

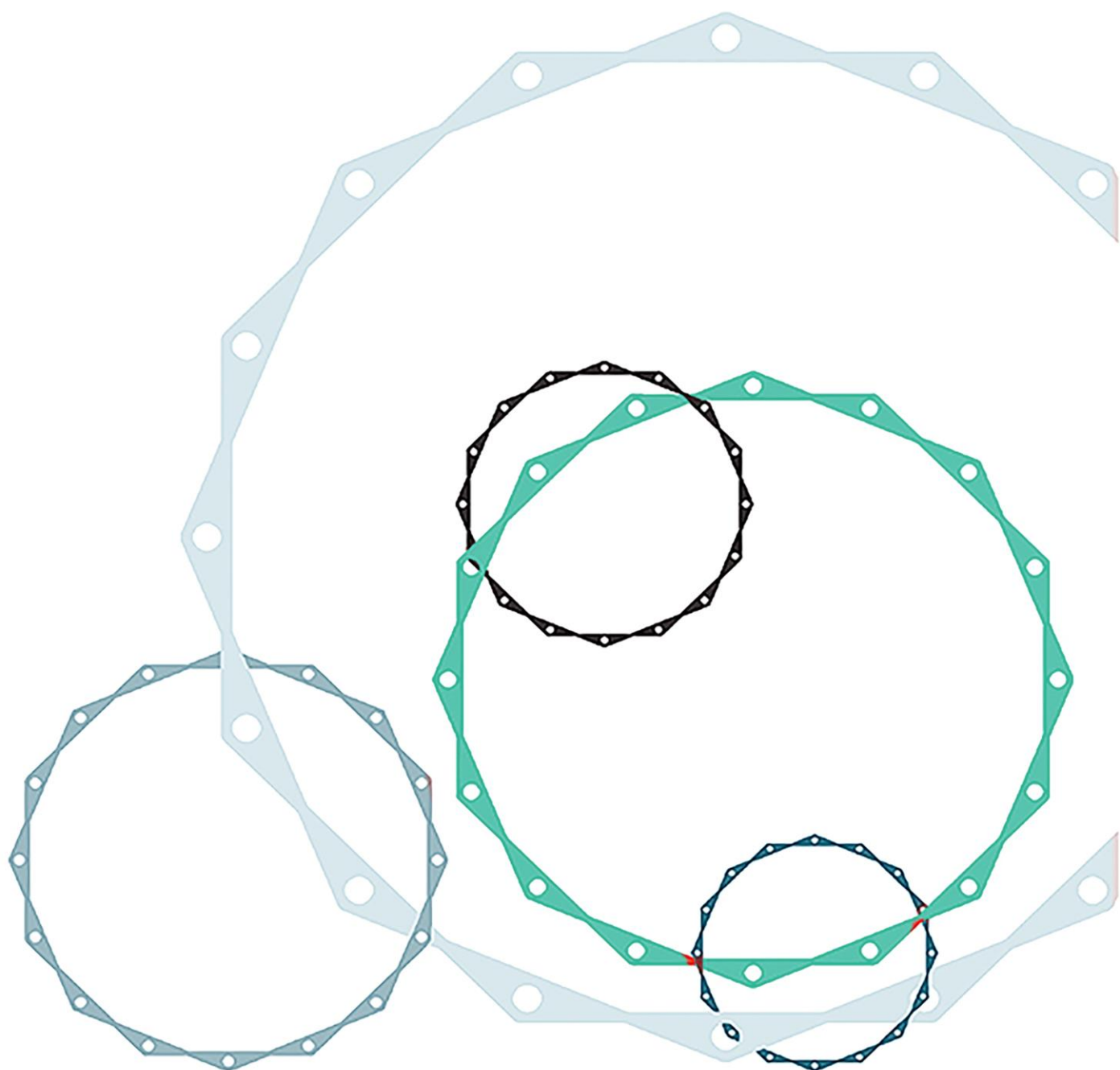
A Transformed World

iCV TAnK

Technology Advisory
& Knowledgebase

The Power of Future Industries

October 2023
Canada, Singapore



Disclaimer

The opinions expressed in this report strive to be independent and objective, and do not constitute any advertisement.

The data in this report are mainly public information, as well as the collation of public data.

The copyright of this report is owned by ICV TAnK. Any other form of use or dissemination, including but not limited to publications, websites, public accounts or personal use of the content of this report, needs to indicate the source (2023 Global Quantum Computing Industry Development Prospect. ICV TAnK, 2023.02).

When using the content of this report, any quotation, deletion and tampering against the original intention of this report shall not be carried out. Without written permission, any institution or individual shall not reproduce, reproduce or publish in any form. If consent is obtained for quoting, reprinting, and publishing, it must be within the scope of permission. Those who use this report in violation of regulations shall bear corresponding legal responsibilities.

The purpose of citing data, events and opinions in this report is to collect and summarize information, and it does not mean that we agree with all of their opinions, and we are not responsible for their authenticity.

This report involves dynamic data, expresses the situation as of the time of publishing, and does not represent the future situation.

The information or opinions expressed in this report do not constitute investment advice, please refer with caution.

For other questions, please contact infer@icvtank.com.

Key Points

- Over the next 20 years, the pace and impact of technology development will likely increase, transforming and enhancing human experiences and abilities. Technology can provide potential solutions to challenges such as aging populations, climate change, and low productivity growth. At the same time, the growth and transformation of technology will bring about fresh tensions and disruptions within and across societies, industries, and nations.
- In the coming decades, the competition for critical resources of technology dominance, such as talent, knowledge, and markets, will be fierce. The emergence of new tech leaders or hegemonies is possible.
- The competition for technological dominance is closely tied to the shifting geopolitical landscape and the broader US-China competition. However, companies with a long-term focus, resources, and global influence will strengthen their technological advantage.
- However, identifying and industrializing cutting-edge technologies enables developing countries to leverage the latest breakthroughs and develop global applications in niche markets. This contribution to global supply chains will further strengthen their position.

Foreword

Technologies have fundamentally been a means of creating new tools and products, and the ability to construct tools and products is a defining trait of humanity. Assessing technological trends and their broader impacts pose challenges. The timeline is uncertain, and the path from base science to transformative applications can be difficult to distinguish. The relationships between technology and its potential wider impacts are indirect and complex. Revolutionary technologies have also raised numerous ethical, social and safety issues, including questions of humanity's identity, the impact on the environment, and the limits of acceptable war.

Disruptive technologies refer to innovative technologies that create entirely new technologies, products, or services, and have a significant impact on traditional or dominant technologies and practices. Disruptive technologies may involve creating a new technology or simply fusing existing technologies across disciplines or industries. Continuous technology innovation enhances existing products and encourages market growth and expansion, up to a certain point, after which disruptive technology innovation becomes essential to promote further market and technology development. Disruptive technology innovation may involve a new invention or a non-continuous approach to innovation, such as reversing established practices or conventions in a given domain.

Table of Contents

- 1** Future Industry Trends
- 2** Quantum Information and the Transformation of Military Defense
- 3** Artificial Intelligence Becomes Mainstream
- 4** Smart Materials and Manufacturing Redefine the Future
- 5** Biotechnology Facilitating Rapid Innovation
- 6** Emerging Technologies Fueling the Commercial Space Industry: Fostering Competition or Threatening Freedom?
- 7** Hyperconnected, Divided and Disconnected Society

I 01

Future Industry Trends



The Competition for Tech and Industry Hegemony

The competition for technological and industry hegemony is becoming increasingly intense. It is inextricably tied to the shifting geopolitical landscape and is increasingly affected by wider political, economic, and social competition. This competition will be influenced more and more in the future, particularly by the competition between the United States and China, which is set to be the key factor.

