

# EXECUTIVE COMPANION



`/Prompt` What will smart technology in the future look like?







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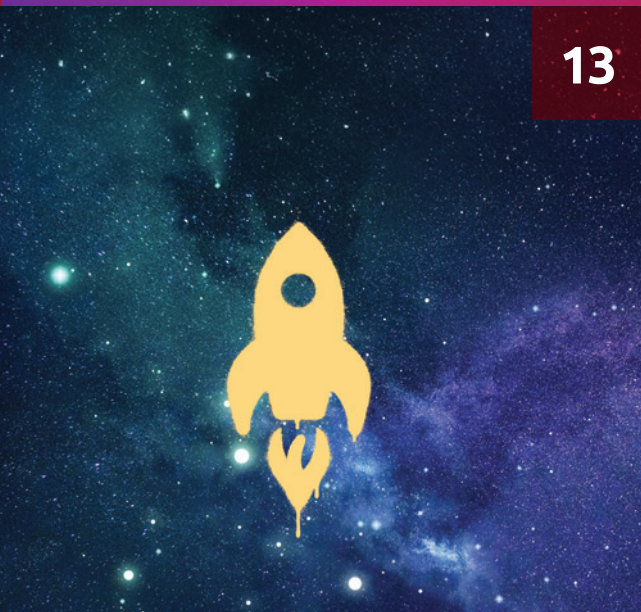
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# INTRODUCTION

The quote “We shape our technologies and afterwards our technologies shape us” echoes Winston Churchill’s famous words during the reconstruction of the Commons Chamber in 1943, after its destruction by incendiary bombs in the Blitz. Churchill, emphasizing the significance of the Chamber’s adversarial rectangular pattern, believed that its shape was crucial for Britain’s two-party system and parliamentary democracy.

Similarly, we could argue that we are inevitably shaped by the technologies we create. Technology’s primary role is to augment and enhance human abilities, a trait distinguishing humans from most mammals. However, we often overlook how technology, in turn, influences our behavior, organizations, and society. A critical question arises: How will technology shape our world in 2024 and beyond?

For over 15 years now, Capgemini’s TechnoVision has been exploring this question but so far it has mainly focused on IT Trends. This year we decided to add a companion to our TechnoVision full report, taking a wider view of technologies that are moving the world.

Overall, our intent is not to build futuristic forecasts; we see TechnoVision as a tool to facilitate strategic dialogue between technologists and business leaders, helping to identify priorities and opportunities for business operations and digital systems development.

TechnoVision aims to be the guiding ‘North Star’ in the dual transformation towards a digital and sustainable economy. This journey involves numerous technological and business decisions, made more complex by the urgent need for strategic choices that might seem simple at first glance but often have far-reaching implications.

Generative AI, which took the world by storm in 2023, is expected to continue shaping the future. Alongside this, several other key technology megatrends are critical for decision-makers planning for the future. This is the starting point of our discussion, leading to the 37 trends outlined in TechnoVision 2024. Together, these trends will provide insights for shaping the future and determining the necessary ‘prompts’ for organizations in 2024 to turn their visions into reality.



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# WHICH TECHNOLOGY (MEGA)TRENDS WILL SEE INFLECTION POINTS IN 2024?

When it comes to shaping the future, all technology trends might hold equal significance, as forecasting is often a challenging, if not an impossible task. However, certain trends emerge as more prominent due to their anticipated substantial impact and the expectation of significant breakthroughs in the near future. We have pinpointed five such prominent technology megatrends that should have inflection points in 2024:



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## GENERATIVE AI – SMALL WILL BE THE NEW BIG

In 2024, will Generative AI live up to the massive amount of hype it has generated? The short answer is yes.

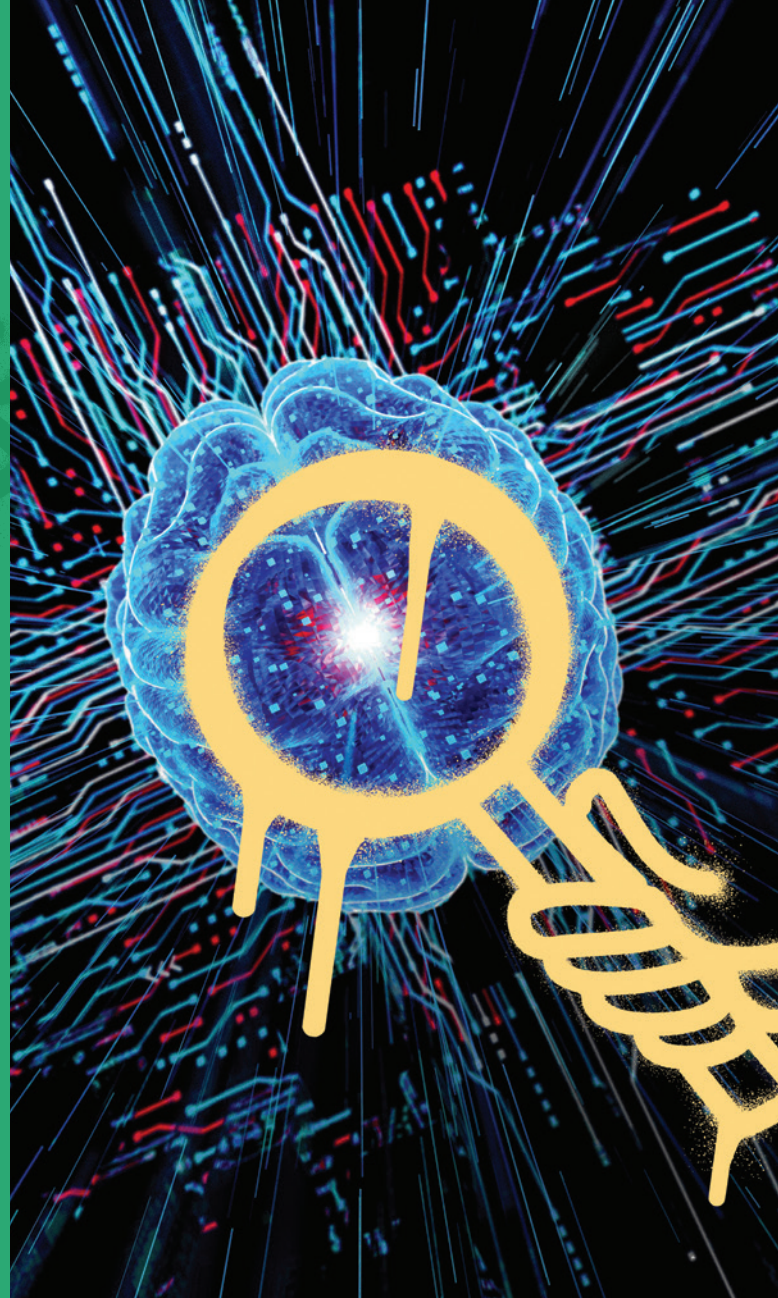
Generative AI has made a crashing entrance in the global technology and business conversation in late 2022 and 2023, with expectations of significant business impact.

