All About The Chinese Space Programme

Go TAIKONAUTS!

龙腾太空

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Content

From left: Dr. Enyu Gao (co-founder and CEO of MinoSpace), Dr. Shufan Wu (co-founder and Board Director of MinoSpace, co-founder of LandSpace), Changwu Zhang (co-founder and CEO of LandSpace) in front of LandSpace's Zhuque 1 rocket at Jiuquan Satellite Launch Centre. (credit: LandSpace/MinoSpace)

Chinese Space Quarterly Report
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by Jacqueline Myrrhe

SPACE TRANSPORTATION

CZ-9
The China Academy of Launch Vehicle Technology (CALT) is testing designs and technologies for the heavy-lift carrier rocket (core stage diameter: 10 m; height: 93 m; payload capacity to LEO: 100-140 t; to lunar transfer orbit: 50 t; to Martian transfer trajectory: 44 t). Progress was made on the test production of the large-diameter aluminium alloy structural components and a 480 t-thrust kerosene/liquid oxygen rocket engine, including development of turbopumps and gas generators. CZ-9 will serve deep-space and manned lunar exploration, Li Hong, the Director of CALT told media at the beginning of March. The CZ-9 is not yet approved by the Chinese government. Experts confirmed that considering China's existing technologies, the project could be completed within 10 years after approval with the first launch around 2030.

CZ-8
CALT is working on the optimisation of various designs for the new generation medium-lift CZ-8 carrier rocket with a payload capacity of 3 - 4.5 t to SSO. CZ-8 features are, lower cost, international competitiveness, better adaptability to customers' needs, shorter launch cycle and compatibility with multiple satellite launch centres. The first flight is expected in 2020.

CZ-5B
At the beginning of March, the China Manned Space Engineering Office (CMSEO) announced that the CZ-5B is undergoing modal testing of the fully-equipped and assembled core module of the Space Station. Other related large-scale joint tests on the ground will be implemented step-by-step. The CZ-5B developed and built by the China Academy of Space Technology CAST (core-stage diameter: 5 m; height: 53.7 m; payload capacity to LEO: 22 t, booster diameter: 3.35 m; take-off weight: 837 t) will be used for the transport of the CSS modules. First launch is planned around June 2019.

CZ-5
In mid-April, the State Administration of Science, Technology and Industry for National Defence finally confirmed the cause of the CZ-5 failure from July 2017. A broken structure of the turbopump in one of the YF-77 cryogenic engines of the CZ-5 core first stage led to a shortage of oxygen supply to the engine and consequently the sudden loss of thrust. A number of simulations, calculations, ground experiments and verifications were carried out whose results pointed to structural abnormalities inside the turbine exhaust device.

Already during the IAC2017 in Adelaide, Australia, China confirmed that the failure of the CZ-5 was related to the first stage's core engines. In November 2017, unofficial reports emerged that the turbo pump caused the failure. Several space expert websites (compare: http://spaceflight101.com/long-march-5-shijian-18/china-progresses-toward-long-march-5-return-to-flight-via-yf-77-engine-testing/) wrote that "a structural problem causing the turbopump rotor shaft enclosure cap within one of the YF-77 engines to break off and created a blockage within the propellant line."

Only the CZ-5 uses the YF-77 engines, built by the Academy of Aerospace Propulsion Technology (AAPT), a CASC company. The pumps are driven by a gas-generator cycle which means a separate pre-burner is propelling the fuel pumps using some of the overall propellant. The exhaust fumes of the pre-burner cycle are discarded without contributing to the actual combustion process, allowing for simpler and lighter structure, higher reliability and convenient maintenance. The YF-77 engine will be improved for an up to 50 times re-usability, fuelled by methane and liquid oxygen. The YF-100 engine, burning kerosene is used in the CZ-5 booster and the main engine for the CZ-6 and CZ-7 and the future CZ-8.

The engine has been improved and several ground ignition tests on the modified engine were carried out. It is expected that a successful third flight of the CZ-5 Y3, planned for the second half of 2018 with the Shijian 20 GEO comsat on board (compensating for the lost SJ-18), will lead to the CZ-5 Y4 launching the Chang'e 5 sample return mission.

CZ-3
Jiang Jie, Chief Designer of CALT's CZ-3A series of rocket launchers told media on the side-lines of the 13th Chinese People's Political Consultative Conference (CPPCC) in March, that demand for the launcher is increasing. He emphasised that the engineers pay special attention to rigorous work standards since they clearly understand the importance of quality and failure-free production for successful missions.

CZ-2
In February, CALT confirmed that the upgraded Yuanzheng-1S will be put into operation in 2018 for a launch into SSO on a CZ-2C. Yuanzheng-1S is a simplified, more efficient and economic version of China's upper stage.

