



Virtual Reality Business Report

"The Manual for adding Value to your Business"

Inspiration Edition
(Free Demo Version 2018-02)

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About present4D:

present4D is a full-service Virtual Reality agency for strategic consultancy, turnkey projects and software development. With its unique VR-Suite software solution users can easily create their own professional VR presentations for trade fairs, training courses, marketing and sales.



The three founders of present4D have more than 20 years experiences in interactive multimedia, 360° media, 3D animation and innovation

Give us a call:

Duesseldorf, Germany +49 211 4685240

Executive Summary

After more than 50 implemented VR projects coming from 20 different industry segments and numerous VR strategic consultancy workshops, it appeared to the present4D team that many businesses are unable to envisage the full potential of Virtual Reality technology. To that end, present4D wants to demonstrate the added value that this technology can provide to companies evolving in many different industries. This report includes information for every businessperson who wants to acquire extensive knowledge about the VR industry and is suitable for beginners and experts alike.

A brief explanation is given as to how the report and its analysis are structured but most importantly, why it is valid. The Customer Value Proposition is a powerful tool to take the place of a company's customers and to subsequently better its products and services.

Because understanding the mechanisms surrounding the VR industry is key, an overview of the VR ecosystem and especially how hardware, software, content generation tools and platforms function together is provided. Current challenges facing VR technology are evaluated and ten cross-industrial Use Cases are highlighted to show how this technology can be used in every type of industry.

Eight industry segments have been selected based on the potential added value VR can provide, in the short term, to companies active in those industries. The goal, thanks to the Customer Value Proposition methodology, is to determine the added value of VR technology over target groups' current solutions. Implementation is key and thus, for each industry, key trends are identified and studied via VR Use Cases. These allow readers to understand how other companies have successfully benefitted from VR in their digitalization strategy. For inspirational purposes, an extensive list of companies having used VR has been collected for each analyzed industry. Readers of this Business Report can subsequently source reference projects and new project ideas to better understand their competitive environment.

In the appendices, readers will find information to help them understand technical words or gain further knowledge about the technology itself.

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1 Introduction

1.1 How this Report will add Value to your Business

In today's business world it is tough to manage a strong and sustainable business especially when dynamics of a global competitive environment challenge industries in all regions of the world. New product development and new service offers are essential for nearly all business sectors. Based on Megatrends or driven by social trends, the markets literally yearn for good solutions to solve problems and fulfill the needs of customers and end consumers. In many cases innovative technologies help to overcome the struggle of finding the right access point for strengthening or expanding one's own business.

But innovative technologies are often complex and expensive due to high investment and turn out to become uncontrollable if not managed properly with the right team, the right expertise and sometimes also with the right patent portfolio to protect the high investment costs. Many questions arise during the implementation of such new technologies into the existing business processes. The management of risk, budget, time and human resources together with the challenge of convincing the company's decision makers to invest in a new technology, in new applications or in new markets is a difficult job for product managers, business developers, innovators or project leaders.

Diverse business assessment tools are available to support managers' tasks. For a first approach readiness or opportunity assessment tools [1] are effective tools for an orientation in the complex ecosystems and for positioning the company within its strategic scope market. Industry reports from analysts give valuable insights about key players, market sizes and sales forecasts in different industry segments and different regions. Information in these reports support the decision process of the company's management with quantitative data of actual and forecasted sales potential. The quality of the sales potential depends on many assumptions based for instance on the Porter's five forces model [2] which determines the competitive intensity and, therefore, the attractiveness of an industry in terms of its potential and profitability.

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To demonstrate the usefulness of the Customer Value Proposition and to better understand how this document can add value for readers of this Business Report, we conducted a CVP analysis of this VR business report:

The value proposition of this report results from readers' jobs-to-be-done

- to find out the added value with VR for one's own business
- to identify the most relevant Use Cases
- to start first VR prototypes

The biggest pains during the process of doing those jobs are

- understanding the complex VR ecosystem
- prioritization of the most relevant Use Cases
- no added value analysis of Use Cases available
- high implementation risk
- competitor has already started VR activities



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Gains which help to do the jobs

- support from management board to invest in VR
- existing corporate digitalization strategy
- running innovation initiatives
- dedicated budgets for new technologies and innovations

Added value of this VR business report

- most comprehensive overview of complex VR ecosystem
- description of the 10 cross-industrial VR Use Cases
- overview of key Use Cases in 8 selected key industry and key business segments
- customer value proposition analysis of many key Use Cases

This report will become the pain reliever and

- gives quick access to the most relevant Use Cases which significantly reduces the time for one's own desktop research
- summarizes added value analyses of most important Use Cases in different industry segments

Virtual Reality Business Report

- is an enormous source for inspiration
- significantly reduces the risk during VR implementation

This report can be regarded as a gain creator for

- many reference examples for the digitalization strategy
- recommendations for quick implementation and cost estimations
- a manual for innovation and business development teams

1.2 Potential Added Values using Virtual Reality Technology

The key question for investors and for decision makers in all industries is how to add value to their business with the Virtual Reality technology. During the study of hundreds of Use Cases the author's team has identified the following potential added values that Virtual Reality can provide to existing businesses:

-  • Emotionalization of products
-  • Generate more revenue
-  • Cost reduction
-  • Process efficiency improvement
-  • Quality improvement
-  • Image enhancement
-  • Risk reduction
-  • Competitive advantage
-  • More customer proximity
-  • New business models
-  • Global availability
-  • Ideation and inspiration
-  • Improved decision making
-  • Increase of customer and employee loyalty
-  • Higher information retention
-  • Contribution to sustainability



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2 Structure of this Report

The first implementation of VR into the processes of a company can be difficult due to the complex nature of this technology and the countless possibilities that can be created. Thus, this business report was conceived with the sole purpose of enabling readers to master this fascinating technology.

2.1 What this Business Report is

The goal of this report is twofold

- allow readers to quickly gain an understanding of how to use VR technology in their day to day business and add value to it
- ideation and inspiration about VR, i.e. how VR can be used or learn from best practices

It includes the most up to date numbers and analysis about VR technology and focuses on B2B interactions by taking the view, in the analysis, of the companies proposing a VR product or service.

2.2 What this Business Report is not

All readers of this business report should be able to understand the issues of VR without prior knowledge of the technology. Thus, this document addresses people who want to use VR in a practical way and is not intended for technical engineers.

There is no analysis of any market estimates in this report, the focus lies in the understanding of how one can take advantage of VR to add value to an existing business.

Moreover, it is not a handbook for end consumers but focuses on businesses.

2.3 Who this Business Report is for and how to read it

2.3.1 Newcomers

Those who are completely new to VR and want to get a preliminary understanding of the technology and the terms encompassing this industry, should start by reading the following

parts in the appendices: “Definition of key terms” and “History of Virtual Reality”. Those lectures could then be followed by part 4 “VR vs AR vs MR” and part 5 “The VR Ecosystem”, to better interpret the industry.

Once this holistic idea of the VR industry has been gained, the reader can dive into the cross-industry VR categories to comprehend in which Use Cases VR technology is most useful. Depending on the industry of origin, the reader can focus on a specific industry in part 7.

Finally, part 8 concerning “The Outlook” or the future of VR will leave the reader with enough information to prepare future developments of this technology and how to address them from a business point of view.

2.3.2 Professionals who want to use VR for a business project

Professionals who want to quickly learn about VR technology and implement it into their processes or during a project can start with part 5 combined with the definition of key terms in part 9.1 to gain an overview of the VR industry. Then, they can continue and read part 6 to select and understand which VR applications are relevant to their industry. In part 7, they should prefer the industry they are involved in, in order to learn about their competitors, the hurdles and future possibilities in their industry. Finally, those professionals can prepare for the future developments of VR technology by reading part 8.



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2.3.3 VR Professionals

VR Professionals already familiar with the technology will enjoy parts 6 and 7 which include cross industry one-pagers and in-depth analysis of VR Use Cases throughout 8 industries. These can help them understand how VR is used in an industry different than theirs, and which Use Cases are relevant to their activity.

