Ageing@Work

Smart, Personalized and Adaptive ICT Solutions for Active,

Healthy and Productive Ageing with enhanced Workability

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Requirements and use cases

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Executive Summary

This deliverable is related to task "T2.1. Worker needs, industrial requirements and use cases" of Ageing@Work, which deals with the formulation of the basis of the user-centred approach that will be followed throughout the project. This activity focuses on the detailed analysis of the users' needs and specifications, alongside with the industry requirements, and the use cases, in order to establish the user requirements for the smart, personalized and adaptive ICT solutions for active, healthy and productive ageing with enhanced workability of the Ageing@Work project.

The main achievements of this document are:

- The proposal of a common methodology to discover the workers' needs in the proposed pilots, define the use cases and requirements, to feed the design and development of the Ageing@Work project
- The analysis and identification of the workers' needs related to their aging process in the mining and factory environments.
- The definition of the pilots, the personas and usage scenarios of each pilot
- The definition of common use cases to be applied in each of the pilots.
- The elicitation of the requirements related to the use cases.

A series of Annexes is provided at the end of the deliverable with regard to the inclusion/exclusion criteria of the target end users of the AGEING@WORK project, the informed consent and the procedures of the workshops, as well as the questionnaires that were used in the scope of the user surveys to conclude the deliverable.

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List of Terms and definitions

Abbreviation	Definition
AI	Artificial Intelligence
ANEFA	Asociación Nacional de Empresarios Fabricantes de Áridos (National Association of Aggregates Manufacturers)
AR	Augmented Reality
DR	Design Requirement
FR	Functional Requirement
IR	Interaction Requirement
R&D	Research & Development
RQ	Research Question
SAG	Siemens
SW	Software
UC	Use Case
UsReq	User Requirement
VR	Virtual Reality
WS	Workshop

Table 1 Definitions

1. Introduction

The Ageing@Work project, focuses on the need to adapt the working conditions of the workers older than 45 years old, to the new needs that arise from their ageing using ICT tools that will help tailoring working conditions to the changing needs of the workers as they age. The integrated system will be developed in accordance to a user-centred design process and evaluated in the two pilot sites with regard to core Industry 4.0 processes of mining and machines production.

1.1 Scope of the deliverable

The purpose of the present deliverable is to report the needs of the targeted users and managers alongside with the industry requirements, as well as the project use cases derived from the conducted analysis. In this line, this deliverable reports the results of the user requirement collection and analysis performed with the aim to identify the requirements and expectations of the Ageing@Work target user group (open pit miners and industry workers) and on this basis, define the expected use cases in the context of everyday activities of this user group. Finally, a prioritization of use cases was performed based on the results of the surveys and focus groups.

1.2 Relation to other activities and deliverables

This deliverable is the first step in the WP2 "User requirements, system specification and architecture, that will be developed from month 1 to month 33. It will provide the basis to D2.2 "enabling and motivating approaches, technologies and current supportive tools", which performs an analysis of technologies and tools that are used to help workers into workability, support active and healthy lifestyles or to schedule daily life. Also, it will be the basis to the D 2.3 "system specifications and architecture", as it will be built upon user requirements in line with the prioritization of D 2.1.

1.3 Structure of the deliverable

The deliverable is structure as follows. Chapter 2 describes the methodological approach proposed by Ageing@Work project. Chapter 3 presents the results of the Pilot working environments description, based on the pilot partners experience, real life workers and workplaces specifications and literature review. Based on the results of the previous chapter, Chapter 4 define the pilots Personas and scenarios, that have served as tool to present the information to workers during the surveys. The results of these surveys are available in Chapter 5, with the preliminary use cases definition that is presented in Chapter 6.

Chapter 7 presents the methodological approach to make different workshops with the workers as part as the co-creation framework used in Ageing@Work, as final step before to present the user requirements (Chapter 8) and the final Use cases (Chapter 9). Finally, Chapter 10 presents the conclusions.

The text material, questionnaires and surveys used as part of the work during surveys sessions and workshops is in Annexes section at the end of the document.

2. Methodology

User centred design methodology is described as a multi-stage problem solving process. In case of the Ageing@Work project, it comprises three different stages, in which each one feeds the next step.

In order to design a solution such as the proposed Ageing@Work system, it is essential to know the problems of the sector, workplaces and the needs of potential users. That is why it has become necessary to capture these specifications of both sectors involved in the end users side of this project, that of the extractive industry and that of the factories, in order to serve as a basis for guiding the rest of the research. Alongside, a research on the literature was carried out on related projects, publications, documentation and other public and private initiatives relevant to the aging of workers.

As such, during the first step, Ageing@Work designers have tried to discover the context of use and the final users' global requirements (in terms of characteristics). Literature review, real pilot sites working conditions description and pilot partners' experience were gathered to define Personas and preliminary needs to guide the survey and the focus groups in the next steps.

During the second step of our approach, a set of surveys, focused on the people that will potentially participate in the pilot sites as users, were performed with the objective to understand their needs, preferences and attitudes to technology, so that we could describe a set of preliminary use cases of interest for the final users.

Finally, focus groups were also performed, in order to allow us to better understand experiences, consider motivational aspects and real settings elements, so that we could define final use cases and requirements for Ageing@Work technology. The following figure shows the structure of the methodology followed to find out the requirements of the Ageing@Work solutions.
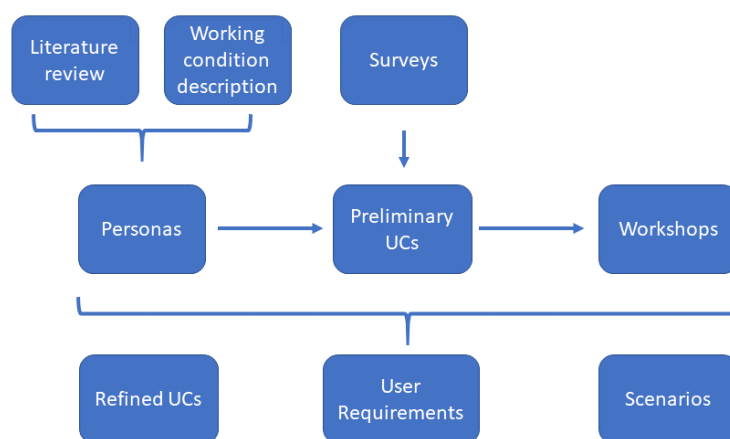
Figure 1 Methodology schema

The table below summarizes the participations of users in the surveys and focus groups.

Table 2: Number of participants in the focus groups and surveys.

Participants	Extractive industry workers	Factory workers
Moderated discussion/ Focus Groups		
ANEFA (Spain)	5	
Siemens (Germany)		9
Surveys		
ANEFA (Spain)	101	
Siemens (Germany)		33

The following sections are devoted to explaining the specific procedures and results in each of the steps that were employed in our user requirements and use cases definition approach at this stage of the project. Next version of this deliverable (D2.6 User requirements and use cases v2) will present the results over the next interaction of the user centred design methodology proposed in this deliverable.

3. Pilot working description

This section describes the current working conditions in the two pilots sites deployed in Ageing@Work project. The first one is a Mining - Quarry exploitation and quarry treatment factory (Outdoors) in Madrid (Spain), where workers perform some physically demanding tasks and operate heavy machinery under extreme weather conditions, and the second one is a Factory - Machines operation (Indoors), where workers are in complex machine-based environments, stressful and very noisy.

The objective of this preliminary description of the pilot sites working conditions is necessary to establish some parameters to guide the literature research. In this line, in what follows, first the description of the extractive industry is provided, followed by the description of the factory workplace and workers specificities. The third part of this section concludes with the outcomes of the relevant literature review that was performed in this context.

3.1 Extractive industry workplace and workers

3.1.1 Workers in the extractive industry

The extractive industry is that it is a highly specialized sector in which jobs are acquired with experience in machinery management. It is an unattractive sector for young people, due to the harsh conditions and it is gradually aging. The pilot site in the extractive industry will be focused on aggregates subsector. The following main roles can be found in this type of mining areas:

- Managers & Technical staff: The usual responsibilities of workers who respond to this profile are planning, verification and supervision of the works to be carried out in the plant. The worker is also responsible for developing, implementing and maintaining a prevention system at the plant.
- Drilling / Cutting / Blasting operators: they oversee preparing and executing the blasting to tear the material from the rock.
- Mobile machinery operators: extraction / load / transport: worker in charge of driving the machine (loader, tipper, backhoe), to load and transport the material from one side of the farm to another.
- Mechanical and / or electrical maintenance operators: workers in charge of the maintenance tasks that check and repair the equipment of the operation. These works are carried out both on the ground floor and in the workshop.
- Plant operators: crushing / milling / grinding / classification / washing: the operator is responsible for verifying the status of the equipment before the start-up, the absence of people in the areas of operation, starting and stopping the plant, and ensure the well-functioning of the operation.

- Laboratory operators' people who work in the laboratories of the sites usually work with several teams, making the different samples, for their subsequent treatment depending on the analysis to be performed.
- Administration and personnel of services other than maintenance: people who perform administrative tasks. The service personnel perform different functions, which, even though they are not the central activities of the operation, are necessary for the operation.

Other personal in extractive Industries are:

- Operators of ornamental rock plants.
- Oil or gas production operators.
- Separation and concentration operators.
- Furnace operators.
- Mixing operators

Each worker performs one or more jobs in a daily basis. The facultative director or manager plans the work to be done for two or three days in advance, and the foreman , more closed to the workers, distributes them among all the workers, taking into account, in addition, the maintenance plan of the equipment and facilities, as well as the possible breakdowns that may arise or even weather conditions, which can influence the development of the task on a particular day.

The main risks for the workers in the extractive industry, according to the statistical data published by the Spanish Ministry of Labour, Migration and Social Security (Minetur), can be summarized as follows:

- Slipping, tripping hazards
- Working at height
- Flammable gases
- Electricity
- Noise
- Vibration
- Stress
- Machinery/work equipment
- Entrapment in machinery like conveyors, crushers and screens
- Run over by heavy vehicles
- Hand tools
- Transport
- Pressure systems
- Manual handling
- Chemicals
- Dust and Fume
- Confined spaces

- Repetitive manual work
- Temperature
- Lifting Plant

So the operators have to use a personal protection equipment (PPE) consisted on a Safety helmet and Auditive protectors:

- Abdominal anti-vibration belt
- Safety gloves
- Non-slip safety footwear
- Workwear
- Safety glasses
- Filtering mask

In certain cases, the operator may have other additional protection equipment and must be familiar with them and trained accordingly.

3.1.2 Prototyping Open cast extractive

The Ageing@work pilot is planned to take place in an Open cast extractive. The activity in this type of mining is unlike the underground mining, carried out on the surface. This extractive industry presents some peculiarities both in the process of drilling and transport, with workers having to withstand outdoor working conditions (with extreme temperatures, rain, snow, etc., dust in the summer months and mud in those of rain and snow).

Depending of the sites, different techniques are used, with the involvement of different types of machines, mechanical equipment, even explosives. The process of treatment of aggregates allows to obtain finished products suitable for consumption. It is a highly automated and technologically complex process, since many disciplines intervene in it. However, as to its basic principle, it can be said that it is simple, since it consists of crushing and milling the "all in aggregate" from the site to obtain smaller sizes and classify them in order to store each particle size separately. In some cases, it is necessary to wash the material to improve its properties.
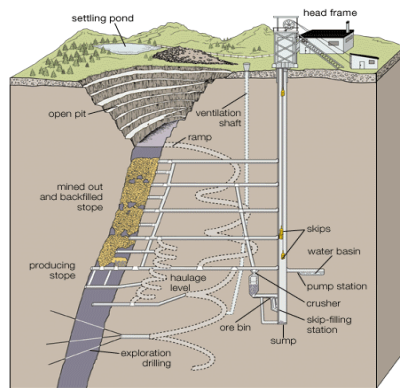
Figure 2: plane of a quarry

The open-pit mining and loading operations aim to carry out the necessary tasks in such a way that the material on the front of the mine, if necessary after drilling and blasting has been carried out, is drawn off directly through the mine with a hydraulic excavator, loaded into the transport equipment with a loader or hydraulic excavator and loaded back into a truck or dumper to be transported. The wheel loaders and hydraulic excavators are used to extract and load these materials. The operators that handle them must have specific knowledge to carry out their task in safety conditions.

The process of transportation in a quarry aims to perform the necessary tasks so that the material is transferred to different places. For this purpose, the used equipment consists on trucks, which depending on a series of characteristics, must meet certain regulatory requirements to be able to carry out the work in safety conditions.

The treatment plant equipment can be grouped into two categories: fixed equipment and auxiliary equipment:

Table 3: Treatment plant equipment

Fixed equipment	Auxiliary Equipment
Hoppers	Cranes and hoists
Feeders	Compressors
Crushing and gridding equipment	Mini shovel loaders
Screens	Lift platforms
Conveyor belts	Hydraulic Hammers
Washing equipment	Hand tools
Motors and pumps	
Electrical installation	
Control Systems	
Drilling machines	

In the open cast, the work is distributed in different areas. The office is typically placed at the entrance of the site in which, in addition to completing the bureaucratic tasks of the exploitation, the weighing scale of the trucks is controlled. In the same area is the parking space of those vehicles that should not circulate through the exploitation. In this area the common facilities are located, such as locker room, services, storage, dining room, first aid kit, etc.

Figure 3: mobile machinery

Once inside, we can find the mechanical workshop with its generator sets and compressors, the storage area and machinery parking, as well as the water and fuel deposits.

Next, if the site has a treatment plant, it will be located with its feeding hopper, crushing equipment, grinding, separation, classification, conveyor belts, etc., its decanting ponds and other auxiliary elements. From this point the vials will take us to the areas of site that will lead by branches (accesses) to the different site fronts where minerals are plucked and loaded.

As it can be noticed, an open cast site, although not very large, has a diversity of work equipment, each one with its specific risks and whose operators will have to be trained adequately to perform their work in conditions of safety and health, both for the operator himself and for all the workers of the quarry.

In addition, to the hazardous workplace, the weather conditions affect workers in these extraction areas, with extreme temperatures, rain and windy conditions, etc. In case, of the Ageing@work pilot, that will take place in Madrid (Spain) area, with a Mediterranean climate, with extreme temperatures, very hot in summer (over 35º) and cold winters (below 0º) and heavy rainstorms during spring and autumn.

Safety in aggregate sites, which is taken into account in the early stages of the project, is a social and legal requirement and should be a sign of companies´ commitment to their employees. For this reason, there are more and more cases of good practices in the prevention of occupational risks. Since compliance with regulations on occupational health and safety is not an option but an obligation of the employer, it is essential to adopt measures to ensure the training, updated information and right to consultation of workers. In fact, in mining we are governed not only by general legislation, but we also have a specific regulation of basic mining safety standards that must be complied with.

The simple fact of not adopting any of the measures established in the law or doing it insufficiently would make the employer to be directly responsible for the damages caused to the workers.

3.1.3 Ageing in the extractive industry workers

As can be deduced from the text so far, the working conditions of the extractive industry, although they have improved substantially in recent years, are hard and demanding conditions and can cause serious deterioration of the workers´ health who end up manifesting in the Long term, this is when they can already be considered as ageing workers.

There are no official statistics regarding the most serious ailments presented by older workers in the extractive industry, so we must rely on the results presented by other related sectors, such as the construction sector, and our own experience. The following sections describe problems that aging workers experience when working in the extractive industry.

Issues according to the deteriorating physical abilities.

- According to statistical data, workers lose between 15% and 20% of their strength in the period of age between 30 and 60 years.
- In a sector such as extractive, the use of force is essential for the handling of heavy machinery and for the development of productive processes.
- Miners must keep their agility and flexibility longer than a normal worker, given that in the repair and access to fixed and mobile machinery, they must make great physical efforts.
- Ageing workers can present musculoskeletal problems with joint deterioration due to the vibration produced by machinery and controlled explosions.
- Quarry dust can cause respiratory problems.
- The noise of the quarries, caused by the functioning of the machinery and the controlled explosions, can produce severe hearing loss.

- The longer the worker is subjected to these noises and vibrations, the greater the adverse effects on his musculoskeletal health and hearing. Therefore, older workers have the greatest hearing loss and musculoskeletal problems.

Issues according to learning & cognitive functions:

- Machinery in the extractive industry is, if not the most important, one of the most important investments of the entrepreneur. Therefore, many years pass between the renovation of one machinery and another, so it is harder for workers in the extractive industry to adapt to technological innovations and changes. A support tool in learning or in adapting to changes is essential for the extractive sector, in which an oversight of a worker in the use of heavy machinery can prove fatal.
- Older workers may have memory problems that can result in carelessness or forgetfulness. This, in a sector like the extractive can prove fatal since heavy and dangerous machinery is being handled.
- Hearing problems of older workers can have adverse effects on the worker's ability to communicate and understand, which can cause stress and anxiety.

3.2 Factory workplace and workers specifications

The Siemens pilot of the Ageing@Work project focuses on workplaces in factories. Factory workplaces vary significantly depending on their produced items. While in some factories production machines and/or robots dominate, other factories still have huge amount of manual work to do. For our Pilot in Ageing@Work we considered a factory which has both types of workplaces. The envisaged pilot factory is producing a huge amount of different parts (some of them are produced since 1959) and some of them with an extreme small quantity.

The following chapter describes two typical workplaces in this factory.

3.2.1 Factory Workplaces

Factories are complex environments in which many different workplaces work together, in a coordinate way, to perform a global task. Following, two of these tasks are presented as a representation of factory workplaces for Ageing@Work piloting purposes.

3.2.1.1 Machine tool workplace

The Siemens pilot focuses on workplaces at production machines, manual assembly of PCB, relay adjustment and related distribution work. The typical production machine workplace consists of different machines in an industrial environment setting that need to be equipped with tools, be programmed and observed. Typically, workers need to observe several machines at the same time.

After loading the program, which is required to manage the respective production step, the machine needs to be set up accordingly. To get the machines ready, one needs to check which tools are needed, walk to the tool stock and collect the required tools and bring them to the machine and equip it.

Workers have to either remember which tools have to be fetched, or they write it down somewhere e.g. on a sheet of paper. In the next step the work piece needs to be clamped into the machine. At the beginning of the machine operation several calibrations need to be done manually. This is mostly based on experience of the users.

Figure 4: Worker operating a machine

When working on some machines, the workers have to go to several locations e.g. when working in the work room, they have to go to the control panel to operate the controls and get back to the machine room. This is annoying and takes time and it is performed in a busy, sometimes stressful, and noisy environment. However, mobile devices are not really a solution, because the workers need to have their hands free.

At the same time users get only limited support during operation, e.g.

- Determination of the required tools (not automatically),
- Provision of the necessary tools,
- Input of the tool data and the installation of the corresponding tools into the machine are separate steps
- Acquisition of the tool data

One of the main challenges is the increasing complexity: Production machines have become more and more complex. Despite of this development there have been no fundamental improvements on the

operating concepts. Therefore, the requirements for the workers have increased steadily. Especially for older employees and young professionals, it became difficult to keep up with the new technologies.

Figure 5: Worker in workroom

3.2.1.2 Manual PCB assembly workplace

PCB assembly is a manual work therefore the typical workplace for the manual PCB assembly consists of a special table aligned with various boxes containing the parts. The workers have to equip the PCB with the electronic components. Some workplaces have an automatic laser pointer that guides the worker in placing the right parts at the right place.
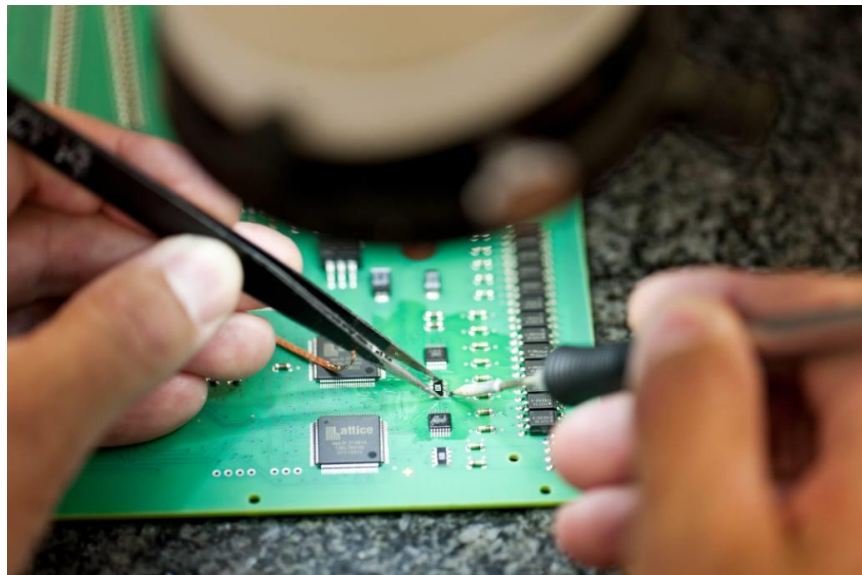
Figure 6: Manual PCB assembly

3.2.2 Collective and individual protection equipment

Collective Protection Equipment

Access to the factory floors is generally only permitted to previously trained personnel or – in case of customer visits for example, along with a trained person and a previous safety briefing. Inside the factory there are marked paths for people to walk on, machines to stand on, materials to be stored on etc.. Further examples of collective protection in the factory floor are:

- Marked paths on the ground guiding the workers
- Marked work zones, machine zones and material zones
- Handrails, stairs and walkways
- Acoustic protection barriers (e.g for cubes in the factory)
- Fire extinguishers
- Lighting and acoustical sings at machines, doors or any sort of vehicle
- Training and/or licenses are required depending on the machine
- Often, machines have to be certified by TÜV, in general there are continuous in-house and/or partner-scheduled machine maintenance intervals

Figure 7: Emergency Stop

- Every machine (or in general, everything operating highly automated) has an emergency stop (Figure 7)
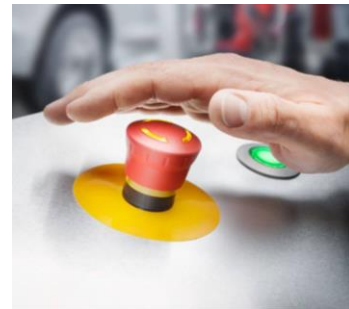
Individual Protection Equipment

- Safety helmets
- Steel caps shoes
- Earplugs
- Safety goggles or safety glasses (for some machines)
- Antistatic, non-slip safety shoes and clothing

3.2.3 Prototyping Laboratory Office

To be able to evaluate Ageing@Work technologies very early during the project, Siemens is planning to consider also a small laboratory Siemens Maker Space (SMAC) containing several prototyping tools such as 3D printers, borer, laser cutter, other types of cutters, soldering iron, etc. This room is much smaller than any of the fabric rooms and allow faster access for evaluators. This laboratory has been arranged with the aim that all Siemens office employees of different ages and with different background can learn and try new technologies and obtain new qualifications. In this room, more experienced makers help newbies during the operation, configuration, and maintenance of the equipment.

Figure 8: Prototyping laboratory Maker Space

Although this laboratory has limited size and small number of equipment, safety criteria are still crucial for all office employees who want to exploit any machine. There are different potential hazards, and all participants must take mandatory safety training for this room.

Figure 9: Working with laser cutter and soldering at Maker Space

Currently, all safety trainings and usage instructions are performed live on site. It is easy for newbies to miss some points and run into a risky situation when operating equipment later on their own. All instructions are distributed among many sources, online as well as off-line. It is also difficult to find a proper expert available when assistance is needed, or a risky situation occurs. The electronic devices (3D printers) are not secure enough and not allowed to be connected to the Siemens intranet. So, they can only be used off-line, which makes the remote monitoring very problematic.

3.2.4 Ageing in the factory workers

With increasing age, the abilities and physical characteristics of humans change, motor, sensory and cognitive abilities decrease, slowly but noticeably. According to Saup (Saup, 1993) people over 35 have an increased need for light from 40 onwards; this is accompanied by increased sensitivity to glare and reduced depth perception. The same is true for hearing; the first hearing loss occurs at the age of 32 for men and 5 years later for women. Thus, already younger persons, who are typically in the middle of their working life, experience a decrease of their sensory abilities. In the context of an ageing society and a shortage of skilled workers, it is important for everyone to design age-appropriate workplaces because sooner or later everyone will benefit accordingly.

The following sections describe problems that aging workers experience when working with production machines in factories:

Issues according to learning & cognitive functions
(dual-task activities, memory decline, decreased information processing, increased reaction time)

- Multi-machine operation is not only stressful and unpleasant, it also requires concentration, agility and a strict time management.
- Sometimes calibration is an iterative process: Workers need to change several times between working room and control unit following a predefined order.
- Incomprehensible error messages, which do not support a fast removal of disturbances and problems
- Use of abbreviations whose meaning is unclear

Issues according to the decreasing physical abilities
(decreasing muscle strength and reduced mobility/flexibility)

Machine operator or service technicians have to constantly move between the control panel, control cabinet and the machine's sensors or drive technology for fault analysis and troubleshooting. With decreasing physical abilities this can be exhausting.

Some machines require the workers to climb into the working room to be able to fulfil certain tasks.

Figure 10: Control panel

Issues according to the decreasing sensory abilities
*(*visual acuity, depth perception, contrast sensitivity, noise detection etc)

- The increased need of light and time for clear perception of objects is a major issue when continuously changing the position: Some machines require the workers to climb into the working room to fulfil certain tasks, go back to the control panel and if necessary, climb back into the machine again.
- The working room is not always well illuminated (e.g. shadows by reaching into the room).
- Insufficient contrast between workpiece and machine floor or clamping device.
- Small font sizes and symbols on the control panel of the machines as well as the lack of a zoom function are another issue based on the decrease of sensory abilities: older users in particular are not always able to easily see what is being displayed.
- Readability of G-Code partly problematic because of font (Differentiation between 0 and 8 is especially difficult for older users, since the 0 has a crossbar).
- Similarity of the digit 0 and the letter O occasionally leads to incorrect entries which are only recognized later. Confusing the commands "GO" and "G0" does not immediately lead to the recognition of a syntax error.

Table 4: Issues with increasing age and vision

Age	20	30	40	50	60	70	80	90
Vision								
Increased need of light		35 →						
Decreased accommodation range			40 →					
Increased sensitivity to glare			40 →					
Reduced adaption to glare			40 →					
Reduced depth perception			40 →					
Reduced visual acuity				50 →				
Reduced adaption to darkness				55 →				
Limitation of the visual field				55 →				
Increased time for clear perception of objects				55 →				
Reduced color perception						70 →		

Source: Saup W., Alter und Umwelt: eine Einführung in die ökologische Gerontologie, 1993, S. 76

Table 5: Issues with increasing age and hearing and touch

Age	20	30	40	50	60	70	80	90
Hearing								
Reduced hearing ability (men)		32 →						
Reduced hearing ability (women)		37 →						
Susceptibility to background noise			45 →					
Reduced ability to discriminate and follow speech						70 →		
Old-age-related hardness of hearing						70 →		
Severe disfunction of speech perception								90 →
Touch								
Reduction of tactile corpuscles	20 →							
Gradual deterioration of skin sensitivity		30 →						

Source: Saup W., Alter und Umwelt: eine Einführung in die ökologische Gerontologie, 1993, S. 76

3.3 Literature review

Recently, an economic need and a greatest interest has been created for older adult workers to remain in the labour market. The demographic transition in recent years towards a more aging population has been fast and intense not only in developed countries but also in low and middle-income countries. In the upcoming decades, a quite significant number of people aged 60 years and older will be living in important emerging economies, such as those of India, China, and Brazil *(Le'gare, 2015)*. The trend towards a shift in the proportion of the older population compared to the overall population has occurred in many countries and there are expectations that this may result in numerous health and socioeconomic challenges *(Le'gare, 2015) (World Health Organization, 2015)*. A good example of the challenges is the increased number of years lived with disability and in the disease burden.

In addition, there is an increased demand for social services and health care as a result of the rise in life expectancy and an extension of the life cycle *(Kluge, 2014)*, *(World Health Organization, 2015)* worldwide. This will further create several issues relevant to countries with low and middle income, where the social security system has a wide coverage.

Furthermore, the rise in the number of years before retirement has maintained a steady increase of older workers in the labour market. The decision to continue to work can be found in various reasons such as financial needs, the nature of the work as well as the desire to maintain power and prestige when older *(World Health Organization, 2015)*.

Due to the above reasons, the role of work as marker of active aging society being physically and mentally healthy has been appointed as highly important *(Robroek, 2013)* *(World Health Organization, 2015)*. Older adults, irrespectively of the reason will continue to participate to a greater extent in the workforce *(Warren, 2008)*. However, age-related changes, multiple chronic diseases, unhealthy habits, cognitive impairment may contribute to negative health outcomes in older workers *(Padula, 2013)* and thus to the well-being of the older workers and the society.

The following section we review the challenges that the working workforce is facing currently. In Annex, we have a summary of the review research we have done in these sections.