In the competition for technological and industry hegemony, accumulating resources to maintain a wide technological lead, including human talent, foundational knowledge, and supply chains, requires long-term investments and visionary leadership over several decades. Those who invest in these resources today may ultimately become the technological leaders of 2040, as this competition is a long-term one.

In open economies, private efforts and partnerships between governments, private companies, and research projects will be an effective choice for national-leading economic competition. While state-led economies may have advantages in guiding and concentrating resources, they may lack the open, creative, and competitive environment necessary for success in this competition. In this competition, those who are better able to concentrate resources and achieve higher creativity and efficiency have a better chance of winning.

The Spread of Technology: Global Integration and Local Innovation

The spread of technology is a global phenomenon, and it can be accelerated by dividing technology and applications, providing for the rapid adoption of new technologies around the world and the development of global applications in niche markets. Through this process, developing countries can also take advantage of the newest core advancements, and this can also contribute to the supply chains of more developed economies.

Many countries will seek to expedite and leverage this process by sponsoring key efforts such as regional replacements for Silicon Valley or biotechnology incubators. Doing so can increase the risk of unexpected applications emerging from unlikely locations.

The Acceleration of Technology Development and Evolution

As technology evolves and changes, the time period required to develop, deploy, mature, and phase-out legacy technology has become significantly shorter, from several decades to just a few years or shorter.

Multiple stakeholders, including companies and countries, who are on the cutting edge of disruptive technologies may deploy and leverage new technology before others even begin to position, potentially giving them an advantage. However, this may also leave some participants vulnerable to not having enough time to understand the impact of the new technology and make informed decisions when facing potentially disruptive new technology.

Those who try to catch up, especially in developing countries, may face the risk of choosing technology cul-de-sacs or being left behind irreversibly, as they may have to choose between the next generation of technology without fully understanding its potential impacts.

It should be noted that these issues may pose greater challenges for entities with planned economy characteristics, such as the government of China. In a planned economic system, the government tends to prioritize short-term profits and economic growth over prospective long-term risks and reduced efficiency. Additionally, these political systems often lack sufficient mechanisms to support the development and deployment of new technology and innovation.

Emerging Technologies Driving Transformation

Quantum information, artificial intelligence, biotechnology, materials, and manufacturing technologies are all fields with potential revolutionizing advancements.

Quantum information technology offers a new computing model with capabilities beyond what supercomputers can achieve. However, the development of this technology needs to overcome multiple technical challenges, such as improving the stability of entangled particles and reducing the cost of quantum computers.

Artificial intelligence technology offers a new form of intelligent systems that can transform the way work is done and improve efficiency across multiple sectors. However, the development of this technology also needs to address multiple important issues, including data privacy and risk, AI bias, etc.

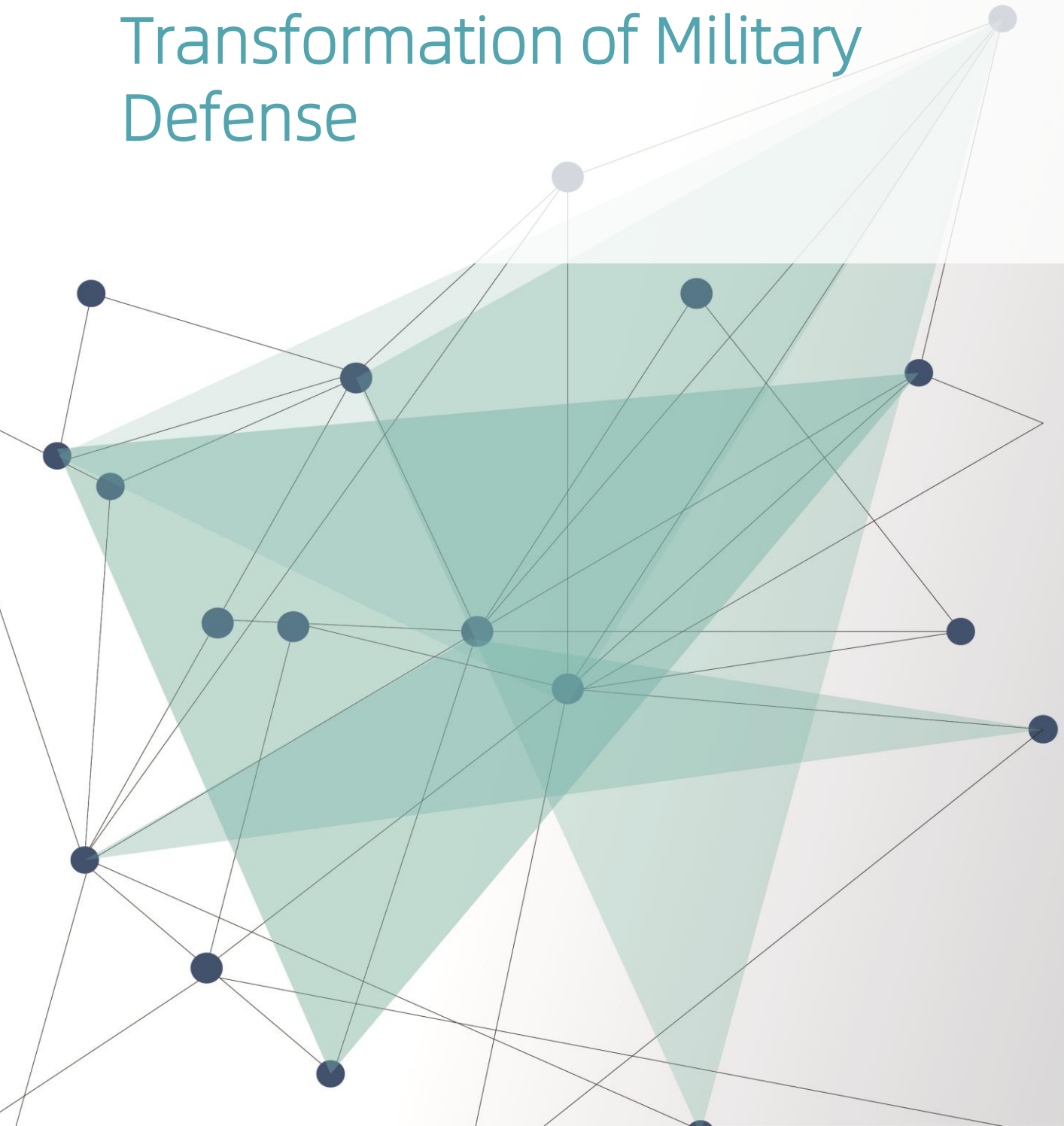
Biotechnology offers new medical and agricultural capabilities, but its development needs to overcome gaps between fundamental research and applied research, as well as imbalances between academic laboratories and pharmaceutical factories.

Material and manufacturing technologies offer new material design and manufacturing capabilities, but their development needs to address issues such as energy consumption, sustainability of materials, scalability of manufacturing capabilities, etc.

These technological advancements will be combined with other technologies, such as energy storage, and will be shaping social, economic, and perhaps the very nature of power itself. Since these technologies have revolutionary potential, it is essential to consider their long-term consequences, particularly in social, economic, and political spheres.

