All About The Chinese Space Programme

Go TAIKONAUTS!

龙腾太空

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The return of the return capsule. On 15 May 2020, the re-entry capsule of China's new-generation crewed spacecraft arrived at the China Academy of Space Technology (CAST) in Beijing. The transport convoy was welcomed by the company's staff. Credit: CAST/WeChat

Content

Chinese Space Quarterly Report
April - June 2020
by Jacqueline Myrrhe

SPACE TRANSPORTATION

CZ-3B (Chang Zheng 3B)

In May, the last Beidou navigation satellite - a GEO satellite - and its CZ-3B/G2 launcher, have been moved to the Xichang Satellite Launch Centre. The launch preparations were going according to plan. The GEO satellite will complete the navigation constellation and would make all Beidou services available to global users.

The CZ-5B during transfer from the assembly building to the launch pad. Credit: Su Dong/Xinhua

CZ-5B

Despite the special circumstances caused by the Corona pandemic, progress was made on the CZ-5B launch preparation. Special hygiene concepts were applied and lessons-learned from the launch failures of the CZ-7A and CZ-3B were taken into consideration, leading to a thorough quality assurance implementation.

After the arrival of the rocket components at the launch site on 5 February, the engineers started assembling the launcher. In late March it was undergoing a wet dress rehearsal and fit checks with the earlier arrived space station module. After that, the rocket was prepared for launch with the prototype of a new-generation crew spacecraft.

On 29 April, the CZ-5B was rolled out to the launch pad for final launch preparations. The human-rated spacecraft was fuelled with 10 t of propellant, simulating a realistic mass equivalent of launching a space station module and high-speed re-entry. The unmanned test flight aimed at verifying avionics, parachute deployment, airbag-supported landing and recovery procedures.

More details see: gray text box to the right

CZ-5B

The Long March 5 series includes the CZ-5 and CZ-5B. Both have a core-stage diameter of 5 m and 4 boosters supporting the 1st stage with a diameter of 3.35 m each. The main difference is in the height, configuration and payload fairing. The core stage is powered by two YF-77 hydroLOX engines. Each of the side boosters is powered by a pair of YF-100 keroLOX engines.

The CZ-5B rocket was developed by CALT (China Academy of Launch Vehicle Technology). It has a total height of 53.66 m. Characteristic for the CZ-5B is the enlarged payload fairing. It is 20.5 m long and has a diameter of 5.2 m - which makes it the biggest fairing in China and will be needed to host the Space Station modules. Overall, the CZ-5B is a bit more than 3 m shorter compared to the CZ-5 but with the larger fairing its main task will be to lift heavy cargo into LEO (22 to 25 t) as needed for the Space Station construction while the CZ-5 is designed for transporting big satellites into GEO or to support deep-space exploration, also crewed. The CZ-5B has a core stage and 4 strap-on boosters, also referred to as a "first-and-a-half" stage rocket – China's only one.

The CZ-5B is fuelled with liquid oxygen, liquid hydrogen and kerosene. Its lift-off mass is 849 t.

For the 5B version, technological breakthroughs have been achieved such as the separation mechanism of the large fairing and of the payloads in space and the precise control of the rocket to enter orbit directly with high thrust.

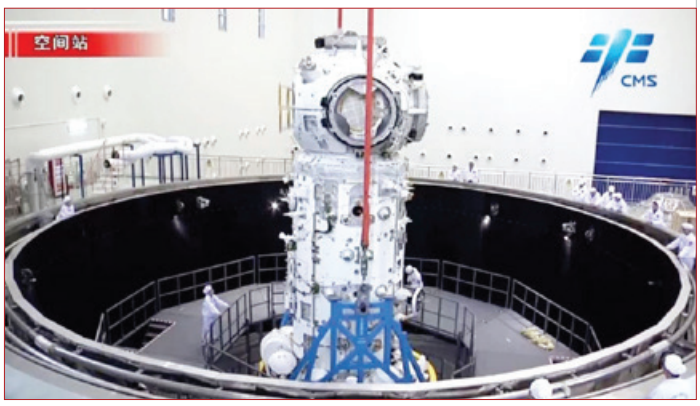
The launch with the test version of the new-generation crewed spacecraft was the 1st Chinese launch with a P/L capacity of over 20 t.

For details on the New-generation Reusable Crewed Spaceship, please, compare Quarterly Report 1-2020 in GoTaikonauts! issue no 31, p. 4 and text box in this issue on page 6.

- **CZ-5B: LAUNCH**

The new CZ-5B heavy-lift rocket made its 1st flight on 5 May, sending the test version of the new-generation crewed spacecraft and an inflatable cargo return module into space. The flight verified the design of the launcher and its sub-systems as well as the new spaceship which did not host a crew during this test. The CZ-5B is specially developed for China's manned space programme and this successful flight marked the start of the "3rd step" of China's manned space programme - the beginning of the China Space Station (CSS) assembly. The overall rocket take-off mass was about 849 t.

The CZ-5B also launched a flexible and inflatable test cargo return capsule which was developed by the 2nd Academy of the



The Tianhe core module and docking hub of the Chinese Space Station is undergoing testing in the thermal-vacuum chamber. Credit: CMSA


Launch of the 1st CZ-5B from Wenchang Space Launch Centre on 5 May 2020. The flight served for testing China's new-generation manned spaceship and a cargo return capsule. Credit: Xinhua/Guo Cheng

China Aerospace Science and Industry Corporation (CASIC).
More details see: LAUNCH section

Photo Gallery on CZ-5B

After the successful launch of the CZ-5B, the Central Committee of the Communist Party of China, the State Council and the Central Military Commission sent a congratulatory message to all personnel involved in the mission, stressing that the success marks a good beginning for the national space station programme.

• CZ-5B: 3D printed parts

For the 1st flight of the CZ-5B, the CALT's Factory 211 developed a 3D-printed core stage booster connecting structure made of titanium alloy. The connectors have to bear a load of 200 t. After this flight verification test, the factory will further improve the product.

• CZ-5B: Re-entry of spent core stage

After launch on 5 May, the core stage of the CZ-5B spent nearly one week in orbit, circling the Earth between 41.1° Northern and Southern latitude.
On 11 May, the stage with an estimated weight of 18-20 t, re-entered unguided the dense layers of the atmosphere, passing directly over Los Angeles, New York's Central Park and impacted the Atlantic Ocean at 20° W, 20° N, off the West African coast of Mauritania at 15:33 UTC, short before the ground track would continue to pass over Nouakchott, the capital and largest city of Mauritania. Debris was recovered near the village of Mahounou in Ivory Coast.
The 18th Space Control Squadron of the U.S. Department of Defense' Space Force confirmed the impact time. The stage was 33 m long and 5 m wide. Most of the rocket was made up of hollow propellant tanks, but pieces of the robust pumps of the core stage's two YF-77 main engines could have survived the re-entry. The spent core stage was the largest piece of space debris to fall uncontrolled back to Earth since 1991 and the 4th biggest ever. For the launch of the main modules of the China Space Station 3 more launches of the CZ-5B are required.

CZ-7A / CZ-3B - Launch failure

Ji Qiming, Assistant to the Director of the China Manned Space Engineering Office (CMSA), said at a press conference on 5 May regarding the launch failure of the CZ-7A on 16 March and the CZ-3B on 9 April that the experts have "basically identified the location and the cause" of the 2 malfunctions.
At the same time, relevant departments have organised a comprehensive quality assurance check and a review of the entire space programme and made adjustments to the launch manifest.

No U.S. chips in Chinese rockets

In response to claims by Western media (among them the Chinese language channel of German radio broadcaster Deutsche Welle) that China's recent 2 rocket launch failures within less than 1 month (CZ-7A on 16 March 2020 / CZ-3B on 9 April 2020), were due to U.S. chip export restrictions, Global Times quoted mid-April an insider from a governmental rocket manufacturer that there are no chips from the U.S. used in Chinese rockets. The insider spoke to Global Times mid-April on the condition of anonymity. The insider also stressed that the causes of the 2 launch failures have not been located as of yet and therefore conclusions cannot be drawn.

Infographic Report on China's Orbital Launch Activity
Bryce Space and Technology is an analytics and engineering firm that partners with technology and advanced R&D clients to provide comprehensive insight and expertise on the space economy. Bryce Space and Technology analyses the interaction of national security, civil and commercial space programmes, technical capabilities, and markets. On 27 May, Bryce Space and Technology published an infographic report on China's Orbital Launch Activity. The infographic provides foundational data on China's orbital launch sites and launch vehicles, as well as on the general structure of China's state-managed space industry.

CZ-8

In the 2nd quarter of 2020, CASC's engineers were preparing for the 1st launch of the CZ-8. The new rocket will provide an improved payload capability for SSO, filling the gap of 3 to 4.5 t. The CZ-8 will support commercial launch services for the domestic and international markets. Estimations predict an annual flight rate of 10 to 20 launches.
The CZ-8 has a modular design and incorporates technologies that have been used by the CZ-3A and CZ-7.
With 2 core stages and 2 boosters, the rocket is 50.3 m tall, has a lift-off weight of about 356 t. It is propelled by liquid oxygen, liquid hydrogen and kerosene. Its core stages are basically identical to those used for the CZ-7 and CZ-3A. The 1st stage and boosters are intended for future recovery and reuse.

CZ-11A

CASC's engineers have begun to develop the solid-fuelled CZ-11A, an upgraded version of the CZ-11 carrier rocket. The conception phase should conclude by the end of 2020 and the 1st launch could take place in 2022. Compared to the CZ-11, the CZ-11A will be wider, taller and will provide sufficient thrust to place a 1.5 t P/L into a 700 km SSO. In comparison: the CZ-11's P/L capacity is 500 kg into a 500 km SSO. CZ-11A can support land and sea launch. The launch costs are calculated at 10,000 USD per kg.

Part 1: A Historical Perspective on Chinese Spaceplanes

Chinese Spaceplanes - Historical overview and current developments
Jean Deville published in his Aerospaceblog a two-part article on Chinese spaceplanes. The 1st part sets the context of spaceplanes in China and goes over past attempts for such vehicles. Part 2 provides an overview analysis of current projects under development from Chinese state-owned and private companies.

Part 2: China's Spaceplane Projects: Past, Present, Future

YUANWANG

YUANWANG 5

Yuanwang 5 (YW-5) returned from the Pacific Ocean to its home port on 12 May, after finishing the CZ-5B launch monitoring mission. The crew has stayed 81 days at sea, sailing over 20,000 nautical miles. Due to the COVID-19 pandemic, no port calls were made and more than 80% of the crew did not disembark for more than 100 days. After berthing, the ship's crew was taking a rest, checking facilities and replenishing supplies for upcoming missions including the launch of the Tianwen 1 Mars probe and the Chang'e 5 lunar sample return mission.

YUANWANG 6

The 3rd generation Yuanwang 6 (YW-6) left its home port in Jiangsu Province on 20 May to sail to the Pacific Ocean for supporting the launch and early operation phase of several space missions. Also, new equipment and improved space tracking operations were tested since YW-6 underwent an overhaul from end of April 2019 until end of January 2020 at Jiangnan Shipyard in Shanghai, making YW-6 technically fit for the support of deep-space missions. Additionally, the crew examined facilities and conducted a series of training programmes and tests before embarking on a new voyage to improve their emergency response capabilities.
YW-6 was put into service in April 2008. According to international practice, ocean-going survey ships will undergo major overhaul every 10 years, mainly to maintain the engines, power systems, make outfitting repairs, carry out hull structure maintenance and install new measurement and control equipment.
On 23 June, YW-6 supported the last launch for the Beidou Navigation Satellite System (BDS). While stationed in the Pacific Ocean, the vessels' radar detected the target 20 min after lift-off from Xichang Satellite Launch Centre and followed the trajectory of the satellite. The whole maritime monitoring

The upgraded space tracking vessel YW-6 is leaving port on 20 May 2020 and is sailing to the Pacific Ocean for several space-tracking missions. Credit: Xinhua

After YW-6 had arrived in the designated waters in the Pacific Ocean for the launch of the Beidou satellite, the crew conducted a readiness inspection. Credit: Xinhua

Yuanwang Photo Gallery

process lasted for nearly 600 sec. After the completion of operations, the YW-6 crew started preparing for the next monitoring task: China's 1st Mars planetary probe.

MANNED SPACE FLIGHT

Chinese Space Station - CSS

For the CSS assembly 11 launches are planned: 3 launches of the CZ-5B for the Station's modules, 4 launches with the CZ-2F for the Shenzhou crewed spacecraft, and 4 launches of the CZ-7 with the Tianzhou cargo spacecraft. The Tianhe core module is ready and the 2 science modules Wentian and Mengtian, as well as scientific payloads, are under development.

After the CZ-5B's 1st flight on 5 May, the next flight will be the launch of the Tianhe core module, followed by the launch of the 2 science modules, forming the CSS' basic configuration. The crews for the 4 construction flights have been selected and are in training.

NEW TAIKONAUTS GROUP

A 3rd batch of astronauts will be selected in July, said Zhou Jianping, Chief Designer of China's manned space programme, in Beijing in an online interview on the side-lines of the 3rd session of the 13th National Committee of the Chinese People's Political Consultative Conference (CPPCC). Up to 18 new astronauts, including men and women, will be drawn from the People's Liberation Army Air Force and, for the 1st time, civilians with science and engineering backgrounds are considered to add research expertise to the science programme.

NEW-GENERATION CREW SPACESHIP

• CZ-5B Flexible Inflatable Cargo Re-entry Vehicle

In addition to the new space capsule, the 1st CZ-5B mission also carried a prototype of a 3 m-diameter inflatable cargo re-entry system - a 1st for China. It was a test for a new retrievable space transport vehicle. On 6 May, after 19 hours of flight, the Flexible Inflatable Cargo Re-entry Vehicle was supposed to unlock and dispose the protective cover. Then the vehicle should begin to inflate and form into the shape of an inverted umbrella of 3 m diameter so it could stabilise and decelerate. After passing the blackout phase during the atmospheric re-entry, it should have sent position signals to guide ground recovery personnel while making a parachute-assisted landing at the Dongfeng Landing Site in the Inner Mongolia Autonomous Region.

During re-entry, a non-specified abnormality occurred. Experts were analysing the collected data.

The designers of the China Aerospace Science and Industry Corporation (CASIC) expect that once the vehicle is in operation - in parallel with the conventional Tianzhou cargo craft - it will provide a new solution for space cargo retrieval by combining a solid carrying capacity of low cost and good compatibility with a high level of safety.

Chinese Space Station - CSS

After the successful test flight of the next-generation crew spacecraft, more details about the Chinese Space Station became public. The standard missions will be long-duration stays of 6 months or longer for 3 taikonauts. During crew rotation, the number of taikonauts could increase to up to 6.

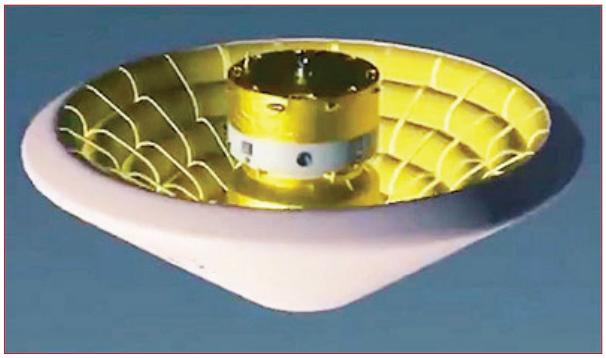
Each of the Station's 3 main modules has a mass of over 20 t, while the Station's total mass is expected to be 66 t.

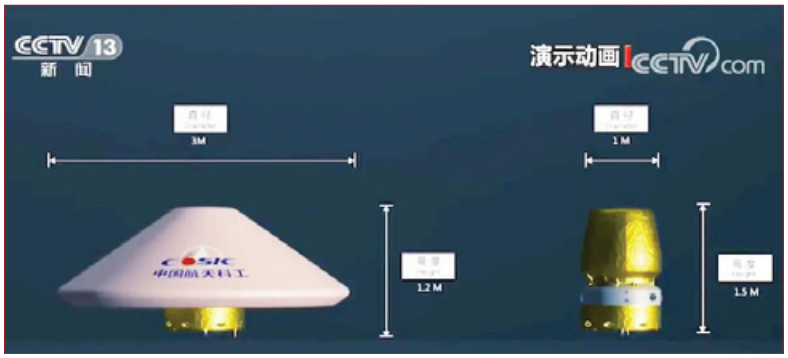
The *Tianhe* core module will have a mass of 22.5 t, a length of 16.6 m, a max. diameter of 4.2 m and a volume of 50 m^3. It will serve as the data management and control centre and accommodates the main living area for the crew. Once the 2 research modules are added, the Station's volume increases to 110 m^3. The core module is equipped with 2 berthing ports for the science lab modules, 3 docking ports for space craft - crew or cargo - and with an airlock. The interior is separated into 6 zones for work, sleep, sanitation, dining, healthcare and exercise. For the daily fitness training, the module will be equipped with treadmills, spin bikes and a resistance exercise device. All modules will feature modern technology, such as Wi-Fi sensors for recording the parameter of the module's environment, controlled via a tablet application. – *compare text box "New Generation Spacecraft" on page 6.*

The *Wentian* module is suitable for science and technology research and can be used as living compartment. *Wentian* also has an airlock and a small robotic arm. In case of need, it can serve as backup for the core module, taking over data management and control functions. *Mengtian* is similar to *Wentian* with similar equipment including another type of robotic manipulator. The research modules will host several science racks, supporting diverse research and investigations.

The CZ-2F is the launcher for the Shenzhou crew space craft. The CZ-7 serves for lifting cargo crafts and the CZ-5B will bring the modules and the 2 m free-flyer telescope *Xuntian* into space. *Xuntian* has a 10-year lifetime during which it can dock with the Station for maintenance and refuelling. The CSS can be expanded and upgraded according to research needs.

The Station will be fitted with 2 pairs of flexible solar panels, with each panel about 30 m long providing the on-board energy. The Station will also use electric propulsion technology for attitude control. The Station's expected lifetime is between 10 and 15 years, with maintenance and repair bringing it closer to 15 years.





Schematic of the inflatable re-entry module. Credit: CASIC/CCTV

• In-Orbit Operations

At the same time the test version of the next-generation crewed space craft worked nominally in orbit, completing a series of operations as planned. It deployed its solar panels and oriented them toward the sun, unfolded its relay antenna and established a communication link, as well as conducting 4 autonomous orbit adjustments. It continued in a stable flight attitude in a highly elliptical orbit, with the power supply, measurements and control links operating nominally. It raised its orbit 3 times before braking at apogee for initiating the re-entry.

LANDING of new-generation spacecraft

The return capsule of the test version of the new-generation manned spaceship landed 68 hours after launch in the waste steppe of the Dongfeng site in the Inner Mongolia Autonomous Region on 8 May at 13:49 BJT.

The return process was initiated by the Beijing Aerospace Control Centre (BACC) sending a command for a deceleration manoeuvre at 12:21 BJT.

The re-entry module then separated from the service module at 13:33 BJT at a speed of 9 km/s. At a height of 8 km, two deceleration parachutes deployed and after jettisoning them, a set of 3 main parachutes unfolded to slow the fall. Before the final touch-down, 6 airbags inflated to cushion the landing impact. Helicopters accompanied the last phase of the landing and a team from the Jiuquan Satellite Launch Centre was responsible for the retrieval. The landing phase and the retrieval were challenging, due to the fact that the prototype spacecraft returned from a highly elliptical orbit with an apogee of 8,000 km, testing the return of crewed deep-space missions. The engineers had rehearsed the procedure multiple times and worked out several emergency-response plans. The test was a full success. The 1st crewed test flight is planned for the 2nd half of 2023.

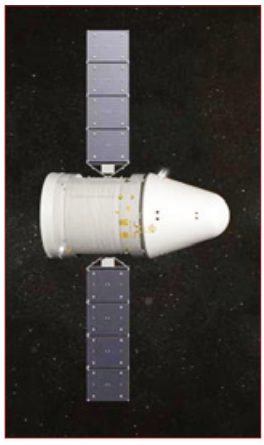
NEW-GENERATION CREW SPACESHIP – UNPACKING THE PAYLOADS

On 15 May, the re-entry capsule of China's new-generation crewed spacecraft arrived at the China Academy of Space Technology (CAST) in Beijing. The transport convoy was welcomed by the company's staff.

In the afternoon of 29 May, engineers at CAST opened the re-entry module. Nearly 100 items, ranging from test equipment and experimental devices to cultural products, were unpacked from the module.

At a ceremony the items were distributed to their owners or related parties. Among the items were the national flags of Pakistan and Argentina. Hao Chun, Director General of CMSA, handed back the Pakistani flag to the Ambassador of Pakistan to China, Miss Naghmana A. Hashmi. Ms. Hashmi expressed her hopes that Beijing and Islamabad would further extend their cooperation in space exploration, culminating into the space mission of the 1st Pakistani astronaut in 2022. Pakistan's national flag was provided to CMSA in Beijing on 11 February 2020.

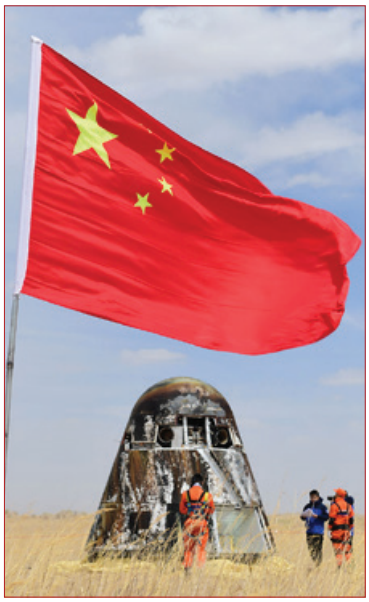
Photo reports from the landing.



Rendering of the prototype of the new-generation crewed spaceship during its in-orbit operation. Credit: CAST

The prototype of the new-generation crewed spacecraft in the testing facility. Credit: CAST

Group photo of the recovery team of the re-entry module of the prototype of the new-generation crewed spacecraft. Credit: Wang Jiangbo/ Chinadaily



The re-entry module of the prototype of a new-generation Chinese spacecraft after its landing at the Dongfeng Landing Site in the Inner Mongolia Autonomous Region. Credit: Wang Jianbo/China Daily

NEW-GENERATION SPACECRAFT – TECHNOLOGY TESTS and EXPERIMENTS on the test flight

7 key technologies were tested:

- HAN-propelled engine
- Large-volume tank made of composite material winding structure and aluminium alloy lining
- Data management and processing system
- Autonomous tracking and control technology
- On-orbit data acquisition system
- New lightweight inflatable heat shield
- Combined parachute and airbag landing

3D Printer

A "Space-Based Composite Material 3D Printing System", developed and built by the Beijing Spacecraft Manufacturing Factory, a CAST subsidiary, was installed in the re-entry section of the new-generation manned spaceship for testing of advanced technologies in material processing, precision control and automation.

