All About The Chinese Space Programme

GO TAIKONAUTS!

龙腾太空

Issue 30

September 2020

Content

The return to flight of the CZ-5 on 27 December 2020 paved the way for China's Mars mission, the CE-5 lunar sample return mission, and the long-awaited launch of the CSS core module "Tianhe". Credit: Guo Wenbin/ChenXiao

Chinese Space Quarterly Report
October - December 2019
by Jacqueline Myrrhe, Chen Lan

SPACE TRANSPORTATION

CZ-5
On 21 December at 8:25 BJT, the CZ-5 Y3 was vertically transported by the mobile launch platform from the assembly hall to the launch pad. The procedure took two hours. At the launch pad further examinations and testing were carried out.

CZ-5 Y3 at the Wenchang Space Launch Centre on 21 December 2019. Credit: Zhang Gaoxiang/Xinhua

Green ignition flash of the CZ-5. Credit: CAST

Why China's next Long March 5 rocket mission will be about restoring national pride

The setback of the CZ-5 dealt a huge blow to China's space industry and national prestige. Before the failure, morale was high because China had just launched the world's first quantum satellite and its astronauts had lived and worked in orbit for more than a month on the Tiangong space lab.
China was catching up to Russia and the United States with more than 20 space launches annually.
After the failure, however, many programmes were put on hold for quality and safety reviews.
Data from the second launch showed that a pump injecting high-pressure fuel into the rocket engine's combustion chamber had failed, causing a sudden loss of thrust.
Engineers made the pump more reliable. It was a simple job that could have been done in a few months, but to be thorough, engineers spent more than two years testing the device and the rest of the engine in costly ground experiments.
"The CZ-5 is probably the most exhaustively checked and verified model in Chinese history," one researcher said.
Wu Yansheng, the president and Communist Party secretary of the China Aerospace Science and Technology Corporation, flew to Wenchang last month to work with technicians. "The CZ-5 launch … is the biggest political [duty] of the corporation at present," he was quoted as saying.

CZ-5 - reanalysis, redesign and revalidation

In preparation for the CZ-5 Y3 flight, the engineers of the China Academy of Launch Vehicle Technology (CALT) completed over the last 2 years a series of ground tests and an in-depth analysis of the failure of the 2nd CZ-5 flight. When a turbopump on one of the two YF-77 cryogenic 1st stage engines failed in July 2017, it was decided to redesign the YF-77 by adding guide vanes and substitute steel parts with nickel super alloy components. During the "reanalysis, redesign and revalidation" the launcher's reliability was improved and optimised. With the CZ-5, China's LEO payload capability increased from 14 t to 25 t, the GEO launch capability from 5 t to 14 t and the Moon transfer orbit capacity from 4 t to 8 t.
The Mars-transfer capacity is 6 t. The 5 m-core stage is powered by 2 LH2-LOX YF-77 engines. The 4 side boosters of 3.35 m-diameter are propelled by a pair of YF-100 engines. The 2nd stage uses 2 YF-75D engines and the 3rd (Yuanzheng 2 upper stage) 2 YF-50D engines.
For the rocket's development, 12 engineering projects were implemented and 200 key technologies developed, e.g. vibration management, cryo-material handling, and friction stir welding.
The newly developed high-performance YF-100 engine is based on an oxidizer-rich staged combustion cycle fuelled by kerosene and LOX. The YF-77 and YF-75D engines have a vacuum thrust of 70 t and 9 t respectively. The overall advanced level in engine technology is laying a solid foundation for the subsequent development of a heavy-lift launcher with 100 t LEO capacity.
The CZ-5 development required the modernisation of the whole industrial chain at CALT's establishments and drove the implementation of new materials, new processes as well as innovation and new technology, e.g. advanced manufacturing, 3D design, testing and simulation. At the Tianjin factory, a new assembly line and testing facilities were put in place. In Xi'an, a new liquid rocket engine development is operational.

Long March 5 - Three Times a Charm

Excitement has been building up in China and among space enthusiasts ever since Chinese authorities have hinted at a possible return of the Long March 5 to the launchpad at the end of the year. First mentioned by CGWIC during the Satellite Business Week in September 2019, it was then further confirmed by the departure for Tianjin of the Yuanwang 21 and 22 cargo ships (which specialise in the transportation of rocket parts, notably Long March 5). The current launch date is estimated to be at the end of December, although this could easily be shifted to early 2020 due to the usual uncertainty around launches.

CZ-8
By November, the medium-lift CZ-8 was in its final stage of assembly and testing, getting readied for its 1st flight in 2020. At the beginning of December, the 2nd stage hydrogen-oxygen engine was successfully tested. The engine performed nominally. There is a projected demand of 10 CZ-8 annual launches, which will increase later to around 20 per year.

Staff prepare for the test of the 2nd stage engine of the CZ-8 rocket, on 25 November 2019. Credit: VCG Photo

LAUNCH SITES

Xichang – Launch Capacity

After the successful Beidou launch on 16 December, the Deputy Director of the Xichang Satellite Launch Centre (XSLC), Wang Zemin, told media that the centre has increased its launch capacity from 2-3 annual launches previously, to 20 missions a year. Xichang is able to handle a launch every 16 days. A new launch pad for the CZ-8 next-generation rocket, is currently under construction.

Xichang – Rocket Debris

Falling rocket parts are a problem for launches from China's inland rocket launch sites.

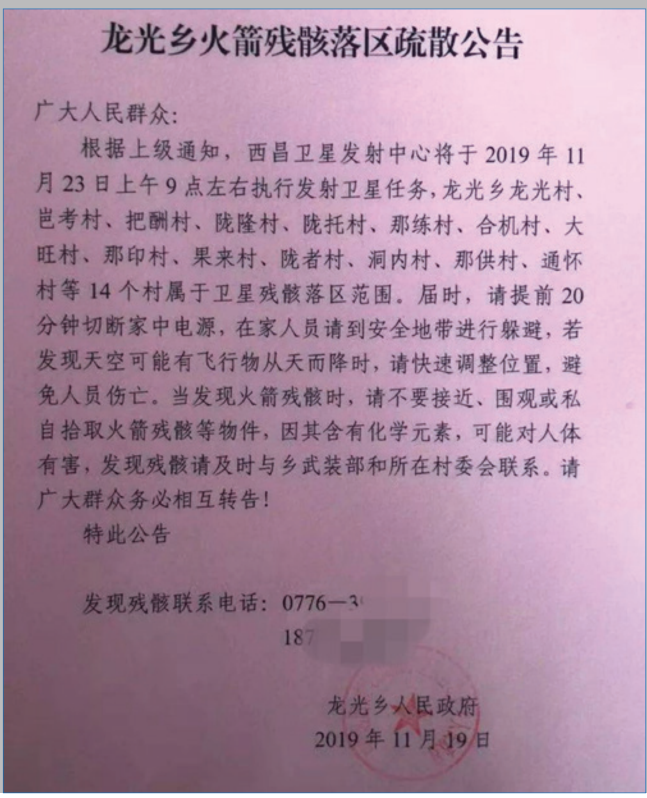
CNBC got hold of the official warning note, that authorities released to all affected villages in the rocket stage dropping zone for the launch of the pair of Beidou satellites from XSLC on 23 November. The note states when the launch is to be expected and how to shelter. Most importantly, it does instruct the villagers not to touch any rocket parts which have fallen from the sky. See text box below.

Long Guangxiang Rocket Launch Area Evacuation Notice

To the people:

According to a notice from the administration, the Xichang Satellite Launch Centre will conduct an operation around 9:00 h on 23 November 2019. 14 villages in the Longguang community (Longguang village, Bakao village, Bachou village, Longlong village, Longtuo village, Nalian village, Heji village, Dawang village, Nayin village, Guolai village, Dongnei village, Nagong village and Tonghuai village) are in the range where the satellite debris will drop. Please cut off your power at home 20 minutes before that time and hide at a safe area. If you see any flying objects falling from the sky, please, adjust your location quickly to avoid any harm. If you discover any debris, please don't get close or pick them up because they could be harmful to human bodies due to the chemicals. Please, contact the village committee if you find any pieces from the rocket. Please, spread the word about this announcement.

Contact number for reporting rocket debris: 0776-XXXX
Longguang Xiang People's Government
19 November 2019



龙光乡火箭残骸落区疏散公告

广大人民群众：

根据上级通知，西昌卫星发射中心将于2019年11月23日上午9点左右执行发射卫星任务，龙光乡龙光村、岜考村、把酬村、陇隆村、陇托村、那练村、合机村、大旺村、那印村、果来村、陇者村、洞内村、那供村、通怀村等14个村属于卫星残骸落区范围。届时，请提前20分钟切断家中电源，在家人员请到安全地带进行躲避，若发现天空可能有飞行物从天而降时，请快速调整位置，避免人员伤亡。当发现火箭残骸时，请不要接近、围观或私自拾取火箭残骸等物件，因其含有化学元素，可能对人体有害，发现残骸请及时与乡武装部和所在村委会联系。请广大群众务必相互转告！

特此公告

发现残骸联系电话：0776—3
18

龙光乡人民政府
2019年11月19日

Yuanwang 21 and 22 for CZ-5 transport

The transportation vessels Yuanwang 21 (YW) and Yuanwang 22, exclusively made to ship rocket stages, departed on 12 October from their home port in Jiangsu Province. They loaded the CZ-5 Y3 rocket parts at Tianjin Port, located close to the CZ-5 production facility. Both ships are equipped with 120 t-cranes allowing for efficient hoisting methods in lifting the large rocket parts.

YW-21 and YW-22 set sail from Tianjin Port on 22 October, bringing the rocket stages to Wenchang Qinglan Port-Langang Wharf on Hainan Island where they arrived on 27 October. From Qinglan Port, transport to the Wenchang Satellite Launch Centre was made by road, where the rocket was assembled and tested. The CZ-5 Y3 was prepared for the launch of the DFH 5-based Shijian 20 communications technology demonstration satellite into GEO, compensating for the loss of Shijian 18 during the launch mishap in July 2017.

YW-21 and YW-22 returned to their port in Jiangsu Province on 25 November. The vessels belong to the China Satellite Maritime Measurement and Control Department.

The 3rd CZ-5 rocket is transported to Wenchang on 27 October 2019. Credit: Chinadaily.com.cn

The 3rd CZ-5 carrier rocket is loaded at Tianjin on 18 October. The rocket arrived in Wenchang, Hainan province, on 27 October and will undergo final tests before its launch. Credit: China Daily

CZ-5 rocket parts arrived on 27 October at Qinglan Port on Hainan Island. Credit: CASC

Yuanwang 5 and 7

On 10 November, YW-5 and YW-7 left from their port in Jiangsu Province for the Indian Ocean to serve 5 upcoming maritime space tracking missions. The departure of the 2 ships means that all 6 vessels of the YW fleet were on sail: YW-3, 5, 6, 7 and the transport mission for the CZ-5 (YW-21 and YW-22).

Before departure, crew members analysed challenges and risks of the mission, carried out a general maintenance and tests of the facilities, and received a mission-specific training.

Yuanwang – Wedding Location

24 couples took part in a mass wedding ceremony on 20 October 2019 on board of one of the Yuanwang space monitoring and tracking vessels. The ceremony was specially arranged for staff members who work for the Yuanwang fleet. The wedding couples joined a flag-raising ceremony on the deck of one of the YW ships.

The wedding couples joined a flag-raising ceremony on the deck of one of the Yuanwang ships. Credit: www.chinadaily.com

MANNED SPACE FLIGHT

CMSA – Staff Appointments

By mid-October China Manned Space Agency (CMSA) made public that Zhou Jianping was appointed as the Chief Designer of China's manned space flight programme, and Gu Yidong as the Chief Space Scientist. China's first taikonaut Yang Liwei and 7 other experts in the fields of spacecraft, launchers, space technology applications, monitoring and communication systems have been appointed Deputy Chief Designers.

CSS (China Space Station) - Status

Zhou Jianping, confirmed at the 4th China Summit Forum on Human Factors Engineering held on 16 and 17 November at the Sun Yat-sen University in Guangzhou, Guangdong, that China plans to complete the construction of the CSS around 2022. He reiterated that the station can be enlarged if necessary and the currently planned 10 years of operation can be extended by in-orbit maintenance. International astronauts and spacecraft with docking capability for the Chinese docking mechanism are welcomed. The CZ-5B, indispensable for the launch of the space station modules, is expected to make its first flight in 2020.

Manned Lunar and Mars Landing

China is undergoing long-term planning and preparation-study for its manned lunar exploration, and has consolidated overall consensus and a preliminary plan. At the 1st China Space Science Assembly held from 25 to 28 October in Xiamen, Fujian Province, Chen Shanguang, Deputy Chief Designer of China's manned space programme, said the overall aim is to go to the Moon for scientific research, establish a lunar base, test the in-situ utilisation of resources, and accumulate technology and experience for future deep-space endeavours.

The long-term goal is to send people to Mars in the 2050 timeframe. Some Chinese experts have proposed an earlier manned Mars mission which seems too ambitious considering the technological challenges to master such as: high-performance propulsion system, reliable bio-regenerative life-support system, handling the communication delay between a Mars-bound spacecraft and Earth, providing energy supplies for Mars surface operations and human health risks.

Lunar Manned Exploration - Taikonauts

On the occasion of the 16th anniversary of his historic space mission, Yang Liwei told media that he is still taking part in weekly training and undergoes regular examinations and that he would look forward to setting foot on the Moon. It was not clear whether that meant himself or a future taikonaut. He also stressed that "China has started to develop the key technologies related to a manned lunar landing. It would be exciting to see Chinese astronauts stepping onto the extra-terrestrial object."

Deep-Space Man-rated Rocket

A pre-study for China's a new generation man-rated launch vehicle, which started in 2017, has been successfully concluded by CALT. The research results were passed on for review and approval by CMSA. The Acceptance Review took place on 9 October. The engineers were starting the detailed design phase and will continue to improve the rocket's technical plan. The new rocket will be based on mature engine technology and the highly reliable flight control technology of the CZ-5 and CZ-7. It will adopt a new escape system design, lightweight and efficient structural design, advanced manufacturing, new materials, lightweight high-reliability thrust vector control, vibration management, large tank design as well as temperature control and management.

Prime contractor for the 87 m tall rocket with a lift-off mass of 2,200 t and 2,700 t thrust will be CALT in Beijing. It will be able to place 25 t into lunar transfer trajectory, a prerequisite for manned lunar landings. In combination with the new CZ-9, the new man-rated launcher will enable the construction of a permanent lunar base. It is hoped that this rocket - which has not yet been officially named but was nicknamed the 921 rocket - will be ready before the CZ-9 and will have lower costs.

TAIKONAUTS

On 14 December, Yang Liwei held talks with Mamoru Mohri, Japan's first astronaut and Director of the National Museum of Emerging Science and Innovation of Japan in Tokyo. Both attended a public event in the museum where they discussed their experience in space, the status of their respective national space industries and options for future cooperation.

Bed Rest

From August to October, the Earth Star-2 bed rest study with 36 subjects was conducted at a research institute in Shenzhen, Guangdong province. The 3 research phases comprised: 15 days of adaptation, 90 days of bed rest and 33 days of recovery.

Bed rest studies are an effective analogue environment to investigate the effects of weightlessness on the human body. During the 3 months-long study, 36 male volunteers selected from 400 applicants, stayed in bed with their upper body tilted by -6°degree. This head-down position induces changes in the human body similar to the physiological changes astronauts experience in space. Scientists from the China Astronaut Research and Training Centre carried out more than 10,000 tests and collected data on basic physiological, cardiovascular, bone, psychological evaluations and other indicators.

The study is preparing for humans' stays of up to 180 days on board the CSS, helping to understand the impact of long-term weightlessness on the human body and whether the existing protective measures are effective and how they can be improved. The experts hope that all these questions can be answered before the astronauts fly to the CSS.

Previously, China conducted such experiments on men for 30 days, 45 days and 60 days, and on women for 15 days, providing data and considerations for a series of manned space missions. Bed rest studies originated in the Soviet Union in the 1970s.

CSS Research - "Tumours in Space" project for studying cancer risk of cosmic radiation

One of the 9 research projects that has been approved for research on the CSS is designed to answer the question whether the conditions in space can stop cancer cells from growing. The research project, called "Tumours in Space", is led by Canadian researcher Tricia L. Larose from the Faculty of Medicine and Health Sciences at the Norwegian University of Science and Technology (NTNU). The project will examine the roles of both microgravity and cosmic radiation in tumour growth and development. 3-dimensional stem cell organoids, taken from cancerous and healthy tissue of the same person will be sent to space. The hypothesis is that the cancer organoid growth will be slowed or stopped. Previous research on two-dimensional cells has shown that weightlessness has an influence on gene expression linked to tumour development.

LUNAR and DEEP-SPACE Exploration

LUNAR EXPLORATION

CHANG'E 3

The Chang'e 3 (CE-3) lander on the near side of the Moon is still operational. It awakened on 7 December 2019 to start work for the 75th lunar day. CE-3 landed on the Moon on 14 December 2013 and is now operating since 2,189 Earth days (over 6 years), the longest time for an active lunar probe.

CHANG'E 4

Chang'e 4 continued operation on the far side of the Moon. For more details, please, see our special report on pages 26 to 27.

CHANG'E 5

ESA is preparing for deep-space network support during LEOP for the upcoming Chang'e 5 lunar sample return mission via its Kourou ground station. For the return of the spacecraft with lunar samples, the Maspalomas antenna on the Canary Island of Gran Canaria will be involved.

LUNAR / MARS MISSION

At the end of October, Ye Peijian, a leading lunar scientist at the China Academy of Space Technology, said in Beijing that there is confidence in the improved reliability of the CZ-5 to proceed with the launch of the Chang'e 5 (CE) lunar sample return mission and the Mars lander mission in 2020. If CE-5 is successful, CE-6 will be sent to the lunar south pole to collect samples and bring them back to Earth. A Mars Sample Return mission is expected around 2030

Mars Landing Simulation

On 14 November, scientists and engineers were simulating the landing phase of the Chinese Mars 2020 spacecraft on a test facility in Huailai County, Hebei Province, near Beijing. The site is run by the Beijing Institute of Space Mechanics and Electricity. The test range comprises a 140 m high 6 pylon tower structure, a servo system and a simulated Martian landscape. A rack structure in the middle of the pylons is held by 36 steel cables which are precisely controlled to simulate the Martian gravitational conditions during landing.

It was demonstrated how a Mars lander model, suspended from the structure, separates from the main craft and descends close to the Mars surface, while conducting a hovering and obstacle-avoidance manoeuvre.

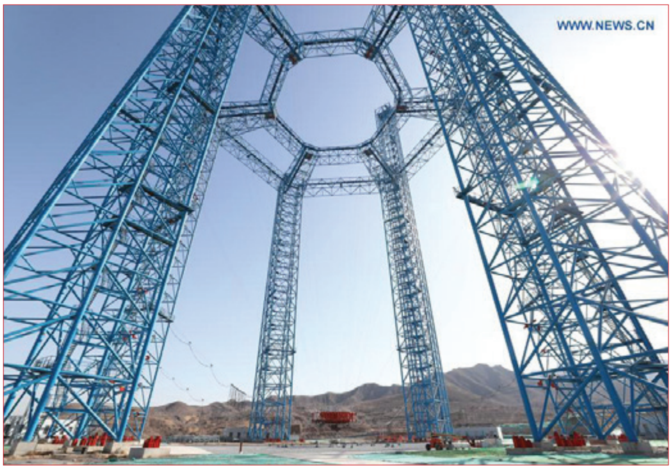
The test verified the procedures including the lander's separation from the main body of the spacecraft from an altitude of 70 m, and then hovering at 67 m above the surface, searching for a safe landing spot in an obstacle-avoiding manoeuvre, and then descending to 20 m above the surface where the lander stopped.

The experiment also aimed at verifying the design and capability of the Mars lander. It was the 1st of its kind in China. It was also the 1st time that such a test was done in the presence of foreign visitors or any public. China National Space Administration (CNSA) invited almost 100 representatives from 19 diplomatic missions, such as France, Italy and Brazil as well as representatives of international organisations (European Union, the African Union and the Asia-Pacific Space Cooperation Organisation) and journalists.

Zhang Kejian, Director of CNSA, addressed the audience and stressed that China is interested in international cooperation.

Zhang Rongqiao, Chief Designer of China's first Mars mission, explained that the flight to Mars will take about 7 months, while landing will take 7 min but those 7 min will be one of the most difficult and challenging parts of the mission. Therefore, engineers built the facility to simulate the Red Planet's gravitational condition and surface.

China does key test on Mars probe lander - video footage of the test

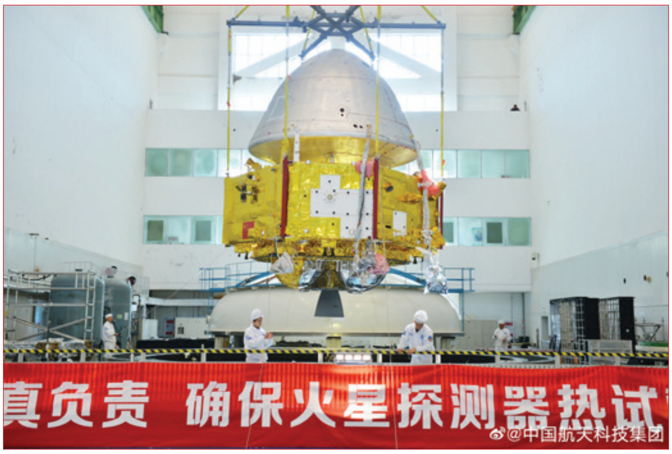


This photo taken on 14 November 2019 shows the testing facility for Mars landing simulation in Huailai County, Hebei Province. Credit: Xinhua/Jin Liwang


Mars landing simulator where the process of hovering, avoiding obstacles and descending to land on Mars was tested on 14 November 2019. Credit: Xinhua/ Jin Liwang

Mars Mission Hardware

China Aerospace Science and Technology Corporation (CASC) unveiled on 11 October the 1st picture of the Mars probe, showing the hardware in the clean room. Ye Peijian, Chief Scientist for Space Science and Deep-Space Exploration with CAST (Chinese Academy of Space Technology) confirmed that preparation of the orbiter-lander-rover mission is on track and is scheduled for launch on a CZ-5 in 2020 and should land on Mars in 2021. The idea is to land on the Red Planet in May 2021.



The Mars probe in a clean room at CAST. The dome shape houses the lander and rover while the lower body is the orbiter. Credit: CASC/CAST

Asteroid-Comet Mission ZhangHe

At the 1st China Space Science Assembly in Xiamen, the China Academy of Space Technology presented the mission profile for the ZhangHe near-Earth asteroid and a main-belt comet mission, planned for 2024. The space craft would fly to asteroid 2016HO3 (40-100 m diameter), land on it and take a 1 kg sample. The spacecraft will then fly-by the Earth and release a return capsule containing the samples. After that, the probe will continue its mission conducting Earth and Mars swing-by manoeuvres. Last destination is the main asteroid belt where the probe will enter an orbit around comet 133P, posing characteristics of both an asteroid and a comet. It has a 5.4 km nucleus and its density is estimated to be around 1.4 g/cm^3. ZhangHe would stay 1 year for remote sensing of the comet.

Currently the key technologies, such as advanced scientific detectors, electric propulsion technology, automated navigation and intelligent control functions are under development. The mission remains a technological challenge because little is known about the shape, composition, structure and the special features of the two targets. Asteroid 2016HO3 is making one rotation in about ½ h, making it difficult to land there. Comet 113P's location is at the outer edge of the main asteroid belt, making it difficult to determine its orbit. Also, connecting both mission phases flawlessly is needed. China gained some experience in fly-by manoeuvres during the extended CE-2 lunar mission when the probe flew-by asteroid Toutatis at a distance of 770 m in December 2012.

CNSA has invited the international community to contribute scientific payloads to this mission.

Deep-Space Operations

According to a Chinese academic paper published in 2018 in the Journal of Deep-Space Exploration, Chinese astrophysicists were using the 35 m-dish of Kashi ground station in Xinjiang for receiving signals sent by NASA's Jupiter probe Juno. The purpose was to check China's tracking, telemetry and command (TT&C) capabilities to learn for future deep-space missions. The Juno planetary probe uses X-band and Ka-band radio waves to communicate with NASA. Chinese space experts used the signals to measure the Doppler shift and consequently determine Juno's trajectory. Juno's signals are open and can be received by anyone with an antenna of sufficient performance.

