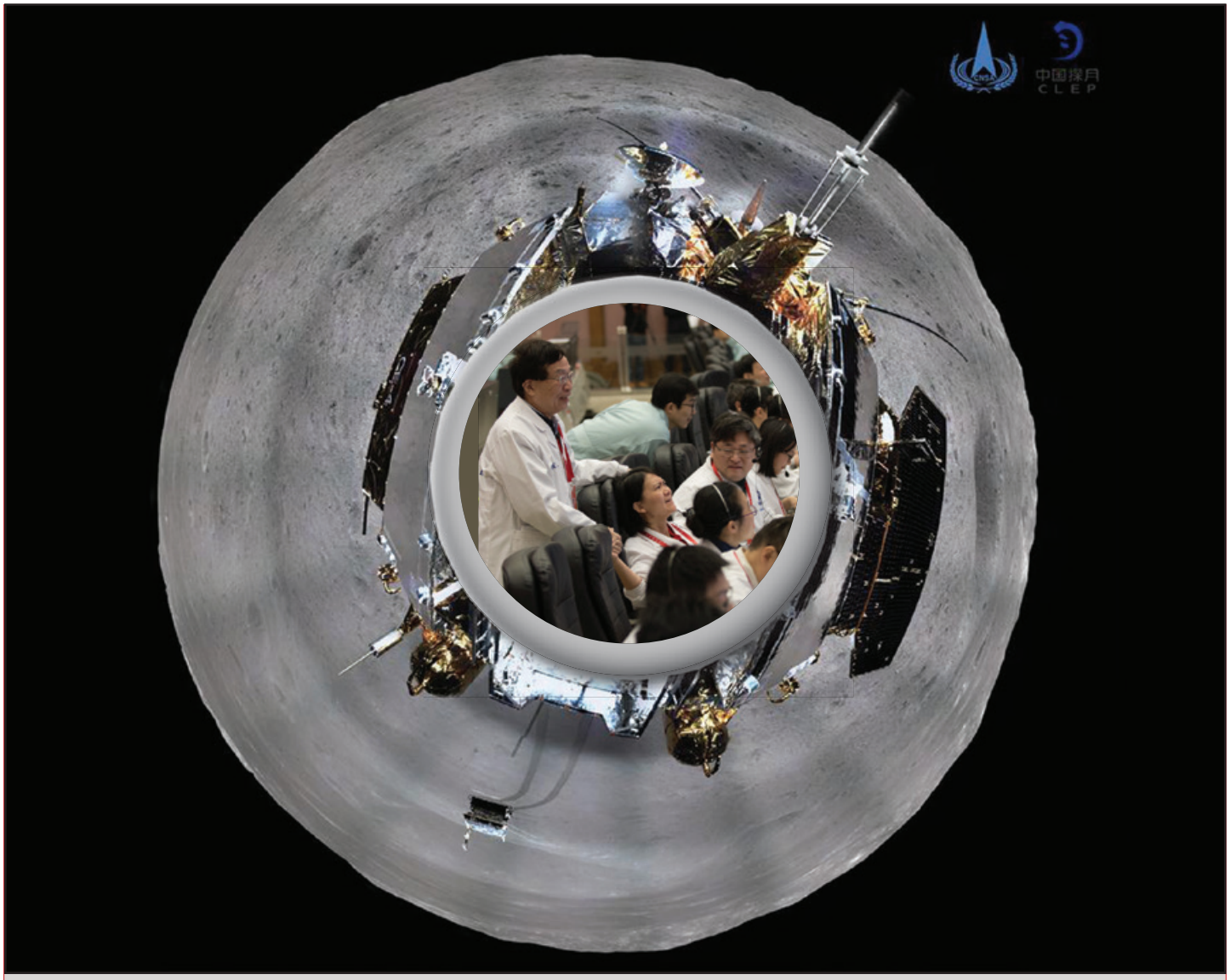
All About The Chinese Space Programme

Go TAIKONAUTS!

龙腾太空

Issue 27 | December 2019



On 3 January 2019 the Chinese lunar lander mission soft-landed on the far side of the Moon. Space history was written. On 11 January, CNSA released this 360° panoramic photo in azimuthal projection, taken by the lander's camera. The insert in the middle shows Zhang He, Executive Director of the Chang'e 4 project, overwhelmed by the successful landing. credit: CNSA, CLEP

Content

Chinese Space Quarterly Report
January - March 2019 ..... page 02

Chang'e 4 – Behind the Moon
An overview on the first three lunar days of operations on the far side of the Moon ..... page 17

Perspectives on Europe from the Far East
A Tale of Two Very Different Space Industries ..... page 19

Following Yuanwang Tracking Ships
Autumn 2019 ..... page 22

Unearthing Aviation, Aerospace, and the Cosmos at Beijing's Air and Space Museum
Discovering an museum exhibition ..... page 25

Chinese Space Quarterly Report
January - March 2019
by Jacqueline Myrrhe, Chen Lan

SPACE TRANSPORTATION

CZ-5 / CE-5
The China Aerospace Science and Technology Corporation (CASC) announced on 1 January that it plans to launch the Chang'e 5 near-side sample return mission with the second of the two planned CZ-5 launches in 2019.

CZ-6
A modified version of the CZ-6 rocket, with four additional solid-fuel boosters for increased medium-lift capacity, is under development at Shanghai Academy of Spaceflight Technology (SAST). First launch is planned for 2020.

CZ-9
On 24 March, CASC has successfully completed a compatibility test of the turbopump and gas generator of the CZ-9 heavy-lift rocket engine, verifying the design of the two components and preparing for the system test of the 500-t liquid oxygen/kerosene engine. The test was done at the facility of the Academy of Aerospace Propulsion Technology (AAPT) in the Baolongyu area of Xi'an, Shaanxi Province. The 500-t thrust engine will become the most powerful engine. Also, it will be run with newly developed advanced cooling devices. The CZ-9 will be complemented with one 200-t thrust engine and one 25-t engine.

On the side lines of the 13th National Committee of the Chinese People's Political Consultative Conference (CPPCC) in Beijing, Shang Zhi, Head of CASC's space exploration programmes, said that the CZ-9's overall design plan has passed internal technical reviews and is awaiting government approval. Several tests on the rocket's key parts are ongoing. CASC estimates that within the time period 2030 to 2035 about 10 CZ-9 rockets per year will be needed to meet China's demand in heavy-lift transport for lunar and Martian exploration. CZ-9 will have a payload capacity of 50 t to lunar transfer orbit and 44 t to Mars transfer orbit. CALT in Beijing is responsible for the CZ-9's overall design.

CZ-11
For the new solid-fuel motor of the improved CZ-11's rocket booster, hot firing tests were completed on 5 March. The 2.65 m diameter motor, developed by AAPT in Xi'an, provides a thrust of 200 t. It was built with advanced technologies and high-performance composite materials, allowing to diversify the CZ-11 rocket and forming a sub-family of rockets. The new motor is based on the predecessor, a 180 t-thrust motor developed by the China Aerospace Science and Industry Corporation (CASIC) 4th Academy in Wuhan, Hubei Province

CZ-11 - Sea Launch
Jin Xin, Deputy Chief Commander of the CZ-11 rocket announced that the first sea launch will take place mid-2019 in the Yellow Sea. For that, key technologies were developed and implemented. Through sea launch, China acquires a flexible launch site. It is important to avoid falling rocket parts that will hit inhabited areas. Using civilian ships allows to reduce costs and enable commercial opportunities, including launch services for countries participating in the Belt-and-Road Initiative. Additionally, three CZ-11 land-based launches are planned for 2019.

Yuanwang 3
Yuanwang 3 left its home port in Jiangsu Province on 13 March for two upcoming maritime space monitoring missions in the Pacific Ocean, lasting approximately two months. Before departure, the crew concluded a series of training and tests to improve emergency responses.

Yuanwang 5
After finishing its observation mission for the 10 March launch of the ChinaSat 6C communication satellite, Yuanwang 5 returned from the Pacific Ocean and docked at its port in Jiangsu Province on 22 March.

CASC 2019 plans - Blue Book
On 29 January, CASC held a press conference for introducing its first "Blue Book of China Aerospace Science and Technology Activities (2018)" and giving an outlook on the activities in 2019.

CASC Blue Book: Launch Manifest
The 2019 launch manifest comprises 30 launches with 50 spacecraft, including 10 Beidou satellites (on seven CZ-3 rockets), a new Gaofen 7 satellite, the second launch for the Hongyan LEO communications constellation, the first sea launch, and the lunar sample return mission.

CASC Blue Book: CZ-5 / CE-5
One of the most important missions will be the CZ-5's back-to-flight. Yang Baohua, Vice President of CASC confirmed that the CZ-5 rocket is set to resume operations with its third launch in July 2019, placing the DFH-5-based Shijian 20 communications satellite into orbit. Provided that launch is successful, the CE-5 lunar sample return would launch on the fourth CZ-5 rocket. Shang Zhi, Director of CASC's Space Department stressed that the CZ-5 rocket will be the key hardware for China's future space missions. For that, a test version of the CZ-5B carrier rocket is under development, needed for lifting the China Space Station (CSS) modules. The development of the CSS core module is on schedule.

In preparation of the first flight of the CZ-5B, mating tests and exercises will be carried out in the Wenchang Space Launch Centre at the end of 2019.

CASC Blue Book: Beidou
The Blue Book also lists the achievements of the Beidou satellite navigation system (BDS). 6,000 fishing boats in the eastern province of Zhejiang have been fitted with the BDS monitoring system. BDS receivers were installed on 6.17 million vehicles, 35,000 postal and express delivery vehicles and 80,000 buses in 36 major cities or are compatible with BDS. 30,000 BDS terminals are connected with the BDS-based information management platform. E-commerce giant JD.com equipped 1,500 logistics vehicles and 2,000 couriers with smart BDS terminals. The BDS global network is planned to be completed by 2020.

CASC Blue Book: CASC's Revenue
CASC also stated that revenues increased by 8.6 percent to a total of 251.3 billion RMB (37.3 billion USD) in 2018. The total profit grew by 5.6 % to 20.73 billion RMB.

CASC Blue Book: Chang'e-5
During the CASC Blue Book press conference, the mission profile of the CE-5 mission was reconfirmed. The target landing area on the near side of the Moon remains the region of Mons Rümker in Oceanus Procellarum. CE-5 consists of an orbiter, a return capsule, a lander and an ascent stage. The probe itself is divided into 15 sub-systems, including structural elements, thermal control system, antenna, sample collecting and sealing unit and propulsion segment.

After launch on the CZ-5 into LEO, the lunar probe will accelerate for entering the Earth-Moon transfer trajectory. In the vicinity of the Moon, CE-5 will brake to enter lunar orbit. From there, a lander will descend and land. The orbiter

remains in lunar orbit. Down on the lunar surface, the rover will collect 2 kg of material.
The ascent stage will rendezvous and dock with the waiting orbiter in lunar orbit. The re-entry capsule will then fly back to Earth, conduct a decelerating manoeuvre, re-enter the Earth's atmosphere and land back on Earth in Siziwang Banner (County) of Inner Mongolia Autonomous Region. *(compare GT! issue no 19, page 3)*
After recovery, the samples will be sealed again and taken to research institutes in Beijing for analysis.

LAUNCH CENTRE - JSLC

The staff at the Jiuquan Satellite Launch Centre conducted an emergency training in the first days of 2019 to prepare for an upcoming dense launch manifest. After the successful launch of the Yunhai 2 satellites on 29 December, the launch site staff started new training sessions, one of which simulated a fuel leakage, detected short before a hypothetical satellite launch. Based on the experience from 2018 launch campaigns, the training for the ground staff followed real procedures, comprising preparations, emergency response and test launch.

MANNED SPACE FLIGHT

CSS - China Space Station

Zhang Bainan, Chief Engineer at the China Academy of Space Technology (CAST) and deputy to the National People's Congress (NPC) told media on the side lines of the 2nd session of the NPC in Beijing that the development of the CSS is on track. It will be completed as planned around 2022. Zhang said that China, being just the third country to build a space station, has “learned” and “borrowed” many space design “things” from other space nations. Albeit with lessons learned adapted to Chinese needs. Tiangong has been the smallest space lab in the world and so will the future CSS be the smallest space station but sufficiently large to achieve its objectives: “More and more we are doing things that haven't been done before. The risk is thus greater. When we were learning from others, the best part is that we won't be going the wrong way. Or there may be two existing paths and we'll take the safer path. Now that we've gradually walked to the frontiers, you just couldn't tell which path works. Which is why we advocate that at this stage people should tolerate failure."

The China Manned Space Engineering Office (CMSEO) announced on 4 March that in preparation of the space station assembly, the core module of the CSS, the CZ-5B rocket and its payloads will be sent to the Wenchang launch site on Hainan Island in the second half of 2019. The schedule remains with the objective of 'Station Complete' by around 2022. The expected lifetime of the orbital outpost is 15 years. The selection and training of astronauts are underway.

Tiangong 2

Tiangong 2 (TG-2) (COSPAR ID: 2016-057A) remained in stable operation and was utilised for in-orbit tests. It will be de-orbited around July 2019.

Tiangong 2 and Tianzhou 1 - Science Outcomes

Researchers from China's Academy of Military Medical Sciences of the Tsinghua University and the Shanghai Institute of Technical Physics of the Chinese Academy of Sciences investigated during the Tianzhou 1 (TZ-1) cargo space mission in April 2017, how spaceflight affects cardiac differentiation of mouse induced pluripotent stem cells (iPSCs). iPSCs were cultured in 48 units in an incubator onboard of TZ-1. During the whole duration of the experiment, a camera, capable of automatic or remotely controlled operation, took bright-field microscopy images and green fluorescence images of the cell samples, which were then transmitted to the ground. From the images, the scientists were able to show that microgravity enhanced the cardiomyocyte differentiation process of iPSCs four days after launch and lasted for 10 days afterwards. The scientists hope that more automated stem cell experiments can lead to new discoveries in regenerative medicine and may support personalised cardiac tissue biomanufacturing and drug testing during space travel.

link to the publication "Spaceflight Promoted Myocardial Differentiation of Induced Pluripotent Stem Cells: Results from Tianzhou-1 Space Mission" in "Stem Cells and Development"
https://www.liebertpub.com/doi/full/10.1089/scd.2018.0240

POLAR on Tiangong 2

The Gamma-ray Burst (GRB) polarimeter POLAR on the TG-2 space laboratory has completed its high-sensitivity measurement of GRBs. Launched on 15 September 2016, POLAR ended operation on 31 March 2017, detecting 55 GRBs. The results, published in Nature Astronomy magazine, suggest that the gamma-ray emission is most polarised at a level lower than some popular models have predicted, although the results also show intra-pulse evolution of the polarisation angle. This indicates that the low degree of polarisation could be due to an evolving polarisation angle during a GRB.

Female Taikonauts

Pang Zhihao, National Chief Communication Expert for Space Science told media on the occasion of International Women’s Day, that China's two female taikonauts, Liu Yang and Wang Yaping, continue training for future space missions. Pang predicts that the two will attract attention during the CSS assembly. He also pointed out that female astronauts have unique psychological and physiological advantages, such as emotional stability and endurance of loneliness. Also, women have better work efficiency as they are more considerate and have better superior communication skills than men. However, taikonaut training and selection standards are basically the same for men and women.

UNOOSA-CMSA 1st AO for CSS - experiments shortlisted

On 21 February 2019, the United Nations Office for Outer Space Affairs (UNOOSA), published the Preliminary Evaluation results of the applications through the "First Announcement of Opportunity for Space Experiments on-board China Space Station":

“A total of 42 applications, from organisations in 27 countries, have been received by UNOOSA and carefully evaluated by around 60 experts from UNOOSA, China Manned Space Agency (CMSA) and international space experts, in line with the eligibility and selection criteria outlined in the first AO. Based on the results of the evaluation, a comprehensive preliminary selection meeting was held to shortlist proposals.

The selection exercise for this first cycle has been extremely competitive. The proposed experiment ideas stretch from simple to complex, from space medicine to astrophysical observations - all reflecting the creativity and commitment of the involved scientists from public and private entities in both developing and developed countries. After careful evaluation of all the applications by the Project Evaluation and Selection Committee (PESC), 18 applications out of the 42 received have been shortlisted for preparing implementation schemes for the final evaluation and selection, the results of which will be announced in June 2019.”

LUNAR AND DEEP-SPACE EXPLORATION

CHANG'E 4

On 3 January, at 02:14 UTC, Chang'e 4 began its descent burn from lunar orbit, and landed at 02:26 UTC in the Von Kármán crater at 177.59°E, 45.44°S. At 14:22 UTC the same day, the

Yutu-2 rover rolled onto the surface and began its exploration of the area. Please, see our detailed report on the Chang'e 4 lunar mission on pages 17 and 18.

Longjiang 1 (2018-045B)

The small lunar probe Longjiang 1 did not reach lunar orbit and remained in a highly elliptical Earth orbit.

The mission controller lady with tears in her eyes for China's Moon lady

Maybe this was the most remarkable photo of the New Year and maybe it remains the most symbolic photo of Chang'e 4's landing on the far side of the Moon when one of the ground staff at the Beijing Aerospace Control Centre (BACC) in Beijing went emotional and media captured her tears (see title page). Others photos were also showing how much the Chinese staff were moved by the success of the landing. Later, Chinese media revealed the story behind "the lady with tears in her eyes". It was Zhang He - Executive Director of the lunar probe project and staff of the China Academy of Space Technology.

The burden of responsibility was high and so was the relief when everything worked. The successful landing of CE-4 left the staff at mission control moved. credit: CCTV/Weibo/Xinhua

Future Lunar Missions

"Experts are still discussing and verifying the feasibility of subsequent projects, but it's confirmed that there will be another three missions after Chang'e 5," said Wu Yanhua, Deputy Head of the CNSA (China National Space Administration), at a press conference of the State Council Information Office on 14 January.

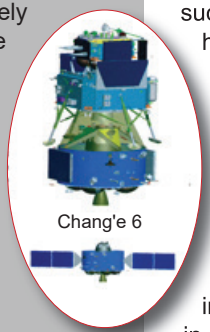
Chang'e 5

Lunar sample return mission, planned for launch by the end of 2019. Details on the mission profile, see section: SPACE TRANSPORTATION - CASC 2019 plans - Blue Book or: *GT! issue 19, p.3*

Chang'e 6

Lunar sample return mission to the Moon's South Pole. Depending on the success of CE-5, a decision will be taken whether to land on the near side or the far side of the Moon.