3.3.1 Physical Health

Older workers differ from younger ones in several important ways physically that might have an impact on their safety and health at work. Some of the ways are the following: 1) age dependent increases in various ''abnormal'' conditions (e.g., coronary artery disease), 2) normative effects of aging (e.g., loss of visual acuity), 3) age related body changes from decline in brain cell connections to decrease in muscle mass. Maximum physical strength is at age 20–30, gradually declining until 40–50 and from 50 and on even more quickly *(M M. , 1998)*. Resistance to heat and cold stress, pulmonary oxygen uptake, bone density, exercise capacity, visual acuity and many other physiologic functions decline predictably with age. The prevalence of work-limiting disabilities increases with age, from 3.4% of workers aged 18–28 to 13.6% of those greater than 60, according to the National Health Survey.

In a most recent survey, the Spanish Foundation for the Prevention of Occupational Risks found that the most diagnosed pathologies for older workers are: arthritis and osteoarthritis, hypercholesterolemia, chronic back pain and diabetes. The diseases that increase significantly from the age of 55 are osteoporosis, heart attacks and strokes; cataract; embolisms; lung diseases and other heart problems. In general, older workers suffer mostly from back and neck, knees, limbs, hands and feet pain *(Spanish Foundation for the Prevention of Occupational Risks, 2015)*.

A research review of the European Agency for Safety and Health at Work revealed that while most jobs do not require workers to work at full physical capacity, some older workers with physically demanding jobs may be working at (or close to) the limit of their capacity and may, therefore, be more at risk of musculoskeletal injuries or chronic fatigue than their younger counterparts. In general, the prevalence of musculoskeletal disorders (MSDs) increases with age, probably as part of the normal ageing process. Furthermore, some age-related changes could result in increased risk under certain circumstances, for example exposure to extreme temperatures or driving at night *(European Agency for Safety and Health at Work , 2016)*.

3.3.2 Cognitive Ability

The impact of age on cognitive function is more complicated. Psychologists distinguish cognitive functions in two major groups, the ''fluid'' functions which involve processing information at the time of performing a task and there are age dependable and the ''crystallized'' cognitive functions which are the cumulative results of earlier learning and thus are better preserved with age. Some examples of ''fluid'' mental processes are processing of complex stimuli, problem solving and spatial abilities. Multitasking or holding multiple items in working memory are some more examples of fluid processes. Cross sectional findings suggest that the decline in these domains start at the aged of 20. The ''crystallized'' functions are for example the knowledge of word meaning or the ability to retrieve familiar information which are relatively age stable.

"Fluid" cognitive abilities can be divided into several specific cognitive domains including attention, memory, language, executive cognitive function, and visuospatial abilities. Each of these domains has been found to have measurable declines with age *(Lezak M D, 2012)*. Both processing speed and sensory perception are being impaired by age and as a result they impact the performance in many cognitive domains. For example, the auditory ability begins to decline after age 30, and almost 70% of people at the age 80 have measurable hearing loss *(A., Selective review of cognitive aging, 2010)*.

The most noticeable changes in attention that come with age is the performance on complex attentional tasks such as selective (the ability to focus on specific information) or divided attention (the ability to focus on multiple tasks simultaneously; *(Lezak M D, 2012)*). However, some other simple attention tasks such as digit span are not influenced by age.

Although some aspects of memory are stable with age, there are some aspects such as new learning abilities and retrieval of newly learned material that decline steadily *(Lezak M D, 2012)*. Immediate or "sensory memory" and historical memories for public events and autobiographical memories are relatively stable while people age, however, the accuracy of source memory (knowing the source of the information) and the level of detail of recalled episodic memories decline.

Speech and language function are not in generally affected by age *(Lezak M D, 2012)*. Vocabulary, speech comprehension in a normal setting and verbal reasoning all remain stable. However, speech comprehension in a noisy and ambiguous speech content setting declines with age *(Wong P C, 2010)*. Verbal retrieval and verbal fluency show some decline with age.

Executive cognitive function involves multitasking, problem solving, decision making, planning and sequencing of responds. All of them declines with advancing age.

When it comes to visuospatial processing and constructional praxis, there some aspects that decline with age such as visual-perceptual judgment and ability to perceive spatial orientation. However, some other aspects such as visual recognition of gesture, shapes and objects and conventional signs remain stable into advanced age *(Lezak M D, 2012)*.

3.3.3 Mental Health

About psychological challenges elderly workers face, two are indicated as most common, depression and burnout. Depression can have a great impact on people and leads to impaired functioning in daily life. Depression occurs in about the 7% of the general older population and it accounts for about 5.7% of Years Lived with Disability (YLD) in people over 60 years old. Depression is both undertreated and underdiagnosed in primary care settings, as the symptoms are often overlooked and untreated because they co-exist with other problems encountered by older adults *(World Health Organization, 2015)*.

There is mounting evidence on the link between working stress and burnout, however, there is limited knowledge about the extent to which workers' age is associated with burnout *(Marchand A, 2015)*. Some findings suggest that age is negatively associated with the occurrence of burnout *(Norlund S, 2010)* *(Marchand, Blanc, & Beauregard, 2018)*. Some studies have also indicated that there is a bimodal relationship between age and burnout *(Cheng Y, 2013)*, with burnout being elevated in both younger and older workers. Last, some other studies have shown higher levels of burnout only in older workers *(Lindblom KM, 2006)* *(Verdonk P, 2010)*. Although, research is not conclusive about the link between age and burnout, working stress is an important issue for the well-being of working population in general and therefore special attention must be paid.

3.3.4 Safety

In general, older workers (compared to young workers) experience lower overall rates of non-fatal work-related injury and illness. According to the National Health Interview Survey Supplement on Occupational Health and Safety, men older than 50 averaged half the number of lost workdays and injury rate of men in the age category of 30–49 *(Landen DD, 1992)*. In a review of 13 studies, it is reported that one of the most common findings in the topic of safety and age is that accident frequency tends to decrease as age increases *(Laflamme L M. E., 1996)*. The reasons for this finding are not fully understood yet. While some possible reasons might be experience, skill and maturity of older workers, another plausible reason is the systematic differences in the exposures to hazards of different age groups. Although injury rates overall are low, there is evidence that some subgroups of older workers with pre-existing problems (such as poor eyesight and hearing) may be vulnerable to a variety of adverse outcomes higher and workplace injury rates.

Although injury rates are relatively low, the impact of workplace injury among older workers compared to younger workers has been found disproportionately high in many studies *(Layne LA L. D., 1997)* *(Layne LA P. K., 2004)*. One of the most common findings in studies investigating workplace injuries is that the accident severity in terms of the absence days tends to increase with age *(Laflamme L M. E., 1996)*. According to the Bureau of Labour Statistics, the median duration of injury related absence from work increases consistently with age, it spans from 5 days among for workers less than 25 years old to 12 days for workers 55 and older *(Rogers MW, 2003)*.

3.3.5 Conclusions on literature review

The aging workforce faces several challenges related to physical health, cognitive ability, mental health and safety. Aging comes with a toll which sometimes is low, for example slightly reduced attention, but sometimes can be quite high, e.g. severe back pains. These issues can potentially undermine not only the working performance of older individuals but also their well-being. This coupled with the fact that in the recent years we experience a fast and intense demographic transition towards a more aging population can cause several problems in the economic and the societal fabric as a whole.

As a result, several European national policy groups have appointed the issue of the well-being of older workers of utmost importance. The former Belgian National Strategy for Wellbeing at Work 2008-2012 mentioned older workers as a new risk group that requires particular attention. In Portugal, the National Strategy for Health and Safety at Work for the period 2008-2012 and the National Plan of Occupational Health 2013-2017 perceive older workers as a very vulnerable group. The latter considers age-related risk factors and health problems at work as a priority area for research. In Malta, the National Strategy for Health and Safety at Work 2008-2012 identified old age as a cause of vulnerability and an emerging risk. In France, the National Plan for Health at Work for the period 2010-2014 included an objective related to the safety and health of older workers, acknowledging that action is needed on work organisation and working time, the adaptation of workplaces and professional reorientation. In Norway's OSH strategy, older workers are mentioned in relation to flexible working schemes that would enable people to work until they reach retirement age.

All the above make apparent the need for designing tools that can help aged workers to deal with the issues caused by aging. Tools that can monitor several aspects of workers activity, provide them with insights about their physical and psychological state, as well as with potential solutions for improving their well-being and insights about their progress.

In this context, the following table summarizes some of the main findings of the literature review performed in the scope of the present deliverable.

Table 6. Main conclusions for Ageing@Work pilots separated by research topics

Ageing process	Workers older than 60 years old are the ones that suffer less accidents, while workers between 50-59 present average levels. Severe accidents for workers from 50 to 64 years represent only the 1,43% of the total of accidents. For workers older than 64, severe accidents represented the 1,94% of the total. For workers older that 55 years old minor accidents represent the 98,33% of the total. **The cause of most accidents suffered by older workers was due to carelessness, forgetfulness and lack of attention.**

Occupational diseases	The sector in which occupational diseases have the most influence is the extractive industry, followed by the manufacturing industry. There is a direct relation between the age of the worker and the duration of the work leave. The mostly diagnosed pathologies for older workers are arthritis and osteoarthritis, hypercholesterolemia, chronic back pain and diabetes. The diseases that increase significantly from the age of 55 are osteoporosis, heart attacks and strokes; cataract; embolisms; lung diseases and other heart problems. In general, older workers suffer mostly from back and neck, knees, limbs, hands and feet pain. Among the most obvious limitations of older workers, are visual and hearing, which in some cases cannot be sufficiently corrected with devices. The health problems to which workers are most exposed are forced postures, movements or handling of heavy loads; the pressure or work overload; noise and vibration.
Noise risk	Noise can cause accidents in the following ways: making it difficult for workers **to hear and understand voices and signals correctly**; **hiding the sound of an approaching danger** or of the warning signs (for example, driving signals behind vehicles**); distracting workers** such as drivers; **contributing to work stress that increases cognitive load and increases the likelihood of making mistakes.** As a result, older workers on the extractive industry are more likely to have hearing problems as a result of the continue noise exposure, which can result in frequent accidents, problems on oral communication and stress.
Sleep quality	According to scientific studies, **sleep quality decreases with age, especially with regard to deep and continuous sleep**. This is particularly true for older people aged 65 and over but, can already start at the age of 50 to 60. Therefore, it can be beneficial to measure the quality of sleep.
Absenteeism	Older workers have higher long-term absenteeism rates, although older workers do not have significantly higher rates of work-related accidents than younger workers, the consequences of these are usually worse
Productivity	Employability and willingness to change decrease with age. Research has also shown that older workers are less interested in learning and development opportunities. The consequence of this decrease in training and development may be the obsolescence of the worker' skills
Workability	The workability is directly related to the possibility of carrying out activities that include physical, mental and social skills. The balance between labour demands, control and recognition is the key point of job satisfaction for workers over 50 years. Intergenerational relationships appear as a factor that can favour labour welfare.

Then the study of the literature provides us with the following best practices in form of possible mitigation measures:

- A comprehensive approach to age management in the workplace, to promote sustainable work and counter the effects of ageing, includes OSH, **health promotion and human resources measures.**

- **Ergonomics** has an important role to play in reducing the demands of work for all workers and making specific adjustments for groups of workers or individuals.
- Workplace **health promotion** interventions should be age appropriate, gender appropriate and inclusive of all age groups.
- Older workers can often benefit **from appropriate flexible working arrangements,** allowing them to accommodate other activities such as responsibilities as carers or to facilitate working with health problems. **Social policy also influences whether workers can combine caring responsibilities and work**.
- Other measures include **maintaining up-to-date skills and knowledge,** with training methods adapted to different age groups; and viewing older workers as an asset and developing their roles, for example through training and mentoring of younger, less experienced workers.

4. Personas and scenarios definition

In the following section, "Personas" and "Scenarios" relevant to the Ageing@Work use cases are described. The term "PERSONAS" can be defined as archetypes of workers that can be found more commonly in the extractive industry and in the factories. These are fictitious profiles that reflect the state of health, fears, work habits and technological knowledge of the average extractive and factory worker.

As for the scenarios, fictitious situations are also described, but based on real events, in which it can be seen how the proposed solutions in the use cases can be useful so that the older workers of both pilots are more productive for more time and in a healthier way.

4.1 Profiles in extractive industry

Table 7 Extractive Industry persona 1: Pablo Lopez

Pablo López Age: 47 Sex: Male Location: Madrid, Spain. Marital status: Married Education: Professional training Job: mobile machinery operator
Pablo is 47 years old, is married to his wife Teresa, and has two children. He has a degree in professional training and obtained a certification to be able to use mobile machinery. He spends most of his day sitting inside the cab of the machinery that he must drive. He has recently been diagnosed with a herniated disc, although the operation has not been considered appropriate, due to excessive complexity. He is a smoker, one and a half boxes per day. He had chest angina last March for which he was off until July. In addition, due to noise levels in the quarry environment, he has lost 20% of hearing in the right ear and 15% in the left.
Technology Use Pablo has a smart phone that he uses regularly. He likes to be informed of the news and weather changes. He also uses an app to check the traffic status. At home, he has a smart tv and two laptops, in addition to a computer for his children. He is active on social networks, especially on Facebook and Instagram. Sometimes he uses Skype to talk to his parents who live in Chile. He usually does not pay attention to the notifications of the mobile, in fact during his working day he has it silenced, and he activates the vibration mode only for calls in case it is important. He has never used voice mode to use his smart phone.
Work Habits Pablo arrives at the quarry at 9 in the morning. He puts on his security equipment and goes to his position as operator of mobile machinery. He remains in a closed cabin handling machinery and he rarely takes breaks, apart from a half an hour break to eat. At 3.30 he goes back to work until 6.30 in the afternoon. Sometimes he drinks water when it is hot outside but tries to hold it until the pre-

established breaks. Since he was diagnosed with a herniated disc, he takes anti-inflammatories because muscle relaxants are contraindicated for handling heavy machinery. He does not have a work accident record.

Fears

Pablo realizes that it is getting harder and harder for him to spend so much time sitting inside the cabin. There are times when his legs are stitched, and he needs more of the set rest time to recover. During the summer there are moments of real heat to the point of becoming dizzy. In his opinion the time of the breaks should be more flexible so that his back would not suffer so much, but he compares himself with the other young workers of the quarry who work their hours without presenting complaints and prefer not to say anything to the employer in order of not putting his work at risk. He arrives exhausted at home and feels frustrated at not being able to enjoy his family life. After suffering from angina, he has realized that he is not so young anymore and would appreciate external help to improve his habits and take care of his health.

Table 8 Extractive Industry persona 2: Angel Gutierrez

Angel Gutierrez Age: 59 Sex: Male Location: León, Spain Marital Status: Married Education: Bachelor's degree Job: Mechanic
Angel is 59 years old. He is a mechanic, and he is dedicated to the repair of stationary machinery of the quarry. He is married and does not have children. He has been working in the quarry since he was 22 years old. He is in charge, above all, of the maintenance and repair of the equipment that make up the treatment plant. He has a workshop for carrying out minor repairs. He also manages the spare parts store. After many years of service, he has earned the trust of his superiors. Two years ago, he suffered a serious accident when he fell down a flight of stairs. He dislocated his shoulder and has had difficulty carrying weights ever since. The truth is that he has been afraid of a new accident since the accident and would rather stay in the camp as long as possible, where there is less noise and vibration.
Technology Use After the accident, Angel's wife, Marisa, gave him a smartphone to locate him. Until then, Angel had never had a cell phone. He only uses it to make calls. He doesn't use WhatsApp or any other applications. He almost never hears the phone, partly because his numbness and noise prevent him from knowing that someone is trying to contact him. He usually forgets it at home. He has an old computer at home, but the only one who really uses it is his wife. He knows the benefits and importance of knowledge about the use of the Internet, but he is ashamed to ask for help in learning.
Work Habits He arrives at the quarry at 8:50 in the morning. He puts on his safety equipment and goes to his post. He must be very careful when carrying out his work, as in addition to the problem of unevenness, he also comes into contact with machines that can be very hot, so that the risk of fire is high. The dust floating in the mine causes respiratory diseases and sometimes the noise is unbearable.

He has a lunch break at 2 pm and continues working until 6 pm. His vision is not what it used to be and sometimes it takes a long time to find the right parts to repair the machines. He notices that his younger colleagues sometimes lose patience with him. Most of the time he feels exhausted and frustrated

Fears

Angel is afraid of suffering a new accident. His eyesight is not what it was, and a few weeks ago he was about to get his arm stuck to the machine. He does not ask for help and performing daily tasks has become excessively painful. Going to work with the noise, vibration and dangers inherent in his profession generates a lot of stress. His level of working performance is still excellent, but he would like to have tools to relax and not have so much anxiety in the workplace. He is afraid that the managers will consider him useless and he comes home with increasing levels of frustration and stress.

Table 9 Extractive Industry persona 3: Pedro Uria

Pedro Uria Age: 54 Sex: Male Location: Asturias, Spain Marital Status: not married Education: professional formation Job: Plant operator
Pedro is 54 years old, he is single, and he lives alone. He has been in the mine since he was 26 and works as a plant operator. He is a person very aware of his health and controls in his everyday life his hours of sleep, his food and exercise that he does with the help of existing apps. He is involved in the union organization within his company. His main concern is that the stipulated breaks are met and that the training courses are taught throughout the duration set by law, especially the ones about health and safety. On Saturdays he plays football games with friends and on Sundays he goes running. He has never suffered serious work accidents, although he is increasingly suffering from superficial cuts, blows and burns.
Technology Use Pedro has a Smart Phone and a FitBit to control his physiological functions. He also has a laptop that he uses regularly for preparing the union initiatives. He surfs the internet at least once a day and he is active on social networks. During his working hours he wears his mobile phone in vibration mode, because otherwise he would not hear it due to the noise of the workplace. As for the rest of the notifications, he reads them at the end of the day so as not to lose focus.
Work Habits As far as his working habits are concerned, Pedro arrives before opening time in order to be able to talk to his colleagues in the union before the start of the day. He puts on his protective suit and works regularly during breaks. He is aware that these are inadequate, especially in summer when temperatures are higher, and the heat sometimes suffocates. He is currently fighting with the union to have more drinking water tanks installed in the plant. He stands practically all the time and has to strive for mobility and the lifting of loads. He finishes work at 5.30 in the afternoon and spends an hour on his union activities when he gets home. At home he lacks adequate office furniture and therefore has back pain.
Fears

Five years ago, Pedro saw a companion rush from a drop-off, and since then he became more active in the activities of the union. He realizes that most of the blows, cuts and burns he suffers happen because the pulse of his hands is not as stable as it was, his hands shake, and there are times when he accidentally drops things or things slip from his fingers. On some occasion he has felt dizzy from heat and stress and has been afraid that something more serious would happen to him in an isolated place and help would not come on time. He tries to stay young by doing sports, eating well and leisure habits, but he is aware that his performance is going down and he is afraid of being replaced by a younger worker. He believes, however, that he must fight for the rights of all instead of asking for help for his own needs. In addition to back pain, he comes home very tired.

4.2 Profiles in Production factories

Table 10 Production factories persona 1: Philip Mueller

Philip Mueller Age: 46 Sex: Male Location: Amberg, Germany Marital Status: not married Education: mechanical engineering Job: Mechanic
Philip is 46 years old, and he is the newbie in the shift. After several years in the office he got back pain from sitting all the time. So, he decided to change to a more practical work, where he does not have to sit all the time. Since his education is in mechanical engineering, he was always fascinated by production machines. Therefore, it was the logical next step for him to change into this group.
Technology Use Philip started to play with computers when he was a teen, therefore he has a lot of IT background, but he is still always astonished about the UIs of modern machines. He could not imagine that there is no touch screen, no fancy UI but only a small control panel with a small display and mechanical keys. In principle, he is familiar with the machines, because he did his apprentice training here, but a lot has happened in recent years. Especially when unforeseen things happen, he is happy that Nadine, who also works in his shift, can help him with his expertise.
Work Habits This week he is responsible for a new machine. First, he has to load the according program into the machine, which is a bit complicated when doing this for the first time. He thinks that the screen and the fonts are very small, and he is wondering how the older colleagues manage to read this. In the next step he needs to identify the corresponding tools needed by this program, walk to the tool stock, collect the required tools, bring them to the machine and equip the machine. The new machine offers to put the list on a USB-Key, which is a huge assistance, instead of writing a list or remember it. To equip the machine, he has to bend into the working room of the machine and put the tool in the correct magazine, adjust it and check with the control panel if everything is correct. After this he needs to adjust the work piece and calibrate the machine. The calibration is an iterative procedure, where he manually has to adjust different parts of the machine and the work piece following the commands on the screen of the panel. Doing so he needs to move between the working room and the panel as long as everything is adjusted and calibrated correctly.
Fears

Philip has no fear to be physically harmed by the machine (due to its safety requirements and features) or at the workplace due to its surroundings (e.g. because of heavy materials being transported).

Fears rather go towards monetary damage for company, e.g. damage to expensive materials caused by machine malfunction or machine malfunctions that actually render the machine inoperable, causing delays in the production workflow.

Table 11 Production factories persona 2: Nadine Schmidt

Nadine Schmidt Age: 58 Sex: Female Location: Amberg, Germany. Marital Status: married. Education: mechanical engineering Job: supervisor.
Nadine is 58 and in her Job for more than 20 Years. There's probably nothing Nadine hasn't experienced before, so she's appreciated by all her colleagues and managers. "If there is a fire somewhere, she is immediately on the spot and always has an idea how to solve the problem", is the common opinion of her colleagues. The shift supervisor makes sure that Nadine is given tasks appropriate to her age, so she takes on more and more supportive work and helps the young colleagues to become more efficient and to react wisely to problems. Luckily also the management has recognized that older employees have a wealth of experience and are accordingly very productive, so they initiated several instruments to ensure that employees like Nadine stay with the company instead of thinking about retirement. Nadine enjoys having more flexibility in her work schedule and additional days off, but she also takes part in the health campaigns regular offered to all employees. "I like my Job and I am far from retiring at the moment".
Technology use Nadine is continuously looking for products which could ease her work tasks. Therefore, she tried out several potential software solutions, not in the company but at home within a stress-free environment. The methods of augmented reality are completely new for her and she wants to improve her individual learning curve without any kind of distraction. Besides the AR software resources, Nadine also tested many additional equipment like e.g. special glasses, tablets with gesture control as well as voice controllable headsets. But which of the available hard- and software components could allow her to optimise her work tasks within an unrestricted and tailor-made work environment? As the owner of a smartwatch, her family presented her a nice model for her last birthday, Nadine is already a little bit familiar with this kind of modern technology and often uses her new watch for her individual health assessment.

Work Habits
Nadine is working as supervisor for the young colleagues. She is responsible for three young workers that recently started in the factory. First, she needs to explain to the newbies what they have to do. Later she needs to support them to load the according program into the machine, which is sometimes a bit complicated when doing this for the first time..
Fears
Nadine has some concerns that she will only be able to partially use the above-mentioned new technologies, due to several minor age-related health problems she already suffers from. E.g. she can't control her smart watch completely with finger gestures, because he has been suffering from a chronic tenosynovitis for about 5 years, which unfortunately affects both hands. Nevertheless, she is still able to successfully cope with all incoming notifications or alerts on her smartwatch, and both of these real time functionalities could be very useful in her field of work. Another issue she faces, seems for her an effective usage of headsets or headphones, because she has a mild hearing loss and therefore sometimes problems to deal with audible information. Closed headsets with noise-cancelling could solve this problem, but in her working environment, surrounding sounds are very important for Nadine, in particular to ensure a quick and direct communication with her colleagues in case of any problems. Bone conducted headsets could allow Nadine to perceive all environmental sounds, but mostly only at a lower volume level, depending on the used model. Nadine will have to test a wider range of potential bone conducted headsets more intensively in her work environment to find an appropriate solution on this specific requirement. She also intends to interview three of her younger colleagues on this topic. These colleagues, in the age of 20 up to 30 years, wear hearing aids and use specific headsets to perform phone conferences in their daily work routines. But Nadine's most favoured technology is the use of augmented reality software on modern tablets. However, when she looks at his incipient cataracts, the tablets must support high contrast as well as a non-reflecting display to enable her to recognise the enriched contents

Table 12 Production factories persona 3 Melanie Meyer

Melanie Meyer Age: 47 Sex: Female Location: Hannover, Germany Marital Status: not married Education: administrative assistant Job: team assistant
Melanie is 47 and in her job for 25 Years. She is a team assistant in an IT-company. As she is a very open and has a lot of experiences. "If you don't know what to do with all the administrative work, Nadine is always ready to help", is the common opinion of her team. In her job, she usually sits. As a consequence, she has got more and more back pain over the years. Finally, half a year ago, she had a slipped disc. For a few days she couldn't move at all until the therapy finally started. To allow her to return as gently as possible, she received a height-adjustable desk. Unfortunately,   it happens over and over again that she forgets in all the stress that she also can work in a standing position. She only remembers that when her back hurts again.
Technology use

Melanie is using a standard laptop and sometimes a tablet. Due to her age Melanie has sometimes problems reading without glasses. E.g. when she has to switch between paper and display. For paper reading she needs glasses, while for reading on the 27" display it works without glasses. She is sitting in an open-plan office sometimes the noise level is very high when a lot of colleagues are talking on the phone. However, wearing hearing protection is not a real issue.

Work Habits

As team assistant she is responsible for the holiday planning of her team. To be able to do this, she needs to know the status of all running projects and which colleagues are involved. She must also consider the knowledge of her colleagues in order to ensure that there is always at least one specialist in-house who can step in on certain topics.

Fears

One of her biggest fear is that the back pain is coming back and that she has to leave with all projects running and no one able to overtake her job. All colleagues are busy doing their projects, so there is no one that could overtake her duties. Another fear is that her eyes become even more worth. Her doctor recommended her to stop looking on the display for more than one hour, but how should she do this. She loves her job and does not look on the watch.

Table 13 Production factories persona 4: Mattew Dick

Matthew Dick
Age: 49
Sex: Male
Location: Munich, Germany
Marital Status: married
Education: Computer science
Job: Chief developer

Matthew is a developer in a small IT-Company. "He is living in Bits and bytes" is what his colleagues say about him. He grew up with computers, so he is very fast in developing and debugging software. Because of his abilities he is very appreciated by his colleagues and his boss. All his life he takes it with Winston Churchill „No Sports ". When all his colleagues take a walk, he prefers to read his mails or do some beta testing. He's been behaving like this his whole life, so he' s overweight. The result of this lifestyle has catched up with him. Half a year ago his doctor diagnosed diabetes and high blood pressure. His doctor said he had to lose weight! He said that World health organization recommends walking 10.000 steps per day so he should by a pedometer and start to walk 1.000 steps per day more until he reaches the 10.000 steps per day. He also should avoid sweets and eat more fruits and vegetables.

Technology use

Matthew is a techy. He grew up with all kind of IT technology. He uses tablets, PCs and loves his smart TV. Up to know he hasn´t seen any advantage of a smartwatch yet, so he never tried one. Now that he should use a pedometer, he is thinking of buying a smartwatch instead of a pedometer.

Work Habits

As a developer, Matthew sits in front of his PC all day long. Instead of going to his colleagues, he uses Mail or Skype to discuss issues with them. Although all employees received a height-adjustable desk a year ago, Matthews' table was never adjusted because he saw no advantage in working in a standing position.

Fears

The fact that he suffers from diabetes and high blood pressure has shaken him awake. He fears that his illness will have a negative influence on his life. He knows very well that diabetes can have influence on vision. Therefore, he is very much motivated to lose weight with the hope that the blood pressure and the diabetes will go back to normal

Table 14 Production factories persona 5: Lugger

Lugger Age: 58 Sex: Male Location: Hannover, Germany Marital Status: married Education: Technician Job: supervisor
Ludger is a 58-year-old, male plastic injection tooling technician, who works in a medium-sized injection molding company in Northern Germany. For 7 years, he suffers from diabetes and two years ago, he had a light stroke, but fortunately he was able to fully recover his state of health. Nevertheless, since this time, he only works in the early and in the late shift, but no more in the night shift, due to safety reasons.
Technology use Ludger is very technology affine, he uses all available new technologies, like e.g. augmented reality software tools as well as appropriate notification apps on his smartwatch, everything that eases his (work) life.
Work Habits His workday therefore either starts at 6 o'clock in the morning time or at 14 o'clock in the afternoon and lasts 8 hours, only interrupted by a 15 minutes pause. He has to perform physical and theoretical work tasks, depending on his shift plan and as well from the number and design of the injection molding machines that are maintained by him. Lodger's daily shifts are dominated by the following work tasks: 15 minutes schedule of his individual shift plan each day   15 minutes discussion with a process technician who has to release his developed shift plan   30 minutes general work preparation   2 up to 3 hours assembling of injection molds   15 minutes shift break   3 hours installation, configuration, maintenance and reparation of injection molds and injection mold machines   1-hour quality control, including the review of unsuitable produced polymer pieces, which helps to adjust the corresponding injection mold machine   The dimensions of the maintained injection machines significantly differ according to product types. Some injection machines are 2 meters wide, 3 meters high and have a length of 5 meters while other machines are larger designed, e.g. 4 meters wide, 6 meters high and about 10 meters long. The size of the machines depends on the tool that has to be installed according to the different product types. Before his shift starts, Ludger has to discuss and plan together with a process technician which tools and machines should be used during his shift, and which additional tools like e.g. hydraulic cranes are available to accomplish his daily work goals. Ludger has excellent experiences in his field of work and he

often supports new apprentices during their trainings. Learned from his health problems, he tries to perform his work tasks in a in well organized and safe process sequences and moreover, he teaches the apprentices to schedule their work tasks following his rules, to ease and secure their working routines right from the beginning. As a positive result, his trainees pass on their knowledge to the following apprentices.

