

# EXTENDED REALITY (XR)

Industry 4.0 · AR · VR · MR

Tim Ruther & Valentin Fiderer



# Structure

---

01

## Definition & XR spectrum

What is XR? · AR, VR & MR · How XR works

p. 3

02

## From gaming to industry

History & market numbers

p. 11

03

## XR in industry

VR · AR · MR industrial applications

p. 13

04

## Opportunities & risks

Benefits of XR & challenges to address

p. 22

05

## Market & future

Market numbers · Trends · Outlook

p. 25

# DEFINITION & SPECTRUM

# WHAT IS EXTENDED REALITY?

## Definition

- umbrella term for all technologies that change how we perceive reality
- Range: from a slight enhancement to a complete digital world

## Why it matters

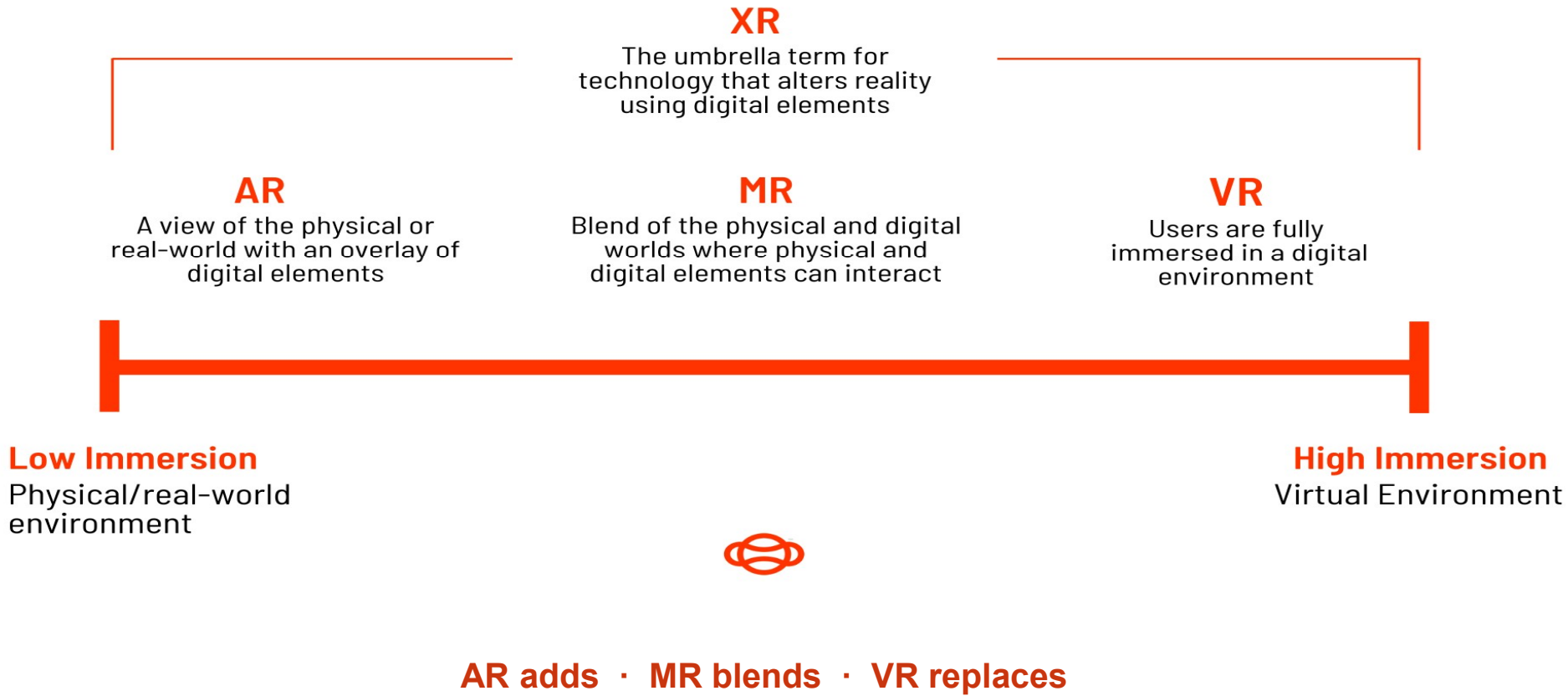
- XR makes invisible things visible
- Products that don't exist yet, dangers before they happen
- Knowledge that is hard to convey any other way.

