WORKINGAGE

Smart Working Environments for All Ages

D2.5 Field Test Strategy

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WP2 – User Centric Design

D2.5 – Field Test Strategy

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Document Revision Log

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Acronyms and Terminology

The following table reports the acronyms used in this deliverable.

Term	Definition
AR	Augmented Reality
BMI	Body Mass Index
DSE	Display Screen Equipment
DSS	Decision Support System
DMP	Data Management Plan
ECG	Electrocardiogram
EEG	Electroencephalogram
EMG	Electromyography
GA	Grupo Antolín
GSR	Galvanic Skin Response
HCI	Human Computer Interaction
TRL	Technology Readiness Level
UI	User Interface
WA	WorkingAge

Executive Summary

This deliverable is one of the outputs of the project task T2.5 DEFINITION OF PILOT TESTS, whose main objective is to address the specifications of the pilot prototype to be deployed, in terms of

- WA Tool: the whole WA system: sensors, servers and network infrastructure
- WA App: the smartphone application that represents the interface between the WA Tool and the worker

D2.5 defines the how & when of the lab & company pilots: time schedule, workplaces, description of sample workers.

Note that the protocol for system evaluation is given in D2.6. D2.5 provides guidelines for preparing and conducting the tests.

The output of the work depicted in D2.5 and D2.6 will be the basis for WP3 and WP9; in particular WP9 is in charge of providing document D9.1 Pilot Operational Manual specifying the field test protocol.

In particular, D9.1 will specify, among other things, per-use-case protocols to comply with the Covid-19 regulations we will find in Countries where the use cases will be based.

Notice that, with respect to the DoA, we switched from the "drive" use case to the "teleworking" use case, at EXUS. Our choice is mainly due to:

- The company which that agreed to host WA pilots, suddenly retired from the project. Moreover, in part due to the current health situation, we did not find another company.
- The current "lockdown" situation makes it very interesting to explore the "teleworking" scenario, comparing it with the more conventional "office" scenario.

Other variations with respect the DoA:

- The Piraeus Bank offices mentioned in the DoA turned out to hardly have personnel over 45 years old: substituted with MUTUA.
- For budgetary and practical reasons, the involved subjects in the in-company field tests are:
    - Short-term field test: office (15), teleworking (5-10), manufacturing (15)
    - Long-term field test: office (30), teleworking (10-20), manufacturing (30)

This document is structured as follows:

- Section 1 introduces the goals of the test strategy and its relationships with D2.6;
- Section 2 describes the use cases;
- Section 3 describes measurements during the subject's daily life
- Section 4 specifies what we are going to measure;
- Section 5 focuses on the description of Lab Tests;

- Section 6 introduces the Field Tests;
- Section 7 further specifies short-term Field Tests;
- Section 8 further specifies long-term Field Tests.

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1 Introduction

1.1 Goals of the test strategy

The goal of the test strategy is providing a guideline for conducting the testing activity about all the modules of the WA Tool.

In particular, the testing strategy is divided into three parts:

- Lab Tests
- Short-term Field Tests
- Long-term Field Test

For each of them, this deliverable provides an initial set of guidelines, and specifies the differences about the three case studies where the WA Tool will be deployed.

Such case studies are:

- Office
- Teleworking
- Manufacturing

1.2 Main interrelationships with other deliverables

The present deliverable is strictly bound to D2.6 "Intervention Protocol". It receives inputs and/or provides guidelines and requirements to:

- WP3, in particular for the definition of measures to be adopted at the different pilot sites;
- WP4 where Lab Tests will be prepared;
- WP7, dealing with ethical, security and privacy issues;
- WP9, dealing with the final Pilot Operational Manual.

It will provide basic input to WP9 for the definition of the "Pilot Operational Manual" (D9.1) that will describe in detail the pilot application, the documents to be used during the pilot tests (e.g., informal consent, questionnaires, etc.), user recruitment rules at each pilot site, performance metrics and their assessment procedures.

Figure 1 depicts the interrelationships between D2.5 and other WPs.

Finally, D2.2 "Analysis of Available and Suitable Sensors" provides an in-deep analysis of the technologies adopted by sensors we are going to deploy, while D2.3 "Data Management Plan" provides details on the pseudo-anonymisation and encryption.

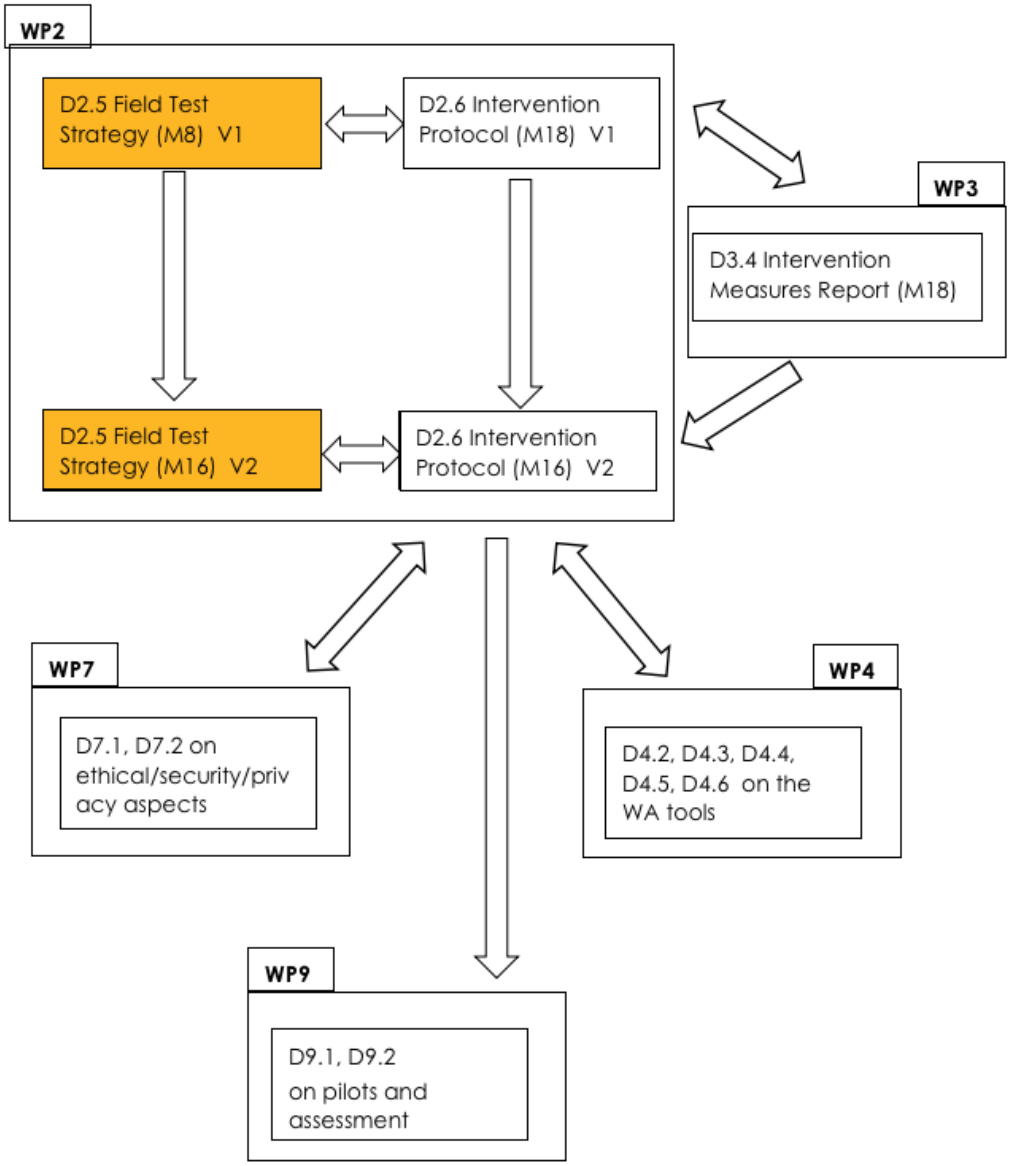

Figure 1 - Interrelationships between D2.5 and other deliverables/work packages

2 Use cases

The goal of the WA project is to improve the workers' life habits and health state by means of targeted advices. The WA system collects information about the worker and her/his working environment, by means of a set of sensors, and provides advices by means of a Decision Support System (DSS) installed on a WA-provided smartphone.

To test the WA project, we define three reference use cases:

- Office
- Teleworking
- Manufacturing

Such use cases provide a good overview of the typical workplaces, and thus we believe they will permit to effectively testing the WA Tool.

2.1 Office

The Office use case will be at MUTUA in Barcelona (Spain). Figure 2 shows a typical office setting.

2.1.1 Workplace

Under the general denomination of "Office", there are different positions in the company. We have selected those with people 45 years old and over.

- Clerks. Their main tasks are those related to office work, phone calls, data managing, reporting and other office tasks.
- Prevention engineers. Their tasks are to provide advice to customer companies, in order to foster their commitment to health and safety and to reduce permanently the occupational injuries rates. They combine on fieldwork with office work.
- Informatics. Development and maintenance of systems and applications help desk for users.
- Managers. Persons responsible of the different teams, with general management duties

In such settings, workers spend most of their time in workstations composed by a table, an ergonomic chair, a computer that may be a desktop or tower computer, or a notebook or tablet, desk telephone provided with headphone piece, a monitor, keyboard and mouse. Most of the computers will be tower computers, except for prevention engineers and manages, who will use notebooks or tablets.

It is very common the use of headsets while talking by phone or attending a virtual meeting. This could interfere in the use of some sensors. However, it is possible to use the phone in the conventional way. On the other hand, it is possible to consider the capture of voice using the headsets.

Some workers combine the office work with other kinds of work (fieldwork for prevention engineers, meetings for managers, both groups travel across Spain in private cars or public transport). For those groups of people, the collection of information will be carried out in office tasks. It is important to consider that for

these groups of workers, office tasks may take only part of the day, so maybe in these situations it is not advisable to collect data.

Figure 2 - Office setting

2.1.2 Supporting infrastructure

Electric power supply is available.

Some space can be set to deploy WA servers in the area. Coordination with persons responsible of IT in the company will be organised as needed.

2.1.3 Possible issues affecting sensor deployment

In principle, sensors may be physically deployed without foreseeable problems.

Regarding voice capture, in some moments of the day it is possible that conversations between other employees in the vicinity of the person participating in the pilot are captured and may produce interferences.

In some cases, the person works in a more isolated environment, but most of them are working in arrangements of 4 or 6 tables, with a separation of a low shield between facing tables.

Due to the COVID-19 situation, preventive measures including the installation of shields between workplaces are being placed.

2.1.4 Privacy concerns

Privacy concerns are mainly related to:

- Public disclosure of images containing sensitive information for the company. It is possible that other employees working in the vicinity of the participating workers appear in the recording. These people would not have signed any document allowing WA team the use of the images.
- Public disclosure of voice recordings, containing sensitive information for the company or subjects' private information. Some of the conversations may also contain information regarding health conditions of employees of the client companies, as well as sensitive information of the client companies.

2.1.5 Health and stress problems

A summary of the risk factors, for various positions involved into the project, is represented in Table 1.

We assume that the factors related to safety (falls from heights, contact wit electricity, burns, cuts, emergencies, etc.) are well controlled.

