VTT

Handbook for Human-Driven Industrial Metaverse

Exploring business opportunities in value networks to support strategic planning

beyond the obvious

Introduction

This handbook summarises the key topics that companies should consider when planning their industrial metaverse strategy. It outlines the critical strategic questions – and provides insight to help answer these issues.

At VTT, we believe the industrial metaverse will radically improve how industrial work is done in the future. Early movers who develop and provide the necessary solutions will occupy the best positions in this rapidly growing market.

Our key takeaways for different value network partners are:

1. Industrial end-user companies in manufacturing, maintenance, construction, and logistics should seek innovative use case examples beyond their industry verticals to learn and apply similar ways of working in their own operations.
2. Major opportunities will emerge for service providers able to consolidate infrastructure, data management & connectivity to support multiple user companies with scalable end-to-end industrial metaverse solutions.
3. Technology providers must prioritise user experience and worker well-being in their solutions. The solutions can be applied in work tasks of varying complexity and duration, from process optimisation to emotionally adaptive user interfaces. They should also promote the convergence of professional and private applications, leveraging the same user equipment, just as with mobile handsets.

Contents

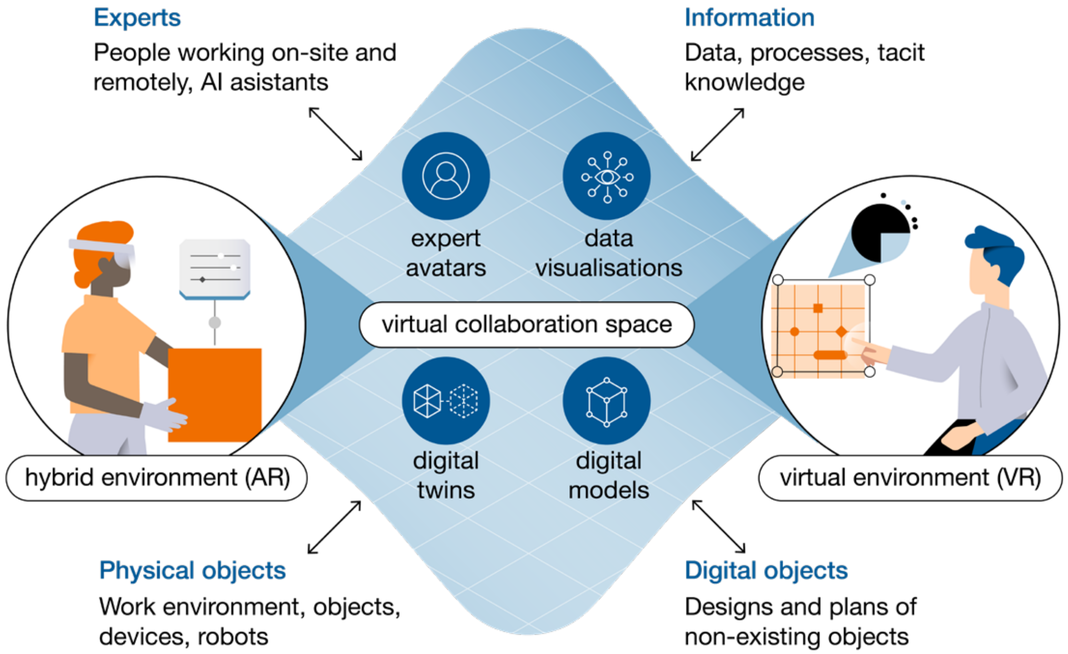
This handbook was created based on the views of 25 experts from different research fields at VTT and discussions with industrial partners over the last two years. The content will continually evolve and receive updates when needed.

Understanding the possibilities of the industrial metaverse

Long-term vision

At VTT, we envision the industrial metaverse as interconnected virtual collaboration spaces that people can use for their work tasks, regardless of physical location. People can use these virtual spaces to access and interact with different work environments, digital twins, digital models and information visualised in the space. Virtual collaboration spaces also provide a seamless way to collaborate efficiently with other experts and AI assistants.

