



EUROXR

DELPHI REPORT

A CONSENSUS STUDY ABOUT THE STATE OF XR
2022-2030

Jolanda G. Tromp, Gabriel Zachmann, Jerome Perret,
Beatrice Palacco

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The European Association for eXtended Reality (EuroXR)

Rue du Trône 98

1050 Brussels

Belgium

www.euroxr-association.org

info@euroxr-association.org

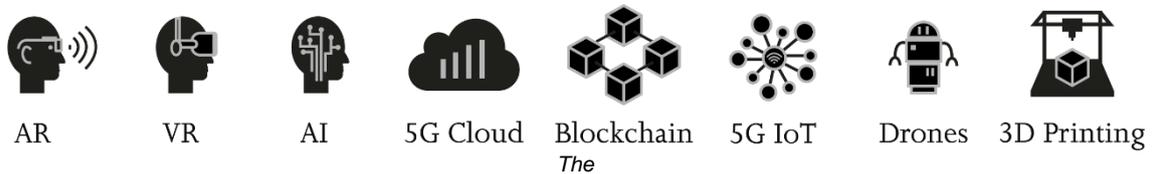
Authors: Jolanda G. Tromp, Gabriel Zachmann, Jerome Perret, Beatrice Palacco

Layout Design: Mónica González Gálvez

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EXECUTIVE SUMMARY

The path towards realizing the full potential of XR technologies needs to be clarified in order to make informed decisions about research and development agendas, investment, funding, and regulations. XR (VR/AR) is part of the “Essential Eight” key enabling technologies (KETs) of the 21st century.



“Essential Eight” key enabling technologies (KETs) of the 21st century – Illustration by Maxelante Bussemaker ©

Together, these KETs will drive the digital transformation that has started only recently in many areas of business, daily life, and leisure. Furthermore, XR can play a major role in achieving several if not all of the 17 Sustainable Development Goals set forth by the UN.

In order to provide insights into the best approach to further develop XR towards its full potential, the EuroXR Association has initiated and financed a study that draws on the expertise of independent senior XR experts throughout Europe.

The results were analyzed into a concise roadmap using the well-known Delphi method. This can help members of the European Commission and the XR community to take appropriate measures and decisions on the path forward so that XR can contribute to the solutions of the global problems of our society and planet.

EuroXR Delphi

The main findings of our XR roadmap are summarized here: there are several areas for the EC to act upon, in order to ensure Europe remains at the cutting edge of XR and, thus, has this Key Enabling Technology at its disposal throughout industry and society.

Funding of high-risk research and development in XR technology:

- 1) The race towards the ultimate XR display is still going on; while other countries (US, Japan) are currently ahead of Europe in that area, it is still not too late. So, massive investment in R&D to develop novel display technologies can bring the EU ahead of the contenders. There are many opportunities to do so: light field displays, super-high resolutions, combining headsets with 5G, integrated systems combining display with cameras with compute, light-weight form factors, etc.
- 2) Research into natural user interfaces (NUIs), especially camera-based, both for mobile XR as well as room-sized XR applications. Such NUI's will usually involve physically-based simulation of the interactions among virtual objects.
- 3) R&D into collaborative XR applications, both collocated as well as remote; this includes telepresence, tele-medicine, remote driving, and many more; this also requires fundamental research into data compression, latency mitigation, dynamically updating avatars.
- 4) Other modalities are still under-researched, such as audio, haptics and force-feedback, sound synthesis, temperature and air-flow. This should be tackled on the level of both hardware and algorithms.
- 5) In order to break free from dependency on US providers of software platforms, the EC should invest in development of European, open-source software platforms. There exist promising candidates in Europe already. Such new software platforms (game engines) should adhere to established standards (e.g., OpenXR) proposed by international bodies such as the Khronos group.

Novel regulations regarding XR:

- 1) GDPR for XR: Privacy and security could be seriously breached by providers of XR technologies on all levels, utilizing AI in combination with eye-tracking, user-behaviour, and many other physiological factors. The EU is called upon to establish clear regulations that will prevent that from happening without users' explicit consent.
- 2) Regulations should be established that will allow for EU-wide research and deployment of XR applications in health care and medicine, without going through all national regulatory bodies, or at least that should be greatly simplified. Otherwise, companies will target US markets first, and probably move to the US altogether.

3) In the long term, when XR will have become an everyday tool, regulations should be devised that ensure our European values of protection against discrimination of sexual, ethnic, religious, and economic minorities.

Novel funding instruments:

1) Provide more funding instruments for long-term, multinational projects. There are already many opportunities for multi-national funding, which is good, but none of them are really long term.

2) Create better incentives for industry and businesses to engage in high-risk projects together with academia; so far, companies are not willing to engage in high-risk projects that might, by definition, fail; also, researchers in academia are unwilling to take risks in funded projects, since that would jeopardize their funding.

3) Create funding instruments that will level the playing field for all countries within the EU, in the long run. So far, it is pretty much impossible for countries with lower technological standards to catch up with the richer countries in the EU.

4) In order to foster the exchange of ideas between academia and industry/businesses, there should be funding or other incentives for companies to bring experts from academia into advisory boards or other consulting roles for long periods of time.

5) There should be funding schemes between the FET-type and the RIA-type, which might have applications only in 5-10 years' time.

6) Funding schemes that better help start-ups and scale-ups to enter the EU market as a whole and establish a user base; again, these schemes should be mid-term to long-term, especially for companies that need to compete with Chinese competitors.

7) Study and developed explicit facilitation of best practices for successful XR collaboration and knowledge exchange, specific to the complexities of the XR development pipeline, and the diverse international experts and rapidly evolving hardware and software development workflows involved.

Overview of the EuroXR Delphi Statements

Four groups of statements were collected. The statements are grouped and ordered in terms of urgency and importance: Column A: very important / strongly agree / very urgent; Column B: important / agree / urgent; Column C: necessary.

1) XR Market Statements	A	B	C
MC1 XR technologies are a strategic source of competitiveness, and their development must be strongly supported. (R2 Q31)	7		
MC2 Focus on the potential market share in creating 3D asset libraries specific to Industry 4.0 use-cases, to help speed up XR development, because many industry use-cases are early-adopters of high-precision manufacturing using XR Industry 4.0 solutions, and the Industry 4.0 use-case specific 3D assets are expected to become of interest world-wide. (R2 Q9)	5	1	
MC3 Urgently support the development of industry specific XR Development Asset stores, with high quality shareware assets that are available for developers under a sustainable non-profit business model, crowdsourced, no-cost or low-cost. (R2 Q25)	5	1	
MC4 It may or may not be too late for newcomers to catch up on the global consumer XR input/output device manufacturing market, because there are many big companies producing consumer XR input/output devices, but stakeholders should explore this direction. (R2 Q14)	3	2	1
MC5 XR developers and stakeholders can capture the market by prioritizing research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data. (R2 Q11)	2	4	
MC6 With several global companies interested in monetizing users' data, more research into General Data Protection Regulation (GDPR) is needed, specifically regarding protection and regulation of XR users' personal and psychophysiological data, and because the GDPR may not cover all legal aspects, additionally a complete classification of the psychophysiological data should be made, and this will be especially important for BCI solutions. (R2 Q15)	2	3	1
MC7 XR technologies are essential for the development and success of Industrial Data and Clouds. (Q48)		7	
MC8 Facilitate the market uptake of XR applications for healthcare, by establishing more flexible rules for experimentations, and by creating a funding instrument dedicated to the certification process. (R2 Q19)		6	

2) XR Enabling Environment Statements	A	B	C
<p>EE1 Urgently fund R&D and standardization work towards the cybersecurity of XR technologies, especially personal XR devices which are going to be part of the mobile phone. (R2 Q44)</p>	7		
<p>EE2 Make available and subsidize easily accessible prototyping solutions, for R&D and end-user invention support in electronics and optics R&D and testing, including facilities such as publicly accessible design and manufacturing spaces and 3D printing equipment for rapid-prototyping of XR hardware designs by XR end-users, in order to foster diversity in the designs based on real end-user UXUI XR experiences, and enabling an end-user driven evolution in input/output solutions, in a short cycle of human-centred design-implement-test-redesign. (R2 Q 23)</p>	3	2	1
<p>EE3 Support XR R&D for input/output devices that go well beyond the currently developed devices, for instance climate input/output devices (wind, rain, etc), olfactory IO devices (providing scents), hand tracking and use-case specific haptic devices, including standards for these new items. (R2 Q35)</p>		7	
<p>EE4 Make funds more accessible for facilitating innovation via new XR labs and independent developers, by increasing the success rate of proposals, and by providing active help and support with the application process. (R2 Q41)</p>		7	
<p>EE5 Orientate on how to prioritize, support and facilitate access to state-of-the-art XR technologies for the development of multi-user, remote collaboration XR solutions, as this involves multiple institutes collaborating, coordinating and doing (their part of) a R&D project together. (R2 Q46)</p>	3	3	1
<p>EE6 Promote the collection of rules of best practice concerning the licensing of intellectual property rights in the field of XR, covering in particular the amounts of the royalties, the criteria of exclusivity, and the periods of validity, and encourage coordinated, open access to code which has been developed with public funding. (R2 Q20)</p>	3	2	1
<p>EE7 Create specific funding programs where strategic results (e.g., source code, 3D assets) will be made accessible for free to certain third parties, e.g., SMEs/research institutes, to extend the impact of government funded progress and enter the market, using crowdsourced testing. (R2 Q24)</p>	3	2	1

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<p>EE8 The EC should make available and subsidize easily accessible prototyping solutions, for R&D and end-user invention support in electronics and optics R&D and testing, including facilities such as publicly accessible design and manufacturing spaces and 3D printing equipment for rapid-prototyping of XR hardware designs by XR end-users, in order to foster diversity in the designs based on real end-user UX/UI XR experiences, and enabling an end-user driven evolution in input/output solutions, in a short cycle of human-centred design-implement-test-redesign. (R2 Q23)</p>	3	2	1
<p>EE9 If the government were to partner with existing commercial XR platform vendors and/or provide subsidized bulk-access to commercial XR platforms and assets, then this could create a strong bias in competition depending on the partnership format, however sharing standard APIs and providing more affordable access to commercial platforms may be beneficial. (R2 Q7)</p>	2	3	1
<p>EE10 Focus more on preventing the widening of the digital divide by being more inclusive of countries with a low TRL, and by coordinating the allocation of XR human capital and XR development resources, in a strategic manner that strengthens leadership and competitiveness in the global XR R&D sector. (R2 Q10)</p>	2	3	1
<p>EE11 Promote standardization of 3D scene description format, and also for immersive audio, other XR content and devices. (R2 Q47)</p>	1	6	
<p>EE12 Finance projects dealing with legal issues in XR technologies. (R2 Q45)</p>		7	
<p>EE13 Help improve continuation and reuse of outstanding R&D results, help share, and help increase visibility of XR project results. (R2 Q49)</p>		7	
<p>EE14 Negotiate towards the standardization and open source access of commercial XR SDKs and encourage their adoption in Horizon Europe projects. (R2 Q12b)</p>		4	2

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3) Human XR Capital Statements	A	B	C
<p>HR1 Create more long-term XR R&D projects to facilitate long-term fundamental research, long-term teamwork, skills exchange, and continuity of XR R&D skills development, especially in the areas that are very cutting-edge for XR technology breakthroughs. (R2 Q32)</p>		7	
<p>HR2 Promote, subsidise, and facilitate access to state-of-the-art XR equipment for end-users and the general public; it should also help raise awareness and understanding of the possibilities and potentials, and inspire potential start up ideas, in order to stimulate next generations to include XR technologies in their ideas and innovation proposals. (R2 Q33)</p>		7	
<p>HR3 Promote the creation of scientific councils in high-tech XR companies, and act to facilitate the participation of researchers in these bodies, for example by creating dedicated funding instruments. (R2 Q37)</p>		7	
<p>HR4 Develop specific support for the optimization of academic-industry collaboration for XR R&D projects, because the type of knowledge exchange needed for XR development may affect the success of the collaboration in unknown ways, and improvements could be made in terms of better management of XR researchers' creative capacity, adjustments to the incentives structure, senior management support and strong leadership focused on rapid XR R&D skills development, and more recognition of skills achieved. (R2 Q38)</p>		7	
<p>HR5 Widely disseminate and promote XR R&D research of best practices for successful XR knowledge-transfer cycles within academic-industry collaborations and focus on how to maximize capacity to absorb the new XR skills and XR project output and integrate the new XR technology solutions into the value chain. (R2 Q39)</p>		7	
<p>HR6 Focus more on helping to allocate XR competencies, support mobility of XR experts for international skills exchange, and training of developers at labs and companies for all XR stakeholders, including virtual (pandemic solutions) and real networking events. (R2 Q40)</p>		7	
<p>HR7 XR solutions will help reduce the time-intensive requirements of building physical prototypes dramatically, bringing ideas and innovations to life and products to market far more quickly, although there is still much improvement needed of the XR development pipeline, the learning curve and time needed and the number of experts available. (R2 Q50)</p>		7	

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<p>HR8 Finance R&D regarding the detection, measurement, correction, and protection against discrimination of sexual, ethnic and economic minorities, in the use of XR technologies. (R2 Q18)</p>	6	
<p>HR9 Prioritize, organize, and subsidise XR developers training and affordable train-the-trainer educational events at all educational levels, to address the current and imminent shortage in skilled XR developers and instructors. (R2 Q22)</p>	2	4

4) XR Innovation Ecosystem Statements	A	B	C
<p>IE1 Urgently promote the development of WebXR technologies. (R2 Q36)</p>	7		
<p>IE2 To strengthen leadership and competitiveness, more research is urgently needed towards the development and exploitation of B2B applications using XR, more open databases, and more business for the XR field in general. (R2 Q42)</p>	7		
<p>IE3 Urgently understand/create/adopt worldwide standards and support solutions for low cost, reusable, interoperability solutions for integrations of domain specific data such as BIM, scientific simulations, etc., and these solutions should be best practices in industrial R&D projects, be independent from the current mainstream XR software companies, and make it as efficient as possible to plug into the currently most used interactive XR platforms. (R2 Q26)</p>	5	1	
<p>IE4 Foster research into how to make XR technologies and designs more accessible to all diverse user groups, exploring how to include more than the currently targeted market-segment (male, educated, English speaking consumers), making sure that communication is unbiased and checking contents for localization, and using AI to automate adaptations where possible. (R2 Q21)</p>	4	2	
<p>IE5 Engage and provide full support to startups, SMEs, scale-ups and manufacturers of XR components, such as Zeiss, Bang & Olufsen, STMicroelectronics, etc., in order to spur on the development of XR devices, since breakthrough innovations generally come out of startups and combinations of parts and components from diverse manufacturers (while those components are expensive), and use market calls for R&D and XR startups, so that market-driven companies and solutions will grow and create breakthrough innovations. (R2 Q28)</p>	4		2

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<p>IE6 Urgently support R&D to expand and improve the XR development pipeline in terms of asset types, complexity of data and ontologies, and to improve interoperability between the different asset formats used in different industries. (R2 Q27)</p>	3	3
<p>IE7 Urgently improve the support for XR R&D scaling up of its innovators and SMEs and reduce the currently existing notable scaling-up gap for XR tech scaleups and unicorn companies (European governments so far offer less in comparison to the United States and China). (R2 Q8)</p>	2	4
<p>IE8 Give more support to individual XR startups directly, to bring them into the XR ecosystem and help with commercialization of ideas, help with market-entry, and generally make seed money for XR startups more easily accessible. (R2 Q16)</p>	2	4
<p>IE9 It is important to fund projects that investigate methods to establish anonymity when using XR technologies, but it should also fund projects to achieve strong identification and authentication in a secure manner in cases where applications need it. (R2 Q17)</p>	2	4
<p>IE10 XR technologies have the potential to provide a strong and adequate response to the problem of carbon emissions, by making remote work and interactions between people more efficient, thus reducing the need for personal or professional travel and developments for solutions into this direction should be prioritized, especially as a response to pandemic related travel restrictions and precautions. (R2 Q34)</p>		7
<p>IE11 Focus the R&D in XR technology in order to establish strategic leadership and competitiveness in the global XR R&D sector: in terms of hardware, the focus should be on human factors, interaction paradigms, ergonomics, customization, form factor, technology vs size, weight, and power consumption, and in terms of software, the focus should be on applications and SW platforms built on top of de facto market standards (IOS, Android). (R2 Q13)</p>		6

Additional insights were deduced from the statements when they were analysed by the EuroXR Delphi analysis team. Six additional themes were identified by reorganizing the statements based on additional commonalities:

1. Speed up XR Development: 10 Statements
2. Streamline XR Research to Market: 12 statements
3. Standardization: 9 statements

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4. Business opportunities and challenges: 10 statements
5. XR and the 17 global Sustainable Development Goals: 17 statements
6. XR R&D Collaboration and Knowledge exchange.

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1. INTRODUCTION

Leaders, governments, companies, educational institutions, researchers and members of the general public aim to understand the opportunities of new technologies, especially for those technologies that are expected to have a transformational or high impact potential. Extended reality (XR) technology solutions (Virtual reality, Augmented reality, Mixed Reality and 360) have been put forward as part of a collection of Key Enabling Technologies (KETs), and the “Essential Eight”, that will transform the way we organize work, education, communication style, access, and time needed to get things done, creating a multi-billion euro industry [1], [2], [3], [4], [5], [6], [7] [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19]. Early adopters of novel solutions using XR in combination with Artificial Intelligence and the Internet of Smart Things will be able to optimize their product or service design via big data analysis using AI and Machine Learning and will be able to gain a rapid advantage [20], [21], [22], [23], [24].

The KETs have the potential to save users and institutions time and money, accelerate development processes, measure user engagement to personalize their experience, facilitate communication and collaboration better than a video-conference, and enable new business models with novel types of objective measurements to calculate Return-On-Investment (ROI). These days, advancements in eye and hand-tracking capabilities are built into XR headsets and allow for psychophysiological measurements of the user while interacting with the XR experience. This information is used to analyse user, i.e. customer engagement and the data is automatically collected and analysed. What is more, AI and ML can be used to analyse and improve the effectiveness of the user experience designs and changes in the design can be continuously tested and quantified, thus allowing calculations to measure ROI based on actual time and motion studies with quantitative data [12].

In order to understand where funding for future XR R&D will be best allocated, the EuroXR Association members conducted a consensus survey amongst global XR developers, using the Delphi method. This document describes the EuroXR Delphi study and the results.

For a quick overview of the results the reader is referred to the Executive Summary at the beginning of this document. For a full overview of the main results, ranked in terms of urgency and importance, the reader is referred to section 7. For an overview of the new themes identified by the open survey of Round 0, see section 4.3 and 4.3.2 (items 1-10) and from the two Delphi rounds, Round 1 and Round 2, new themes that were found are listed in section 8.5 (items 1-6). For a brief review of the effectiveness of the Delphi method for the EuroXR consensus study, see section 6.3 and 9.5.1. To go directly to the overview of the roles and responsibilities of the different stakeholders of the XR Industry, go to section 9.4. Go to section 9.1 for a scenario of the state of the art of XR in 2030. To go directly to the predicted XR R&D timeline, go to section 9.2 pre-pandemic up to 2021, and section 9.3 for the predicted XR R&D timeline of 2023, 2026, 2028, 2030 respectively.

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The structure of this document is as follows: Section 1 is this introduction. Section 2 describes the Delphi method in general terms. Sections 2.1 describes how a Delphi consensus panel is put together, and section 2.2 how the Delphi study and statements are prepared. Section 2.3 describes how statements are analysed and conciliated with each other after the panel members rewrite the statements to make them in line with their own views. Section 2.5 discusses the reliability and validity of the analysis and how these are constructed.

Section 3 describes the EuroXR Delphi design. Section 3.1 describes the materials that were used to conduct the EuroXR Delphi study. Section 3.2 describes the consensus threshold that was used for the EuroXR Delphi study. Section 3.3 describes the EuroXR analysis team and their XR and other expertise.

Section 4 describes the EuroXR Delphi Round 0 preparatory round for the Delphi. Section 4.1 describes how the EuroXR Round 0 survey was developed. Section 4.2. describes how the participants for Round 0 were found. Section 4.3. describes the results from Round 0.

Section 5 describes the first round of the EuroXR Delphi, Round 1. Section 5.1 describes how the EuroXR Round 1 survey was developed. Section 5.2 describes how the XR Panel expert participants for Round 1 were found. Section 5.3 describes the results from Round 1.

Section 6 describes the second round of the EuroXR Delphi Round 2. Section 6.1 describes how the EuroXR Round 2 survey was developed. Section 6.2 describes the participants (same participants as in Round 1). Section 6.3 describes the results from Round 2.

Section 7 describes the findings of the EuroXR statements, ranked for urgency and importance. The statements from all four sections (1. XR Market, 2. XR Enabling Environment, 3. Human XR Capital, 4. XR innovation Ecosystem), are ranked within their respective sections, from top to bottom, most important/urgent in descending order.

Section 8 discusses the statements that did not reach consensus, new and reconciled statements, and the statement that continued to be controversial causing a split opinion in the Delphi XR panel. Additionally, there is a description of six additional clusters of statements that were found through further analysis of the statements: 1. Speeding up XR Development, 2. Streamlining Transfer of XR Knowledge, 3. Standardization, 4. Business Opportunities and Challenges, 5. XR and the 17 Sustainable Development Goals (17SDGs), 8. XR R&D Collaboration and Knowledge Exchange.

Section 9 describes the conclusions of the EuroXR Delphi study. A scenario of the state of XR in 2030 is given in section 9.1 and in section 9.2 and 9.2 a timeline for XR development from Pre-pandemic, 2021, 2023, 2026, 2028, 2030 as a list of milestones and potential for XR in the future, given that certain prerequisites as identified via the EuroXR Delphi and describes in the statements, are met and funding

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starts now. Section 9.4, provides an overview of the roles and responsibilities of the stakeholders involved in the XR industry: XR Research community, XR SME community, and the legislation and government bodies relevant to XR. Section 9.5 draws some final conclusions and briefly discusses the limitations of this Delphi study and the opportunities for further research and analyses.

Throughout the research and results reference is made to the European Commission (EC) and EC funding however, funds may also come from other sources, including crowdsourcing and crowdfunded solutions. Clearly the EC has the immediate pressing goals of reducing CO² emissions and addressing the 17 SDGs including the Beating Cancer plan. It is the opinion of the XR experts that XR solutions will be able to play a significant role in vital communication, health & safety, medicine, education, production, management and training solutions, and more, while the impact of XR technologies on the way we organize ourselves and our societies is still largely unknown and unexplored.

2. THE DELPHI METHOD

The Delphi method is a forecasting technique – a structured, interactive multi-stage forecasting procedure, where specific experts are guided through a group consensus process to identify novel technical developments and trends [25], [26], [27], [28], [29]. It was developed to structure complex group opinions among a set of experts participating in a panel to develop consensus on future developments for complex problems, using participative inquiry which has its roots in humanistic psychology [30]. The method was developed by the RAND Corporation in the 1950–1960s to generate scenarios for long-range strategic planning and became a widely accepted approach to facilitate the development of reliable group opinions using expert panels [31], [32].

A core benefit of the Delphi method is the opportunity to provide domain experts a place to reach consensus within a structured asynchronous and synchronous text-based information exchange setting and to share views with each other, directly or indirectly, depending on the online consensus tool interface and design of the study [33], [34], [35]. Especially since the COVID-19 pandemic the frequency of use and popularity of using consensus tools via the internet such as an online Delphi, have risen dramatically. The Delphi method and the development of the Delphi study reported here can be found in appendix A.

2.1 DELPHI EXPERT PANELS

The central element of a Delphi study is the evaluation of projections by domain experts. The projections consist of statements about possible future outcomes and desirable directions. The experts in the panel must have the professional background that enables them to formulate future projections of their colleague experts, in order to facilitate their ability to make sense of the individual suggestions and changes to the statements. The experts are asked for their opinion in several rounds of feedback to avoid ambiguity about what the consensus process has revealed [26]. The feedback rounds consist of statements in a survey and the experts in a panel are asked to refine the statements until they are in line with their expert opinion.

The expert panel must obviously be chosen carefully in terms of their knowledge and expertise regarding the topic of the Delphi that is going to be conducted. It is vital to have their commitment and availability to respond to several survey rounds to avoid drop-out in the number of participants. Delphi surveys are generally conducted anonymously, to avoid peer-pressure in terms of expressing different opinions [28]. The Delphi survey is typically administered in written form, in a multi-stage process with a minimum of 2 feedback rounds.

The size of the panel depends on the time and budget available for the Delphi, however a minimum 5 panel members is acceptable although panels of 50 members have also been tried out. However, small sample size Delphi panels have been found to produce robust results [45].

2.2 ROUNDS OF A DELPHI STUDY

Consensus is reached when a certain threshold of agreement is reached between members of the team. Typically, this threshold is set at 70% for a Delphi consensus seeking procedure, but the developers of the Delphi can adjust this threshold to their own requirements, as long as the threshold is set in advance, to avoid bias in data manipulation after collecting the data. It must be noted that consensus is not the same as uniformity. In a consensus seeking process we want to know the diversity and the majority points of view. In a uniformity seeking process we are only interested in those points of view that everyone shares 100%. Depending on how much time and budget is available for a Delphi study, more rounds can be added to reach if there is a need to reach more than 70% consensus and higher accuracy and / or a deeper understanding of the issues under investigation in the statements on which no uniformity could be reached, should this be relevant and important for the study at hand [46]. A Delphi survey typically has at least the following six phases of execution:

- **Phase 0:** preparation - explore problem statement
- **Phase 1:** selection of the stakeholders panel, problem statement, survey tools and database-platform(s).
- **Phase 2:** first round of survey - participants answer questions. The moderator analyses the responses.
- **Phase 3:** synthesis of the first round - Results of the first round are used to build the second questionnaire.
- **Phase 4:** 1 or more iterations, keep iterating until the desired consensus level - Use as many rounds as necessary to reach a satisfactory level of consensus or saturation.
- **Phase 5:** closing the survey - final analysis synthesizes the diversity in opinions of the panel on any and all topics of relevance to the problem statement.

A Delphi survey can be successfully administered via the internet and various commercial Delphi platforms and tools have been developed [47]. The first activity for the design of a Delphi study, is an open survey to generate ideas for statements for the Delphi process. The first exploratory round starts with an open-ended set of questions, thus allowing a community of respondents' complete freedom in the expression of their ideas. This approach can generate many items and the entire set can become large and unwieldy [48] and similar items have to be collapsed by searching for themes, creating

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categories and eliminating overlap between statements. Typically, the procedure to analyse the responses from the respondents is called Content Analysis, which is further defined in the section below. The Delphi consists of several round of presentation of the statements to the panel members, so that they can rewrite the statements to make them in line with their professional opinion, in several rounds of refinement. The panel is asked to rewrite the statements based on their expert opinions, in order to reach a set of consensual, short, unequivocal, and concise statements.

2.3 CONTENT ANALYSIS

The basic coding process in content analysis is to organize large quantities of text into much fewer content categories [49]. Categories are patterns or themes that are directly expressed in the text or are derived from them through adding a tag to describe the content in one or a few words, and then analysing the similarities and different in the tags, combining similar ones or grouping similar ones under a new tag or label, naming the theme they all have in common in one or a few words [50]. The relationships among categories are identified in order to seek meaningful patterns and overarching connections between diverse statements and topics.

2.4 STATEMENT RECONCILIATION

During the Delphi, statements are reconciled by the members of the panel in each round of the Delphi, and between rounds by the analysis team to facilitate the consensus process. Reconciling a statement involves rewriting it in such a manner that it includes all corrections of all panel members one way or another, to reflect the opinions of the panel members if possible or rewrite it entirely and ask the panel to reassess it. Any suggestions the panel members make towards rewriting and fine tuning the statements are included to make the statement reflect the group consensus to the best effort. However, by including all the panel members' feedback from the initial preliminary round, the wording of the statements and the number of second and subsequent rounds can become large and with that the time needed to respond to the survey becomes long and difficult to manage and this means that the number of statements may need to be reduced to keep the amount of information and task manageable. Additionally, questions and statements that are not well phrased or not clearly defined, are increasingly more clarified during the stages of the Delphi.

2.5 RELIABILITY AND VALIDITY

The result of each round of a Delphi are the rewritten statements, reflecting the consensus opinion of the panel of experts. Their feedback is integrated by the Delphi analysis team and the reconciled statements become the input for the next round of the Delphi. With each round of a Delphi, the wording of the statements and their meaning should become more refined, and this is the way the Delphi method achieves the aim of reaching the highest reliability and validity of the final statements and conclusions.

Another way to check for reliability and validity of results is by using triangulation. Triangulation refers to the validation strategy of using of multiple methods of data collection for the same research question. Triangulation is often used in qualitative research to develop a comprehensive understanding of phenomena through the convergence of data from different information sources. Typically, this starts with the literature comparisons and analogous research results summaries, and during the assessments, interviews and questionnaires can be used alongside or before and after the actual experimental task that we are asking a sample of representative end-users to perform in order to measure the success of the item under evaluation.

