BUSINESS FINLAND

FUTURE **WATCH** 2022

GROWTH OPPORTUNITIES IN EXTENDED REALITY

Prepared for
Business Finland

March 29, 2022

Engagement Context

Business Finland aspires to strengthen Finland's economic position through enabling Finnish companies to expand globally, explore market opportunities and turn them into success stories

Business Finland has requested assistance to evaluate the global landscape for Extended Reality (XR), analyzing recent development trends, assessing XR value chain and its key stakeholders and identify potential opportunity areas in the XR landscape.

The aim is to provide market insights and highlight opportunities for co-operation for Finnish players in the XR landscape

Definitions

Immersive Experience

- The concept of immersion has been commonly used when talking about virtual reality. The immersive experience is defined as the extent to which a person's cognitive and perceptual systems are tricked into believing they are somewhere other than their physical location.
- There are three levels of immersive experiences: engagement, engrossment, and full immersion. The level of immersion experienced by users highly depends on their attention and emotions. A better understanding of the immersive experience and how to leverage it could lead to the better virtual technologies development.

Extended Reality and the Metaverse

- Extended reality refers to real and virtual combined environments or interfaces generated by a set of technologies through digital simulation. Breakthroughs in computing performance, advanced hardware, and 3D expertise have enabled improved immersive experiences in recent years.
- Growing applications for extended reality technologies continue to push technology advancement. These include: virtual workplaces, digital campaigns, marketing activities, VR-based therapies, and many others.
- **Metaverse** enables individuals with a sense of shared social presence and spatial awareness, and provides them with the ability to participate in an extensive virtual economy with profound societal impact

Types of Extended Realities

Virtual Reality (VR)
VR allows the users to step into a completely immersive environment in a virtual world and cannot see the real world around them.

Mixed Reality (MR)
MR allows you to immerse yourself in the world around you even as you interact with a virtual environment. It is the combination of augmented reality and augmented virtuality, which means the real augments the virtual and the virtual augment the real. Mixed Reality is covered for the proposed study.

Augmented Reality (AR)
AR overlays digital information on real-world elements. The technology can augment the visual field of information to help users to perform their mundane tasks.

Source: Frost & Sullivan

Market Highlights

Global XR Market Highlights

Market Leaders Remain a Key Driving Force

- Extended reality (XR) refers to the spectrum of experiences that blurs the line between the real and the simulated world. The technology immerses the users through audio, visuals and as well, haptic cues.
- Combination of technologies including AR, VR, and MR and their proliferation and convergence have led to the emergence of XR.

More than **$6 BN USD** invested in XR companies during 2019-2021

12000+ patents filed in 2021 across various technology areas including waveguides and advanced displays.

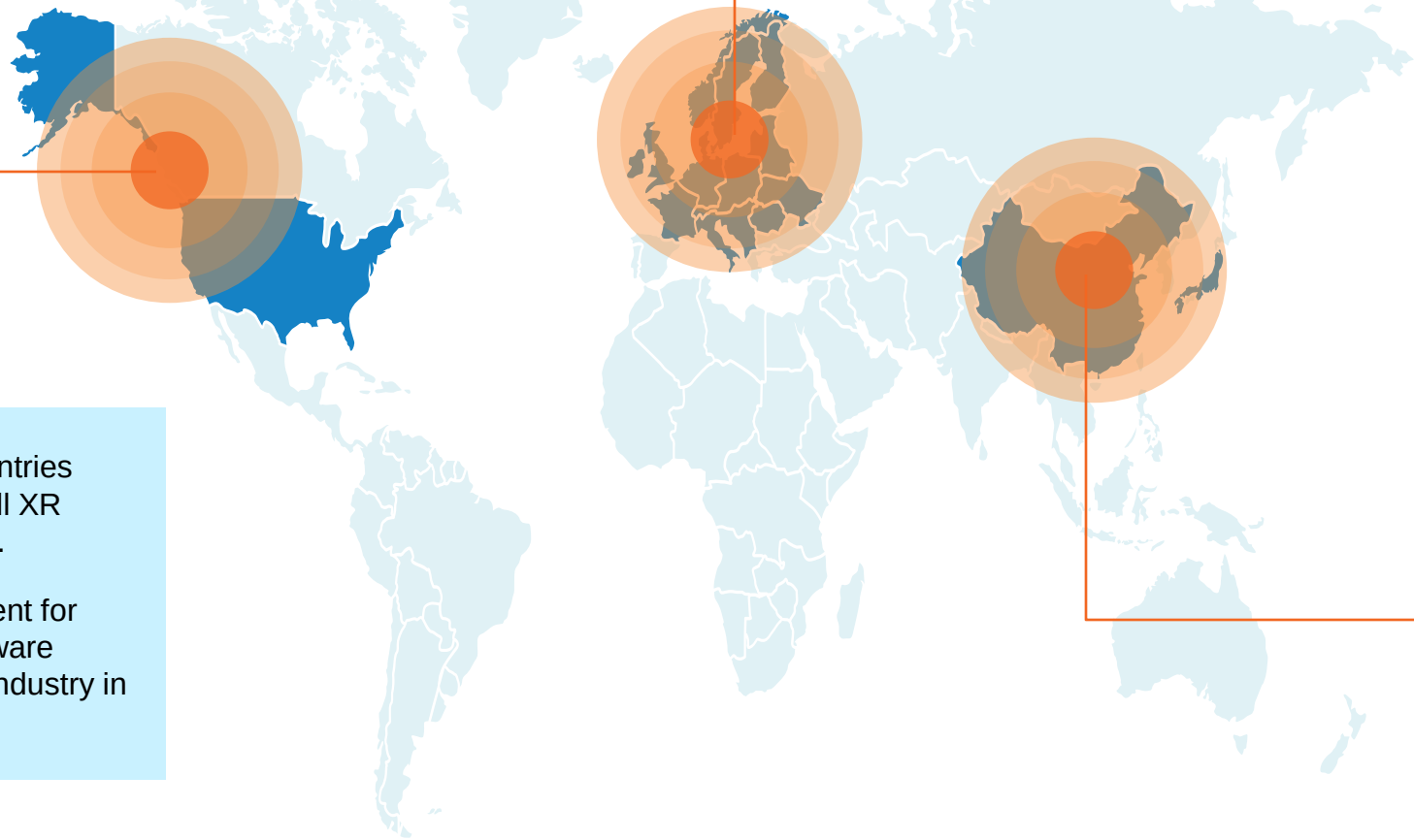
Global XR startup valuation has reached close to **$50 BN USD** in 2021E led by companies such as Magic Leap, Niantic, and Oculus.

