



## Editorial

## Global Top Ten Engineering Achievements 2022

Junzhi Cui, Jian-Feng Chen

Chinese Academy of Engineering, Beijing 100088, China



Junzhi Cui



Jian-Feng Chen

Engineering is an integrated activity in which humans create or change the characters of things by using science and technology and employing resources in an organized manner in order to survive, develop, and achieve specific purposes [1]. From the pyramids in ancient Egypt to the Eiffel Tower in modern Paris, and from the Apollo Manned Lunar Landing Project in the United States to the Three Gorges Key Water Conservancy Project in China, human engineering practices profoundly change the planet we live on and are constantly enriching and expanding our world.

Founded in 2015, *Engineering* is committed to spreading cutting-edge engineering knowledge, promoting progress in engineering, leading engineering innovation, and actively guiding public attention and support for engineering undertakings across the globe. In 2022, *Engineering* organized its second “Global Top Ten Engineering Achievements” selection. The Selection Committee is jointly composed of *Engineering*'s Editorial Board and experts from the Project Group of the Global Engineering Frontier of the Chinese Academy of Engineering. With extensive support from engineering and technology practitioners from all over the world, after a global solicitation of nominations, expert comments and recommendations, and public questionnaires, the Committee reviewed and determined this year's Global Top Ten Engineering Achievements.

### 1. The BeiDou Navigation Satellite System

On 31 July 2020, the BeiDou-3 Global Navigation Satellite System was officially launched, as the third mature global navigation satellite system after Global Positioning System (GPS) and Global

Navigation Satellite System (GLONASS). The BeiDou Navigation Satellite System consists of three parts: space segment, ground segment, and user segment. It can provide positioning, navigation, timing, global short-message communication, and international search-and-rescue services on a global scale, as well as satellite-based augmentation, ground-based augmentation, precise point positioning, and regional short-message communication services for the Asia-Pacific region. BeiDou has been successfully applied in the fields of transportation, marine fisheries, hydrological monitoring, geographic surveying and mapping, power dispatching, disaster relief and mitigation, weather forecasting, and emergency search and rescue and has produced significant economic and social benefits [2,3].

### 2. The Chinese Lunar Exploration Program

In January 2019, Chang'e 4 successfully landed in the South Pole–Aitken Basin on the far side of the moon; in December 2020, Chang'e 5 successfully returned to the earth with 1.73 kg of lunar soil samples from the young Kreep Terrain in the northern region of the Lunar Oceanus Procellarum, marking the Chinese Lunar Exploration Program's successful goals of orbiting, landing, and returning. The Chinese Lunar Exploration Program has realized the first soft landing and patrol survey of a probe on the far side of the moon, left the first mark in the world's history of lunar exploration on the far side of the moon, obtained the first geological profile of the near and far sides of the moon, and opened up a new chapter in the exploration of the mystery, development, and utilization of the moon [4].

### 3. COVID-19 vaccine development and application

Since 2020, in response to the global outbreak of coronavirus disease 2019 (COVID-19), researchers in various countries have urgently carried out the development of COVID-19 vaccines. The research and development (R&D) for COVID-19 vaccines has adopted five technical routes: inactivated vaccines, nucleic acid (messenger RNA (mRNA) or DNA) vaccines, recombinant protein vaccines, adenovirus vector vaccines, and attenuated influenza virus vector vaccines. The R&D cycle has been greatly shortened to 10–18 months, creating a new record for human vaccine R&D and realizing the large-scale application of mRNA vaccines for

the first time. As of 31 December 2021, more than eight billion doses of COVID-19 vaccines have been vaccinated worldwide, playing a significant role in preventing novel coronavirus infection and significantly reducing the numbers of serious cases and deaths [5].

#### 4. The Falcon Heavy (FH) recoverable rocket

On 7 February 2018, Space X launched the FH carrier rocket, whose two boosters were successfully recovered in the lander area for the first time. With a total height of 69.2 m and a weight of 1420.8 t, FH has a carrying capacity of 63.8 t to a low earth orbit, 26.7 t to a geosynchronous orbit, and 16.8 t to a Mars orbit. The total thrust provided by all its engines at the launch stage is over five million pounds (1 pound = 0.4535924 kg), making it the largest carrier rocket in service in the world. The rocket is based on a core-stage parallel structure designed with 40% structural strength redundancy. The first stage of the rocket can be recovered and reused, which greatly reduces the operation cost; thus, the FH rocket provides a more economical and efficient vehicle for humans to enter deep space [6,7].