One note of caution with interpreting Delphi consensus results is that panel members have been found to overestimate success and outcomes of positive future scenarios and projections, and simultaneously underestimate the negative potentials of future scenarios and projections [51], studied this common human cognitive “desirability bias” and the effect of it amongst Delphi panel member, in six Delphi studies and found that the bias decreases during the course of a multiple-rounds’ Delphi. These findings amongst other things, emphasizes the importance of the repetition in the consensus seeking process through multiple rounds of refinement of the forecasts, between domain experts and that more than one round of consensus seeking is essential in decreasing any desirability bias as much as possible, thus protecting the trustworthiness of the Delphi results as well as increasing reliability and validity [52]

3. EUROXR DELPHI DESIGN

The EuroXR Delphi consists of 3 rounds: 3 surveys followed by an analysis of the survey results. The first round was a preparatory round that we refer to as Round 0, through which information for the statements of the Delphi was collected and used to formulate the statements. The respondents were invited to nominate themselves and/or colleagues for the panel of experts for the Delphi panel.

The surveys were designed as online questionnaires, and the link to the Round 0 survey was distributed widely via mailing lists, and open for anyone to respond to. For Round 1 and 2 of the Delphi, a carefully selected panel of XR experts was asked to respond to the Delphi Round 1 and 2 consensus seeking process. The selection criteria and procedure are described in detail in section Round 1 Participants.

The EuroXR Delphi consists of 3 rounds, to stay within time constraints for the study. In principle this Delphi can be considered a pilot for a more extensive Delphi project with more time to delve deep into different technical issues and future scenarios. Considering the rapid changes in the XR technology field and the Key Enabling Technologies for XR solutions, a Delphi administered on a regular basis could be used as a source of information to detect obstacles in the path of the advance of these technologies and find solutions early.

A Delphi employed on a regular basis, has the potential to provide a detailed overview of the best estimates of the experts in the field, regarding the likelihood and outcome of future events and help define the desirable directions via this democratic consensus process. Such a medium for the community of XR experts to exchange views, and facilitate each expert to independently give their estimates and share underlying assumptions in a discussion, via the Delphi process and platform, mediated by a facilitator who reviews the data and issues the summary report.

3.1 MATERIALS

The EuroXR Delphi survey was developed in Word and SurveyMonkey, and administered online via an invitation email with a link to the survey, which was widely shared via the EuroXR mailing list and relayed within the scientific XR community. On average each of the surveys required about 45 minutes to respond to, but this can obviously vary per respondent and their style, commitment and time available. Respondents had one week to return their survey responses, although in each case there was an extension of a few days, and several reminders went out, in order to gather more responses

3.2 CONSENSUS THRESHOLD

For the Delphi study reported here we used a 70% threshold for the final selection of statements. During the analysis we used a 70% threshold as well, meaning that statements are included in the next round if they received a minimum of 70% agreement or more from the XR Panel members on the criteria of consensus, expressed via a Likert scale type response (a sliding point scale with a number of explicitly defined points regarding a criterium such as degree of agreement: (Strongly disagree = 1, Disagree = 2, Agree = 3, Strongly Agree = 4, or Not urgent = 1, Urgent = 2, Very Urgent = 3, etc) [26]. See table 1 for a definition of the thresholds used for the EuroXR Delphi study.

Table 1: The EuroXR Delphi Development and Analysis Thresholds.

Consensus Threshold	Threshold Definition
Inclusion	Greater than 70% of panel members provide a positive result (3 or 4) on the Likert scale.
Exclusion	Greater than 70% of panel members provide a negative result (1 or 2) on the Likert scale.
Non Consensus	When the candidate statement has neither met the inclusion nor the exclusion thresholds.

In addition to the percentage of panel members who agree to the statement, the strength of agreement and urgency/sense of priority is also assessed, and the implications of the indicated priorities are discussed in the Discussion section. In the discussion we also return to the statements which did not make it into the final selected set of statements, because the panel members could not reach consensus within this Delphi study timeframe. In principle the fact that the panel cannot agree on a statement could lead to the identification of informative open issues that are still not clearly defined and under debate in the XR R&D community.

3.3 THE EUROXR DELPHI DEVELOPMENT AND ANALYSIS TEAM

The EuroXR Delphi was designed and analysed by a team of 4 XR experts from 4 different areas of XR R&D: a Human-Computer Interaction XR expert, a Computer Science XR expert, a Business XR expert, and an Intercultural Collaboration XR expert, with a combined 80 years of experience in XR R&D, on

more than 8 long-term EU funded projects and many other XR R&D activities such as teaching in our respective fields, running an XR business, facilitating virtual team long-distance, cross-cultural communication and collaboration, attending, presenting and organizing at XR events and conferences, and memberships of XR and related communities.

4. EUROXR DELPHI PREPARATION ROUND 0

The first round of the EuroXR Lean Delphi is the exploratory round, to collect information to generate information for statements. In the next sections we describe how the Round 0 survey was developed, which participants we selected for Round 0, how we contacted them, and the results are from this preparation round.

4.1 ROUND 0 SURVEY DEVELOPMENT

The Round 0 survey was developed in the following way: A preparatory survey was created in SurveyMonkey with 13 open ended questions and 12 demographic questions to understand more about the background of our respondents. The survey was distributed via email and a link to the survey on the SurveyMonkey website. The EuroXR Delphi analysis team put the questions together based on the more recent XR review literature, participating in discussions of current issues regarding XR R&D via recent XR conferences and events (see list of events attended by the EuroXR Delphi analysis during the runtime of the EuroXR Delphi study, Appendix A), and their diverse, combined professional knowledge and expertise from the four dominant areas of XR development.

The open-ended questions were based around the classic Delphi starter question format:

“According to you, what are the <...> that will <...> in the next <..> years? This can be existing <..> or new <..>.”

The following statement is an example of the format, Delphi statement for the EuroXR Delphi Round 0:

“In your opinion, how can XR innovations help address European commitments to achieve the Global Sustainable Goals within the next 10 years? This may be existing innovations, or your predictions for new innovations.” (R0 Q20)

As an incentive to respond to the survey, the potential respondents were offered a copy of the survey report in exchange, and they were told they could nominate themselves for the subsequent Delphi XR Expert panel. Additionally, they could nominate their XR lab for a follow-up interview by other members of the EuroXR Association interested in Mobility and Knowledge exchange between XR labs around Europe and the world.

The first question of the survey asked for the consent of the respondents to allow us to share their ideas in the Delphi analysis and to ask for non-disclosure of their responses to the Delphi for the duration of the project run-time. Respondents were assured that their responses would be treated anonymously at all times. See Appendix B for an overview of the Round 0 survey question

4.2 ROUND 0 PARTICIPANTS

The potential participants for Round 0 are members of the XR community, mostly European but potentially worldwide, because the survey was distributed via the EuroXR Association (www.euroxr-association.org), the VRISI network (www.vrissi.de), and others, and many members of these list forwarded the invitation to their mailing lists, such as the German and the French VR/AR/XR Association.

4.3 ROUND 0 RESULTS

Eighty-two respondents submitted a response to the survey, however of those 82, 40 records of respondents had to be discarded because they were very incomplete, leaving 42 complete records for our analysis. Presumably many respondents started the survey and then planned to come back to it later but then did not manage to complete.

4.3.1 ROUND 0 DEMOGRAPHICS

On average it took respondents 1 hour to reply to the survey. There were 24 academics in the sample, and 18 employed in business, and 4 of the respondents stated that they were both involved in academia and business, see table 2 for an overview of the respondents' professional background in XR.

Table 2: Round 0 respondents' current job description and role (R0 Q2).

Job / role description	Responses	
Professor	11	26,19%
Research associate/scientist	10	23,81%
Project leader/manager	6	14,29%
Scientist principal/senior	4	9,52%

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CEO	3	7,14%
Managing director	2	4,76%
Ph.D. candidate	2	4,76%
VR startup	2	4,76%
Electronic defence	1	2,38%
Forecaster-fundraiser	1	2,38%
Head of department	1	2,38%
Lecturer	1	2,38%
Physical therapist	1	2,38%
VR game developer	1	2,38%
Total	46	100%

In total they worked 42 years in XR R&D, and there is some visibility of the three waves of the VR/AR development, as described in the Gartner Hype Cycle [1] in the clusters in the number of years involved in XR R&D and the current influx of newcomers in the field, see table 3. A similar distribution can be seen in the age brackets in which the respondents fit, see table 19, showing the normal distribution in age of the respondents that one would hope and expect for a field that has been in existence for more than 30 years. Forty-one out of forty-two respondents are a member of one or more professional XR membership groups.

Table 3: The number of years respondents have worked in the XR field (R0 Q3)

Number of years worked in the XR field	Responses	
Less than a year	0	0,00%
1-2	5	11,90%
3-4	4	9,52%
5-6	5	11,90%
7-8	0	0,00%
8-9	2	4,76%
10-11	4	9,52%
12-13	6	14,29%
14-15	1	2,38%
16-17	0	0,00%
18-19	3	7,14%
20-21	4	9,52%
22-23	2	4,76%
24-25	2	4,76%

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26-27	2	4,76%
28-29	0	0,00%
30-31	1	2,38%
32-33	1	2,38%
34-35	0	0,00%
36-37	0	0,00%
38-39	0	0,00%
40-41	0	0,00%
42+	0	0,00%
Total	42 years	100%

There were 9 women (21%) and 33 men (79%) in the sample (see table 4), and they are aged between 25 and 75 (see table 5). The original full set of 82 records (before excluding the abandoned / incomplete responses) showed a similar ratio of female:male respondents of 16 females (22.2%) and 58 males (75%) and includes 2 respondents who preferred not to share their gender information (2.8%).

Table 4: The gender breakdown of the respondents of Round 0.

Gender	Responses	
Female	9	21,43%
Male	33	78,58%
Other	0	0,00%
Prefer not to say	0	0,00%

Table 5: The age brackets of the respondents in Round 0.

Age bracket	Responses	
Under 18	0	0,00%
18-24	0	0,00%
25-34	5	11,90%
35-44	13	30,95%
45-54	14	33,33%
55-64	8	19,05%
65-74	2	4,76%
75+	0	0,00%

Table 6: The countries of the respondents in Round 0. (the 42 respondents in the sample)

Country	Total	Percentage
Germany	11	27%
France	6	15%
Netherlands	5	13%
Greece	3	8%
Italy	3	8%
Mexico	2	5%
Spain	2	5%
UK	1	3%
Malta	1	3%
Sweden	1	3%
Portugal	1	3%
Switzerland	1	3%
Turkey	1	3%
Colombia	1	2%
Finland	1	2%

EUROXR DELPHI PREPARATION ROUND 0

Table 7: The counties of the respondents in Round 0. (The original 82 respondents, before deleting incomplete records.)

Country	Total	Percentage
Germany	11	27%
France	7	14%
Netherlands	7	14%
Italy	5	10%
Greece	5	10%
Spain	3	6%
Turkey	2	4%
Mexico	2	4%
Estonia	1	2%
Portugal	1	2%
Sweden	1	2%
Luxemburg	1	2%
Switzerland	1	2%
Malta	1	2%
UK	1	2%
Colombia	1	2%

4.3.2 SURVEY RESPONSES FROM ROUND 0

The results from the Round 0 survey are presented per question below. Each question yielded a lot of useful information as summarized below. SurveyMonkey was used to collect, summarize and tag the responses, and content-analysis was used to summarize the tags, identifying emerging themes from the tags by looking for commonalities in the tags and responses. Responses with very similar tags were grouped accordingly and summarized. The themes that were identified are summarized and listed below each question, and the lists start with those that were mentioned most often and continues in descending order in terms of how often the tag occurred, listing everything that was tagged. These themes and their respective summaries are presented below and the sections follow the same numbering as in the list below for easy reference:

4.3.2.1) EU Projects (Question 9):	10 themes
4.3.2.2) XR Software (Question 10):	10 themes
4.3.2.3) XR Input and Output devices (Question 12):	10 themes
4.3.2.4) XR Pipeline (Question 13):	10 themes
4.3.2.5) XR Expertise (Question 14):	10 themes
4.3.2.6) XR Solutions for 17 SDGs (Question 20):	10 themes
4.3.2.7) Strengths of XR for Business (Question 16):	3 themes
4.3.2.8) Weaknesses of XR for Business (Question 17):	3 themes
4.3.2.9) Strengths of XR for Academia (Question 18):	4 themes
4.3.2.10) Weaknesses of XR for Academia (Question 19):	4 themes

The Strengths & Weaknesses analyses described in section 7-10 are also summarized in a Strengths & Weaknesses matrix. See figure 1 below.

4.3.2.1 XR R&D PROJECTS

EU-funding could help overcome limitations in applying, joining, or working in XR R&D projects in the following ways (R0, Q9):

1. *Ensure knowledge exchange, and share R&D results and report more widely*
2. *Bring together the XR ecosystem, networking with other researchers*
3. *Stimulate industrial and academic collaboration*
4. *Help allocate XR competencies, especially in relation to TRL of EU labs*
5. *Focus on XR cutting edge R&D, focus on strategy to capture AR EU market share, explore CX measurements in XR (apply Consumer-Culture Theory, etc) and added-value, ethics, privacy, security, EU related 3D assets and libraries, Health & Safety, Human Factors & Ergonomics, Open source XR research platform with research data analysis features*
6. *Help allocate XR resources, coordinate sharing and reuse of XR resources, especially in relation to TRL of EU labs*
7. *Increase the amount of funding for XR, make funds more accessible for new XR labs with low track record, help with application process, more funds for university R&D, improve continuation and reuse of R&D results, from one project to next project, help EU labs with TRL1 and stimulate inclusiveness and prevent digital divide, help visibility of EU XR projects, help elevate the status of XR projects made in the EU.*
8. *Ensure strategic EU leadership and competitiveness in international AR R&D, hardware, software, marketshare: displays, tech v. size, weight, power consumption, etc.*
9. *Help attract investors, support prototype 2 market, help commercialization of ideas, demo latest XR innovations and XR UXUI to raise awareness of possibilities, help with market-entry, seedmoney for XR startups*
10. *Ensure strategic EU leadership and competitive Open Source XR platform, EU relevant 3D assets, built-in data analysis features*

4.3.2.2 XR R&D SOFTWARE

EU-funding could help overcome limitations of XR R&D software in the following ways (R0, Q10):

1. *Develop interoperable, Open Source, research orientated (plug-in for biosensors, data-collection, etc), EU XR development platform, i.e. standardize format for 3D models etc to reduce friction of import/export, of XR software development platforms in the different industries that can benefit from XR solutions and integrations, to take strategic leadership in EU: parallel processing, real-time, collaborative XR platform needed.*

2. *Develop the XR developers' skills in EU, train XR users*
3. *Increase funds for cutting-edge technology development*
4. *Promote WebXR standards*
5. *Promote XR Dev platform: No coding needed to develop XR*
6. *XR Dev Asset store, shareware, EU enabled no-cost/low-cost reuse*
7. *Organize and subsidize XR skills development training for EU*
8. *Focus on cutting-edge research and research into fundamental XR issues*
9. *Include TRL1 countries and units*
10. *Create EU subsidized bulk-access to existing/commercial XR platforms.*

4.3.2.3 XR R&D IO DEVICES

EU-funding could help improve the limitations for XR R&D input / output devices, in the following ways (R0, Q11):

1. *Support HMD R&D that goes beyond the current HMDs, haptic devices, climate and olfactory IO, hand tracking and all things that go well beyond all current designs of IO devices.*
2. *Support IO devices R&D that are tailored to the diverse EU use-cases.*
3. *Ensure EU based IO R&D leadership and independent developers, support startups.*
4. *Ensure affordable IO devices for EU R&D and European citizens, support access to state-of-the-art XR tech, run multi-user tests, make available and easily accessible 3D printers rapid-prototyping of end-user tailored IO device designs.*
5. *Develop and implement ISO standards and urgently start research into long term health & safety, concerns for long-term use and Human Factors & Ergonomics for XR.*
6. *Support for XR tool exchange.*
7. *Support for XR R&D experts' exchange.*
8. *Strategic public-private partnerships needed, full support to engage and combine them (i.e. Zeiss, Bang & Olufsen, STMicroelectronics, etc).*

9. *It is too late for the EU to catch up on the IO global market.*
10. *IO progress driven by market, not EU-funding, so no need to do anything.*

4.3.2.4 XR R&D DEVELOPMENT PIPELINE

EU-funding could help overcome the limitations in the XR development pipeline, in the following ways (R0, Q13):

1. *Promote standardization. Including 3D scene format, immersive audio.*
2. *Improve pipeline interoperability, reduce quality loss in import/export conversions.*
3. *Support knowledge and skills exchange, organize XR skills train-the-trainer educational events, create long-term EU projects to facilitate long-term teamwork and continuity of skills development, create and keep up to date, overviews of XR hardware and software available, including developers, labs and companies and all stakeholders.*
4. *Low cost, reusable, interoperability solutions for integrations of BIM data and scientific simulations, etc., independent from the current mainstream XR software companies, to plug into the currently most used interactive VR platforms.*
5. *Expand pipeline in terms of asset types, complexity of data and ontologies, create 3D assets specific to EU XR projects, create a central asset store, support asset sharing.*
6. *EU facilitated and promoted Open Source XR R&D platform needed, specifically designed to facilitate research.*
7. *Prioritize solutions for High-level semantic XR language for XR behaviour development.*
8. *Prioritize XR Health & Safety, Human Factors and Ergonomics research, and XR validation research for the various use-cases.*
9. *Access to source code of commercial XR SDKs.*
10. *No need for EU funding. All we need is Blender and Pixyz.*

4.3.2.5 XR R&D EXPERTISE

EU-funding could help overcome limitations of XR expertise development, including knowledge sharing and exchange, in the following ways (R0, Q 14):

1. *EU support for XR knowledge sharing, make XR experts more visible, make EU XR expertise more visible, create solutions for rapid mobility of XR experts to other XR development projects to speed up the development process, connect academics with industry.*
2. *EU support for research data sharing.*
3. *EU support for XR community building tool, finance for more XR association activities, XR Workshops, XR Tutorials and conference activities.*
4. *Improve, coordinate and standardize XR teaching materials and processes for XR research and development education, create EU standard "XR Expertise" certification, create a quality control tool to assess XR expertise and expertise claims, create and maintain a shared source of XR teaching materials.*
5. *create adaptive intelligent XR development learning tool.*
6. *create one place for all XR related EU activities, tools and topics, including open source and EU related datasets.*
7. *Create an open source XR journal and publish regularly.*
8. *Create open source XR content for EU members and types of use-cases.*
9. *Promote XR awareness via public low entry workshops and demos, as part of STEM incentives.*
10. *Continue lobbying the EU for more XR funding, create more awareness for the potential and dangers of CX analytics in XR and the added value this type of research can bring, such as big medical data analysis and medical XR solutions based on ML and AI predictions from big medical data.*

4.3.2.6 XR INNOVATION AND 17 SDGS

XR innovations can help address European commitments to achieve the Global Sustainable Goals within the next 10 years in the following ways (R0, Q20):

1. *Contribute to CO2 reduction by reducing the need for physical prototypes.*
2. *Digital twins in cyber-physical systems help with optimizing production chains, getting XR into the whole product life cycle would improve product development and manufacturing processes, also in terms of sustainability and resource efficiency.*
3. *Reducing the need of global traveling and commuting, directly contributing to less carbon-fuel usage and less CO2 production.*
4. *Helping to increase global awareness [via simulations] regarding climate change, food supply, measuring air pollution in real-time and levying taxes on polluting industries. Help visualize, calculate and reduce air pollution, and taxes on sustainable industries, and other phenomena that are not easy to visualize or foreseeable Visualization (and emotional experience) of big picture cataclysms. Contributing to a monitor for a healthy planet, XR combined with AI to simulate and calculate green solutions, contributes to prosperous economies, fair and resilient societies.*
5. *Access to remote healthcare for rural areas and developing countries, improved psycho/physiotherapy, increasing human dignity, fair and resilient societies, XR solutions for healthcare, based on predictive analytics.*
6. *Access to remote quality education, creating inclusiveness for rural areas and developing countries Immersive training more efficient and affordable, more scalable, contributing to prosperous economies. XR and social VR for increased participation.*
7. *XR technologies will help to enhance productivity and recover the social component that traditional meetings in 2D cannot offer. Increased intercultural communication, increased cross-cultural collaboration. In the same way we have multiple computers at home now, every household will have multiple XR devices to be able to have more realistic interactions for long-distance work and education.*
8. *Creating awareness of the value of XR for business and society by funding XR projects that help to achieve sustainable goals, such as decarbonisation by virtualisation.*
9. *Experience and training to overcome cultural, racial and gender biases, contributes to fair and resilient societies, human dignity.*

10. *Increased UX by testing and refining virtual prototypes, contributes to prosperous economies, fair and resilient societies, human dignity.*
11. *Implement, display, and maintain solutions and public awareness in the XR industry for adhering and implementing sustainable XR development in terms of work practice and resources.*

4.3.2.7 XR SCIENTIFIC/TECHNICAL STRENGTHS

The most important strengths of XR technologies in Europe, from a scientific/technical point of view are (R0, Q 16):

1. *Excellent research in immersive technologies, with many scientists of top international rank.*
2. *Widespread and active community of academic and research institutions.*
3. *High scientific level for XR applications in healthcare.*
4. *More generally a strong position for professional applications of XR technologies.*

4.3.2.8 XR SCIENTIFIC/TECHNICAL WEAKNESSES

The most important weaknesses of XR technologies in Europe, from a scientific/technical point of view are (R0, Q17):

1. *Base technologies (hardware and software) are not being developed in Europe.*
2. *Difficult transfer of technology from research to market.*
3. *Lack of collaboration between academia and industry.*
4. *Lack of large industrial players in XR technologies.*

4.3.2.9 XR COMMERCIAL/BUSINESS STRENGTHS

The most important strengths of XR technologies in Europe, from a commercial/business point of view are (R0, Q18):

1. *Many small companies providing highly innovative products as well as services for developing applications on demand.*
2. *A strong XR community involving both research and business.*
3. *Market focus on XR applications in healthcare, education, and training.*

	Scientific/Technical	Commercial/Business
Strengths	<ol style="list-style-type: none"> 1. Excellent research in immersive technologies, with many scientists of top international rank 2. Widespread and active community of academic and research institutions 3. High scientific level for XR applications in healthcare 4. More generally a strong position for professional applications of XR technologies 	<ol style="list-style-type: none"> 1. Many small companies providing highly innovative products as well as services for developing applications on demand 2. A strong XR community involving both research and business 3. Market focus on XR applications in healthcare, education and training
Weaknesses	<ol style="list-style-type: none"> 1. Base technologies (hardware and software) are not being developed in Europe 2. Difficult transfer of technology from research to market 3. Lack of collaboration between academia and industry 4. Lack of large industrial players in XR technologies 	<ol style="list-style-type: none"> 1. Lack of scale-up funding 2. Regulations and bureaucracy, which hamper business development 3. Lack of a strong digital platform for XR and big data

Figure 1: Preliminary Strengths & Weaknesses analysis results.

4.3.2.10 XR COMMERCIAL/BUSINESS WEAKNESSES

The most important weaknesses of XR technologies in Europe, from a commercial/business point of view, are (R0, Q19):

1. *Lack of scale-up funding*
2. *Regulations and bureaucracy, which hamper business development*
3. *Lack of a strong digital platform for XR and big data.*

5. EUROXR DELPHI CONSENSUS ROUND 1

The EuroXR Delphi consensus process starts with the selection of a closed group of specifically selected experts for a panel of expert participants, a panel of experts, as explained previously in the introduction to the Delphi method. Participants were invited for the XR Expert Panel, based on several specific selection criteria, which are described below. Statements were prepared based on results from Round 0, the outcome of the analysis of the responses to the preliminary questions. The development of the survey is further described in the next section, 5.1 and 5.2. The results are described in section 5.3 and the consensus statements are summarized in section 5.3.2 (items 1-4).

5.1 ROUND 1 SURVEY DEVELOPMENT

The Round 1 survey was developed in the following way. For the Round 1 survey statements were developed from the responses to Round 0, based on an exhaustive content-analysis. Additional statements were added to further explore themes and topics mentioned by respondents of Round 0, based on a literature review. This produced a set of 66 statements, which was reduced to 43 statements, to make the estimated time to respond to the survey not exceed to agreed estimated amount of time of 45 minutes. For the convenience of analysis, summary and presentation of statements that were created from the surveys, the statements were grouped into 4 themes:

1. **XR Market**

Statements regarding the position of Europe in the XR market and statements are related to building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL) priorities for European Commission (EC) strategies.

2. **XR Enabling Environment**

Statements regarding leadership at European level in terms of standards for XR R&D.

3. **Human XR Capital**

Statements regarding building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL).

4. **XR Innovation Ecosystem**

Statements relating to the XR Development Platform: middleware / game-engine

The final survey design for Round 1 consisted of 57 questions in total, of which were 6 demographic questions, 43 statements and 3 organizational questions with which it would later be possible to verify that the respondents of Round 2 were indeed the same as in Round 1 without knowing their exact identity. This was done in order to be able to match their responses from both rounds together in case that would be relevant during subsequent analyses. The final survey questions and the instructions for the participants of Round 1 can be found in Appendix C.1 of this document.

5.2 ROUND 1 PARTICIPANTS

For Round 1 of the Delphi, a panel of XR experts was specifically selected to be respondents in the consensus seeking process of the Delphi (for all rounds). A Delphi panel of 10 members was selected from all 20 respondents who nominated themselves for the panel via the Round 0 survey, based on the following set of screening criteria:

- At least 35 years old, to ensure significant amount of experience in VR, AR, XR
- Senior position in their respective organization (e.g., professor, team leader, etc.)
- Active position in academia or industry
- Actively working in VR, AR, XR
- Gender balance 50/50 attempted

During the selection process, the identity of the candidates was unknown during the selection process to the EuroXR Delphi analysis team members involved in making the selection. Participants in the Delphi panel were kept anonymous throughout the selection process, and during the communications for the study, to each other and to the analysis team, throughout the whole study at all times. The person of the Delphi analysis team who contacted the Delphi panel members via email was not involved in the analysis. In total 10 panel members were selected, plus 2 reserves in case of drop-out of respondents in Round 1 or 2, with the aim of having no less than 5 members on the panel completing both rounds of the Delphi. An attempt was made to bring more gender balance to the selection of the panel members by explicitly inviting 2 additional female XR researchers.

Emails with a link to Rounds 1 of the survey were sent directly to each of the panel members via a personal email, addressed to them personally to maximize response rates as much as possible. As an

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incentive, respondents were offered a copy of the survey report, and they were invited to nominate themselves at the end of the survey to participate in a XR discussion panel at the next EuroXR Conference in November 2021.

The invitation email and the introduction of the survey contained explicit instructions for the participants (see Appendix C.1 for the instructions). Participants were asked to read each of the statements and decide in what way they agree / disagree with them and correct it if it did not reflect their opinion. The aim of this Round 1 survey was for each participant of the XR Panel, to rewrite the statements in such a way that it is fully in line with their opinion. The statements were followed by a 4-point scale to indicate their agreement with the statement as is: Strongly Disagree, Disagree, Agree, Strongly Agree, and an open response box asking them to rewrite the statement in case they could not fully agree with it, see figure 2 for an example of the survey question layout.

EU XR Market

The following statements are regarding the position of Europe in the XR market and priorities for European Commission (EC) strategies.

* 5. XR technologies are a strategic source of competitiveness for European industries, and their development must be strongly supported by the EC.

Strongly Disagree Disagree Agree Strongly agree

Please rewrite the statement so that it is in line with your opinion.

Figure 2: SurveyMonkey statement and Likert-type scale to express their degree of agreement and open text box to rewrite the statement.

5.3 ROUND 1 RESULTS

The survey was open for 7 days and reminder emails were sent out with an extension of the deadline by a few days, in order to maximize the number of responses. Seven experts from the XR panel responded to the Round 1 survey.

5.3.1 ROUND 1 DEMOGRAPHICS

The demographic data about the respondents in the XR Panel are as follows. There were 7 male and 0 female respondents who replied to the Round 1 invitation email. Nearly 43% of them work in Industry 4.0, and between the 7 of them they work in diverse and different areas of the XR R&D field, see table 1 for a complete overview. (There are 11 areas listed in table 1 because four respondents listed more than one field of expertise.)

Table 1: Respondents of Round 1 describe their Field of Expertise (R1 Q48)

Respondents' Field of Expertise	Responses	
Industry 4.0	3	42,86%
3D Interaction	1	14,29%
Mitigate XR cybersickness	1	14,29%
Optics	1	14,29%
Personalized interaction	1	14,29%
Virtual Tours	1	14,29%
XR for business	1	14,29%
XR for training	1	14,29%

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XR user experience expert	1	14,29%
	11	157, 18%

The respondents are between 35 and 65 years old and 57% is between 45 and 55 years old. See table 2 for a complete overview of age-brackets and frequencies.

Table 2: Age of respondents of Round 1.

