All About The Chinese Space Programme

Go TAIKONAUTS!

龙腾太空

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The CZ-7A rocket was rolled out from the Assembly Facility in the early morning of 8 March 2021 (BJT) in preparation for the launch of an experimental test satellite into GTO. Credit: CALT

Content

Chinese Space Quarterly Report
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by Jacqueline Myrrhe

SPACE TRANSPORTATION

CASC 2021 Plans

On 4 January 2021, the year's 1st working day, China Aerospace Science and Technology Corporation (CASC) held its annual work conference. The 2021 launch manifest was one of the discussion points. Among the more than 40 planned launches, the cargo and crewed flights for the assembly of the Chinese Space Station (CSS) were assigned as "the top priority", followed by the national exploration and space application missions. The 40 launches did not include launches of other Chinese launch service providers.

Also, CASC will continue in 2021 its research on human lunar exploration and promote Beidou Navigation Satellite System (BDS) applications in civil aviation and other fields. Furthermore, the key focus areas for CASC's work in 2021 were addressed during the work conference, among them: batch manufacturing, enhanced product quality, and keeping up with the competition from the commercial sector, which requires efforts to control costs – an issue for the whole space sector in China.

AO for CSS Cargo

On 6 January, China Manned Space Agency (CMSA) published an Announcement of Opportunity (AO) for low-cost cargo transport to the CSS. The aim is to complement as of 2023 the existing 2-3 annual Tianzhou (TZ) cargo flights of 6.5 t capacity. CMSA is looking for a flexible, efficient, diverse, and low-cost cargo transportation system to provide an upload transport mass of 1-4 t and a download capacity of 100-300 kg for the time after the completion of the CSS assembly. Another requirement is that docking to the CSS has to be done within 45 days after the hardware has left the factory. The download scenario is asking for the option of waste removal in accordance with international re-entry and space debris mitigation guidelines. Another option is the return of equipment and science payloads while the returning spacecraft has to be easily trackable and recoverable. Interested parties had to submit their proposals until 28 February. Proposals for sub-segments such as launcher, spacecraft or search and rescue of return cargo are possible. The application had to include the technical description of the approach, the spacecraft capabilities, a description of the compliance with the requirements, and an analysis of the cost and engineering feasibility as well as the manpower structure.

It was not clear whether the AO was also open to commercial companies. So far, only Expace, a subsidiary of CASIC (China Aerospace Science and Industry Corporation), would be eligible.

CZ-2F

The CZ-2F launcher for the Shenzhou 12 (SZ-12) crew flight was undergoing final factory tests, which should be completed soon after the Chinese New Year in February.

Officials confirmed they have selected crew members for the SZ-12 mission, and mission specific training is ongoing.

CZ-2F rocket for the SZ-12 mission undergoes final testing. Credit: CASC/CMSE

CZ-5B

On 8 January, CASC's Aerospace Liquid Propulsion Technology (AALPT - also AAPT or The 6th Academy) completed another 500 s endurance test for its CZ-5B high-thrust hydroLOX engine YF-77 at its rocket engine test facility in Beijing. It was the 4th time the engine had been tested for 500 s – the full work cycle. The test also investigated the engine's ability of extending its service life. The analysis and inspection will be conducted after the conclusion of the hot fire tests.

On 28 February, a 520 s-long hot fire test was conducted. The engine ran 20 s longer than its designed work cycle and as during the other 4 tests before. With this 5th long-duration test the cumulative test time added up to 2,520 s. CASC said it would conduct 3 more 500 s tests to further improve the engine's reliability.

Also, testing of the CZ-5B Y2 hardware for the rocket launching the 1st space station module, was completed in the factory of the Tianjin General Assembly Test Plant in January. The rocket parts were prepared for shipping to Hainan Island and left Tianjing Port in 2 batches on 6 and 8 February. Xuyang 16, most likely a chartered merchant ship, instead of the Yuanwang 21 or 22 was used for the transport. After arrival at Qinglan Port on Hainan, the rocket components were transported by road to the Wenchang Space Launch Centre on 22 February where the launcher was assembled, tested, and mounted with the Tianhe module. The further launch preparation usually takes around 2 months, indicating that the CZ-5B will not launch earlier than the end of April. A launch date had not been released. CMSA confirmed that facilities and equipment at the Wenchang space port were in good condition and preparations were going according to plan.

Parts of the CZ-5B (Y2) rocket for the launch of the Tianhe core module at CASC's manufacturing facility in Tianjin. Credit: CASC/CMSA

CZ-6A

On 24 February, SAST (Shanghai Academy of Spaceflight Technology - 8th Academy of CASC) announced in its Annual Report on 2021 Space Activities that the CZ-6A will make its 1st flight in the coming months.

The SAST-developed CZ-6A is a new generation medium-launch vehicle. It is China's 1st carrier rocket powered by solid and liquid engines. The 1st stage will consist of a 50 m tall and 3.35 m diameter liquid-propelled core stage, driven by 2 liquid oxygen (LOX)-kerosine engines of 120 t thrust and 4 solid-fuel side boosters. Its lift-off weight will be 530 t.

Drawing of the CZ-6A. Credit: SAST

The CZ-6A can be flown with a variable number of liquid and solid engines for different payload requirements, for different orbits, providing a more cost-effective launch service. Also, the rocket has a higher degree of automation and is equipped with intelligent systems which can monitor and diagnose potential problems. Despite being called CZ-6A, the new rocket will be different from the smaller CZ-6, also designed and built by SAST.

CZ-7

The CZ-7 Y3 rocket for the TZ-2 mission, was undergoing final testing in its factory.

CZ-7A

Yuanwang 22 (YW-22) transported the parts of the new-generation rocket CZ-7A to Hainan Island where the vessel arrived on 22 January. After overland transport to Wenchang launch site, the final checks and assembly of the rocket was completed on 1 February. The rocket was rolled out in the early morning of 8 March BJT in preparation for the launch of an experimental test satellite into GTO. On 11 March fuelling started. The CZ-7A is a 3-staged variant of the 2-staged CZ-7. The 1st flight of the CZ-7A in March 2020 ended in failure. A loss of pressure occurred after 1st-stage separation, which led to engine malfunction. The malfunctioning part was corrected and passed the final round of tests on 30 December 2020.

CZ-8 reusable

In an CCTV interview on 28 February, Luan Enjie, Chief Designer of the CZ-3A series of launchers at CALT (China Academy of Launch Technology), said that the development of a reusable version of the medium-sized CZ-8 has been initiated and is progressing well. It is hoped that key technology demonstration tests for vertical take-off and vertical landing (VTVL) can be conducted in 2021. Jiang Jie, a senior rocket expert of CALT, told media on 2 March, that the new launcher will feature a range of new technologies including highly integrated equipment, autonomous technologies and convenient pre-launch preparations as well as the integration of ground tracking, monitoring and control systems. Jiang said, a reusable launcher would reduce safety risks, lower the launch costs and boost space technology.

The designers are focusing on several crucial sub-systems such as low-speed landing navigation and guidance along with a foldable landing buffer system.

The current CZ-8 serves for launching various types of spacecraft into diverse orbits. Its main task is to place satellites into SSO.

CZ-9

In an interview with state broadcaster CCTV on 28 February, Luan Enjie said feasibility studies for a launcher with a capacity of 100 t to lunar transfer orbit had been completed and the project was now in the stage of follow-up research and is waiting for state approval. If approved, the launcher could be used for a crewed lunar mission around 2030 and later for human missions to Mars or for large-scale space infrastructure construction and space resource development. Although Luan did not name the new rocket, it could be concluded that he meant the CZ-9 super-heavy-lift rocket.

On 3 March, Jiang Jie told media that China will work over the next 5 years on the development of 2 types of super-heavy launch vehicles for future lunar projects: a super-heavy launch vehicle and a new generation crew launch vehicle. The super-heavy launcher would be the CZ-9. A test flight is expected in 2030.


Jiang Jie at XSLC. Credit: CALT

The new generation crew launch vehicle is expected to be conceptualised and publicly introduced over the next few years. For some technical specifications of the CZ-9, compare the Quarterly Report in GoTaikonauts! Issue No. 34.

Engine Development and Testing for CZ-9

CASC is creating a new line of rocket engines and has made significant advances in several key technologies for a more efficient new engine. The new carrier rocket for deep-space exploration will use 3 different types of liquid rocket engines: for the 1st stage the 500 t LOX-kerosene engine, and for the other stages 220 t and 25 t engines using LOX and liquid hydrogen.

The unnamed hydrogen/oxygen engine is expected to eventually replace the YF-77 which currently powers the 1st stage of the heavy-lift CZ-5 rockets. The new engine is based on technologies from the YF-77 but features improvements in materials and processes. Instead of the YF-77's gas-generator cycle, the new engine for the 2nd stage of the CZ-9 rocket will use a 220 t thrust liquid hydrogen-liquid oxygen staged combustion cycle, which increases efficiency by burning the propellant more thoroughly, but also poses challenges in design and engineering. Progress was also made on successful hot-fire tests of the pre-burner and propellant turbopumps and combined testing.


Screen shot from CCTV broadcast showing the CZ-9 on a launch pad. Credit: CCTV

On 5 March, CASC successfully conducted a test run of a 500 t thrust LOX-kerosene rocket engine, marking a breakthrough in China's rocket-engine development, and laying a foundation for the planned heavy-lift launcher. The design and management of the engine is fully digitalised.

New fuel tanks

CASC's CALT has developed 2 new rocket tank prototypes. Both have a diameter of 3.35 m. One is made of an aluminium-lithium alloy which is 15% lighter and 30% stronger than conventional tanks made of aluminium-copper alloy. It has passed several tests and has shown good performance. The aluminium-lithium tank is expected to be used for improving the structural efficiency and payload capacity of the CZ-5, CZ-7, CZ-8. It supports the development of heavy-lift rockets with larger diameters and the new generation of manned rockets.

The other prototype tank is made of composite materials and will

A rocket tank prototype made of composite materials. Credit: CASC

be mainly used in liquid oxygen environments. Compared with rocket tanks made of metal, it is around 30% lighter, and has better strength and endurance. It also has the advantages of fewer production processes and a shorter production cycle, which will help to reduce production cost. Researchers are currently carrying out a series of tests and evaluations on the tank.

YUANWANG

Yuanwang 3 (YW-3)

On 21 February, the YW-3 space tracking ship set sail for its 1st voyage in 2021. It departed from its home port in Jiangsu Province for upcoming maritime monitoring missions in the Pacific Ocean.

Yuanwang 5 (YW-5)

On 20 January, space tracking ship YW-5 completed its monitoring mission in the Pacific Ocean for the launch of the Tiantong 1-03 satellite. As the only monitoring ship at the sea, YW-5 was responsible for tracking the rocket's flight, managing the data calculation and the space-to-ground signal transmission. YW-5 will conduct around 10 space tracking missions with more than 200 days of ocean-going operations in 2021.

Yuanwang 6 (YW-6)

On 10 February, YW-6 departed from its home port in Jiangsu Province for maritime spacecraft monitoring missions in the Indian Ocean. Before the voyage, the crew completed vessel maintenance, examined the ship's facilities and replenished supplies. Like YW-5, also YW-6 is booked for over 200 days of operations at sea in 2021.

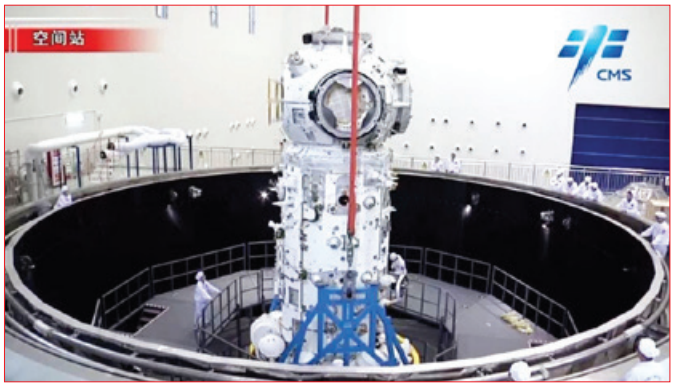
Yuanwang 7 (YW-7)

On 15 January, YW-7 departed from its home port in Jiangsu Province, setting sail for the Indian Ocean. To ensure the success of the 1st maritime monitoring mission of the year, the crew members were brought together and quarantined before the voyage to prevent COVID-19 infection. They have examined facilities and prepared medical supplies before departure.

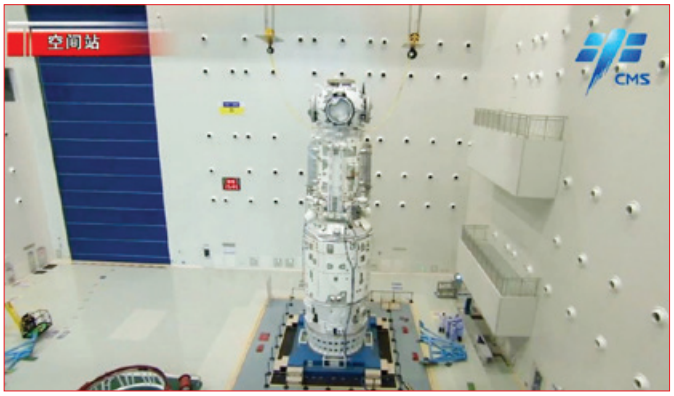
MANNED SPACEFLIGHT

CSS Tianhe module

Manufacturing and testing of the 16.6 m-long, 4.2 m-diameter and 22 t Tianhe core module of the CSS has been completed.
China Manned Space Engineering Office (CMSEO) announced on 14 January that Tianhe and the TZ-2 cargo craft have passed their factory review and are getting readied for shipping to Wenchang. Experts from CMSEO, the Chinese Academy of Sciences (CAS) and CASC reviewed the design, construction and test reports, checked the technical status and quality, as well as whether the docking interfaces between different systems matched correctly. Any risks were identified and controlled. The functions and performance of the Tianhe and TZ-2 have all met the overall project requirements.
Also, the technical status and the inter-system docking interfaces of the flight models of the payload racks in the core module were checked. The science hardware for the core



The Tianhe module is lowered into a vacuum chamber for space environmental testing. Credit: CMSA



The Tianhe module is mounted on a shaker table for testing. Credit: CMSA

module developed by CAS has been completed as well. The compatibility between space application systems and with the ground research units were verified during the review.
The review concluded that the construction of the CSS can enter the implementation phase. Tianhe is planned for launch in spring on board a CZ-5B.

CSS

China Space Station - what to expect?

Rui C. Barbosa wrote for NASASpaceflight.com a comprehensive overview article about what is known about the Chinese Space Station. He lists the expected launches, the station configuration and functions of the respective station modules and how the initial utilisation could look like.

Different types of the Long March rockets are used for the construction of the CSS:

- CZ-5B for the launch of modules
- CZ-2F for crewed launches
- CZ-7 for cargo transport

The 2021 launch sequence: Tianhe, TZ-2, SZ-12, TZ-3, SZ-13.
The SZ-12 and SZ-13 crews have to prepare the inside and outside of the Tianhe module for the arrival of the other 2 laboratory modules in 2022. The operations in 2021 are part of the 1st Phase in the Station construction, called the Key Technology Verification Phase.
In the 2nd Phase, the Orbital Construction Phase, 2 space labs will be launched one-by-one with CZ-5B rockets. 2 more human missions, SZ-14 and SZ-15, and 2 more cargo flights TZ-4 and TZ-5, will be made to finalise the construction of the CSS in 2022.

CSS

In March it was reported that the Saudi Space Commission has signed a bilateral agreement with CMSA to fly a solar cell experiment to the CSS in 2022. The flight opportunity is an outcome of the AO by CMSA-UNOOSA (Chinese Manned Space Agency-United Nation Office of Outer Space Affairs) from May 2018.

The Saudi Space Commission CEO Abdulaziz bin Mohammed Al Al-Sheikh signed the document, which will also be endorsed by the implementing entities, the King Abdulaziz City for Science and Technology and CMSA.
Saudi Arabia wants to develop long-lasting, high-efficient solar cells for space applications. For that, tests in space are needed.

Taikonauts

The 1st group of taikonauts selected for the CSS assembly flights was undergoing mission specific training and prepared for the extravehicular activities (EVA) tasks planned during their mission assignments. Several taikonauts were occupied in 2020 with general training and were in mission specific training at the beginning of 2021.
In the water-tank of the China Astronaut Research and Training Centre in Beijing, Wang Yaping conducted EVA training. For the training of an 4 h-long EVA, 50 h of underwater training are needed. Each of these training unit lasts 6 h.

The diving training suits weigh more than 120 kg which requires a mechanical arm to lower the trainees into the water. During Wang's 4 h long training session she was assisted by 7 divers, supporting her in completing the tasks. Additionally, trainers and Centre staff also monitored the session from a control room.

LUNAR AND DEEP-SPACE EXPLORATION

LUNAR EXPLORATION

Chang'e 4 (CE-4)

On 6 January, the Beijing Aerospace Flight Control Centre (BACC) organised a workshop with all parties involved in the CE-4 mission to discuss the state of the lander and rover and investigate options for mission extension.

Chang'e 4 (CE-4) operational milestones

CE-4 - 26th lunar day

The Chang'e 4 (CE-4) lander and Yutu 2 (YT-2) rover resumed work for the 26th lunar day on the far side of the Moon. The lander woke up on 8 January at 3:13 BJT, and the YT-2 rover woke up on 7 January at 10:29 BJT. During the 26th lunar day, YT-2 moved northwest toward the basalt area with high reflectivity. The rover took panoramic photos, and its infrared imaging spectrometer, neutral atom detector and lunar radar continued to collect scientific data. Research teams analysed the data and released the results.

Chang'e 4 main achievements after 2 years of operation

The lander and rover achieved 2 years of continuous operations providing low-frequency radio astronomical observation, terrain and landform survey, mineral composition and shallow lunar surface structure exploration, and neutron radiation and neutral atom measurement.