Collaboration spaces are always real-time and persistent, meaning users cannot pause or reset events that take place in the space. Digital twins in the space are in synch with real-world elements. The content evolves based on user actions, just as in a physical environment.



Elements of virtual collaboration space

Using virtual collaboration spaces

These spaces can utilise augmented reality solutions (AR) to interact with objects, people and other elements in the space, together with the actual physical environment. It becomes possible to mix elements from both the physical and virtual worlds. Spaces can also be accessed via virtual reality solutions (VR) for remote use.

New ways of working

Working on-site (AR):

Information provided in the immersive collaboration space also enhances on-site work. For example, augmented reality displays instructions, IoT and robot sensor data, and expert input during hands-on tasks. These solutions ensure the right information is available in context, facilitating easy communication with others present in the same space.

Working remotely (VR, video walls):

Pools of remote experts can use the virtual collaboration space to monitor machines, vehicles and robots simultaneously, taking control whenever intervention is needed. Devices range from high-end headsets to video walls, depending on the needed immersion level. Digital twins enable remote interaction with physical objects. For instance, devices, robots, and vehicles can be controlled from home or the office using haptic solutions and purpose-designed tools and services.

Working individually:

Virtual collaboration spaces also support individual work. Workers can deep dive into complex information, bring or build new elements to the space, or leave comments on existing content. This information can also be used outside the virtual collaboration spaces for creating simulations, testing prototypes or as training material for work tasks.

Working together:

In the same space, workers can collaborate with AI assistants as well as other experts, whether from the same organisation or an ad-hoc virtual team formed from a pool of experts offering their services in the industrial metaverse. Each professional avatar has access rights to a specific part of the space. For example, end-users could be granted access to test prototypes in the virtual space.

Identifying the most promising use cases

At the heart of the human-driven industrial metaverse are the needs of industrial workers, their teams and their organisations. By taking a people-centric approach, we can identify the best opportunities to support employees' interaction with metaverse solutions. As a result, employees feel empowered and engaged, ensuring that the human–technology–AI teams work smoothly together.

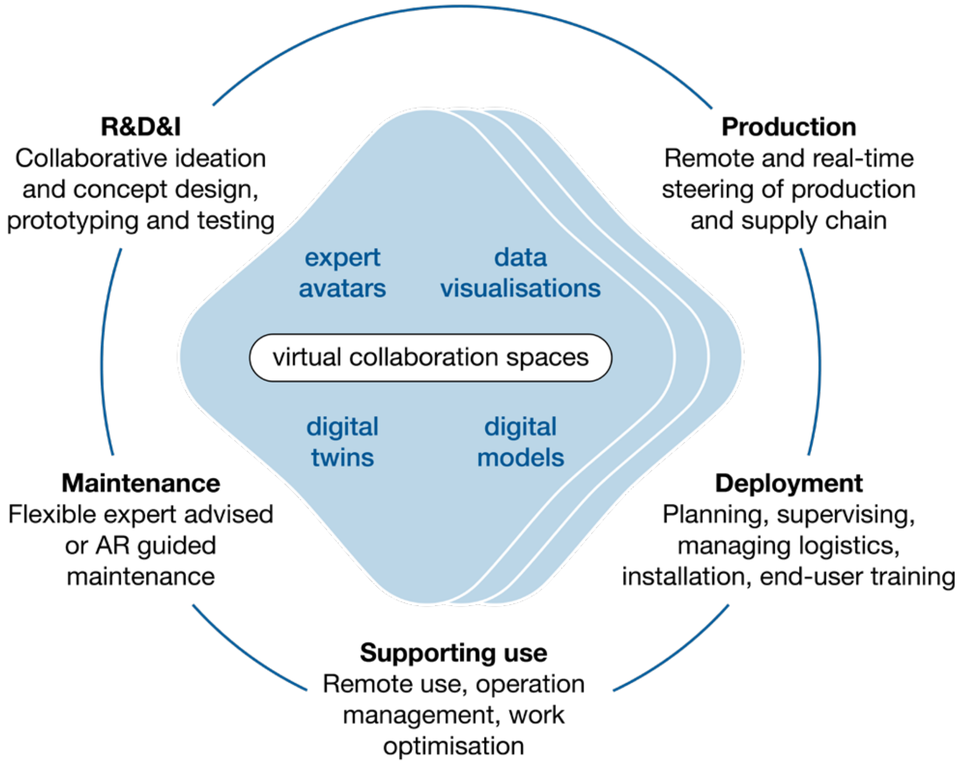
The industrial metaverse can provide significant benefits to workers and teams and promote cross-organisation collaboration throughout the lifecycle of a product, vehicle, building etc. – from planning and design to supporting maintenance tasks.