Answer choices	Responses	
Under 18	0	0,00%
18-24	0	0,00%
25-34	0	0,00%
35-44	2	28,57%
45-54	4	57,14%
55-64	1	14,29%
65-74	0	0,00%
75+	0	0,00%

Table 3: Respondents of Round 1 indicate the country in which they reside

Answer choices	Responses	
France	4	57,14%
Finland	1	14,28%
Portugal	1	14,28%
Spain	1	14,28%

5.3.2 CONSENSUS RESULTS FROM ROUND 1

The results from the Round 1 analysis can be summarized as follows (see table 4). Of the 43 statements, 14 statements were accepted 100%, that is all panel members agreed or strongly agreed with the statement. An additional 14 statements were accepted with 86% agreement, which means there was one panel member disagreeing with it and the agreement level is still above the 70% cut-off level. The statements from Round 1 are the input for Round 2. Round 1 statements are rewritten based on a reconciliation of the feedback that the panel members provided during Round 1. The updated statements are then presented to the panel for another round of feedback and rewriting, described in Round 2.

Table 4: Round 1 Survey Analysis of Statements, n=7.

Participants opinion about the statement	Total	Statement #
100% Agree	14 statements	5, 7, 9, 15, 16, 18, 21, 26, 31, 32, 33, 34, 37, 47
86% Agree (1 disagrees)	14 statements	6, 13, 14, 20, 22, 23, 25, 27, 29, 35, 38, 39, 43, 46
70% Agrees (2 disagree)	12 statements	10, 12, 17, 19, 24, 28, 30, 36, 41, 42, 44, 45

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56% Agrees (3 disagree)	2 statements	8, 40
43% Agrees (4 disagree)	1 statement	11
Total	43 statements	

In terms of the 4 themes the results are organized as follows: 1) XR Market (see table 5 for an overview), 2) XR Enabling Environment (see table 6 for an overview), 3) Human XR Capital (see table 7 for an overview), 4) XR Innovation Ecosystem (see table 8 for an overview):

5.3.2.1 XR MARKET

Statements regarding the position of Europe in the XR market and statements are related to building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL) priorities for European Commission (EC) strategies (Q5-14).

Table 5: Round 1 Survey Analysis of XR Market Statements, n=7.

Participants opinion about the statement	Total	Statement #
100% Agree	3 statements	5, 7, 9
86% Agree (1 disagrees)	3 statements	6, 13, 14
70% Agrees (2 disagree)	2 statements	10, 12
56% Agrees (3 disagree)	1 statement	8
43% Agrees (4 disagree)	1 statement	11
Total	10 statements	

5.3.2.2 XR ENABLING ENVIRONMENT

Statements regarding leadership at European level in terms of standards for XR R&D (Q 15-27).

Table 6: Round 1 Survey Analysis of XR Enabling Environment Statements, n=7.

Participants opinion about the statement	Total	Statement #
100% Agree	5 statements	15, 16, 18, 21, 26
86% Agree (1 disagrees)	4 statements	20, 22, 23, 25
70% Agrees (2 disagree)	3 statements	17, 19, 24
56% Agrees (3 disagree)	1 statement	27
43% Agrees (4 disagree)	0 statements	
Total	13 statements	

5.3.2.3 HUMAN XR CAPITAL

Statements regarding building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL) (Q 28-37).

Table 7: Round 1 Survey Analysis of Human XR Capital Statements, n=7.

Participants opinion about the statement	Total	Statement #
100% Agree	5 statements	31, 32, 33, 34, 37
86% Agree (1 disagrees)	3 statements	28, 29, 35
70% Agrees (2 disagree)	2 statements	30, 36

EUROXR DELPHI CONSENSUS ROUND 1

56% Agrees (3 disagree)	0 statements	
43% Agrees (4 disagree)	0 statements	
Total	10 statements	

5.3.2.4 XR INNOVATION ECOSYSTEM

Statements relating to the XR Development Platform: middleware / game-engine. (Q38-47).

Table 8: Round 1 Survey Analysis of XR Innovation Ecosystem Statements, n=7.

Participants opinion about the statement	Total	Statement #
100% Agree	1 statement	47
86% Agree (1 disagrees)	4 statements	38, 39, 43, 46
70% Agrees (2 disagree)	4 statements	41, 42, 44, 45
56% Agrees (3 disagree)	1 statement	40
43% Agrees (4 disagree)	0 statements	
Total	10 statements	

6. EUROXR DELPHI CONSENSUS ROUND 2

Round 2 of this Delphi is also the final round. During the final round of the Delphi the statements are weighted in terms of importance and urgency. A final effort to find consensus for the statements that were not fully agreed yet was sought and all statements were analysed in terms of their importance and urgency. In many statements the respondents already explicitly expressed urgency or priority or strong agreement in the statement, or it was added at the request of one or more of the panel members. In those cases where no explicit urgency, priority or importance was included in the statement yet, the panel members were asked about their opinions regarding the importance, or urgency, were requested four-point scale (strongly disagree, disagree, agree, strongly agree), or a three-point scale (not urgent, urgent, very urgent), and open answer boxes were also provided in order to capture any new ideas or disagreements.

6.1 ROUND 2 SURVEY DEVELOPMENT

The Round 2 survey was developed in the following way: All responses from the XR Panel members were analysed and all statements were rewritten according to their feedback. Statements that were rewritten by one or more XR Panel members were presented in their old a new version and the participants were asked which statement they preferred and to rewrite it in case the statement was still not in accordance with their opinion.

Statements that received 100% agreement in Round 1, in many cases received additional comments from the panel members were updated and grouped together and presented once more for a final round of feedback in Round 2. Finally, the number of and types of statements were counted and analysed to reduce any duplication or overlap as much as possible, to reduce the number of statements and the amount of time needed to respond to the survey, and to stay within acceptable time frame (about 45 minutes) for time on task, as required from the members of the XR Panel and in order to protect drop-out from happening as much as possible.

The final Round 2 survey consists of 46 statements. Additionally, there were 5 demographic questions, a consent question and a control question for Round 2. An overview of all questions of the Round 2 survey, including the instructions to the panel members can be found in Appendix .

6.2 ROUND 2 PARTICIPANTS

The participants in Round 2 should ideally be the same participants as for Round 1. In order to be able to refine the statements within the group to reach consensus, the participants must be the same in both rounds, rather than bringing in new participants and new opinions, because this would potentially create an ad-infinitum number of consensus seeking rounds needed to reach consensus. For this reason, the same respondents that replied to the Round 1 survey were invited to Round 2 and no one else. For this Delphi that means there was a dropout of 5 panel members after Round 1, and the Round 2 panel in the end consists of 7 members. There are occasions where not all panel members respond to a question or statement, so the total number of respondents in Round 2 is 6 in those cases. While this does have any consequences for our analysis and results, we discuss the implications for analysing the results and we will point out the difference where necessary.

6.3 ROUND 2 RESULTS

Seven experts responded to Round 2. The survey was open for more than 7 days and several reminders were sent out. It took respondents about 75 minutes on average to respond to the survey. The responses of one respondent were not complete, but the amount and quality of their responses was considered sufficient to keep their contribution in the sample. The percentage breakdown for 7 respondents is slightly different than for 6 respondents, see table 9. With 7 respondents the consensus cut-off point is at 70% with 2 disagreeing panel members, while with 6 respondents the consensus cut-off point is at 67%, with 2 disagreeing member, which brings a statement with 2 disagreeing members of the panel below the 70% threshold. This means effectively that the threshold for Round 2 was more stringent, however this did not cause any issues, see table x for the difference in percentages and how this affects the cut-off point for a sample of 7 and 6 respectively.

Table 9: The difference in percentages for a sample of 7 (n=7) and a sample of 6 (n=6).

Number of panel members	N = 7	N = 6
1 disagrees	86% Agree	83% Agree
2 disagree	70% Agrees	67% Agree
3 disagree	56% Agrees	50% Agree
4 disagree	43% Agrees	

6.3.1 ROUND 2 DEMOGRAPHICS

The respondents for Round 2 were the same seven experts as for Round 1. There were 2 weeks between Round 1 and Round 2 and no significant changes in the demographics of the panel members occurred during that time, in terms that would influence their expertise for the Delphi.

6.3.2 CONSENSUS RESULTS FROM ROUND 2

Round 2 closed with a total of 29 statements accepted by all panel members (100%). Thirteen statements still had 1 panel member disagreeing (83%), one statement really had the panel divided once again (Q28) and one statement ended up as potentially two separate statements (Q12). See table 10 for an overview of the results from Round 2.

Table 10: Round 2 survey analysis of degree of consensus of the statements.

Panel members' agreement with statement	Total	Statement #
100% Agree	29 statements	8, 9, 11, 13, 16, 17, 18, 19, 21, 23, 26, 27, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 44, 45, 46, 48, 49, 51
83% Agree (1 disagrees)	13 statements	6, 7, 14, 15, 20, 22, 24, 25, 34, 36, 42, 47, 50
67% Agree (2 disagree)	2 statements	12, 28
50% Agree (3 disagree)	0 statements	0
Total	44 statements	

The results are presented per theme, as described below. The following sections 1-4 describe all the statements for which 100%-70% consensus was reached on the Round 2 statements below: 1) XR Market (see table 11), 2) XR Enabling Environment (see table 12), 3) XR Human Capital (see table 13), and 4) XR Ecosystem (see table 14).

The final sets of statements are listed below and they are grouped according to the degree of consensus (100%, or 83%). The statements that did not reach consensus are listed at the end of each of the 4

themes they are part of, and analysed in terms of the issues that came to light due to the disagreements and feedback from the panel members.

6.3.2.1 XR MARKET

Statements regarding the position of Europe in the XR market and statements are related to building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL) priorities for European Commission (EC) strategies. See table 11 for an overview of the degree of consensus reached.

Table 11: Round 2 Survey Analysis of XR Market Statements.

Panel members' agreement with statement	Total	Statement #
100% Agree	5 statements	9, 11, 19, 31, 48
83% Agree (1 disagrees)	4 statements	6, 14, 15, 25
67% Agree (2 disagree)	0 statements	
50% Agree (3 disagree)	0 statements	
Total	9	

STATEMENTS WITH 100% AGREEMENT

Q9 The EC should focus on the potential market share in creating 3D asset libraries specific to Industry 4.0 use-cases for EU industries, to help speed up European XR development, because many European industry use-cases are early-adopters of high-precision manufacturing using XR Industry 4.0 solutions, and these Industry 4.0 use-case specific 3D assets are expected to become of interest world-wide.

Q11 The EC and XR developers can capture the European and global market by prioritizing research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data. Please feel free to add your comments or rewrite the statement to make it fully in line with your opinion.

Q19 The EC should facilitate the market uptake of XR applications for healthcare, by establishing more flexible rules for experimentations, and by creating a funding instrument dedicated to the certification process.

Q31 XR technologies are a strategic source of competitiveness for European industries, and their development must be strongly supported by the EC.

Q48 XR technologies are essential for the development and success of the European Alliance for Industrial Data and Clouds.

STATEMENT WITH 83% AGREEMENT

Q6 The EC should prioritize the development of a competitive, state-of-the-art open source XR research platform with a clear business model for monetizing contents.

Q14 It may or may not be too late for the EU to catch up on the global consumer XR input/output device manufacturing market, because there are many big companies producing consumer XR input/output devices, but Europe should explore this direction.

Q15 With several global companies interested in monetizing users' data, more research into General Data Protection Regulation (GDPR) is needed, specifically regarding protection and regulation of XR users' personal and psychophysiological data, and because the GDPR may not cover all legal aspects, additionally a complete classification of the psychophysiological data should be made, and this will be especially important for BCI solutions.

Q25 The EC should urgently support the development of a EU specific XR Development Asset store, with high quality shareware assets that are available for global and European developers under a sustainable non-profit business model, crowdsourced, no-cost or low-cost.

6.3.2.2 XR ENABLING ENVIRONMENT

Statements regarding leadership at European level in terms of standards for XR R&D. See table 12 for an overview of the degree of consensus reached.

Table 12: Round 2 Survey Analysis of XR Enabling Environment Statements.

Panel members' agreement with statement	Total	Statement #
100% Agree	7 statements	23, 35, 41, 44, 45, 46, 49
83% Agree (1 disagrees)	4 statements	7, 20, 24, 47
67% Agree (2 disagree)	1 statement	12
50% Agree (3 disagree)	0 statements	
Total	12	

STATEMENTS WITH 100% AGREEMENT

Q23 The EC should make available and subsidize easily accessible prototyping solutions, for R&D and end-user invention support in electronics and optics R&D and testing, including facilities such as publicly accessible design and manufacturing spaces and 3D printing equipment for rapid-prototyping of XR hardware designs by XR end-users, in order to foster diversity in the designs based on real end-user UX/UI XR experiences, and enabling an end-user driven evolution in input/output solutions, in a short cycle of human-centred design-implement-test-redesign.

Q35 The EC should support XR R&D for input/output devices that go well beyond the currently developed devices, for instance climate input/output devices (wind, rain, etc), olfactory IO devices (providing scents), hand tracking and use-case specific haptic devices, including standards for these new items.

Q41 The EC should make funds more accessible for facilitating innovation via new XR labs and independent developers, by increasing the success rate of proposals, and by providing active help and support with the application process.

Q44 The EC must urgently fund R&D and standardization work towards the cybersecurity of XR technologies, especially personal XR devices which are going to be part of the mobile phone.

Q45 The EC must finance projects dealing with legal issues in XR technologies.

Q46 The EC should orientate on how to prioritize, support and facilitate access to state-of-the-art XR technologies for the development of multi-user, remote collaboration XR solutions, as this involves multiple institutes collaborating, coordinating and doing (their part of) a R&D project together.

Q49 The EC should help improve continuation and reuse of outstanding R&D results, help share, and help increase visibility of European XR project results.

STATEMENT WITH 83% AGREEMENT

Q7 If the EC were to partner with existing commercial XR platform vendors and/or provide EU subsidized bulk-access to commercial XR platforms and assets, then this could create a strong bias in competition depending on the partnership format, however sharing standard APIs and providing more affordable access to commercial platforms may be beneficial.

Q20 The EC should promote the collection of rules of best practice concerning the licensing of intellectual property rights in the field of XR, covering in particular the amounts of the royalties, the criteria of exclusivity, and the periods of validity, and the EC should encourage coordinated, open access to code which has been developed under Horizon Europe projects.

Q24 The EC should create specific funding programs where strategic results (e.g., source code, 3D assets) will be made accessible for free to all certain third parties, e.g., European companies/research institutes, in order to extend the impact of EC funded progress and enter the market, using crowdsourced testing.

Q47 The EC should urgently promote standardization of 3D scene description format, and also for immersive audio, other XR content and devices.

SPLIT OPINIONS STATEMENT

Four XR Panel members preferred the new version of statement 12, however, two of them continued to prefer the initial version. One respondent did not reply.

Q12b New version: The EC should negotiate towards the standardization and open source access of commercial XR SDKs and encourage their adoption in Horizon Europe projects.

Q12a Old version: The EC should negotiate access to the source code of commercial XR SDKs for EU-based XR labs and developers.

6.3.2.3 HUMAN XR CAPITAL

Statements regarding building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL). See table 13 for an overview of the degree of consensus reached.

Table 13: Round 2 Survey Analysis of Human XR Capital Statements

Panel members' agreement with statement	Total	Statement #
100% Agree	7 statements	18, 32, 33, 37, 38, 39, 40,
83% Agree (1 disagrees)	3 statements	10, 22, 50
67% Agree (2 disagree)	0 statements	
50% Agree (3 disagree)	0 statements	
Total	10	

STATEMENTS WITH 100% AGREEMENT

Q18 The EC must finance R&D regarding the detection, measurement, correction and protection against discrimination of sexual, ethnic and economic minorities, in the use of XR technologies.

Q32 The EC should create more long-term EU projects to facilitate long-term fundamental research, long-term teamwork, skills exchange, and continuity of XR R&D skills development, especially in the areas that are very cutting-edge for XR technology breakthroughs.

Q33 The EC should promote, subsidise, and facilitate access to state-of-the-art XR equipment for end-users and the general public; it should also help raise awareness and understanding of the possibilities and potentials, and inspire potential startup ideas, in order to stimulate next generations to include XR technologies in their ideas and innovation proposals.

Q37 The EC should promote the creation of scientific councils in high-tech XR companies, and act to facilitate the participation of researchers in these bodies, for example by creating dedicated funding instruments.

Q38 The EC should develop specific support for the optimization of academic-industry collaboration for XR R&D projects, because the type of knowledge exchange needed for XR development may affect the success of the collaboration in unknown ways, and improvements could be made in terms of better management of XR researchers' creative capacity, adjustments to the incentives structure, senior management support and strong leadership focused on rapid XR R&D skills development, and more recognition of skills achieved.

Q39 The EC should widely disseminate and promote H2020 and Horizon Europe research of best practices for successful XR knowledge-transfer cycles within academic-industry collaborations and focus on how to maximize capacity to absorb the new XR skills and XR project output, and integrate the new XR technology solutions into the value chain.

Q40 The EC should focus more on helping to allocate XR competencies, support mobility of XR experts for international skills exchange, and training of developers at labs and companies for all XR stakeholders, including virtual (pandemic solutions) and real networking events.

STATEMENT WITH 83% AGREEMENT

Q10 The EC should focus more on preventing the widening of the digital divide by being more inclusive of countries with a low TRL, and by coordinating the allocation of XR human capital and XR development resources.

Q22 The EC should prioritize, organize, and subsidise XR developers training and affordable train-the-trainer educational events at all educational levels, to address the current and imminent shortage in skilled XR developers and instructors.

Q50 XR solutions will help reduce the time-intensive requirements of building physical prototypes dramatically, bringing ideas and innovations to life and products to market far more quickly, although there is still much improvement needed of the XR development pipeline, the learning curve and time needed and the number of experts available.

6.3.2.4 XR INNOVATION ECOSYSTEM

Statements relating to the XR Development Platform: middleware / game-engine. See table 14 for an overview of the degree of consensus reached.

Table 14: Round 2 Survey Analysis of XR Innovation System Statements.

Panel members' agreement with statement	Total	Statement #
100% Agree	7 statements	8, 13, 16, 17, 21, 26, 27,
83% Agree (1 disagrees)	3 statements	34, 36, 42
67% Agree (2 disagree)	1 statement	28
50% Agree (3 disagree)	0 statements	
Total	11	

STATEMENTS WITH 100% AGREEMENT

Q8 The EC needs to urgently improve the support for European XR R&D scaling up of its innovators and SMEs and reduce the currently existing notable scaling-up gap for XR tech scaleups and unicorn companies, in relation to the United States and China. All respondents agreed that this was urgent.

Q13 The EC needs to focus the R&D in XR technology in order to establish strategic European leadership and competitiveness in the global XR R&D sector: in terms of hardware, the focus should be on human factors, interaction paradigms, ergonomics, customization, form factor, technology vs size, weight, and power consumption, and in terms of software, the focus should be on applications and SW platforms built on top of de facto market standards (IOS, Android).

Q16 The EC should give more support to individual European XR startups directly, in order to bring them into the XR eco-system and help with commercialization of ideas, help with market-entry, and generally make seed money for XR startups more easily accessible.

Q17 It is important that the EC fund projects that investigate methods to establish anonymity when using XR technologies, but it should also fund projects to achieve strong identification and authentication in a secure manner in cases where applications need it.

Q21 The EC should foster research into how to make XR technologies and designs more accessible to all diverse user groups, exploring how to include more than the currently targeted market-segment (male, educated, English speaking consumers), making sure that communication is unbiased and checking contents for localization, and using AI to automate adaptations where possible.

Q26 The EC should urgently understand/create/adopt worldwide standards and support solutions for low cost, reusable, interoperability solutions for integrations of domain specific data such as BIM, scientific simulations, etc., and these solutions should best practices in industrial R&D projects, be independent from the current mainstream XR software companies, and make it as efficient as possible to plug into the currently most used interactive XR platforms.

Q27 In order to capture a market share, the EC needs to urgently support R&D to expand and improve the XR development pipeline in terms of asset types, complexity of data and ontologies, and to improve interoperability between the different asset formats used in different industries.

STATEMENT WITH 83% AGREEMENT

Q34 XR technologies have the potential to provide a strong and adequate response to the problem of carbon emissions, by making remote work and interactions between people more efficient, thus reducing the need for personal or professional travel and developments for solutions into this direction should be prioritized, especially as a response to pandemic related travel restrictions and precautions.

Q36 The EC should urgently promote the development of WebXR technologies.

Q42 To strengthen European leadership and competitiveness, more research is urgently needed towards the development and exploitation of B2B applications using XR, more open data-bases, and more business for the XR field in general. This statement received 100% agreement and additional suggestions have been included.

RECONCILIATED STATEMENT

The original statement: R2 Q28, R1Q46: The EC should engage and provide full support to startups, SMEs, scale-ups and manufacturers of XR components, such as Zeiss, Bang & Olufsen, STMicroelectronics, etc., in order to spur the development of XR devices, since breakthrough innovations generally come out of startups and combinations of parts and components from diverse manufacturers. Final reconciliation statement:

Q28 The EC should engage and provide full support to startups, SMEs, scale-ups and manufacturers of XR components, such as Zeiss, Bang & Olufsen, STMicroelectronics, etc., in order to spur the development of XR devices, since breakthrough innovations generally come out of startups and combinations of parts and components from diverse manufacturers, while those components are

expensive, using market calls for R&D and XR startups, so that market-driven companies and solutions will grow and create breakthrough innovations.

TIMELINE STATEMENTS

A number of questions asked the respondents to project what the state of XR would be like in the future at various points: Current (2021), quarter-way towards reducing CO2 emissions by 50% (2023), the year we need to achieve 50% reduction in CO2 emissions (2025), the year we need to achieve 100% CO2 reductions (2030). See table 15 for a summary of the answers of the respondents.

Table 15: Round 2 Survey Analysis of XR Innovation System Statements.

<p>2021</p>	<ol style="list-style-type: none"> 1. <i>Remove the following barriers to XR prototyping:</i> <ol style="list-style-type: none"> a) <i>Development of competencies in XR necessary.</i> b) <i>More research into making collaborative virtual environments usable.</i> c) <i>Standardization in the use of XR needed: virtual menus, functional buttons in devices such as joysticks, interaction with devices, etc.</i> d) <i>Access to public and private immersive labs and equipment at large scale needed.</i> e) <i>Interoperability improvements.</i> f) <i>Full replacement of the current engineering pipeline needed.</i> 2. <i>Inclusiveness of XR technologies and how XR could improve life quality,</i> 3. <i>Develop XR devices with European standards,</i> 4. <i>Increase IA in the develop of new applications,</i> 5. <i>Support data communications platforms (data centers, satellites, and fiber) to transport information with security survey and best transportation of data,</i> 6. <i>Research in HCI and Human Factors topics which require working with users, which has been banned for more than one year,</i> 7. <i>Field Services as massive adoption and training to enhance even more the use of XR,</i> 8. <i>Industrial applications and training,</i> 9. <i>Tele-existence, Remote collaboration.</i>
<p>2023</p>	<p>Huge investment needed from EC and nationally for XR R&D and manufacturing of:</p> <ol style="list-style-type: none"> 1. <i>HMD display hardware solutions, without cables, stand-alone (wifi to cloud).</i> 2. <i>XR-UI gesture-driven and specific use-cases for BCI-driven solutions for fully inclusive Accessibility.</i> 3. <i>Shared, accessible API - Open source XR development platform,</i>

	<ol style="list-style-type: none"> 4. <i>Cheap and easy access to XR development tools (and training?),</i> 5. <i>Continuous transfer of deployable apps from project demonstrators.</i> 6. <i>Integration of XR with CS, Human-Computer Interaction, Maths, Psycho-neuroscience, and Social Science.</i> 7. <i>Automatic content creation for XR solutions combinations of AI and IoT for support of the XR developer's work of professional applications.</i> 8. <i>XR content for interactive movies and remote presence and interactions,</i> 9. <i>Non-intrusive UI solutions, Multi-sensory UI solutions, gesture-based solutions, ultra-realistic haptic bodysuit,</i> 10. <i>XR data computed in the cloud.</i> 11. <i>Earth-wide system with XR HMDs tracked for collaboration between systems.</i> 12. <i>Increase our knowledge of Human Factors issues of XR, integrations of XR with HCI best practices.</i>
2025	<ol style="list-style-type: none"> 1. Finding solutions for hardware challenges posed by ubiquitous XR for head mounted displays (XR-HMDs) is prioritized. 2. XR and AI integrations need to take place by developing a deep link between XR, AI, ML, CS, Human-Computer Interaction, Math, Psycho-Neuroscience, and Social Science, and by resolving the ethical issues. Using AI to: <ol style="list-style-type: none"> a) <i>Automate decisions, while promoting user centered decision-making, completing the XR experience by simplifying selected tasks,</i> b) <i>Improve the formfactor and usability of the XR devices and support correct modelling,</i> c) <i>Speed up content creation via non-intrusive UI solutions, including automatic BCI-XR content creation,</i> d) <i>Highly usable, safe professional use cases, interactive movies and remote presence apps (tourism, etc.),</i> <ol style="list-style-type: none"> e) <i>Integrated academic-industry commercialization of XR research and development results.</i> 3. <i>Technology breakthroughs are needed for:</i> <ol style="list-style-type: none"> a) <i>Hardware solutions for XR head mounted displays (XR-HMDs),</i> b) <i>Multi-sensory devices, that simplify body tracking, non-intrusive devices that collect UI, information less intrusive and less cumbersome to use than ultra-realistic haptic bodysuit UI solutions,</i> c) <i>XR content creation via experimental BCI and novel HCI solutions,</i> d) <i>XR-UI via experimental BCI and novel HCI solutions.</i>
2030	<ol style="list-style-type: none"> 1. <i>XR and AI will be combined to create an intelligent, human-centered, harmonious, experience and tool for humans</i> 2. <i>The essential public debate around personalization and privacy concerns is better understood; good efforts to clarify the advantages to the user, solutions of user-centric opt-in/out of personal data-collection is available at various levels and is generally accepted.</i>

3. *XR apps will be deployed on smartphones much more than today, seamlessly integrated with sophisticated (physiological) sensors and other electronic devices, enabling new communication solutions for work and social life.*
4. *Personal XR devices that will be fully connected to our smartphones and complement the use of it.*
5. *Developments are underway for devices that replace the smartphone, that will be even more ubiquitous in use than smartphones, for work and social life as they are less intrusive, and more comfortable and lightweight, dedicated to specialized applications.*
6. *Multi-sensory XR (haptics, sound, smell, and taste) with automatic body and gesture tracking by cameras will be developed.*
7. *Multi-sensory, haptic body suits, with high-resolution, automatically created avatars adapted to the anthropomorphic parameters of the user.*
8. *The user interface will be predominantly driven by markerless, camera-based tracking of gestures, body, and eyes. This will utilize cameras that are either integrated directly in the headsets or distributed throughout rooms or workspaces to allow for larger and more precise tracking.*
9. *Developments are rapidly advancing for thought-driven UIs (brain-computer interfaces).*
10. *EU-wide regulations protecting privacy, minorities, and ethics with regards to XR as a whole and brain-computer interfaces, are in place.*
11. *Business models to deploy XR in various application areas have been proven successfully, many more business models are emerging, and further systematic efforts to establish business models in more application areas are underway.*
12. *XR apps for professional use will be widely available and widely in use. Manufacturing industries (the forerunners) continue to use all types of XR and have XR integrated well into their development workflows. Other sectors, e.g., health and medicine, inspection & maintenance, autonomous & remote driving, and many more have adopted XR.*
13. *Tele-presence and virtual collaboration in common virtual spaces is being taken up by many industries.*
14. *Tele-medicine (for general physicians) and tele-consultation (in the operating room) will be feasible and accepted by both professionals and citizens.*
15. *XR movies have matured but will remain a niche market.*
16. *Videogames, home remodelling using VR/AR, and 1st person XR visits to remote places (virtual tourism) are dominating the consumer market.*

7. EUROXR DELPHI RESULTS RANKED BY URGENCY AND IMPORTANCE

The statements that received from 100% to 83% agreement, are ranked based on the importance/urgency attached to the solutions expressed in the statement by the panel members in descending order. To visualize their collective opinions of importance/urgency on the statements the scores placed in coloured columns in the tables:

- Column A: very important / strongly agree / very urgent
- Column B: important / agree / urgent
- Column C: necessary
-

For this analysis “Importance” and “Urgency” or “Priority” is expressed by the XR Panel members in the statements they formulated (depending on the question/statement format the importance is either expressed as strong agreement, urgency, or priority, either indicated in the Likert-scale after the statements in the survey, and/or as worded in the statement itself). The statements are ranked according to the sentiment of how strongly the participants were in agreement, and how many of the participants agreed with a statement. The statements were composed to be as clear as possible. Some statements are covering complex issues, and some statements are complex in wording, which would be suitable for the next stage of in-depth roadmapping in several focus group settings, with domain experts and stakeholders from the different disciplines and application areas.

7.1 XR MARKET

Statements regarding the position of Europe in the XR market and statements are related to building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL) priorities for European Commission (EC) strategies. See table 16 for an overview of the degree of consensus reached and table 17 for the resulting statements for which consensus was reached.

Table 16: Round 2 Survey Results of XR Market Statements.