But this popularity also highlighted some of the drawbacks of general-purpose Large Language Models (LLMs). One notable problem has been the tendency of some of these models to 'hallucinate', in other words, to occasionally produce outputs that are unexpected, irrelevant, nonsensical, or disconnected from the input they received. In 2023, the solution has mostly been to build bigger and bigger models, with more data, more parameters, and more computing power behind them. But this trend is not infinitely sustainable, nor is it suited for all use cases.

While current LLMs will continue to thrive, there is also an increasing need for smaller, more cost-efficient, and specialized models. For example, we will see sector-specific models for advanced use cases in medicine, engineering, education, and many others. We can also anticipate domain-specific models, tailored for specific tasks (like advanced coding assistants). These models will get smaller and smaller to run on low-footprint installations with limited processing capabilities, including on the edge or smaller enterprise architectures.

In addition, for use cases where factuality and correctness matter, the capabilities of LLMs will be enhanced by integrating structured knowledge from knowledge graphs. This promising combination can improve the accuracy, relevance and depth of information provided by LLMs. In 2024, we will see more and more AI systems that not only have a deep understanding of natural language but are also anchored in structured, factual knowledge, making them more reliable and effective for a wide range of applications.

In support of all this, new platforms are emerging, providing tools for companies to leverage Generative AI without the need for deep internal technical expertise. This will lead, in the long run, to the creation of interconnected networks of models designed and fine-tuned for specific tasks, and to the development of true multi-agent generative ecosystems.



**Why it matters:** The developments in Generative AI are indicating an evolution towards a more accessible, versatile, and cost-effective technology. The innovations mentioned before will enable organizations to scale their Generative AI use cases faster while also deriving more long-term value from the technology.

**Things/projects to watch for:** 'Small being the new big' may seem paradoxical, but it's set to become a reality. The quest is on for smaller LLMs that require significantly less resources to train and operate, while generating less false information (the so-called hallucinations), propagating fewer social stereotypes, and producing less toxic language. The mission: make AI models compute efficient, helpful, and trustworthy. Innovations like Stanford's Alpaca, and European ventures such as Mistral AI and Aleph Alpha, are leading this movement but Microsoft and Google are also entering the arena with Orca and Gemini Nano.



## QUANTUM TECHNOLOGY – WHEN CYBER MEETS QUANTUM

Entering 2024, quantum computing has definitively left the era of theoretical exploration and entered a ‘utility-scale’ quantum computation age. As defined by IBM, ‘utility-scale’ quantum computers provide computing capabilities beyond the reach of classical computations and open a door to a quantum advantage in real-world commercial quantum applications. As significant challenges in qubit quality remain, a large-scale, broad quantum advantage

is still many years away. Nonetheless, 2024 will see various claims of a narrow quantum advantage in specialized tasks within larger conventional computational workflows. Boosted by early successes, broader quantum advantages will appear in the coming years.

Driven by the prospect of quantum advantage in the near future, companies, startups, and research institutes are racing to find the first real-world applications. Key areas include:



- **Condensed Matter Physics:** Understanding the behavior of complex materials at a quantum level can revolutionize material science and engineering.
- **Quantum Chemistry:** Solving the Schrödinger equation for larger molecules, which classical computers struggle with, can lead to drug discovery and materials breakthroughs.
- **Computational Fluid Dynamics:** Addressing the challenges in simulating fluid flow, essential for aerodynamics and climate modelling.
- **Partial Differential Equations:** These equations are fundamental in expressing physical phenomena and solving them more efficiently will provide value in fields like finance and engineering.
- **Logistics and Operations Research:** Optimizing supply chains and logistics can benefit from quantum computing by finding solutions to complex optimization problems more quickly.
- **Sampling and Monte Carlo Methods:** Used in statistical physics and finance, these methods can be quadratically faster on a quantum computer, providing more accurate models and forecasts.

Additionally, as quantum computers are supposed to break commonly used public-key cryptosystems (such as RSA and ECC) one day, a large-scale migration to quantum-safe technology is about to start. Driven by technological improvements and regulatory pressure, 2024 promises to be a pivotal year for quantum-safe solutions.

Already in 2017, the National Institute of Standards and Technology (NIST) initiated a public process to select quantum-resistant public-key cryptographic algorithms for standardization. They realized that public-key infrastructures are crucial to digital trust, protecting everything from web connections and email to digitally signed documents and code. The algorithms for asymmetric cryptography in place today rely on mathematically challenging problems, such as factoring very large numbers, which are computationally difficult for current computers. Traditional computers would take years to break these algorithms. A sufficiently powerful quantum computer could solve these hard math problems in a matter of minutes by leveraging its ability to process multiple simultaneous states. NIST's goal is to establish a new standard based on even harder math problems (e.g. lattice cryptography) that are difficult for both traditional and quantum computers. To be clear, quantum-safe algorithms do not require a quantum computer themselves; they protect against an attack leveraging a quantum computer when they become powerful enough.

In late 2022, the US Government enacted the 'Quantum Computing Cybersecurity Preparedness Act,' which promises to catalyze a seismic shift across industries. This groundbreaking law mandates that all private entities conducting business with the US government must migrate to PQC within a year after the NIST standards are finally released. This should affect PQC standards globally.

The release of the final standard, combined with the new regulation should intensify the rush towards a quantum-safe future in 2024. Organizations everywhere need to take immediate steps toward updating their cryptographic systems and software to the new quantum-safe algorithms because average migration will take significant time. Although quantum computers capable of breaking today's encryption do not exist yet, the risk of bad actors collecting encrypted data today with the intention of decrypting it later (harvest now – decrypt later), is very real.

As the rush for quantum preparedness intensifies, starting around mid-2024, industries ranging from finance to healthcare will likely invest heavily in upgrading their cybersecurity infrastructures.

