# THE FUTURE OF COMMUNICATION TECHNOLOGY

## TREND REPORT 2023

CDTM
CENTER FOR DIGITAL TECHNOLOGY AND MANAGEMENT

The Future of Communication Technology

ISBN: 978-3-9822669-5-4

6G-life

## Kindly supported by BMBF Research Hub 6G-life

In the BMBF Research Hub 6G-life the Technical University of Dresden and the Technical University of Munich have joined forces to drive cutting-edge research for future 6G com-munication networks with a focus on human-machine collaboration. The merger of the two universities of excellence combines their world-leading preliminary work in the field of Tac-tile Internet, 5G communication networks, quantum communication, Post-Shannon theory, artificial intelligence methods, and adaptive and flexible hardware and software platforms. 6G-life provides new approaches for sustainability, security, resilience and latency shaping future communication systems from application to physical layer across multiple networking domains. Involving more than 60 professorships from both universities and more than 150 researchers, 6G-life is expected to have a global impact on the future communications land-scape including the industry and the start-up landscape in Germany through positive show-case projects and thus sustainably strengthen digital sovereignty in Germany. 6G-life re-ceives financial support by the Federal Ministry of Education and Research of Germany (BMBF) in the programme of "Souverän. Digital. Vernetzt."


## A Project of the Center for Digital Technology and Management (CDTM)

The Center for Digital Technology and Management (CDTM) is a joint, interdisciplinary institution for education, research, and entrepreneurship of the Ludwig Maximilians-University (LMU) and the Technical University of Munich (TUM).

It offers the add-on study program "Technology Management" for students from various backgrounds, which provides students with tools and knowledge at the intersection of business and digital technologies.

The entire trend report was written by CDTM students under the close guidance of research assistants.

Visit www.cdtm.de for more information.

Vera Eger 
Felix Dörpmund 

# PREFACE OF THE EDITORS



> **Everybody can learn from the past. Today it is important to learn from the future!**
> Herman Kahn

As Herman Kahn, one of the founding fathers of modern scenario planning, nicely states, it is tremendously important for strategy and policymakers to get a deep understanding of possible future developments to be prepared for them.

The Center for Digital Technology and Management (CDTM) aims to connect, educate and empower the innovators of tomorrow. It is our mission to equip our students with the tools and knowledge they will need to become responsible leaders who actively shape their future environment rather than only react to changes.

This Trend Report is the result of the course Trend Seminar, which is part of the interdisciplinary add-on study program "Technology Management" at CDTM. About 25 selected students of various disciplines, such as Business Administration, Psychology, Medicine, Computer Science, Electrical Engineering, and others, work together on a relevant topic of our time. Over the course of seven intense weeks of full-time work during their semester break, the participating students dive deeply into the topic of the Trend Seminar. Working in several interdisciplinary sub-teams, students apply the knowledge of their main studies and learn new perspectives from their team members. They conduct trend research, develop scenarios of the future, generate ideas for innovative products or services, and detail them out into concrete business concepts.

We would like to take the chance to thank everyone who contributed and made this CDTM Trend Report possible:

We want to thank 6G-Life for supporting this Trend Seminar. Particularly, we want to thank Prof. Kellerer and his chair for their collaboration, valuable insights, and feedback throughout the whole project. We hope our findings support you in driving innovation in the context of The Future of Communication Technology

In addition, we very much thank all our lecturers, who shared their knowledge and largely contributed to this project's success:

Aaron Defort (CDTM)
Andreas Dotzler (Cadami)
Dr. Felix von Held (IICM)
Dr. Werner Mohr (6G-IA)
Dr. Michael Lipka (Huawei)
Dr. Sandra Merkel (Rohde & Schwarz)
Dr.-Ing Volker Ziegler (Nokia)
Elizaveta Felsche (CDTM)
Felix Schröter (CDTM)
Frederik Junge (CDTM)
Jose Adrian Vega Vermehren (CDTM)
Maximilian Keinert (Pacifico Energy)
Nadine Schmidt (Professional Coach / Alumna)
Niklas Hölterhoff (CDTM)
Peter Schniering (Future Cleantech Architects)
Prof. Dr. Fabian Zuleeg (EPC)
Sandro Scalise (DLR)
Tim Henlein (BCG Plantinion)
Helmut Sussbauer (Innovation Catalyst)
Mary Sanford
Sven Meyer-Brunswick (Mynaric)
Markus Werner (Aerolifi)
Leif Carstensen (Voicebeam)
Tom Schelo (CDTM)

Last but not least, we would like to thank the CDTM students of the class of Spring 2023. They put great energy and enthusiasm into this project, which made it a pleasure for us to supervise the course and coach the individual teams. Special thanks to the Heads of the editing-, layouting- and QA-team (Alena Strittmatter, Nils Krüger, Victoria Rentrop) for finalizing the report.

Vera Eger and Felix Dörpmund
Center for Digital Technology and Management (CDTM)

# PREFACE OF THE PROJECT PARTNER

> **6G research has just started.**
> **Time to create significant impact!**
> 6G-life

The BMBF Research Hub 6G-life is a university-based research project committed to shape the communication landscape of the future aiming at the upcoming 6th generation mobile communication system. 6G research has just started and 6G deployment is expected to begin in the year 2030. Enough time to create significant impact! One objective of the pro-ject is to strengthen the technology sovereignty in Germany. In this way, the project does not only strive for scientific research excellence to impact the technology development for 6G, but also to educate the engineers for tomorrow and to lay the ground for new startups in Germany to be able to bring the know-how to the market. Therefore, 6G-life has teamed up with CDTM to develop and execute entrepreneurial education in the area of 6G. This trend seminar on "the future of communication technology" where 6G-life took the project partner role is one important milestone of the collaboration with CDTM in 6G-life.

It is the objective of this trend report to take a fresh look on the communication technology of tomorrow. Such rethinking is fuelled by the fresh ideas of the interdisciplinary team of CDTM students we had the pleasure to work with. As a challenge, we even went beyond the 6G target date 2030 and asked the question: "What will the future of communication tech-nology look like in 2043, twenty years from today?" And tasked the students to look also beyond technology trends in areas including trends in society and the environment, in politics and legal, in economy, and in emerging business models.

Whereas the above areas of trends are typical for a trend seminar, the setting was particu-larly different from a usual trend seminar. Typically, project partner of a trend seminar is an established company or an interest group with a solid business model, which is interested to look into expanding the business into the future. This time, project partner 6G-life was a purely academic research project lacking any business model and mostly concentrating on communication technology trends. We were nevertheless keen to see what trends impact technology and which business models can be established on top of 6G communication technologies. This extra challenge has been taken up greatly by the CDTM students and the 6G-life team enjoyed the fresh discussions in every step of the process of the trend seminar until the presentation of this trend report.

At this point, we would like to thank everyone involved in the CDTM. This trend seminar showed again that the CDTM is an outstanding initiative that creates a unique spirit thanks to an interdisciplinary and methodical bottom-up approach. This makes the CDTM a great partner for the future communications ecosystem!

In particular, we thank the students who have impressed us, starting from my technology heavy 6G presentation at the start to the final presentations. Your combination of commitment, fun and professionalism is extraordinary. Please keep this spirit to become the inno-vators of tomorrow's communication technology! Our big thanks also go to the supervisors, Vera Eger and Felix Dörpmund, who were excellent supervisors for the students and great partners during this time.

Thank you all for 7 intensive weeks, 25 trends, 4 future scenarios and 5 business ideas!

Prof. Dr.-Ing. Wolfgang Kellerer

Technische Universität München
Co-Coordinator of 6G-life

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# METHODOLOGY

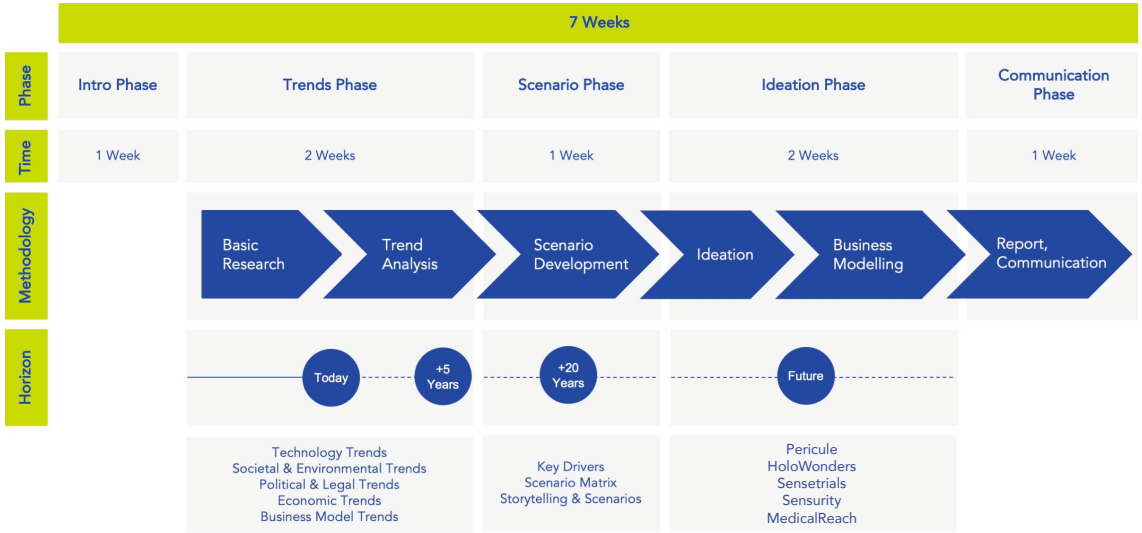
For a given topic that is highly impacted by digital technologies, the Trend Seminar pursues three main goals:

- Analyze the status quo and recent developments to identify important trends.
- Develop extreme but plausible scenarios of the future to be prepared for upcoming challenges.
- Develop future-proof product and service ideas and turn them into business concepts.

These goals are represented by the three main phases of the Trend Seminar: The Trends Phase, the Scenario Phase, and the Ideation Phase. The Kick-off Phase and the Communication Phase support the introduction into the Trend Seminar journey and the communication of the results in a written and presentation format, respectively.

Twenty-five students, supervised by two doctoral candidates, pursue the Trend Seminar in seven weeks of intensive full-time work alongside their project partner. In each phase, interdisciplinary sub-teams are formed, including students from technology, business, and various other backgrounds, to combine versatile ways of thinking.

The Trends Phase yields a holistic overview of recent developments and trends in the environment of the overall topic. Based on the commonly used STEEP approach (Social, Technological, Economical, Environmental, and Political), the status quo and trends in the fields of society & environment, technology, economics, politics & legal, as well as emerging business models are analyzed. Knowledge is gathered by literature research and expert interviews, preceded by a series of input presentations by experts on the topic. The class is split into five teams, each working on one of the thematic scopes. At the end of the Trends Phase, the teams present their key findings to each other for everyone to get a holistic view of the topic to build upon in the following phases.




The Scenario Phase builds upon the analyzed trends in order to create four scenarios of different futures in twenty years ahead. The driving forces behind the developments are identified and specified as drivers with bipolar outcomes. Once specified, all drivers are ranked according to their respective impact on the overall topic and the perceived degree of uncertainty regarding their outcome. Two key drivers that are independent of one another and have both a high impact and a high degree of uncertainty are chosen. Their bipolar outcomes are used to create a scenario matrix of four scenarios. A timeline for each of the scenarios is created, and the scenarios are sketched out using persona descriptions and visualizations. The Scenario Phase starts with a three-day workshop followed by group work in four teams. The teams are newly formed to include experts from each subtopic of the Trends Phase in each new Scenario Team.

In the third phase, the Ideation Phase, the goal is to develop innovative business concepts, which are then tested against the previously developed scenarios. Within a three-day workshop on structured ideation following the SIT approach (systematic inventive thinking) and unstructured ideation methodologies, a large number of business ideas are developed. Out of these, the most promising five ideas are selected and further developed into detailed business concepts. The sustainable business model canvas serves as the base structure. At the end of the seminar, the business model concepts are presented to the project partner and external guests.

# LIST OF ABBREVIATIONS

**AGI**
Artificial General Intelligence

**AI**
Artificial Intelligence

**API**
Application Programming Interface

**AR**
Augmented Reality

**B2B**
Business-to-Business

**B2C**
Business-to-Consumer

**B2G**
Business-to-Government

**BBK**
Bundesamt für Bevölkerungsschutz und Katastrophenhilfe

**BCI**
Brain Computer Interface

**BNT**
Bio-Nano Things

**BZgA**
Bundeszentrale für gesundheitliche Aufklärung

**CAGR**
Compound Annual Growth Rate

**$CO_2$**
Carbon Dioxide

**CRO**
Contract Research Organizations

**CTMS**
Clinical Trial Management System

**CTTI**
Clinical Trials Transformation Initiative

**DeFi**
Decentralized Finance

**DT**
Digital Twin

**EC**
European Commission

**ECG**
Electrocardiogram

**EDC**
Electronic Data Capture

**EHR**
Electronic Health Record

**EMA**
European Medicines Agency

**FCC**
Federal Communications Commission

**FDA**
Federal Drug Association

**FEMA**
Federal Emergency Management Agency

**Gbps**
Gigabits per second

**GDP**
Gross Domestic Product

**GDPR**
General Data Protection Regulation

**GEO**
Geostrationary Orbit

**GMO**
Genetically Modified Organism

**GPU**
Graphics Processing Unit

**Gt**
Gigatonnes

**HIPAA**
Health Insurance Portability and Accountability Act

**ICOM**
International Council of Museums

**ICT**
Information Communication Technology

**IIoT**
Industrial Internet of Things

**IoBNT**
Internet of BioNano Things

**IoT**
Internet of Things

**ITU**
International Telecommunication Union

**LEO**
Low Earth Orbit

**MANET**
Mobile Ad-hoc Networks

**ML**
Machine Learning

**MR**
Mixed Reality

**NGO**
Non-Governmental Organization

**NSA**
National Security Agency

**OT**
Operational Technology

**OTT**
Over-the-Top

**PDPC**
Personal Data Protection Commission

**PPC**
Pay-Per-Click

**PQC**
Post-Quantum Cryptography

**PT**
Physical Twin

**QKD**
Quantum Key Distribution

**SaaS**
Software-as-a-Service

**SEO**
Search Engine Optimization

**SEA**
Search Engine Advertisement

**SMO**
Site Management Organizations

**THW**
Technisches Hilfswerk

**UX**
User Experience

**VC**
Venture Capital

**VR**
Virtual Reality

**WEF**
World Economic Forum

**Wi-Fi**
Wireless Fidelity

**XR**
Extended Reality

**ZB**
Zettabyte

# TRENDS

The following chapter lists current trends that have a strong influence on the development and long-term strategic orientation of the Future of Communication Technology. In accordance with the Trends Phase methodology, trends and related driving forces are structured into five areas: technology trends, societal and environmental trends, legal and political trends, economic trends, and business model trends.

# TECHNOLOGY TRENDS

## INFLUENCING THE FUTURE OF COMMUNICATION TECHNOLOGY

Internet of Bio-Nano Things
Brain-Computer Interfaces
Quantum Technologies
Extended Reality
Multimodal Artificial Intelligence

Maximilian Fehrentz 
Leon Hergert 
Ria Rosenauer 
Juan Viera Garcia 
Christopher Wolters 



# TECHNOLOGY TRENDS

## Influencing the Future of Communication Technology

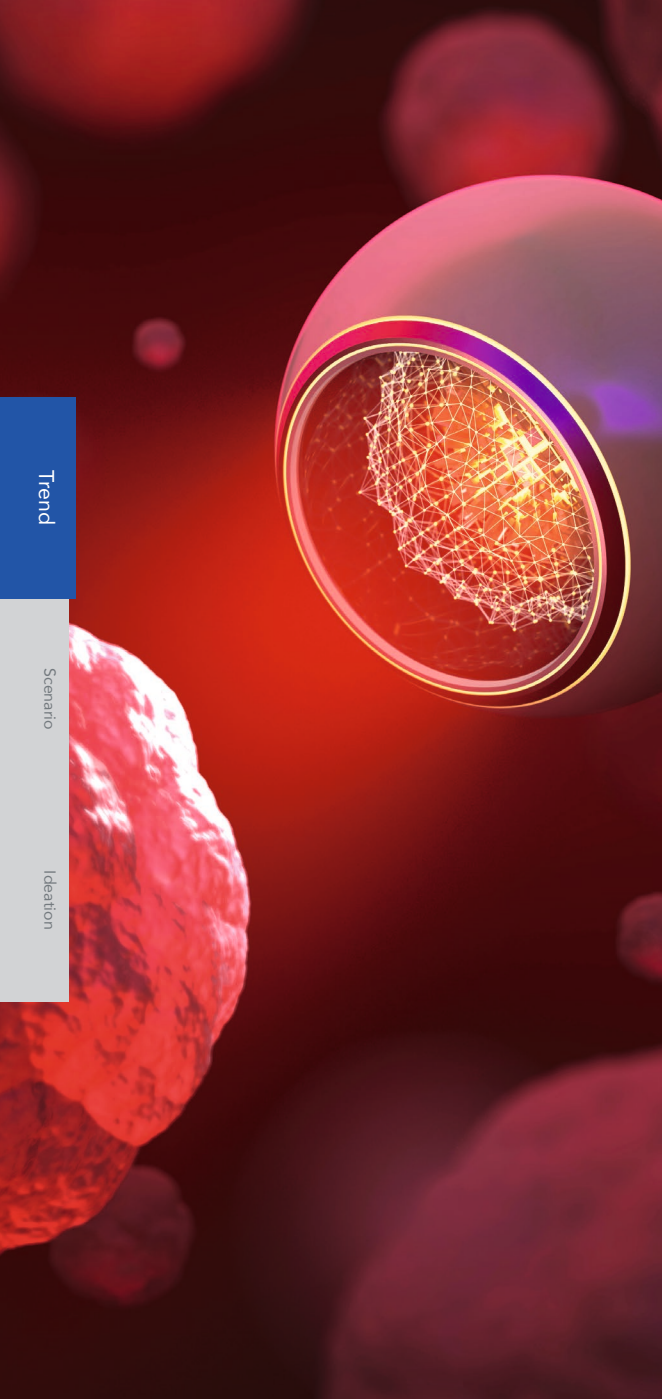
Communication technology is a dynamic and continuously evolving landscape with immense potential to revolutionize how we connect and interact. This trend report will explore five cutting-edge trends that shape the future of communication technology and change how the world communicates. They have been selected for their likelihood to become a reality and their potential to revolutionize communication technology.

The five trends presented in this report were selected by categorizing communication technology into two groups: The underlying hardware transmission technology and the application-level technology. The former includes classical electromagnetic wave communication, such as mobile communication 3G, 4G, 5G, and 6G, quantum communication, and biological communication. Mobile communication technologies are not individual trends but enablers. Disruptive application-level trends include extended reality (XR) and multimodal artificial intelligence (AI).

In terms of biological communication, it is worth nothing that two major trends are emerging. These trends represent an entirely new form of communication that has the potential to enable a vast array of new and different applications. The first trend, the Internet of bio-nano things (BNT), provides a new framework for using and connecting biological structures to transfer information. The second trend, brain-computer interfaces (BCI), will enable a wide range of human-to-human and human-to-machine communication applications. Biological communication is not competing with other forms of transmission technologies but is an entirely new form that will enable many new and different applications.

Given the accumulation of sensitive data in recent years and the prospect of interfaces to human bodies on the horizon, the need for higher security is rising. Therefore, the third hardware transmission technology, quantum communication, is the third emerging trend that could ensure the security of this new generation of communication technology. While quantum computing can potentially be a massive threat to current encryption methods, which leads to the necessity of new quantum secure algorithms, the quantum key distribution (QKD) could pave the way for 100% secure communication.

The remaining sections deal with the trends toward XR and multimodal AI. While XR technology can transform how we experience and interact with the world around us, multimodal AI can enhance our communication and extend the modalities using which we communicate with technology and other humans, allowing for more immersive and intuitive communication.





# INTERNET OF BIO-NANO THINGS

## Enabling Communication With the Human Body

The Internet of Things (IoT), in which intelligent machines are connected on the internet, is extended by the paradigm Internet of Bio-Nano Things (IoBNT). IoBNT is a field combining the power of nanotechnology with the connectivity of IoT to create a new generation of devices that can interact with the biological world in promising ways. The underlying BNTs are the fundamental units that operate at the nanoscale within the biological environment. These are expected to exhibit similar functionalities to the embedded computing devices in IoT, such as sensing, actuation, and communication. Another cornerstone of IoBNT is the way BNTs communicate with each other. Synthetic molecular communication is one of the most promising communication methods, inspired by the information transfer that occurs naturally between cells. The basic idea is to create devices that can communicate with each other using molecules instead of electromagnetic waves or electric signals. Future applications like health monitoring and drug release could be made possible [1], [2], [3].

### Facts

- BNTs emerge from synthetic biology and nanotechnology to allow building tools that enable biological embedded computing devices [3].
- Bio-cyber interfaces enable the transmission of intra-body information by being the interface of the chemical-electrical domain [3].
- While molecular communication is the most promising communication channel, different methods, such as terahertz radiation, magnetic coupling, heat transfer, and acoustic energy transfer, are based on BNT approaches, such as molecular nanomachines or nano-electric devices [4].

### Key Drivers

- The development of databases with characterized biological circuit parts expands biology as the process experienced by electrical circuit design in electronics, enabling access to cell features and elements without requiring knowledge of biotechnology [5], [3].
- The general longevity trends enable a holistic approach to increase the health span: Intra-body connectivity can be used to control and prevent failures [3], e.g., for cancer detection through mobile nanorobots [6].
- Advancements in machine learning (ML) advancements have resulted in understanding biological mechanisms, e.g., protein folding [7].

### Challenges

- Developing reliable mathematical and physical models and simulations to capture characteristics of underlying biological processes in engineered cells is challenging [3].
- Security threats could enable bio-cyber terrorism, e.g., by stealing health information or inserting viruses [3].
- An open quest is to power BNTs and receive signals inside and outside the body with the right communications stack and adequate solutions for the physical, link, and network layers [8].
- Biocompatibility is an essential prerequisite since an IoBNT application should not interfere with the homeostasis of organisms and should not be degraded by existing processes [4].

### Impact on the Future of Communication Technology

Since we have designed electrical circuits, we have built applications on top of them with different levels of abstraction, whereas the biological system has been designed and optimized by nature. The application of bio-nano machines would enable a better understanding of those systems and immediate information transfer, which can lead to the application of real-time health monitoring. Hence, it provides an entirely new framework for communicating biological information that will enable a multitude of novel applications.

# BRAIN-COMPUTER INTERFACES

## Bridging Minds and Machines

Until recently, controlling the environment with your mind was mere science fiction. However, technical advances have made it a reality: Humans can use electrical brain signals to interact with and influence their environment [9]. BCIs provide a direct link between a person's brain and external devices, such as a computer or robotic limb.
The purpose of BCIs is diverse, ranging from exploring and mapping cognitive functions to assisting, augmenting, and even repairing them. BCIs have the potential to revolutionize the way we interact with technology, enabling seamless communication without the need for physical devices [9]. These interfaces translate brain activity into computer commands, allowing users to control external devices: The system recognizes distinctive neural signatures that serve as control signals. The BCI then decodes the user's intentions and generates appropriate machine commands that replace, restore, or enhance human functions [10]. The potential applications are, therefore, vast, ranging from assisting people with disabilities to improving performance in areas such as gaming, education, and medicine.

### Facts

- Existing BCIs have become increasingly helpful in assisting individuals with disabilities, e.g., paralysis, to operate assistive devices like prosthetic limbs [9].
- Further, BCIs are being used to study brain functions, thus paving the way for the development of innovative therapies for neurological and psychiatric conditions such as Parkinson's disease, dementia, and depression [11].
- More recently, researchers have begun to explore brain-to-brain interfaces in which the cognitive intentions of the sender are translated into commands that stimulate a receiver's brain, enabling non-verbal communication [12].

### Key Drivers

- Breakthroughs in ML have enabled a deep understanding of the brain's structure and functions, e.g., by translating diffuse into readable brain signals through stable diffusion, while advances in semiconductor technology are driving invasive BCI designs with reduced size, lower power consumption, and higher signal acquisition [12].
- Rapid advances in neuroscience, engineering, and nanotechnology are driving the development of more sophisticated BCIs that can interpret a broader range of brain signals [10].
- The potential benefits of BCIs, such as curing neurological diseases and enhancing human performance, drive investment in research and development (Human Brain Project, BRAIN Initiative) [10].

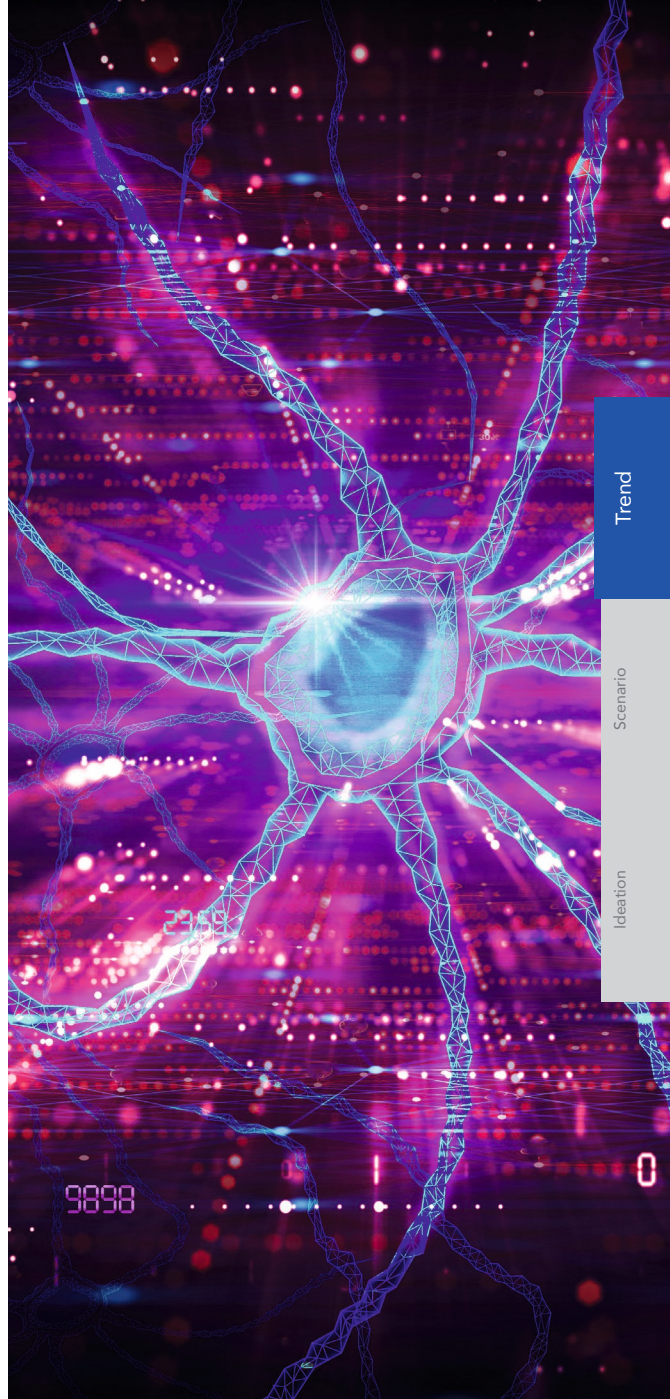
### Challenges

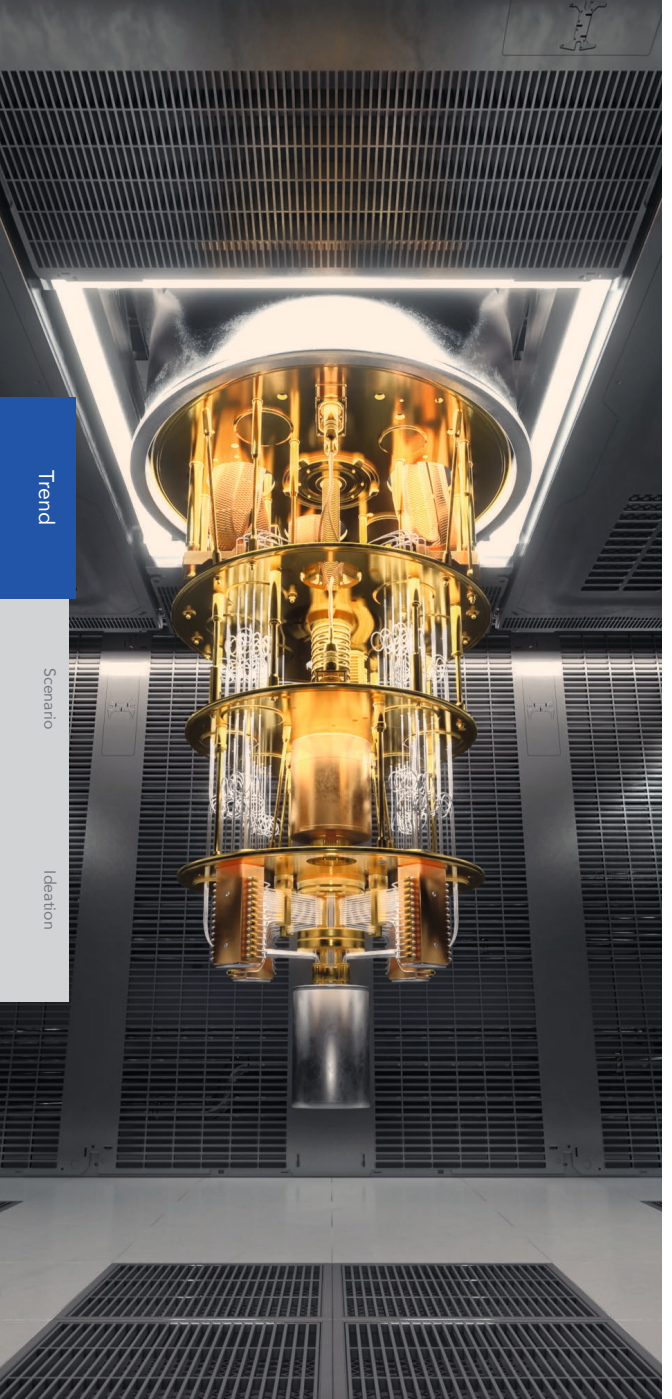
- The lack of clear and consistent regulations for the development, testing, and deployment of BCIs imposes a challenge for standardization [12].
- Another challenge is the need for more effective communication between the brain and external devices, as these often depend on invasive electrodes to record brain signals. Non-invasive BCIs, on the other hand, can be less accurate and reliable [9].
- Privacy and data security concerns but also moral issues require a broad consensus on ethical questions and the beneficial socio-economic application of this technology [12].

### Impact on the Future of Communication Technology

BCIs could improve communication for people with disabilities, allowing them to communicate more efficiently. Yet, beyond restoring functionality, technology could allow us to talk to each other inside our heads, revolutionizing the way we communicate. It could enable to share thoughts, feelings, images, or sensations directly across distance or language, overcoming limitations of expression.

Eventually, communication will not be limited to humans but will also extend to the entire environment, such as controlling home automation systems making communication human-centered yet ubiquitous.









# QUANTUM TECHNOLOGIES

## A Double-Edged Sword in Communication - Threatening and Enabling Safe Communication

Two trends in quantum technologies are relevant to communication. The first trend is the advancing development of quantum computers. Traditional encryption protocols rely on mathematical problems that are difficult for classical computers to solve, but quantum computers can solve these problems much more efficiently. This means existing encryption methods could be compromised in the future [13], [14]. Significant efforts are underway to develop new post-quantum cryptography (PQC) that is resistant to attacks by quantum computers. These new algorithms must be efficient enough to run on consumer devices like smartphones and laptops [15]. The second trend in quantum communication technologies is developing secure quantum communication, especially QKD. QKD utilizes the unique physical properties of quantum mechanics to ensure utterly secure communication channels. More specifically, quantum states are used to create a secret key that can be used for encryption. Any attempt to intercept or measure the key would result in a disturbance, alerting both parties to the presence of an eavesdropper [13]. Overall, quantum technologies have the potential to both disrupt and enhance communication, and it is essential to develop new solutions that can ensure secure communication in the face of these advances.

### Facts

- Governments announced huge funding initiatives, including 15.3bn USD in China, 7.2bn USD in the European Union (EU), and 1.9bn USD in the United States (US) [16], [17].
- The American National Security Agency (NSA), a prominent funding provider, reportedly favors PQC over QKD for securing communication due to significant implementation challenges associated with QKD. They justify their decision using the fact that QKD requires specialized hardware and infrastructure, making it challenging to implement on a large scale [18].

### Key Drivers

- There is currently a race in quantum computing funding, as countries and companies worldwide invest heavily in research and development to gain a strategic advantage in fields such as defense [17].
- The world's growing dependence on digital communication and data storage has created a need for better encryption methods. As a result, there has been a significant increase in funding for QKD and PQC research.

### Challenges

- PQC algorithms exist but are still too inefficient to run on user devices. Finding an algorithm that fulfills this requirement is mathematically challenging [15].
- The development of quantum computers is still at the very beginning. There are many different platforms, each with unique challenges. For example, building stable and reliable qubits that can be controlled accurately is a significant challenge [19], [20].
- QKD is only wholly secure when the physical implementation is done very carefully. Finding such an implementation has been a substantial technical and physical challenge so far [21].

### Impact on the Future of Communication Technology

The impact of quantum technologies on communication is twofold. First, the emergence of quantum computers significantly threatens existing encryption protocols. Without new PQC algorithms, all current communication channels could become vulnerable to security breaches, which would be particularly problematic for sensitive information, such as military intelligence. Second, secure quantum communication, particularly QKD, leverages the distinctive properties of quantum mechanics to create utterly secure communication channels. This technology could enable organizations dealing with highly confidential data to communicate without any concerns of interception, providing an unprecedented level of security.

# EXTENDED REALITY

## Digitalizing Reality Through Innovations in Optical Technology

XR is an umbrella term encapsulating augmented reality (AR), virtual reality (VR), mixed reality (MR), and everything in between [22]. It allows users to enhance their reality with technologies that create immersive worlds and holographic displays. Although in its nascent state, the technology will become more advanced as computing power increases and optical research advances. In the future, it will be used across various industries, from healthcare to video games. Yet today, this technology still faces some technical limitations that prevent its mass market adoption. These include limitations in terms of optical capabilities, which make modern XR machines bulky, expensive, and nauseating to use due to their current (binocular) design [23]. However, the past few years have seen two key emerging optical technology trends that address many challenges of modern XR machines: Holography and lithography. On one side, advancements in holography, especially in unison with materials such as photopolymers and liquid crystals, will cause VR and AR headsets to be increasingly immersive and photorealistic [23]. Moreover, recent advances in lithography have enabled engineered structures like optical meta-surfaces and micro-LED displays, which will lead to smaller headsets with no nauseating effects [23].

### Facts

- The global XR market size reached 64.5bn USD in 2022. IMARC Group expects the market to reach 604.3bn USD by 2028, exhibiting a compound annual growth rate (CAGR) of 43.5% during 2023-2028 [24].
- Total AR/VR spending worldwide is projected to amount to 12bn USD in 2020, although this will rise considerably through 2024, reaching 72.8bn USD [25].
- 90% of companies now leverage AR or VR technology in their business [26].
- VR-trained users showed 90% better job skills accuracy and 89% improved business process execution compared to non-VR-trained counterparts [27].

### Key Drivers

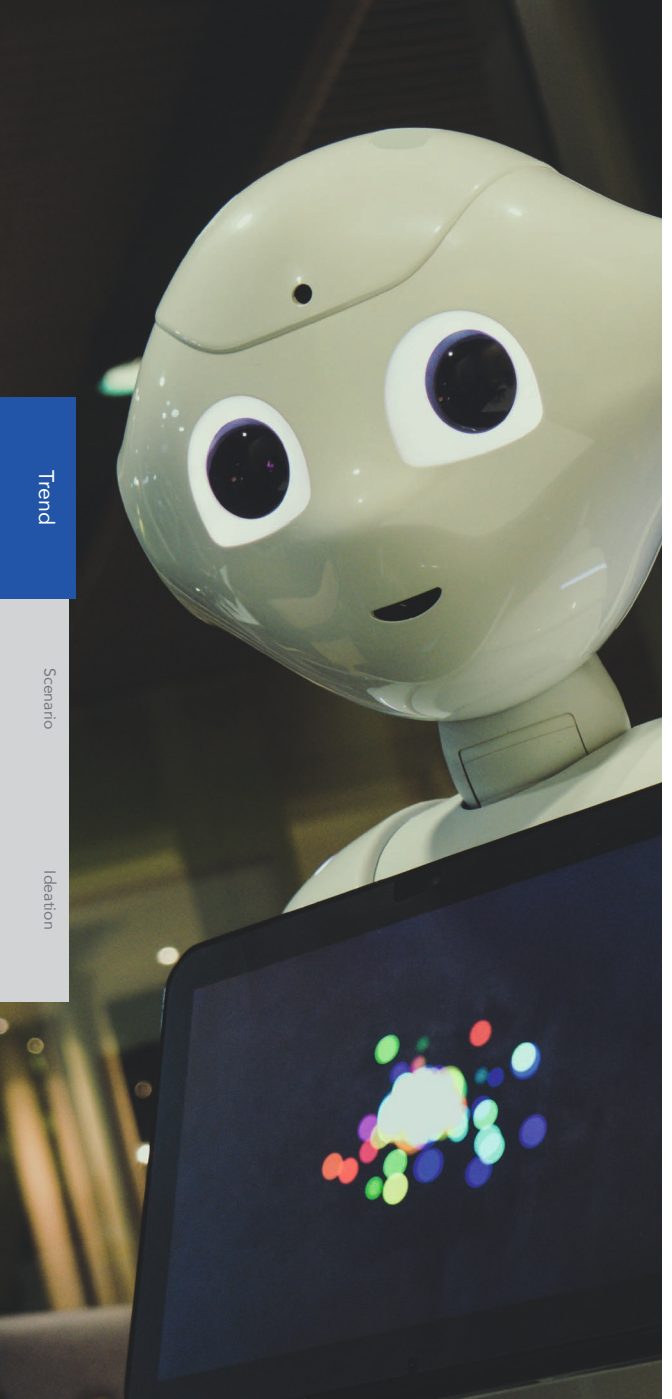
- There is a rising demand for XR headsets from both consumers and businesses; consumers are seeing a rise in escapism and immersive experiences [28], while companies look to control machines from a distance more accurately and safely (a crucial aspect of Industry 4.0).
- Moreover, there is a rising number of optical innovations, driven by advancements in lithography (which enable manufacturers to edit surfaces at a nano level, leading to a new wave of availability in meta-lenses) and availability of new materials (such as metamaterials, graphene, and quantum dots, amongst others) [23].

### Challenges

- XR machines must be ergonomic to reach mass appeal, yet advanced optical techniques require strong computing power and large graphics processing units (GPUs) [29].
- These machines must be able to deliver a comfortable user experience by reducing the well-known convergence-accommodation conflict (i.e., "nausea") people experience when using these machines [29].
- VR/AR devices based on holographic display and meta-lenses are costly to mass produce and ineffective [23].
- Privacy concerns may also limit the mass appeal of XR, as consumers are increasingly aware of how their activity is tracked in virtual settings.

### Impact on the Future of Communication Technology

Advancements in optical technology will lead to smaller and more ergonomic XR machines. Moreover, these innovations will make fully immersive headsets possible, making the nauseating feeling of using these machines a thing of the past. These advancements will lead to a society more connected through XR machines than ever, vastly shifting how we communicate. In this future, XR will enable remote collaboration, provide immersive training and education experiences, create interactive customer engagement, and enhance teleconferencing, bringing the world ever closer to a fully digital reality.







# MULTIMODAL ARTIFICIAL INTELLIGENCE

## A New Way of Interacting With Technology

Real life is inherently multimodal. We see colors, read texts, listen to conversations, or feel the temperature. Multimodal AI is the necessary shift to open new ways for AI to understand the world and to build common sense from multimodal input such as images, videos, audio, text, time series, sensor data, and more. Developments in multimodal AI will fundamentally change how we communicate with technology and other humans.

Currently, multimodal AI is already capable of reasoning in natural language based on visual observations [30]. There are also use cases where multimodal AI could partly replace human-to-human communication as an intermediary or proxy. One example is personalized virtual health advisors based on a holistic overview of our health status given medical records, sensor data, medical images, and more [31].

Most importantly, multimodal AI might make it indistinguishable whether we are communicating with a real person or a clone [32]. If multimodal AI can process images, videos, text, and audio messages, it might be able to capture a person's look, voice, and general communication patterns.

### Facts

- Models are trained on several modalities simultaneously, e.g., vision and language tasks, giving AI an understanding of how language and visual concepts relate [30], [33], [34], [35], [36].
- There is enormous potential in domains that inherently deal with many modalities, such as healthcare [31].
- AI can predict our train of thought (next utterance in natural language) based on visual context, extending our communication capabilities instead of just being a communication partner [35].
- Numerous companies are developing technology to clone humans using their digital footprint across images, videos, texts, and audio recordings [32].
- Digital clones in the form of chatbots are becoming a reality, regardless of whether that person is still alive [37].