For 5 years, Ludger´s company supports the BEM process, a professional reintegration process for employees who had to temporarily suspend their jobs caused by healthy reasons. The responsible persons of the human resource learned a lot during Ludger´s reintegration phase.

Considering Ludgers rarely occurring poor contrast vision, caused by his diabetes, the company decided to equip all production areas, and in particular older machines, with high contrasted warn and alarm signals, like e.g. emergency buttons and escape routes. Moreover, all toilets and shower rooms are additionally equipped with disinfectant aids to allow persons with diabetes to prepare themselves in a sterile environment.

Fears

Ludger fears to lose more of his contrast vision, as a diabetic he is really focusing on his glucose values, how much he walked and what he can eat. Ludger has no fear to be physically harmed by the machine (due to its safety requirements and features) but that he might not see other dangerous situations in the factory hall.

4.3 Extractive industry scenarios

Scenario 1: One day of a facultative director

Alberto gets up at 7.00 in the morning. He checks his smartwatch and see that he has slept 5 hours of effective sleep. On the mobile he receives an alert with the summary of his sleep at night, with these essential points: time from when he lay down until he got up, the times he has woken up and the total effective rest time. It also receives a recommendation of the application to control the intake of beverages and food before sleep, since proper sleep hygiene can contribute to improving its quality.

He moves to the quarry in his own vehicle, located 45 minutes from his home. Through an application he knows that today the day will be rainy, so he must exercise extreme caution.

Once on the quarry, he puts on work clothes and enters the quarry application about absences and vacation request. Two weeks before he received a request from Pedro, machinery operator, to enter two hours later. Pedro is 49 years old and last year suffered an angina. He must undergo periodic medical checks. Having the tool with this information beforehand Alberto has reorganized the work for that day with the rest of the workforce, 6 workers.

At the beginning of the activity, he checks the productivity of the workers in the last week. Antonio, a 52-year-old worker who has returned after a long-term leave seems to have problems handling the dumper.

Alberto establishes a personal alert/note to talk with the worker and figure out the origin of the problem. He is not worried since they have a new virtual reality tool that will allow the worker to be trained, so that he can gain confidence again when handling the machinery.

The rest of the day passes without major incidents. He receives a job adaptation request from Antonio who suffers from dizziness. From the next day on, Antonio will be in charge of the scale work, of an administrative nature, until he improves.

Scenario 2: Mobile machinery operator
Pedro is a mobile machinery operator. He has been working in the quarry since he was 20 years old and, in that period, he has suffered a hearing loss of 22%, shoulder problems due to wear and tear when lifting weights and angina caused by smoking. At 5.15 he wakes up and activates his smartwatch to check the hours of sleep and his resting pulse level. He activates the audio system, as his near vision has decreased with age. The App informs him that he has slept 6 hours of which 4 have been restful sleep. He recommends not to play sports just before sleeping, as it can alter biorhythms. Today he has a medical review, duly informed to the manager through the platform, so he does not reach the quarry until 10.30 in the morning. When he arrives at the quarry, he puts on his work clothes and cross out the individual safety equipment in the application. He finds out that he has forgotten to put on the helmet. The manager, Alberto, tells him that today he needs him to drive the loader. For months he has not used this type of machinery, so he connects to the learning platform and watches a 3-minute video in which a worker explains how it is handled. With the memory refreshed, he checks the security features of the retro through the app. Everything is correct, so it sends the communication to the manager. The smartwatch application, at the beginning of the work activity, has warned Pedro that by noon it will rain in the quarry, so he should exercise caution. Every three hours he receives a reminder via smartwatch and smartphone about the recommended exercises and stretching given his medical history and at 14 hours, mealtime, he receives a recommendation on the consumption of healthy foods. In the afternoon, due to his lack of hearing, he does not hear the companion's notice for the walkie and when crossing with another driver he suffers an incident, although, since he has seen the video of the platform Knowledge sharing he avoids greater consequences. His pulsations are triggered and the smartwatch vibrates, so that Pedro begins to perform a series of more relaxed breaths. He activates the emergency button and automatically connects with Manuel, who is in the area of the scale. He reports the incident and Manuel activates the security protocol for these types of cases. He is instantly geolocated and in less than 5 minutes they get him out without any injury. Once returned home, he performs his exercise chart and decides to request the manager another day off through the platform to undergo a new hearing test.

Scenario 3: One day in a mobile machinery operator
Manuel is a mobile machinery operator. He suffers from dizziness, so he has now been assigned to Scale tasks as it is a much more static position in which he must make less effort. He has also been assigned to the task of receiving peer alerts regarding security, whether of failures in individual or collective equipment, or calls from the emergency button. For this, he wears augmented reality glasses so that the worker who warns of the problem can point the camera of the Tablet or Smartphone to the machinery and transmit it to Manuel's glasses. After checking the nature of the fault, he will decide if it is necessary to notify the manufacturer's mechanic or not. Today he does not receive security alerts. In the afternoon, his companion Pedro suffers an accident and when he presses his emergency button automatically his smartwatch begins to vibrate in a way that alerts him to the danger. He has a conversation with Pedro and activates the security protocol.

Throughout the day he receives three notifications through his smartwatch: one, at the beginning of the day (parameter that the worker must previously introduce) about the weather conditions, and two others about the need to do exercises and stretches, one at 12: 00 and another at 15:00.

At 14 hours, mealtime, he receives a recommendation on the consumption of healthy foods.

He has communicated to the application his dizziness problem so it has designed an exercise table that Manuel should perform especially at home following the advice of the virtual coach.

The avatar will be a representation of the worker himself. It will make a previous demonstration of the exercise and then monitor Pedro's execution.

4.4 Production factory scenarios

Scenario 4: The newby of the shift
When Philip started to work this day he was called by Natalia - the shift leader. His colleague who is responsible for the shift told him, that Nadine has broken her leg and that the factory now is in a serious situation. A long term and big customer is expecting a small charge of products by end of the day and all colleagues capable of producing this part are either on vacation, busy with other things or ill. Natalia asks Philip if he could jump in so that they can deliver the requested parts to the customer on time. Philip was a bit unsure, as he had never used the machines for this product, but Natalia calmed him down, when she told him that Nadine will help him using the new AGEING@WORK Training&RemoteSupport toolkit. They agreed to do so, and Philip puts on the AGEING@WORK Glasses, while at the same time Nadine sits with her broken leg a tablet on her sofa. Philip can talk with Nadine and Nadine can see what Philip sees. She also can point on things and Philip sees by means of AR what he should do. Together with the remote support Philip could make it and he had an advanced training because he learned how to produce these products, so the factory has another employee with the ability to produce these parts.

Scenario 5: Smart is everything
In his working environment, Ludger uses all available new technologies, like e.g. augmented reality software tools as well as appropriate notification apps on his smartwatch, that eases his work tasks. This leads to the positive side effect that many of his work processes are performed much more efficiently than before. In particular, getting real time alerts of his maintained injection molding machines directly on his smartwatch, often enables him to solve problems at an early stage and thus prevents long downtimes from the corresponding machines. In case of any trouble shooting, his smartwatch offers him the possibility to directly open the according repair instruction guideline of the triggering injection machine that corresponds to the required maintenance mechanism. All provided step by step instructions are presented by using augmented reality strategies and Ludger has the option to decide whether to follow the commands using the AGEING@WORK Glasses or by reading the instructions on a tablet which is appropriately mounted on a good visible place at the machine. Both alternatives enable Ludger to work without any restrictions because he has not to use his hands to control his selected instruction method. All instructions can be paused or continued by either performing voice commands or by simple hand gestures, depending on the previously selected method.

5. Surveys

The aim of the surveys was to allow potential users of the Ageing@Work solutions to express their opinion on the functionalities of design, utility and interaction with the technologies selected by Ageing@Work, from the results of the literature and real setting research.

The data subject must have given his/her consent prior to the study in order for the personal data collected to be processed and stored by the members of the consortium. Before the employee gives his or her consent, the person concerned was informed of the objectives of the project, the lines of action, the instruments used and the treatment of his or her personal data, always respecting national and European law. The consent form was signed by the participant.

In the case of the extractive industry, the candidates for the project were selected among workers of the extractive industry who are between 46 and 62 years old[1], with good physical and mental conditions and without serious chronic diseases, included physiologic diseases or mental health diseases. The workers for the pilot are selected among those workers who have a basic knowledge of new technologies. Whether they have a smartphone, a computer or a tablet, is taken into account.

Finally, it is also taken into account whether the subject has a positive attitude, a good predisposition and desire to participate in the project, with enthusiasm about the objectives and improvements that could result in their day to day life. The idea is that with this project workers can work longer in optimal conditions, so this is the message that subjects must internalize and want to achieve by participating in the project as potential users.

ANEFA´S Health and Safety Technical Committee made the decision to derive the part of the survey related to the tools´ and applications´ design to experts on health and security, since, as responsible for complying with safety and health standards and as connoisseurs of the daily problems that workers face when they age, the results obtained would allow us to draw valid conclusions, both from the point of view of the problem of aging and regulatory compliance, ensuring greater acceptance of use cases, both by workers and by the managers.

At Siemens, we address factory workers aged 50+ and office workers aged 50+. Due to German labour laws and Siemens' internal guidelines, all actions had to be approved by both the workers' council and the factory management. Workers' Council and factory management provided possible candidates with pieces of information about our project and asked them whether they are interested in participating in the study.

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[1] *From the workers of the extractive industry point of view, it is important to point out that since it is a dangerous activity, the miners can retire early, so that most of the older candidates will not be older than 59 years in order to complete the three years that the study lasts.*

Like in Spain, all candidates have to give their consent prior to our visit. To ensure maximum privacy, the workers filled out the questionnaire in a room with only an Ageing@Work partner in the room (in case of questions). After this, each worker has put the questionnaire into a locked ballot box, so that neither management nor workers council do have access to raw data. The key to the ballot box was handed out to an Ageing@Work partner prior to the meeting.

5.1 Survey Results

The surveys have the purpose to allow us obtain knowledge on the opinion of the workers regarding the user requirements that arise after analysing the results of the literature and examining the working conditions of the workers and the workplace. The results are divided into quarry and factory workers perspective.

5.1.1 Quarry/gravel workers perspective

In the case of ANEFA, pilot leader of extractive industry pilot, since training courses on occupational risk prevention and workers' health, subsidized by the Ministry, are organized from the association, ANEFA has taken this opportunity to deliver the surveys to the workers, achieving a total participation of 101 workers. Taking as reference the information of the safety meetings, part of this security and safety training, the necessary information has been collected to carry out a first draft of the survey, which was then agreed and approved by all committee members.

The survey was divided into two parts, one for potential users and another, more specific to fill in for those workers who have special health and safety responsibilities, to gather their opinion related to the design requirements in order to comply with the safe and security regulations. According the methodology proposed in section 2, first, the workers were informed about the purpose of these surveys, the objective of the Ageing@Work project and the way the information gathered was going to be treated. Then, their informed consents were collected.

The first survey focused on the functional requirements, and the second focused on the design requirements for the proposed solutions. Both surveys included questions about the work that the potential user performs in the quarry and the kind of relationship that has with the new technology. The survey included multiple choice questions and open answer question. The survey questionnaire is available in ANNEX I of this document.

The extractive industry is an eminently masculine business in which women now hold fundamentally administrative positions. In any case, the female presence is increasingly numerous, and actions to promote the incorporation of women into this type of labour market are being carried out from ANEFA and from other public and private associations. As for the low presence of women in the surveys, a 4%, is a clear reflection of the situation of the sector.

Table 15: Surveys results. Profile of the participants.

AGE	45-54 (44%)		54-65 (12%)	<45 (44%)
GENDER	Male (96%)		Female (4%)	
ACTUAL JOB				
o Mobile machinery operator	34%			
o Plant operator	6%			
o Maintenance	7%			
o Mobile machinery operator & Plant operator	3%			
o Plant operator & Maintenance	4%			
o Mobile machinery operator & Maintenance	6%			
o Mobile machinery operator, Plant operator & Maintenance	15%			
o Facultative director	8%			
o Administrator	4%			
o Technical director	1%			
o Chief on site	3%			
o Driver	2%			
o Other	8%			
o (In case you have marked "other" please specify bellow)				
Years of work experience				

A more detailed age distribution of the participants is in the following figure:
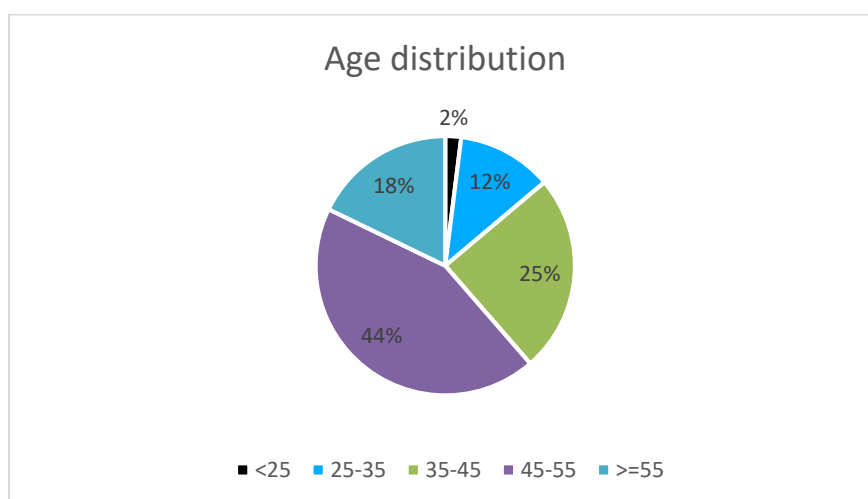
Figure 11: Statistics on age distribution from <25 to >55 in extractive industry workers in the surveys

Data on the use of internet and acceptance of new technologies

The results of frequency of use of the internet and new technologies, for the total of the surveyed workers, have been divided into different graphs, focusing on one hand on the results obtained from potential users over 45 years old and on the other, on experts in health and security.

Table 16: Frequency on technology use. All workers.

FREQUENCY ON TECHNOLOGY USE							
With what frequency do you use the internet?	NEVER		ONCE A WEEK		MORE THAN ONCE A WEEK		EVERYDAY
	Nº	%	Nº	%	Nº	%	Nº	%
	11	14	3	4	14	17	52	64
With what frequency do you use apps?	NEVER		ONCE A WEEK		MORE THAN ONCE A WEEK		EVERYDAY
	Nº	%	Nº	%	Nº	%	Nº	%
	9	11	11	14	12	15	49	60

	NEVER		RARELY		USUALLY	
Have you ever used and smartwatch or vital measurement tools?	Nº	%	Nº	%	Nº	%
	51	63	20	25	9	11
Have you ever used AR tools?	Nº	%	Nº	%	Nº	%
	57	70	22	27	0	0
Have you ever used VR tools?	Nº	%	Nº	%	Nº	%
	56	69	21	26	2	2
Have you ever shared videos or images on the internet or through apps?	Nº	%	Nº	%	Nº	%
	17	21	36	44	28	35

What kind of apps do you use more frequently?	NEVER		RARELY		SOMETIMES		USUALLY		DAILY	
Heath apps	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
	14	17	5	6	18	22	5	6	3	4
Social media	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
	5	6	3	4	11	14	17	21	26	32
News	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
	7	9	1	1	12	15	13	16	26	32
Weather apps	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
	3	4	2	2	10	12	12	15	27	33
Other										

Table 17: Surveys results. Frequency on technology use. Workers over 45 years old.

FRECUENCY ON TECNOLOGY USE WORKERS WITH AGE OVER OR EQUAL TO 45							
With what frequency do you use the internet?	NEVER		ONCE A WEEK		MORE THAN ONCE A WEEK		EVERYDAY	
	Nº	%	Nº	%	Nº	%	Nº	%
	8	17	2	4	7	15	29	62
With what frequency do you use apps?	NEVER		ONCE A WEEK		MORE THAN ONCE A WEEK		EVERYDAY	
	Nº	%	Nº	%	Nº	%	Nº	%
	8	17	6	13	8	17	25	53
Have you ever used and smartwatch or vital measurement tools?	NEVER			RARELY			USUALLY	
	Nº	%		Nº	%		Nº	%
	28	60		15	32		4	9
Have you ever used AR tools?	NEVER			RARELY			USUALLY	
	Nº	%		Nº	%		Nº	%
	36	77		9	19		0	0
Have you ever used VR tools?	NEVER			RARELY			USUALLY	
	Nº	%		Nº	%		Nº	%
	36	77		8	17		1	2

Have you ever shared videos or images on the internet or through apps?	NEVER		RARELY		USUALLY	
	Nº	%	Nº	%	Nº	%
	14	30	22	47	11	23

What kind of apps do you use more frequently?	NEVER		RARELY		SOMETIMES		USUALLY		DAILY	
Heath apps	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
	6	13	4	9	9	19	3	6	2	4
Social media	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
	3	6	2	4	9	19	7	15	11	23
News	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
	5	11	0	9	6	13	8	17	13	28
Weather apps	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
	2	4	1	2	6	13	8	15	13	23
Other										

The percentage on daily internet use is similar for all workers in the workforce regardless of their age. While 64% of the total say they use the internet every day, those over 45 do so on a daily basis by 62%. The use by security experts is however significantly higher, with 90% of daily use.

Security experts are the ones who apparently use the apps more frequently, with a 90% indicating daily use, while the differences by age among workers increase, reaching 62% daily use for all workers and 53% for workers over 45.
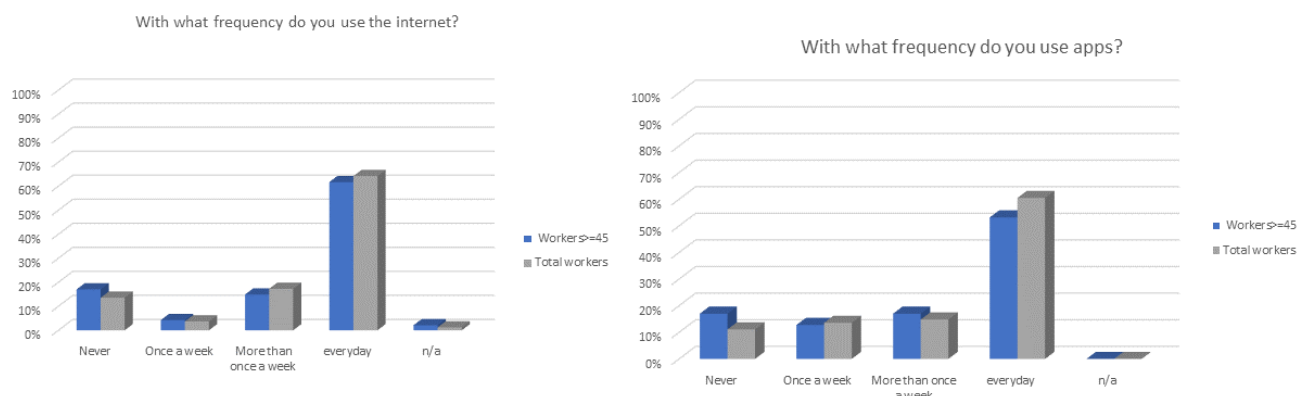
Figure 12 Distribution of workers in terms of usage of internet (left) and apps (right)

Around 60 percent of the workforce, regardless of age, say they have never used smartwatches or vital signs measuring devices. There is a slight increase in habitual use in workers under 45, from 9% to 11%. As for the security experts, the percentage of those who have never taken these sections and those who use them habitually is identical, 45%.
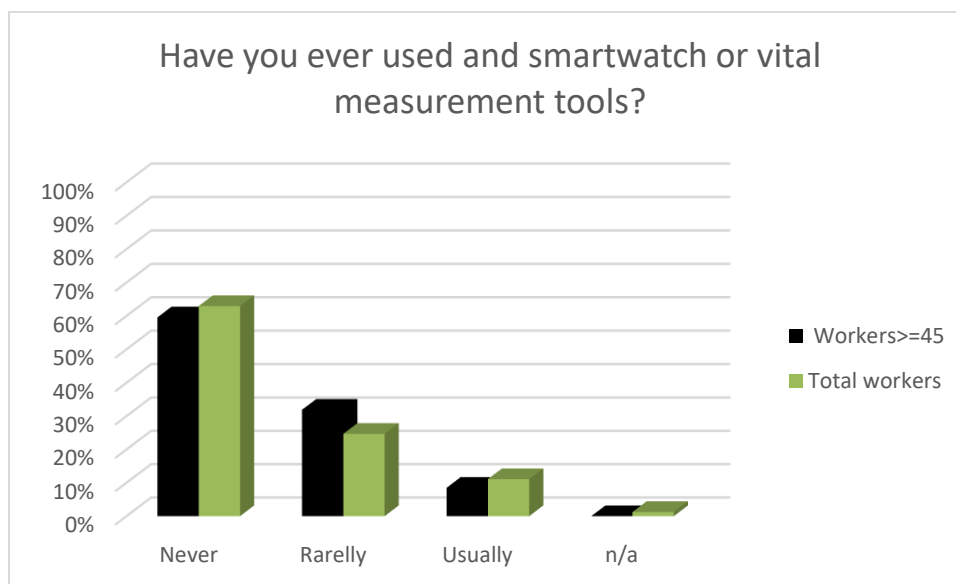
Figure 13 Distribution of workers in the extrative factory in terms of the smartwatch or/and activity bands

On the results of using AR and VR, 77% of respondents over 45 say they have never used these technologies, slightly more than those under 45, 69%. The trend is repeated for the experts of use if we look at the AR, they have never used it at a percentage of 70%. However, they acknowledge having used, although rarely the VR, with 45%.
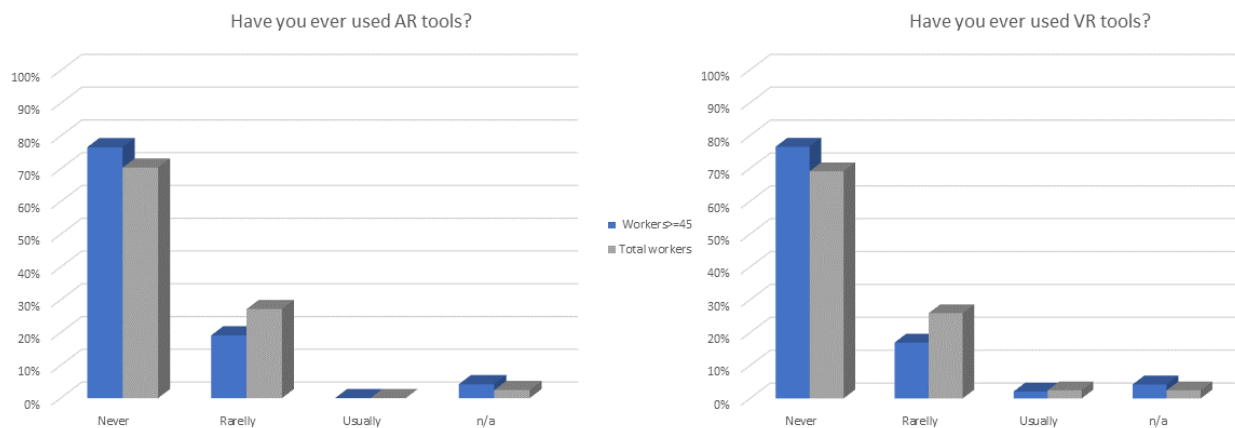
Figure 14 Distribution of workers in extrative producion in terms of AR/VR tools usage

The trend in terms of uploading videos and images to the internet or through the apps is similar for all workers. They say they rarely do it between 45 and 47%, and usually 35% against those over 45, 23%. The security experts are again the jarring note, with most of the respondents, 55%, saying that they usually upload videos and images to the Internet.
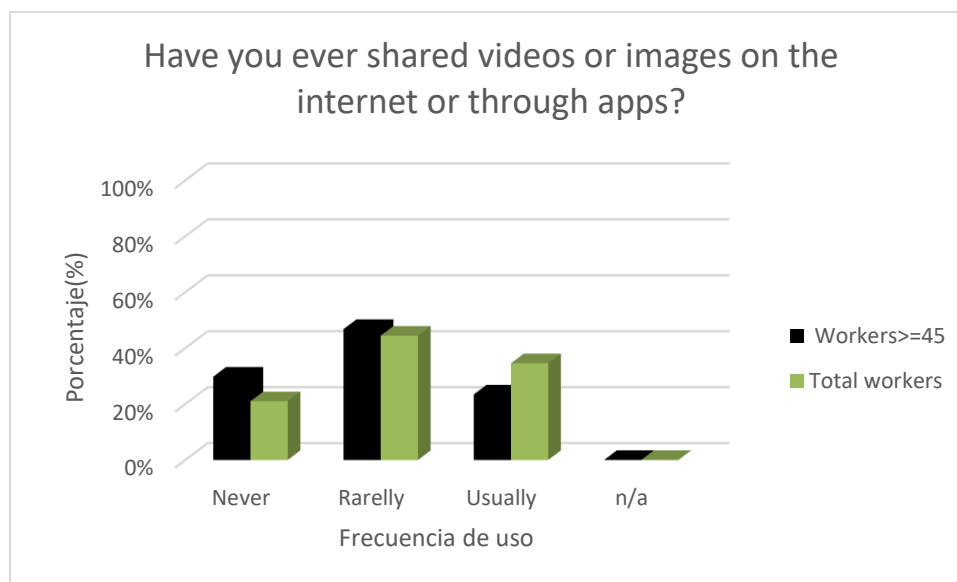
Figure 15 Distribution of workers in the extractive factory in terms of usage of videos and internet

As for the types of applications most used, the winners of the survey with difference, and without distinction by age are the applications on news, climate and social networks. The applications of least use are those of health, between 13-14% of the respondents say they have never used them. The results of the experts in health return to be different, having declared 30% of the respondents never to use the social networks and to use daily the weather and news apps. The use of health apps increases, so 35% say they use them from time to time.
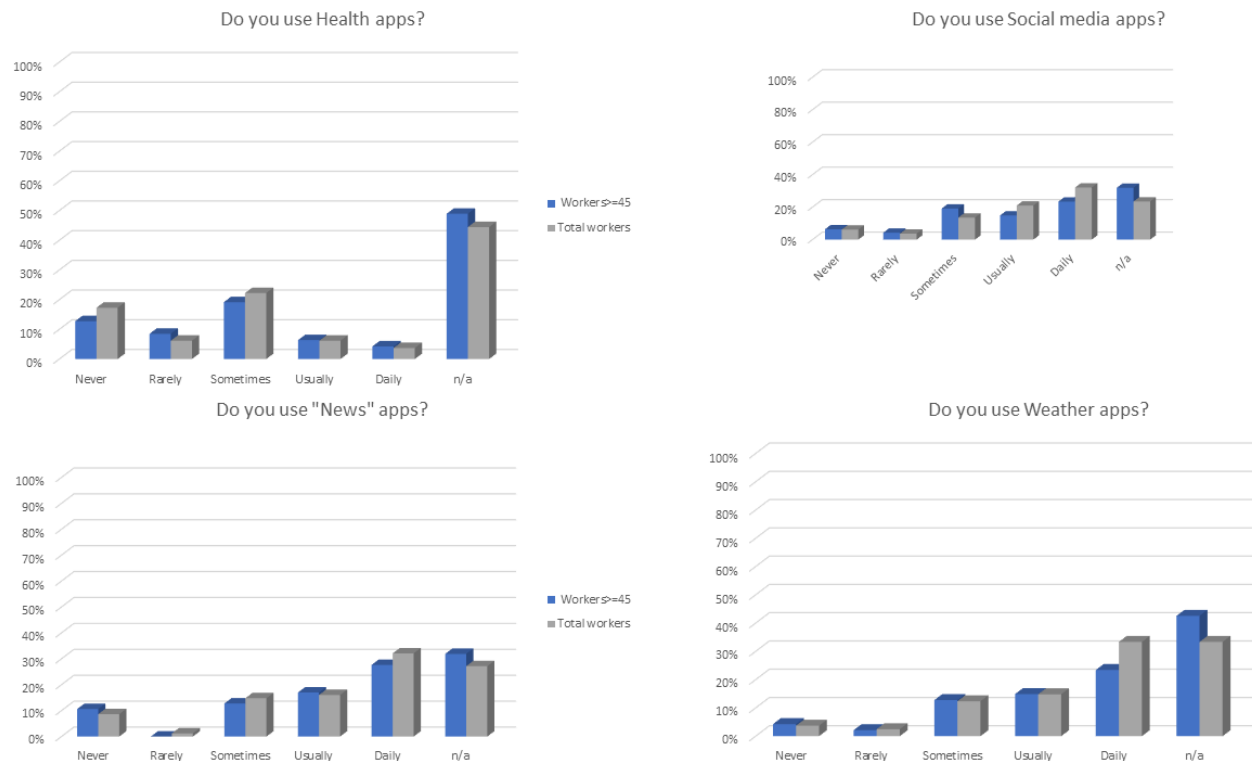
Figure 16 Distribution of workers in extractive factory type of app usage

5.1.1 Factory workers perspective

In the case of Siemens, we took a slightly different strategy than ANEFA. Our usability specialists are, for many years, working with factory workers, thus they are a perfect source for the initial user requirements and thus use cases. In a second step, management, worker's council and shift leaders as well as volunteering workers have been involved in the requirement specification and the creation of an initial set of use cases. These initial use cases have been discussed during several teleconferences with different factories and during a factory visit. Instead of another questionnaire we decided to conduct an observation and interview-based study, to prove and evaluate the preliminary use cases.

