



MIXED REALITY REPORT 2017

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1. Introduction

Already from the 1990's there has been a strong will and hope towards a virtual- and augmented reality based gaming experience. For a couple of decades, the development of technology was quite slow, but after HTC Vive, and the first Oculus consumer version release in March 2016 it seemed that the technology is finally advanced enough, and the market for B2C VR applications, including games, is ready to open.

The Oculus and Vive releases together with available VC funding and the saturation of the mobile market (resulting in some mobile developers fleeing to VR/AR development) created high hopes towards VR. Basically everything required was coming together, funding, technology, skills and companies. However, after a good start and excessive hype the VR games' B2C market didn't develop as expected. One clear indicator of that was that some existing VR studios have closed and even Icelandic CCP, a big advocate of VR games since 2013, announced in the end of November 2017 that they are ceasing all VR development. At the end of the day, install base of consumer VR devices remained too small and fragmented.

However, this doesn't mean that VR is done for good, even in the area of games. When all the bits and pieces are finally in place, VR can hopefully offer not only holistic experiences and emotions, but escape from the ordinary real world to something totally different. It is essentially the same thing that games, or entertainment in general, provide, but VR can offer even much deeper, immersive experiences than games on traditional platforms. This is one of the reasons why VR remains a great opportunity for game developers.

The main focus of this study is to provide a somewhat coherent view of the VR/AR possibilities open to game developers at the moment, and describe some of the future possibilities in the field.

This report is commissioned by Business Finland (formerly known as Tekes, the Finnish Funding Agency for Innovation and Technology) and conducted in cooperation by Neogames Finland, the Hub of the Finnish Game Industry and Finnish Virtual Reality Association. The conclusions and findings of this study are based on 20 interviews conducted during the course of this study and other material available.

2. Terminology of VR, AR, MR and XR.

The terminology of VR, AR and MR can be confusing. What are these R-things exactly? Those new to the field often find themselves unable to distinguish between VR, AR, MR and 360 video. This makes communication of ideas between developers and clients difficult. Umbrella terms, such as extended, or "X" reality (XR) or "immersive technologies", have great use in general discussion, as they provide cohesion and an easy alternative to always separately mentioning VR, AR and MR.

However, terminology regarding immersive technologies still remains elusive for the public at large. Eventually, everyday use of XR devices and applications will create a language for itself. Many in the industry are using existing definitions borrowed from the scientific world: the clearest and most widely adopted taxonomy is Paul Milgram and Fumio Kishino's reality-virtuality continuum, which has played a major part in defining many of VR's core concepts.

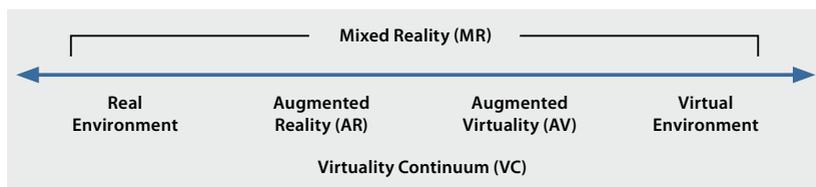


Image 1. Mixed Reality definition

This continuum has fully immersive virtual environments (or Virtual Reality) and real environments at its extremes. An application mixing real world elements and virtual elements together is an MR application. AR is a smaller subset of MR, with less virtual elements than real ones. On a conceptual level, the continuum is a great tool for understanding how interrelated VR, AR and MR are. In current practice, AR devices are generally regarded as head-worn, see-through displays, but the term can also include smartphone or tablet based AR. The terminology is partially muddled because the distinction between mixed reality and augmented reality has become a branding strategy between competing companies. (FIVR XR in Finland 2017)

Another, more controversial way to define the field is the Reality Matrix by Digi-Capital¹ which divides the area to "four segments:

1. *Virtual: real world is blocked out (i.e. user can only see the virtual world and virtual objects)*
2. *Augmented: real world is not blocked out (i.e. user can see the real world and virtual objects)*
3. *Immersive: the technology drivers combine to trick the user's brain into reacting as though it was a real experience*
4. *Ambient: one or more of the technology drivers doesn't provide the same level of experience as Immersive (Note: this may be desirable, particularly for some Augmented Reality applications)*

¹ Digi Capital; Pokémon Go changes everything (and nothing) for AR/VR. Available in: <https://www.digi-capital.com/news/2016/08/pokemon-go-changes-everything-and-nothing-for-arvr/#.WhR610pl9PY>

The Reality Matrix is made up of four sectors, with some players operating across them to meet different user needs:

1. *Console/PC VR makes users jump out of the way when a virtual whale swims towards them under the sea (e.g. HTC Vive, Oculus, Playstation VR)*

2. *Mobile VR provides a very good VR experience, but isn't as immersive because of key drivers like positional tracking (e.g. Samsung Gear VR, Google Cardboard and Daydream)*

3. *Augmented Reality ranges from the equivalent of Iron Man's holographic display with transparent virtual objects in the real world in daylight (e.g. Atheer) to smartphone/tablet "magic window" AR (e.g. Google Project Tango)*

4. *Mixed Reality ("MR") gives users virtual objects that appear solid in the real world in daylight (e.g. Microsoft HoloLens, Magic Leap, Meta), or switches easily between AR and VR (e.g. ODG)"*

Since terminology is complicated, in this study we have chosen to use the terms VR and AR whenever possible.

3. Current Status of the VR/AR field

VR and AR in their current state of development are revolutionary technologies, yet raw, complex and demanding to the user and hardware. Although VR and AR are sometimes thought of as opposing or rival technologies, they are more like two sides of the same coin with currently somewhat different uses and areas of application, but a similar technological and conceptual basis.

There are several VR capable devices in the market at the moment. However, none of the dedicated devices has so far reached far over million sold units. In the case of mobile phones the number of units sold is enough to create a sustainable market, but the problem in mobile VR is that the quality of experience is quite low due to the hardware / bandwidth restrictions.

"However, this doesn't mean that VR is done for good, even in the area of games."

3.1 Available VR & AR devices and platforms for consumers

Major VR and AR devices and platforms since 2013

March 2013	Oculus DK1
June 2014	Google Tango
July 2014	Oculus DK2
November 2015	Samsung GearVR
March 2016	Oculus Rift
March 2016	Microsoft HoloLens
April 2016	HTC Vive
October 2016	PSVR
November 2016	Google Daydream View
December 2016	Meta 2 DK
September 2017	Apple ARKit
October–November 2017	Windows Mixed Reality headsets from Acer, Dell, HP, Lenovo and Samsung
December 2017	Google shuts Tango down in order to focus on ARCore
Expected in 2018	Magic Leap One, Vive Pro, Oculus Go and Santa Cruz, LG's Steam VR Headset, Varjo, Steam VR Lighthouses 2.0 and Knuckles controller, Google ARCore

3.1.1 High-end tethered VR headsets

As mentioned before, HTC Vive and Oculus Rift are currently the most prominent tethered high-end VR headsets on PC for professionals and dedicated consumers. Vive is best known for its lighthouse room-scale tracking and SteamVR, which have made it the most popular high-end VR headset on PC to date, although it is also the most expensive option. Oculus Rift was officially released shortly before Vive, but has been lagging behind in sales and popularity until recently. Neither system has sold particularly well yet, most likely due to cost, complexity and high hardware requirements. PSVR, the VR headset for Playstation 4, is by far the best-selling tethered VR gaming headset currently on the consumer market with well over one million sold units.

The first wave of headsets for the Windows Mixed Reality (WMR) platform were released in the last quarter of 2017 with devices from Acer, Dell, HP, Lenovo and Samsung². These devices represent the newest wave of VR headset design, with improved ergonomics and displays and inside-out tracking. Microsoft has simultaneously introduced a simple two-tier hardware requirement standard for Windows PCs, and a performance evaluation app, which quickly reveals to

Windows users whether their PC is VR ready. The WMR platform is designed to offer a consumer-friendly entry point to tethered VR. Price-wise when bundled with controllers, the current WMR devices drop into the same range with the Oculus Rift. Even if the features of individual WMR devices are nothing entirely new, the combination of design, ergonomics, price, simplified hardware requirements and integration into Windows is something that has the potential to attract an entirely new segment of VR users, at least if the platform can offer quality content for consumers to enjoy.

3.1.2 Smartphone-based mobile VR headsets

Samsung GearVR and Google Daydream are currently the leading headsets in the mobile VR category, both powered by smartphones. The greatest advantage of smartphone-powered VR is the large device base, as VR-capable Android smartphones have become conveniently priced and relatively commonplace. Smartphones are certainly still not an ideal solution for mobile VR, for example due to their limited battery life and performance, which restricts quality of experience. Smartphones also tend to overheat in intense VR use, which makes the user experience not only uncomfortable, but even potentially dangerous. This could change in the future with hardware and optimization improvements. It remains interesting to see whether upcoming mobile standalone VR devices, such as Vive Focus or Oculus Go completely displace smartphone VR on the consumer market or not. If smartphones can offer better user experiences with improved hardware, tracking and performance, or even add hybrid VR/AR capabilities to the mix, they can remain very competitive.