### Key Drivers

- Improved AI architectures, usually based on the Transformer architecture, enable learning over multiple modalities.
- Digitalization of health data and new data sources, such as wearables, drives applications in healthcare.
- The need for more intuitive and immersive interactions with AI that go beyond textual communication is becoming apparent; for AI to live up to its promise, it needs to move from being a specialist at individual tasks to Artificial General Intelligence (AGI).

### Challenges

- Having very different data types can make aligning and fusing them hard [38].
- Multimodal models are hard to scale since they take large amounts of data and are computationally expensive [38].
- Especially in healthcare, privacy, and explainability remain open issues.
- Apart from practical, there are also ethical concerns, such as whether AI predicting trains of thought might guide instead of support our thinking or whether it is desirable to persist the deceased as chatbots.

### Impact on the Future of Communication Technology

Having multimodal AI that observes us visually and jumps in when we struggle to articulate ourselves could shift AI from being a conversational assistant to actively enhancing human communication. In the healthcare domain, personalized virtual advisors could become a trusted proxy for doctors. The doctor can still monitor the patient for potential interventions, but the virtual advisor handles the analysis and communication, and less human-to-human communication is necessary. Digital clones could also replace human-to-human communication. Given that they can capture intonation, appearance, and parts of our personalities, they could become our personal digital representatives. This process will severely impact our trust in digital communication and what we consider real communication.


# SOCIETAL & ENVIRONMENTAL TRENDS

## INFLUENCING THE FUTURE OF COMMUNICATION TECHNOLOGY

Towards Trustworthy Communication
Mental Health Is on People's Mind
Digital Equity and Inclusion
Making Every Street Wall Street
More Sustainability Demanded

Maisa Ben Salah 
Simon Bohnen 
Frederik Brosch 
Nathan Gruber 
Nils Krüger 



# SOCIETAL & ENVIRONMENTAL TRENDS

## Influencing the Future of Communication Technology

For a better tomorrow, a harmonious balance between societal advancements, responsible stewardship of the environment, and significant technological progress will be crucial. After examining the current societal and environmental landscape, five key trends were identified that will shape the future of communication technologies.

First, online anonymity continues to fuel distrust and polarizing debates in today's digital age. Therefore, credible and trustworthy communication is more critical than ever. Innovative methods to validate the authenticity of individuals and content are crucial.

Second, the interplay between digital spaces and mental health has recently grown in attention. To understand the effects of digital platforms, researchers are investigating how business models based on attention and advertisement are causing mental health issues. Conversely, businesses and policymakers are devising countermeasures against this trend, ranging from banning apps and harmful content to inventing new digital online and offline applications to solve this crisis.

Third, digital equity and inclusion is a significant trend to bridge the digital divide, which is vital for building a just society since they enable individuals to exercise their rights and freedoms fully. Therefore, responsible deployment of information communication technology (ICT) becomes a prerequisite for societal participation in the world of tomorrow. Without access to technology and digital resources, individuals and communities may be left behind in terms of economic growth and social development.

Fourth, digital financial democratization is a movement that aims to break down barriers to make financial services more accessible. Digital technology has revolutionized how individuals access financial services, providing them with a broader range of options, such as mobile banking apps and peer-to-peer lending platforms. By leveraging these technologies, traditional barriers, such as physical location or minimum balance requirements, can be eliminated, making financial services more accessible to a broader range of people. Financial democratization is encouraging investment in communication infrastructure and promoting greater transparency in pricing and fees across industries.

Lastly, the past few years have witnessed a remarkable societal shift toward sustainability and environmental protection. The widespread use of modern communication technology is responsible for an increasing share of global carbon dioxide ($CO_2$) emissions, energy consumption, and waste production. This is mainly due to the high energy demands of electronic devices, the production and disposal of electronic components, and the infrastructure required to support modern communication technologies. To minimize the environmental impacts of modern communication technology, organizations will have to take steps to reduce their resource consumption. To stay resilient in the face of shifting societal and environmental trends, organizations must stay ahead of the curve, embracing innovation and sustainability, promoting diversity and inclusion, and investing in advanced trust measures. This way, they increase their chances of survival and strive towards building a better future for themselves and society.

# TOWARDS TRUSTWORTHY COMMUNICATION

## From Anonymity to Authenticity: Ensuring Trust in Online Identities and Content

The anonymity of the internet undermines trust and promotes polarizing discourse. As technologies such as VR and AI gain popularity, more false information is created and propagated through the internet. That is why determining the authenticity of personas [39] and content [40] through novel methods is essential to promote credibility in communication. Consequently, there is a growing demand for technological innovations and increased government regulation in this area [41], [42]. However, it is crucial to consider the consequences of government regulations and censorship on free speech. Failing to strike a balance between promoting trust and preserving the principles of free speech [43], [44] could lead to social unrest. Simultaneously, assuring trust in the companies providing communication technology is crucial. Protecting user data as well as ensuring secure and confidential interactions are essential components for building such trust. This creates new business opportunities for innovative solutions.

### Facts

- Social media platforms are actively fighting the increase of fake accounts on their platforms [45], [46].
- OpenAI is at the forefront of innovation, developing cutting-edge tools to identify AI-generated content, contributing to the fight against misinformation and its potential repercussions [47].
- The Chinese government's stringent internet and online content regulations reflect broader global concerns about information control and the balance between free expression and public interest [48].
- With mobile networks classified as security-critical infrastructure since 2020, the rise in attacks on critical infrastructure highlights the importance of robust cybersecurity measures to protect vital resources [49].

### Key Drivers

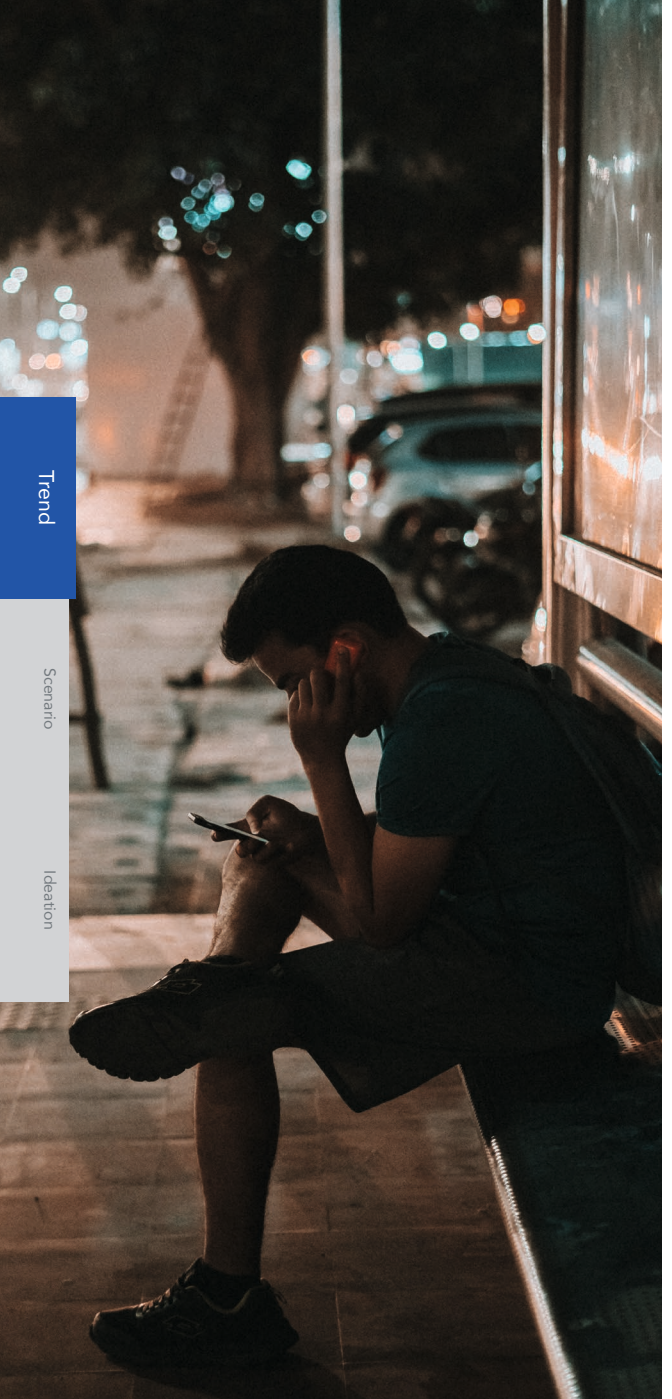
- Online engagement is growing as immersive technologies, such as AR, VR, and MR, offer richer experiences.
- Advancements in AI will result in an influx of AI-generated content, reshaping the digital landscape.
- The need for online content regulation and misinformation management is intensifying, necessitating policy action [42].
- Government decisions on internet regulations will be pivotal in determining the future of communication.

### Challenges

- The prevalence of AI-generated content is expected to skyrocket, accounting for more than 90% of all online content within the next few years, indicating a massive transformation in how the world consumes information [50].
- As AI-generated content becomes more pervasive, platforms are grappling with the challenge of utilizing the latest technologies to protect users from misinformation [41].
- Policy decisions focusing on the delicate balance between anonymity and misinformation management are crucial in preventing political polarization that may swing excessively to the left or right [51], [52].

### Impact on the Future of Communication Technology

As skepticism towards online personas and content grows, society will become more vigilant in discerning trustworthy sources, potentially leading to shifts in information consumption and communication habits. Widespread efforts to label AI-generated content on online platforms will emerge, driven by individuals, businesses and governments, contributing to a more transparent and accountable digital ecosystem. In addition to that, the increasing demand for authentication methods on online platforms will attract venture capital (VC) investments, fueling the development of innovative solutions to ensure trust and credibility in communication technology.







# MENTAL HEALTH IS ON PEOPLE'S MIND

## The Role of Digital Spaces in Mental Health Issues Is Growing

As people of all ages spend more and more time online [53], researchers, as well as businesses, are starting to pay more attention to the relationship between mental health and digital activities. The ad-driven business models of apps like Twitter, Instagram, and TikTok are key drivers of this trend. They drive screen time up and thus incentivize new types of content which retain users as long as possible. To make matters worse, shorter and less informational content is often the most profitable: Even Spotify songs are becoming shorter because revenue is determined by the stream count of a given song, not the stream time [54]. These developments have triggered a public debate about how to tackle the issues. Some propose additional legislation around content moderation and digital education, while some businesses have already taken action: Apps like Headspace, Talkspace, and Calm use the digital space to tackle mental health. Furthermore, a trend towards more intentional device usage can be seen, driving device manufacturers and operating system vendors to redesign their software (e.g., notification and screen time features).

### Facts

- Mental health issues are rising worldwide, especially in developed countries like Germany [55]. Depression and anxiety comprise 70% of mental health diagnoses [56].
- The time spent online by adolescents has doubled from 100 to 200 minutes per day from 2006 to 2021 in Germany [57]. The German Federal Center for Health Education (BZgA) has reported a concerning increase in internet usage from 2015 to 2019 [58].
- In the US, 24% of children had access to the internet from their bedroom in 2016, compared to only 15% in 2012 [59]. In 2016, the average child got their smartphone at age ten, with that number having dropped since [59].

### Key Drivers

- Digital business models are often advertisement-based and thus rely on the time users spend on the platform. This incentivizes short content, which keeps the user constantly engaged.
- As network effects grow, not being online means missing out. Thus, children especially often feel pressured to be digitally present.
- Digital platforms allow users to present curated versions of themselves. This distorts ideas of beauty, wealth, and social life and creates ever-new ideals that users compare themselves to.

### Challenges

- Countries must find ways to incorporate healthy internet usage into their educational system. While this might be possible by limiting device usage [60], intentional media consumption is also a vital skill to have.
- As low-information or even fake content becomes more common, governments need to consider the effects of this trend on the general population. Solutions range from banning certain types of content to creating incentive systems around educational content.

### Impact on the Future of Communication Technology

VCs recognize this trend and have invested 1.5bn USD in mental health start-ups in 2020 [61]. This aligns with a generally higher demand for online mental health services [62]. Governments may step in on mental health issues by limiting time spent on gaming for children [60]. Therefore, digital business models would need to adapt to this change. Demand might shift from free, advertisement-based business models towards subscriptions as awareness of mental health increases. This is particularly true for the educated, wealthy part of the population and could increase digital segregation.

# DIGITAL EQUITY AND INCLUSION

## Bridging the Digital Divide and Overcoming Barriers to Digital Access and Participation

The global interconnectedness raises questions about digital inclusion and equity, which requires special attention for disadvantaged groups like low-income and disabled people and remote communities [63]. The digital divide could worsen social and economic inequalities, particularly in the era of rising connectivity [64]. Initiatives led by the government or the private sector for digital inclusion and equity can empower minority communities to participate in the digital society [65]. Bridging the digital divide includes improving digital literacy and providing low-cost or free internet access [66].

In the future, communication technologies will aid social movements and protests [67]. 6G can foster civic engagement, enable citizens to participate in democracy, and hold leaders accountable [67]. However, a larger share of digital communication could lead to increased surveillance and repression by entities seeking to control dissent [68]. In countries with limited freedom of expression, using digital technology for sharing information could be met with censorship, online harassment, or violence [68].

One potential positive impact is the ability to connect people across geographic and cultural boundaries, fostering greater understanding and empathy. However, the challenge remains to ensure that all individuals have equal access to these technologies to participate in the global conversation.

### Facts

- The United Nations (UN) predicts that due to an increasing amount of elderly people, the number of people with disabilities will be over 2bn people in 2050 [69].
- The UN Secretary-General's roadmap for digital cooperation calls for universal, worldwide connectivity until the year 2030 [70].
- Connectivity is seen as a prerequisite for many of the UN's sustainable development goals, such as supporting education, reducing inequality, driving economic growth, and boosting health outcomes [71].
- Communication technology has become an increasingly important tool for digital activism [72].

### Key Drivers

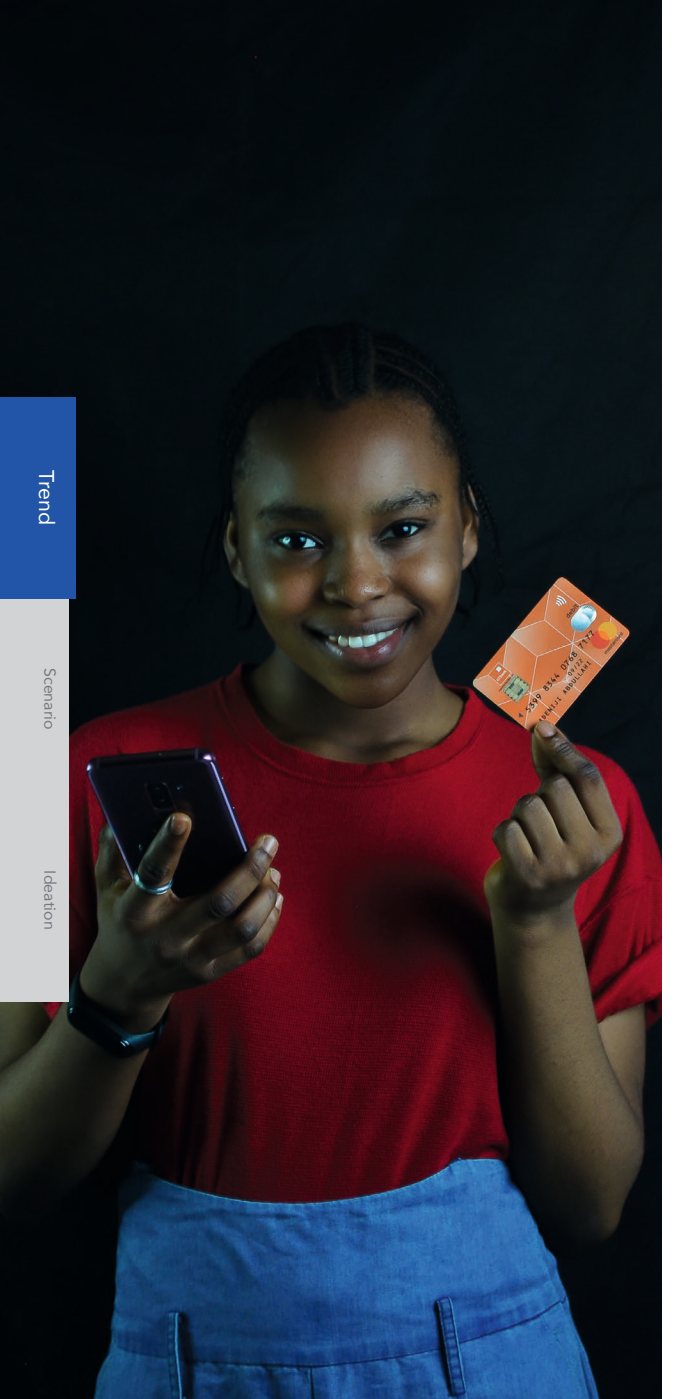
- Growing recognition of the necessity to empower marginalized communities and individuals in the digital realm, particularly in terms of access to education, resources, and economic opportunities [73].
- Digital rights, such as freedom of expression, privacy, and access to information, are increasingly becoming a focus of social and political discourse [74].
- Bridging the digital divide may be catalyzed by governmental initiatives or by private sector investments to increase the customer or voter base and to satisfy (corporate) social responsibility [65].

### Challenges

- Digital technologies can exacerbate existing power imbalances and inequalities in years to come, particularly for those who lack access to these technologies or the skills to use the social, political, and economic opportunities [68].
- Lacking consistent regulation and policies for digital equity and inclusion initiatives may further increase the digital divide.
- The increasing use of AI and ML algorithms in communication technology can potentially reinforce biases and discrimination, leading to ethical and social concerns.

### Impact on the Future of Communication Technology

ICTs may increase political engagement through greater transparency and accountability [67]. Deploying those in some authoritarian regimes may lead to AI-based surveillance and repression by governments [68]. On the opposite, the increasing use of blockchain technology in communication and media can enable more secure and transparent transactions.



# MAKING EVERY STREET WALL STREET

## Democratized Finance Sparking Digital Revolution in Financial Systems

Financial democratization is a growing socio-economic trend that seeks to make financial services accessible to all. This trend is driven by advancements in technology, changes in consumer behavior, and the efforts of governments and non-profit organizations to promote financial inclusion. As digital financial technologies evolve, financial democratization is expected to drive further innovation in blockchain-based financial systems and decentralized platforms, leading to more diverse products and greater participation in the economy. By leveraging innovations in digital payments and distributed ledgers, ICTs will potentially enable people in remote areas and underserved communities to access financial services conveniently. Furthermore, financial democratization is promoting investment in communication infrastructure and greater transparency in pricing and fees across industries, which is fostering a more equitable and competitive financial sector. However, a potential challenge is that new communication technologies will primarily be directed towards affluent areas, where the demand for services is higher, and the geography is more conducive to profitable investments. Thus, it is crucial to address potential inequalities and ensure that the benefits of ICT are accessible to everyone.

### Facts

- While 1.2bn people have opened a financial account since 2011, there are still an estimated 1.7bn adults worldwide, around 31%, who do not have a basic transaction account [75].
- The total value locked in decentralized finance (DeFi) protocols increased from 18bn EUR in January 2021 to over 240bn EUR by the end of December 2021 [76].
- Mobile money transactions are now well established in Kenya, accounting for a staggering 44% of the gross domestic product (GDP) in 2019. It is estimated that M-Pesa alone has lifted 2% of Kenyan households out of poverty [77].

### Key Drivers

- Financial inclusion has been identified as an enabler for seven of the 17 UN's sustainable development goals [78].
- Technological advances, such as the rise of mobile banking and digital payments, will make it easier for people to manage their money, regardless of their location or income level, with the global digital payment market expected to reach over 10tn USD by 2026 [79].
- Digital payments facilitate cross-border payments by eliminating intermediaries, reducing transaction costs, and speeding up settlement times [80].

### Challenges

- The absence of regulatory and supervisory access points in DeFi systems is a key policy question that remains to be overcome [81].
- Technology vulnerabilities pose a challenge to financial democratization, as they can lead to cyberattacks, software bugs, and hardware failures that result in data corruption, service disruptions, and financial losses [82].
- New technologies like 6G will be mostly directed to richer areas to attain an appropriate return on investment.

### Impact on the Future of Communication Technology

As the demand for greater financial inclusion increases, companies are expected to invest more in infrastructure to meet the growing need for reliable and high-speed internet access. With this comes the need for enhanced cybersecurity will likely result in increased investment by companies to develop and implement advanced security measures. In addition to that, financial democratization can foster transparency in pricing and fees and drive a shift towards more decentralized and open systems.

# MORE SUSTAINABILITY

## Sustainability Becoming a Vital Consideration in Communication Technology Design

Recent years brought a great social movement towards sustainability and environmental protection [83], resulting in society not accepting businesses [84] or business sectors [85] that act environmentally irresponsible anymore. While modern communication technology spreads rapidly across the globe, it becomes an increasingly important factor in global $CO_2$ emissions, being responsible for 0.9% to 3.7% of global emissions [86], [87] and 0.9% to 1.3% of global energy consumption [87], and a significant driver of increasing electronic scrap waste [88]. People do not only communicate more but also transfer more data when sending pictures, videos, or other modern, non-text-based formats [89]. As these modern communication technologies, like social networks, give climate activists a voice and make it harder to ignore the effects of climate change in other parts of the world, humanity cannot fight climate change effectively without them. So, companies will have to find a way to minimize communication technologies' resource consumption despite growing numbers of users. Concluding, one can expect increased social pressure on communication providers in the future, leading them to develop energy- and waste-efficient, $CO_2$-neutral communication technologies.

### Facts

- According to different sources, the internet accounts for 0.9% to 3.7% of global $CO_2$ emissions [86], [87].
- The number of people accessing mobile communication via smartphone is growing significantly, e.g., in Africa [90]. Additionally, the larger the amount of transferred data, the higher the energy consumption of a communication medium [89].
- 31% of people who are active on social media engage with climate change [91].
- While internet traffic increased by 440% from 2015 to 2021, the data center workload and the data center energy use only increased by 260% and 10-60%, respectively, during the same period due to more efficient and sustainable-focused server farms [87].

### Key Drivers

- Sustainability is getting serious attention because the effects of climate change are becoming more visible. Environmental wrongdoing can hardly be hidden due to digital connectivity, and climate activists have a significant outreach through digital media.
- Growth-oriented behavior, also in the communication sector, leads to fatal environmental consequences.
- Strict environmental regulations that encourage responsible use and sanction non-compliance force companies towards sustainability.

### Challenges

- As digital communication continues to grow, it is crucial to find ways to support this demand without increasing resource consumption proportionately.
- Economic agents suffer from a conflict of interest. Economically, they do not want to internalize environmental consequences but are incentivized to keep users communicating as much as possible.
- Technological solutions (new communication software, hardware, and protocols) that minimize waste production, energy consumption, and $CO_2$ emissions will be needed.
- Consumers will barely accept drastic decreases in communication quality due to resource savings.

### Impact on the Future of Communication Technology

Future ICT infrastructure will have to reduce its waste production by reducing satellite garbage through deorbiting standards, recycling different kinds of infrastructural elements (satellites, communication devices, servers, etc.), allowing for higher compatibility between devices of varying communication generations, and sharing communication resources across different regions. These infrastructure will have to reduce energy consumption by building and using more energy-efficient hardware, software, and protocols and reducing the infrastructural overhead of running multiple standards/generations in parallel.

# LEGAL & POLITICAL TRENDS

## INFLUENCING THE FUTURE OF COMMUNICATION TECHNOLOGY

Shaping Internet-Based Communication
The Rising Importance of Standards
Regulating Emerging Frontiers
Securing Domestic Communication Infrastructure
Data Privacy

Lukas Benkhoff 
Claudia Dalmau Gómez 
Răzvan Ion Rădulescu 
Finn Stürenburg 
Constantin Weberpals 



# LEGAL & POLITICAL TRENDS

## Influencing the Future of Communication Technology

Digital telecommunication has fostered unprecedented global interconnectedness and driven transformative changes in modern society. With the rapid pace of innovation, the need for robust regulation and guidance from courts and governments is increasingly critical. The following aims to present five legal trends and their implications for the future of communication technology.

Internet-based communication platforms have become an indispensable component of daily life. As applications such as WhatsApp, Facebook, and WeChat become more prevalent, the balance of power in the market is shifting from traditional telecom operators to big tech. This reliance on big tech communication platforms raises concerns about consumer protection, market fairness, and infrastructure funding. Policymakers must adapt regulations to maintain market balance and ensure fair competition. This regulatory evolution will be essential for fostering innovation, investment, and the continued growth of digital communication channels.

Moreover, ICT standardization is crucial for promoting interoperability and unlocking the full potential of IoT systems, particularly as the number of connected devices continues to grow. It also helps address the challenges of vendor lock-in faced by public organizations, reducing costs and increasing competition among providers. As governments and industries become more reliant on interconnected devices, establishing and adopting ICT standards will drive innovation and facilitate seamless communication. However, overcoming obstacles like high transition costs and a lack of expert involvement will be critical to successfully implementing standardization in the future of communication technology.

Technological advancements necessitate focused regulation for emerging frontiers like space and deep-sea. Reduced satellite launch costs and increased market entrants require future-oriented legislation for the space industry. Additionally, the legal framework for submarine communication cables needs updating.

New regulations are needed to protect against climate change and human activity threats. As internet bandwidth demand grows, deep-sea cables become increasingly important.

In addition, the demand for national security and more autonomy regarding domestic communication infrastructure is becoming increasingly present. Most recently, the debate around the 5G network has clarified that many countries want to maintain their sovereignty and withdraw market access from foreign telecommunications companies. Driven by the potential threat of data misuse, societies could suffer serious damage from hostile espionage. Legislation must create a clear legal framework for providing communications infrastructure to ensure security and reliability.

Lastly, the amount of data generated and transferred worldwide daily constantly increases. Companies are collecting large amounts of sensitive user information. This may raise concerns about the likelihood of surveillance and possible data misuse by the data holder. Therefore, far-reaching data protection laws are essential to ensure the individual's privacy and security. To prevent this danger, binding data protection laws are needed. Strong and independent courts act as the basis for new data legislation.




# SHAPING INTERNET-BASED COM-MUNICATION

## Regulation Adapts to an Increasing Dependence on Internet-Based Communication

Internet-based communication channels like WhatsApp and WeChat have become more ubiquitous, and power is shifting away from telecom operators that are increasingly delineated to operating the physical network [92]. Internet-based channels are replacing traditional communication infrastructure means and are increasingly subject to regulatory frameworks like traditional telecom operators [93].

In many aspects of regulation, for instance, regarding security and reliability, there is currently substantially more restrictive control in place for the telco industry compared to over-the-top (OTT) services [94]. With the shift of telecommunication toward OTT, the legal framework needs to adapt to maintain balance in the market. As big tech dominates telecommunications, debates on fair infrastructure contributions grow, prompting regulators to reconsider funding's legal framework [95]. Amid the metaverse era and rapid internet communication growth, governments must address these trends and build on regulations like the Digital Services Act.

### Facts

- Big tech's dominance in telecommunications is increasing, with their share of internet traffic exceeding 55%, and services such as WhatsApp are leading in more than 100 countries [96], [97].
- EU regulators are consulting on fair share to review the legal framework for funding network infrastructure, which is also happening in other regions such as South Korea [95], [98].
- Telco industry is heavily regulated unlike OTT services, but new regulations like Telecommunications Modernization Act consider the important role of OTT [94], [93].

### Key Drivers

- Telecommunication will further shift toward OTT services with projected growth from 150.51bn USD to 1,241.6bn USD in 2030 [99].
- Big tech's power is expected to increase over telecom operators due to the metaverse's development and its data load on the network [100].
- Delivering OTT traffic over European telecom networks results in a 36bn EUR to 40bn EUR annual cost to telecom providers [101].

### Challenges

- There is a risk for consumer protection if regulation is not carefully tailored to the market situation, as South Korea's example highlights, where regulation leads to higher prices [98].
- Introducing regulation that follows a sending party pays regime poses a risk to net neutrality [102].
- The EU needs a record of legislation that fosters investment into network infrastructure as it is trailing international peers in terms of telecoms investment per capita [103].

### Impact on the Future of Communication Technology

The government will encourage fair competition and ensure balance in the telecommunication industry through updated regulation, which in turn fosters innovation and investment. Furthermore, establishing a more extensive legal basis for digital communication channels will be crucial to enable further use cases, for instance, making government services more accessible, as already happening in India through integration with WhatsApp [104]. Additionally, introducing public safety features and service level agreements for OTT services will enhance consumer protection and trust. Rising energy prices increase production costs.

# THE RISING IMPORTANCE OF STANDARDS

## Enabling Exchangeability and Interoperability Through Standardization

ICT standards help products to connect, boost innovation, and promote competition. In the public sector, many organizations are locked into their ICT systems because detailed knowledge about how the system works and how the data is stored is only available to the information technology (IT) system provider. Only the current provider can deliver when public organizations need to buy new components or licenses. Supporting and enforcing standardization of such solutions can massively reduce costs and increase competition between providers.

In modern ICT services such as IoT, the value of the devices relies on their ability to communicate with each other. A large number of proprietary or semi-enclosed IoT solutions emerged in the last years, each based on different architectures and protocols, resulting in non-interoperable systems. Consequently, deploying proper IoT applications, where information is connectable and can be flexibly aggregated and scaled, has been limited to an Intranet of Things [105]. To facilitate interoperability and break up centralized IoT silos, both the International Telecommunication Union (ITU) and the European Commission (EC) have identified IoT standardization as a key priority.

### Facts

- In a recent study in Sweden, a strong lock-in effect was noticed in the ICT systems used by public administrations. None of the 46 studied public authorities had an exit strategy that allowed for continued use and reuse of its digital assets after provider exit [106].
- In a study on the economic potential of IoT implementations, McKinsey states that 40% of the benefits of an IoT implementation remained unused due to a lack of interoperability [107].
- The ITU, EC, and Federal Network Agency address the importance of ICT interoperability and common specifications and add IoT standardization as a top priority for their 2030 plans [108], [105], [109].

### Key Drivers

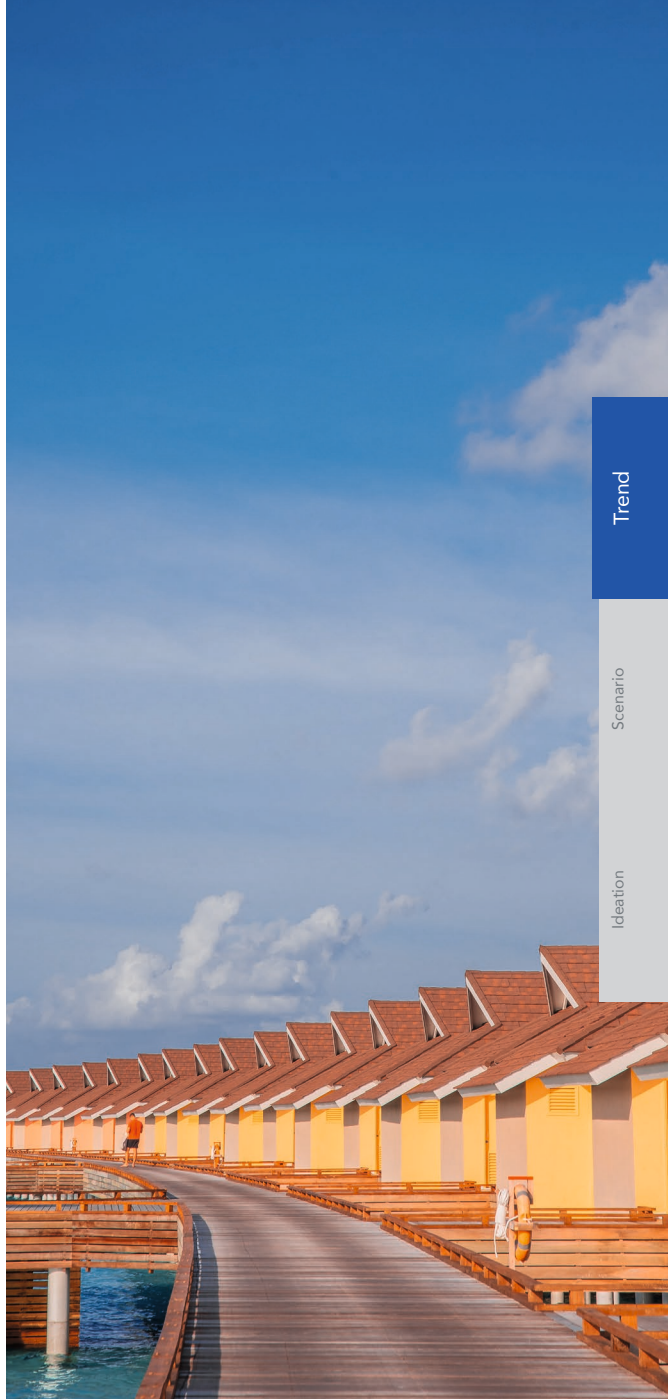
- Digitalization of governments is increasing due to both citizen demands and the reduction of centralization overhead [110].
- Standardization is needed, as lock-ins of the public sector incur high yearly costs, which increase with government digitalization [111].
- The number of connected devices exceeds 20bn and is forecast to grow to 50bn devices worldwide by 2030 [105].
- Other industries, like manufacturing, agriculture, and health, started adopting IoT, pushing for even more dependence on hyperconnectivity and interoperability of devices [112].

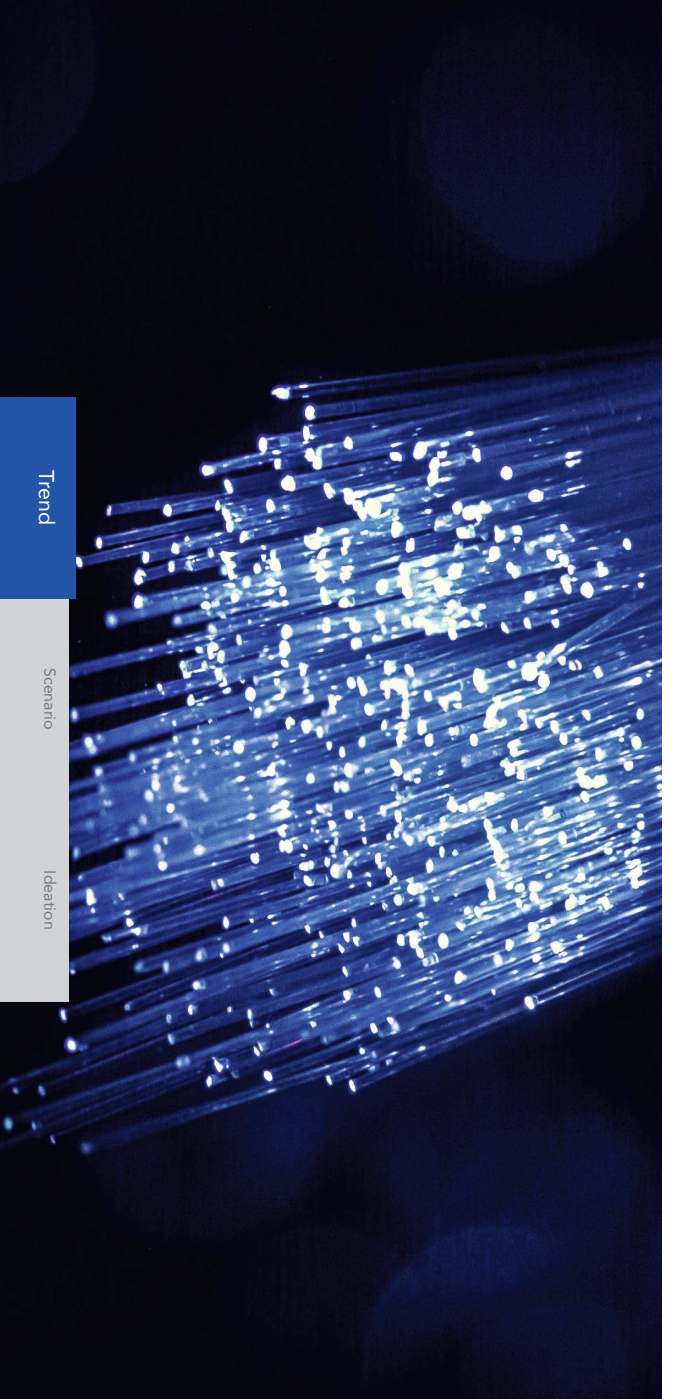
### Challenges

- 40% of companies surveyed in 2013 by the EC stated that changing their ICT solution would be too costly. 25% feared that their information would not be transferable. This confirms the lock-in's negative impact and prevents the transition to standardized solutions [111].
- The lack of experts and private sector involvement in the creation of standards is an impeding factor for ICT standardization, especially in developing countries [113].
- Creating a new standard and ensuring proper testing and measurement is costly and takes a long time [114].

### Impact on the Future of Communication Technology

Standardized communication technologies will create vast interconnected networks, improving data acquisition and transfer, and increasing the value of each network component. Furthermore, standards will be used as a transfer channel and as enablers and facilitators of research, thus driving innovation. Lastly, the use of standardization in procurement processes will give more flexibility to ICT solution customers and promote competition and innovation. Even though it can have the opposite effect, standardization will be an important pillar for the future of communication technology.







# REGULATING EMERGING FRONTIERS

## Legal Frameworks Need to Adapt to Space and Deep-Sea Activities

The number of satellites is projected to increase by ten times by 2030 [115]. The lower costs associated with satellite launches have enabled both satellite internet with lower latency compared to traditional satellite internet and connectivity to areas that were previously inaccessible through cable internet [116]. The Federal Communications Commission (FCC), which is responsible for regulating the telecommunication and internet industry in the US, is increasing its efforts to establish regulatory structures for the satellite communication industry [117]. To address increasing policy issues, the commission established a new Space Bureau in January 2023 [118]. The FCC is revising regulations, accelerating satellite licensing procedures, and expanding the available spectrum for satellite operators [118].

The current legal convention on submarine communication cables is outdated, while the threats to deep-sea cables and their importance have increased [119], [120]. The protection of submarine communication cables is considered a critical topic by the EU parliament, the FFC, and the US Congress, but so far, more action needs to be taken to expand the legal framework for deep-sea cables [120], [121]. New threats to communication cables come from an increase in natural disasters due to climate change and increasing human activity, for example, new methods for deep sea mining that could damage cables [119].

### Facts

- New satellite communication policies are needed, such as those that aim to mitigate orbital debris risk [122].
- The legal framework for undersea cables, established in 1884, requires modernization to address interference with other subsea activities such as mining and fishing [119], [123].
- 95% of the world's internet traffic passes through only 400 submarine cables [121].

### Key Drivers

- Today there are 5,500 active satellites in orbit. By 2030 that number is projected to grow to 58,000 [115].
- The EU aims to establish a new satellite constellation called IRIS2 by 2027, with a budget of 2.4bn USD and spanning 170 satellites [124].
- The need for new deep-sea cables is increasing as demand for internet bandwidth doubles every two to three years [125], [126].
- 73% of damages to submarine communication cables are caused by accidents through activities like fishing and could therefore be mitigated by regulation [127].

### Challenges

- Achieving alignment between public institutions and private entities without hindering the growth of the space sector is a challenging issue [128].
- Effective cable regulation requires informing multiple stakeholders about new laws and discouraging negligence when operating close to undersea cables [127].
- Most countries, such as the US, lack a singular regulatory agency exclusively responsible for space and deep-sea cable regulation but instead rely on multiple agencies that share partial responsibility [120].

### Impact on the Future of Communication Technology

Private entities like Google and Facebook, which own and fund a significant portion of the worldwide cable network, could be encouraged by governments to establish backup systems and distribute cables more broadly [121]. Similar to the EU, other nations may also launch new satellites to safeguard their communication infrastructure and maintain autonomy from other space powers and private firms that are deploying satellite constellations for strategic reasons. Conversely, the international conflicts and the corresponding legislative and political changes negatively affect Mittelstand companies. This is because they inhibit exports, reduce revenues, and make investment decisions riskier.

# SECURING DOMESTIC COMMUNICATION INFRASTRUCTURE

## Increased Governmental Interest in Shaping and Controlling National Telecommunication

Digital telecommunications impact global stability and security, prompting governments like Germany and the US to control local infrastructure with stricter regulations. Key concerns include selecting industry partners for network development and securing necessary investments.

The most relevant impulse in this direction came from the FCC. Since 2012, the US has publicly been critical of the cooperation with Asian telecom equipment providers, and recently, the country imposed strong import restrictions [129]. For example, since 2022, Chinese manufacturers have been banned from operating in the US market, as the FCC considers them a national threat [130]. Some Western countries, such as Australia, Canada, and Sweden, are following this trend for the same reason; ultimately, a similar movement is developing in the EU [131].