Observations by psychologists combined with discussions at the workplace together with feedback from shift leaders, worker's council and management, provide a lot more pieces of information than any questionnaire-based survey.

In the factory we conducted a survey with 33 workers for WP3. To ensure maximum privacy, the workers filled out the questionnaire in a room with only an Ageing@Work partner and a representative of the worker's council in the room (in case of questions). After filling the questions in, each worker put the questionnaire into a locked ballot box so neither management nor worker's council had access to raw data.

Only after everyone had filled the questionnaire, the ballot box was opened by a worker's council representative. The questionnaire date has been transcribed into an excel sheet for statistical analysis.

This chapter gives only a small view to the results of this survey (only those relevant to user requirements). The complete statistics from the questionnaire survey can be found in D3.1.

The factory in Brunswick is an ideal candidate for our project, since more than 50% of the employees are over 50 years old. Together with the worker's council and in agreement with management, we asked for participants and found 33 volunteers. All participating workers have been 50+.
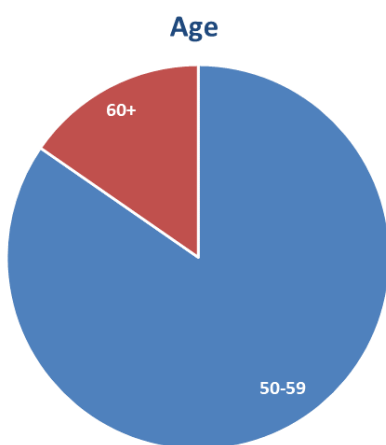
Figure 17: Age distribution

Figure 18: Working in the factory since

Nearly 88% are working with in this factory since more than 20 years (46% even longer than 31 years).
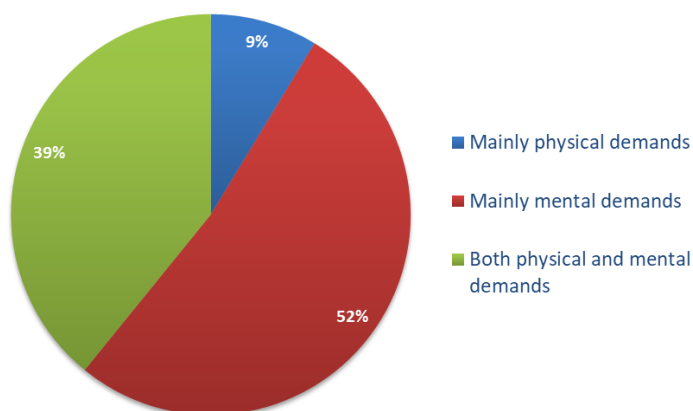
Figure 19: Job Demands

Compared to the jobs in the extractive industry, the job demands are completely different. While 86.1% of the extractive industry workers are performing mostly physical demands, this applies only to 9% of the factory workers. In contrast to the extractive workers, 52% have mainly mental demands and 39% have both mental and physical demands.

Data on the use of computer and acceptance of technology

The results above already showed that the majority of the workers in the factory tend to have mental work demands. Therefore, most workers are also involved with new technologies:

Only 28% of the participating workers mentioned that they never or almost never have to use computers, laptops or smartphones for their work. But 47% mention that they use it all the time or almost all the time. Therefore, the perceived difficulties with new technology is not as high.
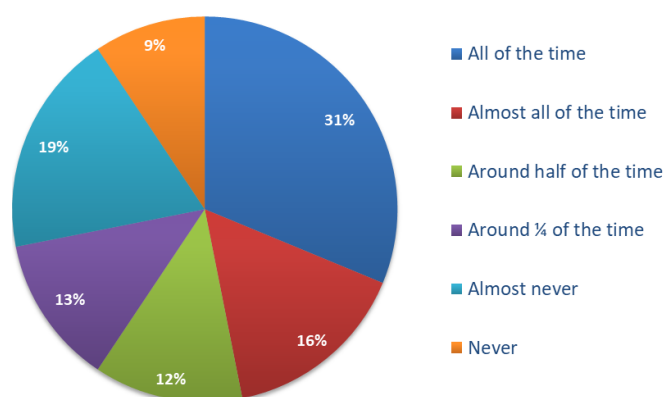
Figure 20: Job and technology

Figure 21: Difficulties with technology

6. Preliminary Use cases

As described previously in the methodology, once the surveys had been administered, preliminary use cases (PUC) were designed, whose content is described as follows. These preliminary use cases were explained in a simple way to the workers during the workshops, who could then express their opinion in a moderated discussion, as further explained in the following Section of the deliverable (Section 7).

6.1 Extractive industry preliminary use cases

ID	Use case Category	Generic description
PUC 1	Check-list platform	Through this app the workers will be able to verify that all the personal and collective security elements are in correct condition, entering into communication with the security managers in case something should fail.
PUC 2	Participatory work orchestration platform	Through the platform the workers will communicate the absences or vacations to the people in charge of personnel, so that it will simplify the daily management of the company.
PUC 3	Support for musculoskeletal problems	Exercises or stretches will be proposed for workers to do at home or at work, with the supervision of a virtual coach, so that musculoskeletal problems are reduced.
PUC 4	Supporting health and wellbeing – Virtual Coach	Use of pulse measuring devices and sleep quality to detect sleep or heart –related issues and give advice to the worker on how to improve the results.
PUC 5	Knowledge exchange platform, collaboration and productivity enhancement	Platform where older workers can share with young workers, experiences, tips and tricks for the best development of their activity; tools supporting collaboration and productivity.
PUC 6	Emergency button	Also called panic button, will allow the worker in distress to be directly contacted in case of emergency and geolocated if possible.
PUC 7	Hydration controller	Application that takes into account the atmospheric conditions of heat and humidity of the day, as well as the physical characteristics of each worker, determining the periodicity with which the worker should drink water and vibrate indicating that it is time to take a drink.

6.2 Factory production preliminary use cases

ID	Use case Category	Generic description
PUC 8	Supporting health and wellbeing – Virtual Coach	Similar to PUC3 and PUC4 of the extractive industry.
PUC 9	Productivity Enhancement through remote surveillance	Use of smartwatch-based interface to remote observe current machines to be aware of the functionality and upcoming steps.
PUC 10	Intergenerational remote support	Allow experienced workers to support younger using augmented reality (AR) and/or conversational UI for cross-generation knowledge transfer / collaboration.
PUC 11	Knowledge exchange platform	Similar to PUC5 of the extractive industry.
PUC 12	Workplace orchestration support	Tool to support the workplace management side into ageing workers' friendly work orchestration; helping to orchestrate remote support needs, automatically recognize when all persons with a single knowledge would ask for holiday etc.
PUC 13	Life Long learning	Using gamification and latest technology like AR/VR to motivate users to learn.
PUC 14	Simulated ergonomic user models	Tool to design the workplace and processes by simulation and testing in a 3D industrial hall simulator

7. Workshop evaluation and individual interviews

With the aim of obtaining more information from the pilots, on the use cases and user requirements, workshops were organized through collaboration between the project end user partners with UPM, one with extractive industry workers, and one with the factory workers.

7.1 Extractive industry Workshop

The structure of the ANEFA´s workshop was the following: firstly, the six participants, all of them quarry workers, were welcomed; secondly, what was going to be done in the workshop was explained to them and the objectives of the project was introduced as well as the informed consent, which was signed by all of them. After this, the Focus Group discussion took place, analysing the 7 preliminary use cases of the ANEFA pilot; subsequently, at the fourth step of the workshop, the semi-structured interviews were conducted individually and finally the participants were thanked for their collaboration and the farewell was carried out.

Figure 22 One of the extractive factory focus groups participants in UPM

PUC 1: CHECK-LIST PLATFORM

The idea of having a check list with the checks they must do before starting the working day, was well received, but with some modifications. They already know they should do that, and because it is a very repetitive action, the do not need a check list only to remember the visual check, but if they can have following additional functionalities, they thought it could be useful:

- Direct call or communication channel with the machine mechanics
- Error code (from the machine internal computer) translation. This functionality depends on the type of machine and of the model and brand of the machine, so maybe we only can deploy the system for piloting a very small number of situations.
- Level of severity of the incident (in case it is detected). This is one of the most valuable functionalities, because it could be used as report to the manager of the quarry, and a control system for errors and breakdowns.

W3 "If you find the error and it gives you a solution in the same list, it's fine. So you do not have to go calling the mechanic"

- Adaptation to the level of knowledge of the machine by the worker (in case the worker is novel using this machine, the visual check should be more guided)

W5 "It is very good help for new ones. So you do not forget anything and for veterans, we sometimes sin of overconfidence"

PUC 2: PARTICIPATORY WORK ORCHESTRATION

The system was well received. They have no problems managing their holidays and their holidays or medical holidays. They would like the system to provide for such a priority system so that they can have access to holidays according to objective criteria in the event of conflict. The system can also be used to add receipts and accompanying documentation if necessary.

The system could be extended with a virtual suggestion box, with a voting system, even with the worker signing system.

In this sense, employees always prefer to use an additional device, not their own mobile phone. One problem could therefore be the lack of network and the total or partial ban on wearing watches or bracelets.

PUC 3: MUSCULOSKELETAL PROBLEMS

This functionality was very well received. About half of the participants already do this type of exercises at home or in a gym. The total of them even says that they were not sure that those exercises are the correct ones or not. They'd feel confident if the system recommends some according to their job, their age, and their specific problem.

One of the participants remember the case of one quarry in Arganda, where the exercises are mandatory, as well as the labour hours with a specialist. In this case, the number of medical loads has been reduced a lot.

The participants were willing to use the application in this case, but always in labour hours, according their routines, taking advantage of their downtimes (for example, when waiting for loading the truck).

W6 "I try to go to the gym twice a week, but it's not easy. I have a family and I want to enjoy free time with them"

W4 "I do exercises while dumper is loading, but I do not know if those are the correct or not"

W2 "Many of the co-workers do not do it (exercises) at home. They do not have time, they are tired, they do not remember. We spent many hours in the quarry. If they (managers) left us 30 minutes during work hours, we would encourage each other (to do the exercises)."

PUC 4: SUPPORTING HEALTH AND WELLBEING – VIRTUAL COACH

The workers think that the measures of stress or heart rate among others would be well received, as long as they are not shared with the work supervisors. In this way, it would be very useful to indicate to the worker that he has to stop a moment to rest or drink a glass of water, which makes his constants normalize. There was a case that a worker almost suffered a heart attack for not attending to the signs of pain in the chest he was suffering. A technology that monitors basic vital signs could help prevent these situations and could help improve workers' health through sleep hygiene or stress management tips.

They also consider that there is no problem in using the system in their homes, for example to measure sleep. The problem is still wearing wristwatches while using the machines of the facilities, even if it is forbidden for security reasons. They should carry something under their clothes, in an appropriate position, that does not endanger their safety.

W3 "Some quarries have poor mobile coverage. In others, the use of mobile phones is prohibited. We all carry it, but if it's in my pocket and I turn over, I cannot access it and even less make a call"

To visualize the data, it would be possible to carry a tablet hooked in the cabin of the machinery, but without altering its structure and without leaving it fixed. All workers carry their mobile, and can use it in free time, although they prefer to have an additional cell phone for reminders and visualization of the

information of use cases. Noise is also a problem and they would require an application that could measure it on the mobile.

W2 "Work is monotonous. We get up very early in the morning. I have a very low point at 9 in the morning and at 15, after eating. These are the worst hours. It's hard to be alert and I'm afraid of having an accident."

W4 "I had to stop the haul truck to pour cold water over me. In summer, with more than 40 degrees is the worst period."

W1 "Those hours are the worst moments of the day. We can stop and take breaks, but we always stop alone. The production can stop and sometimes this is very stressful"

PUC 5: KNOWLEDGE EXCHANGE PLATFORM, COLLABORATION AND PRODUCTIVITY ENHANCEMENT

For them it seems impossible to reduce their working hours to train other workers, from home online. They would see more positively than there was a kind of forum, where the expert workers could answer the doubts of the novice workers. In addition, all mining operations have their internal security provisions to perform the work, and it would be very good to be able to post it in the forum for the knowledge of all the workers. Currently the training of novice operators is very scarce, although it is totally practical on the machines that have to handle. In addition, they must pass a practical and theoretical exam to obtain the mandatory driver's license for machinery. They think that the videos could be useful to transmit the knowledge to the novice workers, but in situ training is necessary because each situation is different and each machine is also different. The augmented reality could serve to identify the machines and their basic information for the novice workers.

W1 "Our work is very practical. But it is a help for the basics. So they do not get so scared when entering. Although it is useless if it is not complemented by practical work."

W5 "For those who work in the part of the control room or in the laboratories it is very good. It is not easy to remember everything at the beginning and it is a useful support. Even for us if we ever have to rotate for other jobs."

PUC 6: EMERGENCY BUTTON

The workers see this solution as useful in cases of health emergency, as well as in cases of serious breakdowns, fires or overturning of the machine. They must call each hour when they are doing an especially dangerous work, but they miss a system, easily accessible to the worker, either integrated into the cabin area or into his clothing, so that it can be accessed easily and quickly, even upon a dumper roll-over, and be quickly geo-located by those in charge of prevention and security, whose will quickly alert the emergency services.

To make the announcement, they prefer to have several alternatives, such as an external push button in the cabin, or through an application on their mobile. Once the emergency message has been sent, a communication should be established automatically with the responsible of the quarry.

W2 "Now we are "lost". If we turn over, we cannot call, we have to wait for them to miss us and come looking for us."

W4 "It is hard for my wife when it rains. I call her or I send her WhatsApp messages when I can, and she feels a lot better"

W6 "If you are alone in a dangerous area, working with a bulldozer or something comparable, the manager knows that you are ok, because we have to call him every hour. But if something happens between calls..."

PUC 7: HYDRATION CONTROLLER

Workers have no problem hydrating during their work. The workers carry a bottle of water in the machines, and they think it is not so useful to be reminded when they have to drink and stop for a moment.

Priorities:

- The most important preliminary use cases for the quarry workers are PUCs 1, 2, 3 and 6.
- Preliminary Use cases 4 and 5 were considered as of intermediate importance.
- The preliminary use case considered less important for the workers is PUC 7.

Interviews Results

After the workshop, workers were separated into two rooms, and an interviewer was assigned to each of them. The interviewers were qualified partners of the consortium, both from ANEFA and the UPM. The interview was structured in a series of pre-established questions that guide the interviewers, although workers were encouraged to give their responses as free and wide as possible. The detailed questions and responses are contained in ANNEX III of this deliverable.

Through the interviews, a more detailed analysis of their opinions on the preliminary use cases was obtained, as well as testimony of their true fears, needs and expectations regarding a project such as the Ageing@Work.

The workers generally expressed that they were satisfied with their job, although the working conditions were getting harder for them as they were getting older. Staying long hours in the same position, being alone most of the time and communication difficulties with managers and colleagues were a constant in all interviewed workers.

Some recognized that if they continue in these conditions, they do not believe they could remain in the same job position in the long term. The untimely schedules and the lack of free time were also described as one of the greatest difficulties of the workers, who ended the week with very little free time to enjoy other activities or to enjoy family life. The majority acknowledged that if it were not for the salary, which also substantially underwent with the economic crisis, they would not continue in their current job.

7.1.1 Conclusions on the preliminary use cases of the extractive industry

Thanks to the opinions expressed by the interviewed workers who participated in the workshops and in the personal interviews, the preliminary use cases were further elaborated.

First of all, the decision was made to eliminate the PUC 7 "hydration control". The workers pointed out that they always carried water bottles and that whenever they were thirsty they could stop to drink, so they did not see the usefulness of a device that advised them to drink.

As for the "Check-list Platform", the PUC 1, a very important conclusion was reached, that the platform should not only be used for the protection of the worker, but also if possible as evidence to prove that there is a failure in the machinery, so that eventually the worker could not be charged with breaking the machine or causing an accident.

As for the platform of vacations and absences, PUC 2, one of the interviewees was in charge of the staff organization and he found the usefulness of carrying out this type of records for the day-to-day of the company. He noted that the application itself should have a system so that the worker could see which days have been requested and the ones that are still available so that there are no overlaps between them.

As for PUC3, musculoskeletal problems, during workshops and personal interviews, workers were in favour of the application, appreciating the usefulness of the application to suggest exercises to do both at home during work breaks. As for the virtual coach they were not enthusiastic, nor reluctant, about it not having previous experience in this type of tools.

As for PUC 4, on stress detection and insomnia, everyone recognized that they rarely slept the recommended hours due to the untimely hours in which they started their working day. In addition, high levels of stress were found in personal interviews, mainly in mobile machinery operators.

The knowledge exchange platform, the PUC 5, was considered useful by the workers, and during the workshop they showed enthusiasm about participating, although, in the personal interviews they recognized that when they had little time to spare so they saw it difficult to participate in the project from house, to which they always arrived exhausted.

Finally, the emergency button or PUC 6, was the PUC that the interviewees most appreciated. Several mentioned previous experiences or those of colleagues who, being isolated from the quarry, had suffered

accidents or other problems, having to wait a long time for help to arrive. They recognized that one of the main stressors that they faced in their workplace was the isolation, so that a button or device that allowed them to communicate the incident and be quickly geolocated, had a great reception.

In summary, the PUCs that were later evaluated by the workers in the interviews and workshops were redefined resulting in the use cases that we will analyse in the next Chapters.

7.2 Production Factory Workshop

With the aim to identify the potential of our 7 preliminary use cases (PUC) Siemens decided to conduct observation and interview-based studies to get a deeper insight to the needs of all parties in the factory. Observations by psychologists combined with discussions at the workplace together with feedback from shift leaders, worker's council and management provide more information than any questionnaire-based survey. These results combined with the long-term experience of our psychologists and usability specialists helped to assess the requirements of all stakeholders.

These stakeholders are management and shift leaders, who are responsible for the factory's success on the one hand and the workers and the worker's council on the other hand.

Positively prominent were the ergonomically and individually adjustable workstations for assembling parts as well as the overall employee perception of a good inter-collegial environment and a relatively stress-neutral task with the ability to almost always work at the own speed.

Figure 23: Assembling and Testing

The spontaneously most intriguing use case for employees was the ambient virtual coach, a smart watch to help stay healthy e.g. while performing ergonomically similar or repetitive tasks over and over again.

Management, shift leader and workers council

Together with management, shift leaders and worker's council (which was involved in all sessions) the aim of the Ageing@Work Project has been discussed. It turned out that a factory in Braunschweig is an ideal candidate for the Project, because more than 50% of the employees are 50+. To get an impression of the biggest challenges' management is dealing with, we asked the participants to share their perspectives. It turned out that the loss of knowledge to be expected from retirements in the next 10 years is one of the biggest problems.

Taking into account that most employees are working in the same factory for many years (see Figure 61), they have a huge expertise and a lot of experience, therefore there will be a huge knowledge drain the moment they retire. Consequently, management, shift leaders and worker's council have a huge interest in solutions that may help either keeping knowledge in the factory or helping to build it with new employees.

Due to the special portfolio of the factory, they are also interested in solutions that would allow employees to support other workers from remote e.g. when at home, away on a training or in meetings. According to the worker's council, this could also become a model for those that will retire within the next year.

Management and shift leaders also mentioned that they are still searching for a tool that would support them in the approval of holiday applications. One result of the variety of special products in the factory is that not all employers are capable of producing everything. So, for each product there is a small group of expert employees, who are capable of producing it. In order to approve applications for days off then, the manager must ensure that all products can still be produced. This means, he has to ensure that there are enough capable employees on site.

Workers and workers council

During a session where part of the project partners were talking to management representatives, another part was given the chance to quickly observe workers while performing their work and talk to some workers directly at their workplaces. In these short discussions, it turned out that the mental health (e.g. concerning the trust in machines and colleagues, the overall stress level and the ability to finish work according to the own speed) was excellent. Looking at the physical health though, many workers would love to have an ambient virtual coach that helps them stay healthy or become healthier. The majority of the workers mentioned to have backpains or muscular pains in the questionnaire and they believe that such an ambient coach, which recommends to change position or to stretch, could help improve their health, since monotonous movements or lengthy seating intervals are interrupted.
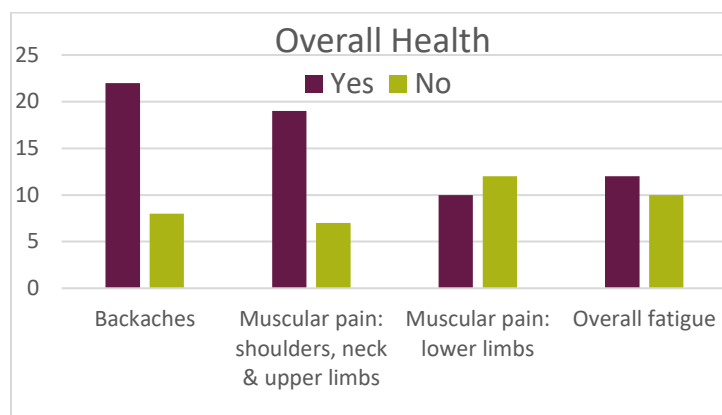
Figure 24. Overall results

Results of the stakeholder evaluations

Besides the evaluation and discussion with workers we additionally also spoke with shift leaders workers council and the management about our preliminary use cases. Based on all these responses we were able to evaluate the Siemens PUC´s and their potential in the factory. The following PUC are sorted by relevance for the factory.

PUC 8: SUPPORTING HEALTH AND WELLBEING – VIRTUAL COACH

An Ageing@Work mirroring avatar running on a smartwatch that supports the users to life a healthier life, e.g. it helps and reminds him users with backpain to change position, stretch, take a walk, or sit for a while. *As mentioned above, such a service would be appreciated by the users. Especially when dealing with ergonomically similar or repetitive tasks over and over again. Such a smartwatch service would be of great interest*.

PUC 9: PRODUCTIVITY ENHANCEMENT THROUGH REMOTE SURVEILLANCE

The smart watch is the digital companion that gives the worker feedback on the current status and reminds him of upcoming tasks that need to fulfil at a certain machine. This will reduce stress, as the worker always knows the status of her/his machines without running around with the fear that some events could be missed. Downtimes of machines are minimized, as errors and warnings are presented immediately in a multimodal way, ensuring the full attention of the workers wherever they are. *This U.C. was seen as helpful at least for persons that deal with several workplaces at the same time. It could also be used for a certain scenario, where one worker is responsible for collecting and providing (milk run) the needed pieces to colleagues that build relays.*

PUC 10: INTERGENERATIONAL REMOTE SUPPORT

The idea of allowing experienced workers to support younger using augmented reality (AR) and/or conversational UI for cross-generation knowledge transfer / collaboration *was perceived very well. Especially the fact that it would allow workers to support from home was perceived as a win-win situation for all including management. Especially the managers and shift-planners have to keep care that the factory is able to produce all of the various parts in time (not all workers are able to produce everything). Therefore such a solution would allow support even when at home.*

PUC 11: KNOWLEDGE EXCHANGE PLATFORM / INSTRUCTIONS ON DEMAND

The idea of this use case is to provide unobtrusive support and assistance to the workers by means of augmented reality (AR) and/or virtual reality (VR).

With the help of the Ageing@Work virtual agent workers could access a cloud based database, on the one hand side prepared by the machine manufacturers with the respective manuals and troubleshooting documentation, and on the other hand side, step by step, by the workers themselves.

Due to the fact that not all workers can produce everything such a database would secure the productivity of the factory even in times with sick leaves or holidays. This is something that managers and shift leader would appreciate.

PUC 12: WORKER AND WORKPLACE ORCHESTRATION

To enable workers to remain productive, happy and healthy and to improve the WorkAbility Index (WAI), it is important to have good work organisation in order to determine which work and which workplace is best suited for each individual worker. Depending on the abilities this might change. It also supports the management site to orchestrate remote support needs and to automatically recognize when all persons with a single knowledge ask for holiday etc

This P.U.C. was discussed controversial. On the one hand the factory already has 3 (SAP) tools that have to be used when asking for days off, so there is not really the need for a 4th tool. However, for the management it would be a simplification if he would have a tool which automatically would recognize when all persons with a single knowledge would ask for holiday.

PUC 13: LIFE LONG LEARNING

Using gamification and latest technology like AR/VR to motivate users to learn.

Again this was only discussed with management and shift leaders. Basically there are already learning platforms available, however these are PC based and not all workers have access to a pc. New forms of education could also improve the willingness to learn.

PUC 14: SIMULATED ERGONOMIC USER MODELS

This PUC 14 was not discussed with the workers. Management and shift leaders were interested in a 3D hall model but were skeptical and did not see a real benefit according to this use case.

This use case aims in realizing a Personalized design of the workplace and processes by simulation and testing in a 3D industrial hall simulator. The 3D map of the hall simulator will be developed with greater detail on the machines, the tool stock area and the corridor in between.

7.2.1 Conclusions on the preliminary use cases of the factory industry

Based on the observation, answers and opinions of the workers, the shift leaders, the workers council and the management our PUC´s have been reviewed and prioritized. As mentioned above the most intriguing use case for both the factory and the office employees was the *ambient virtual coach* that helps to stay healthy.

The second most recommended use case was the Productivity Enhancement through remote surveillance with smartwatch followed by the intergenerational remote support as the 3rd most important use case.

While *knowledge exchange and life long learning* were nice to have the *simulated ergonomic user models* have been eliminated. The *Worker and workplace orchestration* were seen as interesting by the management and the shift leader.

7.3 Prioritized use cases

In order to prioritize the development of the use cases, and perform an iterative development approach, compatible with the user centre design methodology that guides the project, during the workshops, the involved workers have selected those use case more interested by them. In this case, we have defined the following categories of use cases:

- High priority use cases: These cases will be the first to be developed by those responsible for the subsequent phases of the project.
- Medium priority use cases: These cases of use have been considered very useful by workers but less urgent in their implementation. In addition, there is some reluctance about the difficulties that the measuring elements can be compatible with the elements, requirements and safety measures. Efforts should be made in the development of technology in order to reduce adaptation problems.
- Low priority use cases: In this last section we have grouped those cases of use that have been considered by workers as less urgent or more difficult to implement in their day to day due to lack of time.

7.3.1 Extractive industry prioritized use cases

The following table summarizes the results of preliminary use cases prioritization for the extractive industry pilot, after consulting workers over 45 years of age.

Table 18 Use case priorization in case of the extractive industry

High priority use cases	Medium priority use cases	Low priority use cases
PUC1. Check-list platform. PUC6. Emergency Button	PUC2. Communication of absences and vacations PUC3. Musculoskeletal problems PUC5. Knowledge exchange platform.	PUC4. Early detection of stress and insomnia

Once the use cases were priorized by the workers, a technical workshop took place with the participation of ANEFA and UPM, in order to match the use cases with the planned tools developed during the project.

Table 19 Planned tools and workers stations involved per selected use case

Use case	Involved tools (by task)	Applied on
PUC1. Check-list platform.	T6.1. AR-based on-site and remote situation awareness enhancement tool	-Mobile machinery operators. -Laboratory operators. -Drilling/Cutting/blasting operators. -Maintenance operators. -Plant operators.
PUC6. Emergency Button	T5.4. Smart virtual coach with cognition for persuasive, proactive and discreet system behavior T5.5. Data Aggregation to support domain expert decisions	-Mobile machinery operators. -Plant operators.
PUC2. Communication of absences and vacations	T3.5 Participatory work orchestration tool – manager UI and virtual coach/mobile app	-Administration. -Managers and technical staff. -Mobile machinery operators. -Laboratory operators. -Drilling/Cutting/blasting operators. -Maintenance operators. -Plant operators.

PUC3. Musculoskeletal problems	T5.4. Smart virtual coach with cognition for persuasive, proactive and discreet system behavior T3.4. Workplace ergonomics optimization support tool	-Administration. -Managers and technical staff. -Mobile machinery operators. -Laboratoy operators. -Drilling/Cutting/blasting operators. -Maintenance operators. -Plant operators.
PUC5. Knowledge exchange platform.	T6.3. Knowledge sharing tools T6.1. AR-based on-site and remote situation awareness enhancement tool	-Mobile machinery operators. -Maintenance operators. -Plant operators.
PUC4. Early detection of stress and insomnia	T5.4. Smart virtual coach with cognition for persuasive, proactive and discreet system behavior T5.1. The Empathic Ageing@Work Virtual Coach mirroring avatar	-Administration. -Managers and technical staff. -Mobile machinery operators. -Laboratoy operators. -Drilling/Cutting/blasting operators. -Maintenance operators. -Plant operators.