Panel members' agreement with statement	Total	Statement #
100% Agree	5 statements	9, 11, 19, 31, 48
83% Agree (1 disagrees)	4 statements	6, 14, 15, 25

EUROXR DELPHI RESULTS RANKED BY URGENCY AND IMPORTANCE

67% Agree (2 disagree)	0 statements	
50% Agree (3 disagree)	0 statements	
Total	9	

Table 17: Statements on XR Market

XR Market Statements	A	B	C
MC1 XR technologies are a strategic source of competitiveness, and their development must be strongly supported. (R2 Q31)	7		
MC2 Focus on the potential market share in creating 3D asset libraries specific to Industry 4.0 use-cases, to help speed up XR development, because many industry use-cases are early-adopters of high-precision manufacturing using XR Industry 4.0 solutions, and the Industry 4.0 use-case specific 3D assets are expected to become of interest world-wide. (R2 Q9)	5	1	
MC3 Urgently support the development of industry specific XR Development Asset stores, with high quality shareware assets that are available for developers under a sustainable non-profit business model, crowdsourced, no-cost or low-cost. (R2 Q25)	5	1	
MC4 It may or may not be too late for newcomers to catch up on the global consumer XR input/output device manufacturing market, because there are many big companies producing consumer XR input/output devices, but stakeholders should explore this direction. (R2 Q14)	3	2	1
MC5 XR developers and stakeholders can capture the market by prioritizing research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data. (R2 Q11)	2	4	
MC6 With several global companies interested in monetizing users' data, more research into General Data Protection Regulation (GDPR) is needed, specifically regarding protection and regulation of XR users' personal and psychophysiological data, and because the GDPR may not cover all legal aspects, additionally a complete classification of the psychophysiological data should be made, and this will be especially important for BCI solutions. (R2 Q15)	2	3	1

MC7 XR technologies are essential for the development and success of Industrial Data and Clouds. (Q48)	7	
MC8 Facilitate the market uptake of XR applications for healthcare, by establishing more flexible rules for experimentations, and by creating a funding instrument dedicated to the certification process. (R2 Q19)	6	

Clearly, XR has proven to be one of the Key Enabling Technologies (see statements MC1, MC7, MC8); it has done so in the manufacturing industries for decades, and is now entering many new sectors, due to its consumer-grade availability. Consequently, all experts unanimously and strongly think that XR is of strategic importance to the European Union. It is now important for many areas of industry, business, health, science, environment, and many more.

With respect to spurring “supporting” markets and technologies (see statements MC2, MC3, MC4), such as input/output devices and 3D assets, the somewhat mixed responses of the experts suggests that the EU should decide whether to invest heavily in those, if European businesses and companies are to catch up with global developments, otherwise this might be sunken efforts, since the global developments are extremely fast-paced and dynamic in this area.

XR offers serious potentials for multinational companies to intrude on people’s privacy, monetization of user data, and could, potentially, cause serious issues with respect to society as a whole (see statements MC8, MC6). Therefore, the experts feel that regulating the applications of XR is an important task for the EU.

7.2 XR ENABLING ENVIRONMENT

Statements regarding leadership at European level in terms of standards and regulations for XR R&D. See table 18 for an overview of the degree of consensus reached, and table 19 for an overview of the statements and their respective priorities.

EUROXR DELPHI RESULTS RANKED BY URGENCY AND IMPORTANCE

Table 18: Round 2 Survey Results of XR Enabling Environment Statements.

Panel members' agreement with statement	Total	Statement R2 Q#
100% Agree	7 statements	23, 35, 41, 44, 45, 46, 49
83% Agree (1 disagrees)	4 statements	7, 20, 24, 47
67% Agree (2 disagree)	1 statement	12
50% Agree (3 disagree)	0 statements	
Total	12	

Table 19: Statements on XR Enabling Environment

XR Enabling Environment Statements	A	B	C
EE1 Urgently fund R&D and standardization work towards the cybersecurity of XR technologies, especially personal XR devices which are going to be part of the mobile phone. (R2 Q44)	7		
EE2 Make available and subsidize easily accessible prototyping solutions, for R&D and end-user invention support in electronics and optics R&D and testing, including facilities such as publicly accessible design and manufacturing spaces and 3D printing equipment for rapid-prototyping of XR hardware designs by XR end-users, in order to foster diversity in the designs based on real end-user UXUI XR experiences, and enabling an end-user driven evolution in input/output solutions, in a short cycle of human-centred design-implement-test-redesign. (R2 Q 23).	3	2	1
EE3 Support XR R&D for input/output devices that go well beyond the currently developed devices, for instance climate input/output devices (wind, rain, etc), olfactory IO devices (providing scents), hand tracking and use-case specific haptic devices, including standards for these new items. (R2 Q35)		7	

EUROXR DELPHI RESULTS RANKED BY URGENCY AND IMPORTANCE

<p>EE4 Make funds more accessible for facilitating innovation via new XR labs and independent developers, by increasing the success rate of proposals, and by providing active help and support with the application process. (R2 Q41)</p>	7		
<p>EE5 Orientate on how to prioritize, support and facilitate access to state-of-the-art XR technologies for the development of multi-user, remote collaboration XR solutions, as this involves multiple institutes collaborating, coordinating and doing (their part of) a R&D project together. (R2 Q46)</p>	3	3	1
<p>EE6 Promote the collection of rules of best practice concerning the licensing of intellectual property rights in the field of XR, covering in particular the amounts of the royalties, the criteria of exclusivity, and the periods of validity, and encourage coordinated, open access to code which has been developed with public funding. (R2 Q20)</p>	3	2	1
<p>EE7 Create specific funding programs where strategic results (e.g., source code, 3D assets) will be made accessible for free to certain third parties, e.g., SMEs/research institutes, to extend the impact of government funded progress and enter the market, using crowdsourced testing. (R2 Q24)</p>	3	2	1
<p>EE8 The EC should make available and subsidize easily accessible prototyping solutions, for R&D and end-user invention support in electronics and optics R&D and testing, including facilities such as publicly accessible design and manufacturing spaces and 3D printing equipment for rapid-prototyping of XR hardware designs by XR end-users, in order to foster diversity in the designs based on real end-user UX/UI XR experiences, and enabling an end-user driven evolution in input/output solutions, in a short cycle of human-centred design-implement-test-redesign. (R2 Q23)</p>	3	2	1
<p>EE9 If the government were to partner with existing commercial XR platform vendors and/or provide subsidized bulk-access to commercial XR platforms and assets, then this could create a strong bias in competition depending on the partnership format, however sharing standard APIs and providing more affordable access to commercial platforms may be beneficial. (R2 Q7)</p>	2	3	1
<p>EE10 Focus more on preventing the widening of the digital divide by being more inclusive of countries with a low TRL, and by coordinating the allocation of XR human capital and XR development resources, in a strategic manner that strengthens leadership and competitiveness in the global XR R&D sector. (R2 Q10)</p>	2	3	1

EUROXR DELPHI RESULTS RANKED BY URGENCY AND IMPORTANCE

EE11 Promote standardization of 3D scene description format, and also for immersive audio, other XR content and devices. (R2 Q47)	1	6	
EE12 Finance projects dealing with legal issues in XR technologies. (R2 Q45)		7	
EE13 Help improve continuation and reuse of outstanding R&D results, help share, and help increase visibility of XR project results. (R2 Q49)		7	
EE14 Negotiate towards the standardization and open source access of commercial XR SDKs and encourage their adoption in Horizon Europe projects. (R2 Q12b)		4	2

Research and innovation give us the tools to shape our future and the reality in which we want to live. This notion is reflected in the unanimous agreement of the Delphi panel members that looking towards the envisioned usage scenarios of XR towards 2030, standards and regulations regarding cybersecurity, are of the utmost importance and fall directly in the realm of the European Commission (see statements EE1, EE5). Lacking such regulations, uptake, and proliferation of XR as an enabling technology could be seriously hindered.

There is also a strong opinion among the experts that investing in radically novel devices and input/output modalities could put the EU ahead of the curve (see statement EE3). Of course, such efforts have to be accompanied by researching the respective fundamental principles and algorithms, such as human factors, interaction paradigms, physically-based interaction, size, weight, and power consumption.

Another important aspect is the funding process itself: all experts are of the opinion that the Horizon Europe funding processes need to be streamlined, simplified, and – above all – the success rates need to be improved. Otherwise, only research labs and SMEs with a wealth of resources for proposal writing at their disposal will have access to the EU's funding.

7.3 HUMAN XR CAPITAL

Statements regarding building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL). See table 21 for an overview of the degree of consensus reached, and table 22 for an overview of the statements.

Table 21: Round 2 Survey Analysis of Human XR Capital Statements

Panel members' agreement with statement	Total	Statement R2 Q#
100% Agree	7 statements	18, 32, 33, 37, 38, 39, 40
83% Agree (1 disagrees)	3 statements	10, 22, 50
67% Agree (2 disagree)	0 statements	
50% Agree (3 disagree)	0 statements	
Total	10	

Table 22: Statements on Human XR Capital

Human XR Capital Statements	A	B	C
HR1 Create more long-term XR R&D projects to facilitate long-term fundamental research, long-term teamwork, skills exchange, and continuity of XR R&D skills development, especially in the areas that are very cutting-edge for XR technology breakthroughs. (R2 Q32)		7	
HR2 Promote, subsidise, and facilitate access to state-of-the-art XR equipment for end-users and the general public; it should also help raise awareness and understanding of the possibilities and potentials, and inspire potential start up ideas, in order to stimulate next generations to include XR technologies in their ideas and innovation proposals. (R2 Q33)		7	

EUROXR DELPHI RESULTS RANKED BY URGENCY AND IMPORTANCE

<p>HR3 Promote the creation of scientific councils in high-tech XR companies, and act to facilitate the participation of researchers in these bodies, for example by creating dedicated funding instruments. (R2 Q37)</p>	7	
<p>HR4 Develop specific support for the optimization of academic-industry collaboration for XR R&D projects, because the type of knowledge exchange needed for XR development may affect the success of the collaboration in unknown ways, and improvements could be made in terms of better management of XR researchers' creative capacity, adjustments to the incentives structure, senior management support and strong leadership focused on rapid XR R&D skills development, and more recognition of skills achieved. (R2 Q38)</p>	7	
<p>HR5 Widely disseminate and promote XR R&D research of best practices for successful XR knowledge-transfer cycles within academic-industry collaborations and focus on how to maximize capacity to absorb the new XR skills and XR project output and integrate the new XR technology solutions into the value chain. (R2 Q39)</p>	7	
<p>HR6 Focus more on helping to allocate XR competencies, support mobility of XR experts for international skills exchange, and training of developers at labs and companies for all XR stakeholders, including virtual (pandemic solutions) and real networking events. (R2 Q40)</p>	7	
<p>HR7 XR solutions will help reduce the time-intensive requirements of building physical prototypes dramatically, bringing ideas and innovations to life and products to market far more quickly, although there is still much improvement needed of the XR development pipeline, the learning curve and time needed and the number of experts available. (R2 Q50)</p>	7	
<p>HR8 Finance R&D regarding the detection, measurement, correction, and protection against discrimination of sexual, ethnic and economic minorities, in the use of XR technologies. (R2 Q18)</p>	6	
<p>HR9 Prioritize, organize, and subsidise XR developers training and affordable train-the-trainer educational events at all educational levels, to address the current and imminent shortage in skilled XR developers and instructors. (R2 Q22)</p>	2	4

People, their minds, their expertise and knowledge, their skillsets, are clearly the most important factor when research, development, and innovation are to be advanced. This is why the XR expert panel states that investment in research and skills (see statements HR1, HR2, HR6, transfer of knowledge and skills (see statements HR3, HR4, HR5 are very strongly and unanimously recommended by the XR experts to the European Commission. Important ideas here are long-term funding of fundamental research, novel instruments to facilitate smooth flow of information between companies and academia (see statement HR4 and fostering public understanding of XR technologies.

7.4 XR INNOVATION ECOSYSTEM

Statements relating to the XR Development Platform: middleware / game-engine. See table 23 for an overview of the degree of consensus reached, and table 24 for an overview of the statements.

Table 23: Round 2 Survey Results of XR Innovation System Statements.

Panel members' agreement with statement	Total	Statement R2 Q#
100% Agree	7 statements	8, 13, 16, 17, 21, 26, 27
83% Agree (1 disagrees)	3 statements	34, 36, 42
67% Agree (2 disagree)	1 statement	28
50% Agree (3 disagree)	0 statements	
Total	11	

Table 24: Statements on XR Innovation Ecosystem

XR Innovation Ecosystem Statements	A	B	C
IE1 Urgently promote the development of WebXR technologies. (R2 Q36)	7		
IE2 To strengthen leadership and competitiveness, more research is urgently needed towards the development and exploitation of B2B applications using XR, more open data-bases, and more business for the XR field in general. (R2 Q42)	7		
IE3 Urgently understand/create/adopt worldwide standards and support solutions for low cost, reusable, interoperability solutions for integrations of domain specific data such as BIM, scientific simulations, etc., and these solutions should be best practices in industrial R&D projects, be independent from the current mainstream XR software companies, and make it as efficient as possible to plug into the currently most used interactive XR platforms. (R2 Q26)	5	1	
IE4 Foster research into how to make XR technologies and designs more accessible to all diverse user groups, exploring how to include more than the currently targeted market-segment (male, educated, English speaking consumers), making sure that communication is unbiased and checking contents for localization, and using AI to automate adaptations where possible. (R2 Q21)	4	2	
IE5 Engage and provide full support to startups, SMEs, scale-ups and manufacturers of XR components, such as Zeiss, Bang & Olufsen, STMicroelectronics, etc., in order to spur on the development of XR devices, since breakthrough innovations generally come out of startups and combinations of parts and components from diverse manufacturers (while those components are expensive), and use market calls for R&D and XR startups, so that market-driven companies and solutions will grow and create breakthrough innovations. (R2 Q28)	4		2
IE6 Urgently support R&D to expand and improve the XR development pipeline in terms of asset types, complexity of data and ontologies, and to improve interoperability between the different asset formats used in different industries. (R2 Q27)	3	3	
IE7 Urgently improve the support for XR R&D scaling up of its innovators and SMEs and reduce the currently existing notable scaling-up gap for XR tech scaleups and unicorn companies (European governments so far offer less in comparison to the United States and China). (R2 Q8)	2	4	

EUROXR DELPHI RESULTS RANKED BY URGENCY AND IMPORTANCE

<p>IE8 Give more support to individual XR startups directly, to bring them into the XR eco-system and help with commercialization of ideas, help with market-entry, and generally make seed money for XR startups more easily accessible. (R2 Q16)</p>	2	4	
<p>IE9 It is important to fund projects that investigate methods to establish anonymity when using XR technologies, but it should also fund projects to achieve strong identification and authentication in a secure manner in cases where applications need it. (R2 Q17)</p>	2	4	
<p>IE10 XR technologies have the potential to provide a strong and adequate response to the problem of carbon emissions, by making remote work and interactions between people more efficient, thus reducing the need for personal or professional travel and developments for solutions into this direction should be prioritized, especially as a response to pandemic related travel restrictions and precautions. (R2 Q34)</p>		7	
<p>IE11 Focus the R&D in XR technology in order to establish strategic leadership and competitiveness in the global XR R&D sector: in terms of hardware, the focus should be on human factors, interaction paradigms, ergonomics, customization, form factor, technology vs size, weight, and power consumption, and in terms of software, the focus should be on applications and SW platforms built on top of de facto market standards (IOS, Android). (R2 Q13)</p>		6	

Since the world will become more and more digitally connected, a big theme in this category is the interplay between XR and the internet/WWW (see statements IE1, IE2, IE3, IE6). This is relevant both for academia as well as industry; and funding by the EC should focus on XR standards, data pipelines, cloud storage and edge computing for XR, seamless and fluid switching of devices, settings, and environments.

Additionally, since the EU is a diverse, multi-cultural, and multi-economic union of nations, it is important to expand funding on levelling the playing field both for diverse groups of population as well as for diverse nations with highly different economies, and there is a huge difference in market power between the international, global players (such as Google and Facebook) and aspiring start-ups and scale-ups (think David v. Goliath). The EC should urgently help SMEs by simplifying the funding schemes, helping with commercialization efforts.

8. DISCUSSION

Round 1 and Round 2 collected consensus towards statements regarding the directions for R&D in the XR field. During Round 1, seven respondents unanimously accepted 14 statements, while 13 statements had two panel members who disagreed, and 16 statements had 2 or more panel members disagreeing. During Round 2, 28 statements were accepted unanimously, 13 statements had one panel member disagreeing, and two statements had two panel members disagreeing. See table 9 for a side-by-side overview of the degree of consensus reached per round.

We first discuss the statements for which reaching agreement was a complex or unfinished process and we highlight the implications of the disagreement regarding the topics that the statements are referring to. After that we analyse the statements based on three overarching themes: Speed up XR R&D, Support XR Research to Market, and Standardization, and we revisit the statements that reached 100% consensus to discuss the priorities and urgencies based on the rankings that the panel members provided in terms of implications, urgency and importance. The discussion section ends with an overview of the role which XR can play in creating solutions for the 17 SDGs.

Table 24: Round 1 and Round 2 analysis of the degree of consensus achieved per round.

Panel members' agreement with statement	Round 1	Round 2
100% Agree	14 statements	29 statements
86% (n=7) 83% (n=6) Agree (1 disagrees)	13 statements	13 statements
70% (n=7) 67% (n=6) Agree (2 disagree)	13 statements	2 statements
67% (n=7) 50% Agree (3 disagree)	2 statements	0 statements
33% Agree (4 disagree)	1 statement	0 statements
Totals	43	44

8.1 STATEMENTS THAT DID NOT REACH CONSENSUS

There is one statement (R2Q6) where it seems it should actually be two separate statements, according to the panel members. There are two statements that did not reach consensus at the end of Round 2 and we revisit them below for that reason. There was one statement (R2Q12) that continued to split the panel in two camps. One statement (R2Q28) continued to have more than one panel member disagreeing. These statements are presented and discussed below.

8.1.1 NEW STATEMENTS IDENTIFIED BY THE XR PANEL

R2Q6: The EC should prioritize the development of a competitive, state-of-the-art open source XR research platform with a clear business model for monetizing content.

According to the experts of the panel, a strong commitment of the European Commission is needed to develop open software platforms for XR. This would have at least two benefits: first of all, software platforms provide de facto standards (which have proven highly successful in the past, e.g., OpenGL); second, for European developers, it would reduce the dependency on commercial US software platform providers. In the XR domain, the window of opportunity to do so is not closed yet. With appropriate investments, existing European software platforms (several promising candidates do exist) could be developed further and turned into attractive alternatives within the next 3-5 years. After that, it will probably be difficult to compete with existing commercial platforms (e.g., Unreal and Unity), because there will be too many products and applications based on those, and they will be extremely advanced, so that those will be the de facto standards.

The experts also called for standards in several comments. Open specifications on all layers of XR software (e.g. OpenXR) developed by international bodies, such as those by the Khronos group, should be promoted for adoption throughout Europe. In fact, the EC should invest in experts who are willing and proficient to contribute to the standardization work done by the Khronos group, since it is the only international body that works on open standards in the area of XR. This would enhance the influence Europe has on those standards.

DISCUSSION

8.1.2 RECONCILED STATEMENT

Based on the experts' feedback in the study, we were able to reconcile one statement with regards to start-ups, scale-ups, and SME's (R2 Q28, R1 Q46):

The EC should do both: invest in development of novel XR devices (and XR parts and platforms) as well as in market-driven developments by providing full support to start-ups, scale-ups, and SMEs, so that market-driven companies and solutions will grow and create breakthrough innovations.

There are a large number of existing SME's that are working in areas relevant to XR technology. But the existing funding programs do not seem to help those companies enter the XR market, which is a high-risk and highly dynamic market. This results in lost opportunities, since novel XR technologies often arise from combining and adapting existing, relatively new technologies, such as new display technologies, new optical methods, new electronic devices, new communication technologies, etc.

Similarly, start-ups and scale-ups often lack the financial stamina to enter and grow in the highly dynamic XR market.

8.1.3 SPLIT OPINIONS STATEMENT

One statement, regarding the open access to the source code of commercial XR SDKs, could not be consolidated so as to reach consensus. This is probably mostly due to the short time period over which this study was conducted (R2Q12).

Overall, there seem to be important use cases (in academia and in businesses), where open access is important for the successful completion of the developments, and for the long-term maintenance of the software. So, legal frameworks, developed by the EC in collaboration with commercial (foreign) software platform vendors, would be helpful to facilitate such open access.

8.2 ADDITIONAL THEMES IDENTIFIED FROM THE 100% CONSENSUAL STATEMENTS

The statements that received 100% agreement were reanalysed and regrouped according to their commonalities into the following overarching themes:

8.2.1. Speed up XR Development

8.2.2. Support XR Research to Market

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8.2.3. XR Standardization Issues

8.2.4. XR Business Issues

8.2.5. XR and the 17 Sustainable Development Goals

8.2.6. XR Collaboration and Knowledge Exchange

In the tables below (using the same numbering and titles as listed in the overview above), the statements are listed again, now grouped in each of the overarching themes, and we discuss the statements, and the priorities and urgencies that the panel members identified in the sections below.

8.2.1 STATEMENTS ON SPEEDING UP XR DEVELOPMENT

In terms of speeding up XR development, the XR Panel prioritized establishing a XR market share and various suggestions were made. Additionally, the statements cover the need for skills development, access to complex XR configurations for R&D, awareness raising of the possibilities of the new technologies, see table 25.

Table 25: Statements on speeding up XR development.

Speed up XR Development Statements	A	B	C
SU1 <i>Promote, subsidise, and facilitate access to state-of-the-art XR equipment for end-users and the general public; it should also help raise awareness and understanding of the possibilities and potentials, and inspire potential start up ideas, in order to stimulate next generations to include XR technologies in their ideas and innovation proposals. (R2Q33)</i>	7		
SU2 <i>Support XR R&D for input/output devices that go well beyond the currently developed devices, for instance climate input/output devices (wind, rain, etc), olfactory IO devices (providing scents), hand tracking and use-case specific haptic devices, including standards for these new items. (R2Q35)</i>	7		

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SU3 Focus more on helping to allocate XR competencies, support mobility of XR experts for international skills exchange, and training of developers at labs and companies for all XR stakeholders, including virtual (pandemic solutions) and real networking events. R2Q40	7		
SU4 Make funds more accessible for facilitating innovation via new XR labs and independent developers, by increasing the success rate of proposals, and by providing active help and support with the application process. R2Q41	7		
SU5 Create more long-term EU projects to facilitate long-term fundamental research, long-term teamwork, skills exchange, and continuity of XR R&D skills development, especially in the areas that are very cutting-edge for XR technology breakthroughs. R2Q32	7		
SU6 Promote the development of WebXR technologies. R2Q36	7		
SU7 Focus on the potential market share in creating 3D asset libraries specific to Industry 4.0 use-cases for EU industries, to help speed up European XR development, because many European industry use-cases are early-adopters of high-precision manufacturing using XR Industry 4.0 solutions, and these Industry 4.0 use-case specific 3D assets are expected to become of interest world-wide. R2Q9	1	5	
SU8 Focus the R&D in XR technology in order to establish strategic European leadership and competitiveness in the global XR R&D sector: in terms of hardware, the focus should be on human factors, interaction paradigms, ergonomics, customization, form factor, technology vs size, weight, and power consumption, and in terms of software, the focus should be on applications and SW platforms built on top of de facto market standards (IOS, Android). (R2 Q13)		6	
SU9 Orientation needed on how to prioritize, support and facilitate access to state-of-the-art XR technologies for the development of multi-user, remote collaboration XR solutions, as this involves multiple institutes collaborating, coordinating and doing (their part of) a R&D project together. R2 Q46	3	3	1
SU10 Capture a market share by urgently supporting R&D to expand and improve the XR development pipeline in terms of asset types, complexity of data and ontologies, and to improve interoperability between the different asset formats used in different industries. (R2 Q27)	3	3	

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According to the XR panel of experts, there are three critical areas that need to be addressed in order to speed up XR development and, thus, stay at the international cutting edge of the technology:

1. Easier and more funding for training, connecting people, and developing competencies in XR; this needs to be done both on the experts and researchers' level as well as on the student's level.
2. Easier access to XR hardware and platforms for educational institutions on all levels.
3. Better support for start-ups and scale-ups to enter a highly dynamic and competitive market; better support for researchers to get access to funding, in particular, higher acceptance ratios of proposals so as to reduce researchers' wasted time investments.

8.2.2 STATEMENTS ON STREAMLINING TRANSFER OF XR RESEARCH TO MARKET ADOPTION

In terms of streamlining XR research results to enter the XR marketplace, the XR Panel prioritized concerns for more support for academic-industry knowledge exchange, making EC funded XR research results more visible to potential end-users, addressing the legal issues regarding collecting privacy sensitive data via XR UIs, creating XR end-user UX prototyping facilities, see table 26.

Table 26: Statements on streamlining transfer of XR research to market.

Streamline XR Research to Market Statements	A	B	C
RM1 XR technologies are a strategic source of competitiveness for European industries, and their development must be strongly supported by the EC. R2Q31	7		
RM2 Promote the creation of scientific councils in high-tech XR companies, and act to facilitate the participation of researchers in these bodies, for example by creating dedicated funding instruments. (R2Q37)	7		
RM3 Develop specific support for the optimization of academic-industry collaboration for XR R&D projects, because the type of knowledge exchange needed for XR development may affect the success of the collaboration in unknown ways, and improvements could be made in terms of better management of XR researchers' creative capacity, adjustments to the incentives structure, senior management support and strong leadership focused on rapid XR R&D skills development, and more recognition of skills achieved. R2 Q38	7		

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<p>RM3 Widely disseminate and promote H2020 and Horizon Europe research of best practices for successful XR knowledge-transfer cycles within academic-industry collaborations and focus on how to maximize capacity to absorb the new XR skills and XR project output, and integrate the new XR technology solutions into the value chain. R2 Q39</p>	7		
<p>RM4 Strengthen European leadership and competitiveness, by urgently doing more research towards the development and exploitation of B2B applications using XR, more open data-bases, and more business for the XR field in general. R2 Q42</p>	7		
<p>RM5 Finance projects dealing with legal issues in XR technologies. R2Q45</p>	7		
<p>RM6 Facilitate the market uptake of XR applications for healthcare, by establishing more flexible rules for experimentations, and by creating a funding instrument dedicated to the certification process. R2 Q19</p>	7		
<p>RM7 XR technologies have the potential to provide a strong and adequate response to the problem of carbon emissions, by making remote work and interactions between people more efficient, thus reducing the need for personal or professional travel and research and developments for solutions into this direction should be prioritized, especially as a response to pandemic related travel restrictions and precautions. R2 Q34</p>	7		
<p>RM8 Urgently improve the support for European XR R&D scaling up of its innovators and SMEs and reduce the currently existing notable scaling-up gap for XR tech scaleups and unicorn companies, in relation to the United States and China. R2 Q8</p>	2	4	
<p>RM9 Capture the European and global market by prioritizing research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data. R2 Q11</p>	2	4	
<p>RM10 Give more support to individual European XR startups directly, in order to bring them into the XR eco-system and help with commercialization of ideas, help with market-entry, and generally make seed money for XR start-ups more easily accessible. R2 Q16</p>	2	4	
<p>RM11 Make available and subsidize easily accessible prototyping solutions, for R&D and end-user invention support in electronics and optics R&D and testing, including facilities such as publicly accessible design and manufacturing spaces and 3D printing equipment for rapid-prototyping of XR hardware designs by XR end-users, in order to foster diversity in the designs based on real end-user UXUI XR experiences, and enabling an end-user driven evolution in input/output solutions, in a short cycle of human-centred design-implement-test-redesign. R2 Q23</p>	3	3	

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The XR panel identified 2 issues that should be addressed to improve the transfer of research into sustainable XR businesses in the European and global market:

1. Two-way exchange between academia and companies should be improved. This could be done, for instance, by funding long-term scientific council boards in companies, by better support for researchers' creative capacities, adjustments to incentive structures, and promotion of best practices for knowledge transfer and XR integration into value chains.
2. Fund projects dealing with the multitude of legal issues around XR technologies, which can be a significant barrier to market entrance, especially for SME's. In particular, legal issues around XR products and research in the health sector should be addressed and simplified by the EC, since these can be a real obstacle to innovate in that sector.

8.2.3 STATEMENTS ON STANDARDIZATION

In terms of standardization the XR Panel prioritized concerns regarding XR health and safety standards, cybersecurity, accessibility for all, and interoperability XR development skills training, see table 27.

Table 27: Statements on standardization.

