontal and Parietal	Frontal and Parietal				SCR Peaks Amplitude
Cognitive Control	Parietal	Frontal Right						
Mental WL	Frontal	Parietal				LF/HF		

- ✓ By means of **different tasks** it has been possible to **elicitate different levels** of the selected Human Factors concepts.
- ✓ Several **neurophysiological features** appeared to be **sensitive** to variation of different Human Factor concepts.
- ✓ It has been possible to **characterize each Human Factor concept** by **specific neurophysiological features**.

... to ecological tasks...

HF concept	Laboratory tasks	Neurophysiological index
ATTENTION	Conjunction Visual Search Task (CNJ)	EEG, ECG, GSR
STRESS	- the Stroop task for time pressure - White Coat stressor to elicit social stress	EEG, ECG, GSR
COGNITIVE CONTROL	Skill, Rule, and Knowledge ad-hoc tasks	EEG, ECG
MENTAL WL	Taken from NINA	EEG, ECG



**Ecological
tasks**

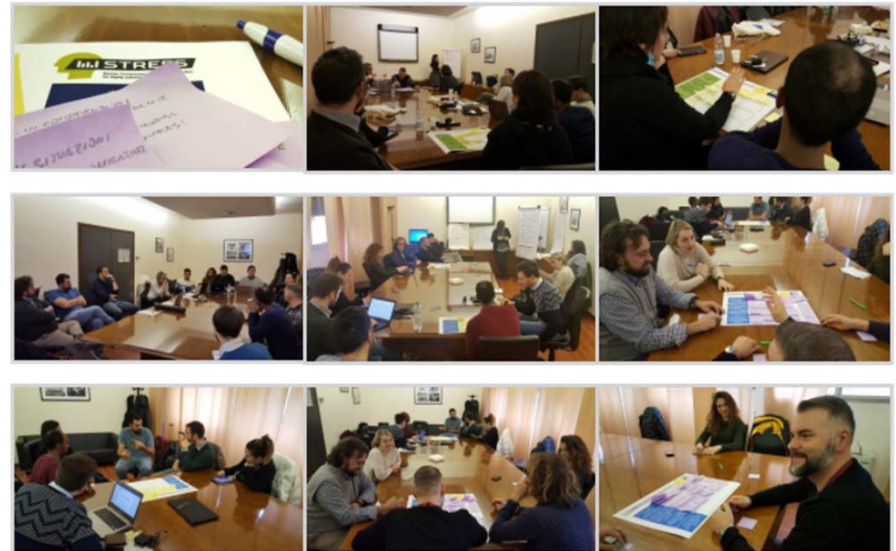
Attention

	Low Workload	Medium Workload	High Workload
High attention	Traffic Flight level changes due to Mode C failure	Traffic changes route uncoordinated	Traffic Flight level appears as 0000 due mode C failure
	Traffic speed changes uncoordinated	Traffic Flight level changes due to Mode C failure	Traffic changes route uncoordinated
	Traffic Flight level appears as 0000 due mode C failure	Traffic speed changes uncoordinated	Traffic changes route uncoordinated
Low attention	Uncorrelated callsign	Uncorrelated callsign	New traffic appears in airspace
	Unauthorised change of Flight level	Unauthorised change of Flight level	Traffic label colour change to yellow
	Traffic label colour change to yellow	Traffic callsign turns to squawk code	Departed traffic appears in the airspace

Workload

The workload factors in simulated air traffic environment can be listed as:

- The number of aircraft,
- Types/performances of aircraft,
- The complexity of airspace/sector,
- The air traffic operational profile (military/civil/general, ambulance ext.),
- Conflicting air traffics,
- Departing and arrival traffics