The mission profile would be similar to that of the CE-5 mission. The CE-6 lunar sample return mission will consist of four modules: a lander to collect approximately 2 kg of samples from 2 m below the lunar surface and place them in an attached ascent vehicle to be launched into lunar orbit. The ascent vehicle would then make a rendezvous to dock with the orbiter, which would transfer the samples into a capsule for delivery back to Earth.



In October 2018, it became known that a call for international partners to propose additional payload(s) of up to 10 kg for this mission, will be issued.

Chang'e 7

South Pole exploration mission, including studying terrain and landform, physical composition as well as the space environment in the region.

Chang'e 8

Will include scientific surveys and experiments, testing of key technologies for the construction of a science and research base on the Moon.

CHANG'E 4 Cooperation with NASA

Wu Weiren, Chief Scientist of CLEP (China's Lunar Exploration Programme), told CCTV that NASA scientists had asked permission to use the CE-4 spacecraft and the Queqiao relay satellite for the planning of an U.S.-American mission to the far side of the Moon. The U.S. experts made the request at an international conference a few years ago, asking about the possibility to extend Queqiao's lifespan and allow an U.S. beacon to be placed on CE-4. That would support the U.S.' own lunar landing strategy, Wu said.

Also, it became known that Chinese space scientists had exchanged landing data with NASA to facilitate the option of photographing the CE-4 landing site with NASA's LRO (Lunar Reconnaissance Orbiter).

ON A SIDENOTE

Dr. Leroy Chiao, former NASA astronaut of four space flights, has been in 2006, the first American to visit the Astronaut Centre of China in Beijing. In the past, he often raised his voice in favour of cooperation with China. In a commentary for CNN beginning of January, he wrote:

"China started out the year by doing something that no nation has done before: It landed a spacecraft and an accompanying rover on the far-side of the Moon ... Almost equally impressive from a technical standpoint, China successfully placed a communication relay satellite into a lunar halo orbit to enable the command of, and communication with, both the spacecraft and rover ... I had mixed feelings about these events. I was born in the United States, but my parents were both born in China, before they made their way to Taiwan and immigrated to America in the 1950s. On the one hand, I am proud of my heritage and what China has accomplished. On the other, my family is American, and we take pride in US accomplishments. ... Now we have come to the moment of China's ascendency in space exploration. We must face the reality that it has, in a small but significant way, shown the world that it can be the first to accomplish things in space, too. We had better realize this soon, or we may very well wake up to find that we are no longer top dog in the space business. And if we don't learn from our complacency in space, we could end up losing our edge in other areas as well."

Lunar In-situ Research

Prof. Vladimir Nikolaevich Khmelev from the Altai State Technical University, told TASS News Agency on 15 January that his university will cooperate with the National Key Laboratory of Robotics and Systems at the Harbin Institute

The "Moon goddesses" behind Chang'e-4 lunar probe

In Chinese legend, Chang'e flew to the Moon and became a goddess, but could never return to Earth to reunite with her husband. Today, China's lunar exploration programme, named after the Moon goddess Chang'e, is highlighting the contributions of female scientists and engineers.

of Technology on a ultrasonic drilling project. The research has won financing from Russia's Fundamental Research Fund and China's National Natural Science Fund. The 2-year project's aim is the development of an ultrasonic drill, driven by piezoelectric ceramics for the exploration of extra-terrestrial surfaces to discover water and ice, including on the far side of the Moon and on Mars. The Altai University will carry out the preliminary research for the Chinese side to study ultrasonic drilling methods. In contrast to conventional drilling which develops heat, and consequently evaporates water and other volatile materials, ultrasonic drilling is not damaging to water and ice.

A Piezoelectric-Driven Rock-Drilling Device for Extraterrestrial Subsurface Exploration

SCIENCE

QUESS – Micius

• R. W. Wood Prize

Pan Jianwei, Chinese quantum physicist and professor at the Hefei National Laboratory for Physical Science at the Microscale at the University of Science and Technology of China and lead scientist for the QUESS (Quantum Experiments at Space Scale) satellite, won the 2019 R. W. Wood Prize of the Optical Society of America. Pan is honoured for his pioneering experimental research at the frontier of quantum foundations and optical implementations of quantum information, including quantum nonlocality, quantum key distribution, quantum teleportation, and optical quantum computing.

• Newcomb Cleveland Prize / extended operations

The 34 scientists of the QUESS project team received the 2018 Newcomb Cleveland Prize of the American Association for the Advancement of Science (AAAS) on 14 February 2019 in Washington for the most impactful research paper published in the journal Science (in June 2017) and for the ground-breaking work for ultra-secure communication networks of the future. QUESS team member Prof. Yin Juan represented his colleagues. He confirmed that the QUESS satellite's operation was extended for at least two more years beyond its projected two-year lifetime. The team will carry out intercontinental quantum key distribution experiments with teams from Italy, Russia and South Korea.

Based on the quantum key distribution technology, three more small-size satellites might be launched within the next 3-5 years to form a quantum communication network, as a critical step to create the infrastructure of a globalized quantum internet in the future.

• Plans for Improved Operation

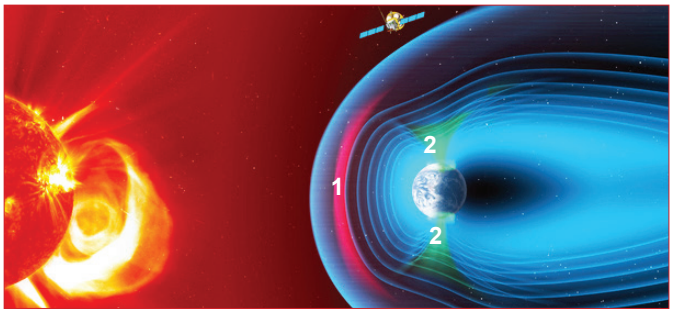
At a press conference on the side-lines of the annual session of the 13th National Committee of the CPPCC, Pan Jianwei, a member of the 13th CPPCC told CCTV: "We have improved the coding speed of satellite-to-ground quantum keys by 40 times in the past two years. So about 400,000 secure keys can be sent in just one second... Now Micius only works at night since the interference from sunlight is too strong during daytime. We hope to develop a satellite that can be placed in a middle or high orbit so that it can work all around the clock. Then it can produce quantum keys for a longer time and meet the demand for secure information transportation of operations."

Public Private Partnership for Deep-Space Exploration

Wu Ji, told media on the side-lines of the annual session of the 13th National Committee of the CPPCC, that he is proposing to the CPPCC to set up a national space science lab and to create business opportunities for private enterprises in the area of deep-space exploration. He suggested to merge lunar and Martian exploration missions with the operation of space science, space weather and Earth observation satellites, and bring all these projects and results of the missions under the umbrella of one institute and one overall administration. He pointed out the importance of a legal framework and incentives for private enterprises' participation in this work. This will significantly lower project costs and speed up the work. He added: "The total amount of what China invests in space science every five years is just a fraction of what the United States invests each year. That's because we are just at the beginning and our space investment focuses on applied satellites like meteorology, remote sensing, and navigation that are closely linked with our national production activities." Wu said that in the next 20 to 30 years, the development and utilisation of solar system resources will become the most active field in the civil aerospace market because of the rapid development of information technology and life science technology.

SMILE

On 5 March, the China-ESA joint mission Solar wind Magnetosphere Ionosphere Link Explorer (SMILE), was adopted for implementation by ESA's Science Programme Committee. This kicks-off the engineering phase of the satellite project and the full development of the mission. SMILE will study the interaction between the solar wind and the Earth's magnetosphere. Planned for launch in 2023, the satellite's projected operational life is 3 years.



SMILE will observe the solar wind interaction with the magnetosphere, gathering simultaneous images and video of the dayside magnetopause (where Earth's magnetosphere meets the solar wind - indicated with "1"), the polar cusps (a region in each hemisphere where particles from the solar wind have direct access to Earth's ionosphere - indicated with "2"), and the auroral oval (the region around each geomagnetic pole where auroras most often occur). credit: ESA/ATG medialab

SKA - Square Kilometre Array

Seven countries, involved in the SKA project have signed on 12 March, a convention to move ahead with the establishment of the coordinating and administrative body for the project, named the SKA Observatory. It will take over from the SKA Organisation which has guided the project since 2011. The SKA Observatory will have its base in the UK, close to Manchester. The new entity can award contracts and will oversee the construction and operation of the SKA.

The signatory countries are: Australia, Italy, South Africa, the Netherlands, the United Kingdom, Portugal and China. Their parliaments have to ratify the convention. Sweden and India are expected to sign later. In total 12 nations are involved in the SKA project. Nations which like to join the project at a later stage, have to undergo an accession process.

FAST - Five-hundred-meter Aperture Spherical Telescope

An intelligent operational system of robots will assist with the daily operation and maintenance of FAST. The robots will

perform tasks like weed growth control on the slopes and automatic interference detection.

In preparation of the start of FAST's formal operation this year, the rules for visitors were reinforced as of 1 April 2019. Cell phones, digital cameras, smart wearable devices, and drones are prohibited in the core silence zone within 5 km distance from FAST. The Guizhou provincial government has revised the existing regulation to keep the noise down and prevent human activities from affecting the operation of the telescope. The intermediate zone stretches over a 5 km to 10 km radius and the peripheral zone covers 10 km to 30 km in radius. The maximum fine for violating the rules will be raised from 5,000 RMB (about 734 USD) to 30,000 RMB (about 4,500 USD). Since FAST's test operation in 2016, thousands of daily visitors were hosted by the visitors centre.

SATELLITES

Fengyun

In March, China provided a remote-sensing monitor report based on Fengyun (FY) data on the flooding in Iran, which greatly assisted the country's evacuation efforts. Data from the FY satellites are shared with over 2,600 users in more than 90 countries and regions. The FY emergency mechanism serves especially users and countries along the Belt-and-Road region.

FY-2E

On 11 January, approved by China Meteorological Administration (CMA), the FY-2E meteorological satellite (located over 86.5°E) was officially taken out of operation. During its 9-year operation, FY-2E worked from two different positions (105°E and 86.5°E), formed network observation with FY-2D and FY-2G successively, and serviced 104,000 times for meteorological observations in China and Asia. After decommissioning, FY-2E will find its application in scientific research experiments and development, and provide remote sensing data service for the pre-flood season in South China.

Gaofen 5, Gaofen 6

During a ceremony at CNSA's headquarters in Beijing on 21 March, the two high-resolution Earth observation satellites Gaofen 5 and Gaofen 6 went into operation, SASTIND (State Administration of Science, Technology and Industry for National Defense) reported. Both satellites finished several months of testing and trial runs. The data from the satellites will assist a wide range of public services including environmental protection, air-pollution mitigation, agricultural surveys and disaster relief. Both satellites will form a constellation with other Gaofen satellites in orbit.

The 3 main payloads onboard the Gaofen 5 environmental monitoring satellite, the Environment Monitoring Instrument, the Greenhouse-gases Monitoring Instrument and the Directional Polarisation Camera passed on-orbit testing already in late-December 2018. All 3 payloads were developed by Anhui Institute of Optics and Fine Mechanics (AIOFM).

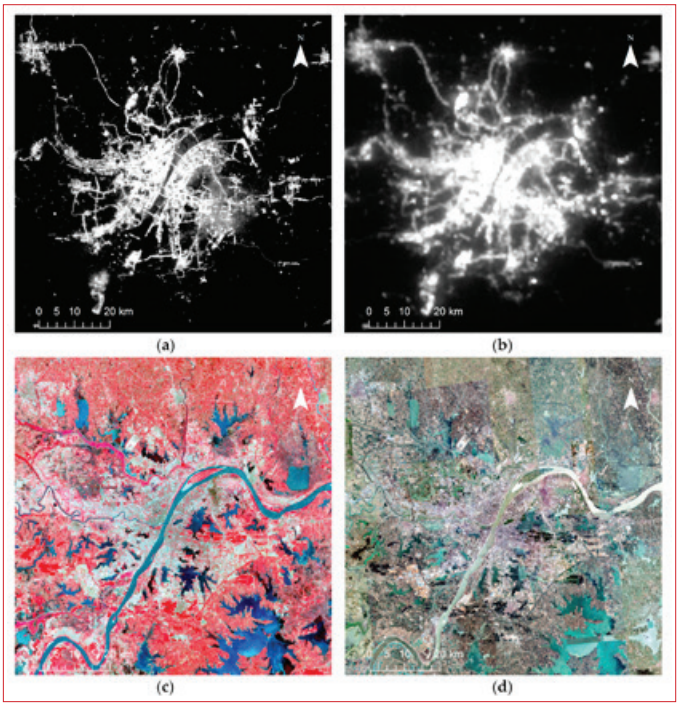
The high-resolution camera on the Gaofen 6 satellite took this photo of the new Beijing Daxing International Airport. credit: Gaofen 6/China Daily

Hongyun

The development and construction of CASIC's Hongyun low-orbit broadband communications satellite network, is on track. The first Hongyun satellite in orbit will soon start a trial run to demonstrate how high-speed internet services from space can work. Ma Jie, Party Secretary of CASIC's 2nd Academy, which developed the system, told media on the side-lines of the 2nd session of the 13th CPPCC National Committee in Beijing: "The first Hongyun satellite has conducted communication tests with ground control. These tests were successful in establishing a space-based internet connection and proved that the Hongyun network will allow internet browsing, video display and use of the WeChat instant messaging service. In the second half of this year, the satellite will begin an application demonstration to provide communication services to a selected group of users. And this will become the first trial operation of low-orbit broadband internet service in China." The Hongyun test satellite was designed with an operational life of one year, but it is expected to exceed this target.

Luojia 1

At the end of January, Wuhan University and the Hubei High-resolution Earth Observation Statistics and Application Centre in Wuhan released a batch of 275 night-time remote sensing images taken by the experimental satellite Luojia 1 from June to December in 2018 across China. The 130 m spatial resolution photos show details of artificial light, oil or natural gas burning, forest fires and volcanic eruptions. Luojia 1 night-time imagery has been provided to over 3,000 users in 16 countries and regions.



Study area (Wuhan) under different data sources: (a) LJ1-01 NTL image in June 2018; (b) VIIRS DNB image in May 2018; (c) Landsat 8 OLI false color composite (R/G/B = 5/4/3) in April 2018; (d) Google Map remote sensing satellite image in 2018. credit: Sensors 2018, 18(11), 3665; https://doi.org/10.3390/s18113665

TanSat

TanSat, China's global carbon dioxide monitoring satellite, has been serving over 120 users since launched in December 2016. The cumulative service data volume has reached 187.54 TB, accessible to the global science community.

NAVIGATION - BEIDOU

In February, the Chinese cargo ship "Rongda Changsha" made the first Beidou-supported sea journey through the South China Sea, sailing from Luojing Port near Shanghai to

Beidou Goddess or Beidou Superstar?

Shoulder-length hair, black leather jacket, arms across her chest, a faint smile, Xu Ying graces the cover of a youth magazine. A rock star? No, Xu, 36, is a scientist. Xu leads a team at China's prime natural sciences research institute in developing the ground system and augmentation technology of China's BeiDou satellites. She is fond of giving lectures to the general public to explain the cutting edge features of Beidou. One she likes a lot is that 6 Beidou MEO satellites are equipped with the rescue payload compliant with international standard. Also, she has a message for anyone wanting to crack BeiDou's military codes…

Borneo in Southeast Asia. The purpose of the trip was to test the Beidou 3 capacity in the South China Sea as well as to collect data and test the user experience in order to update and improve the Beidou receivers on the ship. Those tests will help to promote Beidou products on the international market. CASC is manufacturing the Beidou user terminals.

Yang Changfeng, Chief Engineer of the Beidou navigation system told CCTV at the end of January: "The weak point of our present satellite navigation system is that it cannot be used indoors or underwater. In the next step, we will improve the performance of the core system, making the system more resistant to disturbances and more accurate by combining it with other systems, such as 5G, our low-orbit communications systems, underwater navigation systems and indoor navigation system."

During its 2 1/2 months journey into the tropical West Pacific, scientists onboard the research vessel Kexue (means: Science) achieved real-time transmission of deep-sea data at a depth of 6,000 m through Beidou satellites. The scientists replaced batteries on 20 sets of submersible buoys on the scientific observation network, optimised their positions and installed Beidou satellite communication modules in them. The data collected by the submersible buoys include temperature, salinity, speed and direction of the flow of seawater. Beidou has a messaging function and a buoy at the ocean's water surface relays the signals to the satellites from where the data are then transmitted back to the ground. Kexue returned to Qingdao, Shandong province on 31 January 2019.

APPLICATIONS

CASEarth Data Archive

The Chinese Academy of Sciences (CAS) released on 15 January about 5 million gigabytes of global data related to Earth science, biology and ecology, allowing scientists and officials worldwide to study and tackle issues in climate change, food security, disaster relief and environmental protection.

The data, stemming from remote sensing satellites and ground-based research, can be accessed on the CASEarth Databank at: data.casearth.cn.

BRI - Maritime Silk Road Satellite Data Service

A Maritime Silk Road Satellite Data Service Centre has opened in Fuzhou, Fujian Province, SASTIND reported mid-January. The data service centre, providing standard data products, value-added products and satellite remote sensing application system, will serve users in land, forestry, and environmental protection, water resources, agriculture, disaster alleviation, weather and oceans. By the end of 2018, the centre had been able to receive, store, process and distribute real-time remote sensing data from 26 domestic satellites.

ADVANCED TECHNOLOGY

Solar Cells

Researchers from the Peking University, Academy of Opto-Electronics, Chinese Academy of Sciences and from the Northwestern Polytechnical University launched on a high-altitude balloon from Inner Mongolia perovskite solar cells (PSC) test parts into a near-space altitude of 35 km. According to the findings, one type of PSC used, retained more than 95 percent of its initial power conversion efficiency during the test. These findings open up new perspectives on the possible utilisation of PSCs in space. PSCs are known for high efficiency and lower production costs.

Graphene for Space Use

Scientists at Nankai University started research into the use of graphene for space solar sails, showing that graphene sails can be driven by various light sources including sunlight, and the thrust generated is 1,000 times higher than that of polyimide film in vacuum conditions. The studies are still at an early stage.