3 Validity and Method of the Business Analysis

3.1 Principles of Analysis and Basis for Validity

- The validity of the findings and claims in this report is fundamentally based on the expertise of present4D authors from more than 100 VR projects , 25 years of experience in multimedia and 4 years of dedicated Virtual Reality workshops in a variety of different industry segments together with “real” customers, including 10 DAX enterprises. The outcome not only represents the “Voice of Customers”, but also their perception and their success stories in implementation (<http://www.present4d.de>).
- Together with KPMG in 2016 the present4D team published the VR/AR study with a first standardized qualitative analysis of added value chains from 260 concrete reference applications and a subsequent description of the VR ecosystem. The results from this study are the foundation of this report.[3].
- The CVP methodology itself was developed by Alex Osterwalder and in collaboration with more than 470 strategy experts from 45 countries. First published in 2015, the book “Value Proposition Design” is an essential companion to the best-selling ”Business Model Canvas” and globally used by business developers from startups and large corporations such as MasterCard, 3M, Coca Cola, GE, Fujitsu, LEGO, Colgate-Palmolive, and many more [4] [5]



Figure 1: KPMG Study, New Dimensions of Reality

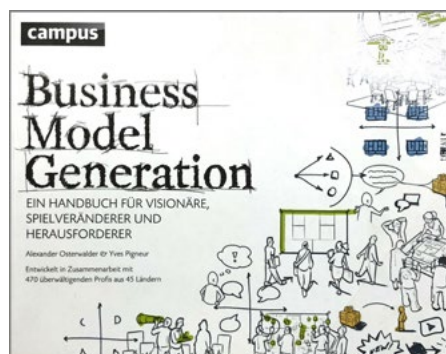


Figure 2: Business Model Generation from A. Osterwalder and Y. Pigneur



Figure 3: Value Proposition Design from A. Osterwalder and Y. Pigneur

3.2 The Business Model Canvas

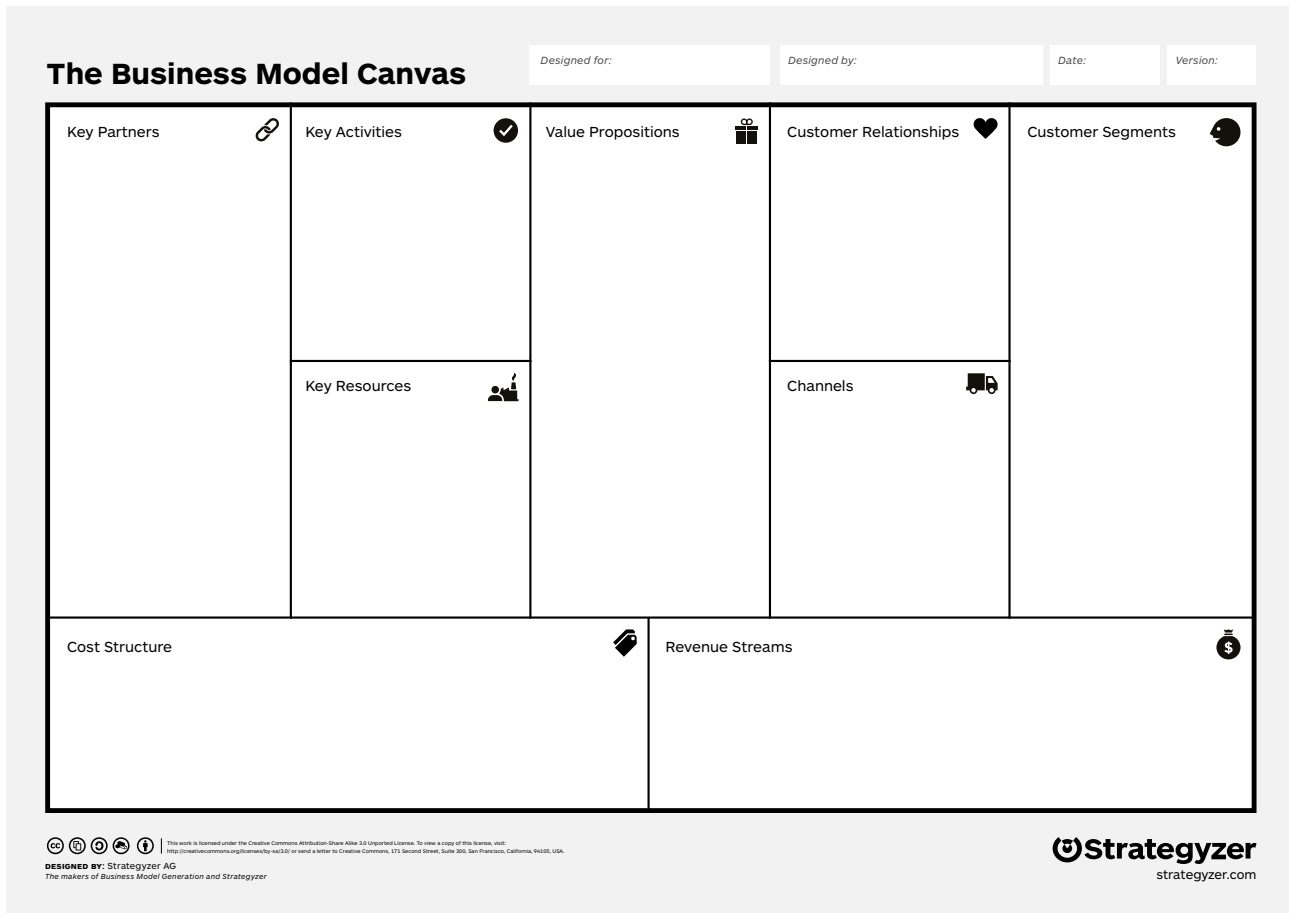


Figure 4: The Business Model Canvas from Strategyzer

To capture value for the organization, a company can use the Business Model Canvas, a tool to describe how an organization creates, delivers, and acquires value.



YouTube video, which explains the Business Model Canvas:
www.youtube.com/watch?v=QoAOzMTLP5s

The value proposition, which is used to analyze the different Use Cases, is an essential part of this Canvas.

The Business Model Canvas and Value Proposition Canvas are fully integrated allowing users to drill down into the details of how they are creating value for customers. According to Alexander Osterwalder [4] the different parts of the Canvas they will be explained in the following bullet points:

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- “Customer Segments are the groups of people and/or organizations a company or organization aims to reach and create value for with a dedicated value proposition
- Value Propositions are based on a bundle of products and services that create value for a customer segment
- Channels describe how a value proposition is communicated and delivered to a customer segment through communication, distribution, and sales channels
- Customer Relationships outline what type of relationship is established and maintained with each customer segment, and they explain how customers are acquired and retained
- Revenue Streams result from a value proposition successfully offered to a customer segment. It is how an organization captures value with a price that customers are willing to pay
- Key Resources are the most important assets required to offer and deliver the previously described elements
- Key Activities are the most important activities an organization needs to perform well.
- Key Partnerships shows the network of suppliers and partners that bring in external resources and activities
- Cost Structure describes all costs incurred to operate a business model
- Profit is calculated by subtracting the total of all costs in the cost structure from the total of all revenue streams”

After the overview of the Canvas, the main part of the discussion and analysis - the value proposition - will be described, which gives detailed insights on how value is created for the customer.