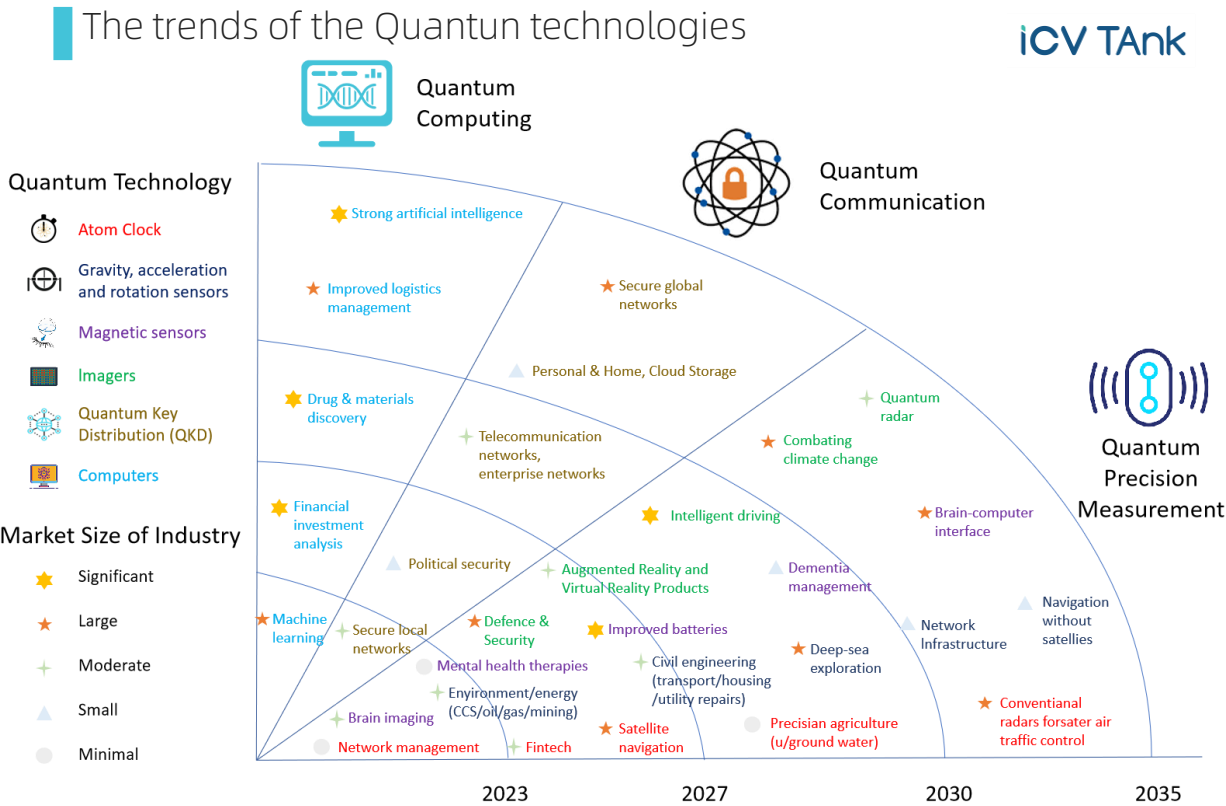
I 02

Quantum Information and the Transformation of Military Defense



Quantum mechanics originated in the early 20th century and is often used to describe the behavior of matter at the atomic scale (less than 10 nanometers). Quantum phenomena are the foundations of modern technology, including semiconductors, nuclear power, electron microscopes, superconductivity, photo detectors, and various medical imaging techniques, such as functional magnetic resonance imaging and positron emission tomography. Lasers and solid-state devices also take advantage of quantum behavior rules.

Modern military systems depend on classical, statistical, quantum, and relativity physics. Particularly, the first quantum revolution laid the foundation for many of today's military technologies, including semiconductors, computer chips, lasers, and modern communication. These practical applications have changed society and the battlefield, but recent advances bring even greater opportunities. Over the past few decades, a new generation of quantum technology has slowly emerged, enabling the production, exploitation, and engineering of more intricate aspects of quantum phenomena. This has opened the door to previously unimaginable technology advances.



Quantum mechanics originated in the early 20th century and is often used to describe the behavior of matter at the atomic scale (less than 10 nanometers). Quantum phenomena are the foundations of modern technology, including semiconductors, nuclear power, electron microscopes, superconductivity, photo detectors, and various medical imaging techniques, such as functional magnetic resonance imaging and positron emission tomography. Lasers and solid-state devices also take advantage of quantum behavior rules.

Modern military systems depend on classical, statistical, quantum, and relativity physics. Particularly, the first quantum revolution laid the foundation for many of today's military technologies, including semiconductors, computer chips, lasers, and modern communication. These practical applications have changed society and the battlefield, but recent advances bring even greater opportunities. Over the past few decades, a new generation of quantum technology has slowly emerged, enabling the production, exploitation, and engineering of more intricate aspects of quantum phenomena. This has opened the door to previously unimaginable technology advances.

Two additional research fields can be identified as the technological drivers for the above three:

4. Quantum materials: Materials whose properties can only be explained by quantum phenomena. For example, graphene or graphyne are often called quantum materials, as are topological insulators or quantum materials.

5. Quantum optics: Applying quantum mechanics to understand and harness the interaction between light and matter. This includes various applications, such as interferometry, photonics, quantum computing, communication, sensing, etc.

While quantum technology is unlikely to appear in large-scale deployments in the foreseeable future, its advances in sensors, communication, and computing will intersect and manifest themselves in several domains. The success of these technologies will have a transformative impact on military actions. Although new quantum technologies may have the potential to revolutionize the military capabilities of nations, most (but not all) quantum technologies are currently in their early development stages and face significant technical challenges before they can be developed into operational systems. The use of hyper-precise gravity, magnetic, or acoustic sensors will greatly enhance the effectiveness of underwater warfare, potentially making the oceans "transparent". Quantum radar may render stealth technology obsolete, providing more accurate target identification and enabling covert detection and surveillance. Accurate time keeping will help develop (accurate) positioning, routing, and timing (PNT) systems that can be used in areas where GPS is denied or unable to penetrate, such as under ice. Unhackable

computational tasks in optimization, BDAA, AI, modeling, and simulation possible. The computational advantage of quantum computing can greatly enhance the decision-making and operational efficiency of combat forces and even break current encryption technologies and encrypted data.