Stress



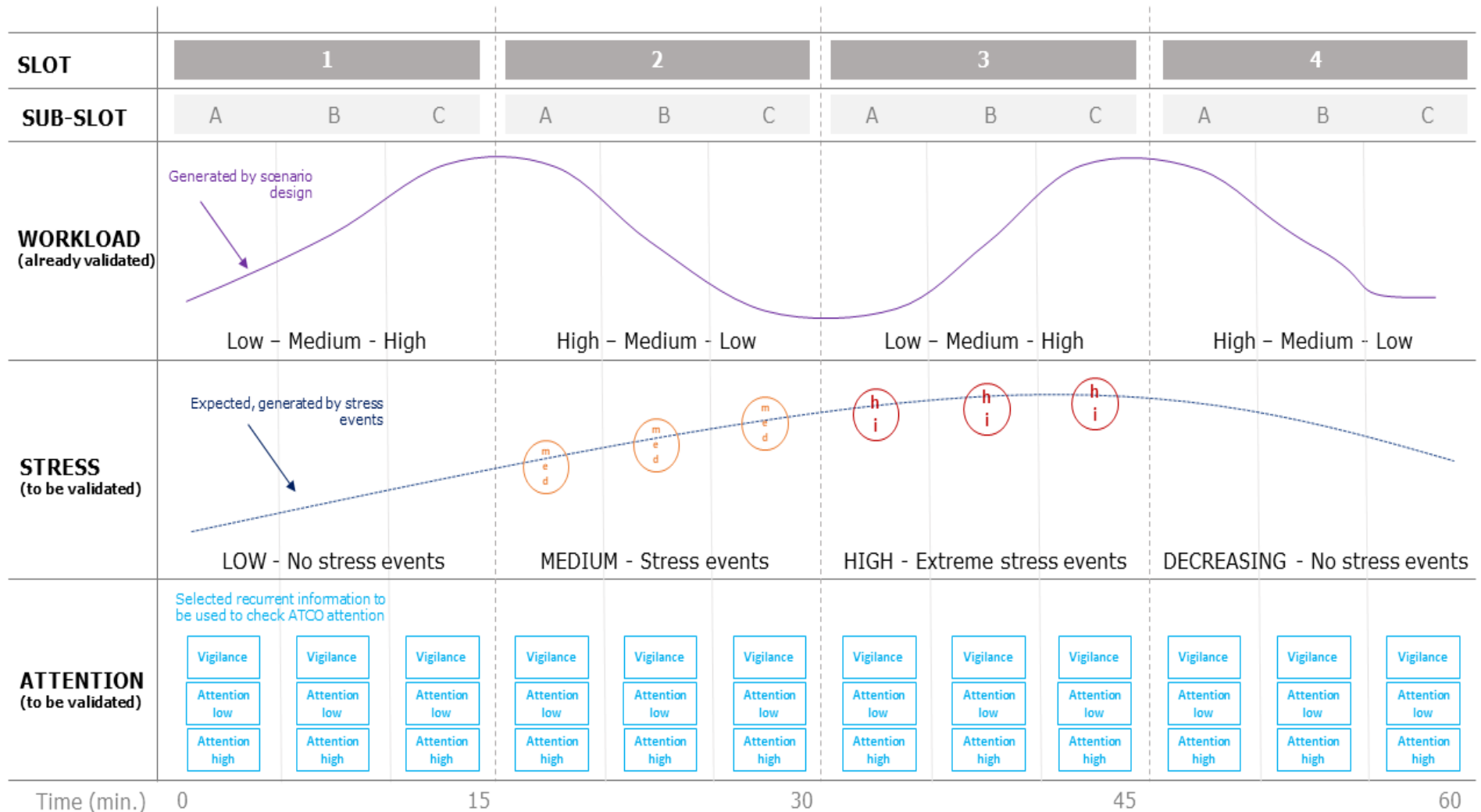
	Low Workload	Medium Workload	High Workload
High Stress	Radio Noise for one a/c	Emergency descent	Radar off
Medium Stress	Social pressure	Mode C failure during conflict	Conflicting traffics in high complexity point

... to the 1st simulation...



HF concept	Laboratory tasks	Neurophysiological index	Ecological tasks
ATTENTION	Conjunction Visual Search Task (CNJ)	EEG, ECG, GSR	A/c change route, FL, ...
STRESS	- the Stroop task for time pressure - White Coat stressor to elicit social stress	EEG, ECG, GSR	Radio noise, emergency descend, social pressure...
COGNITIVE CONTROL	Skill, Rule, and Knowledge	EEG, ECG	A/c type and number, conflicts...
MENTAL WL	Taken from NINA	EEG, ECG	Traffic complexity...