SCIENCE

HERD - High Energy cosmic Radiation Detection

From 16-18 December, the 8th High Energy Cosmic Radiation Detection (HERD) International Workshop, organised by the Xi'an Institute of Optics and Precision Mechanics (XIOPM) of the Chinese Academy of Sciences (CAS), was held in Xi'an. The workshop aimed at enhancing cooperation in indirect dark matter search. Scientists from China, Italy, Switzerland, Spain, and the United States discussed the overall progress of HERD payloads, detector and electronics research, Monte-Carlo simulation and software framework.

The HERD facility is one of the astronomy payloads of the "Cosmic Lighthouse Programme" on board the CSS, planned for a duration of 10 years after starting around 2025. The main scientific objectives of HERD, next to indirect dark matter search, are precise cosmic ray spectrum and composition measurements up to the knee energy, and high energy gamma-ray monitoring and survey.

At CERN in Switzerland, beam tests for the verification of HERD's innovative design and performances have been successfully conducted.

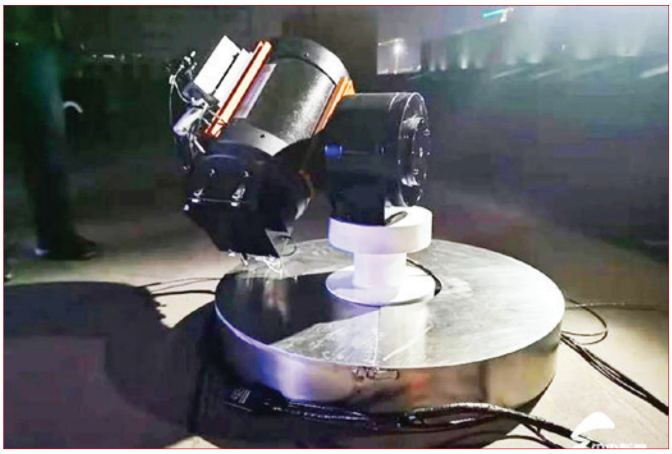
QUESS - Quantum Experiments at Space Scale

The QUESS (Micius) satellite has for the 1st time successfully conducted an 8 min-long encrypted data transmission with a miniaturised mobile ground station. The experiment was conducted on 30 December from the rooftop of a high-riser in Jinan, Shandong Province when the satellite was approx. 500 km overhead. At 23:31 BJT, the portable ground station, weighing just over 80 kg, connected with QUESS which relayed the quantum key distribution to a fixed station in Shanghai.

The mobile quantum satellite device can be installed on a vehicle and can work anytime and anywhere provided the weather conditions are suitable. With a 28 cm telescope attached, it can connect with Micius-QUESS, and receive encryption keys in the form of entangled photons. The ground station was jointly developed by the University of Science and Technology of China (UTSC), QuantumC Tek, a leading manufacturer and provider of QIT-enabled ICT security products and services and the Jinan Institute of Quantum Technology.

Earlier ground stations weigh around 10 t and the telescope has a minimum diameter of 1 m. The miniaturisation comes with a reduction in transmitting power. The mobile station transmits data at a rate between 4,000 and 10,000 bits per second, compared with about 40,000 bits per second for larger stations. Full details of the test are being prepared for academic publication in 2020. The project is led by Pan Jianwei.

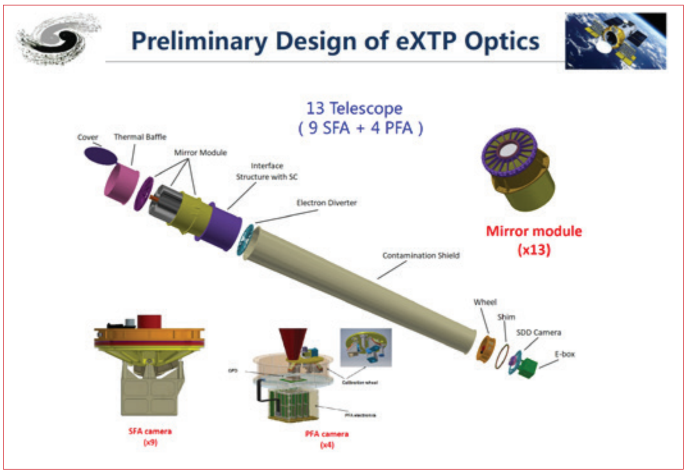
ICBC and the People's Bank of China are already using satellite-based quantum key distribution between Beijing and Urumqi.

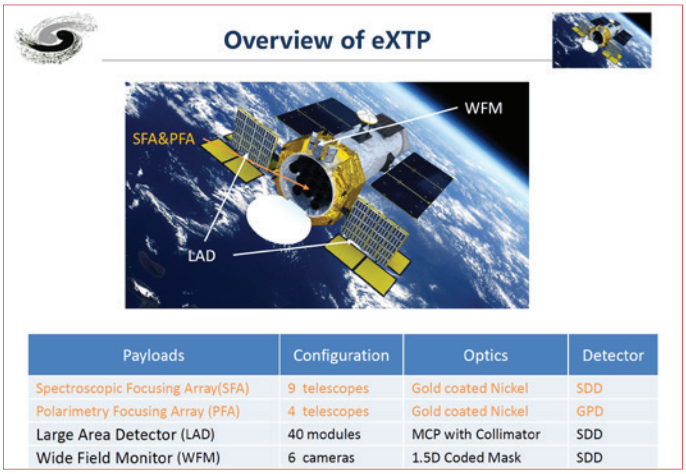


The mobile quantum satellite ground station fits inside a family car. Credit: Shandong Television

eXTP - enhanced X-Ray Timing and Polarimetry mission

The eXTP satellite is a China-led space-based observatory for the exploration of black holes and neutron stars. Planned for launch in 2027, eXTP is a cooperation with scientists from more than 20 countries, including Italy, Germany, France, and the Czech Republic.





Payloads	Configuration	Optics	Detector
Spectroscopic Focusing Array(SFA)	9 telescopes	Gold coated Nickel	SDD
Polarimetry Focusing Array (PFA)	4 telescopes	Gold coated Nickel	GPD
Large Area Detector (LAD)	40 modules	MCP with Collimator	SDD
Wide Field Monitor (WFM)	6 cameras	1.5D Coded Mask	SDD

Status of X-ray Telescope onboard the enhanced X-ray Timing and Polarimetry (eXTP) mission, presented by Yanji Yang on behalf of eXTP Opitcs Team, IHEP - Institute of High-Energy Physics, 04 December 2019; AXRO2019, Prague, 02-06 December 2019

The satellite will carry 4 payloads - the Spectroscopy Focusing Array (SFA) and the Polarimetry Focusing Array (PFA) will be developed by China and the Large Area Detector (LAD) and Wide Field Monitor (WFM) will be provided by Europe. The Czech team is composed of scientists from the Astronomical Institute of the Czech Academy of Sciences, the Silesian University in Opava as well as Czech industrial partner.

At the International Workshop on Astronomical X-ray Optics (AXRO2019) from 2-6 December in Prague, the status of the development of the X-ray telescope optics for eXTP was presented. Also presented was the Einstein Probe mission status.

CSES - China Seismo-Electromagnetic Satellite

CASC reported by the end of November that the China Seismo-Electromagnetic Satellite Zhangheng 1 (CSES), a Chinese-Italian space cooperation, has obtained valuable electromagnetic data, information about global artificial sources, magnetic storms and signals of earthquakes above 7 magnitude. The data contribute to the understanding of the coupling mechanisms of the lithosphere, atmosphere and ionosphere. Also, a global geomagnetic map and an ionospheric map could be produced. China is expected to have 3 electromagnetic satellites in orbit by 2022.

SKA - SQUARE KILOMETER ARRAY OBSERVATORY

• South Africa

On 9 October, South Africa's Parliamentarian Committee on Higher Education, Science and Technology approved the SKA Observatory convention and concluded the project membership procedure. The founding Member States (China, Australia, Italy, The Netherlands, South Africa, Portugal, and the UK) signed the document in March 2019 in Rome to create the SKA inter-governmental governing body. The convention needs to go through ratification by national parliaments.

• SKA Protoype Data Centre

On 11 November, Chinese experts have completed the installation of the first prototype of a SKA regional data centre. It was developed by the Shanghai Astronomical Observatory (SHAO) with the support of the Ministry of Science and Technology and CAS. The commissioning of the prototype is expected to take place in 2020.

The prototype serves as an example for future SKA regional centres and will provide scientists worldwide with the necessary computing resources, high-quality data products and convenient technical support to conduct SKA early science and to understand the data structure. The future 5 regional centres distributed over the globe will become a platform for multi-disciplinary science research, in-depth data processing, long-term storage and advanced technique development and also support and facilitate communication between China and east Asian members in the SKA Organisation. The SKA headquarters will be located in the UK.

The construction of SKA Phase 1 is set to begin in 2021 and should conclude around 2028.

• Data Processing Test

Researchers from the International Centre for Radio Astronomy Research (ICRAR) in Perth, Australia, Oak Ridge National Laboratory in the United States and Shanghai Astronomical Observatory in China processed 400 GB/s as they tested data transmission for the SKA telescope. The scientists used for the simulation the world's fastest supercomputer with a peak performance of 200,000 trillion calculations per second. The computer, called Summit, is located at the U.S. Department of Energy's Oak Ridge National Laboratory. The test run used a cosmological simulation of the early universe when the first stars and galaxies formed and became visible.

• SKA Shanghai Meeting

From 25 - 28 November the SKA Shanghai Meeting, organised by the SKA China Office and the Shanghai Astronomical Observatory of CAS, took place. Scientists and engineers from 25 countries reviewed the current state of the project and shared advice on the project's next stage of operation.

At a meeting one week earlier in Nice, France, it became known that the project is short of 250 million Euro in funds, of which 100 million Euro are needed in 2020 to prevent reducing the scope of scientific work, a move which would impact the usefulness of the project. Increases in prices are putting pressure on the once agreed 691 million budget. The minimum demand is now at 800 million Euro, however the current estimated total cost is 940 million Euro.

FAST

After the discovery of the repetitive fast radio burst, code-named FRB121102, researchers at FAST continued over the following months to closely monitor the signals. Scientists want to find out what kind of celestial body the radio burst comes from and determine its distance from Earth.

SMILE - Solar Wind Magnetosphere Ionosphere Link Explorer

From 18 to 20 November 2019, the 14th Scientific Working Team and Joint Meeting for the SMILE Mission was held at the European Space Astronomy Centre (ESAC) in Spain.

60 scientists and engineers from the United Kingdom, Canada, Austria, Belgium, the United States of America, Brazil, Czech Republic, Japan, ESA and China attended the meeting and reported on the progress of their respective developments.

Insight-HXMT

During a press conference at the 1st China Space Science Assembly in Xiamen on 25 October, the Hard X-ray Modulation Telescope (Insight-HXMT) team from the Institute of High

Group photo of the SMILE SWT#14 and Consortium meeting #8. Credit: CNSA

Energy Physics of the CAS presented their new results on black holes and X-ray binary stars (X-ray binaries emit X-rays and are composed of a "normal" star and a neutron star or black hole). The scientists detected areas that - so far - are probably the closest to black holes, giving clues about the basic properties of black holes and neutron stars and the behaviour and radiation of matter near the strong magnetic and gravitational fields. They were able to study quasi-periodic oscillations (QPOs) in black hole X-ray binaries up to 100 keV, an increase from the previous upper limit of 30 keV, and revealed the energy dependence of QPO amplitude and centroid frequency ranges from 1-100 keV.

2nd Phase of Space Science Programme

The successful implementation of the DAMPE, QUESS, HXMT space science missions has concluded the 1st phase of the Space Science Programme of the Chinese Academy of Sciences. With the launch of the Taiji 1 satellite on 31 August 2019, the 2nd phase started which also includes GECAM (Gravitational Wave Electromagnetic Counterpart All-sky Monitor), ASO-S (Advanced Space-borne Solar Observatory), EP (Einstein-Probe), and SMILE (Solar Wind Magnetosphere Ionosphere Link Explorer).
Additionally, Chinese scientists have completed conceptual research on 5 satellite missions to be launched within the next 10 years. These missions will focus on the physics in extreme conditions in space, space-based gravitational wave detection, medium and high-orbit quantum technology experiments, ultra-long-wave astronomical observation and asteroid and comet exploration.

Taiji 1 - Space-Based Gravitational Wave Detection

Taiji 1 is China's 1st space probe to conduct in-orbit experiments on key technologies for space-based gravitational wave detection. The satellite has successfully completed 4 month-long in-orbit testing, CAS announced on 25 December. The test satellite is the 1st step of the 3-step strategy to implement the full "Taiji" space-based gravitational wave detection programme. *compare GoTaikonauts! issue 29, page 9*

Space Science 2030 to 2045 – Miyin Project for Discovery of Exoplanets

During a public lecture on 12 December at the Beijing University of Aeronautics and Astronautics, Yuan Jie, the General Manager of CASC laid out China's space science programme for the years 2030 to 2045. It includes the Miyin project ("Searching Sound"), a space mission by 2030 for discovering exoplanets including the determination of its habitability. The Miyin mission will involve direct imaging methods to detect planets outside the solar system. At the same time, they will conduct a spectral survey of the solar system celestial bodies to reveal the distribution of water. The instrument will feature a spatial resolution of 0.01 arc-second.

SATELLITE

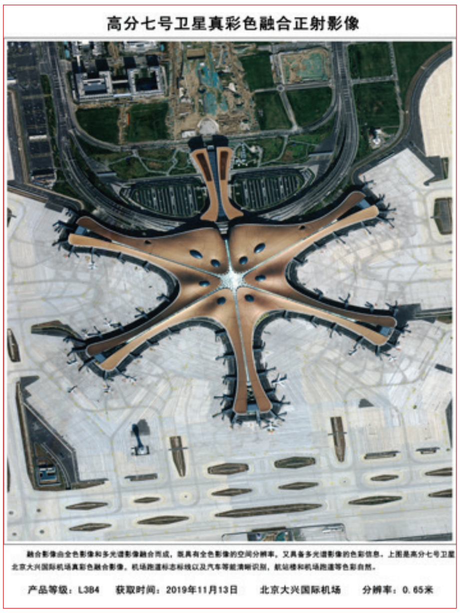
Hongyan

When the 1st Hongyan test satellite was launched 1 year ago as part of a 9-satellite test constellation, it was assumed that the full constellation would consist of 320 satellites, operated by state-owned smallsat manufacturer Aerospace Dongfanghong, which has created a new division for this purpose. Latest information reveals that the Hongyan constellation, providing initial service by 2022, will consist of 864 satellites. They will circle in a 1,175 km high orbit and have a data throughput capacity of around 8 TB.
The Hongyan satellites are currently being developed by CASC. When the constellation is complete, China hopes to provide mobile connectivity to 2 million users, broadband connectivity to 200,000 users, and IoT connectivity to 10 million users within China and the Belt-and-Road countries. The constellation will also support China's 5G network, by connecting the constellation directly with 5G base stations for lower latency.

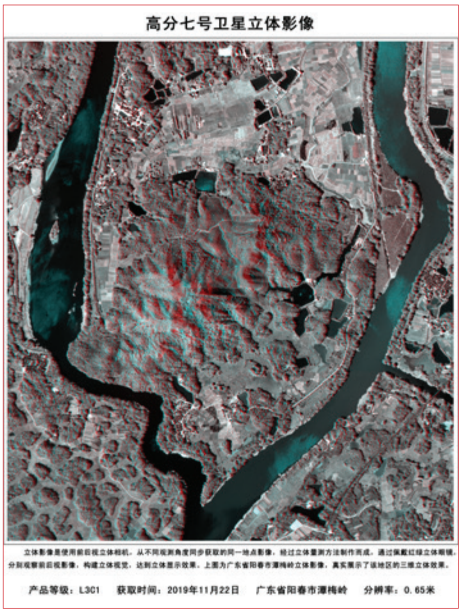
Gaofen

On 10 December, CNSA released the 1st batch of 22 3D-images based on Gaofen 7 data. They show the Beijing Capital International Airport, the new Beijing Daxing International Airport, as well as some regions in China's Anhui, Guangdong and Shandong provinces. Because of the sub-meter resolution, airplanes, vehicles, buildings and trees can be clearly distinguished and the height can be determined. Overall, Gaofen 7 has transmitted 14,000 images, mainly used for 3D mapping at a scale of 1:10,000 by the Ministry

Beijing Capital International Airport (PEK) Credit: CNSA



Beijing Daxing International Airport (PKX). Credit: CNSA



Guandong. Credit: CNSA

of Natural Resources, the Ministry of Housing and Urban-Rural Development and the National Bureau of Statistics. Its horizontal positioning accuracy of ground objects is within 5 m, and the height measurement accuracy about 1.5 m. The Gaofen data will serve major national projects, planning and economic construction, resource exploitation and land utilisation.

Free Access to Gaofen EO Data

At the GEO Week 2019 meeting of the Group on Earth Observations (GEO) in Canberra, Australia, CNSA announced that data from its Gaofen (GF) satellites are freely accessible on the web portal www.cnsageo.com. The portal is run by CNSA's Earth Observation and Data Centre in Beijing, offering 3 types of GF 16 m-resolution multispectral data from GF-1 and GF-6: a global coverage map generated with archived data, historical archived data, and daily updated 16 m-resolution wide-view images. The China High-resolution Earth Observation System integrates data from satellites, aircraft and ground systems.

China is one of the 4 Co-Chairs of the GEO initiative. The focus of the GEO Week 2019 was the Ministerial Summit, held every 4 years. The theme of the 2019 Summit was "Earth observations: Investments in the digital economy".

GEO is a partnership of more than 100 national governments and approx. 100 organisations that envisions a future where decisions and actions for the benefit of mankind are informed by coordinated, comprehensive and sustained Earth observations.

RECOVERABLE SATELLITE

• Seed Satellite

Preparations for the launch of a recoverable satellite in 2020 are ongoing. The free-flyer will carry 240 kg of seeds and plants, as well as bacteria. The main goal is to see if during the 2 week-mission, seed mutations take place in the space environment that in the consequence might lead to better crops. Mutations are considered to be the driver of evolution which takes very long in nature. Forced mutations can speed up the process but can also contribute to biodiversity. Scientists would combine other biological technologies such as genetic sequencing, molecular labelling and gene editing to help improve the efficiency of new crop species. The second-most widely used mutant wheat variety in China, Luyuan 502, had been developed using space-induced mutation breeding, and had a yield 11 % higher than the traditional variety. China has released more than 1,000 mutant crop varieties, accounting for a quarter of the entries listed in the IAEA/FAO database of mutant varieties produced worldwide.

By using the new, reusable satellite up to 15 times, the costs for space mission are expected to go down considerably.

• Recoverable Satellite – Payload Opportunities

CGWIC is advertising flight opportunities for a wide range of experiments on China's next generation recoverable satellite.

The space craft will consist of the re-entry capsule, a propulsion module, an orbital section and an adapter. The automated satellite offers hosting of external payloads, pressurised and un-pressurised payloads. A typical mission in a circular orbit of 340 km with an inclination of 43° degree can be 10 to 20 days long. The overall weight of the satellite is 3.5 t with 600 kg of payload capacity. Late access of 12 hours before launch is guaranteed for biological samples which upon return can be handed over to the owner already 5 hours after landing. Launch is planned for around 2020/2021.

for a detailed information on the parameters and potential research areas, please, have a look at the PDF:

http://www.cgwic.com/images/20180717%20Space%20Workshop.pdf

Fengyun

From 11 - 14 November, the 6th Session of the International Strategic Consultative Committee on Chinese Meteorological Satellite Programmes was held in Haikou, on Hainan island. Senior experts for meteorological satellites from China and abroad discussed the Fengyun 5 (FY) satellite development plan, the concept, design and layout of the 3rd generation of polar orbiting meteorological satellites. The FY series can be integrated into the global family of meteorological satellites.

Dr. Zhang Wenjian, Assistant Secretary General of the World Meteorological Organisation (WMO), and 12 experts of the International Strategic Consultative Committee on Chinese Meteorological Satellite Programmes, as well as experts from the National Satellite Meteorological Centre (NSMC) and Hainan University attended this event.

FY meteorological satellites are the backbone of the emergency support mechanism (FYESM) for international users. It is projected that until 2040, the demand for meteorological data will surge - in particular with respect to resolution, data quality and coverage.

Fengyun 5

China has started the development of the Fengyun 5 (FY) LEO meteorological satellites and the 3rd generation polar orbit meteorological satellite observation system to be fully deployed until 2035. FY-5 satellites will be incorporated into this 3rd generation system to enable comprehensive as well as high-precision global 3D atmospheric and special-purpose observation and extreme weather monitoring. The combination of FY-5 polar orbit satellites with FY-6 GEO satellites will improve the support for meteorological disaster prevention and enhance global meteorological services.

Fengyun-2H

On 15 November, at the 2019 Fengyun Satellite User Conference held in Haikou, Hainan Province, China Meteorological Administration (CMA) handed over FY-2H satellite data receiving equipment to Kyrgyzstan and Mozambique. A user support team is providing on-site and remote services to international FY satellite users. So far, 27 international users have registered to use the FY meteorological satellite emergency mechanism for disaster prevention and relief.

Since 2013, CMA has organised 9 international training courses on the application of the satellites, with nearly 200 trainees attending. The 2019 Fengyun Satellite User Conference was attended by 100 user representatives and experts from more than 30 countries and regions, as well as the WMO and the Asia-Pacific Space Cooperation Organisation (APSCO).

Satellite Research and Development Centre

On 12 October, a new satellite research and development centre started operation in Shanghai. The north section of the Lingang Satellite Centre was constructed by the Innovation Academy for Microsatellites of CAS. In this 36,000 m² satellite assembly plant comprising 7 halls, communication, navigation and remote sensing equipment can be manufactured, providing a capacity of assembling 100 micro/nano-satellites in parallel.

At the same day, the construction of the centre's south section started, scheduled to be finished by 2021. It will support the mass production of more than 600 commercial micro/nano-satellites in the next 10 years.

Macao Science 1 Satellite

On the occasion of the 20th anniversary of Macao's return to the motherland, an aerospace exhibition was opened at the the Macau University of Science and Technology (MUST) in December.

During the opening ceremony, the result of the MUST competition for naming the 1st Macao space exploration satellite was announced: Macao Science 1. Prof. Zhang Keke of MUST and Director of the Space Science Institute and Director of the

State Key Laboratory of Lunar and Planetary Science at MUST, was assigned as the project's Chief Scientist.
The satellite will be placed in an almost equatorial orbit to measure the geomagnetic field and space environment of the South Atlantic Anomaly (SAA). The probe is the 1st of its kind to explore the SAA, a region of reduced magnetic intensity where the inner radiation belt is at its lowest altitude. Geophysicists hope to find the reason of Earth's weakening magnetic field by studying the SAA. It is a cooperation between the China Space Foundation, Northwestern Polytechnic University of China, the United States Institute of Geology and Geophysics, the Harvard University, the National Space Science Institute of Denmark, the Swiss Federal Institute of Technology, and the University of Leeds and the University of Exeter from the United Kingdom.
The Macao Science 1 satellite programme is operated by China's State Key Laboratory of Lunar and Planetary Science, which was approved by the Ministry of Science and Technology and established on 8 October 2018 at MUST.
The satellite is co-financed by the Chinese Central Government. The costs, Macao has to take over, were given with 200 million patacas (25 million USD).
It was also announced that CNSA would set up the Macao Space Exploration and Science Centre to assist deep-space exploration cooperation between China and the institutions in Guangdong-Hong Kong-Macao Greater Bay Area.

China from space: Satellite images of Inner Mongolia

Satellite images of China's North are showing solar farms, agriculture areas, natural vegetation over the seasons and efforts to green the deserts.