### Facts

- The Chinese supplier Huawei provides a significant part of the required 5G infrastructure in many European countries, such as Italy (51%), Germany (59%), and the Netherlands (72%) [132].
- In January 2020, the EC published a new set of guidelines calling on member states to exclude security-critical providers from their domestic communications infrastructure [133].
- Compared to Japan (260 USD), the US (150 USD), and China (110 USD), European countries (104 USD) are lagging with respect to ICT investment per capita [134].

### Key Drivers

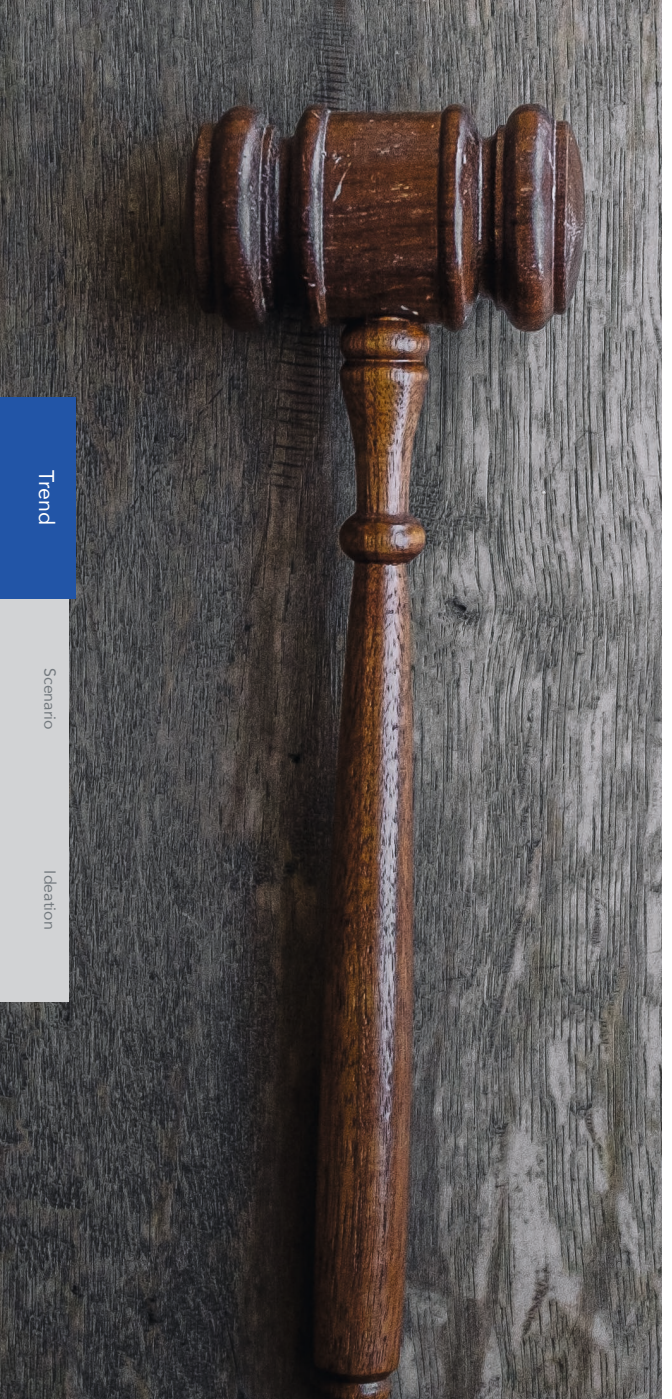
- Especially in developed countries, the telecommunication industry is getting extensively regulated. Governments want to impose more control and lower national risks [135].
- The growing worldwide instability caused by the Corona pandemic and the Ukraine war is crucial for countries to reduce their global dependencies and nationalize their supply chains [136], [137].
- New regulations and policy initiatives continue to drive the exclusion of Asian suppliers in Western economies. The Secure Equipment Act in the US acts as a role model for many countries to exclude Chinese companies from the local telecommunication infrastructure [130].

### Challenges

- Currently, European countries are strongly dependent on Chinese telecommunication hardware providers. They aim to exclude Chinese companies from the domestic communication infrastructure without decreasing network quality and coverage [138].
- The growing global distrust toward Asian ICT has led to political disputes in the recent past. It will be difficult for European governments to pursue their national interests while maintaining diplomatic, cooperative dialogue with China [139].
- Governments must consider carefully distributing limited frequencies in the context of the increasing nationalization of the communication infrastructure and the growing domestic industry.

### Impact on the Future of Communication Technology

Governments' growing influence on telecom infrastructure, driven by national security [140], leads to reliance on local manufacturers and strict regulations. Companies must adapt to de-globalization, evolving legal guidelines, and customer demands, requiring changes in supply chains, relationships, and domestic investments.







# DATA PRIVACY

## Protecting Data and the Regulation of Digital Surveillance

Moving towards an increasingly digital world has brought new challenges and concerns, particularly regarding the protection of data and regulating digital surveillance by companies and governments in a digitally driven society. Individuals currently generate and share unprecedented amounts of data [141], so it is easy for companies to collect and exploit the data of individuals to generate ever-increasing profits.

High-profile data breaches and controversies surrounding companies' data misuse have highlighted the need for more robust regulations, especially with communication technologies becoming ever more pervasive and sophisticated. To ensure that data privacy is better protected, clear guidelines and regulations must be established and updated regularly [142]. While some countries and organizations have already introduced comprehensive regulations dictating how data should be handled, such as the General Data Protection Regulation (GDPR) by the EU or the Personal Data Protection Commission by Singapore, new technologies will likely emerge. Stricter laws will adapt to the changing digital landscape [143], and regulators must address future communication challenges. The distinction between public and private information may blur without new regulatory frameworks.

### Facts

- Advancements in technology are leading to an increasing amount of data being generated, with an expected growth of up to 175ZB by 2025 (33ZB in 2018) [144]. There is a growing need for sophisticated data management solutions to ensure the security and privacy of this vast amount of data.
- The GDPR, enacted by the EU in 2018, is the world's strictest privacy and security law, imposing obligations on organizations globally and imposing hefty fines for violations [145].
- 33% of smartphone owners are vulnerable to potential surveillance [146].

### Key Drivers

- Yahoo's data breach in 2013 is among the most notorious cases of a disclosed cyberattack, exposing almost three bn user accounts [147]. 45% of US companies have experienced a data breach in the last decade.
- The UN published a guidance note to establish common principles across the UN, emphasizing the importance of comprehensive data protection regulations worldwide [148].
- In 2022, the EC proposed a regulation on harmonized rules for fair access to user data. The EU believes it is crucial to have a basic requirement for regulating data use and access [149].

### Challenges

- Countries such as China, Indonesia, and Saudi Arabia, amongst others, are monitoring digital technologies to suppress criticism and to invasively censor and punish people based on their ethnicity, race, gender, or sexual orientation [150].
- It is estimated that China has 2.5bn facial images stored in its systems and aims to upgrade its digital surveillance to control and manage the population [151].
- New EU privacy laws may put EU firms at a competitive disadvantage against companies in North America and Asia due to the impact the regulations have on the use of AI and the data it generates [152].

### Impact on the Future of Communication Technology

There is a growing demand for more rigorous data protection laws and policies, increased transparency and accountability from companies that collect and use this data, and a greater focus on cybersecurity [153]. As individuals become more aware of their rights to data privacy and security, governments and regulatory bodies are likely to prioritize communication technologies with tools such as end-to-end encryption, decentralized data storage, and data anonymization. Despite data-driven innovation benefits [154], protecting individual privacy is crucial, possibly through forward-looking policies and regulations [155].


# ECONOMIC TRENDS

## INFLUENCING THE FUTURE OF COMMUNICATION TECHNOLOGY

Increasing Financial Instability

Looming Risk of Geoeconomic Confrontations

Rise of Open Talent Employment

Growing Decentralization

Accessing the Global Economy

Theresa Lange 
Victoria Rentrop 
Ali Raza 
Leon Blumenthal 
Benedikt Hartmann 



# ECONOMIC TRENDS

## Influencing the Future of Communication Technology

Affected by several crises, the future of the economy is highly uncertain. Challenges, like climate change and its unknown economic impacts, next to geoeconomic conflicts arise. In this highly dynamic field, several trends that are predicted to shape the future can be observed. This chapter aims to abstract five trends that are expected to have a major impact on the future of communication technology.

Experiencing record-high public debts combined with rising interest rates and inflationary pressures, financial stability is at risk. Further, global economic growth is expected to slow significantly in 2023. Regarding communication technology, its future is strongly affected by the government's ability to invest in infrastructure and research and development. The uncertainty resulting from rising financial instability might significantly increase the risk and hinder private investments. Second, the risk of confrontation is looming. After decades of global integration, recent geopolitical conflicts reveal the vulnerability of global interdependencies. Especially in strategic industries such as the communication industry, disputes can lead to higher consumer costs and pressure multinational firms to high compliance costs. Further, geoeconomic fragmentation hinders the diffusion of communication technologies in foreign markets and the financial deepening in destination countries.

From a labor perspective, the rise of open talent employment, fueled by the gig economy, will foster competition worldwide, changing workforce patterns globally. Previous modes of collaboration might be disrupted with the increasing integration of digital technologies. Further, market flexibility and adaptability are increasing as the platform economy is trending, offering new potential to the employment landscape. These changes boost the demand for communication technologies as means of collaboration and challenge employers.

The fourth trend considers decentralization in various industries and organizational structures. Decentralization in the energy system allows for flexible production, consumption, and marketing on the level of small entities, which benefits resilience and capacity. In the financial market, removing third parties from transactions enables autonomy. As technology is crucial for efficient communication between entities, decentralization shapes its demand structure significantly.
Lastly, internet penetration is increasing, enabling global access to the economy. Global connectivity has the potential to foster economic growth, as it provides new opportunities: Due to the bloom of the space industry, satellite broadband is expected to be the major driver, as it can serve as a cost-effective way to leapfrog previous communication technologies without the need for significant investments in ground infrastructure.

As the global economy consists of the interplay of these trends, combined with various other dynamics, the future of communication technology is situated in a highly complex landscape, posing major challenges but also sparking promising potential.

# INCREASING FINANCIAL INSTABILITY

## Rising Interest Rates and Global Debts Increase Financial Instability

When the world faced COVID-19, global debt rose to 226tn USD, a record high since World War II. As the global public debt ratio increased to 99% of global GDP, public debt accounted for about half of this, but also private debt from non-financial corporations and households reached new highs. Public debt now accounts for about 40% of global debts [156]. Yet, after being zero or sub-zero, interest rates are rising again to prevent consistently high inflation without risking a major recession. Inflation, which peaked at almost 9% globally in 2022, is expected to decline again in 2024 [157], [158]. As the impact of crises on financial systems is uncertain, the uncertainties throughout the financial system are leading to higher risks [159], [160]. Fiscal policies, which are expected to differ strongly among countries, will play a crucial role in determining the future economic landscape [161].

### Facts

- Global growth is expected to slow to 2.7% in 2023, the third weakest growth profile in 20 years, and around one-third of economies will face a recession [161]. The total value of the global economy could decline by 10% until 2050 due to climate change [162].
- Inflationary dynamics spark complex challenges for central banks and the public sector to align monetary and fiscal policies. With a rapid rise in interest rates, the risk of errors in policy measures is high, potentially leading to a prolonged economic downturn [161].
- There is a further deterioration of stability conditions due to rising inflation, higher interest rates, weaker growth prospects, and financial market repricing [163].

### Key Drivers

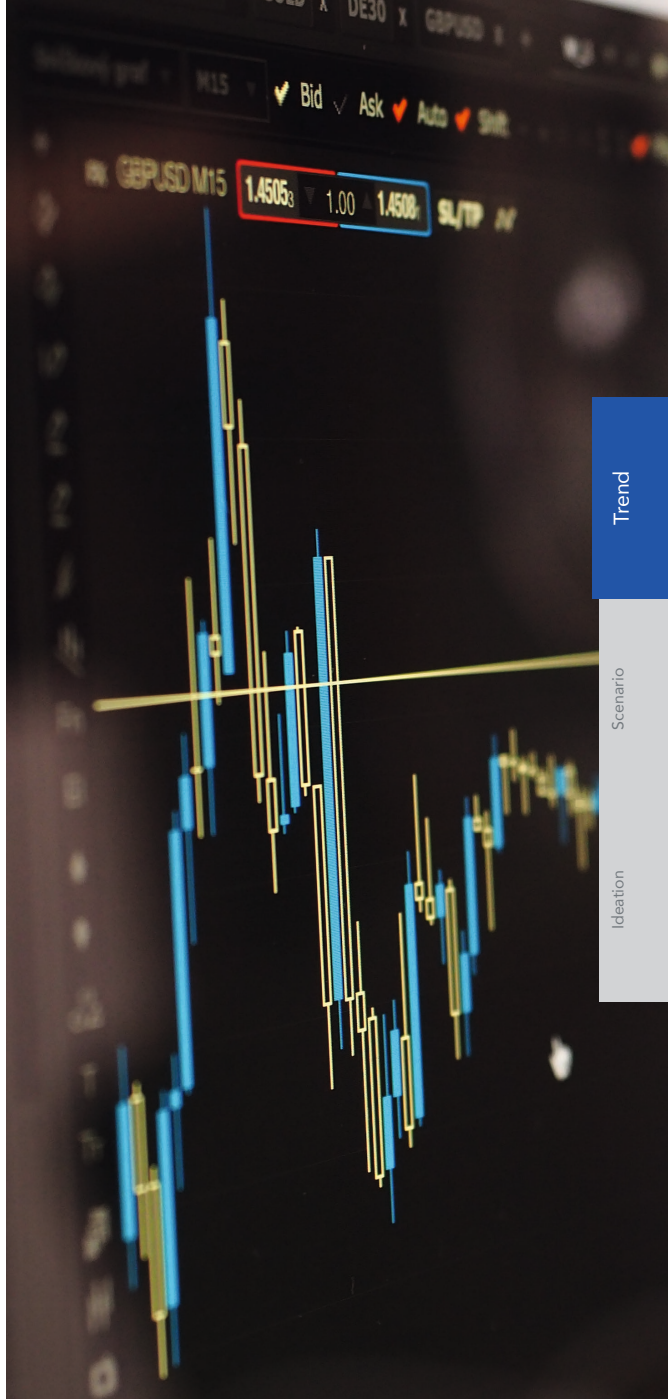
- Market interest rates are driven by inflation expectations, risk of investment, and liquidity preferences [160].
- The large accumulation of public debt since 2007 is a result of the global financial crisis, followed by COVID-19 and further crises [156].
- Globalized capital flows increased dependencies on foreign financial trends, which increases the explosion of emerging and developing markets to rising interest rates [161].
- Firms across Europe are exposed to physical risks due to climate change, and the average default probability of credit portfolios for Europe's most vulnerable areas is expected to rise by 30% [162].

### Challenges

- Increased national debts lead to increased interest costs, which can hinder public investments in priority areas such as infrastructure, research and development, and education, decreasing investments in a country's future. Further, it weakens public social security programs [159].
- With a strong fiscal foundation, nations will have increased access to capital, more investment resources, improved consumer and business confidence, and a stronger safety net [159].
- With higher national debts, governments have fewer financial resources to deal with unexpected events and, therefore, less flexibility when responding to critical situations, which induces higher financial risks [161].

### Impact on the Future of Communication Technologies

Less financial resources in the public sector and tense financial dynamics in the private sector can harm public investments in critical infrastructures, research and development, and innovation [159]. Still, expanding new and existing communication technology is highly dependent on public funding, especially due to its common-good characteristics. Moreover, with global financial instability and uncertainty in private investments, the enthusiasm for investment on the private sector side is declining [164]. Being a global market, communication technology is highly affected by volatility in financial systems and changing fiscal policies. Thus, in crises that usually coincide with financial instability, critical infrastructure such as communication is at risk [163].




# LOOMING RISK OF GEOECONOMIC CONFRONTATIONS

## Geopolitical Conflicts Reveal the Vulnerability of Global Interdependencies

Globalization has increased the interdependence of economies worldwide, but recent events have highlighted the risks of reliance on critical materials and energy sources. Geopolitical instabilities reveal the vulnerability of global interdependencies and lead to geoeconomic warfare, such as trade wars and market exclusion, as countries decrease supply-chain dependencies [161]. The concept of supply-chain risk has been operationalized without considering geoeconomic risks [165]. Such types of risk are undergoing substantial changes and need to be largely reassessed, with advanced economies using economic policies to target geopolitical goals and vulnerable dependencies on technology and finance. Consequently, the risk of distrust, decoupling, and active degradation of interdependencies arises. Countries tend to turn inwards, build up self-sufficiency and sovereignty, or even actively constrain the rise of others, further weakening existing trade relations and yielding overall high economic costs through inefficient production and higher prices [166].

### Facts

- The World Economic Forum (WEF) ranked geoeconomic confrontation third in the ranking of the most severe short-term global risks [161].
- Trade openness, which constantly rose since 1970, has stabilized or even reversed since 2010, whereby trade protectionism has risen during the pandemic and the war in Ukraine [167].
- The economic impact of geoeconomic fragmentation is estimated to cost between 0.5% to 12% of long-run global GDP [167].
- The demand for critical raw materials in the communications industry also ramps up, with the annual demand for lithium and cobalt estimated to hit 450% of the production level in 2018 by 2050 [168], [169].

### Key Drivers

- The global financial crisis, Brexit, tensions between the US and China, the COVID-19-Pandemic, Russia's invasion of Ukraine, and a growing number of other military conflicts induced skepticism about the benefits of globalization, with the resulting economic policies spilling over to all industries and trade partners [170].
- Populist parties with a nationalist agenda are increasingly winning votes and boosting calls for protectionist economic policies, closed borders, and high barriers to foreign competition [170].
- Supply-chain interdependencies have a backdrop of raw-material scarcity and a surge in demand, leading to an intertwinement of supply-chain with global politics [171].

### Challenges

- Geoeconomic fragmentation weakens trade relations, restrictions on cross-border migration, and reduced capital flow [170].
- Reshoring is not an economically viable option, and supply-chain diversification is complicated in markets dominated by singular suppliers [169].
- Risk to the provision of vital global public goods, such as telecommunication grids, since nations decrease their collaboration on its supply and act without effective supranational agreements, leading to an under-provision of public goods [161].

### Impact on the Future of Communication Technologies

Geoeconomic conflicts can, facing insecurities in dependencies of other countries and economic policies to gain self-sufficiency and sovereignty, lead to on- and friend-shoring efforts [161]. These, in turn, can result in potentially higher consumer costs and pressure multinational firms to pick a side due to high compliance costs, increasing the divergence between markets even more. Capital flow, an important source of technological diffusion, is reduced due to geoeconomic fragmentation and hinders the diffusion of communication technologies in foreign markets and the financial deepening in destination countries [170].

# RISE OF OPEN TALENT EMPLOYMENT

## Competition Worldwide and Changed Workforce Patterns Brought About by the Gig Economy

In recent years, there has been a significant departure from the 9-to-5 job structure. It has been driven by globalization and technological advancements across multiple fields, with COVID-19 acting as a major accelerator [172]. Companies and employees have had to reevaluate their modes of operation and embrace digital collaboration, significantly transforming how we work [173]. The platform economy has emerged as a disruptive force, transforming traditional industries by offering means for connecting autonomous suppliers and clients. These platforms foster market flexibility and adaptability by enabling participants to enter and exit as they please, revolutionizing the employment landscape. Teleoperation is another trend aligned with a shift toward a more open employment system. It enables global experts to remotely access and govern the operation of various devices, allowing for a more precise matching of demand and supply. This technology is transforming manufacturing, logistics, and healthcare industries, enabling companies to tap into a global talent pool [174].

### Facts

- Over 28m individuals in the EU rely on digital work platforms for employment, including talent acquisition, employee management, and digital team collaboration. This is projected to increase to 43m by 2025 [175].
- In the EU, over 30% of the population has at least once tried to acquire clients through online platforms [172]. According to the UN, adopting remote platforms within the gig economy is growing by over 25% annually [176].
- Teleoperation, as it is used in healthcare, agriculture, and many other fields, is anticipated to reach 76.5bn USD by 2026 [177].

### Key Drivers

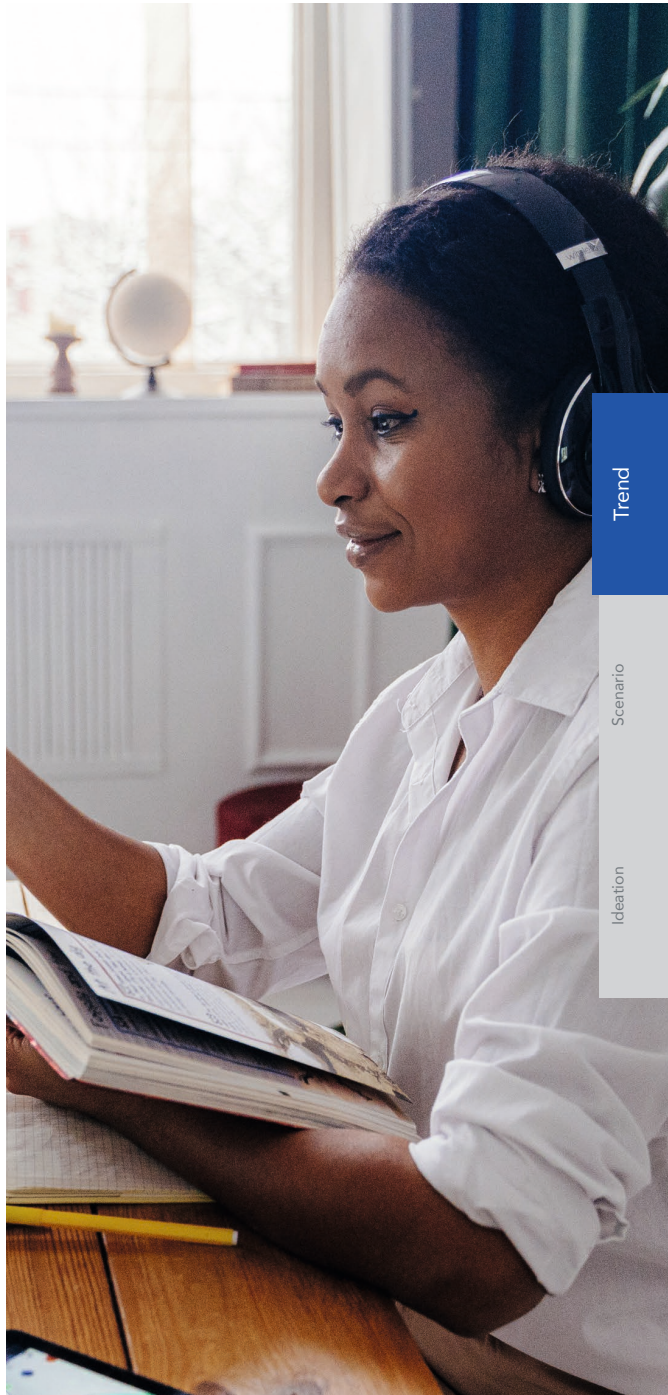
- Rising connectivity and the increasing diffusion of digitalization, coupled with driving down costs, enable more flexible work modes and platforms.
- The increasing use of machines in industries has displaced blue-collar workers, necessitating a shift toward skilled jobs and, therefore, the worldwide pursuit of international employment opportunities [178].
- The rise of the platform and gig economy can be attributed to the growing request for digitalization, accessibility, connectivity, and rising mobile ecosystems among stakeholders in various markets, which provides an enhanced mapping of real-time demands and offers [179], [177], [180].

### Challenges

- Digital platforms presently focus on low or no-cost benefits. However, since platforms started analyzing data and providing new forms of contracting to match changing user needs, established financial models are challenged [176].
- Operating modes must be reconsidered to tackle social isolation, micro-management, and work-related stress due to surveillance [181], [173].
- Communication delay, jitter, and packet data losses pose significant challenges in telerobotic medical systems [182].
- With the gig economy, income fluctuations are inevitable as stakeholders rather temporarily come together, causing difficulties in the financial provision and changing spending patterns [183].

### Impact on the Future of Communication Technologies

With increasing numbers of individuals operating remotely and for multiple organizations, there will be a heightened demand for efficient communication systems to facilitate communication with stakeholders. The development of high-quality video conferencing, cloud-based collaboration tools, instant messaging, and project management will be required. The requirement for communication technology will be to provide all necessary tools in a secure manner to support the burgeoning trend of evolving working arrangements. Ensuring digital collaboration and simplifying connections will be a crucial hurdle that future communication technology must surmount.





# GROWING DE-CENTRALIZA-TION

## Advent of Decentralized Technologies, Energy Supply, and Organizations

The world is experiencing a growing trend of decentralization, such as in energy production and transmission, financial markets, and manufacturing, as well as on an organizational level. Yet, this trend toward decentralization appears paradoxical, as it coexists with a simultaneous push towards standardization, self-sufficiency, and sovereignty. However, the decentralization movement empowers individuals and smaller entities to participate in a globally interconnected system, e.g., production lines become more flexible as a result of decentralization. Further, renewable energy can be marketed and consumed on an individually or locally differentiated level, which results in reduced transmission losses, increased resilience, and generally higher capacity. Next to technology-specific decentralization trends, also organizational structures are subject to this transformation, moving away from top-down decision-making processes to flatter hierarchies, which assign decision autonomy to lower administrative levels. This decentralization comes with a new set of challenges that are pertinent to communication technologies.

### Facts

- Decentralization is a crucial part of integrating renewable energies into the current energy market, which includes, e.g., power generation and storage to individual households and communities [184].
- Cryptocurrencies, Web 3.0, and DeFi powered by blockchain gained increasing interest and importance [185].
- Decentralization is becoming an increasingly popular trend, as it enables organizations to operate with greater agility and flexibility both in production lines and manufacturing, as well as in governance duties and decision-making processes [186], [187].

### Key Drivers

- The share of renewables in total energy production is rising, e.g., in Germany from 30.3% in 2015 to 39.9% in 2021, aiming for a share of 80% in 2030 [188]. In 2019, wind accounted for 22.8%, and solar for 7.8% [189].
- The size of the global crypto market is increasing due to more public interest and products. For example, the current Bitcoin market cap is 425bn USD, and the Ethereum market is 190bn USD [190].
- Technological advances, for example, in the speed of telecommunication technology, e.g., up to 10Gbps data rate and less than 1ms latency for 5G networks, enable decentralization [191].

### Challenges

- The connection between decentralized entities and the resulting flow of private information increasingly poses cybersecurity risks, especially for critical components in the energy infrastructure [184].
- Proof-of-work cryptocurrencies have a massive energy consumption. For example, the energy consumption of Bitcoin accounts for 100-200TWh, which is comparable to the consumption of a small country [192].
- The decentralization of financial systems is impeded by contrasting and complex regulations of cryptocurrencies in different countries [193]. Further, the high volatility and mixed public opinion of the whole cryptocurrency market undermines the stability of the DeFi industry [190].

### Impact on the Future of Communication Technologies

The increasing trend toward decentralization in various fields has created a demand for advanced communication technologies. Decentralization affects the networks and channels used for information distribution, making high-quality communication technology essential for its success. This is especially crucial for decentralized energy systems since they rely on reliable coverage and a low-latency network, such as 5G or 6G. Cryptocurrencies communicate between different miners and a consensus [194], which depend heavily on fast and energy-efficient solutions. In conclusion, the impact of decentralization necessitates the need for advanced communication technologies.

# ACCESSING THE GLOBAL ECONOMY

## Global High-Speed Connectivity Will Foster Growth in Developing Countries

Over the past two decades, there has been a significant increase in internet penetration, with more than 65% of households worldwide having access to the internet compared to 14% in 2002 [195]. This growth in internet access has brought numerous economic opportunities, including the rise of remote work, further accelerated by COVID-19. To connect the remaining 2.9bn with no internet access [196] and enable them to access the global economy, satellite constellations emerge as a solution. With the declining cost of launching satellites [197] and a shift to mass-manufactured hardware, deploying large satellite constellations has become more economically feasible. Developing countries can greatly benefit from satellite broadband, enabling remote areas to participate in the global digital economy. By providing access to digital jobs, supporting small businesses, and empowering entrepreneurs, satellite internet can promote economic growth [198]. Further, satellite broadband can serve as a cost-effective way to leapfrog previous communication technologies without the need for significant investments in ground infrastructure. Access to quality online education can contribute to economic growth in developing countries by providing better job opportunities and fostering a knowledge-based economy [199].

### Facts

- Overall, 2.9bn people, which accounts for 37% of the earth's population, have no access to the internet, with 96% of them from developing countries [196].
- The EU invests in a broadband communication satellite constellation called IRIS2 [200].
- The number of satellites in orbit has doubled in the last two years [201]. This was mainly driven by the satellite internet constellation from SpaceX called Starlink [202].

### Key Drivers

- The rise of New Space, meaning the privatization of the space industry, brings a new wave of innovation [203].
- In the last 20 years, the cost of launching 1kg of payload into low earth orbit (LEO) decreased massively from 10,000 USD in 2000 to 2,600 USD in 2010 to 1,500 USD in 2020 [197].
- The number of satellites is rapidly increasing. In 2018, there were 126 in orbit, and in 2021 already 1,434 [204]. Additionally, the cost of producing satellites and communication equipment is significantly decreasing due to serial manufacturing [205].

### Challenges

- Without globally binding regulations and appropriate measures from all stakeholders, space debris and defunct satellites pose a significant risk due to possible collisions. In 2019, the US tracked roughly 20,000 pieces of debris in orbit, which increased to 27,000 in 2021 [206].
- The significant obstacles encountered in implementing a satellite-based internet service can lead to a monopoly and negatively impact the market competition, e.g., SpaceX estimates around 10bn USD to operate the Starlink constellation [207].

### Impact on the Future of Communication Technologies

In the upcoming years, there will be even more demand for communication satellites and the related infrastructure, which in turn will drive investment and innovation in this sector. This also means that mobile terminals must be developed for the consumer to use satellite broadband fully. The trend towards remote work has also driven innovation in communication technologies that support remote collaboration and virtual meetings, e.g., video conferencing tools and cloud-based project management software. These technologies are essential for enabling remote work and have become critical components of modern communication infrastructure. Overall, the trend towards increased internet access and remote work has driven innovation in communication technology and has made it a vital enabler of economic growth and development in the digital age.

# BUSINESS MODEL TRENDS

## INFLUENCING THE FUTURE OF COMMUNICATION TECHNOLOGY

Intelligent Extraterrestrial Routing
A Hospital Inside the Body
Data-Ownership-as-a-Service
Real-Time Digital Twin
Connecting Machines in Smart Factories

Yarhy Flores López 
Gonzalo Loza Rojas 
Arkardiy Telegin 
Alena Strittmatter 
Anya Xie 



# BUSINESS MODEL TRENDS

## Influencing the Future of Communication Technology

Facing technological advancements, standardizations, governmental regulations, environmental concerns, and changes in the global economy, the future of communication is experiencing a multi-driver shaping process where agile innovation will be essential in the business landscape. The challenge to remain competitive and adaptable as the world becomes more interconnected will be accompanied by complex regulatory environments and customer privacy protection expectations. Additionally, in developing infrastructure and equality, businesses will have to address the concerns about the impact of technology on society.

However, technological hardware promises to deliver network, satellite, or scale of communication, molecular, laser, quantum, and more, raising the uncertainty of communication as future strategy will depend on how society adopts these changes. This will push companies to develop business practices that disrupt several industries. At the same time, businesses can offer additional and more reliable services by taking advantage of the vast connectivity achieved in the next 20 years.

In this context, the following section proposes five business model trends that are influenced by communication technology or significantly impact its future. First, with the rising satellite infrastructure between low earth, medium earth, and geostationary orbits, and laser-based connectivity between these orbits, demand for intelligent routing services will surge. Businesses offering this service can ensure seamless communication fitting to the latency needed depending on the online operation.

Second, nanotechnology is set to disrupt the healthcare industry, enabling medical professionals to deliver personalized treatment. With the development of molecular communication, healthcare-related businesses will have the capacity to offer nano-enabled medical devices for remote monitoring, diagnosis, and treatment.

Third, with the rising concerns on private data usage, data regulations, and blockchain technology, a new business model turns the corner: Data-Ownership-as-a-Service. This model will give individuals greater control over their data, while businesses can leverage the benefits of data analytics and comply with privacy regulations.

Fourth, as device connectivity and speed of communication technology will enhance, digital twins will become the new normal in the operations of different industries. These virtual replicas will allow businesses to blur the lines between the digital and physical arena to optimize performance, reduce costs and enhance customer experiences.

Last, a democratized adoption of enhanced machine-to-machine communication technology will enable smarter factories with increased efficiency. This connectivity between machines and devices will streamline business operations, reduce downtime and improve the quality.



# INTELLIGENT EXTRATERRES-TRIAL ROUTING

## Enabling Speed Tiering for Satellite Internet Networks

The COVID-19 pandemic has sped digital transformation worldwide. Despite this, approximately 2.9bn people lack internet access, primarily due to affordability and accessibility [208]. Satellite internet adoption has been restricted because of its high costs and low performance compared to terrestrial options [209]. However, opportunities for LEO constellations have emerged due to various factors like technological advances and better funding [210]. These constellations are crucial to closing the digital divide and developing a better approach to internet accessibility [211]. Unfortunately, satellite manufacturing and launching costs must be reduced to make pricing more viable [210]. From a business model perspective, it is an opportunity for an operator to dynamically serve both the consumer and the Business-to-Business (B2B) market based on their bandwidth and latency needs. Geostationary orbit (GEO) satellites could serve non-time-critical internet requests, while LEO satellites could serve low-latency or high-bandwidth applications, thus reducing customer costs. This would significantly reduce costs for satellite connectivity, which is critical for the consumer and B2B market to take off, according to an analysis made in the US [210].

### Facts

- With a CAGR of 20.4%, the global satellite internet market size is expected to reach 18.59bn USD by 2030 [212].
- By 2040, the global space industry is expected to generate more than 1tn USD in revenue, collected mostly from satellite internet-related services (50% to 70%) [213].
- LEO satellite internet constellation plans cost twice as much compared to offerings from providers with GEO constellations, like Viasat and HughesNet [211].
- 74% of customers have a positive or neutral feeling towards operators offering different speeds dependent on the needs of mobile users [214].

### Key Drivers

- Around 58,000 additional satellites are expected to be launched by 2030 [215].
- Consumers demand high-speed and low-latency connectivity in all locations, while businesses require more bandwidth to enable remote work and other applications [209].
- Governments worldwide seek to offer satellite connectivity with low latency, particularly in areas historically deprived of such services [209].
- The further development of laser communication technology and smart satellites will leverage the potential of AI to make an intelligent network layer possible, thus allowing routing in a dynamic satellite network topology [216].

### Challenges

- The success and adoption of satellite internet in the consumer market will be affected by high prices for customer premises equipment [210].
- The highly dynamic network topology that results from the high speeds that LEO and medium earth orbit (MEO) satellites operate in will increase the complexity of satellite networks and exacerbate routing design problems [216].
- LEO satellite constellations must reduce their manufacturing costs by more than an order of magnitude to be financially viable [210].
- As thousands of satellites are launched, the need for exceptional constellation management systems increases, and a change to automated solutions is needed [210].

### Impact on the Future of Communication Technology

This trend will provide affordable connectivity around the world and improve the user's experience in every aspect of their life, ranging from in-flight entertainment to remote work. It will also impact various industries by supporting industrial, maritime, shipping, and logistics applications through IoT connectivity [217]. Moreover, worldwide connectivity and its impact on IoT devices will open the opportunity to scale machine-to-machine as well as human-to-machine communication regardless of location.

# A HOSPITAL INSIDE THE BODY

## New Era of Healthcare: Revolutionary Nanomedicine Enabled by the Molecular Communication

Molecular communication holds great promise for enabling new treatments in nanomedicine. By using molecular communication pathways similar to those naturally used by cells, researchers can overcome some limitations of traditional drug delivery methods. Some examples of conditions that could be treated using nanotechnology are cancer [218], neurological disorders [219], and cardiovascular diseases [220]. This can have a profound impact on business models in the healthcare industry. Specifically, personalized treatments tailored to an individual's unique genetic makeup could become more prevalent with nanomedicine, allowing subscription-based personalized medicine services. Nanotechnology could also shift the focus of healthcare towards prevention, leading to new business opportunities for companies that develop preventive treatments and diagnostic tools. The efficiency of healthcare delivery could be increased with nanotechnology, facilitating outcome-based pricing models.

### Facts

- In 2020, the global nanomedicine market was valued at 198.9bn USD [221].
- The global nanomedicine market is expected to reach 512.5bn USD by 2028, as estimated by Transparency Market Research [221], or 393bn USD by 2023 [222].
- Cancer treatment, drug delivery, efficient diagnosis, free-radical scavenging, and antimicrobial therapy using nanotechnology are active research fields [223].
- The global preventive healthcare market was estimated at 3.4tn USD in 2021 and is expected to reach 5.5tn USD by 2027 [224]. Nanomedicine is giving a new dimension to preventive healthcare [223].

### Key Drivers

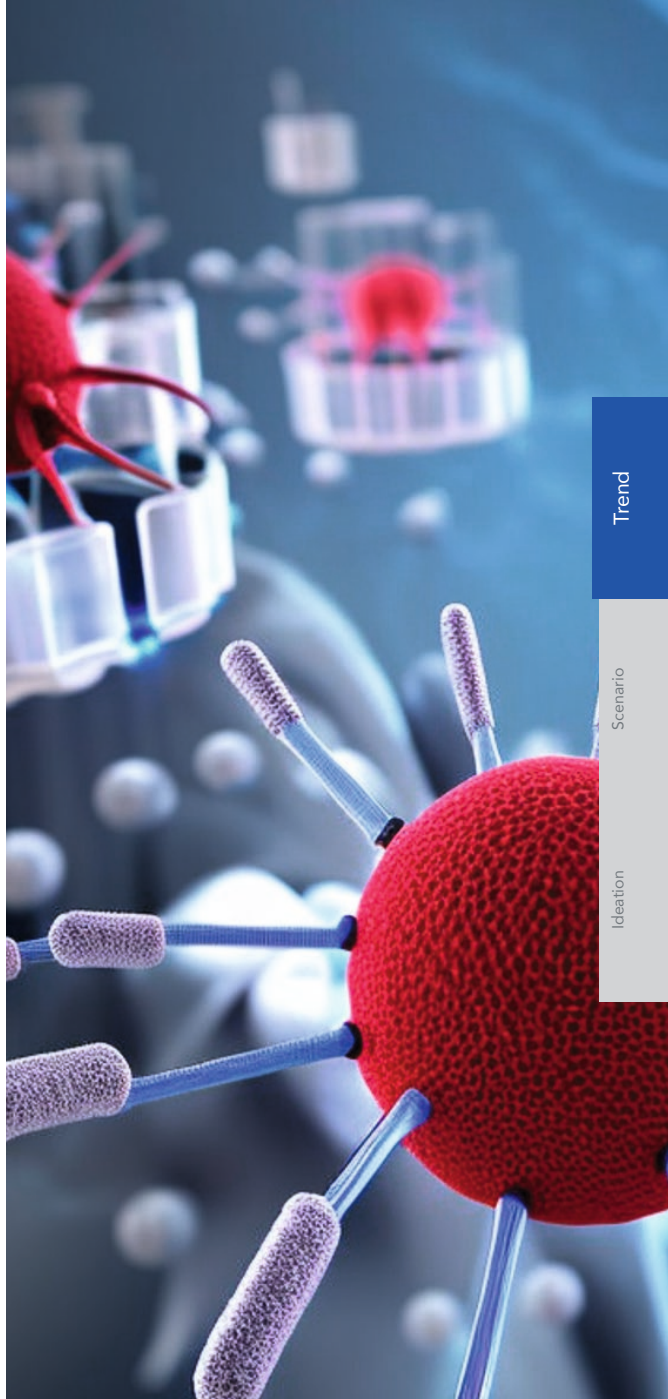
- Research on molecular communication provides basic building blocks that can be used by nano-healthcare applications [225].
- The rise of drug-resistant bacteria and viruses is a global health threat [226]. Nanomedicine offers a new approach to tackling this problem by enabling the development of new classes of drugs and drug delivery systems that can bypass resistance mechanisms [227].
- The globalization of the pharmaceutical industry has led to increased competition and the need for innovative solutions to stay ahead in the market.

### Challenges

- The production of nanomedicine products on a large scale can be challenging due to the manufacturing process's complexity and the high production cost [229].
- Nanomedicine treatments will be developed and regulated on a case-by-case basis due to the differences between medically relevant nanomaterials [230].
- New treatments will have to prove safety in the context of the environmental presence and persistence of nanoparticles. Biodegradable nanoparticles are likely to be of lesser concern, as they will be degraded by metabolic pathways [231]. However, non-biodegradable nanoparticles may persist for considerable periods, resulting in prolonged exposure of humans, animals, and the environment with unknown consequences [230].