Simulation scenario structure



First validation



Experimental Subjects

The experimental protocol involved one group of **16 student ATCOs**.

The group was selected in order to have a homogeneous sample in terms of:

- **sex**: all males;
- **age**: similar age, as much as possible;
- **background** – skill level: same rank or level of ATM operational formation.

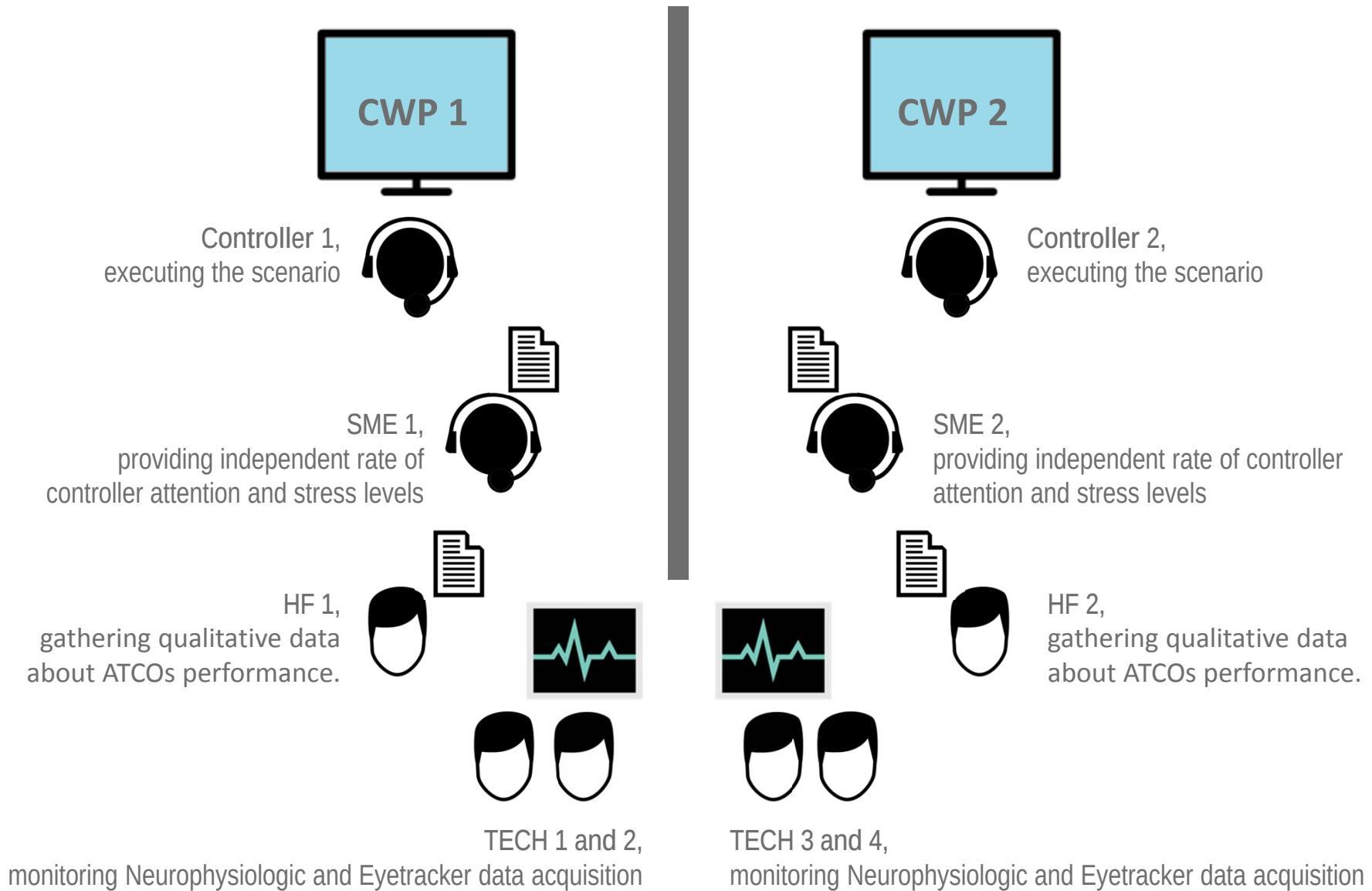


STRESS personnel



- **2 DBL Human Factors experts**, carrying out the briefing and debriefing sessions and monitoring the execution of the whole simulation activities and to gather qualitative data about ATCOs performance during the run of the scenarios.
- **2 AU Subject Matter Experts**, listening to R/T communications, evaluating the controllers' mental workload, stress and attention levels, monitoring stressing events and triggering vigilance ones, and taking note of anything considered relevant.
- **2 UNISAP Physiological measurements experts**, positioning the technical equipment at the beginning of each simulation, monitoring and collecting the signals.
- **4 Pseudo Pilots**, managing the aircraft, communicating with the controllers and triggering events.
- **2 ENAC eye tracker experts**
- **AU technical experts**, starting the traffic sample scenarios, controlling and supporting the technical aspects of each simulation activity.
- **AU cortisol expert**, getting the saliva samples.