## Etymology

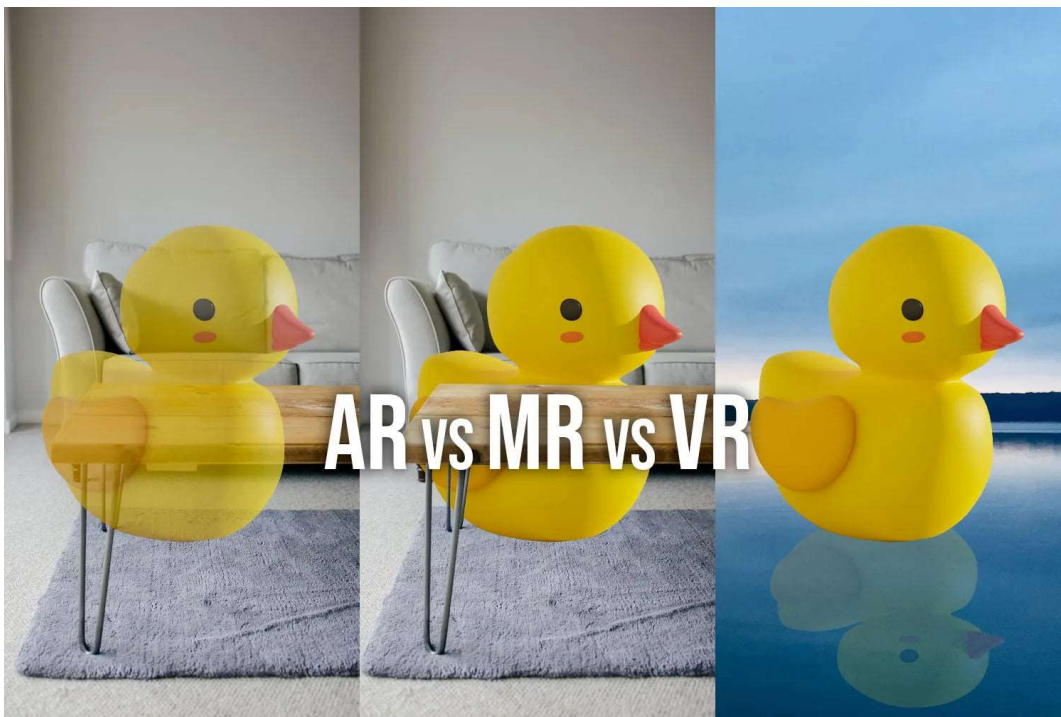
- "Realitas" (Lat.) = the real thing.
- "Extended" = stretched beyond its limits.
- Together: a technologically expanded reality.



# THE XR SPECTRUM



# AR · VR · MR COMPARED



## Augmented Reality (AR)

- You still see the real world
- Digital content is layered on top
- Examples: Pokémon Go, head-up display in cars
- Reality is ENHANCED

## Virtual Reality (VR)

- The real world disappears completely
- 360° digital environment, controlled via a headset
- Reality is REPLACED

## Mixed Reality (MR)

- Digital objects are precisely placed into the real space and respond to it
- Interact with both simultaneously
- Reality is BLENDED

# HOW DOES XR WORK?

## VR — Immersion

- Headset blocks out reality
- Real-time engine renders the 3D world in milliseconds
- Head movements are transferred directly to the virtual camera

## AR — Tracking

- Camera films the surroundings
- Tracking algorithms determine the user's exact position
- Digital content is placed precisely into the image

## MR — Spatial Mapping

- Sensors scan the room in 3D and build a live map
- Digital objects are anchored into that map and stay in place as you move.

## Key requirement

- All three technologies need powerful hardware and fast, stable connections (Wi-Fi / 5G) to work reliably in industrial environments.



# VIDEO 1 – XR EXPLAINED

▶ [Play video here](https://www.youtube.com/watch?v=IFgGzOpjIUM)

*<https://www.youtube.com/watch?v=IFgGzOpjIUM>*

# FROM GAMING TO INDUSTRY

# FROM GAMING TO INDUSTRY



## Origins: Multimedia & Gaming

- First VR experiments in the 1990s — huge, expensive and unreliable..
- The smartphone was the turning point: everyone suddenly had a camera, screen and motion sensor in their pocket.

## Milestones

2014: First consumer VR headset on the market.

2016: Pokémon Go — one billion downloads by 2018.

AR became a mainstream phenomenon overnight.

## AR in daily life

- The head-up display in modern cars projects speed and navigation onto the windshield

## XR in industry

- B2B revenue 2018: 500 million.
- B2B-revenue 2025: approx. 250 billion.
- XR is no longer a toy — it solves real industrial problems.

# VR IN INDUSTRY

## Factory planning

- Walk through the factory before a single brick is laid.
- Optimise workflows and machine positions, identify hazard zones.
- Errors in planning cost far less than errors during construction.

## Product development

- CAD models become walkable 3D prototypes.
- Engineers spot design problems early.
- Clients experience the product before manufacturing begins.
- Physical prototypes become unnecessary.