Table 1 - Risk factors

RISK FACTORS	Managers, different levels	Prevention engineers	Informatics	Clerks
EGONOMICS – Static posture	All time	All time, not all days	All time, all days	All time
ERGONOMICS – Use of DSE	Daily, most of the time	Daily, part time	All time, all days	Daily, most of the time
ENVIRONMENTAL FACTORS – Indoors temperature	Yes	Yes	Yes	Yes
ENVIRONMENTAL FACTORS – Indoors humidity	Yes	Yes	Yes	Yes
ENVIRONMENTAL FACTORS – Background noise	Yes	Yes	Yes	Yes
ENVIRONMENTAL FACTORS – Illumination	Yes	Yes	Yes	Yes
PSYCHOSOCIAL – Mental load	All time	All time	All time	All time
PSYCHOSOCIAL – Emotional load	Part time	All time interaction with clients	No	Part time, interaction with public and phone calls
PSYCHOSOCIAL – Autonomy	Yes	Yes	Yes	Yes
PSYCHOSOCIAL – Pauses	Yes	Yes	Yes	Yes

Note that stress could be induced by the measurements, if the subject perceives them as negative news about her/his health state.

2.1.6 Human Machine Interaction

The job in not dangerous (i.e., distraction by the app will not cause accidents/injuries under normal circumstances), so an interactive HCI is feasible. However, it must be compatible with the performance of the tasks.

In other words, the WA App should be able to provide suggestions and recommendations anytime the worker needs it (for example, when she/he is getting overloaded, or overstressed); thus, the WA Tool should be able to interrupt the worker also during the working activities, but considering her/his status (for example, when the worker is taking a break).

The HCI could be based on a smartphone where a simple touch-based UI will be present. Interaction could be both WA Tool-initiated (sort of "interrupt") and worker-initiated (a "request"). It could also be based on the computer and interact with the user through the screen; we need to check this aspect with the Systems area of the company.

2.1.7 Notes and further issues

All participants will be recruited on a voluntary basis.

Due to the Covid-19 situation, sensors that must be worn by workers may need to undergo a disinfection procedure, in accordance with the corresponding Country regulations.

2.2 Teleworking

This use case is similar to the Office one, but subjects will work at home. This use case will be at project partner EXUS. This use case replaces the foreseen driving use case, for several reasons. The Covid-19 outbreak and the consequent lockdown make it very interesting to explore teleworking, comparing it with the more conventional work at the office. Moreover, previously to this outbreak, the Project Officer had already expressed interest in exploring teleworking. On the practical side, better data quality is expected because there are fewer restrictions regarding the space where to install equipment, easier mounting, no vibrations that influence camera images and loosen mounting brackets, less noise, etc. For teleworking we can collaborate conveniently with project partner EXUS with subjects not participating in the project; it resulted difficult finding a company with many elder drivers substituting the parting IPLUS.

Special interest lies in the comparison between telework and office, i.e. entirely different social climates, heterogeneous physical environments over teleworking colleagues under less (ergonomically) controlled situations (2.2.5). Figure 3 shows a typical teleworking setting.

2.2.1 Workplace

It is preferable, but not mandatory, that participants have a room to work with respect to a space shared with other members of the family or cohabitants of the house. A desk should be available for the setup of all the devices/sensors.

We also assume that the subject's home is provided with Internet, and that enough bandwidth is available for both the subject's working activities and the WA sensors.

Figure 3 - A typical teleworking setting

2.2.2 Supporting infrastructure

Electric power supply is available.

A room could be used to deploy WA servers.

2.2.3 Possible issues affecting sensor deployment

The most limiting factor is the Internet connection bandwidth, both in terms of maximum data rate and in terms of stability of such data rate. Other network-related factors, like latency, are less constraining.

2.2.4 Privacy concerns

Privacy concerns are mainly related to:

- public disclosure of images containing sensitive and private information about the subject or the subject's roommates.
- public disclosure of voice recordings, containing sensitive information for the company or subjects' private information.

2.2.5 Health and stress problems

We foresee that for the risks related to the specific performance of the task, the risks at home are similar to those at the office. However, we must take into account the following aspects:

- Working conditions may vary from individual to individual. While at the office everyone is provided with an ergonomically designed workplace, at home it may be quite different (obvious in Figure 3 above). This may be therefore affect the analysis of the ergonomic factors.
- Teleworking may include workplaces with a high degree of interaction with other persons. We must foresee the possibility that teleoperators, people working in online training, etc. may participate in this test. In that case, there is another risk present, the risk of voice abuse, which is common in these professions.
- Teleworking presents other impacts related to the distance of the individual from other employees of the company. All factors of risks related to it (social support, leadership, etc.) may appear in these workplaces. This aspect may therefore affect the psychosocial factors.

Finally, we assume that the factors related to safety (falls from heights, contact wit electricity, burns, cuts, emergencies, etc.) are well controlled.

A summary of the risk factors, for various positions involved into the project, is represented in Table 2.

Table 2 - Risk factors

RISK FACTORS	Teleoperators and similar	Informatics	Clerks
EGONOMICS – Static posture	All time, all days	All time, all days	All time
ERGONOMICS – Use of DSE	Daily, most of the time	All time, all days	Daily, most of the time
VOICE ABUSE	Yes	No	No
ENVIRONMENTAL FACTORS – Indoors temperature	Yes	Yes	Yes
ENVIRONMENTAL FACTORS – Indoors humidity	Yes	Yes	Yes
ENVIRONMENTAL FACTORS – Background noise	Yes	Yes	Yes
ENVIRONMENTAL FACTORS – Illumination	Yes	Yes	Yes
PSYCHOSOCIAL – Mental load	All time, but depends on the organization of tasks	All time	All time
PSYCHOSOCIAL – Emotional load	All time interaction with other persons (clients, users, trainees…)	No	Part time, interaction with public and phone calls
PSYCHOSOCIAL – Autonomy	Depends on the organization of the task	Yes	Yes
PSYCHOSOCIAL – Pauses	Depends on the organization of the task	Yes	Yes
PSYCHOSOCIAL – Other factors	Social support (from managers and supervisors, from colleagues), leadership and sense of belonging to the company	-	-

Note that stress could be induced by the measurements, if the subject perceives them as negative news about her/his health state.

2.2.6 Human Machine Interaction

The job in not dangerous (i.e., distraction by the app cannot cause accidents/injuries), so an interactive HCI is feasible. In other words, the WA App should be able to provide suggestions and recommendations anytime the worker needs it (for example, when she/he is getting overloaded, or overstressed); thus, the WA Tool should be able to interrupt the worker also during the working activities, but considering her/his status (for example, when the worker is taking a break).

The HCI could be based on a smartphone where a simple touch-based UI will be present. Interaction could be both WA Tool-initiated (sort of "interrupt") and worker-initiated (a "request").

2.2.7 Notes and further issues

None.

2.3 Manufacturing

The factory, belonging to the GA RyA, which agreed to be the WA project pilot site for the "Manufacturing" use case, is in Valladolid (Spain). The factory manufactures car interior components such as dashboards, doors, etc. Figure 4 depicts some workplaces at GA RyA.

2.3.1 Workplace

The factory is organised into several "islands" where specific jobs are performed by workers with the aid of specific tools. Many different jobs are performed, such as assembling a dashboard, for example, which require several steps.

After observing the whole process, we selected some feasible "island" that allowed, more easily than others, to place sensors without interfering too much with the worker's activity:

- Leather inspection for Mercedes G-Class
- Stitching for Mercedes G-Class
- Assembly for Mercedes G-Class
- Assembly for Jaguar XFB
- Welding for Jaguar XFB

In such settings, workers do not move a lot (which is good for sensors based on cameras). Unfortunately, the whole factory is too noisy for any kind of microphone (even noise-cancelling ones) to be employed to the porpoise of the WA Tool, so voice recording is not feasible.

Temperature, humidity and noise could make the environment not comfortable for workers, especially for some of the selected "islands", while light seems good (intensity and position).

Figure 4 - Some workplaces at GA RyA

2.3.2 Supporting infrastructure

Electric power supply is available.

A room could be used to deploy WA servers.

2.3.3 Possible issues affecting sensor deployment

In some areas of the factory, heat and humidity could harm sensors.

2.3.4 Privacy concerns

Since audio recordings are not to be collected, privacy concerns are only related to the public disclosure of images containing sensitive information for the factory.

2.3.5 Health and stress problems

The major health and stress problems are due to the posture, and to the stress of keeping up to the pace required by the job procedure.

Moreover, temperature, humidity and noise could negatively impact the comfort, inducing further stress.

Specific risk factors vary for the various "islands" we selected. However, we can reassume the most relevant ones, in Table 3.

Finally, we assume that the factors related to safety (falls from heights, contact wit electricity, burns, cuts, emergencies, etc.) are well controlled.

Table 3 - Risk factors

RISK FACTORS	Manufacturers
EGONOMICS – Static posture	For some "islands"
ERGONOMICS – Load handling	For some "islands"
VOICE ABUSE	Yes

RISK FACTORS	Manufacturers
ENVIRONMENTAL FACTORS – Indoors temperature	Yes
ENVIRONMENTAL FACTORS – Indoors humidity	Yes
ENVIRONMENTAL FACTORS – Background noise	Yes
ENVIRONMENTAL FACTORS – Illumination	Yes
PSYCHOSOCIAL – Mental load	All time, but depends on the organization of tasks
PSYCHOSOCIAL – Emotional load	All time interaction with other persons (clients, users, trainees…)
PSYCHOSOCIAL – Autonomy	Depends on the organization of the task
PSYCHOSOCIAL – Pauses	Depends on the organization of the task
PSYCHOSOCIAL – Other factors	Social support (from managers and supervisors, from colleagues), leadership and sense of belonging to the company

Note that stress could be induced by the measurements, if the subject perceives them as negative news about her/his health state.

2.3.6 Human Machine Interaction

The job could be dangerous (some machines require high attention to avoid injuries), so an interactive HCI could feasible but requires special care. In other words, the WA App should be able to provide suggestions and recommendations anytime the worker needs it (for example, when she/he is getting overloaded, or overstressed); thus, the WA Tool should be able to interrupt the worker also during the working activities, but considering her/his status (for example, when the worker is taking a break).

The HCI could be based on a smartphone where a simple touch-based UI will be present. Interaction could be both WA App-initiated (sort of "interrupt") and worker-initiated (a "request").

2.3.7 Notes and further issues

None.

3 Daily life

The WA project aims at collecting information both at the working place and during the daily life.

3.1 Measurements collected during daily life

A specific subset of the WA sensors will be deployed to subjects to monitor their lifestyles. All the subjects involved in the WA in-company tests will be involved in daily life measurements.