3.2 Technological demands in general

Multiple features that are elementary in the further development of VR, AR or both, such as higher resolution displays and greater field of view, eye tracking, wirelessness and better positional tracking, are being constantly developed around the world to push immersive technologies further. The seamless interplay of highly complex hardware and software makes development a very challenging joint effort, but the sheer amount of key development areas is also testament to the great potential within VR and AR, waiting to be unlocked. The development of computer hardware is a major factor in improving VR and AR performance, but it can evolve only so much over a given time. Innovative use of hardware resources can still boost performance in various ways. Improving game engines and graphics optimization, such as rendering solutions utilizing the Vulkan API, or techniques such as foveated rendering are all major breakthroughs that will greatly impact VR and AR performance and user experience in the future.

² C-net, Joshua Goldman; Windows Mixed Reality headsets are here and they're affordable. Available in: <https://www.cnet.com/news/windows-mixed-reality-headsets-coming-this-fall-acer-lenovo-dell-hp-asus/>

3.3 User expectations

Currently, one of the greatest challenges for immersive technologies lies in fragmented and unrealistic expectations that are in conflict with one another. The hardware requirements of VR and AR devices are very high, as are expectations regarding their quality. It is quite evident that the demand for better quality experiences, the restrictions of current hardware and the co-existent demand to make immersive technologies cheaper and more convenient to use is not a very sustainable combination of expectations.

These are challenges that cannot be solved quickly and simultaneously. They rather need to be addressed in accordance with the needs of different user segments: For design professionals, industry use or hard core gamers, it is the quality and reliability of experience that matters most, while cost and complexity can be tolerated.

For the average consumer, prices have to come down and the use of devices has to be convenient, but not with a severe impact on quality. From a game industry point of view, average consumers are the key to a viable mass market.

Right now, managing development based on potential use cases and user groups for each individual device and target audience is a must, at least until the general state of technology improves. Fragmentation of the field can even be a blessing for now: It ensures that solutions for VR and AR development are sought from different angles for different needs.

4. Future - Towards casual VR

There seems to be significant demand for affordable casual VR devices, as the current high tier devices have not sold as well as expected. Major device developers are making an effort to push VR towards the mainstream by offering simpler, affordable wireless VR headsets with dedicated internal hardware. Google, HTC and Oculus have all signed up for this race.

In May 2017 Google, in co-operation with HTC and Lenovo, announced a future release of standalone Daydream VR headsets with dedicated hardware³. Later HTC cancelled their co-operation with Google⁴ and announced their own standalone Vive Focus headset running HTC's own Wave platform⁵. Oculus followed up in October 2017 with a similar announcement to release a standalone VR headset labelled 'Oculus Go' in early 2018⁶. Oculus also announced that it's working on a more

³ The Inquirer, Carly Page; Google teams with HTC and Lenovo to launch standalone Daydream VR headsets.

Available in: <https://www.theinquirer.net/inquirer/news/3010332/google-teams-with-htc-and-lenovo-to-launch-standalone-daydream-vr-headsets>

⁴ Variety, Janko Roettgers; HTC Cancels Google Daydream Standalone VR Headset.

Available in: <http://variety.com/2017/digital/news/htc-google-standalone-daydream-vr-1202614626/>

⁵ Engadget, Richard Lai; HTC Vive Focus is a standalone VR headset with 'world-scale' tracking.

Available in: <https://www.engadget.com/2017/11/13/htc-vive-focus-standalone-vr-headset-daydream/>

⁶ Tech Crunch, Lucas Matney. Facebook announces \$199 'Oculus Go' standalone VR headset.

Available in: <https://techcrunch.com/2017/10/11/oculus-announces-199-oculus-go-standalone-headset/>

powerful standalone VR headset called 'Project Santa Cruz', which is said to deliver a more Rift-like user experience sometime later in the future⁷. These two headsets would extend Oculus' VR headset family with two middle-ground options between the high-end Rift and smartphone based mobile GearVR.

4.1 Four tiers of future VR devices

Oculus' plans for future VR devices sets up a four-tier ecosystem of consumer VR headsets, which could be the almost-perfect model for classifying other upcoming VR headsets and systems as follows. In addition to these four tiers, devices designed for demanding professional use, such as the Varjo headset, can be considered the fifth tier.

- The high-end consumer device Rift.
 - Needs a high-end PC to run. Expensive and complicated. Six degrees of freedom (6DoF). Tethered. Optical outside-in tracking demands a predefined play area.
- The high grade standalone device Santa Cruz. (Release date and technical specifications unknown)
 - External hardware not required. Simple to use. Cheaper than Rift. 6DoF. Untethered. Inside-out tracking.
- The low grade standalone device Go. (To be released in 2018)
 - External hardware not required. Simple to use. Very affordable but least powerful hardware. 3DoF. Untethered. Inside-out tracking.
 - "The easiest way to experience VR." Likely attracting casual users.
- The mobile smartphone-based GearVR.
 - Needs a compatible smartphone to run. Biggest audience but least capable performance (for now.) 3DoF. Untethered.

The best feature of dedicated hardware is the precision of performance: As a developer, you know exactly what you get to work with. As an average consumer, you will not have to worry about the hardware performance or hacking the device to make it work.

But how long can the life cycle of early standalone VR devices be? Technology progresses and dedicated hardware can quickly become outdated. The question of cross-platform availability of content with different control methods also becomes relevant here: Is there a way of making content available across these platforms? Will different devices on the platform have similar controllers?

For low-end mobile VR, content subscription services delivering branded, promotional or user-generated content might provide a route to profitable business.

⁷ Tech Crunch, Lucas Matney; Oculus says high-end 'Santa Cruz' wireless VR headset will ship next year to developers. Available in: <https://techcrunch.com/2017/10/11/oculus-says-high-end-santa-cruz-wireless-vr-headset-will-ship-next-year-to-developers/>

However, there are small chances for a Pokémon Go -like nostalgia-driven family-friendly killer app to push mobile VR to mass markets.⁸

4.2 High-end consumer VR devices

High-end headsets are currently being developed further. The next versions of Vive (Vive Pro) or Rift are likely to be released only after they offer significant upgrades to those currently on the market. This makes sense to both consumers and professionals using existing equipment. Updating an expensive high-end headset now with minor improvements would be strange considering that major breakthroughs in technology could drastically improve resolution, tracking, control methods and perhaps introduce wireless VR within a few years.

VR systems can also be upgraded with a modular approach: Valve seems to have taken this approach with SteamVR technology, as they have reported of upgrades to their Lighthouse tracking devices⁹, headset lens technology¹⁰ and VR motion controllers¹¹, but have not announced a new headset. Valve may continue to develop VR platform infrastructure and key technologies for optics, tracking and control methods, while leaving headset manufacturing to partners. SteamVR's opening up to WMR headsets is yet another signal of Valve having no intention to introduce device restrictions to its platform, which can play together with potentially any VR headset.

The Finnish company Varjo is currently developing a mixed reality headset with immensely improved visual fidelity compared to existing devices, which targets an even higher echelon of premium pro users than current high-end VR headsets. Varjo's upcoming headset might prove to be too expensive for the consumer market for now, but the development of technology is likely to lower the price point in the future. Varjo's HMD will be a major step forward in VR headset resolution development.

Most probably, location based VR solutions will lead the way for wider domestic VR adoption. However, it is likely that especially high-end VR will remain an enthusiast market unless Facebook succeeds in mainstreaming social VR games.¹²

5. AR Devices

Smartphones and tablets are the most used devices for AR applications. Face filters for Snapchat and Facebook have already become everyday technologies. The existing

⁸ Medium/Virtual Reality Pop, Aki Järvinen; Mobile AR & VR Games in 2020: Six Scenarios. Available in: <https://virtualrealitypop.com/mobile-ar-vr-games-in-2020-six-scenarios-7c90fe22bb9a>
⁹ Upload VR, Jamie Feltham; SteamVR Tracking 2.0 Improves Base Stations To Cover Warehouses. Available in: <https://uploadvr.com/steamvr-tracking-2/>
¹⁰ Upload VR, Ian Hamilton; Valve Develops Custom Lenses For Next Generation VR. Available in: <https://uploadvr.com/lenses-valve-custom/>
¹¹ Road to VR, Dominic Brennan; Developer Videos Show Valve's Knuckles Controllers in Action. Available in: <https://www.roadtovr.com/developer-shows-valves-knuckles-controllers-action>
¹² Medium/Virtual Reality Pop, Aki Järvinen; Mobile AR & VR Games in 2020: Six Scenarios. Available in: <https://virtualrealitypop.com/mobile-ar-vr-games-in-2020-six-scenarios-7c90fe22bb9a>

device base and familiarity of smartphone use is a major competitive advantage in mobile AR. Apple (ARKit) and Google Android (ARCore) are the AR platforms of major mobile manufacturers

There are numerous AR-glasses already on the global market and several in development, but the market is fragmented, and in everyday use these devices are not common yet. So far none of them have been able to penetrate the mass market in a significant way due to cost of production, which translates into high retail prices and complexity of both technology and use. The Microsoft HoloLens is one of the most prominent devices in professional use because of its great spatial mapping capabilities, but it still has a lot of room to improve in regard to its field of view, battery life, availability, pricing and various minor glitches.

On 20th December 2017, Magic Leap announced some of the specs of their first product, Magic Leap One (to be released in 2018). Magic Leap has potential to be a significant player in the AR field in the future, if all the expectations towards their device are fulfilled. Other current AR-glasses worth mentioning are DAQRI Smart Helmet, Meta 2 and ODG r9.

6. General market situation

As implicated above, the current market situation of VR and AR looks very different when comparing the business-to-business (B2B) market and the business-to-consumer (B2C) market. Opinions on VR have been swinging from excessive hype to declarations of VR being dead in just within a year in 2017. In the earliest days of VR, the hype got hold of the predictions about consumer adoption of VR with ultra-optimistic estimates. So far, the consumer VR market has been growing much more slowly than hoped, while business to business VR solutions have found a solid early market to operate in.

