



MED1stMR
Mixed Reality Training

TRAIN
[SKILLS.
RESILIENCE.
PERFORMANCE]
SAVE LIVES

D4.5

Smart Wearables for First Responder Monitoring

Version
V1.0

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List of Acronyms and Abbreviations

Acronym/ Abbreviation	
ACC	Accelerometer
ADC	Analogue to Digital Converter
API	Application Programming Interface
BLE	Bluetooth Low Energy
BPM	Beats per Minute
BR	Breathing Rate
BT	Bluetooth
ECG	Electrocardiogram
EDA	Electrodermal Activity
HR	Heart Rate
HRV	Heart Rate Variability
MCI	Mass Casualty Incident
MFR	Medical First Responder
MR	Mixed Reality
SCR	Skin Conductance Response
VR	Virtual Reality

Relation to Objectives


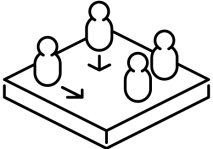
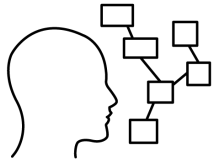
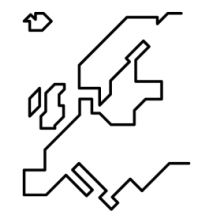
Objective	Description
	<p>Obj. 1: Pioneering MR training approach for enhanced realism</p> <p>This deliverable will contribute to this objective by enabling the acquisition of real-time physiological data from MFRs in a non-invasive manner. The hardware devices provided will be comfortable and easy to wear, facilitating the collection of physiological data in real-time.</p>
	<p>Obj. 2: Effective training scenarios and a training curriculum</p> <p>The development of hardware that allows the physiological signals acquisition of multiple trainees in real-time will contribute to better and enhanced training scenarios.</p>
	<p>Obj. 3: Physiological signal and trainee behaviour feedback loop and smart scenario control</p> <p>This deliverable directly supports this objective as it focuses on the development of sensors that gather physiological data from the trainees. The data collected through these wearable devices will be important for the integration into the dashboard and smart scenario control.</p>
	<p>Obj. 4: Position the pioneering MR training approach across Europe</p> <p>By integrating physiological data into the Med1stMR system, we are implementing a groundbreaking approach that enhances training effectiveness through the use of new wearable technologies. This innovative system is expected to generate interest among MFR organizations throughout Europe, fostering the exchange of knowledge between countries.</p>

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Executive Summary

This deliverable D4.5 - Smart Wearables for First Responder Monitoring presents the produced hardware devices developed for Med1stMR.

The wearable devices constitute an important part of the MED1stMR project as they allow for the physiological data of MFRs to be collected. This information is key for the assessment of MFRs' level of stress displayed in the dashboard application that will be used for smart scenario control and the exercise debriefing.

Relation to other deliverables and tasks in MED1stMR

Table 1 - The work and the document build on results from the following deliverables.

No.	Title	Information on which to build
D2.2	End Users Perspective: Requirements Report, Stakeholder Map and Expectation Summary for Smart Wearables, MR Training Framework and Curriculum	D2.2 serves as a summary of the end users' needs, forming the foundation for all subsequent developments aimed at meeting the required specifications. It offers valuable insights into the necessary physiological signals to fulfill the learning objectives for medical training.
D2.4	High-Level System Architecture	High level system architecture describes the integration of the modules that integrate the MR training system: the VR training system, manikin ADAM-X, PLUX wearable sensors, and the dashboard application.
D3.4	Real-Time Training Progress Assessment Tool	The integration of psychophysiological outcomes, obtained from sensors, into the dashboard enables real-time visualization of trainees' stress levels, providing the trainer with valuable insights.
D4.4	Physiological signals Acquisition Hardware and Software Framework	This deliverable presents the PLUX Hardware and Software Framework which is composed by the wearable devices (Hardware Component) and by the Python Server and Unity Client APPs (Software Component).