It printed 2 samples of continuous carbon fibre-reinforced polymer composites. CCTV footage showed the printer working on a flat section of a honeycomb-shaped structure and a printed CAST emblem.

Lightweight - high strength carbon fibre is well suited for aerospace applications. Continuous carbon fibre can improve the performance of composite materials.

The fully automated printing was finished on 7 May at 1:58 BJT. Upon return, the researchers checked and evaluated the 3D printer and the printed samples. The tested type of 3D printer is considered for use in extra-vehicular activities and in-orbit construction of large structures. Previous experiments were conducted during parabolic flight campaigns.

Experiments conducted inside the new-generation crewed spacecraft

• Tribological behaviour of liquid lubricating materials

Liquid and solid-liquid composite lubricants were tested for future use on the CSS. The aim was to understand the wetting behaviour and distribution of lubricants on different surface morphologies to develop a reliable and long-lasting space lubricant as well as to acquire data for the analysis and diagnosis of the CSS's long-term on-orbit operation and maintenance.

• Microgravity acceleration measurement technology

In low-Earth orbit, residual forces (atmospheric drag, solar radiation pressure, accelerations from orbital and attitude manoeuvres) act on objects. Those influences, although minor, have an effect on the scientific research conducted on the CSS and need to be measured and documented. For that purpose, different types of acceleration measurement technology experiments were conducted. The results will be applied to the installation of the experiment racks to allow for science research with little or no external interferences.

• Integrated electronic information architecture design/ Ethernet system

A new-generation integrated electronic information architecture and a time-triggered Ethernet system completed the verification of global time synchronization, multi-source data sampling, and high-definition image transmission for future use in large and complex spacecraft like the CSS where high data transmission speed within a local area network is required. The test reached a transmission speed in the range of Gigabits with a bandwidth of 1 MB. On the CSS, all housekeeping applications will be fed into a single control unit, forming an intelligent spacecraft information system. The taikonauts can access the control unit via a tablet computer, independent of the location within the station.

• Acoustic leakage and collision system

This experiment tested the identification and localisation of leaks and collisions by using acoustic signals and sensors.

• Fibre grid sensor system

It is a sensor network which provides temperature readings and information on the structural stress of the material.

• Metal / ceramic materials for additive manufacturing

In order to further improve the manufacturing accuracy and expand the spectrum of materials that can be used in space manufacturing, this experiment tested sub-micron-level fine soft material (cermet) for the use in space and adjusted the rheological properties to complete the material morphology in orbit.

• CubeSat Deployer

The structural strength, material performance and space environment adaptability of a lightweight 3D printed CubeSat deployer was tested. It was developed by commercial start-up Beijing CoSats Space Technology Co., Ltd. within 1 week. The test was used to verify the vibration level during the deployment process, the accuracy of the release moment and the separation signal transmission.

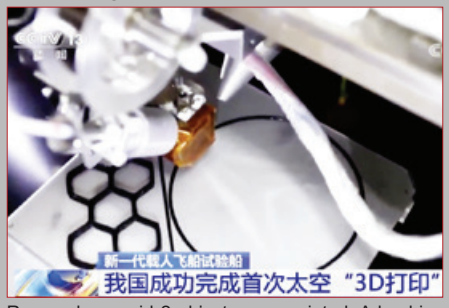
• Microbial oil extraction strain

Microbial oil recovery is an investigation by the East China University of Science and Technology. This novel technology uses the activities of microorganisms or metabolic bio surfactants to improve oil recovery and extend the life of oilfield development. In this experiment, the space environment was used to mutagenize the original wild strains. It is expected to obtain mutant strains with strong specificity, higher performance and higher industrial application value.

• Seed in Space experiment

The test spaceship flew for about 68 hours in a 300 to 8,000 km orbit, a trajectory that crossed the Inner Van Allen Belt with its increased radiation levels. That provided a unique opportunity for space radiation biology research and space mutagenesis. For that purpose, 75 space breeding and space biology projects with 988 samples were flown. The researchers wanted to find out whether the species would mutate and whether those possible mutations will lead to improved or new plant variations. This experiment included projects from Yunnan Province, Ningxia Hui Autonomous Region - local governments which have a strategic cooperative relationship with the China Manned Space Engineering Office (CMSEO) - but also special projects recommended by the China Aerospace Breeding Industry Innovation Alliance. The investigation covers agricultural crops, forests, grasses and flowers, Chinese herbal medicine seeds and biological strains of experimental devices, as well as experimental samples of model plants and model animals that have important scientific value for basic research.

Among the samples were also 11 species unique to Tibet, e.g., seeds of barley, forage grass, rose rhodiola, and lemon. The specimens were back in the labs for testing beginning of June where the plants were studied for germination characteristics of the seeds, crop output and plant growth cycles.



Researchers said 2 objects were printed: A beehive pattern and the logo of CASC. Credit: CCTV


Packs of the seeds experiment. Credit: CMSA

CAST engineers opened the re-entry module of the prototype of the new-generation crewed spacecraft on 29 May. Credit: Zhao Lei/Chinadaily.com.cn

A national flag of Pakistan, which has been flown to space on board the next-generation spacecraft is given to Ms. Naghmana Alamgir Hashmi, Pakistani Ambassador to China, at a ceremony at CAST in Beijing on 29 May. Credit: Xu Jingxing/Chinadaily.com.cn

Zhang Bainan. Credit: cnsphoto

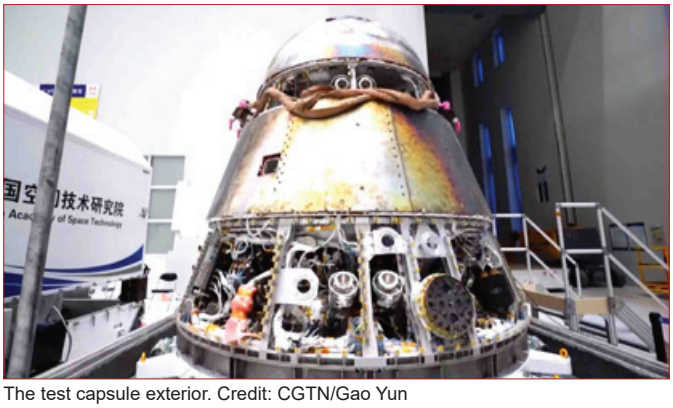
Inside the new crew spacecraft - June 2020

"Manned space flight is a dream career, and my dream is to make the Chinese people travel farther." - Chief Designer of China's new-generation spaceship reveals process of design

"In developing the new-generation manned spaceship, it feels obvious that China has significantly improved its manufacturing of spacecraft, especially if you compare our latest efforts with the Shenzhou spacecraft," said Zhang Bainan, Chief Designer of the test version of China's new-generation crewed spaceship. China's aerospace technology level is cutting-edge in the world, and the development of many other spacecraft and satellites benefited from improvements in our manufacturing ability, he added. Now that China's aerospace technology is approaching the world's advanced level, its designers are facing more decisive risks.

The test capsule before flight. Credit: CAST/CGTN

The test capsule dismantled. Credit: CGTN/GaoYun



The test capsule exterior. Credit: CGTN/Gao Yun

NEW CREWED SPACE CRAFT

Mid-June, photos and footage of the interior of the 13 m^3 return capsule of the test version of the new-generation crew spaceship emerged on Chinese media (see photos to the right). One photo showed that cargo was packed to the right side of the craft. During the test flight, the capsule carried nearly 1,000 items to verify the cargo capacity. On its left side was the living area, with a folding table and a toilet. The interior surfaces and fixtures were in good condition after return, leading to the conclusion that the split-up design inside the capsule is suitable. Once in operation, the racks and cargo bags will not be included since they were introduced only for this test flight. Engineers were also satisfied with the status of the heat shield after return.

LUNAR AND DEEP-SPACE EXPLORATION

MARS

Tianwen 1

In anticipation of the launch of China's 1st Mars mission, CASC announced at the beginning of June details about the mission profile and the scientific payloads.

3 scientific objectives

- comprehensive remote observation from Martian orbit,
- landing on the planet's surface,
- deploying a rover for in-situ scientific exploration of Martian soil, geological structure, environment, atmosphere and water.

After 7 months of flight, Tianwen 1 will reach Mars in February 2021. An attempt for landing may not take place immediately leaving time for remote sensing of the planet. The Tianwen 1 orbiter is equipped with 7 scientific payloads among them a high-resolution camera, a medium-resolution camera, subsurface radar, mineralogy spectrometer, neutral and energetic particle

analysers and a magnetometer. The instruments will collect data of the Martian magnetic field and atmosphere, map the surface and characterise the planet's geology. The orbiter will also function as a relay for the rover. The orbiter's lifetime is designed for 1 Martian year, roughly 23 terrestrial months.

There are 2 candidate landing areas in Utopia Planitia, each stretching approx. 100 x 40 km. The site pre-selection was driven by factors such as: constraints of the flight system design, challenges of entry, descent and landing (EDL) on Mars, and the science goals of the mission.

The soft landing will take approx. 8-9 min., consisting of 4 stages:

1st: during a 290 s long aerodynamic deceleration, the probe's speed will be reduced from 4.8 km/s to 460 m/s,

2nd: the probe will deploy the parachute to further decelerate to ~95 m/s within approximately 90 s

3rd: the retro rockets fire for 80 s and reduce the speed to 3.5 m/s

4th: 100 m above the surface, the lander has a relative speed with the ground of 0 m/s. The craft will hover and scan the surface landscape with the obstacle avoidance system and to automatically search for a suitable spot.

After landing, the rover will be deployed. The design life of the rover is 90 Martian sols, more than 3 months on Earth. One day on Mars - one Sol - is about 24 h and 37 min.

The rover has 6 wheels and 4 solar panels and will carry 6 scientific instruments. With roughly 240 kg it is nearly twice the mass of the Yutu lunar rovers and 25 % of NASA's Perseverance rover.

It will carry a ground-penetrating radar for mapping the geological characteristics of the underground, e.g., sub-surface layers, structure and ice or permafrost features. The rover is also equipped with a multispectral camera, a Laser Induced Breakdown Spectroscopy (LIBS) instrument and payloads for detecting the climate and magnetic environment.

The rover will receive a name later through a public poll.

If Tianwen 1 succeeds, the mission will become the world's 1st Mars expedition accomplishing all 3 goals of orbiting, landing and roving, with one probe.

Additionally, a successful mission could become the starting point for a Mars sample return mission around 2030.

DEEP-SPACE ANTENNA

In preparation of the Mars mission, a 70-m steerable radio telescope is built by the National Astronomical Observatories of the Chinese Academy of Sciences in Wuqing District of Tianjin (south of Beijing). It will become the largest steerable radio antenna in Asia and a key facility to receive scientific data and weak signals sent back by Tianwen 1. Many new technologies have been utilised to improve efficiency and reduce interference noises. The new telescope joins China's deep-space network and will support future deep-space missions to other planets, asteroids, or comets. The Tianjin antenna will operate in combination with the existing radio dishes in Beijing and in Kunming. The construction of the telescope began in October 2018 and is expected to be completed this year.

SCIENCE

FAST - Five-hundred-metre Aperture Spherical Radio Telescope

The FAST team joins SETI, the international project for the search for extra-terrestrial intelligence. SETI matches with one of FAST's 5 main scientific goals (the others are: 21 cm Hydrogen line (galaxies and ISM); spectral lines; pulsars; VLBI).

In September 2018, researchers from the National Astronomical Observatory, the University of California, Berkeley and Beijing Normal University and other units tested the installation of a high-resolution extra-terrestrial civilization search back-end at the FAST site. In July 2019, the researchers analysed and processed the drift scan data to achieve a frequency resolution of 4 Hertz (Hz), and successfully removed most of the radio frequency interference (RFI), screening out multiple sets of narrowband candidate signals.

In May 2020, an international research team announced the results of test observations used in searching for extra-terrestrial intelligence. The team concluded that the radio telescope has the potential to detect exoplanets in particular in the neighbouring Andromeda galaxy "M31-Andromeda" and possible signals of extra-terrestrial life. The study was published in *The Astrophysical Journal* (ApJ) and *Research in Astronomy and Astrophysics* (RAA). *See QR Code below*

During summer, the back-end equipment was upgraded to prepare for the search of extra-terrestrial signals after September.

China's Cislunar Space Ambitions Draw Scrutiny

Mandy Mayfield is looking for National Defence Magazine at the different evaluations of China's lunar ambitions by U.S. analysts: "Some members of the space community are sounding the alarm as China indicates it may seek to establish a commanding position in cislunar space, to include the area near the Moon's orbit. Experts say China's ambitious plans raise important questions about the national security implications of cislunar space..." Mandy Mayfield was asking Rep. Doug Lamborn, Brian Weeden and Dean Cheng to explain their views.

Zhi-Song Zhang, Dan Werthimer, Tong-Jie Zhang, Jeff Cobb, Eric Korpela, David Anderson, Vishal Gajjar, Ryan Lee, Shi-Yu Li, Xin Pei, Xin-Xin Zhang, Shi-Jie Huang, Pei Wang, Yan Zhu, Ran Duan, Hai-Yan Zhang, Cheng-jin Jin, Li-Chun Zhu, Di Li, (2020), "First SETI Observations with China's Five-hundred-meter Aperture Spherical Radio Telescope (FAST)", *The Astrophysical Journal,* 891, 2, DOI: 10.3847/1538-4357/ab7376, article ID: 174

Construction site of the steerable radio telescope in Wuqing District of northern China's Tianjin. Credit: National Astronomical Observatories/Xinhua

Scientists and workers pose for a photo after the antenna disk's installation at the construction site of the steerable radio telescope in Wuqing District of Tianjin. Credit: National Astronomical Observatories/Xinhua

Ready, SETI, go: Is there a race to contact E.T.?
Researchers using China's new Five-hundred-meter Aperture Spherical radio Telescope (FAST) are piecing together a technological strategy to carry out a major and sweeping search for extra-terrestrial intelligence (SETI).
What if China someday announces that this hunt has been successful? How would such a claim be verified, and what might the consequences be? And could an unofficial international SETI race already be underway? Space.com asked several SETI authorities to line out the implications of China being the first nation to get a ping from ET.

FAST DATA CENTRE

A feasibility report for the FAST Scientific Research and Data Processing Centre, to be built in Guizhou Province, has been approved by the National Development and Reform Commission. With a total investment of roughly 170 million RMB (24.14 million USD), the data centre will facilitate 3 scientific research frameworks of observation, scientific research and data and will support the storage and calculation of massive data generated by long-term operations.
The operation of the telescope produces constantly data which is stored and analysed. In particular recording pulsar and hydrogen data streams demand extensive processing and computing performance, making the data centre essential.

QUESS - MICIUS
QUANTUM KEY DISTRIBUTION

The team of quantum scientist Pan Jianwei from the University of Science and Technology has demonstrated secure quantum communication between 2 ground stations, bridging a new record distance of 1,120 km at a finite secret-key rate of 0.12 bits per second, without the need for trusted relays. Entangled photon pairs were distributed via 2 bidirectional downlinks from the Micius satellite to 2 ground observatories in Delingha in Qinghai Province and Nanshan near Urumqi in Xinjiang Uygur Autonomous Region. A secured quantum link between the two ground stations was established with no trusted relays, and the satellite Micius (QUESS - Quantum Experiments at Space Scale) had no information about the secure key. Doing it this way, avoided using the satellite as a communication relay just as the “password” provider. The development of high-efficiency telescopes and follow-up optics for the ground stations crucially improved the link efficiency. This entanglement-based quantum-key distribution method not only increases the secure distance on the ground 10-fold but also increases the practical security of quantum key distribution to an unprecedented level.
The results of the demonstration were published in *Nature*.
Yin, Juan, Li, Yuhuai, Liao, Shengkai; Yang, Meng; Cao, Yuan; Zhang, Liang; Ren, Ji-Gang; Cai, Wen-Qi; Liu, Wei-Yue; Li, Shuang-Lin; Shu, Rong; Huang, Yong-Mei; Deng, Lei; Li, Li; Zhang, Qiang; Liu, Nai-Le; Chen, Yu-Ao; Lu, Chao-Yang; Wang, Xiang-Bin; Xu, Feihu; Wang, Jian-Yu; Peng, Cheng-Zhi; Ekert, Artur K.; Pan, Jian-Wei, (2020) “Entanglement-based secure quantum cryptography over 1,120 kilometres”, *Nature*, 582, 501-505, DOI: 10.1038/s41586-020-2401-y

QUANTUM-SECURE TIME TRANSFER

The Pan Jianwei team published another paper in Nature Physics which described how the Quantum Experiments at Space Scale (QUESS) satellite was used to verify for the 1st time a quantum-secure time transfer. For the satellite-based quantum-secure time transfer (QSTT) scheme, a single photon is used as the carrier for both - the time transfer and the secret-key generation - offering quantum-enhanced security for transferring the time signal and time information. By using QUESS, a satellite-to-ground time synchronisation using single-photon-level signals was performed and a quantum bit error rate of less than 1%, a time data rate of 9 kHz, and a time-transfer precision of 30 ps were achieved. This experiment lays the foundation for a safe satellite navigation system. So far, time synchronisation relies on atomic clocks which is considered as highly precise. However, time synchronisation based on quantum mechanics would be even more precise and safe.

Dai, Hui; Shen, Qi; Wang, Chao-Ze; Li, Shuang-Lin; Liu, Wei-Yue; Cai, Wen-Qi; Liao, Sheng-Kai; Ren, Ji-Gang; Yin, Juan; Chen, Yu-Ao; Zhang, Qiang; Xu, Feihu; Peng, Cheng-Zhi; Pan, Jian-Wei, (2020), "Towards satellite-based quantum-secure time transfer", *Nature Physics*, 16, 8, pp. 848-852, DOI: 10.1038/s41567-020-0892-y

ZEISS Research Award

Pan Jianwei, Professor at the University of Science and Technology of China, in Hefei and one of the world's leading researchers in the field of quantum technology, is the winner of the German ZEISS Research Award 2020. The award recognises that Pan Jianwei's research team realised the distribution of entangled photons over a distance of 1,200 km by using a light source on the QUESS satellite which emits entangled photons. Entangled photons can be used as a resource for many applications, e.g., in quantum cryptography to exchange a secret key.
The ZEISS Research Award is presented every 2 years and is attached with a prize money of 40,000 Euros. It is given for outstanding achievements in the field of optics or photonics. The awardee should still be actively conducting research, and the work should offer major potential for gaining further knowledge and enabling practical applications.

SOLAR RING MISSION

A team from the University of Science and Technology of China under the lead of Professor Wang Yuming, and in collaboration with the teams from Purple Mountain Observatory of the Chinese Academy of Sciences (CAS), Innovation Academy for Microsatellites of CAS, Shandong University, and the University of CAS, proposed a new concept of solar research. The idea is to deploy 6 spacecraft, grouped in 3 pairs, in 3 elliptical sub-AU (Astronomical Unit) orbits between the Earth and Venus around the Sun to observe and study the Sun and the inner heliosphere in a full 360-degree perspective in the ecliptic plane.
The 2 spacecraft in each group are separated by about 30° and every 2 groups by about 120°. This configuration combined with the necessary science payloads will allow to establish 3 unprecedented capabilities:

(1) determine the photospheric vector magnetic field with unambiguity,
(2) provide 360° maps of the Sun and the inner heliosphere routinely, and
(3) resolve the solar wind structures at multiple scales and multiple longitudes.

In order to achieve the scientific objectives, the researchers suggest the following science payloads:

- Spectral Imager for magnetic field and helio-seismology,
- Multi-band Imager for EUV emissions,
- Wide-angle Coronagraph,
- Radio Investigator,
- Flux-gate Magnetometer,
- Solar wind Plasma Analyser, and
- High-energy Particle Detector.

With these capabilities, the Solar Ring mission aims to address the origin of the solar cycle, the origin of solar eruptions, the origin of solar wind structures and the origin of severe space weather events. The successful accomplishment of the mission will advance our understanding of the Sun and the space environment.
The total mass of the payloads on each spacecraft is estimated to be less than 110 kg, the power consumption is no more than 180 W, and the peak data transmission rate is about 52.06 Mbps. Based on the payload capacities of Chinese carrier rockets, the CZ-3A or CZ- 3B can be used to deploy the spacecraft over 3 launches using 1 rocket for 2 spacecraft. The deployment period and the selection of the launch vehicle depend on the orbital parameters. The most challenging task is the data transmission. In the traditional communication mode, the data transmission rate is about 5 Mbps at a distance of 0.25 AU away from the

Earth, and it will decrease to as low as 70 kbps at a distance of 2 AU, what is far lower than the desired scientific demand. A solution could be to reduce the data rate by enhancing the capability of the on-board data processing, compression and storage and decreasing the sampling frequency, or develop more efficient techniques for deep-space communication, e.g., laser communication.

The mission has a long implementation period and high cost, but significant prospects for science and applications. It can be implemented in 3 phases, with 2 spacecraft deployed per phase. The successful implementation of any stage can bring great progress in detection ability and scientific research; at the same time, the design of grouping allows for international cooperation. The concept of the Solar Ring mission was gradually formed from L5/L4 mission concept, and the proposal of its pre-phase study was funded by the National Natural Science Foundation of China in November 2018 and then by the Strategic Priority Programme of the Chinese Academy of Sciences in May 2019.

Wang, YuMing; Ji, HaiSheng; Wang, YaMin; Xia, LiDong; Shen, ChengLong; Guo, JingNan; Zhang, QuanHao; Huang, ZhengHua; Liu, Kai; Li, XiaoLei; Liu, Rui; Wang, JingXiu; Wang, Shui, (2020), "Concept of the solar ring mission: Overview", *Science China - Technological Sciences*, 1869-1900, DOI: 10.1007/s11431-020-1603-2

Wang, YaMin; Chen, Xin; Wang, PengCheng; Qiu, ChengBo; Wang, YuMing; Zhang, YongHe, (2020), "Concept of the Solar Ring mission: Preliminary design and mission profile", *Science China - Technological Sciences*, 1869-1900, DOI: 10.1007/s11431-020-1612-y

SATELLITES

FENGYUN

A new Fengyun (FY) meteorological weather satellite was undergoing final tests at the Shanghai Academy of Spaceflight Technology and was expected to come out of the factory by the end of 2020. The new satellite will operate from a polar morning-evening orbit, a configuration, not done before. This will enable China to update its global polar-orbiting meteorological satellite data in 4 hours, improving its numerical weather forecast capacities. 4 more FY-3 satellites are under development.