6.1 Business to consumer (B2C) VR and AR

The greatest reasons for the slow consumer adoption of VR have most likely been the complexity, high price point of devices and lack of good content.

So far, only PlayStation VR has been successful in combining plug and play levels of reliability, reasonable pricing and interesting content, which has resulted in a significant market lead to make it the number one VR gaming platform. The challenges related to cost and complexity of devices are partly symbiotic with hardware and software development, as improving technology will help make VR

"The current market situation of VR and AR looks very different when comparing the business-to-business (B2B) market and the business-to-consumer (B2C) market."

devices generally easier, more comfortable and casual to use, and is also likely to drive prices closer to consumer expectations.

The prices of high-end consumer VR headsets already started to come down during the third quarter of 2017, which sparked hopes of a consumer market revitalization. Oculus slashed their prices for the Rift in a summer campaign, followed by a permanent cut down to \$399 in October¹³. HTC Vive also got a permanent discount in August 2017 down to \$599¹⁴. The reasons behind these price cuts are simple: not enough sales, introduction of new competition and rumours of upcoming upgrades to Rift and Vive. Rift and Vive have been selling poorly. WMR headsets' prices bundled with controllers range from \$400 to \$499, so without price cuts Rift and Vive would have been not only slightly outdated, but also severely overpriced. The successors to Rift and Vive are only rumours so far, but without a doubt under development. If Oculus and HTC want to sell their current high-end devices, now is the time to do something about it.

The largest install base of devices for both VR and AR can be found on the mobile market. Apple's ARKit SDK was released in the fall of 2017 along with iOS 11¹⁵. It has generated a lot of anticipation regarding AR's consumer mass adoption in the near future, which, according to the boldest estimates, could happen within six months. The tracking capabilities of smartphones have reportedly taken major strides due to this new software development kit, but hardware restrictions in mobile device battery life and cameras still leave a lot of room for improvement.

6.2 B2C Market AR

Smartphone AR is anticipated to be the first widely adopted immersive technology phenomenon. AR actually already is an everyday technology, but rather limited in its use. Snapchat and Facebook's face filters are hardly the pinnacle of AR, even if they are used daily on a mass scale. Communication between people and things in public spaces and everyday situations is what AR is expected to change: from marketing campaigns to social media, accessing information and navigating. While VR is a technology for home entertainment and art, AR is ideal for visualising and sharing information and experiences. A global network of three dimensional spatial maps capable of containing virtual elements, also referred to as the AR cloud, will be a key infrastructural technology in the development of AR allowing the existence of a virtual space within our physical realm.

AR games have proven difficult to define. The smartphone megahit of 2016, Pokemon Go, was quite instantly labelled as an AR game, regardless of the fact that

¹³ The Verge, Adi Robertson; Oculus Rift price drops permanently to \$399.

Available in: <https://www.theverge.com/2017/10/11/16459664/oculus-rift-price-drop-permanent-399-connect>

¹⁴ The Verge, Adi Robertson; The HTC Vive just got a \$200 price cut.

Available in: <https://www.theverge.com/2017/8/21/16176862/htc-vive-vr-headset-price-cut>

¹⁵ Apple Developer; ARKit. Available in: <https://developer.apple.com/arkit/>

the actual AR-features in the game were cosmetic at best. Opinions differ greatly on whether geolocation gaming, which is at the heart of Pokemon Go's game mechanics, can be regarded as an AR feature. What was interesting about the phenomenon is that nearly everyone wanted to get on the hype bandwagon and label Pokemon Go an AR game. The future of AR games is vague, as everyone seems to be busy trying to figure out what an AR game on a smartphone could be: a tabletop puzzle or strategy game, a geolocation adventure game with AR features or perhaps something entirely different?

Smartphones and tablets are not technologically ideal for AR use, but before AR glasses become cheaper, easier to use, more easily available and reach a significant market share as an AR app platform, AR content will be mostly designed with the smartphone user in mind.

6.3 B2C Market VR

Despite its brief existence, the VR game phenomenon is already relatively well known by gamers worldwide, albeit the device base is still small which makes sales difficult. PSVR has been well received as a gaming platform with well over million units sold, over one hundred titles to choose from and new game content steadily released in the PS store. That still doesn't mean it is an easy market for developers to penetrate. The PSVR platform is dominated by big game titles, such as Resident Evil, Gran Turismo and Skyrim VR.

On the PC, the VR game market is split between Steam, Oculus Store and Viveport. Steam is widely regarded as the most dominant marketplace as it has the largest amount of content, while SteamVR supports most, if not all, VR devices. The pricing of VR content on the Steam store, however, is tricky. Underpricing a game makes it look cheap among competition and overpricing a game in relation to playable content annoys consumers very easily. Finding a good balance between content, product image and pricing has been a challenge among the robust supply of VR games in the Steam store. The marketplace is cluttered with cheap content, which has played its part in making gamers sceptical about the quality of VR games in general.

The availability of content has, according to some developers, decisively changed consumer behaviour, as prices have come down while consumer quality standards have risen. Early access game releases increase the hype of titles with promised cool future features and content. These promises may sometimes be never fulfilled as developers move on to other projects. This has brought along hefty, though justifiable consumer scepticism to the picture, which developers need to battle with quality games, even if standing out among hundreds of games competing for the same attention is increasingly difficult. Furthermore, the PC market is in constant motion depending on currently available hardware and content. Long development times are usually not an option as it is more important to keep up with recent

“B2B business solutions have become a viable way of generating income and honing VR development capabilities, especially regarding usability and agility.”

market trends, which change rapidly with the emergence of new game concepts, design conventions and equipment.

All this combined with other difficulties has created an environment which makes it almost impossible for studios to sustain VR game development on customer revenues from VR games alone. This might sound like a problem, which it unquestionably is for a studio that would like to focus solely on VR game development without external investments.

Even if the early VR game market is deemed an especially tough one to compete and succeed in, there have been a few notable success stories, when compared to VR sales in general. Titles like Job Simulator, Audioshield, The Gallery, Raw Data, Star Trek Bridge Crew, Space Pirate Trainer, Onward and Arizona Sunshine have all done well and set quality standards for basic VR game experiences. These games have a distinctive core idea or theme, polished gameplay and fun basic mechanics, but little content, compared to many conventional video games, which has disappointed some gamers that are used to tens of hours of gameplay. Some have described the average VR game as “demo-like”, which is true in the sense that most current VR games are the first ones from their developers and they set out to try some very basic features and mechanics. Eye tracking, foveated rendering, improved resolution, wireless headsets, larger play areas and new control methods are features that will drastically improve VR game experiences.

7. Business to business (B2B) VR/AR

The lack of consumer demand has forced studios to search business outside the consumer market from the B2B side. VR games and the companies behind them have received significant interest and attention from different businesses wishing to utilize VR. B2B business solutions have become a viable way of generating income and honing VR development capabilities, especially regarding usability and agility.

Many interactions and cornerstone design features of VR games can be customized and reused for different use cases with relative ease. Finding these business cases and balancing between B2B and game development has proved another challenge, which developers need to find quick solutions to.

Other pressing business challenges with VR game developers, relative to the market situation, are talent acquisition and finding funding partners. These challenges clearly reflect one another, as it is difficult to make profitable VR games and therefore difficult to attract private equity. Talent acquisition problems are a combination of lack of available expertise and resources, as recruiting top line

talent requires top line benefits and experienced individuals are highly sought after across the whole gaming industry. VR game studios have one significant ace in the hole, though, which is that VR game development is a passion business of discovery, experimentation and novelty with high risk and potentially high rewards in the future. This X factor attracts bold individuals who are willing to take their chances with new possibilities and challenges. Nearly all participants of this study stated that the choice of starting VR game development originated from a personal passion towards new game design experiences and an interest in the future of entertainment.

The immersiveness of high-end VR is the key strategic aspect in most use cases. An industrial designer, engineer or architect can finally engage with virtual models from a first-person perspective, observe them from any desired point of view and manipulate scale, proportion and placement of these models within the virtual environment. Healthcare industry professionals are keenly pursuing possibilities of utilizing VR in elder rehabilitation and psychological therapy, where patients can safely navigate environments and interact with objects relative to the treatment of their condition. VR also makes visceral and cost-effective training simulations possible for high-risk activities, such as aviation, spacefaring, firefighting and combat.

Perhaps the greatest perk of VR is malleability, which extends the possible applications of VR to the frontier of our imagination. Any scenario that is possible to picture and program is possible to create in VR as an interactive environment, where all kinds of interactions can be made possible.

All in all, B2B VR has emerged and continues to raise its significance in countless sectors of industry with use cases ranging from product visualisation, design and marketing to treatment and training.

On the developer side overall, VR and AR awareness is already at a high level in most companies, but most are still observing the markets and technological advancement while warming up R&D and waiting for the right opportunity to jump in and make actual use of these technologies. Accessing the B2B market sometimes requires a change in the attitudes of game developers. It should not be seen as a necessary evil in order to stay alive for the next 3-4 years. Rather it is a very good opportunity for fast and up-to-date R&D on many levels, including technology and usability.