To identify the most promising use cases, we must explore how adopting virtual collaboration spaces could transform various work operations and the additional value this would bring to employees, teams, and their organisations.

Questions to consider

How can the Industrial Metaverse be used to enhance our own or our customers' operations and work tasks?

What are the most promising use cases to begin leveraging the Industrial metaverse?



Examples of using metaverse throughout the product lifecycle

R&D&I

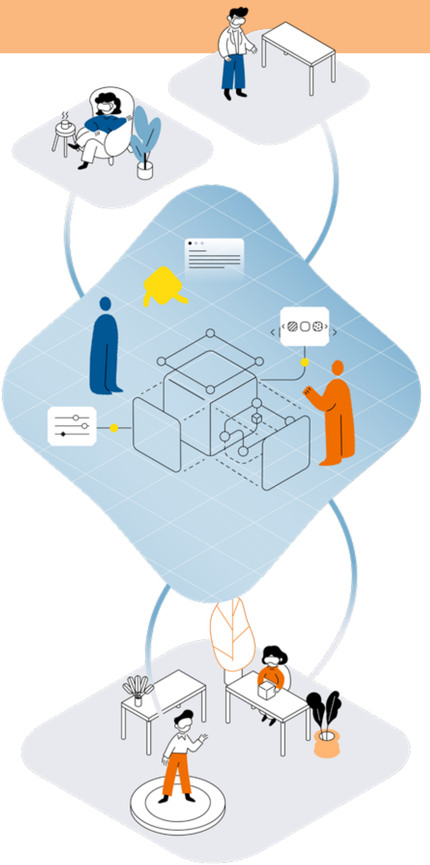
Design and innovation work in the use context with cross-organisational virtual team

Virtual collaboration spaces will be used in R&D&I work because it requires a detailed understanding of the end-user environment and tight collaboration between local & remote experts and stakeholders from different organisations.

Ideation & concept design: Design teams can plan alternative solutions atop existing digital twins in the virtual collaboration space, thereby developing the best ideas and concepts together in real-time. Teams can also experiment, using haptic technologies prior to crafting physical models.

Prototyping: In the end-user environment, teams can prototype different features to determine the effectiveness of alternative design options.

Testing & validation: Solutions can be validated with end-users to see how design would work in the actual use environment. Collaboration spaces also enable multiple perspectives to help with design validation – for example, insights from maintenance or sustainability experts from maintenance or sustainability can be gathered.



Key benefits: Easily accessible visual information makes the end-user context easy to understand, leading to innovations and better solutions. Virtual space helps to get the best experts globally to collaborate in the R&D&I work.

Example use cases: Detailed design and validations for products, buildings and environments using the end-user context.

Production

Human-technology-AI collaboration in hybrid production work

Factory floor work will no longer be tightly bound to the production space and can be operated also through virtual collaboration spaces. Hybrid tasks will appear, and roles and tasks will be divided between workers, AI, and different technologies even across organisations.

Hybrid operators: Human and robot machine operators can work from various locations and manage larger machines simultaneously while receiving pre-analysed data and decision suggestions from AI.

Material flow optimisation: Production processes are optimized using real-time digital twin of production status in the whole supply network. Multi-purpose robots and self-optimising machines send and receive information, organising tasks for machines and people accordingly.

Problem solving: On-site and remote workers collaborate using the same visual real-time information of the production status and can test and try out different options. While helping the on-site worker in repairs, multi-purpose robots also update the digital twin with rich situational awareness data from fixed sensors, robots, and environments.