COMMERCIAL SPACE

Launch Companies

Landspace

On 7 January, Landspace test-fired the gas generator for its 80-t thrust Tianque 12 (TQ-12) methalox engine.

Between 16 and 18 January, Landspace successfully performed several hot fire tests of the TQ-11 80 t-thrust methalox gas generator with the longest one on 18 January lasting 1,000 sec. The tests, verifying the design of the gas generator, the testing process and the overall design quality, took place at the test facility close to its Huzhou manufacturing base.

On 25 March, a joint test run for the power-pack of the TQ-12 engine was conducted successfully in the Huzhou test facility. The test data confirm the reliability of the design and the stability of the performance.
The tested system components comprised the turbo-pump, valve components, the gas generator, ignition and actuating device and the assembly pipelines. The smooth run of the turbo pump and valves were verified as well as the workmanship process scheme, the feasibility of system coordination and compatibility. Also, the start-up sequence was validated. The test consolidated the technical basis for the full system test of the TQ-12 engine, scheduled for May 2019.

Mid-March Landspace released the ZQ-2 development time schedule:

March 2019:	Scheme design review
May 2019:	Full system test of the TQ-12 engine
March 2020:	Preliminary design review and launcher test model commencement
October 2020:	Launcher system assembly
November 2020:	System test
November 2020:	Pre-shipment review
December 2020:	Transport to launch site; launch readiness

OneSpace Technology

OneSpace conducted in January comprehensive electrical systems and payload fairing separation tests for its solid fuel OS-M rocket.

OneSpace Technology announced on 12 March that in preparation of its first orbital launch attempt by the end of March, it has finished the final assembly and system checks

The One-Space-OS-M1 rocket in Xi'an in March 2019. Credit: One-Space

of its OS-M1 rocket in Xi'an. The rocket was readied for transport to the Jiuquan Satellite Launch Centre. Zhang Jie, Chief Designer of OS-M, said engineers have examined and tested the compatibility and stability of equipment mounted on the rocket and the launch platform. They have also verified the launch sequence, ground control and tracking procedures.

The first OS-M1 (Chongqing Liangjiang Star) rocket launch by OneSpace on 27 March ended two minutes after lift-off from the Jiuquan Satellite Launch Centre in a failure. A velocity gyroscope on the 2nd stage of the 4-stage OS-M1 rocket failed after 45.68 sec. The launch should have placed the ZG6U-1B (Lingque-1B) into a sun-synchronous orbit of about 500 km. ZG6U-1B is a small technology satellite for Earth observation, designed and built by nano satellite company ZeroG Labs.

Shu Chang, CEO of OneSpace Technology, said his company is determined to continue the work and fulfilling this year's launch schedules. OneSpace plans another OS-M rocket launch, as well as 2-3 OS-X suborbital rocket launches before the end of 2019. Engineers are analysing the flight data and investigating possible causes of the accident. also see section: LAUNCHES

iSpace

iSpace announced on 3 January that it had raised 110 million RMB capital, accumulating 700 million RMB (104.33 million USD) of total funding since its establishment in 2017. A series of tests, including joint tests of a turbopump and secondary systems for a 15-t thrust engine named JD-1, lasted until end of March. Meanwhile, the Hyperbola 1 rocket was ready for launch, without a launch date announced.

Kuaizhou 11

Hu Shengyun, Senior Rocket Designer at CASIC's 4th Academy in Wuhan told media at the side-lines of the 2nd session of the 13th National People's Congress in Beijing that preparations for the Kuaizhou 11 mission are ongoing. At the same time, designers at the Wuhan academy have begun to develop two new solid-propellant rockets of bigger size and payload (P/L) capacity, the Kuaizhou 16 and 21 (KZ-16 and KZ-21).

KZ-16 will have a diameter of 3.5 m. Its P/L capacity for LEO will be 4 t. KZ-21 is designed with a diameter of 4.5 m and a P/L capacity of 20 t into LEO. The two new models are likely to conduct their first mission in about five years, serving the commercial demand. The KZ-21 could also be used for the space station programme.

China's NewSpace: Mapping of its 60+ Start-ups

Since the beginning of the year, Jean Deville is tracing and mapping the Chinese space start-ups. On his china-aerospace.blog it is possible to find a continuously updated graphic of China's space industry: *https://china-aerospace.blog/space-industry-mapping/*

Jean Deville also reported that another Chinese launcher start-up emerged. Translated from Chinese "凌空天行" it could be called "Space Transportation Co.". The company was already founded in August 2018 and is based in Beijing. The launcher manufacturer aims at developing reusable rockets for small payloads (100 - 1,000 kg P/L capacity on its TianXing 1 rocket). Source Code Capital had provided Space Transportation Co. several tens of millions of RMB in an angel round to fund the start-up.

LinkSpace

In January 2019 Linkspace conducted hover tests of the liquid-fuelled RLV-T5 demonstrator for VTVL technology (vertical take-off, vertical landing). The 5 variable thrust engines propelling the demonstrator could be verified. RLV-T5 is a prototype of a reusable rocket. Its height is 8.1 m and its weight 1.5 t.

As a new and larger version of the LinkSpace RLV prototype, the RLV-T5 demonstrator accomplished an un-tethered test

Robert Zubrin, the CTO of Alibaba and the LinkSpace team at the launch pad of the RLV-T5 demonstrator. credit: LinkSpace

on 27 March at a location in Shandong province. After rising to a height of 20 m, the demonstrator hovered in place for 10 seconds and returned to the take-off spot. RLV-T5's purpose is to verify key technologies including the operation of variable thrust engines, engine re-ignition and roll control with its flight and recovery tests. In a next step a height of 1,000 m shall be achieved.

Robert Zubrin, President of the Mars Society USA along with the CTO of Alibaba were present during the RLV-T5 testing at LinkSpace's site. Zubrin said he was impressed by the rocket's accuracy in returning to the target area, in particular since there has been a side-wind of 30 km/h.
A suborbital test with the RLV-T6 is planned for later in 2019.

Launch Site

Officials of Jiuquan Satellite Launch Centre (JSLC) told media that it is planned to support more private rocket missions. They stressed that supporting commercial launches is what a world-class space centre is supposed to do. At JSLC a dedicated support system for such activities was set-up. Since early September 2018, JSLC has hosted the launches of OneSpace, i-Space and LandSpace.

CGWIC - China Great Wall Industry Corporation

On 15 January, CGWIC, signed a Multiple Launch Services Agreement (MLA) with private Argentine company Satellogic to launch 90 satellites of Satellogic's Earth Observation Constellation on six CZ-6 rockets from the Taiyuan Satellite Launch Centre. The first launch - scheduled for later in 2019 - will deliver the first batch of 13 Satellogic small-sats to LEO. The remaining satellites will be launched in quarterly intervals. Provided that Satellogic can manufacture the satellites quicker, the larger CZ-2D could be considered. At the time of contract signature, 15 satellites, each of 45 kg mass and 100 x 50 x 50 cm dimension and equipped with one multispectral camera and one hyperspectral imager, were under assembly in Satellogic's facility in Montevideo, Uruguay. Satellogic's constellation is capable of a global, weekly mapping at 1 m resolution, something not currently available. The data from the constellation can significantly reduce the cost of high-frequency geospatial analytics. Potential customers are from a variety of industries, including agriculture, environmental monitoring, cartography, forestry, oil and gas, finance and insurance.

The contract details were not disclosed. A Satellogic representative stated that the availability and cost of launch services offered by CGWIC made Satellogic decide to choose them. It will be the first time for the CZ-6 to provide launch services for an international user.

In 2017, Satellogic raised a 27 million USD Series B round led by Chinese company Tencent. For the completion of the constellation, additional funding is required.

COMMERCIAL Satellites

CGSTL - Chang Guang Satellite Technology

CGSTL announced on 24 January 2019, that it had secured an Angel Round of financing of 250 million RMB.

Overview on China Commercial Space Investment in 2018

Based on the FutureAerospace's China Commercial Space Investment Report 2018, Jean Deville is summarising the investments in Chinese space tech in 2018.

Interview with Essential Capital (元航资本) on the Perspectives of Commercial Space in China

Essential Capital (a.k.a 元航资本 in Chinese) is a Chinese VC firm founded in 2015 and based in Beijing. Essential Capital considers itself an early-middle stage investor, with a major focus on "hard tech". In an interview with Chinese media Iyiyou 亿欧 in December 2018, the company's founders gave some interesting insights on the topic. Jean Deville translated the interview and summerised the main point while also adding some comments.

Minospace

Minospace raised an estimated 20 million RMB on 15 January.

Satellite TV Service for Nigeria

Chinese StarTimes together with its local partner, the Nigerian Television Authority, launched a digital satellite television project on 21 January in Kpaduma, a suburb of Nigeria's capital Abuja, offering direct-to-home pay TV services. It is the start of a wider project across Nigeria, providing 1,000 Nigerian villages with low-cost access to digital television and simple-to-install decoders. StarTimes has been able to disseminate digital terrestrial television in 80 cities across the West African country in the last nine years.

The project is one of the outcomes of the Johannesburg Summit of the Forum on China-Africa Cooperation (FOCAC) in 2015, in which the Chinese government pledged to provide satellite television for 10,000 African villages. Each of the 1,000 villages chosen in Nigeria, Africa's most populous country, received two sets of solar-powered projector television systems and one set of solar 32-inch digital television integrated terminal system. Additionally, 20 recipient families per village with television will be provided with 20 sets of direct broadcast satellite terminal system free of charge.

APT Satellite

Hong Kong-based APT Satellite published its annual financial report in mid-March. The 2018 revenue increased by 2.5 % compared with 2017 and had a value of 1.24 billion Hong Kong dollars (160 million USD). This success was achieved by expanding to new markets and businesses to compensate for the decline in transponder lease prices due to a transponder overcapacity in satellite broadcasting and satellite telecommunication.

HEAD Aerospace

China HEAD Aerospace Technology Co. and its subsidiary HEAD Technology France (HEAD) have been awarded a multi-million Euro contract through a consortium led by HEAD and its partner China Centre for Resources Satellite Data and Applications (CRESDA). The consortium won the international open tender issued by Ethiopian Space Science and Technology Institute (ESSTI) to procure a commercial Earth observation (EO) satellite ground receiving station. The contract, one of the biggest for HEAD, includes the procurement of a ground receiving station, data processing software, satellite imagery and related training services. It will be the first commercial EO ground station to receive Superview and Gaofen data in the Sub-Saharan Africa area.

Portrait of HEAD Aerospace

The ground station, planned to be installed in the Entoto Observatory and Research Centre in Addis Ababa, Ethiopia, will allow the country to receive the satellite data and develop applications for agriculture, forestry, land use management, urban mapping, mining, natural resource and disaster monitoring.

In November 2018, the Ethiopian government announced that it would launch its first satellite in September 2019 with the support from China, while the control and command station will be in Ethiopia. Most preliminary and critical design is done by HEAD scientists.

National Space Law Needed

On the side-lines of the 13th National Committee of the CPPCC in Beijing, Lei Jun, Head of Xiaomi and Deputy to the 13th National People's Congress, mentioned that it is in the interest of many space start-ups in China to rely on a national space law to provide a legal framework and secure the interests of private enterprises. He also asked for governmental support in opening up the national space infrastructure to private companies, enabling a sustainable ecosystem for the growth of commercial space in China.

Xiaomi is connected with Shunwei Capital, which participated in fund raising for iSpace, Galaxy Space and Deep Blue Aerospace.

INTERNATIONAL COOPERATION

APSCO

An APSCO (Asia-Pacific Space Cooperation Organisation) delegation, led by the Secretary-General Dr. Li Xinjun, visited Shanghai Jiao Tong University (SJTU) on 27 March 2019. The Vice President of SJTU, Prof. Xi Lifeng reassured that the university will continue to support APSCO programmes such as the 3rd summer camp of APSCO Student Small Satellite (SSS) project which will be held from 15 July to 3 August 2019. Prof. Wu Shufan reported about the progress of SSS-2A.

After the meeting, the APSCO delegation visited the Student Innovation Centre of SJTU, accompanied by Dr. Chen Jiangping, the Director of the Student Innovation Centre of SJTU.

credit: SJTU/ APSCO

EGYPT

China continues to fund the EgyptSat Earth observation satellite programme project with 72 million USD. The money is intended for the development of EgyptSAT-A, the replacement of EgyptSat-2 which was lost in 2015 due to technical failure. This is the 3rd round of financing. In 2016, 23 million USD were transferred and in 2018, 45 million USD. During a signature ceremony at the Chinese Embassy in Cairo, Han Bin, Trade Counselor of the PRC Embassy and Mahmoud Hussein, the Head of the National Directorate of Remote Sensing and Space Science of Egypt, signed the agreement.

EgyptSat-A (MisrSat-A). Source: NARSSS

EgyptSAT-A (also called: MisrSat-A), built in cooperation with Russia and launched on a Soyuz rocket in February 2019 is Egypt's 3rd Earth remote sensing satellite and a pillar of the national Earth observation project. Through the cooperation with China, Egypt hopes to gain from space technology. China intends to strengthen the Sino-Egyptian all-round strategic partnership.

World Meteorological Centres Workshop

On 28 and 29 March, the 1st World Meteorological Centres Workshop - co-hosted by the World Meteorological Organisation (WMO) and the China Meteorological Administration (CMA) took place in Beijing. The 60 delegates from 9 World Meteorological Centres (WMC) of WMO, Regional Specialised Meteorological Centres (RSMC) of WMO, WMO Commission for Basic Systems, and WMO Commission for Atmospheric Science agreed that, against the backdrop of globalisation, the WMCs will improve cooperation mechanisms and build WMO Earth System Prediction together to serve global users. WMCs will provide support for capacity development for National Meteorological and Hydrological Services (NMHS) in Least Developed Countries (LDCs) and Small Islands Developing States (SIDS) via some high-priority pilot projects. The meeting summary will be submitted to the WMO in preparation for the 18th World Meteorological Congress in June, in Geneva, Switzerland.

FRANCE

Chang'e 6

On the occasion of the state visit of the President of the People's Republic of China Xi Jinping to France, CNES President Jean-Yves Le Gall and CNSA Vice-Administrator Zhang Jianhua signed a partnership agreement on joint space exploration on 25 March at the Elysée Palace. The signature ceremony was held in the presence of France's President Emmanuel Macron and China's President Xi Jinping. The agreement states that China will fly French scientific payloads on Chang'e 6 (sample return mission), planned for 2023.

Jean-Yves Le Gall, told Xinhua that the list of other joint projects between the two countries include:

- the successful CFOSat oceanography satellite, launched in October 2018. Before the 25 March signature ceremony, the CFOSat science teams held a meeting at CNES Headquarters in Paris to present the first data from the SCAT and SWIM instruments. Calibrated CFOSat data will be available to the international science community as of May 2019.
- the SVOM astrophysics mission to study high-energy phenomena;
- the Space Climate Observatory (SCO) to deliver satellite data in support of tackling climate change and its impacts;
- CNES and CNSA have started work on their next joint Earth-observation mission, focused on ocean salinity and soil moisture;
- the Cardiospace 2 device for the China Space Station which will collect data for studying the impact of weightlessness on the human cardiovascular system.

(In September 2016, the first French Cardiospace 1 instrument was installed on the TG-2 module, to monitor the crew's cardiovascular systems. Cardiospace 1 was developed under a French-Chinese agreement, with CNES responsible for the development and qualification of the system. It was delivered in March 2014 to the Astronaut Centre of China. Research teams at the University Hospitals of Angers and Tours provided scientific support during development and, along with their Chinese counterparts, will use the collected medical data.)

INDIA

Hindustan Times reported on 11 March, that China's CNSA received a Chang'e 4 payload proposal from India's ISRO in response to a letter by Xu Dazhe, Head of CNSA in 2015. CNSA invited major space nations to participate with piggy-back payloads to the Chang'e 4 lunar mission. The Indian payload - a satellite or space probe equipment - did not make it through the evaluation process. ISRO did not comment on this article by Hindustan Times.

China-India Space Cooperation

India and China formally established the Sino-Indian Joint Committee on Space Cooperation in 2015, with a first meeting of the committee taking place in Beijing in 2015. An outline of Sino-Indian space cooperation was signed, including 19 projects in seven areas: remote sensing satellites, space-based meteorology, space science and lunar and deep-space exploration, education and training, piggy-back launch services, satellite navigation, and space components. The MoUs signed, serve as a base for bilateral cooperation but it remained at the stage of dialogue. In 2018, the then Indian ambassador to China, Gautam Bambawale, visited CNSA twice in half a year and exchanged views with Zhang Kejian, the Head of CNSA, on promoting Sino-Indian space cooperation. CNSA told Hindustan Times, that it is open to cooperating with India: "The two sides reviewed the course of Sino-Indian space cooperation in recent years, agreed to further promote the process of Sino-Indian space cooperation with an active and open attitude of cooperation, and agreed to convene the 2nd meeting of the Sino-Indian Space Joint Committee in 2019."

ITALY

President Xi Jinping and Italian Prime Minister Giuseppe Conte held talks in Rome on 23 March, aimed at bringing China-Italy relations into a new era. They witnessed the signing of a MoU on the Belt-and-Road project. Xi said that the two countries should increase the convergence of their interests, optimise and upgrade their cooperation and achieve more early results in such priority areas as space technology, infrastructure, transportation, environment protection and energy conservation and focus on cooperation in the space industry.

China-Italy cooperation programmes include:

- Wukong satellite, whose key part was built with the help of Italy.
- China Seismo-Electromagnetic Satellite mission (CSES-1) or: Zhangheng-1 is equipped with two high energy particle detectors. One was domestically built, another provided by Italy.
- Astronaut training: Chinese astronaut Ye Guangfu had some of his training in Italy in June 2016, while his Italian counterpart Samantha Cristoforetti was part of a training mission in Yantai, China in August 2017.
- Sino-Italian Cooperation Programme for Environmental Protection (SICP) http://www.sinoitaenvironment.org

RUSSIA

The President of the Russian Academy of Sciences (RAS), Alexander Sergeev, led a delegation for a working visit to China at the end of March. He discussed with the President of the Chinese Academy of Sciences (CAS), Bai Chunli, topics of mutual interest. Sergeev proposed to cooperate in the area of astronomy by using China's observatory in Tibet and that Chinese scientists could take part in scientific research of the North Pole region. Also, he proposed cooperation with China on a Russian space station.