Global XR market has reached over $40 billion in 2021E.

Source: Frost & Sullivan

Key Global XR Trends

Evolving Start-up Ecosystem and Government Initiatives are Driving the XR Growth



- The US is the major countries contributing to the overall XR market in North America.
- The favorable environment for start-ups has led to software development in the XR industry in this region.

- The European XR market has been growing rapidly with Germany, the UK and France being the major countries contributing to the growth.
- The European XR industry is competing in the global XR market by contributing through creative content production, developing innovative applications for the highly specialized advanced industries.

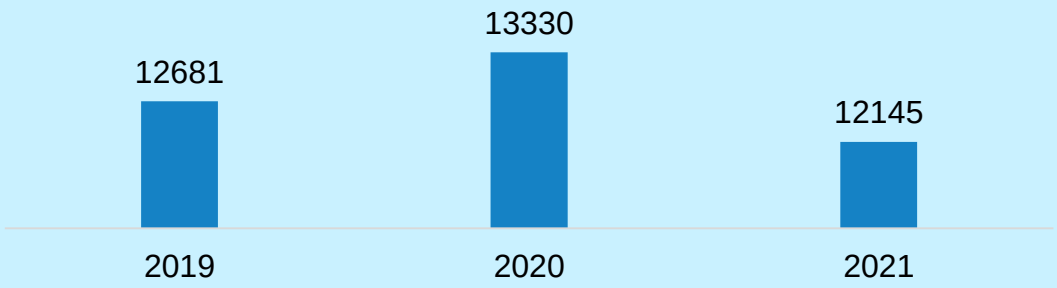
- China and Japan are leading in hardware manufacturing in this region.
- The government's initiatives to support technology development is stimulating market growth.

Source: Frost & Sullivan

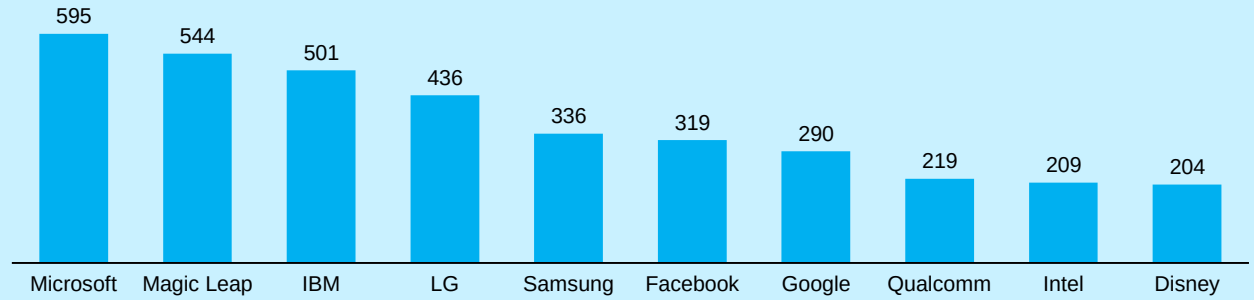
XR Patent Landscape

The US and China Emerge as Innovation Hotspots in XR

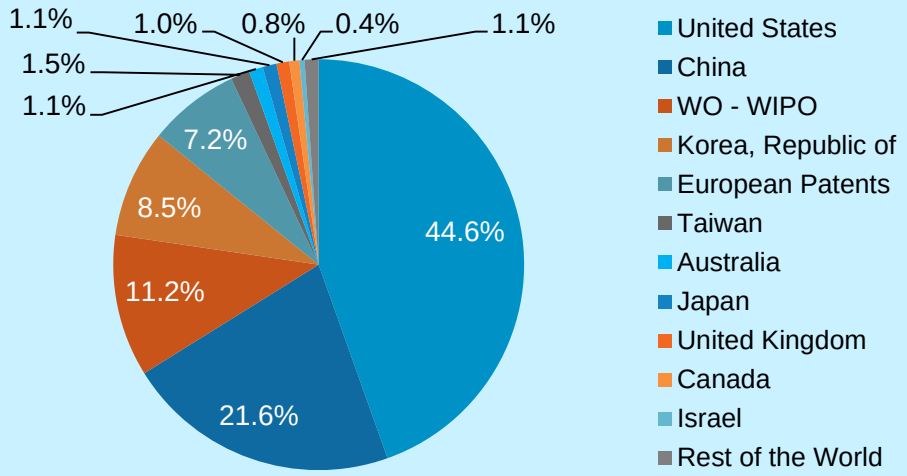
XR: Patent Landscape, Global, 2019-2021



XR: Top Patent Owners, Global, 2019-2021



XR: Patent Jurisdiction, Global, 2019-2021



XR: Top Areas of Research, 2019-2021

Hardware	Software	Application
• Displays • Audio • Power and Thermal Management • Sensors • System Architecture • Stereoscopic Devices • Interfacing	• Image and Video Processing • Data Processing • Data Transferring • 3D Modeling • 3D Image Rendering • Error Detection	• Gaming • Education • Medical • Media • Retail • Automotive

Source: Frost & Sullivan

Overview of Key Technology Trends

Key Focus Areas include Improving FOV, Efficient Power and Thermal Management and Resolving Network Latency

POWER AND THERMAL MANAGEMENT

The focus of AR And VR hardware design is leaning towards development of components which offer energy efficiency as well as ergonomic form factor

HEADSET FIELD OF VIEW

Field of View (FOV) is one of the biggest limitations in the development of AR/VR devices.

INTEROPERABILITY

The focus is on the development of interoperable standards that will be used to provide structure into evolution of newer applications.