Technology
Liu Zhirang, Head of the No. 6 Research Institute of CASC (China Aerospace Science and Technology Corporation), revealed at the beginning of March that the Institute is currently tackling problems on the key technologies of three types of liquid rocket engines for its heavy-lift rockets: the 500 t-engine fuelled by liquid oxygen and kerosene, 200 t- and 25 t-engines using liquid oxygen and liquid hydrogen as fuel, and also that thermal tests on core modules together with some sub-models for the engines are completed.

YF-77
A successful test of the YF-77 rocket engine was accomplished in mid-February at AAPT test site near Xi'an.

Launch Sites
The Taiyuan Satellite Launch Centre (TSLC) has undergone a series of upgrades including a new Network Transmission Platform with a command information system for real-time processing of data from 4,000 processes and hardware, as well as from the operation of the rocket and satellite launch platform, refuelling operation, air conditioning and power supply. The launch cycle was shortened from more than 20 days to 7 days.

Tracking Ships

Yuanwang 6
The Yuanwang 6 tracking ship left its military home harbour in Jiangyin on the Yangtze River in east China on 8 January to be positioned near the Equator. Yuanwang 6 supported the Beidou MEO-02 mission, which took-off at 23:18 UTC on 11 January (12 January - 7:18 BJT) from Xichang. 10 minutes after launch, Yuanwang 6 took over the tracking and control of the satellite for 10 minutes in the early mission phase, exchanging information with Xichang Satellite Launch Center and Xi'an Satellite Control Centre. It conducted radar tracking, establishing of an information link, data acquisition and validation, and information

exchange. In the early morning of 12 January, Yuanwang 6 completed its first ocean-going observation and control mission for the Beidou-3 project.

Again, on 30 March, Yuanwang 6 supported the launch of the Beidou 30 and 31 satellite from its equatorial position. It was the 3rd time that Yuanwang 6 was responsible for a Beidou tracking during the early mission phase. Before the TT&C duties for the Beidou launch, the crew trained several contingency scenarios to improve their emergency skills. After completing the operational mission, Yuanwang 6 returned to the dock of CSMTC - China Satellite Maritime Tracking and Control Department.

Yuanwang 3

Yuanwang 3 departed from Jiangyin on 12 March ready to support upcoming launches of the Beidou 3rd generation navigation satellites and the APSTAR-6C commercial telecommunications satellite for APSTAR. Yuanwang-3 was active earlier in the year.

MANNED SPACE FLIGHT

Taikonauts

At the beginning of January, on the occasion of the 20th anniversary of the PLA's (People' s Liberation Army) space battalion, all 11 taikonauts with space flight experience held a ceremony where they renewed the oath, they took upon joining the group. The oath included a commitment of dedicated training to be ready for a space mission at any time.

China has, so far, trained 21 people for its space programme, out of these, 11 have been assigned to a mission. These 11 taikonauts have accomplished six spaceflights, over 100 experiments and accumulated an operations space flight experience of 68 days and nights.

The PR Department of the Communist Party of China (CPC) Central Committee awarded all taikonauts the title "role models of our times". In 2017, 3-time taikonaut Jing Haipeng was awarded the country's highest military award, the Order of Bayi.

Yang Liwei, Deputy Director of the China Manned Space Agency (CMSA) confirmed during an open day at the end of January at Beijing's Astronaut Centre of China (ACC), that the selection for the next generation of astronauts will start soon. It would be the third taikonaut selection after the selection of 14 taikonauts in 1998 and another 7 taikonauts, among them 2 women, in 2000. He confirmed that not only military talents but also Chinese scientists and engineers will be eligible to apply to "train them into engineers and payload specialists capable of working on the Space Station." He added that next to a minimum of three years of working experience, engineers need a master degree and payload specialists a doctoral degree.

At the end of March, Huang Weifen, Deputy Head of ACC, told media that China's taikonauts are undergoing comprehensive training in preparation of Space Station missions, including long-term ones, as well as for regular extra-vehicular activities, in-orbit assembly and repair of the Station. The taikonauts are currently studying space station technology, robotic arms and extra-vehicular activities. They accomplished diving training, strength and stamina training and preparation for desert survival tests and space craft egress training in water. Huang Weifen confirmed that the selection of the third class of taikonauts is ongoing. 1 April 2018 marked the 50th anniversary of the foundation of the ACC.

Striving makes dreams come true
- Chinese astronauts undergo daily training

Chinese astronaut candidates have to undergo years of training before they can qualify for a potential space flight. The extensive training programme includes physical conditioning, buoyancy and hypergravity training, listening tests, medical training and other skills which are required for space flight. The short video by the Ministry of National Defense shows the training elements.