Key benefits: Efficient and flexible use of operator resources, attractive jobs, productivity increase with material optimisation, shorter machine downtimes.

Example use cases: Discrete manufacturing factories, also suppliers, process industry production sites, logistics sites and warehouses.

Supporting use

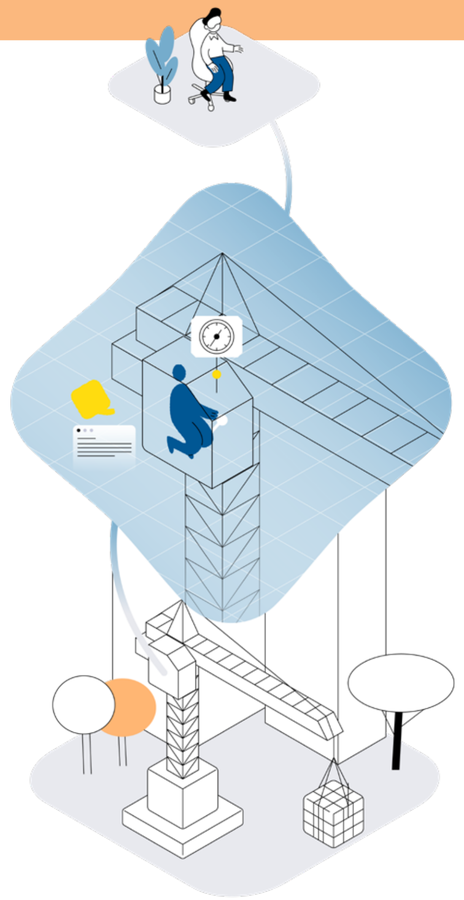
Common Cockpit for remote operation of autonomous equipment

In the future, a large proportion of autonomous equipment – like vehicles, mobile robots and machines – will be remotely monitored and operated by remote operators.

Operator intervention: Remote operators can be assigned to pre-planned or ad-hoc tasks whenever intervention is needed. Operators, certified for various remote operation tasks, form a global pool of experts and will be employed by staffing companies.

Resource allocation: Connecting the operator to the equipment would happen instantly through virtual collaboration spaces, covering advanced resource planning, operator authentication, cybersecurity and commercial transactions.

Working: The operator would work in a regulated Common Cockpit virtual space (based on dominant design) that fits practically anywhere. Shared reality and haptics-based control provide an enriched experience with interactive AI assistants, an immersive environment and cognitive load monitoring and adaptation.



Key benefits: Resource efficiency for equipment operators, attractive jobs and wellbeing for employees.

Example use cases: Autonomous mobile work machines in isolated forests, trucks and cranes in fenced harbours & airports, maintenance vehicles and public transport in populated areas, mobile and industrial robotics, future unmanned drones and aviation.

Maintenance

Maintenance operations with local super janitors

In the future, basic maintenance work will be done by “super janitors”– a pool of workers supported by immersive guidance, remote experts and AI assistants accessed through virtual collaboration spaces.

Planning & training: Maintenance experts can check the maintenance targets and environment from the digital twin and plan the required work. If needed, experts can create a training space for on-site workers (“super janitors”).

Immersive guidance: On-site workers can receive instructions (added to the objects) via AR glasses. Information and advice is also accessible through AI assistants.

Remote expert support: On-site workers can draw from a pool of remote experts for more complicated work or to solve unexpected problems.

Validating results: Once maintenance is ready, the changes can be simulated and tested in a virtual collaboration space.

Key benefits: Local employment, attractive secondary jobs, rapid response and short downtime, reduced travel/commuting related time and OPEX.

Example use cases: Basic maintenance and checks of building infrastructure, factory devices or construction sites enabled by local super janitors.

Assessing the key value for different actors

The goal is to create an industrial metaverse that not only helps people with their work tasks but also provides a competitive edge for the organisations they work for. Solution & tech and service provider companies who develop and supply industrial metaverse solutions will reap the benefits of this growth.