**Why it matters:** This emerging shift to Post Quantum Cryptography promises to upend the very basis of cybersecurity standards globally. All business leaders and technology experts will be affected by this approaching milestone, while more and more organizations begin their quantum transition.

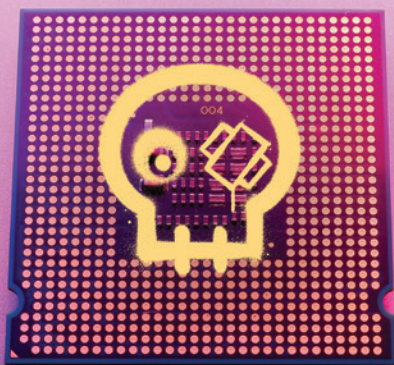
**Things/projects to watch for:** Although enterprise scale quantum computing is probably still many years away, promising progress is being made in several areas. Google and IBM believe commercial quantum systems, applying error mitigation techniques, are only a few years away. Both tech giants have also released public roadmaps reaching one million qubits, by 2029 for Google and 2030 for IBM. In the meantime, hybrid classical and 'noisy' quantum computing (NISQ – Noisy Intermediate-Scale Quantum) will deliver the first practical use in specific problem areas, while we wait for large-scale fault-tolerant quantum computers to be available.

# SEMICONDUCTORS – MOORE’S LAW ISN’T DEAD, BUT IT IS CHANGING

The semiconductor industry stands on the brink of a revolutionary shift in 2024, influenced by various factors that are collectively transforming its dynamics.

Throughout 2023, there has been an intense discussion among experts about the future of Moore’s Law, which posits that the number of transistors on an integrated circuit doubles approximately every two years, thereby enhancing the computing power of a microchip. As chip technology approaches the 2-nanometer (0,0000001 cm) scale, with the costs of manufacturing expanding at an exponential rate, questions arise about the feasibility of continuing this trend, especially considering the impending physical constraints at the 1-nanometer scale.

However, 2024 is poised to demonstrate that Moore’s Law is not obsolete but rather undergoing a metamorphosis. We’re likely to witness shifts in approach, such as the adoption of vertical stacking in multi-layer structures, exploration of non-silicon materials, and new lithography techniques. In essence, we can label this technological shift as going for ‘more than Moore’, i.e., aiming to sustain the growth in computing power, even as traditional methods of chip miniaturization approach their physical limits.



Simultaneously, the semiconductor ecosystem is set to undergo reconfiguration. This will encompass the establishment of new gigafactories, the adaptation to local regulations, the expansion of fabrication capacities, the introduction of novel business models, and enhanced foundry services. Semiconductor companies are expected to intensify their focus on catering to industry-specific demands by producing chips that significantly enhance customer experiences, marking a new era in semiconductor technology.

**Why it matters:** An accelerated digital transformation is expected across industries, enabled by more powerful connected objects, from smartphones to electric vehicles to data centers and telecoms. These technological breakthroughs will be reflected in shifts in the ecosystem of semiconductors itself, with new gigafactories, regulations, business models, and foundry services emerging in 2024.

**Things/projects to watch for:** Cramming more components onto integrated circuits will come to an end because we are approaching the boundaries of physics. Despite this insurmountable asymptotic peak of physics, chip design is now contemplating a 1.x nanometer scale. However, energy and heat challenges pose significant challenges. In addition, the cost of fabrication of such chips grows aggressively. One approach to improving performance and lower energy use is to add AI into the chip (IBM Z Systems) to reduce the movement of data to the compute and back and have it available in the processor chip and its caches.

Others use AI to optimize the power consumption leveraging periods of lesser activity where not every compute resource is being used to its fullest. Another way to leverage AI is to assist the software engineer understand the tradeoff between the performance of the system and the precision of the numbers. If they need more bandwidth, they can reduce the precision, training specifically for reduced precision, effectively exchanging a hardware problem for a software problem.

Other approaches include adding more nodes or using heterogeneous architectures like handing off tasks to specialized co-processors like GPUs, TPUs, and XPU's exemplified by Nvidia’s Hopper + Grace solution, Intel’s Sapphire Rapids, and Falcon Shore platforms.





## BATTERIES – THE POWER OF CHEMISTRY

Improving the performance and reducing the costs of batteries is a major focus for both businesses and governments, as the industrial stakes are high for each nation. The aim is to support electric mobility and accelerate long-duration energy storage, which is critical to speed up the energy transition to renewables and the acceleration of smart grids. There are five key performance characteristics of battery technology evolution:

- 1. Energy Density:** Energy density in batteries is measured in two ways: volumetric (Wh/L) and gravimetric (Wh/kg), indicating the energy stored per unit volume or mass. This is crucial for electric vehicles (EV) and stationary energy storage, where battery size and weight matter.
- 2. Power Density:** Power density refers to the energy a battery can release in each capacity, with specific power denoting energy per unit mass. The charging rate (C-rate) describes the power needed to charge a battery, and discharge power indicates the energy output at any moment.
- 3. Lifespan:** The lifespan of a battery decreases with each charge-discharge cycle, affecting its longevity and suitability for its original purpose. Eventually, batteries should be repurposed or recycled.
- 4. Costs:** Cost is a significant factor, often calculated per kWh. For EVs, achieving cost parity with internal combustion engine vehicles is key, as the battery pack is the most expensive component.
- 5. Safety:** Safety concerns arise due to the flammable liquid electrolyte and thermal energy release from the cathode material after several cycles. These safety issues could hinder the broader adoption of EVs and battery-based energy storage solutions.





While LFP (lithium ferro-phosphate) and NMC (nickel manganese cobalt) are becoming standard for electric vehicle applications, several technologies concerning the chemistry of batteries are being explored, such as cobalt-free (sodium-ion) and solid-state batteries, with a likely acceleration in 2024. The primary driver for the market of sodium-ion batteries is the increased demand for energy storage generated through solar and wind. Market leaders in this industry are Faradion Limited (UK), NGK Insulators Ltd (Japan), Tiamat (France), HiNa Battery Technology Co. Ltd (China), and Contemporary Amperex Technology Co. Limited (China).

The development of solid-state batteries represents a major shift in battery technology, primarily for electric vehicles, as they have higher energy densities (i.e. storage capacity), for a price which will become lower than traditional batteries. They also reduce dependency on materials such as lithium, nickel, cobalt, rare-earth minerals, and graphite, while promising longer lifespans and more robust safety. QuantumScape (USA), Toyota (Japan), Solid Power (USA), Samsung (South-Korea), and LG Chem (South-Korea) are among the leaders in this rapidly evolving field.