Standardization Statements	A	B	C
ST1 Urgently fund R&D and standardization work towards the cybersecurity of XR technologies, especially personal XR devices which are going to be part of the mobile phone. R2 Q44	7		
ST2 XR technologies are essential for the development and success of the European Alliance for Industrial Data and Clouds. R2 Q48	7		
ST3 Urgently promote standards for Health & Safety for long-term XR use and foster research into Human Factors & Ergonomics for the design of XR input/output devices. R2 Q51	7		
ST4 Finance R&D regarding the detection, measurement, correction and protection against discrimination of sexual, ethnic and economic minorities, in the use of XR technologies. R2 Q18	7		
ST5 Promote standardization of 3D scene description format, and also for immersive audio, other XR content and devices. R2 Q47	7		

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<p>ST6 Urgently understand/create/adopt worldwide standards and support solutions for low cost, reusable, interoperability solutions for integrations of domain specific data such as BIM, scientific simulations, etc., and these solutions should best practices in industrial R&D projects, be independent from the current mainstream XR software companies, and make it as efficient as possible to plug into the currently most used interactive XR platforms. R2 Q26</p>	5	1	
<p>ST7 Foster research into how to make XR technologies and designs more accessible to all diverse user groups, exploring how to include more than the currently targeted market-segment (male, educated, English speaking consumers), making sure that communication is unbiased and checking contents for localization, and using AI to automate adaptations where possible. R2 Q21</p>	4	2	
<p>ST8 Investigate methods to establish anonymity when using XR technologies, and fund projects to achieve strong identification and authentication in a secure manner in cases where applications need it. R2 Q17</p>	2	4	
<p>ST9 Prioritize, organize and subsidise XR developers training and affordable train-the-trainer educational events at all educational levels, to address the real shortage in skilled XR developers and instructors. R2 Q22</p>	2	4	

An important step for widespread adoption of XR technologies is standardization. This relates to data exchange standards, facilitating exchange of virtual scenes and communication between XR systems at runtime. It also relates to research into human factors regarding long-term use of XR, which can then be turned into best practices and standards to ensure users' safety and health. Furthermore, standards regarding the security of XR systems and users' data, especially in light of the massive, organized security breaches lately and the massive monetization of user's data, is urgently needed to facilitate widespread adoption of XR.

8.2.4 STATEMENTS ON BUSINESS OPPORTUNITIES AND CHALLENGES

The following table lists, ranked by order of urgency, the consensual statements of the XR panel with a strong relevance with regards to Business questions. See table 28 for an overview.

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Table 28: Statements on business opportunities and challenges

Statements on Business opportunities and challenges	A	B	C
BI1 <i>The EC needs to improve the support for European XR R&D scaling up of its innovators and SMEs and reduce the currently existing notable scaling-up gap for XR tech scaleups and unicorn companies, in relation to the United States and China. R2 Q8</i>	2	4	
BI2 <i>The EC should focus on the potential market share in creating 3D asset libraries specific to European Industry 4.0 use-cases to help speed up European XR development, because many European industry use-cases are early-adopters of high-precision manufacturing using XR Industry 4.0 solutions, these use-case specific 3D assets are expected to become of interest world-wide. R2 Q9</i>	5	1	
BI3 <i>The EC and XR developers can capture the European and global market by prioritizing research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data. R2 Q11</i>	2	4	
BI4 <i>The EC need s to focus the R&D in XR technology in order to establish strategic European leadership and competitiveness in the global XR R&D sector. In terms of hardware, the focus should be on human factors, interaction paradigms, ergonomics, customization, form factor, technology vs size, weight, and power consumption. In terms of software, the focus should be on applications and SW platforms built on top of de facto market standards (IOS, Android). R2 Q13</i>	6		
BI5 <i>The EC should give more support to individual European XR startups directly, in order to help with commercialization of ideas, help with market-entry, and generally make seed money for XR start-ups more easily accessible. R2 Q16</i>	2	4	
BI6 <i>Q19The EC should facilitate the market uptake of XR applications for healthcare, by establishing more flexible rules for experimentations, and by creating a funding instrument dedicated to the certification process. R2 Q19</i>	5		
BI7 <i>XR technologies are a strategic source of competitiveness for European industries, and their development must be strongly supported by the EC. R2 Q31</i>	5	2	
BI8 <i>The EC should promote the creation of scientific councils in high-tech XR companies, and act to facilitate the participation of researchers in these bodies, for example by creating dedicated funding instruments. R2 Q37</i>	5	2	

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BI9 <i>The EC must finance projects dealing with legal issues in XR technologies. R2 Q45</i>	7	
BI10 <i>XR technologies are essential for the development and success of the European Alliance for Industrial Data and Clouds. R2 Q48</i>	7	

Although the experts in the XR panel are mostly coming from academic research, they express the need for business-oriented measures. The statements can be grouped in four categories:

1. Regulations. The EC is an effective player for regulations. Regulations can be restrictive for businesses (e.g. experimentation in healthcare), but they can also act as protection for European companies with respect to other global players (e.g. legal issues).
2. Strategy. The role of the EC is also to define strategic orientations, in order to foster the creation of strong industrial sectors (e.g. Industrial Data and Clouds). There is a need to think broadly (see statement BI10), but also to be aware of the detailed roadmap (see statement BI4).
3. Funding. The financing conditions of companies in Europe are less favourable than those in Asia or in the USA, and a direct involvement of the EC is called for. Funding is not only needed for start-ups, but also innovators, high-tech SMEs, scaleups and unicorns.
4. Knowledge. The technology transfer from academic research to business is difficult because of the differences of culture and organization. Europe needs a legal framework and incentives for mobility between research and industry.

8.2.5 STATEMENTS ON XR AND THE 17 SUSTAINABLE DEVELOPMENT GOALS

Statements about XR and the 17 Global Sustainable Goals were collected in Round 0, 1 and 2 of the Delphi, and the respondents listed a number of XR solutions for the 17 SDGs, because they have a large bearing on global and European goals, and considerations regarding priorities are influenced by the urgency for the solutions for the 17 SDGs [36]. The results from these statements are presented below. These statements are not specifically ranked in order of urgency here, as they obviously all are important and urgent if XR solutions can help, and it will be important to explore the innovation opportunities with priority.

CO1 *XR technologies have the potential to provide a strong and adequate response to the problem of carbon emissions, by making remote work and interactions between people more efficient, thus*

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reducing the need for personal or professional travel and research and developments for solutions into this direction should be prioritized, especially as a response to pandemic related travel restrictions and precautions. R2 Q34

CO2 *XR solutions will help reduce the time-intensive requirements of building physical prototypes dramatically, bringing ideas and innovations to life and products to market far more quickly, although there is still much improvement needed of the XR development pipeline, the learning curve and time needed to reach proficiency, and the number of experts available. R2 Q50*

CO3 *What XR developments will help reduce the CO2 emissions by half by 2030 and to neutral by 2050:*

- 1. Visualizations of consequences of the 17 SDGs risks and strategies,*
- 2. Virtual prototyping and testing,*
- 3. Virtual access to healthcare, education, work and colleagues,*
- 4. Soft skills and diversity training in XR,*
- 5. Empowering low TRL members to leapfrog to 21st century ecological, economic and social levels,*
- 6. Device-less interaction to lower manufacturing of interfaces (reducing the number of materials needed to build them and pollution by less shipping),*
- 7. Increase remote meetings and showrooms,*
- 8. Educational applications to raise awareness,*
- 9. Remote field services, using XR, leveraging remote operations and reducing the Carbon footprint,*
- 10. More collaborative applications,*
- 11. Immersive Training by enhancing quality content development and global deployment using XR to reduce time spent, travel demands and decreasing after training problems,*
- 12. Increase remote training and education with XR experience,*
- 13. Develop individual assistance using IA Applications (medical, education, etc),*
- 14. Integrate XR applications integrated in transports.*

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CO4 XR researchers and the EC should prioritize XR validation research by systematically mapping out the wide variety of XR use-cases specific to Europe and globally - including EU commitment to the 17 Global Sustainable Development Goals (17 SDGs), XR health & safety, human factors and ergonomics for long-term use in serious XR applications, and age- and gender-related issues. R1 Q43

For some recent leading example initiatives specifically focussed on demonstrations of XR technology solutions for the 17 SDGs, see for instance:

<https://xrimpact.com/> <https://globalfestivalofaction.org/virtual-library/>

<https://digitalpromise.org/initiative/360-story-lab/my-world-360/>

XR technologies as a whole have great potential to realize many of the 17 SDG's. For instance, SDG 3 (Good Health and Well-Being) can be helped through adoption of XR in health care, e.g. long-distance, immersive tele-medicine to provide health services to rural areas; or by using XR gamification to fight obesity, which is quickly becoming the predominant health risk in industrial countries. For SDG 9, XR has been and will continue to be an important tool in industry, especially for the development of new products in all phases of the product life cycle. XR will become an increasingly important tool to improve resilience of infrastructure, in particular using tele-presence for remote inspection and maintenance (e.g. bridges, pipelines, wind parks, aircraft, etc.). XR will play an important role in pursuing SDG 13 (Climate Action): true, immersive and interactive tele-presence will help reducing the number of business travels substantially. At the same time, it will contribute to SDG 9 (Industry and Innovation) by allowing worldwide distributed companies to communicate more efficiently. SDG's 14 (Life below Water) and 15 (Life on Land) will take advantage of XR technologies by creating all kinds of immersive digital twins of ecosystems that will help scientists improve their understanding of those ecosystems; they will also help local authorities to take sustainable decisions; and they will help the general public to better appreciate the value of those ecosystems. XR technologies can even help SDG 4 (Quality Education) by providing relatively inexpensive tools for developing countries to leapfrog into modern business and industrial processes.

8.2.6 STATEMENTS ON XR R&D COLLABORATION AND KNOWLEDGE EXCHANGE

Collaboration is a process that needs to be fostered. The statements reported above have been reanalyzed to explore any further issues of collaboration and knowledge exchange specific to XR. On the one hand a multi-disciplinary and multi-cultural team brings the diversity

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perspective, it gives a broader view and wider potential pool of ideas from the different team-members across cultures and countries. On the other hand, the cross-cultural collaboration and knowledge exchange process may suffer from the fact that managing culturally determined work style differences is an unfamiliar process, such as when different culturally determined styles of interaction and problem solving hinder team-work, or not having one shared language that all team members speak sufficiently fluently to achieve success of meetings and communications. In addition to that there are different terminologies for different development disciplines and experts from the different fields involved. This can create an additional source of misunderstandings that must be discussed, and solutions put in place in advance. The following statements were recommendations towards the collaboration success factors and quality assurance prerequisites of successful knowledge exchange. These statements are not ranked for urgency, because they are obviously prerequisites for project success and as such clearly all urgent and important.

CC1 *The EC should focus more on helping to allocate XR competencies, support mobility of XR experts for international skills exchange, and training of developers at labs and companies for all XR stakeholders, including virtual (pandemic solutions) and real networking events. R2 Q40*

CC2 *The EC should widely disseminate and promote H2020 and Horizon Europe research of best practices for successful XR knowledge-transfer cycles within academic-industry collaborations and focus on how to maximize capacity to absorb the new XR skills and XR project output and integrate the new XR technology solutions into the value chain. R2 Q39*

CC3 *The EC should develop specific support for the optimization of academic-industry collaboration for XR R&D projects, because the type of knowledge exchange needed for XR development may affect the success of the collaboration in unknown ways, and improvements could be made in terms of better management of XR researchers' creative capacity, adjustments to the incentives structure, senior management support and strong leadership focused on rapid XR R&D skills development, and more recognition of skills achieved. R2 Q38*

CC4 *The EC should create more long-term EU projects to facilitate long-term fundamental research, long-term teamwork, skills exchange, and continuity of XR R&D skills development, especially in the areas that are very cutting-edge for XR technology breakthroughs. R2 Q32*

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CC5 *The EC should make funds more accessible for facilitating innovation via new XR labs and independent developers, by increasing the success rate of proposals, and by providing active help and support with the application process. R2 Q41*

CC6 *The EC should prioritize, support and facilitate access to state-of-the-art XR technologies for the development of multi-user, remote collaboration XR solutions. R2 Q46*

It is recommended that more is done to understand the best ways of cross-disciplinary and cross-cultural collaboration, including culturally determined and technical domain determined collaboration differences, and industry-academia collaboration of different experts. It is recommended to create more opportunities to be inclusive about access to the new technology tools and education, by creating technology spaces, open to the general public where anyone with an interest in new technologies, or ideas for XR solutions, can come to explore the latest hardware/software and build a prototype. A free to attend knowledge exchange center, showcasing project results, with workshops and international trainers and knowledge exchange visiting researchers, and knowledge multiplier train-the-trainer workshops. What is more, achieving the synergy of diversity from intercultural knowledge exchange, cross-cultural collaboration, and interdisciplinary innovation success needs to be put high on the agenda. Additionally, the results from previous XR projects should be exhibited more publicly and more internationally, to raise TRL awareness for and STEM education demand for future generations, and a deep study specifically to the XR development collaboration success factors is recommended to achieve the potential synergy of cross-disciplinary and cross-cultural collaboration.

9. CONCLUSIONS

XR has been put forward as an accelerator and a mega trend [9], with interdependencies with other Key Enabling Technologies, the “Essential Eight” [37]: AI, AR, Blockchain, Drones, IoT, Robots, VR, and 3D Printing. How it affects society and the way we work, socialize and communicate is being discovered as more functionalities become available [3].

The Delphi expert XR Panel suggested various themes for a future scenario for 2030 and how XR will be used by then. These suggestions were summarized and we used them to create the outline of a scenario for XR in 2030. Additionally, we created a XR development timeline, dividing the current decade into a number of stages (current, 2-3 years from now, 5 and 10 years from now), constructed from the XR expert panel’s suggestions as to what needs to be done to reach the state of XR by 2030 that they forecasted. The scenario, the timeline and our analysis of these, embedded in our current economic recovery phase in the aftermath of the COVID-19 pandemic, are presented in the following sections.

9.1 SCENARIO OF THE STATE-OF-THE-ART OF XR IN 2030

An optimistic / positive scenario outline, for the adoption of XR by 2030, based on the suggestions from the panel is listed in the table below. It is optimistic in the sense that this scenario describes a positive growth for the XR field for 2030, see table 29. Depending on the actions taken in the next 1-2, and 3-5 years from now we will reach some form of this scenario, however, there are certain conditions and requirements that need to be in place for this positive scenario to be able to unfold. These conditions and requirements will be discussed below, after the scenario.

Table 29: Scenario for XR in 2030, if funding starts now

2030	<p>XR and AI will be combined to create an intelligent, human-centred, harmonious, experience and tool for humans</p> <p>The essential public debate around personalization and privacy concerns is better understood; good efforts to clarify the advantages to the user, solutions of user-centric opt-in/out of personal data-collection is available at various levels and is generally accepted.</p> <p>XR apps will be deployed on smartphones much more than today, seamlessly integrated with sophisticated (physiological) sensors and other electronic devices, enabling new communication solutions for work and social life.</p> <p>Personal XR devices that will be fully connected to our smartphones and complement the use of it.</p>
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Developments are underway for devices that replace the smartphone, that will be even more ubiquitous in use than smartphones, for work and social life as they are less intrusive, and more comfortable and lightweight, dedicated to specialized applications.

Multi-sensory XR (haptics, sound, smell and taste) with automatic body and gesture tracking by cameras will be developed

Multi-sensory, haptic body suits, with high-resolution, automatically created avatars adapted to the anthropomorphic parameters of the user.

The user interface will be predominantly driven by marker less, camera-based tracking of gestures, body, and eyes. This will utilize cameras that are either integrated directly in the headsets or distributed throughout rooms or workspaces to allow for larger and more precise tracking.

Developments are rapidly advancing for thought-driven UIs (brain-computer interfaces)

EU-wide regulations protecting privacy, minorities, and ethics with regards to XR as a whole and brain-computer interfaces in particular are in place.

Business models to deploy XR in various application areas have been proven successfully, many more business models are emerging, and further systematic efforts to establish business models in more application areas are underway.

XR apps for professional use will be widely available and widely in use. Manufacturing industries (the forerunners) continue to use all types of XR and have XR integrated well into their development workflows. Other sectors, e.g., health and medicine, inspection & maintenance, autonomous & remote driving, and many more have adopted XR.

Tele-presence and virtual collaboration in common virtual spaces is being taken up by many industries.

Tele-medicine (for general physicians) and tele-consultation (in the operating room) will be feasible and accepted by both professionals and citizens.

XR movies have matured, but will most likely remain a niche market.

Video Games, home remodelling using VR/AR, and 1st person XR visits to remote places (virtual tourism) are dominating the consumer market.

9.2 XR TIMELINE: PRE-PANDEMIC - 2021

Overall, XR in conjunction with other key enabling technologies, will be powerful innovation accelerators in many application areas across the consumer and professional markets. To demonstrate its transformational potential, the XR field needs to showcase solutions that address our real-life global sustainability problems and help create a public debate and help make visible how XR can contribute to the greater benefit of society as a whole. We discuss the impact of the scenario pre-pandemic and current in terms of the four broad areas of action, XR Market, XR Enabling environment, Human XR Capital, and XR Innovation Ecosystem.

9.2.1 XR MARKET

Regarding the position of Europe in the XR market and statements are related to building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL) priorities for European Commission (EC) strategies, the pre-pandemic status quo and future expectations can be summarized as follows:

In the wake of the financial crisis and the pandemic, it is advisable to direct financial resources towards long term investments, and strengthen stability, while continuing to expand and facilitate inclusion of more companies entering and grow. Around the world, governments will have to introduce financial incentives to stimulate companies to engage in sustainable and inclusive investments to find solutions for the 17 SDGs and the 2030 commitment to reduce CO2 by 50% [38].

Pre-pandemic, the expectations were that due to the strong growth of XR content-related development activities in Europe, the share of Europe in the global market will increase, and the overall impact of the XR industry for Europe at a total production value of between 24 billion and 54.5 billion, will have a gross value added of between 14.4 billion and 33.6 billion and 225,00-480,000 jobs [5].

The XR4All project assessed the state-of-the-art of the XR R&D field and that Europe had h a multitude of players from start-ups and SMEs to very large enterprises, but the VR/AR market is fragmented, and dominated by US internet giants such as Google, Apple, Facebook, Amazon, and Microsoft. By contrast, European innovation in AR and VR is largely driven by SMEs and start-ups. The large companies in the XR R&D field are from the US, such as Google, Microsoft, Oculus, Eon Reality, Vuzix, CyberGlove Systems, Leap Motion, Sensics, Sixsense Enterprises, WorldViz, Firsthand Technologies, Virtuix, Merge Labs, SpaceVR, etc, and Asian Pacific region companies such as, for Japan: Sony, Nintendo; for South Korea: Samsung Electronics; for Taiwan: HTC), (XS4All, 2020, p 22). Aside from

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these large companies involved in XR, they also found there are many SMEs and smaller companies involved in XR R&D worldwide.

9.2.2 XR ENABLING ENVIRONMENT

Regarding leadership at European level in terms of standards for XR R&D, the pre-pandemic status quo and future expectations can be summarized as follows:

Against the backdrop of the financial crisis and the health crisis, governments will have to prioritize improving long-term thinking capacity within government, create enhanced mechanisms to deliver public services, including digitization of the public services, based on strong governance principles and service to the citizens [38]. Additionally, national reforms and international frameworks are essential to plan future public debt leveraging. Governments will have to prepare support measures for highly indebted low-income countries, plan for public debt leveraging, and focus on shifting to more progressive taxation, rethinking how corporations, wealth and labour are taxed. The COVID-19 crisis has accelerated digitization in advanced economies and widened the digital divide, making it more difficult for countries, regions and people to catch up and care must be taken to include them in upgrading utilities and infrastructures for countries, industries, institutes and citizens, such as access to electricity, ICT and energy transition solutions.

The European Commission supports research and start-ups in Europe. The new Horizon Europe framework programme represents the largest collaborative multinational research and innovation investment in Europe and is open to participants worldwide, with a budget of 100 billion euro from 2021–2027 [39]. The European Union support this investment because research and innovation are essential for finding new solutions to the 17 SDGs that are too large be addressed or resolved by one country alone, and research and innovation create new opportunities, helps to tackle climate change, supports sustainable economic growth and the competitiveness of businesses and industries, and provides better public services for all Europeans.

One specific objective of Horizon Europe (art. 3, 2b) [40], is: “to generate knowledge, strengthen the impact of research and innovation in developing, supporting and implementing Union policies and support the access to and uptake of innovative solutions in European industry, notably in SMEs, and society to address global challenges, including climate change and the Sustainable Development Goals. European research and innovation is setting a world standard for excellence, however the potential of the impact of research and innovation investments is greatest when efforts are informed by an awareness of the challenges ahead and successful attempts at clearing the path forward.

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9.3.3 HUMAN XR CAPITAL

Regarding building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL), the status quo before the pandemic and future expectations can be summarized as:

The pandemic has accelerated the need for technology adoption, however, before the health crisis, there was already a mismatch between demand and available skilled workers and the number of unemployed workers not skilled in the technology skills that are needed has dramatically increased due to the health crisis. Countries have to redesign their incentives and rewards and reskill, upscale, and rapidly scale up by expanding investment in the skills needed for jobs of the “market of tomorrow”, to meet the demands of the “markets of tomorrow”, and they need to use new technologies to manage talent and the needs of the new workforce in new ways, rethinking labour laws to facilitate the new economy and talent engagement [38]. Additionally, the pandemic has raised the awareness globally for the need for new ways to organize healthcare access and ‘the capacity of healthcare systems, including for remote and/or expanding populations in the developing world and aging populations in the developed world, and the infrastructure for healthcare, childcare, and eldercare have to utilize new technologies to innovate and manage current and future healthcare needs for all.

XR in combination with the other Key Enabling Technologies, is capable of transforming and innovating manufacturing, construction and healthcare, education, culture, traveling and entertainment, and the European skilled XR R&D entities have the potential to be strong and promising player on the global VR scene. Europe’s competitive advantage was found to be the long-standing tradition in VR research and manufacturing industry applications, as well as creativity and cultural diversity, and the top VR application developers' skills areas were entertainment, gaming, simulation, training for professional and industrial use, healthcare, real estate and architecture [5].

By 2030, more than 85 million jobs could go unfilled because there are not enough skilled people to take them, and governments and organizations must make talent strategy a key priority and take steps now to educate, train, and upskill their existing workforces, or the talent shortage will erode economic lead very fast. Forward thinking companies and governments who rethink education programs and generate the talent pipelines the industry will require and continuous life-long learning practices will have to be facilitated, extending far beyond our current traditions for education and vocational training.

9.3.4 XR INNOVATION ECOSYSTEM

Regarding the XR Innovation ecosystem and the development of an XR Platform (middleware / game-engine), the pre-pandemic and future situation can be summarized as follows:

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Technology needs to deliver solutions to the 17 GSDs and create innovation for the urgent issues of energy consumption, reduction of emissions and the need for inclusive social services and societies. Countries are advised to expand public investments in R&D, incentivize venture capital and R&D in the private sector, promoting the diffusion of technology solutions, firms and jobs for the “markets of tomorrow”, incentivizing firms to utilize the creative human capital synergies of diversity, equity and inclusion, and to invest in research and innovation and the invention of the “markets of tomorrow” [38].

The XR ecosystem map topology created by [5] consists of the following interrelated entities: VR Ecosystem support, Awareness and Community Building, VR Research, VR Companies – Supply side, VR Companies/Applications – Demand side, Policy makers, Funding bodies, VR Consultation and training services.

The Ecorys study of VR and its potential for Europe [5] found that the European ecosystem is indeed part of a global value chain and about half of the European VR companies choose their suppliers from around the world and target customers globally, and the other half choose their customers from Europe and focus mainly on the European market. They also found that most VR companies in Europe were self-funded or are spin-outs financed by a larger parent company. Finance has clearly been a major challenge for European VR.

The XR4All study of the state-of-the-art of the XR R&D field in Europe found that Europe has a strong reputation for having been active in XR research for a long time. Typically, this research would take place at European universities such as ParisTech (FR), Technical University of Munich (DE), and King’s College (UK) and by non-university research institutes like Laval (FR), Fraunhofer Society (DE), and INRIA (FR), and this includes applied research and creative projects that push the boundaries of the technology and set the stage for public debate regarding the role and effects of the new apps, a large number of XR associations, think tanks, associations and institutions such as EuroXR, Realities Centre (UK), VRBase (NL/DE) and Station F (FR) that connect stakeholders, provide support, and enable knowledge transfer.

Research activities in Europe tend to concentrate in France, the UK, and Germany, while business activities tend to concentrate in France, Germany, the UK, and The Netherlands. The VR Fund published the VR/AR industry landscapes providing a good overview of industry players. Besides some of the companies already mentioned, one finds other well-known European XR companies such as: Ultrahaptics(UK), Improbable (UK), Varjo (FI), Meero (FR), CCP Games(IS), Immersive Rehab (UK), and Pupil Labs (DE). Others are Jungle VR, Light & Shadows, Lumiscaphe, Thales, Techviz, Immersion, Haption, Backlight, ac3 studio, ARTE, Diota, TF1, Allegorithmic, Saint-Gobain, Diakse, Wonda, Art of Corner, Incarna, Okio studios, Novelab, Timescope, Adok, Hypersuit, Realtime Robotics, Wepulsit, Holostoria, Artify, VR-bnb, Hololamp (France), and many more [41].

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9.3.5 XR TIMELINE: 2023, 2026, 2028, 2030

Below we present the timeline for the proposed XR Roadmap (see table 30). The points in time signify the year when specific technologies or developments can be expected to mature to a usable level, **provided funding is started now**. If research and development is started now and funded appropriately, then the items will be achievable to a mature point at the respective points in time. In order to facilitate XR to reach its potential to deliver solutions it has been suggested it can deliver, the funding for all of the technologies in the timeline needs to be started now, since they have different complexities. If the start of funding happens later, then the points in time would have to be shifted accordingly. However, in order to have a role of influence in the global market, it is recommended to start immediately.

This timeline should, of course, not be viewed stand-alone but in conjunction with other current, key enabling technologies, most importantly AI/ML, optics and photonics, IoT, and 5G. Consequently, those KET's need to receive similar amounts of funding and push, so that the necessary conditions for a ubiquitous, immersive XR experience, providing real-time, interactive, multi-user, fluid industrial, professional, and consumer solutions will not be jeopardized. While not explicitly mentioned in this table, it is essential to bear in mind that the XR roadmap is meant to be embedded in appropriate health & safety standards and policies with regards to XR technologies.

Table 30: Timeline for our XR R&D.

Year	Technology / Development matured
2021	Increasingly more inexpensive and easy access to XR development tools
2023	<p>XR competencies both on a professional level as well as with consumers are proliferating</p> <p>Living labs and access to public and private XR labs and equipment at large scale will be possible</p> <p>AI/ML will be integrated into consumer applications, sometimes to their benefit (improving user interaction), sometimes to their potential dismay (privacy concerns)</p> <p>Untethered AR/VR displays with unnoticeable latency, either as stand-alone headsets or over WiFi using a local PC</p> <p>Gesture-driven UI's for XR, including other modalities such as eye tracking, body tracking, voice, and physiological sensors</p>

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	<p>Tool chains for 360 movies will be commercially available; 360 movies will still remain niche market</p>
<p>2026</p>	<p>Truly long-distance collaborative virtual environments with personalized avatars will be feasible and beginning to be used professionally (tele-existence, tele-presence)</p> <p>Standardization of basic UI elements in XR systems will be stabilizing: virtual menus, functional buttons in devices such as controllers, interaction with virtual objects, etc.</p> <p>The content creation pipeline will be amplified by integration of AI in specific modelling tools; modern data exchange format (which are still relatively new as of 2021) will be adopted on a wider basis</p> <p>Content creation in VR will be part of the content creation pipeline, using all multi-modal user interface channels available</p> <p>XR technologies are beginning to improve life quality for inclusive minorities</p> <p>European XR software platform (VR-capable game engine) is available</p> <p>Accessible XR user interfaces, accessible to some people with some specific disabilities, potentially including BCI-driven control</p> <p>Best practices with regards to XR experiences and human factors will stabilize</p> <p>Non-intrusive, high-precision body and hand tracking for large working volumes commercially available</p> <p>First adopters of AR tele-presence in the operating room for expert consultation</p> <p>Novel funding instruments for cross-fertilization between academia and industry, providing incentives for industry to employ experts from academia as consultants</p>
<p>2028</p>	<p>European regulations will be in place so that XR technologies will have to adhere to European standards</p> <p>First XR consumer applications will be provided using streaming technologies (by data/rendering/compute clouds, 5G and fiber)</p> <p>Throughout industry, and in many businesses, XR will be a well-accepted tool for collaboration, prototyping, and training</p> <p>Ultra-realistic haptic bodysuits available, including full-body tracking</p>

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	High-precision HMD tracking with huge ranges will be possible without external base stations (probably SLAM-based)
2030	<p>Collaborative virtual environments over international distances with individual avatars updating in real-time will be feasible, potentially using 6G for the “last mile”</p> <p>Form factor of XR displays (size, weight, power) will have improved dramatically (closer to sunglasses)</p> <p>Usage of XR as an immersive learning tool in STEM subjects, health and medicine, and other areas</p> <p>First demonstrators for using XR and creating XR content using brain-computer interfaces</p>

9.4 ROLES AND RESPONSIBILITIES

The challenges for the growth of XR for the XR research community, the SME XR developer and early-adopter community, as well as the government and legislators are summarized below in terms of the roles and responsibilities for the different stakeholder groups involved. These roles and responsibilities are based on an analysis of the themes collected from the strengths & weaknesses analysis of the XR field for business and academia, collected from the respondents to this Delphi study. We extrapolate the roles and responsibilities from these themes for each of the stakeholder groups’ perspectives respectively: XR Research community, XR SME community, Legislation and Government bodies.

9.4.1 XR RESEARCH COMMUNITY

In summary, the roles and responsibilities identified for the scientific/technical XR community in Europe and the European Commission are:

1. Improve the efficiency of transfer of technology from research to market and provide better incubation periods and guidance for startups.
2. Improve collaboration between academia and industry outside of funded projects; and create incentives for industry to engage in such collaboration.
3. Attract and support large industrial players in XR technologies.