8. Game Developer requirements - VR/AR - DIY

Computer and video games are the result of a complex developer team effort, where the requirements of platform technologies, programming, game design and visual design must be brought together with creativity and precision. In some aspects, VR is very similar to game development in general, as most of the tools and technologies required are same. Game developers have all the necessary know-how to step into VR development right away, and many feel that now is the right time to start at least

researching it. VR developers still need to learn quite a few new tricks, and perhaps unlearn old ones, in order to be successful.

The principle of VR development, as of now, is to Do It Yourself, which covers all aspects of development. Some best practices have already emerged and basic toolkits for locomotion and interactions, such as VRTK, are available and help developers get started quickly and test ideas. But if you want to give your VR experience a personal touch, it is necessary to dig deeper.

Everything must be considered with the high resolution immersive display (headset) in mind, which is aligned with the user's perspective and moves freely in six degrees: Six degrees of freedom (6DoF) means that the headset is capable of tracking both rotation and movement in three dimensions, which are represented by X, Y and Z. This means that the user will look at things from all possible angles in three dimensional space and that many GFX tricks that work on two-dimensional screens will not look good in VR. Everything made on a computer screen has to be verified to work in VR, including the scale and proportion of all visual assets relative to the player's perspective. The user's sense of scale is greatly enhanced in VR, which is why transitioning from a narrow space to an expansive one and vice versa can be utilized to great dramatic effect.

8.1 Design - Designing content

VR game developers do not have an absolute consensus about how games should be developed for VR. Most of the developers interviewed argued that VR changes every aspect of game design, while a small minority of developers believed that well a designed computer game can be a good game for both VR and conventional control and display methods.

However, if we think about future development of VR, there was a consensus that in long term it should find a diction of its own. This perspective was also heavily emphasised in the interviews conducted for this study. This is especially true when designing interaction or user interface, but also when creating content.

*"VR is a new audio-visual communication medium, whose mission is to sell the idea of entering a computer-generated, three-dimensional environment where the experience is so immersive it tricks our brain into believing this virtual world is actually reality. Its ultimate goal is to allow us to experience sensations that we could never undergo in our daily lives otherwise. Things like getting out of our bodies and seeing ourselves from the outside, or being tele-transported to real and fictional places are now becoming possible with this new medium"*¹⁶

Game developers described how they had to start the whole game design and especially user interaction from scratch. Games which have been designed for traditional platforms, without VR in mind, cannot be simply transferred to a VR

platform without compromises. In VR, the goal is immersivity and a fluent user experience is a crucial part of that.

Based on interviews conducted for this study, one of the challenges faced by VR game developers was player engagement. In VR/AR, creating engaging experiences is not as easy as one might think. All this boils down to a very fundamental question: **What is the actual added value of AR or VR and how can it be attained?**

Some game developers say that the first thing to learn when designing a VR game is to unlearn a lot. All existing game design conventions go out the window when designing a VR game from ground up. The inclusion of immersive displays (headsets) and motion controllers in six degrees of freedom (6DoF) changes almost every way the player interacts with the game. Somatic control over the game challenges the player to think in terms of the body in a virtual space, which is one important aspect of immersion: The answer to the hypothetical basic question of "how do I pick items up" is to do it almost like you would in the real world, just go and grab it. Somehow the combination of playing a video game and the possibility to use one's body to control it instead of pushing buttons for commands has been hard for users to fathom and it takes some time to get used to it.

Because of these challenges, there seems to be an exhilarating sense of discovery in the VR gamer/developer community, with new experimental game mechanics and concepts surfacing at a steady pace. As a new medium for art and entertainment, VR still has immense untapped potential in innovating new forms of expression. The spirit of experimentation naturally wanes as best design practices start to take shape.

The emergence of best practices, cumulating developer experience with VR, improvement of computer hardware in general and better optimization techniques and better availability of formidable developer toolkits shorten development times. They also make learning curves less steep and potentially bring the amount of game content closer to conventional computer game standards and customer expectations.

8.2 Design - Human Computer Interaction/ User Interface Design

User interface design, HCI / UI Design for VR-devices, can be considered from the point of view of the following aspects;

- 1) In real life physical environment and devices
- 2) How to act in virtual reality.

The approach is to some extent convergent in both VR and AR. In detail, however, there are lots of differences.

As headsets are becoming lighter and wireless, the VR user experience will improve without question. When it comes to smartphone AR, its use is still a little inconvenient. Not only physically, but also socially. E.g. pointing the phone to

¹⁶ Net magazine, Laura Cortes; The UX of VR.

different directions, especially towards other people, is quite awkward. Many see mobile AR as a temporary substitute before AR glasses become mainstream. Social acceptance will be considered separately later. Physical devices were already partly covered earlier in the study.

In VR, the user experience is deeper. It is crucial that the world the user is stepping into is convincing and solid. Since the surrounding real world is totally or partly excluded, immersion is an important part of the experience. Essential parts of the UI and interaction need to be based on intuitive behaviour in virtual reality. That applies to movement, controls and how the user is guided through the experience. For example, reading text in VR is mostly annoying, not only because the screen resolution in many cases is not yet good enough, but also because it is not a convenient or an interesting way to offer information for the user/player in VR.

Based on interviews conducted for this study, one distinct requirement was for the developer to understand well enough the principles of HCI and UI in VR compared to other platforms. Practices that are common in “traditional” Game UI do not work on VR. This is not due to the limitations of VR, but rather to the amount of new possibilities of interaction design. Haptic and audio feedback can complete the user / gaming experience and immersion. These rules are valid also in see-through AR experience.

The wearer of a VR headset can also be severely affected by VR sickness (a type of motion sickness) if their vision is disrupted in the wrong way. This can happen in many ways, most noteworthy being sudden changes in the field of view, uncontrolled camera moves (disparity between vision and the movement detected by the inner ear is the usual explanation), poor refresh rate and flickering of graphics. The symptoms of VR sickness vary by a number of factors, including experience with VR. Eliminating motion sickness is the primary reason why developers have to use a significant amount of time in optimizing the performance of the VR experience. All features must be designed so that the VR experience runs smoothly in 90fps. This may force developers to compromise in visual fidelity, but can also be seen as a creative opportunity: VR games have successfully utilized a variety of playful visual styles that are just as fun to experience as photorealistic representation.

In mobile AR the user can use physical movements and location that are quite intuitive controls. The same controls as in mobile platforms in general, pointing and dragging is already familiar from “traditional” platforms. However, playing with AR in a moving vehicle can sometimes disturb gyro sensors. Also, physically big movements, especially in a crowd of people, are not always convenient to use. That is also related to social acceptance which will be considered further on in this study.

9. Why VR/AR games

Building engagement between user and content is vital for good user retention, and good user retention is crucial in consumer business. In the interviews it became

clear that the user's feeling of added value was the core element in content. Both VR/AR games should provide something unique the users haven't experienced before.

A somewhat unexpected finding in the study was that even creative content providers, especially in the entertainment and games sector, found it challenging to provide content that would be appealing for users/players to return to after the initial amusement. At least concerning this point of development, it seems that reaching retention in VR/AR games is harder than expected.

A positive finding was that the so-called serious and gamified apps are starting to find their place in the B2B market. With these apps the challenge of creating added value is solved, because in B2B applications the added value is usually created via a need, not via entertaining content as it is in games.

The initialization of a device or an app is a challenge. The threshold to starting the use is high especially with headsets, but applies also to mobile AR. That means that the reason to start using an app or a game needs to be good enough, in other words, the content needs to be appealing enough, or somehow offer clear added value for the user. Appeal is also related to social acceptance.

An appealing user experience is naturally convenient. A convenient user experience is functional and smooth in its interaction, including UI and HCI. Being able to create conveniently appealing content or obvious added value is a key advantage to any developer.

9.1 Social Acceptance

A hermit-like isolation from the outside world is said to be one of the crucial features of VR. At the same time, including real social features in VR is for many users one of the most fascinating experience they have had in VR. These matters are commonly acknowledged. For example, Facebook is making a lot of effort to find solutions for that. Their VR-app called Spaces,¹⁷ introduced in April 2017, is based on social interaction that takes place between avatars sharing the same virtual world.

It is obvious that in real life an isolating experience is harming the enthusiasm to use VR headsets for many. But an AR user can also feel embarrassment and awkwardness related to the use of mobile AR. In these cases, the issue was that the use of an AR app can easily appear as if the user would be recording their surroundings with their phone's camera.

“Serious and gamified apps are starting to find their place in the VR / AR B2B market.”

¹⁷ The Verge, Ben Popper; Facebook's head of social VR talks about the future.
Available in: <https://www.theverge.com/2017/10/15/16478084/interview-rachel-franklin-spaces-social-vr-facebook>

9.2 Staying competitive in the VR/AR game market

As already mentioned, game developers in general tend to have quite a passionate approach to game development. The same is true of VR game development and developers. Nearly all participants of this study stated that the choice of starting VR game development originated from a personal passion towards new game design experiences and an interest in the future of entertainment.

In his Tech Crunch article, Doug Clinton summed up the following advice on how to maximize your chances in the tech wave;

*“If you can create an operating system (OS), create an OS. If you can't create an OS, optimize a component of the new technology platform. If you can't optimize anything in the new platform, at least disrupt an industry that's been relatively untouched by technology”.*¹⁸

A developer should have a clear vision of where the viable market is. It is also important to see where the business is already. It is very challenging to perceive what will happen in three years' time. Since interaction with users is the key in content development and extended R&D, only cockroach-mode ruins the developer's DNA and agility. Changes in trends and customer behaviour are hard to follow from the isolation of a R&D laboratory.