STRESS personnel



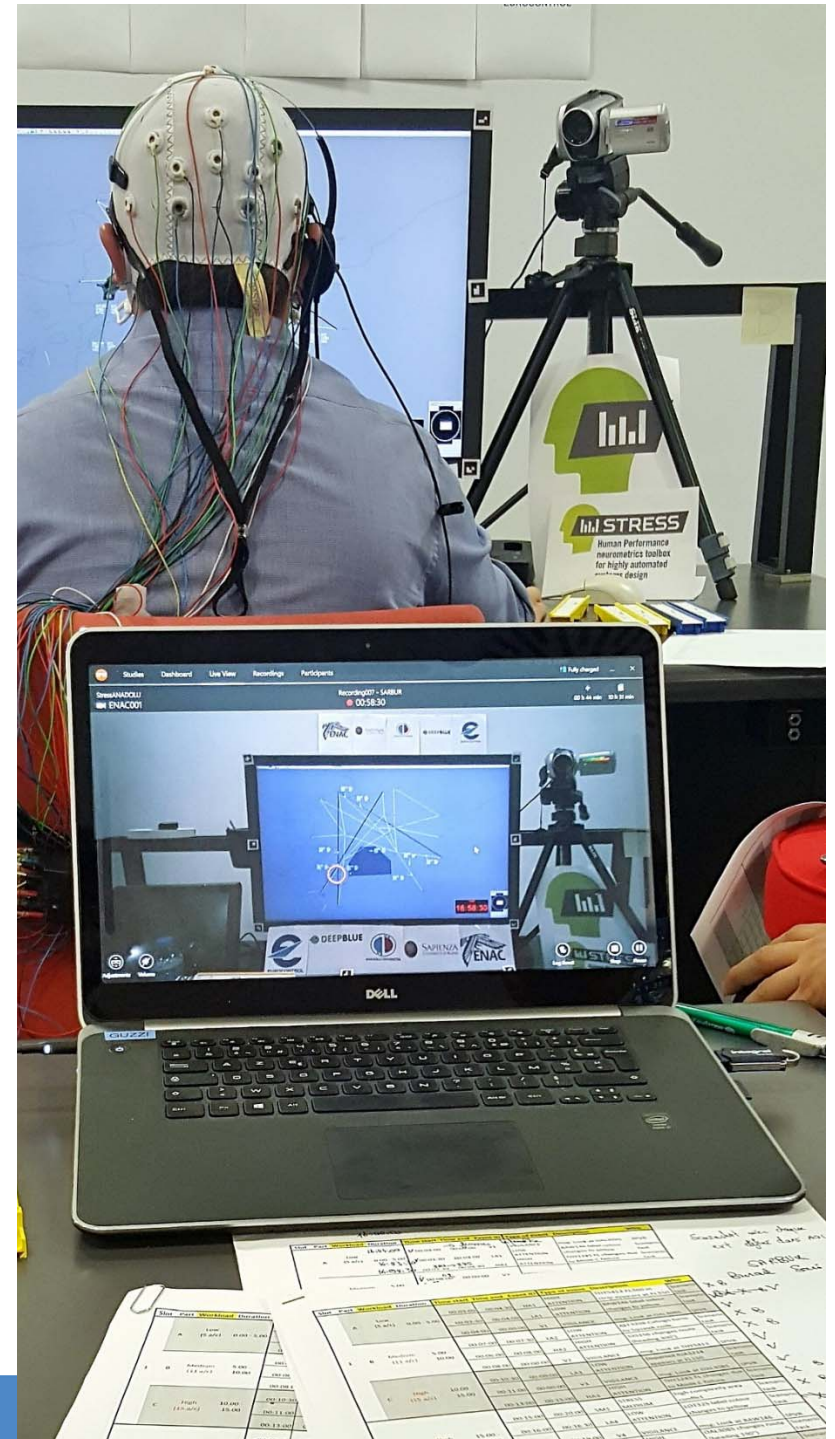
Data-collection tools set-up

- Electroencephalography
- Heart rate and Eye blink
- Galvanic skin response
- Eyetracker