Yutu 2 (YT-2)

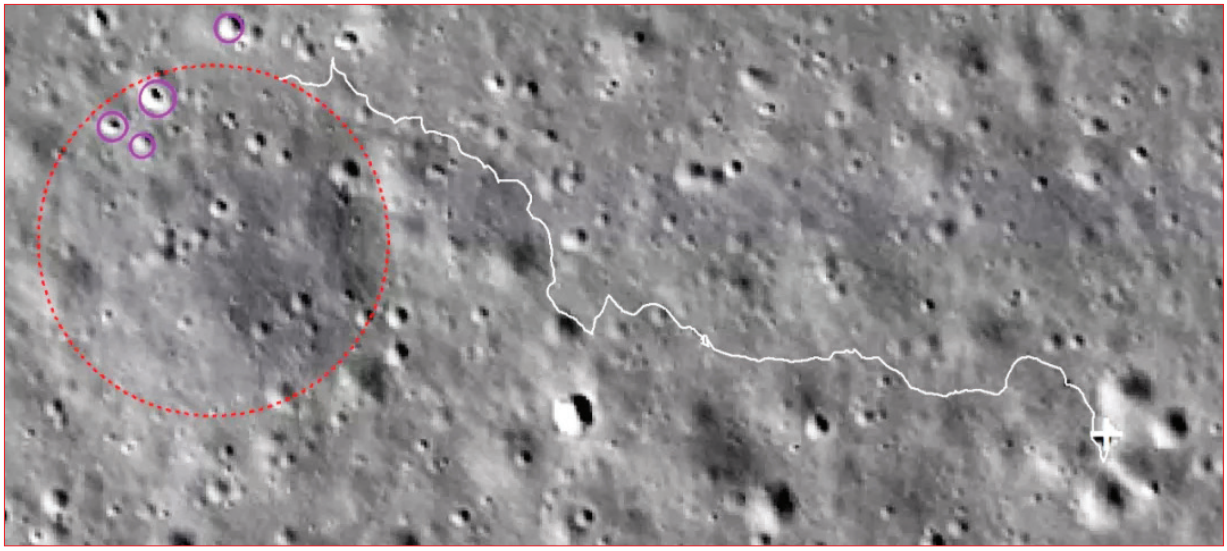
- The rover drove 600 m, exceeded its 3-month design lifetime, and became the longest-working lunar rover on the Moon.
- By using the Visible and Near-Infrared Imaging Spectrometer (VNIS) on the rover, it was determined that the material in the landing area of the CE-4 probe contains olivine and pyroxene which came from the lunar mantle from deep inside the Moon.
- The Lunar Penetrating Radar (LPR) reached into a depth of 40 m under the surface, collecting data which allowed the researchers to develop a diagram of the sub-surface stratigraphy of the far side of the Moon.

Lander

With data from the lander's instruments, the thickness of the regolith was determined and the fine subsurface structures and evolutionary history of the landing site revealed. It could be concluded that the terrain around the landing site had experienced multiple impact events and basalt magma eruptions. The material detected by YT-2 came from the nearby Finsen impact crater rather than the basalt erupted from the lunar mantle. This in turn led to the conclusion that the in-situ characteristics of mafic components in the South Pole-Aitken basin are similar to remote sensing results. The mafic components are mainly clinopyroxene and are consistent with rapid-cooling magmatic systems. The materials at the landing site are probably recrystallised from impact melt.

CE-4 - 26th lunar night

After concluding the operations for the 26th lunar day, the CE-4 lander switched to stand-by on 20 January at 21:10 BJT and the rover earlier the same day at 14:06 BJT. The CE-4 mission has been working for 749 Earth days, with the rover travelling a total distance of 628.47 m.
A new publication in Geophysical Research Letters presented the results of the rover's Visible- and Near-Infrared Imaging Spectrometer (VNIS) data:
"VNIS measured thermal emission on the surface of the Moon



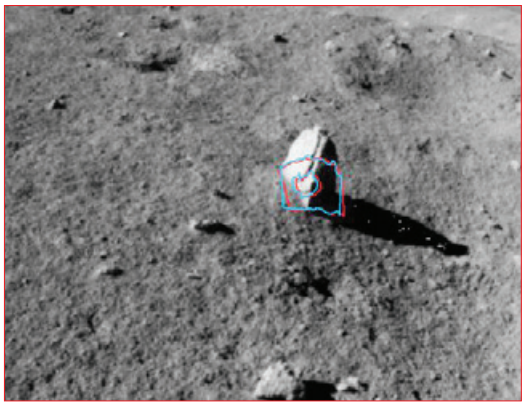
The white line marks the route, Yutu 2 drove until January 2021. The closest crater with higher reflectivity material is the purple circled area. The dashed red circle marks the degraded crater. Credit: CLEP - China's Lunar and Deep Space Exploration

at short wavelengths. During the 1st, 2nd, and 10th day of rover operations on the lunar surface, temperature variations at cm-scales were retrieved. These in-situ observations are an important complement to the existing large-scale measurements taken from orbit providing information from mid-to-long infrared (IR) wavelengths. VNIS data reveal that the millimeter scale roughness plays an important role when deriving temperatures and physical properties of the lunar surface regolith."

Yunzhao Wu, Ekkehard Kührt, Matthias Grott, Qi Jin, Tianyi Xu, Joern Helbert, Maximilian Hamm, Nannan Qin, Jinsong Ma, Jean-Baptiste Vincent, Paul Hayne, (2020), Chang'E-4 rover spectra revealing micro-scale surface thermophysical properties of the Moon, Geophysical Research Letters, DOI: 10.1029/2020GL089226

CE-4 - 27th lunar day

The CE-4 lunar lander and rover resumed operations for the 27th lunar day when the lander woke up on 6 February at 16:48 BJT and the YT-2 rover entered operational mode earlier the same day at 4:26 BJT. By that time, YT-2 had travelled 628.5 m. At the beginning of the lunar day, it was located 430 m northwest of the landing site. During the 27th lunar day, the panorama camera on the rover took colour images of lunar rocks and impact craters. The rover moved southwest towards an elongated rock of about 18 cm diameter in 17.8 m distance. The rock which sticks out of the landscape was spotted by the mission science team on photos taken during the 26th lunar day. Together with the operations team they planned a route to get closer to that particular rock for close-up investigation by the rover's VNIS instrument. Follow-up detections and data from VNIS will provide better insight into the rock's characteristics. The neutral atom detector and lunar radar continued scientific investigations.



above: Image of the landscape with the rock sticking out from the ground. Credit: CLEP

left: CE-4 rock detection method shows the infrared-viewing field projections for 2 detection methods. Credit: CLEP

CE-4 - 27th lunar night

After working smoothly through the 27th lunar day, the CE-4 lander and the YT-2 rover switched to dormant mode for the 27th lunar night. The lander powered down on 19 February at 13:30 BJT and YT-2 earlier the same day at 01:48 BJT. As of 20 February, the lander and rover have been in operation for 778 Earth days, and the rover has travelled 652.62 m. YT-2 was in good condition, and all scientific payloads were working normally.

CE-4 - 28th lunar day

The CE-4 lunar lander and the YT-2 rover resumed work for the 28th lunar day. YT-2 was located about 429 m northwest of the landing site. On 3 March, a new batch of 605 data files collected during the 15th lunar day was released.

CE-4 - 28th lunar night

After working through the 28th lunar day, the CE-4 lunar lander and YT-2 rover switched to hibernation mode for the 28th lunar night. The lander went dormant on 21 March at 02:00 BJT and the rover on 20 March at 17:09 BJT. Both craft have been on the far side of the Moon for more than 800 Earth days. Since landing in January 2019, YT-2 has driven 682.77 m across the Von Kármán crater.

CHANG'E 5 - CE-5

International Lunar Cooperation

Xu Yansong, Director for International Cooperation at the China National Space Administration (CNSA), stated that CNSA is preparing for sharing the CE-5 lunar samples with the international community. China considers international cooperation as essential for deep-space exploration. While lunar exploration is feasible on a national level, missions beyond the Moon would require much bigger resources and therefore transnational cooperation. He hoped that bilateral cooperation with the U.S. will resume and be revived through the mechanism of consultation and bilateral dialogue.

CE-5 - Access to Lunar Samples

On 18 January, CNSA announced during an event at the lunar sample storage and processing facility in the Chinese Academy of Sciences' National Astronomical Observatories in northern Beijing the "Regulations on the Management of Lunar Samples" from the CE-5 mission. In the event under the motto "Access to China's Lunar Exploration Programme" more than 70 diplomats and representatives from France, Russia, the European Union, APSCO (Asia-Pacific Space Cooperation Organisation) and other countries and international organisations participated. The framework covers in 9 chapters and 37 articles the general principles for preserving, managing, using, borrowing and returning the lunar samples, as well as the information release and research results management of the samples.

According to the regulations, the lunar samples will be used for 4 purposes: permanent storage, backup permanent storage, research and public outreach. About 80% of the lunar samples will be used for scientific research, and 20% will be preserved for future more advanced scientific research methods.

The document explains that the samples' distribution will be in accordance with international treaties China has signed or is part of. CNSA encourages national and international researchers to use the samples in joint studies on space science and to share their findings with each other.

The foreign guests got a tour of the lunar sample storage and processing facilities where the scientists were still in the pre-processing stage of the lunar samples, including sample unsealing, preparation and the establishment of the archives.

CNSA also awarded commemorative plaques to the international cooperation partners including the Argentina National Space Activities Commission, the European Space Agency (ESA), the Namibian Ministry of Higher Education, Training and Innovation, and the Pakistan Space and Upper Atmosphere Research Commission (SUPARCO), to thank them for their support during the CE-5 mission. Yu Qi, Director-General of the Asia-Pacific Space Cooperation Organisation (APSCO), said her organisation has discussed with its Member States participation in research on the samples and that Thailand has begun to solicit proposals from their science community.

Norbert Paluch, Space Counsellor and CNES (French Space Agency) representative to the French Embassy in Beijing, expressed his appreciation of China's opportunities for cooperation in lunar exploration, adding that French scientists intend to apply for lunar samples. French space institutes are talking with their Chinese partners about working together during China's next lunar missions, he said.

Commemorative plates were awarded to representatives from the international cooperation partners for the CE-5 mission at the National Astronomical Observatories of China under the Chinese Academy of Sciences in Beijing, on 18 January 2021. Credit: Xinhua/Jin Liwang

Extended mission at Sun-Earth L1

According to BACC, the CE-5 orbiter has successfully entered the L1 Sun-Earth Lagrange Point (Sun-Earth L1) on 15 March 2021 at 13:29 BJT. After an 88-day flight during its extended mission, CE-5 became China's 1st spacecraft to enter Sun-Earth L1. BACC reported on 18 March that the orbiter is 936,700 km from the Earth and working normally with stable attitude and power level. On the way to Sun-Earth L1, BACC conducted 2 orbital manoeuvres and 2 midway corrections. The CE-5 orbiter separated from the re-entry capsule on 17 December 2020, at 5,000 km above the southern Atlantic Ocean. While the re-entry capsule landed in Inner Mongolia, the orbiter started its extended scientific mission. The extension was possible because of the accurate performance of the CZ-5 launcher which placed the probe in the exact orbit, limiting the manoeuvres to those required by the flight profile and consequently saving fuel.

CALT said in a statement on 18 January that the CE-5 orbiter consumed just 0.3% of the propellant reserved for orbit correction during the lunar mission in December and had over 200 kg left for further manoeuvres. Since then, the orbiter flew 1.43 million km, had spent 100 kg of fuel and would take over 2 months at a reduced speed to reach Sun-Earth L1. The decision for L1 was taken after the assessment of many factors by ground controllers: including the orbiter's remaining propellant and the conditions of its devices as well as the data it sent back.

Sun-Earth L1 is an ideal position for monitoring solar activities and to conduct communication experiments with ground control. In 2011, the CE-2 orbiter carried out a similar mission but to the Sun-Earth L2 point outside the Earth's orbit. After monitoring high-energy particles and solar wind, in December 2012 it went further into space to conduct a fly-by of asteroid 4179 Toutatis.

President Xi met CE-5 team

On 22 February, Chinese President Xi Jinping and the entire Standing Committee of the Politburo met space scientists and engineers involved in the research and development of the CE-5 lunar mission at the Great Hall of the People in Beijing. Xi said that the success of the CE-5 mission marked the conclusion of China's 3-step lunar exploration programme CLEP. Xi urged for the implementation of CLEP's 4th phase.

He called for giving full play to the advantages of the new system of pooling national resources and strengths, enhancing independent innovation, strengthening overall planning and working harder to promote the innovative development of China's space science, space technologies, and space applications. He also stressed the importance of international cooperation and making contributions to humanity. On that occasion, Xi inspected some of the lunar material brought back by the sample return mission.

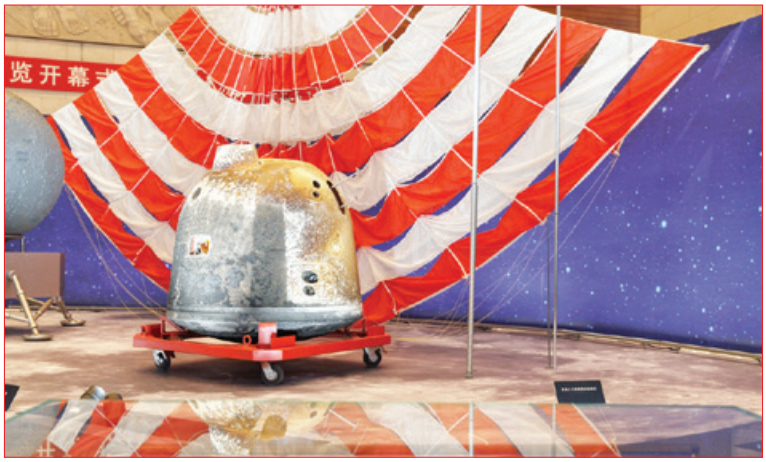
CE-5 samples in the National Museum of China

The National Museum of China announced on 23 February that it will exhibit a sample of 100 g of the lunar material brought back by the CE-5 mission. The sample arrived at the museum on 22 February and the exhibition opened on 26 February. The lunar soil is preserved in a specially designed transparent container made of artificial crystal and labelled: Lunar Sample no. 001. It has the shape of a Zun, a bronze wine holder used at rituals in the Shang Dynasty (16th to 11th century before our time) and Western Zhou Dynasty (11th century to 771 before our time). The container is 38.44 cm high and 22.89 cm wide. The height refers to the average distance of 384,400 km between the Earth and the Moon. The width represents the 22.89 days of the CE-5 mission. The exhibition on the ground floor of the museum also showed 40 objects related to the mission, together with photos and videos. Major centrepieces were the return capsule and parachute of the CE-5 re-entry capsule, as well as life-size models of its lander and ascent stage. A model of the rover of the Tianwen 1 Mars mission was also shown. The exhibition went on a nationwide tour afterwards.

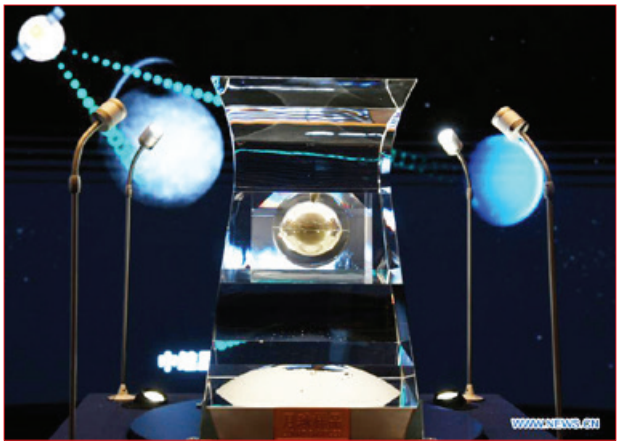
The museum possesses other important space flight exhibits for permanent display, including the spacesuit worn by Yang Liwei. It also curated the long-term online exhibition "Dongfanghong Forever", showcasing China's progress in aerospace technology in the past half century.

Space Breeding

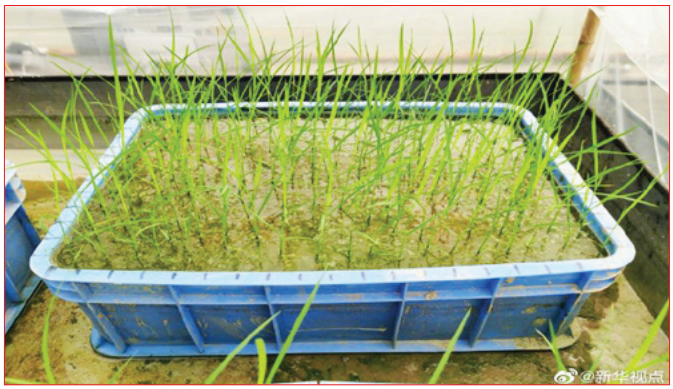
Around 1,500 rice seeds (40 g) that travelled for 23 days on board the CE-5 spacecraft were planted at the National Engineering Research Centre of Plant Space Breeding of the South China



This photo, taken on 27 February 2021, shows the CE-5 return capsule at the National Museum of China in Beijing. Credit: Jiang Dong/Chinadaily.com.cn



The CE-5 lunar sample No. 001 displayed at the National Museum of China in Beijing on 27 February 2021. The samples container is made of artificial crystal. Credit: Xinhua/Jin Liangkuai



Space seeds cultivated. Credit: Xinhua

Agricultural University (SCAU), in Guangzhou, Guangdong Province. The seedlings left the greenhouse on 29 March 2021 and were planted in the fields. They will be further cultivated for 2 to 4 generations to select beneficial characteristics. Each seed contains 40,000 genes. The deep-space environment induced mutations, which can be tracked in a targeted way to identify favourable genes for new rice variants. Additionally, Chinese scientists will be able to study the evolution of species and aerospace biosafety by looking into the molecular and genetic mechanisms of model organisms responding to deep-space environment through rice seeds.

Chang'e 5 (CE-5)

For a detailed mission report compare the 2-part article in GoTaikonauts! Issue no 31 and Issue no 34.

International Lunar Research Station – ILRS

On 12 February it was reported that the Russian government had backed Roscosmos' proposal for an MoU with China on the international lunar research station project. Prime Minister Mikhail Mishustin signed the relevant resolution.

On 9 March, approved by the governments of China and Russia, Zhang Kejian, Director of CNSA, and Dmitry Rogozin, Director General of Roscosmos State Corporation, signed the "Memorandum of Understanding between the Government of the People's Republic of China and the Government of the Russian Federation on Cooperative Construction of International Lunar Research Stations" via video conference. Both countries will cooperate on the construction of an international scientific, research station on the Moon.