**Why it matters:** In a business world driven by the energy transition, the fight against climate change, and organizations in transition to a sustainable economy, these emerging developments may offer a pathway towards better tradeoffs for the battery industry and more sustainable use of materials.

**Things/projects to watch for:** When looking at this technology megatrend, two categories of players need to be distinguished: the unicorns and the startups. Amongst the unicorns, well-established companies can be recognized such as Tesla (USA), accelerating the transition to EVs and energy storage, Northvolt (Sweden), manufacturing Li-ion for EVs, Verkor (France), manufacturing low-carbon batteries for EVs, QuantumScape (USA), develops solid-state battery technology to increase the range of EV's, Freyr (Norway), manufacturing semisolid Li-ion batteries for energy storage and EVs, Sila (USA), provider of nano-composite silicon anode that powers breakthrough energy density in EV batteries, and SES AI (USA), manufacturing of scalable, dense, smart and light Li-Metal batteries for electric transportation on land and in air.

Since battery technology exhibits genuine quantum mechanical and quantum chemical behavior, it is a very natural area to apply quantum computing. Several government-funded and promising projects are ongoing, and a large amount of startup activity can be witnessed — e.g. IonQ (USA), psiQuantum (USA), Phasecraft (UK).

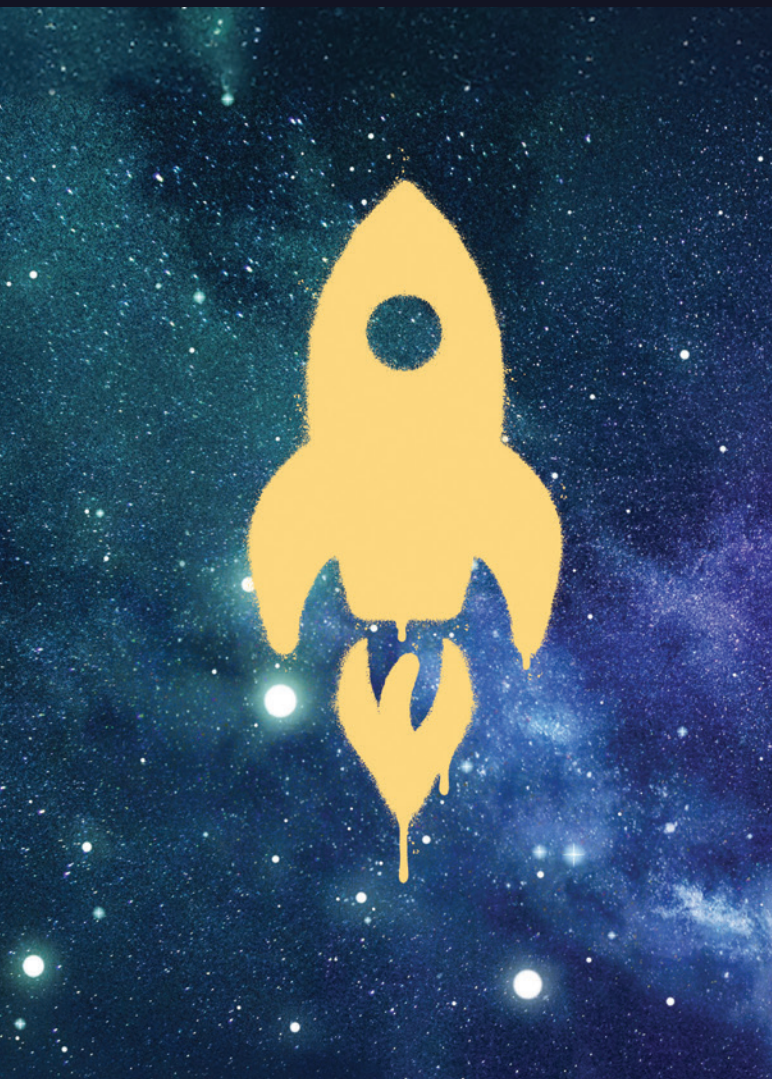


# SPACETECH – ADDRESSING THE EARTH’S CHALLENGES FROM OUTER SPACE

In 2024, humanity will be preparing to return to the moon. The NASA Artemis II Mission, scheduled for a November 2024 launch, will send astronauts into lunar orbit for the first time since the 1972 Apollo 17 mission. This landmark event is a symbol of a broader industry trend that can be described as a new Space Age.

This renewed interest in space technologies is driven by two major shifts in the industry. Firstly, and contrary to the Space Race of the '60s and '70s, it is driven not just by government agencies, but also by a multitude of private actors, from startups to corporations. Secondly, aside from the major scientific missions headed to the Moon or Mars, this race is mostly headed for Low Earth Orbit (LEO), in the pursuit of cheaper use cases and more performance. All in all, the year 2024 is set to usher in an array of exciting technological projects in many domains:

- In the field of space communications and networks, we can see a surge of exciting projects such as the development of laser communication systems, hybrid ground and space networks, or even seamless 5G connectivity from space.
- In Earth Observation, we can look forward to fascinating projects to advance our understanding of the planet and its changing environment. In particular, the increasing integration of AI in Earth Observation is offering more efficient data processing, enhanced analytical capabilities, and the potential for new insights into Earth's environmental and climate-related challenges.
- Simultaneously, the Internet of Things is expanding into an entirely new dimension with the development of satellite constellations. CubeSats, ChipSats, and other nanosatellites are being launched in their thousands, each onboarding its own array of miniature sensors and communications equipment. An exponentially growing volume of data is being collected and shared for a variety of purposes, including gathering data on weather patterns and wildlife migrations.
- There are also several exciting projects at the intersection of cyber and space, even in the field of quantum cryptography. Cybersecurity in space has become a crucial frontier, especially as the reliance on space-based assets for both military and civilian purposes increases. There's an increasing emphasis on improving cybersecurity for space-bound equipment, with strategies like Zero Trust architectures, and even research into Quantum Key Distribution (QKD).
- Finally, this new space age is driven by a complete 'sustainable by design' philosophy. This approach emphasizes the importance of sustainability from the outset by emphasizing the development of spacecraft and satellites that are not only more efficient but also reduce space debris.