## Trade shows & sales

- Show the entire product portfolio with a single VR glasses.
- No logistics and no transport necessary.
- Large machines, complete facilities: from every angle, from the inside, zoomed in.

## Training & simulation

- Critical situations (e.g. chemical spill, machine failure ) can be simulated safely.
- The trainee can not damage anything.
- Training sessions can be repeated as many times as needed + location independent





### Case study: Bell Helicopter

- The FCX-001 was developed entirely in VR.
- Result: under 6 months instead of the usual 5–7 years.
- Test pilots gave feedback directly from the virtual cockpit.

# AR IN INDUSTRY

# AR IN PRODUCTION & ASSEMBLY



## Instructions in the field of view

- The next work step appears via AR glasses directly in front of the worker.
- Both hands stay free.
- Safety warnings appear automatically.

## Automatic documentation

- Each completed step is confirmed with a gesture and immediately logged digitally.
- no follow-up paperwork required.

## Consistent quality

- All workers follow the same digital instructions.
- Changes are made once in the system and take effect immediately for everyone.

# ONBOARDING & MANUFACTURING CONTROL

## Onboarding new staff faster

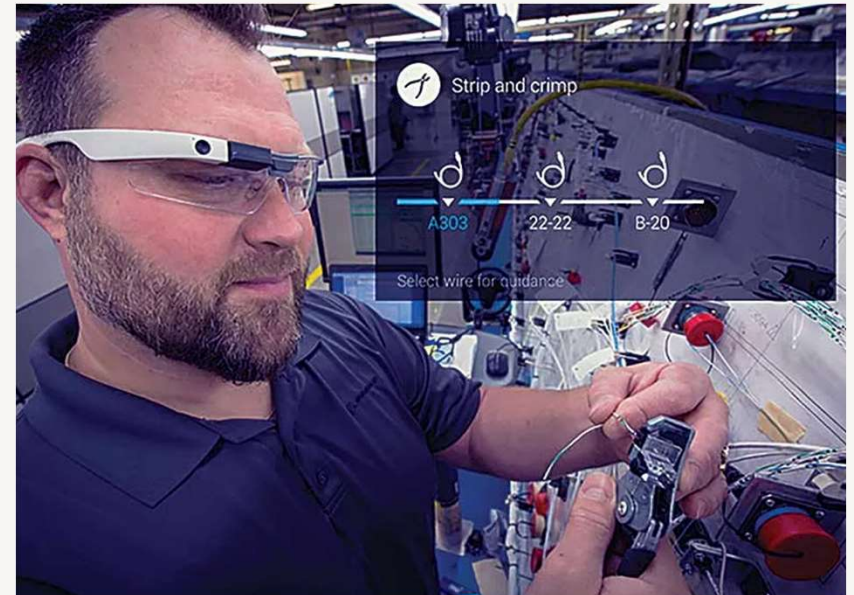
- Step-by-step instructions for every task, always accessible via AR glasses.
- Expert knowledge stays within the company, even when experienced staff leave.

## Machine data in real time

- Status, error codes and maintenance data appear directly in the field of view.
- Faults are spotted sooner, even from a distance.

## Case study: Boeing

- Technicians view aircraft wiring diagrams directly in their field of view
- 25 % working time · +40 % productivity.



# VIDEO 2 – AR IN INDUSTRY

▶ [Play video here](https://www.youtube.com/watch?v=UhW12bILH7U)

*<https://www.youtube.com/watch?v=UhW12bILH7U>*

# MR IN INDUSTRY

# MR IN INDUSTRY



## Remote expert support

- The expert sees through the technician's eyes and draws arrows and instructions directly into their field of view
- Less downtime, no travel costs.

## Warehouse logistics

- Navigation arrows guide the picker along the shortest route to the right shelf.

## Remote training

- Trainer and trainee in different locations.
- The trainer sees exactly what the trainee sees and adds instructions directly to their field of view.

# OPPORTUNITIES & RISKS

# OPPORTUNITIES OF XR



## Communication & efficiency

- Complex processes are explained visually
- Multiple senses are engaged at once
- Information is absorbed faster and retained longer

## Cost savings & quality

- No physical prototypes required
- Errors are caught earlier — especially in the VR planning phase
- Corrections are still inexpensive at that stage

## Safety & talent attraction

- Safety warnings appear at exactly the right moment directly in the field of view
- Modern technology makes companies more attractive as employers

## Reduced travel

- Experts accompany colleagues worldwide via MR — without travelling
- Lower costs, greater flexibility

# RISKS OF XR



## Employee acceptance

- Biggest risk --- workers who reject XR undermine the entire investment
- Solution: involve them early, shape new processes together, train everyone

