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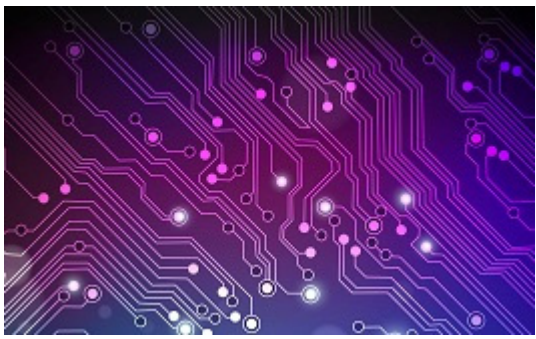

RESEARCH REPORT

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EXECUTIVE SUMMARY

Virtual Reality for Enterprise and Industrial Markets

Training and Simulation, Education, Virtual Prototyping/3D Modeling, Attractions, and Medical Therapy: Global Market Analysis and Forecasts

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SECTION 1

EXECUTIVE SUMMARY

1.1 INTRODUCTION

While enterprise and industrial markets have made use of professional-grade virtual reality (VR) technology for some time, the recent debut of consumer-grade VR head-mounted displays (HMDs) from companies like Facebook/Oculus, HTC, and Samsung has raised the profile of VR immeasurably and, more importantly, sparked the potential for enterprise VR use cases leveraging consumer-grade VR solutions.

This report examines the market and technology issues surrounding enterprise VR, with an emphasis on hardware, software, ecosystem, and use cases, taking into consideration both professional and consumer-grade VR equipment, software, and ecosystems.

Consumer VR is further defined as when the wearer uses his or her own headset only. If an experience requires that user to wear an HMD provided by a third party, then it would be classified as a commercial application and will be covered in this report.

1.2 MARKET DRIVERS AND BARRIERS

There are several market drivers and barriers for enterprise VR.

Some of the key drivers include:

- **VR Awareness:** The entrance into the consumer VR market of huge multinational companies like Facebook, Google, HTC, and Samsung is increasing the understanding of VR on a new level and there is an argument that this will drive interest in the use of the technology across multiple enterprise markets.
- **Low-Cost Consumer-Grade Solutions:** A rapidly growing number of companies are aggressively pursuing enterprise use cases that leverage accessible, cheaper consumer-grade HMDs. Smartphone-based VR expands the enterprise market even further.
- **Increased Productivity, Improved Results, Efficiency:** In a new era of consumer-grade VR availability for enterprise use, potential benefits expand. Enterprise VR can potentially produce superior results over other methods for mental or physical healing, as well as learning and understanding complex subjects.
- **Large Market Potential for Simpler VR Experiences:** Most consumer VR use case experiences require a high level of immersion to work; accurate and immediate head and hand movements for games and sophisticated all-angle video shooting for e-commerce. Many enterprise use cases can be very effective with less sophisticated VR application development and performance, potentially expanding the market.

Some key barriers include:

- **Consumer-Grade Cost and Requisite Equipment:** While vastly cheaper than professional-grade equipment, the cost of consumer-grade VR HMDs, accessories, premium content, and the requisite computing hardware for personal computers (PCs) will be one of the barriers to wider enterprise adoption for the next few years. Complete setups from Oculus and VIVE run in the $700 to $900 range. These PC-based HMDs require significant CPU and GPU capabilities. Tractica estimates that of the global installed base of more than 2 billion PCs, only about 10 million machines meet the minimum requirements to run these HMDs.

  The cost of consumer-grade VR hardware will steadily drop. Some components required today for VR will be built into HMDs in the next few years; inside-out tracking will eliminate the need for external cameras/sensors. Gesture control will eventually become more commonplace and eliminate the need for external motion controllers. All-in-ones will gain popularity and eliminate the PC or console requirement and PC or console costs associated with VR.

- **Consumer-Grade Quality of Experience:** VR experiences on consumer-grade VR equipment can be unsatisfactory for a number of reasons. Immersion and realism can suffer when a user experiences frozen video, judder, skipping, and streaking. Even worse, a VR user can become nauseous and experience motion sickness.

  Tracking issues and field of view (FOV) limitations are also major contributors to poor experiences. Over time, technological breakthroughs in optics, processing efficiencies, cloud computing, software application development, and streaming, as well as increased access to higher quality, high-speed broadband, will improve and accelerate the broad availability of consistent, high-quality VR experiences.

1.3 Market Observations/Key Trends

Thanks primarily to recent exponential advances in graphics component technology, cheaper, mass-produced consumer-grade VR is coming to market, with ramifications for both consumer and enterprise markets.