NAVIGATION

BEIDOU Satellite Navigation System - BDS

1st China-Central Asia BDS Cooperation Forum

In parallel with the 7th China-Central Asia Cooperation Forum, the 1st China-Central Asia BDS Cooperation Forum, themed "Applications and Cooperation of Navigation Satellite Systems", was held on 18 October 2019 in Guangxi Zhuang Autonomous Region. The combination of the two events allowed a new dimension for satellite navigation cooperation between China and Central Asian countries.
The forum was attended by over 100 delegates from 11 countries including Kazakhstan, Kyrgyz Republic, Tajikistan, Uzbekistan, Turkmenistan, Cambodia, Indonesia, Laos, Thailand, Vietnam and Pakistan, from the Shanghai Cooperation Organisation (SCO), Asia Pacific Space Cooperation Organisation (APSCO) and Eurasian Economic Forum, from the Ministry of Industry and Information Technology, Nanning and Lanzhou Municipal People's governments as well as industry and other institutions.
Central-Asia, considered as the hinterland of Eurasia and the hub of the Silk Road Economic Belt, has a long history of economic and cultural exchanges with China. Consequently, a big part of the forum focussed on establishing and strengthening satellite navigation cooperation mechanisms with Central Asia and ASEAN countries and regions under the framework of the China-Central Asia Cooperation Forum and the SCO.
Delegates explained their needs and intentions for the use of BDS. It is hoped that BDS contributes to more practical cooperation projects, diverse applications, academic exchanges, education and training programmes.
The forum also included a BDS exhibition, which showcased examples of BDS applications and related products in the areas of transportation logistics, agriculture, forestry, animal husbandry, fishery, disaster prevention and mitigation, with a focus on the BDS application situation in Guangxi.
During the 1st China-Central Asia BDS Cooperation Forum, Chinese representatives and relevant institutions of Uzbekistan and Thailand signed 3 cooperation agreements, on satellite navigation monitoring and assessment, education and training, and industrial cooperation as well as research and application of the BeiDou system in transport, precision agriculture and disaster relief.
Thaicom Public Company Limited (THCOM) and China Great Wall Industry Corporation (CGWIC) signed a Memorandum of Understanding (MoU) to cooperate in the area of Beidou navigation applications for Unmanned Aerial Vehicles (UAV). The MoU is part of Thaicom's strategy to diversify its business and enter emerging markets through the integration of space, air, ground and maritime networks with next-generation service platforms for a wide variety of customers.
The China-Central Asia BDS Cooperation Forum is the 3rd platform to promote the international development of BDS by using the mechanism of national cooperation platforms. The other two are the China-Russia Satellite Navigation Key Strategic Cooperation Project Committee and the China-Arab States BDS Cooperation Forum.

UN ICG-14 - International Committee on Global Navigation Satellite Systems

The 14th Meeting of the International Committee on Global Navigation Satellite Systems (ICG) of the United Nations, hosted by the Indian Space Research Organisation (ISRO), took place from 8 - 12 December 2019 in Bangalore, India.
A Chinese delegation of 50 experts, led by Yang Changfeng, Chief Designer of the Beidou Navigation Satellite System, participated in the ICG-14.
During the event, delegates exchanged views on compatibility and interoperability, high-precision applications, and other relevant satellite navigation topics.
The Chinese participants gave an update on the development of the Beidou system, discussed satellite search and rescue capacities, space debris disposal, precise point positioning, and expanding application areas.

Release of Beidou Coordination System (BDCS) template, BDS/GNSS satellite parameters and Image Electron Spectrometer (IES) space weather data

The approved BDCS template was released on 9 December by the China Satellite Navigation Office, promoting the compatibility and interoperability of BDS with other GNSS systems.

Also released were the related BDS-2 satellite parameters in the document: "Definitions and descriptions of BDS/GNSS satellite parameters for high precision application" to promote the high-precision applications of BDS.

Additionally, data from the Image Electron Spectrometer (IES) space weather payload on board BDS satellites were released in order to promote international cooperation on space weather research and applications. The data contain observations of energetic electron distributions in the energy range of 50-600 keV on the satellites' orbit.

BEIDOU PRESS CONFERENCE

During a press conference of the State Council Information Office on 27 December in Beijing, BDS Spokesperson and Director of the China Satellite Navigation System Management Office, Ran Chengqi, told media that China will finish the construction of the Beidou-3 Navigation Satellite System (BDS-3), with another 2 geostationary orbit satellites to be launched before June 2020, about half a year ahead of schedule. To meet the tight launch schedule, satellite manufacturer CAST streamlined the construction process, halving the development cycle of a single satellite model to 18 months. After BDS-3 completion, more stable, diversified services with better performance and higher accuracy of up to 5 m can be provided. BDS-3 employs upgraded intelligent operations and maintenance capabilities.

BDS can serve global users with basic navigation, global short message communication, and international search and rescue services, while offering users in China and surrounding areas regional short message communication of up to 1,000 Chinese characters, satellite-based augmentation, ground augmentation and precise point positioning services.

BDS's regional short message communication is expected to be integrated into mobile platforms like smartphones. Global short message communications is enabled by payloads on 14 MEO satellites.

For the ground-based augmentation system, China has built more than 2,000 stations, forming a nationwide network providing positioning services at different accuracy levels.

For international search and rescue, 6 MEO satellites will work with other global medium-orbit search and rescue systems to provide more efficient and high-quality services. People in distress can obtain rescue confirmation info through these services.

In 2019, 10 BDS satellites were launched, completing the deployment of the core BDS-3 constellation system with all of the BDS-3 MEO satellites.

Official data showed that the direct output of China's domestic satellite industries reached 345 billion RMB (43 billion USD) by the end of 2019 and is expected to exceed 400 billion RMB in 2020, with Beidou contributing 70 to 80 % of the total.

With the arrival of the 5G commercial era, China will further promote the technological integration between BDS and mobile communications, cloud computing, Internet of Things, industry internet, big data and block chain.

Ran Chengqi explained that with the BDS as the core, a more ubiquitous, integrated and intelligent navigation and timing system with comprehensive national positioning is scheduled to be established by 2035.

An intergovernmental cooperation agreement on satellite navigation between China and Russia has entered into force, and the China-Russia satellite navigation monitoring and assessment platform has been put into operation.

So far, the BDS-based products have been exported to more than 120 countries and regions, and the BDS-based solutions have been successfully adopted in different regions and fields, such as land registration, precise agriculture, digital construction, monitoring and management on vehicles and ships, and intelligent port management, in ASEAN, South Asia, East Europe, West Asia and Africa, Ran said.

Beidou Applications

• Remote Pipeline Observation

Beidou's applications in pipeline leakage detection have made substantial progress, being applied in 600 cities, counties and towns across China. The Beidou management has cooperated with Swiss ABB in establishing a gas leakage detection system with an accuracy in the range of parts per billion (ppb), improving the previous accuracy of parts per million.

• Disaster Prevention

More than 4,000 sets of disaster prevention equipment were installed in Southwest China's Guizhou Province and 29 geological disaster forecast devices built or renovated. Over 60,000 sets of equipment were developed and applied to help ease traffic congestion, accident reduction and emergency rescue. More than 10,000 pieces of equipment at scenic spots and travel agencies are supporting smarter tourism.

• Civil Aviation

The Civil Aviation Administration of China (CAAC) has released a 3 phase-roadmap for Beidou application. It lists specific targets for 2021, 2025 and 2035 to eventually foster a global navigation satellite system with Beidou as the core that is compatible with other systems. By the end of 2035, the civil aviation sector should gradually see full coverage of the Beidou application to enhance the safety and efficiency of the aviation industry. The inclusion of the Beidou system is hoped to reduce safety risks from a single system and make up for the inadequacy of traditional navigation systems.

TELECOMMUNICATION

ChinaSat-18

Satellite operator China Satellite Communications Co., Ltd., (China Satcom) filed an insurance claim of 250 million USD after the loss of its ChinaSat-18 (Zhongxing-18) comsat. Despite a flawless launch, China Satcom could not establish a communication and data transfer link with ChinaSat-18 and rescue attempts failed. Investigators concluded a power failure of the satellite. Based on the enhanced DFH-4E satellite bus, ChinaSat-18 was built by CAST.

TECHNOLOGY

SBSP – Space Based Solar Power

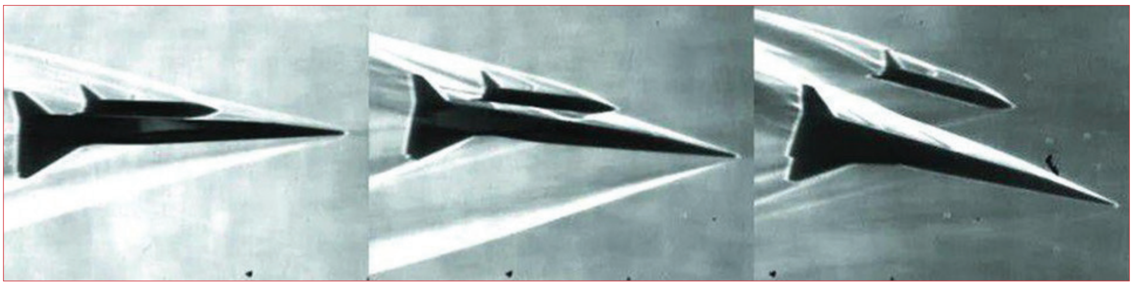
China became the first country to establish a 30 million USD state-funded SBSP base plant in Chongqing's Bishan district early this year. The base plant is being constructed under the guidance of the Chongqing Collaborative Innovation Research Institute for Civil-Military Integration (CCIRICMI) in south-western China in partnership with researchers from Chongqing University. Technologies being tested include the construction of SBSP satellites in GEO using automated assembly, the wireless transmission of power and its impact on the environment.

SBSP and Wireless Energy transmission

At the 6th China-Russia Engineering Forum held in the last week of November in Xiamen, a CAST representative said that China plans to accomplish by 2035 a 200-t space-based solar power station, producing energy in the megawatt range. The energy would be converted to microwaves or lasers and then beamed wirelessly back to Earth. The project is suited for international cooperation. Since 2008, SBSP is a key research programme in China.

Hypersonic Space Plane

The 1st Research Institute of the Chinese Academy of Aerospace and Aerodynamics successfully conducted a wind tunnel tests of a two-staged hypersonic space plane. During the test, the aerodynamics of a launch (detachment) of the 2nd-stage rocket plane from its 1st-stage carrier aircraft of a two-stage-to-orbit (TSTO) space plane were simulated. The tests were intended to solve multiple technical difficulties and to set up a universal wind tunnel experiment protocol, providing an advanced method to develop future space planes. Both parts of the air launch system would be reusable. The research institute released a graphic of the experiment, which suggested the two vessels had a similar body shape to several other hypersonic vessels such as the DF-17 missile. The space plane could have military and civilian applications.



Hypersonic Space Plan - After the launch, the smaller vessel will separate to deliver its payload into space. Credit: Handout/SCMP

APPLICATIONS

Data

Researchers of the Aerospace Information Research Institute of the CAS compiled a high-resolution forest and non-forest database using satellite remote sensing data. They created a 30 m-resolution Global Forest Cover Map (GFCM) of 2018 for forest management by applying machine learning for automatic information extraction and big data analysis.

Big Data

During the 1st China Digital Earth Conference in November in Beijing, a Big Earth Data System was inaugurated. The system enables quantitative research for global users, supports data storage, data management and data mining. Also, the Digital Earth Handbook was released. It gives an overview on the theory, technology and application of digital Earth data, analyses the present situation of the development in this area, and predicts the development of future trends of digital big data in Earth observation.

COMMERCIAL SPACE

LAUNCHERS

China Commercial Space Alliance

On 11 December 2019, the China Commercial Space Alliance (CCSA) was officially launched as a federation of space industry entities as well as "state-owned defence and space contractors", such as CASC and the China Aerospace Science and Industry Corporation (CASIC), China Aerospace Foundation, China Huateng Industry Co., Ltd., China Great Wall Industry Group Co., Ltd., and Chinese Academy of Sciences Holdings Co., Ltd. The alliance has 4 main aims:

- support the formulation of policies for the space sector and conduct industry research and analysis regarding planning, standards, market opportunities;
- advance the integration of the space industry and of innovative models;
- strengthen development and functioning of the industrial chain and the space ecosystem;
- deepen international cooperation with focus on BRI.

By the end of 2018, there were 141 registered commercial aerospace companies in China. Among them, 36 are satellite manufacturing companies, 22 are launch vehicle manufacturing companies, 39 are satellite operating companies, and 44 are satellite application companies. The CCSA will be guided by CNSA.

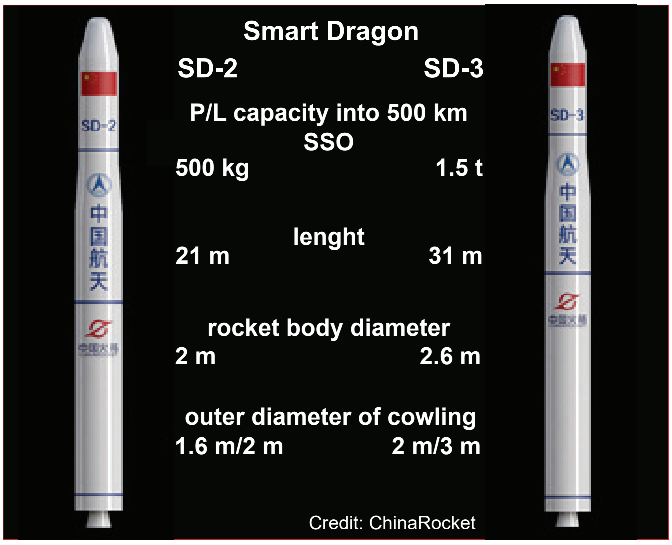
China Rocket Co., Ltd

The President of China Rocket Co., Ltd, Tang Yagang, explained the company's commercial carrier rockets research and development plan during a press conference on 19 October in Beijing. The solid-propellant rockets Jielong 2/Smart Dragon 2 (SD-2) and SD-3 are expected to conduct test flights in 2020 and 2021, respectively. SD-2 will be 21 m tall with a diameter of 2 m, and a lift-off mass of 60 t. The payload capacity into a 500 km SSO will be 500 kg. SD-3 will be 31 m long, employ a diameter of 2.6 m and a launch mass of 116 t. Its payload capacity into a 500 km SSO will be 1.5 t. China Rocket is planning for 8-10 annual launches of the SD-2 and 5-8 of the SD-3.

The company is also developing the Tenglong 1 (Flying Dragon 1) rocket, a medium-sized, liquid-fuelled launcher with a reusable 1st stage. The 2 or 3 m variable fairing can accommodate medium to larger satellites as used in satellite constellations. A 1st test flight is envisaged for 2021.

The SD series is designed to provide reliable, convenient and economic launching services for commercial satellite users in the constellation network and payload tests. The 4-staged solid-fuelled Jielong 1 rocket had a successful 1st flight on 17 August 2019.

Tang Yagang said that China Rocket is aiming for launch cost of 5,000 USD per kg. China Rocket Co. Ltd., is CALT's commercial spinoff.



Beijing Aerospace Propulsion Technology Co. Ltd.,

Beijing Aerospace Propulsion Technology Co. Ltd., tested the gas generator for its Canglong 2, a variable thrust 10 t methalox engine.

Galactic Energy (Beijing Xinghe Dongli Space Technology Co. Ltd.,)

• Funding

In October, Galactic Energy secured a 150 million RMB (21.5 million USD) pre series-A funding, led by Puhua Capital and Huaqiang Capital and 6 other investors. With that, the total funding of the company is 43 million USD (300 million RMB). The new funds will be needed for the launch of the Ceres 1 and the full-system test run of the reusable liquid oxygen/kerosene Pallas 1.

• Engine Testing

On 3 December, the hot fire testing of the 3rd-stage engine for the Ceres 1 rocket was completed successfully. The engine worked for 70 s with an average pressure of 5.4 MPa and a vacuum specific impulse of 287 s. The 3rd-stage engine was independently developed by Galactic Energy. Tests for the 1st and 2nd stages engines were accomplished in September and November.

Ceres 1 is expected to launch for the 1st time in March 2020, while Pallas 1 is scheduled for December 2022.

• 2019 World Innovation Awards

On 8 December, Galactic Energy was honoured with the 2019 World Innovation Awards, being selected as a Top-100 Star Enterprise of Tomorrow in China. The criteria for the Star of Tomorrow award are: vitality, growth potential, company structure, reputation and attraction for capital. It also judges the potential of the respective company in a global perspective and explores the prospective for growth.

Galactic Energy's 3rd stage in test stand. Credit: Galactic Energy

Galactic Energy was also certified as national high-tech company, giving the enterprise access to tax benefits and recognition as a relevant industrial enterprise.

Concept of Ceres 1. Credit: Galactic Energy

iSpace

i-Space completed a 500 s-long hot test firing of its 15 t reusable LOX-methane engine JD-1 for the Hyperbola 2 rocket. It is expected that the engine can be reused up to 30 times, reducing the manufacturing costs for the rocket by 70 %. i-Space' Hyperbola 2 made its first public appearance at the 2019 Zhongguancun Forum exhibition in Beijing on 18 October. Its first launch is planned for 2021. Hyperbola 2 is 28 m long, has a take-off mass of 90 t and a P/L capacity of 1.9 t into LEO.

Left: Model of the Hyperbola 2. Credit: iSpace

LandSpace

• Funding

LandSpace completed a 500 million RMB (71 million USD) C-round of funding in the beginning of December, mainly from Country Garden Venture Capital, a real estate development company, which also invested in other Chinese space startups. Alone in 2019, Landspace's acquired 600 million RMB, making it China's best funded private launch company.

Earlier in 2019, Landspace secured 14 million USD in a series B+ funding round from Shanghai Yi Sheng Investment, Luxin Venture Capital and others.

• Launch Contract

At the beginning of December Landspace signed a ZQ-2 launch service contract with SpaceTY.

• Engine Test

On 26 October, LandSpace conducted a successful 200 s-long test run of the variable thrust of its reusable TQ-12 liquid oxygen methane engine. The duration is equivalent to the entire flight time of the rocket. The test team focussed on the engine's thrust regulation and preliminary examination of the reliability of the engine itself. The test is a breakthrough in the development of the cryogenic rocket engine thrust regulation and the high-precision cryogenic regulator. It will also help optimise the rocket's flight trajectory and the fault diagnosis before take-off.

S-Motor

S-Motor, founded in 2017, tested a dual pulse solid-fuel rocket motor. In October it performed successful stage separation tests. It has previously announced plans to develop a small 3-stage solid-propellant launcher.

Space Pioneer - Beijing Tianbing Technology Co., Ltd.,

In November, Beijing Tianbing Technology Co., Ltd., (Space Pioneer), continued tests of a 30 t HCP liquid engine.

SpaceTrek – Sub-orbital Launch

Space Trek's commercial sub-orbital carrier rocket Tansuo 1 took off from the Jiuquan Satellite Launch Centre in Jiuquan on 25 December 2019, at 16:50 BJT. The rocket, launched for the 1st time, can serve for meteorological observation and data acquisition, microgravity testing as well as satellite payload experiments.

Tansuo 1 launch by SpaceTrek. Credit: Photo by Wang Jiangbo/Xinhua

Earth-Moon Economic Zone

On 30 October, the 1st Science and Technology Committee Meeting and the 2019 CALT Forum were held in Beijing on the occasion of CALT's (1st Academy of CASC) 40th anniversary of its founding.

Academicians, experts and scholars conducted exchanges and discussions under the motto: "Embracing the New Era of Aerospace and Developing a New Aerospace Economy". They debated topics such as Earth-Moon space, intelligent aerospace, and commercial aerospace.

Bao Weimin, Director of CASC's Science and Technology Commission, talked about "Several Thoughts on the Development of Earth and Moon Space". He said at the forum that China should consider to set up an economic zone in cislunar space - the environment inside the Moon's orbit - within the next few decades and presented a roadmap for building the Earth-Moon Space Economic Zone until the middle of this century. His comments were reported by the Science and Technology Daily, a newspaper affiliated with the Ministry of Science and Technology.

Citing the vast economic potential of the project, Bao said China will expand research into reliable, low-cost aerospace transport systems featuring regular spaceflights to and from Earth. The country will seek to master the basic technologies for that by 2030, and build the highly reliable and cost-efficient space transportation system by 2040, and establish the Earth-Moon Space Economic Zone sometime around 2050.

The scope of the Earth-Moon Space Economic Zone is projected on the near-Earth space, the lunar gravitational space and the Earth-Moon transfer space. Its business forms include basic industries, application industries, development and utilisation industries, and expansion industries, which will be transported by flights. It consists of 3 major systems: the space transportation system, the space resource exploration and development system, and the space infrastructure system. According to anonymously quoted experts, China's annual total output value in the Earth-Moon Space Economic Zone could reach more than 10 trillion USD by mid-century.

COMMERCIAL SPACE - SATELLITE

HorizonX - 5G LEO constellation

HorizonX (Nanjing Shiyu Tianji Communication Technology Co., Ltd.), founded in 2016 and based in the Nanjing High-tech Zone, Jiangsu Province, is a company specialising in 5G world-wide integrated network research, which consists of HorizonX Communications, HorizonX Future Network Research Institute, and HorizonX Space Technology. The company plans to build the next generation 5G LEO satellite constellation system, relying on the space-based communication platform to develop a communication system suitable for passenger aircraft and driverless vehicles, to realize air and land traffic management and entertainment terminal applications. It's also the actual operator of the China University Cube Satellite Competition. The constellation concept is also targeting customers along the Belt-and-Road region and in Africa.

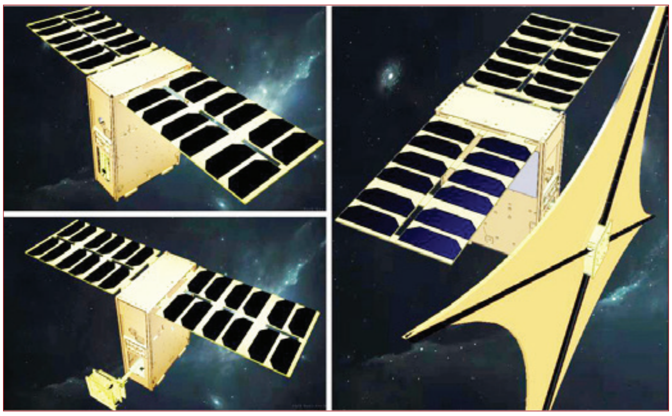
SIASail-1

Integrated into SpaceTY's Xiaoxiang 1-07 satellite, SIASail-1 was launched by a Kuaizhou 1A carrier rocket from the Jiuquan Satellite Launch Centre on 30 August (31 August BJT). By 30 December, the sail was fully deployed. The test verified the de-orbiting capability of the solar sail and explored its potential application in space debris mitigation.

The solar sail was developed by the Shenyang Institute of Automation (SIA) under CAS.

In folded configuration upon launch, the sail's size was less than 0.5 U. After entering orbit, a series of technical tests was started. Photos that have been returned to Earth, showed that SIAsail-1 had been deployed. The unfolded solar sail is only about 0.6 m^2. More tests to verify the de-orbiting capability of the solar sail and to explore its potential application in space debris mitigation and for larger solar sails will be carried out at a later date.

The Shenyang Institute of Automation (SIA), a division of the Chinese Academy of Sciences (CAS) based in Liaoning Province, focuses on robotics, industrial automation and optoelectronic information processing technology. Founded in 1958, SIA has been working since 2011 on the design of a flexible deployment mechanism for space applications.



SIA sail deployment: In the 1st phase, the solar sail body is pushed out of the satellite platform and turned 90 degrees. The 2nd phase is to erect the masts and gradually spread the sail. The unfolded solar sail is about 0.6 m^2.
Credit: Shenyang Institute of Automation-SIA/Chinadaily.com.cn

Evaluation of China's Commercial Space Sector

In September, the Science and Technology Policy Institute (STPI) published a detailed report about "Evaluation of China's Commercial Space Sector". Using original documents and first-hand Chinese-language interviews with Chinese companies and China's industry experts, this report provides a review of the current landscape of China's nascent but growing commercial space sector.

The STPI is a so-called FFRDC of the Institute for Defense Analyses - IDA. FFRDC are Federally Funded Research and Development Centres and are private-sector entities that have unique relationships with their sponsoring Federal Government agencies. FFRDCs operate in the public interest as strategic partners with their sponsoring agencies to ensure that the highest levels of objectivity and technical excellence are applied to the research and development they conduct on behalf of the government.

https://www.ida.org/research-and-publications/publications/all/e/ev/evaluation-of-chinas-commercial-space-sector

SOAR-China Siwei Partnership

Australian digital mapping and imagery company SOAR has entered into a strategic partnership with the CASC subsidiary China Siwei Surveying and Mapping Technology Co. Ltd,. SOAR gets access to Chinese 0.5 m resolution imagery from the SuperView satellites and of 0.8 m resolution from the Gaofen satellites. The partnership can be seen for Chinese service providers as a door-opener to the international downstream market. SOAR intends to meet high demand from users in the commercial sector with its improved online platform: https://soar.earth/

Origin Space

Origin Space, an asteroid mining start-up, has raised 7 million USD in an angel round funding from Matrix Partners China and Linear Venture.

Established in 2017 in Shenzhen, the company will use the fund for the development of space telescopes enabling multi-band observations of asteroids and to detect suitable objects. In a first step, the company launched on 11 September a small UV telescope, attached to the Taurus 1 satellite, for monitoring the atmosphere for impact events. Origin Space has cooperation agreements with Chinese universities and research institutions, including CAST.