UNITED KINGDOM

On 26 March, Mr. Yu Yong, Deputy Administrator of China Meteorological Administration (CMA) met with Ms. Carole Mundell, Chief Scientific Advisor of the Foreign and Commonwealth Office of the United Kingdom. Both sides exchanged, among others, views on Climate Science for Service Partnership (CSSP). Both representatives expressed their hope that their countries continue the long-standing partnership and pragmatic cooperation and support further bilateral meteorological cooperation.

EDUCATION

Mars Simulation Base in Qinghai Province

On 1 March, another educational Mars simulation base opened in Mangai city, Haixi Mongolian and Tibetan Autonomous Prefecture in Northwest China's Qinghai Province. The projects and programmes are targeting young people to make them interested in science and space exploration.

The red rock area in the Qaidam Basin in Qinghai has been called the most "Martian" place on Earth, resembling to a certain degree natural features, landscape and climate similar to those on the Red Planet. At the simulation base, visitors can try out how to live in a remote environment and train procedures which could be faced by future astronauts on Mars. Covering an area of 53,330 m^2, the base can accommodate 60 people in its modules and hundreds in the base's tents. Construction started in June 2018. The building costs are estimated at about 150 million RMB (22.3 million USD). (In October 2018, the educational C-BASE Jinchang - Gobi Desert was opened.)

Aerial view of the Mars Simulation Camp Qinghai. Credit: China News Service

New Planetarium

The world biggest planetarium, of which construction began in November 2016 in Lingang in the Pudong New Area, Shanghai, is expected to be finished by the end of 2020 and open to the public in 2021. At the end of January 2019, the main structure of the modern and architectural attractive assembly inspired by astronomical instruments was completed. The complex will comprise the Shanghai Planetarium for the Shanghai Science and Technology Museum (SSTM), including a cupola dome for night sky projection, IMAX cinema, solar telescope, observatory, space camp and galleries.

Also, under construction is a planetarium within the Tibet Museum of Natural Sciences in the city of Lhasa, which should be completed at the end of this year.

Science-Fiction

On 27 January, the science-fiction movie adaption of Liu Cixin's novel "The Wandering Earth" had a preview screening in Beijing's Space City, attended by taikonauts, space engineers and staff. The movie premiered in the public cinemas on 5 February. At the event, Liu Cixin, also executive producer of the film, was awarded the title "Space Culture Ambassador" by the China Satellite Launch & Tracking Control General Department. “The Wandering Earth” had big success during the Chinese New Year holidays and created the number two Chinese box office record - 4.7 billion RMB.

Mars Society China

On 30 March, the Chinese Chapter of the Mars Society was founded at an event at the Beijing Planetarium, attended by the President of the Mars Society USA, Dr. Robert Zubrin, who also went on a tour in East China to talk about the exploration on Mars. On 29 March Zubrin spoke at the Beihang University in Beijing about his "Mars Direct" concept, advocating a permanent settlement on Mars within the next 20 years.

The founding assembly of the Mars Society China at the Beijing Planetarium
credit: Mars Society China

MISCELLANEOUS

SPACE PEACE Treaty

A two-week long, non-public, meeting of the UN Conference on Disarmament in Geneva, involving a UN panel called the "Group of Governmental Experts (GGE)" with experts from 25 countries worked on the text of a space peace treaty, which ended on 29 March in Geneva without reaching consensus on a list of recommendations. Russia and China have backed the concept to prevent the deployment of certain types of military hardware in space, an approach rejected by the US, which prefers to focus on the prohibiting of specific aggressive conduct or behaviour or action in space. During the conference, the U.S. Assistant Secretary of State for Arms Control, Verification and Compliance, Yleem Poblete, accused China and Russia of raising the risk of conflict in space by developing anti-satellite weapons. "The Chinese side did not, and will not take part in an arms race in outer space of any form. Our stance remains unchanged," Chinese Foreign Minister Spokesperson Geng Shuang, told reporters in response to this accusation, reiterating the Chinese government's long-standing position of preventing the deployment of weapons in outer space.

Seminar: U.S.-China Engagement in Space

The Secure World Foundation (SWF) held a seminar on U.S.-China Engagement in Space on 29 March at the Carnegie Endowment for International Peace in Washington, DC. - for more detail about the event, see next pages 13 and 14.

Lunar Crew Space Craft - Call for Ideas

The winner of the Call for Ideas from the 2018 National Space Day were announced on 19 January. CMSA asked the general public to come up with creative approaches for the design of its manned lunar landing and ascent vehicles. A total of 108 entries were received in the contest. 24 award-winning works were selected. From 16 to 17 January 2019, CMSO organised for some awardees a visit to the China Astronaut Centre, China Academy of Space Technology, Tianjin Space City and other places. Liu Boming, Shenzhou 7 taikonaut, received the group.

Space Ambassadors

On 16 January, during the “Zhenzan Popular China” event, the China Association for Science and Technology announced that Yang Liwei, Ouyang Ziyuan, Zhang Shuangnan, Xu Ying, Chen Sisi and Huang Xuan were appointed as "Ambassadors of Science in China", supporting science popularisation and communication.

New Year Address for rocket scientists

Chinese President Xi Jinping's New Year Address has

encouraged scientists and engineers to make greater contributions to the country's scientific and technological progress in the aviation and aerospace industry. In the New Year Address delivered on New Year's Eve, Xi hailed a changing China with its achievements in manufacturing, innovation and construction.

ON A SIDE-NOTE

Jacqueline Klimas of Politico magazine interviewed Republican Rick Larsen who is a Member of the U.S. House of Representatives' Committee on Transportation and Infrastructure and also co-chairs the U.S.-China Working Group. To her question as to whether US politicians understand the Chinese space threat, he answered: "I don't think a lot of folks have a full understanding of the Chinese space program. Some of it is a threat, some of it is not. ... I think having a better understanding of the Chinese space program gives you an understanding of what the Chinese threat is. One thing I have concluded is the attempts in the late 90's to try to prevent China from growing its space program failed miserably. So, the focus on trying to stop China from doing something perhaps diverted us from investing in the things we could do better. .... We shouldn't be doing things to respond to China. We should be doing things to make China respond to us because we did it first. Right now it just seems like ... because China is doing something, we have to do something like it to show we can do it, too. That's not a way to innovate."

ESPI Executive Brief 28

"China is One Step Closer to the Moon… and Europe?"

Located in Vienna since 2002, the European Space Policy Institute's (ESPI) main mission is to provide decision makers with independent and informed content on space matters of strategic importance to Europe and its relevant space institutions. With this aim in mind, ESPI regularly publishes a number of analyses, studies, reports and newsletters.

One of these regular publications is the 'ESPI Briefs'. The January 'ESPI Brief', issue no 28, was dedicated to China's landing on the far side of the Moon. Titled "China is One Step Closer to the Moon… and Europe?" ESPI is asking the right questions about what Europe and ESA want to achieve in a space arena where China has more and more a say. Is Europe prepared and willing to cope with China's expanding space achievements and its long-term ambition to send astronauts back to the Moon in the changed reality of "the post-ISS space exploration context"?

By recognising that the landing of Chang'e 4 on the far side of the Moon was another key milestone achievement in China's incremental, strategic and long-term effort for lunar exploration the conclusion is obvious that those efforts will culminate in a manned lunar landing after 2030.

China's growing successes in carrying out its diverse and interlaced space programmes, its interest in cooperation together with its interest in geopolitical influence raises questions and considerations that, the international space community should engage with, because no major space nation has to date set up a significant space cooperation project with China.

The ESPI Briefs outlines that open competition with China could help in particular the U.S. to boost NASA's budget and an ambitious space programme, similar to the U.S. Space Policy Directive to counteract the U.S.' decreasing leadership role in space.

As long as the U.S. and China cannot find common ground, the ESPI experts stress in the ESPI Briefs no 28: "*a new space race may eventually prove beneficial for NASA and the implementation of the Lunar Orbital Platform-Gateway (LOP-G) venture but would imply a deep change in the international landscape. In such scenario, the capacity for other countries to cooperate with both the United States and China seems unlikely. Other, less ambitious, space actors - including Europe - would therefore be forced to reconsider their approach to international cooperation.*" Europe, aware of its limited space power capacities, likes to see itself as a bridge between those big players. Taking into consideration its successful experience in the ISS programme, where Europe could work highly successfully with the US and Russia, it would be best to stay in a similar position when it comes to the US and China.

The ESPI Briefs reflects on that by stating: "*The driver behind such posture is the recognition that the privileged way for Europe to retain a key role in the future space exploration context is to position itself as a key, although minor, player as Spanish Minister Pedro Duque recently put it at the Brussels Space Policy Conference on 22 January 2019.*"

ESA has committed to NASA's Lunar Orbital Platform-Gateway. It has been trying to engage with China in the area of manned spaceflight, without visible results. But it might be forced to choose between the one or the other or will remain also for the future a junior partner to other partners' programmes. "*The effects of the current absence of position of Member States in the definition of Europe's long-term overall ambitions shall not be overlooked, for they will not only preclude any possibility for Europe to shape the timing and priorities of the future space exploration agenda, but also condemn the continent to become a follower, most likely of U.S. plans. It appears in fact clear that if the prospect of "two separate highways" to the Moon will eventually freeze, Europe might have no other option than to bandwagon with U.S. plans, leaving up eventual cooperation with China to national initiatives. Equally worrisome is the risk that current inaction undermines Europe's coordinated approach to space exploration, favouring more limited national initiatives as opposed to broader communitarian efforts vis-à-vis possible partners.*

In order to avoid such prospects, Europe should urgently firm up a common strategy for the post-ISS space exploration context. Time is of essence here .... [to find] concrete answers on the role that Europe wants to play in the future space exploration. Obviously, without beforehand achieving a solid and enduring commitment at the highest political level, any decision on these matters is doomed to remain either fragile or ineffective."

Download of the ESPI Brief:
https://espi.or.at/publications/espi-executive-briefs/send/5-espi-executive-briefs/406-china-is-one-step-closer-to-the-moon-and-europe

US-China Engagement in Space – a Seminar by the Secure World Foundation

As a non-governmental entity, focussing on the study of and informing about cooperative solutions for the sustainability of space and the peaceful uses of outer space, the Washington-based Secure World Foundation (SWF) is actively facilitating the dialog between different space actors to discuss and illuminate the diverse point of view of as many interest groups as possible.

On 29 March 2019, the Secure World Foundation organised and moderated a panel discussion on the topic of US-China Engagement in Space. The seminar took place at the Carnegie Endowment for International Peace in Washington, DC.

We summarise here the main points of the panellists, as reflected in the transcript of the event.

Lincoln Hines, PhD candidate in the Government Department at Cornell University, Cornell University

China's space programme is embedded in the strive of the Chinese Communist Party to regain respect for China, lost in what nationalist narratives describe as China's 'century of humiliation'. It is part of the Great National Rejuvenation of the Chinese nation. Lincoln Hines explained: "*Recognition of China's status as an equal in world politics is an important priority for Chinese foreign policy. ... Political engagement through the United Nations or bilaterally through cooperation with NASA provides an informal means of recognizing Chinese status aspirations as a space power*." On a political level, Hines thinks that "*China should not be rewarded for bad behaviour or violating norms in space. At the same time, however, China should also not be indiscriminately punished. Should China act responsibly, the United States should give it fair credit. Cooperation with China, however, must also be a tailor to adjust to political realities. ... While important differences exist between China and United States, bilateral relations are considerably better than those between the Americans and the Soviets during the Cold War. The cost of not cooperating with China are significant. The question is this, is the current situation in space sustainable? In long term, it is unlikely to be sustainable. Should China continue to be excluded from cooperating with the United States in space,* [inaudible] *create its own order. In this case, I cannot help but think of the case of the Asian Infrastructure Investment Bank. The United States lobbied intensively against the creation of this bank, yet policymakers were shocked when the rest of the world did not follow suit. Consequently, the United States lost an important opportunity to shape this institution and its roles. More broadly, should the two powers not engage one another, the possibility of misperception or the creation of the security dilemma in outer space is quite possible*."

Patrick Besha, Senior Policy Advisor for Strategic Engagement and Assessment in the Office of the Administrator at NASA Headquarters

He recalled the 2010 Joint Statement signed by US President Obama and Chinese President Hu Jintao which foresaw the reciprocal visits of the representatives of NASA and CMSA to their respective human spaceflight facilities. A NASA delegation went to China to see the Beijing astronaut training centre and the Jiuquan Space Launch Centre in the Gobi Desert. Besha told the audience that "*shortly thereafter, legislation was passed that barred further cooperation. Chinese officials never in turn visited US facilities*." He then listed all the political issues of the last years which hampered any effort in space cooperation with China, including the Cox Commission and the Chinese ASAT test. "*To summarize, low-level bilateral cooperation over the years has likely been mutually beneficial, in terms of scientific gains, including the spread of norms of free and open access to data. That's something that NASA champions. ... As for what lies ahead, ultimately, NASA is a science and technology agency. We don't dictate international relations. We follow the mandates that are provided by the White House and Congress. On the topic of cooperation, they are currently very clear*."

Audrey Schaffer, Director, Space Strategy and Plans, Office of the Secretary of Defense, Department of Defense

She opened her statement by saying that China is the priority in the US overall defense guidance in space: "*Frankly, we're not going to treat space any different than any of the other traditional war fighting domains, land, air, and sea, when it comes to thinking about our relationship with China*." Also, she pointed out that the US' "*National Defense Strategy says, the most far-reaching objective of this defense strategy is to set the military relationship between the United States and China on a path of transparency and non-aggression. ... if you think about that US-Soviet relationship, it's probably a helpful model. Now things weren't exactly the same because during the Cold War our primary focus was avoiding the threat of nuclear exchange*." But she emphasised that the relationship with the Soviet Union at that time saw flexible agreements which could also be adapted to other areas and are even still in place, serving as a baseline for confidence in the relationship despite disagreements over security issues and she reminded the audience that, "*The fact of the matter is we don't actually have a lot of that really basic foundation in the US-China relationship. As much as I know folks would like to talk about developing norms, for example rendezvous and proximity operations. That's what I would call a stretch goal because we don't even have the really, really basic stuff in place yet*." She then named the three most helpful examples in the relationship with Russia which are missing with China: 1. Routine exchanges of information, 2. Verification of space vehicle launches, and 3. secure and authenticated communications channels.
As an example for the last point Schaffer mentioned the Nuclear Risk Reduction Center - NRRC: "*It's kind of like a diplomatic ops center. I think it's staffed 24/7*", Schaffer detailed, "*and it provides authenticated and secure communications channels between states, the US and Russia, but also the US and a variety of other countries*." She concluded: "*Now practically speaking, I just don't see the opportunity for a treaty like this between the US and China right now. I don't think that should be a limiting factor. All of the things that I mentioned could be done on a voluntary basis. That's, anyway, the right place to start when we're talking about building trust and increasing transparency in a relationship*."

Mike Gold, Chair of the Commercial Space Transportation Advisory Committee, picked up on the points made by Audrey Schaffer and emphasised an important fact by saying: "*We talk about China, and I think it's so different than the Soviet example. This isn't a conflict so much as it is a competition. No one was ever worried about those amazing Soviet products driving US companies out of the market. We really need to think about this in a different, a new paradigm. Frankly, I think it's one that the US system is fundamentally ill suited to participate in because we don't have this kind of government control and direction for the economy like China does, and frankly many other nations are developing. ... China target industrial sectors, demand to dominate in those sectors and have been very successful in solar rays, etc. From my understanding space launch is next up and that China will want to reduce those expenses by five times what even Space X is offering. ... Meantime in the satellite world, we're already seeing the competition develop from China. ... They weren't really so much on the satellite scene in terms of big products with developed nations. Now we've seen satellite sales by China's Great Wall Corporation to TYCOM*

and to Indonesia, winning contracts that Europeans, Japanese, American entities otherwise could have.

They're doing so with robust and substantial government support. Subsidies, even potential free launches, again these are the concerns that America can't compete or looking at subsidized or potentially free launches of satellites. Financing that allow the companies to not even pay anything until the satellite starts generating revenue.

These are the kinds of forward-leaning economic incentives that I'm not seeing developed in the US, and that again could be a great threat to our company's health in the American industrial base. All of this in a backdrop where we can't even get the export-import bank going." Gold summarised by stressing: "*We're not in a conflict with China, but we're in a competition*." And he made the listeners also aware that finding the right balance is crucial: "*To be clear, absolutely justified by taking action against China to protect our technologies from China, and probably not doing nearly enough in that arena. What you don't want to do is throw the baby out with the bath water and start creating this amazing bureaucracy that makes it challenging, if not impossible, to US entities to work with NATO and major non-NATO allies. Guess what happens when you do that, and you take America out of the partnerships that you want to do with Europe, Japan, or Australia. Guess who fills that void. ... China, right? Let's all be cautious in our zeal to protect our technology and our edge from China that we're not doing things that are counterproductive relative to US competition with China. I think it was Norman Augustine who said, "If you protect your toothbrushes the same that you protect your diamonds, you're going to lose more diamonds than toothbrushes."*

The solution here is higher walls around a smaller area. We need to be probably more robust when it comes to China, but free up everything else so that we can compete effectively with Chinese overseas." He concluded his remarks with his interpretation of the Wolf Amendment: "*What does it say? It says that you can work with China, but you need certification from the FBI, again totally warranted, and notification of Congress. Is that a prohibition? To me, those are two common sense steps right now. NASA can engage with China, has engaged with China under the auspices of the Wolf Amendment*."

Brian Weeden, Secure World Foundation, Director of Programme Planning, took the opportunity to put some of the before mentioned facts into context. He said that "*the US is engaged with China in a long-term strategic competition*" and this "*is happening across diplomatic information in military and economic sectors*." From that he concluded: "*If the US is going to look at engagement with China, it's going to think across all of those different areas and not just focus on one or the other… we deliberately chose the word engagement to title this, because of what that implies. It doesn't imply let's be best friends. It's about a set of interactions between two countries*." Then, he posed the relevant questions waiting to be answered: "*what should the US's engagement strategy be with China across diplomatic information, economic, military sectors? How do all those bits and pieces fit together? Right now, at least in space, unfortunately, our only real engagement with China is in the national security world, and it happens to have the context of a military threat environment*."