Several new enterprise use cases have vast addressable markets. Tractica estimates the addressable market of the five largest areas where enterprise VR will grow will be worth over $1 trillion in 2017. One of the broadest areas is education and training. Many believe VR, leveraging immersion and interaction, can significantly enhance and improve learning for both children and adults. Tractica estimates the addressable market for education and training spending will be more than $265 billion in 2017. Tractica has identified, analyzed, and forecasted five key categories for enterprise VR: education, virtual prototyping/3D modeling, attractions, training & simulation, and medical therapy.

Other key observations include:

- Customized legacy VR hardware and software sales are starting to become negatively impacted by consumer-grade enterprise VR hardware and software.
- Legacy VR hardware and software will remain critical to and grow within narrow vertical markets that require professional-grade equipment and experiences. Areas include many military applications, VR-assisted surgery, some industrial 3D modeling, and aeronautics.

- Leveraging consumer-grade VR solutions, several market forces will be key to driving enterprise VR adoption: profit motive for attractions, improved outcomes for education, virtual prototyping/3D modeling and medical therapies, and cost reductions/economies of scale for training and simulation.
- Due to strong market forces, enterprise VR will complement consumer VR growth and perhaps even become more important to driving overall VR market adoption.

1.4 KEY INDUSTRY PLAYERS

A diverse range of companies operates in the enterprise VR ecosystem. Tractica estimates the number of players to be more than 100. They include tech giants (Facebook, HTC, Intel); professional-grade VR solutions providers (Sensics, Cinoptics, NVIS, TRIVISIO); technology enablers (Vicon, Xilinx, uSens, Leap Motion); and content developers (Autodesk, Virtalis, WorldViz). This report profiles 22 key industry players across various segments of the value chain.

1.5 MARKET FORECAST HIGHLIGHTS

In 2014, Tractica estimated that there were almost 10,000 shipments of VR hardware on a global basis. This included HMDs, motion capture cameras, displays and projectors, and hand tracking devices. Due to the adoption of consumer-grade VR for enterprise use cases, this number will increase to 39.5 million in 2021. Tractica estimates that fewer than 25,000 unit shipments in 2021, less than 1% of the total, will be professional-grade equipment.

The total global revenue associated with enterprise HMDs, VR equipment, and VR content/content creation tools for 2014 has been revised upward from the previous edition of this report (published in 3Q 2015) from $114 million to $348 million. For 2021, Tractica expects revenue to increase to $9.2 billion at a 7-year compound annual growth rate (CAGR) of 59.6%. More easily monetized hardware will account for the vast majority of revenue throughout the forecast period, still accounting for nearly 87% of all revenue in 2021, as a flood of consumer-grade equipment sells into the market. With the exception of legacy content in training and simulation, free or minimal cost enterprise VR content will dominate the market, limiting content revenue over the next few years. Enterprise VR content and content creation tools will slowly monetize as use case adoption takes hold, growing from $295 million in 2016 to $737 million in 2020 and more than $1 billion in 2021.

Overall, North America accounts for the largest share of both VR equipment unit shipments and associated revenue. In 2016, combined shipments of HMDs and other equipment was estimated to be over 200,000 in the region. Revenue, including content, stood at $269 million, about 45% of entire market revenue. In 2021, Tractica expects these figures to grow to 15.8 million unit shipments and $4.1 billion, respectively. The United States spends more than any other country on healthcare, corporate training and investment, and the military.