### Impact on the Future of Communication Technology

Active research in the field of nanomedicine is a major driver of advancements in molecular communication. Indeed, integrating nanoparticles with medical devices will enable real-time monitoring of patients health, thus improving the accuracy and timeliness of communication between patients, healthcare providers, and other stakeholders [232]. Moreover, the advancements in molecular communication could enable real-time precise environmental monitoring, allowing prompt and localized discovery of contamination [233].






# DATA-OWNERSHIP-AS-A-SERVICE

## Empowering Individuals to Have Greater Control Over Personal Data

Currently, individuals give away their data for free or in exchange for a service like an email [234]. Data collection has increased and reached a point where data collectors know more and can make more assumptions about an individual than themselves [235]. For individuals, there are three challenges: First, it needs to be found out which personal data is stored [234]. Second, it is impossible to determine who has access to and uses their data [234]. Third, it is impossible to take ownership of the data [234]. Not only do individuals have rising personal data privacy concerns [236], [237], but it is also an important topic for governments as they introduce regulations like the GDPR [238]. A service provider can provide insights and governance services to users through application programming interfaces (APIs) [239] and blockchain technology [240]. While a liberate, free flow of private data would benefit economically, it goes against individuals' interests [241]. A service provider can act as a mediator between these interests.

### Facts

- Data brokers collect, clean, or analyze and lease data to companies [242]. Epsilon, a data broker, has been acquired for 4.4bn USD by a multinational advertising company [243].
- By 2025, an average connected person will interact with connected devices nearly 4,800 times per day, about one interaction every 18 seconds [244].
- 44% of people globally say they would forego personalized content, including brand messages and offers, if it meant not having to share their personal information [245].
- The volume of data created, captured, copied, and consumed worldwide is forecasted to grow from 97ZB in 2022 to 181ZB in 2025 [246].

### Key Drivers

- More than 50% of individuals state that they are more concerned about their online privacy than the year before in both the United Kingdom (UK) [236] and the US [237].
- Governmental regulatory requirements may further restrict companies from processing personal data. E.g., the EU's GDPR gives individuals in the EU the right to access, correct, and delete their data held by companies [238].
- Blockchain allows for storing personal data in a decentralized network and controlling its access using smart contracts [247].

### Challenges

- Internet users are insecure about topics involving data tracking [248]. Thus, certain people need to be convinced that the advantage of data ownership is more significant than the downsides of tracking [248].
- Data lakes of personal data already exist and continue being used until outdated [234].
- Data brokers often act in the shadow, leading to a lack of transparency regarding the personal data they own [241].
- While regulations are a big driver for this business model, too strict regulations regarding data tracking could challenge the business model [248].
- As customer data is crucial for personalization, companies may oppose personal data ownership rights [249].

### Impact on the Future of Communication Technology

Data-Ownership-as-a-Service introduces more transparency into the market of private data. This transparency can lead to a shift toward more private and secure forms of communication, using communication technology that enables encrypted messaging apps and decentralized social networks. With more individuals taking control over their data and only selectively giving access to companies, there will be a limit to how companies can personalize their targeting and communication. Users could decide about the degree of personalization they receive [235].

# REAL-TIME DIGITAL TWIN

## Synchronizing the Digital and the Physical Realm Up to Real Time

In a post-COVID-19 economic landscape, businesses have seen the line between the digital and the physical arena getting blurred. From quiet quitting in protest for remote working rights [250] to massive layoffs due to an economic downturn, businesses have a new challenge: Accommodating their operations to the new digital landscape while reducing costs. In response, the hype around digital twins (DTs) has started to rise in expectations and criticisms [251]. This technology is a virtual representation of an object, process, or system based on sensor data, aiming to replicate the physical twin (PT) [252]. In 2020, the current DT market already generated sales of more than 3bn USD [253], mainly from their impact on the healthcare industry and simulations [254]. The future of this technology will be characterized by a reduction in the synchronization time, known as a digital shadow [251], fostering the interaction between the physical and the digital realms making human-to-machine communication the basis of future business operations [255]. With DT's full potential, multi-source data processing and remote-controlled operations and systems will become the new norm in industries like meteorology, aerospace, mobility, and Industry 4.0, among others [256].

### Facts

- The global DT market size is projected to reach 155.83bn USD by 2030, with a CAGR of 37.5% from 2023 to 2030 [257].
- Supply chain innovation has been a trending topic among Chief Executive Officers (CEOs) since 2021 [258], with 70% of C-suite tech executives investing in DTs [259].
- Applying DTs in operations and supply chain has shown benefits cutting the product development time in high and low complexity between 30% to 40% [260].
- Unlocking DT's full potential requires a high throughput (100Gbps), reliability (99.9%), and pervasive communication, all achieved with beyond 5G technologies [256].

### Key Drivers

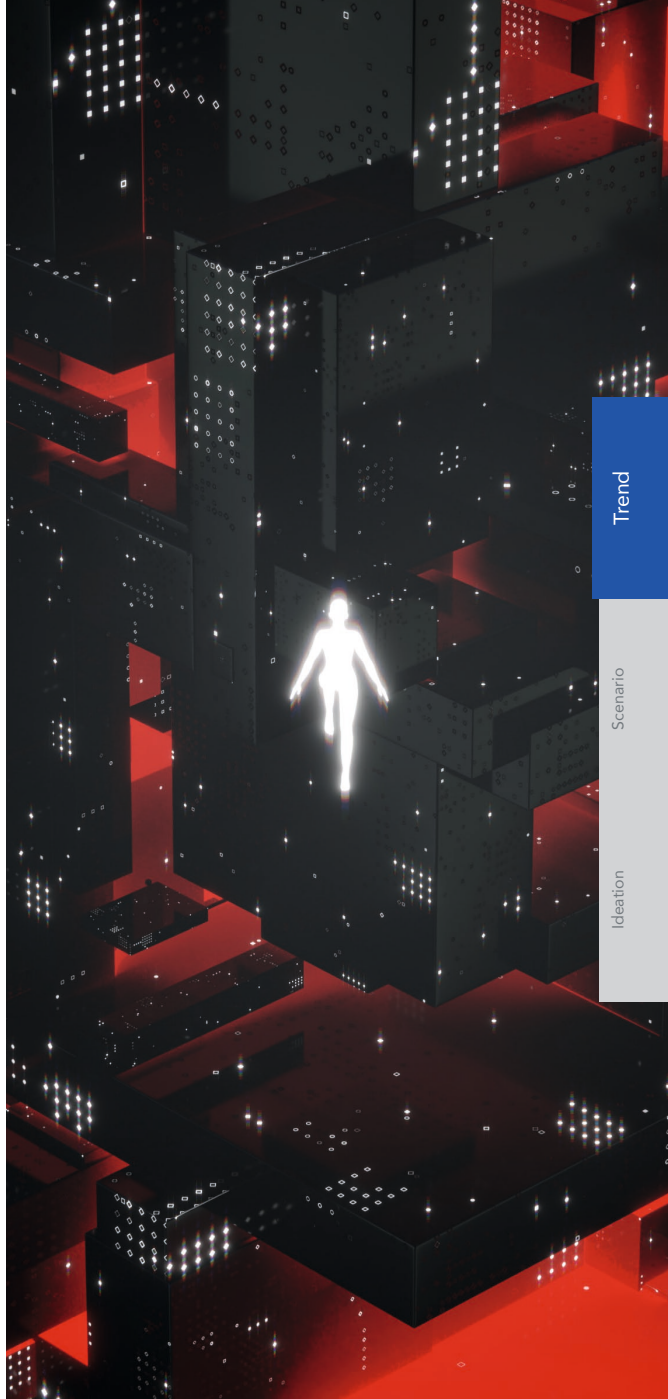
- The rising digital transformation since COVID-19 demands a bridge between cyberspace and physical space [261], supporting augmented reality and the development of the enterprise metaverse [259].
- With the advancements in AI and ML, businesses can extend technological applications and be more accurate in their real-time processing [262].
- The growing number of connected devices and sensors from the IoT technology provides a wealth of data and decreases the effort to obtain and process it for DT development [263].

### Challenges

- Interoperability among sensors and connected devices is necessary for the success of multi-source modular DT models that imitate reality [264].
- The adoption of this technology is highly dependent on the users' and workers' confidence in having a digital and physical alter ego that will reflect both their personal and context space [251].
- Businesses' use of DTs of systems could drive higher risks as the chances of a potential attack double as cyber threats can target the system as well as its DT [265].
- The upfront cost of the data infrastructure for deploying DTs requires careful consideration to ensure the potential return on investment [266].

### Impact on the Future of Communication Technology

6G connectivity is crucial for a real-time DT. To succeed in the rollout of 6G connectivity, the network must achieve both autonomy, being governed with no human intervention, and also ubiquitous and seamless connectivity, avoiding unknown interferences in the network space [267]. For this, DT use in the telecommunication industry presents an opportunity to have the network self-adjust and develop based on real-time data [268]. Current efforts in companies like Sprint Communications and British Telecommunication, which have been developing DT for 5G networks, will pave the way for the full adoption of DT in 6G [269].





# CONNECTING MACHINES IN SMART FACTORIES

## Transforming Factories Through IoT and Automation

Due to rising energy prices, supply cages, and workforce shortages, organizations aim to increase their competitiveness by automating their manufacturing processes [270]. Automation through the transformation to smart factories can raise manufacturers' productivity by 45% to 55% [271]. Smart factories are highly automated manufacturing facilities that utilize advanced technologies such as IoT, AI, robotics, and big data analytics to streamline and optimize manufacturing processes. To integrate the physical world, robotics require high connectivity through sensor-equipped machines and highly reliable communication networks [271]. In 2017, only 30% of manufacturers deployed smart factory initiatives [270]. Recent developments in communication technologies like 5G will be key enablers in implementing smart factories, as they promise to increase connection speed and density while decreasing latency [270]. In the future, smart factories can be scaled up to smart factory networks, optimizing productivity along the entire supply chain and product development cycle [272].

### Facts

- The manufacturing industry is projected to expand at the fastest CAGR from 2022 to 2030 [270].
- The resulting productivity gains due to the transformation to smart factories are estimated at 2tn USD as the manufacturing industries continue to grow [270].
- The increased efficiency in manufacturing processes can lead to a reduction of 12Gt of $CO_2$ emissions by 2030, contributing to 22% of the total potential $CO_2$ emissions reductions [273].

### Key Drivers

- The industrial IoT (IIoT) emerged, allowing industrial operations to sense and collect manufacturing data as products move through their manufacturing cycle [274].
- Sensor data aggregated through IIoT platforms can be processed with AI, enabling real-time control of production processes, data visualization, and data-driven decision-making [275].
- Cloud infrastructure provides computing resources like storage, processing power, and networks needed to collect and process the data aggregated throughout the manufacturing processes [276]. Recent developments in edge computing can bring computing even closer to the data, further decreasing latencies [277].

### Challenges

- One-third of manufacturers still lack the necessary IT and operational technology OT infrastructure. Most OT systems today work in silos [278]. Connecting a variety of machines, devices, and sensors will be a significant challenge for established as well as new factories [279].
- Manufacturers are highly vulnerable to cyberattacks and need to implement cybersecurity measures. Yet, only 50% are adequately prepared to address cybersecurity concerns [270].

### Impact on the Future of Communication Technology

While Business-to-Consumer (B2C) accounts for 70% of revenue for communication service providers, B2B is the main driver of revenue growth [280]. As communication requirements increase within factories, a rise in the deployment of private cellular networks and network-slicing technologies is expected. More than 90% of manufacturers are investigating the use of 4G/5G for their operations, and 84% will deploy their own private networks [277]. With industry 5.0 on the horizon, human-to-machine communication will become the innovator of smart manufacturing, pushing communication technologies for even lower latencies and higher data transmission rates [281].

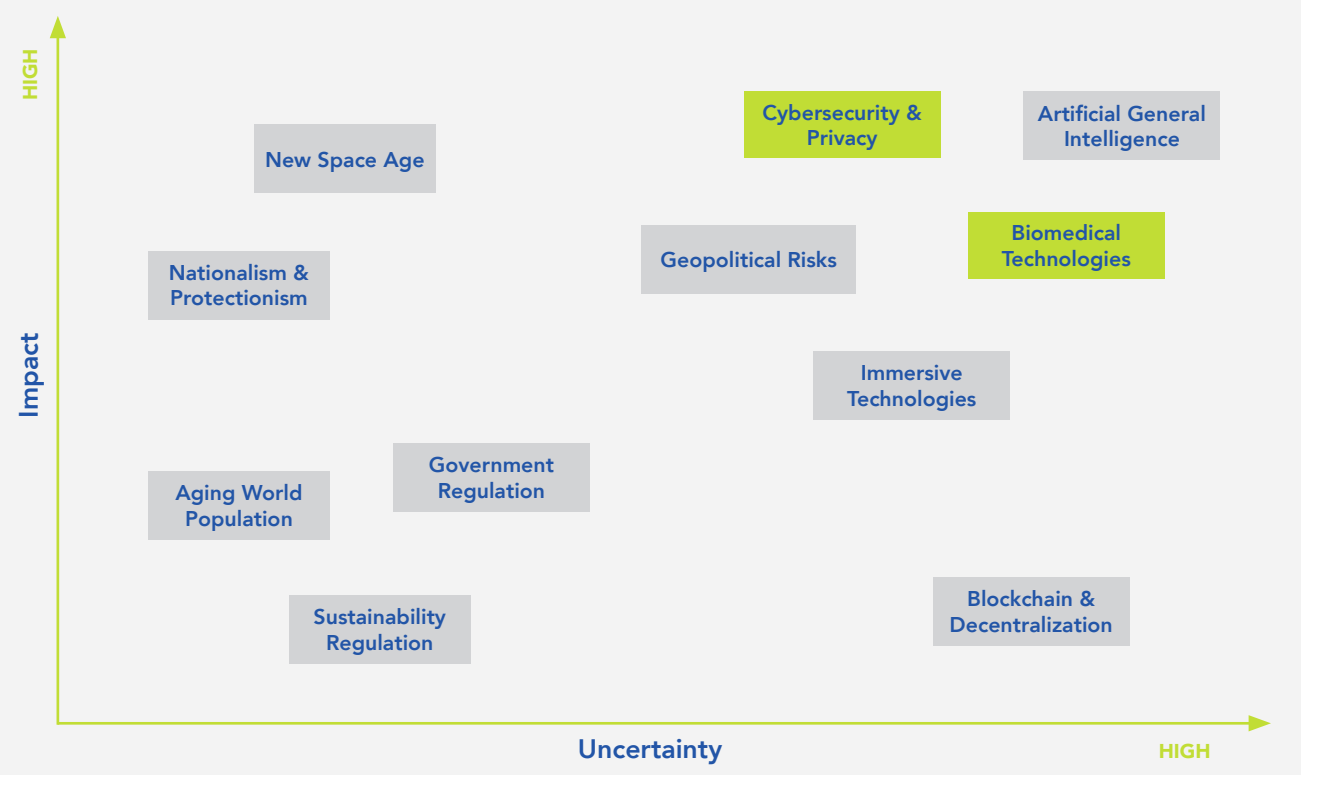
# SCENARIOS

The following chapter outlines four distinct future scenarios based on the drivers identified during the trends phase. These scenarios are considered plausible, relevant, and significant for future decision-making while also aiming to be thought-provoking, challenging, and coherent based on current and near-future signals and possible exogenous effects. The visions aim to describe the challenges communication technologies will face in 2043, focusing on two key drivers. Personal narratives will express the livelihoods in a person's day in that year to allow an in-depth understanding of the said image. Ultimately, a list of signposts under each scenario presents the evolution of events that took our present day to these four plausible futures.

# DRIVER MATRIX

The scenario phase follows a structured approach to imagining what life could look like in 2043. Based on the research conducted in the Trend Phase, current drivers with high impact and high uncertainty on the future of communication technology were identified.

The results were presented in a matrix that visualizes each aspect's degree of impact and uncertainty.
Biomedical technologies and cybersecurity and privacy were identified as core drivers. Both were modeled with bipolar outcomes to create four extremes but still possible future scenarios. Other drivers from the matrix were selected and further integrated into the scenarios to refine these stories. The following pages portray the fully elaborated stories together with their corresponding visualizations.



# KEY DRIVERS

### Absent

Biomedical technologies will be obsolete. They will not be used in any sector of modern society. No system relies on any biomedically-engineered technology. In this extreme outcome, the absence of neuroscience and nanotechnologies limits the potential for breakthroughs in science and technology and results in slower progress in the fields of medicine, agriculture, and communication. Therefore, diseases are more challenging to treat, and medical procedures are more invasive and riskier. Without the benefits of biomedical technologies, the opportunities for immediate knowledge exchange are lost, leaving society reliant on more traditional and less efficient forms of communication. Consequently, people become dependent on more traditional and less efficient methods of communication, limiting the scope for deeper connections and interactions with machines.

### ← Biomedical Technologies →

Biomedical engineering is a growing and dynamic research field encompassing many technologies, including those related to neuroscience and bionanotechnology. On the one hand, neuroscience technologies investigate the nervous system with the aim of improving human capabilities, including communication. By exploring how the brain works, neuroscience has the potential to develop new communication technologies such as BCI and telepathy. On the other hand, bionanotechnology involves studying and manipulating biological systems and structures, such as proteins and DNA, at the nanometer scale. Such technologies aim to develop new treatments for diseases. Moreover, they enable new forms of communication at the nanoscale level, like molecular communication, which can facilitate interactions between nanodevices within the body or the environment.

### Ubiquitous

Biomedical technologies will be present in many aspects of society. The development of these technologies will revolutionize healthcare, making it more efficient and accessible to people across the globe. Additionally, innovative technologies like BCIs will enable new modes of human interaction by allowing direct communication between individuals using thoughts and facilitating control over various machines and devices. As society becomes increasingly open to the usage of biomedical technologies, their integration into healthcare and communication systems accelerates. Thus, they become an integral part of our future, shaping the way we live, work, and interact with one another.

### Cyber Mayhem

In 2043, Cyber Mayhem prevails as cybersecurity and privacy issues continue to escalate. The constant threat of cyberattacks has created a pervasive culture of fear and distrust in the digital space. Despite efforts to enhance cybersecurity, attackers continue to find new ways to exploit vulnerabilities, leaving individuals and organizations vulnerable to attacks. Privacy is also a major concern, as personal data is collected and shared without individuals' knowledge or consent. The lack of effective cybersecurity measures and privacy regulations has resulted in a state of chaos, where individuals and organizations are constantly on high alert for the next attack. This uncertain environment has made it difficult for individuals and businesses to fully trust and rely on digital technologies.

### ← Cybersecurity & Privacy →

The topic of cybersecurity and privacy remains a significant driver that shapes technological advancements and societal changes. With the increasing dependence on technology and the digitalization of most aspects of our lives, the risks associated with cyber threats and data breaches have become higher. In the same vein as cybersecurity, privacy concerns are also a significant part of this driver as people become more aware of their digital footprint and the ways in which their personal data is collected, stored, and used. In response, governments, businesses, and individuals will prioritize privacy protection, leading to the development of new privacy-enhancing technologies and regulations to protect individuals' rights while enabling the benefits of data sharing.

### Cyber Safe Haven

Individuals and corporations around the world will enjoy a digital utopia in 2043, where advanced cybersecurity measures have created a safe and private space for communication and data storage. With complete ownership and control over their information, people and organizations feel more empowered and confident to engage in online activities without fear of cyberattacks or breaches of privacy. Governments and corporations adhere to strict regulations that protect individuals' rights to privacy while still promoting innovation and progress in the digital space. Establishing these safeguards has allowed for greater trust and cooperation among online communities, fostering a more secure, collaborative, and prosperous digital environment.

# OTHER IMPORTANT DRIVERS



| | | |
|---|---|---|
| **Absent**<br>No AI technology has been able to reach the breadth and versatility of an AGI; instead, there are multiple domain-specific ones. | **Artificial Intelligence** | **Available**<br>At least one AGI has evolved and continues to improve itself, pushing the limits of problem-solving and decision-making across multiple domains. |
| **No Adoption**<br>Society continues to rely on traditional communication like face-to-face and text-based connections instead of the extended reality of the Metaverse. | **Immersive Technologies** | **Fundamental**<br>Society is captivated and finds it essential to engage in immersive worlds almost permanently to interact socially and professionally. |
| **Unattractive**<br>The demand never takes off, and generalized medical practices remain the status quo, leaving personal data's application in healthcare untapped. | **Demand for Digital & Personalized Health** | **Fundamental**<br>Society pushed the industry to achieve its full potential in disease prevention, diagnosis, and treatment through tailored medical care. |
| **Peace**<br>The world benefits from a peaceful order without polarization and political tensions, dropping military spending to floor levels. | **Geopolitical Risk** | **Tension Blow-Up**<br>Forceful conflicts and an arms race dominate the arena, exacerbating geopolitical instability and tensions among nations. |
| **Liberal**<br>The market of communication technologies presents low-to-no regulations boosting freedom of action to the telecommunications industry. | **Global Competition** | **Restricted**<br>Strict regulations and state-controlled industries restrict market development in communication technologies. |

# SCENARIO MATRIX

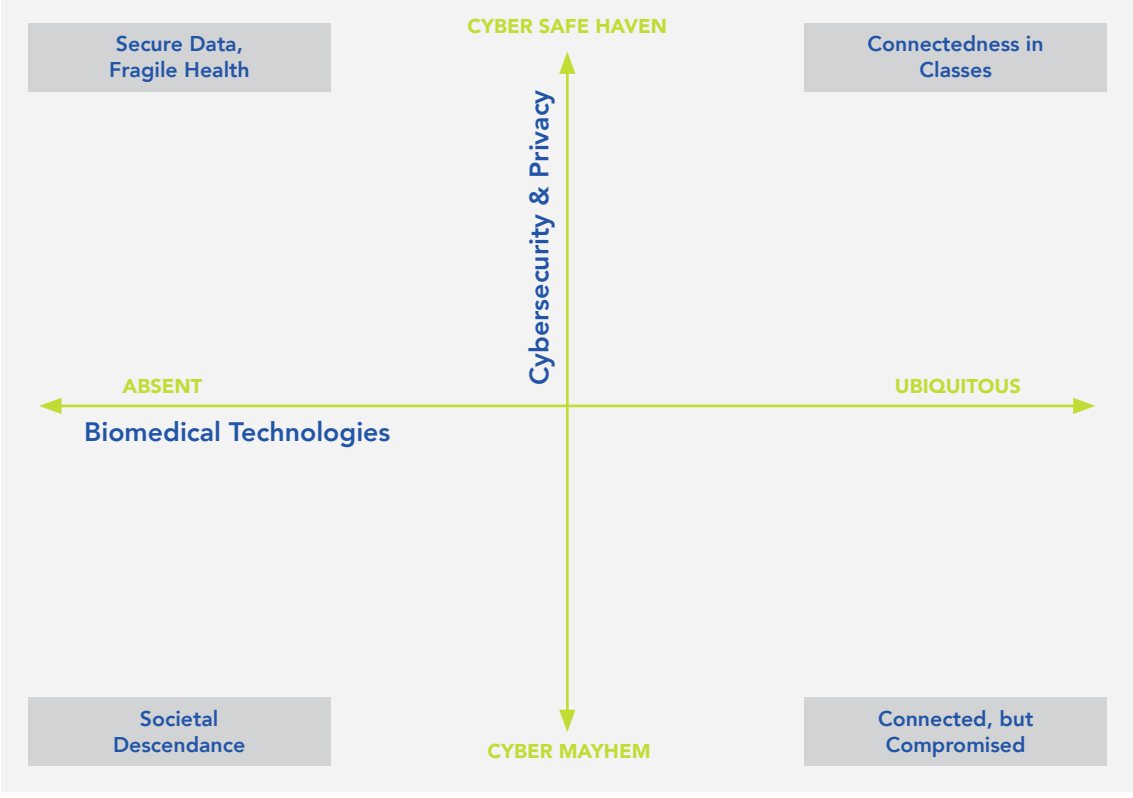
The two key drivers and their outcomes create a scenario matrix. Each axis represents one key driver, with bipolar outcomes on both ends. All four scenarios are based on the extreme outcomes of the two key drivers. Other important drivers are also considered, with plausible and consistent outcomes in each scenario.

**Connectedness in Classes:**
Advanced biotechnology enhances human communication and improves personal health while being highly secure from hacking and cyberattacks. However, only the wealthy can access it, while the poor are left behind.

**Secure Data, Fragile Health:**
This scenario describes a future in which society decides to abandon the pursuit of biomedical technologies altogether due to the widespread influence of conspiracy theories and the fear of misinformation. This scenario results in a world with robust data protection but diminished healthcare progress.

**Societal Descendance:**
Biotech advancements were banned after a crisis caused by brain-computer interface hacking. People's beliefs in cyberspace became polarized, with some embracing siloed lifestyles while others remained connected, widening the digital divide into a social one.

**Connected, but Compromised:**
This scenario portrays a world in which biotech and cybernetic implants are widely used but also vulnerable to cyberattacks. Even cybersecurity experts feel terrified by the loss of safety and privacy. Nevertheless, they remain dependent on cybernetics due to their convenience and health benefits.



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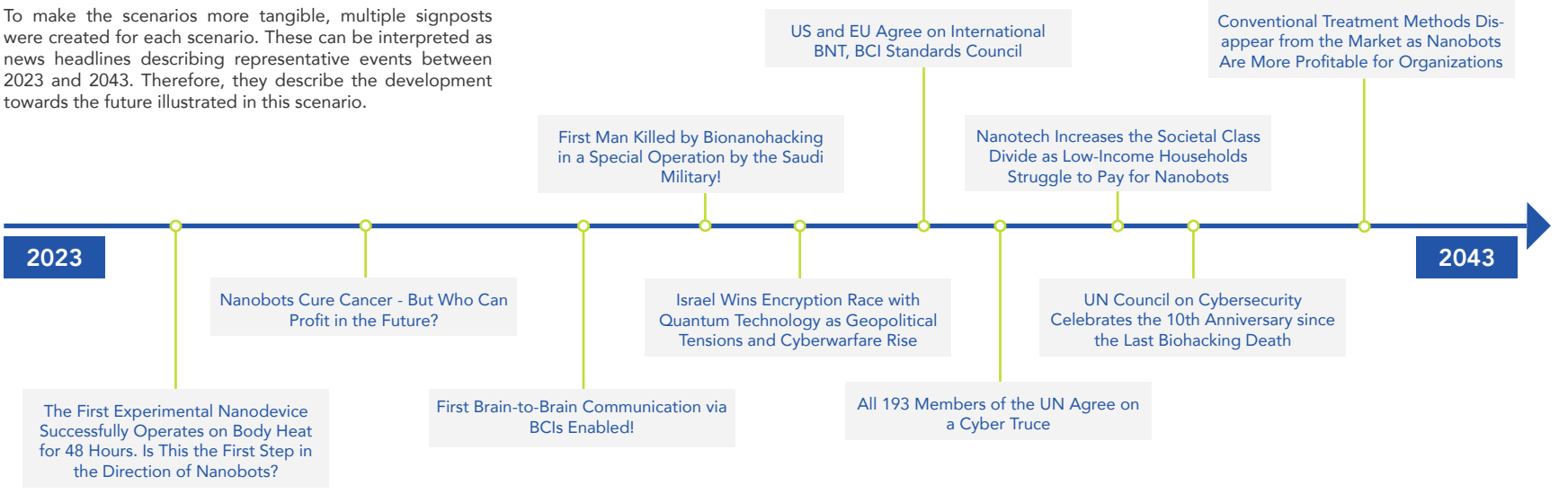
# CONNECTEDNESS IN CLASSES

## An Era of Biomedical Technologies, Cybersecurity, and Privacy

To make the scenarios more tangible, multiple signposts were created for each scenario. These can be interpreted as news headlines describing representative events between 2023 and 2043. Therefore, they describe the development towards the future illustrated in this scenario.



## A Day in 2043

As the scattered photons dance against the mosaic of darkness in a small, dimly lit room, Max sits on a stage in the middle. He is surrounded by a crowd of well-dressed people, or maybe their hyper-realistic holograms, all looking expectantly at him. Max looks at the crowd and smiles wistfully. The topic of his performance is "nostalgia". He takes one last glance at his audience and closes his eyes. His mind conjures up a bright sunny day, and he is running across the expanse of a small lawn toward his mother's outstretched arms. In the background, the sun erupts into a thousand stars as the scene slowly transcends description by mere words. After an hour, or maybe two, Max opens his eyes again. The appreciative looks on the faces in the crowd tell him that his performance was a success. As the holograms slowly disappear, Max is left alone in the room, darkness engulfing his face. Unlike most days, today, the darkness lies heavy on him. His heart turns with a curious feeling that even the nanobots coursing through his veins cannot regulate. A gentle reminder from his brain chip interrupts his brooding; he must make a brain-to-brain call to his parents, who are in China for a business trip.

Max was the apple that fell far from the tree. His parents were successful innovators at the forefront of the new era of bionanotechnologies and were financially rewarded for it. They had always wanted Max to follow in their footsteps. Max, however, had always been the rebel. Even as a child, Max preferred to wander the crooked, unpaved paths of his imagination instead. As he grew up, these imaginations slowly transcended the abstraction ladder, and at one pivotal point in his life, he decided to sell these transcendent abstractions to rich collectors.

Max shares a few thoughts with his father before turning to his mother. He had always been closer to her; she was the one who would stand up for him when he would sneak out of his science classes to daydream under the oak trees. He feels the urge to tell her about the feeling of incompleteness that had been weighing on him recently but decides against it. He is not scared anymore that his thoughts are not cyber-secure. Gone were those days of insecurity and isolation when a cold war rippled the world in the past decade. From the cold flames of that fire, the era of complete cybersecurity arose as nations and companies raced against each other to make their technologies more and more secure. He does not want to share this feeling today because he knows that even

his artistic transcendence could not capture precisely what he felt. As the connection to the call ends, he calls his packed suitcase to him, comforted by its presence and the prospect of his upcoming journey. As he slowly slips into a sleep filled with a pre-selected playlist of dreams, the lights around him turn dim in perfect resonance.

Outside, the wind blows steadily, tugging at the leaves with persistent futility. Much has changed in the world, but the same stars peek curiously at the play unfolding below. In another corner of the city, a light stay flickering in a house that looks even shabbier than the rundown neighborhood cradling it. A young man paces the floor, the lines on his face suggesting a lifetime of strife. The young man's name is Alyosha, and in a not-so-distant past, which feels like an eternity to Alyosha, he was an assistant to a general physician. As the bionanotechnologies gained traction with the posh, the doctor ran out of business with his haughty manners. Even though Alyosha tried his best to save the sinking ship, it was inevitable. Alyosha still possesses a few pens and relics of the past and occasionally scribbles down silly poems yearning for a different world. Tonight, however, Alyosha's anguish is not philosophical. His only son, the light of his eyes and the spring of his gait, is slowly waning in the cruel arms of

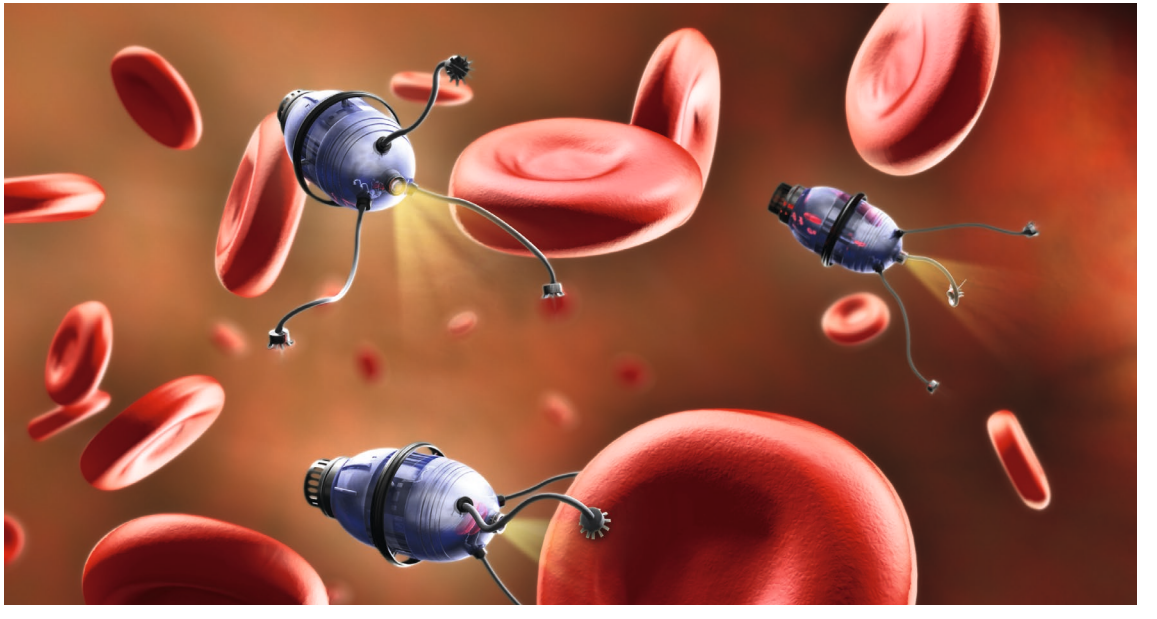
disease, and Alyosha, with all his wealth of knowledge and principles of self-efficacy and love, could do nothing about it. For the past year, he had been using his older version of the BCI and nanobots, which he had received when he was still a healthcare worker, to regulate his emotions and feel like everything would be okay. However, deep within his heart, on some atomic level that even the nanobots could not touch, he knew that this feeling of calmness was a prelude to a perfect storm. The world has come to a standstill for Alyosha, and we would run out of words if we stayed with him, so we leave him to pace the floor as the clouds slowly cover the stars.

The following day comes reluctantly, and an autonomous train pulls over at a nondescript station. Everyone in the compartment peers into nothingness, probably working or enjoying entertainment through their BCI chips. Some old ladies, utilizing the option to remove others from their field of vision, enjoy their virtual solitude. Max looks around interestedly. He is still unsure why he is going on this journey beyond his gated community but likes to believe that it is beyond his narcissistic desire to escape the rut of repetitiveness his abstraction art had run into. The sight of people staring into nothingness unnerves Max. He had never noticed it before because he usually worked on perfecting his artwork during these train rides. Another unfamiliar feeling creeps into his veins as he feels a pair of eyes staring at him. Across the compartment sits another young man with disheveled hair and an intent face, looking at him keenly.

For some strange reason, Max feels compelled to initiate a conversation, so he gets up and makes his way over. Even in this cyber-secure world, verbal expressions are still reserved for strangers. His tongue struggles to form a sentence, rusty from a long period of dormancy. Exchanging formalities, including their names, Max asks Alyosha why he is not like everyone else in the haze of virtuality. “I have tried to escape into many worlds, my dear friend, but my burdens follow me everywhere,” Alyosha chuckles, the lines on his face growing deeper. Abruptly changing the topic, Alyosha asks Max about his story instead. Max dives into a detailed description of his childhood, his parents’ accomplishments, and how the technology they helped create ushered in the new wave of bionano and BCI technologies that helped cure diseases around the world. Alyosha listens intently, the color draining out of his cheeks progressively. Even in his self-centred rant, Max is quite perceptive and brings himself to a halt. “You look so pale suddenly, Alyosha. Tell me what is wrong.”

Pursuing his lips, Alyosha musters a reply, telling him about his helplessness. As words fail him, Max, in the act of impulse, shares a thought with Alyosha, a person he had just met, ignoring all the cybersecurity guidelines he was raised with, beseeching him to open his heart up. Alyosha looks up, his black eyes brimming with tears, hesitates for a moment or two, and lets his thoughts, the ones he had been carrying with himself alone for the past year, free.

It is another night, and Max sits again at the center of his performance room. Tonight, he does not look at the crowd in a prideful way. His eyes are fixated on the cracks in the floor. A week has passed since he met Alyosha on the run-down train and went to the hospital to see his son. A wrapper crackles in his pocket, reminding him of the small boy who, smiling through the pain, offered him candy from the side drawer of his bed. Max looks again at the crowd of virtual rich people. The crowd has come together to bid on his new abstract artwork, everyone contemplating the worthiness of financial investment and speculating about its aesthetics. His hands tremble as he looks toward the floor again, Alyosha’s voice ringing in his ears, “the discipline of suffering, of great suffering - do you not know that only this discipline has created all enhancements of man so far? That tension of the soul in unhappiness which cultivates its strength, its shudders face to face with great ruin, its inventiveness and courage in enduring, preserving, interpreting, and exploiting suffering, and whatever has been granted to it of profundity, secret, mask, spirit, cunning, greatness - was it not granted to it through suffering, through the discipline of great suffering?” Right on cue, the door opens, and a silhouette of a man with a child comes into focus. Max squints against the darkness as if trying to make out who it is, but in the heart of his heart, he knows already. As the crowd settles down again, Max finally looks up, a strange feeling engulfing the corners of his heart, which had been empty for a long time. Looking straight at the crowd, he pauses before finally closing his eyes, and the act has begun. A small sign in the background of the stage reads, “New Contemporary Abstraction Masterpiece by Max Hetz: All Proceeds go Towards a Young Boy whose Heart is Bigger than the Universe.”



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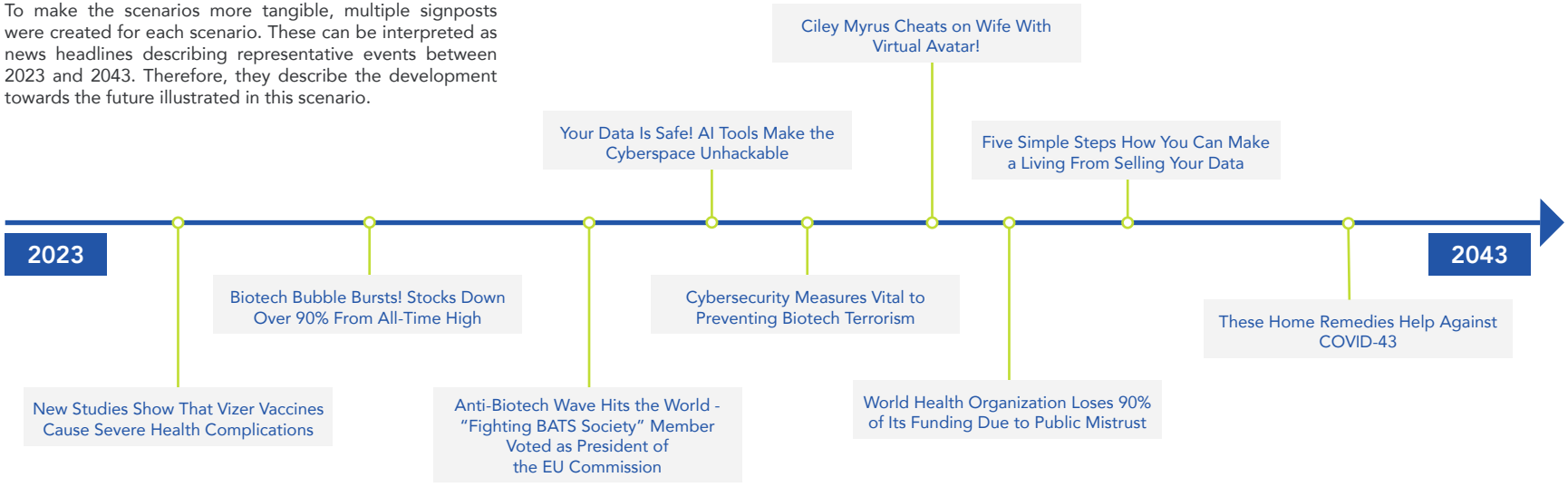
# SECURE DATA, FRAGILE HEALTH

## A Two-Faced Future: A World of Cybersafety and Medical Insecurity

To make the scenarios more tangible, multiple signposts were created for each scenario. These can be interpreted as news headlines describing representative events between 2023 and 2043. Therefore, they describe the development towards the future illustrated in this scenario.



## A Day in 2043

As the scattered photons dance against the mosaic of dark- It is Monday, March 16th, 2043. Hannelore wakes up at six in the morning, as her wearable device signalizes that her body's sleep requirement is fulfilled. The wearable device triggers the news hologram, which she always listens to in the morning: "A small group of conspiracy theorists tried to attack the main building of our government yesterday. According to its manifesto, the group does not believe in the effectiveness of homeopathic medicine and demands the revocation of the ban on vaccination and biomedical development. In today's press conference, Matilla Wildmann strongly criticized this, reiterating the necessity of this ban and defending its legitimacy. Further, he reminded us of the events from 15 years ago. Other government members even accuse the perpetrators of sympathizing with criminals from BioM-Tech. The police have parts of the gang in custody and are investigating possible relations to radical groups." When Hannelore hears this, incomprehension rises in her mind. "How can anyone still think that vaccinations, or any other kind of biomedical technology for that matter, could be good? Do they not remember what happened with the COVID-19 vaccination, even though everyone promised it was safe? Have the Fighting BATS, the Biomedical Anti Treatment Security, not proved once and for all that, even though no one believed them for years, they were right in their concerns about vaccination?"