I 03

Artificial Intelligence Becomes Mainstream

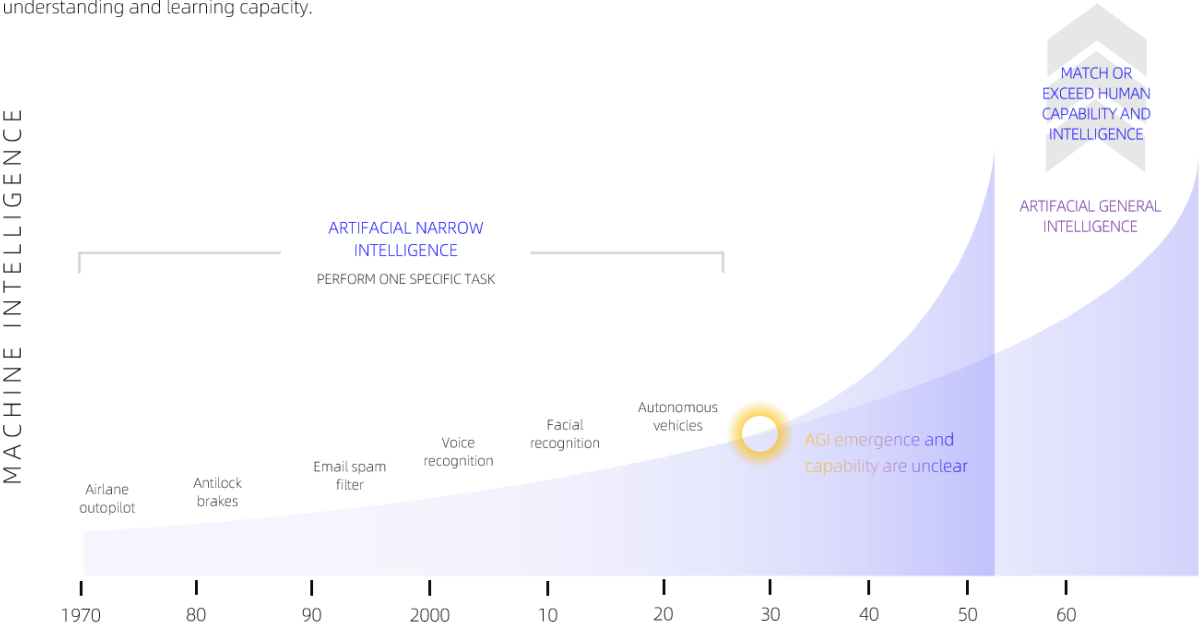


The development of AI technology in the coming decades has the potential to have a transformative impact in various areas, including healthcare, transportation, education, agriculture, and others. As AI technology advances from narrow AI to general AI, it may achieve human-like or even better than human mental capabilities in cognition and creative problem-solving capability, and could potentially surpass human understanding and learning abilities by the mid-2040s. Due to the potential of AI technology, global leaders in politics and business have been searching for talent globally to invest in developing AI technology in the hopes of becoming one of the first to use AI to reshape society, economics, and even wars. With the supporting high-quality data, computing power, and high-speed communication network, AI has the potential to disrupt industry leaders in various applications, catch up, and gain benefits while also mitigating harmful impacts, such as threats to privacy and freedom. AI technology development will bring plenty of benefits, but as it becomes more widespread, certain countries could gain disproportionate advantages, which also carry inherent risks of unfairness and biases. In warfare, widespread adoption of AI also increases the risks of intentional misuse or escalation by opposing forces, therefore, proper monitoring and suitable policy should be implemented to minimize unnecessary risks. As AI continues to progress, the threats to private data and privacy are also increasingly being brought to attention, therefore, proper protection measures should be taken to safeguard these areas.

TRAJECTORY OF ARTIFICIAL INTELLIGENCE

iCV Tank

Artificial intelligence(AI) is the demonstration of cognition and creative problem solving by machines rather than humans or animals, ranging from narrow AI, designed to solve specific problems, to Artificial General Intelligence(AGI), a system that in the future may match a human being's understanding and learning capacity.



Transformation of Industry and Labor Force

With the development and application of AI in the future, new job opportunities will arise, such as data scientists, robotic operators, human-robot collaboration designers, etc. At the same time, many jobs will be replaced by automation and robots. To adapt to these changes, countries and companies need to focus on retraining and reskilling labor force and increasing the investment in the government support and skill training. Furthermore, in the process of using AI, it is important to be aware of the collaborative aspect between humans and machines in many future jobs to better support the implementation of AI and the development of human labor force.

Data is the Way Forward

With the development and adoption of AI, data will become the key driver for future industries and organizations. Strategies, investments, and technologies relating to data will determine the competitive edge and advantages in the future. The acquisition, classification, storage, and monetization of data will become even more important. As a data provider or data manager, having enough technical resources and expertise to collect, process, and analyze massive amounts of data and use it to develop new products and services to improve efficiency and competitiveness is crucial. At the same time, the increasing quantity and complexity of data raises concerns around data security and privacy, becoming increasingly important areas of focus.

Reimagining Security and Privacy

With the continuous development and adoption of data and artificial intelligence, privacy and security become increasingly important issues. Sharing personal data becomes progressively necessary to access applications and use new technologies. However, the sharing and storage of this information also raises serious privacy concerns, especially in authoritarian regimes. On the flip side, with the application of AI, research and innovation in addressing these problems become increasingly important. The development of AI tools such as deep fakes may be used for marketing and pushing narratives, but could also be misused to manipulate and distort the output of AI. Therefore, when developing AI applications, extreme caution must be taken, to avoid data manipulation issues.

Ethics of Autonomous Decision-making

As AI continues to evolve and be widely applied, ethical issues will continue to be a focus. The level of human involvement in decision-making may vary across different countries and cultures, leading to differences in global views on ethical issues. Additionally, the lack of transparency in AI decision-making may lead to greater risks, including unintentional bias and discrimination, not to mention the potential for deliberate manipulation. Therefore, it is crucial to advance trustable AI by implementing transparent and clear decision-making processes to increase trust and confidence from all parties. Furthermore, in order to achieve full AI capability, there are technological and computational requirements, like data, algorithms, and computing power, that need to be fulfilled and considered in accordance with local regulations and privacy protection.

Artificial Intelligence Enhances Warfare

With the constant advancement and application of AI technology, AI will play a central role in military systems worldwide. AI will enhance the performance of existing weapons, defenses, and security systems, both physically and in the digital realm. However, it must be noted that anti-AI technology could also be developed to negate or mislead AI decisions, thus ensuring the safety and freedom of humans. Therefore, the development of AI also implies the existence of more complex ethical and moral issues that must be carefully considered and addressed.

I 04

Smart Materials and Manufacturing Redefine the Future



With the arrival of smart materials and manufacturing, a new world is being built. The emerging technology allows for the creation of materials that can sense, respond and communicate with the external environment, enabling a more efficient and effective production process. This transformation holds great potential for enhancing sustainability and reducing waste in manufacturing industries. Additionally, smart materials and manufacturing will bring about changes in the design, engineering, and supply chain management processes, leading to greater productivity, efficiency, and flexibility. Therefore, businesses and industries across the globe must adapt to these developments to stay competitive and relevant.

The fourth industrial revolution, powered by advanced materials and intelligent manufacturing, is set to transform the world of production starting from low-end consumer goods to high-end military systems. This revolution promises to lower costs, improve quality, expand capabilities, and facilitate innovative design choices, while also redefining traditional industries, jobs, supply chains, and business models.

The development of new materials is at the forefront of this revolution, and new materials will drastically change the way we design and make products, from stronger and more durable aircraft to ultra-portable and powerful mobile devices. These advancements will be facilitated by the convergence of advanced computation, materials modeling, AI, and bio-materials. Additionally, improved connectivity between these technologies will allow for the seamless distribution and access of knowledge and progress at the global scale.

Material science and manufacturing represent a mutually reinforcing cycle, with advancements in one fueling progress in the other. The current cycle, while already having significant progress and potential for continued growth over the next few decades, will be further accelerated by the combination of smart materials and advanced manufacturing. Increased connectivity will amplify the impact of this evolution in a positive feedback loop. Ultimately, this revolution has the potential to vastly improve people's quality of life but will also present new challenges and opportunities that must be navigated.

Increased Design Options

Increased manufacturing versatility through 3D printing, commonly known as additive manufacturing, is changing the game by enabling the local production of a wide range of materials, from titanium to explosives, in smaller facilities with limited resources and expertise. This technology is democratizing advanced manufacturing capabilities for global small businesses and individuals. Despite some technical challenges and reliability constraints, 3D printing is driving a revolution in modern manufacturing by delivering fast and agile prototyping, highly customized components, on-site production, and the ability to create shapes previously impractical.

3D printing is becoming a ubiquitous presence in various industries, including aerospace, architecture, and automotive, to name a few. The technology's ability to create highly complex shapes in a fraction of the time and energy required by traditional methods is a game-changer. 3D printing is empowering the design of stronger, lighter, more robust products, including commercial jets and mobile devices. Its flexibility and versatility make it an appealing alternative to traditional manufacturing methods, which can often be more efficient, less time-consuming, and less costly.

3D printing is poised to create a ripple effect that will transform the way we work, play, and live. As the technology continues to mature and develop in the coming years, we can expect it to play an increasingly significant role in the world of manufacturing, enabling new avenues for creativity and innovation, reducing costs and environmental impact, and helping to bring the benefits of advanced manufacturing to a larger audience.

Real-time Adaptation

The integration of advanced information systems, including modeling and machine learning, combined with advanced physical systems such as powerful industrial IoT and sophisticated robotics, has the potential to enable fully integrated collaborative manufacturing systems. These systems will have the ability to respond in real-time and meet the changing conditions of factories, supply chains, and customer demands.

By incorporating advanced data analytics, machine learning, and IoT into the manufacturing process, real-time supply chain management and material intelligence will not only improve production efficiency but also reduce costs and increase sustainability. By optimizing material usage and minimizing waste, the fourth industrial revolution promises to transform manufacturing and deliver personalized products on an industrial scale.