#### 5. The Hong Kong–Zhuhai–Macao Bridge

On 24 October 2018, the Hong Kong–Zhuhai–Macao Bridge, a bridge and tunnel project connecting Hong Kong, Zhuhai, and Macao, was officially put into operation. This 55 km sea-crossing bridge, which took nine years to build, is designed to last for 120 years and can withstand magnitude eight earthquakes, magnitude 16 typhoons, impacts of 300 000 t, and 300-year floods of the Pearl River Estuary. The Hong Kong–Zhuhai–Macao Bridge adopts a concept known as “bridge, island, and tunnel in one.” It is composed of three navigable bridges, one subsea tunnel, four artificial islands, connecting bridges and tunnels, non-navigable continuous beam bridges in deep and shallow water areas, and land connecting lines in Hong Kong, Zhuhai, and Macao. This super bridge has the largest span, longest length, and longest immersed tube tunnel in the world [8].

#### 6. Hyperscale public cloud computing platform

In recent years, hyperscale public cloud computing platforms based on the new generation of information technologies such as big data and artificial intelligence (AI) have transformed enterprise-level computing, storage, networking, and other technical resources into inclusive basic services. These platforms have been widely applied in scenarios involving national economies and people's livelihood, including governments, industry, energy, medical care, finance, transportation, education, and so forth. In 2021, the global cloud computing market represented by infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) reached nearly 300 billion USD, with Amazon, Microsoft, Alibaba, Google, and Huawei becoming the world's major cloud service providers. Hyperscale public cloud computing platforms provide an advanced information and communication technology (ICT) foundation for social and economic development and industrial innovation, greatly promoting the rapid development of the global digital economy [9].

#### 7. The James Webb Space Telescope (JWST)

On 25 December 2021, the JWST was launched. This space telescope for infrared observation was jointly developed by National Aeronautics and Space Administration (NASA), the European Space Agency, and the Canadian Space Agency. It took thousands of scientists and engineers more than 20 years to design the JWST, which

consists of 18 giant hexagonal sub-mirrors with a diameter of 6.5 m and a weight of 6.2 t. As the most powerful space telescope ever built, the JWST can effectively receive light in bands ranging from 0.6 to 28.3  $\mu\text{m}$ ; it is being used to investigate residual infrared evidence of the Big Bang Theory and to observe the initial state of the visible universe today [10,11].

#### 8. New generation of electric vehicles

Against a background of increasingly severe global climate change and energy-supply issues, the new generation of electric vehicles powered by an onboard power supply and driven by motors are experiencing rapid development. These electric vehicles, which are represented by Tesla and BYD Auto, are a realization of the integration and innovation of ICT and automobile manufacturing. Electric vehicles have been upgraded into software-defined mobile intelligent platforms with functions such as environmental awareness, intelligent decision-making, and collaborative control. Global sales of electric vehicles reached 6.5 million in 2021. The new generation of electric vehicles has set off a subversive change in traditional automobile manufacturing, leading the automobile into a new journey of electrification, electrification, networking, intelligence, and green development [12].

#### 9. The Fuxing electric multiple unit (EMU) train

In June 2017, China's Fuxing EMU train, developed by the China Railway Corporation, was launched in both directions on the Beijing–Shanghai line. In January 2019, the Fuxing EMU achieved the world's first automatic drive at 350  $\text{km}\cdot\text{h}^{-1}$ . Thus far, the Fuxing EMU train comprises various models with different speed levels, different types of marshaling, and centralized or decentralized power, which can meet travel needs in complex and diverse environments with long-distance, long-term, and continuous high-speed operation. As of the end of 2021, the Fuxing EMU is equipped with 1191 units, has safely run for 1.358 billion kilometers, and has transported 1.37 billion passengers. The Fuxing EMU has opened up a new era of high-speed railway transportation [13].