FENGYUN 4 DATA FOR BANGLADESH

In order to deal with the very severe cyclonic storm Amphan, the Bangladesh Meteorological Department on 17 May made a request to the World Meteorological Centre Beijing (WMC-BJ) for satellite data.

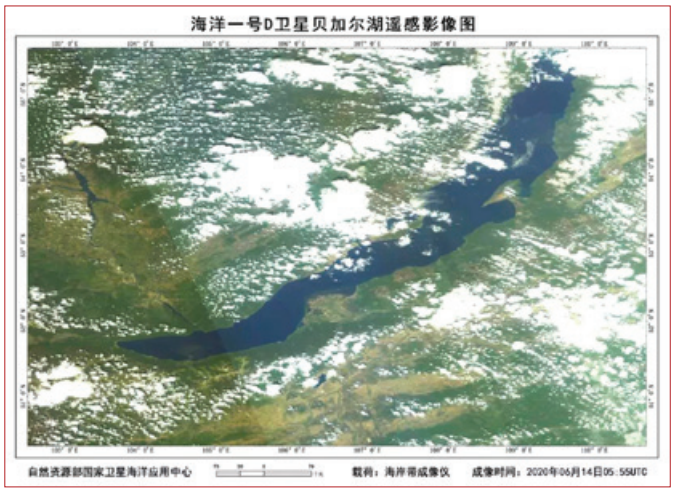
WMC-BJ organised via China's National Meteorological Centre (NMC) real-time FY-4 high precision monitoring data, GRAPES-GFS (**G**lobal/**R**egional **A**ssimilation and **PrE**diction **S**ystem) global NWP (Numerical Weather Prediction) products, and global refined grid point prediction products of NMC. Prior to that, the National Meteorological Information Centre (NMIC) and the National Satellite Meteorological Centre (NSMC) assisted Bangladesh in solving the technical issue of meteorological data reception.

Online resources of Fengyun weather satellites

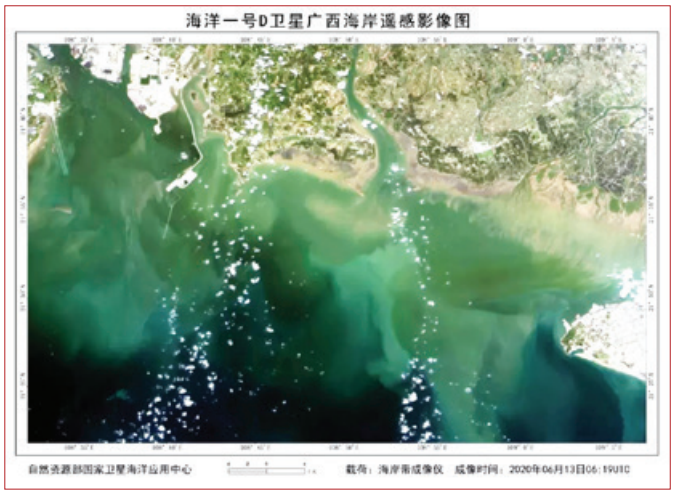
- Emergency Support Mechanism for International Users of Fengyun Satellites
- CMA global satellite images RSAPP
- FY-4 Satellite Image
- CMA-SWFDP-Model Outputs

HAIYANG 1D

The new ocean observation satellite HY-1D (Haiyang 1D) passed factory tests on 9 May. It was launched on 11 June (BJT) and has sent back its 1st batch of remote sensing images on 14 June. The data were received by 3 ground stations in Hainan Province, Beijing and Heilongjiang Province. The satellite is owned by the Ministry of Natural Resources and is operated by the Ministry's National Satellite Marine Application Service. The HY-1D satellite and its payloads, which include an ocean colour and temperature scanner and calibration spectrometer, have started normal operations. The satellite is China's 4th satellite for monitoring ocean colour and - together with HY-1C - became part of China's civil space infrastructure system.



Lake Baikal in Siberia was imaged by HY-1D on 14 June 2020 at 05:55 UTC. Credit: National Satellite Marine Application Centre



This view of Guangxi, Guangdong Province was acquired by HY-1D's Coastal Zone Imager on 13 June, 06:19 UTC. Credit: National Satellite Marine Application Centre

TIANQIN PROJECT

Tianqin 1

On 21 May, Luo Jun, Chief Scientist of the space gravitational wave detection project Tianqin (Lyra) at Sun Yat-sen University in Guangzhou, Guangdong province, told media that in-orbit testing of all 6 technologies of Tianqin 1 were successfully concluded and the results surpassed the mission requirements. The 6 technologies are: high-precision inertial sensing, micro-Newton variable thrust cold air propulsion system, drag-free control, high-precision laser interferometry, high-stability temperature control, and high-precision centroid control.

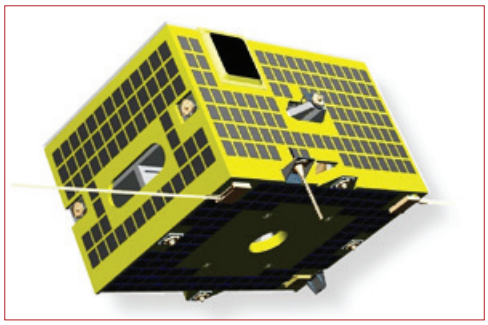
The test results of high-precision inertial sensing technology have been improved by 2 orders of magnitude compared with the current domestic level, making China the 2nd country in the world to master high-precision inertial reference technology. The micro-Newton propulsion system has also reached the international advanced level.

Luo Jun noticed that the excellent performance of the satellite platform contributed to the successful in-orbit verification, stressing the importance of cooperation between scientific research institutions and industrial partners.

Launched in December 2019, the satellite is in good condition, and in a next stage, the experiment will be extended to

2 satellites and finally to 3 satellites forming a triangle-shaped configuration around the Earth.
Tianqin 2 is planned to be launched around 2025. The project proposal documentation for the satellite has been handed over to the relevant departments before the Spring Festival.
The "0-1-2-3 Plan" is a technical roadmap drawing up a staged approach to the development of the key technologies for gravitational wave detection. The 1st stage is realised with the Tianqin 1 satellite. The figure "2" refers to the 2nd stage with two satellites in orbit, once Tianqin 2 is launched. The figure "3" in the roadmap refers to the deployment of 3 satellites in orbit about 100,000 km from the Earth around 2035, resembling an equilateral triangle formation with a side length of about 170,000 km to build a space-based gravitational wave observatory-"Tianqin". When a gravitational wave passes the observation area, the 3 satellite-formation will be able to detect it. At present, several teams such as the Tianqin Centre of Sun Yat-sen University, the Gravity Centre of Huazhong University of Science and Technology, and the Dongfanghong Satellite Co., Ltd. are cooperating on the project.

J. Luo, et.al., (2020), "The first round result from the TianQin-1 satellite", *Classical and Quantum Gravity*, 37, 18, DOI: 10.1088/1361-6382/aba66a



Tianqin 1 satellite design concept. Credit: Tianqin Centre of Sun Yat-sen University

SHIJIAN 20

Shijian 20, China's biggest and most advance communication test satellite has completed all of its 84 in-orbit tests and technology demonstrations and verifications, among them the 1st orbital demonstrations for ultra-high-capacity and ultra-high-speed laser communications, high security, anti-electromagnetic interference capability, electric propulsion and other advanced technologies. *Compare GoTaikonauts! issue no. 30, p. 24*
The 8 t-satellite carries more than 10 high-tech payloads. SJ-20 will continue to conduct other tests and experiments.
Shijian 20 was launched on 27 December 2019. It has a designed lifespan of 16 years. SJ-20 is the 2nd satellite based on the new DFH 5 platform after Shijian 18 which was lost during the CZ-5 launch failure in July 2017.

Sanya 1 satellite in 2021

The province of Hainan plans to launch in 2021 the Sanya 1 satellite for the Hainan Earth-Observation Satellite Constellation System. The double satellite configuration will be used for high-resolution remote sensing to provide data to agriculture and forestry, fishing industry and ocean research. Sanya 1 is being developed by Satellite (Zhuhai) Aerospace Technology using technology from Harbin Polytechnic University.
4 satellites of the Hainan 1 series and 2 of the Sansha 1 series will become part of the constellation.
The Governor of Hainan said earlier, he welcomes the intention to set-up on Hainan island, a China-Russia centre for cooperation in space and aviation technologies. Currently the construction of the Yazhou Bay Science and Technology City in Sanya is ongoing. In 2019, 51 enterprises and scientific research institutions have applied to settle in that area.

PALAPA N1 FAILURE

According to an analysis by Blaine Curcio for the blog westeastspace.com the impact of the launch failure of the CZ-3B rocket carrying the Palapa-N1 satellite onto the Indonesian satellite communications (satcom) market should be short-term. This is despite the fact that it is the 2nd time in less than a year that a Chinese-built satellite with Indonesia capacity has failed to reach orbit, with August 2019 launch failure of ChinaSat-18 having an admittedly much smaller, but still sizable Indonesia Ku-band beam.
Curcio stated that the Indonesian satellite communications market - one of the biggest in the world - has now to deal with ~10 Gbps of less capacity. Analysts say that there are certain overcapacities which can be leased for serving the Indonesian market and the SATRIA satellite (around 15 x the size of Palapa-N1) is planned for completion in 2022. Curcio points out that at the time of the contract-signing for Palapa-N1 in 2017, there was also a non-binding agreement for a PSN-7 satellite that would aim to deliver 100 Gbps of capacity on 104 spot beams in Indonesia, Philippines, and broader Southeast Asia. This project might become more realistic now.

APPLICATIONS

PRECISION AGRICULTURE

In China's major rice-growing region of Guizhou Province, a satellite system based on integrated Big Data is in use for monitoring rice farming from space and supporting decisions on the best time for planting. The system provides remote sensing imagery of paddy fields compared against visual monitoring and combines real-time data of local meteorological and planting conditions.The system was developed by a research team of the University of Electronic Science and Technology of China (UESTC) in Chengdu, in Sichuan Province, using self-designed core algorithms as well as technologies such as satellite remote sensing, the Internet-of-Things, and unmanned aerial vehicles.

Aaerial photos taken on 8 April 2020 show the construction site of Yazhou Bay Science and Technology City in Sanya. Credit: Xinhua/Yang Guanyu

ESASky in Chinese

In cooperation with the National Astronomical Observatories of the Chinese Academy of Sciences (NAOC), the Chinese language version of ESA's interactive celestial atlas, ESASky, has been released on 11 June. ESASky is a web-based application allowing users to zoom in on any celestial object and display data collected from more than 50 space missions and ground-based observatories across all frequencies of the electromagnetic spectrum.

GAOFEN APPLICATION

For the observation of the dynamics of fast-moving landslides, the traditional pixel offset tracking methods work well. Researchers from the Chinese Academy of Sciences proposed an improved offset tracking method using SAR data from the Gaofen 3 satellite and the Advanced Land Observing Satellite 2 (ALOS-2) to optimise a more efficient workflow, as well as an improved algorithm based on homogeneous samples. The method was applied for the first time to study the evolution of the landslide that happened in 2018 in Southwest China's Tibet Autonomous Region. The findings suggest that SAR data seem to be better suited for long-term monitoring of landslide-prone areas.

Hongying Jia, Yingjie Wang, Daqing Ge, Yunkai Deng, Robert Wang, (2020), "Improved offset tracking for predisaster deformation monitoring of the 2018 Jinsha River landslide (Tibet, China)", *Remote Sensing of Environment*, 247, 111899.

PLANETARY DEFENCE AGAINST NEO IMPACT

Experts from the National Space Science Centre (NSSC) under the Chinese Academy of Sciences developed a simulation of a space mission preventing the impact of a hazardous asteroid into Earth. The concept proposes the launch of an unmanned spacecraft which would collect more than 100 t of rocks from a near-Earth asteroid (NEO). With that load the craft would impact an asteroid that poses a threat to the planet. The simulation showed that this method would be effective in redirecting the potential hazardous asteroid out its collision trajectory with Earth.

STARLINK APPLICATIONS FOR CHINA?

An article by Xinmei Shen for the Abacus/South China Morning Post looked into the realistic possibilities for SpaceX to offer internet service to China via its Starlink constellation. While technically there should not be any hurdle, the main problem would be to get the permission from authorities which is needed by any foreign company for providing services in China.

In a 1st step, a permission from China's Ministry of Industry and Information Technology (MIIT) is required. MIIT assesses the system compatibility and frequency coordination between foreign satellites and China's own communication satellite systems. That includes that the foreign operator has to comply with all of China's telecommunications regulations, including data supervision by governmental institutions leading to a certain degree of censorship. If the use of Chinese ground stations is needed, they are exclusively controlled by China. Considering that Starlink is opting for ISL (inter-satellite links), the Chinese authorities might not accept a foreign signal from space with direct access to the Chinese internet. A last hurdle for Starlink's access to the Chinese market could be the fact that China most likely would demand access to the technology.

ONLINE APPLICATION FOR OCEAN SATELLITE DATA

An ocean satellite data archive, developed by the National Satellite Ocean Application Service of the Ministry of Natural Resources and comprising the data of the Haiyang 1, Haiyang 2 series satellites and the China-France Oceanography Satellite (CFOSat), went online on 14 May. The system received 20,000 visits and 838 users registered on the 1st day. 161 organisations downloaded data. Users can check the daily, weekly and monthly archives and distribution of ocean satellite data on the WeChat account of the National Satellite Ocean Application Service.

CFOSat - China-France Oceanography Satellite

Under the leadership of the Chinese and French Chief Scientists of CFOSat, the 1st batch of results of the rotating fan beam microwave scatterometer of China and France, the instrument verification of China and France star wave spectrometer and the evaluation of ocean wave spectrum measurement were published by IEEE (TGRS) magazine.

Jianqiang Liu; Wenming Lin; Xiaolong Dong; Shuyan Lang; Risheng Yun; Di Zhu; Kuo Zhang; Congrong Sun; Bo Mu; Jianying Ma; Yijun He; Zhixiong Wang; Xiuzhong Li; Xiaokang Zhao; Xingwei Jiang, (2020), First Results From the Rotating Fan Beam Scatterometer Onboard CFOSAT, *IEEE Transactions on Geoscience and Remote Sensing*, 58,12, pp. 8793-8806, DOI: 10.1109/TGRS.2020.2990708.

EO Application

Researchers from the Northeast Institute of Geography and Agroecology of the Chinese Academy of Sciences collected 2,152 samples from 34 field campaigns from 2013 to 2018. Based on both measured data and Landsat OLI (Operational Land Imager) remote sensing data, they developed regression models to map water clarity with a 30 m resolution at a national scale. Water clarity is a reliable indicator for quantifying eutrophic status. The map shows that the lakes in north-eastern and eastern China had low clarity while lakes in the Yunnan-Guizhou Plateau, Inner Mongolia Autonomous Region and Xinjiang Uygur Autonomous Region exhibited medium clarity, and lakes in the Qinghai-Tibet Plateau displayed the highest clarity.

EO Application

"Remote Sensing of Urban Green Space" - China's 1st monograph that comprehensively studies urban vegetation from the perspective of remote sensing was published by Science Press beginning of May.

The book focuses on the evaluation of urban green areas such as parks, forests, green roof tops, and gardens, by using remote sensing technologies such as 2D or 3D information extraction technology, measurement technology, multi-scale perception technology, as well as integrating multi-source data from satellites, airplanes, and near-Earth measurement. The book, authored by Prof. Meng Qingyan from the Aerospace Information Research Institute (AIR) of the Chinese Academy of Sciences, can be used as a reference book for urban and landscape planning, environmental protection experts, as well as for students at universities and research institutes.

BEIDOU NAVIGATION SATELLITE SYSTEM (BDS)

45th BEIDOU

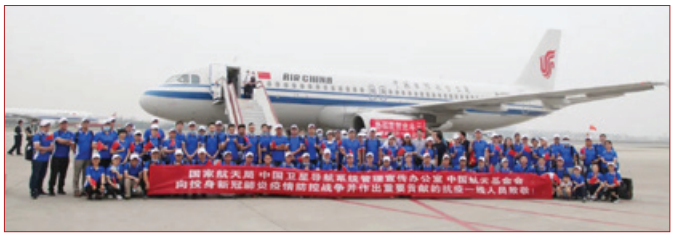
By mid-May, the 45th BDS satellite completed in-orbit testing and started operation. The satellite replaced the 3rd Beidou/Compass satellite, a BDS-2 GEO satellite which was launched on 17 January 2010. The replacement will help to reinforce the BDS-2 system and support a smooth transition from BDS-2 to BDS-3. The 3rd satellite will remain in orbit after operations were shifted to the 45th satellite but it will stop working.

54th BEIDOU

The 54th BDS satellite has started operation beginning of June after completing in-orbit tests and network access evaluations.

55th Beidou satellite

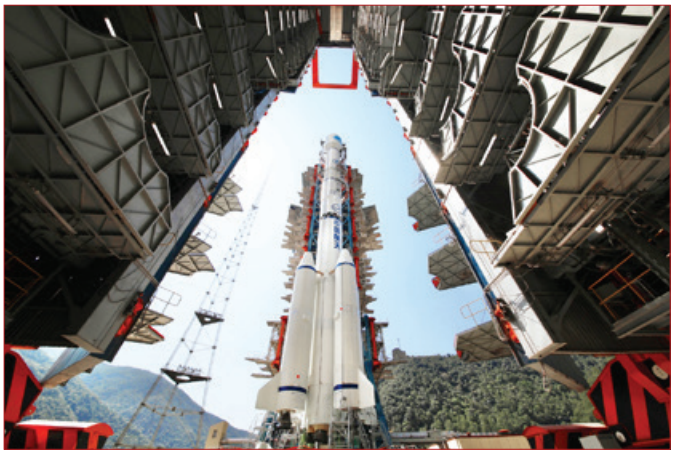
The 55th BDS satellite of the Beidou family which is also the 30th in the 3rd generation series as well as the last BDS-3 satellite, arrived at the Xichang Satellite Launch Centre on 4 April where it was processed and tested. Initially, the launch was planned for beginning of May. On 15 June, the China Satellite Navigation Office announced that the 55th satellite was finally ready for launch. The GEO satellite underwent technical checks, fuelling and pre-launch preparation along with the CZ-3B carrier rocket. The launch window was set for the 16 June between 10:11 and 10:50 BJT. For that date, almost 100 front-line workers who helped fight the Coronavirus pandemic in Hubei or assisted overseas or in their hometown arrived at the Xichang Satellite Launch Centre. They were invited by the China National Space Administration, the China Satellite Navigation Office and the China Aerospace Foundation to attend the launch of the last Beidou 3 satellite.



Frontline workers arrived for the Beidou launch in Wenchang. Credit: Xinhua

On 16 June, engineers discovered during pre-launch checks technical problems with the CZ-3B rocket. As a result, the launch was postponed. On 22 June, Xinhua reported that the technical problems had been solved and the launch was scheduled for 23 June. CASC revealed on 23 June that data reading from a pressure release valve indicated an issue with a 3rd stage hydrolox engine, calling off the 16 June launch.

The CZ-3B carrier rocket is on the launch pad at the Xichang Satellite Launch Centre in Southwest China's Sichuan province. Credit: CALT/Ning Hong, CGTN



The CZ-3B carrier rocket is on the launch pad at the Xichang Satellite Launch Centre in Southwest China's Sichuan province. Credit: CALT/Ning Hong, CGTN

The fairing is lifted to the CZ-3B carrier rocket at the Xichang Satellite Launch Centre in Southwest China's Sichuan province. Credit: CALT/Ning Hong, CGTN

Construction timeline of the Beidou Satellite Navigation System - BDS

China completed the construction of the BDS with the launch of its final, the 55th, satellite on 23 June 2020. (Note: The 55th satellite is sometimes called the 59th satellite what is correct when also counting the 4 test satellites - BDS-1A, B, C, and D of the BDS-1 experimental network.)

Named after the Chinese term for the celestial constellation of the Big Dipper, the Beidou navigation system was deployed in 3 phases. The construction of the 1st phase started in the 1990s.

Milestones

1994-2000: construction of BDS-1

2004-2012: construction of BDS-2

2012: A total of 14 satellites, including 5 GEO satellites, 5 IGSO (inclined geosynchronous Earth orbit) satellites and 4 MEO satellites, were deployed. BDS began providing positioning, navigation and timing services to users in the Asia-Pacific region.

May 2014: The BDS augmentation system achieved a positioning accuracy within 1 m - a major breakthrough for marine applications.

September 2015: The 20th BDS satellite was launched. For the 1st time, a satellite was equipped with a hydrogen atomic clock. The clock and a new navigation-signal system underwent a series of tests.

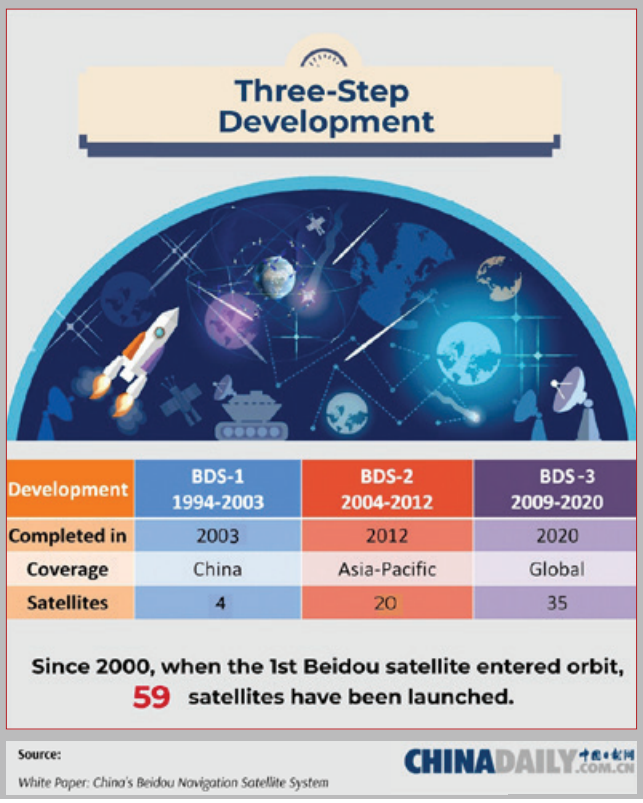
November 2017: The first 2 satellites for the BDS-3 system were launched.