The ***home standard list*** of measurements that will be involved in daily life measurements are:

- SLEEP DURATION
- SLEEP QUALITY
- PERIOD WITHOUT PHONE BEFORE SLEEP
- STEPS/DAY
- HEART RATE
- WEIGHT
- BMI
- DAILY WATER INTAKE (questionnaire)
- SOCIAL RELATIONS (questionnaire)

Such measurements will be collected by means of the following devices (which will be given to subjects, as a gift):

- Smartband (sleep duration, sleep quality, heart rate, steps/day)
- Smartphone (period without phone before sleep)
- Body scale (weight, BMI)
- Questionnaire (daily water intake, social relations)

Optionally, the subjects could be additionally provided with the ***home extension list***:

- HEARTH ACTIVITY (ELECTROCARDIOGRAM - ECG)
- BRAIN ACTIVITY (ELECTROENCEPHALOGRAM - EEG)
- GALVANIC SKIN RESPONSE (GSR)
- EYE BLINK DETECTION
- FACIAL EXPRESSION
- VOICE ANALYSIS
- BODY POSTURE
- GESTURE RECOGNITION
- USER LOCATION
- NOISE
- TEMPERATURE
- HUMIDITY
- CO_2
- LUX MEASUREMENT

See Section 4.3 for the full list of sensors that will be used to get all the measurements listed above. The subjects equipped with the *home extension list*

will have to sign a specific agreement, as privacy could be an issue and subjects must be aware of that. Some of the sensors that are part of the *home extension list* are planned to be provided as a gift, to increase the number of subjects who take part in extended measurements (e.g. the security camera and the professional headset; according to budget).

Measurements collected during the daily life are used to augment the DSS's knowledge about the subject's habits. Taking these habits into account affects the interventions generated by the DSS.

3.1.1 Environments

By "daily life", we mean each activity not related to the subject's working duties. Therefore, the "environment" includes the subject's working environment (for example, during pauses or lunchtime), her/his home, etc. We expect that:

- subjects wear the smartband at any time
- subjects use the WA-provided smartphone:
  - at any time, when at work
  - at any time while commuting
  - most of the time, when at home (i.e., an alert generated by the phone could be handled by the subjects)
  - rarely (we argue), when they are in other environments
- subjects use the body scale when they are at home

3.1.2 Supporting infrastructure

The *standard list* of measurements does not need particular infrastructure is needed, as all the measurements are done directly by the smartphone (questionnaires) or are downloaded to the smartphone by BT (smartband and body scale). In particular, no network is needed.

The *extension list*, however, will need Internet network connection and a WiFi network.

Of course, electric power supply is needed (e.g. recharge the smartphone).

3.1.3 Possible issues affecting sensor deployment

Smartphone damages are the most prominent issues. We expect the smartband and the body scale to be robust enough to make very low the risk of damages.

3.1.4 Privacy concerns

The collected measurements are related to the subject's state of health, so privacy is a concern. Anyway, as such measurements stay into the device that collect them, or into the smartphone (managed by the WA App) where they are downloaded, the risk of a data breach is minimised.

3.1.5 Health and stress problems

Stress could be induced by the measurements, if the subject perceives them as negative news about her/his health state.

3.1.6 Human Machine Interaction

We have three different interaction typologies:

- Interaction with the WA App User Interface. This is under our control and thus we'll try to make interaction as easy and pleasurable as possible.
- Interaction within the physical interface of the smartband. This is not under our control.
- Interaction within the physical interface of the body scale. This is not under our control.

3.1.7 Notes and further issues

None.

3.2 Smart goals

Some measurements collected during the daily life are also used to engage the subject in setting and trying to meet a set of so-called *smart goals*. In particular, we defined the following smart goals:

- Physical activity measured in steps/day. The goal is to reach a minimum, predefined number of steps per day, and to fulfil this requirement for at least a predefined number of days per week.
- Nutrition habits
    - BMI[1]. The goal is to maintain the BMI within a predefined interval (note that excessive BMI may have other causes, not related to the nutrition habits, for example endocrine malfunction; recommendations about the BMI will inform the worker on that).
    - Daily water intake.
- Sleep time. The goal is to meet the predefined sleep time constraint.
- Period without phone before sleep. It is recommended that a person avoids using her/his phone before going to sleep. The goal is to respect the predefined time constraint and leave the phone on time before going to sleep.
- Social relations: social relation frequency.

Every week the goals are checked and the subject informed about the results.

[1] BMI, formerly called the Quetelet index, is a measure for indicating nutritional status in adults. It is defined as a person's weight in kilograms divided by the square of the person's height in metres (kg/m2). For example, an adult who weighs 70 kg and whose height is 1.75 m will have a BMI of 22.9.
See: `http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi`

4 Measurements and sensors

The WA system is going to deploy several sensors and gather their measurements. The following sections provide an overview of what is going to be collected by the WA system.

Note that we have two measurement typologies:

- Objective measurements, by means of electronic sensors
- Subjective measurements, by means of questionnaires

These two different methodologies to gather data about workers permit to compare the behaviour of the WA Tool, assessing its perceived effect on workers' life.

4.1 Objective measurements

The following ***full list*** of measurements, collected by body sensors, will be analysed in Lab Tests and, if proving useful, deployed in Field Tests and daily life measurements; this list was decided after the technical survey provided in D2.2.

- HEARTH ACTIVITY (ELECTROCARDIOGRAM - ECG)
- BRAIN ACTIVITY (ELECTROENCEPHALOGRAM - EEG)
- MUSCLE ACTIVITY (EMG)
- GALVANIC SKIN RESPONSE (GSR)
- FACIAL EXPRESSION[2]
- VOICE ANALYSIS[3]
- EYE BLINK DETECTION
- EYE MOVEMENT
- PUPIL DIAMETER
- BODY POSTURE
- GESTURE RECOGNITION
- WEIGHT
- BMI
- USER LOCATION
- HEARTH RATE, STEP METER, SLEEP QUALITY, SLEEP DURATION [4]

Additionally, the following environmental sensors will be tested:

- NOISE
- TEMPERATURE
- HUMIDITY
- CO_2
- LUX MEASUREMENT

[2] In particular, emotion recognition from facial expressions.
[3] Currently, emotion recognition is planned; stress recognition will be tested in lab and, if successful, deployed in company tests.
[4] Such measurements, collected by a popular commercial smartband, will not actually tested in laboratory. We assume them to provide approximate values (after all, the smartband carries simple, inexpensive sensors), but still good enough for our goals; anyway, the DSS will take into account that such measurements are not precise.

Possible correlations between strain and environmental conditions will be analysed –leveraging the best practices described in the current academic literature– to understand whether this correlation does exist.

As already derived in D2.1, the strain types mentioned in Table 4 can be investigated by means of the physiological parameters monitored by the sensors.

Table 4 - Measurement of mental, emotional and physical strain with the measurements collected in the WA project[5]

X:direct indicator O:indirect indicator	Electrocardiogram (ECG)	Electromyography (EMG)	Galvanic skin response (GSR)(*)	Electroencephalogram (EEG)	Eye blink detection	Facial expression	Voice Analysis	Gesture recognition	Pupil diameter (PD)	Body Posture	Eye-Movement
psychological strain								o			
• mental	o		o	x					o		o
sensory				o	o				o		
discriminatory			o	o					o		
combinatory			o	x					o		
• emotional	o		x	o		o	o	o	o		
physical strain								o			
• muscular	o	x								o	
dynamic	x	x						o			
static	o	x	o							o	
cardiovascular	x		o	o							
• skeletal	o	o								o	

(*) Skin temperature will be tested as an alternative sensor, for collecting comparable indicators.

4.2 Subjective Measurements

We also plan to collect information on workers by administering specific questionnaires to collect different type of data such as:

- Demographic data, e.g. age, gender
- Health status
- Cognitive and emotional situation

[5] Adapted and extended following Kirchner (1986).

- Daily-life time (nutrition, exercise, sleep, social relations, etc.)

Such questionnaires could be paper based or electronic. In particular, during Lab Tests questionnaires will be probably paper based, while during Field Tests, an electronic format will be adopted (the smartphone WA App, used as system HCI, will be used to administer and manage questionnaires).

The information obtained from these questionnaires will provide data regarding the user's general health, both cognitive-emotional and physical, and the user's self-perceived relationship between their usual work activity and their levels of stress and emotional well-being, as well as any physical discomfort and possible musculoskeletal disorders. These data will guide the intervention plan designed and developed in D3.4, allowing the customization of the recommendations sent to the user by the system, and their adaptation to the evolution of the worker's state of health.

On the other hand, the information regarding the user's lifestyles (e.g. physical activity, nutritional style, sleep habits, etc.) derived from the questionnaires will allow the system to guide and support the worker in choosing and achieving SMART GOALS. This will determine the intervention approach derived from the intervention design (T3.4) to promote healthy life habits and, ultimately, a better state of health.

4.3 Measurements and sensors

Measurements introduced above are collected by a set of sensors (see Table 5). Note that the questionnaires (described in Section 4.2) are considered here as measurements since they will also gather data related to each WA user.

Table 5 - Measurements and corresponding sensors

Measurements	Objective / Subjective	Subject / Environment	Sensor
Heart activity	O	S	ECG (Empatica wristband)
Galvanic Skin Response	O	S	GSR (Empatica wristband)
Brain activity	O	S	EEG headband
Muscle activity	O	S	EMG (*)
Facial expression	O	S	Camera
Voice analysis	O	S	Unidirectional, noise-cancelling microphone
Eye blink detection	O	S	Headband or camera (**)
Eye movement, Pupil diameter	O	S	Eye tracker
Body posture	O	S	Camera
Gesture recognition	O	S	Camera
User location	O	S	Via smartphone
Sleep duration, sleep quality, step meter, heart rate	O	S	Smartband
Weight, BMI	O	S	Body scale
Questionnaires (***)	S	S	Questionnaires on WA App
Noise	O	E	Omnidirectional microphone

Measurements	Objective / Subjective	Subject / Environment	Sensor
Lux measurement	O	E	Illumination
Thermo-hygrometric & CO_2	O	E	Environment Condition sensor

(*) EMG sensor will be only deployed in Lab Tests, to derive theoretical considerations/concepts for the future integration of the EMG system into the WA Tool.

(**) To be decided accordingly to the In-Lab tests results; if camera is selected, we preview to use the same camera as for Facial expression.

(***) Multiple measurements on: work environment and working conditions; cognitive, emotional and social aspects; nutrition, sleep, exercise; dynamic and kinesthetic characteristics of the task, etc.; about day-to-day social interaction; initial interview.

4.4 Measurement-use case matrix

Because each use case has its specific constraints, WA is not going to get exactly the same set of measurements for the three use cases. Table 6 shows what WA is going to deploy, for each use case and during the daily life.

Table 6 - Measurements and use cases (X: only for workers with home extension list)

Measurements	Use cases			Daily life
	Office	Teleworking	Manufacturing	
Heart activity	✓	✓	✓	X
Galvanic Skin Response	✓	✓	✓	X
Brain activity	✓	✓	✓	X
Muscle activity	-	-	-	-
Facial expression	✓	✓	✓	X
Voice analysis	✓	✓	-	X
Eye blink detection	✓	✓	✓	X
Eye movement	✓	✓	✓	-
Pupil diameter	✓	✓	✓	-
Body posture	✓	✓	✓	X
Gesture recognition	✓	✓	✓	X
User location	✓	✓	✓	X
Sleep duration	-	-	-	✓
Sleep quality	-	-	-	✓
Step meter	✓	✓	✓	✓
Heart rate	✓	✓	✓	✓
Weight	-	-	-	✓
BMI	-	-	-	✓
Questionnaires	✓	✓	✓	✓
Noise	✓	✓	✓	X
Lux measurement	✓	✓	✓	X
Temperature	✓	✓	✓	X
Humidity	✓	✓	✓	X
CO_2	✓	✓	✓	X

Some measurements will involve all subjects, while others will involve just a subset of them (because sensors are very expensive, difficult to use, or seen as more "research oriented" as technology is at low TRL not good enough for a broad adoption); see Table 7.