CONFERENCES

2nd Silkroad Commercial Space Symposium

In the run-up to the Global Hard & Core Technology Innovation and the Belt-and-Road Innovative Cooperation Conference 2018 in Xi'an, the 2nd Silkroad Commercial Space Symposium took place on 31 October. The event aimed at the promotion of the development of the commercial space industry and the construction of space information infrastructure in the Belt-and-Road region. Officials, entrepreneurs and space experts from Belt-and-Road countries discussed how to further expand the application of commercial space technology and how to effectively integrate commercial space industry resources.

5th CCAF - 5th China (International) Commercial Aerospace Forum

On 19 and 20 November 2019, the 5th China (International) Commercial Aerospace Forum (CCAF) took place in Wuhan.

During the event, CASIC inaugurated a satellite service platform to make integrated satellite resources more accessible for users, in particular for non-expert users.

As part of the Wuhan National Space Industry Base, Expace Technology announced for the end of 2019 the inauguration of a new manufacturing complex for an annual capacity of at least 10 Kuaizhou 1A and 10 Kuaizhou 11. Should demand arise, this capacity can be increased to 30 rockets. Until the end of 2020 alone, Expace has a launch manifest of 10 Kuaizhou 1A. The infrastructure construction for the Wuhan National Space Industry Base began in October 2017 and has been finished in autumn 2019. By the end of November, engineers and technicians were installing and fine-tuning equipment.

The larger Kuaizhou 11 is almost ready and is expected to make its 1st launch.

Upon its completion, the Wuhan National Space Industry Base will cover 68.8 km^2 in Wuhan's Xinzhou district. It aims to attract at least 100 enterprises involved in the space industry before 2020 and generate an annual gross product of 30 billion RMB (4.36 billion USD) by that time, according to CASIC.

The satellite production complex that was mainly invested by CASIC is getting ready as well and will be put into operation in 2020. The complex is for research, design and manufacturing of 100 small satellites per year.

For more details on the forum, please, read our extensive report in GoTaikonauts! issue no 27, pages 24 - 31.

INTERNATIONAL COOPERATION

APSCO

On 17 October 2019, Zhang Kejian, Vice Minister of the Ministry of Industrial and Information Technology (MIIT), Head of CNSA, and APSCO Council Member visited the APSCO Headquarters in Beijing. Zhang emphasised that with cooperation as its core principle, APSCO shall play an important international role for the peaceful use of outer space to benefit the people in the Asia-Pacific Region. China as the host country, shares resources with the Member States through capacity building and data access.

Zhang Kejian and his delegation, was presented with a tour of the APSCO exhibition hall and the building. Credit: APSCO

AZERBAIJAN

Chinese Ambassador to Azerbaijan, Guo Min, told reporters in Baku on 18 October that both countries wish to extend the existing economic cooperation into the area of high technologies and the space sector, seeing great prospects for that.

BRAZIL

• Space Weather Research

On the occasion of the 45th anniversary of the establishment of diplomatic relations between China and Brazil and the 5th anniversary of the China-Brazil Joint Laboratory for Space Weather in Sao Jose dos Campos, Brazil, representatives of both countries expressed their commitment to continue the cooperation for space weather research. The joint laboratory, equipped with a laser radar, ionospheric meter and a magnetometer has collected more than 1.5 terabytes of space weather data.

China and Brazil began cooperating in space weather research in 2010, benefitting from the fact that China is located at around 120° East longitude and Brazil at 60° West. Data collection from the two regions are complementary and contribute to the International Meridian Space Weather Programme which aims at connecting ground-based observatories along the respective meridians and enhancing the monitoring of the space environment.

• CBERS - China-Brazil Earth Resources Satellite Programme CBERS-04A

The CBERS-04A team was making final preparations for the launch of the optical remote sensing satellite. It was designed according to the specific needs of Chinese and Brazilian users in the areas of natural resources, geology and mining, forestry, agriculture, environmental protection and disaster reduction. The National Institute for Space Research (INPE), headquartered in the Brazilian city of Sao Jose dos Campos in Sao Paulo State, has the best satellite assembly and test centre as well as the best researchers in South America. INPE and CAST have cooperated since the 1980s on the CBERS programme.

• BRICS / CBERS

During the 11th BRICS Summit on 13 and 14 November in Brasilia, Brazil's capital, the leaders of the 5 BRICS nations (Brazil, Russia, India, China and South Africa) noted progress towards developing an own remote sensing satellite. The CBERS programme, developed by CAST and INPE is regarded as a role model for strengthening ties in science, technology and innovation among the BRICS countries.

Days later, Jitendra Singh, the Indian Secretary of State responsible for space indicated that during the BRICS summit "progress has been made in technical discussions to realise a virtual constellation of remote sensing satellites, as part of the BRICS Programme. Technical aspects with respect to identifying the satellites and the ground stations for the initial virtual constellation were discussed by the Space Agencies." The BRICS nations plans to share satellite data under a "virtual constellation of remote sensing satellites" which is made up of satellites contributed by BRICS space agencies. Currently, only Brazil, Russia, India and China have remote-sensing satellites in SSO, and they will provide data to South Africa, which does not have a satellite of its own.

Digital Belt-and-Road Conference – MOZAMBIQUE and ARMENIA

On 17 December a 10 m-resolution cropland data tool was handed over to Mozambique. The Dynamic Earth Observation data will help improve Mozambique's ability to deal with natural disasters such as drought, flooding and insect epidemics. The handover ceremony was held during the 4th Digital Belt-and-Road Conference in Shenzhen on 17 December, organised by the Digital Belt-and-Road Programme (DBAR) team of the Chinese Academy of Sciences. The event was attended by 200 experts from 29 countries. *(also see: section SATELLITE, Fengyun 2H)*

During the conference, the Republic of Armenia signed an MoU to join the DBAR. Armenia hopes to improve national land management and environmental supervision ability through information sharing under the scheme of the DBAR.

ETHIOPIA – AFRICAN UNION

Solomon Belay, Director General of the Ethiopian Space Science and Technology Institute (ESSTI) told Chinese media that Ethiopia and China are working on a long-term partnership ranging from training programmes for Ethiopian space engineers to assisting Ethiopia with launching space satellites. A few days before the planned launch of ETRSS-1 (Ethiopian Remote Sensing Satellite), the Ethiopian Minister of Innovation and Technology, Getahun Mekuria, said his ministry has partnered with the Chinese counterpart to train 20 Ethiopian space engineers in China and in Ethiopia.

There are plans that within the next 3 years, China will support Ethiopia in building a continental satellite ground station at the Entoto Observatory and Research Centre - East Africa's only space observatory facility - located on the 3,200-m hills of Entoto on the outskirt of the capital Addis Ababa, which can receive and disseminate satellite data across the African continent.

Addis Ababa is also home to the African Union (AU) Headquarter, therefore it is expected that the satellite ground station and data centre will be ideally placed to disseminate information to various African countries. The African Union adopted a policy on African space development in 2017 and declared that space science and technology could advance economic progress and natural resource management on the continent.

The satellite has inspired the Space Generation Campaign among the nation's burgeoning community of young space scientists led by the Ethiopian Space Science Society (ESSS) - Ethiopia's NGO for space outreach with more than 10,000 members.

Ethiopia also has an agreement with China for the construction of a communication satellite for commercial telecommunications and broadcasting services.

During the Regular Press Conference of the Foreign Ministry on 24 December 2019, Spokesperson Geng Shuang commented on the launch of ETRSS-1 by saying:

"Ethiopia's first satellite was successfully launched ... an event worth celebrating in both countries.

As we often say, the friendship between China and Africa is concrete, not abstract. It is embodied in our fruitful cooperation, of which space and aviation is an emerging and important area. In September 2018, the FOCAC Beijing Action Plan (2019-2021) was adopted at the FOCAC Beijing Summit. In this document, it is stated that China will continue to provide meteorological and remote-sensing application equipment, education and training support for African countries, in order to better equip African countries for disaster prevention and mitigation as well as climate change response. We do our utmost to keep our promises to African brothers.

The satellite launched for Ethiopia is a project under China's climate change South-South cooperation aimed to help Ethiopia with research in climate change response and agriculture and boost economic and social progress. Before this launch, China has also helped send satellites into space for other African countries including Nigeria and Algeria.

I'd like to stress that Chinese and Ethiopian scientists built this satellite in close collaboration. The Chinese side also provided Ethiopian technicians with training in satellite technology. After the satellite enters into orbit, Ethiopia will be able to operate it independently. This is another example showing China's concept of teaching someone to fish rather than giving him a fish.

China and Africa have always been a community with a shared future and common interests featuring win-win cooperation. We stand ready to work with African countries to promote cooperation in space and other sectors to help African brothers realize their African dream with higher quality and at a higher level and achieve win-win cooperation and shared development in the process."

FRANCE

On 6 November 2019, on the occasion of President Emmanuel Macron's state visit to the People's Republic of China, Centre National d'Études Spatiales' (CNES) President Jean-Yves Le Gall and Zhang Kejian, Administrator of CNSA, signed in the presence of the Presidents of both nations, a joint statement covering cooperation in lunar research and Earth observation.

China's Chang'e 6 lunar mission, planned for 2023, will fly the French DORN instrument proposed by the IRAP Astrophysics and Planetology Research Institute. DORN can detect the transport of volatiles through the lunar regolith, the lunar exosphere and lunar dust. Already on 25 March at the Elysee Palace in Paris, CNES and CNSA had expressed their intention to work together on Chang'e 6. *(compare GoTaikonauts! no 27, p. 10)*

In the field of Earth observation, the two space agencies aim for the joint development of a satellite for water cycle research to better understand climate change. The satellite could host a French advanced L-band interferometry radiometer for soil moisture and ocean salinity observations, and a Chinese high-resolution dual-frequency X-/Ka-band interferometry radiometer to measure snow water equivalent and surface freeze-thaw status.

ITALY

The achievements and future chances of Sino-Italian aerospace cooperation along with the strategic value of the cooperation in the space sector, were addressed at a seminar at the Chinese Embassy on 18 October during the Festival of Diplomacy from 17 to 25 October in Rome. Both countries agreed to continue on the success of the joint China Seismo-Electromagnetic Satellite mission (CSES-1), launched on 2 February 2018.

CSES-2, the follow-up mission, is scheduled for launch in 2021.

LUNAR BASE COMPETITION

On the occasion of the World Space Week Activities from 4-10 October, the US-based Space Foundation decided to start its annual series of events in Beijing by participating in the 2019 Future Space Scholars Meet International Final. Space Foundation Vice President for Education, Bryan DeBates was in Beijing for the competition where teams of high school-age students from around the world competed within a 24-h extreme design challenge to design a futurist space settlement on the Moon. Based on a requirements document, the students had to plan a lunar colony at the lunar South Pole, hosting 200 persons. The teams had to describe the needed technologies and had to make calculations on the amount of used water ice, minerals, consumptions of air, food, power as well as for commercial sale of space tourism based on 200 visitors per week. Experts from industry mentored and guided the students through the process which culminated into a presentation in front of a panel of judges, with the final decision based on criteria of rationality, integrity, economy, and consistency.

MALAWI

At the 2015 Summit of the Forum on China-Africa Cooperation (FOCAC) held in South Africa, the Chinese government promised to provide satellite TV capability to 10,000 African villages. On 15 November, the satellite television project concluded in Malawi. The Malawi authorities identified 20 households to receive the TV sets in 500 villages. Each village selected, received a 32" TV screen, 2 projector decoders, 3 satellite dishes, 3 sets of solar panels and batteries to power the TV units.

compare GT!27, QR 1-2019: Satellite TV Service for Nigeria
compare GT!28, QR 2-2019: Satellite TV Service for Rwanda

METEOROLOGY

During the 6th Session of the International Strategic Consultative Committee on Chinese Meteorological Satellite Programmes from 11 to 14 November in Haikou, Hainan, experts from Chinese and foreign meteorological satellite organisations have carried out consultation on the 3rd generation polar orbiting meteorological satellite, Fengyun 5 satellite development plan by discussing concept, design and layout of the FY-5 satellite.

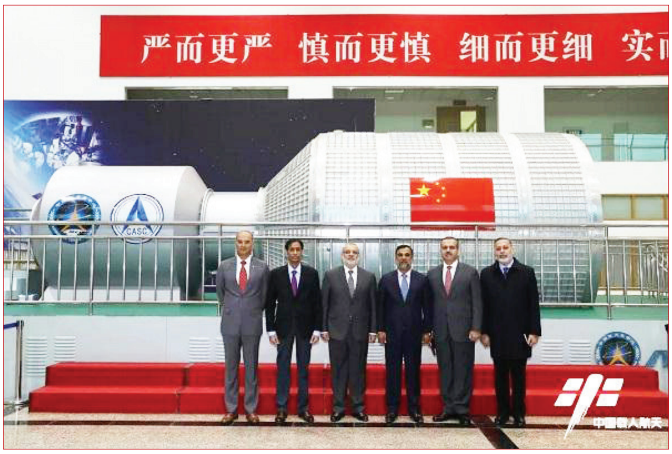
2019 International Symposium on the Peaceful Use of Space Technology (Health)

From 18 to 20 November 2019, the International Symposium on the Peaceful Use of Space Technology took place at the Zhuhai International Convention and Exhibition Centre. It was hosted by the Chinese Society of Astronautics, the China High-Tech Industrialisation Association and the International Peace Alliance (Space). The conference focussed on the development and application of space technology in health care, remote sensing big data, space education and other aspects.

PAKISTAN

From 17 to 19 December, a delegation under the lead of Amer Nadim, Chairman of the Pakistan Space and Upper Atmospheric Research Committee (SUPARCO), visited the China Manned Space Engineering Office (CMSEO) and held the 1st Meeting of the China-Pakistan Manned Space Cooperation Committee in Beijing. The joint committee consists of 3 working groups: space science and technology research; science promotion and education; astronaut selection, training and joint flight. The two sides reviewed reports of the working groups and agreed on the follow-up cooperation plan.

The Pakistani delegation went to Tianjin to visit the 5th Academy of Aerospace Science and Technology Group's General Assembly and Integration Test Centre, the 1st Academy's rocket assembly test factory, and visited the Chinese Astronaut Research and Training Centre and the Chinese Academy of Sciences Space Application Engineering and Technology Centre in Beijing.



The SUPARCO Delegation is visiting the China Astronaut Research and Training Centre. Credit: CMSE/Cao Qian, Lu Yaofeng

On the 27 April 2019, during the visit of Pakistan Prime Minister Imran Khan to the 2nd Belt-and-Road Forum (BRF) in Beijing, CMSEO and SUPARCO signed the cooperation agreement regarding a joint manned space mission. It serves as a high-level foundation for cooperation in space science and exploration. After that, the working mechanism of the joint committee was defined.

RUSSIA

At the end of November, Alexander Bloshenko, Roscosmos Executive Director for Science and Long-Term Programmes, told Russian TASS news agency that it is planned to have a Russian astronomical observation base at the lunar South Pole after 2025. The Moon ground station can be used for tracking asteroids and comets posing a threat to the Earth. Russia and China are discussing plans for joint lunar projects into which this Russian Moon base would fit.

United Nations Regional Centre

The UN Regional Centre for Space Science and Technology Education in Asia and the Pacific (China) - UNRCSSTEAP, celebrated its 5th anniversary on 10 December. It is located at Beijing's Beihang University, a leading Chinese space science education institute.

UNRCSSTEAP has contributed to the expert education of 1,200 professionals, among them 237 master's and doctoral degree holders from 24 developing countries since 2014. The centre has also organised more than 20 training courses for nearly 1,000 people involved in the space industries in 64 countries.

WMO - World Meteorological Organisation

The 3rd Progress Meeting on the implementing of the Letter of Intent Between the China Meteorological Administration (CMA) and the World Meteorological Organisation (WMO) to promote regional meteorological cooperation was held in Beijing on 19 November. The meeting reviewed the achieved results and it was hoped that both sides could intensify the use of cooperative platforms, consolidate cooperation in Fengyun meteorological satellites, advancing the implementation of WMO regional programmes and supporting seamless Earth system research, to build up the disaster preparedness capacity of countries along the Belt-and-Road region.

MISCELLANEOUS

Global Space Programme Spendings

Euroconsult's Government Space Programs 2019 report noted that in 2018 global government budgets on civil and military space amounted to 70.9 billion USD, showing a steady growth over the last 5 years. China was estimated to have spent 5.8 billion USD in 2018 on civil and military space programmes which include launchers and manned space flight.

IAC

Due to visa issues, many Chinese space experts could not attend the 70th IAC, taking place in October in Washington, U.S. The local organising committee confirmed that it started working with the U.S. State Department 18 months before the conference to ensure that visas would be ready in time for attendees. China blamed the U.S. consulates in China for delaying the visa issuing process.

Qi Faren

At the 70th IAC in Washington, the former head of the China Academy of Space Technology, Qi Faren, was included into the International Astronautical Federation Hall of Fame. Qi was honoured for his long-standing contributions to the progress of space science, technology and space benefits to mankind. Born in 1933, Qi was involved in the development of China's first satellite Dongfanghong 1, he was first Chief Designer of China's Shenzhou spacecraft and served as president of Beihang University's School of Astronautics.

Space-time & Remote Sensing Big Data Forum

On 25 October, the Space-time & Remote Sensing Big Data Forum was held under the umbrella of the 2019 Changshu Golden Autumn Economic & Trade Conference. A series of forums and activities focusing on big data, space technology and intelligent manufacturing technology were conducted in an effort to help Changshu to forge a digital economic development demonstration zone and provide fresh impetus for the city's high-quality development. The city of Changshu signed at the conference strategic cooperation agreements with Robot Funder Club (RFC) and Beijing Institute of Spacecraft Environment Engineering (BISEE), a subsidiary of the CAST.

China Space Aviation & Marine Industry Development Forum

The 3rd China Space Aviation & Marine Industry Development Forum opened on 15 October in Changsha, capital of central China's Hunan Province. The 2-day forum discussed topics such as unmanned systems, AI, high-quality development of software, the application of data from remote sensing. Space, aviation and marine industries are fundamental and strategic for the development of the national economy and the construction of China's national defence, according to the organisers.

China's grand strategy in outer space: to establish compelling standards of behaviour

In this article for "The Space Review", Namrata Goswami analyses how China "has worked to build alliance structures, signed memoranda of understanding, and offered to collaborate on lunar missions with other countries. This is part of Xi's vision of creating a world order where China not only has capacity but also legitimacy as the country that champions a peaceful and harmonious world order... The aim is to win the game for influence and power projection, especially in a domain like outer space without bloodshed so that a Chinese order is established and legitimised. And that after all is President Xi Jinping's space dream."

India-China space collaboration is worth a try

Ajey Lele is describing in an op-ed for "SpaceNews" what a possible India-China space collaboration could bring and how this could be initiated. "Space could emerge as one arena where both states could make a fresh beginning. ... India and China are both aware of the financial and technological limitations involved in going solo to deep space. At the geopolitical level, space collaboration could help the two nations lessen their differences."

History: China's long march into space

An interesting read is this article from 23 April 2016 which outlines the early efforts and the political context of the beginnings of China's space programme.

"In 1957 and 1958, the Soviet Union and the United States each launched their first satellites, officially starting a space race. Mao Zedong was quick to pronounce, "We too shall make satellites." Members of the Chinese Academy of Sciences scrambled to turn those words into reality. They aimed to launch their first probe in 1960. Publicly, few at the time deemed the goal far-fetched. But it was the Great Leap Forward, a period of exaggerated agricultural and industrial ambitions."

LAUNCHES

continuation from QR 3 - 2019, GoTaikonauts! issue no 29

2019-059A
2019-059B
2019-059C
12 September 2019 - 03:26 UTC (11:26 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, LC9
launcher: Chang Zheng 4B, CZ-4B
payloads: Ziyuan 1-02D (ZY-1 02D)
Jingshi 1 (Ice Pathfinder, BNU-1)
Jinniuzuo 1 (Taurus 1)

The CZ-4B carried the Ziyuan 1-02D imaging satellite into a 778 km SSO. The ZY-1 satellites are similar to the Chinese-Brazilian CBERS 2B / ZY-1 02B. The 1,840 kg satellite with two solar panels was built by CAST and is based on the Phoenix Eye 2 bus. The bus is hosting a 9-band visible near infrared CCD camera with 5 m resolution and a coverage width of 115 km, enabling it to observe large and medium-sized cities, and be used for urban planning. It also carries a 166-band-hyper-spectral camera that can produce 166 pictures with different colour bands simultaneously at a resolution of 5 m. The camera can capture the reflected light information of various minerals, and be used to analyse complicated mineral compositions and distribution. The satellite can also be used to observe chlorophyll concentration, water transparency and total suspended matter concentration in lakes to help monitor the environment and prevent water pollution. It is the first hyperspectral satellite for a natural resource satellite observation system, which is led by Natural Resource Department. Its wide-angle multispectral and hyperspectral data have broad application in natural resources asset management, ecological monitoring, disaster prevention, energy exploration, land science and technology innovation, environmental pollution monitoring, urban construction, and transportation. The operational lifetime is 5 years. ZY-1-02D is replacing Ziyuan 1-02.

The launch also carried two small satellites. Jingshi 1 (Ice-Pathfinder - BNU-1) is a 16 kg imaging satellite from the College of Global Change and Earth System Science of Beijing Normal University (BNU). It carries a multispectral camera with a 78 m resolution and a high-resolution visible-light camera with an 8 m resolution, able to fully scan the Antarctic and Arctic in 5 days and strengthen monitoring of sea ice drifts and ice-shelf calving. The 3rd payload is an automatic identification system (AIS) for monitoring vessels navigating through the polar regions. After one month of in-orbit testing, it was delivered to the Joint Centre for Polar Research of Chinese Universities to start formal operations. The satellite data connection system became operational on 8 October. Data are transferred to the maritime research centre in Zhuhai but also users from around the world can obtain polar observation data. Registered users can also propose new observation requirements.

It was designed and manufactured by Aerospace Dongfanghong Development Ltd. Shenzhen. From a 730 km SSO, Ice Pathfinder will observe and monitor climate and environmental changes in the Antarctic and Arctic, ending China's reliance on foreign data. The satellite can track sea ice movement along ship tracks and combine the data with passing vessels' information received via the mounted automatic identification system receiver to analyse collision hazards and then autonomously prepare navigation routes. Orbiting the Earth 14 times a day, the satellite supports China's efforts to develop Arctic sea lanes for the Chinese shipping industry but also Antarctic scientific expeditions. Its expected lifetime is 1-2 years.

The Ice Pathfinder is the first of a 24-satellite constellation for 24/7 all-weather polar observation. These satellites will also monitor the middle or lower latitude areas, playing a key role in the research of the Qinghai-Tibet Plateau, or the Third Pole region in the future.

The 3U cubesat Jinniuzuo 1 (Taurus 1) from Shanghai ASES Spaceflight Technology Co. Ltd., was testing a 2.5 m^2 deployable drag sail for deorbit tests over the next months. It also carried a small UV-telescope for monitoring the atmosphere for impact events and an amateur radio system for telecommand, telemetry and an FM to codec2 digital audio V/U repeater with 67Hz PL tone.

2019-060A
2019-060C
2019-060D
2019-060E
2019-060F
19 September 2019 - 06:42 UTC (14:42 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC
launcher: Chang Zheng 11 - CZ-11
payload: Zhuhai 1 OVS-3 - Chunlei Jihua Zhixing
Zhuhai 1 OHS-3A - Xiahaian 1
Zhuhai 1 OHS-3B - Feitian Maotai
Zhuhai 1 OHS-3C - Gaomi-1
Zhuhai 1 OHS-3D - GuoyuanV9

(Note: 2019-060B was the rocket's upper stage which re-entered on the same day.)

The 3rd group of the commercial remote-sensing satellite constellation Zhuhai 1, built and operated by Zhuhai Orbita Aerospace Science and Technology Co. Ltd., is a cluster of five commercial remote-sensing satellites in a 500 km SSO. The one video satellite (OVS-3) has a launch mass of 90 kg and is equipped with a high-resolution video system of 90 cm spatial resolution and a swath width of 22.5 km. The recorded video sequences are 120 sec long covering 2.500 km in push-broom mode.

The 4 hyperspectral imaging satellites (OHS-3A to 3D) with 256 wave-bands and a coverage width of 150 km have a ground resolution of 10 m and a spectral resolution of 2.5 nm. The Zhuhai 1 hyperspectral satellites have the highest spatial resolution and the largest coverage width of their type in China.

Ziyuan 1-02D (ZY-1 02D). Credit: CAST

Space engineers pack BNU-1 (Jingshi 1, Ice Pathfinder) at the Aerospace Dongfanghong Development in Shenzhen City, Guangdong Province, on 14 August 2019, before its transportation to the launch site. Credit: China News Service/ Chen Wen

The mass of the OHS satellites is between 100 kg and 180 kg. All satellites are box-shaped and have two solar panels.
The data will be used for precise quantitative analysis of vegetation, water and crops, and will provide services for building smart cities.
The company aims to cooperate with regional administrations and enterprises to expand the big data satellite services.

