DOI 10.15302/J-SSCAE-2017.05.015

Analysis and Insights from the *MIT Technology Review* "Top 10 Breakthrough Technologies" in the Past Six Years

Tu Hailing[1], Sun Zongtan[2], Yao Yuan[2], Xu Yuan[2]

1. General Research Institute for Nonferrous Metals, Beijing 100088, China
2. China Aerospace Academy of Systems Science and Engineering, Beijing 100048, China

Abstract: The *MIT Technology Review* has been publishing "the world's top 10 breakthrough technologies" every year since 2001, focusing on the commercial potential of technologies and their positive impacts on life and society. To provide a reference for an accurate grasp of future industry dynamics and technology trends, this article presents an in-depth analysis of the 60 breakthrough technologies published in the *MIT Technology Review* over the past six years from the perspective of technology effects and types.
Keywords: technology review; "top 10 breakthrough technologies"; commerce; industry; society

1 Introduction to *MIT Technology Review*

The *MIT Technology Review* is the world's oldest technology business magazine, published in 1899. It covers a wide range of fields, including the Internet, communications, computer technology, energy, new materials, biomedicine, and business technology [1]. Since 2001, the *MIT Technology Review* has published "10 Global Breakthrough Technologies" and focused on the commercial application potential of these technologies and their significant impact on human life and society [2].

Jason Pontin, the editor of the *MIT Technology Review*, said: "Breakthrough technologies can be engineering ideas, solutions to problems and challenges, and cross-disciplinary and cross-industry applications." These breakthrough technologies will revolutionize the entire industry and even the nature of the current society [3]. Therefore, the editors and writers of *MIT Technology Review* use the criteria to select technologies and recommend candidate technologies each year. In addition, they discuss with the chief editor, senior editor, designer, and R&D personnel when they select the 10 technologies.

Editors and writers also use the principles of information collection independence, technology resource reliability, fair reports of dispute technologies, and strict factual verification to guide the writing of the 10 breakthrough technologies. The editors and writers collect information directly from the personnel involved in technology innovation and technology financing. In most cases, the source of the technology information is specified in the content of the article. It is anonymous only when confidentiality is required. In the case of dispute technologies, the opinions of both parties are reported in a fair manner on the basis of the professional experience, judgment, and knowledge, and the data must be strictly verified and edited by multiple persons before being released.

2 Overview of the 10 breakthrough technologies in the past six years (2012 to 2017)

From 2012 to 2017, the *MIT Technology Review* reviewed 60 breakthrough technologies. We mainly study the 10 breakthrough technologies released in the past six years. We focus on the breakthroughs and implementation methods of technologies to understand the effective ways of technology development. We also focused on the impact of technologies on the industry,

Received date: August 30, 2017; **revised date:** September 21, 2017
Corresponding author: Tu Hailing, Chinese Academy of Engineering, Academician; General Research Institute for Nonferrous Metals, Honorary President. Major research field is semiconducting material. E-mail: thhl@grinm.com
Funding program: CAE Advisory Project "Prediction Research on Major Disruptive Technologies that Cause Industrial Change" (2016-ZD-12)
Chinese version: Strategic Study of CAE 2017, 19 (5): 085–091
Cited item: Tu Hailing et al. Analysis and Insights from the *MIT Technology Review* "Top 10 Breakthrough Technologies" in the Past Six Years. *Strategic Study of CAE*, https://doi.org/10.15302/J-SSCAE-2017.05.015

society, and life to grasp the future trends of industry, science, and technology. This article describes the breakthroughs and significance of the 60 technologies in the form of tables based on the time of release of the technologies. In addition, the article predicts the maturity of the breakthrough technologies released from 2015 to 2017.

3 Analysis of breakthrough technologies released within the past six years (2012 to 2017)

3.1 The Technologies take the lead in the Internet and electronics and information fields and appeal to the health and energy fields

The 60 breakthrough technologies are mainly used in seven fields, including the Internet (16 technologies), health (14 technologies), electronics and information (12 technologies), energy (8 technologies), industry (4 technologies), materials (3 technologies), agriculture (2 technologies), and other fields (1 technology). The proportion of technologies in the Internet and electronics and information fields is close to 50%, but the proportion of technologies in the industry and agriculture fields is only 10%, indicating that the technologies in the Internet and electronic & information fields are driving a new round of technology growth. Technologies in the health and energy fields also play an important role. New technologies in drug development and the disease diagnosis and treatment fields are emerging, and the competitiveness of renewable energy technologies is increasing.