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4. Improve success rate of project proposals and the complex application process.
5. Provide more long-term funding for high-risk, fundamental research; review the pressure of success for projects, recognize better that failure is also a potential outcome of innovation processes and allow for failure of (aspects of) research projects, provide multi-national long-term funding.

9.4.2 XR SME COMMUNITY

In summary, roles and responsibilities identified for the SME XR community in Europe are:

6. Lobby for more access to seed money for start-ups.
7. Lobby to improve scale-up funding.
8. Develop base technologies (hardware and software).
9. Lobby for improved regulations and bureaucracy which stimulate rather than hamper business development as is currently the case.
10. Develop a strong European cloud solution including storage and compute services.
11. Lobby for more helpful rules for experimentations in healthcare, and a unified certification process for each and every member state of the EU.

9.4.3 LEGISLATION AND GOVERNMENT BODIES

In summary, roles and responsibilities identified for the SME XR community in Europe are:

12. Increase funds necessary for seed money for start-ups.
13. Increase funds necessary for scale-up funding.
14. Improve regulations and bureaucracy which is currently hampering business development with XR solutions.
15. Provide strong leadership in Europe for the development of a digital platform for XR, big data and R&D.

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16. Review and improve the currently too rigid rules for experimentations in healthcare to develop healthcare solutions with XR and other KETs solutions, reduce the complexity of the certification process.

9.5 CONCLUDING REMARKS

For XR technologies to go mainstream, advances in hardware, software, novel developer partnerships and democratic access to the latest XR technology solution for researchers and developers together with representative end-users is vital. However, for many countries and communities, XR developers face serious barriers to developing prototypes: lack of access to the R&D tools, prototyping centres, education, startup opportunities and resources that many cannot afford [42]. This low Technological Readiness Level (TRL), becomes a bottleneck in the ability to take advantage of XR to drive innovations of product, production, and business models, risking that the digital divide grows wider even faster. Democratization of XR R&D access means improving support for development of XR ideas, commercialization plans, and venture capital.

The skills gap to perform R&D exists to different degrees, not only in XR but for all Key Emerging Technologies. This has two dimensions: a quantitative one (overall dearth in supply compared to demand), and a qualitative one (mismatch in skills supply and demand) [43], [7]. Consequently, a strategic plan is needed to foster XR skillsets on all levels, from beginner through to highly specialized experts, and in a multitude of different sub-areas, ranging from hardware to fundamental XR algorithms and methodologies, to XR software platforms (e.g., game engines) to vertical applications markets. Many universities have already begun to integrate some XR courses in their curricula, but complete study programs are still rare and resources, both teaching staff and student labs, are scarce. Online training (e.g., edX, Coursera, etc.) could be a solution, but only to a point. Teaching using XR technologies itself could also be helpful in closing the gap [2], [11] The availability of skilled XR developers is obviously a prerequisite for companies and countries to get to or stay at the cutting edge of the XR technology R&D. Especially with fast-paced, highly innovative areas like XR, the EC should support universities so that they can provide life-long learning and knowledge exchange opportunities [43].

The EC, together with national governments and regulatory bodies, should provide legal support and guidance so that users' GDPR rights, their privacy, and the exploitation of users' behaviour is managed according to European standards. Even today, users could potentially be identified uniquely based on their IP address, eye gaze tracking, and many other psychophysiological measurements (e.g., heart-rate, pupil dilation, etc.). All of this data could be utilized to the advantage of the users; however, there are also serious potential ethical, legal, and societal implications, such as security and privacy, targeted

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advertising, manipulation using fake information, monetization, and many more [22]. Furthermore, the EC should investigate the addictive potential of XR, especially among the young and adolescent generations, and provide appropriate regulations to protect these groups.

Since virtual technologies are directly associated with spatial computing, it is natural that XR will play an important role in the exploration, visualization, and interaction with digital twins. This is already being done in the manufacturing industries for developing new prototypes, but it can and should be utilized in many other digital twins. To give but one example, XR has great potential for visual analytics (“immersive analytics”) of huge scientific simulations, such as *Destination Earth* (DestinE), a digital twin to be developed by the European Centre for Medium-Range Weather Forecasts (ECMWF) [44]. Overall, there is the need for scientists from all areas to embrace XR technologies as a tool, and to reach out to XR researchers to form interdisciplinary collaborations. In addition, there is the need for the EC to foster such interdisciplinary collaborations through suitable funding programs.

Such interdisciplinary efforts between XR researchers and researchers from other areas should also be created to help the cause of the 17 Sustainable Development Goals. This can be spurred by the EC by developing appropriate funding programs specifically targeted at such collaborations, or by including XR in funding programs targeted at the 17 SDGs.

XR, especially VR and AR, has the potential to transform the workplace in almost all areas of businesses and industries. Especially when XR will, eventually, be blended and combined with AI, robotics, and 5G, it could become a disruptive technology transforming science, industry, and leisure. The EC is called upon to ensure this is to the benefit of all European peoples, and humankind as a whole.

9.5.1 LIMITATIONS AND FUTURE RESEARCH

This study had to take place in a short timeframe to meet the deadline. With more time available, more Delphi consensus seeking rounds can be used, to further explore newly emerging challenges and opportunities for the XR field, and in order to inform decision makers in more detail where to assign funding for XR development and why exactly. This study functions as a pilot study to show the value of the consensus process. The Delphi tool that has been developed during this pilot could be used on a regular basis to monitor concerns in the XR innovation ecosystem regarding the rapid changes in the Essential Eight technology fields and XR in particular. A larger, longitudinal study (i.e. repeat the consensus collection process on a regular basis) could function as a XR future directions group consensus measurement tool. This study used SurveyMonkey to administer the Delphi. There are several commercial dedicated Delphi platforms at various price-tiers with various perks and additional functions and plug-ins, some of which allow a Delphi panel to interact in real-time, and communicate

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regarding the statements, directly in the platform, while maintaining full anonymity. These types of platforms typically have a higher cost and steep learning curve where the underlying business model of the developers of the platforms is to provide the work involved to design the Delphi as a paid service, as part of the optional services in the member account subscription.

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APPENDIX A: EVENTS ATTENDED BY THE EUROXR DELPHI ANALYSIS TEAM DURING THE RUNTIME OF THE EUROXR DELPHI STUDY

The Future of XR in Europe, Facebook event, April 2021

IEEEVR 2021, <https://ieeivr.org/2021/>

XR4All Spring Event Conference, April 2021 <https://xr4all.eu/event/xr4all-spring-event/>

BEYOND ZOOM: PROMISE AND REALITY OF XR PROGRAM

<https://devstudio.dartmouth.edu/wordpress/2021/04/beyond-zoom-promise-and-reality-of-xr-program/>

VR/AR Global Summit 2021, VRARA Association, June 2-4, 2021.

XR4Rehab, June 2021

Immersive Learning and Research Network (iLRN) Conference, 2021

From ideas to Reality, VR4REHAB Conference, 23 June 2021

APPENDIX B: SURVEY OF ROUND 0

Page 1: Welcome!

We cordially invite you to participate in this EuroXR survey and be part of the XR pioneers of tomorrow's choices.

We will submit the report of this survey to the European Commission, to help them define future R&D funding and directions. **Together we have the power to advise the European Commission** - your information will help shape future calls for proposals in the European Commission's framework program Horizon Europe.

It will take about 30 minutes to answer all questions.

Your responses will be treated anonymously at all times.

Thank you so much for your time and effort in advance, your views are vital!

"Help Drive XR R&D forward!"

This survey is funded by the EuroXR Association - 2021

Page 2: Demographic Questions

Q1 I give permission for my survey responses to be used in this survey report. I understand that my contributions will remain anonymous at all times. Furthermore, I promise not to share sensitive IP via this survey.

Q2 What is your current job description and role?

Q3 How many years have you worked in the XR field? Starting with your first project or publication.

Q4 What is your gender?

Q5 What is your age?

Q6 Which country are you based?

Page 3: XR R&D: Technical, Functional and Social Issues

Q7 Which XR R&D topics do you have experience with yourself/in your team?

Q8 Have you worked or are you and/or your team working on one or more EU-funded projects? 1-2

Q9 If you see limitations in applying, joining, or working in XR R&D projects, in what way could EU-funding help overcome these limitations?

Q10 If you see limitations of XR R&D software, in what way could EU-funding help overcome these limitations?

Q11 If you see limitations for XR R&D in terms of input / output devices, in what way could EU-funding help overcome these limitations?

Q12 What are the development pipeline(s) you use (in the team) to create your XR apps, projects and/or setups? For example: "We buy 3D assets from and personalize them in Blender then export/import to Unity where we create a build for our iPhone AR app. We do it this way because".

Q13 If you see limitations in the XR development pipeline, in what way could EU-funding help overcome limitations?

Q14 If you see any limitations of XR expertise development, including knowledge sharing and exchange, in what way could EU-funding help overcome these limitations?

Q15 Are you or your unit a member of any of the following XR Associations?

Q16 According to you, what are the most important strengths of XR technologies in Europe, from a scientific/technical point of view?

Q17 According to you, what are the most important weaknesses of XR technologies in Europe, from a scientific/technical point of view?

Q18 According to you, what are the most important strengths of XR technologies in Europe, from a commercial/business point of view?

Q19 According to you, what are the most important weaknesses of XR technologies in Europe, from a commercial/business point of view?

Page 4: XR Open Issues and European Global Sustainable Goals

Q20 In your opinion, how can XR innovations help address European commitments to achieve the Global Sustainable Goals within the next 10 years? This may be existing innovations, or your predictions for new innovations.

Q21 In your opinion, is there anything else that has not been mentioned in the previous questions of this survey, in terms of how EU-funding can help XR R&D Innovation? Please add any other information and ideas you may have that you have not already mentioned before, in the text box below.

Q22 Update 01/05/2021. Please NOTE: the expert panel selection is underway by now, you can still nominate yourself for the reserve list for the XR Panel consensus surveys below: a) The XR Expert Panel: Two additional surveys which each need about 45 minutes of your time. There will be a week to answer each survey. These additional survey links will be sent to you via email sometime in April-May, 2021.

Q23 b) The XR Lab Best Practices: You can nominate yourself and your R&D lab for a survey or interview of best XR R&D lab practices and future requirements (a 30 minute commitment). A selection of all nominated XR labs will be made by us. This will be 1 survey or interview of about 30 minutes, to be sent to you via email sometime in April - May 2021, if your lab is selected. You will have a week to answer it.

Q24 c) Receive Summary Report: Would you like to receive a copy of the summary of the combined results of the survey you have just responded to?

Q25 What is your best email address? We will not use your information for anything else than to get in touch with you if you replied Yes to one or more of the 3 last questions above. Please add your best email address in the text box below:

Q26 Thank you very much for your time and effort to reply to this survey! We really value your opinion. If there is anything you would like to add, please feel free to use the text box below.

APPENDIX C.1: SURVEY OF ROUND 1

Page 1: Welcome to the EuroXR Consensus study!

Thank you for participating in the XR Panel consensus survey.

You can resize the open answer textbox by pulling on the handle in the bottom right corner.

Please follow the instructions below.

Help us manage the consensus process by not discussing the contents of this survey with anyone until the end of the process, after we close the consensus process, after Round 2. This is Round 1.

Page 2: Lean Delphi Round 1 - May 2021 1 / 11

Q1 Please indicate your agreement to not disclose the contents of this consensus survey, until after we finish both rounds, end of May 2021.

Q2 In your opinion what will be the state-of-the art of XR in 10 years? Please describe the key aspects in 1 or 2 sentences in the textbox below.

Q3 What is needed according to you for the XR field (XR R&D) to reach this potential in the next 10 years? Please describe the key aspects in 1 or 2 sentences.

Q4 What is needed for the XR field in the next 3 to 5 years towards reaching the potential you described in the previous 2 questions? Please describe the key aspects in 1 or 2 sentences.

Page 2: Instructions for the consensus procedure Round 1

Below you will find statements relating to issues for XR Research and Development (XR R&D) progress and innovation.

These statements are based on a literature review and an exhaustive content-analysis of our preliminary survey, representing the opinions of more than 80 respondents from 15 countries in Europe.

The statements are divided into 4 sections: the XR Market, the XR Enabling Environment, XR Human Capital, and the XR Innovation Ecosystem.

Please read each of the statements, and decide in what way you agree / disagree with them.

The aim of this survey, is for you to rewrite the statements in such a way that it is fully in line with your opinion.

The statements are followed by a 4-point scale: Strongly Disagree, Disagree, Agree, Strongly Agree, and an open response box asking you to rewrite the statement in case you do not agree with it.

We kindly ask you to rewrite the statement if you disagree with it.

You can adjust the size of the text box by pulling on the bottom right handle.

Should there be a statement that does not relate to your field of expertise, you can write NA (for Not Applicable) in the text box and move on to the next item.

Please, note that all responses will be treated completely anonymously, and your name will not be mentioned in relation to the information you provide.

As mention in our previous email, we will be glad to share the report of the results of this survey with you in recognition of your time and effort.

Your opinion is vital for the success of this consensus process, so please take your time to express your opinion!

EuroXR

Drive XR Forward

Page 3: XR Market

The following statements are regarding the position of Europe in the XR market and priorities for European Commission (EC) strategies.

Q5 XR technologies are a strategic source of competitiveness for European industries, and their development must be strongly supported by the EC.

Q6 XR technologies are essential for the development and success of the European Alliance for Industrial Data and Clouds.

Q7 XR solutions will help reduce the time-intensive requirement to build physical prototypes dramatically, bringing ideas and innovations to life and products to market far more quickly.

Q8 The EC should focus XR R&D on EU relevant 3D assets, specific to European use-cases.

Q9 The EC should urgently promote standards for Health & Safety for long-term XR use and foster research into Human Factors & Ergonomics for the design of XR input/output devices.

Q10 The EC and XR developers should prioritize R&D to aim for a General Data Protection Regulation (GDPR) for XR users' personal and psychophysical data.

Q11 It is too late for the EU to catch up on the global consumer XR input/output device manufacturing market.

Q12 The EC should focus on XR R&D into hardware, software, and XR displays, in terms of form factor, technology v. size, weight, and power consumption, in order to establish strategic European leadership and competitiveness in the global XR R&D sector.

Q13 The EC should negotiate access to the source code of commercial XR SDKs for EU-based XR labs and developers.

Q14 The EC and XR developers should prioritize research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data, in order to capture the European and global market.

Page 4: XR R&D Enabling Environment at European Level

This section contains statements regarding leadership at European level in terms of standards for XR R&D.

Q15 The EC should help improve continuation and reuse of outstanding R&D results, help share, and help increase visibility of European XR project results.

Q16 The EC should prioritize, support and facilitate access to state-of-the-art XR technologies for the development of multi-user, remote collaboration XR solutions.

Q17 The EC should help increase market growth via more supportive measures for independent XR developers and XR startups, providing more help to fast track breakthrough solutions, help with commercialization of ideas, help with market-entry, and generally making seed money for XR startups more easily accessible.

Q18 The EC must finance projects dealing with legal issues in XR technologies.

Q19 The EC must finance projects investigating anonymity when using XR technologies, but also the role of strong identification when the applications need it.

Q20 The EC must finance R&D regarding the detection, measurement, correction and protection against discrimination of sexual, ethnic and economic minorities, in the use of XR technologies.

Q21 The EC must urgently fund R&D and standardization work towards the cybersecurity of XR technologies.

Q22 The EC must facilitate the certification of XR applications in healthcare, by allocating funds on the one hand, and by establishing favourable regulations on the other hand.

Q23 The EC should promote the collection of rules of best practice concerning the licensing of intellectual property rights in the field of XR, covering in particular the amounts of the royalties, the criteria of exclusivity, and the periods of validity.

Q24 The EC should foster research into making XR technologies and designs accessible to all diverse user groups, not only the currently targeted market-segment (male, educated, English speaking consumers).

Q25 XR researchers and the EC should prioritize XR validation research by systematically mapping out the wide variety of XR use-cases specific to Europe (including EU commitment to the 17 Global Sustainable Development Goals (17SDGs), XR health & safety, human factors and ergonomics for long-term use in serious XR applications, and age- and gender-related issues).

Q26 The EC should urgently promote standardization of 3D scene description format, and also for immersive audio.

Q27 To strengthen European leadership and competitiveness, more research is urgently needed towards the development and exploitation of B2B applications using XR.

Page 5: XR Human Capital

These statements are related to building XR development skills in Europe and awareness for different Technological Readiness Levels (TRL).

Q28 The EC should focus more on preventing the widening of the digital divide by being more inclusive of countries with a low TRL, and by coordinating the allocation of XR human capital and XR development resources.

Q29 The EC should make funds more accessible for new XR labs and independent developers, by increasing the success rate of proposals, and by providing active help and support with the application process.

Q30 The EC should focus more on helping to allocate XR competencies, support mobility of XR experts for international skills exchange, and training of developers at labs and companies for all XR stakeholders.

Q31 The EC should promote research of best practices for successful XR knowledge-transfer cycles within academic-industry collaborations and focus on how to maximize capacity to absorb the new XR skills and XR project output, and integrate the new XR technology solutions into the value chain.

Q32 The EC should promote the creation of scientific councils in high-tech XR companies, and act to facilitate the participation of researchers in these bodies, for example by creating dedicated funding instruments.

Q33 The EC should promote, subsidise, and facilitate access to state-of-the-art XR equipment for end-users and the general public; it should also help raise awareness and understanding of the possibilities and potentials, and inspire potential startup ideas.

Q34 The EC should create more long-term EU projects to facilitate long-term fundamental research, long-term teamwork, skills exchange, and continuity of XR R&D skills development.

Q35 The EC should urgently prioritize, organize and subsidise XR developers training and affordable train-the-trainer educational events at all educational levels, to address the shortage in skilled XR developers and instructors.

Q36 The EC should make available and subsidize easily accessible 3D printing opportunities for rapid-prototyping of XR hardware designs by XR end-users, which will facilitate them to tailor the designs based on their own experiences, and enabling a user-driven evolution in input/output solutions.

Q37 The EC should develop specific support for the optimization of academic-industry collaboration for XR R&D projects, because the type of knowledge exchange needed for XR development may affect the success of the collaboration in unknown ways, and improvements could be made in terms of better management of XR researchers' creative capacity, adjustments to the incentives structure, senior management support and strong leadership focussed on rapid XR R&D skills development.

Q38 The EC should prioritize the development of a competitive Open Source XR platform with specific functions and features built-in or plug-ins for scientific and psychophysiological big data-analysis, and capable of parallel processing, providing real-time, collaborative XR experiences, with a clear business model for monetizing contents.

Q39 The EC needs to improve the support for European XR R&D scaling up of its innovators and SMEs and reduce the currently existing notable scaling-up gap for XR tech scaleups and unicorn companies, in relation to the United States and China.

Page 6: Innovation Ecosystem: XR Platform and Infrastructures

The following statements relate to the XR Development Platform: middleware / game-engine.

Q40 The EC should neither partner with existing commercial XR platform vendors, nor create EU subsidized bulk-access to existing/commercial XR platforms and assets, for members of the European Union, as such actions would create strong bias in competition.

Q41 XR technologies can potentially provide a strong and adequate response to the problem of carbon emissions, by making remote work and interactions between people more efficient, thus reducing the need for personal or professional travel and developments for solutions into this direction should be prioritized.

Q42 The EC should urgently support the development of a EU specific XR Development Asset store, with shareware assets that are available for EU developers at no-cost or low-cost.

Q43 The EC should urgently support solutions for low cost, reusable, interoperability solutions for integrations of domain specific data such as BIM, scientific simulations, etc., and these solutions should be independent from the current mainstream XR software companies and make it as efficient as possible to plug into the currently most used interactive XR platforms.

Q44 In order to capture a market share, the EC needs to urgently support R&D to expand and improve the XR development pipeline in terms of asset types, complexity of data and ontologies, to improve interoperability between the different asset formats used in different industries.

Q45 The EC should support XR R&D for input/output devices that go well beyond the currently developed devices, for instance climate input/output devices (wind, rain, etc), olfactory IO devices (providing scents), hand tracking and use-case specific haptic devices.

Q46 The EC should engage and provide full support to large companies and manufacturers of XR components, such as Zeiss, Bang & Olufsen, STMicroelectronics, etc., in order to spur the development of XR devices.

Q47 The EC should urgently promote the development of WebXR technologies.

Page 6: Demographic Questions

Q48 How would you describe your field of expertise? Please provide 3 to 5 keywords or phrases.

Q49 What is your gender?

Q50 What is your age?

Q51 What is your email address in case we need to follow up on any of your responses. We will not use it for anything else. (There is no obligation to provide this information.)

Q52 If there is anything else essential to the success of XR for Europe and globally, that was not covered by the statements above, please feel free to add your additions below.

APPENDIX C.2: DELPHI XR PANEL RESPONSE SUMMARIES ROUND 1

R1 Q5 XR technologies are a strategic source of competitiveness for European industries, and their development must be strongly supported by the EC.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00%	0,00%	14,29% (1)	85,71% (6)	7	3,86

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,86	0,35

Responses

I believe the most important in Industry is the creation of a continuous information system. AI will be based on it, and the role of XR will not be only competitiveness but to keep human control on AI and information systems. It will be thus a strategic source for societal acceptance of digital era. Competitiveness will be a secondary effect.

EU cannot compete with low labour cost countries. High knowledge work will be future of EU and XR supported work is one key tech for it.

This statement is accurate, and no rewrite is written. However, I will add that the US and China are currently leading the charge in XR and if the EC does not invest heavily, it will never be able to catch up.

Responses

Because industrial data (cloud or other) must be under human control.

N/A (I answer disagree because I could not leave it blank, but This is out of my area of expertise, and I wouldn't answer)

Web / online XR is coming (apple & google). All [typo] in professional work it is essential asset

R1 Q5 XR technologies are a strategic source of competitiveness for European industries, and their development must be strongly supported by the EC.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00%	0,00%	14,29% (1)	85,71% (6)	7	3,86

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,86	0,35

Responses

I believe the most important in Industry is the creation of a continuous information system. AI will be based on it, and the role of XR will not be only competitiveness but to keep human control on AI and information systems. It will be thus a strategic source for societal acceptance of digital era. Competitiveness will be a secondary effect.

EU cannot compete with low labour cost countries. High knowledge work will be future of EU and XR supported work is one key tech for it.

This statement is accurate, and no rewrite is written. However, I will add that the US and China are currently leading the charge in XR and if the EC does not invest heavily, it will never be able to catch up.

R1 Q6 XR technologies are essential for the development and success of the European Alliance for Industrial Data and Clouds.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00%	14,29% (1)	42,86% (3)	42,86% (3)	7	3,29

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	3,29	0,70

Responses
Because industrial data (cloud or other) must be under human control.
N/A (I answer disagree because I could not leave it blank, but This is out of my area of expertise, and I wouldn't answer)
Web / online XR is coming (apple & google). All will be could based and in professional work it is essential asset

R1 Q7 XR solutions will help reduce the time-intensive requirement to build physical prototypes dramatically, bringing ideas and innovations to life and products to market far more quickly.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	28,57% (2)	71,43% (5)	7	3,71

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,71	0,45

Responses

This has been proven in several research papers already in 10 years ago, BUT this has been mainly possible for large companies. Currently SMEs are able to take XR for their design process

XR solutions will help reduce the time-intensive requirement to build physical prototypes dramatically, bringing ideas and innovations to life and products to market far more quickly but will never replace the need for physical prototypes.

R1 Q8 The EC should focus XR R&D on EU relevant 3D assets, specific to European use-cases.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
14,29% (1)	42,86% (3)	28,57% (2)	14,29% (1)	7	2,43

Minimum	Maximum	Median	Mean	Standard Deviation
1.00	4.00	2.00	2,43	0,90

Responses

N/A: indeed, I do not understand what is a relevant EU Relevant 3D asset.

I don't know what does the question mean with "European use-cases". (I answer disagree because I didn't understand that and It is not possible to leave it blank, but I wouldn't answer)

Not only to European use cases because we might be able to work in worldwide projects and also market driven projects for other markets to bring funding to Europe.

As Google, Facebook and Apple are heavily investing this area and data will be used in their business. EU needs own platform which their can control

The EC should focus XR R&D on EU technology companies that have the potential to become world leaders, specifically in the field of XR optics and displays and human machine interface where Europe currently has a lead and which are a key technology missing links to widespread XR adoption.

The EC should focus XR R&D on relevant 3D assets that has strong potentiality of worldwide impact.

R1 Q9 The EC should urgently promote standards for Health & Safety for long-term XR use and foster research into Human Factors & Ergonomics for the design of XR input/output devices.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	14,29% (1)	85,71% (6)	7	3,86

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,86	0,35

Responses

For sure! The form factor of those headsets needs to be lighter and much more comfortable for users and for a long-term use.

As XR will be used in daily bases in professional work and there are not so much research results of Health & Safety & Ergonomic. This is important topic for workers

R1 Q10 The EC and XR developers should prioritize R&D to aim for a General Data Protection Regulation (GDPR) for XR users' personal and psychophysical data.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	28,57% (2)	28,57% (2)	42,86% (3)	7	3,14

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	3,14	0,83

Responses

GDPR is important for XR as for every other digital tools. It must be developed, and it includes new personal information which must be addressed. Not sure if it is the first priority.

It is important, but I would not prioritize this over other research topics

As Google, Facebook and Apple are involved to XR, there should be strong focus to GDPR

The EC and XR developers should prioritize R&D where breakthroughs are needed that are in line with General Data Protection Regulation (GDPR) for XR users' personal and psychophysical data.

For sure!

R1 Q11 It is too late for the EU to catch up on the global consumer XR input/output device manufacturing market.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	42,86% (3)	57,14% (4)	0,00% (0)	7	1,57

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	2.00	2.00	1,57	0,49

Responses

COVID period demonstrate the need of relocalisation of major industries, and digital industries are part of it. European competencies are still high and investments are highly recommended not to be dependent on Asian production.

It is not late, but Europe should put an effort to catch up

It can be created a specific label "Made in EU" with a sort of specific features in according of the people wants. Copy right of contains or high level of visualisation can be a useful tool to protect and develop own devices. Regional Silicon Valley to develop and regional low-cost fabrication have to be done.

There is a large opportunity for this market although I think that for manufacturing, we will always face China as the main competitor. But for R&D we can do it all...

There are still new innovation coming from EU e.g. Varjo's HMDs from Finland

It is not too late for the EU to catch up on the global consumer XR input/output device and display manufacturing market but needs to accelerate investment and focus in these fields.

EU should better promote start-ups and companies contributing to the global consumer XR input/output device manufacturing market.

R1 Q11 It is too late for the EU to catch up on the global consumer XR input/output device manufacturing market.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	42,86% (3)	57,14% (4)	0,00% (0)	7	1,57

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	2.00	2.00	1,57	0,49

Responses

COVID period demonstrate the need of relocalisation of major industries, and digital industries are part of it. European competencies are still high and investments are highly recommended not to be dependent on Asian production.

It is not late, but Europe should put an effort to catch up

It can be created a specific label "Made in EU" with a sort of specific features in according of the people wants. Copy right of contains or high level of visualisation can be a useful tool to protect and develop own devices. Regional Silicon Valley to develop and regional low-cost fabrication have to be done.

There are a large opportunity for this market although I think that for manufacturing we will always face China as the main competitor. But for R&D we can do it all...

There are still new innovation coming from EU e.g. Varjo's HMDs from Finland

It is not too late for the EU to catch up on the global consumer XR input/output device and display manufacturing market but needs to accelerate investment and focus in these fields.

EU should better promote startups and companies contributing to the global consumer XR input/output device manufacturing market.

R1 Q12 The EC should focus on XR R&D into hardware, software, and XR displays, in terms of form factor, technology v. size, weight, and power consumption, in order to establish strategic European leadership and competitiveness in the global XR R&D sector.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	28,57% (2)	28,57% (2)	42,86% (3)	7	3,14

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	3,14	0,83

Responses

I would add, human factors and interaction paradigms to the list

There is already huge market of devices. EU should focus to application and SW platforms

The EC should focus its XR R&D into hardware and XR displays, in terms of form factor, technology v. size, weight, and power consumption, in order to establish strategic European leadership and competitiveness in the global XR market. XR Software should not be a main focus because it will continue to be dominated and driven by established big tech giants such as Apple (IOS) and Android (Google).

The EC should focus on XR R&D into hardware, software, and XR displays, in terms of ergonomics, customization, form factor, technology v. size, weight, and power consumption, in order to establish strategic European leadership and competitiveness in the global XR R&D sector.

R1 Q13 The EC should negotiate access to the source code of commercial XR SDKs for EU-based XR labs and developers.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	14,29% (1)	42,86% (3)	42,86% (3)	7	3,29

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	3,29	0,70

Responses

It would be part of the standardization capacity effort.

Not to interfere in the political view of those but to facilitate the access, costs and mainly to help those companies to get the proper feedback about it.

Especially from Horizon Europe projects

The EC should not put much energy into negotiating access to the source code of commercial XR SDKs for EU-based XR labs and developers since these SDK's will be controlled by dominant tech giants such as Apple and Google.