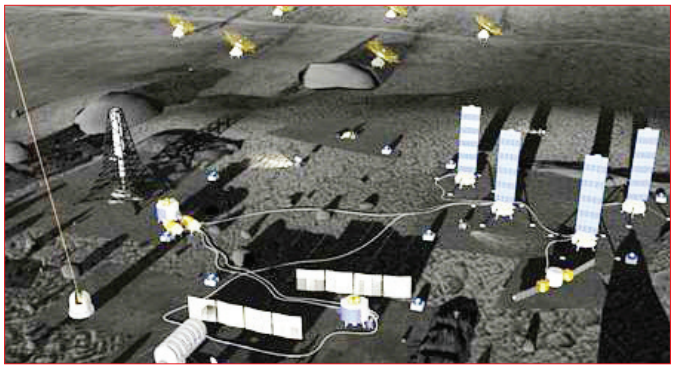
In a 1st step, "China and Russia will apply their accumulated experience in space science, research and development and in the use of space equipment and space technology to jointly formulate a roadmap for the construction of an international lunar research station, carrying out close cooperation in the planning, demonstration, design, development, implementation and operation of the project", reads the MoU. Also, both nations will promote the project to the international space community while every phase of development, from planning to operation, will be jointly led by Moscow and Beijing, according to a statement by CNSA and Roscosmos. "The International Lunar Research Station will be a long-term, autonomous, and comprehensive scientific experiment base, located on the Moon's surface or in lunar orbit that can carry out multi-disciplinary and multi-objective scientific research activities such as exploration and utilisation of the Moon, lunar observation, fundamental scientific experiments and technology verification."

MoU signature ceremony with the delegation in Beijing. Credit: CNSA

After the online meeting and signature ceremony, Rogozin tweeted: "I also invited my Chinese colleague Zhang Kejian to visit the launch of our Luna 25 mission from the Vostochny cosmodrome". The Luna 25 lunar lander mission is set for lift-off this October and is part of the cooperation project.

In the course of the next months, discussions will be held which could lead to additional agreements between China and Russia and might be announced during the GLEX 2021 (Global Space Exploration Conference) in St. Petersburg in June.

Chinese Ambassador to Russia, Zhang Hanhui, told Interfax on 9 March that a memorandum was prepared for the Roscosmos-CNSA cooperating agreement for the establishment of a joint lunar and deep-space database centre.



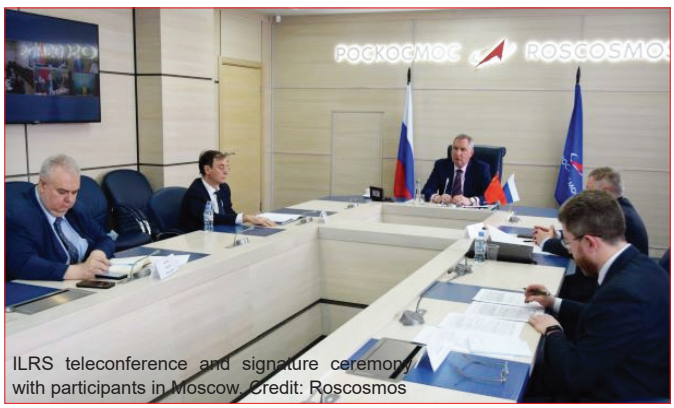
A conceptual layout of the future International Lunar Research Station ILRS, presented at COPOUS 2018. Credit: CNSA/CLEP

The Strategic Implications of the China-Russia Lunar Base Cooperation Agreement

Namrata Goswami analyses for *The Diplomat* the consequences of the Memorandum of Understanding (MoU) for the joint construction of an autonomous lunar research base, signed by CNSA and Roscosmos. She argues: "China and Russia's lunar base MoU has changed the alignment structures around space cooperation and sends a clear signal to the United States and the seven other Artemis Accords partners that space is contested. China and Russia are offering avenues for alternate partnership, especially to encourage countries like Saudi Arabia and Turkey to join, both of whom have aspirations to develop their space sector."

Lunar landing

Wu Weiren, CLEP's Chief Designer confirmed mid-March that the Sino-Russian cooperation for a lunar research station would pave the way for a human landing on the Moon. Chinese scientists and engineers are currently studying crewed landings on the South Pole of the Moon, which is more complex but the environmental conditions are better. It will be a long-term lunar stay for Chinese astronauts, not short-term, stressed Wu.



ILRS teleconference and signature ceremony with participants in Moscow. Credit: Roscosmos

Space programme veteran sees no limits to space exploration
On the occasion of the International Women's Day on 8 March, a portrait of Zhang Yuhua, the Deputy Chief Commander of the CE-5 and TW-1 space missions, was published by the online portal shine.cn. After graduation in 1990, Zhang Yuhua was assigned to SAST, just when China's manned, lunar and Mars space missions were beginning. "I was lucky to get in on the ground floor of China's aerospace industry," she said. Zhang encountered her biggest setback in 2014, when the 6-wheeled Yutu 1 rover, designed by her team, malfunctioned on its 2nd lunar day. She suffered insomnia for 3 days and cried, she admitted.

MARS EXPLORATION

TIANWEN 1 - TW-1

03 January

As of 6:00 BJT on 3 January, TW-1 has been in space for 163 days and has travelled more than 400 million km. It was about 130 million km away from Earth and in a distance of about 8.3 million km from Mars.

The probe was traveling at a speed of 23 km/s, flying about 2 million km per day. At the same time, its relative speed to Earth was 21 km/s, what means the distance to Earth increased by roughly 1.8 million km every day while the distance to Mars decreased by 200,000 km per day.

18 January - Tianwen rover name competition

On 18 January, the Lunar Exploration and Space Engineering Centre of CNSA announced a shortlist of 10 name proposals for the Tianwen rover resulting from a public Call for Ideas. *See: text box below*

Between 24 July to 16 August 2020, 1.4 million entries were received from 38 countries and regions via a voting website hosted by Baidu. Over 200,000 of them were eligible.

In October 2020, after evaluating 39,808 submissions, a panel of 32 experts selected 10 semi-finalists. The age of the participants ranged from 7 to 95 years.

In the final step a public online voting was held from 20 January until 28 February 2021 bringing the 10 names down to 3. "Zhurong" topped the list while "Nezha" ranked 2nd and "Hongyi" 3rd. Judges will then have the last say. Initially, the rover name was supposed to be revealed before the landing on Mars, but at the end it was decided to make the announcement on China Space Day 2021 - 24 April.

The 10 shortlisted names were: Hongyi, Qilin, Nezha, Chitu, Zhurong, Qiusuo, Fenghuolun, Zhuimeng, Tianxing and Xinghuo. The names refer to Chinese mythological figures or animals or Confucian ideas - complying with the competition criteria that Chinese culture had to be connected with modern technology. Also, the name had to be in line with relevant national regulations and match the characteristics of China's 1st Mars mission. The name suggestion had to be catchy and not have been used by any spacecraft before.

- **Zhurong**, the name of the god of fire in Chinese mythology;
- **Chitu**, meaning red rabbit - it is similar to the name Yutu for the lunar rover: Jade rabbit;
- **Nezha**, a household name of a fire breathing child in Chinese mythology;
- **Fenghuolun**, is Nezha's major weapon, a flamed wheel;
- **Qilin**, means kirin, is a dragon-like, hooved chimerical creature in Chinese mythology. It's taken as a symbol of luck, good omens, protection and prosperity by Chinese.
- **Hongyi**, refers the quality of being broad-minded and determined in Chinese;
- **Qiusuo**, means to seek (for things like knowledge or truth) in Chinese;
- **Zhuimeng**, means to pursue dreams in Chinese;
- **Tianxing**, means the movement of celestial bodies in Chinese;
- **Xinghuo**, means spark in Chinese.

03 February 2021

CNSA said in a statement on 3 February that TW-1 was set to enter Mars' orbit around 10 February.

GRAS-4 Deep-Space Antenna

GRAS-4 - Asia's largest single-aperture, fully steerable antenna went into service to communicate with the TW-1 Mars mission – just in time for the imminent Mars orbit insertion. On 3 February, the 70 m-diameter antenna in Tianjin's Wuqing District was handed over to the National Astronomical Observatory of China. Its 1,328 high-precision panels cover 4,560 m^2.

05 February 2021 - 4th orbital correction

On 5 February at 20:00 BJT, TW-1 conducted its 4th orbital correction. The manoeuvre ensured that the probe stayed on course for rendezvous with Mars. Also, CNSA published the 1st Mars image taken by TW-1, captured from a distance of 2.2 million km. The probe has travelled about 197 days since launch, bridging a total distance of about 465 million km. It was 184 million km from Earth and 1.1 million km from Mars. All systems were in good working condition, CNSA said.

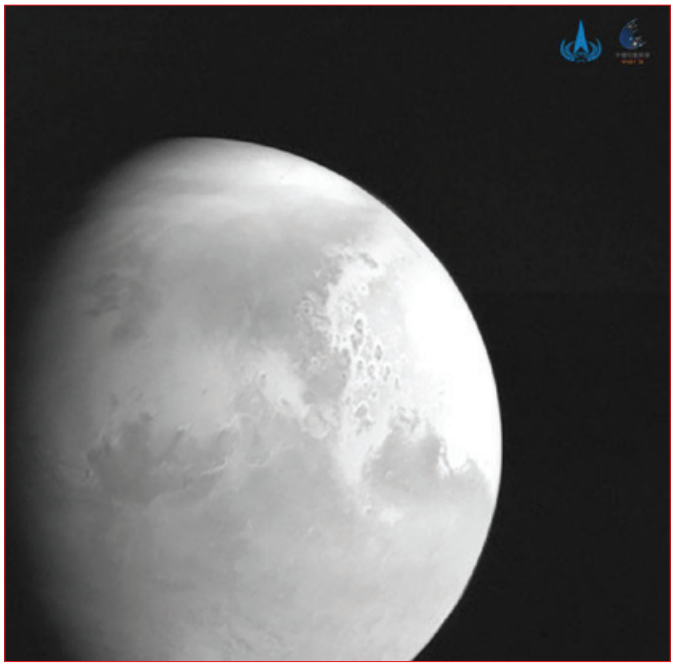


Photo released by CNSA on 5 February 2021 shows the 1st image of Mars captured by Tianwen 1 from a distance of 2.2 million km. Credit: CNSA

10 February 2021 - Mars orbit insertion

On 10 February, TW-1 successfully entered an orbit around Mars. At 19:52 BJT (11:52 GMT) and at 192 million km from Earth, the 3,000 N main engine was ignited to decelerate the probe within 15 min from a speed of 28 km/s to about 1 km/s. The probe entered a 400 x 180,000 km highly elliptical orbit around the Red Planet, with an inclination of 10°. The orbital period was 10 Earth days. The whole process was autonomously executed by the craft. The plan was that Tianwen will inspect the landing site Utopia Planitia and survey Mars for 3 months before making a landing attempt.

The new steerable 70 m radio telescope in Tianjin was the key facility receiving data sent by the Mars probe. The one-way communication delay by 10 February was about 10.7 min.

Mars orbit capture in video

CNSA has unveiled the complete footage of the moment when TW-1 entered the orbit around Mars. The time lapse video shows how Mars is gradually coming into view, the slight vibration of the craft and solar array after engine ignition, and its flight from daylight into the night. It also shows a clear image of the solar panel, the high-gain directional antenna, and the Mars atmosphere and the planet's surface topography. The

KEY FACTS

MARS EXPLORATION PROGRAMME ORIGIN

On 22 April 2016, CNSA announced China's 1st Mars mission for launch around 2020. The project aimed at orbiting, landing, and roving in one mission. China's earlier Yinghuo 1 Mars orbiter, launched on board Russia's Phobos-Grunt spacecraft in November 2011, failed to leave Earth orbit and re-entered the Earth's atmosphere again.

MISSION NAME

On 24 April 2020, CNSA announced the name of the mission: Tianwen 1 (TW-1). It was decided to name all the Chinese planetary exploration missions in the future "Tianwen" and assign a serial number.

LAUNCH

On 23 July 2020, TW-1 was launched on board a CZ-5 rocket from the Wenchang Spacecraft Launch Site on Hainan Island. On 28 July 2020, TW-1 left Earth's gravity field and entered the Earth-Mars transfer orbit.

SELFIES TAKEN

On 1 October 2020, on the occasion of China's National Day, CNSA released mid-flight images of TW-1. The images were taken by a small camera with wide-angle lenses on both sides which was released from the orbiter. The photos captured the golden-shining orbiter and the silver hull encapsulating the lander and rover. The national flag on the orbiter was also recognisable.

video was made from the fast playback of still images at a rate of 10 frames per second. The images were taken by surveillance cameras on the solar panel and the directional antenna. The cameras took images every 3 seconds for about 30 minutes.

TW-1 has a monitoring system consisting of multiple small cameras with low energy consumption. The cameras, installed on solar panels, directional antennas, and the lander-rover combination, can automatically take deep-space selfies, as well as images of the deployment of antennas and solar panels, and of key manoeuvring processes, without ground command control.

15 February 2021 - 1st Mars orbit adjustment burn

On 15 February 2021, TW-1 performed its 1st Mars orbit adjustment burn. The probe's 3,000 N main engine was ignited at 17:00 BJT (09:00 UTC) when passing the apogee of the Mars orbit. That allowed for a plane change to adjust from an equatorial into a polar orbit by changing the orbital inclination of 10° to 86.9°. The manoeuvre also reduced the closest distance to Mars from 400 km to 265 km. There were 3 more orbit corrections expected to bring the elliptical orbit to a circular working orbit.

18 February 2021

The successful landing of NASA's Mars rover "Perseverance" attracted a lot of positive attention in Chinese social media, with the topic leading the Sina Weibo search list. Netizens applauded the safe landing, and extended their sincere congratulations to the U.S. Also, CASC congratulated NASA, saying that "it is hoped that all three missions to the Red Planet can achieve full success and make new contributions to humankind's deep-space exploration."

20 February 2021 - 2nd Mars orbit adjustment burn

Exact date and time not verifiable.

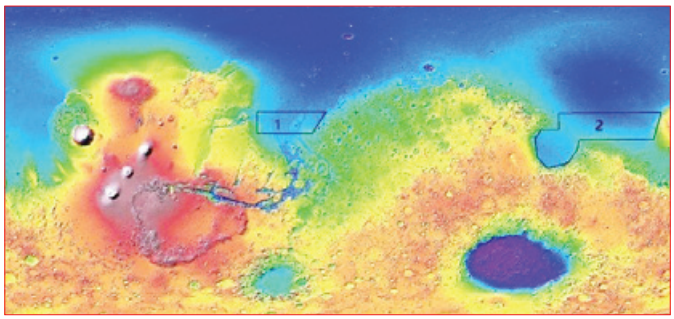
24 February 2021 - 3rd Mars orbit adjustment burn

After conducting the 3rd Mars deceleration manoeuvre, TW-1 entered its 280 km by 59,000 km parking orbit on 24 February at 6:29 BJT (23 February, 22:29 GMT). It took TW-1 about 2 Martian days to complete one orbit. During the next 3 months of remote sensing operations, all 7 mission payloads on the probe's orbiter were gradually activated.

A particular focus was on observing and analysing the landforms and weather condition on the landing site.

TW-1 description of payloads and objectives

Yongliao Zou, Yan Zhu, Yunfei Bai, Lianguo Wang, Yingzhuo Jia, Weihua Shen, Yu Fan, Yang Liu, Chi Wang, Aibing Zhang, Guobin Yu, Jihong Dong, Rong Shu, Zhiping He, Tielong Zhang, Aimin Du, Mingyi Fan, Jianfeng Yang, Bin Zhou, Yi Wang, Yongqing Peng, Scientific objectives and payloads of Tianwen-1, China's first Mars exploration mission, Advances in Space Research, 67, 2, 2021, pp. 812-823, ISSN 0273-1177, DOI: 10.1016/j.asr.2020.11.005.

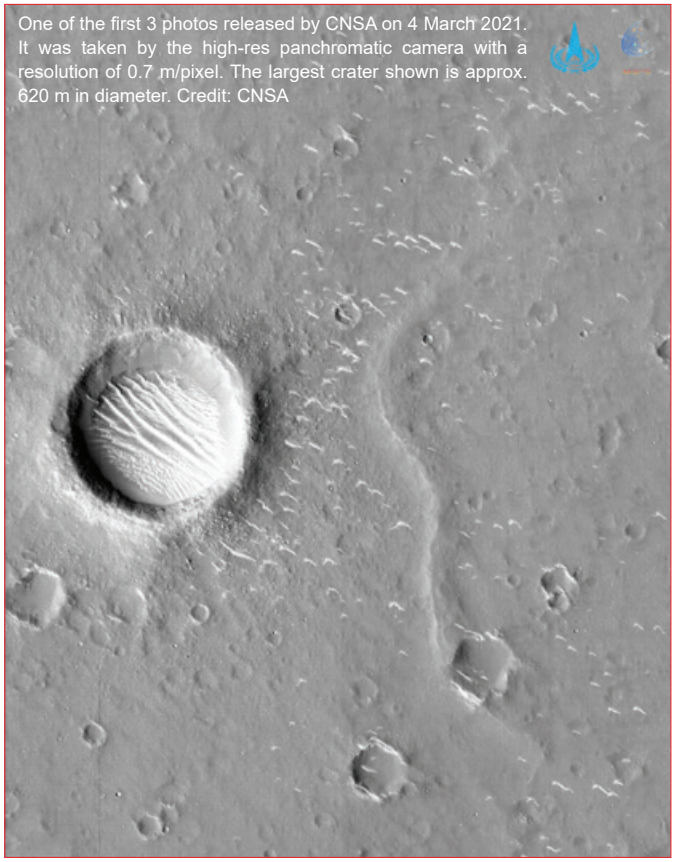


The Tianwen 1 mission's preselected candidate landing area on Mars. Area 1 is located on the Chryse Planitia plain; the preselected landing area 2 is located on Utopia Planitia. Credit: Zou Yongliao, et al.

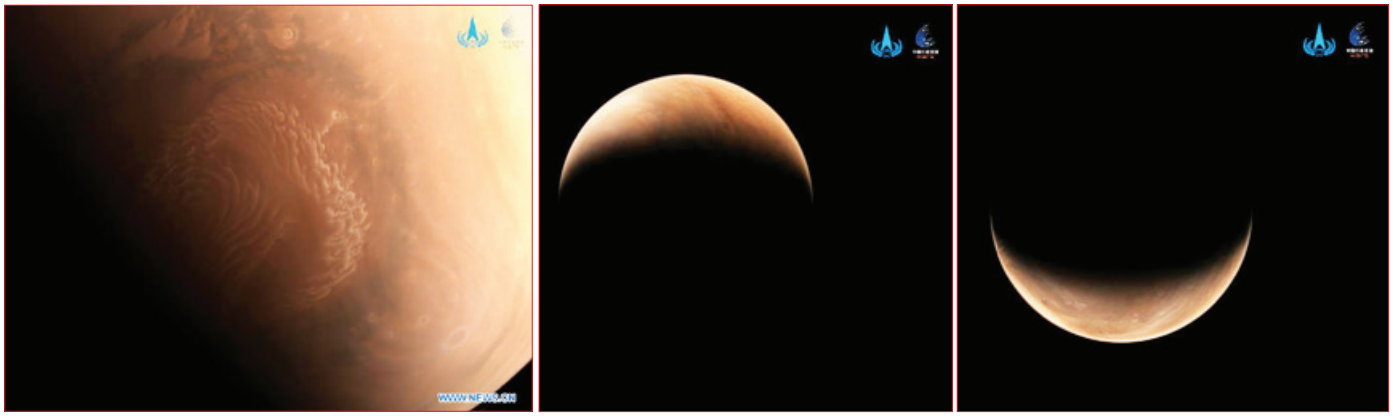
04 March 2021 - photo release

CNSA published 3 high-resolution images of Mars captured by TW-1. Two panchromatic images were taken by the high-resolution camera at a distance of 330 to 350 km above the surface of Mars, with a resolution of about 0.7 m per pixel. Martian landforms such as small craters, mountain ridges and dunes were clearly visible. It was estimated that the diameter of the largest impact crater in the images was around 620 m. The colour image was of the North Pole region taken by the medium-resolution camera.