The satellite's names reflect the sponsors:

Sat	Name	Sponsor
OVS-3	Chunlei Jihua Zhixing	Zhuhai Orbit Co, China Children and Teens Foundation
OHS-3A	Xiahaian 1	West Coast New District Govt, Qindao, Shandong Prov.
OHS-3B	Feitian Maotai	Guizhou Maotai Distillery Co.
OHS-3C	Gaomi-1	Gaomi City Govt, Shandong Prov.
OHS-3D	GuoyuanV9	Jiangsu Jinshiyuan Wine Co Ltd.

The Zhuhai 1 constellation will comprise 34 micro-nano satellites, including video, hyperspectral, and high-resolution optical satellites, as well as radar and infrared satellites. The first 7 satellites were placed in orbit in 2017 (OVS-1A and OVS-1B) and 2018 (OHS-01, 02, 03, 04, and OVS-2).

2019-061A
2019-061B
22 September 2019 - 21:10 UTC (23 September - 05:10 BJT)

launch site: Xichang Satellite Launch Centre - XSLC, LC2
launcher: Chang Zheng 3B, CZ-3B/YZ-1 (with Yuanzheng upper stage)
payloads: Beidou-3M19 (DW 47) MEO23
Beidou-3M20 (DW 48) MEO24

The two satellites are the 47th and 48th satellites of the BDS satellite family since the start of the constellation.
Around 4 hours after lift-off, the Yuanzheng upper stage delivered the Beidou satellites into a nearly circular MEO with an average altitude of approximately 21,800 km and a 55° inclination. They are positioned in the plane C at the locations C3 and C5.
Each of the box-shaped satellites, built by CAST, is based on the CAST DFH-3B, has a launch mass of 1.060 kg and a size of 2.25 m x 1 m x 1.22 m. The satellites are equipped with two solar cells, a phased array antenna for navigation signals, a laser retroreflector, a radiation experimental payload and a MEOSAR-COSPAS/SARSAT search-and-rescue transmitter.
Compared with previously launched MEO satellites, these two are equipped with lightweight high-performance active hydrogen maser clocks next to the Rubidium atomic clock, which provide time-synchronised navigation signals in the B1 and B2 frequency bands. Combined with new processors, the signal performance becomes more stable and accurate.
The satellites also carried new payloads for international search and rescue tasks and short message communication enabling users to exchange messages and determine their exact location when no standard communication networks are available. The operational lifetime of the new satellite is projected for 12 years.
The launch was the first of a MEO satellite in 2019 since the basic BDS constellation deployment was completed in November 2018.
The launch is the start of a series of 10 launches until the end of 2019 and the transition to the complete constellation by mid-2020. To meet the high demand for BDS satellites, CAST streamlined the manufacturing process. There are 12 satellites built in parallel, reducing the development cycle of a single satellite model to 18 months from previously 36 months.

2019-063A
25 September 2019 - 00:54 UTC (08:54 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC
launcher: Chang Zheng 2D, CZ-2D
payloads: Yunhai 1-02

Yunhai-1 02 will be mainly used for observing the atmospheric, marine environment and space environment, as well as delivering data for disaster control and conducting other scientific and technology experiments, for example with the GNSS radio occultation meteorology payload on board. It will also be used for testing the operations of polar weather satellites. Both the satellite and the rocket were developed by the Shanghai Academy of Spaceflight Technology of the China Aerospace Science and Technology Corporation. Yunhai 1-02 is based on the CAST 2000 satellite bus. It is box-shaped with a cylindrical payload unit and a single solar panel.

LAUNCHES - 4th quarter 2019

2019-066A
04 October 2019 - 18:51 UTC (05 October 2019 - 02:51 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, LC 9
launcher: Chang Zheng 4C, CZ-4C
payload: Gaofen 10 (GF-10)

After the launch failure of the 1st Gaofen 10 satellite on 31 August 2016, it was assumed that this launch was the replacement. The Gaofen 10 microwave remote sensing satellite is box-shaped and equipped with several payloads and 2 solar panels. Not many design details are known. GF-10 can take photographs with a resolution of less than 1 m which will be used in land survey, urban planning, road infrastructure planning, crop yield estimate, as well as disaster relief. The data can also serve key national strategies such as the Belt-and-Road Initiative. GF-10 is part of CHEOS (China High-definition Earth Observation System), a near-real-time, all-weather, global surveillance network consisting of the satellite, stratosphere airships, and aerial observation platforms. The satellite and the carrier rocket were both developed by SAST.

2019-070A
17 October 2019 - 15:21 UTC (23:21 BJT)

launch site: Xichang Satellite Launch Centre - XSLC, LC3
launcher: Chang Zheng-3B/G2, CZ-3B/G2
payload: Tongxin Jishu Shiyan Weixing (TJS-4, TJSW-4, Huoyan-1)

The new CAST-buily communication technology experiment satellite will be mainly used for multi-band and high-speed communication technology testing. On the few available photos of the satellite it could be seen that TJSW-4 is box-shaped and equipped with 2 solar panels as well as a device for deploying a big parabolic antenna. As it was the case with previous TJS satellites, not many details became known.

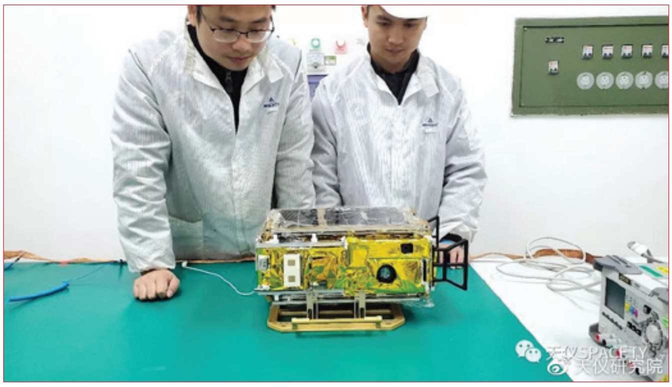
2019-072A
2019-072B
2019-072C
2019-072D
03 November 2019 - 03:22 UTC (11:22 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, LC9
launcher: Chang Zheng 4B, CZ-4B
payloads: Gaofen 7
SRSS-1 (Sudan Remote Sensing Satellite 1)
Huangpu-1 (Jingzhi 1, Jingzhi Gaofen Shiyan Weixing)
Xiaoxiang 1-08 (Dianfeng, Tianyi 15, Tianyi 1-08, TY 1-08)

The main payload on this launch into SSO was the Gaofen 7 (GF-7), a civilian high-resolution 3D imaging satellite, providing optical data on sub-metre level for land surveying and mapping, urban and rural construction and statistical investigation. The users will be mainly from the Ministry of Natural Resources, the Ministry of Housing and Urban-Rural Development and the National Bureau of Statistics. Next to the optical data,

high-precision laser altimetry data can be obtained. The sets of data allow for 1:10,000 scale 3D mapping. GF-7 also has excellent positioning accuracy, being able to locate roads in the countryside. The new GF satellite joined other Gaofen satellites to form an Earth observation system with high-resolution and high-positioning accuracy, which will promote international scientific-technological industrial cooperation through data sharing and support to the Belt-and-Road initiative.
The 2,400 kg, box-shaped GF-7 satellite with 2 solar panels was built by CAST. It is an improved Ziyuan-3 variant. GF-7 will operate from a 489 x 528 km orbit inclined by 97.5°.
On the upper part of the 1st stage of the CZ-4B, grid fins were mounted to support the guided fall of the spent rocket stage. After a 1st test in July, this was the 2nd occasion that grid fins were mounted on a CZ rocket.
Already on 8 November, the Aerospace Information Research Institute of the Chinese Academy of Sciences confirmed that the China Remote Sensing Satellite Ground Station (CRSSGS) has received 616.6 GB of GF-7 data with a very high transmission rate. GF-7 has adopted variable coding and modulation technology, effectively improving its data downlink transmission efficiency. Additionally, the CRSSGS also developed new ground data receiving devices for adaptive, fully automatic and reliable reception of multiple satellite data.

Gaofen 7 is launched on a CZ-4B rocket from the Taiyuan Satellite Launch Centre in north China's Shanxi Province on 3 November 2019. Credit: Sun Gongming/Xinhua



TY-15 - Xiaoxiang 1-08. Credit: SpaceTY

Next to GF-7, 3 other, smaller commercial and scientific experiment satellites were sent into similar orbits than the main payload.

SRSS-1

The Sudan Remote Sensing Satellite (SRSS-1) is Sudan's first-ever satellite. The satellite will enable research in space technology, acquire data and will be used for both, civil and national security remote sensing purposes. According to a Sudanese government document, SRSS-1 will "generate" a comprehensive, cost effective and reliable data base for topographic mapping and developmental planning, exploration of natural resources, environmental and agricultural monitoring, yield estimation as well as public security (intelligence) and defense applications." After the commissioning phase, the satellite will also be monitored from Sudan (not clear whether operations will also be done from Sudan).
SRSS-1 was developed and built by China Dongfanghong Satellite Co., Ltd. on behalf of the Sudanese government.
Sudan has been involved in a national space programme, for decades covering activities such as remote sensing and geo-informatics. In 2013, the Institute of Space Research and Aerospace (ISRA) was established as part of an overall plan to develop space technologies.

Huangpu 1

Huangpu 1 is an roughly 90 kg micro sat (satellite bus = 30 kg and payload = 60 kg), developed by Shanghai Aerospace Technology Research Institute for the Dawan District Research Institute in Guangdong. It is equipped with solar cells, high-precision attitude control, and a multi-spectral camera with 20 m resolution. Huangpu 1 is a test satellite for the planned Davan-Zhitong constellation of 90 satellites.

Xiaoxiang 1-08

Another piggy-back payload on the CZ-4B was Xiaoxiang 1-08. It was the 15th satellite built by SpaceTY Co. Ltd. It is a 6U cubesat with solar panels. The main instrument is a multi-spectral test imager with 20 m resolution and a swath width of 50 km. The new satellite is also part of the planned 480 satellite medium-resolution optical constellation of 40 satellites in 12 orbital planes. The satellite carried other experimental hardware, such as 2 laser communication modules by Nanjing Yingtian Optical Engineering Co., Ltd., a 0.4 kg laser communications payload for Laserfleet, and a tiny, cutting-edge solid iodine I2T5 thruster for French startup ThrustMe. According to a ThrustMe press release, the propulsion system "uses a first-of-its-kind, non-pressurised, cold gas thruster, fuelled by solid iodine." The system is designed for cubesats aiming at the extension of the operational life and performing collision avoidance manoeuvres. ThrustMe said the agreement to place the iodine thruster on SpaceTY's satellite was finalised within a very short time: "From idea to launch in less than a year, from contract to launch in eight months." The iodine thruster project was funded by public investments and government grants from French institutions and the European Union. ThrustMe got support from the French government and the French Embassy in Beijing to make the project happen at the required speed.
Also on board was Xiaomi's #Mi10Pro's 108MP camera hardware module. The camera took photos of 60 m resolution per pixel. For the future, Xiaomi and SpaceTY are considering more cooperation in the area of remote sensing, fitting into SpaceTY's philosophy of "making space as easy as possible".

2019-073A
04 November 2019 - 17:43 UTC (05 November - 01:43 BJT)

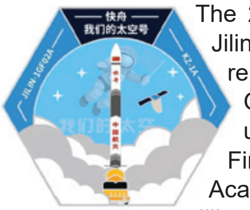
launch site: Xichang Satellite Launch Centre - XSLC, LC2
launcher: Chang Zheng 3B/G3, CZ-3B
payload: Beidou DW49 (Beidou 3 IGSO-3)

The 49th satellite of the BDS satellite family and the 24th satellite of the BDS-3 system was launched into inclined geosynchronous Earth orbit. It is the 3rd IGSO satellite, completing the Beidou IGSO constellation. The new satellite was developed by CAST. The G3 variant of the Chang Zheng 3B has an by 20 cm enlarged payload fairing with a total circumference of 4.2 m. It was the 9th use of this CZ-3B/G3 version (2015-053, 2016-048, 2016-077, 2018-085, 2019-012, 2019-017, 2019-023 and 2019-035)
To improve the flight of the rocket and in-flight data collection, an additional protection device was installed. The structure of the rocket's cryogenic 3rd-stage engine was optimised to reduce the stress level and increase reliability.

The Long March-3B carrier rocket at the Xichang Satellite Launch Centre. Credit: Xie Qiyong/ China Academy of Launch Vehicle Technology

2019-075A
13 November 2019 - 03:40 UTC (11:40 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC, road-mobile launch platform
launcher: Kuaizhou 1A, KZ-1A
payload: Jilin 1-Gaofen 02A



The 2nd KZ-1A mission of 2019 launched the Jilin 1-Gaofen 02A satellite. It is a new optical remote sensing satellite built by Chang Guang Satellite Technology Co., Ltd., under the Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences.

Jilin 1-Gaofen 2A is a 230 kg satellite with 2 solar panels and 2 cameras on board: one optical with static push-scan full-colour imagery capacity of 0.75 m resolution and one multi-spectral with 3.1 m resolution and a swath width of 40 km. The images are downloaded at a data rate of 1.8 Gbps. The satellite will form a network with 13 previously launched Jilin 1 satellites in a 535 km orbit, providing remote sensing data and services in fields like agriculture, forestry, natural resources and environment. The plan is a Jilin constellation with 139 satellites by 2030, providing an all-day, all-weather, full-spectrum high resolution imagery with a revisit time of 10 min. During the initial phase from 2020-2030, the 60 satellite constellation will provide new global data every 30 min. The Jilin constellation is supported by the Jilin Province which aims at the satellite industry as a new economic driver for the region. The data are for commercial customers who use them for geological disasters forecast and mitigation, as well as for the exploration of natural resources.

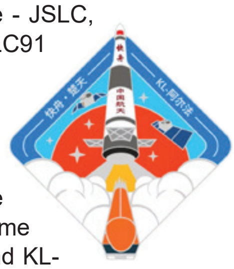
2019-076A 2019-076B 2019-076C
2019-076D 2019-076E
13 November 2019 - 06:35 UTC (14:35 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, LC16
launcher: Chang Zheng 6, CZ-6
payloads: Ningxia 1-01 Ningxia 1-02 Ningxia 1-03
Ningxia 1-04 Ningxia 1-05

Just 3 hours after the KZ-1A launched from Jiuquan, the CZ-6 took off from Taiyuan, placing 5 Ningxia 1 satellites into orbit. The satellites are part of a commercial satellite project invested by the Ningxia Jingui Information Technology Co., Ltd. and will be mainly used for remote sensing. It was also talk of the capability of sensing terrestrial radio emissions. The satellites have a lengthy box-shaped body with a deployable solar panel on the one end and were developed by DFH Satellite Co., Ltd. Operator is the Ningxia Jingui Information Technology Co., Ltd. By the end of January 2020, the 5 satellites reached their final positions phased by 72° from each other.

2019-077A
2019-077B
17 November 2019 - 10:00 UTC (18:00 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC, road-mobile launch platform, located East of LC91
launcher: Kuaizhou 1A, KZ-1A
payloads: KL-Alpha-A (KL-Alpha 1)
KL-Alpha-B (KL-Alpha 2)



Only 4 days after a KZ-1A launch, Expace used again a Kuaizhou rocket from the same launch site with the same team and the same mobile launch platform to bring KL-Alpha-A and KL-Alpha-B, 2 global multimedia Ka-band communications satellites, into slightly different 86° polar orbits. One was deployed into a 1,050 km circular orbit and the other into an elliptical orbit with a perigee of 1,050 km and an apogee of 1,425 km. The A-satellite has a mass of 70 kg and the B-satellite of 90 kg. They were built by the Shanghai Innovation Academy for Microsatellites of the Chinese Academy of Sciences for an unnamed German company which later turned out to be the Munich/Berlin-based commercial space start-up KLEO Connect. The satellites are technology test satellites for a 300 satellite LEO constellation in polar orbit, intended for commercial IoT services. Details can be found on their website: *https://kleo-connect.com/constellation*: "The initial constellation will reside at approx. 1,100 km and the satellites will be distributed evenly across 12 orbit planes with 24 active (and one spare) in each plane. Each satellite will be equipped with state-of-the-art laser communication terminals, connecting satellites within and across orbital planes with a data rate of up to 10 Gbps per link. For communications between the ground and each satellite, advanced Ka-band technologies will be featured. Latency of the connections will vary depending on geographical distance and number of satellites required for a connection. However, typical latencies will be less than 100 ms." It was reported that German and European investors were shy of participating in the project but Chinese investors could be found what consequently lead to the decision to launch with a Chinese rocket.

Launch of the Kuaizhou 1A with the KL-Alpha-A and KL-Alpha-B satellites on board. Credit: Ma Chongpeng/Xinhua

2019-078A
2019-078B
23 November 2019 - 00:55 UTC (8:55 h BJT)

launch site: Xichang Satellite Launch Centre - XSLC, LC3
launcher: Chang Zheng 3B/YZ 1, CZ-3B/YZ 1
payloads: Beidou DW50 (Beidou 3M-21)
Beidou DW51 (Beidou 3M-22)

The CZ-3B was equipped with the Yuanzheng-1 (Expedition-1) upper stage to release the pair of 3rd generation MEO Beidou satellites into their planned orbits. They are the 50th and 51st satellites of the BDS satellite family and M19 and M20 in the Beidou-3 MEO series. Both satellites were developed by the Innovation Academy for Microsatellites of the Chinese Academy of Sciences in Shanghai. M21 went into position A8 and M22 into position A6.

2019-082A
27 November 2019 - 23:52 UTC (28 November - 07:52 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, LC9
launcher: Chang Zheng 4C - CZ-4C
payload: Gaofen 12 (GF-12)

The CZ-4 launched the 3rd satellite of the Gaofen series within the 4th quarter of 2019. The launch was announced on short notice and not many details were revealed. Gaofen 12 is an all-weather, high resolution SAR satellite, providing remote sensing data with 1 m resolution. It was built by SAST in Shanghai. GF-12, residing in a 600 km, 97.9° orbit, is part of China's High-definition Earth Observation System CHEOS.

2019-086A
07 December 2019 - 02:55 UTC (10:55 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, road-mobile launch platform
launcher: Kuaizhou 1A, KZ-1A
payload: Jilin 1-Gaofen 02B

Instead from the Jiuquan Satellite Launch Centre, for the first time the Kuaizhou 1A rocket was launched from Taiyuan. Also, it was the 1st time that 2 Kuaizhou 1A rockets launched from the same launch site and that they took off in less than 6 hours. This launch, the morning launch, which was also the 6th launch of the KZ-1A rocket, placed the Jilin 1-Gaofen 02B satellite in a 535 km orbit. Jilin 1-Gaofen 02B is an optical remote sensing satellite which joined the 14 Jilin 1 satellites of the Jilin constellation already in space providing services for agriculture, forestry, resources and environment. The 230 kg satellite, developed by Chang Guang Satellite Technology Co., Ltd., under the Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, features high resolution, a wide swath width and high-speed data transmission. Jilin 1-Gaofen 2B is similar to the Jilin 1-Gaofen 2A, which orbited on 13 November - see: 2019-075A

Launch of the Jilin-1 Gaofen 02B satellite from the mobile launch platform for the Kuaizhou-1A. Credit: Zheng Taotao/Xinhua

2019-087A? 2019-087B? 2019-087C?
2019-087D? 2019-087E? 2019-087F?
07 December 2019 - 08:52 UTC (16:52 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, road-mobile launch platform positioned at LC16
launcher: Kuaizhou 1A, KZ-1A
payloads: HEAD-2A (HEDE-2A) HEAD-2B (HEDE-2B)
SpaceTY 16 (Tianyi 16) SpaceTY 17 (Tianyi 17)
Tianqi 4A Tianqi 4B

Only 6 hours after the launch of the 6th KZ-1A rocket, the 7th Kuaizhou 1A took off from the same launch site but from a different mobile pad. The KZ-1A became the 1st Chinese rocket to be launched twice the same day as much as Taiyuan became the 1st space port in China to carry out two launches within one day. In total, the afternoon-KZ-1A orbited 6 satellites. Like all KZ-1A launches, both launches on 7 December were managed by Expace Technology Co., Ltd., a CASIC spin-off.

HEAD-2A / HEAD-2B

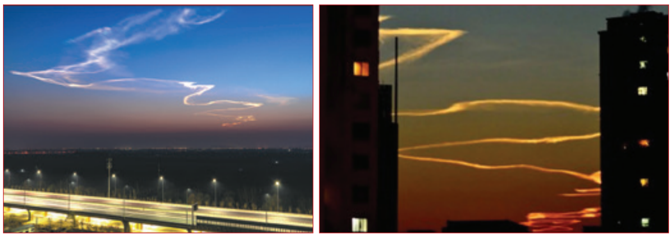
HEAD-2A and HEAD-2B are the 1st two of 48 satellites for the Skywalker Constellation of HEAD Aerospace Technology Co. Ltd. The smallsats, built by SAST, are intended for environmental monitoring, logistics, traffic, emergency communication and AIS data collection from ships and aircraft.
The high performance AIS-receiver is able to process 2 million AIS short messages per 24 hours and to identify 60,000 ships.
With a mass of 45 kg, the satellites are based on different buses equipped with multiple sensor capabilities. 12 sats will be deployed in SSO and 36 in LEO Walker-δ orbits distributed over 6 different orbital planes in 700 km, inclined by 50°, and phased by 60°. They will be included into a wider ICT infrastructure for data processing, machine learning, automation and data access, to provide a secure end-to-end data environment (from space to end-user). Beijing-based HEAD Aerospace has establishments in Hong Kong, the Netherlands and France, and joint laboratories located in Switzerland and Italy. This strong international network enables cooperation for frequency allocation, ground segment, data distribution, and market exploration.

SpaceTY 16 / SpaceTY 17

The 6U SpaceTY 16 and SpaceTY 17 satellites are medium-resolution remote sensing satellites that are mainly used for disaster prevention, maritime applications, agricultural remote sensing and polar environment monitoring. They were developed by Changsha Tianyi Space Science and Technology Research Institute Co., Ltd., and are operated by SpaceTY Aerospace Co.

Tianqi 4A / Tianqi 4B

The Tianqi 4A and Tianqi 4B LEO satellites of Guodian HighTech. are providing IoT data service and emergency communication. They are 6U cubesats of 8 kg mass. Both satellites are intended for the 38 satellite Apocalypse constellation, providing reliable IoT services and data for forestry, geology, and meteorology, also in remote regions.



left: The 2nd KZ launch from Taiyuan left a zigzag shaped contrail cloud in the clear skies which was even visible in Beijing - 500 km away to the East (picture right). Social media quickly spread the photos and called the phenomena “dragon cloud”. Credit: Li Jigong/China Daily /China internet

The road-mobile transport vehicle and launch pad for the Kuaizhou 1A rocket is being prepared. Credit: Expace/People's Daily

2019-090A
2019-090B
16 December 2019 - 07:22 UTC (15:22 BJT)

launch site: Xichang Satellite Launch Centre - XSLC, LC3
launcher: Chang Zheng CZ-3B/YZ1
payloads: Beidou DW 52 / Beidou 56 / Beidou 3M-19
Beidou DW 53 / Beidou 57 / Beidou 3M-20

The launch of the 52nd and 53rd BDS satellites which are also the 23rd and 24th of the BDS-3 core constellation, means, all the 24 MEO satellites are in space. The MEO orbit is at about 21,800 km with an inclination of 55°. BDS MEO satellites are distributed over 3 orbital planes. 3 hours after launch, the satellites successfully entered their designated orbits. Once they completed the in-orbit tests they will be commissioned and ready to provide global service. BDS-3 MEO satellites mainly provide global users with positioning, navigation and timing services as well as with global short-message communication, international search and rescue.
Out of the 24 MEO satellites in orbit, 14 were developed by the China Academy of Space Technology and 10 satellites were built by the Innovation Academy for Microsatellites of the Chinese Academy of Science. With an average launch rate of 1.2 satellites per month, BDS holds the world record in the deployment of a Global Navigation Satellite Systems (GNSS).