R1 Q14 The EC and XR developers should prioritize research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data, in order to capture the European and global market.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	14,29% (1)	42,86% (3)	42,86% (3)	7	3,29

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	3,29	0,70

Responses

That's important, but not a priority over other research topics

European people are more sensitive with the right use of XR. EC have to create a standard of use and declare the risk of use of XR without rules.

Especially from Horizon Europe projects

Not only the European but the global market. Otherwise, we will be closed for the rest of the world with lots of different use cases, behaviours, and richness of CX that could help us to improve ours.

Not expert on this topic

The EC and XR developers should prioritize research into XR User eXperience and User Interface (UX/UI) to capture the European and global market since major breakthroughs are needed in this area for mainstream XR adoption.

R1 Q15 The EC should help improve continuation and reuse of outstanding R&D results, help share, and help increase visibility of European XR project results.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	14,29% (1)	85,71% (6)	7	3,86

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,86	0,35

Responses

Yeah. That should have and open database with some moderation that could help us to show to the rest of the market for example that the use of VR helps users to learn 4x faster or other R&D research results that could help to promote the technology.

Especially from Horizon Europe projects

Especially from Horizon Europe projects

The EC should help improve continuation and reuse of outstanding R&D results, help share, and help increase visibility of European XR project results through a dedicated vehicle with adequate funding.

R1 Q16 The EC should prioritize, support, and facilitate access to state-of-the-art XR technologies for the development of multi-user, remote collaboration XR solutions.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	14,29% (1)	85,71% (6)	7	3,86

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,86	0,35

Responses

Multi-user is definitely the future of all experiences. We can't (or at least shouldn't) do anything alone in our lives. Why would we do it alone in XR?

EU should have DIH like state-of-the-art XR labs and test centers

R1 Q17 The EC should help increase market growth via more supportive measures for independent XR developers and XR startups, providing more help to fast track breakthrough solutions, help with commercialization of ideas, help with market-entry, and generally making seed money for XR startups more easily accessible.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	28,57% (2)	57,14% (4)	7	3,29

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	4.00	3,29	0,88

Responses

It is preferable to group independents in a European consortium where each actor develop specific skills. Consortium drives the global strategic development in the aim to build 2 or 3 global solutions to answer the XR market.

For sure but with global (European) integration, not specifically for one or two countries. I do believe that the integration of small/medium markets could leverage even more the technology.

Not expert on this topic

R1 Q18 The EC must finance projects dealing with legal issues in XR technologies.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	85,71% (6)	14,29% (1)	7	3,14

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	3.00	3,14	0,35

Responses

For me there are other priorities but yes.

Should be part of CSA

R1 Q19 The EC must finance projects investigating anonymity when using XR technologies, but also the role of strong identification when the applications need it.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	28,57% (2)	28,57% (2)	42,86% (3)	7	3,14

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	3,14	0,83

Responses

Even more using XR cause the data that can be collected is even more sensitive.

As Google, Facebook and apple will collect data from their platform.

The EC must finance projects that show the potential of real breakthroughs in XR technologies.

R1 Q20 The EC must finance R&D regarding the detection, measurement, correction and protection against discrimination of sexual, ethnic and economic minorities, in the use of XR technologies.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	14,29% (1)	28,57% (2)	51,14% (4)	7	3,43

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	4.00	3,43	0,73

Responses
How to disagree
Always
Not expert on this topic

R1 Q21 The EC must urgently fund R&D and standardization work towards the cybersecurity of XR technologies.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	57,14% (4)	42,86% (3)	7	3,43

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	3.00	3,43	0,49

Responses
It can guarantee the security of copy right and spy for the companies using XR
Always
Especially personal XR devices which are going to be part of mobile phone

R1 Q22 The EC must facilitate the certification of XR applications in healthcare, by allocating funds on the one hand, and by establishing favorable regulations on the other hand.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	14,29% (1)	28,57% (2)	57,14% (4)	7	3,43

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	4.00	3,43	0,73

Responses

Not expert on this topic

I think that the focus right now should be on the regulation theme cause we do already have a lot of ongoing experiences but the lack or difficulty to certificate those experiences is not helping to promote this subject.

R1 Q23 The EC should promote the collection of rules of best practice concerning the licensing of intellectual property rights in the field of XR, covering in particular the amounts of the royalties, the criteria of exclusivity, and the periods of validity.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	14,29% (1)	57,14% (4)	28,57% (2)	7	3,14

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	3,14	0,64

Responses

Agree but also why not promoting open-source solutions.

Yes, as mentioned before, an open database from a common reference could help a lot the whole market.

There should be open access to code which has been developed under Horizon Europe projects

R1 Q24 The EC should foster research into making XR technologies and designs accessible to all diverse user groups, not only the currently targeted market-segment (male, educated, English speaking consumers).

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	28,57% (2)	28,57% (2)	42,86% (3)	7	3,86

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	3,14	0,83

Responses

Agree but also why not promoting open source solutions.

Yes, as mentioned before, an open database from a common reference could help a lot the whole market.

There should be open access to code which has been developed under Horizon Europe projects

R1 Q25 XR researchers and the EC should prioritize XR validation research by systematically mapping out the wide variety of XR use-cases specific to Europe (including EU commitment to the 17 Global Sustainable Development Goals (17GSDG), XR health & safety, human factors and ergonomics for long-term use in serious XR applications, and age- and gender-related issues).

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	57,14% (4)	42,86% (3)	7	3,43

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	3.00	3,43	0,49

Responses

Not only European but worldwide. We can do it better over here if we can see what's happening all over the world.

As this will be part of daily based work environment, this information is needed

R1 Q26 The EC should urgently promote standardization of 3D scene description format, and also for immersive audio.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	57,14% (4)	42,86% (3)	7	3,43

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	3.00	3,43	0,49

Responses

Not a priority for now but yes.

There are not so many widely used standard in field of XR

R1 Q27 To strengthen European leadership and competitiveness, more research is urgently needed towards the development and exploitation of B2B applications using XR.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	14,29% (1)	42,86% (3)	42,86% (3)	7	3,29

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	3,29	0,70

Responses

More open databases as well

XR field needs more business

R1 Q28 The EC should focus more on preventing the widening of the digital divide by being more inclusive of countries with a low TRL, and by coordinating the allocation of XR human capital and XR development resources.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	28,57% (2)	28,57% (2)	42,86% (3)	7	3,14

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	3,14	0,83

Responses

Not expert on this topic

The EC should focus more on preventing the widening of the digital divide by pushing inclusiveness in each EU country, and by coordinating the allocation of XR human capital and XR development resources.

R1 Q29 The EC should make funds more accessible for new XR labs and independent developers, by increasing the success rate of proposals, and by providing active help and support with the application process.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	14,29% (1)	28,57% (2)	57,14% (4)	7	3,43

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	4.00	3,43	0,73

Responses

If EU want be best of this field, most brilliant ideas should be funded

R1 Q30 The EC should focus more on helping to allocate XR competencies, support mobility of XR experts for international skills exchange, and training of developers at labs and companies for all XR stakeholders.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	28,57% (2)	71,43% (5)	7	3,71

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,71	0,45

Responses

Networks are helping to knowledge exchange

R1 Q31 The EC should promote research of best practices for successful XR knowledge-transfer cycles within academic-industry collaborations and focus on how to maximize capacity to absorb the new XR skills and XR project output, and integrate the new XR technology solutions into the value chain.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	28,57% (2)	71,43% (5)	7	3,71

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,71	0,45

Responses

It is necessary to create a label to guarantee the level of knowledge for each actor in the XR domain,

Results from H2020 and Horizon Europe should be widely disseminated and exploit in companies

R1 Q32 The EC should promote the creation of scientific councils in high-tech XR companies, and act to facilitate the participation of researchers in these bodies, for example by creating dedicated funding instruments.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	28,57% (2)	71,43% (5)	7	3,71

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,71	0,45

Responses

promote and support XR infrastructure for edge technology deployment and usage.

If EU wants to be leader of this area, It needs this council

R1 Q33 The EC should promote, subsidise, and facilitate access to state-of-the-art XR equipment for end-users and the general public; it should also help raise awareness and understanding of the possibilities and potentials, and inspire potential start-up ideas.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	42,86% (3)	57,14% (4)	7	3,57

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,75	0,49

Responses

unclear about this point

It can be interesting to develop public or private centers that can share XR-equipments with other members in the aim to make profitable investments

This is a key point for the evolution of this category.

DIH like XR labs for show casing tech

R1 Q34 The EC should create more long-term EU projects to facilitate long-term fundamental research, long-term teamwork, skills exchange, and continuity of XR R&D skills development.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	28,57% (2)	71,43% (5)	7	3,71

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,71	0,45

Responses

Yes, this should be worked by funding not only specific initiatives but university departments for example.

But is should more in area where is not yet application like smell, temperature...

R1 Q35 The EC should urgently prioritize, organize and subsidies XR developers training and affordable train-the-trainer educational events at all educational levels, to address the shortage in skilled XR developers and instructors.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
14,29% (1)	0,00% (0)	28,57% (2)	57,14% (4)	7	3,29

Minimum	Maximum	Median	Mean	Standard Deviation
1.00	4.00	4.00	3,29	1,03

Responses

This more for universities and/or XR software providers issue

The EC should prioritize, organize and subsidise XR developers training and affordable train-the-trainer educational events at all educational levels, to address the shortage in skilled XR developers and instructors.

R1 Q36 The EC should make available and subsidize easily accessible 3D printing opportunities for rapid-prototyping of XR hardware designs by XR end-users, which will facilitate them to tailor the designs based on their own experiences, and enabling a user-driven evolution in input/output solutions.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	28,57% (2)	57,1457% (4)	14,29% (1)	7	2,86

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	3.00	2,86	0,64

Responses

It looks marginal issue. EC should support hardware design and prototyping.

Not all use of XR ends in a physical prototype. User-experience in XR have to be more realistic and credible to make project assessments inside of virtual simulation

Not expert on this topic

R1 Q37 The EC should develop specific support for the optimization of academic-industry collaboration for XR R&D projects, because the type of knowledge exchange needed for XR development may affect the success of the collaboration in unknown ways, and improvements could be made in terms of better management of XR researchers' creative capacity, adjustments to the incentives structure, senior management support and strong leadership focussed on rapid XR R&D skills development.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	28,57% (2)	71,43% (5)	7	3,71

Minimum	Maximum	Median	Mean	Standard Deviation
3.00	4.00	4.00	3,71	0,45

Responses

Industry has to recognize that XR is not free and anybody can do it. It is necessary to sensitize industry that academic or XR private specialists have a good level of knowledge of this technology. An European label has to be created to guarantee this.

For sure. The timing is different in those areas and it needs somehow to be adjusted to be improved.

Assuming that this is already focus in H2020 and Horizon Europe projects

R1 Q38 The EC should prioritize the development of a competitive Open Source XR platform with specific functions and features built-in or plug-ins for scientific and psychophysiological big data-analysis, and capable of parallel processing, providing real-time, collaborative XR experiences, with a clear business model for monetizing contents.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
14,29% (1)	0,00% (0)	28,57% (2)	57,14% (4)	7	3,29

Minimum	Maximum	Median	Mean	Standard Deviation
1.00	4.00	4.00	3,29	1,03

Responses

I would add research purposes

I think that EC should focus on the standards first.

There are not enough standards or common platforms

R1 Q39 The EC needs to improve the support for European XR R&D scaling up of its innovators and SMEs and reduce the currently existing notable scaling-up gap for XR tech scaleups and unicorn companies, in relation to the United States and China.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	14,29% (1)	28,57% (2)	57,14% (4)	7	3,43

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	4.00	3,43	0,73

Responses

It is necessary to create the European Silicon Valley to get better international visibility in the European products.

We don't need unicorns for XR markets. We need healthy and reliable companies that could leverage the use of XR. And also make lots of money.

Not expert on this topic

The EC needs to URGENTLY improve the support and funding for European XR R&D scale ups and SMEs and reduce the currently existing notable scaling-up gap for XR tech start-ups, scaleups and future unicorn companies, in relation to the United States and China.

R1 Q40 The EC should neither partner with existing commercial XR platform vendors, nor create EU subsidized bulk-access to existing/commercial XR platforms and assets, for members of the European Union, as such actions would create strong bias in competition.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	42,29% (1)	57,14% (4)	0,00% (0)	7	2,57

Minimum	Maximum	Median	Mean	Standard Deviation
2.00	4.00	4.00	3,43	0,73

Responses

It is necessary to create the European Silicon Valley to get better international visibility in the European products.

We don't need unicorns for XR markets. We need healthy and reliable companies that could leverage the use of XR. And also make lots of money.

Not expert on this topic

The EC needs to URGENTLY improve the support and funding for European XR R&D scale ups and SMEs and reduce the currently existing notable scaling-up gap for XR tech start-ups, scaleups and future unicorn companies, in relation to the United States and China.

R1 Q41 XR technologies can potentially provide a strong and adequate response to the problem of carbon emissions, by making remote work and interactions between people more efficient, thus reducing the need for personal or professional travel and developments for solutions into this direction should be prioritized.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	28,57% (2)	28,57% (2)	42,86% (3)	7	3,14

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	3,00	3,14	0,83

Responses

Complete carbon impact should be investigated to ensure this statement. A priori I can agree, but this is not demonstrated. Or EC should invest on low consumption hardware and server solutions.

Maybe XR can have an application here, but I don't think this is an important field of application for XR

Lots of companies are using this and we should have this increased due to the COVID traveling restrictions.

Not expert on this topic

R1 Q42 The EC should urgently support the development of an EU specific XR Development Asset store, with shareware assets that are available for EU developers at no-cost or low-cost.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	28,57% (2)	14,29% (1)	57,14% (4)	7	3,29

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	4,00	3,29	0,88

Responses

Advised to have a strong quality filter for the assets.

This should company driven

The EC should urgently support the development of a EU specific XR Development Asset store, with shareware assets that are available for worldwide developers at no-cost or low-cost.

R1 Q43 The EC should urgently support solutions for low cost, reusable, interoperability solutions for integrations of domain specific data such as BIM, scientific simulations, etc., and these solutions should be independent from the current mainstream XR software companies, and make it as efficient as possible to plug into the currently most used interactive XR platforms.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	14,29% (1)	14,29% (1)	71,43% (5)	7	3,57

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	4,00	3,57	0,73

Responses

Yes, but mainly trying to understand/create/adopt worldwide standards.

Best practices in industrial applications

R1 Q44 In order to capture a market share, the EC needs to urgently support R&D to expand and improve the XR development pipeline in terms of asset types, complexity of data and ontologies, to improve interoperability between the different asset formats used in different industries.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	28,57% (2)	14,29% (1)	57,14% (4)	7	3,29

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	4,00	3,29	0,88

Responses

Support R&D is the key part of this.

Not expert in this topic

R1 Q45 The EC should support XR R&D for input/output devices that go well beyond the currently developed devices, for instance climate input/output devices (wind, rain, etc), olfactory IO devices (providing scents), hand tracking and use-case specific haptic devices.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	28,57% (2)	14,29% (1)	57,14% (4)	7	3,29

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	4,00	3,29	0,88

Responses
I would prioritize hand tracking over the others mentioned in the sentence
Yes, for a more immersive experience, haptics is needed and to research for a standard is needed. Although we might have few options we might work on the standards as well.
Not expert on this topic

R1 Q46 The EC should engage and provide full support to large companies and manufacturers of XR components, such as Zeiss, Bang & Olufsen, STMicroelectronics, etc., in order to spur the development of XR devices.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
14,29% (1)	0,00% (0)	57,14% (4)	28,57% (2)	7	3,00

Minimum	Maximum	Median	Mean	Standard Deviation
1,00	4,00	3,00	3,00	0,93

Responses

EC needs in addition to support integrators of XR devices

But components is out of my area of expertise. I wouldn't answer if not mandatory

This should be market driven

The EC should engage and provide full support to Start-ups, SMEs and scale ups for XR components in order to spur the development of XR devices since breakthrough innovations generally come out of startups and not large groups.

R1 Q47 The EC should urgently promote the development of WebXR technologies.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	42,86% (3)	57,14% (4)	7	3,57

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	4,00	4,00	3,57	0,49

Responses

WebXR is a solution among others.

Definitely WebXR will be a major feature in the future.

This allows wider XR user and better content creation

APPENDIX D.1: SURVEY OF ROUND 2

Welcome to the final round of the EuroXR Consensus study!

This is Round 2, the final round of this consensus study.

It should take about 45 minutes to complete this final round.

Thank you very much for your time and effort.

You can resize the answer boxes by pulling the handle in the bottom right corner of the box down and out to the right.

Lean Delphi Round 2 - May 2021 1 / 12

Q1 Please indicate your agreement to not disclose the contents of this consensus survey, until after we finish both rounds, end of May 2021: yes/no

Q2 I also responded to round 1 of this consensus survey: yes/no

Q3 According to you, the XR panel, the XR field in 2030 could be like: XR and AI will be combined to create an intelligent, human-centered, harmonious, safe symbiosis of humans and data, visualized in 3D, analysed, personalized and targeted by AI, and this will be standardized, and publicly accepted. Personal XR devices will replace the smartphone, and will be even more ubiquitous in use than smartphones, for work and social life, and they are less intrusive, and more comfortable and lighter to wear. Ultra-realistic haptic body suits will have automatic body tracking by cameras, and image accuracy and visual effects will be automatically adapted based on the anthropomorphic parameters of the user. The UI is thought- and gesture-driven. The business model to deploy XR for the various use cases has been clarified. Interactive XR movies, and 1st person XR visits to remote places (virtual tourism) are dominating the consumer market. Expert XR apps will be widely available and widely in use. Does this summarize and reflect your opinion in full? Please rewrite or comment in the text box below so that it is in line with your opinion.

Q4 We asked you, the XR panel, what do we need to do in the next 10 years to reach State of XR 2030? The responses were: XR and AI integrations need to take place by developing a deep link between XR, AI, ML, CS, Maths, Psycho Neuroscience, and Social Science, and by resolving the ethical issues. Using AI to improve the design and size of the XR devices, speed up content creation via automatic BCI-XR content creation, and highly usable, safe professional use cases, interactive movies and remote presence apps (tourism, etc). integrated academic-industry commercialization of XR research and development results Technology breakthroughs are needed for: Ultra realistic haptic

bodysuit, XR content creation via BCI, XR-UI via BCI. Does this reflect your views in full? Please rewrite this statement or describe your opinion in 1 or 2 sentences.

Q5 We asked you, the XR Panel, what to do in the next 3-5 years to reach the predicted State of XR in 2030? The responses were: Huge investment and tax reductions needed from EC and locally for XR R&D and manufacturing of: Ultra realistic haptic bodysuit, XR content for interactive movies and remote presence and interactions, XR-UI via BCI, Shared, accessible API - Open source XR development platform, Cheap and easy access to XR development tools (and training?), Continuous transfer of deployable apps from project demonstrators. Integration of XR with CS, Maths, Psycho-neuroscience, and Social Science. Automatic content creation for XR solutions combinations of AI and IoT for support of the XR developer's work of professional applications. HMD without cables, stand-alone (wifi to cloud). XR data computed in the cloud. Earth-wide system with XR HMDs tracked for collaboration between systems. Does this reflect your opinion in full? Please rewrite the statement above or describe your opinion in 1 or 2 sentences in the text box below.

Page 2: Instructions for the consensus procedure Round 2

Dear XR Panel Member,

Below you will find the results from all statements of our Round 1 survey.

Half of the statements from Round 1 were accepted a by all members of the XR panel. These statements are presented in the second half of the survey for your information.

The other half of the statements were accepted by most, but not all XR Panel members.

These statements were rewritten, based on your suggestions, and they are presented below.

We kindly ask you to check them, and indicate whether you agree with it.

The aim of this final survey is to seek consensus on the statements: for you to tell us if we interpreted your opinion correctly; tell us if we summarized it correctly to achieve the XR panel consensus; and for you to have a final opportunity to rewrite the statements.

Please help us complete this final consensus round of the survey, by rewriting the statements so that they are fully in line with your opinion.

You can adjust the size of the text box by pulling on the bottom right handle.

All responses will be treated completely anonymously, and your name will not be mentioned in relation to the information you provide.

We look forward to sharing the report of the results of this survey with you in recognition of your time and effort.

Your opinion is vital for the success of this consensus process, so please take your time to express your opinion!

EuroXR

Together, Driving XR Forward

P.S. At the end of the survey you can register your interest in being part of the XR Panel discussion at the EuroXR Conference 2021, 24-26 November.

Q6 Old version: The EC should prioritize the development of a competitive, state-of-the-art open source XR platform with a clear business model for monetizing contents. One respondent disagreed with the statement and believes the EC should first focus on standards for XR. Another respondent asked for the addition of the word Research. New version: The EC should prioritize the development of a competitive, state-of-the-art open source XR research platform with a clear business model for monetizing contents. Please rewrite the statement to make it fully in line with your opinion, or explain your opinion using the text box below.

Q7 Old version: The EC should neither partner with existing commercial XR platform vendors, nor create EU subsidized bulk-access to existing/commercial XR platforms and assets, for members of the European Union, as such actions would create strong bias in competition. There seems to be a true 50/50 divide between respondents in the XR Panel in terms of what is best: partner or not partner. We rewrote the statement based on your feedback and ask for your feedback again, in order to clear up this divide in opinions. New version: If the EC were to partner with existing commercial XR platform vendors and/or provide EU subsidized bulk-access to commercial XR platforms and assets, then this would create a strong bias in competition.

Q8 The EC needs to improve the support for European XR R&D scaling up of its innovators and SMEs and reduce the currently existing notable scaling-up gap for XR tech scaleups and unicorn companies, in relation to the United States and China. This statement received some additional comments, six

respondents agreed with it and one respondent withheld their response. One respondent wanted to include the word Urgent. How urgent is this according to you:

Page 3: Section 1: XR Panel requested a rewrite and some newly suggested statements

Q9 Old version: The EC should focus XR R&D on EU relevant 3D assets, specific to European use-cases. Many XR Panel members asked about the meaning of EU relevant assets. This is further explained in the rewritten statement below. New version: The EC should focus on the potential market share in creating 3D asset libraries specific to European Industry 4.0 use-cases to help speed up European XR development, because many European industry use-cases are early-adopters of high-precision manufacturing using XR Industry 4.0 solutions, these use-case specific 3D assets are expected to become of interest world-wide. Please feel free to add your comments below or rewrite the statement if it is not in line with your opinion.

Q10 Old version: The EC should focus more on preventing the widening of the digital divide by pushing inclusiveness in each country, and by coordinating the allocation of XR human capital and XR development resources. This statement received 29% disagreement (1= disagree, 1= no opinion), and the statement has been updated according to the suggestions. New version: The EC should focus more on preventing the widening of the digital divide by being more inclusive of countries with a low TRL, and by coordinating the allocation of XR human capital and XR development resources. Please rewrite the statement if it is not in fully in line with your opinion.

Q11 Old version: The EC and XR developers should prioritize research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data, in order to capture the European and global market. Only one XR Panel member disagreed with this statement on the basis that they are not an expert on the topic. The panel members provided comments. One rewrite was suggested where CX would be replaced with UX, but this is already covered in other statements. The main point of this statement is that there is a market gap in the combination of XR and CX when using psychophysiological user behaviour data, which is recommended to be commercialized. New version: The EC and XR developers can capture the European and global market by prioritizing research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data. Please feel free to add your comments or rewrite the statement to make it fully in line with your opinion.

Q12 Old version: The EC should negotiate access to the source code of commercial XR SDKs for EU-based XR labs and developers. Several respondents suggested variations of this statement, which can be synthesized in the following. Do you agree with the following statement? New version: The EC should negotiate towards the standardization and open source access of commercial XR SDKs, and encourage

their adoption in Horizon Europe projects. Please rewrite the statement if it is not in line with your opinion.

Q13 Old version: The EC should focus on XR R&D into hardware, software, and XR displays, in terms of form factor, technology v. size, weight, and power consumption, in order to establish strategic European leadership and competitiveness in the global XR R&D sector. Several respondents suggested variations of this statement, which can be synthesized in the following. Do you agree with the following statement? New version: The EC needs to focus the R&D in XR technology in order to establish strategic European leadership and competitiveness in the global XR R&D sector. In terms of hardware, the focus should be on human factors, interaction paradigms, ergonomics, customization, form factor, technology vs size, weight, and power consumption. In terms of software, the focus should be on applications and SW platforms built on top of de facto market standards (IOS, Android). Please rewrite the statement if it is not in line with your opinion.

Q14 Old version: It is too late for the EU to catch up on the global consumer XR input/output device manufacturing market. Four XR Panel members disagreed with this statement. Seven XR Panel members write comments. One rewrite was provided. Their rewrite suggests another statement as follows: "EU should better promote startups and companies contributing to the global consumer XR input/output device manufacturing market", which is already covered in other statements. New version: It is not too late for the EU to catch up on the global consumer XR input/output device manufacturing market. Please rewrite the statement to make it fully in line with your opinion.

Q15 Old version: The EC and XR developers should prioritize R&D to aim for a General Data Protection Regulation (GDPR) for XR users' personal and psychophysical data. Two XR Panel members disagreed with this statement and the others made comments about whether this should or should not be prioritized. The main point of this statement is to prioritize protection of user data. New version: With several global players interested in monetizing users' data, more research into General Data Protection Regulation (GDPR) is needed, specifically regarding protection and regulation of XR users' personal and psychophysiological data.

Q16 Old version: The EC should help increase market growth via more supportive measures for independent XR developers and XR startups, providing more help to fast track breakthrough solutions, help with commercialization of ideas, help with market-entry, and generally making seed money for XR startups more easily accessible. There are two XR Panel members who disagree with this statement. One claims they are not an expert of the topic and does not provide a rewrite. The other one makes the following comment: "It is preferable to group independents in a European consortium where each actor develop specific skills. Consortium drives the global strategic development in the aim to build 2 or 3 global solutions to answer the XR market." New version: The EC should give more support to individual European XR startups directly, in order to help with commercialization of ideas, help with market-entry,

and generally make seed money for XR startups more easily accessible. Please feel free to add your comments below or rewrite the statement if it is not fully in line with your opinion.

Q17 Old version: The EC must finance projects investigating anonymity when using XR technologies, but also the role of strong identification when the applications need it. Two XR Panel members disagree with this statement. One leaves no comment or rewrite. The other one believes that the EC must finance projects that show the potential of real breakthroughs in XR technologies. New version: It is important the EC fund projects that investigate methods to establish anonymity when using XR technologies, but it should also fund projects to achieve strong identification and authentication in a secure manner in cases where applications need it. Please rewrite this statement if it is not in line with your opinion.

Q18 The EC must finance R&D regarding the detection, measurement, correction and protection against discrimination of sexual, ethnic and economic minorities, in the use of XR technologies. This statement received a 86% agreement (6= agree, 1= not my field of expertise). Please rewrite this statement if it is not fully in line with your opinion.

Q19 Old version: The EC must facilitate the certification of XR applications in healthcare, by allocating funds on the one hand, and by establishing favourable, e.g., less strict regulations on the other hand. One respondent disagreed with this statement, explaining that the main barrier lies in the regulations, not in the number of XR experiences seeking certification. Would you agree with the following, edited statement? New version: The EC should facilitate the market uptake of XR applications for healthcare, by establishing more flexible rules for experimentations, and by creating a funding instrument dedicated to the certification process. Please rewrite the statement if it is not in line with your opinion.

Q20 Old version: The EC should promote the collection of rules of best practice concerning the licensing of intellectual property rights in the field of XR, covering in particular the amounts of the royalties, the criteria of exclusivity, and the periods of validity. On XR Panel member disagreed with this statement. They believe that there should be open access to code which has been developed under Horizon Europe projects. New version: The EC should promote the collection of rules of best practice concerning the licensing of intellectual property rights in the field of XR, covering in particular the amounts of the royalties, the criteria of exclusivity, and the periods of validity, and there should be open access to code which has been developed under Horizon Europe projects. Please rewrite the statement in it is not fully in line with your opinion.

Q21 Old version: The EC should foster research into making XR technologies and designs accessible to all diverse user groups, not only the currently targeted market-segment (male, educated, English speaking consumers). One respondent observed that it is already too late, and one observant withheld their opinion. The statement has been refined based on the feedback from all respondents. New version: The EC should foster research into how to make XR technologies and designs more accessible to all diverse user groups, exploring how to include more than the currently targeted market-segment

(male, educated, English speaking consumers), making sure that communication is unbiased and checking contents for localization, and using AI to automate adaptations where possible. Please rewrite the statement if it is not fully in line with your opinion.

Q22 Old version: The EC should urgently prioritize, organize and subsidise XR developers training and affordable train-the-trainer educational events at all educational levels, to address the shortage in skilled XR developers and instructors. This statement received 14% (1) disagreement because the respondent wanted to remove the word Urgent. A small correction of the text has been made to incorporate their opinion. New version: The EC should prioritize, organize and subsidise XR developers training and affordable train-the-trainer educational events at all educational levels, to address the shortage in skilled XR developers and instructors. If the statement is not in line with your opinion, please rewrite it below.