Table 7 - Number of subjects involved in measurements

All: all subjects involved in the use case (also equipped with the home standard sensor list*);*
Some: subjects who agreed to be equipped with home standard + home extension sensor lists

Measurement	Per Use case	Daily life (considering all use cases)
Heart activity	3 subjects	Some, max. 9 subjects
Galvanic Skin Response	3 subjects	Some, max. 9 subjects
Brain activity	3 subjects	Some, max. 9 subjects
Muscle activity	-	-
Facial expression	All	Some
Voice analysis	All (*)	Some
Eye blink detection	3 subjects	Some, max. 9 subjects
Eye movement	1 subject	-
Pupil diameter	1 subject	-
Body posture	All	Some
Gesture recognition	All	Some
User location	All	Some
Sleep duration	-	All
Sleep quality	-	All
Step meter	All	All
Heart rate	All	All
Weight	-	All
BMI	-	All
Questionnaires	All	All
Noise	All	Some
Lux measurement	All	Some
Temperature	All	Some
Humidity	All	Some
CO_2	All	Some

(*) Excluding the "Factory" use case.

4.5 Measurement-Data Controller matrix

Each measurement is under the responsibility of one or more WA partners. Table 8 shows the partner(s) responsible for each measured data (i.e., the Data Controller of each measurement). This is important to be compliant with the GDPR.

Table 8 - Measurements and data owners

Measurem.	WA partners								
	POLIMI	AUD	ITCL	BS	INTRAS	RWTH	UCAM	TPZ	EXUS
Heart activity				X					
Galvanic Skin Response				X					
Brain activity				X					
Muscle activity						X			
Facial expression							X		
Voice analysis	X	X							
Eye blink detection				X					
Eye movement						X			
Pupil diameter						X			
Body posture			X						
Gesture recognition									X
User location								X	
Sleep duration			X						
Sleep quality			X						
Step meter			X						
Heart rate			X						
Weight			X						
BMI			X						
Questionnaires					X				
Noise		X							
Lux			X						
Temperature			X						
Humidity			X						
CO_2			X						

5 Lab Tests

Lab Tests will assess system acceptability, usability, and validity. Each partner designs its own tests and manages its own documents, hardware, software, and data.

5.1 Goals

Lab Tests represent the proof-of-concept of the WA sensor components. At this stage, the sensor components for the final WA system will be selected, with respect to the study findings.

The main goal is to assess:

- sensor
    - acceptability and usability
    - validity
- WA App UI usability
- system reliability (integration test)

At the end of Lab Tests, acceptable, usable, and valid sensors will be considered for Field Tests. Moreover, after testing the WA App UI, we could adopt the suggestions and improvements coming from users' feedback.

5.2 Recruitment

The WA project aims at a well-defined category of workers; the main requirements are:

- Possibly, age 45+
- Possibly, gender-balanced groups
- As specified in the DoA, we can't assure to properly support persons with special needs; in particular, when disabilities or impairments could make it difficult for the worker to wear the sensors or to interact with the WA App [6]

The Lab Tests, however, are a part of the development cycle, and the goal is to test the reliability of the subsystems that will compose the WA Tool. Therefore, the requirements mentioned above are not strictly enforced. In other words, each WA partner is free to select the more convenient set of users for testing its equipment.

Table 9 shows how many subjects the WA partners will involve in Lab Tests.

[6] We are aware that workers with disability could benefit from a system like the WA Tool. However, as disabilities and impairments (cognitive, organic, physical, sensorial) pose several and different challenges to the design of the WA system (both sensors and HCI), and taking into account that each person with disability is a unique case, and providing generic solutions is very difficult [6], we prefer to target our prototype to workers who do not pose such issues. Nevertheless, the WA App will implement the accessibility features provided by the phone OS.

Table 9 - Involved subjects, per WA partner

ITCL & INTRAS	UCAM	BS	POLIMI	EXUS	RWTH
5	5	5	5	5	10

5.3 Informed consent forms

It is under the responsibility of each WA partner to collect the informed consent forms from the users involved in Lab Tests. The information consent will involve the permission to:

- Measure
- Elaborate
- Store

the data collected by the WA partner.

The informed consent form will specify how long data will be retained by the WA partner, and how users can request to delete their own data.

Other WA partners will not be allowed to access the data, unless the informed consent form explicitly mentions that possibility, and the user explicitly allows it.

The consent form in paper format will be stored in the correspondent country in which they are generated.

More details are provided in the Data Management Plan, D2.3.

5.4 Acceptability and validity of sensors

In accordance with the User Centric design philosophy this goal aims at understanding whether subjects feel sensors as comfortable enough.

We will carefully consider which sensor combinations is necessary to achieve the WA objectives, taking into account that – especially in the long-term Field Tests – the comfort of wearing sensors is crucial and sensors might hinder work and cause additional stress.

Some wearable sensors, in particular ECG, EEG, GSR are particularly invasive, so we need to understand how we can make them acceptable, and during what amount of time[7].

The camera-based sensors require the subject to remain inside the frame of the camera; how this requirement impacts on the subject's activity will be investigated.

Other sensors seem less problematic; nevertheless, unexpected issues could arise, so we'll investigate on them, too.

Sensor validity ensures that the sensors are reliable and permit to extract useful information. Each partner should provide its own specific:

- goals

[7] EMG will not be deployed during the in-company tests, so the acceptability and validity study is not needed.

- statistical methods
- evaluation methodologies
- safety assessment

5.4.1 Research questions

The research questions to be answered for Lab Tests refer to sensors and the appropriateness of physiological indicators as measure of mental, emotional, and physical strain itself.

About sensors, the objective is to prove that each of them is valid, feasible, and usable to measure its foreseen type of strain in the suggested way.

The general research question for each individual sensor should be validating the measurement parameter/sensor (i.e., does the sensor measure what we want to measure?)

Then, Lab Tests will aim at confirming the appropriateness of the chosen physiological indicators to gauge the mental, emotional and physical strain of workers.

In order to determine the specific research questions, a literature survey for the above-mentioned sensors is necessary. This has to consider especially the nature of the stimulus:

1. Cognitive or informational task influence data collected by eye tracking, GSR, heartbeat measurement devices (sensors)
2. Emotional stimuli influence data collected by face and voice recognition devices;
3. Physical stimuli influence data collected by EMG as well as the body posture analyses;

5.4.2 Study design

The actual planning of the study depends on the kind of strain considered. As Figure 5 shows, uniform questionnaires are used in all settings to collect demographic and other study dependant data, e.g. control variables. To validate the sensors, the stimulus is changed in randomized cycles if it is required so by study design.

Closing questionnaires ask for parameters related to the measurement and the hypothetical system of the WA Tool, such as acceptance and usability. The following list details the study workflow.

1. Questionnaires concerning participants are employed:
    - To collect data about age, gender and health restrictions of the participants.
2. Measurement:
    - alternating strain
    - approximately about 3 to 5 different strain levels (two levels, for mental stress)
    - several cycles
3. Test Persons:
    - Possibly (but not necessarily), gender-balanced group

- The number of participants is related to the study design. For the pre-studies only a small number of participants is enough to recognize tendencies.

4. Additional subjective measurement methods, e.g.:
   - NASA-TLX: To evaluate the relationship of measured and subjective strain [2]
   - Rating Scale of Mental Effort (RSME) [3]
   - Geneva Emotion Wheel Questionnaire (GEW) [4]
5. Statistical Analyses, for instance:
   - Within-subject-design
   - Mean value difference and two-way repeated measure of variance analysis tests for:
     i. Significance of mean value difference between no strain and strain condition, and between different strain levels
     ii. Significance of mean value difference between 45+ and younger test subjects (as stated above, the requirement about subject recruitment are not strictly enforced, as the goal is to find the more convenient set of users for testing the equipment),
   - Correlations between the evaluated physiological and subjective parameters
6. Closing questionnaires about sensor acceptance, feasibility and usability

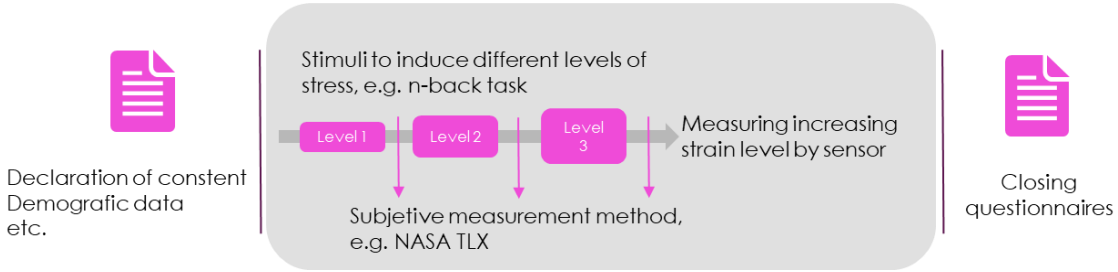

Figure 5 - Study design example

5.5 Usability of the WA App UI

The WA system is equipped with a smartphone that will host the WA native application. The main function of this application is to provide the WA Tool user interface. The aim of this research is to evaluate the usability of the WA native application interface.

The aim is to evaluate a mock-up version of the WA App with regard to the usability and thus to be able to adapt the App in the best possible way to the requirements and wishes of future users. In accordance with the User Centric design philosophy, the WA App mock-up will be tested in order to understand its pros and cons, and integrate the subjects' feedback.

In particular, we aim at following the approach explained in [1], for testing the WA App UI usability.

The User Centric design approach recommends involving users from the beginning of the design process. Thus, we are administering a web-based questionnaire that permits to evaluate a mock-up of the WA App UI.

Figure 6 shows a page taken from the web-based questionnaire, while Figure 7 shows some screenshots of the mock-up developed for the experiment.