November 2018: Launch of the 41st BDS satellite, which was also the 1st BDS-3 GEO satellite.

By the end of 2018: 33 BDS satellites were in operation, allowing for transition from a regional navigation system into a global network. The positioning accuracy of the system reached 10 m globally and 5 m in the Asia-Pacific region. The velocity accuracy was 0.2 m/s, while the timing accuracy reached 20 nanoseconds.

2019: 10 BDS satellites were launched. All BDS-3 MEO satellites started operation what ensured the completion of the core BDS-3 constellation.

23 June 2020: Completion of the fully operational Beidou navigation system with the launch of the final Beidou satellite.



BEIDOU INTER-SATELLITE LINKS

The Xi'an Satellite Control Centre confirmed that the 2 year-long series of testing of inter-satellite links (ISL) between 29 BDS satellites of the 3rd generation meets the demands for the operation of the global constellation. ISL antennae, fitted to the BDS-3 satellites, extend the visible arc of the MEO satellites and enhance ground stations' capability for orbit determination. Also, ISLs enable the communication between satellites when no ground station is in reach and commands sent by the control centre to one satellite in the constellation is transmitted to all. Since China has no BDS ground control network fully covering the globe, this innovative feature of the GNSS will contribute to greater accuracy for the system users.

Currently, the Beidou system is the only GNSS with ISLs for ranging, mission dissemination, and command & control.

The paper: Yang, Y., Mao, Y., Sun, B., (2020), "Basic performance and future developments of Beidou global navigation satellite system", *Satellite Navigation*, 1, 1, DOI: 10.1186/s43020-019-0006-0 summarises the results in the determination of satellite orbit and clock offset, enabled by BDS-3 inter-satellite links: "According to the preliminary calculation results, the ranging accuracy of the ISLs of BDS-3 is about 4 cm; if the satellite orbits are determined using only regional station observations, the three-dimensional orbit accuracy of the overlapping arc is about 60 cm; with ISL measurements, the orbit accuracy is about 30 cm, the 24-h orbit prediction accuracy is also raised from 140 to 51 cm, and the radial accuracy can reach 10 cm, as evaluated through laser observations."

BEIDOU Mt. Everest/Mt. Qomolangma

A new measurement of the height of Mt. Everest/Mt. Qomolangma was jointly organised by the Ministry of Natural Resources, the Ministry of Foreign Affairs, the General Administration of Sports of China and the regional government of the Tibet Autonomous Region. The aim was to find out whether the 2015 earthquake had an effect on the mountain's height.

Since 1949, Chinese surveyors have been on 6 expeditions. In 1975 the height of the peak was calculated to be 8,848.13 m and in 2005 to be 8,844.43 m. This time, Nepal and China jointly calculated the new height. For that, both nations sent expeditions to the peak.

After 2 attempts, 8 members of the Chinese surveying team reached the summit of Mt. Qomolangma in the morning of 27 May 2020 via the northern Tibetan route. On the summit, the expedition team installed a survey marker and a GNSS (Global Navigation Satellite System) antenna. The surveyors used a global navigation satellite system receiver, a gravimeter, snow-depth radar and an instrument to collect meteorological data. China Mobile confirmed to media that it provided the 5G network for communication and high-definition live streaming. Huawei has worked with China Mobile to offer detailed terminal-to-terminal solutions.

Technicians set up a China Mobile 5G base station integrated with the Beidou system at a camp 6,500 meters above the sea level en route to the peak of Mount Qomolangma/Mount Everest in May 2020. Credit: Jigme Dorji/Xinhua

During the 2005 expedition, the GNSS satellite measurement mainly relied on the U.S. GPS system. But in 2020, reference data from all 4 existing GNSS systems - GPS, Galileo, GLONASS, and BDS were used. The BDS receiver can also monitor relevant region's crustal movement.

Data from the 2nd generation GEO meteorological satellite Fengyun 4, as well as the Zhongxing 6A communication satellite were provided to the expedition team. From Lhasa to the Base Camp, and to the Advanced Camp at 6,500 m, the Zhongxing 6A was received by a vehicle-mounted Ku-band communication system, enabling stable internet services and emergency communication.

Also, an aerial gravimeter which can collect gravity data was brought for the first time atop the mountain. It can support the understanding of plate tectonics in the region. It will probably take 2-3 months for the scientists to calculate and release the exact height of Mount Qomolangma.

BEIDOU business platform

On 14 May, 12 Chinese state-owned enterprises (SOEs) inaugurated the Beidou Industry Collaborative Development Platform for the collaborative development of the satellite navigation industry, and for promoting the integration of the BDS with technologies such as 5G, Big Data and cloud computing. The platform will focus on improving innovation, competitiveness and influence of the industry, with more advanced technologies and products as well as business models. The aim is to promote large-scale applications and industrialisation of the BDS.

BEIDOU APPLICATIONS

The Agricultural Machinery Bureau of the Xinjiang Uygur Autonomous Region reported that more than 10,000 sets of agricultural machinery like tractors, planting or harvesting vehicles, drones and other equipment are using the Beidou Navigation Satellite System (BDS) for efficient agriculture.

BEIDOU APPLICATIONS

During a press conference on 18 June, the Ministry of Transport announced a mid- to long-term roadmap for promoting and expanding the implementation and application of Beidou in the national railway, highway, waterway, civil aviation and postal services. The intention is to synchronise progress in the development of the transportation industry with progress in the Beidou system and to provide the public with more extensive, more integrated and more intelligent positioning and navigation services.

BEIDOU INDOOR APPLICATION

The National Key Laboratory of Navigation Satellite System and Equipment Technology installed a testing environment for indoor positioning service. Using 6 pseudo satellites, the indoor positioning accuracy can reach around 10 cm. Still, indoor positioning determination is a challenge. It involves multiple technologies such as a Global Navigation Satellite System (GNSS), WiFi, Bluetooth and 5G. Applications for android robots on wheels and drones are relying on the technology network to navigate through complex indoor environments.

BEIDOU APPLICATION AGRICULTURE

Nanjing Agricultural University has developed the Beidou-supported uncrewed wheat seeding and harvesting technology. The smart technology integrates technological elements of Beidou navigation, IT, and agricultural engineering into the whole process of wheat production. Next to those technologies, data from navigation, multi-dimensional sensors, uncrewed vehicles, and Internet-of-Things are used for this application.

2020 WHITE PAPER on BEIDOU INDUSTRY

The Global Navigation Satellite System and Location-Based Service Association of China released during an online event on 18 May in Beijing the "2020 White Paper on the Development of China's Satellite Navigation and Location Service Industry". The paper is published annually since 2009 and contains a comprehensive analysis and summary of the current status of China 's satellite navigation industry. 2020 is the 25th anniversary of the establishment of China Satellite Navigation and Positioning Association.

As stated in the paper, China's satellite navigation industry in 2019 was affected by multiple factors such as changes in the macroeconomic situation, the decline in domestic demand, the slowdown of new markets, and the intensification of international competition.

In 2019, the overall value of satellite-enabled navigation and positioning services in China was 345 billion RMB (48.8 billion USD), a 14.4% increase compared to 2018.

The output value of the industry's core sectors, which are directly related to the development and application of the satellite navigation technology, reached 116.6 billion RMB.

However, the growth rate of the core output value of chip, device, algorithm, software, navigation data, terminal equipment and infrastructure sectors, was 9.1%, lower than in 2018 caused by lower domestic demand and more competition. The output value of Beidou-related applications reached 228.4 billion RMB, up by 17.3% compared to 2018.

The number of satellite navigation patent applications in China exceeded 74,800.

In 2019, BDS products were exported to more than 120 countries and regions, 20 more than in 2018.

BDS has been applied in more sectors including precision farming, digital construction and smart port construction and was benefiting regions such as the Association of Southeast Asian Nations (ASEAN), South Asia, Eastern Europe, West Asia and Africa.

BDS provided high-precision solutions on the sub-metre level to customers with wearable devices, such as kids' watches, bracelets for seniors and pet trackers.

By the end of 2019, more than 100 million Beidou-based navigation chips, modules and other products had been sold, and the number of China's satellite navigation terminal products reached 460 million pieces.

By the end of September 2019, out of the 400 position-providing smartphone types that applied for wireless network access to the Chinese market, nearly 300 support BDS. About 70% of mobile phones registered in China are compatible with Beidou-enabled services.

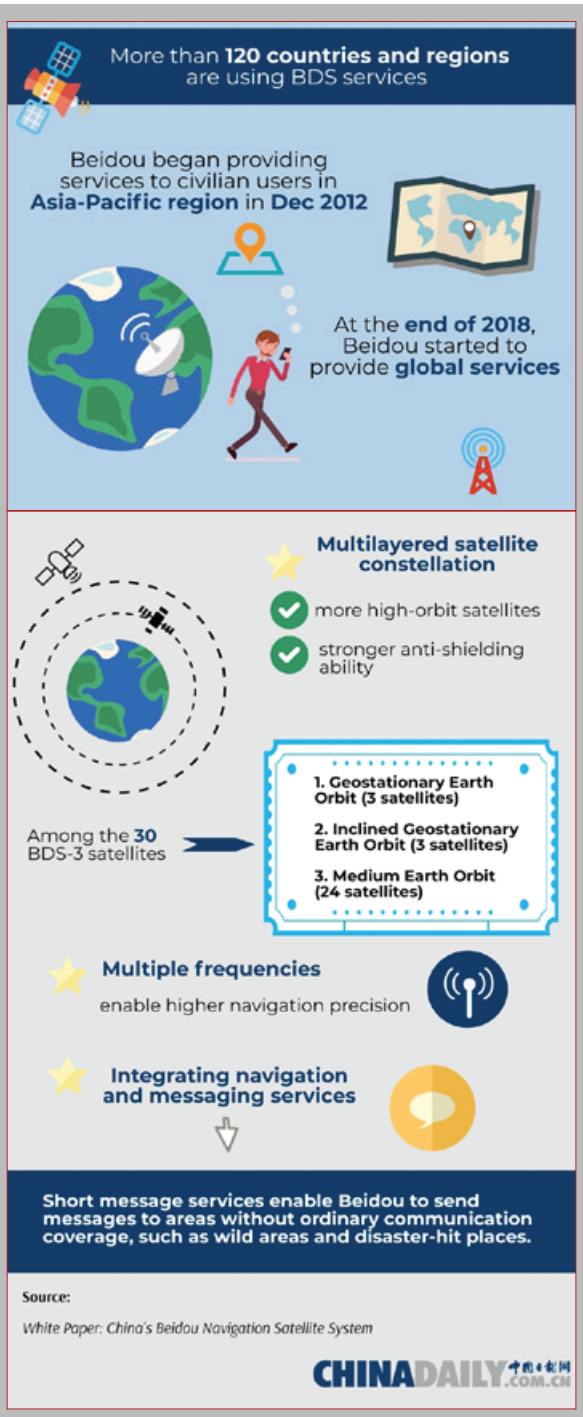
Until September 2019, BDS had been applied to nearly 6.6 million taxis, buses and trucks as well as more than 70,000 fishing vessels. More than 10,000 fishermen had been rescued or received assistance via a Beidou device.

Over 3,200 navigation facilities along rivers and more than 2,900 maritime navigation establishments employ Beidou services.

Beidou-enabled functions for improved efficiency are also used in at least 50,000 agricultural machines.

In the public security sector, more than 400,000 portable terminals used by the police have Beidou-enabled positioning functions. Beidou-based applications ensured the security set-up for events such as the Asia-Pacific Economic Cooperation summit in Beijing in 2014 and the Group of 20 Summit in Hangzhou, Zhejiang province, in 2016.

More than 500,000 Chinese people work at about 14,000 domestic institutes and companies doing business related to Beidou and other satellite navigation and positioning services.



An unmanned tractor equipped with a Beidou navigation system sows a new crop in the village of Anzhong in Dengzhou, Henan province, on 26 May. Credit: Feng Dapeng/ Xinhua

Cotton pickers with Beidou Navigation Satellite System are working on the field. Credit: China Daily/Mao Weihua

ADVANCED TECHNOLOGY

SCMP reported mid-June that scientists at the Xinjiang Technical Institute of Physics and Chemistry in Urumqi have developed a high-performance basalt fibre material from analogue lunar dust that might be strong enough to build a base on the Moon, and could potentially be made by using in-situ volcanic rock on site.
During testing, the researchers achieved a tensile strength of up to 1.4 gigapascals - or 1,400 megapascals. The team sourced soil from the Changbai Mountain, an active volcano on the Chinese-North Korean border. The soil dust is made of about 48% silicon dioxide and 17% aluminium oxide – very close to the composition of samples brought back from the Moon by NASA's Apollo 14 mission in 1971. The dust was heated to more than 1,300ºC until it melted, then rapidly cooled so that it turned into glass. After that, the material was ground to a powder, melted again by a slightly higher temperature, and then fed through a nozzle to produce a continuous filament. A Chinese blueprint for a Moon base construction site includes huge mirrors to reflect sunlight to a heat collector that could go up to 1,000ºC or higher – meaning basalt fibre could be created on site.
An ESA team in ESTEC used lunar dust and urea with a 3D-printed rod to make a construction material that could withstand 32 megapascals of pressure - about half the strength of some commercial concrete. Back in 1998, NASA's "waterless concrete" made from simulated Moon dust broke apart when it was pulled at a force of 3.7 megapascals.

ADAPTIVE OPTICS TECHNOLOGY

The laser communication team from the Institute of Optics and Electronics (IOE) of the Chinese Academy of Sciences (CAS) has applied adaptive optics technology to the geosynchronous orbit coherent optical communication experiment. Atmospheric turbulences affect the satellite-to-ground link resulting in signal beam wave front distortion, spot dispersion and jitter, which affect the reception of ground signal light energy, especially the single-mode fibre reception of coherent laser communication. Adaptive optics technology ensures high-speed, high-reliability satellite-to-ground laser communication, compensating for atmospheric turbulence interference at night and part of the daytime. Under the medium strong atmospheric turbulence intensity, the wave front distortion and beam jitter of the satellite downlink signal beam are significantly suppressed after adaptive correction. The tracking accuracy is superior to submicron arc level, and the wave front accuracy is better than λ/10, both of them ensure a highly efficient coupling of space light to single-mode fibre.
After adaptive optics correction, the average received power of single-mode fibre has increased from 0.2 NW to 4.8 NW, which has significantly improved the SNR of coherent receivers.
Next, the team will work on building a single-station laser communication system that can work all day.

CNF MATERIAL for AEROSPACE

A research team at the University of Science and Technology of China in Hefei developed a plant-based or bacteria produced cellulose nanofiber (CNF) material with properties on the microscale (1/10,000th of a human hair in diameter) superior to ceramics and metals. It could be a greener alternative for substituting plastics in automobiles, aircraft and precision instruments, particularly for aerospace applications, such as optical lens bracket for a lunar rover which requires lightweight, high strength and stability under extreme temperatures.
The density of the new material is only 1/6 of that of steel. With outstanding strength and toughness, it is capable of withstanding temperatures in the range of minus 120ºC to +150ºC.
However, macroscale CNF materials become much weaker and to construct high-performance CNF materials remains challenging.

COMMERCIAL SPACE - SATELLITE

Bilibili

On 1 June, the International Children's Day, China's online video sharing platform Bilibili announced that it will launch a 172 kg multifunctional remote sensing satellite in late June for the production of popular science content.
The satellite was developed by Changguang Satellite Technology Co., Ltd., (CharmingGlobe) and transported to the Jiuquan Satellite Launch Centre on 11 May. Launch preparations were progressing smoothly.
The satellite is capable of high-precision 3D remote sensing of the Earth. Two cameras provide 1 m resolution imagery and wide swath observations with 50 m resolution. The satellite can image city lights at night, observe changes of the Earth's aurora, and also observe space objects such as the Moon and Saturn.
An official account for the satellite has been launched at Bilibili.com for the live streaming of the satellite launch later in June. Popular science videos will be produced and regularly updated based on the remote sensing videos and pictures captured by the satellite. Established in June 2009, Bilibili is a culture community and video platform, popular among the younger generation in China. The company said that the "Bilibili Video Satellite" is a gift to people with a curious mind. Observers expect that the satellite will join the Jilin constellation of satellites operated by Charming Globe.

BNU-1

After 9 months of extensive in-orbit testing and debugging, China's first polar-observing satellite "Ice Pathfinder" (BNU-1) has started its Arctic observation mission. The 1st batch of Arctic remote sensing data has been processed.
BNU-1 was developed by scientists of the Beijing Normal University (BNU) and Sun Yat-Sen University. It was designed to provide coverage between 85º North and South latitudes (Landsat's coverage is 82.5º). BNU-1 is a technology test mission and will have a revisit time of 7 days. The team from the Sun Yat-Sen University proposed to develop a mini SAR (synthetic aperture radar) satellite for polar regions to complement the results from BNU-1.

CGWI and HKATG

China Great Wall Industry Corporation CGWIC and the Hong Kong Aerospace Science and Technology Group (HKATG) signed a "strategic cooperation agreement" in the 2nd quarter of 2020. HKATG intends to purchase the "Golden Bauhinia" LEO satellite system, including supporting ground facilities and related equipment from CGWIC. The two sides agreed on design and planning, development, testing, launch and in-orbit delivery of the "Golden Bauhinia" satellite constellation. In addition, both parties will carry out in-depth cooperation in areas like commercial deep-space exploration, data application services and product promotion, training and capacity building, and will make use of CGWIC's commercial network and international expertise to jointly explore the market.
After step-wise completion in 2021, a 24-hour near-real time monitoring system covering 11 city clusters in the Greater Bay Area will be formed, making it the first intelligent city management basic data operator in the Greater Bay Area, and initiate regional commercialization services for that region. HKATG, a Big Data operator, was founded in September 2019.

China Unicom

As one of China's leading telecom operators, China Unicom, has entered with its subsidiary UnicomAirNet the satellite internet business to provide superfast internet access, video and audio connections, data transmission, remote-sensing data services and emergency response solutions via satellite.
UnicomAirNet is a mixed-ownership satellite telecommunications

company. At the end of April, the company went on an extensive promotion tour for advertising its service to potential customers in the governmental and corporate sectors, such as shipping vessel operators, inhabitants of remote islands, offshore oil rigs, drones, emergency response vehicles, passenger planes and forest fire departments. The company also runs a mapping service using satellite data for airport operators.

Commsat

Beijing Commsat Technology Development Co., Ltd. raised in mid-May 38 million USD in a Series B round of funding. The investment was led by Beijing Wealth Capital and an industry investment fund under AVIC Capital (a state-owned aerospace and defence conglomerate). The funds will be used for the development of internet satellite platforms, automated production lines and research and development of broadband communications systems.

GeeSpace

At the beginning of 2020 Geely Holding announced a commercial space programme executed by its commercial space entity, called: GeeSpace. *See GT! issue 31, p. 13/14*

Apart from the satellite production facility in Taizhou, GeeSpace will also be in charge of building and operating terrestrial ground stations within Chinese territory, remotely operated from a control centre. The first 4 stations will be in Korla in Xinjiang (North-West China), Hulunbuir in Inner Mongolia (North-East China), Taizhou (East China) and Shenzhen (South China). The 1st station in Korla will be equipped with a 7.3 m dish for linking the satellites and communicate through the 5G network with vehicles on the ground.

In April, GeeSpace published around 50 vacancy notes for high-paid space jobs. The company was looking for Photoelectric Engineers, Sales Manager, Satellite Payload Designer, Experts in PPP/GNSS orbit determination, and a Head of Rocket Department for its subsidiary Space-Time Daoyu in Shanghai. For the post of the Head of Rocket Department, a competitive salary of 60 to 120 kUSD was offered. Since April, more new job openings were posted: *https://jobs.51job.com/shanghai-xhq/co5404238.html#syzw*

Space-Time Daoyu aims at the integration of innovative industries, academia and R&D. Through in-depth cooperation with Huawei, China Mobile, universities and scientific research institutions, it will promote the development of China's future low-orbit satellite-based navigation enhancement and the establishment of a combined 5G/6G constellation - high-end terrestrial communication standard as well as promote commercial applications of China Beidou satellite navigation system outside China.

Hongyun

The 1st test satellite of CASIC's Hongyun Project, a LEO broadband communication system, has completed more than 180 communication tests, worked stably for more than 8,800 hours, carried out more than 5,000 instructions and conducted more than 20 in-orbit observation tests on a spectral thermometer. It has obtained more than 70 GB of image data and verified low-orbit satellite internet connection under different weather conditions and for different business scenarios. The 247 kg satellite works in a 1,100 km SSO. It has exceeded its 1-year design life and is expected to continue operating.

4 more Hongyun satellites will be launched for a larger-scale test. By 2025, 80 satellites should be operational. The final 150+ satellite constellation will allow internet access, video display and instant messaging services in remote regions. In case of high market demand, the constellation can be extended.

Internet – "New Infrastructures"

In April, China's National Development and Reform Commission (NDRC) added satellite internet to a list of "new infrastructures" (information infrastructure). This governmental move is a consequent continuation of existing policies (State Grid Project; Tiandi Integration Project) and will help to accelerate the industry's growth. Next to satellite internet also 5G, Internet-of-Things (IoT) and artificial intelligence, will become highly attractive for investment, leading to more innovation in the technology sector and stimulate the Chinese economy.

The planned satellite constellations will deliver internet access to people living or working in remote areas, not economically viable for landline networks. Also, planes or ships in the middle of the ocean would benefit from connectivity via satellite.

What is the National Development and Reform Commission?

The National Development and Reform Commission (NDRC) is responsible for steering and guiding a wide range of economic, financial, industrial and societal strategies and development projects of national importance. Based on the analysis of the domestic and international economic situation and trends in the global societies, the NDRC gives recommendations on which economic and financial instruments, societal stimulus and development policies are suitable for implementing its proposals. These analysis and suggestions are drafted into a comprehensive plan for national economic and social development which is submitted to the National People's Congress on behalf of the State Council.