Value for end-users

For individual workers, increased hybrid work possibilities and augmented skills to perform various tasks.
At a team level, efficient collaboration and knowledge sharing among human-machine-AI teams.
At the cross-organisational level, geographically separated experts help ad-hoc troubleshooting and problem solving.

Value for service providers

New service business: Emerging new business to provide metaverse-as-a-service to customers.
New service models: Renewal of employment from standard workforce contract-based employment to task-based freelance type model can enable new service business models for staffing companies.

Value for end-user companies

Attract and retain talents: Employee wellbeing attracts the best talents and contributes to the longevity of employees.
Productivity increase: Digital models and AI assistants can aid employees with problem-solving, and enhanced data can ease work planning.
Availability of experts: Remote experts from global pools can handle individual work tasks within the virtual collaboration space or operate as part of a broader virtual team.

Value for tech & solution providers

Business growth: Opportunities to provide scalable solutions for different use cases.
Market growth: Opportunities to offer solutions for several industrial domain areas.

End-users

People using industrial metaverse solutions for their work tasks

End-user companies

Companies using industrial metaverse solutions in their operations

Service providers

Companies developing and offering metaverse-as-a-service

Solution & tech providers

Companies developing, offering and maintaining metaverse solutions and related technology

Roles of the key value network actors

Questions to consider

What kind of significant benefits there could be for individual workers, teams, and cross-organisation collaboration?

What kind of new business value we could create for our customers and for our own company?

Planning and creating the solutions

After identifying the most promising use cases, we must plan R&D&I projects with interested companies to test our ideas and hypotheses. The best way is to run rapid experiments where practical solutions are created and validated with end-users and continuously share outcomes and learnings.

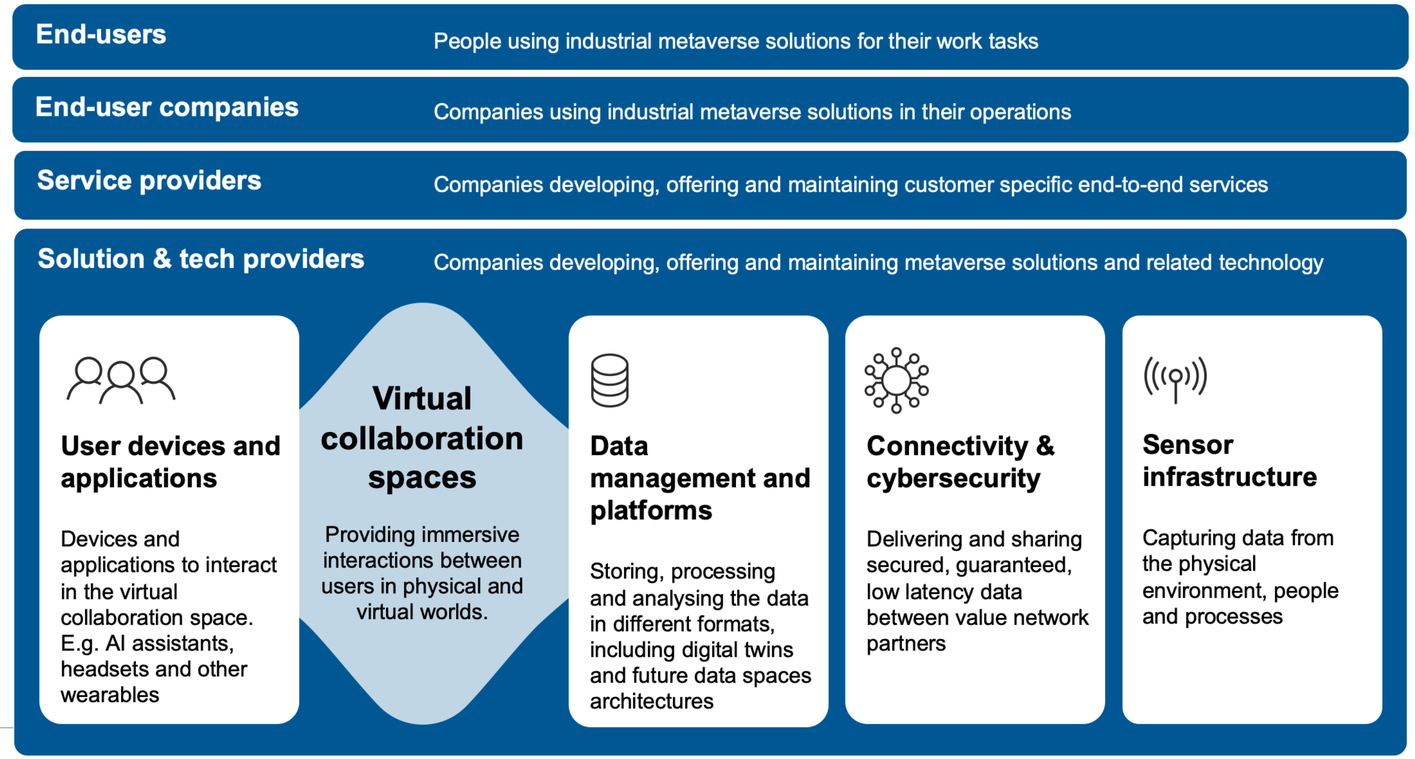
As the aim is to create economically viable businesses with positive impacts, we must create industrial metaverse solutions that can be scaled across multiple industrial domains rather than creating case-by-case solutions. This requires seamless collaboration between all actors in the value network.