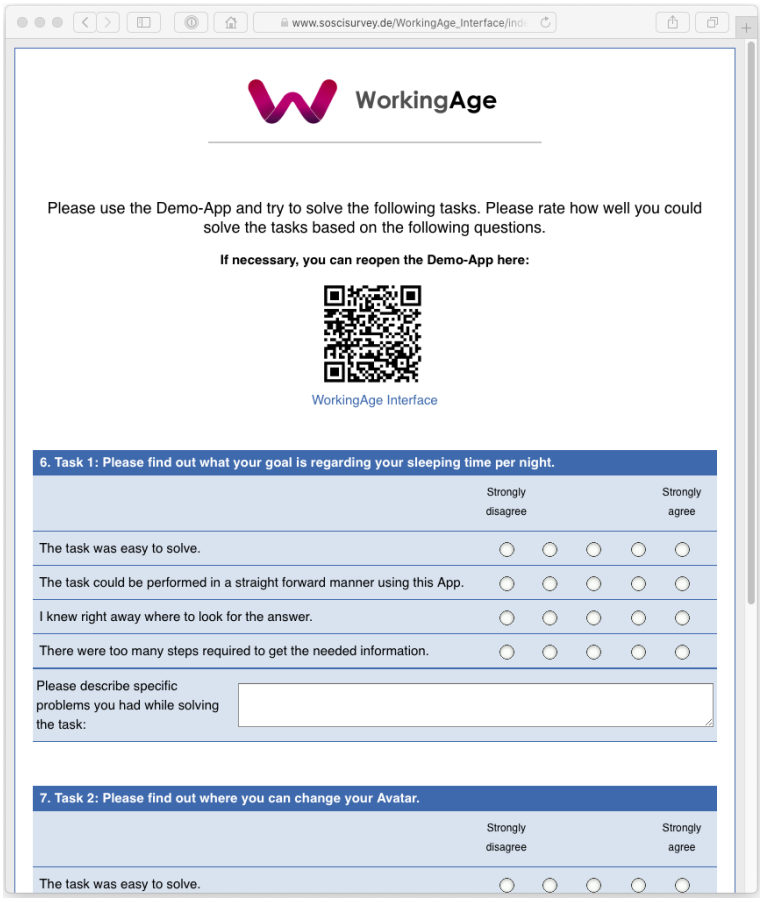

Figure 6 - Questionnaire: an example

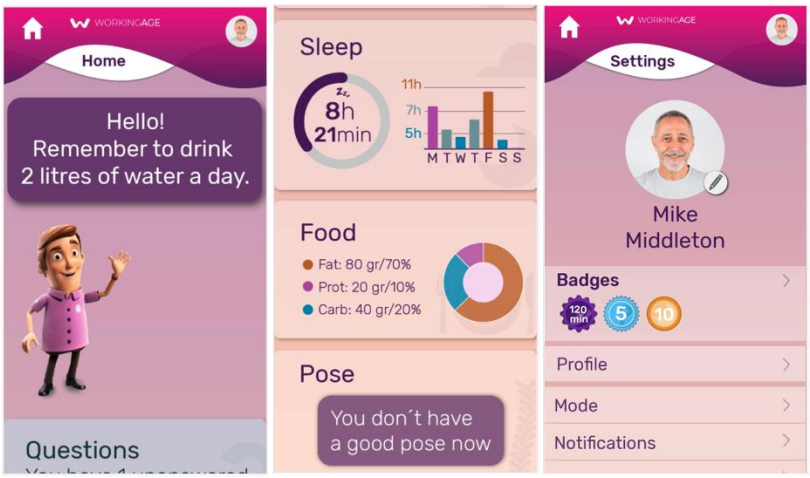

Figure 7 - Some screenshots of the WA App mock-up

5.5.1 Procedure

The original procedure was planned as a personal interview, but due to the Covid-19 pandemic the original procedure was adapted to enable a safe survey without personal contact. The usability study is now realized as an online questionnaire. Although this can lead to loss of data and information, as test persons may have less motivation to address and name concrete problems, there are also advantages for example that a larger number of test persons can be acquired with less effort. The following approaches for testing usability will be applied:

1. Usability and layout
    a. System Usability Scale (SUS) [5], a widely used questionnaire that provides reliable results even for small sample sizes and is also available and tested in several languages. One disadvantage is that the SUS does not diagnose usability problems, so the following methods are used additionally to identify opportunities for improvement.
    b. Not only exciting content and the ease of use convinces a user to use a website or system - the design also plays a major role. The design and thus the aesthetics of a website are becoming increasingly important. Website aesthetics have a door-opening function and help decide whether a user use it or not. Therefore, the short version of the Visual Aesthetics of Websites Inventory (VisAWI) will be used to evaluate the layout of the WA App.
2. Testing with regard to the principles of the human-computer interaction as describes within ISO 9241-110. This part deals with general ergonomic principles which apply to the design of dialogues between humans and information systems. The questions are formulated both as a rating scale and as an open answer format, so that the participants can name concrete problems and opportunities for improvement. The purpose of this supplement is to eliminate the problems of this SUS and to identify concrete usability problems and thus to point out concrete possibilities for improvement.

5.5.2 Online questionnaire

To evaluate the usability in accordance corona related regulations, an online questionnaire was planned. The questionnaire consists of different parts, which are listed and briefly described below:

1. Description of the research project and clarification of the data protection regulations and declaration of consent to the processing of the data
2. Demographic information (gender, age, resistance location and occupation)
3. Introduction into the WA App where user can get a first look into the Apps Design
4. Tasks 1 and 2, where the user is asked to perform a task and rate how easy this task was to solve (changing the avatar, sleeping goal)

5. System Usability Scale (what is your overall rating of the app?)
6. Rating of the overall layout of the App (VisAWI_s)
7. Agreeing/Disagreeing of specified questions, regarding possible problems/concerns with the App (Based on the human-interaction guidelines)
8. Agreeing/Disagreeing of specified questions concerning the layout of the App (icons, diagrams, buttons - based on the human-interaction guidelines)
9. Rating the interventions of the App for usefulness, timing and quantity of intervention notifications and possible features

The questionnaire is performed using SoSci survey[8], software for online surveys, which meet the data protection regulations. The mock-up version of the WA App is accessible with a smartphone or a computer via link or QR-code, which is integrated in the questionnaire (Figure 6). The questionnaire is available in the following languages: English, German, Italian, Spanish and Greek, translated by the respective WA consortium partners.

5.6 Integration test

An integration study, testing the whole WA system will be conducted at the end of the validity Lab tests. During the integration study, we aim at finding:

- Possible interferences with other partners' sensors
- Acceptability, usability, and validity of the whole WA system

To implement the WA Tool, various sensing devices and service modules have to be integrated in a consistent, standardised way. The result of this integration will form the WA Tool, a novel application allowing actors to receive real-time feedback and health-related tips and advice to build healthy habits at work and in their daily lives.

The integration process consists of two main integration cycles that go in parallel with the development process, as displayed in Figure 8. Initially, the user requirements were translated into non-functional requirements, while WA's architecture was designed and then mapped to a set of functional requirements concerning the various components and modules of the platform.

Each development phase ends with a set of internal integration tests, named as 'verification tests', concerning the modules (entities) or components developed in each technical task. Those tests are performed under T8.3 and are executed by each technical partner, aiming to verify the sub-systems' compliance with the functional and non-functional requirements previously defined.

Following the verification tests, the integration will take place at a higher level, leading eventually to the integrated WA Tool, which will be then tested as a whole through a series of 'validation tests' (in WP9) against the user requirements and the KPIs previously defined.

[8] See: https://www.soscisurvey.de

At the end of the validity Lab Tests, a first iteration of verification tests, and a final integration test will be conducted on the whole WA architecture (WP8).

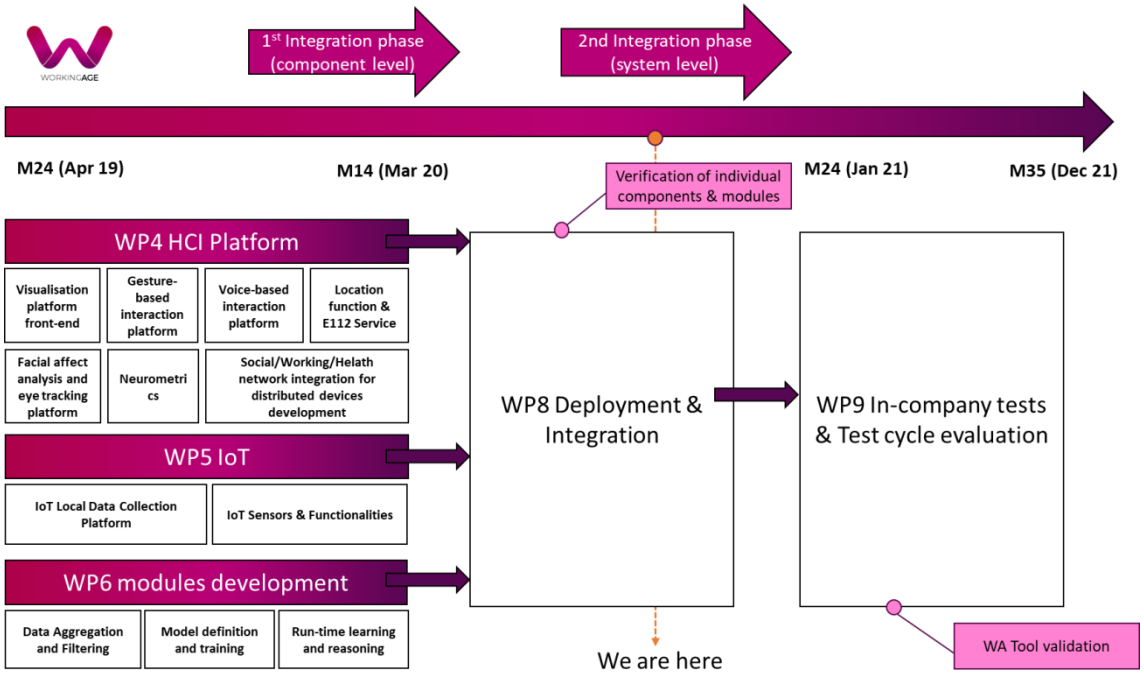

Figure 8 - Development process

5.7 Time schedule

The time schedule for the Lab Tests can be derived from the Gantt chart in the DoA. During this period, the study design will be developed and pre-tests for the preparation of the pilot tests will be completed including the analysis of the results.

M11 (Dec 2019): Begin of setup for acceptance/usability tests
M11 (Dec 2019): Begin setup for validity tests
M13 (Feb 2020): End setup for validity tests
M14 (Apr 2020): End of setup for acceptance/usability tests
M14 (May 2020): Start validity tests and assessment
M15 (Apr 2020): Acceptance/usability tests
M15 (Apr 2020): Start assessment for acceptance/usability tests
M16 (Oct 2020): End of assessment for acceptance/usability tests
M18 (Sep 2020): End of validity tests and assessment

Notice that, due to the current Covid-19 outbreak and the lockdown applied in almost all European Countries, we present an estimation of a modified Gantt based on the assumption that most partners can access their labs as of June and access the pilot company premises as of October (See Figure 12).

6 Field Tests: general info

Field Tests aim at assessing the system reliability and effectiveness. There are two Field Test typologies: short-time Field Tests and long-time Field Tests. In the following, the characteristics that these typologies share will be introduced.

Note that the protocol for system evaluation is given in D2.6. D2.5 provides guidelines for preparing and conducting the tests.

6.1 Test setting at work

Each sensor needs to meet a set of requirements, due to its nature and technological limitations. Therefore, the test settings should be selected in a way that permits to all sensors to operate correctly.

Notice that sensors will be actually deployed if Lab Tests prove they are acceptable, usable, and valid.

6.1.1 Common to all use cases

In general, a static setting is preferable, as cameras and eye trackers cannot "follow" users while they move. Moreover, a "reasonably quiet" environment is needed for the microphones to collect usable vocal samples[9]; in particular we'll explore methodologies for detecting and removing spurious voice recordings (for example, when multiple voices are present or the signal-to-noise value is not good enough). Finally, the environment should not harm the sensors (no excessive humidity, dust, etc.)

The company hosting the use-case should provide a room for deploying some WA servers (see Section 6.2). The company should also provide places where the WA WiFi routers, provided by GC, will be deployed.