CSS

A spokesperson said that CMSEO is cooperating with the United Nations Office for Outer Space Affairs to offer opportunities for research on the Chinese Space Station (CSS), with the European Space Agency (ESA) on module development and with other countries on the lunar probe.

Zhou Jianping, Chief Designer of China's Manned Space Programme and Member of the 13th National Committee of the CPPCC, confirmed that the CSS will consist of three modules and one telescope. The core module and two laboratory modules, each with a mass of 20 t will be arranged in a T-shape. The core module is equipped with five docking interfaces, including one for Tianzhou cargo ships, two for manned spacecraft, and two for the scientific research modules. The core module will be launched in 2020 and be followed by the two lab modules making the CSS complete. These three main modules are currently assembled as well as an optical module. The optical module, carrying a 2 m-space telescope will be launched after the completion of the Station and fly along with the Space Station or will dock occasionally with it. With the same image resolution of the Hubble Space telescope, the field of view is supposed to be 300 times of Hubble, capable of surveying 40 percent of the cosmos in ten years. The Station's robotic arm is undergoing testing. It will be used for the assembly of the CSS, transfer of hardware and the support of other work outside the Station.

Chinese taikonaut Zhai Zhigang, who conducted China's first EVA on the Shenzhou 7 spacecraft on 27 September 2008, said that during the Space Station assembly phase, EVAs will be frequent and each may last five-six hours. For some more complex operations, several extravehicular activities are needed. The CSS will be manned by three-person crews on long-term missions. Since the Station comprises two docking ports for manned spacecraft, a newly arriving team will add to a

Chinese astronauts' corps during the ceremony. credit: Chinanews.com

Wang Yaping, a deputy to the 13th National People's Congress NPC joined a pool interview before the opening meeting of the first session of the 13th NPC in Beijing on 5 March 2018. Wang was elected from the country's armed forces as one of 2,980 deputies to China's 13th NPC. Before that, Liu Yang, served for a five-year term to the 12th NPC. Wang, along with other deputies, elected state officials, reviewed the government work report and discussed the Constitution's revision. Wang told media that she and other astronauts are preparing for work on the space station. credit: Xinhua

Yang Liwei, a member of the 13th National Committee of the CPPCC, answers journalists' questions during a pool interview ahead of the opening of the first session of the 13th CPPCC National Committee at the Great Hall of the People in Beijing on 3 March 2018. credit: Xinhua

temporary crew of six before the longer-serving 3-person crew returns home after hand-over activities and closing out their schedule.

China Reinvents Itself - Space

CCTV has released rare footage, showing Chinese engineers building the main parts of the nation's first space station. The 5th episode of the documentary series "China Reinvents Itself" introduces how China is going to build its own orbital outpost, as well as the core details of the station. Construction on the space station is expected to be finished around 2022.

Shenzhou

The Shenzhou spacecraft is undergoing upgrading. Compatibility tests with the Space Station module were concluded and operational details of Shenzhou and Tianzhou cargo spacecraft for the CSS fixed. China is also conducting preliminary research on low-cost spacecraft for commercial and other purposes.

Next-Generation Manned Spacecraft

CAST is undergoing preliminary work on two versions of the next-generation manned spacecraft for LEO and deep-space exploration. The space vehicle is required to be reusable, versatile, modular, modern, use the latest technologies, adaptable to two different propulsion systems, able to host 4-6 crew, and have a launch mass of 14 t to CSS and 20 t for Moon landings. A downscaled test version of the re-entry capsule was flown in June 2016 on the first flight of the CZ-7, checking the aerodynamics of the craft and its key technologies. It was recovered in Inner Mongolia after 19 hours of orbital flight. The next-generation spacecraft will feature a two-module design with a service section and pressurised, bell-shaped crew section. A test flight is expected for June 2019 on board of a CZ-5B.

Tiangong 1

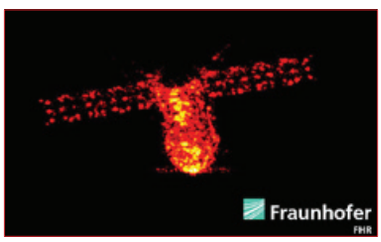
At the beginning of January, Zhu Zongpeng, CAST Senior Scientist and reportedly the Chief Designer of Tiangong 1 challenged Western media reports that the space lab is "out of control". It was not quite clear, what exactly he meant when he spoke to Beijing-based Science and Technology Daily. Maybe it was a reference to the lab itself that was in stable status, not disintegrating at that point. In the meanwhile, the IADC (Inter-Agency Space Debris Coordination Committee) campaign to follow the re-entry of Tiangong 1 kept the module under observation, meaning "controlling" in a passive way the sequence of events without being able to intervene.