Another task of the NDRC is to monitor macroeconomic and social development trends and provide forecasts and guidance for the national situation. It also formulates fiscal, monetary and land policies as well as price policies and it controls China's foreign debts.

The NDRC guides pilot and construction projects for the restructuring or balancing of the economy and for experimental reform zones. This also includes the formulation of strategies, plans and major policies for the development of high-tech industries and the advance of industrial technologies as well as the revitalisation of old industrial bases such as the north-eastern region.

Other areas of responsibility are the control of import and export of agricultural products, industrial products and raw materials and overseeing the state reserves of commodities. NDRC is also tasked with the coordination of social development policies with respect to population and family planning, science and technology, education, culture, health and civil administration, employment and income. Next to other issues, NDRC coordinates with the respective Ministries international negotiations regarding climate change and national efforts within the United Nations Framework Convention on Climate Change. This is a non-exhaustive listing of the NDRC's function, but it gives a glimpse of its importance and power in the national decision making process.

source: http://www.globaltimes.cn/db/government/3.shtml

MarineTel High-throughput Satellite Maritime Service

On 11 April, Sino Satellite Communications Co., Ltd., a subsidiary of China Satcom, started its new communication service, called: MarineTel High-throughput Satellite Maritime Service. Utilising ChinaSat-16, the service provides customised high-speed broadband communication services for different types of shipping and will help to optimise and upgrade the maritime satellite communication industry.

MinoSpace

MinoSpace secured in April a Series A3 funding of tens of millions of RMB from CITIC Construction Investment Co., Ltd., for the development and in-orbit test of larger internet communication satellite platforms and the acceleration of satellite manufacturing. CITIC's joining MinoSpace means also support for management and financial operation of MinoSpace,

making preparations for entering the capital market. The new fund adds to the A2 round of financing of 100 million RMB (14.2 million USD) in February.

One Web and Chinese Investors

The British newspaper *The Telegraph* reported on 9 May that 2 private companies with links to the Chinese government have submitted proposals to buy some of the assets of bankrupt British satellite constellation OneWeb. OneWeb has approached the U.S. Department of Defence about a possible support package and had been appealing to British officials to intervene by providing part of a rescue loan. However, the Government had not entered a bid as of mid-May - the initial deadline. The final call for bids was shifted to June 2020.

Origin Space

On 10 April, Origin Space has signed a contract with DFH Satellite Co., Ltd., for the development of the Yang Wang 1 optical space telescope. Origin Space gained expertise with 2 space telescopes: in September 2019 it launched the Taurus 1 (Jinniuzuo 1) CubeSat with a small UV-telescope for monitoring the atmosphere for asteroid impact events and it also works together with the Hong Kong University on the soft X-ray space telescope utilising lobster eye technology.

SpaceArk

On 11 May 2020, Beijing SpaceArk Technology Corp. Ltd., (Space Ark) held in Beijing's Dianshi Business Park, the Ark 2 satellite delivery ceremony along with the signing ceremony of the Ark series of satellite-carrying customers.

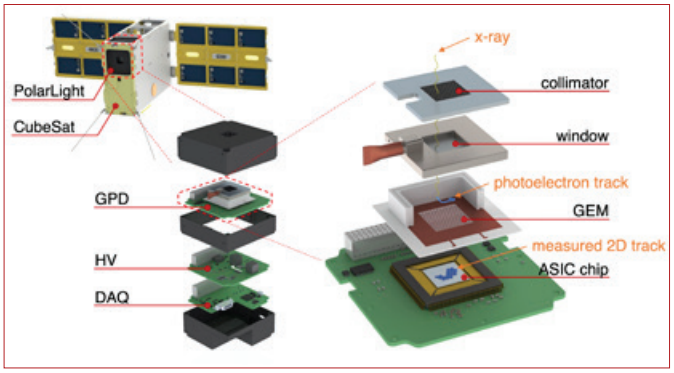
The Ark 2 in-orbit key technology verification satellite for the Ark series of satellites, is based on 6U cube satellite architecture and was independently developed by SpaceArk. It is planned to launch the satellite by the end of June 2020 into a 500 km LEO. SpaceArk's series of Ark satellites are small and medium-sized return spacecraft, suited for suborbital, LEO and deep-space re-entry applications.

SpaceTY

Results from PolarLight, one of 3 science payloads aboard SpaceTY's Tongchuan-1 6U cube sat, launched into SSO in October 2018, were published in *Nature Astronomy* on 14 May 2020. The payload used a novel technique to detect soft X-ray polarization in the Crab nebula.

PolarLight started regular science observations in March 2019 after a commissioning phase and is still in good health. The baseline objective of PolarLight is to have a direct demonstration of the new GPD (gas pixel detector) technique in space and a better understanding of the in-orbit background. Since X-ray polarimetry is relatively underutilised, scientific returns are also expected.

Feng, H., Bellazzini, R. The X-ray polarimetry window reopens. *Nature Astronomy,* 4, 5, 547 (2020). DOI: 10.1038/s41550-020-1103-6



Schematic drawings of the CubeSat, the PolarLight payload and its internal GPD. The right-hand side illustrates how a photoelectron track is measured following the absorption of an X-ray. Credit: Tsinghua University/adopted from Fig. 1 in Feng & Bellazzini 2020, Nature Astronomy, 4, 511.

SpaceTY

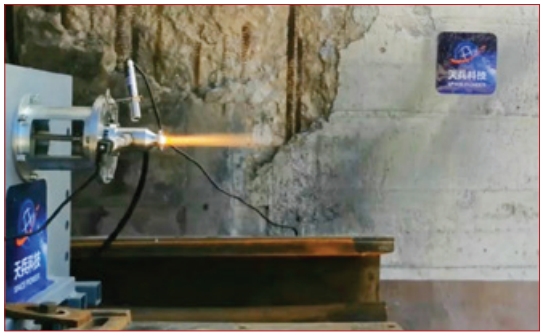
On 14 May, the Chinese version of "Fortune" magazine released a list of "China's 40 Business Elites Under 40". As the only commercial space entrepreneur, 38 years old Feng Yang, founder and CEO of SpaceTY (Tianyi Research Institute), was selected.

Can we Talk about ChinaSat's Market Capitalisation?

China Satellite Communications Company Limited (ChinaSat) is the leading satellite operator in China, with a fleet of more than 10 satellites in geostationary orbit. The company has for decades broadcast central and provincial government TV channels, as well as some foreign channels, across China and broader APAC on a fleet of Chinese-built satellites. This business model is a well-established one. ChinaSat also conducted an IPO last year, floating around 9% of the company's share capital on the Shanghai Stock Exchange. This was a big deal in China, with ChinaSat being one of the rare examples of a well-established space company offering shares for public trading. In the ~11 months since, though, we have found that apparently it was a much, much bigger deal than originally expected. How so, you ask? Blaine Curcio of Orbital Gateway Consulting provides the answer in a blog post on westeastspace.com

Space Pioneer (Tianbing Aerospace)

Space Pioneer (Beijing Tianbing Technology Co., Ltd.) has secured in March a funding round of 100 million RMB (14 million USD) led by Zhejiang University Joint Innovation Investment ZJU and 2 Beijing-based investors: Innoangel Fund and Eagles Fund. The company will spend the money on the development of a new generation of liquid fuel engines, the 30 t thrust Tianhuo 3 rocket engine (HCP liquid engine). The aim is to have hot test firings by the end of 2020.



Test firing of Space Pioneer's Tianhuo 3 engine. Igniter hot fire tests were performed late last year. Credit: Space Pioneer

Xingyun 2-01 / -02

The Xingyun 2-01 and -02 satellites for CASIC's space-based Internet-of-Things (IoT) project have completed Phase 1 in-orbit testing. Engineers at the Xingyun Ground Gateway, located in Wuhan National Aerospace Industry Base, tested for 3 weeks the satellite platforms, payloads, and key technologies such as inter-satellite links. The reliability of the communication link between the satellite multi-user payloads and the user terminal were satisfactory. Additional in-orbit tests will be continued. The Xingyun project aims at closing gaps in the IoT businesses' communication, resulting from gaps in the coverage of cellular wireless communication networks. The next step with additional 2 satellites will see the transfer to the industry user demonstration application.

The Xingyun Ground Gateway, located in Wuhan National Aerospace Industry Base, successfully transmitted and received data from the satellite and successively analysed the photos and related data taken during the separation of the two Xingyun 2 satellites. Credit: CASIC/Xingyun Ground Gateway

COMMERCIAL - ROCKETS

Expace/Kuaizhou

On the occasion of the launch of the Wuhan rocket on 12 May, CASIC told Chinese media that the manufacturing complex for the Kuaizhou rocket series at the Wuhan National Space Industry Base has been partially put into operation. The production line is undergoing qualification checks. The construction of the 68.8 km² Wuhan National Space Industry Base begun in May 2017 and was scheduled to be ready by the end of February 2020. Impacted by the COVID-19 pandemic, work had to halt for more than 2 months but resumed in April.
The rocket complex was expected to complete the acceptance test by end of May 2020 and become fully operational before the end of 2020. The production line has an annual capacity of at least 10 Kuaizhou 1A and at least 10 Kuaizhou 11. The output can be extended to 30 rockets.
The Wuhan National Space Industry Base includes factories, testing facilities, office buildings, a power station and a satellite serial production of 120 satellites per year.

1st April Fun

Expace attracted a lot of attention with an April Fool's stunt. The company live-streamed an auction for its Kuaizhou 1A rocket on Taobao, the world's biggest e-commerce website. Viya (see left), China's most famous live-streaming shopping queen, held the auction. After receiving almost 800 bids within minutes, the launch service package which includes the launch operations, a rocket painting according to the customer's requirements and the launch site access, was eventually purchased for approx. 5.6 million USD (40 million RMB) by Charming Globe (Changguang Satellite Technology), which agreed to make a 500,000 RMB deposit for the rocket. However, the deposit was probably the less significant win for the company, given that as of 22:00 BJT on 2 April, 24 hours after the video was posted, it had received 500 million hits as a topic on Weibo. The auction became a much talked about topic on the Chinese internet being the #4 trending topic on Weibo and was one of the most successful April Fool's stunts of 2020.

LandSpace

LandSpace continued its rocket engine testing series. Until mid-May, the TQ-12 80-t thrust cryogenic methane and liquid oxygen (LOX) rocket engine completed 3 gimbaling hot fire tests. On 5 June, the Tianque 11 (TQ-11) 10-ton liquid oxygen methane engine was successfully tested for 2,000 s, setting a new record for the longest single test run duration of China's LOX-liquid methane rocket engine.

Landspace's test from 5 June 2020. Credit: Landspace

Both type of engines are needed for the 2-stage ZQ-2 launcher. These were the first verification tests of the engine system and control system compatibility, confirming the flight configuration of the engine for ZQ-2. The launcher now enters the joint compatibility test phase before a later 1st launch.

iSpace - Beijing Interstellar Glory Space Technology Ltd.

In preparation of the 2nd Hyperbola 1 (SQX-1 Y2) orbital launch, the electrical system of the rocket underwent a 3-month long verification and testing procedure. The rocket's attitude control system was tested in January. From 28 to 30 March, the liquid flow test of the support engine of the SQX-1 Y2's power system was successfully completed and on 7 April, the ignition test of the electrical system. Through the ignition test, all the pyrotechnical mechanisms for engine ignition, stage separation, fairing separation were verified. These sub-system tests of the electrical system paved the way for the full assembly of the rockets electrical system.

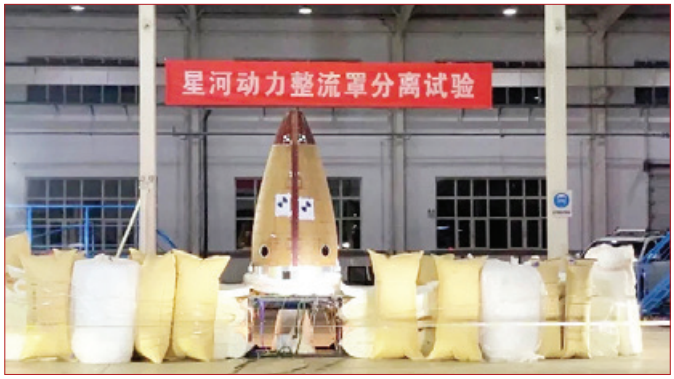
The very low resolution photo above shows the SQX-1 Y2 fairing separation test in Beijing. The time of the test was given with 13 April, 15:00 BJT. Credit: iSpace

The picture left shows an iSpace engineer wearing protective cloth for electromagnetic testing. Credit: iSpace

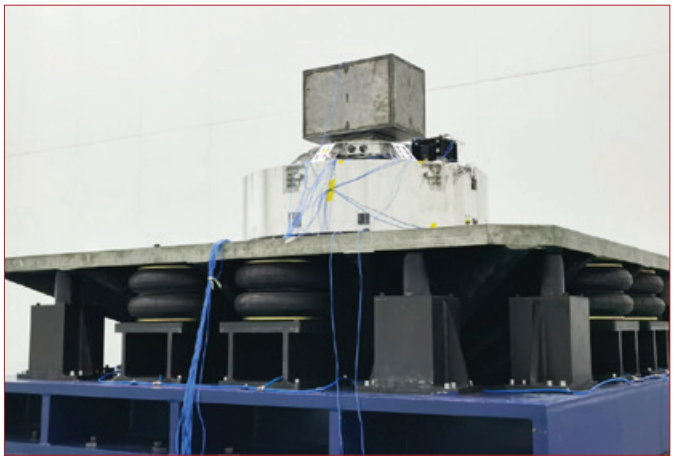
On 19 May, iSpace tested its 15-t thrust JD-1 reusable liquid oxygen-methane engine during a 200 s-long hot fire test bringing the accumulative test time to 1,000 s. The company will continue to conduct JD-1 ground tests such as variable thrust test, swing test, re-start test, engine vibration mode test, various engine boundary tests, engine life and reliability test run.
JD-1 engines are the main engines for the reusable Hyperbola 2 (SQX-2) with a P/L capacity of 1.9 t into LEO.
For later in the year, a 100 km VTVL test of the 1st stage of Hyperbola 2 is planned.

Galactic Energy

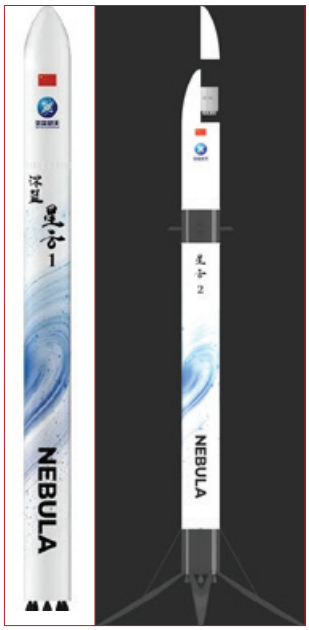
A hot fire test of the Ceres 1 upper stage attitude control engine took place in April, with a full system cold flow test following in May. On 15 and 16 May, the upper stage's control section was successfully exposed to a 15 min vibration test applying 5 to 2,000 Hz in 2 directions of high and low magnitudes and in 3 directions to assess the inertial navigation accuracy of the inertial group.
On 29 May, Galactic Energy concluded a successful payload fairing separation test. Delayed by the Corona pandemic, the Ceres 1 launch is now expected for autumn 2020.



Galactic Energy fairing separation test. Credit: Galactic Energy/Weibo



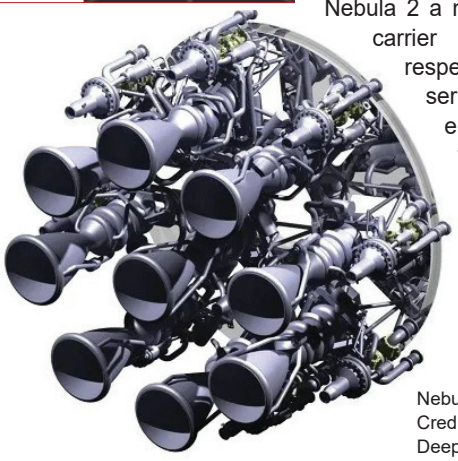
The Ceres 1 upper stage section on the shaker. Credit: Galactic Energy/Weibo



Deep Blue Aerospace Technology

Deep Blue Aerospace Technology Co., Ltd., announced on 5 June it received a Pre-A round of financing of more than 100 million RMB (14.1 million USD). The round was led by Shanghai Zhonghuijin Investment Group Co., Ltd., followed by Captain Capital Management (Group) Co., Ltd., and Nantong Jiayi Fund Management Co., Ltd. It was mainly used for setting up the R&D team, vertical recovery technology verification and in-depth testing of liquid oxygen kerosene rocket engines.

Deep Blue is developing the Nebula rocket series with Nebula 1, a small liquid carrier rocket and Nebula 2 a medium-sized liquid carrier rocket, and the respective Thunder-series of liquid rocket engines: Thunder 20 for Nebula 1 and Thunder 100 for Nebula 2.



above very left: Nebula rocket. above left: Nebula rocket with landing capacity.

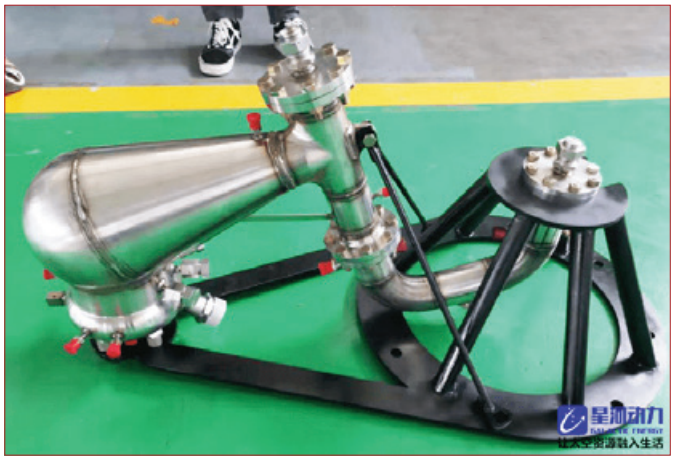
Nebula rocket engines. Credit for all illustrations: Deep Blue/Weibo

INTERNATIONAL COOPERATION

APSCO

• SMMS (Small Multi-Mission Satellites)

The 1st Expert Group Meeting on the Ground Station Network for the SMMS (Small Multi-Mission Satellites) Constellation Programme was held online from 11-13 May 2020. Experts from Bangladesh, China, Iran, Pakistan, Peru, Thailand, Turkey and the APSCO (Asia-Pacific Space Cooperation Organisation) project management team participated in the meeting. During the meeting, discussions on the Implementation Proposal of Ground Station Network of the SMMS Constellation Programme were carried out.



Galatic Energy PALLAS Mockup. Credit: Galactic Energy

The information about potential ground stations and the related policies in Member States were introduced which was important input for establishing the network of ground stations and operating the SMMS Constellation most efficiently. The Member States agreed to propose the project for implementation under APSCO coordination.

• Cooperation with BNU

On 13 May, APSCO and the Northwestern Polytechnical University (NPU) signed online a contract of internship for NPU Students at APSCO.

On 20 May, a working meeting between APSCO and NPU on “APSCO-NPU Strengthening the Development of Aerospace Talent” was held at APSCO HQ, in Beijing. APSCO thanked NPU for its strong support especially in the area of capacity-building of the young generation. NPU proposed to continue the sustainable development of the APSCO Student Small Satellite (SSS) Project through competition and training. The NPU delegation also proposed to jointly set-up a curriculum in aerospace system engineering to promote the further education of aerospace talent in APSCO Member States.

• Roscosmos delegation visit

On 2 June 2020, the representative of Roscosmos, Anton Petrov, visited the APSCO Headquarters in Beijing. He was received by Aisha Jagirani, the Department Head for External Relations and Legal Affairs. Xu Yansong, the Department Head for Programme Management and Data Service, pointed out that there was already cooperation between Russia and APSCO in the past. Both sides exchanged views of common interests and expressed their interest in the continuation of the cooperation.

MOZAMBIQUE

The Minister of Transport and Communication of the government of Mozambique, Janfar Abdulai, announced on 19 May that 1,000 villages, covering all 10 provinces in the country have been connected with digital satellite TV. During a visit to the northern province of Cabo Delgado he said the project had not only benefited over 20,000 families but also generated about 2,000 jobs and trained young technicians to be in charge of the maintenance and provide assistance to the users.

During the 6th Ministerial Conference of the Forum on China-Africa Cooperation 2015 (FOCAC) in Johannesburg, South Africa, Chinese President Xi Jinping announced 10 cooperation plans among which was also the project “Access to Satellite TV for 10,000 African Villages Initiative”.

The project was launched in Dowa District in Malawi in August 2018. In January 2019, the project was implemented in 1,000 villages in Nigeria, and in May in Rwanda.

compare QR 1/2019; GoTaikonauts! 27, p. 9 “Satellite TV Service for Nigeria” and QR 2/2019 GoTaikonauts! 28, p. 7 "Commercial TV Service for Rwanda"

MYANMAR

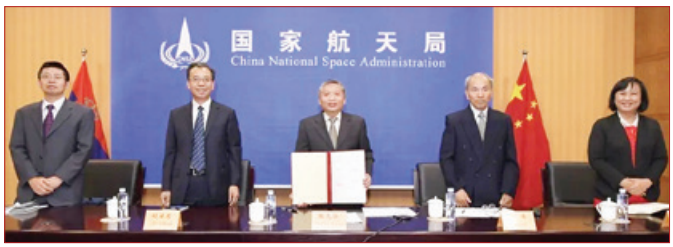
The Shanghai Municipal Meteorological Service (SMMS) assisted the Department of Meteorology and Hydrology of Myanmar (DMH) to integrate the Myanmar regional Numerical Weather Prediction (NWP) system with the Fengyun 4-based regional model verification system developed by SMMS.

The updated Myanmar weather system can now provide more refined and swift model predictions and satellite observation data. The Shanghai meteorological expert team trained the Myanmar staff on the NWP technical and satellite data application and guided them through the meteorological system modernisation. In the future, both sides will engage in more in-depth technical exchanges and cooperation under the Belt-and-Road framework.

SERBIA

On 5 June, Zhang Kejian, Director of the China National Space Administration CNSA, and Nenad Popovic, Serbian Minister responsible for innovation and technological development, signed via a video conference a Memorandum of Understanding (MoU) for cooperation in space technology, satellite systems and in Earth observation, with applications in the field of smart agriculture, telecommunications, ecosystems, remote sensing systems and geolocation positioning. The agreement aims at the involvement of as many scientists as possible in joint space projects. Popovic said that the Chinese partners are willing to share their knowledge and experience in space technology with Serbia.