Validation measures (objective)

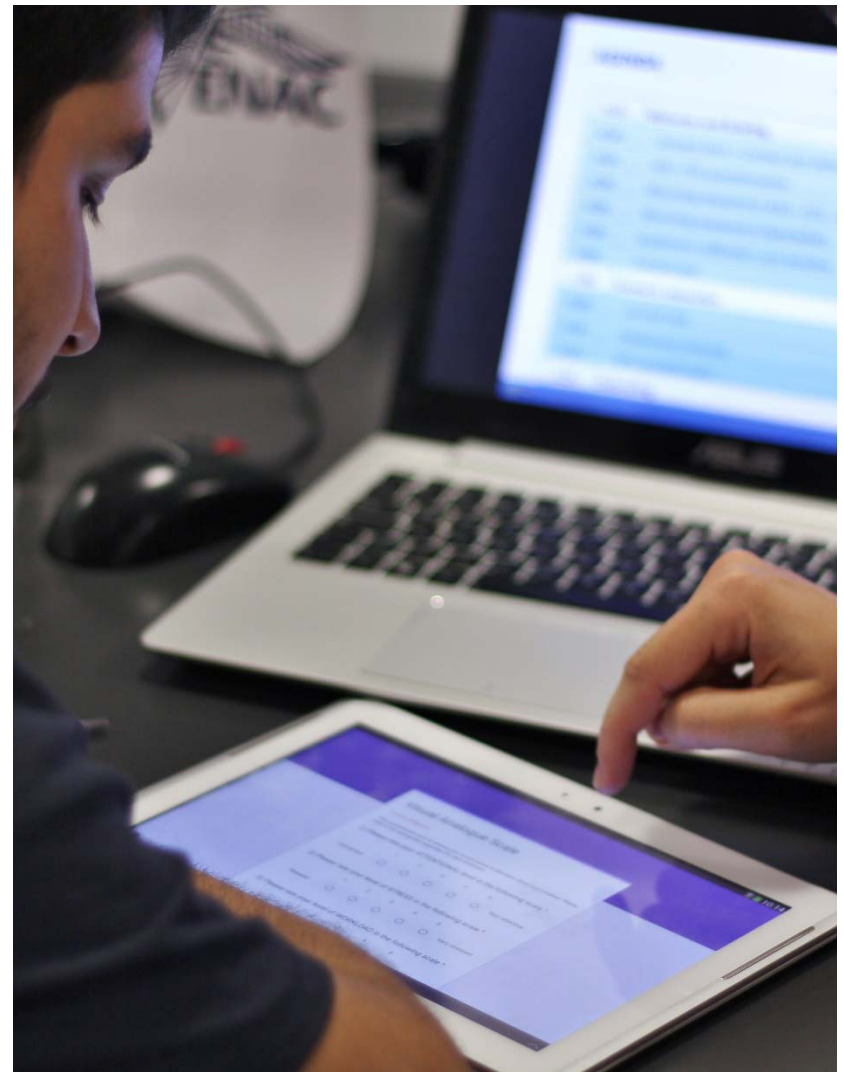
- Cortisol level
- Eyetracker



Validation measures (subjective)

ATCOs were asked to fill specific questionnaires with the aim to assess:

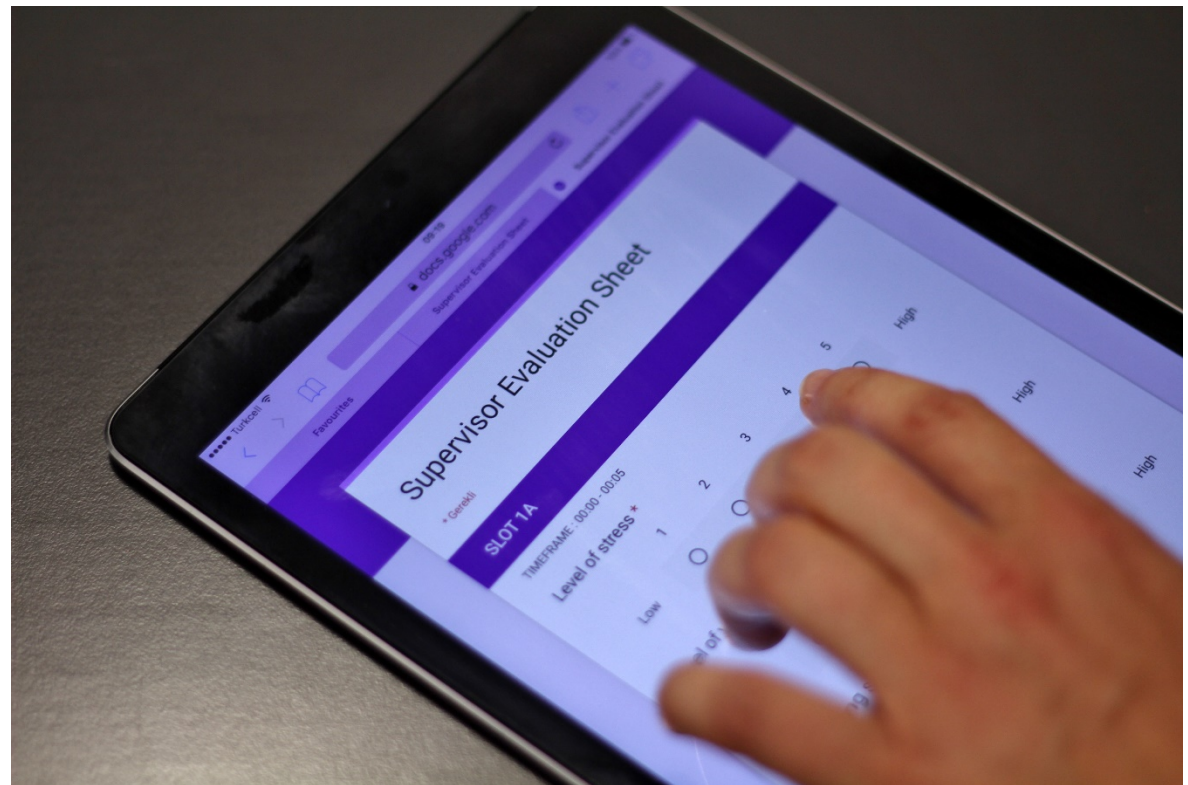
- the **proneness** of the user to get stressed;
- the stress, workload and attention perception **before the experiment**;
- the perceived stress, workload and attention levels **at the end of the experiment**.
- the level of stress perceived **during the experiment** (every 5 minutes)



Validation measures (subjective)

SMEs were asked to fill specific questionnaire with the aim to assess, every 5 minutes:

- Level of stress
- Level of workload
- Level of attention
- Performance



First validation execution



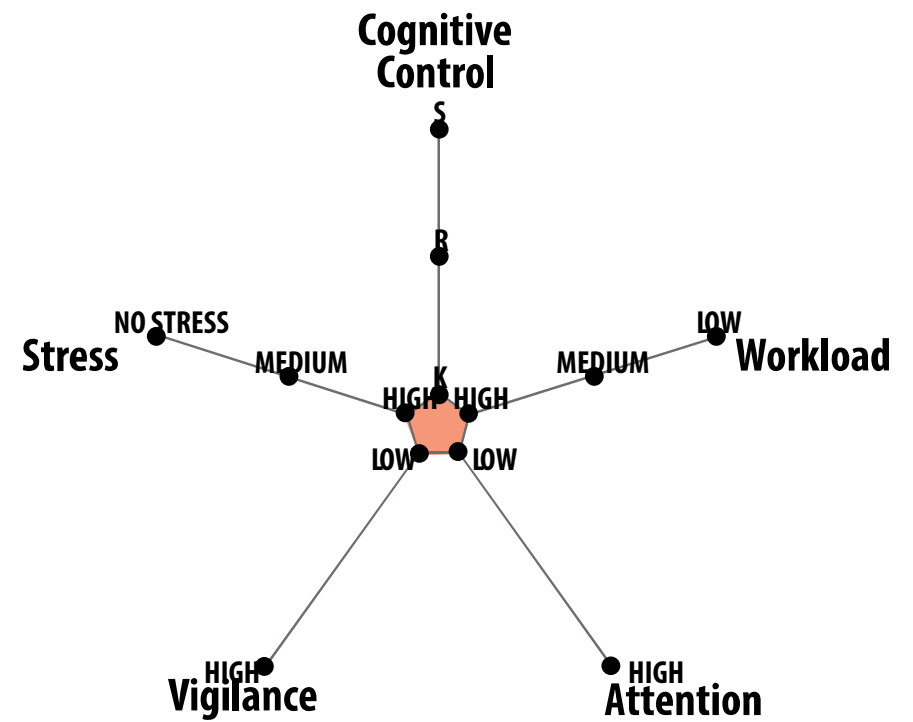
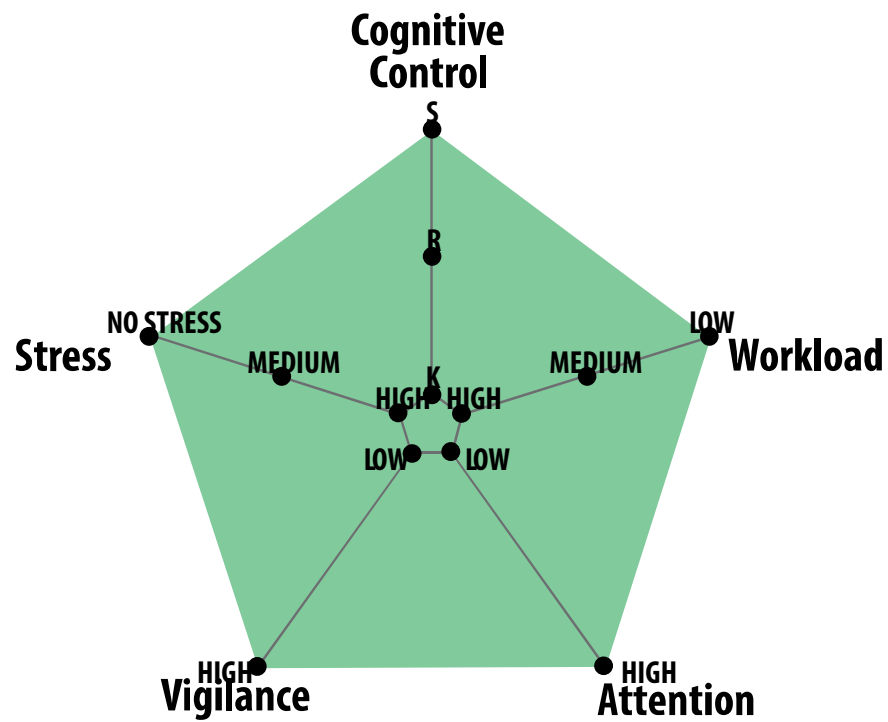
1st validation results



	EEG				ECG		GSR	
	Theta	Alpha	Beta	Gamma	HR	HRV	SCL	SCR
Stress	Frontal, Central, Parietal	Parietal, Occipital	Parietal, Occipital	Parietal, Occipital			SCL mean	SCR Peaks
Vigilance	Frontal, Central, Parietal, Occipital	Frontal, Central, Parietal, Occipital	Frontal, Central, Parietal, Occipital	Frontal, Central, Parietal, Occipital	HR mean			SCR Peaks
Selective Attention	Frontal		Parietal	Parietal, Occipital				
Mental Workload	Frontal, Parietal, Occipital	Parietal, Occipital	Frontal, Parietal, Occipital	Frontal, Central, Parietal, Occipital				