IADC comprises space debris and other experts from 13 international space agencies and organisations. They join together on an annual base to train for uncontrolled re-entries of man-made objects or space debris. In 2017 the members voted for accompanying Tiangong 1's re-entry. The European Space Operations Centre, in Darmstadt, Germany, hosted the re-entry campaign. IADC/ESOC as well as CMSA published updated on-orbit status reports of Tiangong 1.

Tiangong 1 Target Vehicle Orbital Status Weekly Reports on the CMSA website:

Latest re-entry forecast provided by ESA's Space Debris Office, ESOC, Darmstadt, Germany:

On 21 March, the German Fraunhofer Institute for High Frequency Physics and Radar Techniques (FHR) released radar images of the Tiangong 1 space lab. The experts at FHR have been monitoring the lab for weeks with their TIRA (Tracking and Imaging Radar) system, one of the most powerful space observation radars, supporting the German Space Situational Awareness Centre (WRLageZ) and ESA with their re-entry forecasts embedded in the IADC campaign. TIRA combines data from a Ku-band imaging radar with an L-band tracking radar. FHR was requested to determine and investigate the natural rotation of Tiangong 1 because the rotation has the biggest influence on the flight characteristics and decay of the laboratory. The researchers created an animated version of radar images, showing clearly the uncontrolled rotation of the Tiangong 1 module.



TG1-TIRA1 IR image of Tiangong 1.
credit: Fraunhofer FHR

On 26 March, CMSEO published the results of an analysis by the Beijing Aerospace Control Centre which predicted that Tiangong 1 is expected to completely burn up during re-entry. The re-entry window was given for the days between 31 March and 4 April, Beijing Time. Two days later, the window was narrowed to between 31 March and 2 April. On the 28 March, the space lab was at an average altitude of about 202.3 km (perigee: 193.9 km; apogee: 210.8 km; inclination: 42.67°).

The UAE Space Agency joined with the International Astronomical Centre (IAC) in Abu Dhabi to contribute to the global monitoring of the Tiangong 1 re-entry. The IAC operates three ground stations in the UAE, equipped with astronomical observation cameras. The UAE has experience in the monitoring and determination of the coordinates of space objects, meteors and meteorites.

LUNAR AND DEEP-SPACE EXPLORATION

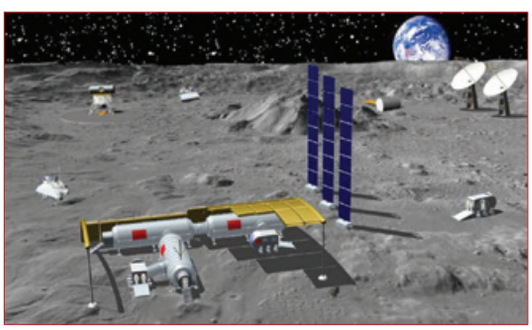
Lunar

In preparation of the Chang'e 4 mission, the Applied Astronomy Group from the Yunnan Observatories accomplished China's first Lunar Laser Ranging (LLR) with a 1.2-meter telescope laser ranging system on 22 January 2018 between 21:25 h to 22:31 h Beijing Time (BJT). The scientists targeted laser pulses onto the lunar retro-reflector installed by Apollo 15 commander David Scott on 31 July 1971 in the Moon's Hadley Rille-Apennine Mountains region and successfully received the laser echos. By measuring the time of the laser pulse travelling, the distance between the retro-reflector and the Yunnan Observatories ground station could be determined to be 385,823.433 km to 387,119.600 km. LLR technology in China has not achieved the same level as in advanced countries like the U.S., France, and Italy. The researcher from the Yunnan Observatories expect that China will install its own retro-reflector on the Moon.

The 1.2-meter Telescope during the LLR.
(credit: Tang Rufeng)

Long-Term Lunar Exploration Plan

At the beginning of March, Zhao Xiaojin, Party Chief of CAST and a Member of CPPCC, confirmed that China is on track for launching the two parts of the Chang'e 4 lunar far-side mission in 2018 and that 2019 will see the third phase of the lunar exploration programme with the sample return mission Chang'e 5 and later Chang'e 6. He also confirmed that China is actively studying a fourth phase of lunar exploration, comprising the establishment of an unmanned scientific research base on the Moon by 2025, and future manned Moon exploration missions around 2030: "Intelligent robots will take care of the base in the beginning, and later we complement with manned lunar exploration during short-term human stays." The main objective is to find out whether there is water on the Moon or not, therefore the pole regions are at the centre of interest. Zhao also laid out a blueprint for deepening reform of the space industry: "One thing we need to do is to establish the modern corporate system. What's more, we need asset securitisation so that we can raise the social capital on the platform of listed company and invest the assets in the space industry. We also need to encourage people from all walks of life. For one thing, how to tackle key technological problems. And then how to develop our technology industry. This will be very supportive," said Zhao.