3.3 Customer is Key – The Customer Value Proposition

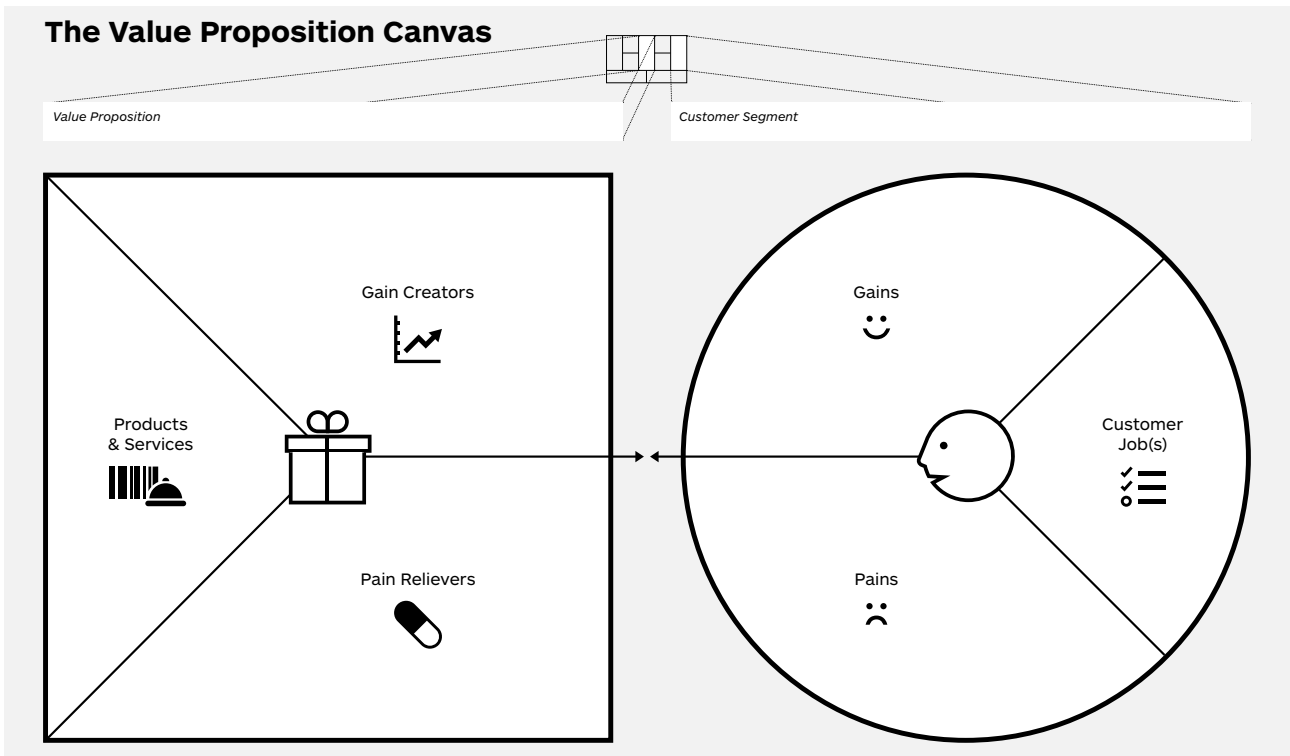


Figure 5: The Customer Value Proposition Canvas from Strategyzer



YouTube video which describes the Value Proposition Canvas
www.youtube.com/watch?v=aN36EcTE54Q

The VR Use Cases from part 7 are analyzed via the Customer Value Proposition method, which is at the heart of the Business Model Canvas from Alexander Osterwalder. A CVP is a 'commitment of potential value' that an organization distributes to its customers. It determines why a customer would choose to buy its products/services. The analysis emphasizes the relevance of a company's product/service by stating how it solves or improves problems faced by the customer. It also measures the specific value of those offerings against customer's needs and over the company's competition [4]. The figure above resumes the main points of the analysis and is an excerpt from Osterwalder's book.

3.3.1 Customer Segment

Customer jobs are the primary objectives the customer is trying to achieve related to a particular requirement.

Gains are solutions the customer already uses to help to fulfill the job or meet particular needs.

Pains are things that prevent the customer from fulfilling the job or meet particular needs.

3.3.2 Value Proposition

Products and Services are what a company has to offer. In our case, it will be the VR Use Case.

Gain Creators refer to the value created from the products/services offered by a company, eg with this VR Use Case.

Pain relievers are the main characteristics of what the company has to offer to address customer pains and help to overcome these pains.

A successful CVP matches the gains and pains of the customer with what the company has to offer.

4 Virtual Reality vs. Augmented Reality vs. Mixed Reality

VR describes a technology for interacting with a computer-generated environment, which can be experienced in three dimensions. Thus, the term VR considers a simulated 3D representation of a world. However, there is no consistent understanding of this term both within the scientific community and among the population at large. There are many different definitions and the term can even be used in the wrong context. However, in order to be able to define VR in detail, the definition of Zhuang / WANG is shown [6]:

“VR is a high-end Human-Machine Interface, that combines technologies such as computer graphics, image processing, pattern recognition, artificial intelligence, networking, sound systems and others to produce computer simulation and interaction, which gives the feeling of being present through multiple synthetic feedback sent to sensorial channels like virtual, aural, haptic and others.”

Through this detailed definition, VR technology can be clearly delineated and display all of its constituents. Synonyms with the same meaning are terms such as Virtual Environment, Artificial Reality, Virtual Worlds, Artificial Worlds and Cyberspace.

The Burdea triangle in Figure 6 offers a good opportunity to clearly show the most important features of a VR system, whereby the quality of the system is derived from the characteristics of the respective features.

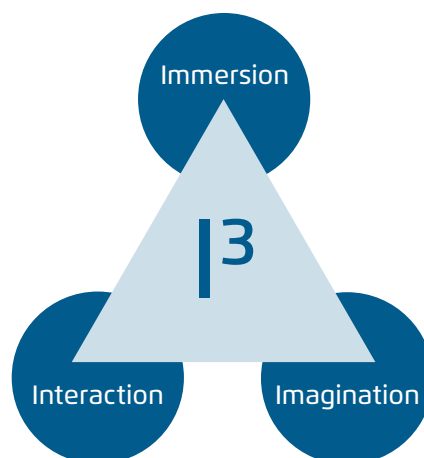


Figure 6: Triangle of VR – The three I's

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“Immersion“, which is also called presence, is the feeling of being part of the computer-generated world. This results from the stimulation of the human senses (visual, acoustic, haptic, smell, etc.) with the aid of the VR system.

“Interaction“ is the way of communicating with the VR system. In contrast to the traditional human-computer interaction in which 1-dimensional or 2-dimensional communication devices, such as a mouse or keyboard are used, interaction with a VR system generally uses 3-dimensional communication devices such as an HMD or a space ball which allows, for example, a real-time reaction.

“Imagination“ as third feature of a VR system is understood as follows: By using a VR system, complex problems in a variety of areas can be represented more effectively and efficiently than in a traditional 2D drawing, text, or explanation. The extent to which a VR application can solve a particular problem depends largely on the imagination of the individual.

Confusion between the terms Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) can occur. The Reality-Virtuality continuum chart below will help readers to better understand the differences between those three technologies.