7.3.2 Production Factory prioritized use cases

The table below summarizes the results of preliminary use cases prioritization, in respect to the factory pilot, pointing among others to the ones that will be the first to be developed by those responsible for the subsequent phases of the project. These have been considered by factory workers aged 50+ and Office Workers aged 46+.

Table 20 Use case prioritization in case of the production factory

High priority use cases	Medium priority use cases	Low priority use cases
PUC8 Supporting health and wellbeing - virtual coach PUC9 Productivity Enhancement through remote surveillance with smartwatch	PUC10 Intergenerational remote support PUC11 Knowledge exchange platform	PUC12 Workplace orchestration PUC13 Life long learning PUC14 Simulated Ergonomic User ModelsUC11

Once the use cases were prioritized by the workers, a technical workshop took place with the participation of Siemens and the Ageing@Work technical partners in order to match the use cases with the planned tools developed during the project.

Table 21 Planned tools and workers stations involved per selected use case

Use case	Involved tools (by task)	Applied on
PUC8 Supporting health and wellbeing - virtual coach	T5.4. Smart virtual coach with cognition for persuasive, proactive and discreet system behavior T5.1. The Empathic Ageing@Work Virtual Coach mirroring avatar	1. PCB manual assembly (AR display) 2. "milk-run" (relays transfer back and forth) (smartwatch) 3. PCBs automatic development through multiple machines/lines 4. Fire alarms (smartwatch/vibration) 5. Office Workers
PUC9 Productivity Enhancement through remote surveillance with smartwatch	T6.1. AR-based on-site and remote situation awareness enhancement tool	1. PCB manual assembly (AR display) 2. "milk-run" (relays transfer back and forth) (smartwatch) 3. PCBs automatic development through multiple machines/lines 4. Fire alarms (smartwatch/vibration) 5. For office workers: in a Siemens Maker Space, a prototyping laboratory with "maker" tools like 3D printer, laser cutter, CNC cutter, borer
PUC10 Intergenerational remote support	T6.4. AR-based telepresence tool for remote collaboration	1.complex machines maintenance/operation 2 development of new, special products that need specialized knowledge.
PUC11 Knowledge exchange platform	T6.3. Knowledge sharing tools T6.2. VR and AR based lifelong learning tools	(1) maintenance of machines (2) manual assembly (3) virtual safety training (mandatory to use Siemens Maker Space) (4) Exploitation & maintenance of prototyping tools by newbie makers
PUC12 Workplace orchestration	T3.5 Participatory work orchestration tool – manager UI and virtual coach/mobile app	

7.3.3 Consolidated view on the extractive industry and production factory use cases

The process for defining use cases has followed several steps in the extractive industry and in the production factory. The reasons behind this were first to discover the main barriers and problems related to aging process in the different pilots, and second, make easy for the worker the understanding of the solutions proposed by Ageing@Work project.

As a result of the whole process, 14 different Preliminary Use Cases have been defined, 7 per pilot. Therefore, following the prioritization of the use cases, and the comments and definition of these use case by the workers, there are common user needs and requirements that cover different worker ageing process domains.

The objective of this section is to establish synergies and common points between the PUCs defined during the pilots co-creation process. This analysis can help defining a set of a common use cases that will serve as the basis for further technological developments and pilots deployments within the project, as further explained in Section 9 (Use cases – detailed descripiton) of the deliverable.

Analysing the results from Table 19 and Table 21 above, several common tools have emerged for a series of use cases. In fact, PUC 10 and PUC 12 use cases from the factory pilot, could be considered sub use cases of the PUC2, because the extractive industry participatory work orchestration has a more general definition, as well PUC9, PUC11 and PUC13 could be considered subcases of the PUC5, as part of the Knowledge Exchange platform functionalities. Finally, PUC6 can be considered a subcase of the PUC8 as part of the ergonomics and adaptation control of the workplace, while PUC7 could be consider on PUC4 as part of the health assessment tool.

The following table summarises these synergies between use cases, which have led to the consolidated detailed definition of the Ageing@Work use cases, which are further described in Section 9.

Extractive industry Use case	Production factory
PUC1 Check list platform	
PUC2 Participatory work orchestration	PUC11 Knowledge exchange platform and PUC12 Workplace orchestration
PUC3 MSK problems	PUC8 Supporting health and wellbeing - virtual coach
PUC4 Supporting health and well being	PUC8 Supporting health and wellbeing - virtual coach
PUC5 Knowledge Exchange platform	PUC11 Knowledge exchange platform, PUC10 Intergenerational remote support and PUC9 Productivity Enhancement through remote surveillance with smartwatch
PUC6 Emergency button	
PUC7 Hydration controller	

8. User requirements definition and prioritization

Following the results obtained from the surveys, workshops and personal interviews, the present section describes the relevant user requirements identified in this scope, divided into:

- Functional requirements.
- Design requirements.
- Interaction requirements.

The overall results of the analysis of user requirements are summarized in the following tables, where each requirement is described along with its relevance and importance value relevant to its prioritization, in respect to each pilot site of the project.

8.1 User functional requirements for the Ageing@Work Solutions

Table 22: User functional requirements for the Ageing@Work Solutions

Nº	Type	Requirement Description	ANEFA/ Siemens	Importan ce value
FR1	Emergency button	An emergency button should be placed in the workplace/cabin or at the smartwatch, to be pressed in case of accident or another emergency, so that an emergency notification is sent to the management side and the worker is instantly geolocated if possible.	ANEFA	H
FR2	Check-list platform	The platform would help the worker to do a check-list of all the security items. The results of the check-list should be uploaded and communicated to the manager or person responsible.	ANEFA	H
FR3	Security elements	The worker should be able to complete the safety element checklist before starting his/her shift using the mobile app.	ANEFA	H
FR4		The app/platform should send an instant alert to the person responsible of the security if there is a failure in any of the security elements, according to a previous list of security	ANEFA	H

		elements, both individual and collective, or in the machinery (for example failure in the break system). An instant dialog would be established between the user and the person in charge. The contents of the platform should be updated.		
FR5		In the event of a failure in the machinery the manager or security personnel will be able to initiate an immediate communication via a mobile device to provide support.	ANEFA	H
FR6		The application should allow workers to virtually perform security checklists for training purposes (without a real machine involved) before taking the responsibility of a shift.	ANEFA SIEMENS	M M
FR7	Participatory work orchestration	An age-friendly flexible work management should be provided to the users by the system (work from home/ request day-off)	ANEFA SIEMENS	H M
FR8		The platform would help the worker to ask the manager for free days or to work from home and to keep control for the free days that s/he has not enjoy yet.	ANEFA SIEMENS	H M
FR9		The manager will be able to approve the worker's requests according to their priority and the needs of each shift work-plan.	ANEFA SIEMENS	H M
FR10		Older and experienced users should be able to report their time availability to support younger workers from distance.	ANEFA SIEMENS	H H
FR11	Support for musculoskeletal problems and healthy habits – Virtual Coach Healthy habits – Virtual Coach	The worker should be able to perform evaluation of alternative ergonomics designs (ergonomics simulator) and receive the simulation results as a proof.	ANEFA SIEMENS	M M
FR12		The app would provide the user with advice on physical exercise –related activities that s/he can perform during the working day, and also while s/he is at home.	ANEFA SIEMENS	H H
FR13		The user would be supported by the system in the form of recommendations in the smartphone/smartwatch- to develop habits that will improve his/her physical health.	ANEFA SIEMENS	H H
FR14		The user should be able to provide information to the app on the type and level of pain.	ANEFA SIEMENS	M M
FR15		The app would give the worker advice on healthy habits to improve her/his sleep quality.	ANEFA SIEMENS	H M
FR16		Worker measurements would be available through the app, so the worker would be able	ANEFA SIEMENS	H M

		to get an overview of parameters relevant to her/his health status, the number of hours s/he has slept, the time dedicated to perform exercises, her/his cardiac rhythm or her/his improvement since starting to implement the advices in healthy habits.		
FR17		Behavior aspects of the worker, in respect of the proposed interventions (e.g. adherence to exercise), should be monitored by the virtual agent.	ANEFA SIEMENS	M M
FR18		The virtual Coach controls the worker while doing the prescribed exercises through a web camera and advices on changing them whenever it is necessary.	ANEFA SIEMENS	L L
FR19		The tool should monitor the cardiac rhythm of the user and vibrate in case that abnormal HR is detected. The vibration should be identifiable by the subject.	ANEFA SIEMENS	H L
FR20	Knowledge exchange Platform, collaboration and productivity enhancement	The platform would help the older workers to share their knowledge with the younger, uploading HD videos, images or documents or addressing the problem directly with an online chat.	ANEFA SIEMENS	H H
FR21		The worker should receive symbolic awards (or any other awards provided by the company policy) according to their personal or team performance.	ANEFA SIEMENS	H H
FR22		Less experienced workers should be able to search for solutions to specific problems using search criteria (e.g. key-words).	ANEFA SIEMENS	H H
FR23		The experienced worker through the touch screen of his/her tablet will be able to provide remote guidance to a less experienced, e.g. younger worker who is on-site, to e.g. repair a machinery.	ANEFA SIEMENS	H H
FR24		From the analysis of the AR Telepresnece log files the manager will be aware of the areas/fields/sectors where the most problems occur, the level of support provided to the worker and the level of satisfaction. In addition, further information on failures or better handling of machinery may be added.	ANEFA SIEMENS	M M
FR25		The app allows the workers to remotely observe several machines and to receive	ANEFA SIEMENS	M H

		notification of upcoming events from each machine.		

8.2 User design requirements for the Ageing@Work Solutions

Table 23: User design requirements for the Ageing@Work Solutions.

Nº	Type	Requirement description	ANEFA/ Siemens	Importance value
DR1	Emergency button	The emergency button should be placed in the cabin or in the smart watch and activated by touch or with a voice command if possible, if the worker cannot use hands.	ANEFA	H
DR2	Check-list platform	The check list for the security elements should be periodically updated. It should be sent to the manager or person responsible immediately after it is completed. The results of the security list should be uploaded to the manager´s platform profile.	ANEFA	H
DR3	Participatory work orchestration	The platform must be designed so that the user can check the days left to enjoy, the weeks or days of vacations available that have not yet been requested by colleague, and the ones that he can no longer request.	ANEFA SIEMENS	H M
DR4		As for the days of absence due to justifiable family or medical needs, the user can mark his request for days with ranges from 1 to 3, one being unchangeable and three changeable.	ANEFA SIEMENS	H H
DR5		Employees will be provided the tools to manage requests based on a digital calendar visible in the mobile app.	ANEFA SIEMENS	H H
DR6	Knowledge exchange Platform, collaboration and productivity enhancement	The platform must be designed so that high-quality videos, images, documents and other content about safety requirements or advices or tips from older workers can be shared with younger workers.	ANEFA SIEMENS	H H
DR7		The content must be updated, and the platform should divide the contents into more recent files, more visualized and better valued.	ANEFA SIEMENS	H H
DR8		The platform will include a chat session to establish instantaneous communications between the workers.	ANEFA SIEMENS	H H

DR9		Users should be guided into the necessary actions to be implemented using virtual objects projected on top of the real world scene (sensed through the mobile device camera).	ANEFA SIEMENS	H H
DR10		The AR-based telepresence tool should provide aids that will help the user into easy overview of the overall process, previous steps etc.	ANEFA SIEMENS	H H
DR11		The younger users will be able to identify the authors of the uploaded materials, so to proceed with asking relevant questions through the platform if needed.	ANEFA SIEMENS	H H
DR12		The worker involved in a learning session will be informed by the virtual coach on the learning plan and the remaining exercises to be performed.	ANEFA SIEMENS	H H
DR13		The application for remote machines surveillance should be incorporated into the user´s smartwatch. It will include information from the user's machines (e.g. status, time2finish, …)	SIEMENS	M
DR14	Supporting health and wellbeing - Virtual Coach	The tools to measure biosignals (e.g. the cardiac rhythm) should be light, easy to use, activated by touch and worn under the clothes.	ANEFA SIEMENS	H M
DR15		The worker should be able to see information relevant to her/his health status (e.g. cardiac rhythm, quality of sleep, perceived stress level, etc.) through the mobile app.	ANEFA SIEMENS	H H
DR16		The user should have access to his/her own data recordings relevant to her/his health and behavior (e.g. number of hours s/he has slept, the time dedicated to perform exercises, cardiac rhythm or improvement traits by following relevant advice).	ANEFA SIEMENS	H H
DR17		The virtual coach must have a human-like appearance, a pleasant voice and respond to the voice of the user. The exercises proposed by the coach should be easy to perform and aimed at helping in the condition presented by the subject (e.g., back pain, shoulder pain, leg pain.	ANEFA SIEMENS	M H
DR18		The system should provide vibration if the worker's heart-beat is abnormally high or low	ANEFA SIEMENS	H M

		(e.g. brady-cardia, tachy-cardia), with a frequency of vibration identifiable for the user so that it does not confuse it with that of the machine.		
DR19		The tools to monitor worker biosignals (e.g. cardiac rhythm) must not compromise the security of the worker or limit her/his movements.	ANEFA SIEMENS	H M
DR20		Sleep control measurements should be taken by the user's smartwatch. It will include information on the total number of sleeping hours, sleep quality, night-time interruptions, heart rate and evolution since the beginning of the measurement.	ANEFA SIEMENS	L L

8.3 User interaction requirements for the Ageing@Work solutions

Table 24: User interaction requirements for the Ageing@Work Solutions

Nº	Type	Requirement description	ANEFA/ Siemens	Importance value
IR1	Emergency button	The emergency button will be activated by pressing or by voice command in case it is not possible to touch it, if ambient noise allows this.	ANEFA	H
IR2		If available to the system, the geolocation of the subject will be sent instantaneously to the responsible of security who will communicate with her/him to know the nature of the emergency.	ANEFA	H
IR3	Check-list platform	In the event of a failure in the machinery or safety equipment from the checklist, an immediate communication will be established via the tablet or mobile phone webcam with the security manager to try to repair the problem. If this is not possible, mechanics will be contacted.	ANEFA	H
IR4		The results of the security checks will be sent to the profile of the manager on the platform.	ANEFA	H

IR5	Supporting health and wellbeing - Virtual Coach	The app will give health-related advice to the user preferably once a day, preferably in the morning when the subject goes to work. The advice should always be positive, encouraging the subject to continue with good habits taking into account the personal conditions of the use.	ANEFA SIEMENS	H H
IR6		The system notifications and recommendations should be provided to the user in an intuitive way, that will try to avoid attention theft.	ANEFA SIEMENS	H H
IR7		The user should be able to control the notification settings (level of intrusiveness) like the time to receive reports, the frequency of notifications, disturbance-free time zones.	ANEFA SIEMENS	H H
IR8		Workers should be able to provide their feedback about health status using online questionnaires on their own time availability.	ANEFA SIEMENS	M M
IR9		The worker will be able to see her/his the measurements and will be able to receive daily summareis of the results obtained.	ANEFA SIEMENS	M M
IR10		The mirroring avatar should support both facial and body emotional expressions when communicating with the user.	ANEFA SIEMENS	H H
IR11		The user's emotional states should be reflected to the behavior of the virtual coach and thus turn its appearance into that of an 'empathic mirroring avatar'.	ANEFA SIEMENS	H H
IR12	Participatory work orchestration	The platform to request free days or vacations will be accessible both to the manager and to those responsible for human resources, so that they can organize work in advance according to the workers available that day	ANEFA SIEMENS	H M
IR13		The application will send a notification to the person in charge in case more worker requests a day of absence to optimize the workplace schedule.	ANEFA SIEMENS	H M
IR14		The managers will be supported by the system with automatically produced	ANEFA SIEMENS	H M

		shifts work-plans suggestions, taking into account worker requests for day-off or work from home.		
IR15		The system will provide managers the ability to access the ergonomics assessment results (performed by the users, upon workers' request) and to perform their own simulation testing.	ANEFA SIEMENS	M M
IR16	Knowledge exchange platform, collaboration and productivity enhancement	The knowledge exchange platform will be accessible to both older workers and young people through private profiles with a password.	ANEFA SIEMENS	M H
IR17		Users should be able to upload videos, images, documents or advice relevant addressing a specific problem in the work process (repairing of a machine, calibration session etc.).	ANEFA SIEMENS	M H
IR18		The videos and other files uploaded by the worker can be deleted at any time by the user who uploaded it. The contents of the platform should not be distributed outside of it.	ANEFA SIEMENS	M H
IR19		The chat that will be included in the platform will allow the young user to address the user who uploaded the content privately or do a general question on the wall and wait for another user to answer it.	ANEFA SIEMENS	M H
IR20		The videos and other content may be punctuated by users, with the best rated ones appearing in the first place	ANEFA SIEMENS	M H
IR21		Distant users should be able to perform telepresence sessions in real-time with audio and share (camera) screen.	ANEFA SIEMENS	L H
IR22		Users will be able to evaluate the quality of the knowledgebase contents and search results received using a metric system (e.g. using smiling faces evaluation).	ANEFA SIEMENS	L M
IR23		Experienced users will be able to provide help by participating in a Question & Answer (Q&A) platform.	ANEFA SIEMENS	L M
IR24		Older and more experienced users should receive symbolic awards for their contribution to the Knowledge	ANEFA SIEMENS	M M

		base and the Telepresence Tool, towards supporting their motivation to contribute.		
IR25		The subject will wear the smartwatch which will notify by means of vibration when an interaction is required.	SIEMENS	H
IR26	General	The users should have access to the system's services on offer through personal smart phones, tablets, smart watches and PC devices.	ANEFA SIEMENS	H H
IR27		The subject will not have to enter more data than the physical ones referring to their gender, age, weight and height at the beginning of the use of the application.	ANEFA SIEMENS	M M

9. Use cases – Detailed description

In this section, the main use cases of the Ageing@Work system are described. The use cases are based on the overall findings of WP2 efforts, consolidating a further elaborated version of the preliminary use cases, as explained in Section 7.3.3 of the deliverable. Notably, the use case descriptions are further elaborated in the present section, focusing on the dynamic behaviour of the system. For this analysis and the detailed definition of the project use cases, the following template has been used:

USE CASE NAME	
Version	Reflects the stage that a use case definition has reached.
Short Description	Please describe the series of steps for the defined use case in a clear concise manner. Include in the description what the Ageing@Work system shall do for the involved actor to achieve a particular goal.
Challenges	This field describes main challenges that the use case wants to address with respect to the ageing workers.
Assumptions & Pre-Conditions	This part may describe the conditions that generally does not change during the execution and should be true to successfully terminate the use case. Moreover, pre-conditions define all the conditions that must be met (i.e., it describes the state of the system) for the meaningfully cause the initiation of the use case.
Goal (Successful End Condition)	The ultimate aim and end condition(-s) of the Use Case
Involved Actors	Who are the actors involved in the use case? The same actor may play two different roles in the same use case. An actor may be a person, a device, another system or sub-system, or time. Actors represent different roles that something outside has in its relationship with the system, functional requirements of which are being specified.
Use Case Initiation	This refers to the potential triggers or events that could initiate the use case. The type of trigger can be temporal, internal or even in respond to an external event. Normally, the initiation of a UC shall take into account also the pre-conditions, e.g. checking them prior the execution of the UC.
Main Flow	This section shall describe the typical course of events that comply with the primary scenario addressed by the UC. Basic course of events could be enough using a step-based approach.
Problem addressed	This field identifies problems that worker face and the problems helps at, whether in the workplace or not.

Results and Benefits	This field briefly outlines the benefits that actors, and in particular the older ones, will have.
Evaluation Criteria	This field outlines some criteria that can be followed in order to evaluate the correct realization of the use case in the pilot trials
Relevance to Ageing@Work WPs	Please report the relevance to the Ageing@Work WPs
Related User Requirements	Please report the relevance to the Ageing@Work User Requirements
Privacy & Regulation restrictions	Refer to any concerns on this perspective during the execution of the use case
Environmental restrictions	Refer to any concerns on environmental restrictions during the execution of the use case
Relationships with other Use Cases	Indicates connection with other use cases
UC Diagram	Provide through a sequence diagram the logic of a complex operation, function or procedure that is implied by the use case. It contains the key architectural elements and outlines the main execution flow during the instantiation of this use case.

9.1 USE CASE 1: CHECK-LIST PLATFORM

USE CASE 1: CHECK-LIST PLATFORM	
Version	V1.0
Short Description	Through this application scenario, the machine operators will be able to check the safety elements related to the task of their shift. Taking as a starting point the current manual process, the checklist platform will be interactive, will speed up the process and try to make it more secure both for the operators and for the machines. In case that something will fail, the right alarms will be triggered (both to the manager and/or to an experienced person in charge).
Challenges	▪ Ensuring that older workers have followed the necessary safety instructions prior to their shift ▪ Increase the safety of machinery operation ▪ Decrease the negative effects of ageing workers' overconfidence (e.g. not paying attention to strict compliance with safety procedures) ▪ Help in cases of memory issues that may appear in ageing workers
Assumptions & Pre-Conditions	▪ The manager registers the security elements at each job position. This list should be periodically updated by authorized users (Manager/ Safety responsible) ▪ The system knows the type of shift of the worker and the relevant safety elements and procedures ▪ An experienced and skilled worker is stand-by to offer support (having in hand the right equipment e.g. tablet) ▪ All involved personnel is trained on how to use the tools (devices and apps)
Goal (Successful End Condition)	The employee must complete the safety elements checklist before starting his / her shift. After the completion of this action a notification is sent to the data aggregation system at the management side.
Involved Actors	- Worker - Manager - Stand-by experienced and skilled worker
Use Case Initiation	▪ The worker is about to start her/his shift and logs into the check-list platform of the Ageing@Work application.

	- The worker enters the details of the check-list scenario to be performed: - id of the machine - his/her own id (machine operator) - The system loads from the database: - the current machine model - the scenario model (series of tasks and rules) - the worker model (machine operator) - The system checks that the current machine operator has privileges to operate the specific machine for the specific check-list - The system confirms (user model) that the current distant worker has the knowledge, skills and privileges to provide support - The system automatically enters: - the current datetime - the working position id - the id of the distant experienced worker in charge (stand-by position) - The system sends a notification to data aggregation system, preparing a possible subsequent notification distribution (if needed) to the management side and the worker in charge of safety
Main Flow	- The system reads the current state of the machine (e.g. through the factory API) and the conditions of the environment (e.g. temperature, humidity, noise, vibrations) - The system keeps track of user activities relevant to the safety check-list and logs them - The system loads next step (from the check-list scenario) and projects recommendations and notifications in the screen with the help of the virtual avatar - The worker, through appropriate application, completes the safety element checklist - The manager and the distant experienced worker are notified if there is an issue with some worker's safety checklist. - In case of failure (sensed by the system or initiated by the machine operator) telepresence session (UC5) automatically starts.
Problem addressed	For the worker: - Technical problems

	- To help maximize confidence that safety instructions have been properly followed (no relying solely on worker's own memory) - Maintenance of the machinery - Internal communication of the safety problems ■ For the manager: - Better efficiency in the control of the safety chain
Results and Benefits	■ Contributes to the worker's capacity to comply with the safety regulations, despite ageing ■ Help supressing the possibility of a failure related to safety equipment or procedures, caused by human mistake ■ It can also improve the way the manager can deal with safety, as well as maintenance issues of the machinery so that he/she can better organize the work processes with the available ones
Evaluation Criteria	■ Level of confidence that the worker has successfully completed the safety element check list ■ Indication that no important steps were missed
Relevance to Ageing@Work WPs	WP3, WP5, WP6
Related User Requirements	FR2, FR3, FR4, FR5, FR6, DR2, IR3, IR4
Privacy & Regulation restrictions	In case that worker's sensitive data are involved (e.g. related to activity and behaviour monitoring), those should be stored locally in his/her smart phone or tablet or if transferring to the data aggregation system is necessary, proper data security mechanisms must be employed.
Environmental restrictions	■ Environmental lighting conditions to allow the machine operator operate the machine, the tablet and the HMD. ■ Working environment safe to operate (machine faults do not lead to emergency evacuation)
Relationships with other Use Cases	UC5
UC Diagram	

9.2 USE CASE 2: PARTICIPATORY WORK ORCHESTRATION

USE CASE 2: Participatory work orchestration	
Version	V1.0
Short Description	The work-orchestration-tool is an essential planning tool for the factory manager. Due to the, usually high, number of employees on the work floor and their different skills, in terms of being certified for different machines, various apprenticeships and additional qualifications, the manager may miss

	some of these details when trying to organize the upcoming period's (e.g. week's) shift plans. Furthermore, in the production area, certain workers get specific trainings for the production of special products and thus, the manager has to ensure that, when these parts are on the production schedule, those employees are on premises or at least, capable to contribute remotely in the production process if necessary. Considering the number of employees, shifts to plan, parts to produce, vacation, sick leave and special requests from various workers e.g. not to be scheduled for night shifts, etc. such a work-orchestration-tool facilitates the daily routine of the production manager enormously. Through the platform, the workers will communicate requests for absences or vacations to the people in charge of personnel, while the aim of the overall system will be to facilitate and simplify flexible work management, both at the ageing worker and at the management side of the company.
Challenges	▪ Establish an online bidirectional communication platform between the worker and the HR department to efficiently handle worker's requests ▪ Support age-friendly flexible work management (for workers) ▪ Facilitate the efficient feasibility test of the requests (for managers) ▪ Insert transparent processes in workers requests and managers decisions (request logistics) ▪ Search for and propose shift reallocations
Assumptions & Pre-Conditions	▪ The managers have already inserted all the required information (worker skills, shift plans, machine details, etc.) into the AGEING@WORK system. ▪ Company personnel should be trained in the use of the platform.
Goal (Successful End Condition)	▪ A full lifecycle of worker's requests has been completed (the manager has approved or rejected the worker's request) ▪ The manager has successfully scheduled the upcoming shifts using the workplace orchestration tool. ▪ Self-management of 'days off' and 'work from home' requests (e.g. the worker is informed of the number of days still available for vacation).
Involved Actors	- Worker

	- Manager
Use Case Initiation	The worker is logged into the user's dashboard (mobile app) and views the schedule/calendar view, his/her personal requests history, open issues and pending requests. The manager is logged into his/her dashboard in order to schedule the upcoming shifts.
Main Flow	▪ Upon entering the platform, the worker is able to be informed of the number of days available for vacation, the weeks during the year to enjoy these vacations. ▪ Upon entering the platform, the manager or the shift responsible is able to be informed of the workers available, worker's requests pending and the production needs for the upcoming shifts. ▪ The worker initiates a request (e.g. for a day-off, or to work from home, or to be stand-by for some exceptional need). The request remains open on the dashboard (pending for approval). ▪ The manager receives the request at the data aggregation and work orchestration tool ▪ The manager assesses the request and makes alternative shift plans as an attempt to satisfy the worker's request (also by consuming data and models from the knowledge base) ▪ In case of a successful shift rearrangement outcome, the manager grants the day to the worker or suggests that he/she has to change it.
Problem addressed	▪ Internal Communication of absences. ▪ Production downtime due to missing knowledge. ▪ Organization of work in the absence of workers. ▪ Account and control of days off and work from home ▪ Ageing worker difficulties in flexible work scheduling.
Results and Benefits	▪ Easier handling of flexible job scheduling for the ageing worker. ▪ The manager will know the absences of the workers as soon as possible. ▪ There will be a more efficient organization of work with the employees available. ▪ The workers will make a better self-management of their working benefits (e.g. be aware of the exact number of days off that they have left, advice the calendar, see the history of past requests, etc.).