Conceptual artists' impression of a manned Moon base. credit: CAST

Wu Weiren, Chief Designer of China's Lunar Exploration Programme CLEP, proposed at the annual session of the 13th National Committee of the CPPCC in March to start as soon as possible the fourth phase of lunar exploration, focussing on the lunar pole regions to take advantage of the presence of sunlight and possibly water. He called for a lunar probe sent to the Moon's South Pole and the construction of a lunar research station, emphasising that research objectives are already worked out and the needed technologies can be tackled. He urged for starting the work as soon as possible to have the mission accomplished before 2030.

With respect to deep-space, Wu told media that a programme for the exploration of the outer regions of the solar system was proposed, making use of available technology: "I am visualising the objective of reaching a distance of 15 billion kilometres by 2049, when the country celebrates the 100th anniversary of the founding of the People's Republic of China. By implementing the lunar probe project, we will build a network for Earth-deep-space control and communications."

Chang'e 4 versus Chang'e 3

Chang'e 4, the backup of the Chang'e 3 lunar probe, requires a relay satellite at the Lagrange L2 Point, where the satellite can keep communication with both the far side of the Moon and the Earth. It will be launched in the first half of 2018, while the actual Chang'e 4 lunar lander will take-off in the second half of the year.

The landing mode and working condition of the Chang'e 4 lunar probe are very different from Chang'e 3 which landed on the near side of the Moon. "Chang'e 3 used a slow and arc-shaped landing, while as for Chang'e 4 we have to adopt a steep and almost vertical landing. Chang'e 4 will have huge improvements on its capabilities because we have adopted new technologies and new products. For example, Chang'e 3 could not work during the night, but Chang'e 4 can take some measurements at night," said Zhao Xiaojin, Secretary of the CPC Committee at CAST.

Chang'e 4

CASC reported that the Chang'e 4 lander and rover have entered mechanical environmental testing in preparation for launch later in the year. Engineers are verifying the system performance and applying a standard set of tests: vibration testing on the shaker, thermal vacuum and acoustic chamber tests. The integration of previously unplanned payloads from international partners lead to additional requirements for spacecraft assembly and testing.

Chang'e 4 will house a 3 kg, lunar mini biosphere, consisting of an aluminium alloy container filled with water, a nutrient solution, potatoes and Arabidopsis seeds, and silkworm eggs. The silkworms are supposed to hatch from their eggs and start producing carbon dioxide. Meanwhile, the potatoes and Arabidopsis seeds will emit oxygen produced by photosynthesis. The configuration allows studying the interaction between those components of the closed ecosystem under lunar gravity conditions. Zhang Yuanxun, the Chief Designer of the container, said that an integrated camera and data transmission system will live-stream the plant's development which can be followed by the public.

The relay satellite for Chang'e 4 will also carry two microsatellites to test low frequency radio astronomy and space-based interferometry. The 45 kg-satellites DSLWP-A1 and DSLWP-A2 (Discovering the Sky at Longest Wavelengths Pathfinder) have a dimension of 50 x 50 x 40 cm and are equipped with low frequency antennas and receivers for very low frequency astronomy (1 MHz-30 MHz). The pair will fly in formation at a variable distance of 1-10 m.

Additionally, DSLWP-A1 will carry an amateur radio payload and DSLWP-A2 will carry the micro camera from Saudi Arabia.

Saudi engineers and researchers have completed work on an optical micro camera payload, to be mounted on the DSLWP-A2 (Longjiang 2), one of the two microsatellites which will be launched along with the Chang'e 4 relay satellite. The camera, consisting of a photographic and data processing unit, will take video and photos of lunar far side surface features from different angles and altitudes. The payload was readied within 12 months, meeting the requirements for a compact payload of only 10.5 cm^3 with a high capacity and a maximum weight of 630 grams. The Saudi Arabia contribution to Chang'e 4 results from a Memorandum of Understanding between China and Saudi Arabia, signed on 16 March 2017 during King Salman's visit to Beijing. Both countries will share the scientific data in this cooperation.

China's Lunar and Deep Space Exploration Centre solicited 8,000 messages out of 120,000 competition entries from all over the world, which will be sent along with the Chang'e 4 communication relay satellite. From 19 December 2017 to 6 March 2018 suggestions could be sent to the WeChat account "slecbj". Three winners were selected to attend the launch.

A semi-public competition for naming the communications relay satellite was announced on 27 March. Teams involved in the mission were eligible. Deadline was 15 April and the winner will be announced on 24 April, China National Space Day.