Weeden also picked on the point made earlier by Mike Gold . The US is not in a race because a race describes "*it in terms of a single event or a single capability or a single goal when it really is this much broader long-term competitions*." According to Weeden it is more complicated than a race. There are two big areas which are of most concern, recalling what was said by Audrey Schaffer: "*one is rendezvous and proximity operations and the other is testing hit-to-kill technologies for anti-satellite weapons and ballistic missile defense*"

Then he explained why the Soviet model of the past has some weaknesses for the world today: "*We talk about the US-Soviet space relationship because that's the only example we have. Even though it's not really a great example, because the context around which today's US-China relationship is happening is so much different than it was back then… We have to think not just in this bipolar capitalism versus communism struggle for dominance, but across all these different sectors of activities, and there's more players*."

Brian Weeden made some suggestions for possible categories of engagement with China:

- Information and data sharing, to establish a common operating picture and set of facts.
- Space policy dialogue, to understand the views, concerns, and intentions, reduce miscommunication understanding,
- and joined activities, to achieve objectives that neither could achieve individually, or to develop experience in working together.

He urged that the "*US is going to have to put together a strategy on how it's going to engage with China in space and why across diplomatic, military, information and the economic industry. It's going to have to think about industry, it's got to think of the military, and everything else*." In the meantime there is "*the recognition that the Cox Commission report and the whole space and ITAR push actually did far more harm to the American industry than it did to protecting it and rolling that back*."

At the end, Weeden gave another interesting thought away when talking about "*US commercial satellite companies and spectrum sales to companies being involved with China ... It's a commodity, it's a commercial technology that is pretty freely available on the market*." Therefore it could make sense "*to encourage US companies to sell commodities and increase trade with China. We should be competing with them for market share, compete with them for customers, because if we're not there, as we've seen, China probably is*."

Brian Weeden was keen to clarify something about the issue with the Wolf Amendment. He stressed: "*You have to come ask permission first, that has a deadening effect on*." If the Wolf Amendment was intended as a protective measure, there should be the option considered to "*at least prescribe areas where we might want to think about having cooperation with China in space*."

During the discussion, Mr. Lee from the Science and Technology Section of the Embassy of the PRC in the U.S.A. took the opportunity to reflect on what was said before. He mentioned that it might have been a good idea to invite some Chinese expert on the matter for the panel.

Then he commented that "*China has never liked to participate or forced to participate in any kind of race*." Also, using the word "*domination*" in the context of China in space is misleading in the sense that China does not want to dominate in any area. Rather, China "*would like to keep parallel with other advanced countries or we'd like to join first-tier category of advanced countries by our efforts subsequently*."

Mr. Lee invited the U.S. to propose research for the utilisation of the future CSS through the UNOOSA-China AO for CSS.

He also pointed out that the practise of the Wolf Amendment might have something to with the lack of confidence Congress has in U.S. administrative agencies such as NASA or OSTP.

With this seminar, the SWF once more has demonstrated that talking about a complex and important issue can give relevant insights, identify problems as well as opportunities and as a consequence might pave the ground for a common understanding in order to define the way forward.

LAUNCHES

2019-001A
10 January 2019 - 17:11 UTC (11 January - 01:11 BJT)

launch site: Xichang Satellite Launch Centre - XSLC, LC2
launcher: Chang Zheng CZ-3B/G3
payload: Zhongxing 2D, ZX-2D (ChinaSat 2D)

The first launch of the new year put the Zhongxing-2D (ChinaSat-2D) communication and broadcasting satellite into geo-transfer orbit. Operated by China Satellite Communications Co. Ltd., the satellite will provide transmission services for the country's radio, television stations and cable television networks.

ChinaSat-2D is a DFH-4-based, CAST-built satellite. The box-shaped satellite bus has a dimension of 2.36 x 2.10 x 3.60 m and is equipped with two solar panels, delivering 10.5 kW at the end-of-life. The expected lifetime is 12 to 15 years.

By 22 January the satellite had arrived at its working position in GEO at 130.0ºE. It is assumed that ZX-2D is co-positioned with ZX-20A (Shentong 1-02) und ZX-1A (Fanghuo 2-01).

Jonathan McDowell reported later in the year, that on 3 July, at 06:16 UTC, the CZ-3B Y56 3rd stage from the launch of ZX-2D re-entered and broke up over southern Florida causing widespread meteor reports.

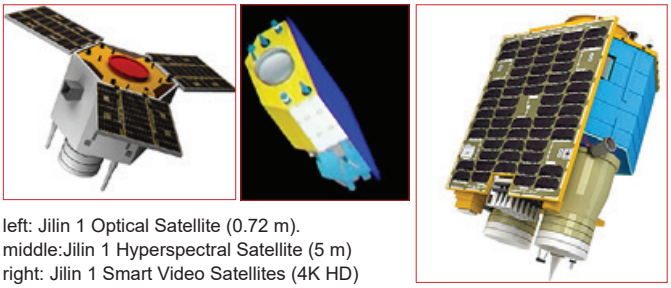
2019-005A
2019-005B
2019-005C
2019-005E
21 January 2019 - 05:42 UTC (13:42 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC
launcher: Chang Zheng CZ-11
payloads: Lingque 1A
Jilin Lincao 1 (Jilin 1-09)
Qingteng Zhi Xing (Xiaoxiang 1-03, XX-1-03)
Wenchang Chaosuan 1 (Jilin 1-10)

The CZ-11 launched two Jilin 1 satellites for multispectral imaging and two test satellites, the Lingque 1A and the Xiaoxiang 1-03.

The two Jilin 1 imaging satellites were developed by Chang Guang Satellite Technology Co. Ltd. (CGSTL). The company is a spin-off of the Changchun Institute of Optics, Fine Mechanics and Physics (CIOMP) under the Chinese Academy of Sciences (CAS). The satellites successfully entered their pre-set orbit. These two identical satellites are the first Jilin satellites, to be equipped with a multi-spectral imager and an infrared camera. The remote sensing satellites join 10 other Jilin 1 satellites already in orbit and that will form a network, providing remote sensing data and services for forestry, shipping and resource and environmental monitoring. The primary observation task for Jilin 1-09 is land remote sensing, while the Jilin 1-10 primary task is ocean observation. The expected lifetime is 3 years. The Jilin constellation is planned to be 60 satellites by 2020 and 130 satellites by 2030.

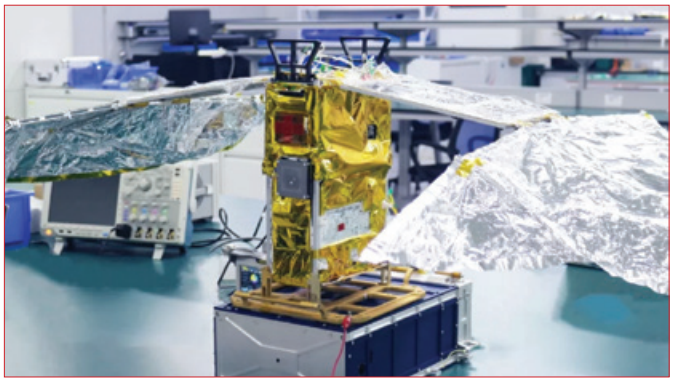
Wenchang Chaosuan 1 is co-sponsored by the Hainan Modern Technology Group and its Wenchang supercomputer project.



left: Jilin 1 Optical Satellite (0.72 m).
middle:Jilin 1 Hyperspectral Satellite (5 m)
right: Jilin 1 Smart Video Satellites (4K HD)

The launch also carried two test satellites. The 6U cubesat Lingque 1A is the first verification satellite for the Lingque (Magpie) Constellation (132 satellites at completion) planned by Beijing ZeroG Technology Co., Ltd. It is an Earth-imaging satellite with high-speed data transmission and inter-satellite communication capability. Beijing ZeroG Lab Ltd., specialises in on-board detection of moving ground targets which is the intended task for the constellation

Xiaoxiang 1-03 is a 6U technology test satellite developed by SpaceTY Co., Ltd., from Changsha in Hunan Province. It will be used to verify radio communication and small remote sensing experiments. It carries a miniature panchromatic remote sensing camera. The expected lifetime is one year with a self-deorbiting capability by deploying a sail-like, super-thin membrane for braking and causing a quicker decay. The cubesat is a joint mission between Tianyi Research and the online Qingteng University business school.



The Xiaoxiang 1 (03) 6U CubeSat. Credit: Spacety

2019-012A
09 March 2019 - 16:28 UTC (10 March - 00:28 BJT)

launch site: Xichang Satellite Launch Centre - XSLC, LC3
launcher: Chang Zheng CZ-3B/G2
payload: Zhongxing 6C - ZX-6C (ChinaSat 6C)

The ChinaSat 6C GEO communication satellite, positioned at 130° East, will provide high-quality radio and TV transmission services for the region of China, Australia, New Zealand and the South Pacific island countries. The CAST DFH-4-based satellite was developed by the China Academy of Space Technology. The satellite's dimensions are 2.36 x 2.10 x 3.60 m, its mass is 5.2 t. It is equipped with 25 C-band transponders, a hyper-modern Ka-band payload, working in the HTP modus, and with two solar panels (min. 10,500 W). It will be operated by the China Satellite Communications Co., Ltd. (China Satcom).

It was the 300th launch with a Long March carrier rocket since 1970. In total, 500 spacecraft were sent to orbit. It took 37 years to complete the first 100 launches, 7.5 years to complete the second 100 launches, and only about four years to accomplish the 3rd batch of 100, with the average number of launches per year increasing from 2.7 to 13.3 and then to 23.5.

2019-F03 Launch Failure
27 March 2019 - 09:39 UTC (17:39 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC
launcher: OS-M1
payload: Lingque 1B

OneSpace became the second private Chinese space company that attempted to launch a satellite into orbit. The 3-stage, solid-fuel rocket OS-M1 (Chongqing Liangjiang Star), equipped with an additional orbital manoeuvring unit, failed after first stage separation, shortly after igniting the second stage - 45.68 seconds after lift-off. A faulty gyroscope caused the loss of

attitude control, leading to the crash of the rocket. Onboard was the 6U cubesat, Lingque 1B, an Earth observation satellite built by ZeroG Lab which would have joined its planned Lingque constellation consisting at completion of 132 6U cubesats, providing 4 m resolution. (see: launch 21 January - 2019-005A)

2019-017A
31 March 2019 - 15:51 UTC (23:51 BJT)

launch site: Xichang Satellite Launch Centre - XSLC, LC2
launcher: Chang Zheng CZ-3B/G2
payload: TL-2-01 (Tianlian 2-01 or: TL-2A)

China launched the 1st of its 2nd-generation tracking and data relay satellites, providing real-time communication between orbiting satellites, manned spacecraft, carrier rockets and ground control stations and complementing the ground-based space tracking and telemetry stations and ships to support future space projects. Tianlian 2-01 was developed by CAST, based on the DFH-4 satellite bus. The 5.2 t TL-2A is a 3-axis stabilised, box-shaped satellite, equipped with two antenna systems working in S- and Ku-band and two solar arrays (10.5 kW). TL-2-01's dimensions are 2.36 x 2.10 x 3.60 m. The planned lifetime is 15 years. Compared with the precursor network of Tianlian 1 satellites, the new generation satellite performs a significantly faster data transfer and higher multi-objective service capability. It will play an important role in improving the real-time transmission, in-orbit security and mission flexibility for medium- and low-Earth orbiting satellites and manned spacecraft.

The TL-2 series will replace the four TL-1 satellites in orbit: Tianlian 1-01, launched April 2008, Tianlian 1-02, launched July 2011, Tianlian 1-03, launched July 2012, Tianlian 1-04, launched in November 2016.

NOTE: Yunhai 2-02 and 2-05 (2018-112B and E)
The orbits of the Yunhai-2 satellites, 02 and 05 (compare GoTaikonauts!, issue no 26, p. 18) were changed.

On 5 March 2019, Yunhai 2-02 (2018-112B) was tracked in a 564 x 574 km orbit at 50,01° inclination and with a period of 96.05 minutes. Yunhai 2-05 (2018-112E) was tracked in a 796 x 804 km orbit with 50,01° inclination and a period of 100.87 min.

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

AAAS	American Association for the Advancement of Science
AAPT	Academy of Aerospace Propulsion Technology
ACC	Astronaut Centre of China
AIOFM	Anhui Institute of Optics and Fine Mechanics
AO	Announcement of Opportunity
APSCO	Asia-Pacific Space Cooperation Organisation
BACC	Beijing Aerospace Command and Control Centre
BDS	BeiDou satellite navigation System
BJT	Beijing Time
BRI	Belt-and-Road Initiative
CALT	China Academy of Launch Vehicle Technology, 1st Academy of China Aerospace Science and Technology Corporation CASC
CAS	Chinese Academy of Sciences
CASC	China Aerospace Science and Technology Corporation
CASIC	China Aerospace Science and Industry Corporation
CAST	China Academy of Space Technology
CCTV	China Central Television
CE	Chang'e
CFOSat	China-France Oceanography Satellite
CGSTL	Chang Guang Satellite Technology
CIOMP	Changchun Institute of Optics, Fine Mechanics and Physics
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
CNSA	China National Space Administration
CPPCC	Chinese People's Political Consultative Conference
CRESDA	Centre for Resources Satellite Data and Applications
CSES	China Seismo-Electromagnetic Satellite mission
CSS	Chinese Space Station/China Space Station
CZ	Changzheng, Long March
DFH	Dong Fang Hong
ESA	European Space Agency
ESSTI	Ethiopian Space Science and Technology Institute
FAST	Five-Hundred Metre Aperture Spherical Radio Telescope
FY	Fengyun
GEO	Geostationary Orbit
GNSS	Global Navigation Satellite System
GRB	Gamma-ray Burst
IGSO	Inclined Geosynchronous Orbit
iPSC	induced pluripotent stem cells
ISRO	Indian Space Research Organisation
JSLC	Jiuquan Satellite Launch Centre
LEO	low Earth orbit
LEOP	launch and early orbit phase
LRO	Lunar Reconnaissance Orbiter
MoU	Memorandum of Understanding

NPC	National People's Congress
NSSC	National Space Science Center
OSTP	Office of Science and Technology Policy
P/L	payload
PSC	perovskite solar cells
QUESS	Quantum Experiments at Space Scale
RLV	reusable launch vehicle
Roscosmos	Russia's State Space Corporation
RSMC	Regional Specialised Meteorological Centres
SAST	Shanghai Academy of Spaceflight Technology
SASTIND	State Administration of Science, Technology and Industry for National Defense
SCO	Space Climate Observatory
SJTU	Shanghai Jiao Tong University
SKA	Square Kilometre Array
SMILE	Solar wind Magnetosphere Ionosphere Link Explorer
SSS	Student Small Satellite Project
TG	Tiangong
TZ	Tianzhou
TQ	Tianque
UN	United Nations
UNOOSA	UN Office for Outer Space Affairs
UTC	Coordinated Universal Time
VC	Venture Capital
WMC	World Meteorological Centres
WMO	World Meteorological Organisation
YW	Yuanwang
ZQ	Zhuque

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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

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Chang'e 4 – Behind the Moon (part 1)

The first three lunar days of operations on the far side of the Moon

by Jacqueline Myrrhe

1st lunar day - from approx. 2 to 13 January

3 January - lunar morning of 1st day

26 days after launch, Beijing Aerospace Control Centre (BACC) commanded CE-4 to initiate the fully autonomous landing sequence at 10:14 BJT (02:14 UTC).

At that moment, CE-4 flew at a relative velocity of 1.7 km/s and was 15 km over the lunar surface. It fired its single variable thruster, starting a 12-min long landing phase.

At an altitude of 5,635 m above the lunar surface with a velocity of ~ 85 m/s, the probe adjusted from horizontal flight to near-vertical flight, to ensure correct navigation results of the range sensor. While descending to 4,130 m above ground, the trajectory moved 77 m to the north and crossed a crater of approx. 200 m in diameter, finally reaching a velocity of ~78 m/s.

CE-4 continued its descent to 1,495 m, decreasing its velocity to ~ 51 m/s, and avoiding some craters with diameters of ~ 70-100 m to the northwest, nearing a more flat terrain. Then, CE-4 moved 244 m to the northwest while sinking to an altitude of 99 m. At this point, CE-4 hovered for ~ 13 s, the 3D laser imaging sensors scanned the terrain to identify smaller obstacles and to measure the slopes on the lunar surface. The scan took 250 millisec and the analysis another 750 milliseconds. Within 1 sec CE-4 "knew" whether the landing spot was safe or not. If not, two more landing opportunities were possible, even on the next day. CE-4 "decided" to move 12 m to the southwest, crossed a crater with a diameter of 25 m and reached a relatively flat region. During this manoeuvre, CE-4 decreased its height to 30 m, and the velocity changed to ~1.5 m/s. CE-4 continued its vertical descent.

At 2 m above the surface, the engine stopped, and the spacecraft landed with its four legs cushioning against the impact shock.

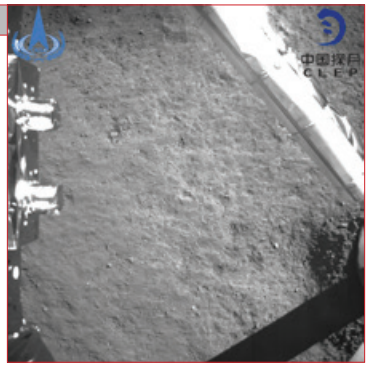
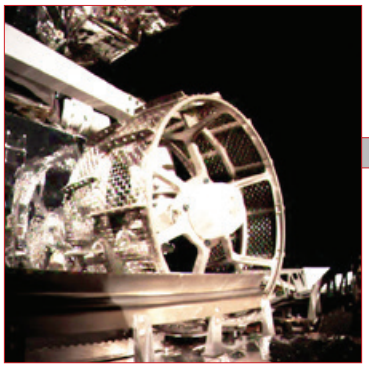
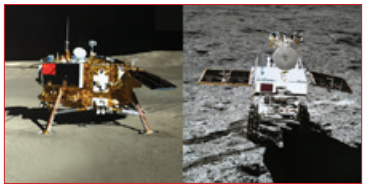


Photo of the landing spot taken by CE-4's descent landing camera. credit: CLEP/CNSA



One of Yutu-2's wheels. credit: CLEP/CNSA



Lander and rover photograph each other. credit: CLEP/CNSA

CE-4 soft landed at 10:26 BJT (02:26 UTC) in the Von Kármán Crater in the South Pole-Aitken Basin at the location 177.5991°E longitude and 45.4446°S latitude - almost super-precise at the planned spot of 178 E and 45.5 S. The elevation of the landing site is -5,935 m. (The deepest region on the Moon is - 9,100 m and is about 700 km to the south of that point.)