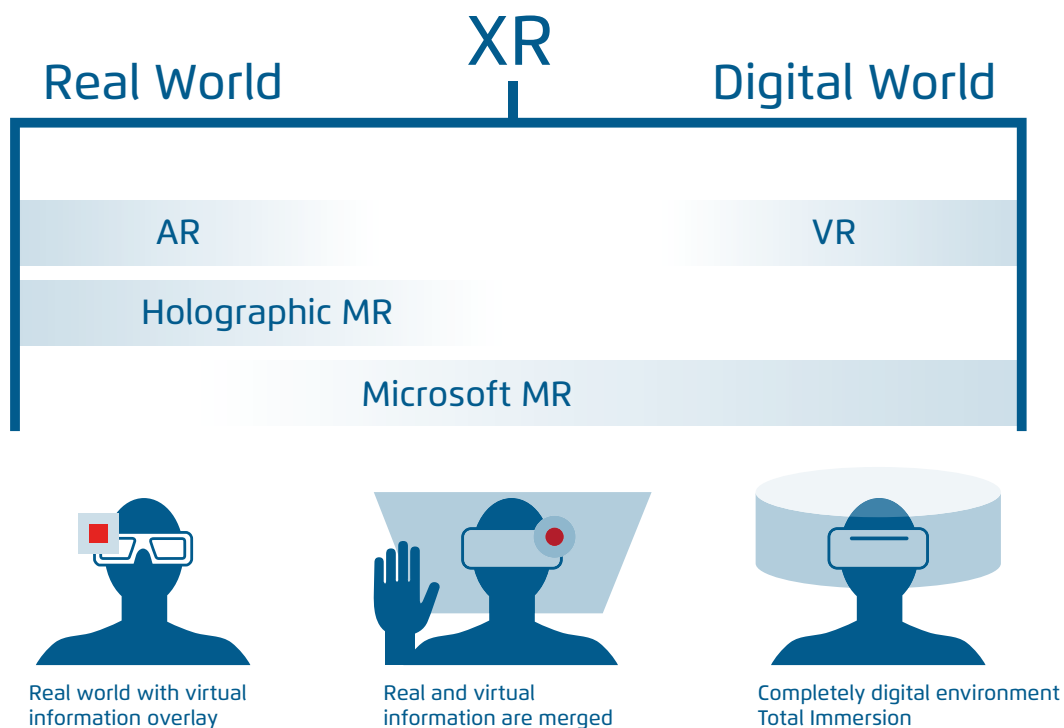


Figure 7: Differences between VR, AR and MR Technologies

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Figure 7 illustrates the difference between real world (RE) and virtual world (VR) and describes the space between these worlds. Augmented Reality (or AR) means to augment virtual objects in the real world. It complements reality by layering additional information over a direct view of reality. Its goal remains user-oriented; the overlaid information needs to be helpful to the user. An example can be GPS maps on a car windshield to keep the driver's eyes on the road. "AR head mounted displays are inevitable, and undoubtedly there will be headsets on the market that do both VR and AR, but that does not mean these activities are the same.

The quest for immersion represented by VR and the desire to be augmented, vis-a-vie AR, are very different things." [7]

MR on the other hand merges digital and interactive objects with the real environment the user is seeing. It is often confused with AR, since both technologies involve a live view of the real world. The virtually generated objects seen by the user can be interacted with and give a deeper sense of immersion. An example can be a user, who is interacting with a virtual hologram placed in front of him. Despite the theoretically clear distinction, the terms VR, AR and MR are not always separated in practice. The focus of this business report, however, is on VR technology.

5 The Virtual Reality Ecosystem

The Virtual Reality technology has formed a very complex ecosystem. In order to use the full potential of VR, a corresponding pair of glasses is not enough. It only forms the core hardware. In addition, it needs the so-called peripheral or secondary hardware, such as controllers, sensors or motion tracker. All those immersive experiences cannot be done without appropriate content. Here the claim “Content is King” is very valid. Besides the new generation of 360° cameras, for the content production, software engines like Unity3D or Unreal Engine as well as video players, stitching software or VR editor like the Virtual Reality Suite and assets stores with thousands of 3D objects for the construction of virtual worlds and tours are basis for filling the HMD-glasses with content.

Essential for the success of VR are social network companies like Facebook, Google, Microsoft or hardware producers like Samsung, HTC or Ricoh that provide the platforms supporting distribution or sharing of VR applications and media. Even the collaboration and meetings with partners in virtual environments often need powerful platforms and cloud providers.

