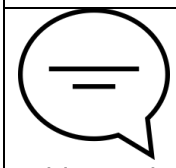
Roadmap for virtual reality (VR)

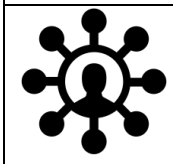
Description and state of the art	
 Definition	Technology evolving from advancements in Computer Graphics, Cognitive Intelligence and Human Computer Interaction. *Virtual Reality (VR)* provides a computer-generated 3D environment that surrounds a user and responds to that individual's actions in a natural way[224]. It refers to computer technologies that use software to generate realistic images, sounds and other sensations (e.g. smell, vibrations, etc.) that replicate a real environment (or create an imaginary setting), and simulate a user's physical presence in this environment, by enabling the user to interact with this space and any objects depicted therein using specialized devices (e.g. display screens, projectors, goggles, headsets or head-mounted displays, gloves, etc.) VR actually brings the user into the digital world by cutting off outside stimuli. In this way user is solely focusing on the digital content[225].
 Addressed societal /business or public sector need	Societal need: • Experiential education and training Public sector need: • Recruitment and training


Existing solutions /applications /services
	Existing solutions include:
	• in terms of hardware
	  ○ Google Cardboard[226]
	  ○ Samsung Gear VR[227]
	  ○ Oculus Rift[228]
	• and in terms of software platforms (for schools and universities):
	  ○ Immerse VR Education[229]
	  ○ Altrange VR[230]
	  ○ Unimersiv[231]
	The number of applications for virtual reality training is increasing over time. Thus, also special applications for the public sector (e.g. in the health area or in the area of emergency management) are possible.

 Main actors regarding R&D of this technology	• Centre National de la Recherche Scientifique • Universitat de Barcelona • University College London • Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V. • Technische Universität München
 Current research activities	In total, there more than 160 projects related to virtual reality. Projects identified by SONNETS, and relevant to the related societal need, which set the focus on virtual reality itself are: • **AbsZero**, with the goal to enable a mass audience of private and business customers to record own VR content in a simple fashion and a highly-defined quality through a VR camera[175]. • **eHERITAGE** (Expanding the Research and Innovation Capacity in Cultural Heritage Virtual Reality Applications), targeting the development of a center of excellence in virtual heritage[232]. • **VRMIND** (Virtual reality based evaluation of mental disorders)[233], • **FURNIT-SAVER** (Smart Augmented and Virtual Reality Marketplace for Furniture Customisation), to make use of VR/AR technologies, recommendation engines and a user interface to produce a smart marketplace for furniture customisation[234]. • **VR4Health** (Revinax platform for 3D Virtual Reality Learning Techniques for Complex Medical Applications), on the development of an innovative solution that will greatly improve surgical training allowing to decrease surgical errors, and the associated burden for EU healthcare systems[235]. • **VR STROKE REHAB** (Virtual Reality Intervention for Stroke Rehabilitation), to assess the effectiveness of VR therapy to promote the participation in daily physical activity of individuals with stroke[236]. • **SP3D** (Virtual reality fitting simulation for electronic e-commerce), an innovative solution for customers to try-on clothes on their mobile devices[237]. • **MicroNanoTeleHaptics** (Micro/Nano Exploration, Manipulation and Assembly: Telehaptics and Virtual Reality System Development and Investigation of Biomechanics and Neuroscience of Touch), developing robot mediated human interface technologies to manually explore, manipulate and assemble progressively smaller objects ranging from micro- to nano-meter scales and demonstrating the power of the interface system in the investigation of the fundamental mechanics and neural mechanisms of touch[238]. • **IMOSHION** (IMproving Occupational Safety & Health