Chang'e 5

The launch for the sample return mission is planned for 2019. The probe is designed for an Earth re-entry at 11.2 km/s.

Lunar Palace

On 26 January, four biomedicine students from Beihang University, two women and two men, completed the second phase of the ground-simulation experiment Yuegong 1 - Lunar Palace 1. They spent 200 days in a self-sustaining facility driven by a Bioregenerative Life Support System (BLSS), in which water, air and waste can be recycled and reused within the system. The objective of the 200-day stay was to test the stability in the operation of the system as well as to observe and learn about the physical and mental conditions of humans in such an environment. For example, the volunteers had to master three unexpected power cuts. The four Chinese students broke the record set by an experiment in the Soviet Union, in which three people stayed for 180 days in a similar closed ecosystem in the early 1970s.

The first group of volunteers, who had previously stayed in the facility for 60 days, re-entered the habitat to replace the second group, starting the third and final phase which will last 105 days and round up the 365-day experiment.

Photo: Volunteers of the first group and the second group wave from inside the Lunar Palace 1 at Beihang University in Beijing on 26 January 2018. credit: Xinhua

Mars

Chinese-American chemist Yang Peidong, Professor of Chemistry at the University of California Berkeley was a special invitee at the first session of the 13th National Committee of the CPPCC. His work in the U.S. includes research on artificial photosynthetic technology to convert carbon dioxide and nitrogen into other chemicals, including oxygen, in support of future manned missions to Mars. During his stay in Beijing, Yang advised on research funding for basic and applied research, involving a mix of funds from government, foundations and industry.

Engineers have completed the aerodynamic design of China's Mars probe and experts at the Beijing Institute of Space Mechanics and Electricity (BISME) are testing the simulated atmospheric entry, descent and landing under Martian conditions.

SCIENCE

HXMT

HXMT, the Hard X-ray Modulation Telescope, renamed "Huiyan" (Insight) upon reaching orbit, has carried out in-orbit tests, including scanning and pointing observations, and gamma-ray burst tests, proving the qualified functionality and capability of the HXMT. On 30 January HXMT was put into service for scientific research. The developers of the instrument, scientists from the Institute of High Energy Physics (IHEP) of the Chinese Academy of Sciences (CAS), are satisfied with its performance. By observing an unusual solar flare eruption on 6 September 2017 and taking part in the observation of gravitational waves, coming from the merger of two binary neutron stars in October 2017, it worked beyond expectations.

QTT

Xinjiang Astronomical Observatory proposed to build the largest steerable radio telescope in the world, the Xinjiang Qitai 110-meter Radio Telescope (QTT), advancing the search for pulsars, dark matter, gravitational waves, and extra-terrestrial intelligence. QTT would be built on the foothills of the Tianshan Mountains, near Shihezi in Qitai County, in the Xinjiang Uygur Autonomous Region of northwest China. 110 m in diameter, it will have a slightly larger aperture than the two largest, fully steerable radio telescopes currently in operation, the Green Bank Telescope in West Virginia, U.S.A., and the Effelsberg antenna in Germany. QTT will be over 100 m tall and weigh around 6,000 t. The first observations could be possible as early as from 2023. It is projected to cover three-quarters of the sky and will operate at 150 MHz to 115 GHz. Xinjiang observatory is already operating a 25-meter radio telescope.

DAMPE

On the night of 29 December, the dark matter detection satellite DAMPE (Dark Matter Particle Explorer) experienced abnormalities with the satellite's high-voltage power supply, causing a decrease in data recording and transmission. The DAMPE team at the Purple Mountain Observatory under CAS, suspected the impact of a micrometeoroid. The experts initiated a series of commands for re-setting the onboard computer and the re-transmission of parameters. As a result, the satellite resumed normal functioning within 19 hours. By the end of January, DAMPE "Wukong" was back to nominal operation.

On 31 January, the State Council of China published a document describing guidelines in support of 20 central tasks for basic science and aiming for global leadership in science by 2035. The strategy proposes more high-quality state laboratories, young talent programmes, international exchanges, and increased funding from versatile sources. As cutting-edge research areas were identified: evolution of the universe, the origin of life, quantum science, and others. The guideline said the government would organise more international collaboration projects, open national research and development programs to foreign participants, and implement science and innovation action plans under the Belt-and-Road Initiative. In 2016, China invested 82.3 billion RMB in fundamental research, up 65 % from 2012. The nation's spending on R&D accounts for 2.15 % of its GDP, reaching 1.76 trillion RMB (about 279 billion USD) in 2017, up 70.9 % from 2012.

FAST

The National Astronomical Observatories of China (NAOC) stated that in its test phase from September 2016 until March 2018, FAST (Five-hundred-meter Aperture Spherical Radio Telescope) has discovered 51 pulsar-like stars of which 11 have been confirmed as new pulsars by observatories in other countries. Scientists of NAOC confirmed that pulsars with high density and energy are unique "celestial laboratories" and could be used to replace navigational satellites to locate spacecraft.