Table 2 - The results of this work will be incorporated into following work and developments.

No.	Title	Basis for
D4.3	Activity Recording for the Exercise Debriefing	The hardware components will be used to record all physiological data from trainees, which will be transmitted through the API and stored for debriefing purposes. This data will be crucial for integrating information that reflects the stress periods experienced by the MFRs.
D5.2	MR Trainings Environment, Trainings-Scenarios and MR Live Editor infrastructure for conducting the Evaluations	The integration of trainees' physiological data is achieved through an API and is crucial to allow a visual display of information into the dashboard application.
D5.4	Integrated Sensorics for Physiological Measurement of Trainees	The physiological assessment of stress (captured through biosignals) and the assessment of trainee behaviour will be integrated into the MR training environment.

1 Introduction

The MED1stMR project places significant importance on capturing physiological signals from the MFRs during training. To accomplish this, wearable devices have been developed specifically to meet the requirements set by end users and the constraints of the MED1stMR system. Subsequently, the collected physiological signals will be incorporated into a real-time dashboard that displays information on the trainees' physiological parameters and assesses their stress levels based on some of those parameters.

Two Wearables are used to access the user stress score, the **cardioBAN** (HR and HRV) and the **edaBAN** (OpenBAN) for the galvanic skin response data.

Both wearables (kit) are placed in the trainee and the connection is made via Bluetooth with the scenario control computers running the MED1stMR Biosignals SW Client that manages the connection and process the RAW data coming in from the wearables, the data processed is, HR, HRV and stress score.

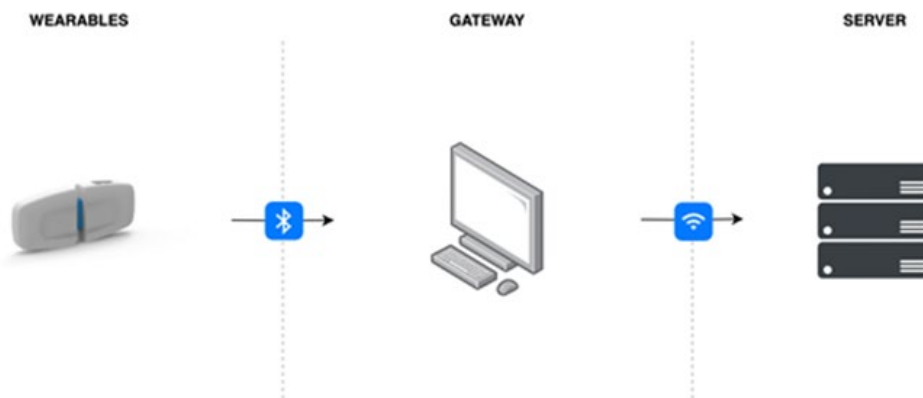


Figure 1: MED1stMR PLUX Hardware Diagram.

2 Wearables

Table 3 - Overview of wearables devices produced and integrated into the VR system.

Item No.		Type	Location	Device ID: Mac-Address
KIT 1	1.1	cardioBAN	Refense	8C:F6:81:6C:CF:14
	1.2	EDA wearable	Refense	00:07:80:0F:31:24
KIT 2	2.1	cardioBAN	Refense	88:6b:0f:ab:97:2d
	2.1	EDA wearable	Refense	00:07:80:0F:30:6D
KIT 3	3.1	cardioBAN	Refense	88:6b:0f:ab:97:27
	3.2	EDA wearable	Refense	00:07:80:0F:31:1D
KIT 4	4.1	cardioBAN	Refense	88:6b:0f:ab:96:d1
	4.2	EDA wearable	Refense	00:07:80:0F:31:11



Figure 2 - CardioBAN front view. This wearable is used to measure Electrocardiogram and extract HR, HRV. Movement is also detected via an accelerometer sensor.



Figure 3 - CardioBAN back view. The metallic snaps allow the direct connection of gelled electrodes.