	in European SMEs with help of simulatION and Virtual Reality), with the objective to stimulate awareness of OSH issues in European SMEs and to support SMEs in their adherence of OSH through training, operation, planning and the design of workplaces[239]. • **IMERSO**, a revolutionary Virtual Reality (VR) system for modernising the multimedia aspects of product design and prototyping, customer engagement, and workforce training[240]. • **V-TIME** (Virtual reality-Treadmill combined Intervention for enhancing Mobility and reducing falls in the Elderly)[241].
 Impact assessment	**Public Sector as an Innovation Driver:** • Quality of Education • Quality of Health • Public Safety
Necessary technological modifications	
 Potential use cases	Virtual Reality can be used in the context of the public sector for several training purposes, indicatively for: • Medical training / surgery simulation[242] • Architectural walkthroughs[243] • Historical re-enactments[243] • Emergency services (paramedic training)[243] • Combat training[243] • Rescue teams training • Professional and citizens training for crisis situations • Virtual tours and field trips to museums, landmarks or even outer space • Enhancing the learning experience of students[244]
 Technological challenges	Technical challenges in the field of virtual reality are located in the areas of: • developing better tracking systems • finding more natural ways to allow users to interact within a virtual environment • eliminating interface constraints and bad ergonomics (cables impeding movement, poorly designed instruments causing fatigue and an unsettling feeling of enclosure) • decreasing the time it takes to build virtual spaces (it can take a long time to create a convincing virtual environment - the more realistic the environment, the longer it takes to make it) • ensuring platform compatibility.
Necessary activities (in or for the public sector)	

 Development of a specific training necessary		There is no need for specific training for the use of the technology. However, caution is needed, when it comes to the development of relevant models, as poor models of the real world may provide faulty training results, as well as in the actual use of virtual reality systems (i.e. having short breaks for every 30 minutes of use), so as to avoid related side-effects.
 Advanced or adapted ICT infrastructure needed	**Open task**	Less than one percent of the 1.43 billion computers in the world have the graphical capabilities needed for VR, according to the research company Gartner[245]. These are definitely high-end computers that are optimized for it, but they're costly, and thus out of reach. On the other hand, virtual reality technology is also very bandwidth-intensive. Last but not least, the need for upgraded hardware isn't limited to just computers. Consoles, cameras, displays and other pertinent gadgets need as well to undergo relevant improvements. These points indicate that for the most part, the technology has either yet to be released, is in early developmental stages or simply beyond the budget of regular consumers[245] and imply the need for advanced or adapted ICT infrastructure.
 Change of (public sector internal) processes necessary		No change of public sector internal processes is necessary.
 Promotion / information of stakeholders necessary	**Open task**	The immersive nature of VR makes it a perfect fit for video games as well as training applications. However, while for gamers virtual reality may be an easy sell, it may be hard to get non-gamers to commit to this technology, and thereby promotion of the latter to the targeted stakeholders is necessary.

 Need to deal with cyber security issues		No cyber security issues identified.
 New or modified legislative framework or regulations necessary		No modifications in the legislative framework are necessary.
 Development of a common standard necessary		No standards' development is necessary.
 Need for a more economical solution	**Open task**	The market of virtual reality gadgets is dominated by high prices. This of course is anticipated to change over time as newer models become more powerful and cheaper to produce, but the fact is that we are not there yet[245].
Dealing with challenges		
 Ethical issues		No ethical issues are identified.
 Societal issues		No societal issues identified.
 Health issues	**Open task**	Prolonged use may cause side-effects, such as sickness, headache, vertigo, nausea, disorientation etc. Oculus Rift's health and safety documentation alone lists the following as potential symptoms: • Seizures • Loss of awareness • Eye strain

		• Eye or muscle twitching • Involuntary movements • Altered, blurred, or double vision or other visual abnormalities • Dizziness • Disorientation • Impaired balance • Impaired hand-eye coordination • Excessive sweating • Increased salivation • Nausea • Lightheadedness • Discomfort or pain in the head or eyes • Drowsiness • Fatigue • Other symptoms similar to motion sickness The truth is, the long-term effects of VR are still unknown. Many side effects are thought to be only temporary, but long-term research studies are scarce so we don't know for sure[245].
 Public acceptance		The technology is likely to encounter problems regarding public acceptance, as for the time being it is only familiar and attractive mostly to gamers, whereas it involves quite expensive equipment which leaves the majority of consumers "priced out" of the VR market.