The high-resolution camera, medium-resolution camera, spectrometer and other scientific instruments were switched on successively to collect data. The medium-resolution camera is capable of both: automatic exposure and remote-control exposure, enabling it to map remote-sensing images of the whole globe of Mars and to survey the planet's topography.



One of the first 3 photos released by CNSA on 4 March 2021. It was taken by the high-res panchromatic camera with a resolution of 0.7 m/pixel. The largest crater shown is approx. 620 m in diameter. Credit: CNSA



left: One of the first 3 photos released by CNSA on 4 March 2021. This image, taken with the medium-res camera, shows the North Pole region.
centre and right: Photos taken by TW-1 's mid-resolution camera on 18 March at the distance of 11,000 km. Credit: CNSA

23 March - landing date detailed

With the arrivals of TW-1 and the UAE's Hope missions, there were 8 orbiters operating around Mars: NASA's Odyssey spacecraft, the Mars Reconnaissance Orbiter, and the MAVEN atmospheric observatory, along with ESA's Mars Express and ExoMars Trace Gas Orbiter, and India's Mars Orbiter Mission.
Wang Chi, Director of NSSC (National Space Science Centre) at the Chinese Academy of Sciences, said in a presentation to the National Academies' Space Studies Board on 23 March: "The first Chinese Mars mission, TW-1, is now orbiting Mars, and we are landing in the middle of May. … We are open to international cooperation, and the data will be available publicly soon."

26 March - photo release

CNSA published on 26 March 2 Mars images taken by TW-1's mid-resolution camera on 18 March at 11,000 km from Mars. The images show a crescent Mars with the texture of surface features visible. Several mission payloads on the probe were activated and collected scientific data, as well as observed and analysed the landforms and weather conditions at the planned landing site.

NASA exchanged data with China on Mars orbiters

In a 29 March statement by NASA and short after confirmed by CNSA it became known that both agencies had from January to March working-level meetings and communications "to ensure the flight safety" of their Mars orbiters. Considering that 8 spacecraft were flying around Mars, NASA approached CNSA to obtain information on TW-1's orbit, in order to avoid collision. Despite bans by U.S. law on bilateral contacts between NASA and China, exceptions can be made when NASA can certify to Congress that it has protections in place to safeguard information. NASA's Acting Administrator Steve Jurczyk revealed the discussions with China during a question-and-answer session after a 23 March speech at a meeting of the Federal Aviation Administration's Commercial Space Transportation Advisory Committee.
Jurczyk said: "To assure the safety of our respective missions, NASA is coordinating with the UAE, European Space Agency, Indian Space Research Organisation and the CNSA, all of which have spacecraft in orbit around Mars, to exchange information on our respective Mars missions to ensure the safety of our respective spacecraft."

Mars Sample Return mission

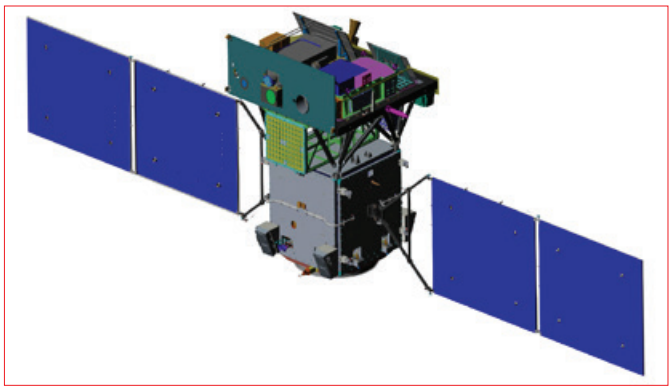
Xu Yansong, Director for International Cooperation at the China National Space Administration (CNSA), stated that based on the success of the Tianwen 1 mission, China will aim for a Mars Sample Return mission.

Manoeuvre/ activity	Date/time	Distance to Earth/ flown distance	activity
	3 January	130 million km / 400 million km	Days in space: 163 - Distance to Mars: 8.3 million km
4th orbital correction	5 February, 20:00 BJT	184 million km / 465 million km	Distance to Mars: 1.1 million km CNSA also published the 1st image of Mars, taken from a distance of 2.2 million km.
Mars orbit insertion	10 February, 19:52 BJT (11:52 GMT)	192 million km / 475 million km	After 202 days in space and at a distance of 1.1 million km to Mars, the 3,000 N main engine worked for 15 min to decelerate TW-1 from 28 km/s to about 1 km/s. The probe was successfully captured by Mars' gravity and entered a 400 x 180,000 km highly elliptical orbit, with an inclination of 10O. The orbital period was 10 Earth days. The whole process was autonomously executed.
1st Mars orbit adjustment	15 February, 17:00 BJT (09:00 GMT)		The probe's 3,000 N engine was ignited at 17:00 BJT - at the apogee of its Mars orbit. The equatorial orbital plane changed into a polar orbit. The manoeuvre also reduced the closest distance to Mars from 400 km to 265 km.
2nd Mars orbit adjustment	20 February		
3rd Mars orbit adjustment	24 February, 6:29 BJT (22:29 GMT)		After the 3rd Mars deceleration manoeuvre TW-1 entered its 280 km by 59,000 km parking orbit with an orbital period of 2 Martian days. During the next 3 months of remote sensing operations, all of the 7 mission payloads on the probe's orbiter were gradually activated. Particular focus was on observing and analysing the landforms and weather condition on the landing site.

SCIENCE

ASO-S - Advanced Space-based Solar Observatory

At the end of January, tests of China's 1st space-based solar observation satellite ASO-S were concluded. The launch is planned for the 1st half of 2022. Next year is the beginning of a new 11-year solar cycle with the peak around 2024-2025. The observatory will be positioned in a 720 km SSO for uninterrupted Sun observation with a relatively short communication delay. For at least 4 years, ASO-S will provide data about the formation of the solar magnetic field, solar flare and coronal mass ejections, as well as the relationship and interaction of these events. The observation results can be used for a space weather forecast system, with a solar storm alert of around 40 h in advance. ASO-S was proposed in 2011 and officially approved by CAS in 2017. The 3 main payloads of the 1 t spacecraft are a Lyman-alpha telescope (LST), a 160 kg Hard X-ray telescope (HXT) and a full-disk solar vector MagnetoGraph (FMG).



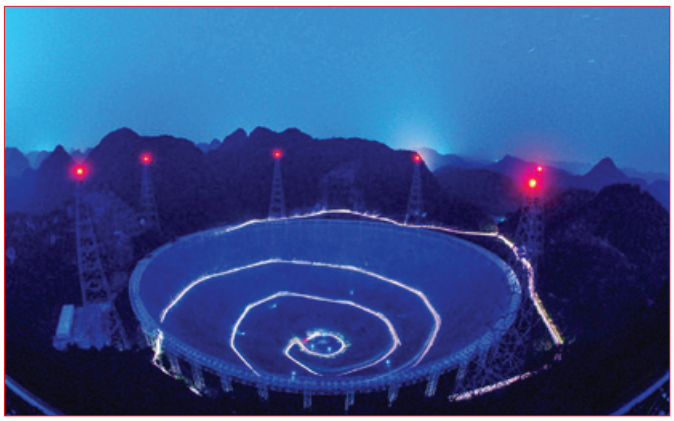
Conceptional illustration of the Advanced Space-based Solar Observatory (ASO-S). Credit: Purple Mountain Observatory, CAS

FAST - Five-hundred-meter Aperture Spherical radio Telescope Observation time for international scientists

The National Astronomical Observatories of CAS announced that as of 31 March, online applications by international scientists will be accepted for the use of 10 % of FAST's observation time during the upcoming campaign year from August 2021 to July 2022. The deadline for application is 15 May. An expert panel will be responsible for the selection of the proposals. The results will be announced on 20 July and projects can start from 1 August. There are no restrictions on the proposals, but FAST is designed for the collection of data on neutral atomic hydrogen in the interstellar medium, on the polarisation of spiral galaxies, and on fast radio bursts (FRBs) which are transient radio pulses.

Although FAST operates at a considerable cost, details are not known as well as whether China will charge foreign scientists for the observation time. For directing the parabolic antenna on a new object, more than 2,000 hydraulic pumps need to be operated. The collected data are enormous and need to be stored and analysed by supercomputers.

Since the loss of the Arecibo Observatory, a verification source is missing what has an impact on the work with FAST.



The photo taken during the regular maintenance period of FAST on 30 March 2021 shows the telescope at night. The illuminated road under the dish is prominently visible. Credit: Xinhua/Ou Dongqu

3 more Fast Radio Bursts (FRB) discovered

A research team led by the National Astronomical Observatories under CAS discovered, 3 new FRBs with a high-dispersion measurement based on FAST data. The scientists suggest that the FRBs happened billions of years ago in the early stage of the universe. The discovery was published in The Astrophysical Journal Letters journal 3 March. The newly discovered FRBs, together with the first FRB discovered in 2020, suggest there could be as many as 120,000 detectable FRBs arriving on Earth every day. Scientists are expecting more discoveries from FAST data while catching up with data processing.

Chen-Hui Niu, Di Li, Rui Luo, Wei-Yang Wang, Jumei Yao, Bing Zhang, Wei-Wei Zhu, Pei Wang, Haoyang Ye, Yong-Kun Zhang, Jia-rui Niu, Ning-yu Tang, Ran Duan, Marko Krco, Shi Dai, Yi Feng, Chenchen Miao, Zhichen Pan, Lei Qian, Mengyao Xue, Mao Yuan, Youling Yue, Lei Zhang, Xinxin Zhang, (2021), CRAFTS for Fast Radio Bursts: Extending the Dispersion-Fluence Relation with New FRBs Detected by FAST, The Astrophysical Journal Letters, 909, 1, L8, DOI: https://doi.org/10.3847/2041-8213/abe7f0

eXTP - enhanced X-ray Timing and Polarimetry

After more than 10 years of preliminary study and key technology development, the eXTP satellite developed by IHEP and other domestic and international partner institutions, has entered the Phase-B (design phase). Data from eXTP will enable scientists to study FRBs, neutron stars and black holes in other galaxies.

SATELLITES

Fengyun 3D (FY-3D)

Experts from the China Academy of Agricultural Sciences (CAAS), the National Satellite Meteorological Centre, Beijing Normal University as well as research institutes from France, Spain, the United States and Israel have initiated a new project to foster cooperation in the field of global agricultural drought monitoring using FY-3D data and providing timely agricultural drought information services for worldwide users. In cooperation with the Group on Earth Observations (GEO) and its members, the project also aims at innovating monitoring models and technical methods and improving the international application of FY-3D satellite data.

Observation Data

A recent report on China's Earth observation (EO) data resources development, written by the National Earth Observation Data Centre and the National Science and Technology Infrastructure (both institutes under the Aerospace Information Research Institute (AIR) of CAS), states that China has collected around 100 PB (about 100 million GB) of EO data from its EO satellites. The collected data resources have been used for both, free and commercial use, to serve more than 300,000 users, inducing significant social and economic benefits, according to the report.

Industrial Internet of Things (IIoT)

On 22 February, the web portal MacroPolo published an overview on China's industrial internet ambitions and the relevance for the space sector.

The Industrial Internet is one of China's "New Infrastructures", a list of digital infrastructures the Chinese government will focus its efforts on and will provide priority investment. The list also includes satellite internet supporting the IIoT. The influence and capabilities of China's provincial and city governments to spur industries are significant. On the example of Guangdong Province and

Huizhou City, the article mentions the incentives they provided for Industrial IoT. This included Guangdong Province offering discounts of up to 30% for using public cloud platforms, and Huizhou making 15 million USD available for IIoT funding.

Atmospheric Environmental Monitoring Satellite (formerly: Daqi 1 (Atmosphere 1))

At the beginning of March, SAST completed manufacturing of the Atmospheric Environmental Monitoring Satellite (AEMS), China's 1st satellite dedicated to the comprehensive monitoring of the atmospheric environment. After testing and final review, the launch was planned for the 2nd half of 2021.

AEMS can monitor fine particle pollution like PM2.5, or sulphur dioxide and ozone, as well as concentration of the greenhouse gases carbon dioxide (CO_2) and nitrogen dioxide (N_2O). It combines both passive and active sensing for comprehensive and more precise monitoring of the atmospheric environment.

In response to China's urgent need for atmospheric environmental monitoring China will produce a series of atmosphere monitoring satellites during the 14th Five-Year Plan (2021-2025), which will be used to monitor atmospheric pollution.

AEMS will be networked with other satellites, including the next satellite for combined active and passive high-precision greenhouse gas monitoring. China is making efforts to peak CO_2 emissions before 2030 and go carbon neutral before 2060.

Note: There were 2 other Daqi 1 satellites in history, launched on 3 September 1990 together with the 1st FY-1 satellite. DQ-1A and DQ-1B were 2 balloon satellites to measure characteristics of the upper atmosphere. The new "Daqi 1" satellite was launched in April 2022 but its official name is "Atmospheric Environmental Monitoring Satellite" though many reports still use Daqi 1.

Meteorology

China will further optimise its meteorological observation and forecasting operations by raising its meteorological capabilities to the most advanced standards until 2035.

So far, China modernised its meteorological capabilities by setting up an integrated observation network consisting of around 70,000 ground observation stations, 216 radars and 7 satellites. The system covers all county-level regions. During the 2016-2020 period, steady progress was made on meteorological forecasting and informatisation, with new technologies such as the Internet of Things (IoT), Big Data and AI widely applied.

In 2021, China will start research and development of next-generation weather radars and smart ground observation stations, upgrade warning systems for floods, geological disasters and typhoons, and explore customised online meteorological services.

NAVIGATION

Beidou Navigation Satellite System (BDS)

Beidou - New National Standards

On 9 January, China's Standardisation Administration published 4 national, technical BDS standards. This is relevant for ensuring the standardised development and industrial application of the BDS. The new standards cover:

- data format, digital map applications, ground-based augmentation systems, and atomic clocks and include GNSS receiver independent exchange format;
- programming interface specification of middleware for developing navigation electronic map applications;
- technical specification for communication network system of Beidou ground-based augmentation system and
- technical specifications and testing methods for Caesium atomic clock.

Since 2014, 39 BDS-related national standards were introduced.

Beidou requirements documents

On 15 January, the China Satellite Navigation Office published 6 documents detailing the technical requirements and test methods for key civilian products using BDS. The documents have been issued to facilitate the construction of a certification system for key BDS-3 products, according to the BDS Office. Technical requirements and test methods were drafted for chip, integrated chip, antenna, receiver board and navigation module products, as well as other key BDS-3 products that are used in civilian applications.

Link to the official BDS website with the documents in Chinese
http://www.beidou.gov.cn/yw/gfgg/202101/t20210115_21843.html

Beidou satellite health check

Xi'an Satellite Control Centre has completed a health check of 52 in-orbit Beidou satellites ahead of the Spring Festival holiday which started 11 February.

The check was the centre's 1st comprehensive operation management examination of all Beidou satellites since the completion of the global BDS-3 constellation in June 2020. With the help of a self-developed satellite health assessment system, the staff at the centre analysed satellite key data collected between 1 July 2020 and 31 December 2020.

The longest-serving satellite is the GEO-1 satellite of the BDS-2 system, which was launched on 17 January 2010. The customised health examination and diagnosis programmes have prolonged the satellite's 8 years lifetime already by 3 years.

Beidou is prominently receivable

Researchers from the National Space Science Centre in Beijing found that a spacecraft travelling at or below a 2,000 km orbit would be able to see at any given time 50 % more Beidou satellites than those from the Global Positioning System.

Infrastructure Safety Monitoring

Within an international cooperation research project undertaken by the National Time Service Centre (NTSC) of the Chinese Academy of Science in cooperation with the Academy of Sciences of the Republic of Tajikistan, Beidou high-precision positioning and communication technology will be utilised for the monitoring of earthquake-caused deformation of the Sarez Lake Dam. The project was launched on 17 March 2021 in Lintong of Shaanxi Province. The data will provide a scientific reference for dam safety, also applicable in other earthquake prone landscapes. Located in the Pamir region in eastern Tajikistan at an altitude of 3,263 m above sea level, Sarez Lake is a barrier lake formed by the mountain collapse after a strong earthquake in 1911. Another earthquake impact could affect millions of people in the lake area, and cause disaster to the ecological environment of Central Asia.

The research team will build base stations to collect data from the dam area and transmit the preliminary-processing data to the Tajik emergency department via BDS. Timely warning on the dam deformation will be broadcast after multi-source comprehensive analysis of all collected data.

Beidou certification for mobile phones

On 31 March, for the 1st time the BDS Products Inspection and Certification Alliance gave certification to 7 cell-phone models from Oppo, Vivo, Xiaomi and Apple. The certification paves the way for Beidou applications in mass market consumer products. More industry participation can further improve the performance, reliability and safety of Beidou applications.