All of these innovations signify the dawn of a new epoch in space exploration, fueled by rapid technological advancements and a rekindled interest from the public. This renewed interest in space technologies aims to drive scientific discoveries and help solve the earth's most critical challenges, including the monitoring of climate risks and disasters, better access to telecommunications, as well as defense and sovereignty.

**Why it matters:** The last Space Race revolutionized the world by accelerating groundbreaking innovations like satellite technology, GPS, integrated circuits, solar energy, and composite materials. This return to the stars promises similar revolutions in the fields of computing, telecommunications, and Earth Observation.

**Things/Projects to watch for:** In 2024, the SpaceTech sector is brimming with innovative startups, each contributing unique advancements to the industry. Some players to keep an eye on include:

- 1. **Blackshark (Austria):** Identifying any object on the earth's surface from space.
- 2. **GalaxEye (India):** Providing all-weather multisensory imaging satellites.
- 3. **Helios (Israel):** Extracting oxygen from moon dust.
- 4. **Orbit Fab (USA):** Fuelling stations for spacecraft.
- 5. **True Anomaly (USA):** Specializing in autonomous orbital vehicles.
- 6. **Spin Launch (USA):** Catapulting rockets into space.
- 7. **GATE Space (Austria):** Offering bolt-on propulsion and deep throttling engines.
- 8. **Keplar Communications (USA):** The internet of space.
- 9. **Planet Labs (USA):** High Frequency geospatial data that drives innovation.
- 10. **Ohmspace (UK):** Innovating with low-pressure water propellants.
- 11. **Firefly (USA):** End-to-end space transportation company.
- 12. **Revolv Space (Netherlands):** Advancing solar array rotary actuators.

- 13. **Abyom SpaceTech (India):** Developing re-ignitable cryogenic rocket engines.
- 14. **Clear Space (Switzerland):** Removing space debris.
- 15. **Vyoma (Germany):** Addressing collision avoidance.
- 16. **Ion-X (France):** Innovating in electric propulsion systems.
- 17. **Quasar (Australia):** Developing Phased array ground stations.
- 18. **Astrix (New Zealand):** Focused on inflatable solar arrays.
- 19. **Astranis (USA):** Building small, low cost internet connectivity satellites.
- 20. **Blue Origin (USA):** Pioneering reusable rocket technology.



These companies are at the forefront of transforming space technology, pushing boundaries in their respective domains.

# BEYOND 2024 – OTHER TECHNOLOGIES SHAPING THE NEXT 5 YEARS

## 1. Low-carbon hydrogen: Towards a credible alternative to fossil fuels

Hydrogen has long been touted as a clean fuel alternative because it produces only water when burned. However, traditional hydrogen production is energy-intensive and often relies on fossil fuels. The trend toward low-carbon hydrogen seeks to change this by using renewable or nuclear energy to power the electrolysis of water, splitting it into hydrogen and oxygen with zero carbon emissions. Advances in electrolyzer technology, including the development of proton exchange membrane (PEM) and solid oxide electrolyzers, are improving efficiency and reducing costs. However low-carbon hydrogen is still not competitive at this point, in addition to other reliability and scaling challenges. Countries and corporations around the world are investing heavily in low-carbon hydrogen as part of their strategies to achieve carbon neutrality, to bring its cost down soon.

## 2. Carbon capture: Accelerating the decarbonation of carbon-heavy processes

While reducing carbon emissions remains the top priority, as defined by the Paris Agreement, several hard-to-abate industries will also need to invest in carbon capture technologies (especially at the point of source, such as a cement or steel factory) to reach their decarbonation goals. New methods of capturing CO<sub>2</sub> are becoming more efficient and less energy-intensive, supported by significant public investment, especially in the US and the EU. Innovations include the development of advanced solvent technologies that require less energy to capture, use, and store CO<sub>2</sub>, as well as solid sorbents offering lower cost and higher CO<sub>2</sub> selectivity. Additionally, the filtering of CO<sub>2</sub> from other gases using membrane technology is being refined to improve its efficiency and scalability. Nevertheless, carbon capture is still facing specific challenges such as cost, storage, or conversion in industrial processes. There is also significant research into the removal of CO<sub>2</sub> directly from the atmosphere via direct air capture (DAC), even though that application remains expensive compared to its alternative carbon capture solutions.



## 3. Synthetic biology: Harnessing the power of nature

The COVID-19 pandemic underscored the importance of synthetic biology to protect public health, highlighting the immense potential of innovations like synthetic mRNA to develop vaccines at unprecedented speeds. In November 2023, a major milestone was reached when the UK medicines regulator approved a therapy leveraging the CRISPR-Cas9 gene editing tool as a treatment against sickle-cell diseases, the first of its kind in the history of medicine. But synthetic biology goes much, much further. It is an interdisciplinary field combining biology, engineering, computer science, and biotechnology, allowing for revolutionary applications that could dramatically impact medicine, agriculture, and environmental sustainability. Standing at the confluence of rapid technological advancements and critical global needs, this technology is poised to be a hot topic in the next few years. Future advancements include programmable cells and organisms, like microbial factories that can produce essential drugs. Examples include fungi engineered for penicillin and recombinant E.coli for insulin production. These techniques also extend to producing green chemicals and sustainable materials, like yeast for bioethanol production and algae for biodiesel, as well as E.coli for bioplastics, which offer better performance and environmental friendliness across their lifecycle. Gene editing is another area of rapid progress, offering hope for individuals with genetic disorders through potential treatments or cures. Additionally, advances in computational methods and bioinformatics are fueling the creation of new biological systems, positioning synthetic biology as a frontier for both scientific discovery and pragmatic solutions to current challenges.



# TECHNOVISION 2024 SUMMARIZED

The overarching theme of TechnoVision 2024 is 'Augment ME! — Elevate Your Possible, Rediscover Ourselves'. Under this flag, TechnoVision offers an extensive and multifaceted look at the impact of emerging technologies on business, society, and the environment. We start by recalling the Apollo 8 mission's Earthrise photograph, symbolizing a moment of global awareness and unity. Today, we find parallels in how emerging technologies like AI, quantum computing, and synthetic biology augment our capabilities. These advancements, while seemingly focused on technological growth, ultimately lead to a deeper understanding of ourselves and our organizational purposes.

However, we also caution against the uncritical adoption of technology. We underscore the need for balancing technological growth with sustainability and ethical considerations. The hottest year on record, 2023, points to escalating climate crises, underscoring the importance of sustainable business practices and the role of technology in achieving these goals.