NETWORK LATENCY

In XR environment, devices need to be able to access and manage huge amounts of data within fraction of seconds which requires high throughput.

ENHANCED RENDERING AND PROCESSING

Solutions are being developed to reduce computational overheads and rendering latency, such as reducing GPU workload and CPU overhead, AI, and deep-learning-based light rendering technology.

TRACKING AND POSITIONING

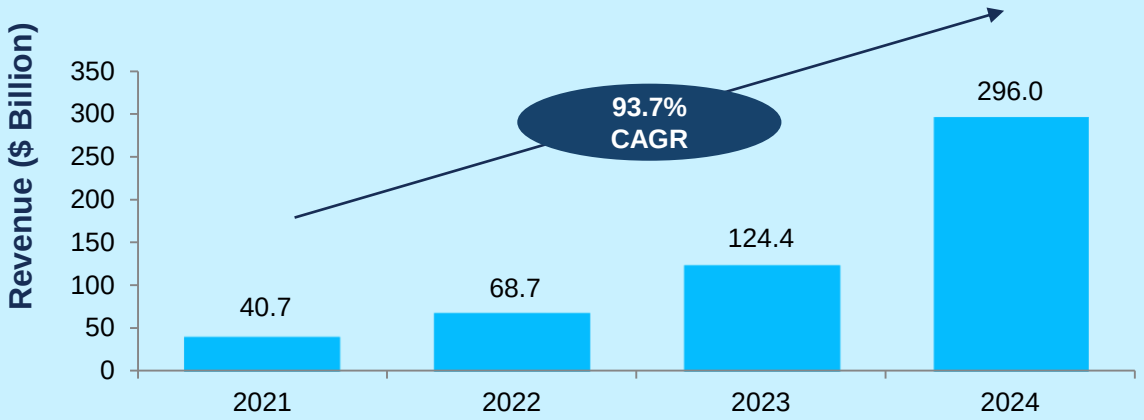
To improve the core characteristics, perception, and interaction, mapping the user or headset's actual and virtual positions is essential

Source: Frost & Sullivan

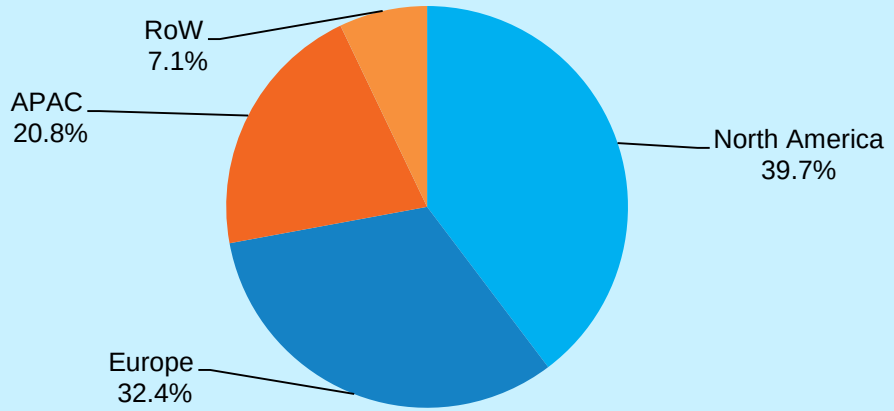
Global XR Market Assessment

Smartphone Penetration, 5G and Widening of End User Applications is Driving the Growth

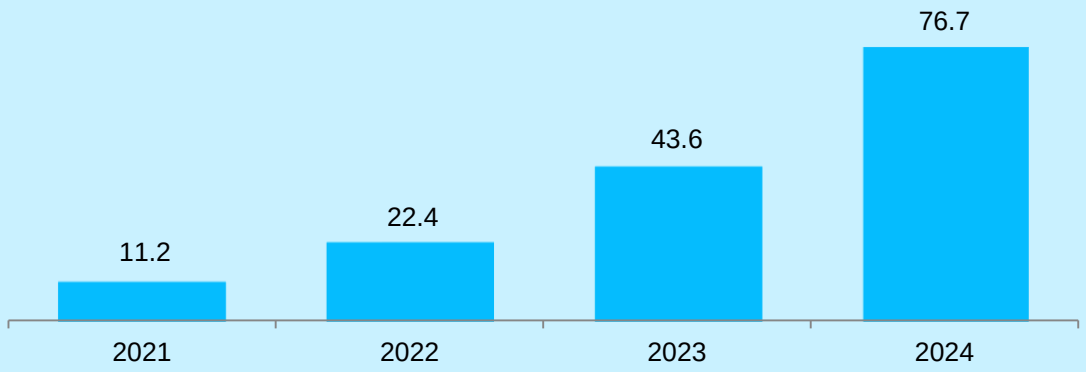
XR Market: Revenue Forecast, Global, 2021-2024



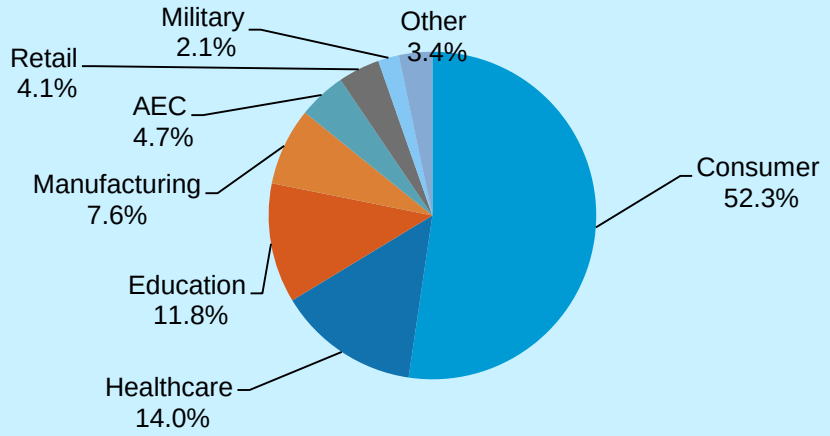
Global XR Market by Regional Split, 2021



Global AR/VR Headsets Shipment (In Millions), 2021-2024



Global XR Spending by Segment, 2021



Source: Frost & Sullivan

Global XR Value Chain Assessment

Global XR Value Chain Analysis

Developments in Hardware and Software are Vital to XR Materialization

XR: Industry Value Chain

5 **End Users:** Key beneficiaries include Automotive companies, hospitals, universities, banks and retail stores, to name a few.