CE-4 became the first spacecraft to land on the far side of the Moon.

Queqiao transmitted images of the landing process and the landing spot back to BACC.

Chinese Vice Premier Liu He sent a congratulatory note to BACC. The Chinese state media reported that CE-4 succeeded landing on the Moon's far side. Considering the high pressure on the whole team, officials decided not to live stream the landing.

CNSA announced that the rover was named "Yutu 2" or "Jade Rabbit 2" as an outcome of a public poll.

CE-4's solar panels and antennas were unfolded by mission controllers in Beijing. The Lunar Lander Neutrons and Dosimetry (LND) experiment from the University of Kiel and the Swedish Advanced Small Analyzer for the Neutrals (ASAN) on the rover had been turned on for testing.

The first close-up photo of the Moon's far side, taken by the camera on the lander at 11:40 BJT, showed the direction the rover would drive into on the lunar surface. Yutu 2's panchromatic camera and the lunar penetrating radar were tested as well. Mission Control would then decide at which time the rover would be deployed.

At 17:00 BJT the three 5-m antennas of the Low-Frequency Radio Spectrometer (LFS, also: NCLE) on the lander have fully spread out.

Rover deployment

At 15:07 BJT, BACC sent the separation command for the rover. Yutu 2 (YT-2), atop the lander, unfolded its solar panel, deployed its mast and started to roll down the ramp very slowly. 3 monitoring cameras on the lander closely observed the six rover wheels and the rover during deployment.

The wheels of Yutu 1 have been the weak point during the Chang'e 3 mission. The new rover has been upgraded for greater reliability and longevity, in particular the cable insulation.

The rover reached the lunar surface at 22:22 BJT (14:22 UTC), and drove to a pre-set location, pausing in front of a small crater. Here, YT-2 entered a stand-by mode for protection from high temperatures of approx. 100°C during the lunar mid-day. YT-2 resumed operations on 10 January.

Yutu's lifetime is expected to be 3 months, while the lander's is 1 year.

4 January - lunar morning of 1st day

Rover and relay satellite established independent digital transmission link.

4 - 10 January – mid-day stand-by of 1st day

10-13 January – lunar afternoon of 1st day

On 11 January, YT-2 moved to the front side of the lander. Both lunar crafts photographed each other. These photos were sent to BACC where they appeared at 16:47 BJT on the screens.

Vice Premier Liu He and Zhang Youxia and high-ranking officials visited BACC to watch the lunar photo session. Liu He read a congratulatory message by the Communist Party of China Central Committee, the State Council and the Central Military Commission. The first-ever soft-landing on the far side of the Moon, was declared a complete success. With that, the 4th phase of China's lunar exploration programme and the deep-space exploration programme were inaugurated.

Also on 11 January, CNSA released several 360° panoramic photos taken by the panoramic camera on top of the lander. The images were pieced together in cylindrical and azimuthal projection from 80 single photos. (see title page) On hand of the photos, the rugged terrain with many small craters of different sizes was analysed and a route for the rover planned. CNSA also released a 12 min video of the landing sequence of the CE-4, which was produced by processing more than 4,700 pictures taken by the lander's descent camera.

Until the end of the 1st lunar day operations, YT-2 accumulated 44.2 m of traversing across the lunar surface.

Queqiao carries the complementary hardware of the low-frequency radio astronomical instrument (NCLE) developed by the Netherlands.

10 January

It became public that CNSA and NASA had pre-mission discussions during which the "Lunar Reconnaissance Orbiter (LRO)" team provided LRO's orbital data to the CE-4 team. In return, CNSA provided the time and position of CE-4's landing to NASA. The aim was to get LRO observing CE-4's landing and operations. LRO was not able to photograph the actual landing, but imagery from LRO's Narrow Angle Camera from before the landing and after the 3 January were compared and checked against the first photos by CE-4 showing the prominent crater in front of the lander (which is actually the back with the ramp) to identify the precise coordinates of the landing site.

12 January – lunar afternoon of 1st day

CE-4 prepared for its first dormant state during the lunar night with temperatures expected around -180° Celsius. YT-2 stayed located at about 18 m northwest of the lander. Rrover and lander switched to sleep mode.

Both craft are equipped with radioisotope heat sources, contributed by Russia, to support the key functions and temperature sensors

during the 14 Earth day-long lunar night. The lander is also equipped with an radioisotope thermoelectric cell to test it for future deep-space projects (like a base in the South Pole region or missions to Jupiter). All data collected during the lunar night, are stored and transmitted after waking up from the dormant mode.

1st lunar night – from approx. 13 to 28 January

14 January - first press conference
Press conference of the State Council Information Office.

16 January - MiniEcosphere
CNSA published a photo of a germinated cotton seed in the MiniEcosphere container on board the CE-4 lander.

19 January
NASA released a press statement in which the support to the Chang'e 4 mission was explained.

2nd lunar day – from approx. 28 January to 12 February

28 January - lunar morning of 2nd day
On 28 January, the sun begun to rise over the eastern edge of the crater. During the lunar night, the temperature readings by YT-2 and the CE-4 lander for the soil on the far side of the Moon showed - 190ºC, lower than the Apollo measurements and colder than expected from CE-3 data (probably due to the difference in lunar soil composition between the two sides of the Moon). For the first time Chinese scientists received first-hand temperature data from the far side.

29 January - lunar morning of 2nd day
According to the elevation angle of the sun over the lunar horizon, YT-2 automatically awoke on 29 January around 20:00 BJT and the lander ended the dormant state on 30 January at 20:39 BJT. The key instruments on the probe switch automatically to operational mode. Communication and data transfer was established and was stable.

30 January - lunar morning of 2nd day
NASA's Lunar Reconnaissance Orbiter LRO passed 330 km east of the landing site, 200 km over the lunar surface, taking a photo on which CE-4 appears a few pixels across and the rover was not recognisable.

31 January - lunar morning of 2nd day
LRO took the 2nd photo when it flew closer to the site. The data now also revealed the Yutu 2 rover at the size of just two pixels north of the lander. Shadows cast by the lander and rover were visible.

1 February - lunar morning of 2nd day
On 1 February, short after midnight (UTC), NASA's LRO passed nearly overhead the CE-4 landing site, taking with the Narrow Angle Camera a photo from 82 km height with the smallest possible pixel size of 0.85 m per pixel to get a sharp view of the lander and YT-2 rover. At the moment the photo was taken, YT-2 was 29 m northwest of the lander. NASA continued to image the site with the LRO cameras as the lighting changed and the rover moved.

4 - 8 February - mid-day stand-by of 2nd lunar day

9 February - lunar afternoon of 2nd day
NASA published LRO photos, showing lander and rover.

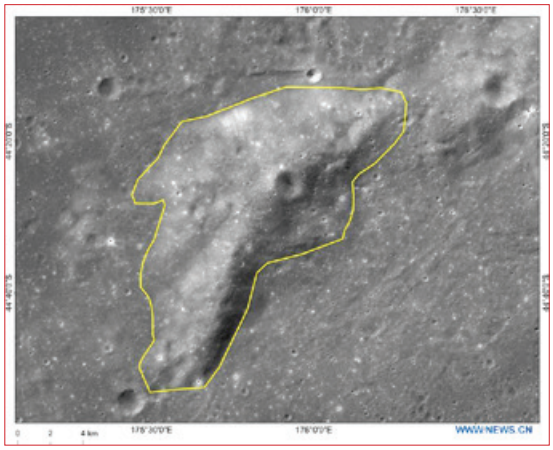
lunar afternoon of 2nd day
The payloads on board including low-frequency radio astronomical instrument, neutron radiation detector, infrared imaging spectrometer and neutral atomic detector have been operating smoothly as scheduled. The camera installed on the Yutu 2 rover took 360º panoramic photos of the lander.
Lander and rover worked stably through the 2nd lunar day. The payloads, including low-frequency radio spectrometer, LND, infrared imaging spectrometer and neutral atomic detector (ASAN) have been operating smoothly as scheduled.
YT-2 traversed 75.8 m, accumulating in total 120 m, breaking the Chinese record of 114 m held by Yutu 1. Although YT-2 is designed to traverse at a speed of 200 m/h (5.55 cm/sec), out of safety concerns it has been operating at a speed of 2 cm/sec.
YT-2 inspected its tracks and nearby rocks. The biggest rock with a diameter of about 20 cm was examined from a distance of 1.2 m with an infrared and visible light spectrometer.
To prevent interference between the communications relay function of Queqiao and the rover on the lunar surface, NCLE aboard Queqiao will only begin operations after Yutu 2's surface operations are concluded.

2nd lunar night – from approx. 12 - 27 February

The lander switched to dormant mode on 11 February at 19:00 BJT; YT-2 at 20:00 BJT on 10 February in preparation for sunset around 24 hours later on 12 February.

12 February - UNOOSA in Vienna, Austria
Lu Liangliang gave a presentation on the status of the Chang'e 4 mission at the UNOOSA Scientific and Technical Subcommittee:
"The introduction of Chang'e 4 mission and the vision of future Chinese lunar exploration activities"

15 February – naming of landing site
At a press conference on 15 February in Beijing held by CNSA, CSA and the International Astronomical Union (IAU), it was announced that CE-4's landing site was named "Statio Tianhe". "Tianhe" is the Chinese word for Milky Way and "Statio" is Latin for base. The IAU approved the naming along with the names for the craters "Zhinyu", "Hegu" and "Tianjin" in the region Statio Tianhe. The craters are located in the newly named hill Mons Tai after Mount Tai, a Chinese mountain of historical and cultural significance. Mount Tai was used to locate the landing site. All the five lunar surface features are located inside the Von Kármán Crater.



The image shows the area around Mons Tai, a hill near "Statio Tianhe", the landing site of the Chang'e 4 lunar probe. credit: Xinhua/CNSA

20 February
President Xi Jinping met in Beijing with SAST space scientists and engineers who participated in the research and development of the Chang'e 4 mission and congratulated them on the success.

3rd lunar day: from approx. 27 February to 13 March

YT-2 woke up at 10:51 BJT on 28 February and CE-4 at 7:52 BJT on 1 March. YT-2 unfolded its solar panels and dissipated heat. Lander and rover were in normal condition and resumed work. During the morning of the 3rd lunar day YT-2 drove 7 m.

3 - 10 March - mid-day stand-by of 3rd lunar day

During the afternoon, Yutu traversed another 36 m. Until the end of the 3rd lunar day, YT-2 accumulated 163 m of exploration across the lunar surface. By the end of the 3rd lunar night, the rover had surpassed its expected design lifetime of 3 months but was expected to continue.

7 March
Wu Weiren, Chief Designer of China's Lunar Exploration Programme confirmed during a press meeting on the side-lines of the 2nd session of the 13th National Committee of the Chinese People's Political Consultative Conference that the enormous amount of data collected during the CE-4 mission will be gradually accessible for scientists from all over the world. He confirmed: Rover and lander are working well.

3rd lunar night - from approx. 14 to 28 March

Expecting the 3rd lunar night, YT-2 entered sleep mode on 13 March, at 12:16 BJT (both spacecraft fold solar panels and are heated by radioisotope heater units).

4th lunar day: from approx. 28 March to 12 April

Yutu 2 woke up at 20:28 BJT on 29 March, unfolded its solar panels and re-established communications with Queqiao relay satellite. The CE-4 lander followed on 30 March at 18:14 BJT. Both – lander and rover – were in normal condition and resumed work. From 29 March to 1 April, Yutu 2 travelled 8 m before shutting down to avoid the mid-day heat.

to be continued in the next issue of GoTaikonauts!

Perspectives on Europe from the Far East

A Tale of Two Very Different Space Industries

by Blaine Curcio (Orbital Gateway Consulting)

At ESTEC. credit: B. Curcio

There are a small number of traditional superpowers in the global space industry, these being the United States, Europe, and Russia. As we have moved into the 21st century, China has ascended from a "middle-power" in space, with an accomplished space program that in many ways beats Russia, and in some ways, rivals Europe and even the U.S. Concurrently, several other space-faring nations, including Japan and India, have also developed into strong space powers in their respective niches. With this increasingly multipolar space world, collaboration between countries and regions is likely to become more important.

As the U.S.-China Trade War and broader tensions cause collaboration between the two nations in space to go from extremely unlikely to outright unthinkable, collaboration between other powers is far more likely. In addition, despite historically very strong political, cultural, and economic ties, U.S.-European space collaboration is not as straightforward as it may seem. With an increasing amount of U.S. space activity being led by private companies - many of which compete with European players for similar customers - collaboration may become more strained moving forward. As a consequence, this means that China-European collaboration will likely become an element of growing importance to the global space industry in the future.

An American China Space Guy in Europe

Given the dynamics between Europe and China in space, there is no better time than now to explore the space industries of these two radically different, but also in some ways surprisingly similar space powers. This is where I come in. As the self-proclaimed #ChinaSpaceGuy, I have spent most of the past several years immersing myself in the budding Chinese commercial space industry. Combined with my China experience was my wholly American background, having spent most of the first 22 years of my life there. Despite a depth of experience in these two places and the space industries therein, my firsthand experience within the European space industry was, up until 2019, limited enough to where I still pronounced the European Space Agency as the "E-S-A", rather than ESA. So, when the opportunity arose for me to attend the Euroconsult World Satellite Business Week in Paris in September 2019 as part of my affiliate role with the company, I not only took it, but I elected to extend the trip far beyond the week of the conference, turning it into a 5-week remote working exercise involving around 2 weeks in Euroconsult offices in Paris and Toulouse, and around 2 weeks visiting space companies in Belgium, France, Luxembourg, Netherlands, and UK (plus one week of a heck of a conference). The overall trip provided many opportunities to compare, contrast, and just contemplate the differences and similarities between China and Europe in the space domain.

The Chinese Space Industry is Geographically Concentrated and Broadly Homogenous. The European One is Not.

One of the most striking aspects of China's space industry is the degree of geographic concentration. While a handful of startups have been so bold as to set up shop in cities ranging from Shanghai to Wuhan to Xi'an to Shenzhen, the overwhelming majority of the industry money, talent, and decision-making are concentrated in Beijing. This is not limited to the space industry - indeed, Beijing is so overly crowded with large companies that the central government has recently elected to start moving research institutes and government agencies to the Xiong'an New Area, around 100 km Southwest of Beijing, in order to relieve pressure on the capital. However, given the concentration of state-owned enterprises (SOEs) in the space industry today, and the extent to which many private companies would hope to do business with those SOEs, the space industry is even more concentrated in Beijing than many industries in China. Separate to the geographic concentration, the Chinese space industry is broadly homogenous, insofar as almost all Chinese space industry employees are, as it were, Chinese. The founders of most Chinese private space companies come from a limited number of state-owned companies, and most of them have graduated from one of a handful of universities, namely, Beihang, Harbin Institute of Technology (HIT), Northwestern Polytechnical University (NPU), and a few others.

This is, unsurprisingly, in sharp contrast to the European space industry. Comprised of several dozen countries and a broader variety of private companies, the European space industry does not necessarily have a true "core", per se, but rather several major focus cities, including Toulouse, Paris, Leiden/Noordwijk, Madrid, Bremen, Darmstadt, Munich, and others, with several other cities/countries, including Luxembourg, Berlin, and London/Surrey playing important roles primarily for private space startups. Likewise, while there are clearly a handful of highly selective space-focused universities in Europe from which a disproportionate number of space people graduate, there is a much wider variety of universities, and indeed, many space industry founders in Europe do not come from such a "traditional space" background, meaning they may have come from a wholly non-space university.

In my experience, the geographic distribution of companies and institutions in Europe, the more diverse variety of backgrounds, and potentially, the more "open" nature of the space industry has contributed to a broader variety of ideas and perspectives. For example, speaking with someone in Paris about the EU space industry, you will hear a wholly different perspective than someone in Noordwijk, or someone in Toulouse. This diversity is a strength in the sense that relative to China, Europe may have a broader variety of space startups, drawing talent from a greater variety of labor markets. With that said, such diversity can also be a weakness, in the sense that coordination is much more difficult, resource allocation is rather more zero-sum, and the interests of a broader variety of groups are consulted.

Moving forward, China is likely to see increased diversification of its space industry across geographic lines. Several cities are starting to attract significant space investment from major companies, with the most noteworthy being Wuhan, which as part of its Wuhan Aerospace Industrial Base, has seen China Aerospace Science and Industry Corporation (CASIC, a major SOE) commercial subsidiaries Expace and Xingyun founded in the city, complementing an existing group of EO data analytics companies that leverage the city's strong university programs in this area (namely Wuhan University and, to a lesser extent in terms of EO, Huazhong University of Science and Technology). Shenzhen, likewise, is working to attract more space companies, companies that will undoubtedly be attracted by the city's exceptional tech industry, highly-talented workforce,

government incentives for educated space workers, and a few sizable space companies already established there. With that said, the geographic dispersion of the Chinese space industry will need to be accompanied by, to some extent, a dispersion of resources, of decision-making ability, and of opportunities, in order for there to be a broader variety of perspectives on Chinese space. Until then, we are likely to continue to see from China a small number of huge space companies all following the same broad statements - "Belt and Road" as a guide for foreign market entry, "China Space Dream", or the now-less-used "Made in China 2025" as a guide for technological advancement, and "National Rejuvenation" as a guide for underlying ethos. While all good concepts, such a small number of vague phrases is not likely to give rise to a diverse variety of companies doing a diverse variety of things. More likely, it will give rise to many companies behaving in more or less the same way, pursuing goals for policy reasons, rather than economic ones.