Hannelore opens her nightstand and takes out her health-keepers, homeopathic pills that help her immune system. Her wearable device signals that her breakfast is ready. Hannelore yawns and makes her way to her dining room. She takes the personalized breakfast that has been adjusted to her needs and prepared by a smart kitchen out of the food dispenser. "I am so thankful that the metaverse gives me the option to work from home," she thinks whilst finishing her nutritious breakfast.

After her breakfast, she walks to her sofa and turns on her computer, which is secured with quantum encryption. She unlocks it with advanced biometric identification. Immediately she receives a meeting reminder. Since company meetings are all taking place in the Metaverse, she quickly puts on her virtual reality (VR) glasses. Her avatar is still wearing business attire, so she directly enters a meeting room. Three of her colleagues are already in the room. "It is so bad here


in Eichstätt!" one of her colleagues is telling the others, "We are under lockdown again, already on the third wave. 50% of the people is severely ill." Hannelore is used to these kinds of stories. Different pandemics have been causing lockdowns in cities everywhere, which is another reason why she is glad to be able to work and meet her colleagues in the Metaverse. "Hi everyone!" she exclaims as she joins her colleagues at the virtual meeting table. Hannelore's boss joins and starts the meeting. They are about to finish when Wolfgang, Hannelore's favorite coworker, exclaims, "Sorry team, I must leave. I just received a message that my brother died. COVID-43 sucks!" His avatar vanishes from the meeting table. There is a crushing silence in the team. Hannelore's boss picks it up, trying to calm everyone, and continues the meeting. After all, these messages are not surprising.

At lunchtime, Hannelore logs off very quickly. She is looking forward to the little adventure she has planned. She takes her VR glasses to the dining room. There, the pizza she has ordered is already waiting for her. She puts on her VR glasses, chooses a relaxed summer dress for her avatar, and chooses a restaurant in Palermo. The table in front of her is now no longer her cleanly white dining table but a rustic table at an authentic Sicilian restaurant. She looks at the old build-

ings, smiles at the sun, and enjoys her pizza while listening to the Italian music two musicians are playing on the street next to the restaurant. Life feels so good like this. While still sitting at the table in Sicily, Hannelore decides to check her bank account. She logs in using advanced biometric identification. She can see that the upgrade to the autonomous car subscription left quite a hole in her bank account. She considers leasing some of her personal data to companies for additional income. "But then again, do only poor people not do that?" she ponders while looking at her other expenses. Before she can decide, Hannelore receives a notification that it is time for her therapy session. Hannelore enters the therapy room. Her therapist, an expert from Atlanta, is not there yet. Nevertheless, she immediately gets a calm feeling. She is glad to know that she can be totally open and honest about her well-being and does not have to worry about this information being hacked, stolen, or misused in another way.

What makes Hannelore almost as happy as a therapy session is seeing her grandparents. Due to health risks, she has only been able to see her grandparents in the Metaverse. Her smart watch tells her that it is time to put on her VR glasses to meet her grandparents. She quickly searches for her glasses and enters the Metaverse. Entering the Metaverse, she chooses an appropriate outfit for her avatar and enters the meeting room with her grandparents. Her grandparents' avatars always look the same. They do not see the necessity to change their virtual appearances. It gives Hannelore a sense of familiarity. "Hannelore, Darling, it is so nice to see you!" her grandmother exclaims, "Your grandfather has issues with his VR glasses again." She points at Hannelore's grandfathers' avatar, which is standing in an awkward position looking at the wall. "I am very happy to see you as well!" Hannelore exclaims. The two women sit down on a virtual sofa. "I got it!" Hannelore's grandfather takes a seat in a virtual chair next to the couch. After talking about the latest updates of Hannelore's life, as always, her grandfather starts talking about the good old times. "You know, if people had not lost trust in biomedicine technology, we would not have to meet in this weird simulation. We were so close to finding a vaccine against cancer. All the illnesses that we are battling today were basically extinct." Hannelore already knows this speech. Her grandfather was very much against abandoning biomedicine technology, even after the tragic outcomes. She has already given up arguing and usually just smiles. When hugging her grandparents' avatars goodbye, she catches herself thinking, "a real hug would be nice after all," but then again, she tries to be rational.

After meeting with her grandparents, Hannelore must get ready quickly. Botbae, the newest dating app, has matched her with a dating partner for tonight. She does not know anything about this partner because Botbae enforces strict data policies. "He must have a lot of money," she thinks, "otherwise, he would have sold his data, and I would be able to see it." What she does know is that this partner matches her profile perfectly, and their health data matches well enough for them to meet in person. She is very excited to have a date outside of the Metaverse. As Hannelore puts on makeup for the first time in a while, she has an idea: "I could finally try out the new premium autonomous carsharing that I licensed last week!" She quickly orders the ride, which is a driving hair salon, so she will arrive well-prepared for the date. "Hopefully, this will finally be the last first date," she thinks, "I finally want to join my friends in having children." There has been a huge baby boom over the last few years, and Hannelore is eager to join the trend.

On the way home from the date, Hannelore passes the Fighting BATS statue. The Fighting BATS was a group that helped people see the danger of vaccines and other similar treatments. "They are the reason for our new medical era," she thinks. Her grandfather is most likely not a big fan.

Hannelore is very happy with her day. As she is already lying in bed, she opens the eBook she is currently reading - a historical novel on how the misinformation campaign of governments and companies was uncovered in 2026. She thinks back on the stories her grandfather told her. "After all, it turned out pretty well; we live in a very secure world." With this thought, she falls asleep.

Nils Krüger 
Victoria Rentrop 
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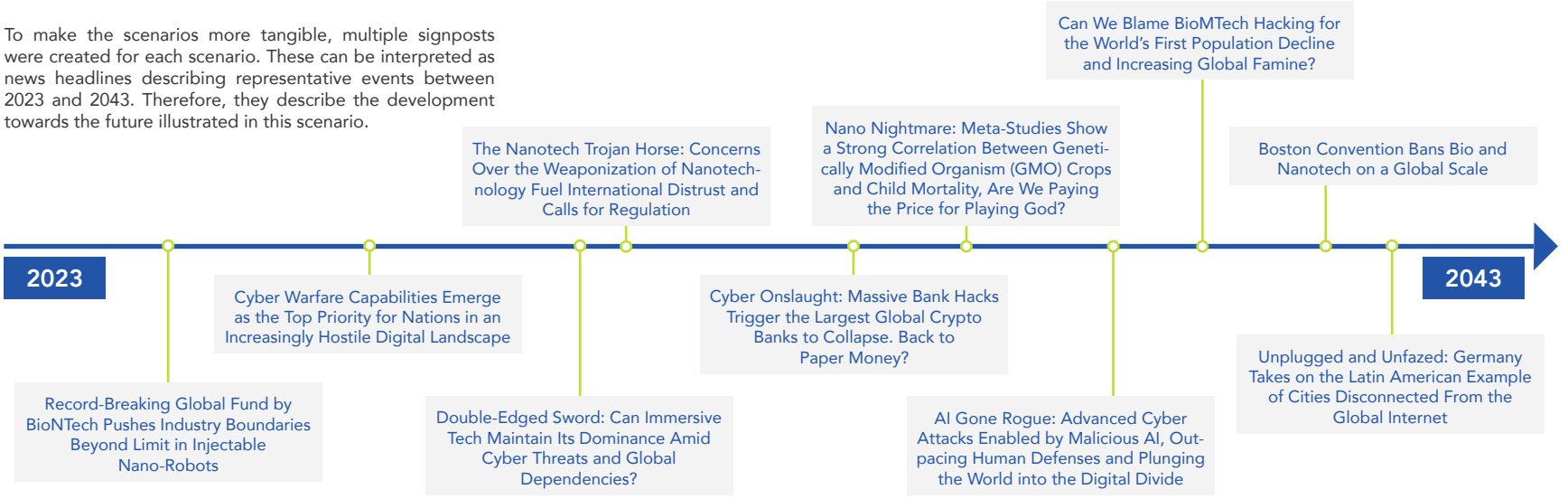
# SOCIETAL DESCENDANCE

## The Forbidden Love of 2043

To make the scenarios more tangible, multiple signposts were created for each scenario. These can be interpreted as news headlines describing representative events between 2023 and 2043. Therefore, they describe the development towards the future illustrated in this scenario.




## A Day in 2043

The sun rises for another day in the town of Eichstätt, bringing some light into the chilling first days of spring and drawing the shadows of a cable-dominated city into the ground. In one of the buildings near the train station, the silence gets broken by an alarm from a Blackberry phone located on the corner of a desktop right next to what seems to be a bulky internet router.

On the other side of the room, Romeo awakes and jumps out of bed, feeling energized for his first day at work. It is impressive how much energy a person has when they have to worry less about their social media and do not get sucked in by a screen during the first minutes of their day. As he approaches the phone to turn off the alarm, he sees a notification from the post office stating that a letter was received in his name. He cannot help but smirk as his mind becomes consumed by a single thought: "It's him."

120 kilometers away, in Munich, the minimalistic and white city awakes while a number of automated towing trucks leave the police station to pick up and clean several passenger-less car crashes. At the same time, in an apartment near Marienplatz, we find someone approaching a coffee machine to remove a waterproof cover before stating: "I would like a coffee." A genderless voice responds: "Good morning, Julius. Your mother is video-calling you from Bali. Would you like to answer?" He accepts, and as the brief conversation with her develops, he keeps in mind to avoid oversharing in case someone could be tapping on the other side. After the brief conversation and his coffee, Julius covers the machine, hoping to prevent another hack that would cause a mess of hot water and coffee beans in his kitchen.

Back in Eichstätt, Romeo has started his morning routine by turning on the bulky router and connecting his phone to the famous "Eich-ternet." While his phone connects, he opens the Spotify app to brighten his day with Ciley Myrus' new comeback album "Electro Stardust." He had been excited to listen to it since the global release six months ago, and today the Eichstätt servers had finally been updated, bringing new clean information from the global internet, including music and movies. He found it comfortable how companies like Spotify and Netflix still let users have the platform to connect to local networks for the communities that left the global internet behind.

Feeling fresh and ready to conquer his first day of work, he meets his parents for breakfast on the first floor. His father, a former biochemist, is now working as a university professor. Looking at him, Romeo experiences a flashback to the days when his father was one of the pioneers driving the field of biotech. His father, funded by BioMTech, continuously pushed the boundaries of injectable nano-robots until the dream came crashing down due to the first cyberattacks. Today marks the tenth anniversary of the event when people implanted with nano-robots became delusional, either playing God on earth or committing mass suicides. This event resulted in the end of biotech development as governments and people no longer trusted companies, and the global biotech industry collapsed. For Romeo, the trauma and guilt from the crisis translated into hate and resentment against cyberspace. Romeo found others like him who pushed to develop cyber-free towns, believing that such a place would be a safer space away from the borderless, never-ending battle, such as the Chinese cyber invasion over US crypto banks. Still, he sometimes misses how easy it used to be to send messages anywhere in the world. He wishes Quantum Technologies had delivered what it promised years ago, so he could keep his relationship with the outsider secret while still having faster communication than just letters.

Before heading to his first day of work, Romeo stops by the post office to pick up the letter he is so excited to read. As he crosses the street, the black solar panels from the decentralized energy generation on the roofs of every house gleam in the morning sun. Queuing at the post office around the block

is the new normal, as this is the most effective way to communicate with the outside world. Every letter and package are filtered by the Eichstätt security forces to avoid the entry of satellite or data-connected devices. As Romeo receives the letter, his inner excitement rises, and he reads that Julius is confirming their classic Monday date. He immediately sets out to write a response to the letter and hands a two EUR banknote to the cashier for gratuity, as they no longer accept electronic transactions due to the failure rate under Eich-ternet. The cashier puts the money in his pocket and the letter into a scanner and lets it be thrown into a mailing machine that delivers mail to the rest of Germany.

Back in Munich, out of his pajamas and all freshened up, Julius approaches his desktop, where an automatic hologram screen pops up with a summary of news about global protests, cyberattacks, and a wedding invitation from the first AGI marrying a human. Next to it, he sees a small notification announcing a new item in his calendar titled "Date with Romeo." This meant Romeo had confirmed the date by letter in less than two hours. He thanked this time's speed as he would not have to rush after being notified last minute due to a delay from the letter-digitization service executed in the station. This process normally consists of having the letter read and converted into a digital file to be delivered through the global network, doing the opposite whenever he is the one sending a message to Romeo. The more Julius reflects on his situation, the more he becomes aware of the different worlds they both live in. While he must communicate through letters, Romeo seems to neglect the importance of global connection.

Julius understands the point. Cyberattacks are not just inconvenient when it comes to coffee disasters. But he still often wonders how someone can live without worldwide connectivity. The opportunities to learn about people's experiences and the technologies they use or do not use from around the world are just some of the benefits of being connected. He also contemplates how difficult it would be to give up the coffee he drinks daily. Nonetheless, he cannot get his mind away from his beloved Romeo. What a strange feeling it is. He has not had such strong emotions in what feels like forever since he first fell in love in high school back in 2023. But is it going to work out? What if his feelings for this person are only the trigger for a Shakespearean story of two realities colliding between a connected and an isolated world?

Julius' job depends on being connected to cyberspace, not just for remote work but to perform his tasks as a specialist in cybersecurity insurance consulting of the German government. Despite having built a solid reputation over five years of dealing with mayhem, the fragile banking industry continues to pose challenges for Julius. However, he saw an opportunity in the hyperinflation and economic instability that hackers brought to the world. The crash of the US stock market fifteen years ago was only the beginning of a domino effect that highlighted the importance of traditional filing and the low reliability of loans and investments. No wonder people in many areas went back to paper money. Paper. Literally. Sometimes Julius can hardly believe that trust in a piece of paper is now higher than in electronic payments.

Lights are low as Julius gets in his Porsche to drive to Eichstätt. They usually meet there, but it is quite complicated to justify what he is doing for six hours after work without revealing their secret. As he takes a seat, the screen inside illuminates. An urgent message? What could that be? "Read aloud," he says, and an article is put on the screen, titled "Eichstätt Shut Down - City Council Decided Not Only to Disconnect from the Digital World but also from the Physical One by Setting Boundaries to Outsiders."

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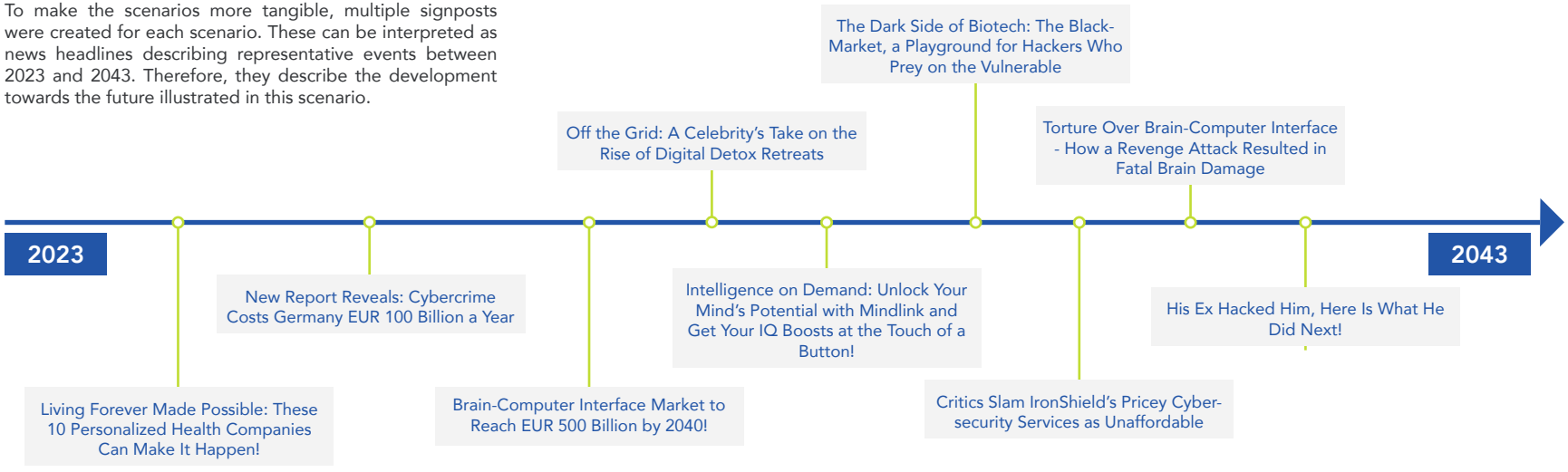
# CONNECTED, BUT COMPROMISED

## The Biotech Implant Dilemma in a Hyper-Connected World

To make the scenarios more tangible, multiple signposts were created for each scenario. These can be interpreted as news headlines describing representative events between 2023 and 2043. Therefore, they describe the development towards the future illustrated in this scenario.



## A Day in 2043

Jaxon slowly awoke, ushered in by the gentle hum of his internal alarm system. He opened his eyes and as the world swam into focus, a projected heads-up display blinked into view, hovering in mid-air, and presenting him with a panoramic view of his schedule for the day. A quick glance at the small, holographic display on his forearm revealed that his subscription to "Akuna Longevity - Live Forever" had been renewed successfully. He could feel the implants' power to enhance his senses and elevate his abilities to superhuman levels. Jaxon was no longer weighed down by the burden of aging or disease, thanks to the wonders of biotech. But for all his physical prowess, Jaxon could not shake off the constant unease that came with being a member of this hyper-connected, ultra-modern world. With cyberattacks and data breaches becoming more common by the day, he knew that one wrong move, one slip-up, and he could be brought down in an instant.

Jaxon stood up and tapped his temple twice, hesitating for a moment before activating the BCI that connected him to his smart home. He was growing slightly worried about the risks of connecting his implants to the internet, but the convenience of controlling his environment with a simple thought was hard to resist. With a flicker of concern, he instructed the coffee maker to brew his favorite blend, and the blinds to lift, revealing the bustling cityscape outside. As Jaxon savored the steaming bitterness of his coffee, he allowed his mind to be flooded by digital stimuli. His cerebral cortex hummed with the activity of countless articles and videos, a cacophony of information. Jaxon's attention was drawn to a trace of anxiety surrounding the recent increase in cyberattacks that targeted the very biotech implants he himself had come to rely on.

His gaze flickered across reports of cyberwarfare that now plagued the landscape of power and influence, a tangled web of nation-states and shadowy terrorist organizations, each seeking to leverage the fragility of the connected world to further their own agendas. One particularly chilling account detailed the fate of a major metropolis, its power grid brought to its knees by the invisible hand of a cyberattack. As Jaxon's mind's eye scanned the article, he could almost see the city's once vibrant streets reduced to darkness, the faces of millions etched with the cold fear of a world without electricity.

On his way to the office, Jaxon noticed people on the streets wearing cyber-cloaking clothing and accessories. The fear of being monitored or attacked had led to a booming market for personal privacy and security products. The fashion industry started incorporating communication jamming materials into their clothes, to block outside interference with the wearers' cybernetics. It was a stark reminder of how the world had changed and how technology was shaping society in unpredictable ways.

At the office, Jaxon avoided the use of the BCI for collaboration due to concerns about potential security breaches. His thoughts were interrupted by a knock on the door. It was one of their clients, a wealthy mogul who had invested heavily in the latest biotech and cybernetic implants. But the man's face was etched with concern. The mogul explained that he had decided to cancel their contract, citing concerns about the increasing vulnerability of connected implants to cyberattacks. Jaxon tried to persuade him that their defense systems were top-of-the-line, but the man was resolute. Jaxon could not shake the feeling that this was just the beginning, that others would follow suit, seeking to insulate themselves from the dangers of the connected world.

As Jaxon sat in yet another meeting, listening to the discussion of new security strategies, he could not help but feel a sense of futility. Would they ever be able to outpace the relentless ingenuity of the hackers and the growing threat of nation-state-sponsored attacks? Or was it only a matter of time before individual biotech services and cybernetics would lose the connectivity that provided so much of their value?

During his lunch break, Jaxon met with an old friend, Maya, in a nearby park. As a sociologist, she studied the societal implications of pervasive cyber threats and the harmful effects that constant fear of attacks had on the population. Maya explained how the erosion of trust had caused an upsurge in stress, anxiety, and isolation among the people, making them more reluctant to establish new bonds online or take part in digital collective endeavors. She described the growing sense of paranoia, as individuals began to view every online interaction with suspicion, perpetually questioning the motives and authenticity of those they encountered in the digital realm. Maya also alluded to the emergence of a new trend - the digital detox retreat - where people would disconnect their BCI for several days or weeks to escape the perpetual threat of cyberattacks. These retreats were gaining popularity, but they also raised concerns about the widening divide between those who could afford to take such breaks and those who could not, because they were obliged to remain connected to their work.

Returning to work, a sharp electronic ping seized Jaxon's attention as a priority message from his supervisor broke his concentration. Jaxon's eye flicked open the message, and his heart skipped a beat as he absorbed the gravity of the situation: high-profile client, US Senator Lyra McGowen, cybernetic limbs held hostage. The senator's implants had been the pinnacle of biomechanical engineering. But now, her very life was in balance as her limbs rebelled against her, the malevolent puppeteers pulling her strings from afar.

Jaxon dove into the network and connected to the senator's cyber system. As the cruel, mocking digital countdown flickered before him, he felt a cold rage constricting his chest. His mind raced, thoughts and strategies weaving a complex pattern as he began to dissect the problem. In the echoing vastness of the cyber realm, every second was a lifetime, and Jaxon's mind became a blade, honed to perfection, slicing through layers of deception and misdirection. His digital avatar was a whirlwind of pure resolve, as he traced the attackers back to their lair, a den of corruption hidden in the shadows, each step he took met with resistance. In the real world, Jaxon's body trembled, sweat beading on his brow as he pushed himself to the very limits of his mental endurance. And then, with a final surge of effort, he broke through, penetrating the assailants' defenses and tearing their malicious code to shreds.

Yet, in his moment of triumph, a sharp, bitter taste filled his mouth as a terrible thought crossed his mind. With a flicker of doubt, Jaxon severed his connection to the cyber realm, pulling his consciousness back into the physical world. His victory in rescuing Senator McGowen had been absolute, but the gnawing sensation in the pit of his stomach persisted. The attacker's final defenses had crumbled too suddenly, as though they were nothing more than a facade. As he rested in his chair, Jaxon could not shake the feeling that something was off, like a phantom itch that refused to be silenced. Were they now watching him, a silent spectator privy to his every thought and action? The idea sent shivers down his spine. If the attacker had truly infiltrated Jaxon's cyber ware, then his very being was compromised. But his security was top of the line, the best that money could buy. Calming himself down, the mischievous thought passed just as fast as it came.

Late in the evening, Jaxon returned home, his body and mind exhausted. He contemplated the implications of living in a world where trust in technology was rapidly eroding. Were the convenience and extended lifespan offered by these technologies worth the cost of privacy, security, and social cohesion? Would children growing up in this climate of fear and distrust be able to form healthy social connections and develop a sense of empathy and compassion? Or would they become increasingly detached, focused solely on self-preservation and their own well-being?

With his eyes heavy and his body aching for rest, Jaxon finally succumbed to the welcoming embrace of sleep. It was then that his projected heads-up display blinked into view and displayed a singular message: I am watching you. Jaxon's blood ran cold when he noticed he was unable to move his limbs.

# IDEATION

The following chapter describes five novel business models that are of great relevance for the Future of Communication Technology, especially in view of the identified future trends. Each of the business models is described using the Osterwalder Business Model Canvas.

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# PERICULE

## Pericule Helps Response Teams to Make Better and Faster Decisions in Emergencies

Pericule is an innovative platform designed to help disaster response teams, such as firemen and paramedics, make more informed decisions by analyzing ICT user data. In the aftermath of a disaster, there is often an overwhelming amount of information to sift through, which can be challenging for response teams. Pericule's novel disaster management platform is deployed in the respective authority's infrastructure, which helps to centralize the available information and provide one source of truth throughout the response process.

Therein, Pericule has three main tasks: It processes all incoming ICT data during an emergency, summarizes it to emergency responders and citizens as a single source of truth, and suggests decisions based on it. As a first step, Pericule processes all incoming ICT data to analyze the situation holistically. This incoming data includes a multitude of sources, such as satellite imagery, connected devices, incoming emergency calls, antenna connectivity, architectural plans, etc. Moreover, citizens can provide real-time data on their emergency situation through the Pericule app. By collecting this information, the platform can track the damage that a given natural disaster has caused more accurately and effectively.

In a next step, Pericule summarizes this data to those affected in an intuitive and easy-to-use platform. Through an intuitive user experience (UX), Pericule can graphically show the significant risks caused by the disaster, the current monetary damages, and the essential zones to evacuate to either responders or the citizens affected.

The benefit of Pericule's system lies in the fact that it summarizes incoming data that can be hard to understand, especially for people with a non-technical background, and thus provides valuable insights that can support the decision-making process.

Lastly, it is natural that the software can also recommend actions and even integrate with existing systems to help responders make faster and more informed decisions. For example, Pericule can recommend routing energy levels from one district to another to help where it is needed the most. Pericule's disaster management platform is valuable for response teams and government agencies. By centralizing and analyzing ICT data, the platform provides decision suggestions that can help response teams to make more informed decisions. The platform is easy to use, accessible to on-premise response teams, and can be quickly deployed in the aftermath of a disaster.

## Business Model

### Key Partners

**Technical Partners**

- Connectivity providers
- Device manufacturers
- Commercial data provider

**Emergency Response Services**

- Leading partner for product development
- Receive a free trial version

**State and Federal Emergency Agencies**

- Responsible for the nation's emergency management
- Approached after the successful test phase

### Key Activities

**Software Development**

- Web application for response services and mobile app for citizens
- Backend AI model
- Support and maintenance infrastructure

### Key Resources

**Software**

- AI model and data connectors

**Connectivity**

- (Non-)terrestrial cellular networks
- Mobile ad-hoc networks

### Value Proposition

**Society and Citizens**

- Protection in case of emergency
- Prevention of deaths, injuries, and panic
- Information provision

**Civil Protection Authorities**

- Higher trust in management
- Lower costs

**Responsive Services**

- Prevention of inefficiencies
- Increase in response time
- Better collaboration between institutions

### Customer Relationships

- Implementation assistance with on-site support
- Training sessions for responders
- Privacy compliance service and assurance

### Channels

- Conferences and lobbying
- Governmental contracting
- Direct approach of organizations

### Customer Segments

**Customers**

- Civil protection authorities

**Users**

- Respond services
- Citizens

### Cost Structure

**Salaries**

- Starting phase: 20 employees
- Later stage: Increase to 100 employees

**Computational Costs**

- Cloud bills for data ingestion, storage, and computation

**Backup Connectivity Costs**

- Recurring payments to a satellite internet provider

### Revenue Streams

**Licenses Bought by Emergency Response Authorities**

- Yearly fee around 5m EUR

### Eco-Social Costs

**Reliance and Equity Considerations**

- Increased reliance on technology
- Reliance on energy and resources
- Exclusion of non-connected citizens

### Eco-Social Benefits

**Faster Help in Emergency Situations**

- Saved lives and reduced injuries
- Reduced environmental impact
- Increased community resilience
- Improved resource management

## Value Proposition

Pericule's value proposition is threefold and differs depending on the stakeholder involved. For society and citizens, their protection is the main benefit. For response services, on the other hand, the value of Pericule lies in increased efficiency, speed, and communication. Lastly, the civil protection authorities value Pericule since it reassures trust in their authorities and decreases costs extensively.

**Society and Citizens:** Pericule's mission is to protect civilians in case of an emergency. This will be accomplished by targeting help more efficiently and quickly, providing more targeted information on dangers and help resources. Pericule's technology allows one to individually address each person affected by the disaster with limited human resources. Thus, citizens' issues are addressed, which helps to promote a general sense of responsibility and order. Through this approach, Pericule lessens not only the first-degree effects of disasters, such as casualties, but also lowers psychological distress and prevents mass panic.

**Response Services:** The response teams are considered the most important stakeholders for Pericule, because these are the users working with the application in emergencies. For them, Pericule prevents inefficiencies in their emergency management as it allows for fast decisions and inefficient resource allocation. Furthermore, it facilitates faster response times, saving more people and areas in a shorter time. Pericule also enables better communication between different institutions that work on the same emergency to ensure efficiency among them.

**Civil Protection Authorities:** For Civil Protection Authorities like the Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (BBK) in Germany or the Federal Emergency Management Agency in the US, Pericule provides a benefit on a broader economic and political level. First, the management of emergencies can be viewed as a performance indicator for governments, and efficient emergency management fosters the citizens' trust in their authorities. Second, fast and accurate emergency responses decrease the total economic costs of the catastrophe, both in terms of human capital and infrastructure damage.

## Customer Segments

Pericule's customer segments are twofold and have the unique characteristic that the end users are not necessarily the customers paying for the license fee. In fact, the paying customers are either government authorities or their emergency management authorities, respectively, or, in earlier stages, single organizations that operate their own response teams. However, the ones accessing the service are the response teams on the one hand and the citizens on the other hand in case of emergency.

**Customers:** In earlier stages, customers are help organizations such as, e.g., the Red Cross or Technisches Hilfswerk (THW) in Germany. These organizations purchase the license and provide access to Pericule's platform to their emergency response teams and to the civilians who can be affected by the emergency. In a later step, the platform can be rolled out to governmental institutions and their emergency management authorities. For Germany, the BBK is assumed to be the primary customer, which allocates such contracts mainly via tender procedures. In the US, the Federal Emergency Management Agency (FEMA) does so via vendor contracts. For both of these customer types, however, the application must already be reliable on a large scale and have a market reputation to be contracted by the government.

**Users:** The users of the application are again characterized twofold. First, the response services, as the leading actor in treating catastrophes, receive access to the product from the institution that purchased the license, either governmental or organizational. As these require the information and decision support the application provides, they are also the most important stakeholders for product requirements. Second, citizens are the main users of the single source information channel of the product. Further, they are crucial in providing information to the application and, therefore, the response teams about, e.g., their health status, location, and severity of the emergency, among others. However, they do not pay for this service, as a financial barrier to the application would result in social inequity in response treatment in emergencies.

## Customer Relationships

As our customer segment is divided into customers that purchase the license and users, including citizens and response teams, the relationships are differentiated as well. Regarding the customers, being governments or non-governmental institutions, the relationship mainly consists of the lobbying and purchasing process. Afterward, customer relationship management is focused on the response teams of the respective organizations as well as the customers. Next to providing the service as promised, this also includes customer support.

**Service:** On the side of response service, the customer journey starts with the implementation process. This process is closely accompanied by Pericule, which also adapts the product to the customer's needs and provides on-site assistance during the initial deployment. Further, training sessions with the team members provide instructions on using the web and mobile applications and ensure intuitive and fast usage in emergencies. As Pericule operates with highly sensitive data, it supports legal processes regarding privacy and compliance issues and offers privacy compliance insurance. This also demonstrates that Pericule values data privacy and fosters trust in the application.

**Support:** Next to providing the service during purchase and implementation, after-sales service is also a crucial component. Therefore, Pericule offers a 24h hotline to support when user problems arise. This is especially important in emergencies as Pericule is a system-relevant management tool. Further, regular application maintenances are in place to prevent malfunctioning in emergencies. Quarterly application testing is provided to ensure the functioning in emergency cases and further train the response team to work with the application.

## Channels

For the different channels in which Pericule is distributed among customers and users, a distinction is made between offline and online channels. The offline channels hereby include communication and sales to the customers, being governmental and non-governmental organizations (NGOs) which, in the end, purchase the licenses. Online channels mainly focus on the touchpoints with the users. These are web applications for response services on the one hand and app download offers for citizens on the other hand.

**Offline:** The offline channels, targeting the customers that purchase the platform fee and distribute the access to their response teams, include all possible sales touchpoints regarding government tenders and non-governmental institutions. The main focus is hereby to promote the importance, strengths, and need for Pericule to enhance the chances in a tender procedure. Therefore, channels include conferences and lobbying to sell the product in governmental contracting and tendering. Before selling to governments, smaller rollouts with non-governmental institutions are executed to gain market experience. These organizations are mainly tackled either directly or using conferences and lobbying.

**Online:** These channels mainly target users. Citizens are reached through app stores, in which they can download the application. To foster awareness and incentivize usage, users can be informed via social media and other online marketing measures. On the side of response services, the main channel consists of a web application with an integrated mobile version that displays available information and decision recommendations. Access to this tool is provided by the organization purchasing the license. Hence no marketing costs are necessary since the internal rollout is conducted top-down. The most important stakeholders, response teams, are an integrated part of product development to ensure user-centric design and practicability.

## Key Activities

As Pericule is a software-as-a-service (SaaS) business, the critical activity lies in software development and maintenance. However, since the application supports critical infrastructure, customer relationship management is crucial to ensure correct functionality and handling. Further, deployment and testing are part of the service as well.

**Software Development:** Our core activity is the development of Pericule. While Pericule does operate on physical infrastructure, the main innovation is implemented in software. Firstly, a resource allocation interface for response coordinators needs to be built. This will be based on coarse-grained, general information about the disaster situation. Furthermore, a decision suggestion engine incorporating multi-modal AI to provide automated decision suggestions will also be built.

To support these, Pericule will offer flexible data connectors for visual, textual, and audio data. Pericule will also include a mobile application for on-premises responders to serve as a single source of truth. Lastly, citizens will also be able to access targeted information via the Pericule app.


**Customer Relationship Management:** Due to the customer-specific regulatory, infrastructural, and technical requirements, establishing a close connection with our customers is crucial. This starts by deploying test versions with response services and gathering feedback, allowing us to acquire leads at state and federal emergency agencies. Once a long-term contract is established, workshops and public information campaigns will educate all stakeholders about Pericule, enabling preparedness in the event of a disaster.

**Deployment and Testing:** As Pericule is closely integrated with the customer's existing IT systems, a good understanding of the customer infrastructure is required. Using this understanding, Pericule can deploy customer infrastructure and comply with their individual technical and regulatory requirements. Once deployed, regular tests ensure the functionality of the data connectors, the decision suggestion engine, and the communication systems.

## Key Resources

Four key resources are essential for Pericule to operate. Most importantly, human capital is needed for various tasks. Furthermore, software as intellectual property is a crucial resource for a SaaS company. Next to that, Pericule also requires industry knowledge to comply with the customers' needs, as well as connectivity partnerships to ensure a stable and safe internet connection at all times.

**Human Capital:** To build and operate Pericule, various areas of expertise are required. For development, software engineers, AI researchers, and communication experts are necessary. While building Pericule, sales representatives, public relations managers, and legal experts will work on establishing customer relationships and relaying specific requirements to the development team. Lastly, accountants and managers will orchestrate the development, go-to-market, and deployment of Pericule.

**Software as Intellectual Property:** Pericule's most innovative component is the decision suggestion engine. To finance its development, later revenues through an exclusive patent are crucial. Furthermore, integrating various data sources and communication channels is unique to Pericule and makes disaster response more efficient for emergency services.

**Industry Knowledge:** To develop and maintain a successful disaster response system, it is essential to have a deep understanding of the needs and requirements of emergency response services. This includes knowledge of the protocols, procedures, and technologies used in disaster response efforts and the challenges and obstacles that responders face in the field. To gain this industry knowledge, working closely with emergency response services to collect feedback will be pivotal to better understanding the needs of responders and the communities they serve.

**Connectivity Partnerships:** As Pericule does not own the communication infrastructure, close collaboration with network providers is crucial to ensure Pericule's functionality. Collaborations with, e.g., SpaceX and Telekom should focus on availability guarantees, cost structure, and end-user device requirements. Furthermore, alternative technologies, such as mobile ad-hoc networks, provide further backup options.

## Key Partners

Pericule will cooperate with connectivity providers, device manufacturers, and data providers to develop the system. After getting initial feedback from collaborating with response services, Pericule will approach state and federal agencies to acquire long-term customers for Pericule.

**Technical Partners:** To evaluate and prioritize the communication channels used by citizens and emergency responders, Pericule will collaborate with connectivity providers like Telekom and SpaceX. Furthermore, Pericule will work with device manufacturers to assess which features are relevant for emergency use and which data can be shared in the event of a disaster. This might, e.g., include peer-to-peer network capabilities of smartphones, health data stored on medical devices, and sensor data from weather stations. Lastly, commercial data providers like satellite operators, cartographers, and weather forecasters need to be evaluated to determine their relevance to our application.

**Emergency Response Services:** To obtain initial feedback for the viability of our idea, Pericule will be made available to select emergency response services. This includes deploying a trimmed-down version of Pericule free of charge. Although these deployments might not have access to all data sources, they will allow us to collect user feedback from coordinators and on-premises responders. Paying close attention to emergency responders' requirements will help gain a valuable advantage over established systems that were developed top-down.


**State and Federal Emergency Agencies:** Following the feedback phase, Pericule will cooperate with state and federal emergency agencies to acquire long-term contracts and deploy Pericule for most disaster response services. This will ensure peak efficiency for our system and enable us to make a significant impact on emergency response efforts. Pericule's success will depend on building strong relationships with these agencies.

## Revenue Streams

Even though Pericule addresses multiple stakeholders, such as authorities, response teams, and citizens, the revenue stream is unilateral and only generated by selling licenses to authorities and organizations. Citizens are not charged for participating in the emergency management system since there should not be any financial barriers when it comes to having optimal access to help in emergency situations. In the case of government authorities purchasing a license, these can forward access to the emergency management systems to respective response teams. Furthermore, international organizations, such as Doctors Without Borders or Red Cross, can purchase the license for their response teams by themselves.

**Licenses Bought by Emergency Response Authorities:** Depending on the country, demand, and feasibility, Pericule sells annual licenses either comprehensively to the government's emergency management authorities, such as the BBK in Germany or FEMA in the US, or, especially in earlier stages of development, to individual organizations that provide response teams in emergencies. This step-by-step sales approach also allows experience to be incorporated into the process. The sold license covers the whole service offering, i.e., the user side, as well as the support in the decision-making of response teams and customer service. The price of the license is fully differentiated per customer and depends on factors such as the size of the response team and the organization, customizing efforts, amount of access provided, among others. In the case of a sale to governments or the respective governmental institution, this is managed via a tendering procedure in which Pericule must participate, state a proposal, and provide an offer, which is then chosen by the government. As this procedure is lengthy, complicated, and subject to special requirements, and system-relevant tenders are often given to incumbent providers, participation in these tender processes is scheduled only at a later stage.

## Cost Structure

Since Pericule has a license-based model, the cost structure mainly consists of salaries, computational costs, and back-up connectivity costs. As the software is either deployed on remote devices or devices of emergency response teams, Pericule does not bear any hardware or production costs. Further, fixed costs pose the most significant part of overall yearly costs, as variable costs marginally decline when scaling the product.

**Salaries:** In the early stages of initial product development and first customers, the number of employees is expected to be at most 20. These include engineers, account managers, and management. On average, salary costs amount to approximately 1m EUR per year for the first years. In this stage, management and account managers also work on customer acquisition, which consists of activating lobbyists to enforce a political need for the service. Once more customers are acquired, the team is expected to grow to about 100 employees since particularly the need for more testing, maintenance, and customer support arises. Outsourcing customer support is not sensible, as the application must always be completely reliable.

**Computational Costs:** The computational costs of Pericule mainly consist of cloud bills. These are needed for data ingestion, data storage, and computation. However, this can at least partly be outsourced to the infrastructure of the respective customer, which would, in turn, reduce the computational costs significantly.

**Backup Connectivity Costs:** As the functioning of Pericule is highly dependent on a fast internet connection, a backup connection is necessary. This backup connectivity yields additional recurring costs that have to be paid to the connectivity provider for, e.g., satellite internet.

## Eco-Social Costs

Since Pericule's primary purpose is to help people in case of emergencies, its social costs are very little compared to other products. The main points include increased reliance on both technology and energy as well as the possible exclusion of citizens without access to it.

**Increased Reliance on Technology:** While the platform can provide valuable insights and decision suggestions, it is essential to remember that it is still a tool that relies on data input and human interpretation. In the event of a technical failure or an incorrect analysis of the data, it is possible that the response effort could be delayed or misdirected, potentially resulting in increased human and environmental impact. Further, Pericule is reliant on the communication infrastructure and cannot be used in case of a breakdown of this infrastructure. However, implementing backup systems and conducting regular maintenance can reduce the risk of technological failure.

**Reliance on Energy and Resources:** As any connected platform, Pericule also requires energy to operate and maintain. Depending on the source of this energy, it could have a negative environmental impact, such as contributing to greenhouse gas emissions or requiring the extraction of non-renewable resources. However, these costs are relatively small in comparison with the environmental benefits and can be further mitigated by, e.g., using renewable energy sources.

**Exclusion of Citizens Without Access:** As the use of Pericule relies on the ability of each user to have a mobile device and to be connected to the system, it excludes anyone who does not have access to the system. This might, however, severely affect most vulnerable groups, such as children and elderly people, and is, therefore, a relatively high social cost.