3.2 The cross-field integration of technologies becomes the main trend, and the implementation of some technologies that can meet actual requirements takes a long time

Based on the criteria used by *MIT Technology Review* to select the 10 breakthrough technologies, we classify the 60 technologies into four categories (Table 7): (category A) technologies with commercial application prospects and industry innovation capabilities, (category B) technologies that have significant impact on the society and public life, (category C) cross-field enabling technologies that are generated by science and technology innovation, and (category D) technologies that can meet actual requirements and address difficulties. Four technology categories and their technical content are as shown in Fig. 2. The cross-field integration and crossing of technologies are important ways to generate cutting-edge technologies in the future and lay an important foundation for promoting technology progress in other fields. It is difficult to implement in a short period some technologies that need to meet actual requirements. For example, a cure paralysis technology relies on other technologies such as biology, communications, and MEMS.

Table 1. Ten breakthrough technologies and their significance in 2017.

Technology	Technology breakthroughs and their significance	Availability
Reinforcement learning	An approach to artificial intelligence that gets computers to learn like people, without explicit instruction. Progress in self-driving cars and other forms of automation will reduce dramatically unless machines can hone skills through experience.	2018–2019
360-degree selfie	Consumer cameras that produce 360° images providing a realistic sense of events or places. Photos and videos with this perspective could become the new standard for everything from news coverage to vacation shots.	2017
Gene therapy 2.0	First gene therapies on track for approval in the U.S. More are on the way; thousands of diseases stem from an error in a single gene. New treatments could cure them.	2017
Hot solar cells	A solar power device that could theoretically double the efficiency of conventional solar cells. The new design could lead to inexpensive solar power that keeps working after the sun sets.	2027–2032
Cell atlas	A master catalog of every cell type in the human body. Super-accurate models of human physiology will speed up the discovery and testing of new drugs.	2022
Self-driving trucks	Long-haul trucks that drive themselves for extended stretches on highways. The technology might free truck drivers to complete routes more efficiently, but it could also erode their pay and eventually replace many of them altogether.	2022–2027
Paying with your face	Face recognition technology that is finally accurate enough to be widely used in financial transactions and other everyday applications. The technology offers a secure and extremely convenient method of payment but could raise privacy concerns.	2017
Practical quantum computers	The fabrication of stable qubits, the basic unit of quantum computers. Quantum computers could be exponentially faster at running artificial-intelligence programs and handling complex simulations and scheduling problems; they could even create uncrackable encryption.	2021–2022
Reversing paralysis	Wireless brain-body electronic interfaces to bypass damage to the nervous system. Thousands of people experience paralyzing injuries every year.	2027–2032
Botnets of things	Malware that takes control of webcams, video recorders, and other consumer devices to cause widespread Internet outages. Botnets based on this software are disrupting larger and larger swaths of the Internet—and getting harder to stop.	2017

Table 2. Ten breakthrough technologies and their significance in 2016.