4 **Content:** Content in the XR value chain refers to the content production and content operations.

3 **Application:**. Gaming, medical, training, retail, defence construction, manufacturing are some of the key end markets wherein XR application development is taking the center stage.

2 **OS/Development Tools:** The OS/Development tools include software development kits (SDKs), framework libraries, application programming interfaces (APIs), and platforms

1 **Hardware:** It refers to the hardware peripherals or technologies related to the displays, sensors, lasers, audio, camera, processors and accessories.

Source: Frost & Sullivan

Hardware Development in XR

Advancements in Displays, Sensors and Interfaces are Vital for Immersive Experience

Headset Manufacturers combine all the above individual elements to create AR and VR devices such as HUDs, Smart Glasses, HMDs and Smart Helmets

Source: Frost & Sullivan

Software Development in XR

AI,5G, Cloud and SLAM are Transforming XR Software Development Ecosystem

XR OS/Development Tools

AI,5G and SLAM are emerging technologies powering XR immersive experiences

XR Application Developers

Multi-industry Solution Development is the Primary Focus

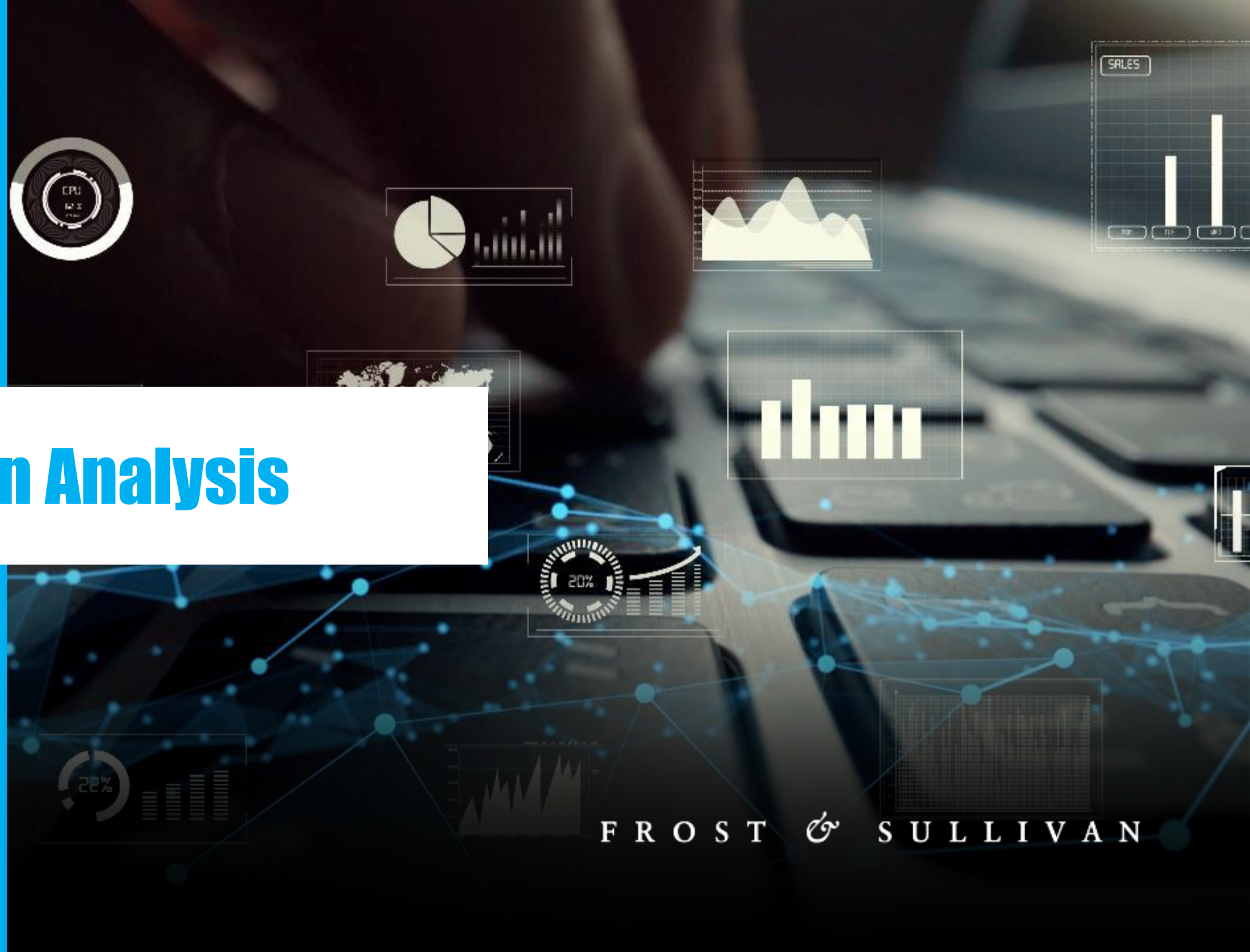
XR Content Management

Focus on delivering streamlined AR/VR content by leveraging cloud and analytics

XR software development has evolved from building simple SDKs to developing advanced UX by embedding innovative features