6.1.2 Use case: Office

Sensors will be deployed on the worker's body and on the desk. The measurements we plan to collect are:

- ECG, EEG, GSR, eye blink detection, microphone, user location: on the worker's body
- Facial expression: a camera standing in front of the worker, on the monitor or on the desk
- Eye movement, pupil diameter: a device put on the desk, in front of the worker (a device mounted on glasses is under evaluation, too)
- Body posture: a camera put sideways, e.g. on a wall, observing the whole worker's body
- Gesture recognition: a camera put in front of the worker
- Voice analysis: a worn microphone
- Questionnaires: provided by means of the WA App

[9] We are going to use noise-cancelling microphones, but this technology has limitations.

- Noise, temperature, humidity, CO_2, illumination: sensors put in the office, on the worker's desk

The environments should not pose risks about sensor integrity.

6.1.3 Use case: Teleworking

Sensors will be deployed on the worker's body and on the desk. The measurements we plan to collect are:

- ECG, EEG, GSR, eye blink detection, microphone, user location: on the worker's body
- Facial expression: a camera standing in front of the worker, on the monitor or on the desk
- Body posture: a camera put sideways, e.g. on a wall, observing the whole worker's body
- Gesture recognition: a device put in front of the worker
- Voice analysis
- Smartband for steps/day, hearth rate
- Questionnaires: provided by means of the WA App
- Noise, temperature, humidity, CO_2, illumination: sensors put a home, on the worker's desk

The environments should not pose risks about sensor integrity.

As the worker will be at home, special care will be taken to training that will be offered remotely, so that they will be able to deploy the sensors, clean and store them when after use, and detect incidences. In case of issues, an on-line support, by means of Skype or similar, will be provided.

6.1.4 Use case: Manufacturing

Sensors will be deployed on the worker's body and on the machine operated by her/him. The measurements we plan to collect are:

- ECG, EEG, GSR, eye blink detection, user location: on the worker's body
- Facial expression: a camera put in front of the worker, on the desk or machine she/he is operating
- Eye movement, pupil diameter: a device put in front of the worker, on the desk or machine she/he is operating (a device mounted on glasses is under evaluation, too)
- Body posture: a camera put on a wall, observing the whole worker body
- Gesture recognition: a device put in front of the worker
- Smartband for steps/day, hearth rate
- Questionnaires: provided by means of the WA App
- Noise, temperature, humidity, CO_2, illumination: sensors put in the workplace, close to the worker's body

Measurements we currently do not plan to collect:

- Voice analysis: the environment is too noisy even for a noise-cancelling microphone

The environments could pose some risks about sensor integrity, in particular dust, temperature, and humidity could harm some sensors. During the field short-term study, these aspects will be investigated.

6.1.5 Augmented Reality at the Manufacturing use case

The AR specific application will be a module of the WA Tool. This module will only be available for the workers in specific workplace(s) selected for it. Due to the fact that this type of application has to be specifically developed for each case, the objective of this part of the study is to understand whether this type of content can contribute to the reduction of the mental overload or the worker.

After the visit to the facilities of GA RyA, the preselected workplace for the AR experiences is the Kitting XFB: the worker needs to pick up several car door parts, in a 10-12 meter corridor containing several stacks. She/he has to pick up the material needed for other workplaces and, in some cases, mount some parts together, add tags, etc.

In this workplace we envision to provide guidance to the worker exploiting several devices: Hololens, Magic Leap, etc.

A new visit to the plant and a more detailed work description will be made to gather all the information needed and start with the development.

6.2 Test setting for daily life

The WA projects previews to follow subjects during their daily life. So, a specific set of sensors will be deployed to a subset of the subjects involved in one of the use cases mentioned above. Subjects that will take part in this activity will sign a specific agreement.

In particular, we plan to collect information by means of:

- Home standard list:
  - Administering specific "daily life" questionnaires using a mobile device
  - Providing a smartband to obtain indication of sleeping habits and physical activation (steps/day). Data stored into the band will be periodically uploaded into the WA Tool system
  - Providing a body scale for BMI and weight
- Home extension list (optional):
  - Headband for brain activity
  - Enhanced wristband for hearth activity and galvanic skin response
  - Cameras for eye blink detection, facial expression, body posture and gesture recognition (teleworking only as the cameras should be moved)
  - Microphone for voice analysis
  - User location
  - Environmental sensors: noise, temperature, humidity, CO_2 and lux measurement

6.3 Privacy, anonymisation, and encryption

Privacy, data anonymisation, and encryption are very important for the WA project. In the following sections, we explain how we plan to tackle these matters (technical detains can be found in D2.3).

6.3.1 Ethics

Data Ethics concerns the usage of personal data by entities in charge of collecting them and entities who are granted rights to access them.

In this respect the usage of raw data measured from volunteers participating to the WA projects that will be shared by a subset of WA partners for research purposes aiming at achieving the project goals is explicitly declared in the consent forms.

The architecture of the WA Tool and the underlying hardware/software stack stores only encrypted data of which only the end-user and explicitly authorized partners have access to.

The amount of data to which each WA partner has access is kept at the minimum to provide the WA Tool services. The user will be in full control of his/her own data and will retain simply and technically enforced rights to data deletion.

No third parties will never be able to access the data stored on the end-user smartphone or on the WA servers unless allowed to do so by the end-user or a WA partner, respectively.

The ethical pillars of Data Ownership, Control over data distribution, and Right to obliviousness are strictly enforced in the WA project and in the WA Tool as the final users are the only entities in full control of data aggregation by the WA application on their smartphone.

Participation is voluntary and in case of refusal to participate, this will not have any consequences on the person.

Participants taking part in the research will be trained to correctly use wearable devices and the whole procedure will be explained by the responsible in the Company.

Participants will not be exposed to risks greater than or additional to those encountered in their normal lifestyles. The purpose of the WA tool is to detect possible situation of stress, therefore in case a risk is detected, the tests will be immediately suspended.

The WA Tool it is not a product to be used for the alleviation of illnesses or disabilities. Therefore, the WA App cannot be considered to be a medical device and as such it is not governed by the scope of the related normative of the Member State where the volunteers live.

6.3.2 Privacy

The WA project must be GDPR compliant. For that reason, privacy was one of the most important goals, from the very beginning of the project.

To be GDPR compliant, we plan to:

- Manage collected data so that only the WA partner that collected them can access them (encryption).
- Pseudo-anonymise users by means of an ID, and all recorded data refer to that ID. For each use case, a WA member (the WA use case manager) will maintain an encrypted file containing the mapping worker's name/ID; only that person will be able to access the content of the encrypted file.
- Prepare, administer, collect, and store informed consent forms.

6.3.3 Informed consent forms

We'll provide two consent forms, written in the local language:

- Involving users
  - Document addressing all data typologies collected by the sensors:
    - Measure
    - Elaborate
    - Store
  - Document addressing elaboration of data by means of a centralised DSS, in change of providing users with personalised advice. Each user involved in Field Tests must agree with these documents.
- Involving the company
  - Document addressing all data typologies collected by the sensors:
    - Measure
    - Elaborate
    - Store
  - Document addressing elaboration of data by means of a centralised DSS, in change of providing users with personalised advices. Each company involved into Field Tests must agree with these documents.

Detains will be provided in D7.1.

6.3.4 Data and consent form management

About management of measurements, our DMP previews that:

- Each WA partner will be Data Controller only for the measurement data that it directly generates and over which it has complete control.
- The consent form will specify the Data Controller for each processing of data and/or each type of data and will inform the subjects about the organisation and contact point associated with each Data Controller. Note that this is merely informative; in practice subjects will have one single contact for questions on privacy-sensitive data.

About the management of the consent forms, our DMP previews:

- One Data Controller per pilot site with the following tasks:
  - Consent form collection in company
  - Consent form validation and sending to BS
  - Point of contact for the users/Company
- BS as Data Processor of all the partners
  - Reception of the paper consent form, digitalization, and storing of the digitalized (and possibly paper) version of the consent forms

The participant's name, and the date of the participation, will be the only pieces of personal information entered on the consent form. The forms will include no participant-related reference numbers. It will not be possible from the forms, nor from the captured test data, nor from the combination of the two, to relate any element of the test data to any particular participant.

The voluntary participant has the **right to withdraw** the consent at any time. In this case, no further data concerning him will be collected, without prejudice to the use of those already collected to determine, without altering them, the results of the research or those that are not attributable to an identified or identifiable person.

The voluntary participant has the **right to ask the deletion of all data** measured from her/him by communicating to the WA contact point her/his anonymous user ID. In this case, all copies of the data related to the said anonymous user ID will be deleted.

6.3.5 Pseudo-anonymisation and encryption

The EU GDPR do not allow us to elaborate sensitive information about workers without their explicit consent. This fact particularly affects voice recording and cameras. From those sensors, in fact, it is possible to recognise the person under measurement. Moreover, voice recordings could contain very private information (person names, bank accounts, etc.)

To respect the data treatment directions mandated by the EU GDPR, the elaboration of the raw data collected through measurements will be performed as close as possible to the measurement base inside the company, employing dedicated machines (named "edge cloud") placed in the company by the WA partners.

For the Teleworking use case, the edge cloud could be split between the subject's home and the company facility[10]; data communications between the subject's home (sensors and home-base edge cloud) and the company-based edge cloud will go through a WA-provided VPN.

Data pseudo-anonymisation will be performed by the edge cloud: any measurement will be associated to an anonymous user ID (which is in turn generated by the WA App at the same time when the public/private key pair associated with the WA App installation is generated). Pseudo-anonymisation preserves data utility but make them unlinkable to the identity of the participant, in compliance with the best practices mandated by the GDPR.

The measured data, coming from sensors in their raw format, will be encrypted and stored securely on the edge cloud (associated to the anonymous user ID) in case the participant explicitly expressed her/his explicit consent to the use of them for research purposes and shared with the WA partners also authorized by the said consent.

[10] A trade-off between minimising costs (which suggests using a common, company-based edge cloud) and reducing bandwidth requirements (which suggests creating a per-user, home-based edge cloud).

Moreover, which WA partner will have access to the raw data will be clearly stated in the consent forms and will be the result of an analysis minimizing data sharing while allowing the WA project to achieve its goals. Data access control will be enforced by means of public key cryptography having the parties collecting the data first-hand re-encrypt the collected data so that they can be decrypted only by authorized WA partners.

Once the processing of the measured data is completed, the obtained results will be securely transmitted directly to the participant's WA App.

Personal data on the smartphone within control of the WA App will be encrypted and stored on a location of the said device in such a way that they remain accessible exclusively to the WA App. The owner of the WA App installed on the smartphone will decide and know the cryptographic key needed to decrypt them.

Finally, BS will manage a central cloud providing remote back-up functionality for the WA Apps. Again, communications will be encrypted, and data will be stored in encrypted form so that only the owner can decrypt and restore them.

6.4 Logistics and management

This aspect is about how to install and remove hardware and software. Moreover, we consider how to provide technical support for workers and maintenance for device failures throughout the whole test.

- Bringing hardware on the field
    - Servers
    - Sensors
    - Telecom infrastructure
    - Devices for running the WA App (smartphones)
- Installing hardware and software, and testing everything
- Managing sensor disinfection, to comply with the Country Covid-19 regulations.
- Removing hardware once the test is over

Moreover, during the test:

- Helping workers to equip with the sensors
- Managing the WA servers
    - Deployed at the company facility
    - Deployed at WA partners
- Managing the WA Tool modules
    - Installed at the company facility
    - Installed at WA partners

We defined the following roles: a **Company Manager**, one or more **WA Field Managers**, several **WA Server Managers**, and a **WA Use Case Manager**. Figure 9 shows the organisational chart.