TECHNOLOGY

Quantum Network

After 2 years of testing, Chinese scientists have established the world's 1st integrated space-to-ground quantum network that realised a ground-to-satellite quantum key distribution (QKD). In

order to reduce the loss of signal, parts of the transmission were moved to space. The test enabled a quantum key distribution between 150 users over a total distance of 4,600 km across China. The method and results were published in Nature:
"In the integrated space-to-ground network, scientists from the USTC combined 700 ground-based optical fibres and two high-speed ground-to-satellite (Micius) links to create a quantum communication network spanning over 4,600 km. The network consists of 4 quantum metropolitan-area networks (QMAN), including Beijing, Jinan, Hefei and Shanghai, a backbone fibre link exceeding 2,000 km, and 2 ground-satellite links that connect Xinglong ground station in Hebei Province and Nanshan ground station in Xinjiang Uygur Autonomous Region, located 2,600 km apart. Xinglong is also connected to the Beijing QMAN via fibre.
The satellite-to-ground QKD achieves an average secret-key rate of 47.8 kilobits per second for a typical satellite pass - more than 40 times higher than achieved previously. Moreover, its channel loss is comparable to that between a geostationary satellite and the ground, making the construction of more versatile and ultralong quantum links via geosynchronous satellites feasible. Finally, by integrating the fibre and free-space QKD links, the QKD network is extended to a remote node more than 2,600 kilometres away, enabling any user in the network to communicate with any other, up to a total distance of 4,600 kilometres."
It represents a major step toward building a practical, large-scale quantum internet. The Chinese scientists have been drafting international standards for relevant technologies with the International Organisation for Standardisation and other groups. In the next 5 years, Chinese scientists hope to develop a long-distance, high-speed quantum communication system, based on domestic hardware that can also be integrated with classical communication technologies. For that it is planned to launch mid- to high-orbit quantum satellites that can work around the clock, providing ultra-secure communication for business operations. The research team also works on the coherent manipulation of more than a few hundred quantum bits for quantum computing. Scientists also need to create new ground-based quantum repeaters that can transmit signals across thousands of kilometres, as well as quantum communication satellites that can provide full-day coverage.

Yu-Ao Chen, Qiang Zhang, Teng-Yun Chen, Wen-Qi Cai, Sheng-Kai Liao, Jun Zhang, Kai Chen, Juan Yin, Ji-Gang Ren, Zhu Chen, Sheng-Long Han, Qing Yu, Ken Liang, Fei Zhou, Xiao Yuan, Mei-Sheng Zhao, Tian-Yin Wang, Xiao Jiang, Liang Zhang, Wei-Yue Liu, Yang Li, Qi Shen, Yuan Cao, Chao-Yang Lu, Rong Shu, Jian-Yu Wang, Li Li, Nai-Le Liu, Feihu Xu, Xiang-Bin Wang, Cheng-Zhi Peng, Jian-Wei Pan, (2021), An integrated space-to-ground quantum communication network over 4,600 kilometres, Nature, 88, DOI: 10.1038/s41586-020-03093-8

Space Objects and Space Debris Monitoring
A civilian-military proposal has been made to build the world's largest system of radars to monitor asteroids and space debris that could threaten humanity but also to monitor satellites and space stations and support missions to the Moon and Mars. China has the technology and resources for such a system. So far, global users rely on the U.S. for such monitoring. When the Arecibo Observatory in Puerto Rico collapsed in December 2020 only the Goldstone Solar System Radar in the Californian desert is available.
The proposed system may involve up to five 35-m diameter radars in Kashgar, Xinjiang, to direct beams into space. The returned signals would be picked up by large antennas across China. The detection range of the system is expected to exceed 0.1 Astronomical Unit - 1/10th of the mean Sun-Earth distance.
The Chinese plan would fit in an existing global advanced warning system. With infrastructure provided by the U.S., the United Nations operates an international asteroid detection network that issues global warnings if an object with a diameter bigger than 50 m and a likelihood greater than 1% in 50 years could hit the Earth. A 2nd and modern warning system could improve the existing infrastructure.

Space Debris
Researchers from the Centre for Advanced Mechanisms and Robotics of Tianjin University have developed a continuum robot that can be used to handle non-operational satellites or space debris. A continuum robot can move by bending through a series of continuous arcs producing motion comparable to tentacles or snakes. The Tianjin University robot is composed of a central backbone made of hyper elastic NiTi alloy (also known as Nitinol – nickel-titanium alloy) and 3D printed constraint disks. The drive rods evenly distributed around the constraint disks can actively control the prototype to curve or passively deform within changing environments. For accessing blind spots, the robot has a camera installed at its end. It also has a grasping claw attached to the head.
The research team has designed a variable stiffness mechanism, powered by a set of embedded shape memory alloy springs, to enhance the robotic arm's load capacity. The team is currently cooperating with a Chinese aerospace research institute to conduct ground testing for the robotic arm and examine its performance in grabbing non-cooperative targets.

Yang C, Geng S, Walker I, Branson DT, Liu J, Dai JS, Kang R, (2020), Geometric constraint-based modeling and analysis of a novel continuum robot with Shape Memory Alloy initiated variable stiffness, The International Journal of Robotics Research, 39, 14, 1620-1634. DOI:10.1177/0278364920913929

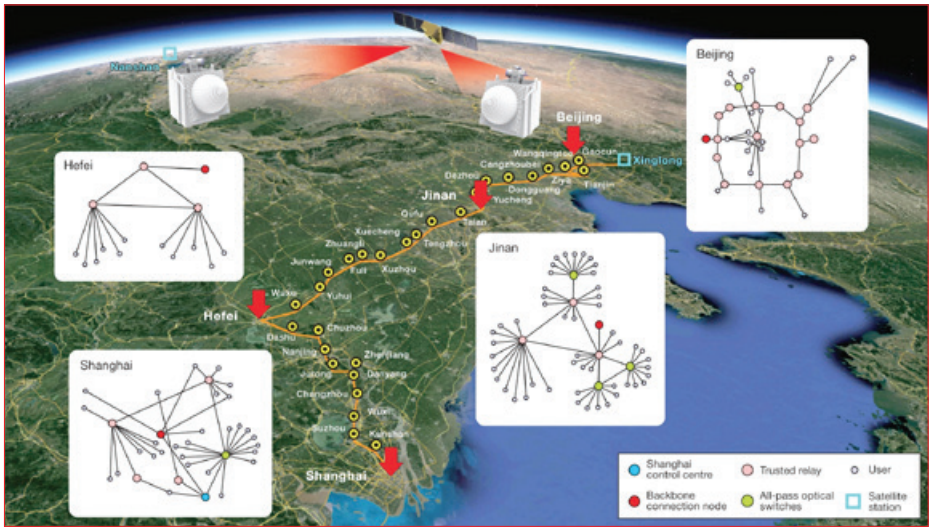
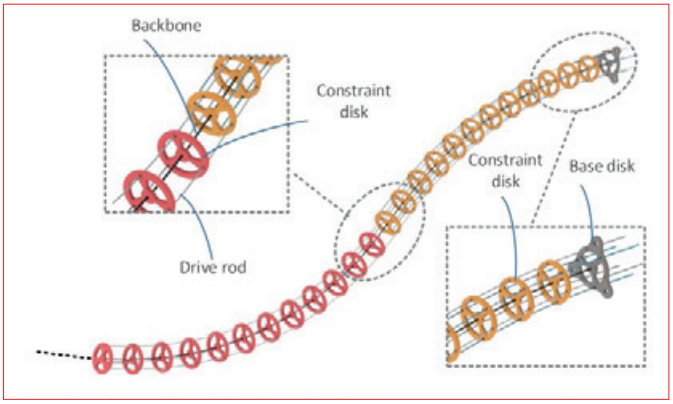


Illustration of the integrated space-to-ground quantum network. The network consists of 4 QMANs (in Beijing, Jinan, Shanghai and Heifei; red arrows), a backbone fibre link over 2,000 km (orange line) and two ground-satellite links that connect Xinglong and Nanshan (blue squares), separated by 2,600 km. There are three types of nodes in the network: user nodes (purple circles), all-pass optical switches (green circles) and trusted relays (pink circles). Each QMAN consists of all three node types (see insets). The backbone is connected by trusted relays (shown as yellow and black circles in the main image and red circles in the insets). A quantum satellite is connected to the Xinglong and Nanshan ground stations; Xinglong is also connected to the Beijing QMAN via fibre. In Beijing, the Beijing control-centre node is located at the same location as the backbone connection node (indicated by the red circle). Map data: Google, Data SIO, NOAA, US Navy, NGA, GEBCO, Landsat/Copernicus; copyright ZENRIN. Credit: Chen, YA., Zhang, Q., Chen, TY. et al. An integrated space-to-ground quantum communication network over 4,600 kilometres. Nature (2021).



Generalised design of a rod-driven continuum robot. Credit: Research Group Tianjin University

APPLICATIONS

Thermoelectric Mobile Phone Charger

Researchers at CALT developed a type of insulated water bottle equipped with a thermoelectric chip that can turn water heat into electricity to charge a mobile phone.

Thermoelectric devices are made from materials that can convert a temperature difference into electricity. The water bottle can provide 20 to 30 min of electricity after 300 to 500 ml of boiling water was poured into it. The device produces low voltage and has no risk of short circuit.

Previous research looked into the option of collecting waste heat which would be otherwise radiated into space and produce electrical energy to back up the battery on the spacecraft.

COMMERCIAL

Beijing goes satellite internet

At the beginning of February, Beijing's administrative leaders discussed at the Municipal People's Congress of Beijing key tasks for the coming years. According to think-tank FutureSpace, the Beijing government put an emphasis on developing the digital economy, promoting high-quality development, and developing services that can be deployed across the Belt-and-Road region. The plans also mentioned 2 specific topics related to satellites: developing a satellite internet industry and accelerating the development of high-end precision sensors for space/aerospace.

CASIC Xingyun

On 18 March, a funding round of 2.632 billion RMB (400 million USD) for CASIC's Xingyun narrowband constellation was announced. The global Xingyun constellation will enable Industrial IoT (IIoT), which is the foundation of the CASICloud suite of Industrial IoT products and services.

The financing was led by several investors, including ICBC Investment, China Merchant's Capital, and Shenzhen Capital Group. Xingyun's operating company, LEOBit Technologies, will continue to develop applications and user terminals for IIoT. Aerospace Xingyun Technology Limited, which leads the project, is developing and manufacturing the Xingyun 3 series with comprehensive enhancement such as increased single-satellite service coverage capability from 320,000 up to 750,000 users per satellite.

China Rocket

On 3 March, China Rocket announced that the Jielong 3 small lift solid-fuelled launch vehicle would make its maiden launch in 2022. Jielong 3 has a payload capacity of 1.5 t to LEO.

Commsat Technology

Commsat Technology Development Co., announced on 3 February that it has received financing from the China Internet Investment Fund (CIIF). This is the 1st time that the CIIF has been involved with a private space business, and it is also the 7th round of financing completed by Commsat. This new round of financing will be mainly used for research and industrialisation of satellites, as well as talent recruitment.

Deep Blue Aerospace

The company completed hot fire tests of the Leiting 5 kerolox engine (for the Nebula M rocket) at different gimballing angles.

ESPI Report 77: New Space in Asia with broad details on China

On 09 February, the European Space Policy Institute in Vienna, Austria published the "ESPI Report: New Space in Asia". The report gives an overview on commercial space activities in China, India, Japan, Malaysia, South Korea and Thailand. China, India and Japan are covered in greater detail, with the 2 chapters about China providing a broad overview on China's space start-ups. The GoTaikonauts! team and its partners, Blaine Curcio of Orbital Gateway Consulting and Jean Deville of The China Aerospace Blog, provided the content for the technical China part: Chapter 3 "Commercial space ecosystem and trends in China".

Link: https://espi.or.at/news/new-espi-report-new-space-in-asia

EXPACE

The 1st of the Wuhan-manufactured Kuaizhou 1A launch vehicles was undergoing final testing in preparation for launch later in the year. The rocket was named "Xinzhou" after Wuhan's Xinzhou district where the new Kuaizhou Rocket Manufacturing Complex is based.

Geely

At the end of January, car manufacturer Geely has officially launched its internet satellite project in Qingdao, East China's Shandong Province, with an investment of 4.12 billion RMB (637 million USD). The facilities for the project are located in the Qingdao Shanghe Demonstration Zone, with an area of 20,474.3 m^2. Already in August 2020, the management committee of the demonstration zone signed a contract with Geely Technology Group on LEO internet satellite cooperation. A subsidiary of Geely, Zhejiang Shikong Daoyu Tech. Co., will be responsible for the project.

On 18 February 2021, the Taizhou satellite factory of Geely Technology Group was given its license by the China National Development and Reform Commission (NDRC) to start with the production of its own satellites. Once the modular and mass manufacturing facilities are fully installed and developed, currently planned for October, the facility will have an estimated production output of over 500 satellites per year.

The in-orbit capabilities, operating via inter-satellite links, are the foundation for Geely's plans for vehicle-to-vehicle (V2V) and vehicle-to-everything (V2X) communications for autonomous driving which requires a positioning accuracy of several cm. Taizhou in Zhejiang is Geely Group's original hometown.

With the introduction of satellite connectivity as a "new infrastructure" in April 2020, Geely Technology Group took this


Artist's impression of the Geely satellite. Credit: Geely


Illustratoin of the Taizhou Satellite Facility. Credit: Geely

opportunity to establish the industrial chain of its own satellite network including R&D, design, manufacturing, launch and market application.

Geely's space headquarters is located in the Nansha district of Guangzhou, in Guangdong Province where also the new rocket production base for CAS Space (Zhongke Aerospace Exploration Technology Co., Ltd). is built. Geely's new subsidiary Shikong Tansuo will coordinate Geespace, Shanghe Aerospace, Xingkong Zhilian and the satellite company SpaceOK. These companies cover satellite manufacturing, ground terminals and satellite operation. There were reports that Geely satellites would launch on CAS Space rockets.

iSpace

• Landing Buffer Test

In January, iSpace successfully completed a landing buffer test of the landing legs for its reusable rocket Hyperbola 2, achieving an important breakthrough in reusable launch technology. Those tests included structural, dynamic and vibration tests, as well as performance under high and low temperatures.

• IPO

The announcement came ahead of a planned IPO on the Science and Technology Innovation Board (STAR Market) in Shanghai, a market established in 2019 to support early-stage tech companies. If the IPO goes through, iSpace will become China's 1st listed commercial space company after it succeeded in 2019 as the 1st Chinese commercial start-up with an orbital launch.

• Launch Failure Investigation concluded

iSpace reported on 1 March the completion of a 28-day long investigation and analysis of the 1 February launch failure of its SQX-1 Y2. The cause was traced back to a piece of insulation foam that fell off and hit the grid fin no. 4 and got stuck by aerodynamic pressure, consequently blocking the fin. Later in the flight, the foam came free again and the control system commanded the rudder to adjust its angle by more than 30^{O} in a short time. That caused a sudden change in the attitude of the rocket body, which led to the breakup of the launcher.

Jiuzhou Yunjian - JZYJ

Jiuzhou Yunjian announced a round of funding, which was likely the 1st round of funding by a Chinese commercial space company in 2021. The company did not specify the amount of money in the funding round, but mentioned several investors: Zhongguancun Aerospace Startup Development Fund (lead investor), Yunhe Capital, Zhongguancun Development Seed Fund, and Ourui Capital.

Landspace

At the end of January, Landspace successfully tested the payload fairing separation for its ZQ-2 liquid-propellant carrier rocket. The test verified the working performance, separation sequence and the whole separation process. All parameters met the design requirements. With a diameter of 3.35 m and a total length of 8.24 m, the ZQ-2 fairing is the largest one in the Chinese private space sector.

Landspace TQ-12 engines. Credit: Landspace

On 30 January, the Tianque 12 (TQ-12) liquid methane-liquid oxygen engine for the 1st stage of the ZQ-2 rocket completed a 400 s long-duration reliability test run. The engine has undergone 5 consecutive long-duration tests, with a cumulative time of more than 2,000 s, covering 13 times the flight duration. The 30 January test was performed under high and low thrust, high and low mixed ratio, limited inlet pressure and temperature tests, which fully verified the reliability and stability of the engine. Landspace has completed the final assembly of 4 new TQ-12 80 t trust engines for its ZQ-2 launcher, and aims for a ZQ-2 launch still this year.

Launch Site

New Launch Site for commercial launches

Remote sensing imagery by Planet Labs Inc. reveals construction activity near the Jiuquan Satellite Launch Centre. Since a while a new launch complex for commercial launch service providers and to facilitate launch operations for a new methalox-fuelled rocket is under discussion. From Jiuquan, LEO and SSO can be conveniently reached. The initial launch capacity could be 1 launch per month. On 13 March, Science and Technology Daily, the official news-paper of the Ministry of Science & Technology, published a list of mega projects during the 14th Five-Year Plan. Regarding the space sector it mentions:

1) Build an integrated communication, EO, satnav space system with global coverage, and
2) build a commercial launch centre.

Qiansheng Exploration (QS-T)

On 5 March, satellite manufacturer Qiansheng Exploration announced a Series A funding round of more than 100 million RMB, with the funding expected to go towards strengthening the company's satellite manufacturing and geospatial information services capabilities. The round was led by Fuzhou (Jiangxi) High-Tech Emerging Industry Development Fund, which is part of the Fuzhou National High-Tech Industrial Zone.

Rocket Pi

Private space technology start-up Rocket Pi is developing until 2025 an orbital space laboratory for biology research. The bio lab, comparable to an early Tiangong 1 module, could be used for studies of the impact of the space environment on the human body. A bioregenerative life support system onboard its lab would study the feasibility of long-term human stays on the Moon or other extra-terrestrial bodies. Rocket Pi is based in Huzhou, East China's Zhejiang Province.

SpaceTY

• Visitors from Luxembourg at SpaceTY head quarters

Vincent Hieff, Consul General of Luxembourg in Shanghai and the Executive Director at Luxembourg Trade and Investment Office in Shanghai visited during his business trip to Beijing the commercial satellite manufacturer SpaceTY. He was impressed by the company's cutting-edge SAR technology for satellite imagery. SpaceTY plans to launch up to 100 in-house designed and produced satellites in the next 5 years. The company

established its European HQ at the Technoport SA in Luxembourg in 2019.

• HiSea 1 SAR imagery

SpaceTY's HiSea 1 SAR satellite (also: Haisi 1) has taken remote sensing imagery of the MV Ever Given, operated by Evergreen Marine, blocking the Suez Canal in March for 6 days. (*see image to the right*) Haisi 1 was launched in December 2020 and was made in partnership with Chinese SOE CETC.

Various EO companies, including Maxar, Capella Space, Airbus, and Planet Labs, monitored the situation in and around the Suez Canal.

Tianxun IoT satellite constellation

On 21 January, the opening ceremony of the Jinyi Industry-City Integration Zone took place in the subdistrict of Luodian, in the Northern district of Baoshan in Shanghai. At this event, the Tianxun project was initiated. Tianxun is an IoT satellite constellation composed of 72 satellites, completed over the next 3 years. The first test satellite would launch in 2021. It is also planned to establish in the Jinyi Industry Zone an ecosystem combining the space-based IoT with cloud computing, Big Data, as well as the design & product of satellites, ground terminals; aiming at both industry and B2C applications. The target is to reach a revenue of 10 billion RMB within 5 years. 2 important space companies attended the event: Shanghai Institute of Electronic and Communications Equipment and Shanghai Beidou Platform Company.