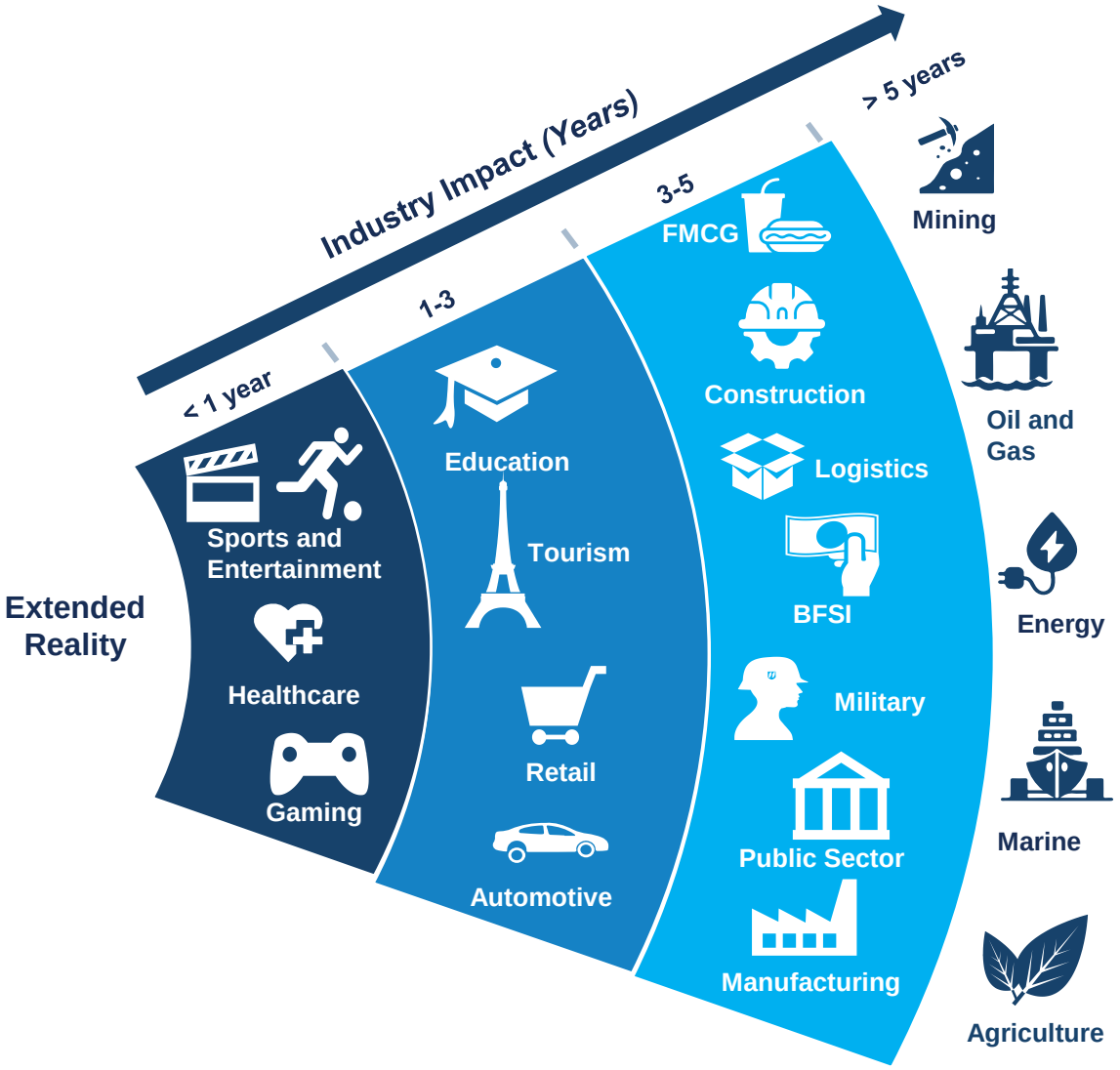
Source: Frost & Sullivan

Application Analysis



XR Application Landscape

Training and Marketing are the Initial Use Cases for XR across Industries



Key Adoption Trends

- Being an early adaptor , gaming became the building block for XR.
- Following the success of gaming, entertainment and sports sectors started experimenting with XR to create a unique experience for the global public, especially during the pandemic period.
- Panasonic used AR and 3D projection mapping technology to show the players actions and performance.

- Industries such has automotive have adopted the technology for to enable them to improve process efficiency and improve the workers skills. Microsoft HoloLens are used to monitor paint coating thickness.
- Another key area were XR gained rapid momentum is marketing in sectors like retail. Walmart, Ikea are some of the key adopters.

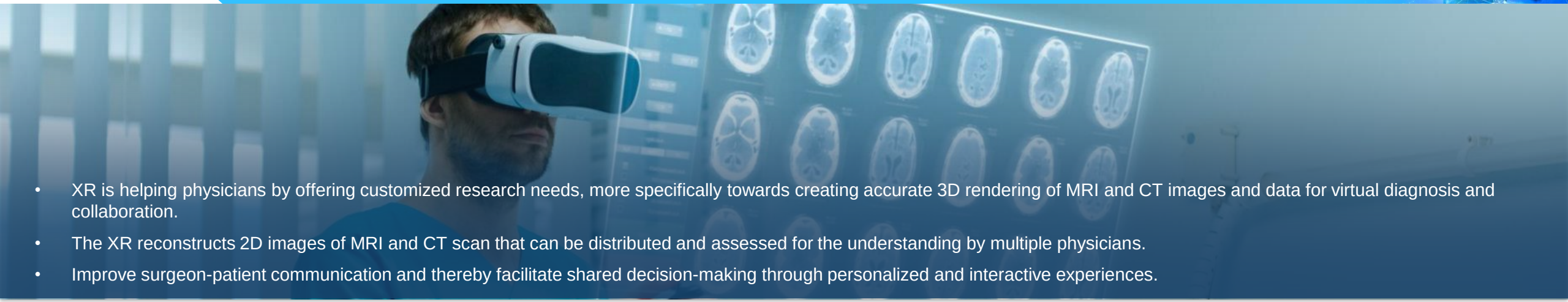
- Key industries like healthcare and military have adopted the technology mainly for training purposes. With the technology, these industries are able to stimulate various situations and train the personnel accordingly.
- Industries like Construction and Manufacturing will be leveraging XR solutions for remote assistance/maintenance, supply chain management, virtual documentation and workflow visualization.

- XR can play a vital role in public sector in areas such as building smart city infrastructure.
- Industries such as marine, energy and oil & gas, have mainly adopted AR technology for technical support in offshore and remote locations.