- ✓ the **neurometrics** derived from the analysis of the neurophysiological data
- ✓ the starting point to generate the **final indexes** for stress, workload, attention and vigilance **online assessment**

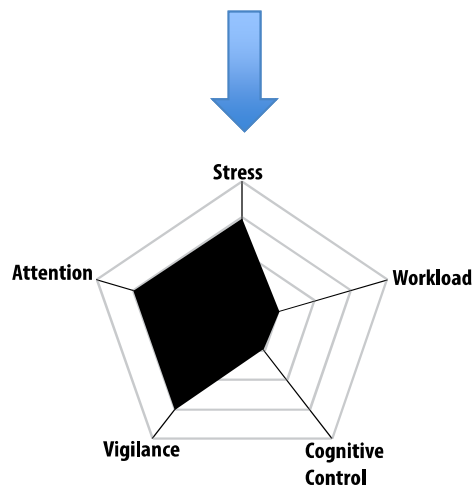
HPE configuration



HPE configuration in different exercises

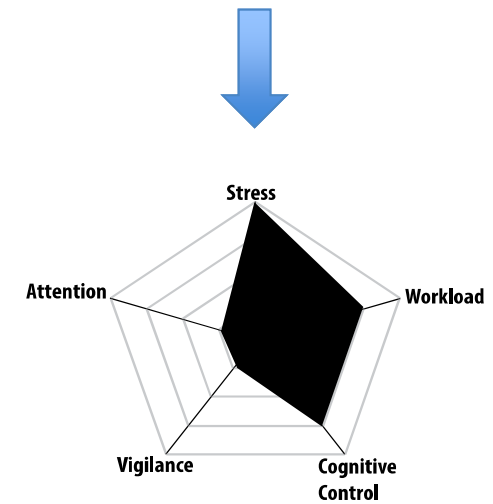
EXE 1a

BASELINE



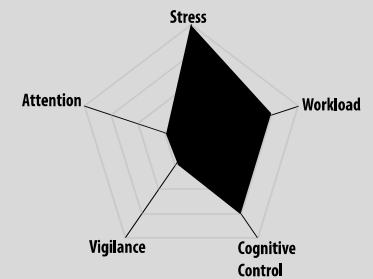
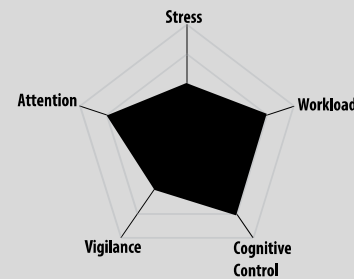
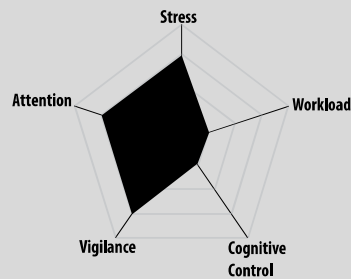
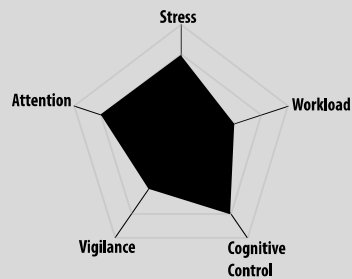
EXE 1c

**HIGH LEVEL OF
AUTOMATION**



HPE configurations and performance

Controller
HPEs



Controller
performance



Good configuration

Bad configuration

Next steps



- **Second** validation @ ENAC
- Focus on **automation** and different **transition levels**
- Develop an **integrated index**
- Provide **guidelines** to design future systems

Project information



- SESAR H2020 funded project, started in June 2016
- Consortium



SAPIENZA
UNIVERSITÀ DI ROMA



- Follow us: www.stressproject.eu
- Stay tuned:  

Questions and Answers...





Development of Neurometrics for Selective Attention Evaluation in ATM

Thank you very much
for your attention!



This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No [number]



Founding Members



The opinions expressed herein reflect the author's view only.

Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.