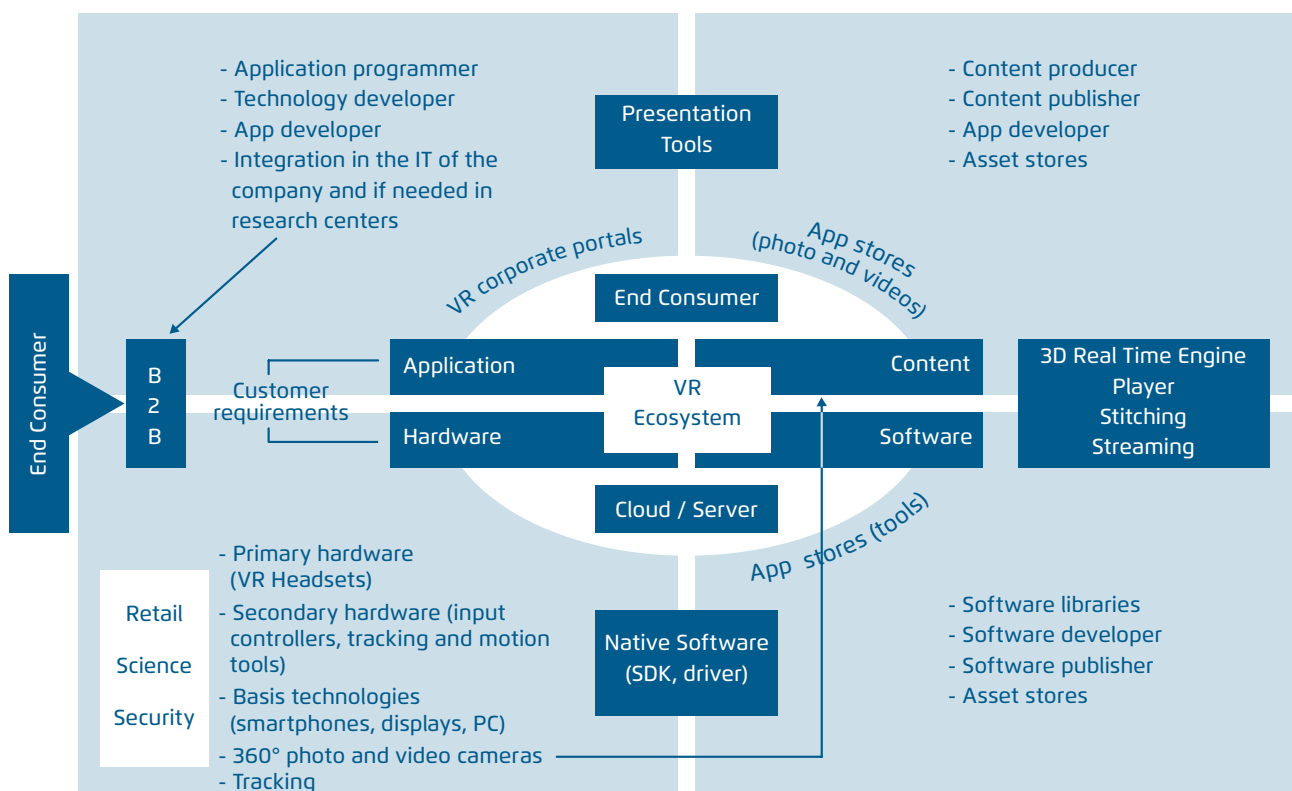


Figure 8: New Ecosystem - VR in the B2B Sector

5.1 The Hardware

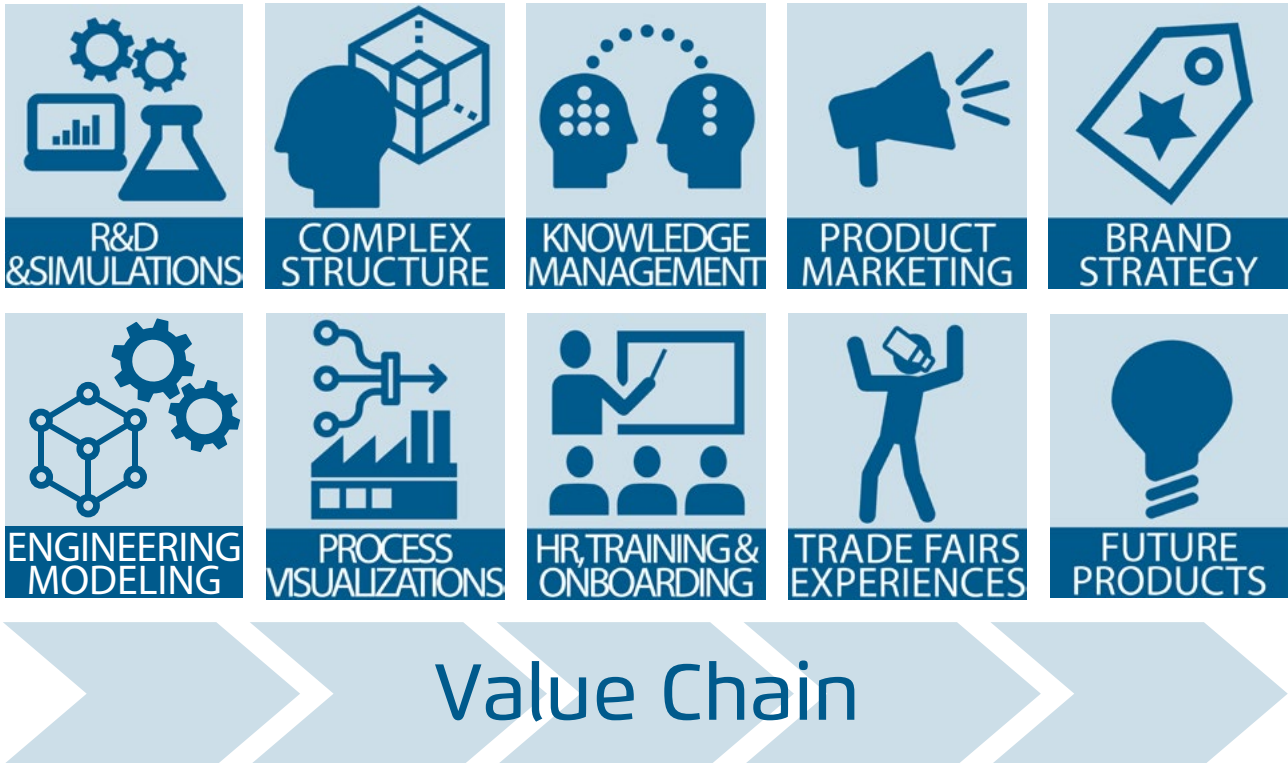
5.2 The Software

5.3 Content Generation

5.4 Platforms

6 Virtual Reality Applications

6.1 The 10 Cross-Industrial Use Cases



During Author's journey through the business world of industrial customers over the last 10 years one can identify cluster of general needs which are very common in all businesses.

All enterprises, organizations and all companies have the need to present company's products or services to a target group (customer, client, user, patient, etc.). To convince the target group is an essential goal. VR is a fantastic method to show potential customers an exciting and emotionalizing [company](#) or [product presentation](#).

Vivid and walkable reference projects of services e.g. of commercial agencies or social organizations can have a very strong impact on the communication or marketing strategy of the company and on the decision-making process of potential customers or clients.

VR as a [training](#) and [learning tool](#) is to author's opinion one of the most powerful tool for business and industrial users. To educate the employee or a team member of the company, to train the user of a specific product or services e.g. customer or business partner is a universal need around the world.

Sharing information and [collaboration](#) on certain internal processes, such as joint virtual tours through reference, social or development projects or in a [multi-user mode](#) make VR a unique method to experience real and virtual products, locations, situations, processes of 3D and 360-degree environments in a very immersive but also efficient (e.g. reduction of travel costs) way together with team members, partners or customers.

These are just four cross-industrial examples where every company and organization can benefit from and add value to their business.

The authors have structured the identified cross-industrial use cases into 10 categories along the value chain of the most businesses.

6.1.1 Product Marketing

6.1.2 Corporate Image & Brand Strategy

6.1.2.1 Description

Companies are constantly searching for better ways to communicate with their customers, not only for better ways to present their products/services, but also for customers to identify and relate to them. VR technology users can readily achieve both of these objectives in a most effective way. It induces a feeling of presence necessary for a more direct and emotional customer-product/service interaction in restricted spaces such as offices during customer sales meetings for example.

We found 2 distinctive uses of VR technology when it comes to corporate image and brand strategy:

6.1.2.1.1 Use Case 1: Corporate presentations for customers

In this category, we describe companies that want to present their assets in 360° videos or pictures with optional interactive content.

These assets can include products, processes, headquarters, production sites or even places where employees perform their job.

6.1.2.1.2 Use Case 2: Public related presentations

Use cases from this category include companies that want to show their sustainable public image. They want to demonstrate that they use politically correct policies to produce their products/services using creative 360° visuals with maximum impact. Examples include the use of clean processes, renewable energy, fair trade and healthy food.

6.1.2.2 Key Target Groups

- Marketing and communication managers in large corporations
- High level management in large corporations
- Employees in large corporations (bigger corporations), to stay up-to-date on the latest achievements/locations/new constructions of the organization
- Journalists, analysts and media producers
- Potential job candidates/applicants
- Company shareholders, stakeholders, politicians and other decision makers

Corporate Image and Brand Strategy

Description of Use Case

The Korean corporation Doosan, in cooperation with VR company present4D, documented many of its construction projects all around the world to be experienced in 360° tours. The facilities can be toured in VR on their website and have been used on trade fairs to explain the complex construction processes.



Company issuing the Use Case

The Doosan Group is a South Korean conglomerate which provides electrical power, desalinated drinking water, construction equipment, advanced machinery, defense supplies, houses, highways and bridges, chemical processing equipment and industrial engines.

Added Value of VR Technology for this Cross-Industry Category



Global availability -
VR web browser tool.



Image enhancement -
Present the image of an
innovative company.



More customer proximity -
Customers get to know the
production site.



Emotionalization of products/services -
Convey emotions for industrial products
and services.

Challenges in this Cross-Industry Category

- VR storytelling needs to be adjusted to corporate identity while maintaining the reputation of the company
- Convey the right impression and message of the company
- VR as potential tool to address new target groups with the right distribution of the message

Outlook on Future Possibilities with VR in this Cross-Industry Category

- New multi-sensory dimensions to the VR user experience with interactive and immersive controller technologies or scent systems
- Heat map technologies for the analysis of the behavior and gazes of the users to collect data to enhance the VR experience
- New standalone HMDs (eg Oculus Go from Facebook and other mobile solutions) to leverage VR web browser solutions with higher quality than existing cardboard offers

Similar Use Cases

- [General Mills 360° virtual visit video to enhance corporate image affecting HR recruitment.](#)
- [Accenture 360° video to present their new innovation center in Paris.](#)

Sources of Use Case

- [Doosan web application presenting various locations in a 360° format](#)
- [Video of the VR experience at trade shows](#)

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- 6.1.3 R&D and Simulation
- 6.1.4 HR, Training & Onboarding
- 6.1.5 Complex Structure & Object Visualization
- 6.1.6 Immersive Experience & Trade Fairs
- 6.1.7 Process Visualization & Documentation
- 6.1.8 Engineering, Design & Modeling
- 6.1.9 Visualization of Ideas & Future Products
- 6.1.10 Collaborative Working & Knowledge Management
- 6.2 Current Status and General Challenges

7 Customer Value Proposition in selected Industry Segments using VR Products and Services



7.1 Automotive



7.2 Machinery & Plant Engineering



7.3 Energy & Environment



7.4 Healthcare, Leisure, Relaxation & Well-Being



7.5 Real Estate & Interior Architecture



7.6 Construction & Architecture



7.7 Service Providers, Agencies & Consulting



7.8 Education & E-Learning



7.9 Public Safety

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7.8 Education & E-Learning

7.8.1 Description of this Section

This industry analysis is written for companies creating, developing and teaching education material. It concerns for example:

- Academia in general
- E-learning service providers
- Companies creating education material
- Corporate training centers
- IT divisions of academia and private companies
- HR training departments
- Service providers for catastrophe scenarios
- MOOC service providers
- Marketing divisions of Universities

7.8.2 Key Trends in that Industry

1. **VR as a complementary tool to common learning material.** VR technology can reduce the complexity of learning material and create virtual content that is engaging and improves user information retention and increases learning efficiency. It can be used in classrooms, homeschooling, R&D or e-learning applications.
2. **Replicate virtually any training environment.** It is possible to configure any virtual environment for a specific scenario, eg. dangerous situations, physically inaccessible places, events that have already occurred, ethical situations, etc. Users can learn to cope with their emotions before facing the situation in real life.
3. **Enhanced virtual collaboration between users from any location.** The users can exchange their knowledge, best practice experiences, as well as collaborate in various virtual environments to increase their understanding of processes.
4. **Virtual 360° campus tours.** Students can get to know University campuses to help them choose which University fits their needs.