## Data privacy

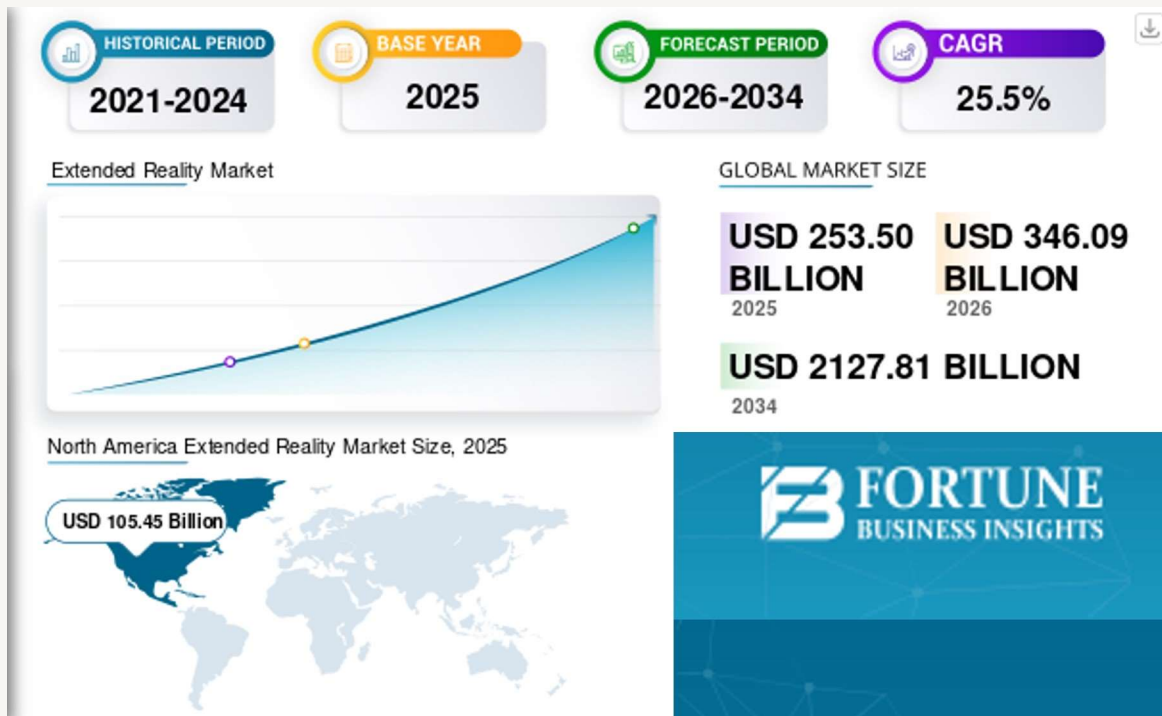
- XR devices capture eye movements, facial expressions, gestures, voice and spatial data in real time
- Research (2024/25): this data can enable sensitive inferences
- Transparency is mandatory — GDPR alone is not enough

## IT infrastructure & legal

- Without stable Wi-Fi / 5G and powerful servers, XR simply doesn't work
- Legal grey areas around remote MR maintenance must be resolved contractually

# MARKET & FUTURE

# MARKET & FUTURE



## Global XR market

- Approximately \$250 billion (2025), with 30–40% annual growth.
- The fastest-growing segments: healthcare and manufacturing.
- XR is no longer a niche topic.

## 5G as an enabler

- Latency below 1 ms enables cloud-based XR applications without lag.
- Large factory floors and outdoor areas become fully accessible for the first time.

## KI + XR & Digital Twin

- AI-powered headsets automatically recognise machines and display the relevant data.
- A digital twin of a factory is walkable and editable in real time via VR headset.

## New Hardware

- Apple Vision Pro, Samsung smart glasses
- Headsets become lighter, cheaper and more powerful every year.
- The barrier to industrial deployment is continuously falling.

# SUMMARY

# SUMMARY

## **XR = AR + MR + VR**

- One umbrella term, three technologies
- AR enhances reality — VR replaces it — MR blends both worlds.

## **VR, AR & MR in industry**

- VR for things that don't exist yet: planning, prototypes, training
- AR for smarter work: instructions, control, onboarding
- MR for remote collaboration: experts, logistics, training

## **Opportunities & risks**

- Efficiency, cost savings, quality, safety and talent attraction speak for XR
- Acceptance, data privacy, infrastructure and legal questions must be addressed from day one

## **Outlook**

- 30–40% growth per year and drivers like 5G, AI and the digital twin, XR is becoming an industrial standard — not eventually, but now



**Thank You**  
For Your Attention!

Any Questions