	▪ Flexible work management for the ageing workers will be facilitated through a transparent, collaborative approach.
Evaluation Criteria	The manager is informed about the absences of the workers on time, towards a more efficient organization of the work with the employees available. In addition, the system provides the capability to support more flexible scheduling for the ageing workers
Relevance to Ageing@Work WPs	WP3, WP5
Related User Requirements	FR7, FR8, FR9, FR10, DR3, DR4, DR5, IR12, IR13, IR14, IR15
Privacy & Regulation restrictions	Workers data related to the requests should not be shared with other workers (number of days off, reasons for applying a request and the results of the requests).
Environmental restrictions	The social environment should allow a private communication with the manager.
Relationships with other Use Cases	UC3
UC Diagram	
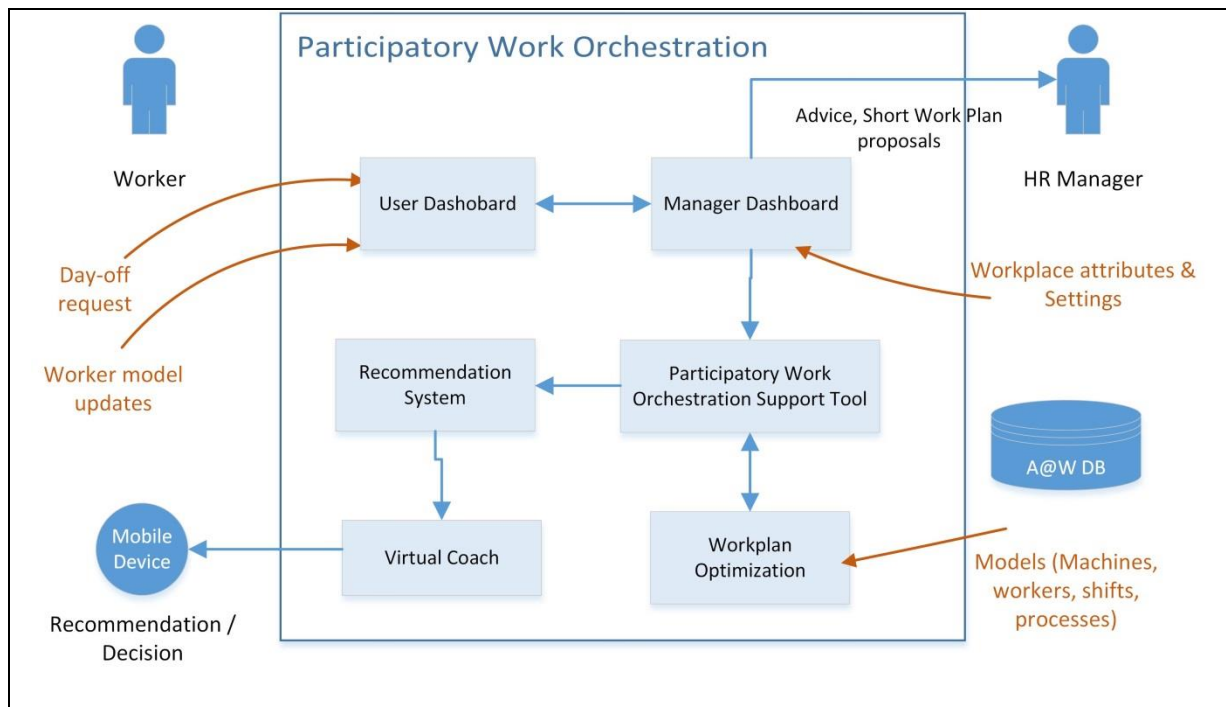
9.3 USE CASE 3. SUPPORT FOR MUSCULOSKELETAL PROBLEMS

USE CASE 3: Support for musculoskeletal problems	
Version	V1.0
Short Description	The system will suggest, through the Virtual Coach, physical exercises or stretches to the worker to do at home or at work, so as to help the user reduce or avoid musculoskeletal problems. This will be coupled with workplace ergonomics assessment, while it can also interact with job scheduling (e.g. worker is not assigned tasks with weight lifting in case of back pain).
Challenges	▪ Provide workers with suggestions so as to help them reduce the incidence of musculoskeletal problems. ▪ Propose efficient ways for tools to be used by workers at home or office environments, to help in avoiding or reducing musculoskeletal problems.

Assumptions & Pre-Conditions	▪ The system should have information on musculoskeletal issues of workers (self-reported) ▪ The system must have knowledge on effects of specific musculoskeletal issues to specific job tasks and interactions thereof (in the knowledgebase given by health & safety professionals) ▪ The system must have knowledge on exercises that can help worker musculoskeletal problems (recommendations for interventions).
Goal (Successful End Condition)	The worker successfully follows the advice provided by the system (e.g. performs the proposed exercise).
Involved Actors	▪ Worker ▪ Health and Safety Professionals (HSP)
Use Case Initiation	The worker uses the user's dashboard to provide information on the type and level of pain.
Main Flow	▪ The worker provides information of the kind of tasks to be performed in the shift and the working position (or this data is already known to the system) ▪ The user provides feedback about kind and level of musculoskeletal issue related pain. ▪ The system loads the right user models, task & workplace models, past user's feedback from online questionnaires ▪ The Virtual Coach provides pieces of personalized advice related to healthy habits, exercises and correction of postures so as to help with worker's musculoskeletal issues ▪ According to the worker's responses to the messages (e.g. performance i.r.t the proposed exercises), the virtual coach will provide encouraging messages to the worker for successfully performing the proposed exercises, and kindly correcting him/her in case of poor performance
Problem addressed	▪ Musculoskeletal problems and the related perceived pain ▪ Bad postural habits at work and beyond
Results and Benefits	▪ Helping the decrease in sickness absences ▪ Helping into increase in workers' productivity ▪ Helping to reduce accidents by changing bad habits (e.g. wrong body posture at work, inactivity for long periods of time, etc.). ▪ Implement healthy habits that ultimately improve the well-being of the worker

	▪ Prevents postural problems from becoming disabling diseases
Evaluation Criteria	▪ Degree of compliance with recommendations (the worker follows a suggested exercise). ▪ The level of pain reduced (self-reported by the worker)
Relevance to Ageing@Work WPs	WP3, WP5
Related User Requirements	FR11, FR12, FR13, FR14, FR16, FR17, FR18, DR15, DR16, DR17, IR15
Privacy & Regulation restrictions	Worker's data should be stored locally in his/her smart phone or tablet.
Environmental restrictions	▪ Enough space to allow the user physically perform the recommended exercises ▪ Social discretion for willingness to perform the recommended exercises
Relationships with other Use Cases	UC2, UC4
UC Diagram	

Support for Muscoskeletal Problems
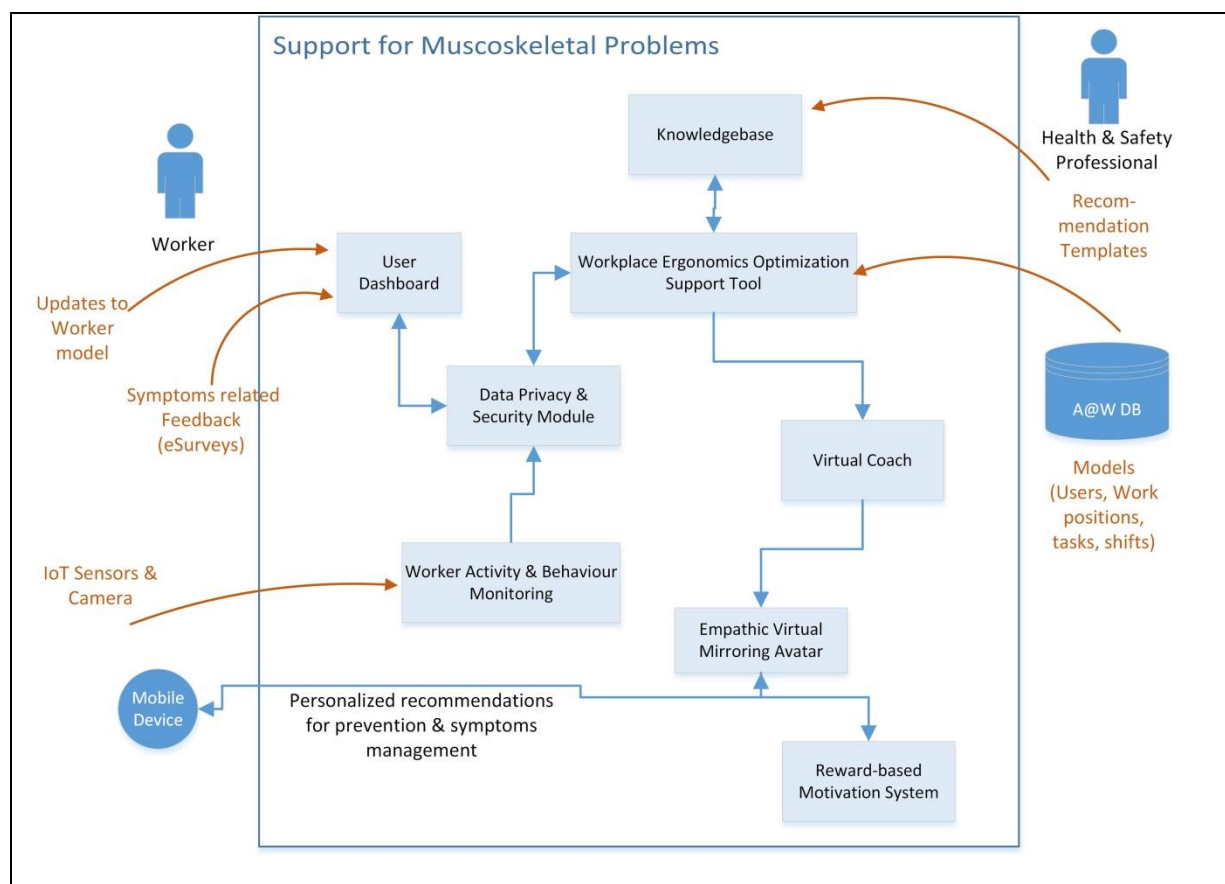
9.4 USE CASE 4: SUPPORTING HEALTH AND WELL-BEING – VIRTUAL COACH

USE CASE 4: Supporting health and well-being – Virtual Coach	
Version	V1.0
Short Description	The overall aim of this UC is to have the Ageing@Work virtual coach motivating users to behave in ways that can improve their health and well-being. The system based on the worker's information about his/her marital status and obligations (childcare, elderly parents) and his/her daily/social activities and behaviour will provide advice to the worker so as to help him/her in this respect.

In this context, the system will monitor several aspects related to the worker's behaviour and routines, in terms of daily activities at work and beyond, as well as aspects of the quality of sleep and level of perceived |

	stress, using a multi-parametric approach; the aim will be to provide personalized recommendations on ways to reduce the negative symptoms and fight the causes, towards supporting health and well-being.
Challenges	▪ Provide workers with suggestions in order to adopt healthier habits ▪ Early detection of the causes of insomnia and interventions to improve sleep quality ▪ Early detection of stress and interventions to reduce it (in working and home environments) ▪ Efficient self-management of relevant symptoms
Assumptions & Pre-Conditions	▪ The user must wear a smart watch on a 24/7 basis ▪ The system has information about worker's social activities and relevant family obligations/routines to the extent possible (e.g. taking grandchildren to regular evening activities; the worker must fill out questionnaires) ▪ The system has information on issues relevant to quality of sleep or stress; user provides relevant data if needed (e.g. kinds of symptoms) ▪ Health & Safety Professionals have authored the required number and kinds of interventions to address the above issues
Goal (Successful End Condition)	▪ Advice provided to the ageing worker towards long-term improvement of health, well-being and work-life balance. ▪ Advice is provided to the user so as to help her/him with sleep problems. ▪ Intervention provided so as to help the worker to reduce her/his stress levels. ▪ Worker adherence over the advice provided by the system.
Involved Actors	▪ Worker ▪ Health & Safety Professionals (HSP)
Use Case Initiation	▪ The user registers into the application and through questionnaires updates the system with relevant information about his/her marital status and obligations (child care, elderly parents) and his/her social activity in order to be supported for a healthier lifestyle.

	▪ System detects user behaviours that can be improved towards better health and well-being, increased worker stress or issues with worker's sleep quality OR ▪ The worker self-reports such issues (though online questionnaires)
Main Flow	▪ The system loads the right user model ▪ The application monitors user activities and biosignals at regular intervals. ▪ If worker's heart rate or stress parameters exceed a predefined threshold, the system searches for the appropriate intervention and creates personalized notifications through the virtual coach. ▪ User's daily behaviours are monitored (on work, home and on the move) and in case some advice is deemed necessary so as to help the user i.r.t. physical health or socialization, this is provided by the virtual coach ▪ For long-term interventions (time-proof symptoms), the personal history of the user is taken into account and long-term strategies are followed ▪ Managers may have access only to anonymized and group-level indicators of achievements against stress or low quality of sleep (groups of 6 or more people) through the manager's dashboard
Problem addressed	▪ Deterioration of health and well-being along with ageing ▪ Balancing work and personal life ▪ Low quality of sleep ▪ Stress (associated with work or lifestyle) ▪ Possible accidents caused by lack of attention derived from stress and insomnia ▪ Low work performance because of relevant symptoms
Results and Benefits	▪ Supporting the ageing worker's health and well-being ▪ Detection of insomnia/sleep problems and provision of tips to improve sleep quality ▪ Detection of stress and tips to reduce symptoms and possibly causes ▪ Improvement on productivity and workability ▪ Reduction of accidents by changing habits

Evaluation Criteria	- Relevant recommendations provided to worker i.r.t. to health and well-being; received with adherence - Relevant recommendations provided to reduce stress levels and improve sleep quality metrics - Improved workability and quality of life
Relevance to Ageing@Work WPs	WP4, WP5, WP6
Related User Requirements	FR13, FR15, FR16, FR17, FR19, DR14, DR15, DR16, DR17, DR18, DR19, DR20, IR5, IR6, IR7, IR8, IR9, IR10, IR11
Privacy & Regulation restrictions	Personal and sensitive data: - not stored in cloud media - not shared with colleagues or managers - encrypted - anonymized before sending achievement indicators in group-level
Environmental restrictions	None reported
Relationships with other Use Cases	UC2 (e.g. requests related to high perceived stress or low quality sleep), UC3 (e.g. low sleep quality due to musculoskeletal problems related pain)
UC Diagram	

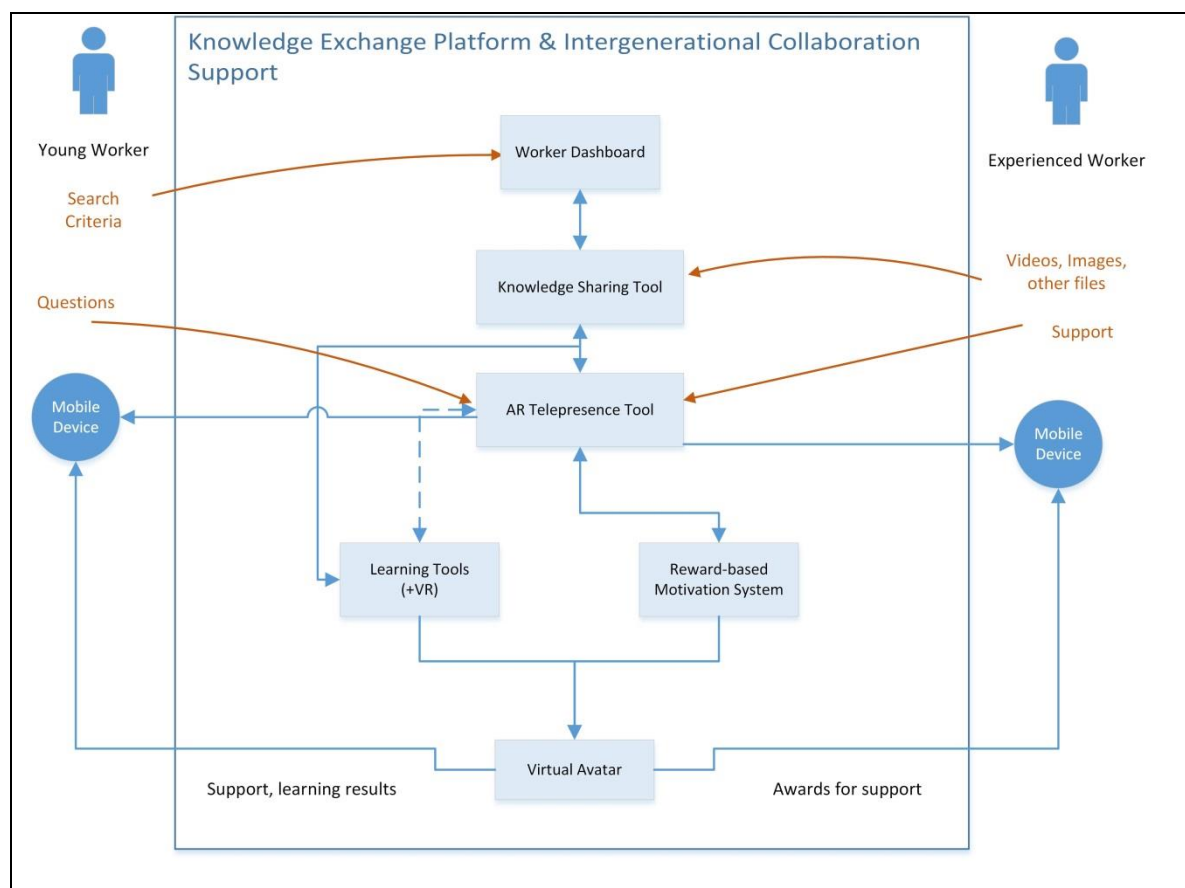Supporting Health & Well-being – Virtual Coach
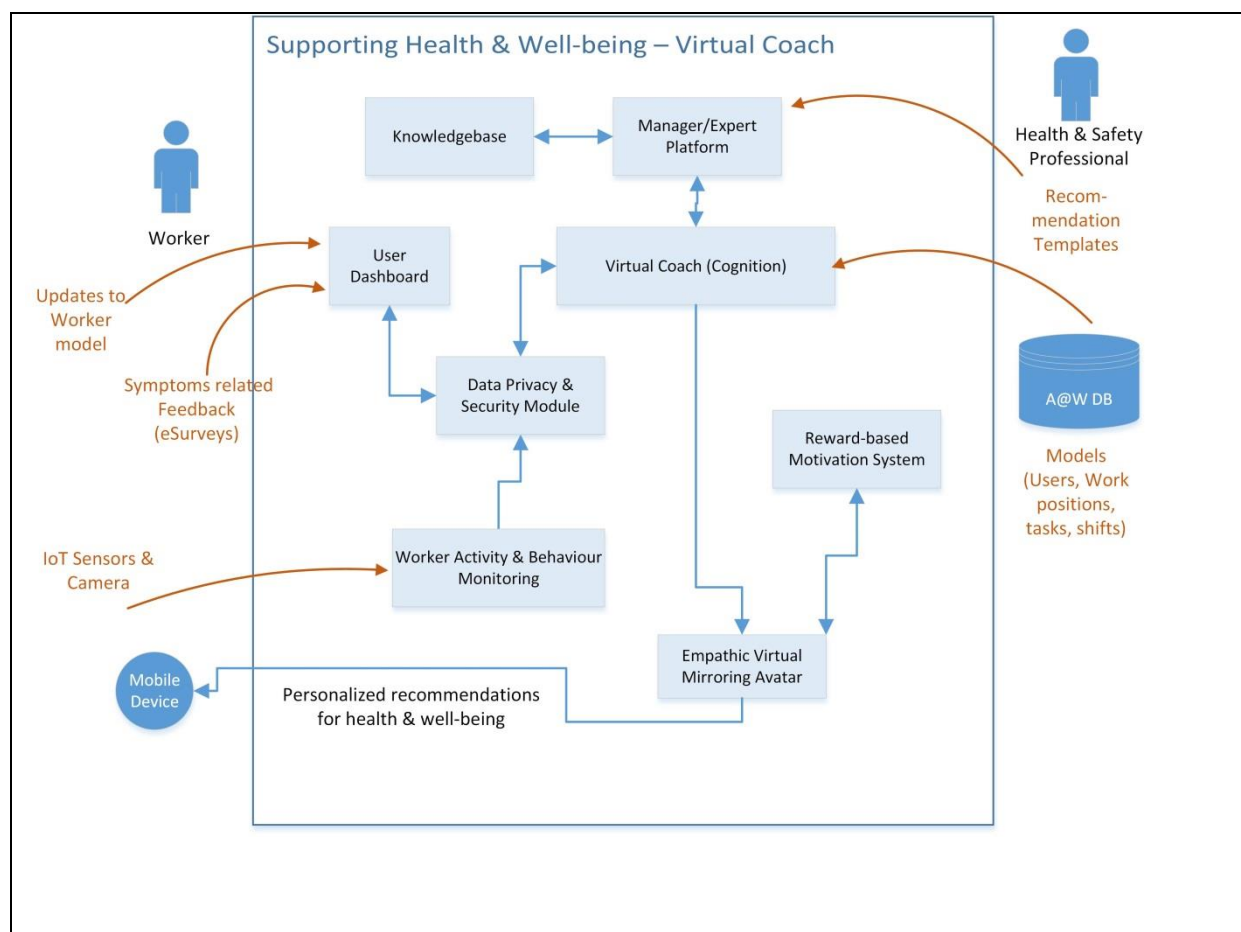
9.5 USE CASE 5: KNOWLEDGE EXCHANGE PLATFORM AND INTERGENERATIONAL COLLABORATION SUPPORT

USE CASE 5: Knowledge exchange platform and intergenerational collaboration support	
Version	V1.0
Short Description	The aim of this use case is to support transferring the long-term experience of older workers to the younger ones. On one hand, older workers share with young workers, experiences, tips and tricks for the best development of their activity. Alongside, the AGEING@WORK system provides advanced interfaces (including VR, AR) so as to support workers' remote collaboration through telepresence. Finally, workability enhancement is further empowered by advanced VR and AR-based Life-Long Learning tools.
Challenges	▪ Improve knowledge transfer from expert to younger employees ▪ Improve knowledge sharing among employee peers ▪ Decrease the occurrences of downtimes due to absence of guidance and mentoring ▪ Increase workability of older workers and productivity ▪ Provide older workers with tools that allow more effective remote contribution to the work process
Assumptions & Pre-Conditions	▪ The system should have complete user models, information about the job positions, and tasks ▪ A knowledge base with categories of possible issues related to the above should exist, along with mechanisms facilitating searching within them. ▪ The knowledge base maintains ▪ The system should be aware of the availability of each aged worker for the AR telepresence tool.
Goal (Successful End Condition)	▪ Young worker successfully completes a search on the knowledge exchange platform. ▪ Older worker provides real-time assistance to young worker through telepresence. ▪ Younger worker solves the problem or finds the right solution. ▪ Older worker follows a training session empowered by the system's knowledge base.

Involved Actors	▪ Younger Worker ▪ Experienced Worker
Use Case Initiation	The user identifies the problem and makes some initial assumption on what he/she is looking for
Main Flow	Flow 1 (looking for relevant content in the knowledge base): ▪ Young worker is entering key-words relevant to the operation of the machine he/she is assigned in the build-in search engine of the Knowledge Exchange Platform ▪ The system provides search results (links to content such as explanatory pictures, step-by-step guides, videos and FAQs) ▪ The user examines the content (articles, videos, recorded AR telepresence sessions, etc.) Flow 2 (participation in learning session) • Ageing worker needs to learn operation of a new machine that is installed in the factory; he/she has extensive experience in operation of similar machines. • Worker searches for relevant content in the built-in search engine of AGEING@WORK. • The system provides results with newly contributed material regarding the machine in question • The worker decides to attend one of the available guided VR sessions, using VR equipment. • The worker follows the interactive steps proposed by the guide, previewing required actions and receiving feedback on their own actions. • Upon successfully finishing the guide, the worker is rewarded by the reward system, which further motivates them to keep learning. In addition, relevant material is proposed by the system as next learning steps. Flow 2 (populating the knowledge base): ▪ Experienced workers log into the Q&A platform and receive notifications of relevant questions they could contribute to ▪ Experienced workers provide educational materials, solve questions in the Q&A platform, participate in AR Telepresence sessions to provide help and support.

	- Users receive personalized awards according to their activity (both young and elderly users) though the virtual coach and personalized reward system. Flow 3 (collaborative problem solving): - An unexpected failure in the machinery occurs during the shift of a new worker OR a young worker wants to calibrate a machine during his/her shift. - The worker seeks in the knowledge exchange database for material (documents, videos, and tutorials) related to the problem he/she is facing. - Into the database, he/she finds some documents and videos where the problem and its solution are explained. Thus he/she can follow step by step the instructions in order to solve the problem - The young worker has not found relevant information on the knowledge exchange platform for the problem he is facing and is calling a more experienced colleague for help via the AR telepresence tool. - The available colleague either from or outside his/her workplace provides guidance to young worker using the telepresence tool.
Problem addressed	- Knowledge sharing between older and younger workers (inter-generational communication) - Reduce stress and risk resulting from multi-machinery operation - Inexperience, feeling useless, willing to change working position - Dwindling company knowledge base as older workforce retires - Production downtime due to insufficient knowledge.
Results and Benefits	- Creation and maintenance of worker's networks - More efficient transfer of knowledge by older experienced workers to younger workers - Older workers' knowledge remains in the company's knowledge base - Problems solved in time (real-time guidance) and with lower risk - Older workers can work and offer their expertise in more flexible ways
Evaluation Criteria	Worker satisfaction (the worker found information about the solution to the problem s/he was facing on the knowledge sharing

	platform, or recognized the guidance of a more experienced worker via the AR telepresence tool) ▪ Worker's level of readiness to move to different/secondary working positions
Relevance to Ageing@Work WPs	WP5, WP6
Related User Requirements	FR20, FR22, FR23, FR24, DR6, DR7, DR8, DR9, DR10, DR11, DR12, IR16, IR17, IR18, IR19, IR20, IR21, IR22, IR23, IR24
Privacy & Regulation restrictions	Internal restrictions (factory regulations)
Environmental restrictions	None reported
Relationships with other Use Cases	UC1, UC2
UC Diagram	

Ageing@Work

Knowledge Exchange Platform & Intergenerational Collaboration Support

Young Worker

Search Criteria

Questions

Mobile Device

Worker Dashboard

Knowledge Sharing Tool

AR Telepresence Tool

Learning Tools (+VR)

Reward-based Motivation System

Virtual Avatar

Support, learning results

Awards for support

Experienced Worker

Videos, Images, other files

Support

Mobile Device

9.6 USE CASE 6: PRODUCTIVITY ENHANCEMENT TOOLS

USE CASE 8: PRODUCTIVITY ENHANCEMENT TOOLS	
Version	V1.0
Short Description	Productivity enhancement tools empowered by advanced ICTs, focusing on helping ageing workers into advanced situation awareness while at the workplace, are provided here so as to support workability despite ageing. The use of AR tools will be employed, so as to help into early identification of some urgent issue in the production line, as well as smartwatch devices to help workers who observe multiple machines, to be better aware of their status and upcoming steps. A smart watch can offer the same functionality as a mobile phone or tablet, but it is always on hand, could not be lost and does not occupy any hands. This will reduce stress, as the worker always knows the status of his machines without running around with the fear that some events could be missed.
Challenges	- Early Error Detection - Ensure older's worker attention when needed - Reduction of machinery downtime
Assumptions & Pre-Conditions	- The system should have complete information about the machinery, job positions and tasks. - The system knows the type of shift of the worker. - The worker must wear a smart watch during his/her shift and/or an AR display (e.g. optical see-through) is provided to the worker. - The system should know the location and the model of the machinery. - Machines related to his/her job position send notifications for regular checkups.
Goal (Successful End Condition)	The worker has completed all the tasks on machinery related to his/her job during his/her shift.
Involved Actors	Worker
Use Case Initiation	The worker starts his/her shift.
Main Flow	Flow 1:

|	
	▪ During the shift, the smart watch gives the worker feedback on the current status of machines and reminds her/him of upcoming tasks that need to be fulfilled at a certain machine. ▪ The system is informed (either automatically or by the user) that the user has finished a certain task. Flow 2: ▪ If a machinery problem occurs, an alert is sent to the worker and gets highlighted through the smartwatch and/or some further AR display if available. ▪ If the worker does not know the solution to the problem, s/he can seek into the knowledge exchange platform or call a more experienced colleague for help using the telepresence tool.
Problem addressed	▪ Mental workload (memory, attention, fast decision making). ▪ Physical ability ▪ Psychology/Mental abilities (decrease of memory). ▪ Reduce stress and risk resulting from multi-machinery operation.
Results and Benefits	▪ Reminders are helpful for remembering how to accomplish a certain subtask in case of multimachine operation (thus, it supports the decrease of memory of the elderly workers). ▪ Surveillance worker duties enhancement increases the personal perceived security, reduces stress and accidents, and supports the decrease of memory of the ageing workforce. ▪ Increased productivity. ▪ Minimized downtimes of machines.
Evaluation Criteria	▪ Feeling of safety. ▪ Worker satisfaction (the worker is informed of the upcoming tasks on each machine while eliminating the likelihood of omitting any of them).
Relevance to Ageing@Work WPs	WP6
Related User Requirements	FR25, DR10, DR12, IR25
Privacy & Regulation restrictions	Internal restrictions (factory regulations)

Environmental restrictions	None reported
Relationships with other Use Cases	UC5

UC Diagram

9.7 USE CASE 7: EMERGENCY/PANIC BUTTON

USE CASE 6: Emergency/Panic button	
Version	V1.0
Short Description	In case of emergency, this use case will allow the worker in distress to notify the management/security side of the plant and be directly geolocated if possible (especially in large areas of land), as well contacted by the security personnel. Moreover, context/environmental details will be transferred to security personnel.
Challenges	▪ Timely and proper recognition of the emergency situation. ▪ Helping towards early intervention in case of emergencies, which can be even further crucial for older workers towards fatal accident avoidance.
Assumptions & Pre-Conditions	▪ The user must wear a smart watch and have smartphone/tablet in continuous connection to the Internet. ▪ The system should know the location and the model of the machinery. ▪ The system should know the location and the model of the job position.
Goal (Successful End Condition)	The manager or security responsible who receives the emergency notification proceeds to the necessary actions to assist the worker.
Involved Actors	• Worker • Authorized personnel (security, manager, Health & Safety)
Use Case Initiation	The worker is in a working position; an emergency notification is triggered.
Main Flow	▪ In case of emergency (the worker faces an accident or a serious health problem), the mechanism is being triggered by the worker (panic button on vehicle, working position) or on the connected mobile device. ▪ The manager or security responsible are instantly notified of the emergency.