Source: Frost & Sullivan

Healthcare – Virtual Diagnosis

Improving Surgeries by Transforming 2D Imaging Scans into informative 3D Information



- XR is helping physicians by offering customized research needs, more specifically towards creating accurate 3D rendering of MRI and CT images and data for virtual diagnosis and collaboration.
- The XR reconstructs 2D images of MRI and CT scan that can be distributed and assessed for the understanding by multiple physicians.
- Improve surgeon-patient communication and thereby facilitate shared decision-making through personalized and interactive experiences.

- Surgical theater offers augmented reality solution, **Precision XR**, which collects the data from conventional 2D patient scans such as MRI, CT, and DTI and builds a realistic 3D, 360-degree reconstruction.
- It enables the doctors to effectively analyze their anatomical structure and plan a surgical approach prior to surgery.

SURGICAL THEATER
Beyond Reality. Beyond Imagination.

Client – Rambam Healthcare Medical Center

Challenge:. There is a need for solution that provides the surgeon with the ability to plan the most optimal approach to perform surgery successfully as 2D images are unable to assist efficiently in surgery pre-planning.

Solution: The Israel based Rambam Healthcare Medical Center is using **Precision XR** to transform 2D images of MRI and CT into detailed 3D information of the brain and simultaneously enabling AR visualization to navigate within the head of the patient.

Key Highlights

- **360°- 3D** AR Visualization: Overlays 360° - 3D AR rendering images onto the live image and allows to analyze brain anatomy from all angles.
- **Enhanced Engagement:** Facilitate shared decision-making through personalized and interactive experiences.

Companies Offering XR Solution for Healthcare

OSSOVR elara DATAMATICS Augmedics

Source: Surgical Theater, Frost & Sullivan

Automotive – AR Windshield Displays

Windshield HUDs will be an integral part of Mobility in Future

- Full windshield HUDs generate entire views of the maps, project visuals of obstacles, enabling each blind spot location and provide driver assistance as well as infotainment. Windshield HUDs will fundamentally transform the driving experience and usher in new advanced features such as AI.
- As the automobiles evolve to Level 3, Level 4 and Level 5 automated driving, the full windshield HUDs will be an essential part of the driving experience.

- Swiss start-up WayRay has developed Deep Reality Display® technology using holographic optical element (HOE), a photopolymer film that retains the properties of a periodic nanostructure after the recording process.
- The HOE will work in conjunction with customized blue lasers which act as lighting source along with a picture generating unit (PGU) to create high quality images and can be integrated into any cars.
- WayRay is collaborating with major automakers such as Hyundai Motor, Porsche, Karma Automotive and Doosan Bobcat.

WAYRAY

- US based start-up CY Vision is taking the spatial light modulator (SLM) approach wherein the hologram to be displayed is computed and projected to the SLM illuminated by a laser.
- The company demonstrated the technology in CES 2022. It has also partnered with BMW for assessing the capabilities of computational holography in future cars.

CYVISION

Key Highlights

- On-street direction markings
- Highlight turns, curves and slopes
- Media and call information
- Lane departure warnings
- Traffic sign alerts
- Speed limit information
- Display non-line-of-sight objects
- Adaptive cruise control indication

Companies Researching on Windshield HUDs

DIGILENS, Panasonic, Continental, FUTURUS, VOLVO, HUAWEI

Source: WayRay, Frost & Sullivan

Education – Distance Learning

AR/VR is a Impactful tool to Deliver Interactive Lectures in a Remote Learning Environment

- Lectures from schools or universities can pre-recorded or stream online vides in real time with augmented and virtual environment or real-world motion captured in a 360 degree format.
- Disruption caused by COVID-19 pandemic such as social distancing that forced a global shift toward distance learning, has strengthened the immersive technology's prospects.

- US-based EON Reality is one of the major company in providing augmented and virtual reality-based solution for transferring knowledge and skills especially in the industrial and education sectors.
- EON-XR solution is aimed at changing the traditional education methods by providing effective, user-friendly immersive lessons and content to the students.

Client – Swinburne University of Technology, Australia

Challenge:. Improve student engagement during online classes in the COVID-19 pandemic time.

Solution: Swinburne university used EON-XR to deliver immersive and interactive learning content in AR/VR and then collaborate in multi-user AR sessions, making remote learning impactful.

Key Highlights

- **Self Directed Learning:** Co-created student learning content for deeper learning and engagement based on the university guidelines.
- **Asynchronous Videos:** Embedding of asynchronous videos allowing access to self-paced learning and high quality materials at any time.

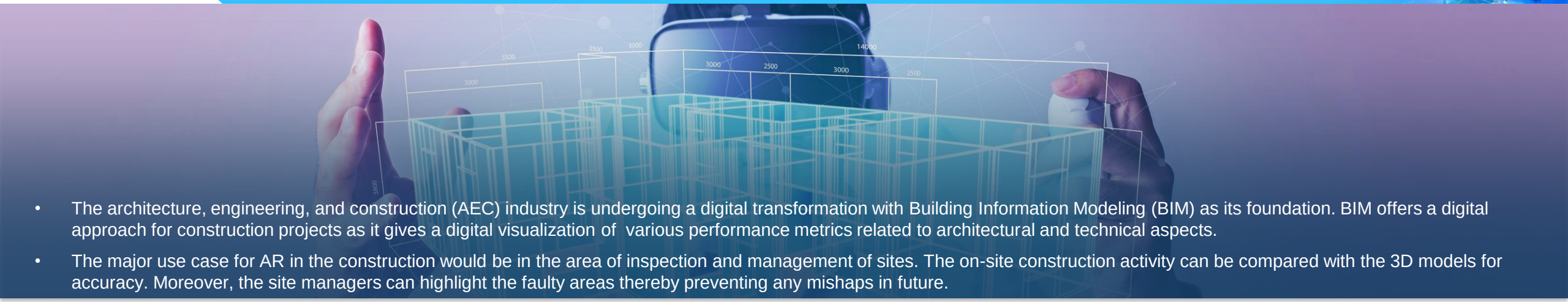
Companies Offering XR Solution for Education

Practically, PlayShifu, ALCHEMY, Discovery VR

Source: Eon Reality, Frost & Sullivan

Building and Construction – Construction Feasibility

AR Perfectly Blends in the Construction Sites through Augmenting BIM Models



- The architecture, engineering, and construction (AEC) industry is undergoing a digital transformation with Building Information Modeling (BIM) as its foundation. BIM offers a digital approach for construction projects as it gives a digital visualization of various performance metrics related to architectural and technical aspects.
- The major use case for AR in the construction would be in the area of inspection and management of sites. The on-site construction activity can be compared with the 3D models for accuracy. Moreover, the site managers can highlight the faulty areas thereby preventing any mishaps in future.