Almost all the interviewed companies stated that especially content innovation is a key advantage, the ability to make AR and VR meaningful for the user.

Several developers mentioned how the big game companies are very interested in AR and VR, but are unable to access them because of a lack of agility, required know-how and the small size of the market. These cases naturally open up opportunities for business with small VR and AR developers.

Regarding B2B, it often came up in the interviews that the customers from other industries had almost zero understanding about VR or AR. So it is mainly the developers' own responsibility to define the customer's needs. This means that developers need to position themselves based on their own vision and create and point out the needs and opportunities on the customer's side. Building a trust between customer and developer is very important. The expectations can be unrealistic, and a customer may be very much unaware of what is possible and what is not. That leaves the VR/AR developer responsible to show the way, but that also means that developers need to gain the trust of the customers. Since the customers in this case are from other businesses and the price tag of the technology used is not an issue, this approach provides developers with the possibility to utilize high-end technology.

Due to fast technological progression, and partly the as-yet immature market, the VR-technology environment is lacking development tools and optimization technology, although the situation is getting better all the time. This has led to a

¹⁸ Tech Crunch, Doug Clinton. How to create the most value for the next technology wave. Available in: <https://techcrunch.com/2017/06/02/how-to-create-the-most-value-for-the-next-technology-wave/>

situation where even VR content developers need to build their own tools in order to create content. Consequently, this can offer a great advantage to a qualified developer, not only as content provider, but sometimes even offer an opportunity to license the technology, tools and engines created.

It is wise to utilize the technology available, i.e. ARkit and ARCore. Just now there is a chance to reach the famous first mover's advantage and become acquainted with new possibilities before your competition. It is also good to realise that it is completely fine to use AR for marketing, if the other use cases are still rare. On the other hand, when talking about first mover's advantage in VR, it might not be wise to rush into an opening market too early, since market transitions usually take some time.

10. Funding

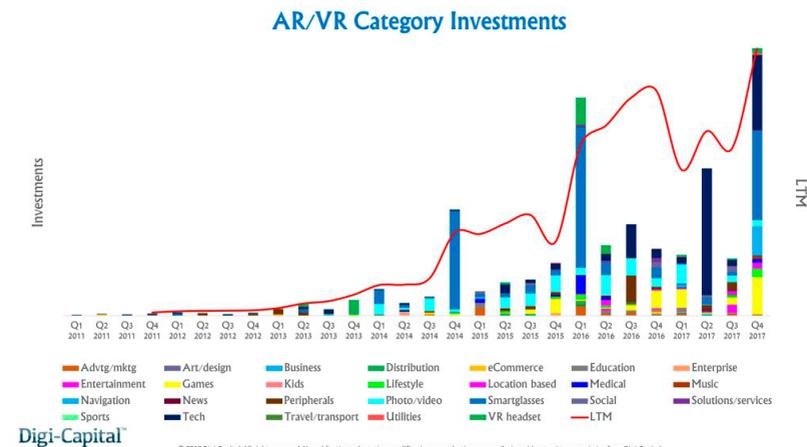


Image 2: AR/VR Investments, Digi-Capital¹⁹

Despite all the challenges mentioned in previous chapters, most of the developers interviewed for this study did not find it too difficult to raise private funding. The range of companies interviewed was from VR- and AR Game development to software and hardware.

In addition to this, Business Finland (formerly known as Tekes / the Finnish Funding Agency for Innovation and Technology) forms a very significant part of funding, especially in the early stage of R&D.

According to Digi Capital Augmented/Virtual Report and Deals Database –

¹⁹ Record over \$3B AR/VR investment in 2017 (\$1.5B+ in Q4), Digi-Capital. Available in: <https://www.digi-capital.com/news/2018/01/record-over-3b-ar-vr-investment-in-2017-1-5b-in-q4/#.Wm8CNqhl9PZ>

report²⁰ and Index by TW²¹ a large amount of money is still invested in VR- and AR. According to Digi Capital technology and medical applications seem to be the driving forces in AR and VR In Q4 2017 and also a transition from a VR driven investment market to a mobile driven AR market can be seen.

According to the latest VR Fund report²², released on Venture beat, VR investments in the games category grew by 40% during Q2 in 2017. The reported success of Oculus, Steam VR, and PlayStation VR are pumping up the faith. Another piece of good news is that according VR Fund's estimates, more than 35 VR game titles have generated \$1 million or more in revenues. This is a sign of an ecosystem getting healthier for VR game studios. In addition to this, the released numbers are positioned for continued growth as headset prices drop.

10.1 Domestic funding Opportunities

There are several domestic funding sources in Finland that offer funding for VR and AR based games, technologies and services.

10.2 Public funding

- Business Finland (formerly known as Tekes) Mixed Reality Program²³
- AVEK; DigiDemo, CreaDemo and StepDemo²⁴
- Local Centres for Economic Development, Transport and the Environment (ELY Centres)²⁵

Business Finland (formerly known as Tekes / the Finnish Funding Agency for Technology and Innovation) **Mixed Reality Program** offers funding for the development and utilisation of virtual and augmented reality based solutions in business. The campaign can fund companies that develop solutions and utilise virtual and augmented reality in their business operations, and build expertise in this area in Finland. In total, € 30 million in funding has been allocated to the Team Finland Mixed Reality campaign. The Mixed Reality campaign is being planned and implemented in cooperation with key actors in the sector, FIVR (Finnish Virtual Reality), VR Finland and various companies.

AVEK distributes **DigiDemo**, **CreaDemo** and **StepDemo** funds from the grants

²⁰ Tech Crunch, Doug Clinton. How to create the most value for the next technology wave.

Available in: <https://techcrunch.com/2017/06/02/how-to-create-the-most-value-for-the-next-technology-wave/>

²¹ Venture Beat, DeaThe VR Fund: Entertainment VR investments jump 79% in second half of 2017.

<https://venturebeat.com/2017/11/19/the-vr-fund-entertainment-vr-investments-jump-79-in-second-half/>

²² Venture Beat, DeaThe VR Fund: Entertainment VR investments jump 79% in second half of 2017.

<https://venturebeat.com/2017/11/19/the-vr-fund-entertainment-vr-investments-jump-79-in-second-half/>

²³ <https://www.businessfinland.fi/en/for-finnish-customers/services/build-your-network/digitalization/mixed-reality/>

²⁴ http://www.kopioisto.fi/avek/en_GB/

²⁵ <https://www.ely-keskus.fi/en/web/ely-en/>

allocated by the Finnish Ministry of Education and Culture. DigiDemo is aimed at the development of digital culture content and CreaDemo at the development of creative culture. In total, around € 12 million of these funds have been granted since 2002. The StepDemo fund is the newest, and it focuses on games and music.

ELY Centres (The Centres for Economic Development, Transport and the Environment) are responsible for the regional implementation and development tasks of the central government. Finland has a total of 15 ELY Centres, which are tasked with promoting regional competitiveness, well-being and sustainable development and curbing climate change. The Centres for Economic Development, Transport and the Environment come under the administrative branch of the Ministry of Employment and the Economy. Game companies can apply for support from their local ELY-Centres. ELY support is generic and non-industry specific.

10.3 Finnish Private funding

There are also some domestic Finnish private funding opportunities. The following investors have all already invested in VR/AR studios.

Nordic VR Startups (NVS) was founded by Gumi to provide especially early stage funding for Companies. NVS aims to contribute to and improve the competitiveness of the Nordic VR/AR ecosystem and accelerate the growth of companies that have been accepted into their **6 month program**. A team accepted into the program can receive an investment from NVS up to € 100 000. NVS's early stage financial support is very welcome, since there are not really any others currently available. The program also offers the support of highly experienced mentors.²⁶

Sisu Game Ventures is a game focused investment company. The company was incorporated in 2014 and is based in Helsinki, Finland. Sisu has invested, among others, in 3rd Eye Studios, Varjo, Umbra and Vizor.²⁷

Inventure is a Finnish early-stage venture capital company focusing on innovative start-ups and high-tech companies. Their investment portfolio includes Vizor, Umbra and Solfar Studios (an Icelandic VR-Game developer)²⁸

Lifeline ventures are a team of serial entrepreneurs that invest in sectors they know by heart from their years as founders and start-up leaders. They have invested, for example, in the following VR/AR companies; Varjo, Vizor, Umbra, Mindfield, Dispelix and Grey Area.²⁹

Reaktor ventures is funding seed stage companies to become global leaders. Reaktor has invested, for example, in Immersal and Univrses.³⁰

Some of the Finnish private investors seem to have doubts especially towards

²⁶ <http://nordicvrstartups.com/>

²⁷ http://thenordicnumbers.thenordicweb.com/investors/sisu_game_ventures/portfolio/grid

²⁸ <http://inventure.fi/>

²⁹ <http://www.lifelineventures.com/> <https://techcrunch.com/2016/02/22/finnish-vc-lifeline-ventures-raises-57-million-euros/>

³⁰ <https://reaktorventures.com/>

game related VR. A lucrative market seems to be too far and there are obvious challenges in scalability. Investors who have already invested in games are now monitoring how the market will evolve before making new investments.

According to our interviews, there was a little more faith in high-end VR-start-ups on the investor side, but that is not necessarily an opportunity for a VR-game developer, but rather for gamification start-ups. Gamification was addressed as potential on many levels, for example in health and education.

Mobile AR was considered worth monitoring, even though some investors found the AR market to be too immature from an investment point of view. As already mentioned, lack of innovation, creativity and engagement is hindering investment in AR, even though the enabling technology is available.