	- The system broadcasts to security personnel and Health & Safety Professionals information such as the worker's location, environmental details (temperature, humidity, noise, and vibrations) and recent biosensor's data (heart rate, blood pressure, body movements). - In case of a suitable camera at the emergency site (e.g. static surveillance camera or camera at worker's helmet etc.) the system automatically initiates an AR Telepresence session with the person in charge and broadcasts the camera image. - The security and authorized personnel proceed to the necessary actions to assist the worker.
Problem addressed	- Health emergencies - Accidents - Risks caused by isolated working positions
Results and Benefits	- The worker would be instantly located in large areas of land, such as those of open-pit mining sites. - An instant alert sent to the security services in case of emergency, increasing the possibilities for rapid response. - Increase in the workers' conception of their own safety and improve their confidence in security services. - Helping ageing workers to both feel safer at the worksite and experience reduced adverse consequences from accidents at the workplace, through more rapid emergency responses.
Evaluation Criteria	- Time of the security personnel response after the panic button trigger - Feeling of safety
Relevance to Ageing@Work WPs	WP3, WP4, WP5, WP6
Related User Requirements	DR1, FR1, IR1, IR2
Privacy & Regulation restrictions	In a case of emergency, recent vital health-related recordings like heart rate, blood pressure, and stress level are transmitted to Health & Safety professionals.

Environmental restrictions	Uninterrupted Internet connectivity is necessary. In indoor situations of emergency, the exact location of the worker might not be available to the system and may not be included in the emergency notification.
Relationships with other Use Cases	Part of UC5 (telepresence)

UC Diagram
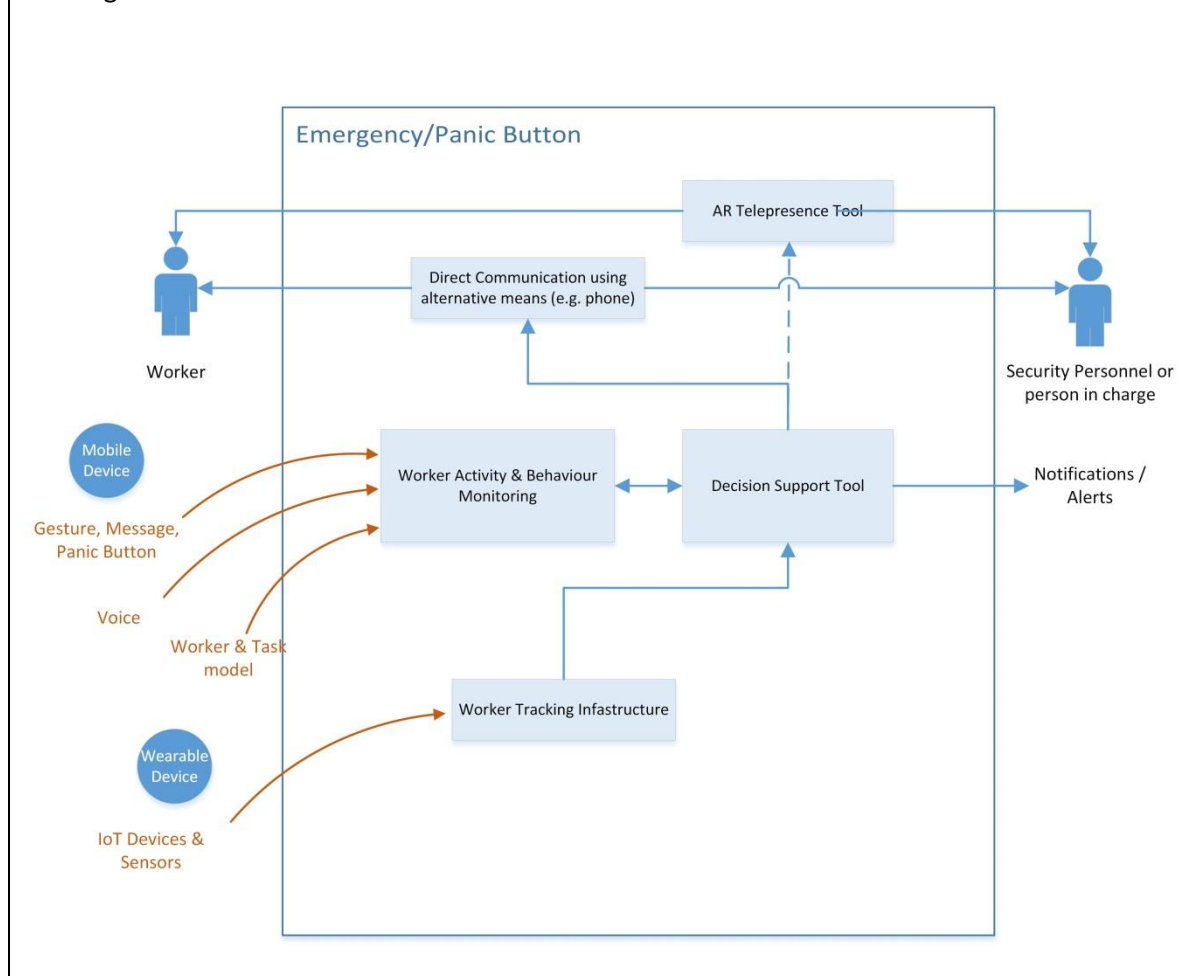
10. Conclusions

The present deliverable focuses on the detailed analysis of the users' needs and specifications in order to establish the user requirements for the smart, personalized and adaptive ICT solutions for active, healthy and productive ageing with enhanced workability of the Ageing@Work project. The main outcomes of this analysis can be summarized as follows:

Ageing workers from 45 to 65 are the main target user groups of Ageing@Work.

By following a requirements investigation approach that included the workers and workplace analysis and literature review, questionnaire-based surveys were performed. The outcome was a prioritized list of user requirements of aspects related to the functional characteristics, the design of the Ageing@Work solutions and their interaction requirements.

On the basis of the list of user requirements, preliminary use cases of Ageing@Work were formulated and analysed through focus groups and personal interviews. These discussions led to the seven final use cases that are described in detail in Section 9 of the deliverable.

Both Siemens and ANEFA have had to do great effort to enrol and engage workers to find out their needs and barriers related to the aging process, so we can define the main requirements and use cases that will guide the Ageing@Work developments and trials, under a user-centric approach. The co-creation process included different phases that can be summarised as follow:

- Pilot scenarios present shared and differentiated problems regarding the ageing of their workforce, the organization of tasks and the nature of work, so the Ageing@Work solutions to be implemented must adapt to these scenarios, developing different aspects or solutions of the selected use cases in each of the pilots.

- The level of prioritization shown by the workers in the final use cases should also be taken into account, in order to focus the efforts of the developers on those who have received better reception among the workers or, to address the less successful use cases and try to restructure them so that they are more attractive to end users.

- The user requirements and use cases can be considered as a living document throughout the project duration and up to the specification of the exact pilot trials protocols. From this month forward, ANEFA and Siemens as pilot end users will continuously provide feedback on the project development.

Since the co-creation process will guide all developments in Ageing@Work following different iteration cycles, in the next months, new focus groups with both ANEFA and Siemens workers will be organized, in which the acceptance of workers regarding the proposed tools and ICT solutions will be analysed in greater depth and provide feedback to technical workpackages to improve the Ageing@Work final solution.

11. ANNEX

11.1 ANNEX I: Literature review summary

Reference	Summary
Data from the Spanish Foundation for the Prevention of Occupational Risks (Barcelo Fernandez, 2015)	The gradual ageing of the active population, the need to accommodate the people and work to the new reality presented by the ageing workers, the obligation to adapt the health and safety plans to the most important risks that the ageing workers face of having and accident in their job post or developing occupational diseases
The ageing workforce: implications for occupational safety and health – A research review (Crawford, 2016).	It examines research in three main questions:(1)'What changes occur in ageing individuals?',(2)'What are the implications of these changes throughout working life?'and (3)'What OSH measures could promote sustainable work throughout working life?'. Gaps in current knowledge are identified and overall conclusions and possible policy implications are presented, highlighting the importance of improved prevention for all workers
The effects of noise at work (Noise at Work, 2005)	Usually, hearing loss as a result of work is caused by prolonged exposure to loud noises. The jobs that are developed in industrial and construction environments are the ones that most affect hearing health. Thus, anyone exposed to noise repeatedly is likely to develop progressive hearing loss as the years go by. That is why the workers who most often suffer from hearing loss are older workers.
Safer and healthier work at any age EU-OSHA	The original aims of the pilot project were to enhance the implementation of existing recommendations, facilitate the exchange of best practice and further investigation of possible ways of improving the safety and health of older people at work. The project also aimed to assess the prerequisites for OSH systems in different European countries to take account of an ageing workforce and ensure better prevention for all throughout working life.
Promotion of road safety in the aggregates sector, ed. 2015 . Legal deposit: MU 83-2016	The need to train workers in adequate road safety and use of machinery is essential to maintain the

	safety conditions in the operation. Within the workplace itself, displacements to the places where they must perform their duties are common, leading them to move to remote and isolated places.
Röschke J, Mann K. Schlaf und Schlafstörungen. München: C.H. Beck'sche Verlagsbuchhandlung; 1998. p.43-44	Sleep becomes **more fractional with increasing age**, i.e. it is interrupted by more frequent and longer periods of wakefulness, and it contains less deep sleep. **Change in sleep behaviour begins between the ages of 50 and 60** in men and ten years later in women. Age-related changes are caused, among other things, by an adaptation of the circadian rhythms in old age.
Volk S. Schlafstörungen. Berlin: Springer Verlag; 1995. p.182	Frequency of sleep disorders increases significantly with increasing age. Up to **60% of people over the age of 65 complain about difficulties in falling asleep.**
Ern G, Fischbach R. Gesunder Schlaf: Endlich wieder gesund schlafen. Hannover: Humboldt Verlag; 2008. p.70-71	During the night, wake-up reactions, so-called arousals, occur more frequently. Studies have shown that up to 150 arousals can occur at night in people over the age of 60. Young people, on the other hand, have an average of five arousals per night. According to an American study (1990), **more than 50 percent of 65-year-olds and older suffer from disturbed sleep,** with most complaints relating to problems falling asleep and sleeping through the night.
Statistical data on the link between fatal accidents at work and personal protective equipment (PPE)	The most common causes that triggered accidents across the EU Member States, were losing control of machines, tools or transport and handling equipment, accounting for almost one third (32.2 %) of the total number of accidents in the EU, while slipping, stumbling or falling (15.2 %) and the breakage, bursting or collapse of material agents (11.3 %) were the only other causes that accounted for double-digit shares of the total number of fatal accidents.

Madrid-Valero et al.: Age and gender effects on the prevalence of poor sleep quality in the adult population. Gac Sanit. 2017;31(1):18–22	The prevalence of poor sleep quality is high among adults, especially women. There is a direct relationship between age and deterioration in the quality of sleep. This relationship also appears to be more consistent in women.
Gadie et al.: How are age-related differences in sleep quality associated with health outcomes? An epidemiological investigation in a UK cohort of 2406 adults. BMJ Open. 2017 Jul 31;7(7): e014920. doi: 10.1136/bmjopen-2016-014920.	Latent class analys, LCA, identified four sleep types: 'good sleepers' (68.1%, most frequent in middle age), 'inefficient sleepers' (14.01%, most frequent in old age), 'delayed sleepers' (9.28%, most frequent in young adults) and 'poor sleepers' (**8.5%, most frequent in old age**).
Absenteeism and accident rate Harper, S. and Marcus, S. "Age-related capacity decline: a review of some workplace implications" 2006	A review that covers physical and cognitive changes in older w orkers. This includes changes in sensory function, musculoskeletal function and aerobic and cardiorespiratory function. Psychological changes should include descriptions of depression, especially w here there is involuntary leaving of the w orkplace; mild cognitive impairment, the impact of increased reaction times and the unexplored area of dementia and measuring early effects of dementia. A summary of safety requirements in the UK is provided including the impact of trade unions. The review also highlights different processes in Australia (the job capacity assessment and OSH and the ageing w orkforce), USA (functional capacity evaluation and other OSH support) and Canada (CCOHS and publications on supporting age and w ork). All these mechanisms need the employer and employee to w ork together and Recruit/Retain/Retrain.
Occupational Risk Prevention in Aggregate Treatment Plants (2004) . Legal deposit: B-17.656-2004	▪ This publication, supervised by the ANEFA Health and Safety Technical Committee, presents the basic recommendations for risk prevention for workers in aggregate treatment plants. ▪ The text lists the main risks that may arise during the various phases of work - operation and maintenance - with different existing equipment, explaining their meaning, indicating where they occur most frequently and the consequences they have on the worker's health.

	▪ It proposes measures and recommendations that should be applied to eliminate or reduce risks. ▪ In describes the main components of the equipment, workplaces, signalling measures and protective equipment, both collective and individual.
c) Protection against mechanical vibrations in aggregate sites (2007) Legal deposit: B-20.866-2007	▪ It contemplates the harmful effects that the constant vibration of the machinery can cause in workers who have suffered long exposure periods. ▪ It makes recommendations on ergonomic designs reduce the harmful effect of the vibrations on the muscles of the workers. ▪ It recommends workers to incorporate exercises and stretching into their daily routines to avoid musculoskeletal problems.
"0 Accidents Campaign". Ed. 2010. Legal deposit: MU 83-2016	▪ Identification of the most common accidents in the sector. ▪ Disaggregation by age and functions of the worker. ▪ Recommendations to achieve the objective: Zero accidents, achieving and adequate integration of occupational risk prevention in the industry
Functional Changes. Font Yeomans, L. 2011 "An update of the literature on age and employment"	Visual and auditory acuity deteriorate with age but can be compensated by technical aids. Muscle strength is reduced between 30 and 65 years, but it is not evident until after 65 years and **this effect can be reduced by regular exercise**. The decrease in cognitive skills (intelligence, language, knowledge and problem solving) from the age of 60 can be compensated with motivation and experience There is no evidence that older workers cannot adapt to changes at work provided they have an adequate training and support system.

	The speed of learning decreases with age, but there is evidence that older workers are able to reach a good level of new skills.
Age and productivity. Font Yeomans, L. 2011 "An update of the literature on age and employment	There is no evidence that older workers are less productive than the younger, but that productivity is the same in both groups. Productivity decreases with age in jobs of strong physical demand. The strategies, skills and experience of older workers help them to maintain high levels of productivity.
Harper, S. and Marcus, S. "Age-related capacity decline: a review of some workplace implications" 2006	Employability and willingness to change decrease with age. Research has also shown that older workers are less interested in learning and development opportunities. The consequence of this decrease in training and development may be the obsolescence of the worker´s skills.
Project Cap lab": strategies to favour the maintenance of their work capacity and the intention of remaining active in work." 2010.	The workability is directly related to the possibility of carrying out activities that include physical, mental and social skills. The balance between labour demands, control and recognition is the key point of job satisfaction for workers over 50 years. Intergenerational relationships appear as a factor that can favour labour welfare

11.2 ANNEX II: ANEFA´S SURVEYS

Questionnaire for the users
D 2.1 M9

PERSONAL INFORMATION

AGE		
GENDER	☐ Male	☐ Female
Actual Job (mark with an X, if you are employed in several Jobs mark them all)		
o Mobile machinery operator		
o Plant operator		

o Maintenance	
o Other	
o (In case you have marked "other" please specify bellow)	
Years of work experience	

FREQUENCY IN TECHNOLOGY USE

With what frequency do you use the internet?
☐ Never
☐ Once a week
☐ More than once a week
☐ Everyday

With what frequency do you use apps?
☐ Never
☐ Once a week
☐ More than once a week
☐ Everyday

What kind of apps do you use more frequently?	Never	Rarely	Sometimes	Usually	Daily
Health apps					
Social Media					
News					
Weather apps					
Other	(identify which ones, limited to 4)				

Have you ever used and smartwatch or vital measurement tools?
☐ Never
☐ I have used pulsometers/ smartwatches/ smart bands
☐ I nowadays use pulsometers/smartwatches/smart bands

Have you ever used AR tools?
☐ Never

☐ Rarely	
☐ Usually	

Have you ever used VR tools?
☐ Never
☐ Rarely
☐ Usually

Have you ever shared videos or images on the internet or through apps?
o   Never
o   Rarely
o   Usually

FUNCTIONAL REQUIREMENTS OF THE APPS, PLATFORMS AND TOOLS

Please, mark in the following table your relevance evaluation on the functional requirements, in a rank of 1 to 1, being 1 the lowest relevance, and 5 de highest.

FUNCTIONAL REQUIREMENT		RANK
The tool allows my geolocation in the quarry		
If I press the bouton in case of emergency, someone would come to help me.		
With the platform I would be able to help my younger mates from home if they need my advice in day to day job situations.		
With the platform, I would be able to ask for free days and have a control on the ones that I have left.		
The platform allows me to upload videos and images of my day to day job.		
The app allows me to do an initial check list before I start my working day in the security items.		
The tool controls my sleep quality.		
The app gives me tips on healthy habits to improve my sleep quality.		
The app gives me advice on exercise to improve my health during my free time.		
The app sends me one alert at the end of my working day on my improvements.		
The app allows me to help my collage to repair the machinery from home using smart glasses.		
The tool measures my pulsations and vibrates in case the levels are abnormal.		
The tool advices me on the frequency on which I should drink water in order to stay properly hydrated.		
A virtual coach advises me on exercises and checks whether if I am doing it correctly through a web camera.		
The app sends advices/tips to the manager on better practices for the older workers: better breaks, better working conditions and better heath and security practices.		

The app would send an alert to the manager if any of the security elements of the machinery is not working properly.	
The app would help me stablish an instant dialog with the person responsible of the security if there is a problem with the individual or collective security equipment.	
A virtual coach advises me on exercises that I can do during my working breaks.	
I would be able to control my progress through the app and fulfil my goals.	
The results on the measurement tools would be upload to the app, so I can see my health status and the way exercises and good healthy habits are improving it.	

Questionnaire for the health and security experts *Initial draft*
D 2.1 M9

PERSONAL INFORMATION

AGE		
GENDER	☐ Male	☐ Female
Actual Job (mark with an X, if you are employed in several Jobs mark them all)		
o Mobile machinery operator		
o Plant operator		
o Maintenance		
o Other		
o (In case you have marked "other" please specify bellow)		
Years of work experience		

FREQUENCY IN TECHNOLOGY USE

With what frequency do you use the internet?
☐ Never
☐ Once a week
☐ More than once a week
☐ Everyday

With what frequency do you use apps?
☐ Never
☐ Once a week
☐ More than once a week
☐ Everyday

What kind of apps do you use more frequently?	Never	Rarely	Sometimes	Usually	Daily
Health apps					
Social Media					
News					
Weather apps					
Other	(identify which ones, limited to 4)				

Have you ever used and smartwatch or vital measurement tools?
☐ Never
☐ I have used pulsometers/ smartwatches/ smart bands
☐ I nowadays use pulsometers/smartwatches/smart bands

Have you ever used AR tools?
☐ Never
☐ Rarely
☐ Usually

Have you ever used VR tools?
☐ Never
☐ Rarely
☐ Usually

Have you ever shared videos or images on the internet or through apps?
o Never
o Rarely
o Usually

DESING REQUIREMENTS OF THE APP/PLATFORM/TOOL

Please, mark in the following table your relevance evaluation on the design requirements, in a rank of 1 to 1, being 1 the lowest relevance, and 5 de highest.

DESIGN REQUIREMENTS	RANK
The measurement tool is light, and you can wear it under the clothes.	
The measurement tool does not limit my movements nor compromise my security.	
The tool keeps the measurements and uploads them to my Smartphone so I can check my progress.	
The platform is private and only I have access through a password.	
Before my petition of free days is sent to the manager, the platform will ask for my confirmation.	
The app is easy and fun to use.	
The virtual coach should have a human appearance.	
The virtual coach should have a nice voice.	
I would receive just one notification on my progress at the end of my working day.	
The cardiac ridden measurement tool will vibrate when my pulsations go under 60 per minute or up to 100 per minute.	
The hydration tool will vibrate each time I should drink water.	
The platform would allow me to upload images and videos in HD.	
The app will incorporate a GPS system for my geolocation.	
The checklist for the security elements should be periodically updated.	
I should be able to see what my partner is seeing through his smartwatches in order to advise him while repairing the machinery.	
The virtual coach answers to my voice commands.	
The platform allows conversations with video.	
The measurement tools are activated with my voice.	
The measurement tools are activated with the touch.	
The platform would be accessible online.	
The app would send tips to the manager so he can better organize the working day of the ageing workers.	
The alert bouton should be located in the cabin, or in the smartwatch so he can push it in case of emergency.	
The devices would not interrupt my working activity at any circumstances. My interactions with the app/tool/platform/virtual coach should be limited to my free time or my working breaks.	
The platform would stablish a rank from 1 to 3, so the worker can classify the urgency of his petition of free days, and the manager can prioritize one petition from another.	

11.3 ANNEX III: WORSHOPS QUESTIONS

A) PRELIMINARY USE CASE 1: CHECK-LIST PLATFORM

- Which of the everyday problems that you face at your work do you think that are being addressed with this solution? Do you think this is useful for your work? Why? Would you be willing to use it?

- Can you think of advantages and disadvantages of such a tool? (What do you like and what don't you like about it?)
- What would be an obstacle and driver to use such a tool?
- Which are the functionalities that this tool should have, according to your opinion, in order to address the relevant problems?

If there is spare time the following questions can be discussed:

- Do you usually remember to use the individual protection equipment? Would you like something to remind you about it?
- What do you think about an alarm system that would transmit the information about unexpected events?
- How many checks are needed to maintain safety?
- From whom do you need help in dangerous situation?
- Would you need support in learning to use this tool? What kind of learning support would **you need?**

B) PRELIMINARY USE CASE 2: COMMUNICATION OF ABSENCES AND VACATIONS

- Which of the everyday problems that you face at your work do you think that are being addressed with this solution?
- Do you think this is useful for your work? Do you think that this app is needed? In what kind of situations? Would you be willing to use it?
- Can you think of advantages and disadvantages of such tool? (What do you like and what don't you like about it?)
- What would be an obstacle and driver to use such tool?
- Which are the functionalities that this tool should have, according to your opinion, in order to address the relevant problems?

If there is spare time the following questions can be discussed:

- Do you prefer to inform/ask about/for your days off by app or in person? Why?
- Would you need support in learning to use this tool? What kind of learning support would you need?

C) PRELIMINARY USE CASE 3: MUSCULOSKELETAL PROBLEMS

- Which of the everyday problems that you face at your work do you think that are being addressed with this solution?
- Do you think this is useful for your work? Are you interested in such way of preventing MSDs? Would you be willing to use it?

- Can you think of advantages and disadvantages of such tool? (What do you like and what don't you like about it?)
- What would be an obstacle and driver to use such a tool?
- Which are the functionalities that this tool should have, according to your opinion, in order to address the relevant problems?
-

If there is spare time the following questions can be discussed:

- Do you suffer from musculoskeletal diseases?
- Do you know how to solve the problem with the back pain?
- Have you ever used similar apps or tools? If yes, did they prove effective? If not, why?
- Do you use some strategy to manage musculoskeletal pain?
- Would you/your colleagues be able and interested in following recommendations about healthy habits, exercises and correction of postures? Why?
- Would you need support in learning to use this tool? What kind of learning support would you need?

D) PRELIMINARY USE CASE 4: EARLY DETECTION OF STRESS AND INSOMNIA, ANALYSIS OF CAUSES AND CONTROL

- Which of the everyday problems that you face at your work do you think that are being addressed with this solution?
- Do you think this is useful for your work? Why? Would you be willing to use it?
- Can you think of advantages and disadvantages of such a tool? (What do you like and what don't you like about it?)
- What would be an obstacle and driver to use such a tool?
- Which are the functionalities that this tool should have, according to your opinion, in order to address the relevant problems?

If there is spare time the following questions can be discussed:

- Have you ever used similar apps or tools? If yes, did they prove effective? If not, why?
- Would employees be interested in using an intelligent bracelet/other technology that measures stress and quality of sleep? Why?
- Would employees be interested in using a tool recommending changes in some daily habits (e.g. changing the diet or practicing sports)? Would employees be interested in following such tips? Why?
- Would you need support in learning to use this tool? What kind of learning support would you need?

E) PRELIMINARY USE CASE 5: HYDRATION CONTROLLER

- Which of the everyday problems that you face at your work do you think that are being addressed with this solution?
- Do you think this is useful for your work? Will it help you to drink the right amount of water? If not, why? Would you be willing to use it?
- Can you think of advantages and disadvantages of such a tool? (What do you like and what don't you like about it?)
- What would be an obstacle and driver to use such tool?
- Which are the functionalities that this tool should have, according to your opinion, in order to address the relevant problems?

If there is spare time the following questions can be discussed:

- Have you ever used similar apps or tools? If yes, did they prove effective? If not, why?
- What is the obstacle to drink right the amount of water during your working day?
- Do you remember to drink the recommended amount of water?
- Do you have enough time to drink the recommended amount of water during your working day?
- Would you need support in learning to use this tool? What kind of learning support would you need?

F) PRELIMINARY USE CASE 6: KNOWLEDGE EXCHANGE PLATFORM

- Which of the everyday problems that you face at your work do you think are being addressed with this solution?
- Do you think this is useful for your work? Would you be interested in using such tool by providing your support to younger workers? Would you be willing to use it?
- Can you think of advantages and disadvantages of such a tool?
- What would be an obstacle and driver to use such a tool?
- Which are the functionalities that this tool should have, according to your opinion, in order to address the relevant problems?

If there is spare time the following questions can be discussed:

− Do you think it is a good way to transfer knowledge from experienced employees to the younger ones? Why?
− Would you need support in learning to use this tool? What kind of learning support would you need?

G) PRELIMINARY USE CASE 7: EMERGENCY BUTTON

- Which of the everyday problems that you face at your work do you think that are being addressed with this solution?
- Do you find this useful for your work? Would you be interested in using such tool by providing your support to younger workers? Would you be willing to use it?
- Can you think of advantages and disadvantages of such tool?
- What would be an obstacle and driver to use such tool?
- Which are the functionalities that this tool should have, according to your opinion, in order to address the relevant problems?

If there is spare time the following questions can be discussed:

- Do you think it is useful to have this tool to be located in an emergency situation?
- Have you or any of your colleagues experienced any emergency situation in which this tool would have been useful?
- How do you currently deal with emergency situations in the quarry?

11.4 ANNEX IV: ANEFA PILOT WORKSHOP – PERSONAL INTERVIEWS RESULTS

Aim

To analyse:

- Users' needs and requirements regarding Ageing@Work solution
- Drivers as well as obstacles in terms of acceptance of Ageing@Work (e.g. ICT skills)
- Factors related to employees work ability, quality of life and productivity (e.g. lifestyle)

In some cases, there are examples of leading questions if a respondent doesn't know what to say or answers with yes/no. But they are not mandatory.

1. User´s needs and requirements: [you can add more detailed questions based on focus group outcomes; you could also skip this part if focus group answers are detailed enough]

Q.1 After hearing about tools to be developed in the Ageing@Work project, what do you think about their usability according your work? Which solutions would be most helpful?

Results:

W1. They are very helpful, quite useful. In order of importance: emergency button, musculoskeletal problems, checklist, vacations platform. The last for me in order of importance is the hydration tool.

W2. In order of importance: emergency button, formation of the younger workers and exercises.

W3. I think that the most helpful is the emergency button.

W4. In my case, because I'm in the control room, the most useful is musculoskeletal problems and vacations platform, but for those that work directly with the machines the panic button will be most important.

W5. I mostly appreciate the first use case related to the assisted checklist for security. Also, I value the use case 7 (emergency button), the use case 3 (exercises for preventing musculoskeletal diseases) and use case 2 (a platform for communicating absences and holidays). I value less the uses cases 4 (stress detection) and 5 (dehydration detection).

W6. It is very interesting to apply new technology to the mining sector because it is a sector more delayed in using technology compared to other sectors. Although at this moment in my position I do not use machinery, I consider that the solution that registers an incident, a breakdown, reports it automatically, and registers it is one of the most useful.

Q2. How do you feel about using some of the tools outside work? (E.g. stress measurement or lifestyle measurement and advices). (Leading questions: Do you think it is possible? If not, why? What could help?)

Results:

W1. I feel great about using the exercises tool outside work.

W2. I feel ok about using them, although I don't know if I would be able to pay sufficient attention to it.

W3. I think I would use them.

W4. I think I would use them; I consider the apps very useful, but it should be used in working hours, otherwise, the engagement will be lower.

W5. I have no problem apart from the privacy concerns. I don't want to be monitored.

W6. There is no problem in using these tools outside of work since I am used to it.

2. Drivers and obstacles in terms of acceptance of Ageing@Work (e.g. ICT skills)

Q 3. In your opinion, what could be helpful in implementing the Ageing@Work solutions at work and in your private life? (Leading questions: e.g. your expertise with ICT, positive attitude of employees, learning support, organizational support, other?)

Results:

W1. I think the emergency button is very necessary. The rest, especially the tool exercises, also looks good. The checklist is a way for it to record the failures in the safety of machinery and not on paper. I believe that in general it would help us to be more productive and to improve the organization and safety of the site.