- Luxembourg-based GAMMA Technologies is an AR start-up that has developed an app wherein will overlay the 3D BIM models uploaded by the users and assist them in keeping track of the progress.
- Around 2400 construction projects across the globe are using the software. The company has received $1.14 million investment from Swedish organization Husqvarna Group.

GAMMA AR

Case Study – PORR AG

Challenge:. Need for an AR tool to use as a site inspection aide and to verify the construction details with the BIM models.

Solution: GAMMA AR app enabled PORR engineers to successfully visualize the BIM model on the site resulting in finding the differences between the planning and construction.

Key Highlights

- Offer better understanding of the planning at the site.
- Compare the plans of the site with original designs.
- Detect potential errors before the structure is built.
- Replace 2D drawing with 3D plans in site.
- Relay site information to architects in real-time for any consultation.
- Precise progress tracking.

Companies Offering AR Solutions for Construction Feasibility

HOLO BUILDER A FARO® Technologies Company | SRI International | DALUX | HOLO-LIGHT | VISUALLIVE

Source: PORR AG, Frost & Sullivan

Growth Opportunities

Technology Evaluation for Market Penetration

Advancements in Sensor and Processing can Improve Immersive Experience

Underserved Areas by Current Products

- Accuracy of 3D models
- Virtual object recognition in limited visibility area.
- Real-time sensor data.
- Miniaturization/form factor of XR devices.

Top Purchasing Criteria

- Intuitive and complete operating system.
- Room-scale tracking without external sensors
- Embedded audio directly into headset
- Remote service access support.
- Uninterrupted cloud data streaming.

Top Required Features

- Accurate tracking head and eye movement. important for smooth live XR experience.
- Foveated rendering implying unique unicast for individual views.
- Intelligent interactions using AI to analyze past inter-actions and predict future moves to provide a better immersive experience.

Key Areas of Interest

- Emerging technologies such as smart AR contact lens, telepresence robots, edge AI, spatial audio have been gaining momentum apart from regular innovation themes such as displays and sensors.
- The major attraction for developers of AR in particular is the emergence of SDKs like ARKit and ARCore which has made AR accessible to people while enabling the developers to create variety of applications.

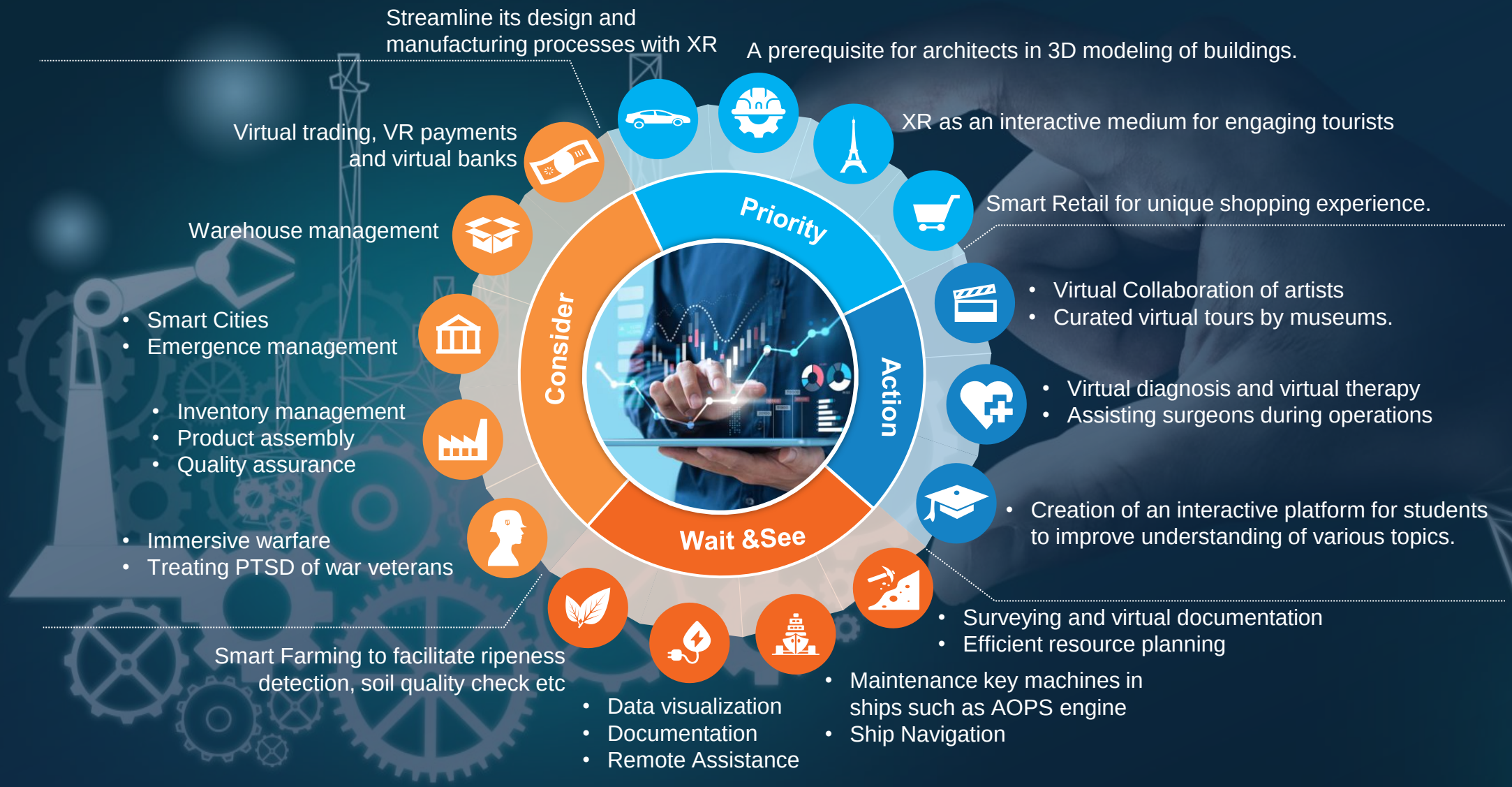
Top Premium Areas Customers are Willing to Pay