These intelligent systems will facilitate dynamic manufacturing, allowing components to be designed and fabricated on-demand, fulfilling individual customer needs and requirements. Smaller batch sizes, reduced material waste, and quicker time to market will transform industries such as aerospace, automotive, and consumer goods manufacturing.

The convergence of smart materials, advanced materials, and AI-powered manufacturing technology, coupled with the advancements in information systems and physical systems, represent a game-changer in manufacturing and logistics. With the power of 4th industrial revolution technology, we can expect the future of manufacturing to be personalized, dynamic, efficient, and sustainable.

Design the Content You Need

The materials industry is undergoing a revolutionary transformation as traditional materials are transitioning towards optimized materials that are designed for customized product manufacturing. This shift is being driven by the incorporation of advanced materials and engineering into 3D printers, enabling the production of stronger, lighter, and more resilient products.

The convergence of advanced materials with additive manufacturing, also known as 3D printing, is enabling the creation of customized products with previously unthinkable characteristics, from aircraft components to mobile devices. This technology will not only make products more durable and reliable, but it will also lead to reduced material waste, cost, and inventory and improve the supply chain with just-in-time manufacturing.

With the integration of new materials and 3D printing, we will see greater control over product specifications, improved supply chain management, and faster time to market, revolutionizing the materials industry and driving innovations in other sectors as well. The impact of this transformation is expected to be significant, with more products being custom-made to meet customer exact needs, leading to happier customers, better-quality products, and greater efficiency across the entire production ecosystem.

Assemble the Things You Need

Over the next several decades, the development of new materials is expected to advance significantly, providing materials with unique properties that go beyond what has been previously attainable. Two-dimensional materials, metamaterials, and programmable materials are prime examples. These materials possess extraordinary attributes, including exceptional strength, elasticity, conductivity, or other distinguishing characteristics, enabling a host of novel applications.

Two-dimensional materials, such as graphene and boron nitride, are atomically thin, yet incredibly strong and conductive, offering new opportunities for applications such as high-performance electronics, sensors, and energy storage. Metamaterials can also be optimized for specific applications, such as cloaking devices, thermal radiation shields, and acoustic impedance matching, while programmable materials are highly adaptable and able to respond to environmental stimuli, leading to new possibilities for applications such as self-repairing buildings, smart textiles, and interactive robotics.

The development of these materials offers significant potential for new uses, pushing the boundaries of what is currently possible. The fourth industrial revolution, coupled with advances in material science, machine learning, and computing, has the potential to drive innovation across multiple industries, from healthcare to energy production, creating new economic opportunities and improving the quality of life for all.

I 05

Biotechnology Facilitating Rapid Innovation



The prospect of predicting and manipulating biological systems is spurring unprecedented innovation in healthcare, agriculture, manufacturing, and cognitive science. Driven by advances in automation, information, and materials science, the field of biotechnology is poised for dramatic growth by 2040.

Biotechnology has the potential to reduce the burden of disease, hunger, and dependence on fossil fuels, while transforming how we interact with the environment and each other. With the aid of this technology, society can revolutionize the way we produce food, generate energy, and care for ourselves, opening the door to a more sustainable, healthy, and equitable future.

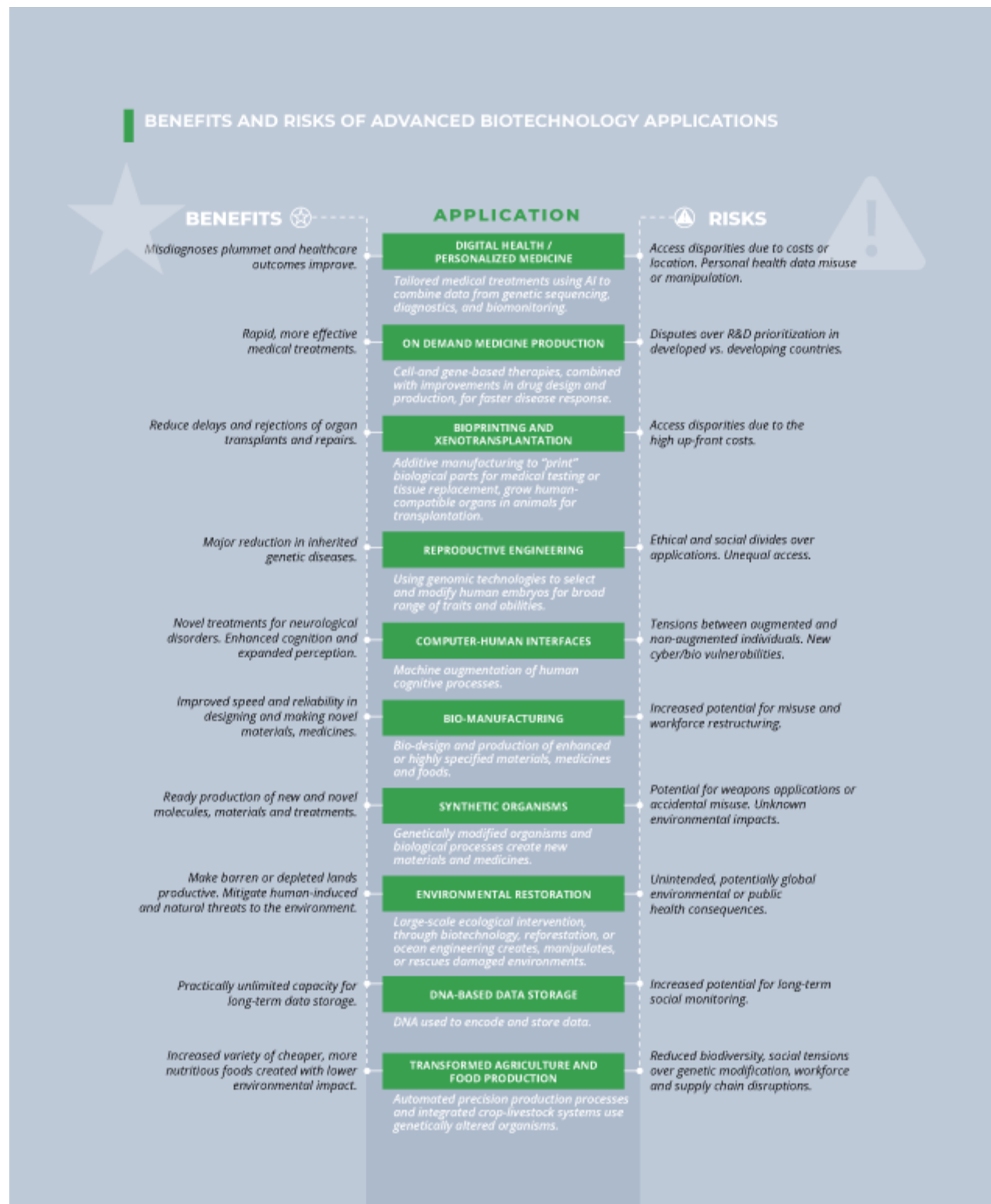
While the trans-formative potential of biotechnology is undeniable, the social and ethical issues surrounding its use will need to be carefully navigated. Markets, regulations, safety, and moral concerns, such as those surrounding genetically modified crops and foods, must be addressed to ensure that the benefits of these innovations are fairly distributed and that their use is in line with societal values.

Ultimately, the future of biotechnology lies in its ability to address some of the most critical challenges facing society today, including climate change, food insecurity, and access to healthcare, while preserving the integrity of the natural world. By taking a nuanced and deliberate approach to its application, the fourth industrial revolution is poised to usher in a new era of innovation, promoting the health and well-being of people and the planet in the decades to come.