2019-093A	2019-093	2019-093
2019-093	2019-093	2019-093G
2019-093	2019-093	2019-093

20 December 2019 - 03:22 UTC (11:22 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, LC9
launcher: Chang Zheng 4B, CZ-4B
payloads:
CBERS-4A (Ziyuan 1-04A, ZY 1-04A)
Tianqin 1
Xingshidai 8 (Tianyan 02, MN6U-02, Kehuan Shijie Hao AI Weixing)
Yuheng
Shuntian
ETRSS-1
FloripaSat 1
BDS-AGR-1 (Weilai 1R, Jinshai 1, Guozhi Henghao Nianjing Zhongyuan)
Yizheng 1 (Tianyan 01)

Because of unfavourable weather, the launch was postponed from 17 December to 20 December.
Jonathan McDowell reported the detailed payload separation sequence. At T+11 m 39 s the 3rd stage finished its burn and entered a 615 x 635 km sun-synchronous orbit with an Equator crossing at 10:30 local time.
At T+13:18 the primary payload, the 1,980 kg CBERS-4A (China-Brazil Earth Resources Satellite 4A), separated and became object 4489, 2019-093A. CBERS-4A was mounted on an adapter covering the remaining payloads. The adapter separated into orbit at T+13:53. It is probably 2.0 m high and 2.9 m in diameter. Next, the Tianqin 1 satellite separated, at T+14:28. At T+15:05, 3 further satellites separated: Tianyan 02, Yuheng and Shuntian and at T+15:47 the final 4 payloads were released: ETRSS-1, FloripaSat 1, Weilai 1R and Tianyan 01. At T+25 min the 3rd stage restarted for a depletion burn which lowered its orbit to 447 x 620 km. The COSPAR assignments were only certain for CBERS-4A (93A) and ETRSS-1 (93G). Therefore, we list them according to their deployment.

CBERS-4A

CBERS 4A is the final China-Brazil Earth Resources Satellite (CBERS) for global monitoring to serve a wide range of public-governmental services such as environmental, urban planning and agricultural applications. The CBERS satellites are part of the larger Chinese Ziyuan series. 70 % of the satellite development tasks including control system, propulsion system and cameras were completed by CAST, with the remaining 30%, including the power system, undertaken by Brazil's National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais – INPE). With a total mass of 1,980 kg, the satellite carries 7 scientific instruments, such as a panchromatic and multi-spectral camera and a wide-field imaging camera. MUXCam (Multi-spectral Camera) and WFI (Wide-Field Imager) were developed by Brazil, PanMUX (Panchromatic and Multi-spectral Camera) and IRS (Infrared System) were made by China. The other payloads are the DCS (Data Collection System) and SEM (Space Environment Monitor).
CBERS-4A is a 1,8 x 2,0 x 2,6 m box-shaped construction, equipped with a 3-segment solar panel of 6,3 x 2,6 m size which provides 2,300 W power. The satellite's life time is 5 years. The successor satellites CBERS-4B, 5 and 6 are already agreed, showing the strong interest both countries have in the continuation of the CBERS programme that began in 1988.
Once the satellite starts formal operations, it will gradually replace the still operational CBERS-4, which was launched by a CZ-4B from Taiyuan in December 2014.
CBERS-4A will be jointly operated by the Brazilian space organisation INPE and the Chinese CRESDA (China Centre for Resources Satellite Data and Application).
After the launch, President Xi Jinping sent a congratulatory letter to Brazilian President Jair Bolsonaro, saying that the CBERS programme has set a good example for high-technology and space cooperation among developing countries. Marcos Pontes, former astronaut and the Brazilian Minister of Science, Technology, Innovation and Communications attended the launch in Taiyuan.
The CBERS satellites would be included in the BRICS (Brazil, Russia, India, China, South Africa) constellation programme for Earth observation. Currently, only South Africa does not have a satellite of its own.
Next to CBERS-4A, the CZ-4B rocket put another 8 satellites into orbit.

Tianqin 1

Built by DFH Satellite Co., the 35 kg microsat Tianqin 1 is a 49 x 49 x 43 cm box-shaped technology test satellite for China's gravitational-wave-astronomy programme.
It was used to test variable thrust propulsion at the micro-Newton level with an accuracy of up to 0.1 micro-Newtons. The weak thrust is needed to offset the continuous solar wind pressure and the residual atmosphere affecting the satellite in order to keep the satellite a highly static and super-stable platform and make the space-based detection of gravitational waves possible. Tianqin 1 is the first technological experiment satellite for the Tianqin programme, meaning "harp in the sky," which was initiated by Sun Yat-sen University (Zhongshan Daxue) in Guangzhou, Guangdong Province in 2015. It will consist of three satellites forming an equilateral triangle around the Earth. Tianqin 1 is also equipped with a sub-payload for amateur radio communication and education and by CAMSAT registered as CAS-6 (China Amateur radio Satellite).

Tianyan 02

Tianyan 02/Xingshidai 8 is a 6U cubesat built by Weina Xingkong Keji (MinoSpace) for Gouxing Yuhang Keji (ADA Space) of Chengdu. It is also called "Kehuan shijie hao AI weixing" (SciFi World AI satellite) and is dedicated to the science fiction community. SF writers including Cixin Liu were invited to the launch. The satellite apparently has a low resolution Earth video camera.

Yuheng and Shuntian

Yuheng and Shuntian were developed by the National University of Defense Technology in Changsha in collaboration with the Deya Innovation Research Institute of Foshan, in the Guangzhou region. They are prototype internet distribution satellites. Shuntian is a box-shaped satellite with two solar panels. It was built by Shanghai ASES Spaceflight Technology and is based on the Star-Light-SL-B platform.

ETRSS-1

ETRSS-1 is a 70 kg, multi-spectral civil Earth observation satellite and was built by DFH Satellite for the Ethiopian Space Science and Technology Institute (ESSTI) in Addis Ababa which will also take over the operations. It is Ethiopia's 1st satellite. A large Ethiopian delegation attended the launch. ETRSS-1 makes Ethiopia the 11th African country with a satellite in space. Egypt was the first in 1998. 21 Ethiopian engineers were trained on the project as part of the technology-transfer agreement between the Chinese government and ESSTI. They will become the space operations teams for the satellite. 6 million USD of the total cost of 8 million USD for the design, construction and in-orbit delivery of the satellite including the cost of setting up the ground station at the Entoto Space Observatory located on the 3,200-m hills of Entoto on the outskirt of the capital Addis Ababa were covered by China while the Ethiopian government provided 2 million USD complementary funds for the ground station infrastructure.

ETRSS-1 will provide data for Ethiopian authorities and research institutions to monitor the environment and study weather patterns for better agricultural planning, early warning for drought, mining activities and forestry management.

During his stay for the 2nd Belt-and-Road Forum in April 2019 in Beijing, the Ethiopian Prime Minister Abiy Ahmed also visited the China Academy of Space Technology to inspect the satellite. Also, the satellite has inspired the Space Generation Campaign in Ethiopia, an outreach activity by the Ethiopian Space Science Society (ESSS) to promote science and technology.

Ethiopia also has an agreement with China for the construction of a communication satellite for commercial telecommunications and broadcasting services.

The Ethiopian government is also investing in indigenous capacity for developing satellites and space technologies. It signed an agreement with ArianeGroup, to build a satellite manufacturing, assembly, integration and testing (MAIT) facility in Addis Ababa until the end of 2022. The African Union adopted a policy on African space development in 2017 and declared that space science and technology could advance economic progress and natural resource management on the continent.

Ethiopia also leases transponders on the SES NSS-12 communications satellite, creating the EthioSat platform. Ethiopia spends currently around 350 million birr (about 11 million USD) annually to receive data from foreign satellites, which is hoped to decrease with the new satellite.

FloripaSat 1

FloripaSat 1 is a 1U/1kg cubesat from the Universida de Federal de Santa Catarina, in the Brazilian city of Florianopolis. It is an educational, research, technology and radio amateur satellite.

BDS-AGR-1

BDS-AGR-1/Weilai 1R is the replacement satellite for the lost one during the Zhuque 1 failure in October 2018. It is a 32 x 29,5 x 24,8 cm box-shaped satellite with 2 solar panels. The 65 kg imaging satellite is operated by GZH-NHR Agricultural Technology Co. (GZH-NHK BDS AGR Co. Ltd) of Zhengzhou in Henan province and is expected to provide accurate remote sensing data on crops in the river basins in north China and help modernise and digitalise China's agricultural industry. BDS-AGR-1 belongs to the first phase of the "Guozhiheng Agricultural Remote Sensing Satellite Constellation" project jointly engineered by GasTianta and GZH-HNJ BDS AGR Co., Ltd. The constellation will consist of 40 satellites covering all of China's territory.

Tianyan 01

Tianyan 01/Yizheng 1 is a box-shaped satellite of 72 kg mass with a high resolution imager, and one fixed and one deployable solar panel. It was built by MinoSpace for the Zhongxing kongjian yaogan (jiangsu) weixing jishu fuwu YG (China Satellite Space Remote Sensing (Jiangsu) Satellite Technology Services Co., Ltd.), based in Yizheng, Jiangsu province.

2019-097A
27 December 2019 - 12:45 UTC (20:45 BJT)

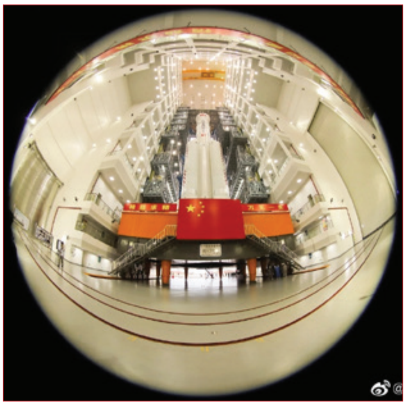
launch site: Wenchang Satellite Launch Centre – WSLC, LC101
launcher: Chang Zheng CZ-5 Y3
payload: Shijian 20 (SJ-20)

The launch failure of the 2nd flight of the CZ-5 in July 2017 caused not only the loss of the Shijian 18 satellite but also a long grounding of the CZ-5. A problem with the turbo pump in one of the two Y-77 engines in the 1st core stage demanded a complete engine overhaul, prompting several delays. Significant improvements in design, materials and technologies were made over a period of 908 days. Compared with the CZ-5 Y2, the Y3 rocket has more than 200 technological improvements. 50 failure scenarios were tested. The modified engine has undergone more than 10 ground tests of a total duration of over 3,000 s. The work paid off, the launch on 27 December was flawless. 2,220 s after take-off, Shijian 20 separated from the CZ-5 Y3 and was positioned into GTO from where it, propelled by its own thrusters, reached its position at 124,5° East on 6 January.

SJ-20, almost a duplicate of the lost Shijian 18, is the first verification satellite for CAST's new generation DFH-5 bus for GEO satellites. With 7.6 t launch mass it was the heaviest Chinese communication satellite. 1,5 t to 1,8 t of the total mass of the box-shaped satellite is reserved for payloads. SJ-20 is also the most advanced. Its double-folded 6-segment solar panels deploy in 2 steps: the 1st time after orbit insertion and the 2nd time after readying for operation in the final geosynchronous position. By then, the total span of the satellite is 45 m - a double record for China: in size and in power with 28 kW of generated solar energy (while the power for the payloads is around 18 kW). The panels can rotate to keep facing the sun. The DFH-5 new generation platform, which development started in 2010, has improved in weight, power and in-orbit lifespan, complying to the needs of high-capacity comsats for the next 20 years. DFH-5's capacity can replace that of 2-3 DFH-4 platforms. Also, the DFH-5 bus can carry different types of payload modules for communications, remote sensing and scientific as well as technology experiments. Compared with the DFH-4 satellite bus which consumes nearly 50 kg of propellant a year, DFH-5 only needs 4-5 kg propellant annually since it adopts a hybrid propulsion system. Chemical propulsion is used for rapid orbit change or satellite attitude adjustment while the several small electric ion-propulsion engines support in-orbit adjustment manoeuvres during the satellite's projected 16 years of operational life.

The main payloads are Ka-band-HTS transponders. Additionally, experimental payloads for infrared-laser and quantum communication as well as Q/V broadband flexible transponder in the microwave range (33-75 GHz) which would enable 1 Tbps bandwidth for ultrafast speed are tested for later use on the next generation of comsats. The laser terminal achieved during first tests a 2-channel transfer rate of 10 Gbit/s. Another focus of the test is in the operation during heavy rain fall (e.g. Monsoon season) which can become a certain problem when the rain drops absorb the signals.

The CZ-5 rocket uses a new 5 m diameter core-structure, bundled with four 3.35 m diameter boosters. Its total length is 57 m, the take-off weight is about 870 t, and the LEO P/L capacity is 25 t, and the GTO capacity is 14 t. Another special feature of the SJ-20 satellite is its innovative cooling system, based on cryogenic loop heat pipes. The hardware for radiating the excessive heat back into space is made of shape memory polymers. The satellite will test the controllable deformation of shape memory polymers, which can switch between temporary shapes, to pave the way for the development of large variable space structures and lay the foundation for the development of highly sensitive space probes.



left: Shijian 20, a technology demonstration satellite developed by the China Academy of Space Technology in Beijing, gets encapsulated for the launch with the Long March 5 carrier rocket at Wenchang Space Launch Centre in Hainan province. Credit: China Daily/Zhuang Qianqian *middle:* Fisheye view of the CZ-5 in the assembly building. *right:* Launch of teh CZ-5 with the SJ-20 satellite on board from Wenchang Space Launch Centre on Hainan Island. Credit: GuoWenbin/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

AO	Announcement of Opportunity
APSCO	Asia-Pacific Space Cooperation Organisation
ASEAN	Association of Southeast Asian Nations
BDS	BeiDou satellite navigation System
BJT	Beijing Time
BRI	Belt-and-Road Initiative
BRICS	Brazil, Russia, India, China and South Africa
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
CBERS	China-Brazil Earth Resources Satellite
CCAF	China (International) Commercial Aerospace Forum
CCTV	China Central Television
CCSA	China Commercial Space Alliance
CE	Chang'e
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
CRESDA	Centre for Resources Satellite Data and Applications
CSES	China Seismo-Electromagnetic Satellite
CSS	Chinese Space Station/China Space Station
CZ	Changzheng, Long March
DBAR	Digital Belt-and-Road Programme
DFH	Dong Fang Hong
ETRSS	Ethiopian Remote Sensing Satellite
eXTP	enhanced X-Ray Timing and Polarimetry mission
FAST	Five-Hundred Metre Aperture Spherical Radio Telescope
FY	Fengyun
FYESM	Fengyun Meteorological Satellites in Disaster Prevention and Mitigation
GEO	Geostationary Orbit
GNSS	Global Navigation Satellite System
GF	Gaofen
HERD	High Energy cosmic Radiation Detection
HXMT	Insight Hard X-ray Modulation Telescope
ICG	International Committee on Global Navigation Satellite Systems
ISRO	Indian Space Research Organisation
LEO	low Earth orbit
LEOP	launch and early orbit phase
LND	Lunar Lander Dosimetry and Neutron
LOX	liquid oxygen
LRO	Lunar Reconnaissance Orbiter

MoU	Memorandum of Understanding
NSMC	National Satellite Meteorological Centre
NSSC	National Space Science Center
P/L	payload
QUESS	Quantum Experiments at Space Scale
RLV	reusable launch vehicle
Roscosmos	Russia's State Space Corporation
SAR	Synthetic-Aperture Radar
SAST	Shanghai Academy of Spaceflight Technology
SBSP	Space Based Solar Power
SCO	Space Climate Observatory
SIA	Shenyang Institute of Automation
SKA	Square Kilometre Array
SMILE	Solar wind Magnetosphere Ionosphere Link Explorer
SSO	Sun-Synchronous Orbit
SUPARCO	Space and Upper Atmosphere Research Commission
TQ	Tianque
TT&C	Space Telemetry, Tracking and Command Station
UN	United Nations
UNOOSA	UN Office for Outer Space Affairs
UTC	Coordinated Universal Time
UTSC	University of Science and Technology of China
VTVL	vertical takeoff, vertical landing
WMO	World Meteorological Organisation
YW	Yuanwang
ZQ	Zhuque

Imprint

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Go Taikonauts! print version is issued by:
Initiative 2000 plus e.V.;
Dümperstrasse 5,
17033 Neubrandenburg,
Germany
copies can be ordered via e-mail:
rcspace@t-online.de

printing house:
WirmachenDruck.de
Sie sparen, wir drucken!

pricing

single printed issue:
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for consultants/analysts/members of media, space companies, think tanks, space organisations: 100 €

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Chang'e 4 – Behind the Moon (part 4)

Operations of lunar days 11 to 13 on the far side of the Moon

by Jacqueline Myrrhe

10th lunar day – approx. 22 September to 6 October

During lunar day 10, the Yutu 2 (YT-2) rover moved in accordance with the mission planning 5.1 m. That distance contributed to the overall accumulated 289.769 m of traversing the lunar surface by the end of the 10th lunar day. See GT! issue no 29, p. 21

10th lunar night – from approx. 7 to 20 October

The Chang'e 4 lander (CE-4) and YT-2 rover switched to dormant mode on 5 October – the lander at 19:30 BJT and the rover at 15:43 BJT.

11th lunar day – from approx. 21 October to 5 November

The CE-4 lunar lander woke up at 5:11 BJT on 23 October and YT-2 awoke at 11:45 BJT on 22 October. Both crafts and its instruments were in normal working conditions upon activation.

Yutu 2 took photos of its tracks. By the end of the 11th lunar day, Yutu 2 had driven 318.62 m on the lunar surface and was positioned 218.11 m northwest of the lander.

11th lunar night – from approx. 5 November to 19 November

On 4 November, before the start of the 11th lunar night, CE-4 and YT-2 switched to dormant mode in the early hours of the 4 November.

14 November - Longjiang 2 impact site found

The team at Arizona State University in the U.S., responsible for the LRO Camera (LROC) on NASA's Lunar Reconnaissance Orbiter (LRO), found on LRO imagery the Longjiang 2 impact site on the far side of the Moon. Daniel Estévez noticed the newly created crater through comparing LRO images from before and after the impact date of 31 July. On 14 November, the LROC-team wrote on its website: "Daniel Estévez estimated that the small spacecraft [45 kg] impacted somewhere within Van Gent crater (16.69°N, 159.52°E). The LROC team used these coordinates to image the area on 5 October 2019 from an altitude of 122 kilometers (M1324916226L). Through a careful comparison of pre-existing NAC (Narrow Angle Camera) images, the LROC team was able to locate a new impact crater (16.6956°N, 159.5170°E, ±10 meters), a distance of only 328 meters from the estimated site! The crater is 4 x 5 m in diameter, with the long axis oriented southwest to northeast." The new crater is located on a steep slope, greater than 20°, measured from an LROC NAC Digital Terrain Model.

19 November - Moon Village Principles – Mission Prize 2019

On 19 November, the Moon Village Association announced the winners of the Moon Village Principles – Mission Prize 2019. The price was awarded for the 1st time. The 2019 honour was given to the Chang'e 4 lunar mission, to NASA's Lunar Reconnaissance Orbiter - LRO and to ISRO's Chandrayaan 2 lunar mission. The prize was handed over to the relevant space agency's representative during the 3rd International Moon Village Workshop & Symposium on 5 December in Tokyo.

12th lunar day – from approx. 20 November to 3 December

The CE-4 lander woke up on 21 November at 17:03 BJT, and the YT-2 rover awoke at 00:51 BJT the same day. Lander and rover along with its scientific instruments were in normal working condition and resumed operations. During the 12th lunar day, a new batch of scientific detection data was sent to the core research team for analysis.

By the end of the day, YT-2 has driven 345.059 m on the far side of the Moon. The space experts are planning Yutu's route very carefully due to the complicated geological and cratered terrain around the rover.

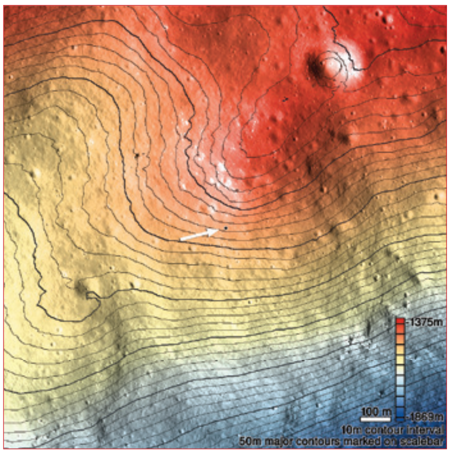
25 November - Team Gold Medal for Chang'e 4 science team

On 25 November, the Chang'e 4 mission team received the only Team Gold Medal of the year awarded by the Royal Aeronautical Society (RAeS) of the United Kingdom at its annual award ceremony held in London. The medal is a recognition of the teams "outstanding achievement of the first soft landing on the far side of the Moon." It was also the first time since the inception of the prize more than 150 years ago that it was presented to a Chinese team. After the award ceremony, Chief Designer and Head of Delegation, Wu Weiren, expressed thanks to the RAeS and the award committee, and encouraged more countries and organisations to cooperate with China in the field of space exploration.

26 November - NCLE - Netherlands-China Low Frequency Explorer

On 26 November, the three 5-m long monopole antennas of the Netherlands-China Low-Frequency Explorer (NCLE) on the relay satellite Queqiao have been partly unfolded and started scientific operations. The antenna detect radio signals at 80 kHz-80 MHz frequency.

The initial mission scenario was that the antennas would deploy after the end of Yutu's surface operations which were planned for 3 months – equivalent to the rover's designed life time. The rover did well and NCLE finally had to wait



Longjiang 2 impact site - see white arrow in the middle. The new crater is located on a steep slope, greater than 20°, measured from an LROC NAC Digital Terrain Model. Credit: NASA/GSFC/Arizona State University

left: Chief Designer Wu Weiren with the Team Gold Medal at the award ceremony of the Royal Aeronautical Society (RAeS) in London, UK, on 25 November 2019. Credit: Ray Tang/Xinhua
right: The Chang'e 4 mission team together with guests at the award ceremony at the Royal Aeronautical Society (RAeS) in London, UK. The scientist received the only Team Gold Medal of the year 2019. Credit: Ray Tang/Xinhua

for over a year. Most likely the long exposure to the space environment had an effect on the antenna. Despite a smooth start of the deployment, the unfolding process became more difficult over time. In order to avoid unnecessary risk, the scientists decided to start data collection with the partly deployed antennas. Once the most scientific objectives could be met, the team would try again to fully deploy the antennas. The shorter antennas allow to record signals from approx. 800 million years after the Big Bang. The fully deployed antenna should be sensitive to signals from right after the time period after the Big Bang.

12th lunar night – from approx. 3 to 18 December

YT-2 went into hibernation for the 12th lunar night on 3 December. By mid-December, the Yutu 2 rover has been in operation on the lunar surface for more than 340 days, setting the record for the longest working rover on the Moon. Before YT-2, the Soviet Union's Lunokhod 1 Moon rover that landed on the Moon in 1970 held the record for the longest operational rover with 321 days, or 10 and half months. Lunokhod 1 roomed a distance of 10.5 km.

DSLWP-B (Longjiang 2)

On 15 December, all telemetry data of the DSLWP-B microsatellite, captured during the entire mission by the DSLWP amateur radio team from the DSLWP-B amateur radio payload were publicly released and published on the Zenodo portal. Spanish amateur spacecraft tracker Daniel Estévez (EA4GPZ) made a Jupyter notebook, enabling a simple way to study the data.

https://github.com/daniestevez/jupyter_notebooks/blob/master/dslwp/telemetry/Telemetry%20CSV.ipynb

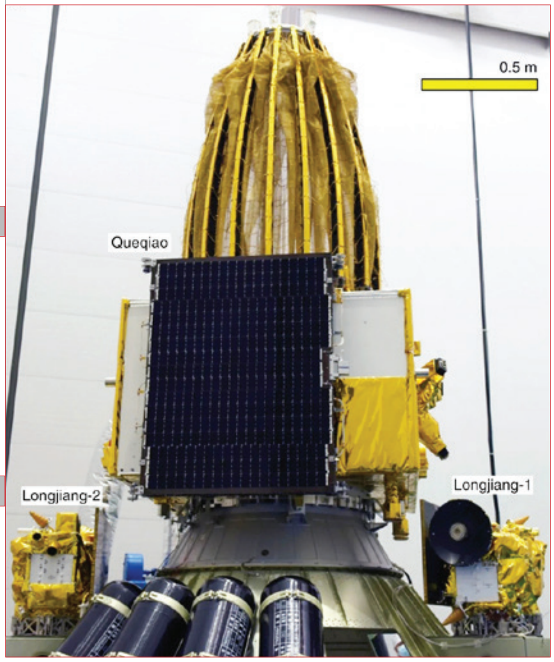
https://zenodo.org/record/3571330#.XgUAmvlKiUk

Introduction to the data set by Daniel Estévez on: *https://destevez.net/2019/12/dslwp-b-whole-mission-telemetry/*

also see: article and interview on the next pages

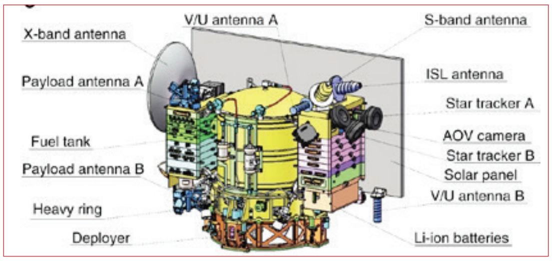
13th lunar day – from approx. 19 December – 01 January 2020

When the lander woke up on 21 December at 5:14 BJT and the rover on 20 December at 18:43 BJT, both were in normal working conditions.



for article on next page: The Longjiang-1/2 microsatellites and Queqiao relay satellite on the final stage of the launch vehicle.