The Relationship Between Government and Private Sector is Similar, but Different

The global space industry has historically been driven by governments, with private companies only more recently coming into the picture. While China has seen a sudden explosion of private companies over the past few years, Europe has a much longer legacy of private space activity. In both places, the government plays an active role in trying to develop the space industry. In China, however, this government action tends to be more regional or provincial-level in nature, whereas in Europe, where none of the companies is an SOE, ESA plays a significant role in helping private companies. It is one of ESA's primary tasks to strengthen the stability and competiveness of Europe's space industry. Based on the principle of "fair return", the funds ESA Member States provide to ESA's programs are redistributed accordingly to their national industries via contracts. Also called "geographic return", this process ensures that the funds given to ESA benefit the respective ESA Member State. For example, if the German government contributed to ESA's Telecommunications Programme 20 % of the total funding, then German industry can expect to obtain 20 % of the value of the contracts for building hardware, conducting research or developing technology in the execution of the corresponding Telecommunications Programme. A second pillar of ESA's support for industry is the targeted breeding of space startups. For that, ESA's Business Incubation Centres (BICs), help companies to build a business model by utilizing - free of charge - space technologies from ESA's portfolio. Startups are provided with 50,000 Euros of seed-money and an office in one of the BIC locations distributed over Europe. So far, 650 startups have created more than 100 new companies, more than 400 successful technology transfers and have attracted more than €20 million in investment. Likewise, ESA Business Applications aim to nurture private companies trying to promote space applications, as well as to develop technologies specific to space, across a variety of verticals including satellite communications, satellite navigation, Earth observation, etc. In the case of Europe, there is also government support on the national level, trying to make life easier for space startups.

In the case of China, it is rather different. The China National Space Administration (CNSA) and China Aerospace Science and Technology Corporation (CASC - combined, probably the most similar entities that China has to ESA) are not nearly as supportive of private space companies. This is due to several factors, but most notably, in a difference in incentives. CASC has an effective monopoly on much of the space industry in China, which means that implicitly, if startups enter the industry, the degree of monopolization should decrease. This means that CASC is much less likely to support commercial space ventures in China. The CNSA, on the other hand, does not benefit from such a monopoly as CASC, but also does not necessarily have the resources or the mandate to actively help private space companies. As such, the most governmental help that private space companies receive in China comes from provincial and city governments. This includes the aforementioned Wuhan Aerospace Industrial Base, which has benefitted from significant support from the Wuhan (city-level) and Hubei (provincial-level) government, as well as free land (one example being Huzhou City, Zhejiang Province, giving LandSpace a free location for their rocket factory), tax deferrals, or access to university R&D resources or talent.

While this type of regional or city-specific incentive also exists in the EU, they tend to be secondary to the broader ESA infrastructure, with this again being due to the different incentive structures in place: CASC is, after all, a company with publicly-reported revenues, whereas ESA is an inter-governmental organization receiving funding from its Member States.

The Power Structure is Very Different

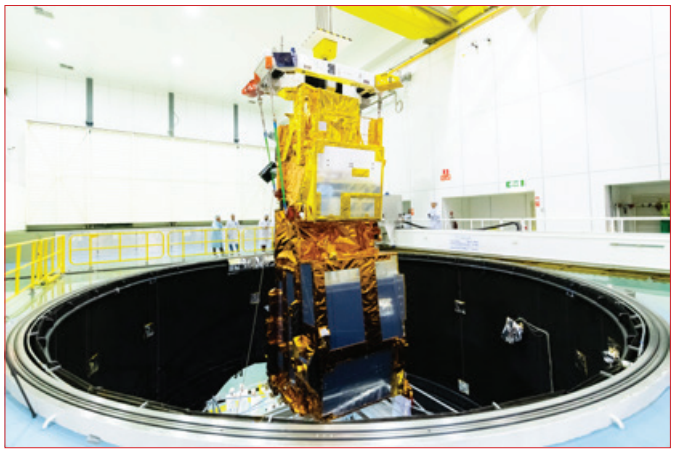
Possibly the most significant difference between the space industries of China and Europe is the power structure. As mentioned above, the closest thing that China has to ESA is CASC + CNSA. However, the fact that there is a division into two different organizations is itself significant. The CNSA has significant administrative power in designing various space programs in China, but unlike ESA (or NASA for that matter), CNSA does not actually **build** anything - it is a purely administrative body. The building is left to CASC, the Chinese Academy of Sciences (CAS), and in some instances, CASIC. This means that CNSA has limited scope for distributing funds to startups, and that CASC and the CAS have much greater scope.

By comparison, ESA has a certain scope for **building** and **testing** space hardware, with the main space hardware development and research taking place at enterprises such as Airbus, Thales, and other European space companies. If Europe were to adopt a similar framework to China, it would basically involve ESA no longer building anything, but rather acting only as an administrative body, and Airbus/Thales/others

Arial view of ESTEC, in the Netherlands, is where most ESA projects are guided through the various phases of development. The location also hosts Europe's largest satellite test centre. Both, individual components and complete satellites, are tested to ensure their readiness for the conditions during launch and the vacuum and temperature extremes of space. Credit: ESA

controlling all of the actual building of things. In such a scenario, there would likely be a marked decline in support for private challengers that might take away pieces of the implicit duopoly or oligopoly that would arise as a result.

Another characteristic specific to Europe is that next to the national and ESA component, the European Commission is increasing its ambitions for space. There are currently efforts ongoing to establish a European Union space agency which would focus on launchers, navigation and space applications. The near future will show in which directions those ambitions will grow.



During the visit to ESTEC, the MetOp-2nd generation satellite was visible through the open hatch of the Large Space Simulator, the largest vacuum chamber in Europe. On this archive photo the MetOp's structural and themal model is being lowered into the Space Simulator, ahead of thermal vacuum testing during summer 2019. ESTEC's test facility also houses Europe's loudest sound system, used to expose satellites to simulated launch noise. Likewise, Europe's most powerful shaker table is hosted at ESTEC. Credit: ESA-SJM Photography

The larger consolidation of power within the Chinese space industry means that startups face a more difficult challenge in finding business, navigating bureaucracy, and otherwise "surviving". While it's surely not easy being a New Space company in Europe, it can be downright hostile in China. This is in even more stark contrast to the United States, where NASA has for years actively encouraged startups to dream big through the granting of contracts. This can be thought of in a very simple way - NASA likes SpaceX (and other such companies), NASA would like the United States to create more companies like SpaceX, therefore, NASA tries to help these companies. Conversely, CASC (and others) are, for understandable reasons given their place in the market, less happy to support upstart space companies.

The Future Relationship Between Europe and the Far East

Europe and China clearly have very different space industries, but this is unlikely to significantly inhibit future collaboration between the two. The most immediately apparent area of collaboration will likely be money - China, and Asia more broadly, has experienced a savings glut the likes of which the world has never seen, and Europe, for better or worse, is facing budgetary headwinds as the economy struggles to emerge from the Global Recession of more than 10 years ago. One of the company visits during my trip to Europe was to the company formerly known as Newtec, headquartered in Sint Niklaas, Belgium. Newtec is one of the most innovative modem manufacturers out there, and has seen strong growth over the past several years across the world. Shortly before our visit, the company was purchased by ST Engineering, a Singaporean conglomerate that also owns iDirect, for US$281 million. While Singapore is obviously not China, the acquisition is likely to mark a larger trend - Asian money coming into Europe. Indeed, while the number of Chinese acquisitions of European space companies has been negligible, this is oftentimes because of political difficulties related to acquiring intellectual property, or other, more "national-level" strategic considerations, rather than due to a lack of interest from the Chinese side in buying into Europe.

Moving forward, these strategic considerations on the side of Europe may be changing. The most apparent example was a recent visit by French President Emmanuel Macron to China, during which time he met with Chinese President Xi Jinping to discuss, among other things, deepened collaboration in the space domain. Specifically, this included points of collaboration on lunar missions and Earth observation missions. This followed a March 2019 summit between the two in Europe, whereby a "letter of intent" for space collaboration was signed, which allowed France to include scientific instruments on the Chang'e-6 Moon mission, to be conducted by China in the early-mid 2020s. During Macron's recent visit to China, his rhetoric was also noteworthy in the sense that he was, at many points, clearly trying to speak on behalf of the broader European Union, rather than simply France. This was evidenced by, among other things, Macron's inclusion of an Irish European Commissioner and a German minister, among other significant non-French delegates, in his trip to China.

While Europe is unlikely to blindly sell its IP to China (or anyone else) in the coming years, there is nonetheless likely to be a certain degree of Chinese money flowing into the European space industry, with European technology flowing the other way. Ultimately, this has the potential to benefit both in what is becoming a larger and more competitive space industry. In order for Europe to have a better chance of competing against the plethora of U.S. startups emerging as we speak, money will be needed. In order for China to compete, technology will be needed. If done well, such collaboration could be of strong mutual benefit.

Conclusions

Having spent more than 5 years living in Mainland China, and having spent a mere 5 weeks exploring Europe's space industry, my perspectives are to some extent limited. However, following a battery of meetings, company visits, and thought-provoking discussions, there are some key takeaways that may serve as food for thought when contemplating these two very different space industries.

In looking at Europe, its strength comes from its diversity. Different regions, different perspectives, and a diffusion of power and influence mean that European space startups will continue to produce diverse ideas propelled by economic incentives, technological necessity, or other "market-based" reasons. The European space industry's strong legacy and its technological depth likewise provide strength - for example, there is a striking difference in the number of older people working in the EU space industry compared to China, where there is a very real "old guard", but where most of the private space companies have founders in their 30s, if not 20s.

China's strengths come from its massive size. The sheer number of engineers, the number of huge state-owned subsidiaries, and the amount of VC funding available to space is on a different scale to Europe. For example, as many as 4 private launch companies in China have raised more than EUR 100 million from VCs, a figure that will probably increase further in 2020 before a likely consolidation in the early 2020s.

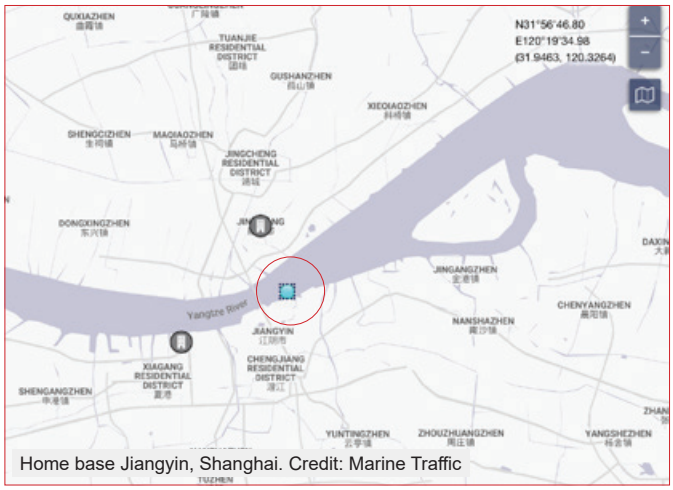
In the long run, China and Europe may well find themselves increasingly intertwined in what may be a new space race between the United States and everyone else. If Jeff Bezos, Elon Musk, NASA, or some combination thereof start to do truly revolutionary things in space, due to the fact that the United States has both the money and the diversity, China and Europe may ultimately find in one another a partner very different from themselves, but one that is indispensable if either hopes to play a leading role in the future development of the human infrastructure in space.

Following Yuanwang tracking ships, autumn 2019

by Brian Harvey

Go Taikonauts! 26 reviewed the operations of China's ocean-going tracking fleet, the Yuanwang for the period mid-June to mid-September 2019 (*Following Yuanwang tracking ships*). With the benefit of the Automatic Identification System (AIS), which sends signals from each ship, it is possible to follow their movements to see what can be learned about the Chinese space programme - principally its launches - and its tracking system. China's current tracking fleet comprises four ships: Yuanwang 3, the oldest; 5 and the recent sister ships 6 and 7. An early point to make is that the tracking fleet does not appear to track all Chinese space missions, but concentrates on those going to high orbit, where the transfer burn is critical (an exception in July was the Yaogan military satellite). The end of this period also saw the long-awaited launch of the Long March CZ-5, a vital part of China's long-term plans for building a space station as well as lunar and Martian space missions, where receiving telemetry was imperative.

The home base of the fleet is generally stated to be Shanghai, or more precisely, Jiangyin. This normally means moored in the river below the bridge at Jiangyin, but may mean a number of anchorages in the vicinity. Ships may be stated to have arrived in 'Shanghai', which may or may not mean the Jiangyin anchorage, or may pass Shanghai en route to this anchorage. Another important feature of the tracking system is that it can be intermittent and there may be no broadcast signal from a ship at sea for several weeks, which may not necessarily be of any significance.

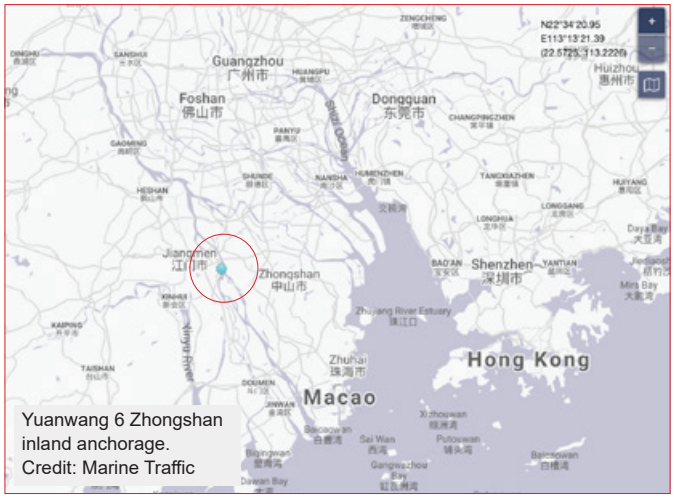


Home base Jiangyin, Shanghai. Credit: Marine Traffic

In addition to the tracking ships, there are two other Yuanwang, 21 and 22, cargo ships which bring the large-size components of the CZ-7 and CZ-5 to the Wenchang launch site on the island of Hainan whence they are later launched. Yuanwang 21 and 22 left Tianjin port on 12 October where the parts are made, arriving at Qinglan port near Wenchang on 27 October, returning on 25 November but to Jiangsu just north of Shanghai.


Yuanwang 22 transporting the CZ-5 to Wenchang in October 2019. Credit: Xinhua

At the start of this period, only Yuanwang 7 was at sea, but it was subsequently, like Yuanwang 5 and 3 to make lengthy sea journeys. The ship that least fits the pattern of the tracking ships is Yuanwang 6. During this period it was principally based on the port and anchorage of Tieshan (21ºN, 109º). Tieshan is in the Gulf of Tonkin, the south-west corner of China contiguous with Vietnam, to the east of the city of Beihai. Yuanwang 6 made two types of journeys: first, through the straits of Hainan, along the coast to Zhongshan, up the Xijiang river to anchor, quite a way inland to the west of Hong Kong and Macau, before returning to Tieshan. Yuanwang 6 also made at least four journeys from Tieshan to Sanya, the principal city on the south of Hainan (pop. 685,000), called 'China's Hawaii' for attracting tourists and the elderly. On no occasion did it stay any length of time, returning quickly to Tieshan. This itinerary does not appear to serve any obvious tracking purpose. It could be ferrying equipment to and from these various locations, but it is difficult to see how it would be a suitable ship for doing so. It could be fulfilling a training purpose, but these relatively short and repetitive journeys seem ill-suited for training personnel for lengthy ocean-going voyages. Yuanwang 6's movements are mysterious.



Yuanwang 6 Zhongshan inland anchorage. Credit: Marine Traffic

Yuanwang 3

The other ships all made ocean-going journeys. In numerical order, Yuanwang 3 was in port in Jiangyin at the start of the period, leaving for the open sea on 29 September. Yuanwang 3 travelled under full power (16-17 knots) for two weeks, through the Philippine Sea, north of the Marianas, east of Guam, through Micronesia, north of Nauru, passing near Baker Island, before stopping on 10 October in the mid-Pacific between Roreti in the Gilbert Islands and Howland Island. Thereafter, the ship kept its engines running, apparently circling at low speed (1 knot) at 3ºS, 177º. At this point, it appears to have been on station, for it coincided with the launch of the TJSW-4 communications test satellite from Xichang on the CZ-3B on 17 October.

On the 18 October, the day after, Yuanwang 3 picked up speed and announced a destination of Suva, capital of Fiji, where it arrived on 21 October. Yuanwang 3 stayed there for six days and headed past Tuvalu and Tonga, stopping for the second time on 31 October at a similar location as before, just south of the Equator east of Roreti (2ºS, 178º). Apparently on station again, this coincided with the launch of Beidou DW49 to 55º inclined geosynchronous orbit on the CZ-3B from Xichang on 4 November. The next day, 5 November, Yuanwang 3 picked up speed to 17 knots. Yuanwang sailed north west, through Micronesia, east of Guam and the Philippine Sea and then surprisingly appeared on 15 November off the Japanese launching base of Kagoshima at the southern end of the Japanese archipelago (20ºN, 137º), where it stayed for some time. The most likely Chinese launching to merit tracking during this period was Beidou DW50 M21 and DW51 M22 to 55º, Medium Earth Orbit (MEO) on 23 November, but why a tracking

location just south of Japan was chosen is unknown. There were no Japanese launchings during this period, either carried out or planned.

Yuanwang 3 off Kagoshima.
Credit: Marine Traffic

Yuanwang 3 was still there on 3 December and shortly thereafter headed south east through the northern Marianas and Micronesia in early December, reaching the Bismarck Sea on 10 December and arriving at Suva, Fiji on 14 December, where it joined Yuanwang 7 which had already docked there on the 11. Yuanwang 3 stayed there until the 19 when it departed, heading east until it took up position on 25 December just south of the Equator at 3ºS, -152º, almost due south of Hawaii in the mid-Pacific and the most easterly point of any tracking ship. There it was for the CZ-5 launch on the 27 December. Unsurprisingly, Yuanwang 3 put on a burst of speed on 28 December (17 knots), sailing westward just south of the Equator and heading past Baker Island (2ºS, -173º) on 31 December. Initially, one might have suspected that it was heading home, but it was back at its traditional position east of Roreti (1ºS, 178º) on 3 January 2020. At the time, no new launch was known to be scheduled to merit its staying at sea and it is normal for the Chinese space programme to wind down its activities after the end of December in advance of the upcoming Chinese new year. It could have been staying at sea in order to continue monitoring CZ-5's payload, the new Shijian 20 communication satellite.

Yuanwang 5

Yuanwang 5 was in its home port in Jiangyin, Shanghai at the start of the period and moored there for two months until it left on 10 November, taking the traditional course east of the Philippines. Whereas Yuanwang 3 sailed eastward far out to the mid-Pacific, Yuanwang 5 headed instead south into the Indonesian archipelago, reaching the Molucca Sea on the 17 November, the Banda Sea on the 18 and passed north east of Timor on the 19. On the 26, it announced a destination of Davao at the southern tip of the Philippines, though it seemed in no hurry to arrive, lingering in the Banda Sea, and not arriving in Davao until 6 December, officially for food and fresh water. Space science students of the Jesuit Ateneo de Davao University were given a tour **(1)**. Four days later it left, announcing Shanghai as the destination, but this was changed to the open sea two days later. Yuanwang 5 proceeded past Timor Leste to the Timor Sea where it reached 10ºS, 125º on 15 December, travelling slowly (5 knots).