Technology	Technology breakthroughs and their significance	Availability
Immune engineering	Killer T cells programmed to wipe out cancer. Cancer, multiple sclerosis, and HIV could all be treated by engineering the immune system.	2017–2018
Precise gene editing in plants	The ability to cheaply and precisely edit plant genomes without leaving foreign DNA behind. We need to increase agricultural productivity to feed the world's growing population, which is expected to reach 10 billion by 2050.	2021–2026
Conversational interfaces	Combining voice recognition and natural language understanding to create effective speech interfaces for the world's largest Internet market. It can be time-consuming and frustrating to interact with computers by typing.	2016
Reusable rockets	Rockets that can launch payloads into orbit and then land safely. Lowering the cost of flight would open the door to many new endeavors in space.	2016
Robots that teach each other	Robots that learn tasks and send that knowledge to the cloud for other robots to pick up later. Progress in robotics could accelerate dramatically if each type of machine does not have to be programmed separately.	2019–2021
DNA app store	A new business model for DNA sequencing that will make genetic information widely accessible online. Your genome determines a great deal about you, including your likelihood of getting certain diseases.	2016
SolarCity's Gigafactory	Highly efficient solar panels made using a simplified, low-cost manufacturing process. The solar industry needs cheaper and more efficient technology to be more competitive with fossil fuels.	2017
Slack	Easy-to-use communication software that is supplanting e-mail as a method of getting work done. In many kinds of workplaces, the "water cooler" effect that lets people overhear their colleagues' conversations can enhance productivity.	2016
Tesla autopilot	A car that drives itself safely in a variety of conditions. Car crashes caused by human error kill thousands of people a day worldwide.	2016
Power from the air	Wireless gadgets that repurpose nearby radio signals, such as Wi-Fi, to power themselves and communicate. Freeing Internet-connected devices from the constraints of batteries and power cords will open many new uses.	2018–2019

Table 3. Ten breakthrough technologies and their significance in 2015.

Technology	Technology breakthroughs and their significance	Availability
Internet of DNA	Technical standards that let DNA databases communicate. Your medical treatment could benefit from the experiences of millions of others.	2016–2017
Magic Leap	A device that can make virtual objects appear in real life. The technology could open new opportunities for the film, gaming, travel, and telecommunications industries.	2015
Nano-architecture	Materials whose structures can be precisely tailored, so they are strong yet flexible and extremely light. Lighter structural materials would be more energy-efficient and versatile.	2018–2020
Car-to-car communication	Cars that can talk to each other to avoid crashes.	2016–2017
Project Loon	A reliable and cost-effective way to beam Internet service from the sky to places lacking it. Internet access could expand educational and economic opportunities for the 4.3 billion people who are offline.	2016–2017
Liquid biopsy	A blood test to catch cancer early. Cancer kills some eight million people a year around the world.	2015
Megascale desalination	Demonstrating that seawater desalination can cost-effectively provide a substantial portion of a nation's water supply. The world's supplies of fresh water are inadequate to meet the needs of a growing population.	2015
Apple pay	A service that makes it practical to use your smartphone as a wallet in everyday situations. Credit card fraud damages the economy by raising the costs of goods and services.	2015
Brain organoids	Three-dimensional clusters of living neurons that can be grown in a lab from human stem cells. Researchers need new ways of understanding brain disorders and testing possible treatments.	2015
Supercharged photosynthesis	Engineering rice plants to extract energy from sunlight far more efficiently than they do now. Crop yields are not increasing fast enough to keep up with demand from a growing population.	2025–2030

Table 4. Ten breakthrough technologies and their significance in 2014.

Technology	Technology breakthroughs and their significance
Agricultural drones	Easy-to-use agricultural drones equipped with cameras, for less than 1000 US dollars. Close monitoring of crops could improve water use and pest management.
Ultra-private smartphones	Mobile phones for the consumer market that transmit minimal personal information. Governments and advertisers gather intimate details from cell phones.
Brain mapping	A high-resolution map that shows structures of the human brain as small as 20 micrometers. As neuroscientists try to understand how the brain works, they need a detailed map of its anatomy.
Neuromorphic chips	An alternative design for computer chips that will enhance artificial intelligence. Traditional chips are reaching fundamental performance limits.
Genome editing	The use of a genome-tool to create two monkeys with specific genetic mutations. The ability to modify targeted genes in primates is a valuable tool in the study of human diseases.
Microscale 3-D printing	3-D printing that uses multiple materials to create objects such as biological tissue with blood vessels. Making biological materials with desired functions could lead to artificial organs and novel cyborg parts.
Mobile collaboration	Services that make it fruitful to create and edit documents on mobile devices. Much of today's office work is done outside an office.
Oculus Rift	High-quality virtual-reality hardware that is cheap enough for the consumer market. Visually immersive interfaces will lead to new forms of entertainment and communications.
Agile robots	Legged machines that stride over uneven or unsteady terrain. Much of the world is inaccessible to wheeled machines but not legged ones.
Smart wind and solar power	Ultra-accurate forecasting of wind and solar power. Dealing with the intermittency of renewable energy will be crucial for its expansion.