Even though VR and AR related to games was currently considered to some degree a difficult investment target, investors do also see games as a good way to learn, understand and utilize new technologies, including VR/AR.

10.4 Global funding opportunities

At the moment, there are several global investment funds that are, if not dedicated solely to VR and AR, investing also in them:³¹

- The Virtual Reality Venture Capital Alliance (VRVCA)³²
- HTC's Vive X accelerator program³³
- Facebook will invest another \$250 million into VR content in addition to the \$250 million investment it has already made in content³⁴
- IMAX completes first phase of \$50 million fund for new high-quality, immersive content³⁵
- The VR Fund is investing in early-stage VR-, AR- and MR start-ups³⁶
- COLOPL, a mobile gaming company, is committed to make up-front investment in VR.³⁷
- Index Ventures³⁸
- Shasta Ventures launches a fund to accelerate AR and VR app development³⁹

31 Venture Beat, Mary Ermitanio; VR funding and innovation look strong for 2017.

Available in: <https://venturebeat.com/2017/01/10/vr-funding-and-innovation-look-strong-for-2017/>

32 <http://www.vrvca.com/>

33 <https://www.vive.com/us/vivex/>

34 Venture Beat, Jeff Crubb. Facebook and Oculus promise millions in funding for diverse apps, education, and more for VR.

Available in: <https://venturebeat.com/2016/10/06/facebook-will-double-its-250-million-investment-in-vr-content/>

35 Imax completes first phase of \$50 million virtual reality fund that will finance new high-quality, immersive VR content. Available in: <https://www.imax.com/content/imax-completes-first-phase-50-million-virtual-reality-fund-will-finance-new-high-quality>

36 <http://www.thevrfund.com/>

37 <http://coloplnext.co.jp/en/coloplvr/>

38 <https://www.indexventures.com/>

39 <http://www.shastaventures.com/>

Tech Crunch, Brian Heater; Shasta Ventures launches a fund to accelerate AR and VR app development. Available in: <https://techcrunch.com/2017/09/18/shasta-ventures-launches-a-fund-to-accelerate-ar-and-vr-app-development/>

techcrunch.com/2017/09/18/shasta-ventures-launches-a-fund-to-accelerate-ar-and-vr-app-development/

- XR Basefund⁴⁰
- Presence Capital, AR and VR venture fund⁴¹

See more investment made in MR listed in Index by TNW;

VR: <https://index.co/market/virtual-reality/investments>

AR: <https://index.co/market/augmented-reality/investments>

11. Asian market

Like in the in the game industry in general, also in AR and VR Asia, especially China, has been seen as a very promising market. The total value of the Chinese game market surpassed that of the USA in the summer of 2016, and Digi-Capital estimates that in the future (2021) AR and VR revenue could also be dominated by Asia (especially China, Japan and South Korea). In AR and VR the market could be the size of North America and Europe combined.

Regarding the Digi-Capital forecasts, it seems that Asia (especially China, Japan and South Korea), could take half of the mobile AR revenues by 2021.⁴²

11.1 China

Due to the huge population and their developing economy, China is seen as a future super power also in VR and AR. The Chinese government encourages companies and developers to work on VR and AR technology. President Xi Jinping highlighted China's need to establish an innovative approach to dominate world economy, and he sees the growth of VR being an integral part of that⁴³

Alibaba invested \$793.5 million in Magic Leap in early 2016⁴⁴. Shanda (a major Chinese digital entertainment company) announced investing \$350 million in VR by the end of 2016.⁴⁵ Alibaba, Tencent and Baidu have released their ventures for building platforms and content. These three companies have already 688 million internet users⁴⁶ in China alone. China's VR market is expected to reach a value of

40 Venture Beat, Amir-Esmaeil Bozorgzadeh; New XR Basefund preps €60 million fund for VR and AR early stage startups. Available in: <https://venturebeat.com/2017/10/13/new-xr-basefund-preps-e60-million-fund-for-vr-and-ar-early-stage-startups/>

41 <https://www.presencecap.com/>

42 Digi-Capital, Apple and Facebook to drive mobile AR over 1B users and \$60B by 2021. Available in: <https://www.digi-capital.com/news/2017/06/mobile-ar-to-top-a-billion-users-and-60-billion-by-2021/#.WhMxCePl9PY>

43 Tech in Asia, Jennifer Katanyoutanant; This VC says China will drive VR adoption worldwide. Available in: <https://www.techinasia.com/talk/china-vr-worldwide-adoption>

G20 2016 China, Keynote Speech by H.E. Xi Jinping, President of the People's Republic of China, at the Opening Ceremony of the B20 Summit. Available in: http://www.g20chn.org/English/Speeches/201609/t20160909_3415.html

44 Tech Crunch, Ingrid Lunden; AR Startup Magic Leap Raises \$793.5M Series C at \$4.5B Valuation Led By Alibaba. Available in: <https://techcrunch.com/2016/02/02/ar-startup-magic-leap-raises-793-5m-series-c-at-4-5b-valuation-led-by-alibaba/>

45 Forbes, Lisa Hanson; China's Year Of Virtual Reality. Available in: <https://www.forbes.com/forbes/welcome/?toURL=https://www.forbes.com/sites/lisachanson/2016/12/23/chinas-year-of-virtual-reality/&refURL=&referrer=#10dd16c458bd>

46 Tech in Asia, Steven Millward; For the first time, more than half of China's population is online.

Available in: <https://www.techinasia.com/more-than-half-of-china-population-is-online>

techcrunch.com/2016/02/02/ar-startup-magic-leap-raises-793-5m-series-c-at-4-5b-valuation-led-by-alibaba/

www.forbes.com/forbes/welcome/?toURL=https://www.forbes.com/sites/lisachanson/2016/12/23/chinas-year-of-virtual-reality/&refURL=&referrer=#10dd16c458bd

techcrunch.com/2016/02/02/ar-startup-magic-leap-raises-793-5m-series-c-at-4-5b-valuation-led-by-alibaba/

www.forbes.com/sites/lisachanson/2016/12/23/chinas-year-of-virtual-reality/&refURL=&referrer=#10dd16c458bd

techcrunch.com/2016/02/02/ar-startup-magic-leap-raises-793-5m-series-c-at-4-5b-valuation-led-by-alibaba/

techcrunch.com/2016/02/02/ar-startup-magic-leap-raises-793-5m-series-c-at-4-5b-valuation-led-by-alibaba/

over \$ 8 billion by 2020, from last year's \$ 230 000 value.⁴⁷ In addition to that, several other Chinese companies like Xiaomi, HTC and Chukong are keenly following the development of VR and the opportunities it might create.⁴⁸

Many VR hardware companies in China are already able to produce quality devices for the market. However, several manufactures have realized that the VR ecosystem needs also quality content to attract consumers. Due to that, several different sized hardware companies are interested in cooperating with developers to produce content.⁴⁹

According to Niko Partners' latest, Virtual Reality/Augmented Reality/Mixed Reality (VR/AR/MR) Market Report,⁵⁰ Virtual reality hardware and software revenue in China will rise from \$249 million in 2016 to \$1.7 billion in 2021. The report states that mobile VR overall is currently the main driver of virtual reality in China, due to its lower price, easier use and compatibility. PC VR currently faces several hindrances in the China market, but it is expected to become just as big as Mobile VR in the long term.

The overheated boom of new Chinese VR & AR start-ups in 2016 led to a consolidation phenomenon in 2016-2017, with many small companies leaving the market (90% of China VR start-ups were shut down in late 2016)⁵¹. Meanwhile, the remaining top companies were able to expand their leader positions. In addition to this, some Chinese VR developers have also switched to the B2B market.⁵² Despite these challenges, the market is still expected to expand more than fourfold in 2017.⁵³

One typically Chinese phenomenon is VR ARCADES. There are currently over 10 000 VR arcades in China. However, many of them are not profitable. Furthermore, several are suffering from a lack of quality content and software. There is also no distribution channel for content. Due to that, top companies are joining their forces to set up a dedicated distribution channel for high quality foreign content to VR arcades in China. Arcades are also driving adoption towards headsets.⁵⁴

According to New Zoo, at the end of 2016, more than 15 million mobile devices in China had virtual reality apps installed. Meanwhile, AR is surprisingly lagging behind

with a user base of only little over 5 million.⁵⁵

The growth in VR and AR mobile devices, added to the growth in provided mobile content, has led to a growth of the AR and VR audience.⁵⁶

Despite the attractive market, it is good to also understand how heavily Chinese regulation affects especially foreign actors in that market. The fact that, for example, Pokemon Go was banned in China is only the tip of the iceberg of regulation.⁵⁷

"Despite the attractive market, it is good to also understand how heavily Chinese regulation affects especially foreign actors in that market."

11.2 Japan & South Korea

In Japan, the majority (91.3%) of shipped headsets are made by Sony. It makes PSVR the leader in VR business in Japan⁵⁸

Among other companies, Gree and Bandai Namco have opened several arcades⁵⁹ over the past year, but they are not as common as in China.⁶⁰

Japanese companies like Gumi, Colopl and GREE have made investments to VR companies mainly outside, Japan, but in the domestic Japanese market the real breakthrough of B2C VR is likely depending on success of arcades and penetration of Playstation VR. There is Japanese VR start-ups and some of their showcases have gained attention e.g. trade fairs or demo days, but compared to Japanese position in global game markets in general, VR development has taken off relatively slowly⁶¹. However, some of Japanese VR or AR start-ups are experimenting with niches and dictions not experimented by bigger companies.