Credit: Wei, M., Hu, C., Estévez, D. et al. Design and flight results of the VHF/UHF communication system of Longjiang lunar microsatellites. Nat Commun 11, 3425 (2020). https://doi.org/10.1038/s41467-020-17272-8



for article on next page: Equipment arrangement of Longjiang-1/2.

Credit: same as top photo

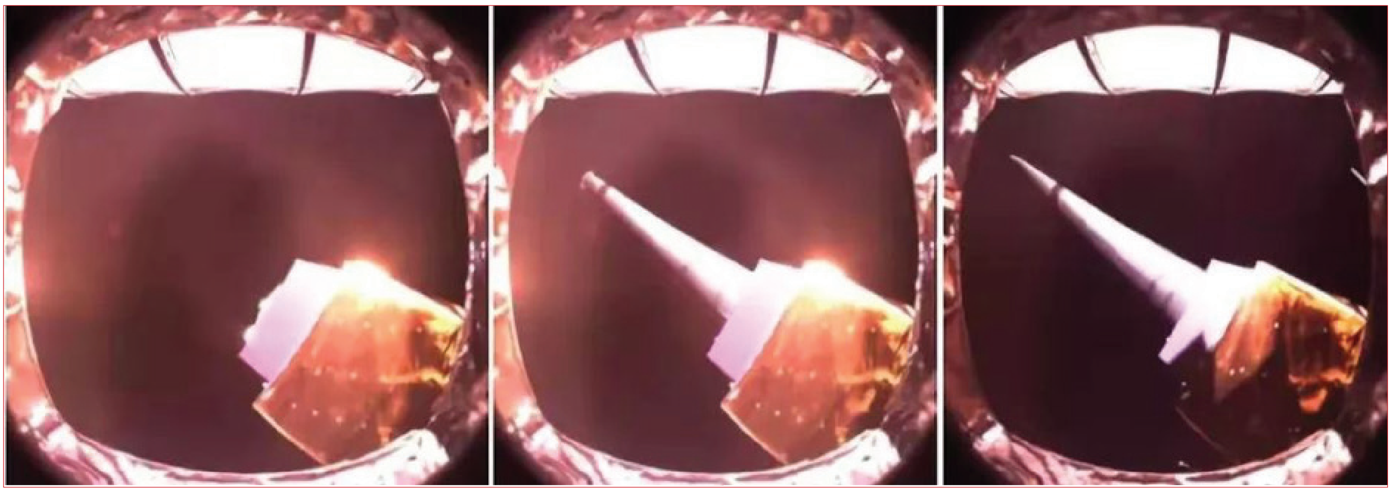
NCLE - Netherlands-China Low Frequency Explorer

The NCLE is a prototype radio telescope built to record weak radio signals from the Dark Ages and Cosmic Dawn - a time period just after the Big Bang. These signals are blocked by the Earth's atmosphere, disturbed by man-made radio-frequency interference (RFI), the Auroral Kilometric Radiation (AKR) and by Quasi-Thermal Noise (QTN), which is why the telescope was sent into space and positioned at a location behind the Moon. From those weak signals, scientist can conclude when the first stars and galaxies formed and which influence Dark Matter and Dark Energy have on the cosmic evolution.

NCLE launched on board of "Queqiao" - the Chang'e 4 communication satellite. Queqiao is used for relaying the commands from mission control in Beijing to the CE-4 lander and rover on the far side of the Moon. It also sends back the science data from the different instruments. NCLE will conduct coordinated measurements with the low-frequency radio spectrometer on the Chang'e 4 lander and with detectors on Earth.

NCLE was developed in The Netherlands by Radboud University Nijmegen, ASTRON - the Netherlands Institute for Radio Astronomy in Dwingeloo and the space company ISISpace in Delft, with support from the Netherlands Space Office (NSO).

The NCLE instrument made the project team the first Dutch team ever to be part of a lunar mission. The longer-term objective is to gain with NCLE sufficient technical information to design a constellation of small astronomical radio satellites.



The unfolding of one of the three antennas. The antenna is the black-and-white rod pointed away from the camera. The gilded cube is the casing in which the antenna has waited to be unfolded for 18 months. © Marc Klein Wolt / Radboud University

to be continued in the next issue of GoTaikonauts!

Longjiang-2 – First UHF-VLBI-experiment in lunar orbit

by Ulrich Fenner - DL2EP

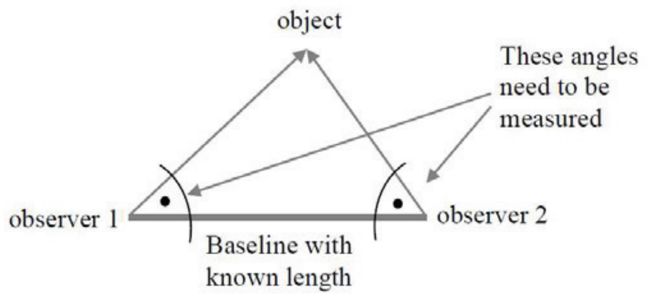
It is in the nature of humans to gather information about unknown things. However, this is sometimes hard, in particular when the unknown objects are far away, very big or very small. Consequently, in the beginning of any investigation, the question has to be answered: how far away is the object from the observer? Depending on the varying boundary parameters, there are several different applicable methods to find an answer, e.g. by using the propagation of sound, radar or geodesy. The principle is: from two locations (observation points) which are at a known distance, the angle between the respective location and the unknown object is measured. By doing so, the distance of the unknown object and its position in space can be determined. This method was already known and applied in ancient Egypt and was a useful tool when land had to be re-allocated after the annual floods by the Nile river.

Triangulation

However simple this might sound, there are a few preconditions in order to achieve useful results. These preconditions are:

- The two observation points have to be at a large distance to each other.
- The angle measuring devices need to have the best possible angular precision.
- The baseline has to be very precisely known.
- The process of the measurements/observations has to be free from disturbances.

The schema illustrates the principle of a triangular measurement:



Interferometry

Another measurement method is interferometry, making use of the superposition property of waves which causes interference. For this method, all types of waves are suited, for example: water waves, sound waves, light waves or radio waves.

Light waves are used to gain information about celestial objects, e.g. from stars or planets. However, light waves are a small fraction of the overall information we can get from space.

In 1932, Karl Guthe Jansky identified the first extra-terrestrial radio source which lead to the development of radio telescopes. The very first radio telescope was built by radio astronomer and radio amateur Grote Reber in parabolic shape in Wheaton, Illinois. In 1946 a research team in Malvern (England) discovered that a tiny region in the constellation of the swan is a source of intensive radio emission.

Over the following years, it was found that a wealth of information can be extracted from radio waves and X-ray waves. Those new findings would complement the information from the visible range of the spectrum or would even bring new revelations which could not be gained otherwise or were not even perceptible otherwise.

The observation of extra-terrestrial radio sources can be disturbed by very weak interfering electrical signals. In order to keep those electrical interferences, so-called RFI (Radio Frequency Interference) as small as possible, only very old diesel cars without board electronics are allowed on the grounds of the National Radio Astronomical Observatory in Green Bank (USA).

Other sources of interfering electrical signals are, among others, mobile phones, WLANs, laptops, electric door opener, cars' ignition system, or solar panels with their converters. All those things are not allowed to be operated in the vicinity of radio antennas.

Also, nowadays, disturbances of terrestrial antennas and telescopes are caused by the growing number of satellites.

First UHF-VLBI-experiment in lunar orbit

Very Long Baseline Interferometry (VLBI) is a high-precision measurement method for applications in astrophysics and geodesy. It has been used since the 1970s and has delivered ground-breaking scientific results. For example: VLBI allows the determination of terrestrial distances with a precision in the range of mm. VLBI contributes significantly to the International Terrestrial Reference Frame (ITRF). For that, globally distributed radio telescopes observe the same object in the night sky. The received radio signals are conditioned, together with the time signal provided by atomic clocks digitally recorded and sent to a so-called correlator. The correlator compares the signals to determine the time difference between a signal arrived at the first radio telescope and when at the second radio telescope. In the beginning of the radio astronomy era it was difficult to achieve the synchronisation of time signals between distant receivers. Today, thanks to GPS this became much easier.

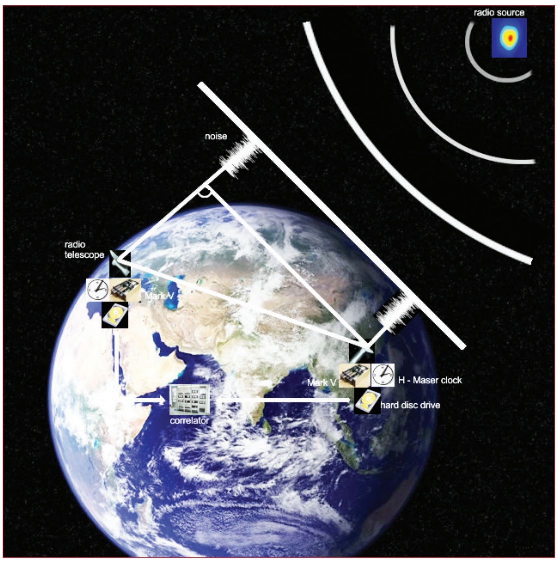
www.nature.com reported that the first signals from Longjiang-2-UHF-downlinks were received on 10 June 2018 from 04:20 UTC until 5:40 UTC in Dwingeloo (NL) and Shahe (CHN). It was the first VLBI experiment with a Moon orbiting spacecraft. Longjiang-2 sent the signal in the 70 cm band. The distance between the ground stations in Dwingeloo and Shahe is 7,250 km.

For the astronomical method of measuring the positions of radio sources, an average precision of 0,00004 arc-seconds can be achieved. That is equivalent to determining from a location on the Earth the position of a tennis ball on the Moon.

More details can be found here:

https://www.nature.com/articles/s41467-020-17272-8
Wei Mingchuan, Hu Chaoran, Daniel Estévez, Tai Mier, Zhao Yuhao, Huang Jiahe, Cees Bassa, Tammo Jan Dijkema, Cao Xibin, Wang Feng, Design and flight results of the VHF/UHF communication system of Longjiang lunar microsatellites. *Nature Communications*, 11, 1, p. 3425 (2020). DOI: 10.1038/s41467-020-17272-8

Geodetic and astrometric VLBI:
https://www.gfz-potsdam.de/en/section/space-geodetic-techniques/topics/geodetic-and-astrometric-vlbi/



Schematic concept of VLBI. Credit: GFZ Potsdam

"... it was a thrilling moment, giving us all goose-bumps."

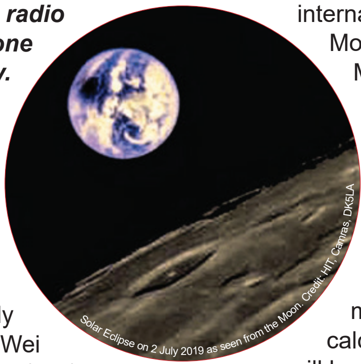
Interview with Reinhard Kühn - DK5LA

Reinhard Kühn, a German radio amateur since more than 50 years, was part of an international team which in 2019 operated the radio amateur payload and camera on board the Longjiang-2 lunar satellite. In the interview with GoTaikonauts! he speaks about how he got involved with this higly recognised Chinese mission and what his plans for the future are.

On 2 July 2019 you have been part of a radio amateur team which established a milestone and pioneering achievement in radio history. How did this happen?

In 2017, Jan van Muijlwijk (call sign PA3FXB) from the CAMRAS team, operating the 25 m Dwingeloo radio telescope in The Netherlands, and I, reactivated the radio amateur satellite ZA-Aerosat of the South-African Stellenbosch University.

The CAMRAS team in Dwingeloo had already in January 2018 cooperated with the team of Wei Mingchuan at the Harbin Institute of Technology (HIT) in China. CAMRAS had been assigned as the European ground station for the receipt of signals from Longjiang-2 - DSLWP-B but what was missing was a European ground station for sending commands to the satellite. Jan van Muijlwijk remembered our successful satellite rescue mission and asked me whether I would be willing to use my station for sending signals up to the Moon orbiting satellite. That would ensure that the communication with the satellite could be continued after the Moon had set in China - and I agreed, as my antenna was built exactly for this purpose - sending signals to the Moon. From that moment on, I became a team member of the Chinese Moon mission.



Solar Eclipse on 2 July 2019 as seen from the Moon. Credit: HIT, Camras, DK5LA

CAMRAS and ASTRON

The CAMRAS (C.A. Muller Radio Astronomy Station) team is maintaining and operating the 25 m Dwingeloo radio telescope in the province of Drenthe, The Netherlands. ASTRON (Netherlands Institute for Radio Astronomy) is the owner of the antenna.

At the Dwingeloo radio telescope, additionally to Jan, other experts from the ASTRON team, Cees Bassa, Tammo Jan Dijkema and Paul Boven PE1NUT, were involved in the operation and receipt of signals. Project leader Wei Mingchuan used not only the antennas at the Harbin Institute of Technology, but also a radio telescope in Beijing.

Often, the team of the radio telescope in Wakayama, Japan also joined in. On 15 July 2018, I received from China the pre-prepared text message "DK5LA Test" for sending to Longjiang-2. This message was sent back by satellite and received by radio amateurs world-wide, confirming that my station was suitable for communication with the Moon orbiter. Actually, the signals were so well received that I was asked in the autumn of 2018 to take over all up-link communication from Europe.

This made more repetition of transmissions possible and increased the redundancy within the short operational windows. Experiments were only done when I could afford the time for it, and as I was fully aware of the responsibility, I adjusted my time schedule accordingly. Sometimes four receiving antennas and their teams were coordinating, and were waiting for the results of my transmissions, e.g. they waited to receive the downlink from the satellite.

We have made a number of successful attempts. Among them were Very-Long-Baseline Interferometry (VLBI) measurements, occultation observations or operating Longjiang-2's camera to take spectacular images.

In January 2019, we received a photo which attracted international attention. It showed the full far-side of the Moon with our blue, fragile planet in the background. Media from all over the world were reporting about it. The photo was printed in *Science* magazine. *The Planetary Society*, *Space.com*, *NBC*, *Global Times* as well as of the German main stream newspaper *Die Welt* and French *Le Figaro* also showed the photo.

On 2 July 2019 we succeeded in capturing a particularly unique photo. The Spanish mathematician Daniel Estevez EA4GPZ, calculated that on that day a very special perspective will become available.

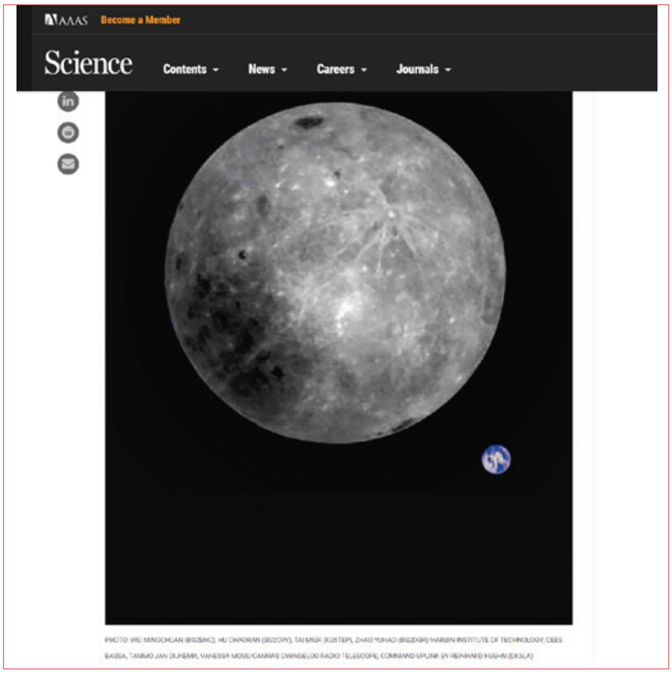
On the next day, 3 July, I was asked by the Chinese team to download Longjiang-2's photos taken the day before and stored in the on-board data memory.

Everybody was waiting with excitement. And indeed, it was a thrilling moment, giving us all goose-bumps. We saw how a picture was developing line-by-line in front of us on our screens. It showed a part of the far-side of the Moon and in the background the Earth. Amazing! We had been able to photograph the solar eclipse of the 2 July. The shadow of the Moon was visible over the Pacific and even Hurricane Barbara, active at the time, could also be recognised. There have not been such moving photos since Apollo 8.

Those photos were the first images of a solar eclipse taken from a lunar perspective.

It turned out to be a media sensation which went all around the world. For the Chinese and everybody in the team it was a success story.

Already on 1 July, I had booked a personal special record (performance). Since the Moon was at its perigee, Wei



Science magazine published the January 2019 photo, showing the Earth and the far side of the Moon. Credit: *Science* magazine, Wei Mingchuan, Hu Chaoran, Tai Mier, Zhao Yuhao, Cees Bassa, Tammo Jan Dijkema, Vanessa Moss, Reinhard Kühn

Mingchuan asked me – in parallel to our running tests – to pay attention to the transponder downlink frequency to see whether the signal is successfully received. The HIT team tried to establish a two-way connection between Harbin and Sörup. For that, the transponder had to get prepared. I received per e-mail the text commands for the official recognition of the connection. The uplink commands took place in the GMSK and receiving was in the 70 cm band in JT4 - an operation mode for the detection of weak signals developed by Nobel prize laureate Joe Taylor. The transmission of the connection files worked from both sides without flaws… wow!

For me, it was an honour to serve as China's partner station for the first two-way-connection between BY2HIT Harbin, China and DK5LA Sörup, Germany via a satellite in lunar orbit. It meant that on 1 July 2019, radio transmission history was written. This first-ever connection over the distance of approximately 2 x 360,000 km = 2.4 light seconds was recognised worldwide as a radio milestone.

How did you communicate with the Chinese experts? Have you mainly exchanged messages with the project lead Wei Mingchuan by e-mail or how was it done?

We started communication via e-mail but quickly realised that this is too laborious. Our time window for the Longjiang-2 (DSLWP-B) link-up was 2 hours and managing our exchange of messages via e-mail took too long. Consequently, we established a procedure: I alone received all the pre-defined commands. Then, we did extensive testing. I got the request via e-mail: … send "download picture". After that I received either from the HIT or the CAMRAS team (Dwingeloo radio telescope in The Netherlands) the e-mail confirmation: "command was received" or "please, send again".

In total I had 75 satellite commands which I sent after coordination with HIT or CAMRAS for the test "uplinks" to Longjiang-2.

After a few months we established a chat channel, connecting all team members. This enabled us to communicate with everybody within seconds and we made best use of the 2-hour communication window. We mainly communicated with the team lead Wei Mingchuan BG2BHC at HIT. On rare occasions Wei would delegate the communication to his HIT colleagues or the team at the Wakayama or Dwingeloo radio telescopes. Of course, not without instructing them beforehand.

Has it been easy to communicate with your Chinese partners or have there been some of those often referred to "cultural misunderstandings"?

There were no misunderstandings in the communication. Our exchange was always brief and professional. Actually, there was not much opportunity for personal issues. Of course, we were so to say "over the Moon" when the unique images of the solar eclipse over the Pacific were processed and we could see it developing line-by-line. That prompted some "wow" from all of us.

Can you still recall a special situation in the communication or during the exchange of messages which made you smile?

It once happened that I did not check my e-mail account for two days. That was when the Corona pandemic got into gear. During this time Wei had sent me a message asking whether I would need face-masks. All of a sudden my telephone at home rang and I could see on the display the words "People's Republic of China". When I picked it up I had Wei on the line. He was concerned about my health - but I could calm him down, and we were very pleased to hear each other's voice after all. He had heard that in Germany there were insufficient supplies of face-masks and therefore, he sent me some from his personal stock. I found this very selfless and a nice example of international understanding.

By the end of this year, Chang'e 5 will launch. Will you be involved again?

It is not foreseen to involve radio amateurs in the Chang'e 5 mission. Wei Mingchuan from HIT wrote me a letter, saying that he is "looking forward to further cooperation in the future." However, right now there are no new projects.

Have you ever been in China?

No…, I have a fear of flying.

Have you been invited by your counterparts at HIT to visit them in Harbin?

So far, I have received an invitation from the CAMRAS team operating the Dwingeloo radio telescope in The Netherlands. That is just 500 km from my home. I know that Chinese people are very hospitable. I am sure that I would be welcomed in Harbin in case I would like to go to China.

You are a radio amateur – which gives some the impression that amateur means something less serious, not professional. However, many radio amateur achievements are of significance. How would you look at this? What actually, is your technical equipment?

A few decades ago, amateur radio was something special and highly recognised by society. New technical means like the internet and the general availability of computers and mobile phones made the world smaller and put everybody within reach of each other. The costs for communication are very low now. The internet has taken over from amateur radio as a general means of communication. So, we are rather working on our image. It is not any longer about just communicating. For example: what would happen if our energy grid or other crucial infrastructure would collapse? Radio amateurs are maintaining an emergency radio net which can provide in case of need, a line of communication with the authorities. We consider the internet as complementary to our radio stations, having merged over time. That made it possible to analyse signals covered up by noise. The Nobel prize-winner Joe Taylor once said: "Professionally, I have benefited from the radio amateurs,

Reinhard Kühn explains:
What are Earth-Moon-Earth echoes?

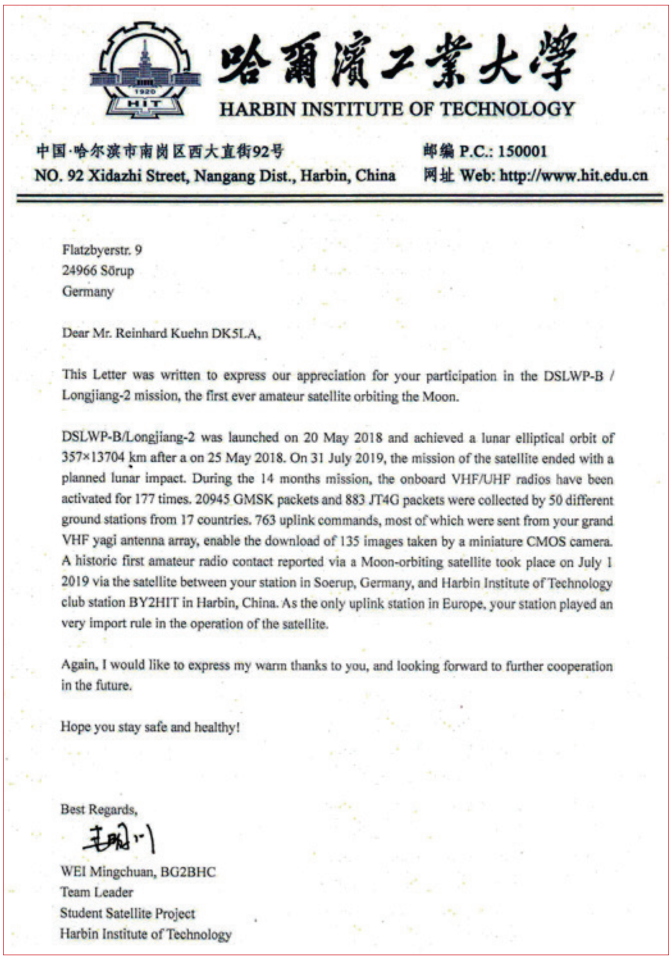
On 23 January 1953, Ross Bateman W4AO and Bill Smith W3GKB received for the first time, valid Moon echoes. The first two-way Earth-Moon-Earth radio connection was made on 21 July 1960 between US-American radio amateurs Sam Harris W1BU and Hank Brown W1FZJ/W6HB. The first intercontinental radio link via the Moon was accomplished on 12 April 1964 by Bill Conkel W6DNG in the U.S.A. and the Finn Lennart Suomisen OH1NL.

An E-M-E echo results from sending a radio signal from Earth into the direction of the Moon where it gets reflected by the Moon's surface and returns as a very weak signal to Earth, where it can be detected, provided your equipment is suitable. The process is similar to radar echoes.