Under the terms of the MoU, Serbia and China will develop bilateral cooperation in research, development and application of space technologies, including joint construction of satellite data reception stations and the development of satellite systems. Zhang Kejian stressed that the MoU represents a step forward in promoting bilateral cooperation in the field of space technologies. "Our goal is to see the Serbian flag on a spacecraft that we will jointly design," Kejian added.



top: Serbia's Minister shows the signed MoU. Credit: Government of Serbia
above: Zhang Kejian, CNSA's Director holds his copy of the signed MoU into the camera. Credit: CNSA/WeChat

MISCELLANEOUS

CHINA SPACE DAY 2020 -
50th anniversary of the launch of Dongfanghong 1
"Promote the spirit of space and embrace the stars and the sea."

On 24 April 2020, the 5th China Space Day took place under the motto "Promote the spirit of space and embrace the stars and the sea". The day was also the 50th anniversary of the launch of Dongfanghong 1. For this special occasion, country-wide activities were held, and the main event should have taken place at the universities in Xiamen and Fuzhou in Fujian province, at the south-eastern coast of China. Due to the restrictions, caused by the Corona virus pandemic, the gala show was held as an online event. In the same way, exhibitions, meetings, public events and workshops were changed to virtual happenings. The social media channels Weibo and WeChat engaged in a public outreach campaign, joined by CNSA, CMSA, science popularisation organisations and all relevant space companies. With respect to the 2020 China Aerospace Congress which would run in parallel with the Space Day events, it was decided to hold it in the 2nd half of the year.

Over the last 5 years, the volume and the quality of the Chinese Space Day celebration increased steadily.

Central Space Day locations:
Xiamen University and Fuzhou University

The 2 universities in Fujian Province's North and South were chosen as the central locations for the SpaceDay celebrations.

Xiamen University is one of the 1st universities in China taking on aviation students. Already in the 1940s, Xiamen University set-up the faculties for Mechatronics Engineering and for Aeronautical Engineering. In April 2015, the university integrated relevant resources and established the Xiamen University School of Aerospace Engineering.

For the 5th China Space Day event, Xiamen University hosted the 4th China Aerospace Science and Technology Education Forum and an exhibition on the history of aerospace, accompanied by festivals and workshops.

Fuzhou University's Institute of Remote Sensing Information Engineering is offering a comprehensive satellite applications master study programme along with doctoral programmes and post-doctoral assignments. Fuzhou University was host to the Joint Engineering Research Centre of Satellite Geospatial Information Technology, dedicated to scientific research, technology development, engineering applications, and information services in satellite applications and their cross-cutting fields.

The 2nd National Innovation Centre attached to Fuzhou University is the Earth Observation and the National Beidou Navigation Location Service Data Centre.

In 2013, Fuzhou University Beidou Communication Technology Co., Ltd., was established. This is a technology-based student entrepreneurial endeavour focusing on the research and development of core components of civil Beidou and one-stop solutions. The company's products have been used in marine fisheries, meteorological collection, emergency rescue, etc.

In 2018, Fuda Xinjie Antenna Technology Co., Ltd., was established, providing supplies for military applications.

On the occasion of the China Space Day 2020, Fuzhou University held a 100-day Space Day countdown ceremony, had the "China Aerospace Day" Science Lecture event, and also hosted the "Young People's Forum in Qinghai, Northeast Fujian" and the second national aerospace school construction and development seminar.

Fujian's universities educated high-ranking aerospace alumnis. Among them are Lin Zongtang, former Minister for Aerospace and Min Guirong, contributing to the "Two Bombs, One Satellite" project.

left:
Lin Zongtang
right:
Min Guirong

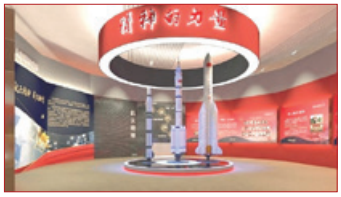
CNSA released this innovative poster for the 2020 China Space Day. Copyright: Li Jie

• China Space Day 2020 poster

During a press conference on 22 April, CNSA officially released the 2020 China Space Day poster. It was designed by Li Jie from Guizhou who participated in a public announcement of opportunity, issued on 20 March. 1,893 artworks were submitted until 5 April. Alone, 57 % of the submissions came from young people, aged between 20 and 29 years. At the end, an expert team selected 11 outstanding works and posters for the final use during China Space Day 2020.

• ONLINE EXHIBITION

To mark the 50th anniversary of the launch of Dongfanghong 1, the online exhibition "Dongfanghong Forever" opened on 24 April. The virtual show, jointly held by the National Museum of China and the China Academy of Space Technology, covered a wide range of items including manuscripts, stamps, simulators and spacesuits, tracking the 50 years of aerospace progress from Dongfanghong 1 to Shenzhou and Chang'e. Viewers were offered a new way to virtually explore space with models of satellites and rockets and enjoyed a 5G live broadcast of the exhibition.



Dongfanghong Forever, the first virtual exhibition hosted by the National Museum of China, marks China's progress in space exploration over the past 50 years. Credit: National Museum of China/China Daily

Follow this link for a small gallery of animated photos (on click) on the occasion of 50th anniversary of China's first satellite launch - text is in Chinese

Special CNSA website in Mandarin dedicated to China Space Day 2020 with access to the online space exhibition.

Online Cloud Exhibition: "Forever Dongfanghong"

• BEIJING SYMPOSIUM

On the occasion of the 50th anniversary of the launch of Dongfanghong 1, China Aerospace Science and Technology Corp held a symposium on 21 April in Beijing. The conference recalled the research and development of Dongfanghong 1 and discussed the experience and challenges in the country's space industry.

• MARS MISSION - LOGO and NAME

CNSA announced during the 5th China Space Day gala on 24 April the name and logo for the soon to be launched Mars exploration mission: Tianwen 1. The name goes back to the poet and philosopher Qu Yuan who lived more than 2.000 years ago in the Kingdom of Chu during the Warring States Period (475-221 BC). He could not find answers to his many questions about life and the cosmos. Consequently, he directed his quest to the heavens above him by writing the poem "Tian Wen" - Questions to the Universe.

CNSA decided to name all future missions for planetary exploration the Tianwen series. Also, the logo was designed to symbolise the Solar System, in the shape of the letter "C". C stands for China, cooperation and capacity.

Ye Peijian, one of China's leading scientists for deep-space exploration, said Tianwen 1 will land on Mars before July 2021. Observers expect that the mission to the Red Planet will be dedicated to the 100th anniversary of the Communist Party of China on 23 July 2021.

• CONGRATULATIONS FROM SPACE

Anatoly Ivanishin and Ivan Wagner, the Russian crew members of the International Space Station ISS, sent a congratulatory video to China from on board the Station.

Other space officials and personnel from the UN Office for Outer Space Affairs (UNOOSA), the International Astronautical Federation, the European Space Agency (ESA), the Asia-Pacific Space Cooperation Organization (APSCO), Brazil, France, Pakistan and Russia also sent congratulatory videos or letters, and expressed the hope to strengthen aerospace cooperation with China.

• COMMEMORATIVE STAMPS – FENGYUN 4

On the occasion of the 50th anniversary of the launch of Dongfanghong 1 and the 5th Space Day of China, China Post issued a set of commemorative stamps and a First Day Cover on 24 April 2020.

The Earth view in the stamp design is based on data from the Fengyun 4 meteorological satellite. By now, 107 countries and territories are using FY satellites data. 29 countries have set up FY satellites data reception stations. 28 countries have registered to become users of the Emergency Support Mechanism for International Users of Fengyun Meteorological Satellites in Disaster Prevention and Mitigation (FY ESM).

A stamp collector shows a First Day Cover marking the 50th anniversary of the successful launch of Dongfanghong 1, issued by China Post along with a set of commemorative stamps. Credit: China Post/Science and Technology Daily/ Xinhua-Long Wei

China has launched 17 meteorological satellites, with 7 still operational. FY-2, FY-3, FY-4 satellites have become important members of a global operational meteorological satellites observing system. China's FY satellites

remote sensing data service website (*http://data.nsmc.org.cn*), providing data from FY-1, FY-2, FY-3, FY-4, and TanSat has 89,000 users.

• Letter to President Xi Jinping

11 veteran scientists including Sun Jiadong, Wang Xiji, Qi Fazhen, Hu Shixiang, Pan Houren, Hu Qizheng, Peng Chengrong, Zhang Futian, Chen Shouchun, Han Houjian and Fang Xinhu who participated in the Dongfanghong 1-Project half a century ago wrote a letter to President Xi Jinping and reviewed the history of the development of the space industry and expressed their hopes and wishes for the future of China's space sector. In his reply, Xi encouraged space industry professionals to follow the role model of the early generation of space experts to overcome difficulties and hardships for achieving new heights in space science and technology.

How Dongfanghong 1 was made to sing

The Space Day of China, which falls on 24 April, is more special this year, as it marks the 50th anniversary of the successful launch of Dongfanghong 1, the country's first man-made satellite. The launch made China the 5th country in the world to develop and launch a man-made satellite on its own and recorded the country's first step in exploring the vast space. Xinhua news agency retells with several anecdotes the story of Dongfanghong 1.

China on Its Way to Becoming a Formidable Satellite Internet Service Competitor

Larry Press, Professor of Information Systems at California State University, looks into the way how the Chinese government is pushing for innovation leaps by allocating resources to competing, state-owned enterprises. In order to illustrate this strategy, the author explains the characteristics of the LEO broadband satellite constellations Hongyun, Hongyan and GalaxySpace. He also points to the recent move of the National Development and Reform Commission, which added satellite broadband, 5G, and the Internet-of-Things to its "New Infrastructures" list. That means more money will be invested in these technologies.

Forum on Regional Climate Monitoring-Assessment-Prediction for Asia

The 16th Session of the Forum on Regional Climate Monitoring-Assessment-Prediction for Asia (FOCRAII 2020) was held on 7 May 2020 via video conferencing.

Sponsored by the World Meteorological Organisation (WMO) and China Meteorological Administration (CMA), co-sponsored by the UN Economic and Social Commission for Asia and the Pacific (ESCAP) and hosted by the Beijing Climate Centre (BCC), the FOCRAII addresses since 2005 topics such as long-term weather forecasting, climate monitoring, data services and product training.

Around 50 participants attended the online forum and addressed topics like climate monitoring and prediction, climate impacts and services as well as the possible climate impacts on the agriculture, human health, water resources and emergency management over Asia. A "consensus" prediction of the summer climate in the Asian region was produced as an output of the virtual meeting.

Lead scientist of Mars exploration mission passed away

Renowned Chinese space scientist and planetary physicist Wan Weixing died after illness at the age of 62 on 26 May 2020 in Beijing. Besides being the lead scientist of China's Mars exploration mission, Wan was an academician of the Chinese Academy of Sciences, a member of the Central Committee of the Jiusan Society, and a Member of the Standing Committee of the 13th National People's Congress.

In need of a satellite and want to order online?

China Aerospace Science and Technology Corporation (CASC) set up on WeChat a public commercial satellite-shopping platform called Lizheng Satellite Shopping Mall. Customers, domestic or abroad, can chose their favourite satellites and put them into shopping carts on their phone. It is also possible to buy data services. Potential buyers can talk to a customer service about details of their purchases. The price of the services was not shown on the platform since the customers can select the components what means any satellite would be tailor-made and so would be the price.

Also the Shanghai Institute of Satellite Engineering (SISE), a subsidiary of the Shanghai Academy of Spaceflight Technology (SAST) under CASC announced that satellite platforms with masses of 50, 100 and 300 kg can now be purchased online.

CMA Training Centre Online Course

On 22 June, the CMA Training Centre held an international training course on satellite meteorology and applications. 620 participants, mainly technical personnel in the field of satellite meteorology from 87 countries and territories learned about the basic principles of satellite remote-sensing, satellite telemetry, and meteorological applications. The CMA Training Centre has given international courses since 15 years, but in 2020 it was the first time done online.

ON A SIDENOTE

Jim Bridenstine has a point

"The empty core stage of the Long March-5B, weighing nearly 20 tons, was in an uncontrolled freefall along a path that carried it over Los Angeles and other densely populated areas. As a matter of fact, had this spent rocket stage, which is the largest uncontrolled object to fall from low-Earth orbit in almost 30 years, re-entered earlier, it could have hit New York. .... Space exploration should inspire hope and wonder, not fear and danger." said Jim Bridenstine, during a meeting of the NASA Advisory Council's Regulatory and Policy Committee on the release of the "Artemis Accords" on 15 May 2020.

ENTERTAINED by SPACE

• Glass-bottom deck opens atop China's 'horizontal skyscraper'

A 300-m-long sky bridge across the top of 4 of the 8 skyscrapers that make up Raffles City Chongqing, a multi-use riverside complex in the southwest China megacity, is hosting "The Exploration Deck" which is a cooperation with National Geographic to create a space exploration-themed exhibition.

The Exploration Deck guides visitors from the ground floor to the outdoor viewing deck through a five-part exhibition. After taking a space-inspired express lift, visitors go on to the Mars exhibition on level 47.

The exhibition illustrates space exploration through 5 multi-dimensional exhibition zones and showcases how mankind is making life possible on Mars.

Exceptional photos from China's space projects

Photographer Jiao Huang took extraordinary photos of China's space programme.

Taikonauts in front of the photographic lens

Photographer Xu Bu of China's Astronaut Centre captured unique moments during astronaut training and launches of China's manned missions. Photography: Xú Bù, 徐系

• SpaceX over CHINA

On 1 June, SpaceX Crew Dragon space craft docked to the port on the U.S. Harmony module of the ISS. Docking occurred when the Station was flying at a height of 420 km right above the border between China and Mongolia. Chinese netizens had been closely following the U.S. space mission and were wondering if such a docking site selection had a deeper meaning.

Chinese space experts confirmed that the location of docking is a matter of orbital mechanics, determined by the launch window, fuel consumption and docking procedure and is not based on a political agenda.

• Space Force and "China space threat"
In May the new comedy series *Space Force* premiered on Netflix. The series is a bizarre and eccentric reflection of the real installation of the U.S. Space Force, employing all possible stereotypes and prejudices about space and international space efforts, about the U.S. and China. Near the end of the season, the "China threat" gets incorporated in the plot and involves hostile acts by Chinese space craft and taikonauts on the Moon toward the U.S. astronauts. The whole plot is bad, but it is so bad that it is good in a way since the movie maker inserts many real facts from the space community. There are reports that despite the fact that Netflix is not available in China, the series found an enthusiastic audience in China through uploads of scenes to Bilibili and Douban. And most of them can enjoy and laugh about the bad jokes. One comment on Douban summarises the core of the Space Force series nicely: "But compared to trolling China, it also trolls itself [U.S.] with full force."

LAUNCHES

2020-F03
9 April 2020 - 11:46 UTC (19:46 BJT)

launch site: Xichang Satellite Launch Centre - XSLC, LC2
launcher: Chang Zheng 3B - CZ-3B/G2
payload: Palapa N1 (Nusantara 2/Nusantara Dua)

The launch failure of the CZ-3B/G2 on 9 April was the 2nd failure within one month (the CZ-7A failed on 16 March).
On 9 April, the 1st and 2nd stage of the CZ-3B worked nominally but the first burn of the cryogenic 3rd stage malfunctioned. Consequently, the rocket reached only 7.1 km/s speed and a height of 170 km. The rocket and payload re-entered over the Pacific near Guam and Saipan where sightings of burning up debris were reported.
Palapa N1 (Nusantara 2/Nusantara Dua) was developed under a contract, signed in May 2017 between the China Great Wall Industry Corporation (CGWIC) and the Palapa Satelit Nusantara Sejahtera of Indonesia (a consortium of Pasifik Satelit Nusantara PSN and Indosat Ooredoo).
The 5,550 kg satellite is based on the enhanced DFH-4E bus developed by CAST. The GEO satellite was supposed to provide C-band and Ku-band communication and broadcasting services to Indonesia as well as other countries and regions participating in the Belt-and-Road Initiative. The planned position in GEO was at 113° East.
Palapa N1, with a projected life time of 15 years, would have replaced PALAPA-D, launched in 2009.
An investigation has been opened. It was not known if the failed launch will have an impact on other CZ-3B satellite launches planned for later in the year.

2020-027A
2020-027B
5 May 2020 - 10:00 UTC (18:00 BJT)

launch site: Wenchang Space Launch Centre - WSLC, LC101
launcher: Chang Zheng 5B - CZ-5B
payloads: XZF-SC
RCS-FC-SC (Re-entry Test)

The 1st flight of the CZ-5B launched a test version of an unmanned new-generation crew spaceship and a test cargo return capsule built by CASIC. The successful flight marked the start of the space station construction what is the 3rd phase of China's manned space programme.
Around 20 min after take-off, CASC reported launch success. About 488 s after launch, the combination of experimental crew spacecraft and test cargo return capsule, separated from the rocket and entered the planned orbit.
The 8.8 m-long prototype spacecraft with a mass of 21.6 t was using its own propulsion to raise its orbit to an apogee of around 8,000 km. From that height, a high-speed re-entry of approx. 9 km/s was conducted to test the new heat shield for missions returning from deep-space. For LEO missions, the launch mass of the crew space craft would be 14 t. The mission also tested avionics, performance in orbit, parachute deployment, a cushioned airbag landing, and recovery.
An unofficial broadcast of the launch was available on social media/YouTube.
Re-entry of the test crew spacecraft was on 8 May. The inflatable cargo return unit was expected back from space on 6 May but the re-entry process was not successful.
The launch success was important, as this rocket configuration will transport the main modules for the CSS.

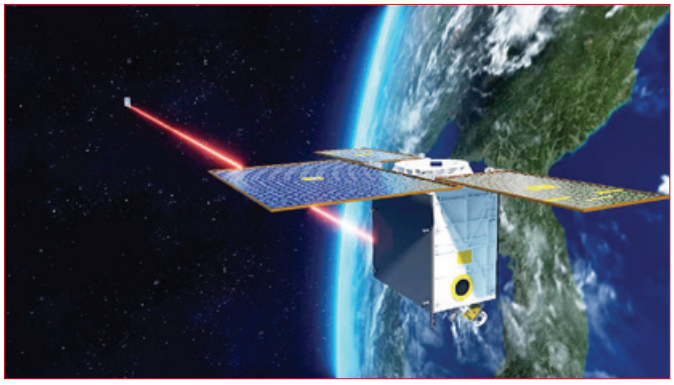
2020-028A
2020-028B
12 May 2020 - 1:16 UTC (9:16 BJT)

lauch site: Jiuquan Satellite Launch Centre - JSLC, mobile launch platform at LC43/95
launcher: Kuaizhou 1A - KZ-1A
payloads: Xingyun 2-01 - Wuhan
Xingyun 2-02

The 2 technology demonstration satellites Xingyun 2-01 and Xingyun 2-02 are the first satellites in the Xingyun constellation - China's first space-based IoT network.
Both satellites successfully entered the planned 561 km SSO. The 1st satellite separated 25 min, 55 s into the flight and the 2nd satellite separated 2 min, 30 s later.
The Xingyun 2-01 satellite was named Wuhan in dedication to the outstanding efforts of the Wuhan people against the Coronavirus pandemic. The rocket body featured a special painting symbolising the joint effort of the medical work force, logistic and other support workers, military and security services.
Initially, the launch was planned for mid-to-late April. For that, more than 130 CASIC staff arrived at the Jiuquan Satellite Launch Centre on 29 March. While taking into consideration the special hygiene conditions for disease prevention, the engineers prepared the rocket for the launch.
Guangzhou Automobile/Chuanqi Automobile Sales Co., Ltd. officially became the launch partner. Both satellites were developed by the Xingyun Satellite Co., a CASIC/Sanjiang Group subsidiary in Wuhan. The satellites are cube-shaped, equipped with 3 solar panels, an antenna and have a launch mass of 93 kg each. The main payload is an L-band communication system and a trans-satellite laser communication package. The narrow-band data transfer rate is 2.4 - 9.6 kbps for uplink and 2.4 kbps for downlink.

A Kuaizhou-1A rocket is prepared at the Jiuquan Satellite Launch Centre in Northwest China, on 12 May 2020. Credit: Wang Jiangbo/China Daily

The 2 satellites are tasked to verify technologies such as laser-enabled inter-satellite links (ISL), space-borne digital multi-beam communication payload, and air-to-ground satellite communication protocol. Additionally, the satellites provide data for applications such as intelligent container tracking, polar environmental monitoring, meteorological forecasting as well as marine transport communication and lay the foundation for the following space-based IoT network.
In a next step, 12 Xingyun 2-series satellites will be launched to join the first two and operate in a test constellation. CASIC plans to have 80 narrowband communications satellites in the Xingyun LEO constellation around 2023 and will provide global coverage to users by that time, in particular to users in currently "communication blind spots." By then, it will offer users around-the-clock IoT access. The final constellation is planned with 156 satellites, in orbit by 2025.


A rendering of a Xingyun satellite. Credit: CASIC/WeChat

2020-032A
2020-032B
29 May 2020 - 20:13 UTC (30 May - 04:13 BJT)

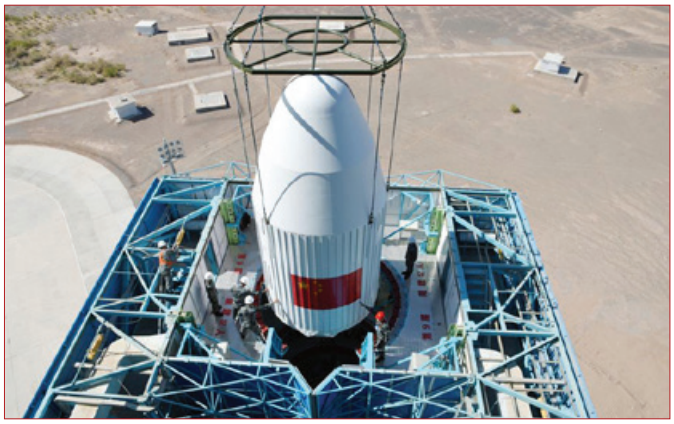
launch site: Xichang Satellite Launch Centre - XSLC, LC4
launcher: Chang Zheng 11 - CZ-11
payloads:
XJS-G (XinJiShu Shijan G, Chuangxin 6-01, CX-6-01)
XJS-H (XinJiShu Shijan H)

On 29 May, for the first time a CZ-11 took-off from Xichang. Also, for the first time the rocket was equipped with a 2 m-diameter fairing. The CZ-11 is the first and only solid-fuel rocket in the Long March family.
The launcher carried 2 technology development payloads: XJS-G, from the Shanghai Innovation Academy for Microsatellites, and XJS-H, from the National University of Defense Technology in Changsha, Hunan Province.
The satellites successfully entered the planned orbit, and the mission was a complete success. The new technology test satellites G and H are mainly used for in-orbit testing of inter-satellite data links and new Earth observation technology.