Predictions suggest that biotechnology may continue to make significant contributions to economic growth, with the potential to increase its impact on global GDP by up to 2040. The agricultural and manufacturing sectors are expected to benefit particularly from these advances, as the use of biotechnology in crop production and food processing continues to increase. In the United States, where the biotechnology economy is already estimated at almost \$100 billion per year, the industry is expected to create even more economic opportunities in the years to come, both through technological innovation and increased investment.

In Europe, where the biotechnology industry is estimated to contribute as much as 10% to the overall economy, the focus is on developing new products and services that can address some of the most pressing societal challenges, from food insecurity to healthcare. As the use of biotechnology in these and other sectors continues to evolve, the potential for the industry to drive economic growth and social prosperity will likely become even clearer.

It is important to note, however, that the biotechnology industry is not without its challenges, including ethical and regulatory concerns related to the use of genetic engineering in agriculture, as well as the potential risks associated with the creation or release of genetically modified organisms. As the biotechnology industry continues to develop and expand, it will be important to carefully consider and address these and other issues in order to ensure that the benefits of biotechnology are maximized while risks are minimized.



| 06

Emerging Technologies Fueling the Commercial Space Industry: Fostering Competition or Threatening Freedom?



By 2040, the space industry is expected to experience significant advancements in emerging technology, leveraging existing capabilities to drive commercial adoption and new applications. Services such as communication, navigation, and satellite imaging will become ubiquitous, offering enhanced functionality, lower costs, and increased efficiency. The efforts of governments and commercial entities are likely to create new spheres of competition in space, particularly between the United States and China.

As technological advancements continue to reshape the space industry, emerging technologies such as artificial intelligence, machine learning, and 5G connectivity will play a vital role in enabling new business models and applications. These developments are poised to revolutionize industries such as resource extraction, infrastructure development, and disaster relief.

The expansion of the space economy is not without its challenges, however. Governance and regulation will need to keep pace with these new technologies, and the risks associated with the increased commercialization of space will need to be carefully managed. Despite these concerns, the potential benefits of a thriving space industry are immense, and the opportunities for innovation and growth are abundant. With continued investment and collaboration across governments, industries, and communities, the future of space exploration and development is set to be filled with new possibilities.

The Endless Possibilities of Space Exploration

By 2040, an increasing number of countries are expected to participate in space exploration as part of international collaborative efforts. Through this engagement, these nations will have the opportunity to garner national prestige, make scientific and technological advancements, and gain potential economic benefits. While governments will remain the primary funding source for large-scale space exploration activities, commercial entities will play an increasingly significant role in most aspects of space activity. Commercial efforts will exist alongside government-sponsored space programs and may collaborate or partner to advance space technology.

As space exploration becomes more commercialized, it is likely that private companies will become the main drivers of innovation and development in the field. These entities will have the freedom to explore new avenues and pursue novel approaches that may not be possible within the confines of traditional government-funded space programs. These advancements could lead to breakthroughs in technology, medicine, and other areas, as well as unlocking new business opportunities and economic growth.

China: A Front-Runner in the Space Race

By 2040, China is likely to become the most significant competitor to the United States in the space realm, both commercially, civilly, and militarily. China will continue to pursue an independent technological path in space, and it will have its own set of foreign partners participating in China-led space activities. China's space services, such as their BeiDou Satellite Navigation System, will be widely used across the world as an alternative to Western choices.

China has been investing heavily in its space program and has already made significant progress in its capabilities, including the development and launch of the Tiangong Space Station and the successful landing of a lunar rover on the far side of the Moon. These achievements have paved the way for further advancements in the field, including the potential development and operation of space-based weapons, which could further contribute to the military competition between China and the United States.

Despite this ongoing competition, commercial opportunities remain significant, especially in areas such as satellite communications and navigation, as well as in the development of new products and services. These developments will continue to drive the expansion of the space economy and create new opportunities for economic growth and prosperity for nations and businesses alike.

Space Support for Government and Military Needs

The increased capabilities of space services and new technologies have the potential to be utilized for both military and civil applications, including government and commercial use. The strategic importance of having control over national space assets is becoming increasingly apparent, as governments worry about the potential vulnerability of commercial or foreign-government space services in a conflict scenario.

As the space economy continues to evolve, new opportunities for business growth are likely to emerge across a wide range of industries, including space mining, infrastructure development, and disaster response. However, the possibility of conflict in space is also a concern, particularly in the areas of satellite navigation and communications, which are critical for both military and civilian applications. Governments around the world are likely to continue to invest heavily in their space programs, both to ensure their national security and to take advantage of the growing commercial and economic potential in this field.

In-orbit Activity Becomes Norm

By 2040, governments may begin to pursue in-orbit services, assembly and manufacturing activities using advanced autonomous and additive manufacturing technologies, in support of national space systems and international efforts. Commercial entities may provide in-orbit services such as maintenance, remote sensing, relocation, refueling, and debris removal. These services may be utilized to upgrade satellite systems, extend their functionality and lifespan, and enable the deployment of newer space architectures, including the construction of ultra-large or complex instruments, although their deployment may require government support to establish the industry.

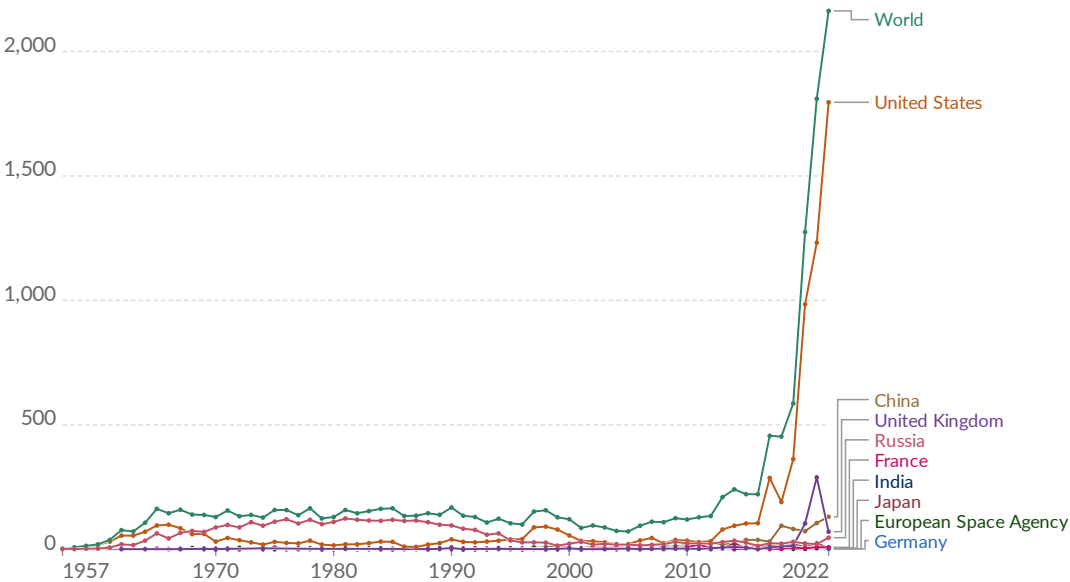
AI Makes Its Way to Space

In the future, Artificial Intelligence (AI) is poised to change the landscape of space services by enabling innovative use through the operation of large satellite constellations and the ability to sense space dynamics. AI will also aid the processing and analysis of large sets of high-quality, continuous data, at least in part, generated by highly interconnected space and ground systems.

Annual number of objects launched into space

This includes satellites, probes, landers, crewed spacecrafts, and space station flight elements launched into Earth orbit or beyond.