- Powerful processor with extremely low latency.
- Sleek design and a lightweight build.
- High-resolution micro LED displays for high quality immersive experience.
- Advanced 3D-sensing for detecting hand gestures and nearby objects through spatial detection.

Source: Frost & Sullivan

Key Application Areas Across Featured End Markets

Retail, Automotive, Construction and Tourism are Evolving using XR in their Workflow

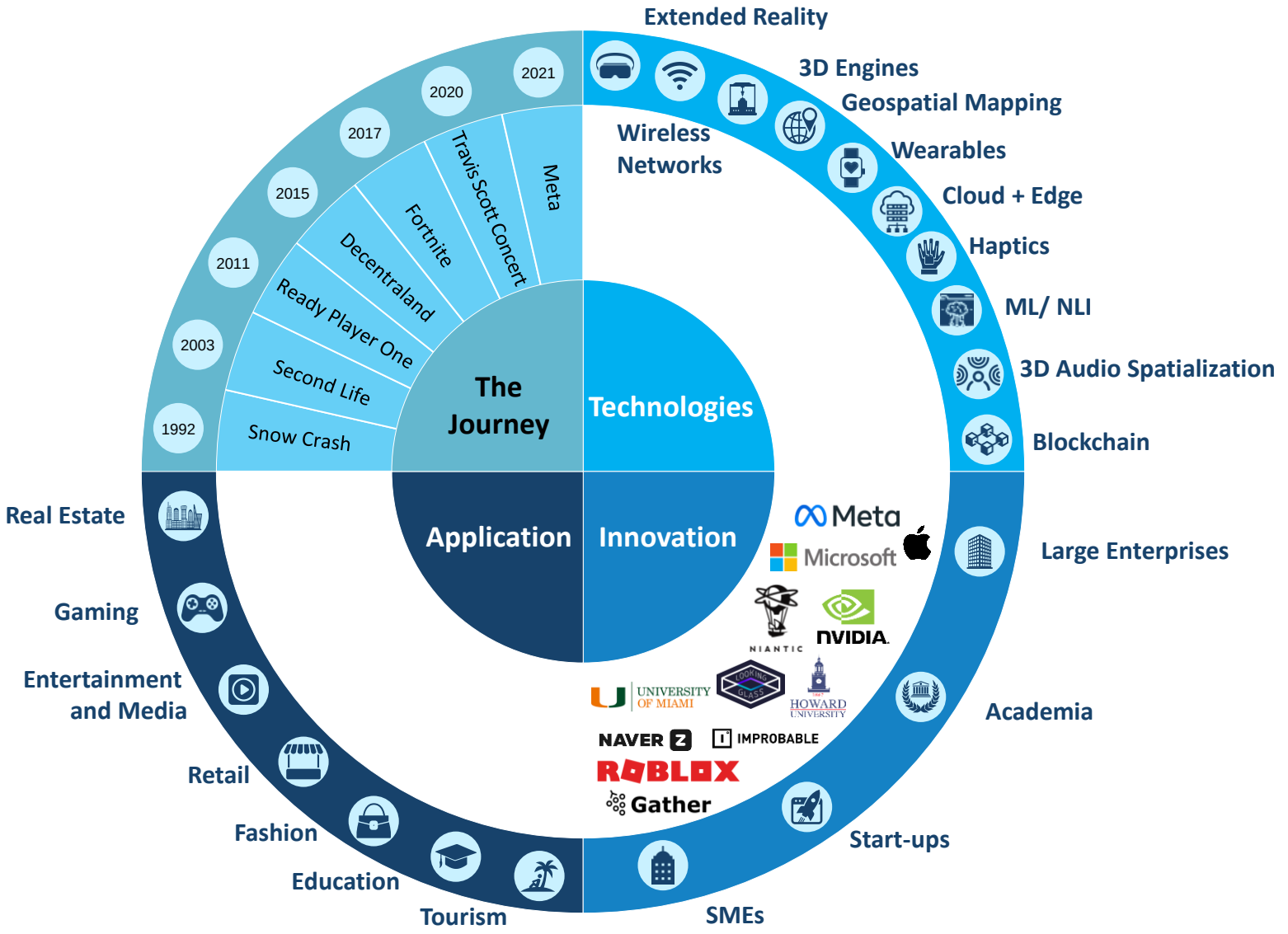


The Metaverse

FROST & SULLIVAN

De-Constructing Metaverse

From a Concept to a Bold Bet



Source: Frost & Sullivan

Growth Opportunities in the Metaverse

Newer Opportunities to Create, Own, Experience, Transact and Socialize

NEW WAYS TO ENGAGE USERS

- Creating new avenues for value creation and capture
- Metaverse could be the 'second act' in order for companies to re-engage with its users

CREATION OF NEW PRODUCTS AND SERVICES

- Creating new categories of virtual goods and services
- Creating a new class of service applications that will support the growth of the ecosystem

MONETIZATION OPPORTUNITY

- Generate revenues by offering digital experiences, curating exclusive content or providing platforms for transaction of rare digital goods.
- Unlock new channels for economic transaction

NEWER INTERACTION MECHANISMS

- With the metaverse, the customer base can be expanded at one go
- It allows traditional brands to interact with Gen Z customers and close the distance between the brand and the user.

Source: Frost & Sullivan


Thank you

FROST & SULLIVAN

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The Growth Pipeline™ Company
Powering clients to a future shaped by growth