Table 5. Ten breakthrough technologies and their significance in 2013.

Technology	Technology breakthroughs and their significance
Ultra-efficient solar power	Doubling the efficiency of solar devices would completely change the economics of renewable energy.
Supergrids	A high-power circuit breaker could finally make DC power grids practical. It is likely to connect to extremely dispersed wind farms and solar electric fields.
Prenatal DNA sequencing	The pregnant women's blood is used for fetal DNA sequencing, and it may be able to obtain a complete list of a child's genetic advantages and disadvantages at birth.
Baxter: the blue-collar robot	Industrial robots can be safely and conveniently used in manufacturing. The cost of industrial robots is greatly reduced, and the role of industrial robots is significantly increased.
Big data from cheap phones	The data on mobile phones is used to invent the tools to fight diseases. The technology is used by undeveloped countries for data collection.
Additive manufacturing	General Electric is making a radical departure from the way it has traditionally manufactured things. Its aviation division, the world's largest supplier of jet engines, is preparing to produce a fuel nozzle for a new aircraft engine by printing the part with lasers rather than casting and welding the metal.
Smart watches	A smartwatch can obtain specific data from a mobile phone, and the wearer can obtain information at only a glance. Although the computing is complex, consumers still want to easily and conveniently use the web UI.
Temporary social media	Messages that quickly self-destruct could enhance the privacy of online communication and make people feel freer to be spontaneous.
Memory implants	Brain damage can cause people to lose their ability to form long-term memories. Animal experiments show that implanting electrodes may correct memory problems. Once the technology is further developed and improved, it can be used to enhance and restore human memories.
Deep learning	With massive amounts of computational power, machines can now recognize objects and translate speech in real time. Artificial intelligence is finally getting smart.

3.3 The technology selection focuses on mature technologies and medium- and long-term technologies, and the mature application of technologies has a clear evolutionary path

According to the analysis on the maturity periods of the selected technologies (seen from the column for Availability in Tables 1 to 3), the proportion of mature technologies (30 technologies), technologies that will become mature within five years (including five years), technologies that will become mature after five years is 3∶2∶1. The proportion meets the rule of focusing on short-term breakthrough technologies and giving consideration to medium- and long-term technologies. Furthermore, the analysis shows that most mature technologies are included in category B and have significant impact on social and

Table 6. Ten breakthrough technologies and their significance in 2012.

Technology	Technology breakthroughs and their significance
Crowdfunding	An alternative to angel investment or venture capital that can help technology startups raise funds. It provides a method for funding the commercialization of new technologies and new products.
Facebook's timeline	It organizes a large amount of data generated by users, which not only benefits advertisers but also helps users explore their digital footprint.
High-speed materials discovery	A new way to identify battery materials suitable for mass production could revolutionize energy storage.
3-D transistors	A more power-saving and compact 3D transistor can not only improve the computing speed and reduce errors and power consumption but can also drive the generation of small-size and powerful mobile devices.
Light-field photography	A camera that can adjust a photo after shooting can change the photography market and people's photographing habits.
Ultra-efficient solar	With new materials and new poly technology, small solar cells can convert nearly 34 percent of the light that hits them into electricity, without cooling.
Solar Microgrids	The solar microgrids use an independent power source system to support lighting and phone charging for rural residents. The costs of lighting and phone charging are spread across a group of homes rather than being paid by a single user.
Nanopore sequencing	The digital interpretation of long-chain DNA can make gene sequencing become a routine medical process, which reduces the cost of gene sequencing and increases the speed of gene sequencing.
A faster Fourier transform	A new algorithm for processing data streams. It increases the data processing speed by 10 to 100 times, which leads to the emergence of better multimedia devices.
Egg stem cells	Stem cells in ovarian tissue can form new eggs or be used to restore the vitality of existing eggs and extend the age at which women can have babies.