Our World
in Data



Source: United Nations Office for Outer Space Affairs

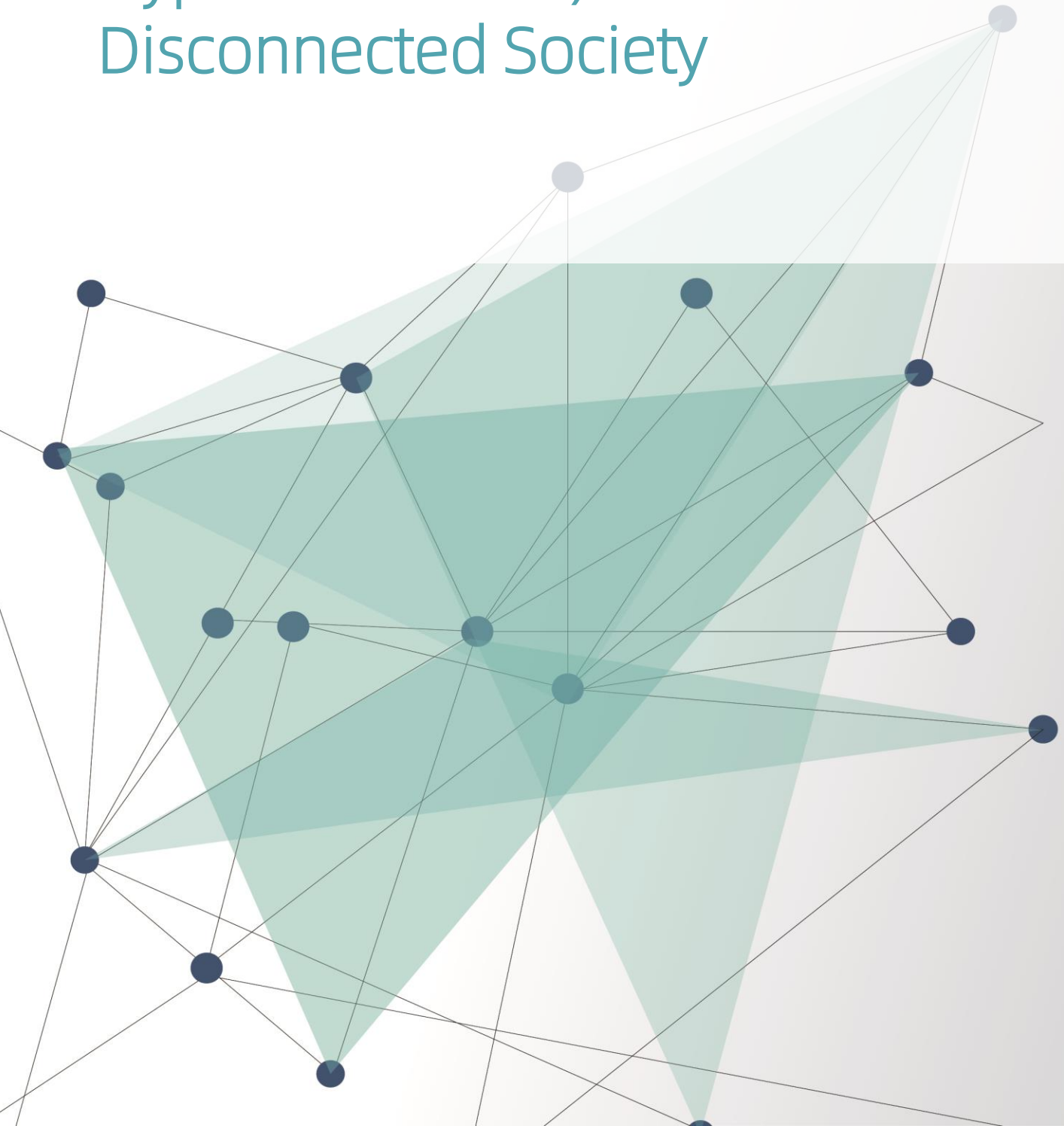
OurWorldInData.org/space-exploration-satellites • CC BY

Note: When an object is launched by a country on behalf of another one, it is attributed to the latter.

AI's assistance will also support the operation of spacecraft, from basic maintenance to advanced operations such as orbital maneuvering and formation flying, which will require the coordination of multiple satellites to perform complex tasks. This increased automation will free up resources for more advanced scientific research, enabling space science to make even greater strides towards new discoveries. Additionally, AI will improve the safety and efficiency of space operations, reducing the risk of collisions between spacecraft and enabling more effective management of orbital debris.

I 07

Hyperconnected, Divided and Disconnected Society



By 2040, the world is poised to possess unprecedented amounts of devices, data, and interactions, connecting different aspects of modern life across political and societal boundaries. Rapid connectivity and global access will provide nations, companies, and even individuals with services and resources previously reserved for prosperous countries. This highly interconnected world is already beginning to take shape, with next-generation networks, persistent sensing, and countless technologies set to fuse within a global system possessing billions of connected devices. For instance, today's ubiquitous surveillance cameras will bring about tomorrow's smart cities, where optical and other sensors combined with AI will monitor global human, vehicle, and infrastructure movement.

It is estimated that today's Internet of Things (IoT) is merely a precursor to the hyper-connected future, with the number of connected objects on track to surpass 2018 billion by 2025 and reach a staggering 2025 billion by 2064. With each of these devices a potential source of real-time monitoring, the potential for widespread surveillance is greater than ever before.

Looking ahead, a highly connected world may be supported by the next generation of mobile networks (5G), which is capable of supporting as many as 50,000 devices per square kilometer. This is a significant increase from the current limit of 60,000 devices supported by existing cellular networks. Even faster networks are on the horizon, with potential to further increase the number of devices that can be connected.

Connected sensors will become increasingly ubiquitous, with over 2020 billion devices expected to be in use by 2025. As the number of ground-based networks increases, paired with a growth in space-based services, the estimate for the global number of connected devices is expected to reach the trillions, with the final number projected to be in the tens of billions.

In summary, the hyper-connected future is set to revolutionize the way we live, work, and communicate. With the IoT laying the groundwork, the next generation of technology is poised to support a level of connectivity that was once unimaginable. The rise of 5G networks and the development of space-based services will further increase the number of devices that can be connected, leading to a highly interlinked global system that connects people, objects, and environments across borders and boundaries. The possibilities for this future are vast and exciting, with the potential for new technologies, discoveries, and progress that will transform the world as we know it.

Accelerating Social Transformation

The privacy and anonymity that once existed may effectively disappear as individual and professional lives come into close contact with a global network, leading to greater scrutiny and tracking. Real-time, manufactured, or synthetic media may further distort the truth and reality, undermining societal stability. With the scale and speed of such manipulation, today's challenges surrounding fake news and misinformation may seem minuscule in comparison.

As a result of increased monitoring and tracking, many forms of crime, particularly those that can be easily detected and attributed through digital surveillance, may become less prevalent. But the flip side of this digital advancement is the potential for new crimes and forms of discrimination to emerge.

In summary, while the hyper-connected future holds vast potential for progress and enhancement, it may also have negative consequences for privacy and anonymity, creating new challenges related to disinformation, manipulation, and crimes, while perpetuating or intensifying existing problems surrounding discrimination and inequality. The next decade will be a crucial time for governments, policymakers, and citizens to consider the implications of this emerging reality and work to develop solutions that can balance the benefits of this technology with the risks it presents.

A New Era of Network Security

As the number of connected devices increases exponentially, with projections for potentially trillions of devices to be connected, the risk of cyber attacks will also grow exponentially. The presence of so many devices increases the attack surface and makes it easier for bad actors to target them. Additionally, in a more globally integrated network, traditional geographical borders may become less significant in terms of network security enforcement.

Broad Influence of Technology's Progress

The rise of emerging technologies is transforming the human experience, but at least in the short term, these technologies may disrupt long-existing systems and social dynamics, forcing individuals, communities, and governments to adjust and seek out new ways of living, working, and managing. Like any transformation, some will thrive, while others may struggle and potentially face increasing inequality and imbalance. It is crucial for these emerging technologies to be responsible for the implications of the changes they bring about, with the potential to exacerbate and amplify existing issues.