Yuanwang 5 picked up speed on the 22 December (14 knots), heading northward, passing east of the Philippines but then disappearing from the tracking system until the 29 December when it appeared north east of Taiwan, homeward bound for Shanghai where it arrived on the 31 and dropped anchor. This gap is important, because it was over the Philippines when the second CZ-5 failed in July 2017. We do not know, but it would not have brought Yuanwang off its course on the 27 to stop east of the Philippines under the CZ-5's flight path for the critical completion of the burn to orbit.

The other question, though, is what was the purpose of Yuanwang 5's expedition to the south-western Indonesian archipelago? (17 November until 6 December) This was not a traditional Yuanwang location. The most likely candidate is Beidou DW50 and DW51 to MEO on 23 November, also likely being tracked by Yuanwang 3 to the far north off Japan.

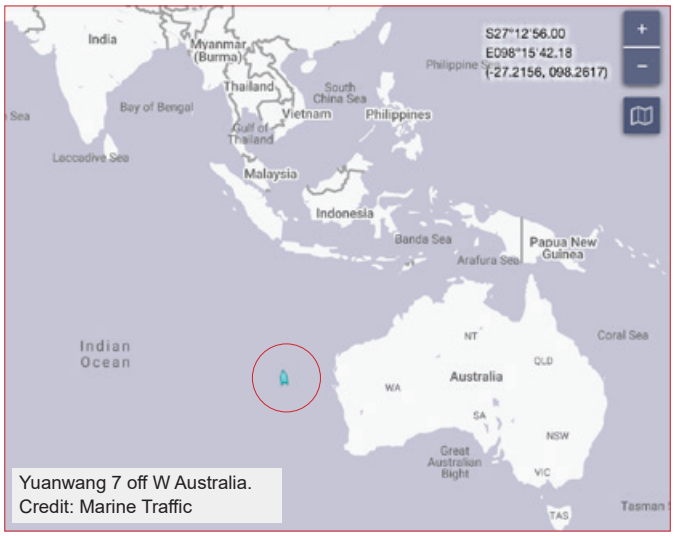
Yuanwang 7

Finally, Yuanwang 7 left Shanghai on 12 September and passed Davao in the Philippines on 18 September. Yuanwang 7 sailed at what could be considered a moderate speed (7 to 12 knots) through the south eastern Indonesian archipelago for a week (Banda Sea, Timor Sea) before accelerating westward to reach what seems to be its station off western Australia on the 29 September (24ºS, 109º). Its stay in the Timor Sea coincided with Beidou DW47 M23 and DW48 M24 to Medium Earth Orbit (MEO) on 23 September on the CZ-3B from Xichang.

Yuanwang 7 circled on station off western Australia - Carnarvon being the nearest point of reference - for a little more than a week, before announcing a return to Shanghai on 4 October. There were no launches during this period, so the purpose of this excursion is not evident. Was a later launch (e.g. Beidou, TJSW) intended for this period but delayed? By 7 October, Yuanwang 7 had passed Christmas Island on its way home, back in Shanghai by 15 October and anchored in Jiangyin on the 16 after a five-week voyage. It stayed moored there for three weeks.

Yuanwang 7 departed Jiangyin on 10 November, the same day as Yuanwang 5, so it was a double departure. Yuanwang 7

Yuanwang 7 Molucca Sea.
Credit: Marine Traffic



Yuanwang 7 off W Australia.
Credit: Marine Traffic

headed south, past the Philippines to the east and into the south eastern Indonesian archipelago, through the Molucca Sea, arriving north of Timor on 17 November. Three days later, it announced 'Destination Suva'. Far from proceeding to Suva, Yuanwang 7 then made a detour to western Australia again, arriving on the 21 and being almost stopped west north west of Perth on 25 November. This coincided with the Beidou DW50 and DW51 launch on 23 November. By the 27 Yuanwang 7 was on the move again, traversed the Indonesian archipelago and reached the Bismarck Sea on 7 December. Yuanwang 7 sped through the Solomons to arrive in Suva, Fiji on 11 December, to be joined three days later by Yuanwang 3. During the visit to Fiji, Yuanwang 7 crew members went ashore to Tamavua village where they presented villagers with volleyballs, sporting equipment, household cleansing gear and soccer balls, with none of the diplomatic fuss from the Australians that characterised earlier visits. Yuanwang 7 left Suva for the open sea on 20 December **(2)**. There was then a gap in the signalling record until 1 January when it signalled a 'Returning to Shanghai, due back 18 January' message. By this stage, Yuanwang was far across the Pacific, at 8ºS, -132º, on the latitude of Peru. This suggests that it may have tracked the CZ-5 launch from the mid-Pacific but stayed at sea for continued monitoring.

Finally, some family news. On 20 October, 24 couples took part in a mass wedding ceremony on one of the Yuanwangs, most likely when moored in port. It was most likely on Yuanwang 5 or 7, both in port at the time.

Yuanwang mass wedding in October 2019. Credit: Xinhua

Observations

As may be seen, the signal record is incomplete and we lack information on Yuanwang 7 and 5 at the time of the CZ-5 launch. We are left with a number of mysteries:

- What explains the itinerary of Yuanwang 6? Its multiple journeys from Tieshan, both to Sanya and inland locations west of Hong Kong and Macao have established a well-set pattern, but cannot be readily explained for purposes of tracking, transporting equipment nor training. Is it even possible that it is not currently sailing as part of the tracking fleet but is being used for another purpose? This too would seem unlikely and the official, most recent position is that China does still have four tracking ships in its fleet **(3)**.
- Is the southern Indonesian archipelago in effect a new station? It is reasonable for ships en route to the western Australia station to sail through this route, but several ships spent time there;
- Was the location offshore of Kagoshima, used by Yuanwang 3 at the southern tip of Japan, also a new station?
- Why was Yuanwang 7 off Carnarvon in early October when there were no launches then - or were they delayed?

To answer the question, What launches were the Yuanwang tracking? the evidence suggests that the tracking fleet of

Yuanwang 7 furthest east. Credit: Marine Traffic

Yuanwang 3, 5 and 7 was used to monitor the following launches:

- Beidou DW47 M23 and DW48 M24 on 23 September (MEO);
- TJSW 4 on 17 October (geosynchronous);
- Beidou DW49 on 4 November (geosynchronous);
- Beidou DW50 M21 and DW51 M22 on 23 November (MEO); and
- Shijian 20 on 27 December (the CZ-5 launching).

It is not difficult to match the movements of the fleet to these particular events. In the lead-up to these launches, the ships take up a position, travel at slow speed, possibly circling. They normally depart the moment a mission is successfully

Festive atmosphere in October 2019 on a Yuanwang tracking ship with a mass wedding of staff usually doing duty on the vessels. Credit: Xinhua

concluded, although Yuanwang 7 remained in the Pacific long after the CZ-5 test. Our problems arise for brief periods when we do not have ship data. One more problematical launch was the double Beidou launching to MEO on 16 December (DW52 M19, DW53 M20) (MEO) (CZ-3B, Xichang). Yuanwang 7 was in port in Suva at the time and Yuanwang 3 was putting into port in Suva, where it arrived the next day. This left only Yuanwang 5 to track the mission from the Timor Sea, though it is possible that its companion ships also did so from their locations in Suva or nearby. There were other Chinese launchings for low Earth orbit or commercial missions during this mid-September to end December period, but they were not apparently connected to or had the necessity for maritime tracking.

The use of the tracking fleet, which is a substantial and costly outlay, indicates the priority given to tracking missions to geosynchronous and MEO orbit, especially in the Beidou and TJSW series, as well as the obvious importance of tracking the successful return to flight of the CZ-5.

Acknowledgements

My thanks go to Marine Traffic for the raw data reports.

Notes:

1. Consulate: *Chinese research vessel in Davao to get provisions*. ABS CNS News, 8 December 2019.
2. Madigibilu, Ana: *Tracking ship stops to refuel, restock*. Fiji Times, 18 December 2019.
3. Li, Yan: *China's spacecraft tracking ships depart for missions*. Xinhua, 11 November 2019.

Unearthing Aviation, Aerospace, and the Cosmos at Beijing's Air and Space Museum

by Donovan Cosby
https://www.donesladventure.com/

"5...4...3...2...1, liftoff! We have liftoff!" Ah, music to my ears, and if you're reading this, probably to yours too, eh? Mankind's journey into space, from Russia's launch of the first satellite, to NASA putting a man on the Moon, and in today's world, Space X blasting the first reusable rockets into the upper regions of the atmosphere, has been nothing short of an astonishing feat.

But one wonders - where does China come into play? As both a bonafide space geek and expat of the Hermit Kingdom for the past 7+ years, I've always been curious about what accomplishments and developments China, now the world's second largest economy, has done in the race to explore this beautiful universe we live in?

And over those years I've come to discover that, well, China's done plenty, from launching its first satellite in 1970, founding the China National Space Administration in 1993, and conducting manned space flight missions by 2003, to laying the foundation for Tiangong-1, its homegrown orbiting space station, in 2011, creating its own BeiDou Navigation Satellite System in the same year, and dropping a rover on the far side of the Moon at the start of 2019. Jeez, that's just the abridged version!

But there's still much to uncover about China's awe-inspiring history and future in the 'space race'. So where to? Where could I possibly go in China to learn more about the country's history and budding developments in the field? The short answer: Beijing's Air and Space Museum. Well, duh!

Tucked away on Beihang University's campus in Haidian Qu, the Beijing Air and Space Museum was founded in 1985 - then under the name Beijing Aviation Museum - and opened to the public in 1986, with the purpose of highlighting China's long-standing evolution in aviation and aeronautics. It covers an exhibition area of 8,300 m^2, contains over 300 artifacts, and is open for individuals and small to big groups. And with that, here...we...go.

The Launch

Liftoff, again. An engine turns. Millions of electronics and lifeless gadgets suddenly spring into action. A long, shiny honk of metal powers up and reaches speeds of 300 km/h in minutes. Nope, it isn't a shuttle rocket this time around - it's China's high-speed train.

It was early morning, and from my home in Shanghai it clocked into Beijing, some 1,300-kilometers away, in just under 5 hours. Beat that NASA!

I'd make an online ticket reservation to visit the museum, crash at a hotel, and hit the attraction by 9 a.m. sharp the next day. Yep, easy does it.

I reached the Air and Space Museum at Beihang University with the help of Apple Maps, and strangely enough, on the outside, it looked like any other building you'd see on campus. But inside, oh boy, therein lay a powerhouse of information, models, and cultural relics spread across several comprehensive exhibitions.

Dream of the Sky

Walk in and you're immediately greeted by a showroom riddled with propellers, wings, engine parts, landing gear, onboard equipment, and other proponents belonging to commercial passenger aircrafts. You know, planes us regular folks use when flying from, let's say, London to New York.

Seeing real life mechanical parts from everyday airliners that've flown across the planet was a great introduction, and warm-up, for the museum's next exhibitions, which featured advanced aircrafts equipped with faster speeds, firepower, and the capability of reaching Earth's outer realm. Speaking of which ...

Silver Eagle Air Patrol

There I was - the coolest portion of the Beijing Air and Space Museum right in front of me. It was the Silver Eagle Air Patrol Exhibition - massive hanger that housed over 30 small to large-scale homegrown and internationally-made aircrafts. Now that was something you don't see every day!

The collection represented a timeline of aircraft developments over decades, and each plane, or even, helicopter, came equipped with a digital panel containing photos and detailed information of their design and history. The exhibition housed

The family of Long March rockets.

China's Feitian space suit for EVAs.

combat planes, bombers, patrollers, reconnaissance jets, transporters, vertical take-off planes, and multipurpose aircraft.

For the kid and adult that's had dreams of one day soaring over the seas and across the open skies, I'd say the exhibition was every bit of a perfect source of inspiration.

Air-Day Corridor

On the 2nd floor lay small models of various aircraft hanging from the ceiling and numerous text displays documenting significant people, technology, and events that have shaped today's aviation and aerospace industries.

Did it look cool? Sure. Was it very well organized? No doubt. And I'm sure the information was just as intriguing and thorough as the museum's physical collections, but there was just one problem: It was all in Chinese! Aaaarrgh!

Shenzhou Qiantang

And finally, on to the last leg of the museum, and exactly what I had come to see: China's achievements in the field of space exploration.

Heading into the Shenzhou Quantang exhibition one thing was clear from the start; that is, space isn't always just about big rocket ships, the search for new planets, making contact with UFOs, and 'out-of-this-world' tech. No, no, no. Concurringly, investigations into Earth's upper atmosphere and beyond also includes coverage on a number of indispensable aerospace topics such as air defense, communication networks, mapping Earth, weather tracking, science experiments, and monitoring the planet to improve conditions for human beings.

For instance, one of the exhibition's prominent displays, and, only English display in the entire museum, focused on the development and application of China's BeiDou Navigation Satellite System.

Now for me, BNSS - the equivalent of GPS - is just an everyday tool one may use to help get around town. But for China's plan at large, BNSS's ultimate purpose is to enrich people's lives and promote both social and economical development by way of providing accurate weather analysis, positioning services, navigation, and real-time synchronization for users not only in China, but around the world. Cool, ain't it? And truthfully, that's an extensive approach to space-related topics I've rarely thought about!

On the other end of the exhibition sat a collection of various types of missiles used to defend China's airspace, including the SY-1 anti-ship missile, HQ-1 surface-to-air missile, and PL-5 air-to-air missile. With China emerging as a powerful player on the world stage, safeguarding its airspace against foreign threats is a cardinal priority that cannot be undermined in any way, shape, or form, and the museum's examination of China's progress, proficiency, and artillery used in aerospace defense, though regrettably brief, proved to not only be a fitting touch to its overall theme, but also an important reminder of just how important aerospace is towards the study of, well, space.

There were more showcases highlighting the decades-long significance of this relationship, as well. Take China's prominent Long March rocket family, which was on display as 10 ft. tall replicas. I learned through translations that each rocket - and actually, most space rockets in general - was developed based on concepts and principles originally derived from Chinese intermediate range and intercontinental ballistic missiles.

And while the missiles of aerospace focus on speed and destructive power, the rockets of space have been typically engineered with one thing in mind: maximizing payload.

Beidou exhibition area.

Since the launch of China's first satellite into space on Long March 1 in 1970, for instance, rockets of the Long March family have carried a number of satellites, manned and unmanned spacecraft, cargo, and astronauts into orbit. Now that, my friends, is a perfect display of aerospace technology being used to foster mankind's grand journey into space, is it not?

Furthermore, located around the exhibition were other notable space-related artifacts too, including a real life taikonaut spacesuit, portions of a used re-entry vehicle, and some interactive sections that were, unfortunately, closed.

A New Beginning

Truth be told, the Beijing Air and Space Museum didn't offer as much insight and presentation as I hoped for in covering China's actual accomplishments and developments in space, and that's ok. After all, something better happened while I was there.

Ironically enough, I'd wind up leaving the museum feeling more inspired than ever. Wait, what?

That's right, it was …aerospace. It's awesome! I loved the museum's teeny-tiny look at space through a wide inspection of aviation and aerospace, and it's that angle of aeronautics and astronomy I've rarely paid heed.

Forget about things like galaxy hunting, landing on asteroids, making contact with E.T., and establishing bases on Mars - well, for now at least. Instead, I left Beijing Air and Space Museum wanting to discover more about how developments in technology, aircrafts, commercial investments, and defensive applications in aerospace have progressed over time, and just how much these 'small' triumphs made in and around Earth's atmosphere have helped propel mankind into unfathomable depths of the universe. Hey, aerospace can be fun too!

In Conclusion

Like mankind's illustrious journey into space, my own personal mission 'into' the cosmos has constantly evolved, and with each new chapter - each fresh set of theories, ideas, facts, and discoveries learned, comes a chance to undergo new adventures, new experiences, new tasks, and new opportunities, in my quest to unearth the wonders of the universe.
Space launches, museums, movies, camps, observatories, tech, science experiments - I want to see and do it all, and anywhere, too.

Who knows where I'll end up next? After all, my trip to Beijing's Air and Space Museum has opened up a whole new path for me that I've once overlooked.

And no matter where I head, one thing's for sure: Space isn't going anywhere, but I'll need to go everywhere to find it. And boy, I can't wait!

Directions to the Beijing Air & Space Museum:

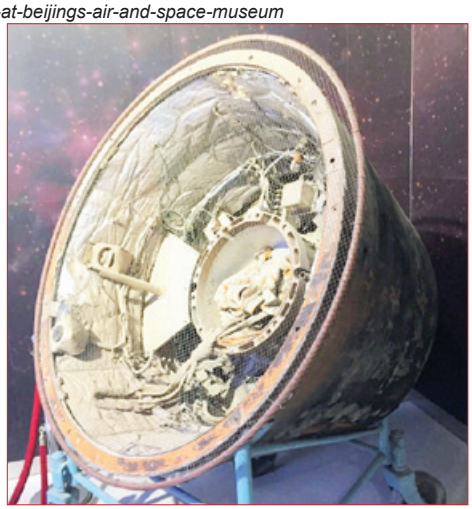
In Beijing, hop on Subway Line 10 to Xitucheng Subway Station. Take Exit A. Walk up Xueyuan Road until you reach Beihang University's Southeast Gate #2, which intersects with Xiaoyuan Road. Head into the campus and down Xiaoyuan Road until you reach the Air and Space Museum on the right, just before the tennis courts.
You can make a reservation to visit the museum at http://airandspacemuseum.buaa.edu.cn/book/v_list.jspx. Translate the pages using Google Chrome's automatic translation feature, or have a Chinese friend help. Safe & happy travels!

link to the article on the author's website with many more photos: https://www.donesladventure.com/all-blog-articles/unearthing-aviation-aero-space-and-the-cosmos-at-beijings-air-and-space-museum

A model is showing the docking maneuvre in space - most likely the first one acomplished by China during the flight of the unmanned Shenzhou 8 (left) which docked with Tiangong 1 (right) on 2 November 2011. In the background, the exhibition hall can be seen.

Entrance ticket. *all photos copyright by the author - Donovan Cosby*

YF-20 motor, used on early CZ rockets.



China's early re-entry space capsule of the FSW series.