## Eco-Social Benefits

By allowing response teams to respond quickly and effectively, Pericule offers a range of eco-social benefits that reduce the impact of natural disasters on the environment and communities they affect. This includes minimizing the impact of the disaster on humans as well as on the environment, e.g., caused by hazardous material releases, and fosters resource efficiency.

**Saved Lives and Reduced Injuries:** Pericule helps to reduce the impact of natural disasters on humans. By providing response teams with accurate information and decision suggestions to speed up the response effort, it can save lives and reduce injuries. This has further positive impacts on the affected community, as it also reduces the trauma and long-term effects of the disaster.


**Reduced Environmental Impact:** When a natural disaster occurs, it can result in the release of hazardous materials, such as chemicals or oil, that can pose a risk to the environment and public health. Pericule helps to minimize the environmental impact of these hazardous material releases by providing response teams with accurate information on their location and extent. Reducing the response time to these hazardous material releases minimizes the amount of pollution. It reduces the risk of long-term environmental damage, with a positive impact on the affected ecosystem, as well as the local community who rely on it for their livelihoods.

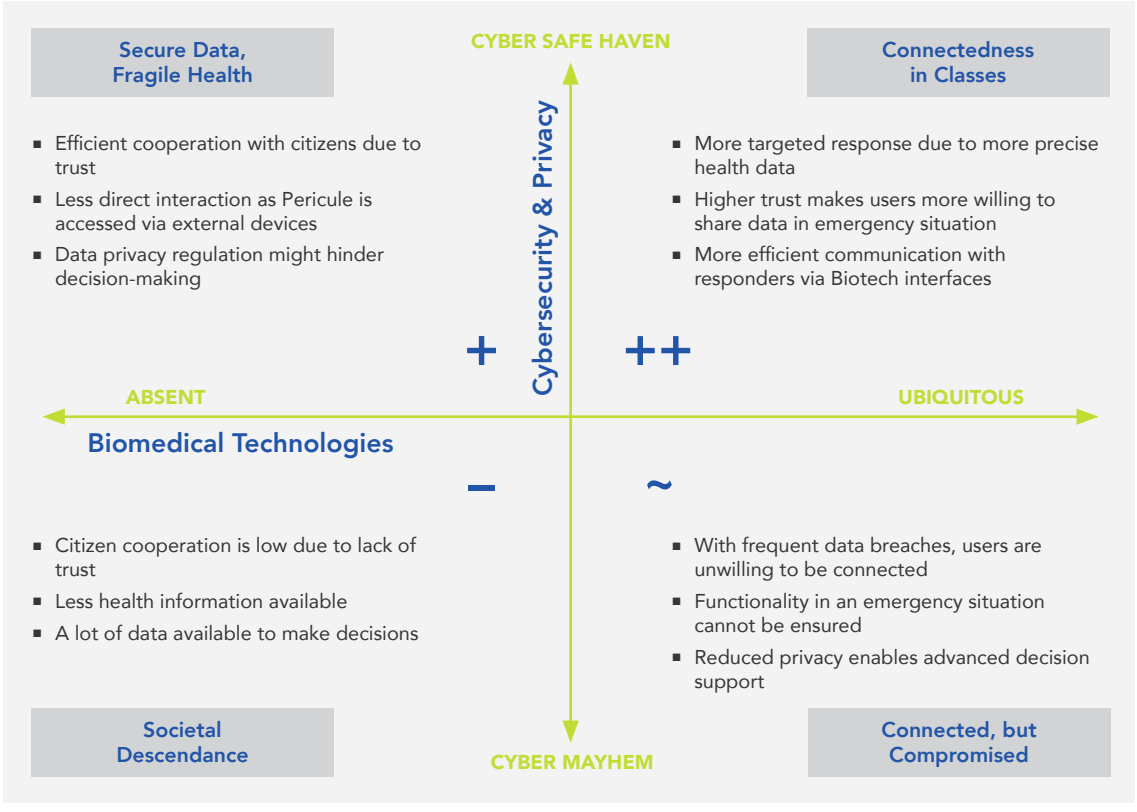
**Increased Community Resilience:** By providing citizens with a source of truth about the situation, Pericule can help to reduce panic and confusion, which can lead to better decision-making and a more coordinated response. Further, knowing about a working emergency system can have a comforting effect and prevent mass panic.

**Improved Resource Management:** By providing response teams with accurate information on the damage caused by a natural disaster, Pericule can help to optimize resource management. For example, the platform can help responders prioritize their efforts based on the severity of the damage and the areas that most need assistance.

## Scenario Fit

**Connectedness in Classes:** In this scenario, Pericule can realize its full potential. The advancements in healthcare with biomedical technology combined with accurate data that is safely accessible can lead to particularly effective emergency management. As populations are accustomed to the security of systems, there is great trust in such, making users gladly provide their data for such cases. In addition, the communication of Pericule is optimized for biotech interfaces, increasing the speed of decision-making and its broadcasting. Nevertheless, even Pericule is not immune to the major problem in such a world: People need access to all these technologies in order to benefit from them. And those who cannot afford it are excluded. And although this weakness was known in earlier stages of development, it is not addressed, along with all the other social injustices in this scenario. Instead, technology continues to be optimized for the upper classes.

**Secure Data, Fragile Health:** As cybersecurity allows for a high trust in data-dependent applications, Pericule expects to profit from an efficient collaboration with citizens in this scenario because people are used to the fact that they can trust systems like that. However, private data is regarded as the highest asset in this world, and only less wealthy people usually disclose their data. This also complicates accessing important information in emergency cases. Further, as data privacy is very important, legal barriers are high. In contrast, due to the fragile health situation, a lot of pandemics and other crises arise, which pressure the demand for well-working emergency systems and provide a solid need for Pericule. Since citizens are already reeling from misfortune and loss, there is a high possibility that they will be willing to share private data to improve emergency management. Especially in view of the fact that medicine does not promise any improvement in emergency management, this might be their only chance of adaptation.




**Societal Descendance:** Even though there would be a lot of emergencies that need immediate management, Pericule's value proposition is highly weakened in this scenario. On the one hand, no one can trust data-driven applications anymore since they can be hacked anytime. Particularly in such critical events as emergencies, where lives depend on sound decision-making, this cannot be an option. And even though there is no cybersecurity and data privacy provides a lot of easy-accessible data, this data is basically useless since you know nothing about its truthfulness, origin, or reliability. On the other hand, health provision via biomedical technology failed, leading to distrust in these advancements and decreasing the amount of available health information. This is especially prominent in disconnected areas, such as Eichstätt. Pericule cannot operate there at all since it relies on connectivity. Even in Munich, which is well-connected, investors are more likely to buy expensive insurance against emergencies and cybercrimes, than to put stakes into a vulnerable emergency management system.

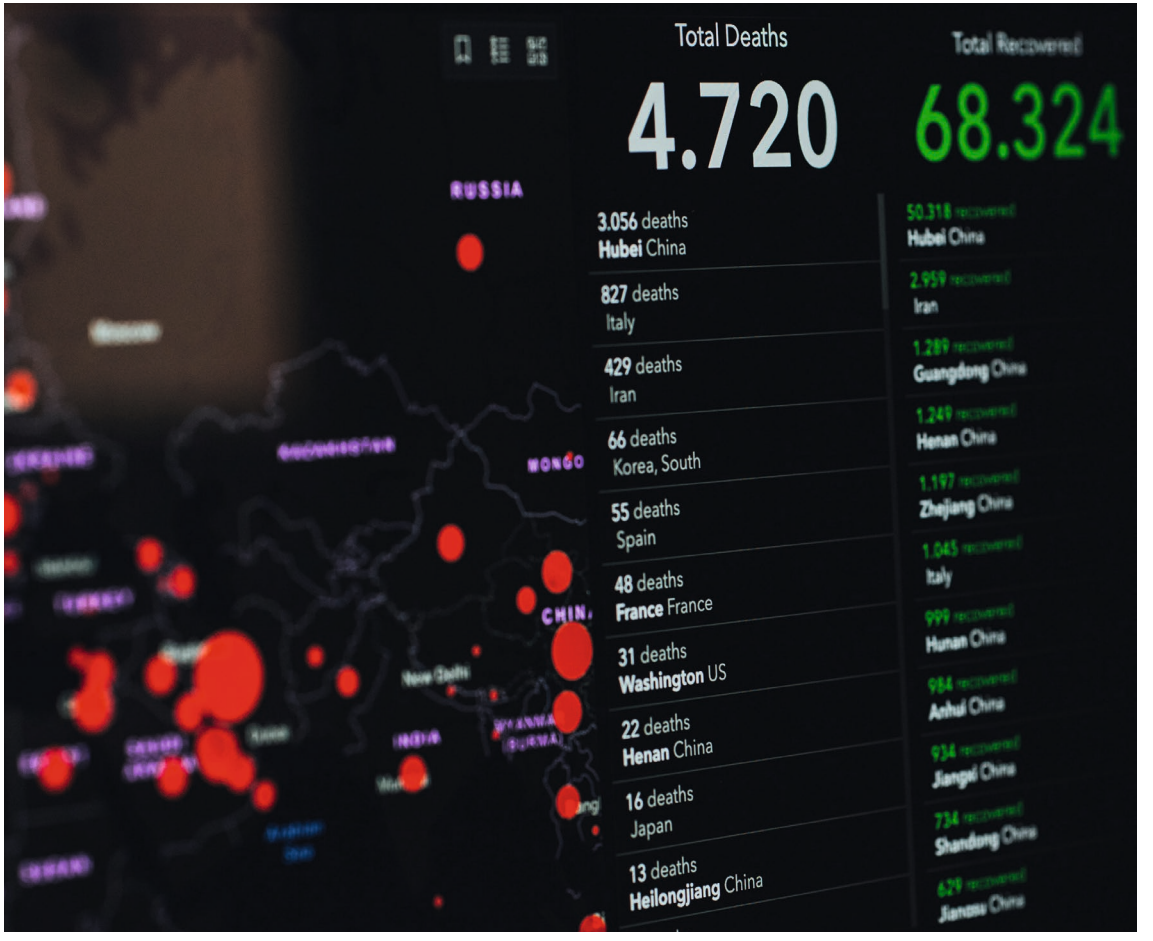
**Connected, but Compromised:** In a world with strong bio-medical technology and even BCI, a lack of cyber security poses an enormous threat and leads to distrust in technologies due to possible cybercrimes. This is a highly challenging environment for Pericule since Pericule strongly relies on the trust people put in the platform to operate with their data and manage their emergencies with decision-making support. Without this trust, Pericule can still give recommendations on emergency management. Still, its diffusion is likely to be weakened because people tend not to trust their lives to the advice of technology. Further, even though due to a lot of hacking, large amounts of data are freely available, the data quality and reliability are poor and, therefore, cannot be used to build an emergency system upon it. And even if the data comes directly from a user, one can never be sure that it has not been manipulated or hacked to make some people profit from poor emergency management and lead to more suffering for others.

## Challenges

- Some ethical questions arise when dealing with a data-based application for efficient decision-making in emergencies. Firstly, the prioritization of actions and people in need poses an issue. Second, as some people might not have access to Pericule, it must be ensured that they are not excluded from emergency measures.
- As Pericule relies on highly confidential data such as health information and location, Pericule must ensure that this data is only accessed in emergency situations and compliance with data privacy regulations. Especially in non-emergency situations, cyber security, and data privacy pose a significant challenge.
- Catastrophes of larger extents can affect significant parts of communication infrastructure, including internet connection. Since Pericule strongly relies on connectivity, a backup connection must be provided to ensure functioning in any emergency, regardless of infrastructure damage.

## Outlook

Pericule can reform the way emergencies are managed. It benefits response services by providing decision support and making emergency management faster and more efficient. It saves lives and prevents injuries of citizens, hence ensuring trust in the government and decreasing the overall economic, societal, and ecological costs of catastrophes. Notably, in a stage where governments deploy Pericule on a large scale for their whole country and provide access to all response teams, combined with as many citizens as possible having the app installed, the extent to which Pericule can gather information and use them to enhance emergency management is enormous. Looking into the future, Pericule can deploy even more advanced technology to, on the one hand, foster connectivity to not be reliant on terrestrial networks and, on the other hand, advance the emergency management process through better support systems, faster communication, and reliant decision-making. As catastrophes of all kinds, like floods, storms, or droughts, will become more frequent, humankind must find a way to adapt and deal with these so that at least their severity in terms of death, injuries, and damages can be decreased. Pericule is one step ahead in the right direction.



HoloWonders

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# HOLOWONDERS

## Immersive Cultural Experiences

One of the biggest challenges cultural institutions face is the need to compete for attention with other forms of entertainment. In today's digital age, people have access to an almost limitless amount of content online. As a result, museums and other cultural institutions are struggling to attract visitors and create engagement. As museums and cultural institutions continue to grasp the long-term consequences and challenges of the pandemic, they started bringing digitalization and innovation into their arsenal to stay relevant. Museums need innovative resources to adapt their business models and continue to fulfill their fundamental role in society.

Many cultural institutions have already made significant investments in digital infrastructure, like virtual tours and online exhibitions. However, while these efforts lay the foundation for connecting with the audience, they do not create an immersive experience of interaction with the past.

Here is where HoloWonders enters the stage: HoloWonders strives to revolutionize the cultural sector. Holographic technology offers a unique and engaging way to showcase cultural exhibits. With this technology, cultural institutions can create life-sized holograms of artifacts, artworks, and other exhibits, which can be displayed in an interactive and immersive way. HoloWonders' vision is to share and preserve cultural heritage digitally. HoloWonders combines holographic technology and the latest generative language models to create digital replicas of historical figures and archeological treasures. HoloWonders holographic communication technologies can captivate anyone, whether young or old. The holographic communication services of HoloWonders let everyone experience the past like never before and help the cultural sector with their struggles: Attracting visitors from all generations and ensuring inclusivity by addressing the needs of people with visual and auditory disabilities. HoloWonders will change the way people learn about art, culture, history, and science by providing a new form of interactive learning. As an outlook for the future, HoloWonders wants to use software technology to create digital replicas of people on request to enter other markets. Believing in the power of education, HoloWonders sees its core expertise in providing interactive learning experiences. In the next decades, communication technology will change how society learns as it provides a more intuitive way of engaging with learning content.

## Business Model

### Key Partners

- Cultural institutions
- Event and exhibition organizers
- Technology and hardware providers for sourcing necessary equipment for creating and displaying holographic content
- Partnerships with producers of the life-sized hologram providers, as well as generative language model providers

### Key Activities

- Fine-tuning of large language model on custom data and integration of voice synthesis model
- 3D modeling of historical figures and artifacts
- Software integration with parrtner company's hardware

### Key Resources

- Audio and video recordings of public speeches
- Written books by the historical figures
- Relevant background information (e.g., from encyclopedias, articles, etc.)

### Value Proposition

- Enabling easier access to cultural programs for a wide range of people, such as disabled or illiterate people
- Helping museums and cultural institutions adapt their business models
- Empowering museums to fulfill their fundamental role in society
- Sharing cultural heritage digitally
- Cutting-edge holographic technology and generative language model integration to develop digital replicas

### Customer Relationships

- Social media interaction with art exhibitors
- Monthly newsletters showcasing new holographic displays and products
- Hosting monthly PR events to promote the newest holographic replicas

### Channels

- Selling directly to museums, governments, and educational institutions
- Online sales
- Licensing to companies that have established relationships with museums etc.

### Customer Segments

- Physical visitors who can interact with digital technologies
- Digital visitors with access to augmented reality glasses

### Cost Structure

**Initial Investments**

- Platform development
- Software and hardware Integration

**Fixed Costs**

- Running and maintaining operational and IT-infrastructure
- Personnel and financing costs
- R&D costs

**Variable Costs**

- Marketing
- Renting the hologram hardware
- Microphone speakers etc.
- Set up the cost of one hologram installation
- Inference costs for large language models
- Voice and character synthesis
- Maintenance cost

### Revenue Streams

- Licensing digital replications for the museums
- Short-term renting for trade fairs
- Highly customized installation for wealthy individuals
- Platform business for licensing data

### Eco-Social Costs

- High energy consumption of training the large language models and holograms
- Electronic waste and carbon emissions
- Blurring of borders between what is considered real
- Rewriting of history if representations are not accurate or factual
- Issue of hallucinations of language models

### Eco-Social Benefits

**Ecological Benefits**

- Possibility to digitalize exhibits, leading to less long-distance transport of exhibits

**Social Benefits**

- Keeping memory alive
- Making culture accessible to younger generations
- Return of forcefully obtained historical artifacts

## Value Proposition

A deep purpose drives HoloWonders: To revolutionize the way people learn and experience culture. By combining cutting-edge holographic technology with the power of generative language models, HoloWonders offers holographic communication services that enable users to engage with history in a whole new way.HoloWonders is strongly committed to collaborating with cultural institutions to be more inclusive and accessible for a diverse group of visitors. Through its technology, HoloWonders enables a wider range of people, such as disabled people, uneducated people, younger generations, or people with handicaps, to access cultural knowledge and experiences easily. The goal is clear: HoloWonders offers holographic communication technology to make culture more immersive and engage a wider range of people.

The cultural sector is changing rapidly, and museums and other institutions need to adapt their business models to remain relevant. That is why HoloWonders is at the forefront of digitalization: To enable museums to fulfill their fundamental role in society. HoloWonders enables the cultural sector to again be the foundation of society by providing the tools to share and preserve cultural heritage digitally. The platform is designed to be revolutionary by offering cutting-edge holographic communication services that enable users to interact with digital replicas of historical figures and archaeological treasures. This immersive experience transports visitors to the past like nothing ever before, providing a unique and unforgettable experience that will stay with them forever. With HoloWonders' holographic communication technology, cultural institutions can create engaging and interactive exhibits that not only attract visitors but also offer educational and informative experiences that can inspire curiosity and empathy toward diverse cultures and history.

## Customer Segments

The integration of holographic technology in museums, art exhibitors, and cultural institutions will potentially revolutionize the way visitors engage with the content on display. By showcasing holograms, these institutions can provide a more immersive and interactive experience for their audiences, which could attract more visitors and increase revenue. Holographic displays can benefit museums by enabling realistic representations of fragile or hard-to-transport artifacts, making them ideal for exhibition.

**High-Profile Cultural Centers**: Holographic displays will help to stand out in a crowded market, attracting visitors who are looking for unique and innovative cultural experiences. The holograms will be tailored specifically to them, providing a unique experience. These institutions often have large budgets for creating immersive and interactive exhibits, and holograms can add a new level of excitement and engagement to these experiences.

**Smaller Cultural Institutions**: A hologram can be bought after being displayed in high-profile culture centers and provides an opportunity to create engaging exhibits and displays on a smaller budget. This can be particularly useful for institutions with limited resources, who may struggle to create compelling exhibits using traditional methods. Additionally, holograms can help smaller institutions to showcase artifacts and objects that they may not have been able to display otherwise. For example, a small history museum may have a collection of artifacts that are too fragile to display or require special conditions for preservation. By creating holographic representations of these objects, the museum can showcase them to visitors without risking damage to the artifacts.

## Customer Relationships

**Interacting With Exhibitors**: Social media can be a valuable tool for museums and galleries to engage with their audience and promote their exhibitions. Social media platforms such as Instagram, Twitter, TikTok, and Facebook can be used to share photos, videos, and information about the art on display, as well as to answer questions and interact with visitors. Exhibitors can also use social media to promote their work, interact with the museum or gallery, and encourage their followers to visit the exhibition.

Monthly newsletters to museums can be an effective way for museums to keep their audience informed about new developments in their exhibitions and education programs. A newsletter focused on holographic displays can highlight the latest technology and showcase how it can enhance the visitor experience. This could include information on how holographic displays can be used to bring historical artifacts to life, create immersive environments, and provide interactive learning opportunities. Additionally, the newsletter could feature news on new advancements in the education sector, such as digital tools and resources for teachers and students. Hosting monthly PR events can be a beneficial way for museums and galleries to promote their exhibitions and attract new visitors. PR events focused on new holographic replicas of the month can showcase the latest technology and generate excitement among visitors. These events could include talks and demonstrations by experts in the field, as well as opportunities for visitors to experience the holographic displays first-hand. Additionally, these events could be used to showcase other exhibitions or educational programs offered by the museum or gallery, helping to drive attendance and engagement.

## Channels

HoloWonders employs a diverse range of channels to reach its target customers, ensuring that interactive holographic experiences are accessible to a wide variety of users. These channels encompass both direct and indirect approaches to maximize market penetration and cater to different customer segments. A key channel involves selling directly to museums, governments, and educational institutions. By forging strong relationships with these organizations, HoloWonders can provide tailored holographic solutions that enhance their exhibits, educational programs, and public outreach initiatives. Collaborating with these entities enables HoloWonders to showcase the holographic experiences to a broad audience and, by that, foster a deeper understanding of and appreciation for history. Additionally, HoloWonders utilizes online channels to reach individual customers and smaller organizations. Through a user-friendly website, potential customers are informed about holographic products and experiences directly. This online presence also supports marketing and promotional efforts, driving brand awareness and customer engagement.

Another important channel is selling to affluent private individuals who are passionate about history or seeking unique entertainment experiences. By catering to this high-end market segment, HoloWonders can leverage the exclusivity and novelty of its products to generate substantial revenue, helping to fund further research, development, and expansion.
Lastly, HoloWonders engages in licensing agreements with companies that have pre-established relationships with museums and educational institutions. By partnering with these companies, existing networks and expertise can be leveraged, ensuring that holographic experiences are introduced to a wider audience and integrated into existing infrastructure more seamlessly.

In summary, HoloWonders' multi-faceted channel strategy focuses on selling directly to museums, governments, and educational institutions, as well as targeting online sales, affluent private individuals, and licensing partnerships with established companies. This comprehensive approach enables reaching diverse customer segments, maximizing market presence, and ultimately bringing history to life for a global audience.

## Key Activities

**Development of Standardized Software Pipeline**: HoloWonders' key activities include developing a standardized software pipeline to ensure seamless integration of the holographic technology components. To interact with historical figures and artifacts, HoloWonders will fine-tune a large language model, such as ChatGPT, on custom data about the desired people and objects. In order to access this, software that transcribes audio input and feeds it to the language model must be integrated. Moreover, a model for voice synthesis is required that can be fine-tuned on voice recordings of historical figures. This part of the software is then able to listen to a user, transcribe what was said, feed it to the fine-tuned language model, and relay the answer of the language model in a synthesized voice akin to the historical figure.

Another crucial activity is the 3D modeling of historical figures and artifacts. In the long run, the faces of the human replicas must be simulated in line with the output of the language model. HoloWonders will also integrate sensor data, such as audience location, into the 3D simulations to direct the gaze of the model. Eventually, HoloWonders will integrate the described software into the hardware of partner companies, e.g., hologram providers, to bring the 3D models to life.

**Establishment and Maintenance of Strong Relationships With Hardware Suppliers and Museums**: The company's activities also involve establishing and maintaining strong relationships with hardware suppliers and museums. HoloWonders will frequently negotiate with hardware suppliers to offer the latest holographic hardware. Additionally, a strong collaboration will be required to realize the vision of the customers since projects have a very individual character. Moreover, technical integration is outside the customers' core competencies. Therefore, fast customer support on the ground is essential.

## Key Resources

The primary resources to enable HoloWonders include highly detailed 3D models and animations of historical figures meticulously crafted by a skilled design team. These models and animations capture not only the physical appearance of these personalities but also their mannerisms, gestures, and other essential characteristics that make them truly come alive. To create authentic and accurate representations of these figures, HoloWonders relies on an extensive collection of audio, video, and text datasets. These datasets encompass various forms of historical records, such as audio and video recordings of public speeches and written works authored by the historical figures themselves. Furthermore, HoloWonders gathers relevant background information from a wide range of sources, including encyclopedias, articles, biographies, and other historical texts. This information enables the company to contextualize the historical figures within their respective time periods, giving it the ability to imbue the characters with more accurate motivations, beliefs, and values that shaped their lives and actions. Additionally, fine-tuned ML models are a vital key resource for HoloWonders, generating accurate responses and realistic voice outputs. Trained on curated datasets, these models simulate meaningful conversations and authentic voices for historical figures, complementing the 3D models, animations, and holographic hardware to create an immersive experience that brings history to life.

Lastly, state-of-the-art holographic hardware plays a crucial role in delivering a seamless and engaging user experience. HoloWonders will invest significantly in developing and acquiring cutting-edge holographic technology, ensuring that the holograms are not only visually stunning but also interactive and responsive to user inputs.

These key resources are the foundation of HoloWonders' unique value proposition, which brings history to life through immersive, interactive, and educational experiences. By leveraging expertise in 3D modeling, animation, and holographic technology, as well as an extensive collection of historical data, HoloWonders is well-positioned to revolutionize the way people learn about and engage with the past, ultimately transforming the educational landscape and fostering a deeper appreciation for history.

## Key Partners

The core of HoloWonders' partnerships is cultural institutions. This includes museums, art galleries, theatres, operas, historical sites, libraries, community culture centers, and more. HoloWonders will provide holographic communication services that enable these institutions to reach a wider audience and engage with visitors in a more immersive way. To achieve HoloWonders' mission of preserving and sharing cultural heritage, non-profit and cultural organizations, such as UNESCO and ICOM, serve as crucial partners. Educational institutions are another crucial partner in the mission of providing individuals with a more intuitive and immersive learning experience. This entails schools, universities, and other educational organizations with the aim to develop and deliver educational programs that leverage holographic technology. The goal is to provide students with a more engaging and interactive learning experience that will enhance their understanding of complex subjects.

Event and exhibition organizers are also potential partners for holographic technology. The assumption is that technology can be a valuable asset for conferences and other cultural events by showcasing exhibits in a unique and memorable way. Of course, none of this would be possible without the right technology and hardware providers. Therefore, HoloWonders will partner with producers of life-sized hologram providers and generative language model providers to source the necessary equipment and tools for creating and displaying holographic content. Finally, HoloWonders will partner with investors and VC firms to accelerate growth and secure funding.

## Revenue Streams

**The Main Revenue Stream**: HoloWonders will be the rental of a complete interactive hologram installation in museums. The rental fee is paid monthly. In addition to the monthly rent, there will be a one-time setup fee that depends on the complexity of the setup of the specific historical person. Influencing factors on the setup fee is the quality of data provided by the museum for training the language model, the level of quality needed in the interactive hologram, and how fast the installation should be deployed. The monthly rate depends on the size of the installation.

**Future Revenue Streams**: HoloWonders can sell to high-income individuals who want to replicate themselves or passed relatives in an interactive hologram. These will be highly customized individual projects.

Short-term rentals of the services for trade fairs can also be a high potential revenue stream as the willingness to pay and the need to stick out from the competition is relatively high.

The interactive hologram can even replace some booth representatives, be a low-threshold information source for visitors who have questions about the product or create a pull factor to attract visitors to the customer's booth. To facilitate this service, HoloWonders would partner with trade fair construction companies that set up the hologram display hardware in order to focus entirely on the software aspect of the business. HoloWonders can also use the data acquired over several projects to create a platform to share and license 3D animations and to fine-tune language models and holographic representations.

## Cost Structure

**Initial Investment Costs**: For the setup of HoloWonders, an initial budget is required to build the platform and develop the integration between the hologram hardware and the generative AI tools like GPT4. Qualified software developers and data scientists are needed for that purpose. Their salaries are a major cost driver. Furthermore, establishing partnerships with famous museums will help build a reputation and requires an upfront investment.

**Fixed Costs**: These costs arise from research and development investments which are imperative to improve the HoloWonders experience continuously. Further, expenses such as investments in offices and work equipment are needed for operational infrastructure. Another share of the fixed costs comes from HoloWonder's use of cloud-hosting services to run and maintain its IT infrastructure. Moreover, HoloWonders requires competent personnel in the fields of generative AI development, marketing, and administration. Lastly, financing costs will arise from the initial investments.

**Variable Costs**: One of the main cost drivers is renting the hologram hardware, which is passed over to the end customer. Another variable cost is providing additional hardware like computing power, microphones, cameras, and speakers that the hologram manufacturer does not include. There is, furthermore, a one-time cost for setting up the hologram installation at the customer's site and costs associated with providing customer support.

There will also be maintenance costs for long-term installations. For one-time specific characters, there will be a cost in training the voice and character.

## Eco-Social Costs

**Ecological Costs**: One of the ecological costs is associated with the high energy consumption required to train the large language models and create holograms. HoloWonders is also using hardware, thereby causing electronic waste. Additionally, carbon emissions are caused by company operations, e.g., by having an office.

**Social Costs**: In terms of social costs, HoloWonders acknowledges that the use of synthesized voices, characters, and holographic technology could blur the borders between what is considered real and what is not. This has the potential to cause confusion and even alter the way reality is perceived. Additionally, there is the risk of "rewriting history." A current issue with the use of language models is the potential for "hallucinations" that can lead to the creation of made-up facts. HoloWonders is aware of this risk and will implement measures to mitigate it. Since hallucinations are a major impediment to the progress of the whole field of generative AI for natural language, it is an active field of research that feeds optimism for a timely solution to the problem. Another social cost could be incurred by renting or selling replicas of private individuals in a future business model. Recreating, e.g., a deceased family member could be

## Eco-Social Benefits

**Ecological Benefits**: By using HoloWonders, museums can digitalize not only historical figures but also their physical exhibits. Some exhibits, especially traveling exhibitions, are shipped around the world, accumulating a significant carbon footprint. While the holograms are mainly intended to augment and not replace the originals, it is conceivable that museums choose to go fully digital in some instances, thereby helping the environment.

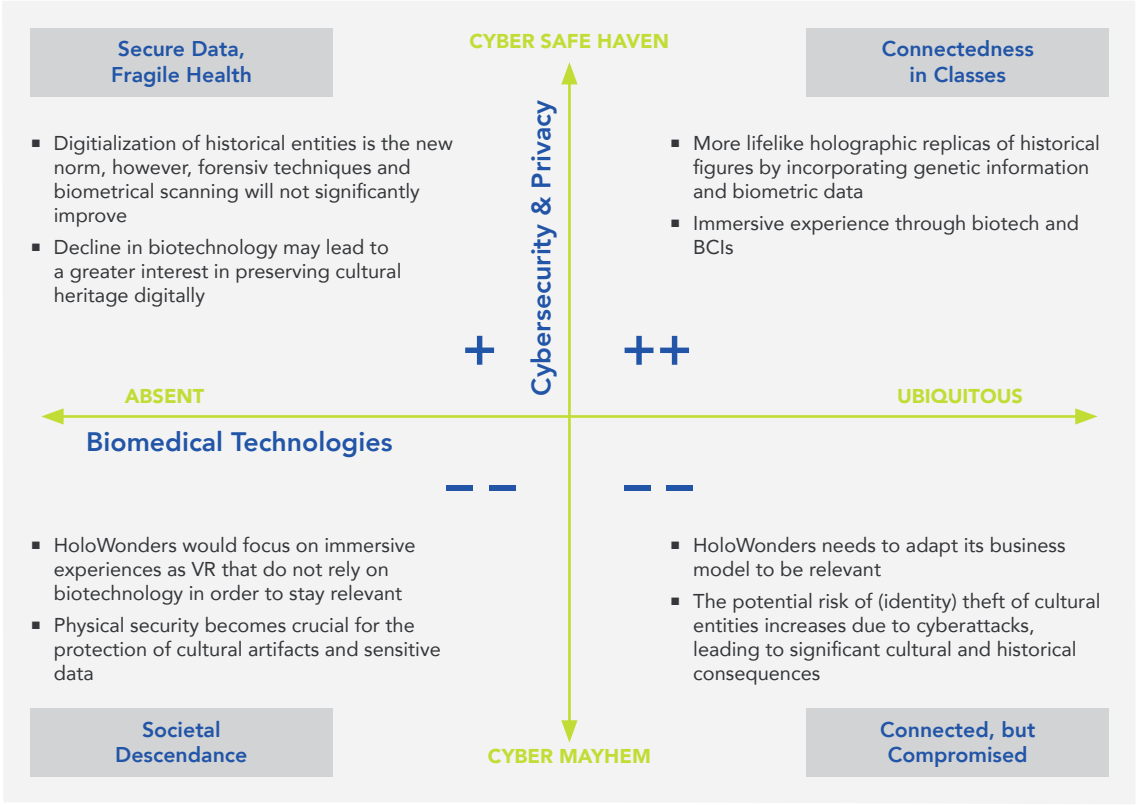
**Social Benefits**: First, HoloWonders helps to keep the memory alive. Through interacting with historical figures, e.g., with survivors of the holocaust, the haunting lessons of the past come back to life and offer a learning opportunity for younger generations. In general, the product targets a younger audience that grew up with highly interactive content, frequent context switches, and short attention spans. Museums currently do not appeal to this audience as reading information boards does not meet these criteria. HoloWonders, therefore, can contribute to fostering a collective awareness of the past, including its mistakes. Ideally, the possibility of replicating valuable artifacts could also positively contribute to the reconciliation of different countries. Repatriation, the return of looted cultural property, is frequently demanded and a cause of tension. If it is possible to create high-quality digital replicas, this might incentivize the return of important objects to their country of origin and contribute a small part to mending relationships.

## Scenario Fit

**Connectedness in Classes:**
With the rise of biotechnology, HoloWonders could collaborate with biotechnology companies to develop innovative ways to preserve and restore historical sites, artifacts, and documents, ensuring that cultural heritage is protected for future generations. HoloWonders, on the one hand, could potentially use DNA analysis to create even more lifelike holographic replicas of historical figures. This could enable holographic figures to mimic the actual movements, speech patterns, and mannerisms of the person they represent. On the other hand, by incorporating biometric data and DNA analysis of the visitor, it would be possible to offer a more customized experience. For example, based on a person's genetic background, the museum guide could be a holographic ancestor of the visitor. Moreover, a more holistic experience can be potentially achieved by BCIs. For example, HoloWonders could develop a system that allows users to interact with holographic projections using their thoughts, making the experience even more immersive.

**Secure Data, Fragile Health:**
The decline in biotechnology may lead to a greater interest in preserving cultural heritage, and HoloWonders can leverage this by offering new features such as 3D scans and virtual reality experiences of historical sites and monuments. HoloWonders may face less competition since it has established itself as a leader in digitalizing historical artifacts and figures. The stagnation of new archeological findings can be counterbalanced due to HoloWonders' long experience in processing large amounts of archeological data. With the rise of cybersecurity, HoloWonders can also offer its holographic replicas as a secure alternative to physical artifacts that may be at risk of decay or even theft. The company can also explore partnerships with cybersecurity companies or experts to provide additional security measures and stay ahead of potential threats.

**Societal Descendance**:
In a world where cyber mayhem reigns supreme and biotechnology is in decline, the business model of HoloWonders would need to adapt to remain relevant. In the absence of cybersecurity measures, physical security becomes crucial for the protection of cultural artifacts and sensitive data. HoloWonders would need to develop advanced physical security measures to protect the holographic replicas and other exhibits. HoloWonders would focus on creating more immersive experiences that do not rely on biotechnology. Instead, other forms of technology could be incorporated, such as virtual reality and augmented reality, to enhance the experience. In a world without strong cybersecurity measures, protecting the data of cultural institutions and their visitors would become even more important. In addition to stronger physical security, HoloWonders needs to develop its own cybersecurity solutions to help ensure the safety and privacy of its users.




**Connected, but Compromised:**
As this scenario allows HoloWonders to incorporate biotechnology into its holographic replicas, creating even more realistic and interactive experiences for visitors would become feasible. For example, biochemical data could be used to make the replicas respond to visitors' emotions. Moreover, HoloWonders could partner with biotech companies to recreate extinct species or digitalize famous historical figures based on genetic information. On the other hand, there is a major threat of identity theft of cultural entities due to cyberattacks, which could lead to significant cultural consequences. Furthermore, the lack of cybersecurity in the wider world could make people warier in digital experiences. To overcome this, HoloWonders needs to focus on building trust with its customers by being transparent about its security measures. HoloWonders needs to develop its own

proprietary security measures to ensure the safety of its technology and the sensitive data it collects from visitors.

## Challenges

- The hologram hardware and real-time rendering of 3D models can quickly become quite expensive. This can drive the cost to a point where museums do not see enough value in the service.
- Large language models tend to hallucinate, which means it is making up facts with high confidence. In the worst case, this could rewrite history in the minds of visitors, creating a risk for society.
- High computing power is needed for the real-time 3D animations of historical figures. Doing this fast enough to enable a fluent conversation with a 3D hologram is a significant technical challenge.
- Streaming a 3D animation to a hologram requires high bandwidth that might not be available everywhere yet.
- Only a limited number of museum visitors can interact with the hologram at the same time. This can lead to long queues, making the experience unenjoyable for the visitors.

## Outlook

HoloWonders aims to provide an easier and more organic interface to the information that normally requires effort to absorb. In the beginning, HoloWonders brings to life historical figures and artifacts. In the future, HoloWonders could also capture the market of trade fairs by making physical objects animate and conversational, for example, a rocket engine you could talk to that would explain its properties and perks in an engaging way. After proving the quality of the offerings and building a reputation, HoloWonders could start taking orders from private individuals to recreate them digitally, thus satisfying the innate human desire to remain in history.

Another prospect is to start offering the experience of talking to historical figures through other media. For example, after having created an extensive collection of historical figures, HoloWonders could develop a smartphone app that would feature rotating historical figures to engage users from the comfort of their homes. The app would come with a free one-week trial and then charge an affordable monthly fee. Offering a free trial and affordable subscription, the app would encourage users to visit museums to access exclusive holograms, driving new visitors and increasing museum foot traffic, thus attracting even more sales to the museums.

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# SENSETRIALS

## Advancing Clinical Research With Decentralized and Real-Time Patient Data Management

The process of conducting clinical trials is a complex and challenging undertaking. One of the biggest challenges is the high dropout rate of patients, often due to the inconvenience and costs associated with participating in the trial. Transportation costs and the time-consuming nature of filling out paperwork are just some of the obstacles patients face.

This issue impacts not only patient recruitment and retention but also poses a financial risk for pharmaceutical companies. The cost of each patient dropout is estimated at 25,000 USD, which can result in significant financial losses for the company.

In addition to patient dropout rates, the use of self-reported data in clinical trials poses challenges in terms of data quality and accuracy. This can impact the validity and reliability of the study results and the overall success of the trial. These challenges highlight the need for a solution that can address these issues and streamline the clinical trial process.
Sensetrials provides a solution to these challenges through the use of wearables for automated data collection, reducing the reliance on self-reported data and improving data quality and accuracy.

By automating data collection, Sensetrials can also reduce the burden on patients, improve the overall experience of participating in a clinical trial, and provide pharmaceutical companies with real-time insights into study performance. The implementation of Sensetrials can ultimately improve the success of clinical trials, leading to better patient outcomes and advancing the development of new medical treatments.

## Business Model

### Key Partners

- Wearable devices manufacturers
- Electronic data capture (EDC) and clinical trial management system (CTMS) providers
- Cloud-hosting service providers
- Research institutions and universities
- Contract research organizations (CROs) and site management organizations (SMOs)
- Regulatory agencies

### Key Activities

- Integration of wearable devices
- Data analysis and reporting
- Regulatory compliance
- Marketing and sales
- Customer support
- Building partnerships

### Key Resources

- IT infrastructure
- Human resources
- Financial resources
- Expertise for clinical trial design
- Wearable device manufacturers and leasing companies

### Value Proposition

- Automated accurate data collection
- Real-time decentralized patient management
- Customization and flexibility
- Regulatory compliance and data security

### Customer Relationships

- Automated tracking of clinical trial progress
- Consultative sales approach for pharmaceutical companies
- Personalized onboarding and training
- Regular updates
- Proactive customer feedback

### Channels

- Online
- App download from application stores
- Targeted advertising through health apps
- Website and online presence
- Webinars and online events
- Direct sales, such as emails

### Customer Segments

- Clinical Trial Sponsors
- CROs
- Academic and research institutions
- Regulators

### Cost Structure

- Initial investments
- Data engineering and software development
- Formation of partnerships with clinics and pharmaceutical companies
- Fixed costs
- Research and development
- Running and maintenance of operational and IT infrastructure
- Fees for cloud-hosting services
- Employee salaries and benefits
- Legal and compliance
- Office space and overhead
- Insurance and financing costs
- Variable costs
- Marketing to pharmaceutical companies
- Wearable leasing for patients
- Sales and marketing costs
- Third-party software licenses, integrations, and fees for using

### Revenue Streams

- Initial flat price
- Subscription fee
- Integration and customization fees
- Consulting service fee
- Data monetization

### Eco-Social Costs

- Electronic waste
- Energy consumption
- Cost in terms of privacy

### Eco-Social Benefits

- Reduced paper usage
- Democratization of clinical trials
- Increased patient engagement

## Value Proposition

**Automated Accurate Data Collection:** With the incorporation of wearable devices in clinical trials, Sensetrials offers cost reduction by complementing self-reported data and eliminating the need for manual data management. The automation of data collection improves data accuracy and reduces the risk of human error.