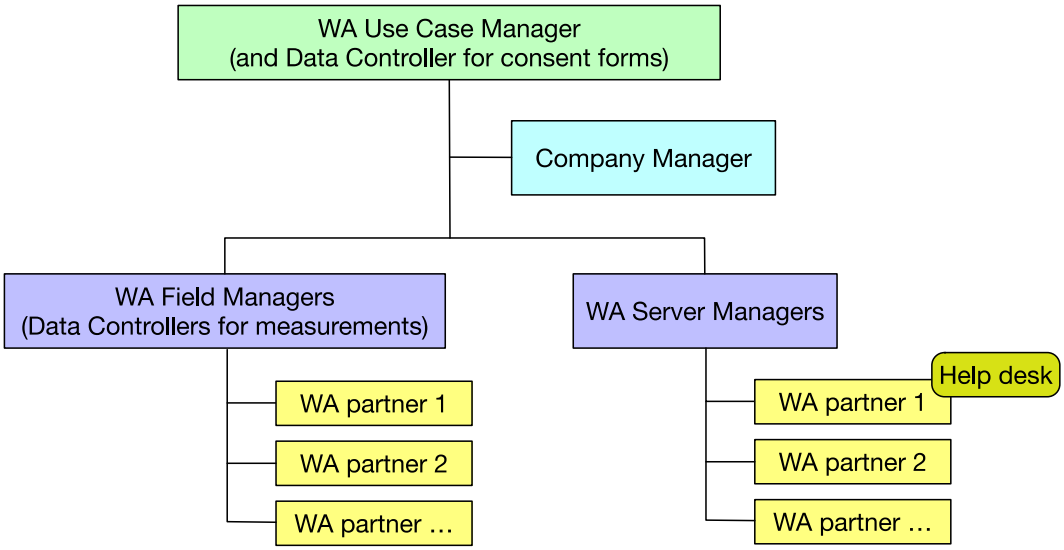

Figure 9 - Organisational chart, for a given use case

The WA Field Managers:

- Bring all the WA servers, WA telecom infrastructures, and devices for the WA App, to the company facility
- Install the WA Tool modules on the servers
- Bring the sensors; install the environmental sensors, in collaboration with the company maintenance staff
- Instructs the Company Manager about how to deploy wearable sensors, manage disinfection procedures, and use the WA App UI
- Test everything
- At the end of the test, remove everything

The Company Manager:

- Helps workers to equip with the sensors
- Instruct workers about the disinfection procedures
- Instruct workers about how to use the WA App UI
- Support the participants on topics about how data is managed by WA
- Moves the environmental sensors, when needed

The WA Server Managers (one for each WA partner deploying sensors or telecom infrastructure, or running the DSS; each WA partner is Data Controller for its own data):

- Monitor software installed in their edge cloud servers, and fix errors
- Monitor the WA telecom infrastructure
- One of the WA Server Managers will provide a remote "help desk" (via e-mail, Skype or related technologies), being the WA contact point for the Company Manager and the workers. The "help desk" will support workers in fixing issues with the WA hardware and software.

The WA Use Case Manager (Data Controller for the consent forms):

- Monitors that the whole WA Tool works well
- Maintains an encrypted file containing the mapping worker's name/ID, for that use case

- Administers the consent forms, for workers and company, which will then be safely stored by BS

The WA Field Managers are not required to stay at the company facility during the long-term Field Tests, whereas during the short-term Field Tests they (the whole group of WA Field Managers or part of it) will supervise the test.

Finally note that, to simplify the use case management, the same person could play several roles.

6.5 Time schedule

The time schedule for Field Tests can be derived from the Gantt chart in the DoA (see

Figure 10) and the methodology for involving companies described in Figure 11.

Notice that, due to the current Covid-19 disease and the "lockdown" applied in almost all European Countries, the time schedule could be delayed.

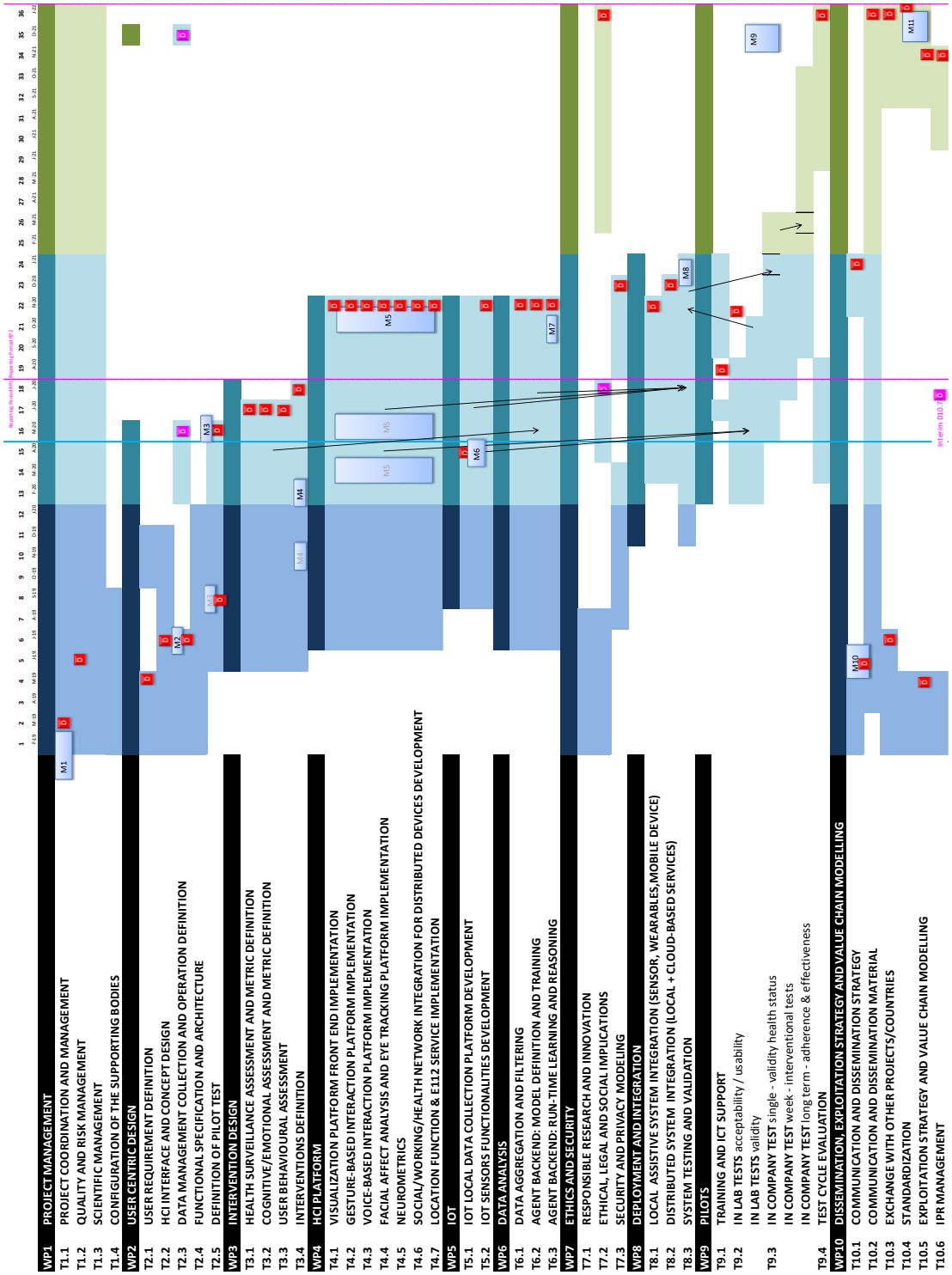

Figure 10 - WA general Gantt

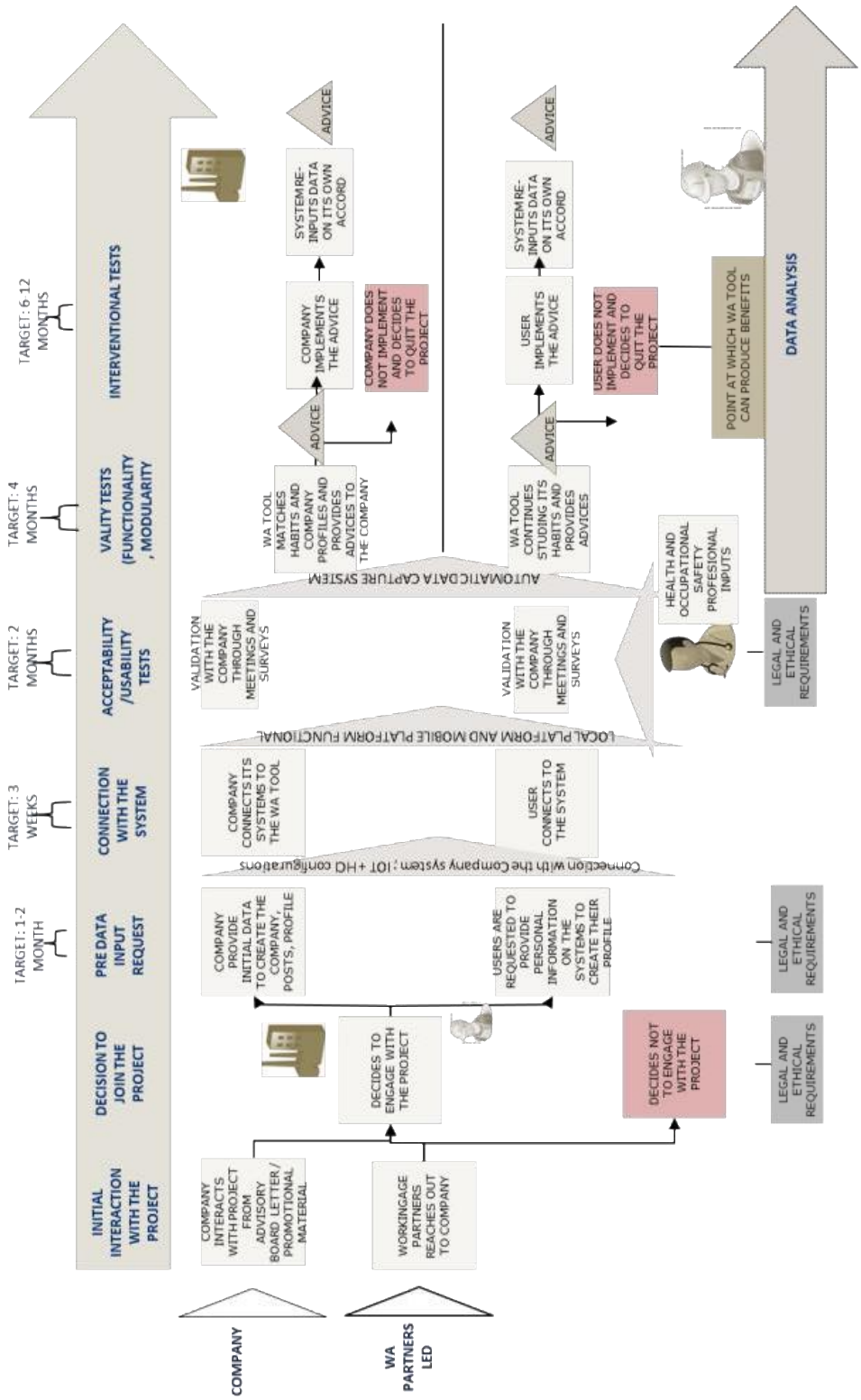

Figure 11 - Company implication in WA

Details about the schedule of the testing activities (including Lab Tests) can be found in Figure 12.