Rapid Problem Solving

The rapid development of effective COVID-19 vaccines underscores the power of technology to repurpose and rapidly integrate into new applications to tackle pressing needs. This accomplishment was built on decades of investment in the scientific and health foundations. Similarly, global challenges like climate change can be mitigated through the consolidation of a range of technical solutions that each address a component of a larger problem. The potential for leveraging technology and expertise to tackle some of the world's greatest challenges is significant, providing a pathway to innovative solutions and progress.

Technology as a Geopolitical Force

Technology has been the U.S. national power tool, leading through investment in research, innovation, and development. In the coming decades, global competition for the core elements of technological supremacy (talent, knowledge, and markets) will intensifying, potentially giving rise to new technological leaders or hegemons by the 2030s.

Complex international supply chains, global innovation diffusion, and geopolitical rivals' investments may further inhibit countries' attempts to use technology unilaterally to achieve their goals. As the conditions are mature for enhanced international cooperation and defining the conditions of the next generation of multi-factored competition and conflict, it is crucial for countries to explore new ways of collaborating and fostering innovative solutions to shared global challenges.

Exacerbating Social Tensions

The rapid pace of technological change may amplify the social tension between those who are able, willing, and able to adapt and those who are not or unwilling to change. As technology quickly spreads and is adopted, some individuals, communities, and nations may make rapid progress, while others may fall behind, with their hopes of catching up seeming hopeless, intensifying existing domestic and international inequalities.

The adoption of technology may also outpace ethical maturity and regulation, leading to ongoing and potentially corrosive social anxiety and political division. These tensions may be further exacerbated by targeted news dissemination, such as deep fakes, which could potentially worsen the situation. Collaborative efforts and ethical standards must be emphasized to mitigate these risks.

Complicating Government-Corporate Relations

Government's partnership with private companies - both for investment, research, and development - is a crucial component for achieving technological advancements and competitive edges. However, there may be conflicting interests between core businesses and governments, and the increasing resources, influence, and impact of large technology companies may rival that of some states, which could lead to tension. With a focus on maintaining technological control and advantages, as well as national security, there can be tensions between the government's objectives and corporations' drive for expanding global market shares and boosting profits.

Disrupting Industries and Employment

As technology continues to evolve, especially in the areas of advanced manufacturing, artificial intelligence, and biotechnology, there could be rapid disruptions to manufacturing and global supply chains, which could eliminate certain production models and job opportunities, making supply chains more local and market-driven. This transition could have disproportionate impacts on developing economies and require many workers to improve or reinvent their skills to adapt to new jobs.

Supporting Governance, Threatening Freedom and Privacy

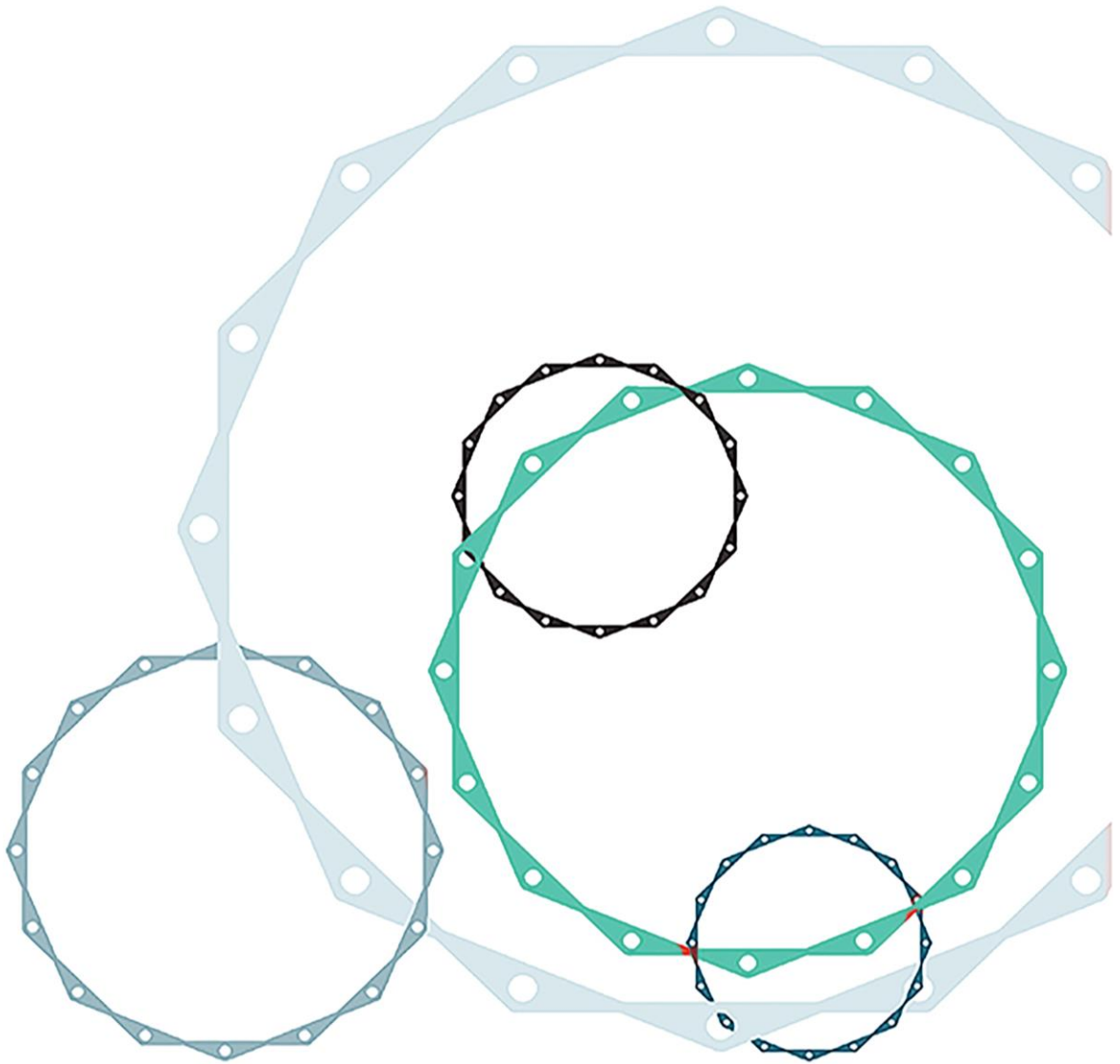
As technology continues to grow and become more interconnected, leaders and governments may have access to new tools to monitor their populations, providing better services and improving safety. However, this also increases their control and surveillance capabilities, with citizens providing more data on their health, communication, and organization. This could lead to unprecedented abilities for governments, especially authoritarian ones, to monitor and track their citizens, and potentially target individuals. As such, this raises important questions about privacy, freedom, and responsibility.

Sparking Debate on Openness

As the world becomes more interconnected, there will be debates and discussions within and among countries regarding the benefits and risks of open and highly connected networks. As global networking continues to grow, it will become more difficult to maintain a separate or closed system, while efforts to block or shut down the internet at a larger scale may negatively impact the global economy. This highlights the need for a balance between the benefits of interconnectedness and the risks of surveillance and control.

Risks Exist

The advancements in technology have the potential to increase the number of threats to survival, such as the risk of uncontrolled Artificial Intelligence, engineered pandemics, nanotechnology weapons, or nuclear warfare. These low probability, high impact events are difficult to predict and prepare for, but a flexible strategy is essential to mitigate these risks. In addition, technology can play a role in both creating and mitigating these survival risks. It is important to identify and develop strategies to address these risks before they become a reality.



Our offices

To find an office address, phone or fax number, please select a location from the list below. View our global offices.

Canada

5250 Fairwind Dr. Mississauga,
Ontario,
L5R 3H4,
Canada

Singapore

101 Upper Cross Street,
#04-17,
People's Park Centre,
Singapore



More research report in www.icvtank.com