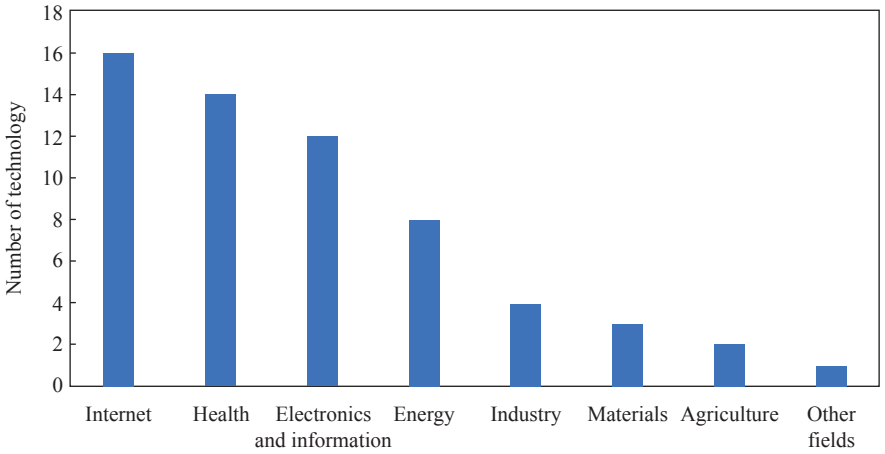

Fig. 1. Distribution of 60 breakthrough technologies in different fields.

Table 7. Four technology categories.

Technology category	Specific technologies
Category A	Reusable rockets, SolarCity's Gigafactory, Google balloon, Self-Driving Trucks, Hot Solar Cells, Ultra-Efficient Solar Power, Supergrid, Ultra-Efficient Solar, Solar Microgrids, Agile Robots, Agricultural Drones, and Additive Manufacturing.
Category B	Magic Leap, Liquid Biopsy, Apple Pay, DNA App Store, Conversational Interfaces, Slack, 360-Degree Selfie, Paying with Your Face, Botnets of Things, Light-Field Photography, Prenatal DNA Sequencing, Ultra-private Smartphones, Mobile Collaboration, Oculus Rift, Smart Watches, Temporary Social Media, Crowdfunding, and Facebook's Timeline
Category C	Brain Organoids, Cell Atlas, Internet of DNA, Reinforcement Learning, Power from the Air, Nano-Architecture, Robots That Teach Each Other, Practical Quantum Computers, Neuromorphic Chips, Memory Implants, Deep Learning, 3-D Transistors, A Faster Fourier Transform, Smart Wind and Solar Power, Microscale 3-D Printing, Brain Mapping, Genome Editing, Nanopore Sequencing, and High-Speed Materials Discovery
Category D	Megascale Desalination, Gene Therapy 2.0, Immune Engineering, Precise Gene Editing in Plants, Supercharged Photosynthesis, Reversing Paralysis, Egg Stem Cells, Big Data from Cheap Phones, Baxter: The Blue-Collar Robot, Tesla Autopilot, and Car-to-Car Communication

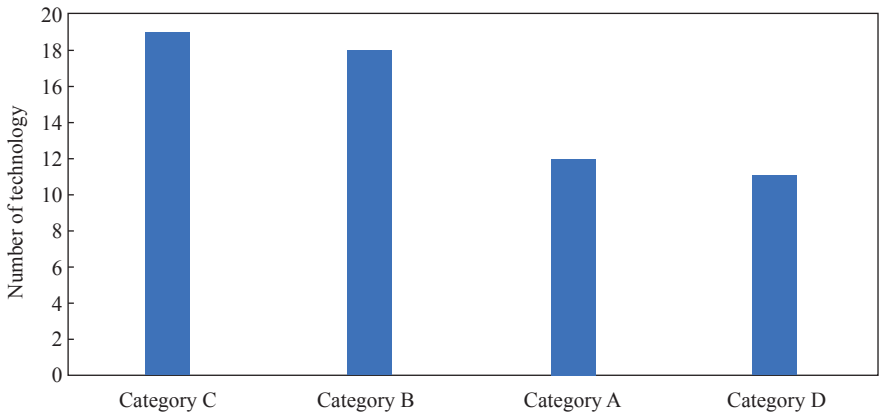

Fig. 2. Four technology categories and their technical content.