55 Newzoo; Monthly China Mobile Market Update. Available in: http://resources.newzoo.com/hubfs/Reports/Newzoo_Monthly_China_Mobile_Market_Update_2017_2.pdf?hsCtaTracking=abc48b85-2e49-41db-8ce4-33f422721122%7Cebaa-d0b3-cd1c-4c93-aa86-aa15f3962cc9

56 Newzoo; Monthly China Mobile Market Update. Available in: http://resources.newzoo.com/hubfs/Reports/Newzoo_Monthly_China_Mobile_Market_Update_2017_2.pdf?hsCtaTracking=abc48b85-2e49-41db-8ce4-33f422721122%7Cebaa-d0b3-cd1c-4c93-aa86-aa15f3962cc9

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50 Niko Partners; 2017 China Topic Report: Virtual Reality/Augmented Reality/Mixed Reality (VR/AR/MR) Market Report. Available in: https://www.researchandmarkets.com/research/p5pn8n/2017_china_topic

51 Fast Company; Report: China's VR industry is crashing and burning.

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52 Tech in Asia, Jennifer Katanyoutanant; This VC says China will drive VR adoption worldwide.

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53 IDC; China's VR market set for 4-fold expansion in 2017 after a wild ride in 2016.

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12. VR/AR - Why Finland - Ecosystem support

Finland is famous for its technological and creative know-how and successful game industry. Those form a very good foundation for VR and AR to bloom. The game industry community and ecosystem are extraordinarily strong in Finland. That is partly due to a virtually non-existing domestic games market, which encourages companies to co-operate rather than compete. The same phenomenon can be seen also in VR and AR development.

FIVR (Finnish VR- and AR developers association) has a strong leader role in supporting the local VR- and AR ecosystem and in sharing information. A supportive ecosystem is based on trust and collaboration between individual developers. Experiences, learned lessons and tacit knowledge are shared among developers.

The impact of Business Finland (formerly known as Tekes / , the Finnish Funding Agency for Innovation and Technology)⁶², not only the latest MR-program,⁶³ but their funding and support for technology already from 1983 onwards, has given an undeniable boost and encouragement for technological development and innovation.

To speed up development in AR and VR it is also necessary to have enough high-quality talent. Unfortunately, despite the high quality of Finnish developers, the amount of VR/AR developers is too few to respond to the current demand. Therefore, recruiting talent abroad is one of the key challenges.

Despite the success of the Finnish game industry, Finland seems to be a quite unknown country for many. More effort could be made in positive marketing regarding Finland as a potential hot-spot of technology, innovation and creativity. Not to mention that the country is safe, stable and has excellent healthcare and free education. Finland was rated second in a global very high social progress rating.⁶⁴

13. Future predictions

13.1. AR and VR markets

Almost all the interviewees (as well as many other professionals and internet sources) stated that it will still take approx. 3-5 years for the VR and VR B2C market

62 <https://www.tekes.fi/en/>

63 <https://www.tekes.fi/en/programmes-and-services/campaigns/team-finland-mixed-reality/>

64 Social Progress Index 2017, Social Progress Imperative. Available in: http://www.socialprogressindex.com/assets/downloads/resources/en/English-2017-Social-Progress-Index-Findings-Report_embargo-d-until-June-21-2017.pdf

to open.⁶⁵ B2C is the major market for game developers. Before the amount of individual headsets in consumer side reaches a critical mass, B2C market will be dominated by different implementations in amusement parks, shopping centres and arcades.

In the B2B market there is huge potential in education, health care, industry and simulations. At the moment it seems that the growth potential there is probably bigger than in the entertainment B2C business.

There are high expectations towards Microsoft mixed reality solutions, that could (if possible) finally offer the holistic immersive experience with web camera and headsets combined. Along with this vision Microsoft aims to provide technology that enables reality and virtual/augmented reality to blend together.⁶⁶

Big players (like Facebook, Apple, Google, Tencent, Snap, Alibaba, Baidu, Samsung, Huawei etc.) are at the moment in heated competition in AR and VR on all the levels of technology; hardware and software. Ultimate competition over market dominance is speeding up the development of technology, which benefits both developers and end-users.

Over the next few years, technological development will improve usability and interaction significantly. Due to investments made by several big manufacturers, there are quite high expectations for headset development. Headsets are expected to be wireless and in the long run also standalone devices. However, enhanced technology does not necessarily (or even probably) mean lower prices, which will consequently hinder growth in the customer market.

Controls in VR are likely to become more intuitive to use. It is also quite likely that hand tracking technology will enable us to use our own hands as controls. This, together with enhanced eye tracking, completes intuitive interaction on an acceptable level. In addition to this, eye tracking will allow better optimization in performance, when a system can focus only where the user is currently looking. This means a better quality in visuals, but it can also function as a form of interaction control. Eye tracking is also offering an extra dimension of data on genuine user behaviour and analytics.⁶⁷

Advanced augmented reality, seamlessly blending the digital world to real life physical elements, will hopefully finally lead to a mixed reality experience in its actual definition. This requires advanced real time spatial mapping and object

65 IDC, Worldwide Spending on Augmented and Virtual Reality Expected to Double or More Every Year Through 2021, According to IDC. Available in: https://www.idc.com/getdoc.jsp?containerId=prUS42959717&utm_source=Triggermail&utm_medium=email&utm_campaign=Post%20Blast%20%28bii-apps-and-platforms%29%20Why%20AR%2C%20VR%20are%20set%20to%20take%20off%20%2E2%80%94%20Google%20is%20expanding%20its%20Africa%20initiatives%20%2E2%80%94%20-Mobile%20forges%20ahead&utm_term=BI%20List%20Mobile%20ALL

<http://www.businessinsider.com/ar-vr-2017-8?r=US&IR=T&IR=T>

66 The Verge, Tom Warren; Microsoft's Windows Mixed Reality: everything you need to know. Available in: <https://www.theverge.com/2017/10/17/16487936/microsoft-windows-mixed-reality-vr-headsets-guide-pricing-features>

67 The Medium, Lucas Rizzotto; The Next 5 Years: Predictions for VR/MR.

Available in: <https://medium.com/futureepi/predictions-whats-next-for-vr-mr-2c9663d58c46>

recognition technology. Artificial Intelligence already has, and virtual assistants will have, a crucial role in interaction. One future option is the so called conversation-based UI.

Until dedicated stand-alone headset technology is advanced enough and the prices are affordable for a customer market, mobile will dominate AR at B2C. Smart glasses will eventually appear, but it will probably take at least a decade until they reach penetration in the customer market. When it comes to mobile VR, it seems, at least in the short term, to give way to mobile AR.⁶⁸

AR/VR Platform Revenue

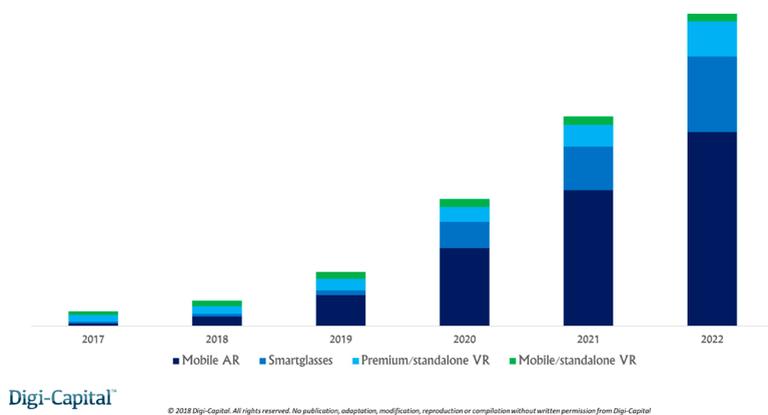


Image 3. AR/VR Revenue. Digi-Capital⁶⁹

Digi-Capital estimates that AR (mobile AR, smartglasses) could grow over to approach three and a half billion installed base by 2023. According to same estimates, VR (mobile, standalone, console, PC) might reach 50 to 60 million installed base revenue at the same time frame.

According to same estimates games will dominate AR content market in short term, but in long term growth is expected also from other areas. In VR games are likely to be the dominant form of content also in the long run.

67 Ubiquitous \$90 billion AR to dominate focused \$15 billion VR by 2022. Digi-Capital. Available in: <http://www.digi-capital.com/news/2018/01/ubiquitous-90-billion-ar-to-dominate-focused-15-billion-vr-by-2022/#.Wm7jKhl9PY>
69 Ibid

AR/VR App Store Category Revenue (IAP/Premium)

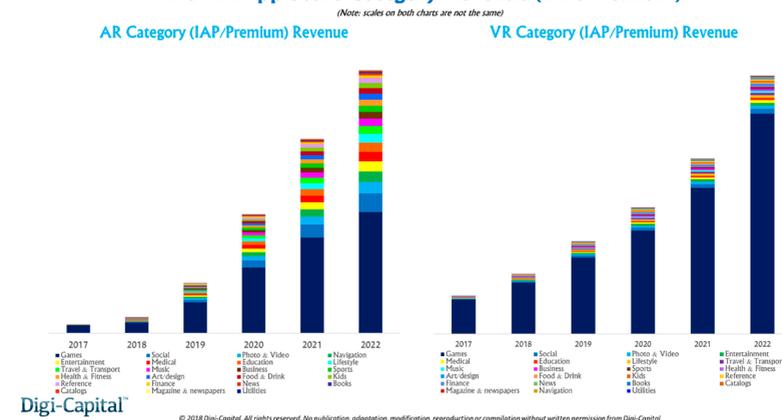


Image 4. Mobile AR Sector revenue (2021F). Digi-Capital⁷⁰

13.2. The key regulatory challenges for AR and VR game development

AR and VR and copyright

The freedom of panorama, or the lack of it, determines whether or not you are allowed to take photos, film, create paintings or any other images on buildings, sculptures and other works of art that are permanently located in public space, without an authorisation from an architect or artist behind those works. How far the freedom of panorama covers 3D spatial maps used in AR games is currently an open question.⁷¹ Those market areas, where AR content enjoys the widest freedom of panorama, are also the ones with the lowest market access barriers for AR developers.