Questions to consider

What type of industrial metaverse solutions are needed for identified use cases in both the short and long term?

What could be our role in the value network for using, providing or developing these solutions?

Who could we collaborate with in the value network?



VTT’s role in enabling industrial metaverse solutions

At VTT, we understand that the industrial metaverse provides excellent potential for the future of work, for companies and workers alike – we want to support this development with our expertise and human-driven approach.

Our expertise

VTT is a forerunner in developing metaverse solutions for industrial contexts with extensive experience and insight into the building blocks of the industrial metaverse. At VTT, we have expertise in AI, robotics, cyber security, spatial computing, human sensing, and other technical enablers.

Human-driven approach

VTT’s human-driven approach ensures employees and businesses thrive in the industrial metaverse. Our target is to create a human-centric industrial metaverse in which people want to work and which ensures significant benefits for end-users and end-user companies.

Holistic solution creation

At VTT, we always aim to build industrial metaverse solutions that are

- **Desirable** from end-users’ perspectives
- **Viable** from end-user organisations’ and solution providers’ perspectives
- **Feasible** from a technological perspective
- **Responsible** from environmental and social perspectives

VTT as R&D&I partner

At VTT, our goal is to support individual companies with our research, innovation and development services. VTT can help companies in different parts of the industrial metaverse value network to develop economically scalable solutions and concepts.

We understand both the potential of the industrial metaverse and the technologies that enable it. Above all, we know how important it is to understand the needs of employees and create desirable solutions that people can trust.

VTT can manage and build complex projects with several stakeholders or provide our expertise to a single company tailored to their individual needs.

Questions to consider

What R&D&I actions are needed now and in the future for us to reach our targets?

What R&D&I activities and projects can we create or participate in to implement the required actions?

How can we get started with our actions? Who can help with project planning, getting funding and identifying the required enablers and partners?

Company specific contract R&D and innovation projects

Business Finland funded **co-innovation projects** involving international companies

Horizon Europe funded joint projects

Project types to investigate and develope metaverse solutions

VTT is a visionary research, development and innovation partner for companies and the society. We bring together people, business, science and technology to solve the biggest challenges of our time. This is how we create sustainable growth, jobs and wellbeing and bring exponential hope.

VTT has an extensive research background in several critical enablers, such as XR software and hardware, spatial computing, robotics, human factors, human AI and human sensing, safety and cybersecurity, sensors, connectivity, critical systems, fore- sight, and ethics. This diverse expertise forms a unique combination of the essential technical and non-technical foundations required to transform work across different industrial domains.

We promise to always think beyond the obvious.

For more information

To learn more about the human-driven industrial metaverse, please contact

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