public life. The technologies that will become mature within five years are included in categories A and C. The technologies that will become mature after five years are included in category D. There are two ways for breakthrough technologies to achieve a profound impact on social and public life. One way is through the breakthrough technologies that have to meet the commercial application conditions and the core competitiveness of industry transformation. The other way is to integrate existing technologies across fields so that the technologies can be widely applied. The breakthrough technologies that meet practical requirements and address difficulties must rely on the progress of basic science and the breakthrough of technologies. These technologies may be implemented in the long term.

3.4 Freelance writers and senior editors are deeply involved in the technology review to ensure extensive technology selection and deep technology analysis

The senior writers of each technical field participate in the selection and review of the 60 breakthrough technologies as off-staff members of the magazine, which improves the objectivity and credibility of the magazine (Fig. 3). In addition, a cadre of senior editors has completed 50% of the writing of the technical documents, which ensures the in-depth analysis of the technology breakthroughs and the mastery of technology impact.

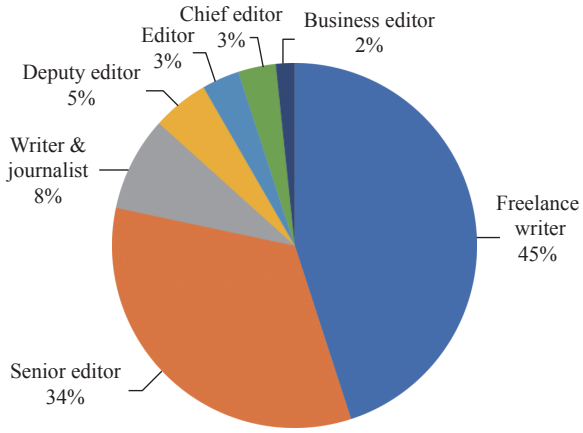

Fig. 3. Position type and personnel proportion of the people who reviewed 60 breakthrough technologies.

4 Conclusions

4.1 The progressive development of technologies is conducive to the steady commercialization of the technologies

The progressive development and spiral innovation have little impact on the technology roadmap or industrial pattern, which is conducive to reduce the cost and steady implementation of the commercial application of technologies. For example, from 2012 to 2017, solar panels gradually improved the efficiency of PV conversion, efficiently utilize the light energy, and reduce the commercializing manufacturing cost by using new materials, new optical technologies, light control, and manufacturing technologies.

4.2 Fully consider the negative impact of technologies and take measures in advance

During technology innovation and commercialization, we need to recognize the impact of certain technologies on existing business models and social life and develop countermeasures in advance. For example, the automatic driving of long-distance goods vehicles may result in the decrease in the salary of drivers of the trucks. The capability of malware to destroy the Internet will become increasingly large. Therefore, we need to actively develop technologies such as the web filtering service to cope with this problem.

4.3 Breakthrough technologies are difficult to predict accurately, but their development rules can be identified

There are many uncertainties in the process of technology development. Many technology factors cannot be quantitatively

modeled. As a result, it is difficult to predict the development of technologies. For example, virtual technologies are not correctly judged, some difficulties are underestimated, and the impact of technology breakthrough in related fields is not accurately predicted. About 50% of the 60 breakthrough technologies selected by the *MIT Technology Review* in the past five years are developing as planned. Therefore, we should use the *MIT Technology Review's* roadmap for predicting the development of technologies based on their commercial application potential and their impact on social and public life.

References

[1] Shen X S, Liu C L, Wu J. et al. Ten years of *Technical Review* top 10 emerging technology interpretations [J]. Science & Technology Progress and Policy, 2013, 30(1): 155–160. Chinese.

[2] MIT Technology Review. Summit of science and technology [M]. Beijing: Posts & Telecom Press, 2016. Chinese.

[3] MIT Technology Review. Summit of science and technology 2 [M]. Beijing: Posts & Telecom Press, 2017. Chinese.