7.8.3 Main Use Cases with CVP Analysis

NOTE: In this context it is important to differentiate between a CUSTOMER within the CVP analysis and the END CONSUMER of the product or the service. The customer in the CVP analysis is the user of the VR technology, whose viewpoint is adopted. To illustrate this differentiation between “CUSTOMER” and “END CONSUMER”, let’s have a look at the first Main Use Case below. In this example the customers are e-learning service providers or corporate training centers and the end consumer is the user of this VR experience proposed by eLearning Studios, i.e. students or employees from companies.

Main Use Case 1: Key Trend 1

“VR as a complementary tool to common learning material”

Description of the Use Case

eLearning Studios is a company developing tailor made VR simulations for business e-learning platforms. They can recreate any environment or product in a virtual environment so that students can interact with it. The simulations are used for hard and soft skill training and can be used with three different VR HMDs: Google Cardboard, Oculus Rift and Samsung Gear VR.

<http://www.e-learningstudios.com/> (official website with description in English)

<https://www.youtube.com/watch?v=1MpUUDr60FM>
(official services teaser video with description in English)

7.8.3.1 Customer Profile/Target Customers

- E-learning service providers
- Corporate training centers

Customer Jobs



- Designing and creating engaging, effective e-learning courses
- Providing a functional e-learning experience
- Undertaking research to provide the most up to date class material
- Planning the implementation of an e-learning platform for different organizations
- Supervising platform support for users in difficulties

Pains



- End consumer aversion to new technology or new teaching methods
- Student motivation, if the students are not motivated enough to learn, the risk is that the e-learning material will not be as useful
- Lack of awareness of the e-learning platform, depending on where the e-learning platform is implemented, it needs to be well publicized or well communicated
- Bandwidth, high traffic and connectivity issues, if the content is only available online and not for download, a stable server and internet connection is required
- Keeping the website content up to date
- Easy to use and to understand e-learning platform

Gains



- Availability of dedicated software, the possibility to experience learning content anywhere
- Creating the e-learning content with experts to ensure the quality of the learning material
- Knowledge sharing functions, so that users can exchange best practices while learning
- Policies, procedures and standards for e-learning content and the way it is communicated. It ensures that the learning material is transmitted the right way

Products and Services



- Tailor made e-learning simulations where environments can be recreated virtually, users are teleported into learning context

Pain Relievers



- Increased student motivation, VR provides engaging content that will motivate the students to learn in a new and more immersive way
- VR increases understanding of the e-learning content because the user can experience the same situations as in real life but virtually

A 2015 survey from West UC provided an insight into employee views of e-learning. Two thirds of respondents would be more likely to participate in training if it was interactive and engaging. Moreover, 78% felt that hands-on learning boosted engagement.

<https://immerse.io/the-global-classroom-how-vr-helps-collaborative-learning-for-dispersed-workforces/>

Gain Creators



- Global availability, the immersive VR e-learning material can be experienced anywhere thanks to a mobile VR headset such as the Samsung Gear VR
- Competitive advantage and image enhancement, VR e-learning content is relatively new and thus companies using this technology will more likely be chosen by the end consumer
- Higher information retention, VR technology increases the retention of the learning material. In fact, a study measuring the impact of VR on academic performances of students in China found that VR increased the number of students passing an exam. The pass rate for students that engaged with the subject matter in VR was 90% whereas the pass rate for the non-VR students was 40%

https://cdn.uploadvr.com/wp-content/uploads/2016/11/A-Case-Study-The-Impact-of-VR-on-Academic-Performance_20161125.pdf

Main Use Case 2: Key Trend 2

“Replicate virtually any training environment”

Description of the Use Case

Virtually Better is a team of psychologists, designers, and software developers with over 20 years of experience developing evidence-based VR applications for phobias, substance use disorders, PTSD, stress/pain management, and more. A possible Use Case is a virtual Iraq & Afghanistan experience.

<http://www.virtuallybetter.com/> (official website with description in English)

Customer Profile/Target Customers

- Training centers
- Psychologists

Customer Jobs

- Research and identify behavioral or emotional patterns
- Designing and creating engaging, effective methods to understand the psyche of a human
- Use their knowledge to increase understanding among individuals and groups
- Help us to understand behavior, memory and mental health disorders
- Train end consumer in different environments to prepare them for every situation
- Analyze end consumers reactions in dangerous situations

7.8.4 Further Use Cases from this industry

7.8.4.1 Product Marketing

7.8.4.1.1 Use Case 1: Software and Hardware

VR training platform for Academia



©Munfarid

7.8.4.1.1.1 Munfarid VRXONE

With the VRXONE kit the company Munfarid has developed custom made VR education software and hardware platforms to leverage virtual educational applications. As a Google Expeditions partner they also promote their VR services through the professional VRXONE kit concept.

<https://www.munfarid.org/vrx/>

7.8.4.2 Corporate Image & Brand Strategy

7.8.4.2.1 Use Case 1: 360° University campus tours

7.8.4.2.1.1 University of Hartford

The University of Hartford's Barney School of Business tapped Primacy to develop its VR campaign, which immerses students into campus life via a customized and fully branded website with video and audio, and a Google Cardboard VR headset. In April, the school mailed the custom web-app and headsets to 1,300 students that were accepted by the university. The goal is to turn them into part-of full-time students this fall.

<http://www.edityinteractive.com/blog/6-innovative-colleges-universities-using-virtual-reality-tours-enhance-recruitment/> (description in English)
<https://ifttt.com/uhartvr> (video in English)

7.8.4.2.1.1.1 University of Hartford

7.8.4.2.1.3 Savannah School of Art and Design

Virtual 360° tour of the Savannah School of Art and Design. The school welcomes prospective students, sending them a set of goggles so that they can immerse themselves in campus locations in 3D as well.

<http://www.youvisit.com/scad>

7.8.4.3 R&D and Simulations

7.8.4.4 HR, Training & Onboarding

7.8.4.5 Complex Structure & Object Visualizations

7.8.4.6 Immersive Experiences & Trade Fairs

7.8.4.7 Process Visualization & Documentation

7.8.4.8 Engineering, Design & Modeling

7.8.4.9 Visualization of Ideas & Future Products

7.8.4.10 Collaborative Working & Knowledge Management

7.8.5 Challenges to the adoption of VR

7.8.5.1 VR viewed as a threat for existing e-learning platforms

Developers of e-learning platforms can see the advent of a new technology such as Virtual Reality as a threat for their business. In fact, VR offers new possibilities and is more immersive than current e-learning solutions.

But VR should rather be seen as a complementary tool to existing e-learning platforms, which enhances the learning experience without replacing it. Moreover, as our next point suggests, not every e-learning scenario can be translated into Virtual Reality.

7.8.5.2 VR is not useful for every e-learning scenario

7.8.6 Potential Evolution

7.9.1 Challenges to the Adoption of VR

- VR viewed as a threat for existing e-learning platforms

Developers of e-learning platforms can see the advent of a new technology such as Virtual Reality as a threat for their business. In fact, VR offers new possibilities and is more immersive than current e-learning solutions.

But VR should rather be seen as a complementary tool to existing E-Learning platforms, which enhances the learning experience without replacing it. Moreover, as our next point suggests, not every e-learning scenario can be translated into Virtual Reality.