#### 10. Solar photovoltaic (PV) power generation

Solar PV power generation has the technical advantages of safety and reliability, no noise, no pollution, and convenient station construction. In recent years, affected by global climate change and energy transformation, unprecedentedly rapid development has been achieved in solar PV power generation. As of the end of 2021, the world's cumulative PV installed capacity is 942 GW, with China, the European Union, and the United States, leading the field. Breakthroughs have been made in silicon solar cells, thin-film solar cells, and concentrated solar cells. The energy conversion rate in laboratories has reached 24.7%, and the energy conversion rate of enterprises has reached 17%. As the most popular and promising technological path for human use of solar energy, solar PV power generation is expected to lead the future global green energy revolution [14].

*Engineering* began to select Global Top Ten Engineering Achievements since 2021 [15]. This year's Global Top Ten Engineering Achievements were appraised based on the principles of independence, objectivity, and scientificity; they were globally selected with an emphasis on the combination of expert evaluation and public participation. The engineering achievements selected this time are accomplishments in engineering innovation from countries around the world that were completed within the last five

years and have produced significant economic and social benefits. Some of these engineering achievements were independently accomplished by a single innovation entity, such as the FH recoverable rocket, while others were accomplished through simultaneous competition among many innovation entities, such as hyperscale cloud computing platforms and solar PV power generation. Some were accomplished through coordination within a single country, such as the Hong Kong–Zhuhai–Macao Bridge, while others were accomplished through multinational collaborations, such as the JWST. All these engineering achievements—whether they are major innovations related to current human life and safety, such as the R&D and application of novel coronavirus vaccines, or great efforts promoting our future exploration beyond the earth—demonstrate the noticeable characteristics of remarkable breakthroughs in engineering technology, outstanding innovation in system integration, and great application value. They have received widespread attention from the international community and are expected to bring changes into human production and life. These achievements will help to promote the development of human society to a higher level.

We offer our warm congratulations to the scientists and engineers who made significant contributions to the R&D, construction, and operation of the Global Top Ten Engineering Achievements! Your outstanding work has given rise to great projects and promoted economic and social development and human progress. We highly appreciate the support given to *Engineering* during the selection process from domestic and foreign experts, scholars,

engineers, and colleagues from the selecting teams for each topic area; we also express our gratitude to the Selection Committee for the Global Top Ten Engineering Achievements of *Engineering*.

## References

- [1] He JS, Chen XH, Hong KR. On engineering management. *Eng Sci* 2005;7(10):5–10. Chinese.
- [2] BeiDou Navigation Satellite System. System. Report. Beijing: BeiDou Navigation Satellite System; 2017 Mar.
- [3] Xie J, Kang C. Engineering innovation and the development of the BDS-3 navigation constellation. *Engineering* 2021;7(5):558–63.
- [4] Li C, Wang C, Wei Y, Lin Y. China's present and future lunar exploration program. *Science* 2019;365(6450):238–9.
- [5] Lipsitch M, Dean NE. Understanding COVID-19 vaccine efficacy. *Science* 2020;370(6518):763–5.
- [6] Davis LA. Falcon Heavy. *Engineering* 2018;4(3):300.
- [7] Universe Today. SpaceX does it again with second retrieval of Falcon Heavy rocket. Report. Courtenay: Universe Today; 2019.
- [8] Zhu Y, Lin M, Meng F, Liu X, Lin W. The Hong Kong–Zhuhai–Macao bridge. *Engineering* 2019;5(1):10–4.
- [9] Cloud. The future of hyperscale computing. Report. Cloud; 2019.
- [10] James Webb Space Telescope. About Webb Space Telescope. Report. Washington: NASA; 2021.
- [11] Leslie M. With great expectations, Webb Telescope finally lifts off. *Engineering* 2022;11:3–5.
- [12] Palmer C. Electric car market poised to accelerate. *Engineering* 2021;7(2):136–8.
- [13] Qi Y, Zhou L. The Fuxing: The China standard EMU. *Engineering* 2020;6(3):227–33.
- [14] Kong F, Dai S. Current situation and prospects of the solar photovoltaic industry in China. *Eng Sci* 2016;18(4):56–9. Chinese.
- [15] Cui J. Top Ten Engineering Achievements 2021. *Engineering* 2021;7:1651–2.