TechnoVision 2024 explores the potential of technology in addressing these challenges, advocating for dual transitions in technology and sustainability. This involves integrating IT, OT, and Biotechnology, reimagining our approach to global issues.

TechnoVision categorizes IT trends into six containers: user experience, collaboration, data, process automation, applications, and infrastructure. Each trend is detailed with its impact, use cases, and links to key technologies. In addition to those containers, there is a seventh container consisting of the overall design imperatives that must be observed.

The **'You Experience'** container highlights the rapid evolution of digital experiences driven by technological advancements. Businesses are enhancing their digital presence, offering seamless, human-centric experiences that merge the physical and digital worlds. This evolution is propelled by AI, immersive technologies, and the Metaverse, aiming to create more natural online interactions. The Metaverse is emerging as a platform for both personal expression and industrial applications, blurring the line between virtual and real life. Digital Twins are being used to efficiently simulate and manage real-world entities. Emotional intelligence in technology is gaining importance, with advancements in AI enabling more empathetic interactions. The concept of 'No Experience' involves intuitive, stress-free technology use, where interactions are as natural as in real life, largely facilitated by Generative AI. This transformation is also reshaping workplaces, driving increased engagement, productivity, and sustainability. Overall, these developments aim to meet rising user expectations for more authentic, convenient, and seamless digital experiences.

**'We Collaborate'** explores the dynamic evolution of collaboration in the digital age, driven by AI and distributed technologies. It describes a shift from traditional teamwork to innovative models involving human-to-machine and machine-to-machine collaborations. The rise of decentralized identity management empowers individuals to control their data within complex digital networks, enhancing security and personal empowerment. Hybrid work environments blend remote and in-office collaboration, leveraging digital tools to optimize team dynamics. The token economy is reshaping value exchange through digitization, decentralization, and democratization. Mesh technology facilitates agile, adaptive collaboration across diverse sectors. The 'Economy of Things' integrates IoT, AI, and Web3 to create a decentralized economic landscape, redefining traditional business models and interactions in a digitally interconnected world.

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**‘Thriving on Data’.** In the data-centric business world, data is pivotal for enhancing customer experiences, optimizing operations, and achieving sustainability. Organizations strive to master data, leveraging AI and automation tools to make data accessible and actionable. Data sharing and collaboration within ecosystems amplify value, driving innovation and societal benefits. The self-service data revolution is democratizing data access, empowering individuals across businesses to engage in data science roles. Generative AI fosters creativity and productivity but requires careful oversight. Sustainable data practices are crucial for net-zero ambitions, emphasizing efficient data use. The Internet of Things (IoT) and edge computing are turning everyday objects into intelligent, data-driven assets, reshaping industries, and personal lives.

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**‘Process on the fly’.** In the fast-paced business environment, processes must be adaptable, quickly responding to changes and challenges. AI and automation are key to enabling efficient, touchless management of processes. Digital Twins provide risk-free environments for testing changes, while business process automation breaks down silos, connecting disparate systems. Processes are increasingly miniaturized into micro-forms, enhancing speed and agility. This evolution towards autonomous, AI-driven systems requires less physical space and energy, leading towards a sustainable, ‘lights out’ enterprise. Ultimately, this transforms how organizations operate, blending human capabilities with technology for innovative and purpose-driven business operations.

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**‘Applications Unleashed’.** In the digital era, software has become a vital asset for competitive success. Organizations are transitioning to become software-centric, adopting agile, cloud-based applications built from microservices. AI is significantly enhancing developer productivity, with natural language processing emerging as a new programming paradigm. This shift includes adopting low/no-code tools, empowering more people to develop applications. Applications are also being redesigned for sustainability, focusing on lower energy use. AI is increasingly integrated into applications, adding smart functionalities. The future of software is marked by miniaturized, agile applications, AI-assisted development, and sustainable engineering, all converging towards a more efficient and intelligent software ecosystem.

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**‘Invisible Infostructure’.** The journey towards invisible IT infrastructure is advancing, with the cloud as the default, offering hybrid options and industry-specific solutions. AI-driven autonomy addresses skill shortages, reduces CO<sub>2</sub> emissions, and simplifies IT operations. The infrastructure integrates cutting-edge technology like sensors and 5G, bringing technology closer to people and things. However, awareness of IT’s carbon footprint is lacking, prompting a focus on sustainable IT practices. Emerging computing paradigms like quantum and neuromorphic technologies promise significant innovation. The cloud’s role is expanding beyond migration to encompass sustainability, financial transparency, and multi-cloud options, aiming for seamless integration with business operations.

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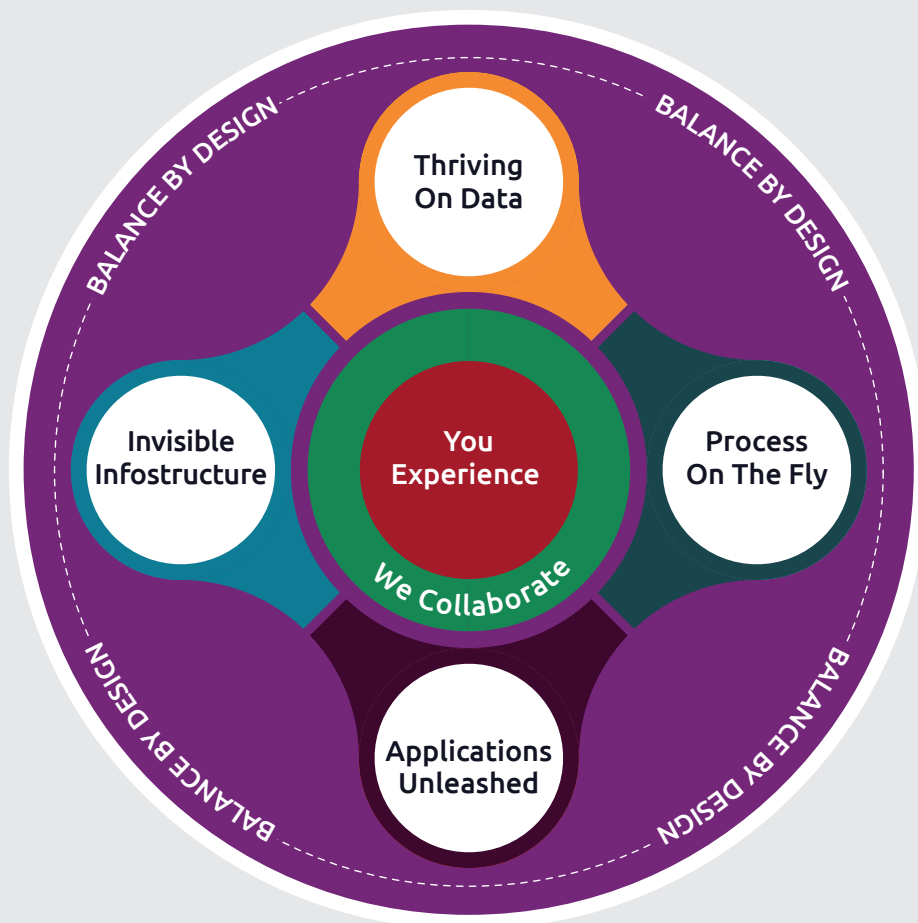
**'Balance by Design'** highlights the importance of balancing different elements in technology decision-making. It emphasizes aligning business and IT, leveraging AI for judgment, and prioritizing social and environmental value. The concept suggests embracing flexibility and openness, balancing corporate intelligence, creativity, and emotional quotients, and preparing for a hands-free, automated business future. This approach requires a unified, agile, and adaptable organization that effectively integrates technology and human elements. The aim is to create a Technology Business that is responsive, ethical, and sustainable, while also being innovative and efficient.