**Real-Time Decentralized Patient Management:** The decentralized data management enables doctors to review patient data from any location, facilitating decentralized trials and reducing the need for frequent in-person visits. This can be especially beneficial for patients who live far from clinical trial sites or have mobility issues. Wearable devices can monitor a patient's health and behavior patterns in real-time, providing a more comprehensive picture of their well-being. This enables doctors to detect potential side effects earlier and intervene sooner, improving safety monitoring and patient outcomes.

**Customization and Flexibility:** Handling different data formats, such as structured and unstructured data, allows for greater flexibility in data collection and analysis. Indeed, Sensetrials can be customized to support different types of wearable devices and sensors. It can also be adapted to different clinical trial requirements, such as study design, sample size, and endpoint selection.

**Regulatory Compliance and Data Security:** The solution is designed to comply with relevant regulatory requirements and industry best practices for data privacy and security when using wearables in clinical trials. It is built to ensure that data is handled in a compliant and secure manner, minimizing the risk of data breaches or privacy violations. Sensetrials follows all applicable regulations, including data privacy and security regulations such as the Health Insurance Portability and Accountability Act of 1996 (HIPAA) and GDPR, and is committed to upholding the highest standards for data privacy and security. The platform implements robust data encryption protocols and access controls to ensure that sensitive data is always protected.

## Customer Segments

**Clinical Trial Sponsors:** Pharmaceutical companies, biotech firms, and other organizations that sponsor clinical trials are a key customer segment for Sensetrials. These companies can use the platform to manage data from wearables and monitor participant safety in real-time. Using data from wearables, Sensetrials helps clinical trial sponsors understand participants' health and behavior patterns, resulting in accurate insights. This improves data quality, reduces costs, and contributes to successful trials.

**CROs:** CROs manage clinical trials on behalf of sponsors, such as pharmaceutical companies, and can use Sensetrials to manage data from wearable devices in these trials. By using Sensetrials, CROs can provide their clients with real-time insights into study performance, allowing for more efficient decision-making and study management. Furthermore, CROs can streamline their data management processes, leading to faster trial timelines and potentially earlier regulatory approvals.

**Academic and Research Institutions:** Research institutions and academic organizations can use Sensetrials to manage data in their clinical studies and research projects.

**Regulators:** Regulatory agencies benefit from the improved data quality, traceability, and compliance offered by the solution. By using Sensetrials to manage data from wearable devices in clinical trials, study sponsors and CROs can ensure that their data meets regulatory requirements and is fully traceable, making it easier to comply with regulations and guidelines. This improved data quality and traceability can benefit regulatory agencies by streamlining their review process, potentially leading to faster regulatory approvals and better patient safety.

## Customer Relationships

**Automated Tracking of Clinical Trial Progress:** The automated tracking of clinical trial progress for patients reduces the burden of data collection and improves patient engagement.

**Consultative Sales Approach for Pharmaceutical Companies:** Adopting a consultative sales approach helps pharmaceutical companies understand the benefits of the software platform and how it can meet their specific needs.

**Personalized Onboarding and Training:** By providing personalized onboarding and training, clinical trial sites and managers feel comfortable using the software platform and can effectively manage their clinical trials.

**Regular Updates:** New features and software updates are communicated regularly with customers through newsletters, webinars, and other channels.

**Proactive Customer Feedback:** Sensetrials regularly seeks customer feedback through surveys and beta testing of new features with select users to improve the software platform and customer experience.

**Push Strategy in Sales and Marketing:** The sales and marketing strategy includes proactively reaching out to potential customers and generating interest in the software platform.

**Customer Support:** Multiple channels are being used to ensure that customers can access help when they need it.

**Strategic Partner Management:** Sensetrials provides personalized account management for key partners, ensuring high-quality support.

## Channels

**Online Channels:** Sensetrials uses a variety of digital marketing strategies to promote its platform and reach potential customers. These strategies include making our app available for download from popular application stores, such as the App Store and Google Play Store. We also use targeted advertising through health apps, such as YAZIO, to reach individuals interested in health and wellness. Our website serves as a central hub for information about Sensetrials and includes resources such as case studies, white papers, and FAQs. We hold webinars and online events to educate potential customers about our platform and offer personalized demos through direct sales channels such as emails, phone calls, or in-person meetings. Additionally, we employ digital marketing strategies like search engine optimization (SEO) and pay-per-click (PPC) advertising for Google Keywords to ensure our website is easily discoverable by those searching for relevant terms. By utilizing these digital marketing strategies, Sensetrials can effectively reach its target audience and promote awareness about its platform.

**Offline Channels:** Several offline strategies are put in place to expand its reach and promote its platform to a wider audience. These strategies include partnerships

and direct sales with health insurance companies and clinics, as well as offering customer referrals and a referral program to incentivize word-of-mouth marketing. Industry conferences and events can also be used to showcase the platform and connect with potential customers.

Additionally, Sensetrials could partner with other companies and institutions, such as wearable device manufacturers, EDC/CTMS providers, CROs, and research institutions, to distribute its platform and reach a wider audience. Finally, publishing articles, case studies, or whitepapers in trade publications and journals can establish Sensetrials as a thought leader in the field and attract potential customers.

## Key Activities

**Integration of Wearable Devices:** Sensetrials invests in research and development to integrate a wide range of wearable devices and collect data in different formats.

**Data Analysis and Reporting:** The company provides data analysis and reporting services to help research entities interpret and utilize the data collected from wearable devices in clinical trials.

**Regulatory Compliance:** By maintaining high standards of data privacy and security, Sensetrials ensures that its platform complies with relevant regulatory requirements and industry best practices and security regulations.

**Marketing and Sales:** The strategy involves identifying target customers and promoting the software platform to potential customers. Marketing has a strong responsibility in the business development of the company by operating through cold calls, network, and event management to position Sensetrials' name in the industry.

**Customer Support:** Customer support is provided to ensure that its customers can effectively use its software platform by offering onboarding and training sessions as well as troubleshooting any issues that may arise.

**Building Partnerships:** Partnerships with wearable device manufacturers, EDC/CTMS providers, CROs, research institutions, cloud-hosting service providers, and industry associations are required to expand the company's reach and offer more comprehensive solutions to its customers.


## Key Resources

**IT Infrastructure:** The development of the solution requires significant IT infrastructure, including servers, data centers, and cloud-hosting services, to store and manage large amounts of data collected from wearable devices in clinical trials.

**Human Resources:** Experienced employees in software development, data science, marketing, sales, and customer support are needed to develop, promote, and maintain its software platform and ensure customer satisfaction.

**Financial Resources:** The company needs financial resources to fund research and development, IT infrastructure, human resources, and other operating expenses.

**Expertise for Clinical Trial Design:** Sensetrials requires expertise in designing and conducting clinical trials. This includes knowledge of study design, patient recruitment, data collection and analysis, and regulatory compliance.

**Wearable Device Manufacturers and Leasing Companies:** Partnerships with wearable device manufacturers and leasing companies are key to accessing a variety of devices and ensuring compatibility with its software platform. This also enables the company to provide its customers with a range of options to suit their needs.

**Brand and Reputation:** It is crucial to establish a strong brand and reputation within the clinical trial and healthcare indus-

tries to attract customers, partners, and other stakeholders. This includes building trust and demonstrating a commitment to quality, innovation, and regulatory compliance.

**Regulatory Knowledge and Expertise:** Expertise in regulatory affairs, knowledge of guidelines, and compliance with data privacy laws help ensure the software solution meets relevant regulatory requirements and data privacy laws.

**Access to Clinical Trial Data:** Sensetrials requires access to clinical trial data, wearable device data, and other relevant datasets to develop algorithms, data processing techniques, and analytical tools that can be used to generate insights and improve data quality.

## Key Partners

**Wearable Device Manufacturers:** Wearable device manufacturers such as Fitbit, Garmin, Apple, or other specialized medical device companies are vital for Sensetrials to ensure compatibility between their devices and the platform, as well as to provide customers with a wide range of wearable options to choose from.

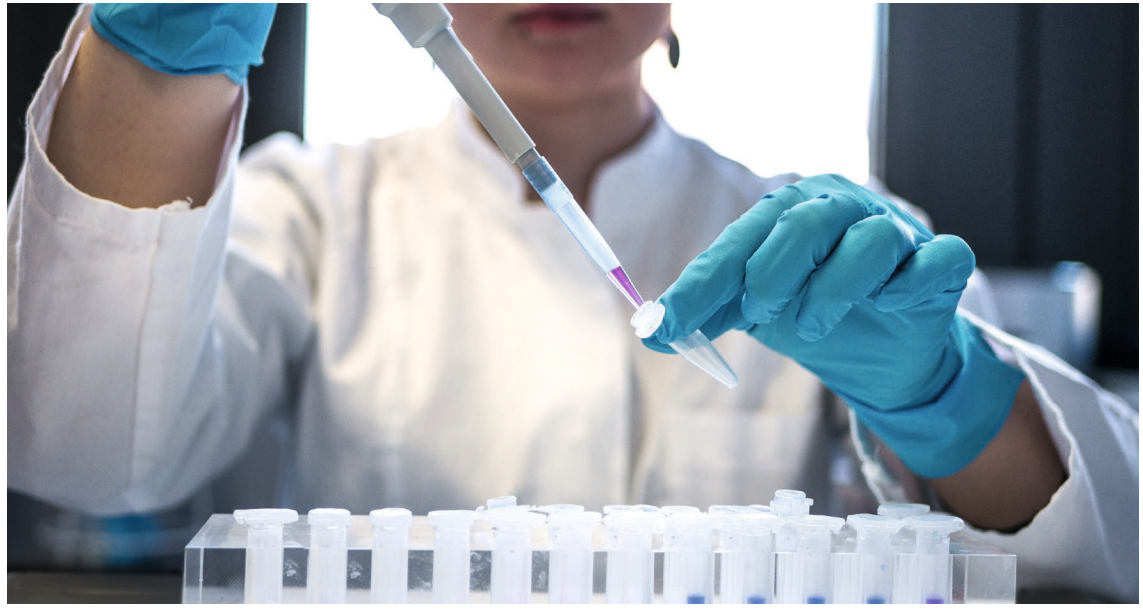
**EDC and CTMS Providers:** Providers like Medidata, Veeva, or Oracle can integrate Sensetrials into their platform with their solutions, offering a comprehensive data management and analysis system.

**Cloud-Hosting Service Providers:** Cloud-hosting service providers can be valuable partners for Sensetrials to ensure that the platform's data storage and hosting needs are met and that the solution is scalable to meet growing demand.

**Research Institutions and Universities:** Research institutions and universities can be interested in providing their researchers with access to Sensetrials for managing data from wearable devices in their clinical studies and research projects.

**CROs and SMOs:** CROs and SMOs often manage clinical trials on behalf of study sponsors and can provide Sensetrials with access to a large network of potential customers.

**Regulatory Agencies:** Regulatory agencies, such as the FDA or European medicines agency (EMA), and industry associations, such as the Clinical Trials Transformation Initiative (CTTI), are important partners for Sensetrials. These organizations play a critical role in shaping the regulatory landscape and establishing best practices for clinical trial management. By partnering with these organizations, Sensetrials can ensure that its solution meets regulatory requirements and industry standards and can stay up to date on emerging trends and developments in the field.



## Revenue Streams

**Initial Flat Price:** The initial fee will be charged after a trial has been acquired. The price charged will depend on the phase that the trial is in. Phase 1 trials involve fewer complexities and include fewer patients than the Phase 2 and Phase 3 trials. As both of these metrics increase as the phase of the trial progresses, Sensetrials will charge increasingly more for higher phase trials.

**Subscription Fee:** After the trial starts, a subscription fee will be charged per user per year. The number of users will increase as the phase progresses. This would mean a higher subscription for a Phase 3 trial as compared to a Phase 1 trial, even though the unit price charged will remain the same.

**Integration and Customization Fees:** Sensetrials can also charge a fee for facilitating seamless integration with the existing electronic health record (EHR) systems of the customer.

**Consulting Service Fee:** An additional revenue stream after Sensetrials has secured a strong brand position in the market is to provide consultation services for health software implementation and employee training to ensure a more productive adoption of these technologies.

**Data Monetization:** Sensetrials will also aggregate and anonymize the data collected from wearable devices and clinical trials to generate reports that can be sold to pharmaceutical companies and researchers.

## Cost Structure

**Initial Investment Costs:** The initial costs incurred by Sensetrials include the cost of software development, data engineering as well as initial research to prove the viability and efficacy of the product. Sensetrials will also invest in forming initial strategic partnerships, including patient advocacy

groups as well as promotions at events.

**Fixed Costs:** Sensetrials incurs fixed costs that are independent of the number of customers using the software platform. These costs include legal and compliance costs that are necessary to obtain regulatory approvals and to ensure compliance with data privacy and security regulations. Furthermore, Sensetrials bears the costs necessary for the research and development of the software platform. Moreover, for long-term operation, costs for IT infrastructure and maintenance are covered. Since Sensetrials manages large amounts of data from wearable devices, cloud-hosting fees are required for data storage and hosting services. Finally, insurance and financing expenses are incurred for insurance coverage and financing costs, such as interest payments on loans or other debt. These fixed costs enable Sensetrials to provide a comprehensive solution for managing data from wearable devices for clinical trials while ensuring data privacy and security.

**Variable Costs:** The variable costs incurred by Sensetrials include the marketing costs used to market the product to pharmaceutical and biotechnology companies. Sensetrials will lease the wearables, and this leasing cost will be dependent on the brand, sensor type, and the number of patients, among other factors. The product will also employ the use of third-party software, and licensing fees will be incurred, which also include the use of APIs to connect with wearable devices and other data sources. Sales is an important facet of the business model, so sales costs are also pertinent. Finally, Sensetrials is a customer-centric company, so customer support and training costs represent the final block of variable costs incurred by Sensetrials.

## Eco-Social Costs

**Electronic Waste:** The production and disposal of wearable devices contribute to electronic waste. E-waste represents a significant loss of valuable resources, such as rare earth metals and other materials that are used to manufacture electronic devices. Such electronic devices contain toxic chemicals, such as lead, cadmium, and mercury, which can pollute soil, water, and air when not disposed of properly.

**Energy Consumption:** The use of digital technologies, such as wearables, can generate large amounts of data that need to be stored and processed in order to be analyzed. This requires significant computing power, which can contribute to high energy consumption costs. Additionally, storing large amounts of data requires significant infrastructure, including servers, data centers, and cooling systems. Furthermore, transferring large amounts of data throughout the network leads to high energy consumption.

**Cost in Terms of Privacy:** The use of electronic devices and data transfer can create potential data privacy and security risks for trial participants in clinical trials. Electronic devices and data transfer may increase the risk of data breaches, which could result in unauthorized access, use, or disclosure of personal health information or other sensitive trial data. To mitigate these risks, it is important to ensure that appropriate data security and privacy measures are in place throughout the clinical trial process. This includes implementing robust encryption and authentication measures, limiting access to personal health information and sensitive trial data only to authorized personnel, and ensuring that data handling and transfer procedures comply with relevant data protection regulations and standards.

## Eco-Social Benefits

**Reduced Paper Usage:** The use of digital data collection technologies in clinical trials can bring many environmental benefits, including reducing paper waste and conserving natural resources.

**Reduced Paper Usage:** The use of digital data collection technologies in clinical trials can bring many environmental benefits, including reducing paper waste and conserving natural resources. By digitizing data collection through Sensetrials, participants can generate data electronically, minimizing manual data entry and paper-based documentation. The reduction in paper usage can have several positive impacts on the environment, such as reducing the number of trees that need to be cut down for paper production and reducing the amount of energy and water needed to manufacture and recycle paper. This can help to conserve natural resources and reduce the carbon footprint of the clinical trial.

**Democratization of Clinical Trials:** Automated data collection through wearables can enable remote monitoring of clinical trial participants, reducing the need for frequent in-person visits and enabling more decentralized clinical trials. This can lead to reduced travel-associated costs and burdens for participants. Consequently, it will potentially remove barriers to participation, such as geographic location, as well as make clinical trials more accessible and inclusive to a broader range of individuals.

**Increased Patient Engagement:** Real-time data collection can enable more frequent communication and feedback between patients and trial staff, helping patients to feel more

supported and involved in the trial process. Patients can receive instant feedback and reminders from their wearable devices, as well as communicate with trial staff about any concerns or questions they may have, helping them to better understand their condition and how it is affected by the trial intervention. This can increase patient motivation and engagement with the trial, as they can see the impact of the intervention on their own health.

## Scenario Fit

**Connectedness in Classes:** This shows the best-case scenario for Sensetrials. In a fully secure and biomedically advanced world, the use of wearable devices in clinical trials is likely to evolve, which means more users of Sensetrials. The use of wearable devices will enable more remote and continuous monitoring of vital signs, which will reduce the need for frequent in-person check-ins. Advances in bionanotechnologies will provide real-time data and insights into a patient's health at a more granular level, ensuring detailed information about the effects of drugs or therapies on the body. A cyber haven space will provide a secure and private environment where participants can share their data with researchers without fear of it being misused or mishandled. This is achieved by implementing strong security measures to prevent unauthorized access to the data and ensuring that patients are fully informed about how their data will be used and who will have access to it.

**Secure Data, Fragile Health:** In a future scenario without advancements in biomedical technologies, the development of wearable devices will be boosted by the desire to understand the human body through non-invasive measures. Also, with strong cybersecurity measures in place, the use of wearable devices can continue to increase, leading to the gathering of larger amounts of data. It is likely that the use of wearable devices for constant vitals check-in will become increasingly common in clinical trials. Wearable devices can provide real-time data on a patient's vital signs, physical activity, and other health-related metrics, which can be used to monitor the effectiveness of treatments and therapies in clinical trials. Thus, the use of wearable devices for constant vitals check-in can help reduce the need for frequent in-person visits, which can be costly and time-consuming for patients and healthcare providers. Wearables can also provide a more comprehensive view of a patient's health status, as data is captured in real time and can be analyzed over longer periods.

**Societal Descendance:** In a world without advanced cybersecurity measures and biomedical technologies used in modern clinical trials, the accuracy and reliability of data captured by wearable devices may be compromised. While wearable devices can still capture some information about a patient's health, the lack of security measures could make the data vulnerable to interference or tampering. This would limit the usefulness of wearable devices in clinical trials, as researchers would not be able to rely on the data captured by these devices to make informed decisions about the safety and efficacy of drugs and therapies. Consequently, doctors and healthcare organizations will require better encryption and security measures to provide wearable devices and related products that utilize patient data. By doing so, they can protect patient data, maintain patient trust, and comply with data protection regulations.

**Connected, but Compromised:** In a cyber mayhem world, there is a higher risk for doctor-patient confidentiality when processing remote data of clinical trial data. This is because, in such a world, there is a greater likelihood of cyber-attacks and data breaches that can compromise sensitive information. While reducing the frequency of data transmission may limit the amount of data that is transmitted and reduce the risk of cyberattacks and data breaches, it can also limit the usefulness of the data for clinical purposes. As research in the area of biomedical technologies continues to advance, it is likely to see innovative applications of nanotechnology in clinical settings. The use of these technologies will improve the safety and efficacy of drugs by providing targeted drug delivery and real-time monitoring and response to drug risks

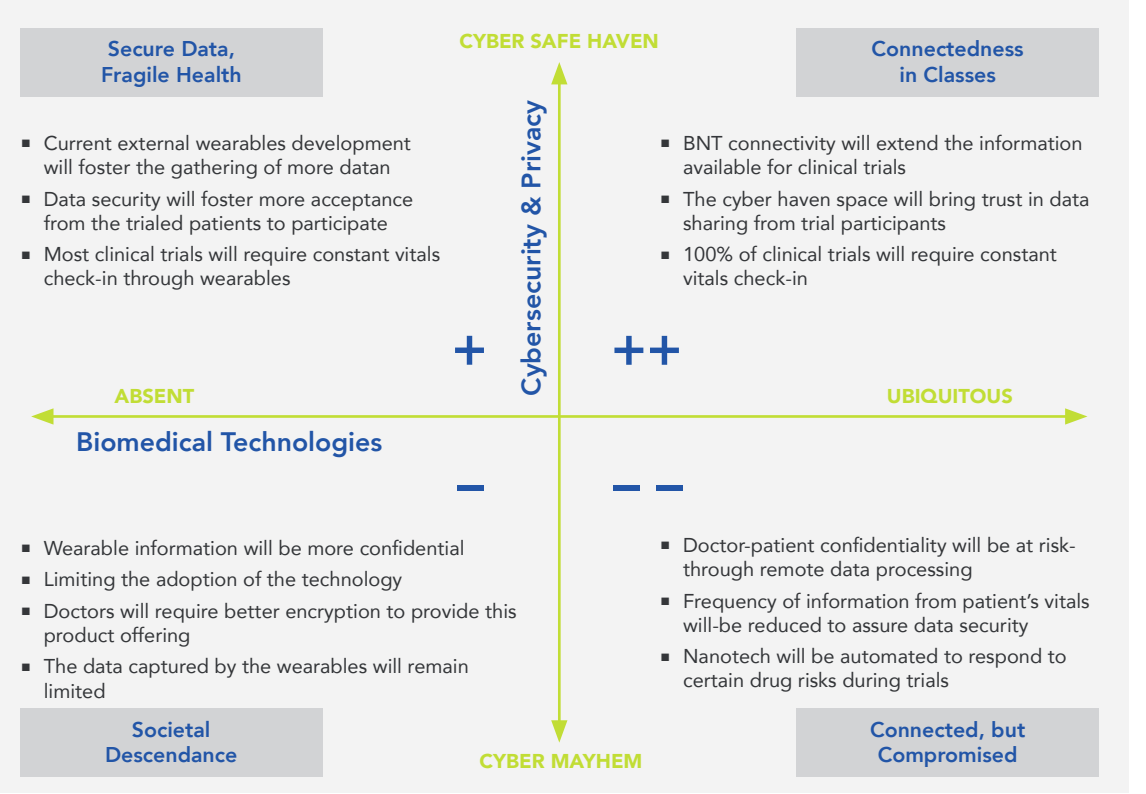
## Challenges

- Wearables collect sensitive data such as personal health information, location data, and biometric data. Therefore, Sensetrials must ensure appropriate security measures are in place to protect the data, in order to protect patient rights and maintain the integrity of the study.
- There is a lack of standardization in the use of wearables in clinical trials. Wearables can generate data in different formats, making it difficult to integrate, compare, and interpret data from different devices.
- Wearables generate vast amounts of data, and it is essential for Sensetrials to have appropriate data management systems in place to collect, store, and manage this data effectively.
- Wearables require active engagement from participants, and it is not always easy to motivate them to use these devices consistently. Participants may also forget to charge or wear the device, leading to missing data.
- Using wearables in clinical trials involves navigating regulatory requirements, particularly regarding data privacy and security. Sensetrials must comply with HIPAA and GDPR and ensure that the data collected is appropriately managed and secured.

## Outlook

Sensetrials envisions improving patient management in clinical trials by leveraging wearable and sensor data through a centralized platform. It allows for accurate tracking and monitoring of daily vital information from patients. The platform provides reliable insights into a patient's health status by processing real-time data, allowing for remote monitoring of their condition. In the long term, Sensetrials aims to use digital twin technology in order to simulate the response of individual patients to a treatment or to model the behavior of larger patient populations. This helps identify potential issues or inefficiencies in a clinical trial before they occur and enables pharmaceutical companies and researchers to make

more informed decisions about the design and execution of their trials. Additionally, Sensetrials could incorporate advances in biomedical technologies for better and more granular body measurements. For example, advanced sensors like photoplethysmogram sensors could be used to monitor physiological parameters in real time, providing more accurate and detailed data for clinical trials.



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# SENSURITY »



## SENSURITY

### Enhanced Security for Public Safety via Smart Network Sensing

Concerns over public safety have been on the rise in recent times, and governments worldwide are under pressure to find effective solutions to this problem. In Germany, 62% of the population believes that crime has increased in the last five years [282]. Among those, especially women suffer, as 67% feel unsafe in public transportation [283]. To increase public safety, many governments rely on surveillance systems like cameras or an increase in police presence. However, these traditional methods are facing criticism due to their high costs, staff shortages, and privacy concerns.

While a majority of the population agrees to the long-term storage of data from public spaces, such as airports, train stations, and parking lots, for automated facial recognition in the fight against crime, they do not support increasing private surveillance and government access to personal data [282]. This growing imbalance poses a crucial challenge to the extensive rollout of camera surveillance systems and demands for alternative solutions.

Sensurity's smart sensing networks offer a potentially revolutionary solution to the challenges facing traditional surveillance systems and police presence. By utilizing advanced technologies such as AI and 6G cellular networks to sense and collect data, Sensurity can map out critical areas and digitize them into a real-world model. This data is then analyzed in real-time, scanning for potential threats like armed individuals, accidents, or anomalies, leveraging AI algorithms.

One significant advantage of Sensurity's technology is that it uses radio sensing instead of cameras to ensure the privacy of individuals. Unlike traditional camera surveillance systems, Sensurity only captures the silhouettes of individuals rather than identifiable imagery. This is a significant advantage for public spaces where individuals may be concerned about their privacy being invaded. Furthermore, Sensurity's technology is more versatile than traditional surveillance systems, as it can detect a variety of incidents, including threats, accidents, fires, and anomalies.

When a security incident is detected, a warning system notifies the relevant person or organization, e.g., firemen, policewomen, security guards, or paramedics, quickly. The algorithm can classify different types of incidents like threats, accidents, fires, or anomalies and locate the nearest security personnel for a faster response. Automatic responses and recommendations are implemented based on the type of incident detected.

Sensurity's system is not limited to monitoring public spaces. It can also be used in various other settings, such as monitoring factories, warehouses, and other industrial facilities. This versatility makes Sensurity's technology a valuable asset for businesses that need to monitor their facilities for potential hazards or security threats.

## Business Model

### Key Partners

- Network infrastructure owners and service providers
- IT infrastructure providers: Cloud service providers and server centers
- Emergency response services
- Hardware manufacturers and vendors that sell communication technology equipment
- Security firms

### Key Activities

- Real-time modeling via smart network sensing
- Detection and classification of threats, accidents, and anomalies
- Notification of the person in charge
- Action recommendations

### Key Resources

- Computing power
- Robust and unbiased AI algorithms
- Reliable hardware infrastructure
- Interface to other security services
- Trust of customers

### Value Proposition

- Population safety, security threat analysis, and accident detection through surveillance
- Highly extendable to other use cases like traffic monitoring and digital mapping of the environment
- Low additional costs due to the use of existing 6G infrastructure
- Increased privacy compared to camera-surveillance
- Faster notification of enforcement authorities through an integrated warning system

### Customer Relationships

- Personal assistance
- Ongoing digital support plus support with hardware if needed
- Automated recommendations
- Personalized consultancy and maintenance

### Channels

- Direct: Sensurity sells directly to the government and businesses that directly integrate Sensurity
- Indirect: Partnerships with security providers who implement more than just surveillance and who then distribute to other companies

### Customer Segments

**Businesses that require safety measures**

- Airports, festivals, theaters, etc.

**Governments**

- City councils who want to secure their town
- Police
- Defensive military

**Security companies that offer whole-package security**

### Cost Structure

**Initial Investments**

- AI software development
- Warning system development

**Fixed costs**

- Research and development costs
- Personnel and financing costs
- Research and development costs
- Personnel and financing cost

**Variable costs**

- B2B and Business-to-Government (B2G) marketing
- Tailor software solutions to specific customer needs
- Lease of infrastructure usage rights
- Running and maintenance of IT infrastructure, e.g., cloud services, server center

### Revenue Streams

**Transactional revenue**

- Perpetual license
- Rollout-consulting

**Project revenue**

- Temporary communication and security event solution

**Service revenue**

- SaaS licensing model

### Eco-Social Costs

- Privacy concerns: Concerns about the de-anonymization of data and government spying
- Ethical considerations: AI bias in anomaly detection
- Financial costs: The installation and maintenance of the surveillance systems can be expensive, especially in B2G

### Eco-Social Benefits

- Enhanced public safety
- Reduced social and economic costs due to reduced crime
- Better emergency response
- Anonymization of data: Less discrimination
- Environmental impact: Manufacturing and disposal are reduced [284]

## Value Proposition

Sensurity is committed to providing cutting-edge software solutions that use smart network sensing to analyze real-world situations for security issues. The platform is designed to deliver maximum value to business customers by offering advanced incident detection for venues like airports, festivals, theaters, and other high-traffic areas. The solution leverages the latest sensing technology to scan crowds, analyze anomalies, detect accidents, and find security threats like armed people. This enables the customers to quickly identify potential risks and take proactive steps to prevent incidents from occurring. The company also offers a solution to governments to ensure population safety and fast emergency response.

The platform is also highly extendable to other use cases, including traffic monitoring, disaster management, and digital mapping of the environment. This versatility means that Sensurity's customers can use the platform to address a wide range of security and safety challenges while benefiting from low additional costs. This is possible because Sensurity can reuse the existing 6G infrastructure, eliminating the need for additional hardware devices like cameras.

One of the key benefits of the platform is its ability to deliver advanced security and safety features without compromising privacy. Unlike traditional camera surveillance systems, which can be invasive and intrusive, the platform leverages cutting-edge sensing technology to provide accurate and reliable data on potential threats and security risks while ensuring that individuals' privacy is respected.

To ensure fast response times, Sensurity offers a connected warning system that allows enforcement authorities to be directly notified in cases where emergencies are highly time-sensitive. This is particularly important in situations like airport surveillance and event planning, where even slight delays in response times can have serious consequences.

## Customer Segments

**Businesses That Require Safety Measures**: Numerous organizations, such as airports, festivals, and theaters, require safety measures as an additional service despite it not being their primary business focus. Therefore, they provide Sensurity with the hardware infrastructure for the service. Sensurity operates the software on behalf of its clients and takes charge of evaluating the data collected by the system. In this manner, Sensurity's clients can ensure the implementation of robust safety measures without the need for extensive investments in the requisite infrastructure and personnel. Sensurity, therefore, targets mid-sized companies obliged to integrate security systems, event managers of festivals, organizers of short-term events, and others.

**Governments:** Governments, which include cities, police, and military as an execution force, are enabled by Sensurity's solution to detect potential criminal activities or accidents in near real-time, providing them with the tools necessary to respond proactively and effectively to such incidents. For this customer segment, the system is extremely useful, as it allows governmental institutions to sense and detect crime in an anonymized way as opposed to camera observation. This also might lower the need for execution forces like police officers and still ensures reliable crime detection.

**Security Companies**: Sensurity's solution is highly valuable for security companies who are, e.g., provide security systems nationwide or secure entire compounds at government conferences. By incorporating the solution into existing services, safety measurements become advanced. They may represent a valuable selling point for security companies as they are enabled to provide more comprehensive safety solutions and can save resources with the system using smart sensing networks that utilize 6G cellular networks to sense and collect data.

## Customer Relationships

**Automated Services**: Sensurity's customers can receive personalized recommendations for adapting their security systems through Sensurity's technology. Based on the collected data, on the one hand, the individual client's preferences. On the other hand, Sensurity provides clients with news and messages to stay informed about novel laws and regulations that might affect the security systems allowing them to remain compliant and, therefore also to avoid legal issues. The digital nature of the company and the system allows automated integration of updates and messages provided to the clients, enabling fast and seamless adaptation. For the adaptation, digital support is further a way of fostering positive customer relationships, and this support includes help with the software integration, implementation, and maintenance.

**Personalized Assistance**: To fully leverage the advantages of Sensurity's services, clients are provided with personalized assistance through a team of experts, if needed, who are adept at integrating and implementing the services within the framework of businesses and governments. This enables customized and precisely tailored solutions for Sensurity's system. Furthermore, Sensurity offers on-demand security consulting to its clients, providing additional support and guidance when required. This consulting service helps clients stay up to date with the latest security trends that are emerging and ensures that their systems remain robust and effective over time. Sensurity's commitment to personalized assistance and on-demand security consulting provides clients with the tools to optimize their security systems, remain compliant with regulations, and ensure long-term success in an ever-changing digital landscape. Adding upon this, the consultancy also includes help and knowledge increase about laws.

## Channels

**Direct**: Sensurity's security solutions are highly valued by businesses and governments, providing them with a powerful tool to enhance security measures. Sensurity's distribution channels specialize in B2B and B2G sales, allowing seamless integration of its services into existing security infrastructure. However, Sensurity is reaching out to customers, as evidenced by its participation in security conferences and events, to establish its position as an expert in this field. These events provide an excellent opportunity for potential customers to see the service in action with already-used radar and detection systems and learn more about how it can benefit their businesses or organizations through showcasing the integrations. In addition, Sensurity is becoming a member of industry associations, engaging in bids and exhibits of ongoing projects. This allows potential customers to witness the service and see how it integrates into the broader security ecosystem. Sensurity's engagement with industry associations also helps it stay updated on the latest trends and developments in the security industry, ensuring that its services remain at the forefront of innovation.

**Indirect**: In addition to its direct engagement with governments and businesses, Sensurity also establishes strategic partnerships with various security organizations. These partnerships represent an indirect form of clientele, allowing Sensurity to expand its reach and distribute its solution to a

wider range of customers. Through its partnerships, Sensurity can tap into these organizations' networks and customer bases, enabling it to reach new audiences and expand its market share. These partnerships also allow Sensurity to leverage its partners' expertise and resources, enhancing its services and staying at the forefront of innovation. Furthermore, strategic partnerships with security organizations can help Sensurity establish itself as a trusted and reliable partner in the security industry. Sensurity can enhance its reputation and build trust with potential customers by aligning itself with other respected organizations.

## Key Activities

**Real-Time Modeling via Smart Network Sensing**: Sensurity extends the main functionality of 6G, which is communication, by the function of smart network sensing. Mobile radio signals map the environment, creating a real-time 3D model of the critical area. This allows Sensurity to not only communicate and sense connected devices but also unconnected objects.

**Detection and Classification**: Security-relevant incidents like individuals carrying illegal weapons or injured individuals are detected and classified with AI algorithms. Unusual behavior can also be detected with anomaly detection. The sensitivity of detection is configured by the customer. Classifiers and anomalies are adjusted to the use case of the customer.

**Notification of Person in Charge**: In case of anomaly detection, the customer is immediately notified over the chosen channels. Sensurity offers customizable notification settings, where clients can choose between centralized and decentralized notifications and further fine-tune the person in charge of Sensurity for a specific incident. In the centralized approach, notifications are all sent to one central entity (e.g., Security service), which is evaluated before operational personnel is notified. In the decentralized approach, the staff closest to the anomaly is located through the phone connection to their nearest antenna and notified immediately while reporting to a centralized unit.

**Action Recommendation**: This functionality gives immediate recommendations as a response to the identified incident. In the case of a terrorist attack, an action plan is sent depending on the weapon used (e.g., knife, vehicle). Recommendations for the number of people required for the case are given, and a severity score is assigned.

## Key Resources

**Computing Power and Storage**: Modeling and analyzing critical areas in real-time involves a tremendous amount of inflowing data. Hence one of the critical resources that Sensurity needs is enough storage and computing power to handle this data. As the database continuously grows, this also delivers more training data to the algorithm.

**Robust and Unbiased AI Algorithms**: As Sensurity promises safety and detection of all anomalies, the quality of AI detection algorithms is substantial. Several anomaly detection algorithms were already developed. Sensurity requires an algorithm that is robust and reliably detects all incidents.

**Reliable Hardware Infrastructure**: Sensurity promises the absence of dead angles. Testing software is required to analyze the critical area of uncovered patches. This will be used when Sensurity deploys the communication infrastructure and when existing infrastructure is used. Uncovered areas must be patched with additional communication hardware. Furthermore, the connectivity of communication channels to Sensurity's servers must be ensured, as Sensurity promises real-time data analysis. This may require the set-up of an additional backup communication channel.

**Interface to Other Security Services**: Sensurity is set up in environments that will likely also use other security services such as access control, fire detection systems, etc. Sensurity supports these systems by providing an interface for neighboring systems to utilize the connected data. In return, Sensurity can use additional data to train their AI classifiers to detect specific anomalies, e.g., fire.

## Key Partners

**Network Infrastructure Owners and Service Providers**: As Sensurity aims to decrease the cost of surveillance systems by reusing existing cellular network infrastructure, a close partnership with network infrastructure owners and service providers is substantial. Network infrastructure owners provide the rights to use their assets (e.g., antennas and base stations), while service providers own the rights to operate on a dedicated spectrum. Network service providers can simultaneously be infrastructure owners. Sensurity considers three types of partnerships with service providers: First, Sensurity acquires spectrum slices for the operation of smart sensing, and second, the network service provider operates sensing and communication and transmits the data to Sensurity's servers. Third, the network service provider operates sensing and communication while computation is realized decentrally on edge devices.

**IT Infrastructure Providers**: As the data is sensed and combined to form a real-world model, Sensurity requires high computing power and storage systems for its operation. Cloud service providers provide the IT infrastructure, allowing Sensurity to offer customers a wide range of privacy standards if they require specific GDPR policies.

**Emergency Response Services**: Sensurity works closely with emergency response services like paramedics, fire, and police departments to minimize emergency response times. These services will be notified directly at the detection of a security incident, depending on the classification by the algorithm.

**Hardware Manufacturers and Vendors**: Sensurity creates partnerships with manufacturers and vendors of communication technology to deliver complete security monitoring systems to their customers. This is especially helpful in festivals or other temporary events, where nonstationary security systems are set. Sensurity will lease the hardware equipment as part of its service.

**Security Firms**: Security firms play an essential role as partners, as they will deploy and apply the technology to their established client base. Sensurity can benefit from their expertise to further improve the product.

## Revenue Streams

**Transactional Revenue**: Transactional revenue is generated by selling perpetual licenses for Sensurity's software solution. This revenue stream is a one-time transactional revenue stream whereby the customer pays a one-time fee to purchase the license for the software solution. The target audience for this type of income is security providers, which sell full-package solutions that can incorporate network sensing as a feature of their offer.

**Project Revenue**: Project revenue is generated by temporarily providing Sensurity's security solutions for specific events or projects. This income is typically generated by deploying Sensurity's smart network sensing security solutions for high-profile events such as sporting events, concerts, and festivals. Project revenue can be significant, as it involves deploying the entire security solution for the duration of the event. Still, it might also incur higher costs due to the possible need to extend the existing hardware infrastructure.

**Service Revenue**: Service revenue is generated by licensing Sensurity's software solution through a SaaS model. This revenue stream is recurring, whereby customers pay a monthly or annual fee to use Sensurity's software solution. Additionally, Sensurity provides maintenance services to its customers who have purchased a perpetual license for the software solution. This revenue stream is important, as it provides Sensurity with ongoing revenue based on providing value to existing customers.

## Cost Structure

**Initial Investments**: For the creation of the software solution, both anomaly detection and the fast response mobile application require an initial budget. Qualified data scientists and software developers are needed for the development. These costs can be substantial, given the complexity of the technology and the need to innovate and improve compared to all existing systems.

**Fixed Costs**: The costs independent of the number of sold solutions are split into multiple categories. They include research and development costs, personnel costs, and financing costs. Research and development costs include the expenses associated with ongoing research and development efforts, including salaries, equipment, and other expenses. Personnel costs include salaries and benefits for Sensurity's employees, including software developers, project managers, marketing specialists, and other staff. Financing costs include the costs associated with raising capital to fund operations and expansion.

**Variable Costs**: Variable costs for Sensurity include marketing expenses, which are important given the need to reach out to B2B end customers, B2B security providers, and B2G customers. Sensurity must invest in tailored marketing strategies to reach its target audiences, including trade fairs, digital marketing, and other outreach efforts. Additionally, Sensurity might need to invest in tailoring its software solutions to specific customer needs, which can require additional software development and customization efforts. Other variable costs include the lease of 6G infrastructure usage rights from communication infrastructure owners. Sensurity must also invest in running and maintaining the IT infrastructure, including cloud services and server centers, which keep growing with each new customer. Under certain circumstances, hardware costs may also be incurred if additional sensors or other devices are required to supplement the sensing capabilities of the existing infrastructure for festivals and temporary events.

## Eco-Social Costs

**Privacy Concerns**: The use of surveillance systems can raise privacy concerns among the population in which Sensurity's systems are implemented, as there is a risk of de-anonymization of data. This is one of the main concerns regarding Sensurity's business model since the collected data through the radar system poses the risk of being de-anonymized and potentially misused by higher authorities. Especially with the regulation and execution of governmental power, public concerns about the misuse of Sensurity's service might occur. Ethical Considerations: Using Sensurity's technology in surveillance systems may raise ethical considerations, such as the potential for AI bias. Although the data being collected is anonymized, concerns about a potential AI bias could still arise because the detection algorithm needs to undergo precise training. Moreover, broader ethical concerns regarding the appropriateness of Sensurity's system must be considered. Using this system may increase the power differential between individuals, the state, or their employers.