2020-034A
2020-034B
31 May 2020 - 08:53 UTC (16:53 BJT)

launch site: Jiuquan Satellite Launch Centre – JSLC, SLS2
launcher: Chang Zheng 2D - CZ-2D
payloads: Gaofen 9-02
HEAD 4

The CZ-2D launched as the main payload a Gaofen 9-02 satellite and as secondary satellite the HEAD 4.
Gaofen 9-02 is used for optical remote sensing with a resolution of about 1 m.
It will provide data for land surveys, urban planning, road network design and crop yield estimates, as well as disaster relief. It can also serve projects along the Belt-and-Road region.


The CZ-2D carrier rocket is assembled in the launch tower at the Jiuquan Satellite Launch Centre. Credit: Wu Jiadong/Ti Gong

HEAD 4 was developed by Beijing-based HEAD Aerospace Technology Co. Ltd. The 45 kg satellite is equipped with AIS, ADS-B, and IoT relay communication payloads. It will be used for ship and aircraft tracking and for IoT data connectivity.
The SAST team managed to shorten the launch readiness process from previously 20 days to 13 days. That helped in catching up on delays caused by the Corona pandemic.

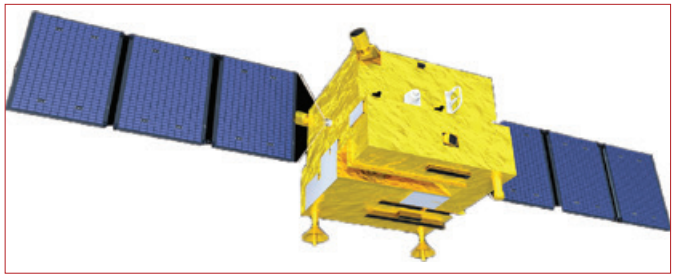
2020-036A
10 June 2020, 18:31 UTC (11 June, 02:31 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, LC9
launcher: Chang Zheng 2C, CZ-2C
payloads: Haiyang-1D (HY-1D)

HY-1D is a newly developed maritime environment monitoring satellite. The 1,4 x 1,1 x 0,953 m box-shaped satellite is based on a CAST2000 small satellite platform and was built by the DFH Satellite Co. Ltd.
The instruments on the 442 kg satellite include:

- An Ocean Colour and Temperature Scanner, for the global daily scanning of the ocean water colour and water temperature with a spatial resolution of 1.1 km and a swath width of 2,900 km.
- A Coastal Zone Imager for the imaging of the coastal waters, coastal zone and ecological environment of rivers and lakes with a spatial resolution of 50 m, a swath width of 950 km and a re-visit time of 3 days.
- The UV Imager is used for atmospheric correction of near-turbid water bodies.
- A Calibration spectrometer is used to monitor the on-orbit radiation accuracy and stability of the Ocean Colour and Temperature Scanner and UV Imager.
- The AIS system enables automatic ship identification and position determination.

The satellite data will become useful for marine disaster prevention and mitigation, meteorology, agriculture, water conservation and ocean going transportation.
The satellite is owned by the Ministry of Natural Resources and operated by the Ministry's China National Satellite Ocean Application Service.


Rendering of the HY-1D satellite. Credit: CAST

HY-1D will form a marine observation network with the HY-1C, launched in September 2018 and equipped with similar payloads. Each satellite can see the globe twice a day: in the morning and evening, doubling the current capacity and helping to avoid morning solar flares and temporary cloud covers. HY-1D's expected life time is 5 years.

2020-039A
17 June 2020, 07:19 UTC (15:19 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC, SLS2
launcher: Chang Zheng 2D, CZ-2D
payloads: Gaofen 9-03
HEAD 5
Zheda Pixing 3A (ZDPS-3A)

Gaofen 9-03 is a sub-meter resolution optical remote sensing satellite. It follows the Gaofen 9-02 satellite, launched less than 3 weeks ago, into a 503 x 487 km orbit, inclined by 97°. The 1st Gaofen 9 satellite was launched in 2015.
Gaofen 9-03 was developed by DFH Satellite Co., Ltd. Gaofen satellites are part of the civilian China High-resolution Earth Observation System (CHEOS). The satellites are used for land surveying, urban planning, road network design, agriculture, disaster relief and other purposes.
There were 2 more satellites launched with the CZ-2D rocket.
Zheda Pixing 3A (ZDPS-3A) is a picosatellite technology test, developed by Zhejiang University. The box-shaped satellite will be used to test pico-satellite and nano-satellite technologies.
HEAD 5 of HEAD Aerospace is similar to HEAD 4, launched on 31 May. It carried out on-orbit global AIS vessel data collection and ADS-B flight data monitoring.

One day before the planned transfer of the rocket parts to the launch tower where they would be lifted up for vertical assembly, launch site staff discovered that the wind conditions would become unfavourable for this work. On short notice it was decided to start the assembly work in the afternoon on the same day when the wind was less severe. Credit: JSLC/WeChat

2019-040A
23 June 2020 - 01:43 UTC (9:43 BJT)

lauchsite: Xichang Satellite Launch Centre - XSLC, LC-2
launcher: Chang Zheng 3B/G2, CZ-3B/G2
payloads: Beidou-3G

On 23 June, the last satellite of the BeiDou Navigation Satellite System (BDS) was launched. Once the satellite starts operations, expected by the end of July 2020, BDS can provide global services. So far, Beidou's location services offer an accuracy of 10 cm in the Asia-Pacific.
The geosynchronous 3rd generation satellite (Beidou-3G) was also the 55th in the Beidou family. The BDS-3 constellation consists now of 30 satellites, including 24 MEO satellites, 3 IGSO satellites and 3 GEO satellites.
The 4,600 kg Beidou-3G is based on CAST's DFH-3B bus, equipped with a phased array antenna for navigation signals and a laser retroreflector. The bus also has an apogee propulsion system for final orbit insertion. The BDS-3 satellites are equipped with high-precision Rubidium and Hydrogen atomic clocks, independently developed by China to improve accuracy. Positioned at 110° East, the satellite is designed to work for at least 12 years.
Observers noticed that the Beidou satellite's launch was announced well in advance and a CCTV live stream with an English translation was provided.

BEIDOU - RDSS and RNSS

As a space infrastructure of national significance, BDS provides all-time, all-weather and high-accuracy positioning, navigation and timing services to global users.
Along with the development of the BDS service capability, related products have been widely applied in communication, marine fishery, hydrological monitoring, weather forecasting, surveying, mapping and geographic information, forest fire-prevention, time synchronisation for communication systems, power dispatching, disaster mitigation and relief, emergency search and rescue, and other fields.

The Beidou navigation system supports 2 different kinds of general services via its GEO satellites: RDSS and RNSS.

RDSS - Radio Determination Satellite Service

In the RDSS, the user position is computed by a ground station using the round trip time of signals exchanged via the GEO satellite. The RDSS long-term feature further includes short message communication (guaranteeing backward compatibility with Beidou 1), large volume message communication, information connection, and extended coverage.
The short message communication capability of the BDS-3 system is unique to BDS and has been improved 10 times. Users of the system can send a message of 1,200 Chinese characters at one time (originally only 120), as well as pictures, a useful function in emergencies.

RNSS - Radio Navigation Satellite Service

The RNSS is very similar to that provided by GPS and Galileo and is designed to achieve similar performances. Active positioning, employing radio measurement technology, provides the locations of the users, not only to themselves, but also to relevant parties who are monitoring the users' mobility, through the joint efforts of two GEO satellites. The function is widely used in search and rescue, fishing and other fields to help guarantee people's safety. The BDS system provides navigation signals of multiple frequencies, and is able to improve service accuracy by using combined multi-frequency signals.

Developed decades after GPS, Beidou could incorporate lessons learned from the GPS experience. Some signals have higher bandwidth and give better accuracy. The fewer orbit planes, make constellation maintenance easier.

Beidou-related services such as port traffic monitoring and disaster mitigation have been exported to about 120 countries. Many of those countries are involved in the Belt-and-Road Initiative.

Next, Chinese researchers will develop an intelligent management platform for the system, which will have the capabilities of multi-source reception, independent monitoring, intelligent diagnosis, process visualization and rapid evaluation on the basis of massive data from the satellites, ground stations and user assessments.

By 2035, BDS will be built into a more comprehensive, integrated and intelligent positioning, navigation and timing system, providing services with stronger functions and better performance.


Assembly of the CZ-3B rocket in Xichang on 23 June. Credit: CALT/Ning Hong/CGTN


The CZ-3B takes off from Xichang on 23 June 2020. Credit: Hu Xujie/Xinhua

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

AIR	Aerospace Information Research Institute
AIS	Automatic Identification System
AIT	Assembly, Integration & Test
AO	Announcement of Opportunity
APSCO	Asia-Pacific Space Cooperation Organisation
AU	Astronomical Unit
BACC	Beijing Aerospace Control Centre
BDS	BeiDou satellite navigation System
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
CFOSat	China-France Oceanography Satellite
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
CPPCC	Chinese People's Political Consultative Conference

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
ESA	European Space Agency
FAST	Five-Hundred Metre Aperture Spherical Radio Telescope
FY	Fengyun
FYESM	Fengyun Meteorological Satellites in Disaster Prevention and Mitigation
GEO	Geostationary Orbit
GF	Gaofen
GLONASS	Russian Satellite Navigation System
GNSS	Global Navigation Satellite System
GRAS	Ground Research Application System
GTO	Geostationary Transfer Orbit
HKATG	Hong Kong Aerospace Science and Technology Group
HY	Hongyun
ICG	International Committee on Global Navigation Satellite Systems
IoT	Internet of Things
ISL	inter-satellite links
LEO	low Earth orbit
LEOP	launch and early orbit phase
LND	Lunar Lander Dosimetry and Neutron
LOX	liquid oxygen
LRO	Lunar Reconnaissance Orbiter
MEO	medium Earth orbit
MIIT	Ministry of Industry and Information Technology

MoU	Memorandum of Understanding
NAOC	National Astronomical Observatories of the Chinese Academy of Sciences
NDRC	National Development and Reform Commission
NEO	near-Earth asteroid
NPU	Northwestern Polytechnical University
NSSC	National Space Science Center
P/L	payload
PNT	Positioning Navigation and Timing
QSTT	quantum-secure time transfer
QUESS	Quantum Experiments at Space Scale
Roscosmos	Russia's State Space Corporation
SAR	Synthetic-Aperture Radar
SAST	Shanghai Academy of Spaceflight Technology
SBSP	Space Based Solar Power
SETI	search for extra-terrestrial intelligence
SISE	Shanghai Institute of Satellite Engineering
SMMS	Small Multi-Mission Satellites
SOE	State owned enterprise
SSO	Sun-Synchronous Orbit
SSS	Student Small Satellite
SQX	Shuang Quxian / Hyperbola rocket
TQ	Tianque
TT&C	Space Telemetry, Tracking and Command Station
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
YW	Yuanwang
ZQ	Zhuque

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Chang'e 4 – Behind the Moon (part 6)

Operations of lunar days 17 to 19 on the far side of the Moon

by Jacqueline Myrrhe

17th lunar day – from approx. 16 to 30 April 2020

The Chang'e 4 (CE-4) lander woke up on 17 April at 13:24 BJT and the rover awoke on 16 April at 20:57 BJT. Both were in normal working condition and resumed work for the 17th lunar day.
Yutu 2 (YT-2) continued its exploration to the northwest of the landing site and obtained a new batch of scientific data. All scientific instruments on the rover and lander operated nominally. During the lunar mid-day, the rover's panoramic camera took a 360° photo.
Until the end of the 17th lunar day, YT-2 accumulated 447.68 m of traversing the far side of the Moon. The rover remained until the 19th lunar day at its location in a distance of 292 m from the lander, taken by the end of the 17th lunar day.

29 April – 2nd batch of scientific data released on Chang'e-4

On 29 April 2020, the National Space Science Data Centre - the ground application system of the lunar exploration project - released the 2nd batch of scientific data of CE-4. The data were prepared by the Lunar and Deep-Space Exploration Research Department of the National Astronomical Observatory of the Chinese Academy of Sciences. The data released this time, included the data acquired by 4 payloads on the CE-4 lander and the YT-2 rover during the 3rd and 4th lunar day. 1,471 data files with a total amount of 7.18 GB were made public.
Lander payload data:
Low Frequency Radio Spectrum Analyzer - 2C level scientific data
Rover instrument data:

- **Panoramic Camera** - class 2B scientific data
- **Lunar Penetrating Radar** - 2B level scientific data
- **Infrared Imaging Spectrometer** - class 2B scientific data

Data can be accessed here: http://moon.bao.ac.cn/pubMsg/detail-CE42.jsp

17th lunar night – from approx. 1 to 15 May 2020

The CE-4 lander and YT-2 rover concluded the operations of the 17th lunar day. YT-2 switched to dormant mode on 29 April at 20:36 BJT and the lander on 30 April at 5:30 BJT.

18th lunar day – from approx. 16 to 29 May 2020

YT-2 woke up on 16 May at 11:53 BJT while the lander woke up on 17 May at 3:25 BJT.

The deep-space antennas in Jiamusi and Kashi have been undergoing a more than 1-month long upgrade from May until 13 June and the CE-4 mission control centre was undergoing some modifications. The upgrade was needed in preparation for the imminent Tianwen 1 Mars mission, but the ongoing CE-4 mission operations will also benefit from improved operations capabilities. The antenna upgrading limited the communication capabilities with the CE-4 mission. For that reason, only the Lunar Lander Neutrons and Dosimetry (LND) and the Low Frequency Spectrometer (LFS) on the lander were turned on for routine data collection. The YT-2 rover remained stationary during the 18th lunar day.
Although YT-2 did not move, the ground science team conducted in-depth research and analysis of the scientific data obtained by the instruments. They analysed the spectral data collected by the rover with respect to the mineral composition of the lunar soil and the space weather data from the CE-4 lander.

500 day milestone

On 17 May 2020, the CE-4 mission on the far side of the Moon has been operational for 500 days.
YT-2 continued to hold the longevity record for a working rover on the surface of the Moon, once set by the Soviet Union's Lunokhod 1 rover which operated for 322 days on the Moon.

2nd anniversary for Queqiao

On 21 May 2018, the communication relay satellite Queqiao was launched from Xichang Satellite Launch Centre. Queqiao entered its Halo orbit at Earth-Moon-Lagrange Point L2 on 14 June 2018. Since then, the satellite has been working flawlessly and ensured the reliable 2-way communication between Moon and Earth. Queqiao is equipped with 3 types of antennas: an umbrella-shaped parabolic antenna, a measurement and control antenna, and a data transmission antenna. The satellite conducted a total of 74 precision orbit maintenance manoeuvres to maintain its Halo orbit with high precision.

World Space Award for China's lunar mission scientists

In June, the International Astronautical Federation - IAF decided to confer the 2020 IAF World Space Award to Wu Weiren, Chief Designer of China's Chang'e Lunar Exploration Programmes (CLEP) and Academician of the Chinese Academy of Engineering; Yu Dengyun, Deputy Chief Designer of CLEP and Deputy Director of Science and Technology at China Aerospace Science and Technology Corp; and Sun Zezhou, Chief Designer of the Chang'e 4 probe and a senior researcher at the China Academy of Space Technology. This is the 1st time the IAF has given the award to Chinese scientists.
The award is presented for outstanding contributions in space science, space technology, space medicine, space law or space management of exceptional impact to the world's progress in astronautics.

18th lunar night – from approx. 30 May to 15 June 2020

The CE-4 lander switched to dormant mode in preparation for the lunar night on 29 May at 17:00 BJT and the rover at 7:15 BJT the same day.

19th lunar day – from approx. 14 to 27 June 2020

The YT-2 rover woke up on 15 June at 0:54 BJT and the CE-4 lander at 13:49 BJT the same day and started the operations for the 19th lunar day.

Since the 2 deep-space antennas in Jiamusi and Kashi have been undergoing upgrades until 13 June the communication link with the CE-4 mission needed rebooting before new instructions could be transmitted.

After re-establishing the communication link, the YT-2's Visible and Near-Infrared Imaging Spectrometer (VNIS) for spectrographic analysis of the composition of the lunar material was commanded to explore a small depression, located 3 m southwest of the rover. The exploration was guided based on images from the rover's panorama camera collected during the 17th lunar day. The depression has a diameter of about 1.3 m and a depth of approx. 20 cm and it seemed that reflective surface material in the central and south-eastern areas of the depression gives the areas a distinctive luminance that sets it apart from the lunar soil of the surroundings.
For this investigation in the morning of the 19th lunar day, Yutu 2 moved 5.177 m, accumulating a distance of 452.858 m since start of operations.

On 17 June, at 19:05 BJT, Yutu 2 switched to dormant mode for the lunar mid-day stand-by.

After completing the investigation of the depression, the rover turned in North-western direction with respect to the landing site, The rover investigated the characteristics of its trails with its IR spectrometer, panoramic camera, neutral atom detectors, and radar and settled on a location for the upcoming lunar night.

During the 19th lunar day, YT-2 drove in total 15.58 m so that by the end of the day, it had accumulated 463.26 m of traversing on the far side of the Moon.

As usual, the science data were transferred from mission control to the science team by the end of the lunar day.

13 June 2020 – 3rd batch of scientific data released

On 13 June 2020, the National Space Science Data Centre released the 3rd batch of scientific data of the CE-4 mission for public release. The data were obtained by the 4 scientific payloads on the lander and the rover during the 5th and 6th lunar days. The 1,096 data files amount to 6.11 GB of data.

The following lander data were published:
Low Frequency Radio Spectrum Analyzer 2C level scientific data
Rover instrument data:

- **Panoramic Camera** - class 2B scientific data
- **Lunar Penetrating Radar** - 2B level scientific data
- **Infrared Imaging Spectrometer** - class 2B scientific data

19th lunar night – from approx. 28 June to 13 July

The lander switched to dormant mode on 28 June at 1:00 BJT and the rover on 27 June at 16:23 BJT.
During the lunar night the science team was busy with analysing the downloaded data.

all dates and times: BJT = Beijing Time

FAST Impressions

by Chen Lan

The Guizhou (a province of China) trip was definitely the most impressive travel I made in 2020. It was not only because of the stunning scenery of the Karst landscape there but also the usually crowded and noisy tourist attractions suddenly became peaceful and quiet during the coronavirus pandemic when cross-province group tours were still restricted in July 2020. FAST, the Five-hundred-meter Aperture Spherical radio Telescope, was one of such places, and was one of my planned destinations. To reduce risk of human-to-human infection as much as possible, I rented a car in the Guiyang Longdongbao International Airport. In five days of this holiday trip, my wife and I drove for nearly 1,600 km and the FAST was the last stop we visited.

The expressway to the FAST is well-built and the scenery along it was beautiful. There were countless tunnels and bridges. Out of a dark tunnel were green round-shaped hills, range upon range, and then another tunnel came abruptly. Just before arrival, we saw a great bridge, the Pingtang Bridge. It was claimed as comparable to the Millau Viaduct in France with the tallest tower of 328 m and height of 305 m from the deck to the bottom of the valley. It was a nice experience driving through such a huge and entirely empty bridge.

Pingtang Bridge. Credit: Chinese Internet

Our destination is the Astronomical Town which was built together with FAST. It has wide roads and large-scale buildings - from the tourist centre to the planetarium, to the dome cinema, and even to the shuttle bus station. It was easy to buy a ticket which is also open to foreigners. Before boarding the shuttle bus, we got through the strictest security check I ever met - all electronic devices that potentially transmit electromagnetic radiation are not allowed to brought into the Radio Quiet Zone within 5 km around the FAST. Mobile phones, digital cameras, wireless earphones, laptops and tablets all must be left. I forgot to take out a wireless mouse but when my bag passed the X-ray screening machine, it was immediately detected. Great job! No loopholes!

The half-hour shuttle bus journey along winding mountain roads among the beautiful Karst landscape was also pleasant. I saw abandoned cottages covered by rattan plant sparsely located in the valleys. It was reported that totally 8,097 farmers have migrated to other places in order to give way to a 5-km radius electromagnetic quiet zone. Off the bus, we climbed up 789 steps and finally reached an observation deck on top of the mountain surrounding FAST.

The deck provides a spectacular panoramic view. In all directions, there are countless peculiar round peaks, one by one, range by range, extending into the distance. At my foot is a huge white or silver color disk, though it still looked smaller than I expected. Due to the pandemic, there were only about a dozen of people on the deck. However, at almost the same time as we got there, a heavy rain came with thunder and lightning. Thanks to a large roof above the deck, we enjoyed a vibrant and breathtaking performance by nature, without getting wet. I saw distant peaks were stuck by lightning. And suddenly came a huge bang with bright flash that illuminated everything all around. It was so close that I guessed it may have hit one of the six lightning towers around FAST. The picture I saw that time was a so surreal. I felt that the lightning was from heaven and I was in somewhere between the Earth and the universe. This was a moment I would never forget.