W2. I think it would be a useful way to show the problems of the ageing workers and to generate empathy.

W3. I think they would improve the employees´ attitude and they would be a good learning support.

W4. I think they would improve the employees´ attitude and they would be a good learning support. But always it is needed the understanding of the managers and their engagement with the solution is needed.

W5. To increase the security in the quarry and also to help keeping healthy habits in his personal life.

W6. An obstacle for the implementation of this technology, is the time that "can be lost" or it is necessary to invest to implement it from the point of view of the bosses. Another obstacle to accept it could be the subjective assessment of a breakdown in a machine. That a worker reports a breakdown as serious and that the person in charge tells him that he has to work despite the breakdown due to the need to do the work on time.

Q4. In your opinion, what could be a barrier in implementing the Ageing@Work solutions at work and in your private life? (Leading question: Think about your workplace, job organization, your ICT skills, your attitude towards new technology and changes in your lifestyle etc.)

Results:

W1. I don't believe that there would be great problems in using the applications at work, as long as managers do not see a decrease in productivity. The biggest problem that I see using them in my private life, is that I do not have much time. I get up at five in the morning every day and I get home at 7.30 at

night. I do not feel like doing anything. I would need the app to be very easy to use and entertaining to take the time to use it.

W2. I don't believe that there would be great problems in using the applications at work.

W3. I don't think there would be any difficulties. It would be a good change.

W4. I don't think there would be any difficulties.

W5. The main barriers for the project are the directives and posture of the business man in charge of the quarry, the normative that may limit the reach and application of certain IT solutions in the working environment and also, from a user perspective, the comfort in case they are required to wear a set of IT devices (wearables).

W6. A barrier to implement these solutions at work depends on the organizational structure. In family businesses, even if a breakdown of a machine is reported, the boss can assess if the worker's life is in danger or not and ignore the breakdown. In multinational companies, where there are more middle managers, it is more difficult to overlook failures, especially if this technology is used to report information to the machine responsible.

Q5. How do you feel using new technologies? (Leading questions: Are you confident using ICT? Are you afraid of it? Motivated to learn?)

Results:

W1. I feel good using new technologies. I'm not at all an expert, but I have a smartphone, e-book, smart tv and PC. I think that, compared to the rest of my generation, I would be average.

W2. I feel motivated to learn.

W3. I feel good about using new technologies, comfortable and eager to learn.

W4. I feel good about using new technologies, comfortable and eager to learn.

W5. I have no technical problems using IT and I am used to them. My main concern is for my privacy and that I feel comfortable when using them.

W6. I do not have problems with technology, I currently have three computers on my desk and three smartphones.

Q.6 What How do you feel about monitoring your physiological parameters (e.g. heart rate, using a smartphone or chest band) for the purpose of adjusting working conditions to your capabilities?

Results:

W1. It seems good to me that they measure my vital signs whenever the information is used to give me advice to improve, and not to be used for other things.

W2. It seems good to me that they measure my vital sings, I think it would be a good way to early detect problems in my health.

W3. I think it is something good and useful.

W4. It seems good to me.

W5. I already use a heart rate monitor as I am a frequent runner. I would not have any trouble wearing something similar at work if it is comfortable and the normative allows it.

W6. There is no problem with it and more than for safety I would do it for health.

Q.7 What would be the best way for you to learn to use new technology (new app or program on your computer or working machine)? What kind of learning support would you need? [If there is no answer, interviewer may suggest: Some people prefer to read instruction and try it by themselves, sometimes it is easier if someone shows how things work. What about you? Do you have any other ideas?]

Results:

W1. I think the best way I can learn is to see how it is done, to have a little initiation course, and from that point on, to use it for myself.

W2. I think the best way I can learn it is to have someone to explain it to me.

W3. I think the best way I can learn is through an app with clear instructions.

W4. I think the best way I can learn is through and app.

W5. Tutorials, mainly videos would be interesting.

W6. To learn how to use new machinery, it would be necessary to do it on the same real machine. Virtual reality can help but it is not the same. There are many sensations that cannot be transmitted in virtual reality, for example, it is not the same to load stone, to load mud, etc. The first thing that would be necessary is that each machine has its instruction manual and the operators are obliged to read it.

Q.8 What kind of difficulties have you encountered while learning to use new technologies (Internet, apps, smartphone, computer, program)? [If there is no answer, interviewer may suggest: Some people are afraid of the new technologies or they lack learning support, sometimes it is hard to memorize all the steps or

the instructions can be too complex, or the design of the program or device can be distracting. What are your experiences?]

Results:

W1. The biggest difficulty is that sometimes you find yourself with very complex instructions that you do not understand, or that you need a step and you do not know what it is and in the end you have to see a tutorial on the internet

W2. I have not had great difficulties so far.

W3. I have not faced any difficulties.

W4. I have not faced any difficulties. I like them

W5. I have not had any trouble so far.

W6. I don't have any problem in learning to use new technologies, on the one hand because I've already use them and on the other hand because for the programs I use in the company, I have been taught by the IT personnel.

3. Factors related to employees work ability, quality of life and productivity:

Q.9 Out of all physical environment factors at work (e.g. noise, dust, uncomfortable body postures, physical strain) what is most tedious to you? What would you like to change?

Results:

W1. What is more tedious for me is the noise. In my last medical review, I have been told that I am losing hearing. The earplugs are very uncomfortable and really deprive you of a sense. You do not know, for example, if a wheel has been punctured.

W2. What is more tedious for me is the forced postures and the conditions of the sites. I think it would be great to have more ergonomic chairs in the cabin.

W3. What is more tedious for me are the forced postures. I think it could be improved by little breaks.

W4. The more tedious is the weekend, and the long day doing the same thing

W5. The most tedious is the physical effort.

W6. The first environmental factor that has affected me most has been the noise. I have been working in this sector for 29 years and have lost 30% of my hearing due to noise. Right now, I am in an administrative position and therefore I would not change anything. They have not changed my position due to the noise conditions but because I have been promoted during my career in the company.

Q.10. Out of all other job demands (e.g. work tempo, amount of work, working time, work organization) what is the most tedious to you? What would you like to change?

Results:

W1. The worst are the forced postures. Sometimes you spend six hours in the same position and as you are concentrated in the work you do not even notice, and when you leave the cabin your whole-body hurts. I think it could be improved with a few little exercises or stretches.

W2. I think they could make some changes in the schedule, to enable more breaks.

W3. The amount of time that I have to spend doing the same tasks.

W4. The amount of time that I have to spend doing the same tasks.

W5. I am happy with the current working environment; more salary would be great.

W6. I have gone through almost all the positions in the company and I have adapted to all of them. Currently, in the administration position there is a peak of work between day one and day five of each month, but I have adapted to it and after it the work is ok.

Q.11 What helps you to deal with job demands? (e.g. support from colleagues, supervisors, family, sports, job organization, task rotation) How?

Results:

W1. On Monday and Wednesday afternoons I go to the gym and play a game with my friends. It's my way of disconnecting. The Saturdays in the afternoon when you finally finish, and you can be with the family is the happiest time of the week.

W2. I think about it as a way to cover my needs.

W3. The necessity.

W4. I think the trade union is very useful, but the workers, in general, don't realise of that.

W5. A nice working environment and relationship with all the co-workers is essential.

W6. The support of the supervisors and their consideration when a new position with more responsibility arose has improved my quality of life.

Q.12 What helps you to deal with age-related changes in work ability? How?

Results:

W1. I have been in the company for five years and I notice that I have lost elasticity and agility. I think twice about doing things, it gives me respect even though I have not had any accidents. Now I'm doing things slower and safer.

W2 I try to go to the gym whenever I can.

W3. The pills prescribed by the doctor.

W4. Really, the only thing I have noticed with age is that I need glasses.

W5. The ease adaptation to suitable environments (reallocation)

W6. As I have advanced in age, I have changed my working positions within the company, but not because of my changes in the ability to work, but because the opportunities within the company have emerged. For example, when in the position that I am in administration the previous person left, they offered it to me, and I accepted it.

Q.13 Could you try to imagine yourself in the same job in two years' time? What is your health status in two years? Will you be able to perform your current tasks?

Results:

W1. Yes, I think that in two years' time I will be able to perform the same tasks. The main problem is emotional stress, not physical.

I see myself working in the site in two years because the salary allows me to pay debts, and with the schedule that we have, my wife can also work. If it were not out of necessity, I would be looking for something else.

W2. Yes, I think that in two years' time I will be able to perform the same tasks.

W3. I don't think that I will be able to keep up with the job at the same rhythm.

W4. Since I work in the control room, I do not have many problems

W5. I believe I will be able to deal with my current work in the next two years but eventually I will not work in the same tasks as long as my health deteriorates.

W6. I can imagine myself to be retired in two years but having worked always in the same job. I hope that my health will be the same in two years and I will be able to do the tasks that I currently have in my job. I do not think it would be possible to perform my tasks in my previous position with heavy machinery.

Other questions (if time allows):

General questions

Q.14 If you could change anything about your job, what would it be?

Results:

W1. I would not want to work on Saturdays. Before the crisis, we worked from Monday to Friday for the same salary as now. I do not have time to relax and enjoy the family.

W2. I believe that I would make changes in organization and in formation of the workers.

W3. The lack of competence of some workers.

W4. The lack of competence of some managers and to reduce the number of hours.

W5. The salary for better.

W6. I would change the salary.

Q.15 When do you think about your job, what is the most difficult or challenging to you?

Results:

W1. The most difficult part of my job is the time I have to dedicate to it, and the little time left for me and my family.

W2. I don't think there is anything difficult at all.

W3. The most difficult part of my job is to keep up with the work rhythm, as you have to face the age limitations.

W4. The most difficult part of my job is to keep up with the work rhythm, with the long daily hours and the working weekends.

W5. The employee states that rising early is the worst of all of his working experience, sometimes rising at 5am.

W6. A challenge in my work is to learn something new every day.

Q.16 What motivates you to stay at your current work?

Results:

W1. What motivates me to stay in my position is that it is a job I know, and I feel safe doing it.

W2. Salary and to keep contributing to have my retirement pay.

W3. What motivates me to stay in my position is the salary.

W4. I'm 53, I think I will not find a better work and the salary is not bad.

W5. The stability.

W6. I like my job, I have not changed in 29 years of work, although I have been promoted in the company in positions of greater responsibility.

Stress

Q.17: What kind of work-related situations are stressful to you?

Results:

W1. The most stressful thing about my work is that sometimes, the lack of organization and means, poses that I accumulate tasks, so I end up being rough with colleagues.

W2. The ones that do not depend on me but on my colleagues´ performance or work force. The ones I cannot control but at the end became a problem to me.

W3. The most stressful thing about my work is the lack of seriousness of some colleagues.

W4. None, the work is easy to do, and I have enough reaction time.

W5. My work is not especially stressful.

W6. The first five days of each month that we have to do the billing, or when the internet connection fails.

Q.18: How do you handle stressful situations? What is your way to deal with stress?

Results:

W1. Sometimes I'm rough with my teammates, or sometimes I keep it for myself and then release tensions with the exercise.

W2. I try to keep my mind out of it.

W3. Trying to abstract myself of the problem.

W4. I have not stress.

W5. I do not need to deal with stress at all.

W6. I face stress working.

Lifestyle

Q.19 Do you have enough time to eat, drink water or have a break at work?

Results:

W1. Yes, they give us an hour of rest to eat and sometimes I have plenty to spare.

W2. Yes, I have enough time.

W3. Yes, I do.

W4. Yes, I do.

W5. Yes, I do.

W6. Yes, I have enough time for these things.

Q.20. Would you need to change anything in your lifestyle? What would it be? (Eating habits, physical activity, smoking, etc.)

Results:

W1. I do not think I should change anything. I would like to work less hours and have more free time, but it does not depend on me.

W2. Yes, I could stop smoking and do more exercise.

W3. I don't think so.

W4. I don't think so.

W5. I am happy with my current lifestyle.

W6. Yes, I would like to give up smoking.

Social support and relationships at work

Q.21. Are you satisfied with social support at work? From whom?

Results:

W1. Yes, colleagues support each other. Sometimes there are tensions but nothing serious. We try to solve everyone's problems as a team.

W2. Yes, I am.

W3. Yes, but sometimes I have problems dealing with the person in charge.

W4. Yes, but sometimes I have problems dealing with the person in charge.

W5. I am happy with all my co-workers.

W6. I am very satisfied since I have always received support from my supervisors.

Q.22. Do you feel that you are part of the team?

Results:

W1. Yes, although I have been much less time in the company than others, I am part of the group. There are many things that you do with 40 years that you cannot do with 60. The companions help us to fill these gaps.

W2. Yes, I do.

W3. Yes, I do.

W4. Yes, I do, we have a very good relationship.

W5. Yes, I do.

W6. Yes, I do.

Health

Q.23. What is your main health problem? (e.g. musculoskeletal disorders, chronic diseases, fatigue, sleep problems, stress or anxiety, hearing problems).

Results:

W1. Hearing problems and above all sciatica and lumbago that I attribute to the forced posture. Sometimes the leg does not respond and it's very difficult for me to get out of the cabin.

W2. Musculoskeletal problems and stress.

W3. Respiratory problems.

W4. None.

W5. None.

W6. Until now, I do not have any serious health problems in the everyday. Although I have lost 30% hearing in one ear, it does not prevent me from following my daily routine.

Q.24. What could help to improve your health?

Results:

W1. More exercise and small breaks to stretch. I do not think I should improve my diet and I do not have serious sleep problems.

W2. To change my current position.

W3. To stop working.

W4. Working less hours.

W5. More exercise and having time to do it.

W6. Give up smoking.

Factory workers perspective

***Please complete

11.5 ANNEX V: ANEFA PILOT WORKSHOP – Detailed results of prioritization on functional and interaction requirements

In order to select and prioritize user requirements, surveys given to workers were design to get information about two issues, **the functional requirements**, this is the solution that the applications gave to a specific problem, **and the interactional requirements**, that is, the way in which the user relates to the application or the tool.

ANEFA´S Health and Safety Technical Committee made the decision to derive the part of the survey related to the tools´ and applications´ design to experts on health and security, since, as responsible for complying with safety and health standards and as connoisseurs of the daily problems that workers face when they age, the results obtained would allow us to draw valid conclusions, both from the point of view of the problem of aging and regulatory compliance, ensuring greater acceptance of use cases, both by workers and by the managers.

As can be inferred from the statements of the survey questions referring to the user functional, design and interactional requirements, the workers were asked to rate them from one to five in order of importance or priority, being one the least important and five the most important. Based on the results obtained we have organized the scores as high (H), medium (M), and Low (L) priority.

Since the approach to the requirements was made, as explained in the paragraphs above, after a resounding analysis of the needs of the workers in the extractive industry, none of the requirements scored below average, a 2.5 score. This led us to conclude that our preliminary approach to the matter had been adequate to the extent that the proposed solutions did respond to worker´s real expectations of improvement.

Therefore, the results were sorted by priority even though none of them can be considered low. The scale was organized considering the scores from 5 to 4,1 as high priority (H); 4 to 3,6 as medium (M); and low priority (L), the scores below 3,6.

Table 25: Detailed results of prioritization on functional and interaction requirements. Potential users.

FUNCTIONAL AND INTERACTION REQUIREMENTS	MEAN	OVERALL PRIORITY
If I press the button in case of emergency, someone would come to help me.	4,74	H
The tool measures my pulsations and vibrates in case the levels are abnormal.	4,27	H
The app would send an alert to the manager if any of the security elements of the machinery is not working properly.	4,14	H
The app would help me establish an instant dialog with the person responsible of the security if there is a problem with the individual or collective security equipment.	4,14	H
The app gives me advice on exercise to improve my health during my free time.	4,11	H
The app sends advices/tips to the manager on better practices for the older workers: better breaks, better working conditions and better heath and security practices.	4,05	M
With the platform, I would be able to ask for free days and have a control on the ones that I have left.	4,02	M
The app gives me tips on healthy habits to improve my sleep quality.	3,98	M
The platform allows me to upload videos and images of my day to day job.	3,95	M
With the platform I would be able to help my younger mates from home if they need my advice in day to day job situations.	3,95	M
The app allows me to do an initial check list before I start my working day in the security items.	3,93	M
The tool advices me on the frequency on which I should drink water in order to stay properly hydrated.	3,93	M
The tool allows my geolocation in the quarry	3,88	M

The results on the measurement tools would be upload to the app, so I can see my health status and the way exercises and good healthy habits are improving it.	*3,80*	M
The app sends me one alert at the end of my working day on my improvements.	*3,77*	M
I would be able to control my progress through the app and fulfil my goals.	*3,77*	M
The app allows me to help my collage to repair the machinery from home using smart glasses.	*3,64*	L
The tool controls my sleep quality.	*3,52*	L
A virtual coach advises me on exercises that I can do during my working breaks.	*3,39*	L
A virtual coach advises me on exercises and checks whether if I am doing it correctly through a web camera.	*2,91*	L

Going from higher to lower prioritization by respondents, the **functional requirements** that have been considered most important are those related to the preservation of worker's own safety.

Respondents have considered as the most important functionality that there is an emergency button so that, in case of accident or other risk, it is quickly geolocated.

Secondly, they have considered it a priority that the application can measure their vital signs, their pulsations, and vibrate in case something does not go well.

Thirdly, that the app or the platform allows to establish a direct and instant communication with the manager in case of failure of any security element of the machinery.

It has been considered of medium importance that the application gives advice to the worker to improve their health and the quality of their sleep.

Secondly, that through a platform the worker can request free days and control of those that are left to enjoy.

Thirdly, the workers have considered important that the app or platform allows them to upload videos or images of their day to day job in order to help younger mates, if they need work related advice.

It is also considered of medium importance that the tool allows the geolocation of the worker in the site. Compared to the result obtained about the emergency button, it should be noted that workers prefer the geolocation to be limited to emergency situations.

The workers have considered of medium priority that the data of their vital measurements is uploaded to the app, so they can follow their improvement, also that they receive an alert of their improvement.

As for **the interaction requirements**, it will be a high priority for the platform to help the worker to establish direct contact with the manager and security managers when any element of the machinery or equipment presents problems or fails.

It is considered important for the app to involve the manager in the best practices to help older workers.

It is considered a medium-high priority for the platform to upload videos and images to help younger workers. It is considered as a medium priority for the application to send alerts about the progress of the worker at the end of the day, or that the data of the measurements are placed in a database.

Finally, it is considered as a medium-low priority that the tool controls the worker during sleep and that the virtual trainer can control that the exercises performed by the worker are correct through a web camera.
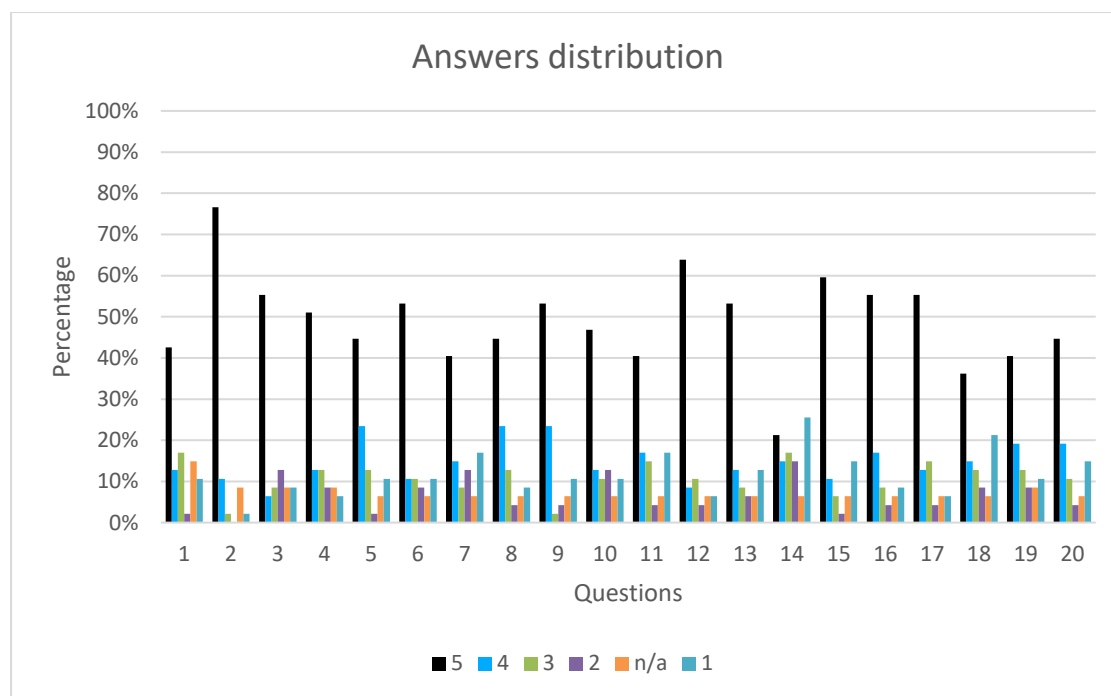

Figure 25: Priority on functional and interaction requirements

Ageing@Work

11.6 ANNEX VI: ANEFA PILOT WORKSHOP – Detailed results of prioritization on design and interaction requirements

Table 26: Detailed results of prioritization on design and interaction requirements. Security experts

DESING AND INTERACTION REQUIREMENT	MEAN	OVERALL PRIORITY
The tool keeps the measurements and uploads them to my Smartphone so I can check my progress.	4,82	H
Before my petition of free days is sent to the manager, the platform will ask for my confirmation.	4,82	H
The alert bouton should be located in the cabin, or in the smartwatch so he can push it in case of emergency.	4,78	H
The measurement tool is light, and you can wear it under the clothes.	4,73	H
The measurement tool does not limit my movements nor compromise my security.	4,73	H
The check-list for the security elements should be periodically updated.	4,67	H
The app would send tips to the manager so he can better organize the working day of the ageing workers.	4,56	H
The hydration tool will vibrate each time I should drink water.	4,44	H
The platform would be accessible online.	4,44	H
The platform is private and only I have access through a password.	4,27	H
The app is easy and fun to use.	4,27	H
The virtual coach should have a human appearance.	4,27	H
The virtual coach should have a nice voice.	4,27	H
The platform would allow me to upload images and videos in HD.	4,11	H
The app will incorporate a GPS system for my geolocation.	4,11	H

The platform allows conversations with video.	4,11	H
I should be able to see what my partner is seeing through his smart glasses in order to advise him while repairing the machinery.	4	M
The virtual coach answers to my voice commands.	4	M
I would receive just one notification on my progress at the end of my working day.	3,90	M
The cardiac ridden measurement tool will vibrate when my pulsations go under 60 per minute or up to 100 per minute.	3,89	M
The measurement tools are activated with the touch.	3,67	M
The devices would not interrupt my working activity at any circumstances. My interactions with the app/tool/platform/virtual coach should be limited to my free time or my working breaks.	3,56	L
The measurement tools are activated with my voice.	3,33	L
The platform would establish a rank from 1 to 3, so the worker can classify the urgency of his petition of free days, and the manager can prioritize one petition from another.	3,11	L

When analysing the interaction and design requirements, safety and health experts have specifically asked to ensure that the devices used comply with the regulations and in no way compromise the safety of potential users.

First of all, with a 4.82 out of 5, there are two interaction requirements, the first one, that the data of the subject's measurements are directly transferred to the subject's smartphone and secondly, that before asking the manager for free days the platform asks for confirmation of the subject. The concern about the privacy of the subject is also given in another requirement as it is considered to be of high priority that only the subject can access the platform through a password. Online profiles should be designed for each user when accessing the platform and online content.

In the third place, a design element referring to the emergency button, establishing that it should be placed in the cabin or in the smartwatch so that the potential user can press it in case of emergency. Again, the safety button is placed in the highest priority positions by the safety and health experts.

The design elements of the tools considered priority are the following: that the device is light and easy to use, that it does not limit the movements of the subject and that it can be used under clothes. This requirement is definitely important when complying with safety regulations. Nothing that can be caught in the machinery can be carried by the subject.

It occupies a position of high priority that the AGEING@WORK solutions include a dialogue with the manager, communicating best practices to meet the needs of the older workers.

As for the way of activation of the devices and interaction with the subject, the option of activation by touch is preferred than activation by voice, although when it comes to the virtual coach, it is preferred that the interaction would be by voice if possible (i.e. when ambient noise levels allow it). In addition, regarding the coach's design, it is considered important that it has a human-like appearance and a pleasant voice.

Another design element that is considered important is that the pulsation measuring device vibrates when abnormalities in the heart rate are detected. A range of vibrations should be established that is easily identifiable by the subject, so that it is not confused with the normal vibration of the machinery.

As far as the platform is concerned, it is considered important that it is accessible online and that it allows the uploading of high-quality videos. These two requirements have been considered even more important than the fact that the user can see what the partner is seeing in real time when facing problems such as repairing the machinery.

It is considered of medium-low priority that the subject limits his interactions with the tools to his free time or that he only receives a notification of the progress per day. It can be interpreted, taking into account that it has been considered important that the subject can monitor their measurements by the smartphone, that the security experts do not see any inconvenience in that the subject can use or consult the application while working, as long as it does not involve a dangerous distraction or lower the productivity of the subject. It is also considered of low importance that the measurement tools are activated by voice. Here we can conclude that there is a preference for touch activation rather that voice.

The requirement that seem less important, although it receives an average score of 3.11, is that the subject, when requesting free days, establishes a priority range.
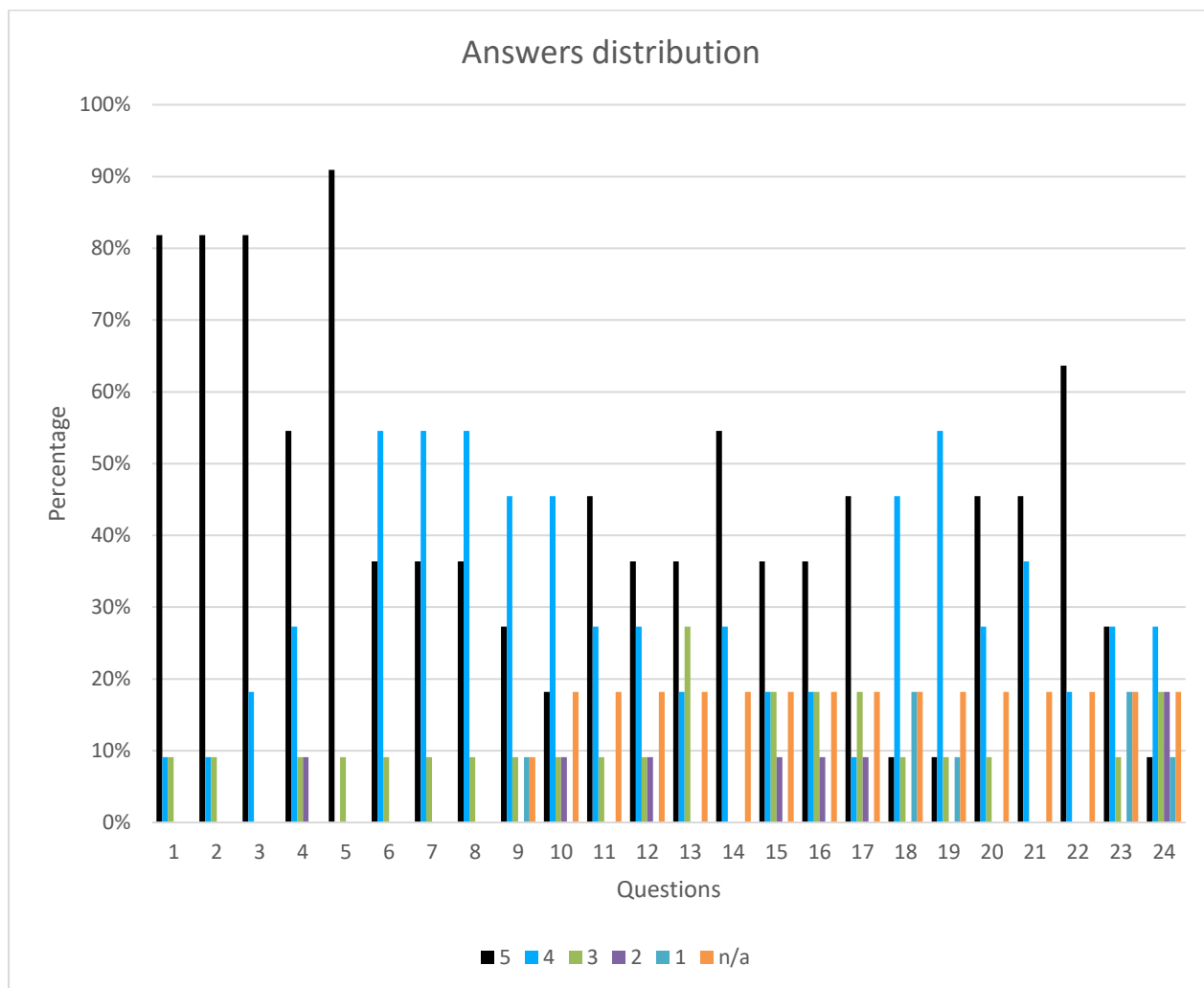
Figure 26: Prioritization on design and interaction requirements.