Up to April, FAST underwent a technical upgrade which saw the installation of an advanced 19-beam receiver system to replace the current single-beam receiver, which was easier to calibrate and test during FAST's operational test phase since 2016. The new receiver will be at least six times more accurate than the old one, and can survey the night sky 19 times faster, significantly shortening the time needed for data collection. Currently, scientists are looking into the option of setting up two to ten smaller radio telescopes of 30 or 50 m diameter around FAST to create a telescope array that would have a 100 times higher resolution and a better data accuracy.

SKA Square Kilometre Array

The 54th Institute of China Electronics Technology Group Corporation (CETC54) has completed the structural assembly of the first Square Kilometre Array (SKA) radio telescope dish, bringing together components from China, Germany, and Italy. This 15 m-prototype dish was unveiled on 6 February in

Shijiazhuang, the capital of north China's Hebei Province. It will be used for testing before the production of a series of 6 dishes in 2019. A second dish, currently under production at CETC54 and funded by the German Max Planck Society, will be shipped to South Africa and assembled there to conduct real observations for the first time within the next few months. The SKA is an international effort by 20 countries to build the world's largest radio telescope using arrays in Western Australia's Murchison Shire region and South Africa's Karoo region. 3,000 individual radio telescopes will be linked to create a total collecting area of about 1 million m^2. After completion the SKA network will detect faint radio waves from deep-space with a sensitivity about 50 times greater than that of the Hubble telescope. Data will be fed into data centres in Australia, China, UK and Europe.

Combined photo taken on 6 February 2018 shows the front (left), side (centre) and the back of the prototype dish for the Square Kilometre Array (SKA) radio telescope. credit: Xinhua/SKA

Southwest China's Guizhou Province, home to the FAST telescope, will apply to build an Asian Data Centre for the Square Kilometre Array (SKA) this year. Guizhou has become a leader in big data with a suitable climate, power supply and network infrastructure. Apple and Huawei have big data centres there. Hosting the SKA Asian Centre could take Guizhou to the front of the big data industry.

eXTP

At a kick-off meeting in Beijing on 2 March, China's National Space Science Centre (NSSC) announced that it would start with a new flagship X-ray space observatory for the research of black holes, neutron stars and quark stars. The enhanced X-ray Timing and Polarimetry (eXTP) satellite will succeed the Hard X-ray Modulation Telescope (HXMT) launched in 2017. eXTP, designed to consist of a large-area spectroscopic focusing array, a large-area collimator array, a sensitive polarimetry focusing array and a wide field monitor, is expected to have a much better comprehensive performance than previous X-ray astronomy satellites. Open for cooperation, the eXTP has attracted more than 100 research institutions from over 20 countries and regions, including Italy, Germany, Spain, Britain, France, the Netherlands and Switzerland. It is hoped to become the largest international astronomical satellite project initiated and led by China. China will cover about two-thirds of the cost (about 3 billion RMB), the rest of the expenses will be met by contributions in kind by the partners.

SATELLITES

CFOSat

In January, the Chinese-French Oceanography Satellite (CFOSat) was in its final integration phase. At the end of March, CALT announced that it is planned to launch CFOSat in September aboard a Long March 2C rocket.

The State Oceanic Administration (SOA) reported on 21 January that China plans to put three maritime satellites into space to improve maritime research. SOA stressed that the gross production value of China's maritime industry showed an average annual growth of 7.5 % over the past five years, accounting for nearly 10 % or 7.8 trillion RMB of the country's GDP in 2017.

Jilin

In addition to the 10 currently operational high-resolution optical remote sensing Jilin 1 satellites, the Chang Guang Satellite Technology Co. Ltd., plans to build and launch 60 more Jilin 1 video satellites by 2020.

BNU 1

On 9 February, Beijing Normal University (BNU) and China Great Wall Industry Corporation (CGWIC) signed a cooperation agreement on the development of the polar observation microsat BNU 1. The 20 kg BNU 1 will monitor the planet's polar regions every second day and record high-resolution multi-spectral remote sensing data, useful for ship navigation. It will become the first remote sensing, scientific university satellite. BNU 1 will be jointly developed by BNU, CGWIC and Shenzhen Aerospace Dongfanghong Development Ltd., and is scheduled for launch in December 2018.

TanSat

Based on data of the carbon dioxide recording satellite TanSat, Chinese researchers were able to construct a global map of solar-induced chlorophyll fluorescence, indicating the intensity of vegetation. The data map shows the vegetation productivity in the corn belt in North America, European plain, and agricultural regions in East Asia in July 2017 and in the Amazon forest in December 2017.