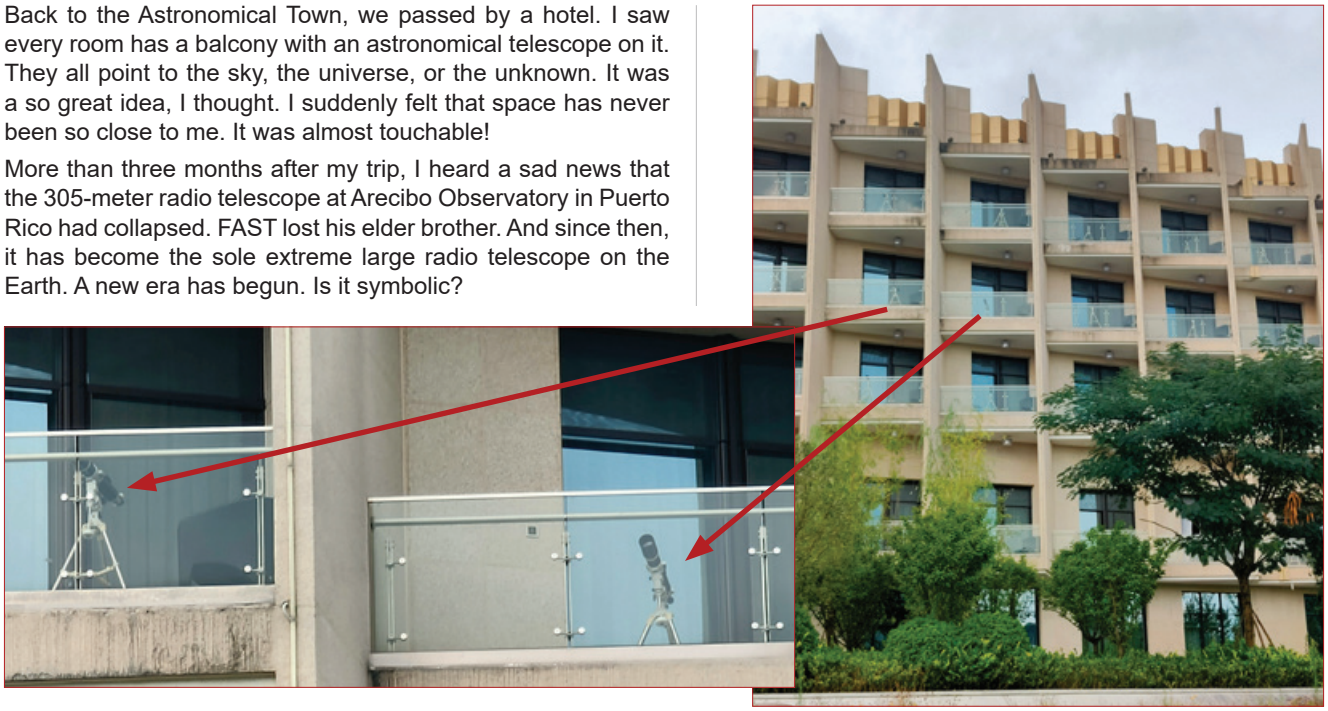
When the rain eased off and the sky became a little brighter, I started to observe the disk. It was so huge that I cannot identify details of the 4,450 panels composing the disc and the Feed above it. There were not any human activities observable nearby the antenna. But I knew that many scientists were working hard there, just a few hundred metres from me.

FAST was completed on 25 September 2016. On 11 January 2020, the world's largest radio telescope began its operation. In four years since its completion including the three years of the testing phase, the telescope has already produced valuable scientific findings and more than 40 papers based on the data it obtained have been published. It was reported that FAST has discovered 240 pulsars up to November 2020. On 29 August 2019 and afterwards, FAST detected multiple FRBs (Fast Radio Burst) from the source FBR 121102 followed by another FRB observation on the FRB 180301. But both are known FRBs. In April 2020, FAST scientists announced their own discovery - the new FRB 181123 identified with help of AI based on FAST observation data in 2018. On 24 January 2020, FAST and the Tianma telescope in Shanghai did a joint VLBI observation with success, which showed FAST's potential in future space vehicle tracking. In July 2020, it found neutral hydrogen emission in 3 low-redshift galaxies. This was exactly at the time I visited it.

It was a very pleasant surprise that the rain stopped and the sun shined again. I can then look further through clean air after the rain. Countless round green peaks, cast with bright sun glow, emerged among the mist. Unfortunately, the stunning beautiful picture can only be recorded by my memory as taking photo by yourself was impossible there without a camera. There was a paid service using old-style mechanical film camera. A photographer sitting at top of a ladder clicked one by one for people who queued. No other choice. I got the scanned photograph a few days later when I was back in Shanghai. I was so disappointed that the photo quality is terrible - blur image, dim and inaccurate colour, a lot of noises. Well, I finally got a photo, better than nothing.

Back to the Astronomical Town, we passed by a hotel. I saw every room has a balcony with an astronomical telescope on it. They all point to the sky, the universe, or the unknown. It was a so great idea, I thought. I suddenly felt that space has never been so close to me. It was almost touchable!

More than three months after my trip, I heard a sad news that the 305-meter radio telescope at Arecibo Observatory in Puerto Rico had collapsed. FAST lost his elder brother. And since then, it has become the sole extreme large radio telescope on the Earth. A new era has begun. Is it symbolic?

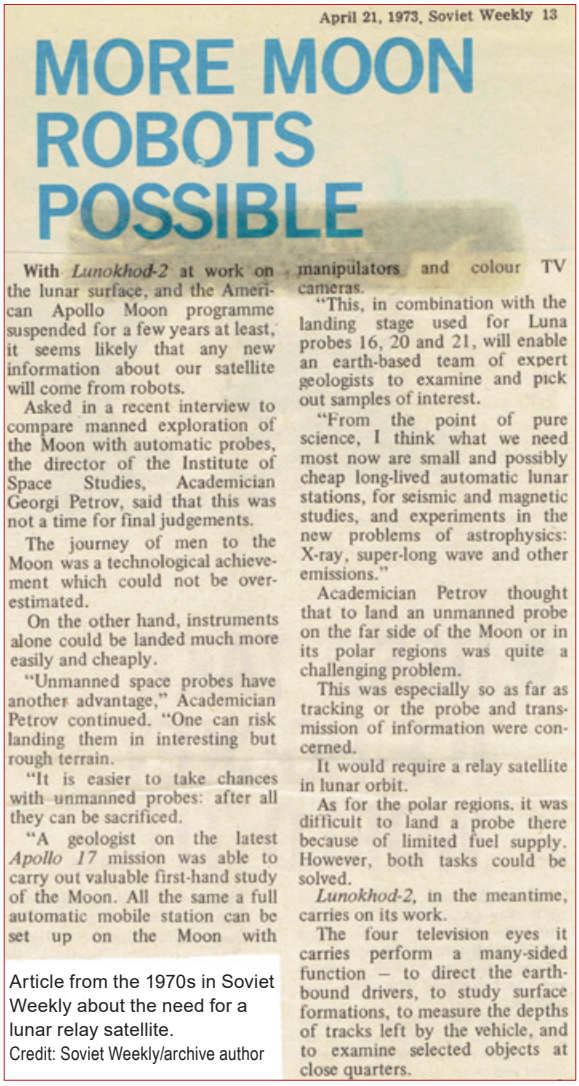


Queqiao 2: new design lunar relay

by Brian Harvey

Earth's skies may be filling with communications satellites - there are so many now that some astronomers call the Starlinks 'vermin'. But what about lunar orbit? Plans for lunar bases by the United States (Artemis) and Russia and China (International Lunar Research Station) (ILRS), both for the lunar south pole, have prompted new designs for communications satellites in lunar orbit.

Such lunar relays are essential for farside and polar missions. The idea is not new. In the early 1970s, Goddard Spaceflight Centre's Robert Farquhar outlined the idea of halo orbits for farside communication relays **(1)**. Soviet academician Georgi Petrov defined the need for a lunar communications relay satellite as far back as the 1970s, a project seriously considered for a farside lunar sample return in the Luna programme **(2)**. No farside mission was carried out until 2018 when China put the Queqiao relay into a halo orbit (2018), not for a sample return but to support the landing of Chang'e 4 and its rover Yutu 2 in crater von Kármán (2019). Queqiao is still there, a small satellite of 448 kg with a big dish (4.3 m), 105 litres of fuel and hydrazine propulsion system (130 N).



April 21, 1973, Soviet Weekly 13

MORE MOON ROBOTS POSSIBLE

With *Lunokhod-2* at work on the lunar surface, and the American Apollo Moon programme suspended for a few years at least, it seems likely that any new information about our satellite will come from robots.

Asked in a recent interview to compare manned exploration of the Moon with automatic probes, the director of the Institute of Space Studies, Academician Georgi Petrov, said that this was not a time for final judgements.

The journey of men to the Moon was a technological achievement which could not be overestimated.

On the other hand, instruments alone could be landed much more easily and cheaply.

"Unmanned space probes have another advantage," Academician Petrov continued. "One can risk landing them in interesting but rough terrain.

"It is easier to take chances with unmanned probes: after all they can be sacrificed.

"A geologist on the latest *Apollo 17* mission was able to carry out valuable first-hand study of the Moon. All the same a full automatic mobile station can be set up on the Moon with manipulators and colour TV cameras.

"This, in combination with the landing stage used for Luna probes 16, 20 and 21, will enable an earth-based team of expert geologists to examine and pick out samples of interest.

"From the point of pure science, I think what we need most now are small and possibly cheap long-lived automatic lunar stations, for seismic and magnetic studies, and experiments in the new problems of astrophysics: X-ray, super-long wave and other emissions."

Academician Petrov thought that to land an unmanned probe on the far side of the Moon or in its polar regions was quite a challenging problem.

This was especially so as far as tracking or the probe and transmission of information were concerned.

It would require a relay satellite in lunar orbit.

As for the polar regions, it was difficult to land a probe there because of limited fuel supply. However, both tasks could be solved.

Lunokhod-2, in the meantime, carries on its work.

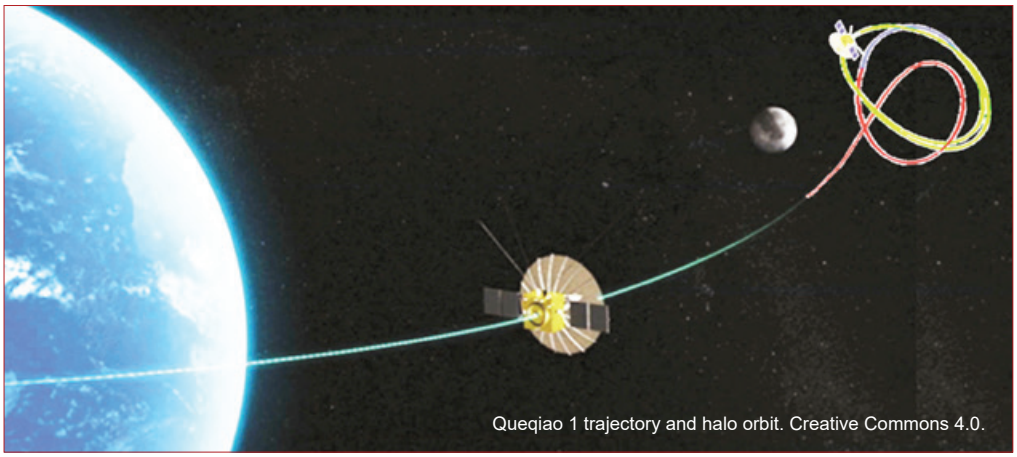
The four television eyes it carries perform a many-sided function — to direct the earth-bound drivers, to study surface formations, to measure the depths of tracks left by the vehicle, and to examine selected objects at close quarters.

Article from the 1970s in Soviet Weekly about the need for a lunar relay satellite.
Credit: Soviet Weekly/archive author

The real challenge, though, was to insert it into and maintain the right orbit behind and under the Moon, so that crater von Kármán and Earth were both always constantly in Line-Of-Sight (LOS). Queqiao was not in an ordinary lunar orbit, but a 14-day halo up to 79,000 km distant from the Moon called an Earth Moon L2 (EML2) trajectory. This took the form of an unstable, irregular three-dimensional curve, one which must be constantly monitored and corrected, for it will waltz away over time. This link has to function continuously and faultlessly, or communications with the surface mission in von Kármán will be over. By 2021, 97 correction adjustments had been made, typically every nine days. So far, fuel usage has been kept down and there is enough to keep Queqiao going until 2023. Six communication channels have provided a combination of forward, backward, real-time data and store-and-forward data (512 GB storage) between ground tracking stations, Queqiao, Chang'e 4 lander and Yutu 2.

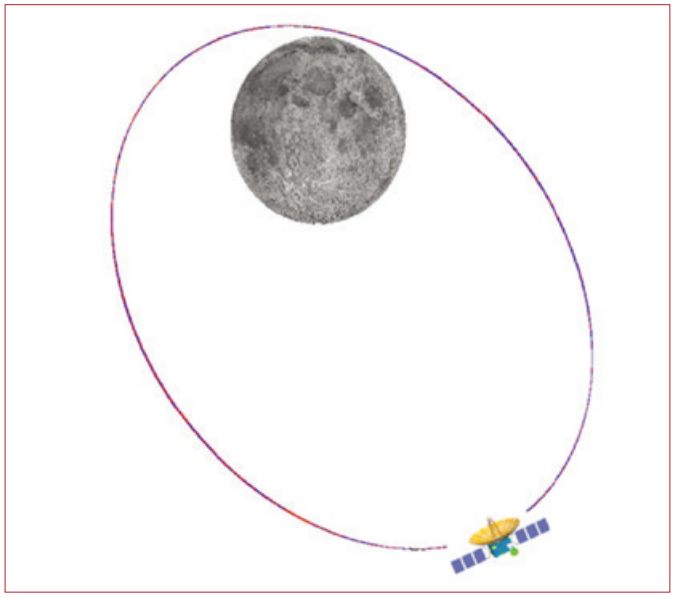
With the collection of its first cargo of Moon rock from the Ocean of Storms in December 2020 by Chang'e 5, China is now in a position to move on to its next three lunar missions: Chang'e 6, 7 and 8 for the mid to late 2020s which will pave the way for the ILRS. Chang'e 6 will be a sample return mission; Chang'e 7 will be an orbiter,

lander, rover and 'mini flying probe'; while Chang'e 8 will test In Situ Resource Utilization (ISRU), 3D printing and techniques for base construction. They have one thing in common: a south pole destination. Such locations offer Line-Of-Sight communication with Earth only half the lunar day, while craters and slopes may obscure communication completely.


Queqiao 1 trajectory and halo orbit. Creative Commons 4.0.

For these missions, China has published in *Space: Science & Technology* its first detailed paper on a second lunar relay satellite **(3)**. This relay has generally been associated with the Chang'e 7 mission. The author was Zhang Lihua of the Dong Fang Hong satellite company, the article *Development and prospect of Chinese lunar relay communication satellite*. It may be presumed that she is the spacecraft designer, or at least prominently involved. She moderated the September 2020 Fuzhou conference forum on Small Satellites and Electromagnetic Information Technology Applications in her capacity as Research Fellow and Member of the Advanced Small Satellite Technology Application Committee of the Chinese Society of Astronautics.

Designing a lunar polar relay satellite is not easy and involves many trade offs. A high, eccentric lunar polar orbit is desirable for being overhead the south pole most of the time, but the distance less suitable for high-density data reception and transmission; while lower orbits are better for data reception and transmission, but fly over the landing site for shorter periods. There are further trade-offs around the size of the dish; transmission power; frequencies and bandwidth (currently S- and X-band, but Ka band will be necessary in future); the use of bent pipe technology (automated onward transmission of received data); and the amount of fuel required to reach different types of orbit.

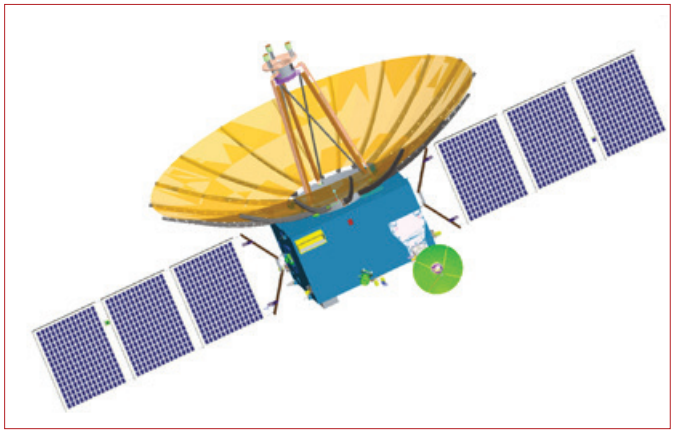

High orbit over lunar south pole. Creative Commons 4.0.

According to Zhang Lihua, the design of a new relay satellite is now underway, presumably with the Chang'e 7 and 8 missions in mind, with an operational life of up to eight years. The technical requirement will be six S-band transponders (low data rate); two X-band transponders; and two Ka-band links using a gimballed 60 cm diameter dish (high data rates), the overall system working in ten channels simultaneously. The use of Ka-band will mark an advance on the first Queqiao. Communication rates with the surface are expected to be between 50 kbits/sec and 1 Mbits/sec. The orbit currently favoured, described as 'frozen highly elliptical' is 300-8,600 km, 54.8°, 12 hr, which will give 8 hr coverage each orbit, analogous to the Earthly 'Molniya orbit'. If this proves to be inadequate or unsatisfactory, then a second relay will be sent. The satellite could be launched either on top of Chang'e 7 in the place of the sample return craft used on Chang'e 5; or independently, in advance, on a smaller launcher on its own, possibly the CZ-4C again, like Queqiao.

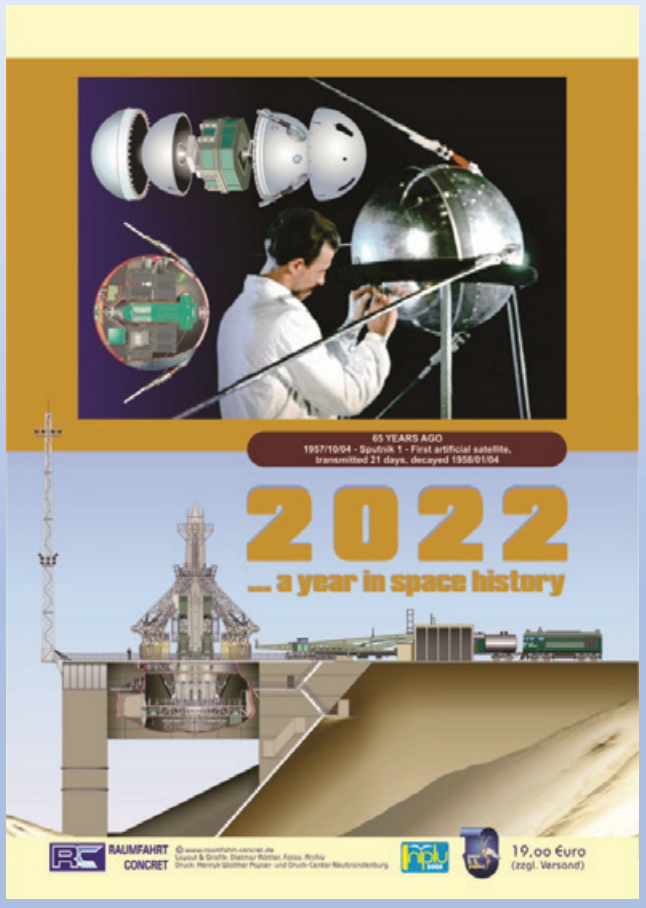
Although not formally called Queqiao 2, its design is described as 'inherited from' Queqiao, so it is more than likely to be so. It will be heavier, 600 kg (against 448 kg), with more power (1,000 W against 780 W) and being in a 'frozen' orbit will not need to carry propellant for orbital manoeuvres. We know from a presentation to the 51st Lunar and Planetary Conference in Houston, Texas, that two experiments will also be carried on the relay: a grid-based energetic neutral atom imager to obtain, from its distant vantage point, global imaging data of neutral atoms in the Earth's magnetosphere; and a Very Long Baseline Inferometry (VLBI) experiment **(4)**. More information is expected to emerge in the next few years.

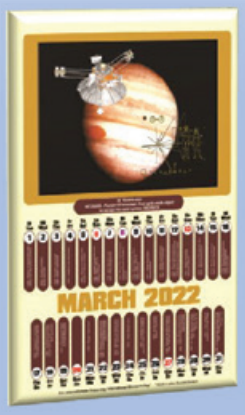
References:

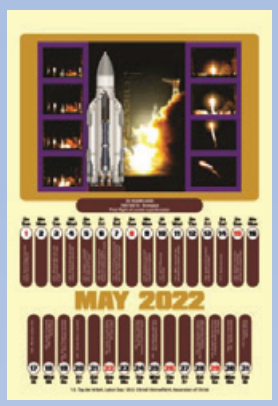
(1) Farquhar, Robert: *The utilization of halo orbits for advanced lunar operations.* NASA Goddard Flight Centre, 1971.
(2) *Moon robots possible.* Soviet Weekly, 21 April 1973.
(3) Zhang, Lihua: *Development and prospect of Chinese lunar relay communication satellite.* Space: Science & Technology, 2021, 27 April 2021.
(4) Zou, Yongliao; Liu, Yang; & Jia Yingzhuo: *Overview of China's upcoming Chang'e series and the scientific objectives and payloads for the Chang'e 7 mission.* Presentation to 51st Lunar and Planetary Science Conference, Houston, Texas, 2020.

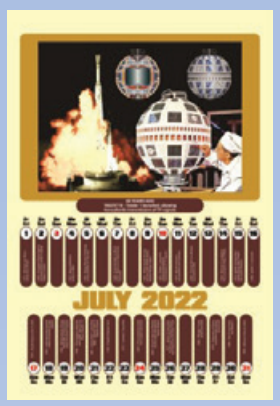

Queqiao 2 preliminary design. Creative Commons 4.0.

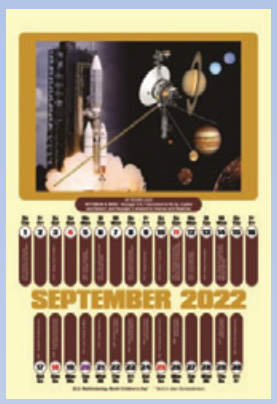
Wall calendar 2022

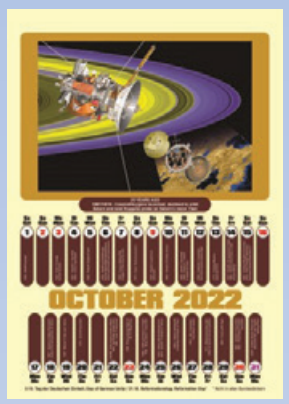


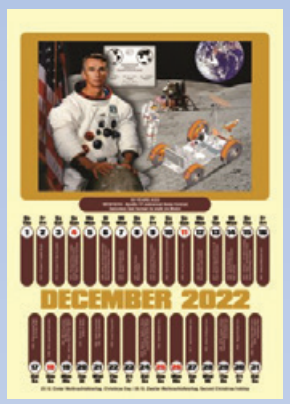












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