As VR is often considered to be a new medium, it is possible that the current licensing agreements do not automatically cover it. Therefore game developers using third party IPs should carefully assess whether their licencing agreements include VR use, and if modifications required to adapt the content to VR use are allowed under the licence⁷².

70 Ibid

71 Game Industry Biz, Jari-Pekka Kaleva; Pokémon Go is just the beginning of an absurd copyright struggle in AR. Available in: <http://www.gamesindustry.biz/articles/2016-10-20-pok-mon-go-is-just-the-beginning-of-an-absurd-copyright-struggle-in-ar>

72 Allen & Overy; Virtual Reality - The expected future ubiquity of consumer virtual reality equipment and consequent legal and regulatory challenges. Available in: http://www.allenoverly.com/SiteCollectionDocuments/AO_WP_Virtual_Reality.pdf

New AR and VR specific product liability questions

The introduction of Pokémon Go quickly led to a whole new debate in the USA on how far a game developer is liable for the personal damages or damages caused by their gamers while they are playing the game in a real environment⁷³. In Europe, this debate is likely to become part of a wider, on-going debate on who is liable in cases of damage caused by data-intensive products in general⁷⁴. In the short run, this means that AR game developers run a greater risk of legal battles than other developers. In the long run, the global regulatory framework on the liability of an AR game developer will become more and more fragmented, building a whole new regulatory market access barrier.

On the VR side, the debate on the liability of a game developer circulates around the liability for the injuries players cause to themselves while being blinded by the virtual reality equipment, and the possible long-term health effects of the extensive use of VR equipment. Especially the psychological impact, caused by potentially traumatising virtual reality content or cyber bullying, is likely to lead to further liability debate on the subject.⁷⁵ Consequently, VR game developers should be particularly careful to build safety measures together with VR platforms and hardware manufacturers for both avoiding physical injuries while playing a game and minimising the risk of long-term psychological impact of in-game content.

VR specific age ratings

The challenges the VR technology brings for age rating systems are two-fold. On the other hand, if the age rating systems used for VR games will not be relying on self-ratings, VR games might require a more burdensome and thus more expensive review process than traditional games, as the reviewers might have to play the games themselves instead of just reviewing them from a regular screen, as the 360° surrounding is an essential part of the game experience⁷⁶. On the other hand, the introduction of VR content to mass markets was quickly followed by a public debate calling for higher age ratings for them than traditional games due to their stronger immersiveness⁷⁷.

The more expensive the age rating process is, the bigger market access barrier it becomes for small developers. Furthermore, traditionally, the publishers of AAA games have been hesitant to fund 18+ games due to their limited market potential

⁷³ Bloomberg Law; Can Pokémon Go and Product Liability Coexist?

Available in: <https://www.bna.com/pokmon-go-product-n73014446561/>

⁷⁴ EUR-Lex, Communication from the commission to the European Parliament, The Council, The European Economic and Social Committee and Committee of Regions. Available in: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2017%3A228%3AFIN>

⁷⁵ Allen & Overy; Virtual Reality - The expected future ubiquity of consumer virtual reality equipment and consequent legal and regulatory challenges. Available in: http://www.allenoverly.com/SiteCollectionDocuments/AO_WP_Virtual_Reality.pdf

⁷⁶ Hilgert Summermann. Youth Protection in Virtual Environments. Available in: https://www.americanbar.org/content/dam/aba/images/entertainment_sports/meetings/2017-video-games/m6-cri-2016-75.pdf

⁷⁷ Osborne & Clark; Digital Entertainment, virtual reality, games and classification. Available in: <http://connectedconsumer.osborneclarke.com/digital-entertainment/virtual-reality-games-and-age-classification/>

and regulatory restrictions for their distribution and marketing in some countries. Therefore, higher age ratings for VR games might lead to more limited access to funding.

Legal uncertainty of the VR data protection practices

The new European data protection regulation (GDPR), enforced from May 2018, sets strict requirements for the use of personal data in the game industry. VR equipment is currently leading the technological innovation on novel solutions for human-computer interfaces. These solutions are going far beyond traditional user interfaces (such as eye-tracking) and thus VR games are likely to become also the forerunners of the data protection practices related to these new solutions. This will be a particular challenge for VR fitness games linked with other fitness equipment like a heart rate monitor that might therefore be processing particularly sensitive health data.⁷⁸

The lack of predictable and coherent enforcement of the data protection framework in the area of VR games makes them particularly vulnerable for suddenly changing implementation practices. For a game developer, this means potentially bigger legal risks, as they cannot be certain of the sustainability of their technological solutions from a data protection perspective, and thus risk higher development costs due to increased legal consulting expenses.

14. Summary

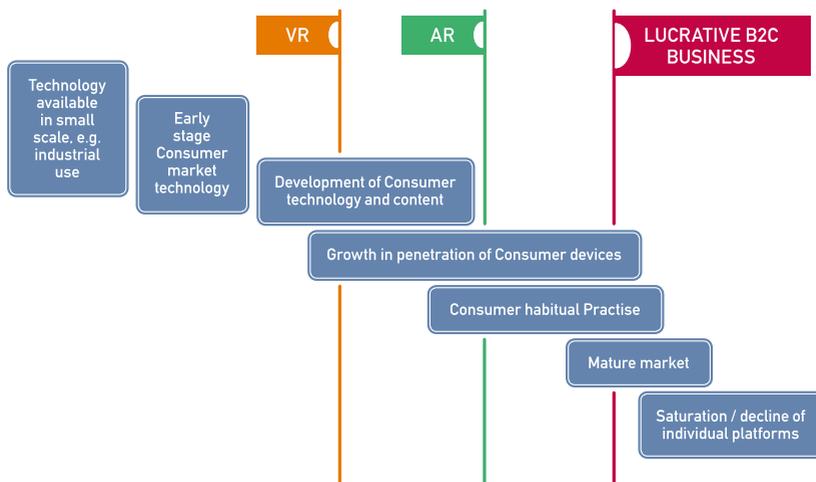
Based on the findings made in the course of this study, the following should be considered important for game developers in the current situation:

- In B2C the price point of devices, technological challenges, fragmentation in platforms and lack of content slow down the development of the B2C market
- At the moment, the market for VR seems to be in B2B, tools and technology, not in B2C content
- It will take 3-5 years before the B2C market for VR opens
- Regulatory fragmentation and legal uncertainty are a particular challenge for both VR and AR markets
- AR in B2C is more mature, but finding suitable content is not easy.
- However, the ecosystem is developing rapidly. Investments in the ecosystem are still big. 40% growth in Q2 2017
- B2B environment offers a good proving ground also for game- and gamified content.
- Asia, especially China, is expected to be the biggest market for VR in the future
- Full cockroach mode (R&D only) is not advisable. Content is best developed in interaction with an audience.

⁷⁸ Allen & Overy; Virtual Reality - The expected future ubiquity of consumer virtual reality equipment and consequent legal and regulatory challenges. Available in: http://www.allenoverly.com/SiteCollectionDocuments/AO_WP_Virtual_Reality.pdf

- Game developers' advantage is that they can provide a full service (Design & Graphics & Programming) better than anybody else.
- Especially in UI / HCI design, game developers should have a clear advantage.
- Creativity & Innovation is as important as UI / HCI design. The key question is, "what is meaningful content?"
- VR might prove to be the ultimate tool for applied (serious) B2C games.

The picture below shows where the VR/AR B2C market is at the moment compared to a lucrative B2C market



PEOPLE INTERVIEWED TO THIS STUDY:

Harri Manninen, Director at Nordic VR Startups
 Suman Rath, Senior Vice President, Nordisk Film PlayStation
 Tero Särkkinen, Founder, Board Director, BaseMark
 Oskari Häkkinen, CPO, Founder, FutureFly
 Sampo Lappalainen, COO, Umbra
 Kari Koivistoinen, CEO, 3rd Eye Studios
 Sami Ronkainen, Creative director, Physical & Digital, Rovio Entertainment Ltd.
 Petteri Koponen, Founding Partner, LifeLine Ventures
 Emma Huovinen, COO, Shipyard Games
 Pyry Parkkola, CEO, Founder & Niko Ranta, CTO, Virtual Dawn
 Jufo Peltomaa, Head of Special Ops, Co-founder, Immersal
 Antti Kuosmanen, Business Group Lead, Microsoft
 Jussi Laakkonen, EVP, Unity
 Jan Hursti, Co-founder, VirvaVR/Pikseli
 Otto Laurila, CTO & Teemu Viljanen, Developer, Arilyn
 Kaarlo Kananen, CEO, Vizor
 Urho Konttori, CEO, Varjo
 Samuli Syvähuoko, Co-founder, Partner, Sisu Ventures

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