Q23 Old version: The EC should make available and subsidize easily accessible 3D printing opportunities for rapid prototyping of XR hardware designs by XR end-users, which will facilitate them to tailor the designs based on their own experiences, and enabling a user-driven evolution in input/output solutions. This statement received 14% disagreement and was updated to include the suggestions. New version: The EC should make available and subsidize easily accessible 3D printing opportunities for rapid-prototyping of XR hardware designs by XR end-users, which will facilitate them to tailor the designs based on their own end-user UXUI XR experiences, and enabling an end-user driven evolution in input/output solutions, in a short cycle of design-implement-test-redesign. Please rewrite the statement if it is not in line with your opinion.

Q24 This is a new statement that came out of suggestions of the XR panel: The EC should create specific funding programs where all results (e.g., source code, 3D assets) will be made accessible for free to all other European companies/research institutes.

Q25 Old version: The EC should urgently support the development of a EU specific XR Development Asset store, with shareware assets that are available for EU developers at no-cost or low-cost. One respondent believes this should be company driven, not by the EC. Several other respondents suggested variations, which have been synthesized here below. Do you agree with the following new version? New version: The EC should urgently support the development of an EU specific XR Development Asset store, with high quality shareware assets that are available for developers at no-cost or low-cost. Please rewrite the statement if it is not fully in line with your opinion.

Q26 Old version: The EC should urgently support solutions for low cost, reusable, interoperability solutions for integrations of domain specific data such as BIM, scientific simulations, etc., and these solutions should be independent from the current mainstream XR software companies, and make it as efficient as possible to plug into the currently most used interactive XR platforms. This statement received one disagreement and a rewrite has been attempted based on their suggestions. New version: The EC should urgently understand/create/adopt worldwide standards and support solutions for low

cost, reusable, interoperability solutions for integrations of domain specific data such as BIM, scientific simulations, etc., and these solutions should best practices in industrial R&D projects, be independent from the current mainstream XR software companies, and make it as efficient as possible to plug into the currently most used interactive XR platforms. If the statement is not fully in line with your opinion, please rewrite it in the text box below.

Q27 In order to capture a market share, the EC needs to urgently support R&D to expand and improve the XR development pipeline in terms of asset types, complexity of data and ontologies, and to improve interoperability between the different asset formats used in different industries. This statement received 2 disagreements: one withheld their opinion, and neither did provide an explanation. Are the opinions truly divided or did someone make a mistake? Please rewrite this statement if it is not fully in line with your opinion.

Q28 The EC should engage and provide full support to startups, SMEs, scale-ups and manufacturers of XR components, such as Zeiss, Bang & Olufsen, STMicroelectronics, etc., in order to spur the development of XR devices, since breakthrough innovations generally come out of startups and combinations of parts and components from diverse manufacturers. This statement received 1 disagreement: The respondent believes that this should be market driven. Please explain your point of view. What is your reply to the respondent that disagrees with your point of view? Please write your opinion in the text box below, or rewrite the statement if it is not in line with your opinion.

Q29 According to you what activities should the XR field prioritize in the 1 to 2 revival years after the pandemic?

Q30 According to you what XR developments will help reduce the CO2 emissions by half by 2030 and to neutral by 2050, aside from the following items already mentioned by previous respondents: Visualizations of consequences of the 17 SDGs' risks and strategies, Virtual prototyping and testing, Virtual access to healthcare, education, work and colleagues, Soft skills and diversity training in XR, Empowering low TRL members to leapfrog to 21st century ecological, economic and social levels.

Q31 XR technologies are a strategic source of competitiveness for European industries, and their development must be strongly supported by the EC. This statement received 100% agreement. Please feel free to add your comments or rewrite the statement to make it fully in line with your opinion.

Q32 The EC should create more long-term EU projects to facilitate long-term fundamental research, long-term teamwork, skills exchange, and continuity of XR R&D skills development, especially in the areas that are very cutting-edge for XR technology breakthroughs. This statement received 100% agreement. Please feel free to add your comments or rewrite the statement to make it fully in line with your opinion.

Q33 The EC should promote, subsidise, and facilitate access to state-of-the-art XR equipment for end-users and the general public; it should also help raise awareness and understanding of the possibilities and potentials, and inspire potential startup ideas, in order to stimulate next generations to include XR technologies in their ideas and innovation proposals. This statement received 100% agreement, although one respondent mentioned they were not fully clear on what it meant, while another one respondent mentioned that this statement was a key point. Neither provided further explanations or a rewritten statement. If the statement is not in line with your opinion, please rewrite it in the text box below.

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Q34 XR technologies have the potential to provide a strong and adequate response to the problem of carbon emissions, by making remote work and interactions between people more efficient, thus reducing the need for personal or professional travel and developments for solutions into this direction should be prioritized, especially as a response to pandemic related travel restrictions and precautions. This statement received 100% agreement, and a small clause was added that the potential has not been scientifically proved yet at the request of one respondent. Please feel free to add your comments or if the statement is not in line with your opinion, please rewrite it in the box below.

Q35 The EC should support XR R&D for input/output devices that go well beyond the currently developed devices, for instance climate input/output devices (wind, rain, etc), olfactory IO devices (providing scents), hand tracking and use-case specific haptic devices, including standards for these new items. This statement received 100% agreement. Please feel free to add your comments or to rewrite the statement to make it fully in line with your opinion.

Q36 The EC should urgently promote the development of WebXR technologies. This statement received 100% agreement. Please feel free to add your comments or rewrite the statement to make it fully in line with your opinion.

Q37 The EC should promote the creation of scientific councils in high-tech XR companies, and act to facilitate the participation of researchers in these bodies, for example by creating dedicated funding instruments. This statement received 100% agreement. Please feel free to add your comments or rewrite the statement to make it fully in line with your opinion.

Q38 The EC should develop specific support for the optimization of academic-industry collaboration for XR R&D projects, because the type of knowledge exchange needed for XR development may affect the success of the collaboration in unknown ways, and improvements could be made in terms of better management of XR researchers' creative capacity, adjustments to the incentives structure, senior management support and strong leadership focused on rapid XR R&D skills development, and more

recognition of skills achieved. This statement received 100% agreement. Please feel free to add your comments or to rewrite the statement so that it is fully in line with your opinion.

Q39 The EC should widely disseminate and promote H2020 and Horizon Europe research of best practices for successful XR knowledge-transfer cycles within academic-industry collaborations and focus on how to maximize capacity to absorb the new XR skills and XR project output, and integrate the new XR technology solutions into the value chain. This statement received 100% agreement. Please feel free to add your comments or to rewrite the statement to make it fully in line with your opinion.

Q40 The EC should focus more on helping to allocate XR competencies, support mobility of XR experts for international skills exchange, and training of developers at labs and companies for all XR stakeholders, including virtual (pandemic solutions) and real networking events. This statement received 100% agreement. Please feel free to add your comments or to rewrite the statement to make it fully in line with your opinion.

Q41 The EC should make funds more accessible for facilitating innovation via new XR labs and independent developers, by increasing the success rate of proposals, and by providing active help and support with the application process. This statement received 100% agreement. Please feel free to add your comments or to rewrite the statement to make it fully in line with your opinion.

Q42 To strengthen European leadership and competitiveness, more research is urgently needed towards the development and exploitation of B2B applications using XR, more open data-bases, and more business for the XR field in general. This statement received 100% agreement and additional suggestions have been included. Please feel free to add your comments or to rewrite the statement to make it fully in line with your opinion.

Q43 XR researchers and the EC should prioritize XR validation research by systematically mapping out the wide variety of XR use-cases specific to Europe and globally (including EU commitment to the 17 Global Sustainable Development Goals (17 SDGs), XR health & safety, human factors and ergonomics for long-term use in serious XR applications, and age- and gender-related issues).After refining the wording slightly at the request of one respondent, by adding "globally" to this statement, it has 100% agreement. If the statement is not in line with your opinion, please rewrite it in the box below.

Q44 The EC must urgently fund R&D and standardization work towards the cybersecurity of XR technologies, especially personal XR devices which are going to be part of the mobile phone. This statement received 100% agreement. Please feel free to add your comments or to rewrite the statement to make it fully in line with your opinion.

Q45 The EC must finance projects dealing with legal issues in XR technologies. This statement received 100% agreement. Please feel free to add your comments or rewrite the statement to make it fully in line with your opinion.

Q46 The EC should prioritize, support and facilitate access to state-of-the-art XR technologies for the development of multi-user, remote collaboration XR solutions. This statement received 100% agreement. According to you, how urgent is this?

Q47 Old version: The EC should urgently promote standardization of 3D scene description format, and also for immersive audio. This statement received 100% agreement provided that the word "urgently" would be removed at the request of one of the respondents. New version: The EC should promote standardization of 3D scene description format, and also for immersive audio. If the statement is not in line with your opinion, please rewrite it in the text box below.

Q48 XR technologies are essential for the development and success of the European Alliance for Industrial Data and Clouds. There was a 100% agreement with this statement. Please feel free to add your comments or rewrite the statement to make it fully in line with your opinion.

Q49 The EC should help improve continuation and reuse of outstanding R&D results, help share, and help increase visibility of European XR project results. This received 100% agreement. Please feel free to add your comments or rewrite the statement to make it fully in line with your opinion.

Q50 XR solutions will help reduce the time-intensive requirements of building physical prototypes dramatically, bringing ideas and innovations to life and products to market far more quickly. There was a 100% agreement with this statement. According to you, what are the barriers that stop virtual prototyping from going mainstream? Please describe what in your opinion are the barriers.

Q51 The EC should urgently promote standards for Health & Safety for long-term XR use and foster research into Human Factors & Ergonomics for the design of XR input/output devices. There was a 100% agreement on this statement. Please feel free to add your comments or if the statement is not in line with your opinion, please rewrite it in the box below.

Page 5: Demographic Questions:

Q52 How would you describe your field of expertise? Please provide 3 to 5 keywords or phrases.

Q53 What is your gender?

Q54 What is your age?

Q55 What is your email address in case we need to follow up on any of your responses. We will not use it for anything else. (There is no obligation to provide this information.)

Q56 You are invited to be part of a XR Panel discussion about the results from the survey and the future of XR. You can indicate your interest in a role in the XR Panel discussion at the EuroXR Conference 2021, 24-26 November, here. What role would you like to take? The panel discussion will probably be a virtual 30-minute event taking place during or in the days before the conference starts. We are open to your proposals and ideas to make the most of this discussion opportunity.

Q57 If there is anything else essential to the success of XR for Europe and globally, that was not covered by the statements above, please feel free to add anything else in the text box below. Thank you!

APPENDIX D.2: DELPHI XR PANEL RESPONSE SUMMARIES ROUND 2

R2 Q6 Old version: The EC should prioritize the development of a competitive, state-of-the-art open source XR platform with a clear business model for monetizing contents. One respondent disagreed with the statement and believes the EC should first focus on standards for XR. Another respondent asked for the addition of the word Research. New version: The EC should prioritize the development of a competitive, state-of-the-art open source XR research platform with a clear business model for monetizing contents. Please rewrite the statement to make it fully in line with your opinion, or explain your opinion using the text box below.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
17% (1)	0,00% (0)	33% (2)	50% (3)	6	3,17

Minimum	Maximum	Median	Mean	Standard Deviation
1,00	4,00	3,50	3,17	1,07

Responses

Agree as EC should focus platforms not hardware

R2 Q7 Old version: The EC should neither partner with existing commercial XR platform vendors, nor create EU subsidized bulk-access to existing/commercial XR platforms and assets, for members of the European Union, as such actions would create strong bias in competition. There seems to be a true 50/50 divide between respondents in the XR Panel in terms of what is best: partner or not partner. We rewrote the statement based on your feedback and ask for your feedback again, in order to clear up this divide in opinions. New version: If the EC were to partner with existing commercial XR platform vendors and/or provide EU subsidized bulk-access to commercial XR platforms and assets, then this would create a strong bias in competition.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	17% (1)	50% (3)	33% (2)	6	3,17

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	3,00	3,17	0,69

Responses

EC should focus open source platform, which could link commercial platforms

The bias in competition only depends on the partnership format. If commercial solutions open access to their facilities and share standards API, this may be beneficial.

R2 Q8 The EC needs to improve the support for European XR R&D scaling up of its innovators and SMEs and reduce the currently existing notable scaling-up gap for XR tech scaleups and unicorn companies, in relation to the United States and China. This statement received some additional comments, six respondents agreed with it and one respondent withheld their response. One respondent wanted to include the word Urgent. How urgent is this according to you:

Not urgent	Urgent	Very urgent	Total	Weighted Average
0,00% (0)	67% (4)	33% (2)	6	2,33

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	3,00	2,00	2,33	0,47

Responses

EC should focus open source platform, which could link commercial platforms

The bias in competition only depends on the partnership format. If commercial solutions open access to their facilities and share standards API, this may be beneficial.

R2 Q9 Old version: The EC should focus XR R&D on EU relevant 3D assets, specific to European use-cases. Many XR Panel members asked about the meaning of EU relevant assets. This is further explained in the rewritten statement below. New version: The EC should focus on the potential market share in creating 3D asset libraries specific to European Industry 4.0 use-cases to help speed up European XR development, because many European industry use-cases are early-adopters of high-precision manufacturing using XR Industry 4.0 solutions, these use-case specific 3D assets are expected to become of interest world-wide. Please feel free to add your comments below or rewrite the statement if it is not in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	17% (1)	83% (5)	6	3,83

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	4,00	4,00	3,83	0,37

Responses

EC focus should be in applications in industry

I believe I understood now. But it looks like a contradiction between European dedicated assets which become of interest worldwide.

R2 Q10 Old version: The EC should focus more on preventing the widening of the digital divide by pushing inclusiveness in each country, and by coordinating the allocation of XR human capital and XR development resources. This statement received 29% disagreement (1= disagree, 1= no opinion), and the statement has been updated according to the suggestions. New version: The EC should focus more on preventing the widening of the digital divide by being more inclusive of countries with a low TRL, and by coordinating the allocation of XR human capital and XR development resources. Please rewrite the statement if it is not in fully in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	17% (1)	50% (3)	33% (2)	6	3,17

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	3,00	3,17	0,69

Responses

If we want to stablish strategic European leadership and competitiveness in the global XR R&D sector, we cannot distribute XR R&D resources too much.

I feel myself not competent to have an idea.

R2 Q11 Old version: The EC and XR developers should prioritize research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data, in order to capture the European and global market. Only one XR Panel member disagreed with this statement on the basis that they are not an expert on the topic. The panel members provided comments. One rewrite was suggested where CX would be replaced with UX, but this is already covered in other statements. The main point of this statement is that there is a market gap in the combination of XR and CX when using psychophysiological user behaviour data, which is recommended to be commercialized. **New version:** The EC and XR developers can capture the European and global market by prioritizing research into XR Customer eXperience (CX) measurements and psychophysiological user behaviour data. Please feel free to add your comments or rewrite the statement to make it fully in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	67% (4)	33% (2)	6	3,33

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	4,00	3,00	3,33	0,47

R2 Q12 Old version: The EC should negotiate access to the source code of commercial XR SDKs for EU-based XR labs and developers. Several respondents suggested variations of this statement, which can be synthesized in the following. Do you agree with the following statement? **New version:** The EC should negotiate towards the standardization and open source access of commercial XR SDKs, and encourage their adoption in Horizon Europe projects. Please rewrite the statement if it is not in line with your opinion.

Disagree with both	Prefer initial version	Prefer new version	Total	Weighted Average
0,00% (0)	33% (2)	67% (4)	6	2,67

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	3,00	2,67	0,47

R2 Q13 Old version: The EC should focus on XR R&D into hardware, software, and XR displays, in terms of form factor, technology v. size, weight, and power consumption, in order to establish strategic European leadership and competitiveness in the global XR R&D sector. Several respondents suggested variations of this statement, which can be synthesized in the following. Do you agree with the following statement? **New version:** The EC needs to focus the R&D in XR technology in order to establish strategic European leadership and competitiveness in the global XR R&D sector. In terms of hardware, the focus should be on human factors, interaction paradigms, ergonomics, customization, form factor, technology vs size, weight, and power consumption. In terms of software, the focus should be on applications and SW platforms built on top of de facto market standards (IOS, Android). Please rewrite the statement if it is not in line with your opinion.

Disagree with both	Prefer initial version	Prefer new version	Total	Weighted Average
0,00% (0)	0,00% (0)	100% (6)	6	3,00

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	3,00	3,00	3,00	0,00

R2 Q14 Old version: It is too late for the EU to catch up on the global consumer XR input/output device manufacturing market. Four XR Panel members disagreed with this statement. Seven XR Panel members write comments. One rewrite was provided. Their rewrite suggests another statement as follows: "EU should better promote start-ups and companies contributing to the global consumer XR input/output device manufacturing market", which is already covered in other statements. **New version:** It is not too late for the EU to catch up on the global consumer XR input/output device manufacturing market. Please rewrite the statement to make it fully in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	17% (1)	33% (2)	50% (3)	6	3,33

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	3,50	3,33	0,75

Responses

There are many big players whom are producing consumer XR input/output device e.g. Microsoft, apple,

Europe may not forgive this capacity and we need an ambition into this direction.

R2 Q15 Old version: The EC and XR developers should prioritize R&D to aim for a General Data Protection Regulation (GDPR) for XR users' personal and psychophysical data. Two XR Panel members disagreed with this statement and the others made comments about whether this should or should not be prioritized. The main point of this statement is to prioritize protection of user data. New version: With several global players interested in monetizing users' data, more research into General Data Protection Regulation (GDPR) is needed, specifically regarding protection and regulation of XR users' personal and psychophysiological data.

Not important at all / already covered by the GDPR	Not very important / mostly covered by the GDPR	Important / not covered by the GDPR	Very important / not covered by the GDPR at all	Total	Weighted Average
0,00% (0)	17% (1)	50% (3)	33% (2)	6	3,17

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	3,00	3,17	0,69

Responses

I got a lot of questions from new users and curious about XR that are willing to use the technology but are afraid to lose privacy mainly in VR due to the Oculus/Facebook login situation. We can't afford to lose newcomers to this and should encourage the enablement of new industry players that respect a well-developed and inclusive GDPR.

GDPR is covering partially the point. Many XR interfaces need more physiological data about users and it must be protected. GDPR provide the legal mechanisms to get consent and to manage it. But a complete classification of the data which can be recorded may be established with potential usage. Many issues come with BCI.

R2 Q16 Old version: The EC should help increase market growth via more supportive measures for independent XR developers and XR start-ups, providing more help to fast track breakthrough solutions, help with commercialization of ideas, help with market-entry, and generally making seed money for XR startups more easily accessible. There are two XR Panel members who disagree with this statement. One claims they are not an expert of the topic and does not provide a rewrite. The other one makes the following comment: "It is preferable to group independents in a European consortium where each actor develop specific skills. Consortium drives the global strategic development in the aim to build 2 or 3 global solutions to answer the XR market. "New version: The EC should give more support to individual European XR startups directly, in order to help with commercialization of ideas, help with market-entry, and generally make seed money for XR start-ups more easily accessible. Please feel free to add your comments below or rewrite the statement if it is not fully in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	67% (4)	33% (2)	6	3,33

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	4,00	3,00	3,33	0,47

Responses

XR start-ups should be part of existing eco-system, so support should be focusing to get them in to eco-systems

R2 Q17 Old version: The EC should help increase market growth via more supportive measures for independent XR developers and XR start-ups, providing more help to fast track breakthrough solutions, help with commercialization of ideas, help with market-entry, and generally making seed money for XR start-ups more easily accessible. There are two XR Panel members who disagree with this statement. One claims they are not an expert of the topic and does not provide a rewrite. The other one makes the following comment: "It is preferable to group independents in a European consortium where each actor develop specific skills. Consortium drives the global strategic development in the aim to build 2 or 3 global solutions to answer the XR market. "New version: The EC should give more support to individual European XR start-ups directly, in order to help with commercialization of ideas, help with market-entry, and generally make seed money for XR start-ups more easily accessible. Please feel free to add your comments below or rewrite the statement if it is not fully in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	67% (4)	33% (2)	6	3,33

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	4,00	3,00	3,33	0,47

R2 Q19 Old version: The EC should help increase market growth via more supportive measures for independent XR developers and XR start-ups, providing more help to fast track breakthrough solutions, help with commercialization of ideas, help with market-entry, and generally making seed money for XR start-ups more easily accessible. There are two XR Panel members who disagree with this statement. One claims they are not an expert of the topic and does not provide a rewrite. The other one makes the following comment: "It is preferable to group independents in a European consortium where each actor develop specific skills. Consortium drives the global strategic development in the aim to build 2 or 3 global solutions to answer the XR market." **New version:** The EC should give more support to individual European XR start-ups directly, in order to help with commercialization of ideas, help with market-entry, and generally make seed money for XR start-ups more easily accessible. Please feel free to add your comments below or rewrite the statement if it is not fully in line with your opinion.

Disagree with both	Prefer initial version	Prefer new version	Total	Weighted Average
0,00% (0)	0,00% (0)	100% (6)	6	3,00

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	3,00	3,00	3,00	0,00

R2 Q20 Old version: The EC should promote the collection of rules of best practice concerning the licensing of intellectual property rights in the field of XR, covering in particular the amounts of the royalties, the criteria of exclusivity, and the periods of validity. On XR Panel member disagreed with this statement. They believe that there should be open access to code which has been developed under Horizon Europe projects. **New version:** The EC should promote the collection of rules of best practice concerning the licensing of intellectual property rights in the field of XR, covering in particular the amounts of the royalties, the criteria of exclusivity, and the periods of validity, and there should be open access to code which has been developed under Horizon Europe projects. Please rewrite the statement in it is not fully in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
17% (1)	0,00% (0)	33% (2)	50% (3)	6	3,17

Minimum	Maximum	Median	Mean	Standard Deviation
1,00	4,00	3,50	3,17	1,07

Responses
Code could be part of existing platform e.g. Unity3D
We should encourage the open access but if we obligate, they to do this, we might push back those interested ones: "...and EC should encourage open access to code which has been developed under Horizon Europe projects."
I agree the need of open access to EU funded projects for almost European developers

R2 Q21 Old version: The EC should foster research into making XR technologies and designs accessible to all diverse user groups, not only the currently targeted market-segment (male, educated, English speaking consumers). One respondent observed that it is already too late, and one observant withheld their opinion. The statement has been refined based on the feedback from all respondents. New version: The EC should foster research into how to make XR technologies and designs more accessible to all diverse user groups, exploring how to include more than the currently targeted market-segment (male, educated, English speaking consumers), making sure that communication is unbiased and checking contents for localization, and using AI to automate adaptations where possible. Please rewrite the statement if it is not fully in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	33% (2)	67% (4)	6	4,67

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	4,00	4,00	3,67	0,47

R2 Q22 Old version: The EC should urgently prioritize, organize and subsidize XR developers training and affordable train-the-trainer educational events at all educational levels, to address the shortage in skilled XR developers and instructors. This statement received 14% (1) disagreement because the respondent wanted to remove the word Urgent. A small correction of the text has been made to incorporate their opinion. New version: The EC should prioritize, organize and subsidize XR developers training and affordable train-the-trainer educational events at all educational levels, to address the shortage in skilled XR developers and instructors. If the statement is not in line with your opinion, please rewrite it below.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	67% (4)	33% (2)	6	3,33

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	4,00	3,00	3,33	0,47

Responses

I believe urgency is real.

R2 Q23 Old version: The EC should make available and subsidize easily accessible 3D printing opportunities for rapid-prototyping of XR hardware designs by XR end-users, which will facilitate them to tailor the designs based on their own experiences, and enabling a user-driven evolution in input/output solutions. This statement received 14% disagreement and was updated to include the suggestions. New version: The EC should make available and subsidize easily accessible 3D printing opportunities for rapid-prototyping of XR hardware designs by XR end-users, which will facilitate them to tailor the designs based on their own end-user UXUI XR experiences, and enabling an end-user driven evolution in input/output solutions, in a short cycle of design-implement-test-redesign. Please rewrite the statement if it is not in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	17% (1)	33% (2)	50% (3)	6	3,33

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	3,50	3,33	0,75

Responses

I don't see that 3D printing will helps in here as electronics/optics is main issue.

I can agree but it is not the single solution to prototype systems.

R2 Q24 This is a new statement that came out of suggestions of the XR panel: The EC should create specific funding programs where all results (e.g., source code, 3D assets) will be made accessible for free to all other European companies/research institutes.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	17% (1)	33% (2)	50% (3)	6	3,33

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	3,50	3,33	0,75

Responses

Not all results can be accessible for free, depending on the type of results.

R2 Q25 Old version: The EC should urgently support the development of a EU specific XR Development Asset store, with shareware assets that are available for EU developers at no-cost or low-cost. One respondent believes this should be company driven, not by the EC. Several other respondents suggested variations, which have been synthesized here below. Do you agree with the following new version? **New version:** The EC should urgently support the development of a EU specific XR Development Asset store, with high quality shareware assets that are available for developers at no-cost or low-cost. Please rewrite the statement if it is not fully in line with your opinion.

Disagree with both	Prefer initial version	Prefer new version	Total	Weighted Average
0,00% (0)	17% (1)	83% (5)	6	3,00

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	3,00	3,00	2,83	0,37

Responses

We should keep ..."available for EU developers..."

R2 Q26 Old version: The EC should urgently support solutions for low cost, reusable, interoperability solutions for integrations of domain specific data such as BIM, scientific simulations, etc., and these solutions should be independent from the current mainstream XR software companies, and make it as efficient as possible to plug into the currently most used interactive XR platforms. This statement received one disagreement and a rewrite has been attempted based on their suggestions. **New version:** The EC should urgently understand/create/adopt worldwide standards and support solutions for low cost, reusable, interoperability solutions for integrations of domain specific data such as BIM, scientific simulations, etc., and these solutions should best practices in industrial R^D projects, be independent from the current mainstream XR software companies, and make it as efficient as possible to plug into the currently most used interactive XR platforms. If the statement is not fully in line with your opinion, please rewrite it in the text box below.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	17% (1)	83% (5)	6	3,83

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	4,00	4,00	3,83	0,37

Responses

"...R&D.." and not "...R^D...", right?

R2 Q27 In order to capture a market share, the EC needs to urgently support R&D to expand and improve the XR development pipeline in terms of asset types, complexity of data and ontologies, and to improve interoperability between the different asset formats used in different industries. This statement received 2 disagreements: one withheld their opinion, and neither did provide an explanation. Are the opinions truly divided or did someone make a mistake? Please rewrite this statement if it is not fully in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	0,00% (0)	50% (3)	50% (3)	6	3,50

Minimum	Maximum	Median	Mean	Standard Deviation
3,00	4,00	4,00	3,50	0,50

Responses

Agree with the statement

I do agree with the initial statement.

R2 Q28 The EC should engage and provide full support to startups, SMEs, scale-ups and manufacturers of XR components, such as Zeiss, Bang & Olufsen, STMicroelectronics, etc., in order to spur the development of XR devices, since breakthrough innovations generally come out of startups and combinations of parts and components from diverse manufacturers. This statement received 1 disagreement: The respondent believes that this should be market driven. Please explain your point of view. What is your reply to the respondent that disagrees with your point of view? Please write your opinion in the text box below, or rewrite the statement if it is not in line with your opinion.

Strongly disagree	Disagree	Agree	Strongly agree	Total	Weighted Average
0,00% (0)	33% (2)	0,00% (0)	67% (4)	6	3,33

Minimum	Maximum	Median	Mean	Standard Deviation
2,00	4,00	4,00	3,33	0,94

Responses

Agree with the statement

I do agree with the initial statement.

R2 Q46 The EC should prioritize, support and facilitate access to state-of-the-art XR technologies for the development of multi-user, remote collaboration XR solutions. This statement received 100% agreement. According to you, how urgent is this?

Not urgent	Urgent	Very urgent	Total	Weighted Average
14% (1)	43% (3)	43% (3)	7	2,29

Minimum	Maximum	Median	Mean	Standard Deviation
1,00	3,00	2,00	2,29	0,70

R2 Q50 XR solutions will help reduce the time-intensive requirements of building physical prototypes dramatically, bringing ideas and innovations to life and products to market far more quickly. There was a 100% agreement with this statement. According to you, what are the barriers that stop virtual prototyping from going mainstream?

No barriers	I don't know	Barriers are described in the text box below)	Total	Weighted Average
14% (1)	0% (0)	86% (6)	7	2,71

Minimum	Maximum	Median	Mean	Standard Deviation
1,00	3,00	3,00	2,71	0,70

ABOUT THE EUROXR ASSOCIATION

EuroXR – the European Association for eXtended Reality is a non-profit organization gathering individuals, large companies, SMEs, as well as research institutions, universities, and laboratories. EuroXR has been operating on the European territory for more than 10 years, providing a solid international network for all those interested in extended reality and new immersive technologies (VR/AR/MR).

EuroXR's mission is to promote research excellence and stimulate the development and deployment of XR technologies in existing, new and emerging fields. The Association provides also different kinds of services, such as white papers, scientific expertise, consultancy for new projects and project dissemination, opportunities for collaboration in European and international projects, and organization and support of XR-related events.

EuroXR 2021 International Conference

EuroXR conference presents each year Novel VR AR and MR technologies, interaction devices and applications. The annual appointment is a unique opportunity for international key players to network, discuss and share the latest innovations around commercial and research applications.

[EuroXR 2021](#), 18th International Conference, taking place on **24-26 November 2021**, organized in collaboration with CNR-STIIMA institute Milano, Italy. The XR event to grow your knowledge, connections, and business.