288 satellite constellation

There were reports about a 288-satellite constellation, financed by a consortium of European and Chinese investors. One of the Chinese investors is Shanghai Alliance Investment Ltd (SAIL). Shanghai Spacecom Satellite Technology Ltd (SSST) will build and operate the satellites. SAIL also holds 42 % of SSST shares.

Data distribution and management will be done by GMS, a Switzerland-based operator. Trion Space, based in Liechtenstein, is supporting the project from Liechtenstein mainly for frequency application with the ITU which was done together with Kleo Connect GmbH Germany. 2 Kleo Connect satellites are already in space securing the frequency allocation.

CAS Space (Beijing Zhongke Aerospace Exploration Technology Co., Ltd.)

On 26 March, CAS Space tested in Shandong Haiyang Dongfang Aerospace Port, a 23 kg vertical launch-vertical landing demonstrator for future reusable launch vehicles.

The prototype of the launch and recovery verification system is 0.45 m long, 0.45 m wide, and 0.6 m heigh. Development costs were given with 300,000 RMB.

Policy – Proposals for the promotion of commercial space

Lei Jun, CEO of Xiaomi and founder of Shunwei Capital, one of the VC funds backing Chinese space start-ups, submitted as a member of the National People's Congress 4 proposals to the 2021 "Two Sessions" to promote Chinese private commercial space:

- Inclusion of satellite internet as a strategic emerging industry for key development in China's "14th Five-Year Plan" and clarifying that satellite internet-related commercial space companies are part and parcel of the national aerospace industry.
- Deepen the reform of the domestic satellite frequency application mechanism, and simplify the management process of China's satellite network data application.
- Increased liberalisation of the space industry, reducing restrictions on private enterprises using commercial satellites to develop commercial services.
- Encouraging funding of private commercial space companies, at a national level (national funds) and local level (local governments, financial institutions). Facilitate access to the Starboard for private commercial space companies.

Lei Jun had proposed these points already in 2020.

INTERNATIONAL

APSCO (Asia-Pacific Space Co-operation Organisation)

• 2nd Expert Group Meeting on the Feasibility Study of APSCO CubeSat Competition Project

The 2nd Expert Group Meeting on the Feasibility Study of the CubeSat Competition Project was held online from 27-29 January by the APSCO Secretariat. 19 delegates from all Member States of APSCO participated in the meeting, including Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand, and Turkey.

• APSCO and PhilSA for space cooperation opportunities

On 08 March, APSCO Secretary-General, Ms. Yu Qi and the Director General of the Philippines Space Agency (PhilSA) Mr. Joel Joseph S. Marciano, took part in an online meeting information on activities and programmes of both organisations

and identified possible areas of cooperation. They exchanged views on a future roadmap for cooperation in disciplines such as: space applications, disaster warning and management, space education and training, satellite data sharing. Both sides also discussed processes for the exchange of experience, knowledge and best practices of selected institutions, jointly organising education/training courses for capacity-building, knowledge sharing and capacity building in the field of space law and policy.

• PDR for APSSO Project

The Preliminary Design Review (PDR) meeting of the Asia-Pacific Space Science Observatories (APSSO) Project took place via teleconference from 8 to 11 March 2021. The team from the project lead CNSA's Space Debris Observation and Data Application Centre (SDOAC) and experts from APSCO Member States participated in the meeting.

They discussed various aspects of the project, including the preparation of the hosting sites, the updated project implementation plan, telescope design and data centre hardware and software design. All Member States agreed on the updated 5-year project implementation plan. After the PDR meeting, SDOAC gave a 2-day technical training to introduce telescope technology and data centre software development.

The Asia-Pacific Space Science Observatories is a network of 8 new observatories in APSCO Member States Iran, Bangladesh, Thailand, China, Mongolia, Pakistan, Peru and Turkey. The observatories not also provide information about satellites, space debris and space objects but also maintain an updated astronomical data base.

• APSCO-NPU Cooperation

An APSCO delegation visited the Northwestern Polytechnical University (NPU) in Xi'an from 22-24 March. The delegation visited the Micro-satellite Research Lab, the NPU museum, the Institute of Culture and Heritage, and the Engineering Simulation and Aerospace Computing Joint Laboratory. NPU and APSCO had in-depth discussions and exchanged ideas on talent training, exploration research and scientific cooperation. Both sides agreed to continue the cooperation framework of "APSCO-NPU Development Base for Aerospace Talent" for developing new training methods, establish the 2-degree education programme, organise competitions in space technology application, etc. The objective is to strengthen the capacity building of APSCO Member States and the “Belt and Road” Aerospace Innovation Alliance (BRAIA) Members in the use of space-related technologies for economic, social and cultural development.

RUSSIA

TASS news agency reported on 25 January that the Head of Roscosmos, Dmitry Rogozin, said via his Telegram account that Roscosmos is continuing talks with China and other international partners on the options for cooperation in a joint Moon base: "We are holding talks with all international partners, first and foremost China, on establishing a Moon research base," Rogozin wrote. He also mentioned that the Russian Moon research programme is set to begin in 2021 and that "We plan to begin a piloted Moon programme in 2028." Earlier, CNSA spokesperson Xu Hongliang stated that China would continue researching the Moon and join efforts with Russia.

Beginning of February, Sergey Savelyev, Deputy Director General for International Cooperation at Roscosmos, told TASS that he is in talks with his Chinese colleagues regarding lunar exploration. "At present, work is under way to determine possible scientific tasks of mutual interest in the Moon research. Besides, possible technical implementation of the project is being analysed," he said. "Until agreements are reached with the Chinese partners and a relevant legal basis for cooperation is created, it will be too early to speak about engaging certain countries or organisations," he added.

All cooperation issues are discussed by Russian and Chinese specialists within the framework of a special working group.

The Government of the Russian Federation published on 11 February an Order of the Government in which Russian Prime Minister Mikhail Mishustin instructed Roscosmos to prepare a MoU with China for cooperation on establishing an International Lunar Scientific Research Station ILRS. Roscosmos’ task was to draft proceedings to harmonise such an MoU between the Government of the Russian Federation and the Government of the People’s Republic of China. The MoU was awaiting official announcement and signature.

The ILRS is a robotic base at the lunar South Pole according to a 2020 presentation to the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space (COPUOS) by CNSA’s Lunar Exploration and Space Engineering Centre. The planned Chang’e 6, -7 and -8 missions and Russia’s Luna 27 would be the first steps in the project. This phase would give China the opportunity to learn from the best in the Russian industry. At a later stage, around 2030 the ILRS will involve long-term robotic and crewed missions with the long-term goal of a permanent human presence at the lunar South Pole after 2040.

Focus on: ITALY
A brief overview on the developments in space cooperation with China

Italian-Chinese efforts for space cooperation can be traced back to March 1998, when an Italy-China cooperation conference took place in Beijing. Main discussion points were Earth observation, space science and telecommunications. This initial contact did not bring results.

On 22 February 2017, ASI (Italian Space Agency) and CMSA signed an agreement on the occasion of the state visit of the Italian President Sergio Mattarella to China from 21-26 February 2017.

The agreement was signed in Beijing in the Great Hall of the People by ASI President Roberto Battiston and CMSA Director General Wang Zhaoyao.

The Presidents of both nations, Sergio Mattarella and Xi Jinping witnessed the signature ceremony.

The agreement foresaw "new scientific experiments aboard the Chinese space station" and was aimed at the "study of long-duration missions of astronauts", in particular to deepen the aspects of "biomedicine, physiology and related technologies".

The cooperation also included the access to scientific data, joint publications, exchange of staff and joint participation in technical reviews in the field of human space flight.

The 2 agencies would set up a Joint Committee for Cooperation that would be responsible for drafting the partnership guidelines.

One year later, on the side lines of Xi Jinping's visit to Rome in March 2018, with Italy's controversial accession to the Silk Road, ASI signed a Memorandum of Understanding (MoU) to build one module of the Chinese Space Station. Thales Alenia Space in Turin would be responsible for manufacturing the hardware. It would be launched any time after 2022.

At that time Samantha Cristoforetti started studying Mandarin.

Again, one year later, on 23 March 2019, an agreement was signed by ASI’s Extraordinary Commissioner, Piero Benvenuti and CNSA’s Deputy Director, Zhang Jianhua. China and Italy committed to the launch of a 2nd satellite for earthquake

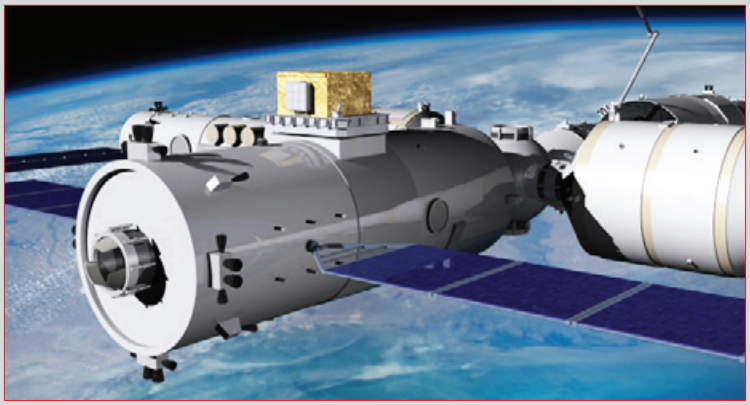
monitoring. The agreement also mentioned the "participation of Italian astronauts in the flight missions on the Chinese space station ".

On 26 November 2019 La Repubblica quoted Italian Research Minister Lorenzo Fioramonti: "We have communicated (to the Chinese government, ed.) that on some particular elements, for example the pressurised modules for space stations, the cooperation that was planned, is suspended." When asked about the reasons he mentions "a more general reflection of the government on the issue of aerospace".

On 13 October 2020, ASI signed the Artemis Accords with NASA.

On 29 December 2020, State Councillor and Foreign Minister Wang Yi met with Italian Foreign Minister Luigi Di Maio via video link. China and Italy celebrated 50 years of diplomatic relations. During the conference call, space industry was a topic in the discussion. Both sides stressed that Italian-Sino space cooperation took off relatively early with relatively concrete ideas and defined steps.

One project which survived the times is the High Energy cosmic-Radiation Detection facility (HERD), a Chinese-Italian cooperation under the lead of China and with contributions from Spain and Switzerland. HERD is a high-energy cosmic ray detector that should be installed around 2025-26 on the CSS. The instrument should have been installed on the envisaged Italian module but will now be relocated to a Chinese module.



The High Energy cosmic-Radiation Detection facility (HERD) mounted on the outside of the Experimental Module 1. It is expected to be installed around 2026.

HERD Project Website: http://herd.ihep.ac.cn/

EDUCATION

IAF-CSA Space Universities CubeSat Challenge (IAF-CSA SUCC)

The International Astronautical Federation (IAF) and its Space University Administrative Committee (SUAC) in cooperation with the Chinese Society of Astronautics and the Dalian University of Technology (DUT) announced a competition for a free launch opportunity of a 3U CubeSat on CALT's Long March or Smart Dragon rocket. The organisers were looking for innovative CubeSats or new ideas or concepts for CubeSats missions.

The topics of the challenge were:

- Innovative CubeSat missions;
- Design of new concepts for CubeSat platforms and innovative subsystems;
- Payload and applications of innovative CubeSats;
- Innovative CubeSat deep-space exploration mission and design (including Moon, Mars, asteroids, etc.);
- Other new concepts or ideas for CubeSats.

The competition was open until 15 June 2021 to all IAF Member Universities.

Shanghai Hongqiao International Airport is one of the busiest transportation hubs in the country. Credit: Yin Liqin/China News Service

MISCELLANEOUS

EXHIBITIONS

Shanghai International Commercial Aerospace Exhibition is taking over the Beijing Airshow

Shanghai will be hosting the 1st Shanghai International Commercial Aerospace Exhibition from 15 to 19 September 2021 at Shanghai Hongqiao International Airport. The exhibition will feature an Aeroengine Forum, a Superalloy Industry Summit, a Commercial Aircraft Conference, a Commercial Aerospace Financial and Technological Symposium and a business-matching workshop for small aerospace enterprises in the Yangtze River Delta. Educational activities for the public will promote aviation and space knowledge. The exhibition will replace the Beijing Airshow and will alternate with the Zhuhai Airshow but will be in direct competition with the Paris Air Show in LeBourget. About 60,000 visitors are expected to attend the 1st edition.

The Shanghai exhibition is about to become a world-class aerospace industry show that can strengthen exchanges and cooperation in the aerospace sector and help Shanghai develop its aviation and space industries. Shanghai's government also wants to boost its efforts to build a top-tier air transport centre. Shanghai is home to the central government's large jetliner programme and Commercial Aircraft Corp of China. It has a solid, comprehensive industrial foundation required for the development of aerospace businesses.

'Fly to Space' Exhibition

On 18 March, a new interactive technological exhibition about China's manned space programme was opened in the China Science and Technology Museum in Beijing. Co-hosted by the China Association for Science and Technology and CMSEO, the 'Fly to Space' exhibition tries to give visitors a spaceflight experience. The exhibition is divided in 6 parts: Journey through Time, Fighting for Dreams, Realizing the Space Dream, Aerospace Homeland, Aerospace Dining, and Future Tunnel. Interactive virtual reality and 3D displays, allow visitors to understand the development of the Chinese human space programme, experience the selection and training of astronauts and learn about the launch of a spacecraft and the work and life in orbit. The exhibition is dedicated to the 100th anniversary of the founding of the Communist Party of China.

SpaceWatchGlobal: Insights into Space law in China
While the space activities of China continue to advance in breadth and depth, less is known about the legal and regulatory framework within the country. It is difficult to find online sources and most texts are only available in Chinese. The article for SpaceWatchGlobal by Jan Helge Mey and Dr. Ingo Baumann tries to shed some light on the current legislative situation, with a special focus on those texts governing the growing commercial space sector.
Link: https://spacewatch.global/2021/02/spacewatchgl-opinion-insights-into-space-law-in-china/

New ESPI Report: New Space in Asia with broad details on China
Chapter 4 - Public policies to support commercial space in China

Link: https://espi.or.at/news/new-espi-report-new-space-in-asia

"Lost Without Translation: Identifying Gaps in U.S. Perceptions of the Chinese Commercial Space Sector"
The Secure World Foundation and Caelus Foundation released the report "Lost Without Translation: Identifying Gaps in U.S. Perceptions of the Chinese Commercial Space Sector". U.S. commercial space actors firmly believe that competition from China will be an inevitable part of their future decision-making. However, beyond this surety, there are significant gaps in understanding of how this competitive relationship will develop. For US stakeholders, it remains unclear who their Chinese competitors will be, what resources they will have, and what rules they will operate under. By comparing common U.S. stakeholder perspectives with discourse and analysis on China's commercial space sector, this paper highlights where more effort is required to better understand these emerging dynamics.
Link: https://swfound.org/news/all-news/2021/02/swf-and-caelus-foundation-release-paper-lost-without-translation-identifying-gaps-in-us-perceptions-of-the-chinese-commercial-space-sector/

Three generations dedicated to China's space programme
A personal story of a family working in the space sector and dedicated to safety and quality assurance.
Link: http://www.chinadaily.com.cn/a/202101/30/WS601491faa31024ad0baa622c.html

Coconuts and Rocket launches
In China's aerospace city, farmers rediscover an ancient art and benefit from space tourism for earning a living at their doorsteps. Before China's space programme put Wenchang on the map, it was known as the "home of coconuts" with a rich culture centered around the tropical fruit, which grows abundantly in the area. At the Honghai Coconut Carving Farmers' Co-op, a small workshop converted from an abandoned farmhouse, local artist Wang Feihai has been leading a group of some 30 villagers to make traditional handicrafts out of coconut wood and shells, known as coconut carvings.

Link: https://news.cgtn.com/news/2021-01-24/In-China-s-aerospace-city-farmers-rediscover-an-ancient-art-XjnAhIPfC8/index.html

10 news stories of scientific and technological progress

On 19 January, the Chinese Academy of Sciences and Chinese Academy of Engineering jointly revealed the Top-10 news stories of scientific and technological progress in China and in the world in 2020. The voting has been done each year for 27 years by academicians of the 2 academies. Among China's 2020 Top-10 scientific and technological news were 2 space topics: the Chang'e 5 mission and the Beidou satellite navigation system.

New CMA Administrator

In January 2021, Zhuang Guotai was appointed as Administrator of China Meteorological Administration (CMA) by the State Council. Mr. Zhuang graduated from the Chengdu Institute of Meteorology with a Bachelor's degree in atmospheric sounding, and from the Peking University with a Master's degree in atmospheric physics. He was Vice Minister of the Ministry of Ecology and Environment before taking office in CMA. Ms. Liu Yaming retired from the post of Administrator of CMA.

Annual consultative meeting on Fengyun satellite programme

On 25 March, the 7th International Consultative Meeting for Fengyun Satellite Development was held online. National and international senior experts contributed their suggestions for long-term and sustainable development prospects of FY satellites to improve service capacities and meet user needs. The National Satellite Meteorological Centre introduced the overall FY satellite strategy and development plan (2021-2035) reviewed and summarised the implementation and operational progress since the last consultation meeting. The experts exchanged views on the concept, design, layout of the future FY programme and its relationship with the WMO space programme, as well as discussing the progress of the WMO data policy.
For 2021 it is planned to launch the polar-orbiting satellite FY-3E and the geostationary satellite FY-4B. CMA is committed to data sharing with international users and make greater contributions to global and regional disaster mitigation.
In 2014, CMA established the mechanism of international consultative meeting for FY satellite development.

On a sidenote – U.S.-China space cooperation

The 1st high-level U.S.-China meeting of the Biden administration on 18 March 2021 in Anchorage, Alaska, was attended by Secretary of State Antony Blinken, National Security Adviser Jake Sullivan, Chinese Director of the Office of the Central Commission for Foreign Affairs Yang Jiechi and Foreign Minister Wang Yi.
In his opening remarks, National Security Adviser Jake Sullivan, pointed out that the recent landing of the Perseverance rover on Mars was an example of a successful cooperation with another space agency.
Yang Jiechi, surprisingly referred to this comment by saying: "While the United States has talked about its cooperation to land on some other planet with the European side, well, China would welcome it if there is a will to carry out similar cooperation from the United States with us."
A Bloomberg opinion piece on 25 March responded to this episode by expressing: "As a start, the U.S. should at least respond positively to China's overture. First steps can be modest ones, including data sharing and cooperation on climate initiatives. As trust grows, more ambitious missions could be explored, perhaps including China's wish to be a part of America's advanced Martian exploration program."