Figure 4 - EDA wearable front view. Back view with the metallic snaps for the Gelled electrodes.

The openBAN device was developed to include an EDA (electrodermal activity) sensor.

3 Sensor donning

Two Wearables are used to access the user stress score, the cardioBAN (HR and HRV) and the edaBAN (OpenBAN) for the galvanic skin response data. The following procedure must be followed to ensure the correct data acquisition.

3.1 CardioBAN to measure ECG and Movement (ACC, MAG)

3.1.1 Turning the device on and off

You can turn the device on and off by sliding the power to 'O' (off) or 'I' (on).

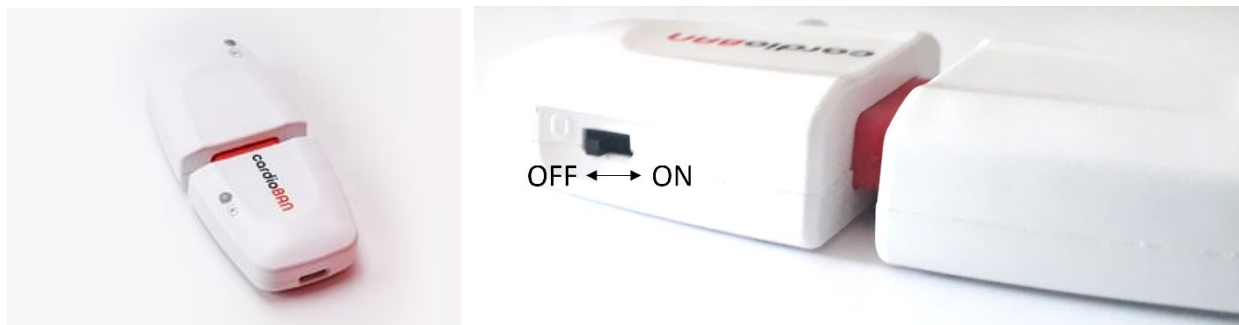


Figure 5 - CardioBAN detail view on power button.

3.1.2 Charging your device

Turn your device off and connect the micro-USB to the cardioBAN. Connect the other end of the micro-USB cable to a USB charging port. All devices must be fully charged before each Trial.



Figure 6 - CardioBAN detail view how to charge.

During the charging process, the charging LED (at the bottom right of the device next to the battery icon) will light up in different colors depending on the device state:




	<p>Charging LED Red:</p> <p>Device is turned on, no charging possible (for safety reasons).</p>
	<p>Charging LED Orange:</p> <p>Device is turned off and charging.</p>
	<p>Charging LED Purple:</p> <p>The device is turned off and charging has completed.</p> <p>(It can take up to 60 min from 0% battery to 100%)</p>

Figure 7 - CardioBAN charging LED color code.

3.1.3 Status LED

The status LED found at the bottom left of the device provides you visual feedback of the device status:

- **Green blinking once a second:** Device is in idle mode



- **Green blinking twice a second:** Device is in acquisition mode



- **Red blinking once a second:** Device is in idle mode & low battery



- **Red blinking twice a second:** Device is in acquisition mode & low battery

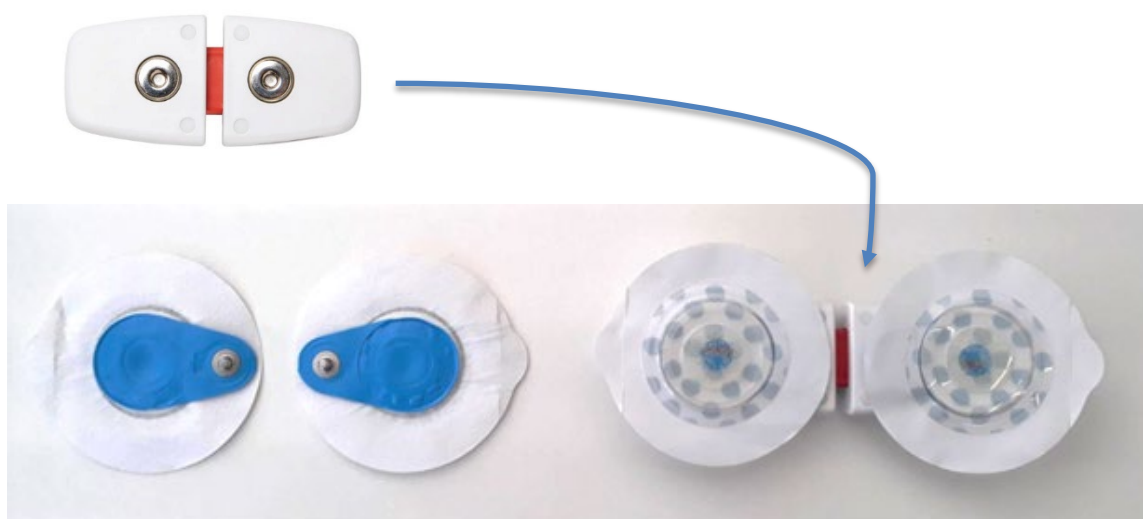


3.1.4 Step 1: Preparing your cardioBAN for acquisition.

- 1 Turn the device on.



- 2 Take 2 electrodes (pre-gelled) and connect them to the stud connects on the backside of your cardioBAN device.



- 3 Remove the plastic from the electrodes and attach them according to Step 2.

3.1.5 Step 2: Preparing the Skin

The skin should be disinfected for ECG. There should be no oil / body lotion on the skin. It must be removed with alcohol wipes.

3.1.6 Step 3: Placing your cardioBAN

cardioBAN Lead II setup

The cardioBAN device comes with fixed positions for the electrodes but you can use the following reference points for your device position:

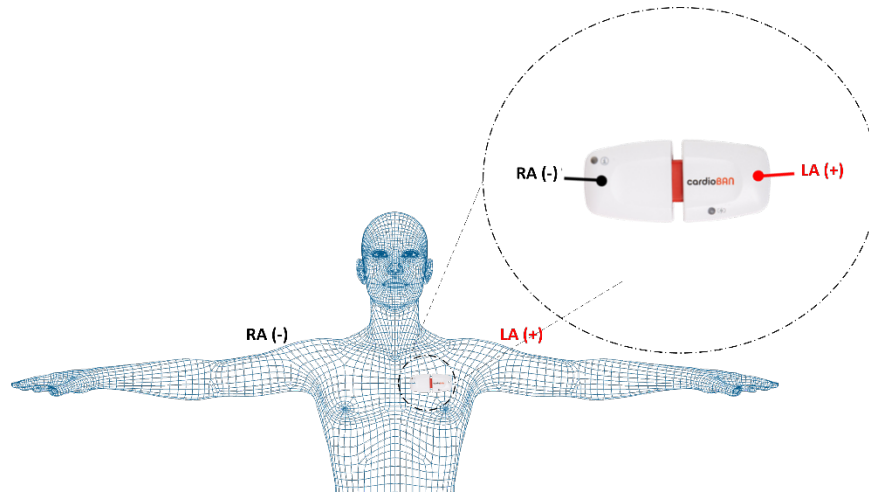


Figure 8 - CardioBAN placement.

- The negative electrode (located on the device half with the status LED) is placed at the center of the chest above the breast.
- The positive electrode (located on the backside of the device's half with the logo) is placed on the right side of the breast above the nipple.