After the 6 lunar landings by Apollo 11, 12, 14, 15, 16 and 17 50 years ago, the interest in the Moon was gone.

Only China's activities and the recent interest in lunar resources brought the Moon back into the focus of several nations. With it came the consideration that the Moon could be of interest as a stepping-stone on the way to Mars.

For us radio amateurs, on a smaller scale, China's lunar mission to the far side of the Moon made it possible to take such amazing photos. Longjiang-2 in its 357 x 13,704 km elliptical lunar orbit made it possible for us.



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24966 Sörup
Germany

Dear Mr. Reinhard Kuehn DK5LA,

This Letter was written to express our appreciation for your participation in the DSLWP-B / Longjiang-2 mission, the first ever amateur satellite orbiting the Moon.

DSLWP-B/Longjiang-2 was launched on 20 May 2018 and achieved a lunar elliptical orbit of 357×13704 km after a on 25 May 2018. On 31 July 2019, the mission of the satellite ended with a planned lunar impact. During the 14 months mission, the onboard VHF/UHF radios have been activated for 177 times. 20945 GMSK packets and 883 JT4G packets were collected by 50 different ground stations from 17 countries. 763 uplink commands, most of which were sent from your grand VHF yagi antenna array, enable the download of 135 images taken by a miniature CMOS camera. A historic first amateur radio contact reported via a Moon-orbiting satellite took place on July 1 2019 via the satellite between your station in Soerup, Germany, and Harbin Institute of Technology club station BY2HIT in Harbin, China. As the only uplink station in Europe, your station played an very import rule in the operation of the satellite.

Again, I would like to express my warm thanks to you, and looking forward to further cooperation in the future.

Hope you stay safe and healthy!

Best Regards,

WEI Mingchuan, BG2BHC
Team Leader
Student Satellite Project
Harbin Institute of Technology

Thank you letter from the Harbin Institute of Technology for Reinhard Kühn. Credit: HIT/Reinhard Kühn

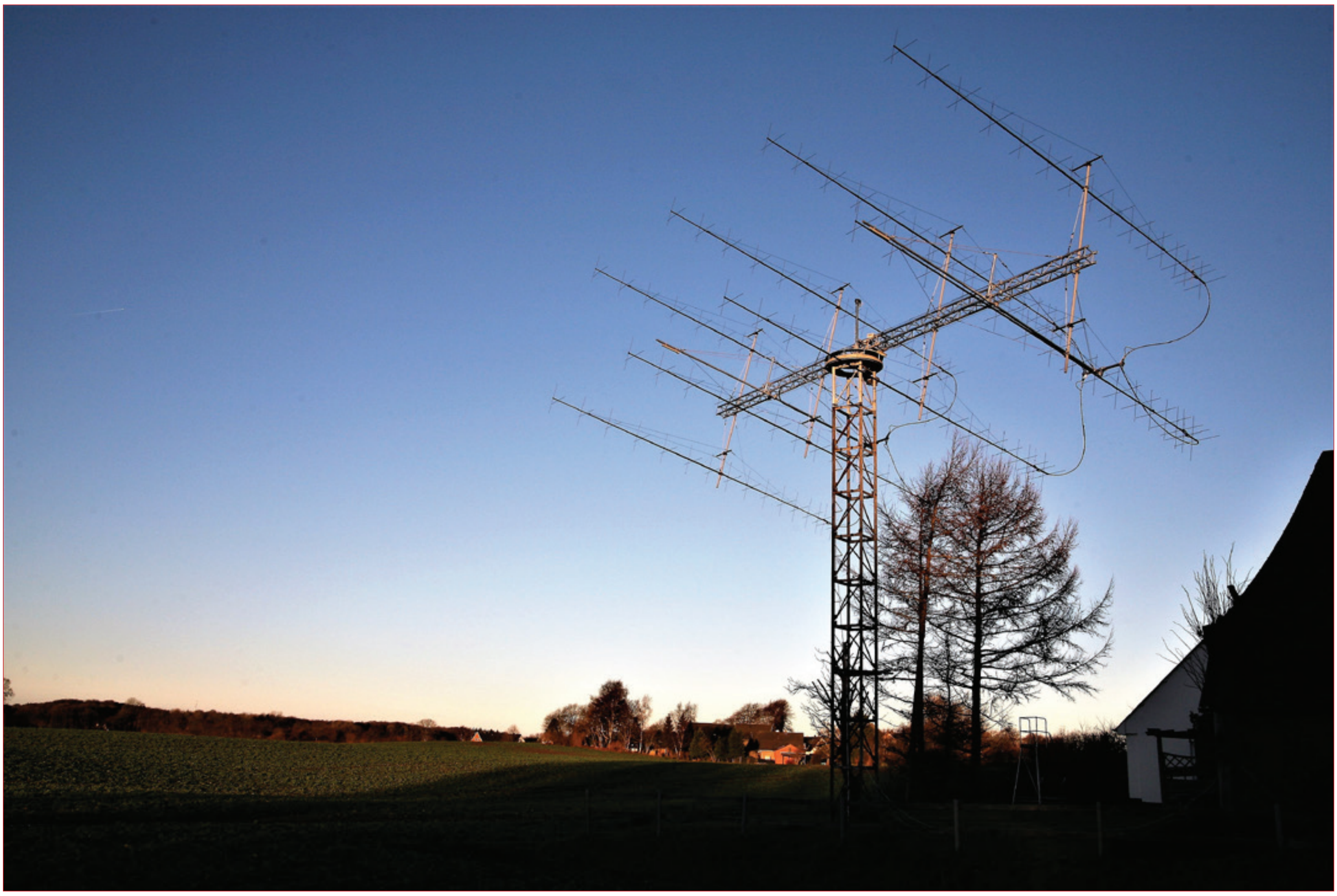
that's why I am glad I can give them something back in return." He wrote the WSJT-X software for us, which enabled ground-breaking improvements. It was about digital operations, e.g. making signals below the audibility threshold, readable. Joe K1JT is an active radio amateur which I was pleased to have met personally. Some years ago, we even had some contacts via the Moon.

I would also like to mention the AMSAT- Radio Amateur Satellite Corporation. Within this network, radio amateurs from around the globe contribute to the promotion of space exploration and communication. For those interested in space, AMSAT offers many areas to become involved. Likewise, there are many examples of technical developments by radio amateurs which could be used commercially. Those examples underline that amateur radio is even today a highly interesting hobby.

Regarding the second part of your question: Since my youth I have been enthusiastic about wireless communication. In 1969 I read a book about the first Earth-Moon-Earth connection in the U.S. That topic fascinated me so much that I decided to build a bigger antenna to do E-M-E connections myself. At the beginning of the 1970s, I tried different antenna constructions, but it was only in 1977 that my 160 element Collinear group antenna of 12 x 7 m, resulted in success. By that time, I have been one of less than 100 radio amateurs world-wide able to establish connections via the Moon.

I had daily E-M-E tests with Bob Sutherland W6PO. Bob was an engineer at EIMAC tubes and he also had a 160 element Collinear antenna. He supported the historic first E-M-E connection with W1BU.

Back in that time, communication via the Moon was rare. Usually, I just heard my own echo. Occasionally 2 or 3 station could be received via the Moon but this was something special. We used the operation mode CW (Morse code). I have been



Reinhard Kühn's antenna construction in Sörup, Germany. Credit: Reinhard Kühn DK5LA one of the first to establish SSB (single sideband modulation) voice communication via the Moon.

Today, I have an antenna array of 8 by 32 elements, polarised horizontally and vertically. That is big – in theory you could fit two 130 m^2 apartments of 2.5 m ceiling height into it. Horizontally, the antenna is rotated by a slew ring bearing from a German tank, and a push rod serves for vertical rotation. The angular accuracy is 0.1 degree! One full rotation takes 18 minutes. In my radio control room, I have installed a modern SDR transceiver, connected to three computers, and I use a state-of-the-art MosFet power amplifier to generate the needed transmission performance. In short, my station is one of the world's largest stations.

What are you doing when you are not receiving Moon imagery from a Chinese satellite? Or in other words: How does your daily routine as a radio amateur look like?

With such a big antenna as mine, maintenance is a never-ending task. At the moment I am working on a circular feed of the antenna's transmission power and an improvement of the display system of the horizontal and vertical angular degrees with automatic path tracking.

In-between I am looking into digital operations and occasionally establish terrestrial or Earth-Moon-Earth connections.

Your house in the countryside is surrounded by quite a stretch of grassland with more than enough space for a big antenna. Did you move to the countryside in order to have sufficient space for your hobby or have you always lived in Sörup?

My house in Sörup was my parents' home where I grew up and which I eventually inherited. 50 years ago I had already built my first antennas. By then it turned out that the location is very suitable with respect to its remoteness and altitude above sea level. This enabled me to win several national "VHF-Competitions". And in fact, there are no obstacles in the field of view for tracking the Moon across the sky. Last but not least, the distance to my neighbours is big enough, so that there is no interference either. Simply put, a perfect location for higher frequencies like VHF, UHF, SHF or even higher frequency amateur bands.

For the longest part of my professional career, I have worked as an authorised signatory in a bank in the town of Kiel. After retirement, I moved back to the countryside into my parents' house. And I started building the very big VHF-antenna. By doing so, I turned my dream into reality: playing a significant role in the network of Earth-Moon-Earth radio stations.

In the near future and with respect to space research, what else can be expected from radio amateurs?

Regarding radio echoes from other planets we have to face technical limitations not only because of the dimensions of the antennas but also the performance. In theory, communication with spacecraft at a distance of several light minutes is possible. If I transmit my signals to the Moon, they could be received there with a pocket radio. The not very sensitive Longjiang-2 receiver was fed by just a 6 cm helical antenna.

The milestone achievement before Longjiang-2 was in 2018 with the positioning of the radio amateur satellite Es*hail QO100 in GEO, what meant: approximately 2 x 36,000 km distance = 0,24 light seconds.

As a next milestone for the radio amateur world it would be nice to have a permanent lunar relay, a transponder on the Moon's surface that allows radio amateurs in a visible line with the Moon to connect with. That radio amateur payload could be realised as a piggyback on a future lunar lander mission.

What are your personal plans? Which challenges would you like to take up?

On the one side, there are fewer and fewer opportunities. On the other side, who can say that he has been a team member of the Chinese Longjiang-2 mission, and has often been the only person or the co-partner of the Harbin ground station for sending command uplinks to the lunar satellite. I had been in charge of 80 command files. It is the dream of any radio amateur to conduct the first connection via a lunar orbiter. This remains an historical milestone and might remain the only one for a while, until another transponder will be placed into lunar orbit. Over time, everybody in the team realised that they have been part of this historical event.

My future challenges are in the further improvement of my technical equipment and to give smaller amateur radio stations the chance of connecting with me via the Moon. My communication partner with the smallest connecting station had just a 50 Watt transmission power and an 8 element Yagi antenna (approx. 3 m long).

There are still many countries which have no suitable ground stations in the 2 m band for E-M-E connections. Radio amateurs all over the world are waiting for these countries to be activated by radio expeditions. It is a challenge to be one of the first radio stations to successfully take part in these radio experiments.

I consider it very important to promote young talent and to show the young generation that amateur radio has something to offer to them. Once they are driven by interest they can turn from consumer to expert. This opens them many new doors to a fascinating world.

BTW: astronauts and cosmonauts have to become certified radio amateurs. It is part of their basic training, and after successful examinations they get their radio amateur licence and a call sign.

I am looking forward to new challenges and remain open for new requests!

Credit: Reinhard Kühn DK5LA

Reinhard Kühn, 24966 Sörup / Schleswig- Holstein, Germany, 71 years, Banker retired
Radio amateur since 1968 – call sign DK5LA - Earth-Moon-Earth station since 1975

Harbin

China's Most Unique Space City

by Blaine Curcio (Orbital Gateway Consulting)

About a thousand drones give performances to celebrate the 100th anniversary of the founding of the Harbin Institute of Technology in June 2020. Credit: People's Daily Online/Geng Hongjie

China's Northeast is one of the country's more interesting places. Known universally throughout China as "Dongbei" (东北, literally "Northeast"), the region is home to freezing cold winters, forests of large pine trees, and vast fields of some of the country's most fertile soil. Comprising the three provinces of Heilongjiang, Jilin, and Liaoning, Dongbei is also home to some of the most warm and welcoming people in China, with the region having a reputation for people who are big, tall, sometimes noisy and boisterous, but always supremely welcoming to visitors.

Economically, the region is considered China's "rust belt", with the region having developed rapidly under Japanese occupation, and thus serving as the initial industrial heartland of the People's Republic of China in the 1960s-1990s. As China liberalized its economy in the 2000s and 2010s, Dongbei has seen a gradual decrease in economic activity, and the region is now home to some of the lowest economic growth rates in China. A common story heard in contemporary China is the anecdote of the state-owned enterprise retiree from Dongbei that buys a retirement apartment in Hainan (an island province in China's south, considered "China's Hawaii") and leaves their home in China's frigid Northeast.

Within Dongbei are a handful of large cities, several of which have some space and aerospace history. Today we will focus on Harbin, due to its history as an aerospace industry hub, and also its relative proximity to Changchun, a secondary space/aerospace hub around 275 km away. Harbin is a city I have visited once, in April 2018, so when relevant I will include some personal perspectives.

Harbin - Brief History of Dongbei's Aerospace City

Harbin has the second-largest urban population, and largest metropolitan population of any city in Dongbei. Harbin's location as the closest major Chinese city to Siberia, as well as being relatively close to the Sea of Japan (and thus, Japan), has meant that the city's recent history is a very international one.

With records of human habitation dating back several thousand years, the modern city of Harbin began to form in the late 1800s as a major junction on the Chinese Eastern Railway, a rail project built by Imperial Russia on a land concession from Qing Dynasty China. At the time (and still today), the Russian cities of Chita and Vladivostok remain separated by more than 1,000 km of China. The Russian Empire wanted to build a railway, and build they did, with Harbin being located at the intersection of a T-shaped rail line linking Chita, Vladivostok, and Changchun and Shenyang to the South. The Chinese Eastern Railway was operated by the Russians and the Qing Government at various times during the early 1900s, before coming under Japanese control partially in 1906 (Southern branch)

A historical map of the Trans-Manchurian section of the Transsiberian Railway. Credit: DeGolyer Library, Southern Methodist University and entirely in 1935. As the map on the previous page shows, the railway had a major interchange at Harbin.

Under the Russians, and to a lesser extent the Japanese, Harbin was one of the most cosmopolitan cities in China, with a large population of Russians, Jews, Poles, Japanese, and Germans. One Russian-language source notes a population of 100,000 in 1917, of which 40,000 were Russians. Walking through the downtown area of Harbin even today, one gets the feeling that the cityscape was not designed to look like most Chinese cities. European-style architecture, multiple Synagogues, and low-rise buildings, parts of the city might not look so out of place in certain parts of Europe today.

Harbin continued to develop under Japanese occupation as a major station on the Manchukuo National Railway, though the arrival of the Japanese (and departure of the Russians) may have coincided with the peak of Harbin's relative importance within Dongbei. Ultimately, Harbin's location is very favorable from a Russian perspective - it is about halfway between Chita and Vladivostok on a straight line. On the other hand, for the Japanese, Harbin's location was quite remote, especially given fact that Japan's other East Asian colonies at the time - namely the Korean Peninsula and concessions in China - were much closer to Dongbei's other two provincial capital cities, Shenyang and Changchun (at the time known as Fengtian and Xinjing, respectively).

In August 1945, the Soviet Union re-took Harbin from the Japanese, and less than a year later transferred control to the People's Liberation Army. In the early years under PRC rule, Harbin was a major focus city for development, with funding coming from both the Chinese government and, during the 1950s, the government of the Soviet Union.

Harbin's street view in April 2018. Credit: Blaine Curcio

A section of the CSS as an exhibit for the China Space Day in Harbin in April 2018. Credit: Blaine Curcio

Local government accounts note that Harbin was the first major city in China to be governed by the Chinese Communist Party following the handover from the Soviet Union, though the city retains significant influence from that time. Harbin's city streets and architecture have a certain Soviet Union/"traditional Communist" feel to them, compared to many of China's newer cities that are dominated by glass and steel skyscrapers and 30-50+ story housing blocks. As the photo above from April 2018 shows, Harbin's streets have many buildings that could be characterised as more "human scale". After being returned to China by the Soviet Union, Harbin began to see gradual development of an aerospace industry, centered around the city's most prominent university, the Harbin Institute of Technology.

The Harbin Institute of Technology (HIT)

The seeds of the Harbin aerospace and space industries are undoubtedly in the Harbin Institute of Technology (HIT), one of China's top universities and also one of its oldest, having been founded in 1920 (happy 100th!). HIT is a member of China's

Main Building of the Harbin Institute of Technology. Credit: HIT

Elite C9 League, and has been ranked by US News and World Report as #6 globally for engineering in 2017-2021. HIT was originally established as the Harbin Sino-Russian School for Industry to educate railway engineers via a Russian method of instruction. The university's Russian roots are clearly visible in the architectural style of its main building, visible in the photo above.

In the mid-1950s, China tried to develop a program of advanced degrees, with institutions involved including the CAS and several leading universities. At the time, a handful of Chinese universities brought in Soviet experts to train graduate students, with HIT and Beihang University in Beijing having the largest number of experts of any universities in China, according to a study from 2006.[1] One could reasonably say that HIT, along with a couple of other universities in China, helped to plant the seeds for modern engineering education in China. Following educational reform centered around HIT and a few other universities, the percentage of graduates studying engineering increased from 18.9% to 35.4% over a period of just 6 years.

HIT is today a leading university in several areas related to engineering, aerospace, robotics, and the space industry, and the university's name makes many appearances in these industries. This includes the minor planet #55838, which was named after HIT by the International Astronomical Union in 1996. The planet was named "Hagongda Star" (Hagongda being the Chinese equivalent of the abbreviation for HIT), to honour HIT's achievements in science and engineering.[2] The HIT's contributions to space were recognised in 2018 with the university's hosting of the China Space Day Conference. Among other impressive sights was the exhibition of the Tiangong-2 space station outside of the exhibit hall, shown above. In addition to its space industry capabilities, Harbin is also considered one of the top universities in the world for robotics, and the university's venture capital firms (not so uncommon in China) have been known to invest in some of China's leading robotics startups.

HIT's Activities in Space

HIT has achieved a number of space firsts for China. The university's astronautics department manufactured China's first satellite capable of producing 3D environmental mapping and surveying, the "Experimental-1" satellite (试验一号), launched in 2004. More recently, the university launched the Kuaizhou-1 and Kuaizhou-2 remote sensing satellites in 2013 and 2014, respectively, on the somewhat confusingly also named Kuaizhou-1 rocket. The naming suggests, but does not confirm, that the satellites are aimed at addressing "fast response" demand for satellites, similar to the "fast response" nature of the Kuaizhou-1 rocket. China's groundbreaking Chang'e-4 Moon Mission, launched in 2018 and still exploring the Moon's far side as of end-2020, also involved assistance from HIT. The university built the Longjiang-1 and Longjiang-2 satellites, at 45 kg each, with the purpose of observing the sky at very low frequencies of between 1-30 MHz, a practice made impossible on Earth due to the planet's ionosphere.

While the Longjiang-1 satellite failed to reach lunar orbit, the Longjiang-2 satellite was a real success, with breathtaking photos made publicly available by the CNSA and HIT[3)](Author's note: many photos from space are very cool, but I highly suggest checking out the Longjiang-2 photos. Amazing angle looking at Earth from behind the Moon, and incredible to consider that a relatively small satellite with involvement from many amateur radio programmers could take such images).

Noteworthily, the Longjiang-2 satellite was programmed using open-source code, which allowed amateur radio programmers from around the world to communicate with the satellite to get it to take pictures.[4)] (*see: previous pages*) The Longjiang-2 satellite also involved international cooperation, with the satellite including a camera developed by the King Abdulaziz City for Science and Technology (KACST) in Saudi Arabia.

Separate to its specific space missions, HIT is also home to the National Key Laboratory of Materials Behavior and Evaluation Technology in Space Environment, and the National Key Laboratory of Metal Precision Thermal Processing. In August 2020, Yuan Jie, the Chairman and Party Secretary of CASC, visited HIT in observance of the university's 100th anniversary, and to thank the university for its providing a steady flow of engineers to CASC. The university's alumni include several very high-level space industry officials, including former head of CASC and current Governor of Hunan Province Xu Dazhe, Founder and CEO of Geely Group Li Shufu, and Sun Jiadong, a rocket and satellite technology expert who was the Chief Designer for CLEP.

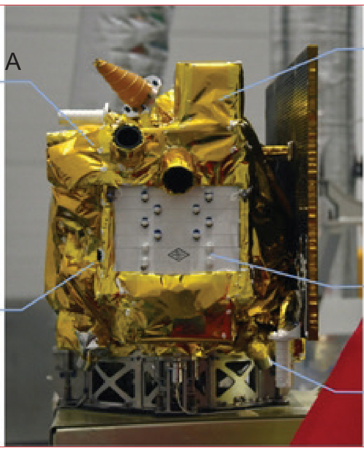


Photo of the Longjiang-2 microsatellite at the launch site, getting prepared for integration with the Queqiao lunar relay satellite. The Longjiang-1 and -2 microsatellites were launched on 20 May 2018 together with Queqiao as part of the Chang' e 4 mission. The lander and rover for lunar far side operations followed on 7 December 2018. Credit: Harbin Institute of Technology

Other Companies of Note in Harbin

To now, relatively few Chinese New Space companies have chosen Harbin as a main outpost, and many HIT graduates will leave Harbin for opportunities in Beijing, Shanghai, or Shenzhen. Indeed, one of CAST's most noteworthy subsidiaries, Shenzhen Aerospace Dongfanghong HIT Company, was created by CAST in Shenzhen with a group of HIT alumni as its core leadership team, with the goal of attracting talent by locating in a city with more opportunity. With that being said, Harbin remains a major economic center and a city of 10 million people, meaning many choose to stay and work for local companies, including those in the space and aerospace sectors.

The city of Harbin also established the Harbin Aerospace Hi-Tech Innovation Park in 2012 in cooperation with the third institute of CASIC, however it is not clear how many companies have since set up in the park. Longer-term, as CASIC participates in more commercial space industry businesses, Harbin could become an important hub city for the company, which could serve as a growth driver for the local space sector.

In addition to its deep space sector roots, Harbin's aerospace industry is one of China's most well-established, with the crown jewel being the Harbin Aircraft Industry Group (HAIG), a subsidiary of AVIC whose name is often shortened to Hafei (哈飞). HAIG was founded in 1952 to manufacture planes for domestic sales, though today the company provides various components for foreign aerospace companies. The company was previously known as the Harbin Aircraft Manufacturing Company.

Harbin is also home to the Harbin Electric Company Limited, major SOE that conducts R&D, manufacturing, and construction of power plant equipment. Along with Shanghai Electric and Dongfang Electric, Harbin Electric Company is one of the three largest manufacturers of power plant equipment in China. The company has a significant global market share in steam turbines.

The Future for Harbin

In the opinion of this author, Harbin's darkest days are behind it, relatively speaking. The unofficial capital of China's rust belt has seen old and young people leaving for decades, but this may be starting to slow. A combination of factors, including more remote work, more centralised planning of the economy, and an increased emphasis on the space and aerospace industries as key industries for growth in China should all be positive developments for Harbin.

Likewise, the city is one of the least expensive in China from a real estate perspective among cities with a top university. For instance, most of China's top universities are either in Beijing or Shanghai (real estate prices of ~>US$10,000 per square meter) or Nanjing, Hangzhou, or Guangzhou (~$7,000-8,000 per square meter). Even cities such as Wuhan and Chengdu, both home to top universities, are on average more expensive than Harbin, with Harbin real estate among the lowest-priced of all major cities in China. In a country where young people basically need to buy an apartment before starting a family, this could be a powerful factor.

Moving forward, Harbin may never return to the glory days of the late 1800s and early 1900s, at which time it was arguably the most international and cosmopolitan city in Northeast Asia, but it will likely see a revival from its Rust Belt status, hopefully in tandem with the city seeing a blooming space industry. In the opinion of your correspondent, there is much going for Harbin, and indeed it may be one of China's most underrated cities, as long as you can handle the harsh winters.

1) *http://english.ihns.cas.cn/Publications_new/Ra/201310/W020131015378079814609.pdf*
2) *http://news.sciencenet.cn/htmlnews/2010/6/233027.shtm*
3) *http://lilacsat.hit.edu.cn/dashboard/pages_en/pics-b.html*
4) *https://www.planetary.org/articles/imaging-the-earth-from-lunar-orbit*


Thinking
in
visions!
$E = m x rc^2$