Focus on Frontier Technologies

China is looking to boost research into what it calls "frontier technology". In its 14th 5-year Development Plan, the government declares that "science and technology self-reliance and self-improvement is a strategic pillar for national development". Premier Li Keqiang said on 5 March that China would increase between 2021 and 2025 research and development spending by more than 7% per year, in pursuit of "major breakthroughs" in technology development. The 7 frontier technologies are:

1) Artificial intelligence (AI).
2) Quantum information.
3) Integrated circuits or semiconductors.
4) Neuroscience.
5) Genomics and biotechnology.
6) Clinical medicine and health.
7) Deep-space, deep-Earth, deep-sea and polar research.

For China, space is both substance and symbol
In an op-ed piece for SpaceNews, Dean Cheng of the Washington-based The Heritage Foundation, analyses what drives China's space programme. His emphasis is on the two major aspects: substance in technology and hardware development which supports and at the same time is interlaced with symbolism. Taking it from there, he shows what are the implications of that for U.S. efforts in space and which lessons the U.S. could learn from the Chinese approach.
Link: https://spacenews.com/op-ed-for-china-space-is-both-substance-and-symbol/

CNSA YouTube channel
CNSA's YouTube channel offers a broad collection of videos.
Link: https://www.youtube.com/playlist?list=PLpGTA7wMEDFjz0Zx93ifOsi92FwylSAS3

The Xisha Satellite Ground Station, on the Xisha Islands southeast of Hainan Island. (16°27'04.2"N, 111°42'49.7"E) Credit: Beidou Office

Niutoushan Satellite Ground Station. About 7 km away from the Xichang launch site is the almost 1,800 m high Niutou Mountain. Its resemblance of a cow head lead to the name. On the hilltop is the Niutoushan Observation Station, the highest and most remote point of the centre. It is the 1st measurement and control point after a rocket launch from Xichang. Credit: Beidou Office

Tongguling Satellite Ground Station on Hainan Island. Northeast from the Wenchang launch site, on the other side of the bay, is the Tongguling Satellite Ground Station on Hainan Island. It is the ground station to catch the rocket signals after launch. (19.64° N, 111.03° E) Credit: Beidou Office

The US and China Must Cooperate in Space

Anne-Marie Slaughter and Emily Lawrence argue in a commentary for Project Syndicate that space cooperation between the U.S. and China should be an aim of the new U.S. government. By focussing on common interests and norms for commercial activities in space, "both countries, along with the rest of the world, would benefit from a set of clear rules governing the exploration and commercialisation of space." This would help before "unregulated commercial activity could cause a host of problems, from orbital pollution that jeopardises spacecraft to biological contamination of scientifically valuable sites."

Link: https://www.project-syndicate.org/commentary/america-china-cooperation-on-commercial-space-activity-by-anne-marie-slaughter-and-emily-lawrence-2021-0

Ralf Hupertz *and* ***Arno Fellenberg*** *kindly contributed information to the section Chinese Space Launches. Other sources of information are:*

http://news.xinhuanet.com
http://www.xinhuanet.com/english/list/china-science.htm
https://www.nasaspaceflight.com
http://www.spaceflightinsider.com
https://spaceflightnow.com
http://www.planet4589.org/space/jsr/jsr.html
http://www.spaceflightfans.cn/
https://dongfanghour.com/

AALPT	Aerospace Liquid Propulsion Technology
AIR	Aerospace Information Research Institute
AIS	Automatic Identification System
AIT	Assembly, Integration & Test
AO	Announcement of Opportunity
APSCO	Asia-Pacific Space Cooperation Organisation
ASAN	Advanced Small Analyzer for Neutrals
ASI	Italian Space Agency
BACC	Beijing Aerospace Control Centre
BDS	BeiDou satellite navigation System
BIT	Beijing Institute of Technology
BJT	Beijing Time
BNU	Beijing Normal University
BRI	Belt-and-Road Initiative
CALT	China Academy of Launch Vehicle Technology, 1st Academy of China Aerospace Science and Technology Corporation CASC
CAS	Chinese Academy of Sciences
CASC	China Aerospace Science and Technology Corporation
CASIC	China Aerospace Science and Industry Corporation
CAST	China Academy of Space Technology
CCTV	China Central Television
CE	Chang'e
CGTN	China Global Television Network
CGWIC	China Great Wall Industry Corporation
CLEP	China's Lunar Exploration Programme
CMA	China Meteorological Administration
CMSA	China Manned Space Agency
CMSEO	China Manned Space Engineering Office
CNES	Centre National d'Études Spatiales
CNSA	China National Space Administration
COPUOS	Committee on the Peaceful Uses of Outer Space

CSES	China Seismo-Electromagnetic Satellite
CSS	Chinese Space Station/China Space Station
CSU	Technology and Engineering Centre for Space Utilisation
CZ	Changzheng, Long March
DFH	Dong Fang Hong
EO	Earth Observation
EVA	extravehicular activity
FAST	Five-hundred Metre Aperture Spherical Radio Telescope
FY	Fengyun
GEO	Geostationary Orbit
GF	Gaofen
GNSS	Global Navigation Satellite System
GRAS	Ground Research Application System
GTO	Geostationary Transfer Orbit
HY	Hongyun
HY	Haiyang
HXMT	Hard X-ray Modulation Telescope
IAU	International Astronomical Union
ICG	International Committee on Global Navigation Satellite Systems
IIoT	Industrial Internet of Things
IoT	Internet of Things
ICAO	International Civil Aviation Organisation
ILRS	International Lunar Research Station
LEO	low Earth orbit
LEOP	launch and early orbit phase
LOX	liquid oxygen
LRO	Lunar Reconnaissance Orbiter
MEO	medium Earth orbit
NDRC	National Development and Reform Commission

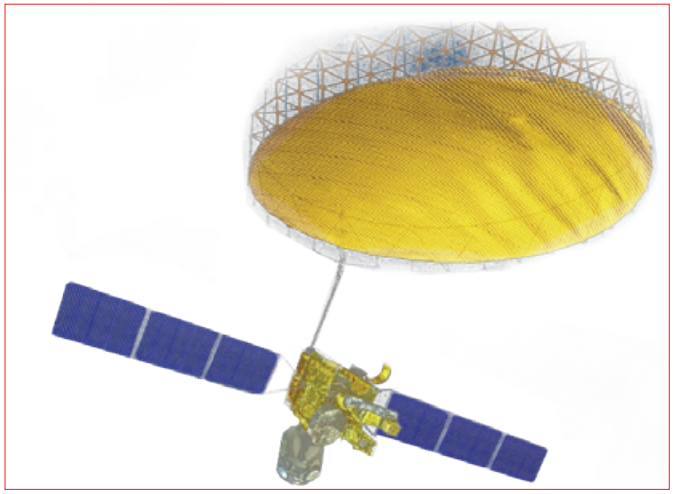
NSSC	National Space Science Center
P/L	payload
PNT	Positioning Navigation and Timing
QUESS	Quantum Experiments at Space Scale
RLV	reusable launch vehicle
Roscosmos	Russia's State Space Corporation
SAR	Synthetic-Aperture Radar
SAST	Shanghai Academy of Spaceflight Technology
SBSP	Space Based Solar Power
SCO	Space Climate Observatory
SCO	Shanghai Cooperation Organization
SQX	Hyperbola
SSC	Sweden Space Corporation
SSEC	Space Science and Engineering Centre
SSO	Sun-Synchronous Orbit
SVOM	Space Variable Objects Monitor
SZ	Shenzhou
TW	Tianwen
TQ	Tianque
TT&C	Space Telemetry, Tracking and Command Station
UAV	unmanned aerial vehicle
UN	United Nations
UNOOSA	UN Office for Outer Space Affairs
UTC	Coordinated Universal Time
VLBI	Very Long Baseline Interferometry
VTVL	vertical takeoff, vertical landing
WMO	World Meteorological Organisation
YT	Yutu
YW	Yuanwang
ZQ	Zhuque
ZY	Ziyuan

LAUNCHES

2021-003A
19 January 2021 - 16:25 UTC (20 January 2021, 00:25 BJT)

launch site: Xichang Satellite Launch Centre (XSLC), LC 2
launcher: Chang Zheng 3B/G3 - CZ-3B/G3
payload: Tiantong 1-03 (TT 1-03)

China's 1st space launch of 2021 placed the Tiantong 1-03 successfully into GTO (geotransfer orbit) from where it moved to its final position in GEO over the following weeks. The 5.4 t satellite is based on CAST's DFH-4 bus. It is a box shaped space craft with 2 solar cells and a very big, foldable parabolic antenna. The satellite's designed life is at least 12 years. TT 1-03's S-band transponder will provide multi-media services, such as voice, short message and data for users in China and its surrounding areas, the Middle East, Africa, as well as most sea areas in the Pacific Ocean and Indian Ocean. The design team at CAST said that they are going to achieve global coverage in the future and explore integration possibilities with 5G technology. TT 1-03 is China's 3rd S-band mobile telecommunications satellite, complementing the Tiantong system, which is part of the national space-based information infrastructure. The Tiantong system consists of a space segment with 3 Tiantong satellites, a ground segment, and about 300,000 user terminals.



Artist's impression of the Tiantong 1-03. Credit: CAST

2021-007A
2021-007B
2021-007C
29 January 2021 - 04:47 UTC (12:47 BJT)

launch site: Jiuquan Satellite Launch Centre (JSLC), LC 603
launcher: Chang Zheng 4C - CZ-4C
payloads: Yaogan 31-02-1
Yaogan 31-02-2
Yaogan 31-02-3

Assembly of the CZ-4C stages for the Yaogan-31-02 launch. Credit: CASC

The 2nd group of 3 Yaogan 31 remote sensing satellites was sent into space and entered their planned orbits in 1,100 km height, inclined by 63.4°. Developed by CAST, the satellites are tasked with scientific experiments, electromagnetic environment surveys and land and marine resources investigation. CCTV reported that due to low temperatures at the launch site, ground staff had to wrap the exposed rocket sections with blankets to keep the hypergolic fuel at a safe temperature.
After launch, the U.S. military catalogued 6 objects in orbit. One of them is the upper stage, and 3 are the satellites. It was not immediately clear if the 2 additional objects were smaller satellites launched on the same mission, or space debris.

2021-F01
1 February 2021, 08:15 UTC, (16:15 BJT)

launch site: Jiuquan Satellite Launch Centre (JSLC), mobile platform
launcher: Hyperbola 1 (Shian Quxian 1, SQ-1)
payload: Fangzhou 2 (Ark 2)

Art and Rocket. The outer hull of the SQ-1 rocket was painted with an art work by artist Xu Bing. The project "Book of Heaven" ("Tianshu") was a cooperation between iSpace and a culture media company from Beijing.

Although iSpace (Interstellar Glory Space Tech) wrote Chinese space history with the successful 1st private rocket launch on 25 July 2019, its 2nd launch of the Shang Quxian 1 (Hyperbola 1) rocket failed. It was the 1st launch failure of the year globally and the 3rd of a Chinese private company since the beginning of commercial space flight in China.
The SQ-1 rocket had an enlarged diameter of 1.4 m compared to the 1.2 m of the 1st one back in 2019. On board was the small cubesat-sized Fangzhou 2 (Ark 2) satellite. iSpace reported short after launch via its WeChat account that the flight failed and the specific reasons were being further analysed and investigated.
Already 1 month later the failure investigation was concluded. A piece of thermal insulation foam broke off and got stuck in one of the 4 grid fins. Later during the ascent, the foam came free again and the control system commanded the rudder to adjust its angle by more than 30 degrees. That happened too quickly, destabilising the rocket, causing the breakup and explosion of the launcher. (Compare section: TRANSPORTATION) The Hyperbola 1 rocket is composed of 3 solid fuel propelled stages and a 4th liquid-propellant stage. The rocket is 20.8 m tall and has a take-off mass of approx. 31 t.

2021-010A
4 February 2021 - 15:36 UTC (23:36 BJT)

launch site: Xichang Satellite Launch Centre (XSLC), LC3
launcher: Chang Zheng-3B/G2 - CZ-3B (G3?)
payload: Tongxin Jishu Shiyan 6 (TJS-6, TJSW-6)

The new communication technology experiment satellite TJSW-6 was launched from Xichang and reached within one hour

after launch geosynchronous transfer orbit. By 19 February the satellite arrived at its final position in GEO at 178.5°E. By March it came as close as 60 km to TJS 5 (2020-002A).
The 6-sided satellite with 2 solar panels, is based on the SAST 5000 platform. There were reports that it is equipped with 2 infra-red telescopes. It will be used in communication, radio, television and data transmission, as well as technology tests.

Sub-Orbital Launch
5 February 2021 - 09:05 UTC (17:05 BJT)

launch site: from a truck-mounted mobile platform, positioned in a location in the northwest of China
launcher: Chongqing Liangjiang Star - OS-X6B
payload: sub-orbital test flight

OneSpace launched its new sub-orbital rocket from a not identified location in the northwest of China. After a 580 s long ascent, it reached a maximum altitude of about 300 km where a test payload was released. The launch served for the verification of a number of key technologies for the Aviation Industry Corporation of China (AVIC) and obtained a large amount of flight and environment data. A new flight method was tested, launching payloads along a trajectory with a small inclination, which offers highly effective and low-cost solutions.
The OneSpace OS-X series was purposely developed for technology verification. Some rocket structures were 3D printed. The OS-X6B rocket adopts on-board launch monitoring technology. Its flight was controlled via a tablet device, supported by independent mobile ground-stations and drones for telemetry. The actual flight status was visualised with an animation, fed by transmitted data on trajectory and attitude. Commands to the rocket were sent through ground-based wireless communication links. At the same time, the upper stage was steered by an attitude control algorithm, which allowed for swift adjustment in the case of engine failure to maintain stable flight.


The OS-X6B sub-orbital rocket Chongqing Liangjiang Star, in launch configuration at the launch site on 5 February, short before sub-orbital launch at 17:05:05 BJT. Credit: OneSpace/Chinadaily.com.cn

2021-014A
2021-014B
2021-014C
24 February 2021 - 02:22 UTC (10:22 BJT)

launch site: Jiuquan Satellite Launch Centre (JSLC), LC 603, LP 94
launcher: Chang Zheng 4C, CZ-4C
payloads: Yaogan 31-03-01
Yaogan 31-03-02
Yaogan 31-03-03

The 3rd group of Yaogan 31 remote sensing satellites was sent into space. CASC announced launch success within 2 hours after lift-off. Having entered their planned orbits, the satellites will be used for electromagnetic environment surveys and other related technology tests. The satellites were developed by Dongfanghong Satellite Co., Ltd. The 1st group of Yaogan 31 satellites was launched on 10 April 2018 and the 2nd on 29/28 January this year.

2021-019A
11 March 2021 - 17:51 UTC (12 March 2021, 01:51 BJT)

launch site: Wenchang Space Launch Centre (WSLC), LC-201
launcher: Chang Zheng 7A - CZ-7A
payload: Shiyan 9 (SY-9, Xinjishu Yanzheng-6-02)

Following a launch failure on the 1st CZ-7A in March 2020, the 2nd launch of the CZ-7A was a success. This time, all went smoothly. The SY-9, an experimental payload for technology verification, was placed in geotransfer orbit (GTO). The DFH-4-based satellite, built by CAST will be mainly used for in-orbit verification tests of new technologies such as space environmental monitoring. It has a life time of 7 years. Its mass was estimated to be 5 t.
The new-generation CZ-7A rocket, fuelled by liquid oxygen and kerosene, was designed by CALT to replace the older hypergolic-fueled launchers. It is planned to reuse the boosters several times. The 3-staged A-variant, combining features of both the CZ-7 and 3A launchers, is 60.1 m tall and has a take-off weight of 573 t. The core stage is 3.35 m in diameter and the 4 side boosters have a diameter of 2.25 m. It is equipped with a re-ignitable 3rd stage. Researchers have also developed a smarter guidance system which plans an optimal path based on real-time information, such as position and speed. Another innovation is the non-separation of boosters which reduces the complexity of the separation system and improves the reliability and economy of the rocket. The rocket will fill the gap in launch capacity to GTO for 5.5 to 7 t payloads. It is also suitable for polar orbits and lunar-transfer orbits. CALT is busy with developing a bigger nose cone for deep-space missions. According to the launch manifest, the CZ-7A is booked until 2025, with 3 to 5 annual launches.

2021-020A
2021-020B
2021-020C
13 March 2021 - 02:19 UTC (10:19 BJT)

launch site: Jiuquan Satellite Launch Centre (JSLC), LC 43, LP 94
launcher: Chang Zheng 4C - CZ-4C
payloads: Yaogan 31-04-01
Yaogan 31-04-02
Yaogan 31-04-03

The 4th group of three Yaogan 31 remote sensing satellites entered their planned orbits. The triplet is similar to the Yaogan-31 group 01, group 02, and group 03. The satellites will be used for electromagnetic environment surveys and other related technology tests. Like for the launches of the other clusters, there was limited information available.

2021-026A
30 March 2021 - 22:45 UTC (31 March 2021, 06:45 BJT)

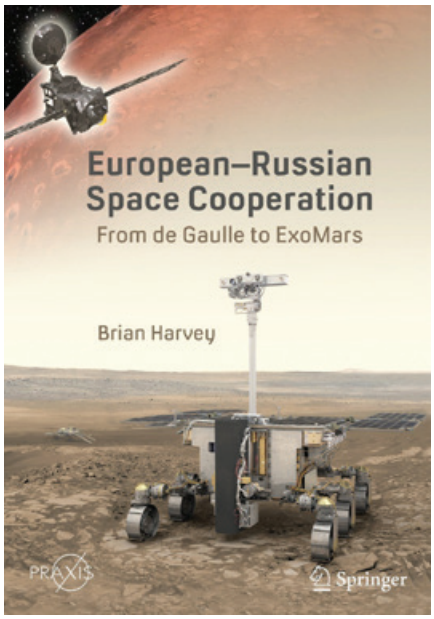
launch site: Jiuquan Satellite Launch Centre (JSLC), LC-94
launcher: Chang Zheng 4C - CZ-4C
payload: Gaofen 12-02

The new Earth observation satellite, Gaofen 12-02, was launched aboard a CZ-4C rocket and entered its planned 630 km SSO successfully.
The SAST-built satellite with an estimated mass of 3.1 t, will be used in land surveys, urban planning, road network design and crop yield estimation, as well as disaster relief.