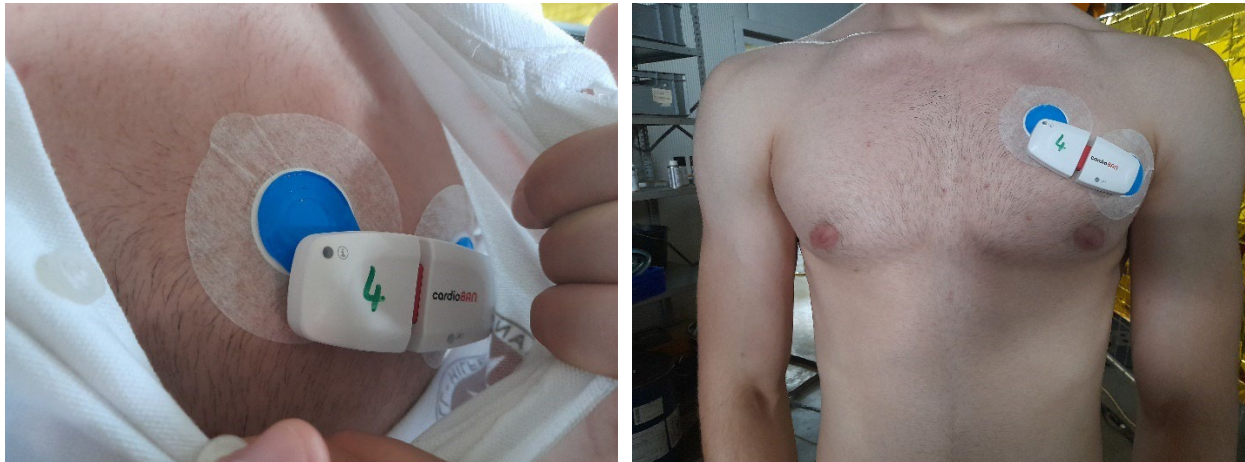


Figure 9 - CardioBAN placement example.

3.2 Wearable EDA Sensor – edaBAN

3.2.1 Turning the device on and off

You can turn the device on and off by sliding the power to 'O' (off) or 'I' (on).

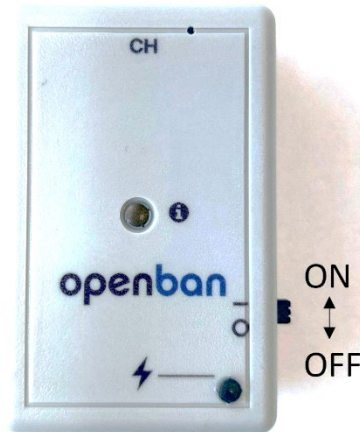


Figure 10 – edaBAN (OpenBAN) ON-OFF switch location.

3.2.2 Charging your device

Turn your device off and connect the micro-USB to the edaBAN. Connect the other end of the micro-USB cable to a USB charging port. All devices must be fully charged before each Trial.



Figure 11 – edaBAN (OpenBAN) charging micro-USB port.

During the charging process, the charging LED (on the right lower corner) will light up in different colors depending on the device state:

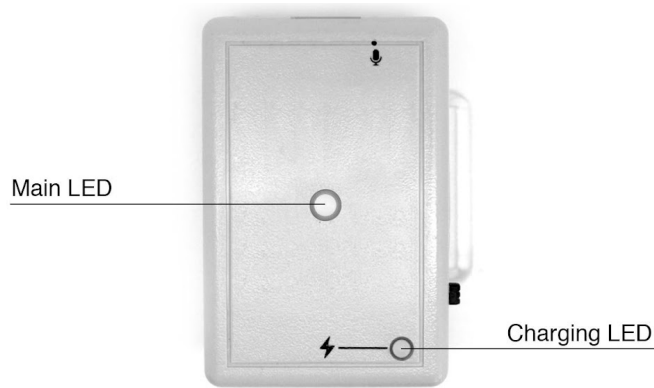


Table 4 – edaBAN charging LED color code.

Battery – Charging LED	
Constantly orange	Charging
Constantly red	Not charging; charging error occurred; switch not in off position
Constantly purple	Charging complete

3.2.3 Status LED

The status LED (in the center) of the device provides you visual feedback of the device status:

Table 5 – edaBAN status LED color code.