- VR is not useful for every e-learning scenario

As mentioned by the website e-learning industry, only 5% of all learning material should be converted into VR. In fact, most learnings are knowledge based and require reading text. While students consider the latter, video based material, VR applications make them understand

7.9 Public Safety

7.9.1 Documentation and Forensics

Virtual Reality in combination with laser technology is a perfect technology for capturing and analysis of on-site real world data to investigate crash, crime and fire, plan security activities and provide very efficient training for public safety personnel.

<http://public-safety.faro.com/en/>

FARO has developed 3D measurement, imaging and realization technologies to enables an immersive VR experience with integration of detailed photographic textures, i.e. surface details of an object and rendering of 3D scan data so quickly that it appears to be generated in real time. With laser scanning and VR an investigator or forensic expert can document the evidence at crime, crash, and fire scenes.

<https://www.faro.com/news/faro-leads-in-virtual-reality-for-construction-design-and-forensics/>

3D capture methods with VR functionalities can also be used for construction projects and factories to document complex structures and perform quality control, planning and preservation in BIM projects (see also chapter 7.6 Construction & Architecture).

8 The Outlook

The view into the future is a mankind's dream and fills stories of uncountable science fiction books and movies.

Since 2015 countless reports and studies were filled with sophisticated calculations and estimations about sales potential of VR, AR and MR Head Mounted Displays (HMDs) and market projections in all parts and regions of the world.



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Many of them used top down calculations from megatrend analysis, some of them with suspicious assumptions about penetration rates in different market segments without comprehensible causality. Only very few reports were based on bottom-up calculations understanding market needs in very specific market segments.

However, even an in-depth bottom-up analysis of a revolutionary technology is facing many open questions about options, alternatives, challenges and risks.

To say, such calculations and market potential estimations are essential and extremely important for business developers and investors in their decision-making processes to understand when and how much money and resources they should spend into such a new opportunity area. The actual lack of profound quantitative data makes it necessary to have a comprehensive picture of additional decision criteria.

The main part of this business report has dealt with the customer value proposition, which is the key for the future success of this new technology.

In this final chapter the authors try to give an outlook to developments and additional factors, which may have an impact on the general sustainability of the Virtual Reality technology in the business world and which may help to reduce the risks of investments and to prioritize the options of opportunities.

- Adaption rates and Gartner Hype Cycle
- Hardware and software developments
- VR merging with AR and MR technologies
- Privacy issues and data security
- Social responsibility
- Economic, ecological and social sustainability

8.1 Adaption Rates and Gartner Hype Cycle

Meanwhile there are several surveys and studies about the adaption rates in different business fields and on the consumer side, a representative list is shown in the following part.

9 Appendix

9.1 Definition of Key Terms

9.1.1 Technical Terms about the Hardware and the Software

9.1.1.1 Virtual Reality (VR) or Virtual Environments

The Virtual Reality Society defines Virtual Reality (VR) as follows:

“The term is used to describe a three-dimensional, computer generated environment which can be explored and interacted with by a person. That person becomes part of this virtual world or is immersed within this environment and whilst there, is able to manipulate objects or perform a series of actions.” [8]

Schroeder defines Virtual Environments as follows:

“a computer-generated display that allows or compels the user (or users) to have a sense of being present in an environment other than the one they are actually in, and to interact with that environment” [9]

Both terms are equal in meaning and are used similarly.

9.1.1.2 Virtual Worlds

As opposed to Virtual Reality and/or Virtual Environments, the definition of Virtual Worlds is applied to persistent online social spaces, where people experience social interactions together. Online Games and Massively Multiplayer Online Roleplaying Games (MMORPGs) are a subset of Virtual Worlds in that Virtual Worlds in general do not have the focus on accumulating points or reaching new levels.

Precise definitions of Virtual Worlds and Virtual Reality is important to guide understanding and to set social implications apart from each other.

9.1.1.3 Cave Automatic Virtual Environment (CAVE)

C. Cruz-Neira states that: “Cave Automatic Virtual Environment is a virtual reality room. Projectors cover the walls of a room with stereoscopic image and the user need to use glasses which are synchronized with the alternating images the projectors (much like current 3D movies) an speakers are placed around the room to surround it with sounds.” [10]

9.1.1.4 Head Mounted Displays or HMDs

When thinking about VR, most people picture a person with a device on the head and covering the eyes. In fact, that is exactly how it looks. Most of the Head Mounted Displays in the market have stereoscopic displays and tracking systems allowing the user to visualize 3D images or 3D rendered virtual worlds through a large field of view. The virtual camera inside the device moves accordingly to the user's head position. This is made possible by gyroscopes and accelerometers that track every movement of the head. There is one display split in two to cover both eyes. If we take the example of the Oculus Rift CV1 HMD, the extended field of view of 110° and the stereoscopic vision saves data that is processed through a 3-axis gyroscope, an accelerometer and a magnetometer in order to give a fast image update and a realistic representation of the virtual world.

9.1.1.5 Tethered (Computer powered VR Headsets)

Wired or tethered Head Mounted Displays refer to devices connected directly to a computer via a cable. Therefore, the resolution of the display and the immersion in the virtual world are higher [11].

9.1.1.6 Untethered (Smartphone powered VR Headsets)

Wireless or untethered HMDs are devices that don't require any direct connection to a computer to work, they use the processor and screen of a smartphone for example, to render virtual worlds. The resolution is therefore lower and there is no space tracking system but the user can walk freely without being limited by cables.[11].

9.1.1.7 Display Type

The VR Headset manufacturers almost exclusively use OLED displays. In contrast to LCD screens, OLED displays have the advantage of reproducing the recalculated image extremely quickly. The picture is displayed for a brief moment and switched to black between two calculations. Thanks to a refresh rate of 60 frames per second, the eye perceives a consistently flicker-free picture. As a result, OLED displays have significantly reduced smearing and redrawing effects and also potentially less problems with VR motion sickness.

9.1.1.8 Sensors and Tracking Systems

The sensors and tracking systems in VR Headsets ensure that every movement of the user's head is registered and transmitted to the virtual environment in real time. For this purpose, most sensors incorporate very sensitive sensors to measure the acceleration (accelerometer), the rotation (gyrometer) or the direction of view (magnetometer). In addition, some VR Headset manufacturers use external tracking systems to detect the movement of the user in the room. In this case, Infrared LED lights integrated in the VR Headset are detected by infrared-sensitive positional cameras in the room, thus additionally implementing the position tracking in the virtual environment. This makes it possible to virtually recreate complete body movements forwards and backwards.

9.1.1.9 Inertial Measurement Unit (IMU)

The IMU is a single unit in an electronic module. The main processors receive collected data like angular velocity and linear acceleration. It is used as a main component in inertial navigation systems which are increasingly implemented in consumer devices. In the field of VR it is used for motion tracking, sensing and capturing capabilities. This component usually includes an accelerometer, a gyroscope and a magnetometer. [12]

9.1.1.10 Degrees of Freedom (DoF)

Degrees of freedom or DoF describe the possible ways an object can move within an area. In a 3-dimensional area, there are 6 degrees of freedom. These 6 DoF can be divided into 2 categories: rotational movements and translational movements.

Rotational movements include pitch, yaw and roll, and are tracked by IMUs.

Translational movements include left/right, up/down and forward/backward and are generally tracked by external cameras or sensors.

When we say that a VR HMD or a controller only has 3 DoF, then it only includes rotational movements.

9.1.1.11 3D and binaural Audio

VR is not a purely visual experience. All additional senses users can activate while in VR increase the sense of presence. Thus, audio signals, the corresponding direction-dependent sounds and background noise enrich the virtual experience of users.

If the sound is dependent on the viewing direction, one speaks of 3D or binaural sound. The recordings of binaural sounds are often made with two microphones or one mockup head with several built-in speakers. The advantage of binaural sound is not only that you can realistically simulate the virtual environment, but also the fact that you can guide the user to a particular direction.