Looking towards the future, we explore the potential of technology in various scenarios, such as space exploration, hybrid work environments, and the convergence of AI, quantum computing, and cybersecurity. We predict a future

where technology is not only a business enabler but an integral part of addressing global challenges like climate change and healthcare.

In conclusion, TechnoVision 2024 serves as both a comprehensive analysis of current technology trends and a roadmap for future innovation. It stresses the importance of balancing technological advancement with ethical considerations, sustainability, and human-centric design.

Our journey with technology mirrors that of Apollo 8's crew: a quest to explore new frontiers that ultimately leads to a deeper understanding of our humanity, and our collective future. As one crew member, William Anders, announced a few years after the mission *"We set out to explore the moon and instead discovered the Earth."*





# TECHNOVISION 2024: WHAT'S NEW?

Because TechnoVision is seeing its 16th edition and some trends stay relevant for multiple years, every year we do see new trends emerging, replacing previous ones that usually have become part of the 'status quo' and are fully adopted in organizations' information technology stack.

To provide a quick overview of what's new for 2024, what follows is a summary of the ten new trends (out of a total of 30) and three new guiding principles.

## No Experience

*Container: You Experience*

*The consilience of Generative AI and immersive technologies will result in controller-less interactions and the merging of the physical and virtual worlds for a natural, intuitive, and stress-free experience of technology; like there is no experience at all*

What if technology could just 'get' what we want, without needing to use 2D touchscreens, buttons, and controllers? What if we could just talk, look, point, and gesture in our digital multiverse, just like we interact in the real world, and move seamlessly between them? High-quality rendering, powerful real-time graphics engines, and immersive displays can make us feel physically present in virtual worlds. Combined with the power of Generative AI, these technologies are unleashing the 'No Experience' paradigm. We will be guided by AI-powered virtual agents that are indistinguishable from us, complete with preferences and personalities. They will deliver personalized experiences, services, and recommendations within highly realistic immersive experiences that will blend into our lives, understanding and responding to our environment, preferences, and needs.

## My Identity, My Business

*Container: We Collaborate*

*The rise of decentralized identity management, powered by the Web3 'Mesh Web', will empower individuals to reassert control over their own data*

Navigating the digital jungle, we're all potentially one misstep away from a cyber calamity, especially while tethered to Centralized Identity Management. Cue Decentralized Identity, armed with Web3 and blockchain, swooping in as our guardian of the online galaxy. It's more than a plot twist, with tools like Self-Sovereign Identity and smart contracts, we're scripting a new narrative, placing the control firmly back in the user's hands. The climax? A tale of bolstered security, user empowerment, and organizations nailing the balance between safeguarding and seamless experiences. Sounds like we're in business.

## Economy of Things

*Container: We Collaborate*

*In a digital dance of devices and decentralization, a new Economy of Things emerges; business as usual gets a revolutionary remix*

Imagine a world where every tangible and digital entity boasts its unique, sovereign identity, seamlessly interacting through groundbreaking technology such as the Internet of Things, AI, multi-agent computing, 5G, and the Web3 'mesh web.' It's not sci-fi; it's the next digital horizon where people, machines, and gadgets can chat,

trade, and even pioneer their own economic blueprints. It's a digital metamorphosis ushering in a realm that's open, secure, and green. A newly invented reality, blending leading practices of decentralized and centralized worlds, people, and physical assets. Meet the Economy of Things, a bold digital-socio-economic landscape. Business as usual just got an extraordinary makeover.

## The Thing with Data

*Container: Thriving on Data*

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*An abundance of data going around within the Internet of Things — at the edge — turns mundane objects into hyper-intelligent, connected assets*

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Here's the thing: in the vast ecosystem of technology, data is the lifeblood coursing through the veins of the Internet of Things (IoT) and edge computing. This isn't merely a symphony of ones and zeros playing in the background; it's the harmonious rhythm powering industries and reshaping business landscapes. Picture this — computing at the edge in-space technology, processing astronomical data in real-time to optimize satellite communications for global enterprises. The IoT, meanwhile, is transforming mundane equipment into intelligent assets, weaving a web of efficiency across factories and supply chains and indeed: earth and space. This evolution isn't just about machines becoming wiser; it's about elevating businesses to unparalleled levels of innovation and connectivity. Harnessing this wealth of data isn't just strategic; it's absolutely visionary.

## My AI Generation

*Container: Thriving on Data*

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*Generative AI enables individuals and organizations to express themselves creatively like never before while boosting productivity — but human oversight and guardrails are key*

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Talkin' 'bout my AI generation: it seems that almost overnight we have gotten accustomed to having productive and creative AI assistants available everywhere, helping us with a wide range of activities. Large Language Models excel in exactly what their name suggests: interpreting and producing 'language', whether it pertains to text, audio, video, images, test data, or program code. Combined with technology for (private) data retrieval and contextual navigation, Generative AI truly becomes a phenomenal augmentation force for the enterprise. But watch out for the AI 'generation gap': beautifully articulated language can perfectly mask the disinformation it may contain. Guardrails are a must, just as human oversight, wherever appropriate.