Main LED	
None	Off
1 green blink per second	Device & Bluetooth on; idle
2 green blinks per seconds	Acquiring/streaming data
2 red blinks	Low battery

3.2.4 Step 1: Preparing your edaBAN for acquisition

- 1 Turn the device on.



- 2 Take two electrodes (pre-gelled) and connect them to the stud connects on the backside of your edaBAN device.



Figure 12 – edaBAN (OpenBAN) Gelled electrodes placement.

Remove the plastic from the electrodes and attach them according to Step 2.

3.2.5 Step 2: Preparing the Skin

The skin should not be disinfected for EDA. There should be no oil / body lotion on the skin. It should be removed with lukewarm water (no soap).

3.2.6 Step 3: Placing your edaBAN

The edaBAN device comes with fixed positions for the electrodes but you can use the following reference points for your device position:

- Along the line of the belt that will be used as a guideline and to have additional fixation for both cardioBAN and edaBAN.
- ON / OFF switch to the top of the belt

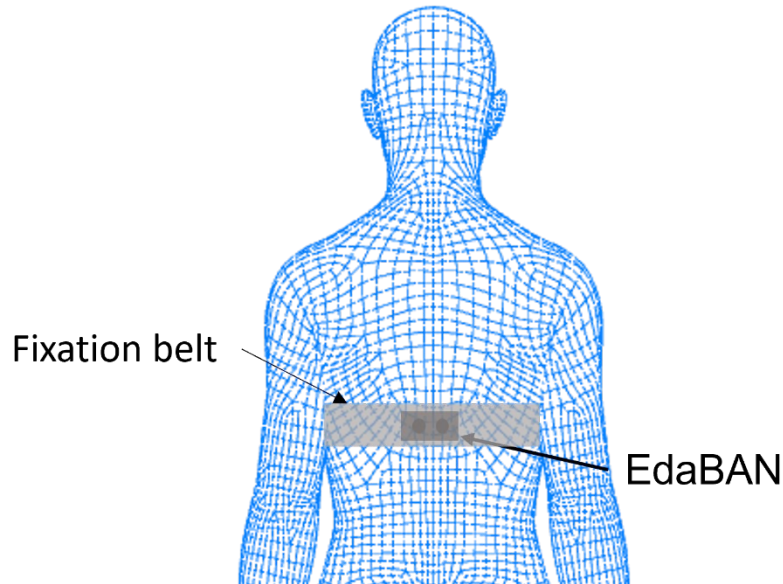


Figure 13 – edaBAN (OpenBAN) body placement.

The EDA wearable should be attached at least **5-10 minutes** before the baseline recording starts to improve electrical contact with sweat gland ducts. The baseline recording for EDA and ECG is in the first 5 min (first 2min for baseline) until the first processed values appear (e.g. HRV).

3.2.7 Baseline setting

Measuring input from biosensors (ECG, EDA) in resting position (standing still, looking at wall) for 2 minutes.

4 Wearables Software – MED1stMR Biosignals Client

The MED1stMR SW Client is automatically initiated by the VR Scenario Control SW. The Interface shows the configured wearables KIT MAC addresses. The status of the connection is also displayed.