9.1.1.12 Building Information Modeling (BIM)

The US National Building Information Model Standard Project Committee defines BIM as “a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.” [13]

9.1.1.13 Computer Aided Design (CAD)

Narayan K. Lalit defines CAD as being all computer systems which include software and geometric modeling techniques to create, virtually test (using a computer and numerical simulation techniques), analyse and optimize a design which will later be manufactured. The output of CAD is generally an electronic file used for printing and other manufacturing operations. [14]

9.1.2 Technical Terms related to the VR Experience

9.1.2.1 Levels of Immersion in Virtual Reality

According to Gervautz from the Technical University of Vienna, there are three levels of immersion when talking about Virtual Reality:

- Desktop VR, it is said to be monoscopic, using a conventional monitor to display the image and no other sensory output is supported.
- Fish Tank VR, this system supports head tracking and is an improvement of Desktop

VR. It also uses a conventional monitor but doesn't support sensory output either.

- Immersive systems, these let the user become immersed in a computer-generated world thanks to a HMD that supports stereoscopic viewing according to users' position and orientation. This type of system can be improved with audio, haptic and sensory interfaces. [15]

9.1.2.2 Virtual Showroom

In a broad sense, a virtual showroom is any VR environment conceived to exhibit products. Certain products such as cars or real estate are difficult to display in detail and VR can help to transport users to a virtual showroom where those products can be freely displayed.

9.1.2.3 Motion Sickness

This is defined by Benson as "a condition in which a disagreement exists between visually perceived movement and the vestibular system's sense of movement." [16]

9.1.2.4 Simulator sickness

This is a subset of motion sickness. When wearing a HMD, discomfort can occur due to movements in the virtual environment that don't match movement felt in the real world. [15]

9.1.2.5 Latency

Latency is "the amount of time (usually measured in ms) between the user's real (physical) action and the beginning of transmission of the report that represents this action." [15]

While the user's head is moving around the Virtual Environment, the display updates or refreshes the image seen in order to match the new angle of view. Simulator sickness is for example caused by slight delays in refreshing the image. Thus better performance is obtained through lower latency values. [15]

An optimal latency time should lie below 20 ms. In fact, at that rate the brain does not notice that a new picture has been built and a believable simulation is generated. If the latency time exceeds 50 ms, it may cause nausea or so-called VR motion sickness for users.

The latency depends on the sensitivity of the motion sensors, the computing power of the CPUs used, the speed of the graphics card and also on the maximum image refresh rate.

9.1.2.6 Frames Per Second (FPS)

The number of frames per second (or FPS) is a unit of measurement equal to the number of images displayed in one second by a device. It is the expression of the frame rate. The higher the number of frames per second, the more fluid the animation displayed on the screen will be. In order to have a fluid animation and reduce motion sickness, a minimum of 60 FPS is needed for a VR experience to run smoothly. [17]

9.1.2.7 Field of View (FOV)

The Field of View is the scope of the observable environment seen through lenses at any given time. The wider the FOV, the higher the presence feeling for the user in a virtual environment. For Virtual Reality, the FOV depends on the lenses used in the HMD. [18]

The aim of the optical system of a VR headset must be to create the largest possible field of vision on the retina of the observer. The human eye has a horizontal field of view of about 180 degrees for both eyes. The vertical field of view is around 60 degrees. The larger the projected field of view, the stronger the feeling of immersion in the virtual world. A viewpoint that is too narrow can cause a tunnel view, whereby the viewer no longer perceives the VR simulation as believable. Viewing angles of 100 degrees are therefore the minimum requirement for VR glasses. It is to be expected that with the help of special lens systems this field of vision will be improved even further.

9.1.2.8 Screen Door Effect and Pixel Density

The screen door effect describes the effect a user feels when the pixels of the display are visible. The user's eyes are very close to the display when wearing a HMD. [15]

The higher the pixel fill factor, the better the immersion in the virtual environment because the user will see less gaps in the screen which is in front of the eyes. A minimum display resolution of 1920x1080 is a requirement to avoid screen door effect. Good resolutions of the first commercial VR headsets lie in the 2160x1200 range.

9.1.2.9 Vergence

This is defined by Gervautz as “visual fatigue caused by looking at a flat screen that is replicating a 3D Environment”. [15]

9.1.2.10 The “Presence” feeling induced by Virtual Reality

The notion of presence is defined by the International Society for Presence Research as being a psychological state or subjective perception in which individuals forget about the role of technology in the experience they are living or rather forget that the technology is involved in/generates the experience. Further details can be found on the website of the International Society for Presence Research. [19]

9.1.2.11 Difference between Immersion and Presence

We previously defined both terms and can thus conclude that presence is a higher degree of involvement in the virtual environment than immersion.

Immersion can be lived through video games for example, when one sees an avatar in front of him and his “immersed” in a virtual world.

Presence on the other hand accentuates this feeling and gives the user the psychological perception of being “present” or “there”, in the virtual environment.

9.1.2.12 Simulations increase Participant’s Information Retention

Edgar Dale conducted a series of studies to understand how the human brain remembers information. He theorized his findings in a “cone of learning”. According to his findings, the human brain, after two weeks, retains 10% of what it reads, 20% of what it hears and 90% of what it simulates. As there are no studies yet, on the effective information retention percentage after VR experiences, the research from Edgar Dale can provide some academic base for further research. In fact, VR experiences immerse users to a point where the line between the real and the virtual world become blurred, allowing for a simulation that is close to actual reality. [20]

9.1.2.13 Industry 4.0

The concept of Industry 4.0 corresponds to a new way of organizing the means of production: the objective is the establishment of so-called “smart factories“ capable of greater adaptability in production and a more efficient allocation of resources, paving the way for a new industrial revolution. [21]

9.1.2.14 Photogrammetry

Photogrammetry is a technique based on making measurements or achieving measurements in a scene using the parallax obtained between images acquired from different points of view. This technique depends on a precise modeling of the geometry of the images and their acquisition in order to reconstruct an exact 3D copy of reality. [22]

9.2 History of VR

9.3 Description of Head-Mounted Displays

9.4 Tools for Content Generation

9.5 VR Network and Information Sources

9.6 The Analyst Team of present4D

Michael Gerards, CFO, Director VR Business Report, Owner and Executive Partner of present4D GmbH

Thomas Trzaska, CTO, Owner and Executive Partner of present4D GmbH

Markus Prenneis, CEO, Owner and Executive Partner of present4D GmbH

Christopher Béraud, Project Manager VR Business Report

Christian Bayer, VR Analyst

present4D VR scouts

Dr. Michael Gerards

present4D GmbH

Michael Gerards is co-founder and Executive Partner of present4D GmbH, headquartered in Duesseldorf. present4D is a full service virtual reality (VR) agency for strategic consulting, turnkey projects and software development focusing on the implementation of VR applications in industrial and non-gaming business environments.

Until the end of 2013 Michael Gerards was Director of Innovation Management at the pharmaceutical and chemical company Merck KGaA in Darmstadt. He can look back on more than 20 years of experience in R & D, innovation, strategy and business development. He was a longtime member of the Merck Millipore Technology Council and the Innovation Steering Committee of the Merck Group and responsible for setting up a cross-company and company-wide innovation process (MERCK innospire and Grass-root Innovation). Innospire was awarded the Innovation Prize of the German Economy in March 2015.



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Since 2014 and together with two co-founders, Michael Gerards has set-up a strong business network in the VR industry including the strategic partnership with KPMG and with many trend, innovation and future experts.

With the unique VR Suite software solution from present4D, his team has developed a VR tool that allows agencies, 360 ° studios and end-users in the industry to easily create their own professional VR presentations for trade fairs, training, marketing and sales.

In 2016, the VR-Suite won the SAMSUNG GearVR Killer App contest.

Michael Gerards is also co-founder of the international network „Healthcare Shapers“ and a strategic partner within the network „Digitale Experten“ Cologne, Germany.

www.present4D.de

www.vr-suite.com

www.healthcareshapers.com

www.digital-experten.de

XING

https://www.xing.com/profile/Michael_Gerards2

LinkedIn

<http://de.linkedin.com/pub/michael-gerards/1/46/459>

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