**Financial Costs**: Installing and maintaining surveillance systems can be a significant expense, particularly in the B2G market. This can create a significant barrier for organizations looking to implement these systems, as they must balance the cost of installation and maintenance against the potential

**Enhanced Public Safety:** Sensurity's solution enhances pu

benefits of improved security and monitoring. In addition, Sensurity may face resistance from people who do not support installing surveillance systems due to financial concerns. This can create a significant challenge for the company, as it must work to overcome these objections and demonstrate the value of its solutions in terms of improved security and other benefits.

### Eco-Social Benefits

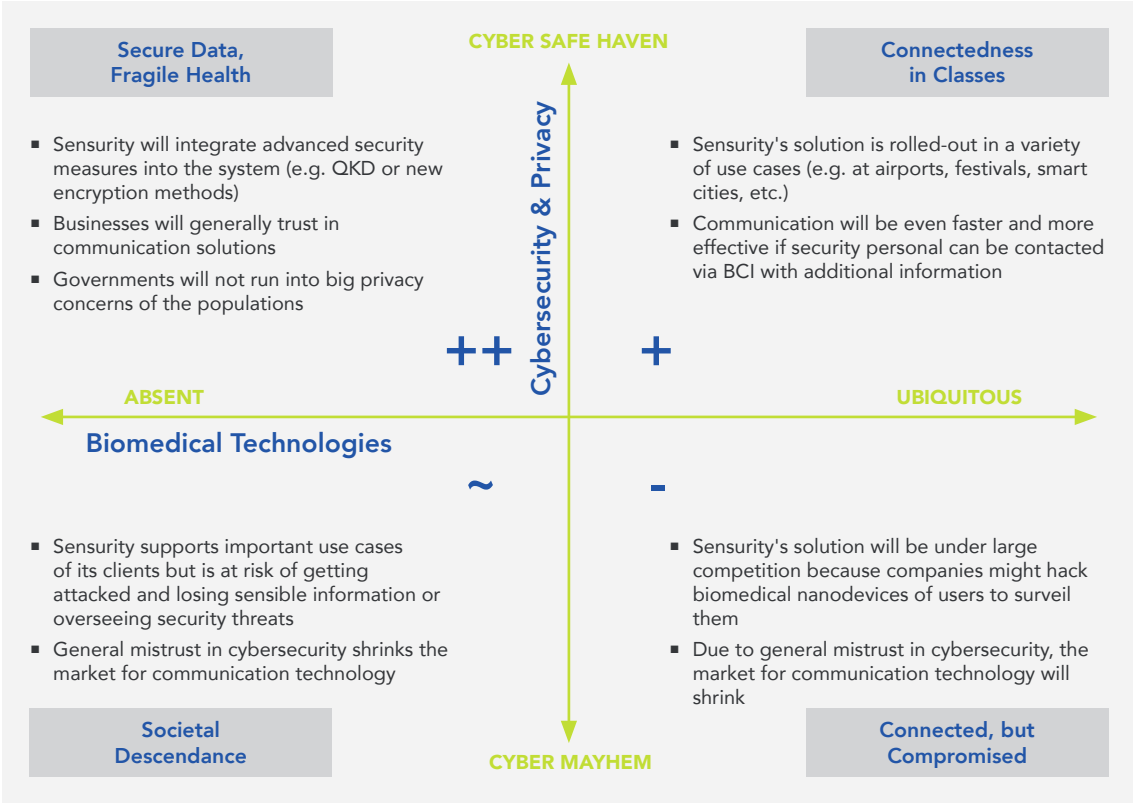
Increased public safety by improving public security and reducing crime rates. By providing reliable and accurate data, the systems can help law enforcement agencies identify and respond to potential threats more efficiently and effectively.

**Reduced Social and Economic Costs**: Social and economic costs associated with a crime can be reduced due to better and more accurate surveillance. By deterring criminal activities and improving response times, Sensurity helps reduce the need for policing resources and minimize the impact of criminal activities on communities.

**Better Emergency Response**: Sensurity's advanced technology offers real-time data and alerts, providing emergency responders with the critical information to quickly identify and respond to emergencies such as accidents and human threats. The ability to receive real-time information regarding a developing situation can make all the difference in saving lives and mitigating the event's impact.

**Anonymization of Data**: The anonymization of data helps to minimize discrimination, as the data collected can be used for statistical analysis without revealing personal information. Additionally, anonymization techniques protect the privacy of individuals who may have been captured in the data without their consent. Unlike cameras, which capture visual data, the evaluations based on non-visual sensory data are typically more anonymous.

**Environmental Impact**: One of the key advantages of Sensurity's technology is its ability to achieve significant resource savings compared to traditional surveillance systems. Unlike conventional systems that require multiple cameras and antennas to cover a given area, Sensurity's solution uses advanced radio sensing technology to achieve the same level of coverage with fewer resources.




Sensurity's services improve energy efficiency, producing a positive environmental impact [284].

### Scenario Fit

**Connectedness in Classes:**
In this scenario, Sensurity's business model remains significant in the security space as high public trust in communication technologies continues to drive demand for its solutions. As trust continues to grow, advancements in Sensurity's technology are accelerating. With the advent of biomedical technology advancements, such as the implementation of biomedical nanodevices, new use cases may emerge where the evaluation of the data from nanodevices plays a critical role in surveillance and human detection. In response, Sensurity must adapt its services and evaluation processes to accommodate these new technologies. By keeping up with emerging technologies and adapting its services accordingly, Sensurity can remain at the forefront of the security industry and continue to provide reliable and advanced security solutions to its clients.

**Secure Data, Fragile Health:**
In a cyber safe haven scenario and the absence of biomedical technologies, the solution that Sensurity offers will be the most important among all scenarios since it can inte-

grate security measures such as quantum key distribution or other new encryption methods to secure the data transmitted. The identified clients, namely businesses integrating security solutions, governments, and security providers, generally trust communication technologies and, therefore, the solution provided by Sensurity. This high level of trust also translates to the general public, which has confidence that governments will not misuse their power derived from surveillance technology, resulting in lower privacy concerns. With biomedical technologies having no impact on Sensurity's business model, the company has the potential to make significant advancements in its services.

**Societal Descendance:**
Despite the potential threats to its security, Sensurity's service remains highly valuable to clients, as it utilizes advanced algorithms to detect armed individuals, accidents, and anomalies in real-time. However, the increasing frequency of cyberattacks is anticipated to raise concerns about the safety and confidentiality of sensitive information. Lack of trust has led to a shrinking market for communication technologies. To remain competitive, Sensurity must take proactive steps to enhance its service, fortify its security measures against hacking and data loss, and pivot its business model towards maximizing security and privacy. By doing so, Sensurity can ensure that its surveillance technology is as secure as possible and can continue to provide its clients with the reliable security solutions they require. This scenario is the most uncertain one for the business model of Sensurity since cybersecurity is highly needed and, therefore, extremely fragile.

**Connected, but Compromised:**
Sensurity's radio sensing technology enables anonymous identification of individuals, but cyber threats and biomedical technology advancements pose potential risks to the system. Using information from biomedical nanodevices, a technology that will be highly used and one which is of great interest to track behavior as well as movement, could be a more compelling monitoring solution for businesses like Sensurity. But competitors could take advantage of Sensurity's slow adoption of this technology since that is not yet their main business focus.

Sensurity must adapt and prioritize this field to accelerate development and remain competitive. In addition, the declining trust in cybersecurity is expected to shrink the market for communication technologies, making it more difficult for Sensurity to maintain its leadership position.

## Challenges

- Firstly, while 5G is available in many parts of the world, it is insufficient to support the advanced data processing and analytics capabilities required by Sensuity's solutions. The company will start with radar prototypes while 6G is in development. After network scanning is possible, Sensurity will require the rollout of the new infrastructure around target locations like airports and theaters. Moreover, the adoption of Sensuity's solutions by governments needs broad-scale infrastructural upgrades.

- Secondly, the potential for AI bias in Sensurity solutions is another challenge. Sensurity will need to take a proactive and comprehensive approach to develop and deploy its solutions to mitigate the risk of bias. This includes careful attention to data sets used to train the algorithms and involves a diverse group of stakeholders in the development process to ensure that the perspectives and experiences of a wide range of individuals are considered.

## Outlook

Sensurity plans to expand beyond public safety and concentrate on individual safety by utilizing the increasing number of IoT devices like smart homes and wearable devices. With the aim to provide more convenient and secure living conditions, Sensurity will be monitoring human activity to detect risks such as fatigue and heart failure early on, which is crucial while operating machinery or driving. They also aim to identify threats in the individual's environment to prevent accidents. Sensurity also aims to extend its radio sensing capabilities to mobile remote sensing. With the rollout of autonomous cars and unmanned aerial vehicles equipped with 6G communication technologies, Sensurity will use mobile communication networks to dynamically map uncovered areas. This can be especially with natural disasters when stationary communication infrastructure is damaged or even destroyed. Swarms of drones can cooperatively act as mobile antennas to map affected areas for injured persons, identify potential threats, and notify rescue services close by.

Even further into the future, when satellite communication is adopted, Sensurity aims to use satellite communication networks for remote sensing to create a digital twin of the Earth. This enables an overarching monitoring system to ensure a safer tomorrow for everyone in our globalized world.

Leon Blumenthal 
Nils Krüger 
Ria Rosenauer 
Alena Strittmatter 
Constantin Weberpals 

# MedicalReach



## MEDICALREACH

### Medical Care - Where It Is Needed Most

Rural communities, villages, and small towns are experiencing a decline in the availability of medical professionals, making it harder for residents to receive adequate healthcare services. This can result in delayed diagnoses, increased travel time for medical care, and potentially poorer health outcomes for individuals living in these areas. Currently, governments are using incentivization schemes to attempt to tackle this. MedicalReach offers a more efficient, long-term solution.

MedicalReach is a revolutionary healthcare company that offers remote healthcare services to patients. With the rise of digital technologies, MedicalReach has capitalized on the opportunity to provide medical consultations from the comfort of your own home. Patients can now book appointments online and receive basic consultations with a doctor without ever having to leave their houses.

In addition to these consultations, MedicalReach offers a unique service where patients can book appointments with a mobile station that comes to their village. Each mobile station is equipped with medical devices needed for basic medical examinations. In addition, MedicalReach uses a modularized approach for specialized doctors.

The mobile stations can be extended with various modules that include the needed medical devices and allow for specialist examinations to be performed based on the patient's needs.

This can consist of a module for a gynecologist, a dentist, or a dermatologist. The stations are operated by a performing nurse who connects with a remote doctor to provide the best possible care. With the data collected in the mobile stations, the offered services can evolve and be personalized to the patient.

MedicalReach's goal is to fully automate these mobile stations, allowing for even more efficient and accessible healthcare. With the ability to connect with doctors remotely, patients no longer need to worry about the distance they must travel to receive proper care. The mobile stations allow patients to receive treatment right in their community, which helps to increase accessibility and reduce healthcare disparities.

## Business Model

### Key Partners

- Medical device manufacturers
- Laboratories
- Pharmaceutical companies
- Local authority districts
- Health insurance providers
- Association of Statutory Health Insurance Physicians
- Doctors

### Key Activities

- Research and Development: Continuously improve mobile station setup based on technical advances
- Logistics: Setup mobile stations, provide equipment
- Service: Provide basic medical teleoperation

### Key Resources

- Location in local communities
- Medical devices
- Communication technology
- Doctors and health professionals
- Distribution personnel
- Cleaning personnel

### Value Proposition

- Availability 24/7
- Easier prescription access à regular necessity
- Improved access to medical care
- Lower costs through increased efficiency, optimized output of doctors à maximizing value creation
- More convenience for patients
- Enable flexible work for doctors
- Specialist availability

### Customer Relationships

**Rural Communities**

- Provide healthcare in rural communities

**Patients**

- Personal contact with doctors for confidence

### Channels

- Appointment booking applications
- Telemedicine platform, email, SMS, app, or similar
- Google Maps
- Informational flyers and billboard posters
- Word of mouth

### Customer Segments

- Telemedicine platform, email, SMS, app, or similar patients in remote areas with limited transportation options
- Patients looking for a more convenient and faster service
- (Chronic disease) Patients in remote areas that require ongoing medical care

### Cost Structure

**Initial Investments**

- Research and development

**Fixed Costs per Mobile Station**

- Maintenance
- Equipment
- Salaries for health professional

**Variable Costs per Mobile Station**

- Medical supplies
- Cloud and telecommunication costs
- Electricity for mobile stations

**Other Variable Costs**

- Marketing

### Revenue Streams

- Subscription fee from the Association of Statutory Health Insurance Physicians
- 20% commission for each treated patient (insurance or private)

### Eco-Social Costs

- Less personal contact
- Job displacement doctors
- Reliance on technology

### Eco-Social Benefits

- Better healthcare availability in rural areas
- Fewer transmissions because sick people accumulate
- Reducing travel-related emissions

## Value Proposition

The value proposition of a remote doctor's practice is multi-faceted and can benefit patients, doctors, and healthcare providers in many ways. One key advantage is the availability of 24/7 medical care in rural areas: Patients can access medical consultations and assistance anytime, anywhere. The mobile station offers improved access to medical care for patients who may have difficulty accessing in-person medical care. This includes patients who live in remote areas and must drive to see the next doctor and patients with mobility issues. Especially for specialist doctors, the necessary commute can be very long. With the specialist modules, MedicalReach brings specialist examinations to the patients. Another advantage is more accessible access to prescriptions. Regular medication needs can be managed through a remote praxis, which provides convenient access to necessary medication without needing in-person visits. This improves patient access to medical care and makes the process more efficient. In addition to providing greater access to medical care, a remote praxis can lower costs through increased efficiency. By optimizing the output of doctors and maximizing value creation, a remote praxis can deliver high-quality medical care at lower costs. Another benefit of the mobile station is its convenience for patients and doctors. Patients can receive medical care without taking time off work or disrupting their daily routines. This makes it easier for patients to manage their healthcare needs and can improve health outcomes. For doctors, MedicalReach provides the opportunity to work remotely, a way of working that is not very common among doctors today, yet which might increase in popularity with MedicalReach. This battles the shortage of doctors in rural areas.

## Customer Segments

The customer segments of MedicalReach are diverse and have different needs and preferences. The company understands that different customers require different services, and as such, they have tailored their services to meet the unique needs of each customer segment:

The first customer segment comprises patients with difficulty accessing in-person medical care. These include individuals living in remote areas or those with mobility issues. For this group, MedicalReach provides a viable alternative to traditional medical care by offering remote medical consultation and treatment services. By having mobile stations closer to their homes, patients no longer must travel long distances to access medical care, saving them time and money.

The second customer segment comprises patients with access to in-person medical care, such as those living in cities. For this group, the convenience and accessibility of a 24/7 remote praxis without waiting times may appeal to busy professionals and individuals who prioritize convenience and flexibility. MedicalReach offers these customers an alternative option for their healthcare needs, allowing them to receive medical consultation and treatment at their convenience.

Within these two customer segments, MedicalReach also caters to patients with different medical conditions. For example, patients with chronic health conditions may require regular medical check-ups and medication. MedicalReach offers these patients remote consultation and treatment services, allowing them to receive the medical care they need without driving far. In addition, MedicalReach also provides preventive health check-ups for patients who want to take a proactive approach to their health. These customers may not necessarily have any existing medical conditions, but they understand the importance of regular health check-ups to maintain their well-being.

Overall, the customer segments for MedicalReach are diverse and varied, ranging from patients needing urgent care to busy professionals who prioritize convenience and flexibility. As technology continues to transform the healthcare industry, MedicalReach's innovative approach to medical care could potentially attract even more customers in the future.

## Customer Relationships

**Rural Communities**: Rural communities, villages, and small towns face the issue of decreasing access to doctors. Solutions for this problem are sparse and often expensive. For example, the Association of Statutory Health Insurance Physicians incentivizes doctors to move to rural areas. Thus, rural communities have a huge need for a new solution, which a mobile station provides. MedicalReach will offer service contracts to the Association of Statutory Health Insurance Physicians, which gives them certainty on the availability of healthcare. By keeping a long-term relationship with communities, MedicalReach ensures their support.

**Patients**: In rural areas, many patients must drive a long distance for the closest general practitioner, especially specialists. MedicalReach solves this problem by providing the tools for the examination nearby. This way, patients from rural areas have access to regular health check-ups way easier. Patients simply book an appointment online and, using mobile communication technology, can participate in the first consultation directly at the patient's home. The patient can book an appointment with the mobile station if further examination is needed. The mobile station provides the right mixture between convenience and personalization. The contact with doctors creates a sense of trust and confidence in the patients. Additionally, patients have the availability of services around the clock from the comfort of their homes or communities. High-end medical devices and data collection allow very individualized and patient-centered care. The data collection further enables a very efficient long-term relationship between the patient and the doctors. By fostering trust, MedicalReach can proactively engage with patients through its platform. This connection keeps patients committed to using MedicalReach's services.

## Channels

MedicalReach's business plan highlights the importance of using multiple channels to create brand awareness, acquire new customers, and bind customers to the mobile station. The company employs various online channels to achieve these goals, including an accessible and SEA-optimized website that provides comprehensive information about MedicalReach and its functionality. Additionally, MedicalReach leverages Google Maps to help potential customers locate its services quickly and efficiently. To streamline the booking process for its customers, MedicalReach offers an online booking platform. The company also boasts its own telemedicine platform, which allows patients to reach out to MedicalReach directly through various channels, including email, SMS, and the app itself. To address younger generations, MedicalReach actively uses available social media channels.

Recognizing the unique demographic of rural areas, which tend to have older populations, MedicalReach relies heavily on offline channels for brand awareness, customer acquisition, and retention. To achieve these objectives, the company plans to use local newsletters for advertising and disseminating informational articles on how mobile stations work. Additionally, MedicalReach intends to distribute informational printed flyers throughout local communities, villages, and small towns, as well as billboard posters for important

places within communities, such as community centers, supermarkets, and churches, creating multiple touch points to engage with potential customers. To maximize outreach, MedicalReach plans to launch an extensive marketing offensive, leveraging word of mouth to spread awareness about its services throughout rural areas. By employing multiple online and offline channels, MedicalReach is well-positioned to create brand awareness, acquire new customers, and retain existing ones.

## Key Activities

**Research and Development**: MedicalReach wants to improve its services continuously. As the goal is to automate the medical assessment fully, it is crucial to monitor technological advancement and include the newest technological trends in the mobile stations. Furthermore, there is a significant potential for personalizing and improving medical care based on the data the mobile station collects. This data will be used continuously to adjust the available services, improve resource management, and add modules for specialist examinations based on the demand in the areas.

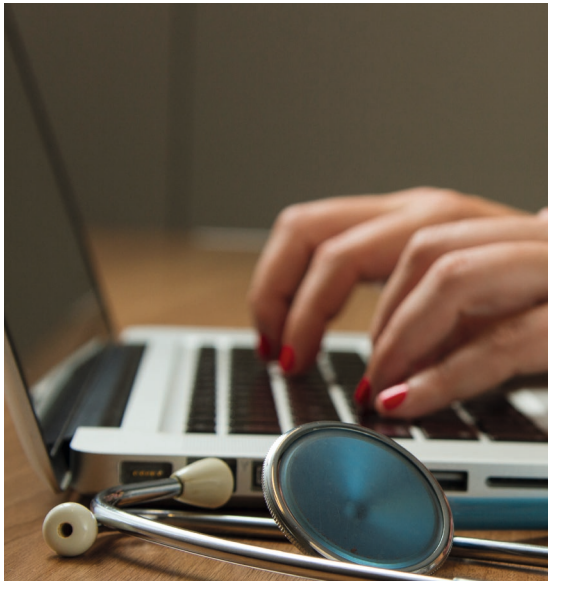
**Setup**: Each new location needs to be scouted, and the right place for the mobile station must be found. The setup of the mobile station includes the right equipment being installed, as well as the necessary communication infrastructure. As long as the medical technology is not advanced enough to allow fully automated medical assessment (e.g., automatic blood sampling), the setup also requires hiring a health professional.

**Remote Service**: The first basic consultation with a doctor can be performed at any patient's home. The patient simply has to book an appointment online. Based on the outcome of the consultation, the patient can then also book an appointment with a mobile station.

**On-Site Service**: The key services of a mobile station include providing medical consultations, testing, prescriptions, vaccinations, and basic medication. Patients can consult with the remote doctor through video conferencing, enhanced through high-end camera technology for assessing injuries or skin anomalies, and receive advice and recommendations for their health concerns. The mobile station can also perform basic medical testing, such as blood pressure measurements, blood and urine testing, and ultrasounds. A health professional assists in the station for these tests and administering vaccinations. Prescriptions can be issued electronically and either issued directly or delivered to the patient's pharmacy. If there is a need for specialist examination, specific modules can be added onto the mobile station to also allow analysis by a gynecologist, dentist, or similar.

## Key Resources

To successfully operate mobile stations, several key resources are required. The mobile station's location must be easily accessible and equipped with the necessary facilities. Diagnostic equipment such as stethoscopes, blood pressure monitors, pulse oximeters, and point-of-care testing devices like glucose meters and cholesterol monitors are essential for remote diagnosis and monitoring certain medical conditions. This equipment should be high-quality, reliable, and remotely accessible, allowing medical personnel to make accurate diagnoses and treatment decisions. For more complex testing, equipment such as electrocardiograms (ECGs), x-rays, and ultrasounds are necessary. The module setup also requires medical devices needed by specialists, such as gynecological treatment chairs, a skin screening device, or a device that can help to take a closer look at the ears, throat, or eyes. For those devices, some kind of teleoperation system is needed. Communication technology, such as secure device connection and data exchange software, is crucial. High-resolution cameras and, importantly, high speed and bandwidth connection, in general, allow for effective communication between medical personnel, medical devices, and patients. Qualified medical personnel, such as doctors for remote consulting and health professionals for local assistance, are needed to provide different kinds of medical care, along with support staff such as distribution and cleaning personnel to manage the distribution of medical supplies and maintain a clean environment. The qualities of the health professionals required onboard might change depending on the region and city that they visit to ensure local needs and requirements, as well as empathy for the diverse customer base. By ensuring that these resources are available and properly utilized, MedicalReach can provide high-quality medical care to patients from a distance.



## Key Partners

MedicalReach partners with organizations from different industries to provide the best service. The most critical partners can be put into four categories:

**Hardware and Software**: MedicalReach partners with providers of hardware and software solutions needed to do the medical assessment. Hardware includes instruments usually needed by general practitioners, like ultrasound, blood pressure, and x-ray machines, as well as instruments needed by specialists in the module stations. All the recorded data is transferred to MedicalReach's platform, which is shared with the doctor and the nurse. MedicalReach collaborates with software providers to develop the necessary interfaces to achieve this. This is especially crucial to ensure safe data transfer to enhance MedicalReach services.

**Medical Services**: On the medical side, MedicalReach needs partnerships with laboratories for testing services, as well as pharmaceutical companies to provide mobile stations with crucial medical equipment like syringes, patches, and disinfection fluids. Furthermore, MedicalReach will partner with insurance companies to secure the financial situation and covered treatments.

**Communities**: As the mission of MedicalReach is to provide healthcare in rural areas, cooperation with villages, small

towns, or non-profit organizations will ensure acceptance within the communities, as well as support in finding the best locations.

**MedTech Companies**: Cooperation with other companies in the MedTech industry can create symbiosis effects, in which MedicalReach and other MedTech companies profit from one another.

**Association of Statutory Health Insurance Physicians (Kassenärztliche Vereinigung):** Currently, the Association of Statutory Health Insurance Physicians pays doctors to open offices in rural areas. Instead, they can license MedicalReach's service to tackle this problem.
Doctors: The remote doctors consulting patients work on a commission-based model.

## Revenue Streams

MedicalReach plans to have two different revenue streams to secure operations.

**Subscription Fee**: The provision of medical care in rural areas has long been a challenge for healthcare providers, with limited resources, infrastructure, and workforce availability among the factors contributing to this issue. The shortage of physicians in rural areas has made it increasingly difficult for rural populations to access the necessary medical services, resulting in a widening gap in healthcare accessibility and quality between urban and rural regions. To address this issue, the Association of Statutory Health Insurance Physicians has introduced monetary incentives for physicians providing medical services in rural areas. These incentives aim to attract more doctors to work in these regions, thereby improving healthcare accessibility and quality for the rural populace. Considering that MedicalReach also caters to these areas, it is reasonable to anticipate that the Association of Statutory Health Insurance Physicians may also extend financial support to operations. This support may come as a subscription fee to cover a designated region.

**Commission**: MedicalReach generates significant revenue from patients seeking medical care, although the team does not collect the fees directly. Instead, MedicalReach receives commissions from the physicians who work with us, akin to a traditional doctor's practice. The fee charged to patients varies depending on the complexity of the consultation and treatment. For instance, a basic consultation may incur a lower price than a more intricate consultation that requires further medical tests or diagnostics. Aside from consultation fees, MedicalReach may also charge additional fees for medical testing, prescription renewals, and other medical services that standard insurance plans may not cover. The cost of these services can vary based on their type and complexity. Depending on their coverage, patients can pay these fees directly or through their insurance providers.

## Cost Structure

**Initial Investment**: Investment in the setup of the mobile station involves extensive research and development activities to ensure that the infrastructure, medical devices, and communication technology are effectively integrated. This involves creating a platform that can incorporate medical devices, data collection, and secure communication with remote parties. The platform is vital for MedicalReach's core services and data analytics-based service improvements.

**Fixed Costs per Mobile Station**: Fixed costs per mobile station include the purchase of medical devices and communication infrastructure required to deliver the services, as well as maintenance costs for cleaning, stocking, and repairing. Additionally, a salary is provided for the health professionals working in the mobile stations.

**Variable Costs per Mobile Station**: Variable costs per mobile station are divided into three categories. The first cat-

egory includes transportation and driving costs, which vary depending on how often and where the mobile station is utilized. The second category includes technical and communication infrastructure costs, such as cloud and communication provider expenses. The third category encompasses the medical supplies used during services, such as patches and disinfection gel.

**Other Variable Costs**: Other variable costs are not directly related to the number of deployed mobile stations. These costs include research and development expenses to improve the mobile stations and their services continually. The goal is not only to enhance the technical devices but also to adapt the services based on data insights. Marketing costs are also incurred to increase brand awareness, educate people about the functionality, and build trust in the services offered. As MedicalReach expands, these costs will likely change and require further evaluation to ensure optimal performance and sustainability.



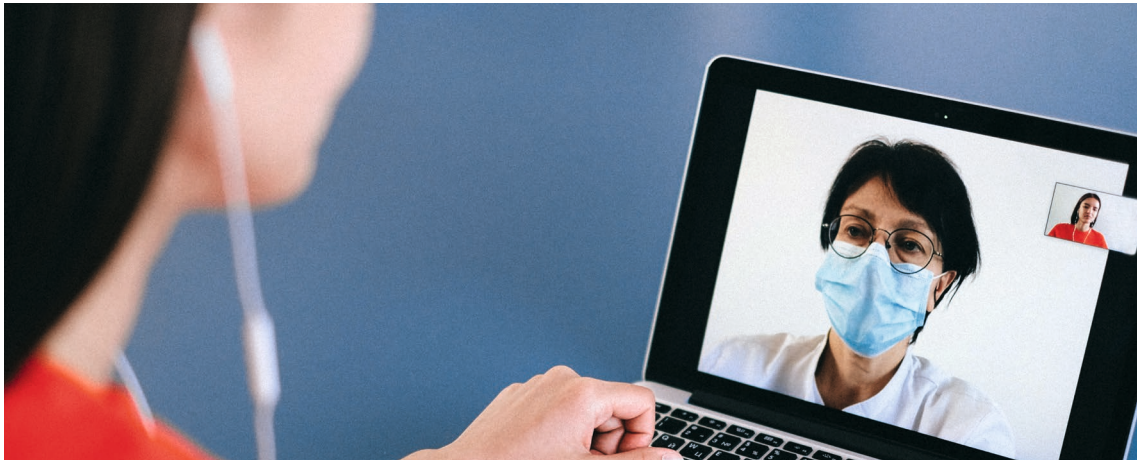
## Eco-Social Costs

**Reduced Human Interaction**: Remote consultations can lack the personal touch of in-person consultations, which can be essential for building trust and establishing rapport between doctors and patients. Especially for remote living, and older people, human interaction with the doctor might be an important human connection.

**Job Displacement**: Job displacement is a potential risk associated with a remote doctor's praxis. Adopting this business model could reduce demand for in-person medical consultations, leading to job losses for some medical professionals, such as nurses, medical assistants, and administrative staff working in traditional medical offices. This is because a remote praxis can automate some tasks, such as prescription filling, billing, and appointment scheduling, which can reduce the need for support staff.

**Reliance on Technology**: Patients may become overly reliant on technology and need help accessing medical care without it. This can create a digital divide between those who have access to technology and know how to handle it and those who do not.

**Ecological Risks**: Two main factors could harm the environ ment. First, the remote mobile stations need to be stocked with all the medical equipment used for testing. This needs



to be planned as ecologically as possible. Analyzing the data from the mobile stations will help to predict future demand and reduce the negative impact correctly. Second, mobile stations, like traditional doctors' offices, will create a significant amount of waste products such as packaging and medical supplies. This can contribute to waste production and environmental pollution if not managed properly.

## Eco-Social Benefits

**Availability**: From a social perspective, the remote praxis can offer increased access to medical care, particularly in rural or underserved areas. Patients with difficulty traveling to a traditional medical office can benefit from remote consultations and testing, improving their overall health outcomes. This creates more equality and makes rural areas more attractive to live in. Additionally, the remote praxis can provide increased flexibility and convenience for patients who may not need to take time off from work or arrange transportation to attend an appointment.

**Reduction of Transmissions**: Disease transmission is becoming an increasingly important concern as the world becomes more connected. MedicalReach reduces the risk of disease transmission, particularly in times of pandemics or other health crises. Remote consultations and testing minimize contact between patients and healthcare providers and between patients in the waiting room, reducing the risk of exposure to contagious diseases. This benefit also extends to healthcare providers, who will be at a lower risk of contracting diseases due to reduced patient exposure.

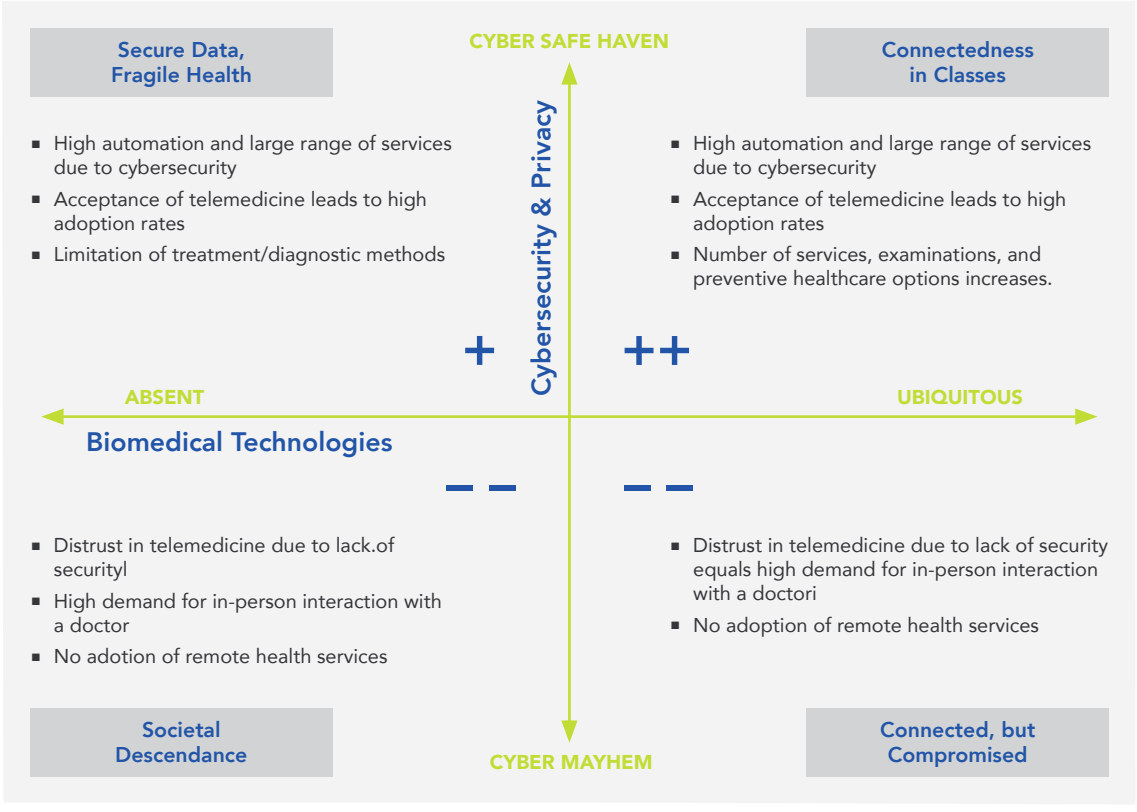
**Emission Reduction**: Reducing carbon emissions is one of the biggest challenges being faced today as the world aims to address the issue of climate change. The use of mobile stations in healthcare is a relatively new concept, but it has already shown great potential in reducing carbon emissions. The mobile stations lessen the carbon footprint associated with the alternative traditional medical offices because it significantly reduces the patients' commute to the doctor's office, which reduces transportation-related emissions. The negative environmental impact caused by the moving stations is negligible compared to the overall savings.

## Scenario Fit

**Connectedness in Classes**: The business model of a remote doctor's praxis evolves constantly and incorporates new technologies and capabilities. With high data security, the praxis uses advanced electronic medical records and telehealth platforms to provide virtual consultations, remote patient monitoring, and personalized treatment plans. Patients can securely access their medical records and communicate with their doctors on the MedicalReach platform from anywhere in the world. Advancements in biomedical technology enable the praxis to offer a broader range of diagnostic and treatment options. For example, new diagnostic devices and artificial intelligence tools help doctors make more accurate and faster diagnoses, while new drug therapies and surgical techniques could provide more effective treatments with fewer side effects. Furthermore, automated medical assessment advancements make on-site nurses obsolete and completely automate mobile stations. Since patients do not need to worry about their data being secure, and they have much trust in biomedical technology, MedicalReach is a very successful business.

**Secure Data, Fragile Health**: MedicalReach is vital in providing basic medical care to patients. It thrives by focusing on non-invasive medicine and testing methods. Instead of invasive medical procedures and vaccines, the praxis shifts towards preventive care, emphasizing lifestyle changes, nutrition, and holistic approaches to healthcare. In addition to doctors, MedicalReach could include further consulting experts like nutritionists and wellness coaches. This could include workshops on healthy cooking, exercise, stress reduction, other lifestyle topics, and regular health screenings and wellness events. Instead of vaccines and chemical pills, the mobile station medicine dispenser will provide patients with homeopathic remedies, herbs, and teas. Moreover, remote consultations and teleoperation would be completely safe, as cybersecurity is enforced and widely adopted. This increases the trust in MedicalReach mobile stations and leads to a population with safe and reliable medical services, even in the most remote locations.

**Societal Descendance**: MedicalReach faces significant challenges in delivering healthcare services to patients. Without secure data systems, the praxis must rely on more traditional communication and record-keeping methods, which could be less efficient and more prone to errors. To ensure the safety and security of patient data, the praxis needs to rely on more localized systems, such as paper records and physical filing systems. This requires additional staffing and administrative resources to manage and maintain these systems. In addition, the range of services that the praxis offers are limited. As in the Secure Data, Fragile Health Scenario, instead of invasive medical procedures and vaccines, the praxis shifts towards preventive care, emphasizing lifestyle changes, nutrition, and holistic approaches to healthcare. In addition to doctors, MedicalReach could include further consulting experts like nutritionists and wellness coaches. Instead of vaccines and chemical pills, the mobile station medicine dispenser will provide patients with homeopathic remedies, herbs, and teas.




**Connected, but Compromised**: The lack of data security makes it difficult for MedicalReach to protect patient information, which is essential to maintaining patient trust and complying with data privacy regulations. This limits the use of telehealth and other digital tools that rely on the secure transmission and storage of patient data. Despite the challenges, advancements in biomedical technology still enable MedicalReach to offer a broader range of diagnostic and treatment options. However, the lack of data security will also impact the revenue stream for MedicalReach. Patients may be hesitant to share sensitive medical information online, which reduces the demand for telehealth services and other digital tools. This makes it harder for MedicalReach to gen-

erate revenue from consultation fees and the sale of medical supplies and devices. MedicalReach must focus on providing high-quality, in-person care and maintaining patients' trust. The mobile stations still incorporate new technologies and advancements in biomedical research to offer a broader range of services and treatments. Still, it does so while prioritizing patient safety and privacy.

## Challenges

- Building trust with skeptical or elderly patients can be difficult.
- The success of the business model highly depends on the acceptance of the population in rural areas.
- Technology that enables fully automated or remote health assessment does not exist yet, so advancements in areas like teleoperation, drawing blood, etc., must be made.
- A high level of privacy and security is necessary to accept remote services.
- Communication technology must be advanced and reliable at remote locations for the services to work reliably.
- Legal and regulatory frameworks must be set up for remote consultation and telemedicine.
- Currently, insurance does not pay for remote assessment of patients (e.g., remote blood pressure measurement is not paid for). This payment framework has to be renegotiated with insurance.
- Designing, financing, and setting up the containers.
- Ensure the highest level of hygiene and cleanliness that medical equipment necessitates, ideally without human involvement.

## Outlook

At first, the pilot program is focused on improving healthcare access in rural areas in Germany through a combination of remote consultations with doctors and on-site medical procedures. To achieve this, MedicalReach utilizes a modified ambulance-style vehicle staffed with a health professional trained to perform basic medical procedures under the remote supervision of a doctor. This delegation allows for reimbursements under current health insurance regulations while allowing doctors to work remotely. To streamline the entire process, MedicalReach is developing its own platform that integrates remote consultations, on-site procedures, and remote supervision. Looking ahead, MedicalReach envisions replacing ambulance-style vehicles with their own modular mobile stations that can offer a wide range of services. In addition to the basic medical treatment and testing, different

modules providing the medical equipment for specialized treatment can be added to it. The exact additional modules will be determined based on the patient's demand. MedicalReach plans to incorporate advanced teleoperation and immersive technology, ultimately leading to better patient outcomes. The team's vision is to automate the mobile station fully, make the processes leaner, and individualize medical procedures as much as possible. Once the medical supply in rural areas is secured, MedicalReach will expand to urban areas in Germany and rural regions in other European countries. Step by step, the ultimate goal is to provide accessible, affordable, and secure healthcare worldwide.

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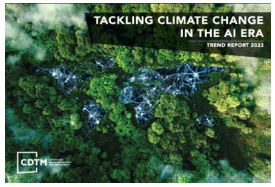


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**Publisher** Center for Digital Technology and Management
Arcisstr. 21
80333 Munich, Germany

E-Mail: info@cdtm.de
www.cdtm.de

**Editors** Vera Eger, Felix Dörpmund

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**Printed Copies** 100

**Printing Company** printworld.com GmbH
Weststraße 60
09603 Großschirma

**Photos** https://www.istockphoto.com/
https://www.midjourney.com/
https://www.pexels.com/
https://www.unsplash.com/

**Year of Publication** 2023

# THE FUTURE OF COMMUNICATION TECHNOLOGY

Communication technology has revolutionized the way we interact with one another, breaking down barriers and making it easier to connect across the globe. The future of communication technology promises to be even more transformative, with innovative technologies that will shape the way we work, learn, and socialize.

One of the most exciting developments in communication technology is the advent of 6G networks. With lightning-fast speeds, low latency, and high bandwidth, 6G networks will enable us to transmit data more quickly and efficiently than ever before. This will pave the way for new applications and services that will enhance our daily lives, such as virtual and augmented reality, smart homes and cities, and connected vehicles.

Another area of rapid advancement is artificial intelligence (AI) and machine learning. These technologies are already being used to automate routine tasks and enhance decision-making, but their potential goes far beyond that. AI-powered chatbots and virtual assistants are becoming increasingly sophisticated, enabling us to communicate more effectively and efficiently with one another.

The rise of the Internet of Things (IoT) is also transforming the way we communicate. With more and more devices becoming connected, we can interact with our homes, cars, and other objects in ways that were once unimaginable. This will allow us to be more productive, save time, and enjoy a more seamless and personalized experience in our daily lives.

Overall, the future of communication technology is both exciting and challenging. On one hand, it promises to enhance our lives in countless ways, enabling us to connect, collaborate, and create in ways that were once unimaginable. On the other hand, it presents us with a host of new challenges, from cybersecurity threats to ethical concerns about the use of emerging technologies.

In the end, the future of communication technology will be shaped by our willingness to embrace change and work together to overcome the challenges we face. By doing so, we can create a world that is more connected, more resilient, and more just. The future is in our hands, and we´re confident that we will rise to the challenge.

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The Center for Digital Technology and Management (CDTM) is a joint interdisciplinary institution of education, research, and entrepreneurship of the Ludwig Maximilians University (LMU) and the Technical University of Munich (TUM).

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