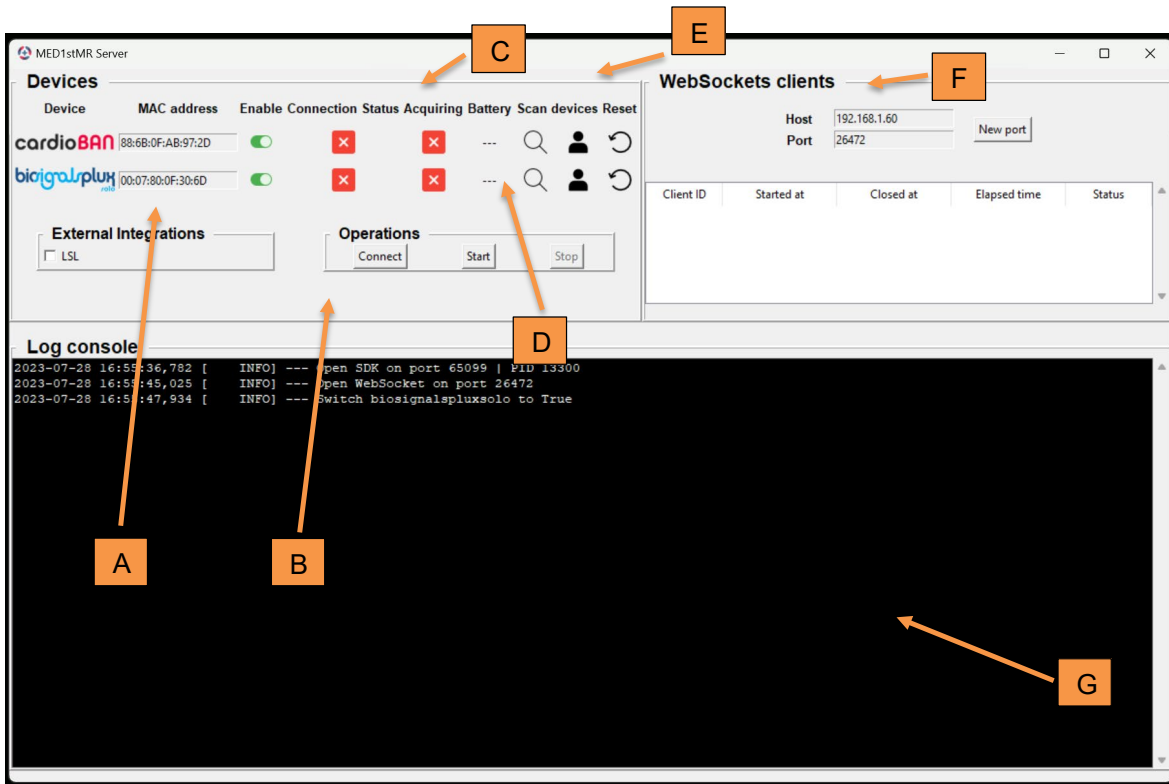


Table 6 – MED1stMR SW client Operation manual.

Label:	Function	Automatically set via VR Scenario Control	Can be set manually?
A	MAC address of the wearable to be connected.	Yes	Yes
B	Operation: connect to the device and start/stop acquisition.	Yes	Yes
C	Status control: Connection status, Acquisition status.	-	-
D	Wearable Battery Level.	-	-
E	Scan new devices automatically or manually add new device. Reset current configuration.	Yes	Yes
F	VR Scenario Control WebSocket IP address and Port setup.	No	Yes
G	Visual Log screen.	-	-