Notice that field studies on the three use cases will be conducted in parallel.

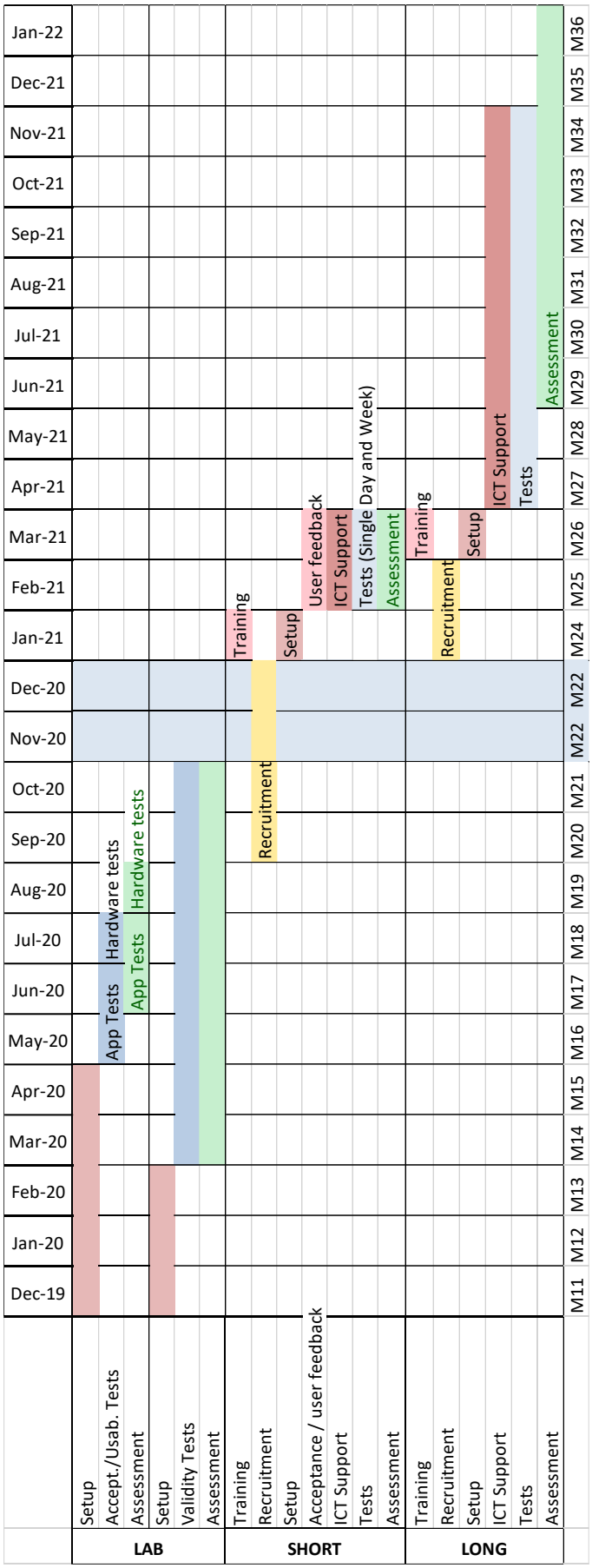

Figure 12 - Schedule

7 Short-term Field Tests

Field tests aim at assessing the WA system reliability, when deployed on the field. This chapter provides information that is specific to the short-term Field tests.

7.1 Goals

The main goal is to assess the WA reliability; in particular:

- Validating the acceptance of the tool by users (user-friendly, non-intrusive, not problematic for proper work conduction, etc.)
- Collect data to validate the data processing algorithms (for instance, validate that no false alarms are raised by the tool)
- Validate reliability of sensors, in particular in potential harmful environments (for example, under direct sun light)
- Validate the architecture of the system (local clouds, global clouds, databases managements, etc.) when deployed on the field; in particular: reliability and robustness

7.2 Recruitment

The WA consortium will need to organise a meeting at each company office to explain the system and the goals of WA and ask for their cooperation.

The main requirements for the recruitment are:

- Age 45+
- As specified in the DoA, we can't assure to properly support persons with special needs; in particular, when disabilities or impairments could make it difficult for the worker to wear the sensors or to interact with the WA App.

Starting from such requirements, each company will provide a list of possible candidates; then, the WA consortium will select the persons who will be involved into the project.

Note that gender aspects will be considered in the data analyses. However, because it is not straightforward to find a large enough sample of workers, it is decided not to put gender restrictions in the recruitment requirements. As a 'nice-to-have' requirement, in case the luxury of choosing participants exists, a gender-balanced group will be sought.

Table 10 shows how many subjects the WA partners will try to involve in short-term Field Tests, per use case (see deliverable D2.6 for further details about the population involved in the tests).

Table 10 - Involved subjects, per use case

Use Case	Office	Teleworking	Manufacturing
Involved subjects	15	5-10	15

7.3 Time schedule

The goal of the short-term Field Tests is to assess that all the WA Tool components are working as expected. Fields Tests are divided into:

- Single Day, aiming at testing the WA components;
- Week, aiming at testing the whole WA system.

The general time schedule is:

M16 (Sep 2020):	Beginning of recruitment
M20 (Dec 2020):	End of recruitment
M21 (Jan 2021):	Training and setup
M22 (Feb 2021):	Beginning of the acceptance test and single day / weekly tests
M22 (Feb 2021):	Beginning of assessment
M23 (Mar 2021):	End of tests and assessment

7.4 Testing protocols

Each component requires a different testing protocol; in particular:

1. Sensor hardware (e.g., the microphone)
2. Server hardware and software, for machines deployed at the company facility (edge cloud)
3. Network infrastructure installed at the company facility
4. Device for running the WA App (smartphone)
5. Questionnaires
6. The whole DSS loop: sensors → information → DSS → advice

Such protocols will be provided by:

- For components 1 and 2, each WA partner will provide a protocol to be adopted for effectively testing everything.
- For component 3, GC will provide a protocol.
- For component 4, UCAM will provide a protocol.
- For component 5, INTRAS will provide a protocol.
- For component 6 (i.e., for testing that the whole WA Tool is working properly), the WA consortium will agree on a protocol.

Notice that here as "protocol" we mean a document specifying the test procedures to apply, the expected results, and how to address issues.

Details will be provided in D9.1 Pilot Operational Manual.

8 Long-term Field Tests

Field tests aim at assessing the system effectiveness, when deployed on the field.

This chapter provides information that is specific to the long-term Field tests.

8.1 Goals

The main goal is to assess system effectiveness, when deployed on the field; in other words, understanding whether the WA Tool is able to reduce user's strain, by advices about stress management, body postures, and environmental control.

All the use cases will permit to highlight issues related to:

- Mental stress
- Physical strain
- Environment conditions

However, each use case, due to its very nature, will be more suitable for one or more of these issues.

8.1.1 Use case: Office

This use case is focused on body posture and mental stress.

Advices generated by the WA Tool could be in "real time" (i.e., proactively provided as soon as the system discovers that they are useful) or "offline" (for example, as a report provided at the end of the shift). The worker could also ask the WA Tool for any "pending" advice.

8.1.2 Use case: Teleworking

This use case is focused on body posture and mental stress, comparing the results with the Office use case.

Advices generated by the WA Tool could be in "real time" (i.e., proactively provided as soon as the system discovers that they are useful) or "offline" (for example, as a report provided at the end of the shift). The worker could also ask the WA Tool for any "pending" advice.

8.1.3 Use case: Manufacturing

This use case is focused on body posture, physical strain, mental stress, and environment conditions.

Advices generated by the WA Tool could be in "real time" (i.e., proactively provided as soon as the system discovers that they are useful) or "offline" (for example, as a report provided at the end of the shift). The worker could also ask the WA Tool for any "pending" advice.

8.2 Recruitment

The WA consortium will need to organise a meeting at each company office to explain the system and the goals of WA, and ask them for their cooperation.

The main requirements for the recruitment are:

- Age 45+
- Possibly, gender-balanced group. Note that, because it is not straightforward to find a large enough sample of workers, this requirement is not strictly enforced. It is a 'nice-to-have' requirement: in case the luxury of choosing participants exists, a gender-balanced group will be sought.
- As specified in the DoA, we can't assure to properly support persons with special needs; in particular, when disabilities or impairments could make it difficult for the worker to wear the sensors or to interact with the WA App.

Starting from such requirements, each company will provide a list of possible candidates; then, the WA consortium will select the persons who will be involved into the project.

Table 11 shows how many subjects the WA partners will try to involve in the long-term Field Tests, per use case. Special attention will be given to optimise the number of teleworkers and seek balance between the use cases (see deliverable D2.6 for further details about the population involved in the tests).

Table 11 - Involved subjects, per use case

Use Case	Office	Teleworking	Manufacturing
Involved subjects	30	10-20	30

8.3 Time schedule

The goal of the long-term Field Tests is assessing the system effectiveness, when deployed on the field; workers will be involved in a 11-months long test.

The general time schedule for the long-term Field Test is:

M21 (Jan 2021): Beginning of recruitment

M22 (Feb 2021): End of recruitment

M23 (Mar 2021): Training

M23 (Mar 2021): Setup of the environment

M24 (Apr 2021): Beginning of activities for long-term Field tests

M24 (Apr 2021): Begin ICT support

M29 (Jun 2021): Begin assessment

M34 (Nov 2021): End of tests

M34 (Nov 2021): End ICT support

M36 (Jan 2022): End assessment

8.4 Pilot protocol

The WA consortium will agree on a common protocol for testing the WA system; as "protocol" we mean:

- A document specifying how to conduct and manage the long-term Field Test: procedures to apply, documents to provide to the workers and the company, and how to address any issues. This deliverable will be the starting point for that document.
- A document specifying how to evaluate the effectiveness of the whole WA Tool. D2.6 will be the starting point for that document.

The two documents above will be part of the final pilot protocol, which will be described in D9.1 Pilot Operational Manual.

Bibliography

[1] Y. Rogers, H. Sharp, J. Preece. Interaction Design. Beyond Human-Computer Interaction, 3rd edition, Wiley, 2011

[2] S.G. Hart and L.E. Staveland. Development of NASA-TLX (Task Load Index): results of empirical and theoretical research. In P.A. Hancock, N. Meshkati (Eds.), Human Mental Workload, Elsevier Science Publisher, North-Holland, pp. 139-184, 1988

[3] F.R.H. Zijlstra and L. Van Doorn. The Construction of a Scale to Measure Perceived Effort. Technical Report. Delft University of Technology. 1985

[4] Scherer, K. R. What are emotions? And how can they be measured? Social Science Information, 44(4), 693-727, 2005

[5] J. Brooke. SUS: a "quick and dirty" usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester, and A. L. McClelland (eds.), Usability Evaluation in Industry. London: Taylor and Francis, 1986

[6] D. de Jonge, M. J. Scherer, and S. Rodger. Assistive Technology in the Workplace. Mosby Elsevier, 2007