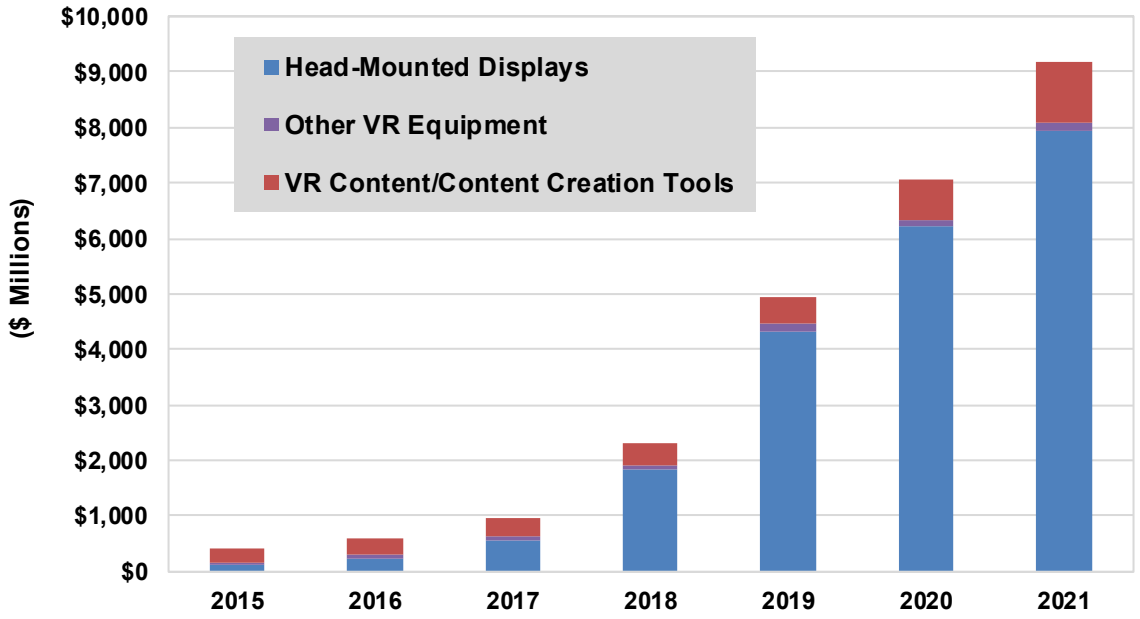
As previously mentioned, the introduction of consumer-grade VR hardware and software into the enterprise market will radically change previous shipment forecasts, both in volume and composition. In 2017, 97% of the shipments for enterprise VR hardware will consist of consumer-grade HMDs (1 million smartphone HMDs and 480,000 other consumer-grade HMDs, out of a total of 1.5 million unit shipments). Consumer-grade HMD shipment dominance will remain throughout the forecast period. Tractica anticipates there will be a high replacement rate for consumer-grade enterprise VR HMDs, particularly due to anticipated heavy/frequent use for equipment in the education and attractions categories.

With the exception of professional-grade HMDs, most other enterprise VR hardware shipments will experience little to no growth or shipments will even shrink over the forecast period. Professional-grade HMDs will experience consistent growth, doubling 2016 shipments to 220,000 in 2020. Motion capture cameras, hand tracking devices, and controller capabilities will become incorporated into HMDs, gradually eliminating the need for this equipment. Displays and projectors for enterprise VR use will slowly lose ground as enterprises adopt the use of consumer-grade VR equipment in their place.

In 2021, category spending on enterprise VR hardware and content will be:

- Attractions, $4.5 billion
- Training and Simulation, $2.2 billion
- Education, $1.6 billion
- Medical Therapy, $357 million
- Prototyping/3D Modeling, $349 million

Chart 1.1 Annual Enterprise Virtual Reality Hardware and Content/Content Creation Tools Revenue by Segment, World Markets: 2015-2021



(Source: Tractica)

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SCOPE OF STUDY

Leveraging highly customized and expensive equipment, enterprise use of VR has existed and improved for a number of years, particularly for military training, civil flight training and simulation, and some industrial 3D modeling. But now, thanks primarily to recent exponential advances in graphics component technology, cheaper, mass-produced consumer-grade VR is coming to market, with ramifications for both consumer and enterprise markets. Most of the world's leading technology companies, including Facebook, Google, and Microsoft, are staking out positions to become key players in what many see as the next significant computing platform.

This cheaper, more readily accessible consumer-grade VR equipment and ecosystem is opening up new enterprise use cases, some of which have vast addressable markets. Tractica estimates the addressable market of the five largest areas where enterprise VR will grow is worth over $1 trillion in 2017.

A broad range of players, both new and established, are aggressively working to develop applications leveraging this new consumer-grade VR ecosystem, aiming squarely at the enterprise market. In-depth analysis of the strategies and trajectories of the key enterprise VR industry players both for professional and consumer-grade VR are covered in Section 4, with further analysis in Section 5, Market Forecasts.

This report provides global market forecasts for the period from 2014 through 2021 for annual unit shipments and associated revenue for VR hardware and content in the enterprise and industrial sectors. The analysis covers HMDs, along with other VR equipment such as motion capture cameras, displays and projectors, and hand tracking devices, as well as software applications and content creation tools. Data is segmented by five major regions (North America, Europe, Asia Pacific, Latin America, and the Middle East & Africa) and five different application markets are examined (education, virtual prototyping/3D modelling, attractions, training and simulation, and medical therapy).

SOURCES AND METHODOLOGY

Tractica is an independent market research firm that provides industry participants and stakeholders with an objective, unbiased view of market dynamics and business opportunities within its coverage areas. The firm's industry analysts are dedicated to presenting clear and actionable analysis to support business planning initiatives and go-to-market strategies, utilizing rigorous market research methodologies and without regard for technology hype or special interests including Tractica's own client relationships. Within its market analysis, Tractica strives to offer conclusions and recommendations that reflect the most likely path of industry development, even when those views may be contrarian.