## Micro Process Magic

*Container: Process on the Fly*

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*Miniaturizing processes into micro-sized forms to achieve greater speed, agility, and efficiency — while learning more about daily operations*

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It's a kind of magic. Imagine miniaturizing processes into smaller and smaller forms, using micro-services, cloud technology, and the Web3 'mesh web'. These tiny, razor-focused micro-components enable rapid adaptation to market shifts and reduce bottlenecks. They also optimize resource usage and minimize waste, while leveraging all goodness from advanced AI and automation. They not only drive cost savings and extreme agility but also keep businesses competitive in a dynamic market. Integrate micro-processes into the corporate workflows to revolutionize operations with precision and adaptability. By escaping the confines of monolithic systems, the finesse of these independent units is harnessed to swiftly adapt and innovate, while rediscovering the essence of each and every process component involved. Enchanting!

## Autonomous Enterprise

*Container: Process on the Fly*

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*Harnessing AI, the autonomous and unattended 'lights out' enterprise continually optimizes itself, bringing harmony and blending capabilities between humans and technology*

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Incorporating AI into the equation elevates mechanistic automation by not only enabling mimicry but also augmenting human intelligence. AI's proficiency in comprehending natural language, and deciphering audio, video, and images allows it to perceive processes within their broader context, uncovering intricate patterns beyond human perception. This AI-human combo not only jazzes up how we work but it fully reshapes our work processes and organizational structures, fundamentally altering the landscape of business operations and daily life. As AI continually optimizes the autonomous and unattended 'lights out' enterprise, it fosters harmony by blending the capabilities of humans and technology, creating a dynamic synergy that propels us into a new era of innovation and efficiency.

## When Code Goes Know

### Container: Applications Unleashed

*Pair programming with an AI assistant can significantly boost coding productivity and quality while steepening your learning curve — if you know what you're doing*

Know what? It was already getting easier to produce high-quality code, through API catalogues, prebuilt templates, automation, and powerful low/no-code systems. And now there is Generative AI, providing both professional and business developers with language models that can produce code as if it was written by the best software engineers on GitHub. It delivers productivity and quality and it's highly educational too. All of this is done through dialog in plain, natural language. Exactly what an aspiring Technology Business needs. But beware, an experienced eye is always needed before releasing AI-generated apps. As the saying goes: you know it when you see it.

## Chat is the New Super App

### Container: Applications Unleashed

*AI-augmented chatting and talking in plain, natural language becomes the new app to rule them all*

It has been the ambition of quite a few captains of the IT industry: Creating one Super App that can be used to manage and launch whatever application service one could possibly need. But it would still be an app, with an interface that needs to be mastered and a logical flow that must be followed. What if all of that would simply disappear and be replaced by a simple dialogue in natural language? The rapid breakthrough of AI-augmented chat systems, combined with an infinity of subject matter-specific plug-in models, is making this a reality. It will democratize access to applications, driven by a radically new design concept for software engineers. Supercalifragilisticexpialidocious!

## Ok Qompute

### Container: Invisible Infostructure

*New horizons of more organic computing are emerging, driven by quantum and neuromorphic chips — breaking the spell of bits and bytes, opening up entirely unexplored opportunities*

To address some of the most significant challenges of our time, such as improving healthcare and the race to net zero, there is a demand for much more computational power. The time has come to explore alternative computing methods. Welcome to the realm of bits, neurons, and qubits. We have already moved beyond a single processor architecture — CPUs, GPUs, TPUs — are here to stay, but their roles will be shaken up by the new kids on the block — quantum and neuromorphic chips. They operate on fundamentally different principles, more closely modeling our own, organic reality. That promises extraordinary, quite OK capabilities.

## NEW GUIDING PRINCIPLES

**Balance by Design — Overarching.**

**Transformative. Purposeful:**

*When augmenting ourselves with technology, we rely increasingly on complex, interconnected systems that no longer fit into our established 'command and control' ways of management. A new balance needs to be established between what we trust from Artificial Intelligence and automation, versus what we still deem human.*

The **AI'll be the Judge of That** principle suggests a new judgment symbiosis between man and machine. The aspirational **Be Like Water** has served as the overall concept of the Technovision edition 2021 which evolved into the practical 'Being like Water' for the consecutive 2022 edition. Today the built-in 'water-like' capabilities of agility, flexibility, responsiveness, resilience, and openness have evolved into a design imperative.

Finally, the **IQ CQ RQ EQ Up** design imperative reverts to a properly measured and monitored balance between four – sometimes conflicting – assets: the corporate intelligence quotient, creativity quotient, robotic quotient, and emotional quotient. An aspect that is essential when trying to Augment MEI, and not replace me.



# FURTHER RESEARCH



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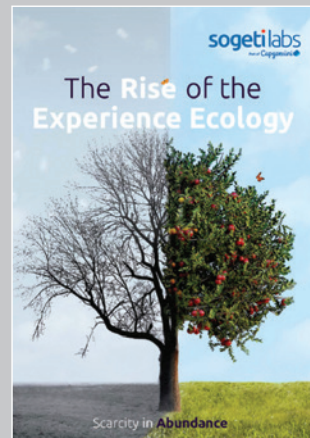
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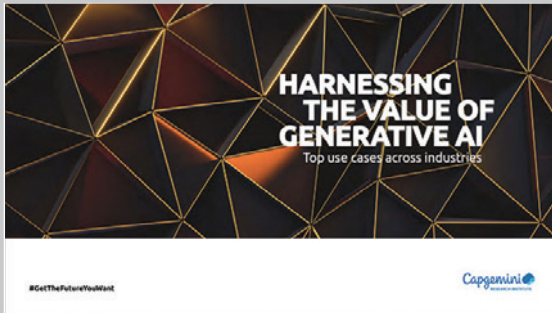
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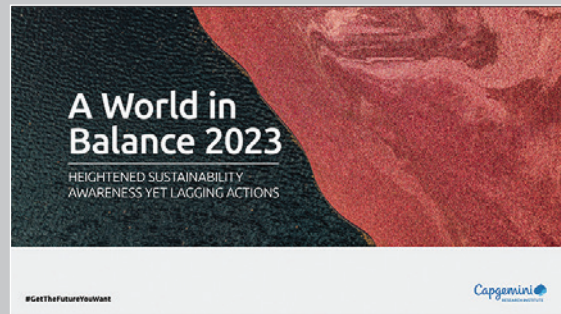
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