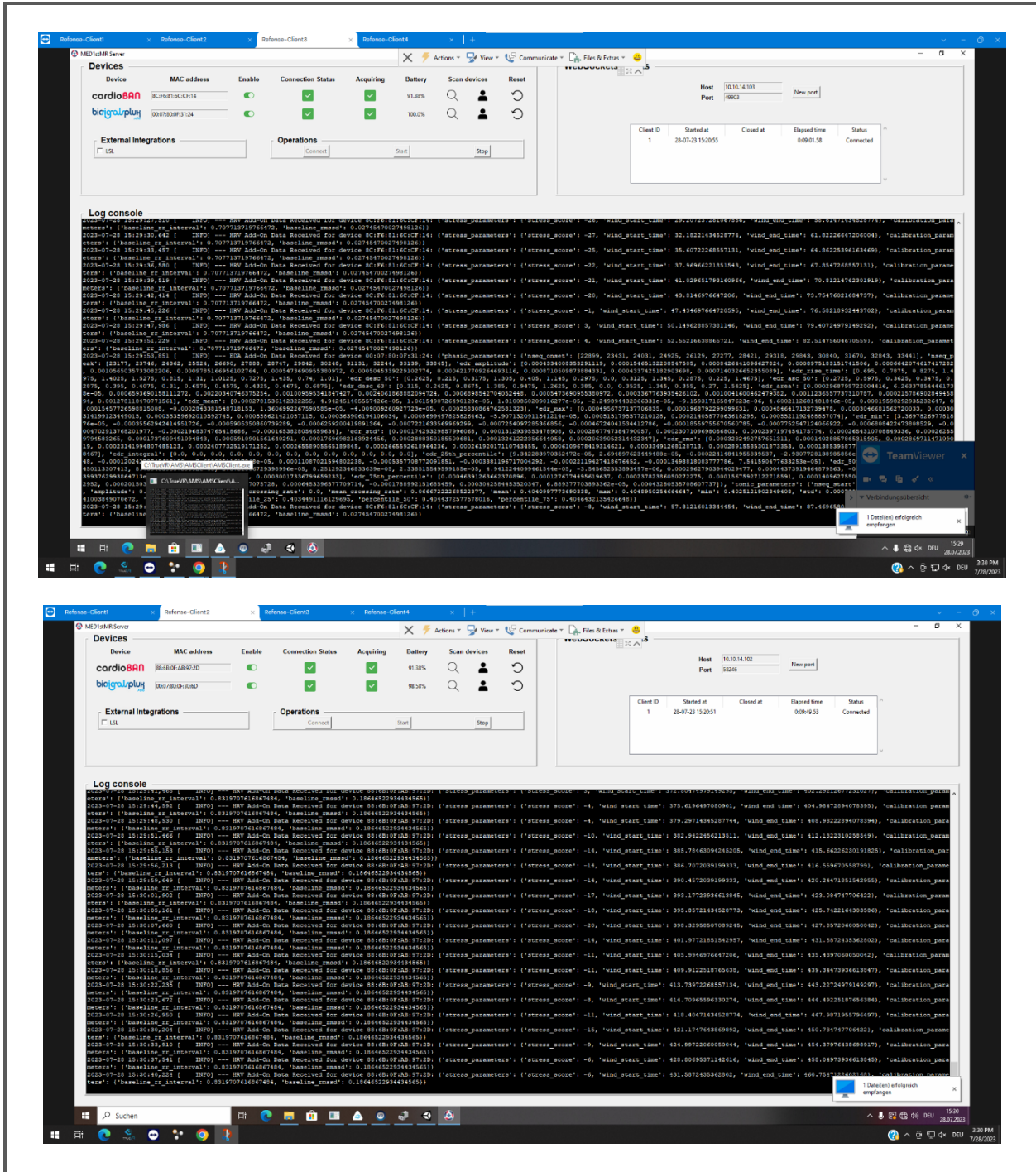


Figure 14 – MED1stMR Biosignals SW client running on REFENSE's computer.

5 Summary

The wearable device designed to capture physiological data from trainees will combine ECG sensors on the front and EDA sensors on the back, integrated within a strap or belt or directly attached with electrodes. This configuration allows for unrestricted movement of MFRs, while fulfilling the requirements outlined by end users in previous deliverables. The wearable device will have the capability to collect data on heart rate, heart rate variability, breathing rate, and EDA parameters.

These wearable devices will ensure all physiological data is collected from MFRs, which is crucial for the D4.3 - *Activity Recording for the Exercise Debriefing* - all physiological data will be systematically recorded, transmitted via the API, and securely stored for debriefing purposes, specifically for the assessment of stress levels. The physiological data will also be relevant for the integration of trainees' physiological data, done through API, to visualize the information in a real-life data dashboard dedicated to trainings (D5.2 - *MR Trainings Environment, Trainings-Scenarios and MR Live Editor infrastructure for conducting the Evaluations*). The availability of physiological data will play a vital role in evaluating stress levels (as part of D5.4 - *Integrated Sensorics for Physiological Measurement of Trainees*), thereby contributing to the comprehensive assessment of trainees' performance during training sessions.