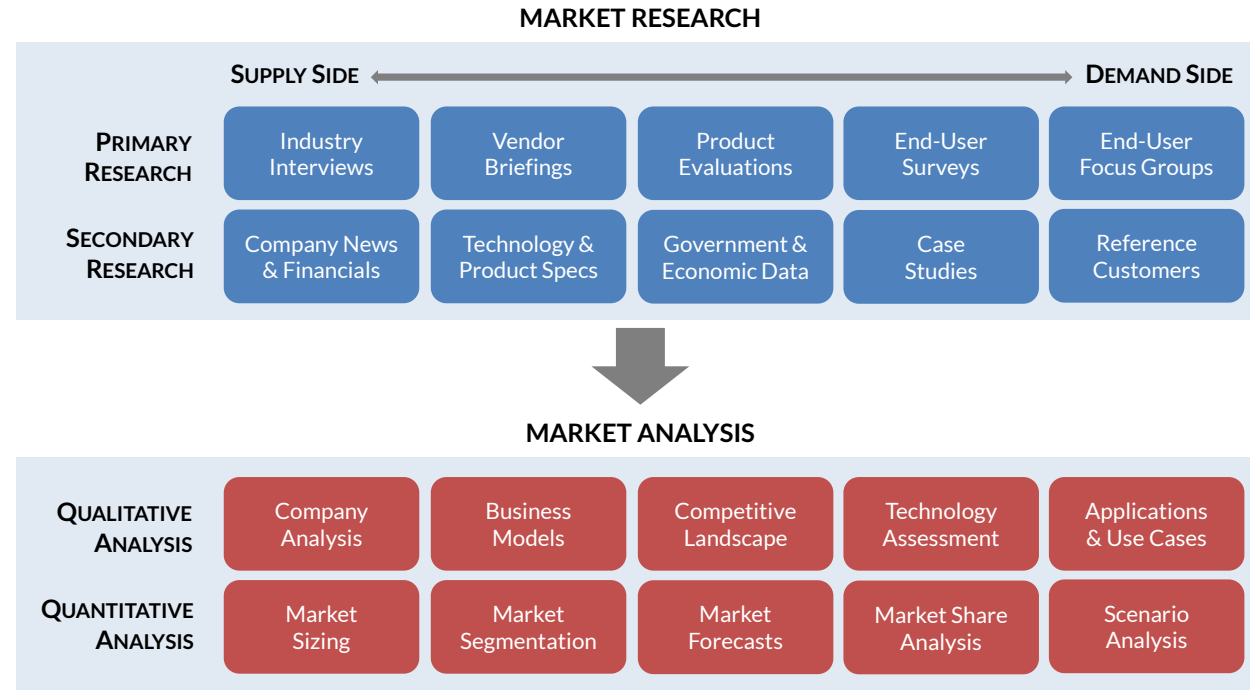
The basis of Tractica's analysis is primary research collected from a variety of sources including industry interviews, vendor briefings, product demonstrations, and quantitative and qualitative market research focused on consumer and business end-users. Industry analysts conduct interviews with representative groups of executives, technology practitioners, sales and marketing professionals, industry association personnel, government representatives, investors, consultants, and other industry stakeholders. Analysts are diligent in pursuing interviews with representatives from every part of the value chain in an effort to gain a comprehensive view of current market activity and future plans. Within the firm's surveys and focus groups, respondent samples are carefully selected to ensure that they provide the most accurate possible view of demand dynamics within consumer and business markets, utilizing balanced and representative samples where appropriate and careful screening and qualification criteria in cases where the research

topic requires a more targeted group of respondents.

Tractica's primary research is supplemented by the review and analysis of all secondary information available on the topic being studied, including company news and financial information, technology specifications, product attributes, government and economic data, industry reports and databases from third-party sources, case studies, and reference customers. As applicable, all secondary research sources are appropriately cited within the firm's publications.

All of Tractica's research reports and other publications are carefully reviewed and scrutinized by the firm's senior management team in an effort to ensure that research methodology is sound, all information provided is accurate, analyst assumptions are carefully documented, and conclusions are well-supported by facts. Tractica is highly responsive to feedback from industry participants and, in the event errors in the firm's research are identified and verified, such errors are corrected promptly.

Chart 10.1 Tractica Research Methodology



(Source: Tractica)

NOTES

CAGR refers to compound annual growth rate, using the formula:

CAGR = (End Year Value ÷ Start Year Value)$^{(1/steps)}$ – 1.

CAGRs presented in the tables are for the entire timeframe in the title. Where data for fewer years are given, the CAGR is for the range presented. Where relevant, CAGRs for shorter timeframes may be given as well.

Figures are based on the best estimates available at the time of calculation. Annual revenues, shipments, and sales are based on end-of-year figures unless otherwise noted. All values are expressed in year 2017 U.S. dollars unless otherwise noted. Percentages may not add up to 100 due to rounding.

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