Mission logo. Credit: SAST

"European-Russian Space Cooperation - From de Gaulle to ExoMars"

a book review - by Jacqueline Myrrhe and interview with the author Brian Harvey



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Part of the book sub series: Space Exploration (SPACEE)
406 pages

6 chapters (Early days/ Scientific cooperation/Human spaceflight/Industrial cooperation/ExoMars/Conclusions) with extensive annexes of lists of acronyms and abbreviations, a timeline of milestone events, a list of heads of governments and space agencies, a bibliography and a very useful index.

It might not often happen that an up-to-date account turns overnight into an historical and archival one. It did happen to the book "European-Russian Space Cooperation - From de Gaulle to ExoMars" by Brian Harvey. The status change was caused by the events since February when space cooperation with Russia was suspended by the European Space Agency and most European national space agencies. On the day of writing this review, 12 July 2022, ESA Member States had their final word: cooperation with Russia on the ExoMars mission is terminated. This serious result was announced by the blink of a tweet on Twitter... Only the letter, sent on 17 March 2022 by ESA Director General Josef Aschbacher to Director General of Roscosmos, Dmitry Rogozin, was worse.

But despite this bitter turn of European decision makers, the book remains a contemporary testimony of decades of successful cooperation and win-win achievements.

First and foremost, the book is solid journalism: well researched information and first-hand accounts through numerous interviews of key persons involved in cooperation projects. Thanks to this book, many interesting and anecdotical stories are now available to the interested reader and cannot be forgotten anymore. Brian Harvey's special expertise is his capabil-ity to put things into wider context and see the historical dimension of what is happening or has happened. That gives a vivid and complete picture of the many years and many projects of space cooperation between Europe and Russia.

Of high value are the conclusions at the end of the book. They are summarising the achievements as well as the lessons learnt. This is why this book is also a highly recommendable read for persons interested in the Chinese space programme. On the one hand, Europe can and should learn from its experience in cooperation with Russia to pave the way for closer cooperation with China in the future. Many stories in the book from the early days of space cooperation reassemble numerous aspects and problems Europe is facing when trying to set-up cooperation relations with China. On the other hand, Europe might not avoid to get into gear again with Russia. China has decided to settle on the Moon together with Russia. This cooperation is up for more and might also become an imperative for other nations to join, in particular for the experienced space powers. The book – for the moment – ended with the Exo-Mars project. The cooperation on that has ended and it seems that the book has not an open but rather a definite end. But it might well be that the book can serve as a “handbook” or “manual” for the time when Russian partners are wanted again. And then it could serve “dual use” to help Europe in its interaction with China.

" ... 'it’s easy to stop things, but a hundred times harder to built things up again' ..."

interview with the author Brian Harvey

What was the motivation for you to write this book?
The idea was suggested by Clive Horwood, the publisher, so he deserves the credit. Cooperation between Europe and Russia (since 1966) had a long history but no one had ever written about it systematically or comprehensively before. Some studies had been undertaken of American-Russian cooperation (for example the Apollo-Soyuz Test Project) and there was some literature about France-Russia, but much less about the other countries. The idea was not just the story of cooperation, but how it worked, the gains on each side, outcomes, difficulties, personalities, why some countries more than others and the politics involved.

Is the book still relevant? Or is it even more relevant than ever?
At one level, you could say that since European-Russian cooperation has ended, it is no longer relevant. That’s not my view. Europe and Russia cannot wall themselves off from one another forever and the lessons from the cooperation experience can be applied once more. There were considerable benefits to both sides, in different ways and there will be so again.

You are a profound expert on the Chinese space programme. Are there any conclusions to be drawn or lessons learned for the space cooperation with China in general and for European-Chinese space cooperation in particular?
Cooperation between Europe and China is much less well developed. Although there have been joint projects (e.g. Tan Ce, earthquake satellite, Simbox, SVOM, CFOS) they are isolated and not an organic, systematic programme of cooperation with joint learning. By contrast, the France-Russia programme was highly structured from 1966 onward and there were formal Russia-Germany and Russia-ESA agreements/structures on a rolling basis. That could still be the case between China and Europe, especially with China’s expanding, ambitious space science programme. China has repeatedly stressed its willingness to engage in more cooperation, so the problem is not on that side. The American isolation of China from 1949, renewed in 1999, has not helped and has acted as a disincentive to European cooperation with China (Beidou/Galileo was a case in point). There is a danger that the Artemis accords (France signed recently) will further inhibit European cooperation with China.

What is your estimation: will European space cooperation with Russia have a future?
For the future, it will indeed be difficult to reconstruct the pre-2022 cooperation between Europe and Russia. If so, it will probably not be around any of the present projects that have been abandoned (ExoMars, ISS, Luna 25, 26, 27, Spektr etc) but others which have not even been conceptualized, probably not till the 2030s. The ball is in Europe’s court. Russia endured 20 years of isolation from Europe over the 1920s and 1930s, during which it made significant scientific achievements (e.g. aviation, stratospheric balloons, arctic exploration, Earth sciences) on its own, so it’s a mistake to assume that Russia cannot manage or progress on its own. A colleague once pointed out that ‘it’s easy to stop things, but a hundred times harder to built things up again’. It’s up to Europe to decide when cooperation will resume, how and in what way.

Xi'an and Shaanxi - Space Aspirations in the Home of the *Terra Cotta*

by Blaine Curcio (Orbital Gateway Consulting)

Central China's Shaanxi Province, and its capital, Xi'an, are famous for many things. Foremost, as one of the four historical capitals of China (中国四大古都, along with Beijing, Nanjing, and Luoyang) Xi'an is one of China's most historical cities, home to an amazing city wall, historical bell towers, and the Terracotta Warriors. The city was also an important hub for the old Silk Road, and has been home to international traders for centuries. Shaanxi Province is also the birthplace of President Xi Jinping's father, and the home of Mount Hua (华山), one of China's most famous mountains.

In more recent years, Xi'an and Shaanxi have played an important role in the development of China under the Chinese Communist Party. The province is home to Yan'an, made famous as one of the birthplaces of the Chinese Communist revolution, with the Party locating there during the 1930s and consolidating a base of power around the region. The past several decades have seen rapid economic growth, with Xi'an as the main commercial center of Western China, and an important node along China's modern-day Silk Road equivalent, the Belt-and-Road Initiative. While still a middle-of-the-table province in terms of metrics like GDP per capita and Human Development index, Shaanxi and Xi'an are moving in a positive direction in these metrics, unlike other middle-of-the-table places we have discussed in previous articles (most notably China's Northeast/Dongbei region of Heilongjiang, Jilin, and Liaoning).

Map of Chang'an During Tang Dynasty, ~600-800 AD. Source https://commons.wikimedia.org/wiki/File:Chang%27an_of_Tang.jpg

Historically, Xi'an has also been a major space industry city, with two pillars of the industry. **First**, Xi'an is the center for China's national Telemetry, Tracking, and Control (TT&C) network, and satcom industry upstream companies more generally. **Second**, Xi'an is known as the "hometown of Chinese aerospace propulsion" (中国航天动力之乡), with this having led to multiple CASC academies in and around Xi'an. In more recent years, Xi'an has attracted a variety of new space companies, attracted to the city's space heritage, local government coordination and support, as well as lower cost of living.

As a "second-tier" city, Xi'an offers benefits for space companies, namely lower cost of living for employees, while at the same time being home to several excellent universities that provide a talent pipeline for such space companies. Having visited Xi'an once, and having enjoyed writing partial travelogues/partial analysis pieces on Wuhan and Harbin in this very publication last year, let us dive into my personal perspectives on the story of Xi'an and Shaanxi's space sector.

The Peaceful Land West of the Shaan Pass

The area now known as Shaanxi Province is one of the most historical parts of China. Xi'an became one of the major centers of China around the beginning of the Zhou Dynasty, in the 11th century BC. Built on a flood plain near the Yellow River, Xi'an was originally built using a grid layout for urban planning, a feature of the city that can still be seen today. The location near a large flood plain and large river allowed for significant agricultural activity, which contributed to Xi'an's population growth and emergence as a major city.

In an early indication of its role as a center of culture and international trade, Xi'an (then Chang'an) played host to several dozen Japanese Buddhist scholars in the early 6th century AD. The Japanese scholars eventually returned to Japan, and the impact of their learnings in Xi'an can be seen to this day. When the Japanese Emperor Kammu moved Japan's capital to Kyoto in 794 AD, the city was essentially built from scratch, with many elements of Xi'an reflected in the city planning. According to Sinologist/Japanologist Ezra Vogel's book China and Japan, "even today Kyoto retains the same basic grid structure that was introduced in 794, based on what the city planners had learned from Chang'an".

The city has also historically been a center of Islam in China, with a large population of Hui People (ethnic Chinese Muslims), including a bustling "Hui Street", or 回民街, one of this correspondent's most favorite areas of Xi'an. This international influence has, to a certain extent, remained in the city even after China experienced periods of being closed from the outside world. While still an unmistakably Han Chinese-dominant city, Xi'an retains an international and in some ways more open-minded vibe than other major cities in China.

Over the centuries Xi'an has remained an important city, and during the Communist Party era, has become a major focus of development as one of the economic centers of Western China. The entire province of Shaanxi is located in a strategically important part of China, namely close to its geographic heart, which has made it a natural home for sectors that China would prefer to be well-defended in the case of military conflict.

This location element has contributed to the development of a space sector in Xi'an and Shaanxi more generally, with the sector based on two main pillars, the aforementioned TT&C/communications, and launch, which are being joined by several new space clusters.

Shaanxi's TT&C Activities

Shaanxi's strategic location made it an early center for China's space sector, originally through the presence of the China Satellite Launch Tracking and Control (CLTC, the country's national TT&C center), and the CASC Academy of Space Information Systems (aka CAST Xi'an, or the 504th Institute of CASC).

CLTC's presence in Xi'an has shaped the city's space sector for many years, and has played an important role in the international expansion of China's space activities. The origins of CLTC were the Satellite Ground Tracking Department, founded in Weinan, Shaanxi Province, in 1968. The Department was instrumental in providing TT&C for China's early space missions, including Dongfanghong-1, launched in 1970.

The CLTC moved its headquarters to Xi'an in 1988, and over the first several decades of the Chinese space program, built out a nationwide network of other ground stations. In more recent years, the organization also acts as an overseas representative of the Chinese space sector in the area of ground segments, including building stations in Chile and Argentina. While China's space industry is likely to continue expanding globally for some time, we should remember that the beating heart of its TT&C network is headquartered in relatively modest Xi'an.

The other major element of the TT&C/general communications element of the Xi'an space industry is the presence of CASC subsidiary CAST Xi'an. CAST Xi'an was founded in 1965 as the 504th Institute of the CASC 5th Academy. The company had around 2,600 employees and annual turnover of RMB 6 billion as of 2019, making it a medium-sized subsidiary of Chinese space industry giant CASC. With focus on satellite communication payloads and subsystems level components, CAST Xi'an is considered one of China's most advanced manufacturers of active and passive antenna products, SSPAs, and TWTAs.

CAST Xi'an has also contributed to the payloads of many of China's communication satellites, and refers to itself as the "main force in the construction of China's navigation system" ("是我国卫星导航系统建设的主力军"). Such a title is made more possible by the fact that Xi'an is also home to the National Time Service Center of the Chinese Academy of Sciences, which maintains the precision timing on China's BeiDou satnav constellation.

Xi'an has a long history in helping to create and maintain communications between China's space assets and Earth. The other major part of Xi'an's space history involves getting China's space assets from Earth up into space in the first place.

The Hometown of Chinese Space Power

The other traditional pillar of Shaanxi's space sector is the rocket industry, with the city and province having a reputation as the Hometown of Chinese Space Power (中国航天动力之乡). Arguably the most famous rocket-related company in Shaanxi is the Xi'an Propulsion Institute (西安航天动力研究所).

It is under the 6th Academy of CASC (or Academy of Aerospace Propulsion Technology, AAPT, 航天推进技术研究院) . It is also called the Institute 101 of AAPT. The Xi'an Propulsion Institute is focused on developing liquid engines for rockets, including engines for the Long March-5/5B, and the upper stage for all Chinese rockets. The Institute is the most advanced liquid-powered rocket engine entity in China. Meanwhile AAPT has also testing and manufacture bases in Xi'an.

The Institute has more than 1,500 employees, of which 1,000 are R&D employees focused on many technologies related to launch, including thermal engineering, valves, and sealing products – all critical to develop liquid-powered rockets. Indeed, the quality of research at Xi'an Aerospace Propulsion Institute is so high, that it has created some interesting and sometime controversial scenarios as Chinese commercial space companies start to hire top talent. In 2018, Zhang Xiaoping left his role from the Institute to join Landspace, for a salary that was rumored to be several times the salary at the Institute. The move created controversy, but was eventually allowed to happen, creating a watershed moment of sorts for China's commercial space sector, while encouraging state-owned firms to increase their competitiveness as employers. On the whole, it is clear that Xi'an Aerospace Propulsion Institute forms the heart of the "Hometown of Chinese Space Propulsion", though it is far from the only example.

Shaanxi province is also home to Shaanxi Zhongtian Rocket, a CALT subsidiary that focuses on solid rocket technology, sounding rockets, and anti-hail rockets, among other things. Founded in 2002 as the merger of several existing CALT production facilities, Shaanxi Zhongtian has grown to become one of China's leading companies in the field of solid rocket technology.

Zhongtian also made headlines in late 2020 when it conducted an IPO and subsequently saw its share price rise by the daily limit of 10% for 16 (sixteen!) straight days, with its share price increasing from an IPO price of RMB 18.6/share to as high as RMB 94 per share at one point (it sits at around RMB 55 per share as of 7 March 2021). With revenues in 2019 of RMB ~800M, the company is around 1/8 the size of CAST Xi'an in revenue terms, making it an important but not massive player in the local space sector.

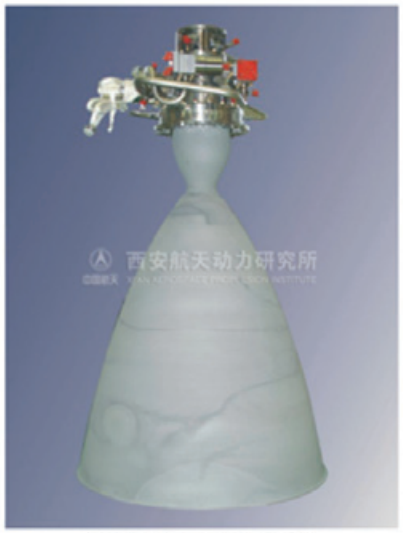
The traditional space sector has clearly made a home in Xi'an, and Shaanxi Province more generally, with two core elements of China's space program - communications and rockets - being built here. In more recent years, as China's commercial space sector has grown rapidly, we have seen the emergence of a commercial cluster in the province.

A Growing Commercial Cluster

Like the rest of the Chinese space sector, Xi'an and Shaanxi have seen a plethora of commercial companies arrive in the city to complement (or in some cases compete with) the state-owned incumbents. Unsurprisingly, several of the commercial companies deal with rockets, including iSpace, Landspace, and OneSpace,


长征系列主发动机


长征系列高空发动机


空间变推力发动机

LM Main Engine, Upper Stage Engine, and Variable Thrust Engine, from Xi'an Aerospace Propulsion Institute http://www.casc11.com/enproduct/index.asp?Cid1=1803

all of whom have set up R&D centers in/around the city. As noted, this has created some interesting interactions with the established firms, though the result seems to have been rapid advancement across China's launch sector, with Landspace now seeming to have highly advanced liquid methalox technology, and Xi'an Aerospace Propulsion Institute moving forward with modifications to the Yuanzheng Upper Stage.

Other commercial entities include multiple satellite manufacturers, such Galaxy Space, which has a Xi'an subsidiary, and Commsat. Smart Satellite, a manufacturer and satellite operator, announced a deal with the city of Tongchuan (near Xi'an) to manufacture the 12-satellite "Silk Road" SAR constellation, a signing which also made note that Smart Satellite had set up a company in Tongchuan. Whether the city of Tongchuan will operate a SAR constellation is yet to be seen, but they have done well to attract Smart Satellite to their city. More established satellite service companies, such as SatPro, a manufacturer of Ka-band and Ku-band antennas, among other things, have been based in Xi'an for some time, creating a commercial ecosystem around the communications/RF equipment side of the industry.

Xi'an National Civil Aerospace Industry Base

The local government in Xi'an, and Shaanxi more broadly has played a role in supporting the development of the space sector. This is most apparent in Xi'an National Civil Aerospace Industrial Base (西安国家民用航天产业基地), part of the Shaanxi National Aerospace Economic and Technological Development Zone (国家级陕西航天经济技术开发区), but is also visible in the city hosting the Silk Road International Commercial Space Industrial Alliance Congress every year. The Congress, in addition to being a chance for China's space industry to gather, is also clearly a reference to Xi'an's status as a Silk Road trading hub. To some extent, the city's size may be a small disadvantage to space firms, in that Xi'an is large enough to not badly need space to diversify their economy, and is too large a city to have a commercial space company make a major difference to the local economy. In this way, Xi'an is different from Changchun, for instance, which is rather smaller, (low single digit millions while Xi'an is high single digit millions), and has a less diversified economy. In the case of Xi'an, the government is large, so it has resources to help the space sector, but it also has strong space incumbents and lots of other big companies. It will be interesting to see how the local government impacts the development of the commercial sector in the future.

The Future for Xi'an

Xi'an is well-placed in the context of China's future growth, assuming that growth continues to move at the trajectory and direction of the Government's plans (i.e. "high-value growth" along "BRI" countries). As China gets larger, and as its role in the world potentially becomes more significant, Xi'an will find itself at the crossroads of China and Central Asia, and by extension the rest of the Eurasian continents. We are already seeing an increasing number of long-distance trains bound for western Europe originating in Xi'an, or at a minimum, passing through Xi'an as the last major city on the Chinese side of the journey. To date, many of these trains remain underutilized, but the infrastructure is there.

This creates a central question for the future of Xi'an - if China's grand geopolitical ambitions are realized, Xi'an will be at a major gateway. There are many variables for this, some extremely high-level in nature (what is China's goal for the BRI?) and some much more tactile (what is the impact on a Suez Canal blockage on the attractiveness of rail travel from Asia to Europe or vice versa?) While we cannot be sure what the future holds for trade between China and the rest of the world, Xi'an has always, and will likely continue to be, an important gateway in the trade routes between China and the rest of the world.

The future importance of the gateway that Xi'an occupies is not yet clear. But we can be sure of two things. Xi'an, with its many cultures, languages, and varied history, knows how to be an international gateway between China and the rest of the world. And, the city and province will have, among other things, a lot of propulsion and TT&C related activities to support it.

1) https://www.scmp.com/news/china/society/article/2166233/how-chinese-rocket-scientists-resignation-started-nation-talking

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