DFH-5 satellite platform

According to Zhang Hongtai, President of CAST, the first test of the CAST-developed DFH-5 satellite platform is planned for November. The new satellite bus is capable of increasing the data transmission capacity from 20 Gbps to 300 Gbps.

On 11 January 2018, the 3 m-diameter ground-based prototype Geostationary Millimetre-wave Atmospheric Sounder Demonstrator, jointly developed by the NSSC of CAS and ESA passed the Joint Acceptance Review, which is the first substantial achievement for CAS-ESA cooperation in the field of advanced payload technology of Earth observation, paving the way for future Millimetre-wave exploration for the Chinese GEO meteorological satellites.

NAVIGATION – BDS-Beidou

From 17-19 January, the 33rd Meeting of the Satellite Based Augmentation Systems SBAS Interoperability Working Group IWG was held in Madrid, Spain.

Dr. Jun Shen, Chief Scientist of Beijing UniStrong Science and Technology Co. Ltd., reported on the development, status and planning of BDS and the BeiDou Satellite-based Augmentation System BDSBAS on behalf of the Chinese delegation. He also spoke about the progress of the BDSBAS PRN number assignment process, Service Provider Identification Number SPIN, and system standard time identification and the integrated test of the first BDSBAS GEO satellite. Chinese experts exchanged details on the progress of BSDBAS ground station construction, single-frequency enhanced service design, enhanced signal ranging capabilities, and improved signal generation methods. Professor Mingquan Lu of Tsinghua University presented the technical report on the new BDS civil signals B1C and B2a. He detailed the design, performance characteristics and receiving methods of the BDS signals, as well as their superior performance. The BDS Signal Interface Control Documents (ICD) were provided at the conference.

For the global use of the BDS open service signals, the BeiDou Satellite Navigation System Signal in Space Interface Control

Document for Open Service Signal B3I (Version 1.0) (in Chinese and English) was released on 9 February 2018.

All the key components of China's Beidou navigation satellites, such as traveling-wave tube amplifiers, microwave switches, and high-power current source controllers are now made in China, ending the reliance on imports. Additionally, all core technologies for the global Beidou network of satellites are mastered, aiming to make it as good as the Global Positioning System (GPS).

The quick positioning platform "Qianxun" of the Beidou navigation and positioning system is serving more than 200 countries and regions around the globe. Qianxun Spatial Intelligence Inc., co-founded by NORINCO (China North Industries Group Corporation Limited) and Chinese e-commerce giant Alibaba, has more than 90 million customers. Qianxun's centimetre-level service is expected to cover the Chinese mainland in 2018, when the high-accuracy positioning service of Beidou will go public.

NORINCO has already set up a network system and statistics processing centre for Beidou's ground-based augmentation system, which consists of 1,355 ground stations.

The company has also won the bid for the construction of a ground station network for foreign navigation satellites, enabling the application of the Beidou system overseas.

On 10 February, Chinese President Xi Jinping who is also chairman of the Central Military Commission, visited the military base of Xichang Satellite Launch Centre (XSLC) in southwest China's Sichuan Province, ahead of the launch of two Beidou 3 satellites. He inspected the preparation work for the launch and spoke to scientists and technicians, asking them about their research, work and lives. They were told to keep pursuing precision and perfection to ensure the success of the launch. Through a video conference connection, Xi talked with soldiers stationed at Xisha Islands in the South China Sea and at a prelaunch testing station in a coastal region. Xi greeted all servicemen for the upcoming Spring Festival.

President Xi Jinping visits the Beidou launch site. credit: Xinhua

China's Satellite Navigation System Committee proposed to the Roscosmos State Space Corporation to work towards compatibility and interoperability between GLONASS and Beidou. Such a system could go under the framework of the Shanghai Cooperation Organization, realising real-time exchange of correction information and data such as status, capacity, and signal quality of the navigation satellites. It is expected that chips and navigation devices based on both systems, Beidou and GLONASS, will arise. China and Russia are considering building joint design centres and joint enterprises for the R&D and production of navigation devices. Discussion about these issues will be continued at a meeting in Harbin in May.

Glimpse of unsung heroes behind Beidou 3 navigation system breakthrough

Wang Yibo is a commander of the satellite tracking system at Xichang Observatory. He and his team provide the mission with optical and radar tracking services. This was the case also for the successful launch of the 5th and 6th satellites of the Beidou 3 network in November 2017.

TELECOMMUNICATION

CASIC - Hongyun and Xingyun

CASIC (China Aerospace Science and Technology Corporation) has two ambitious LEO communication constellations, Hongyun and Xingyun, for broadband and narrowband (IoT) respectively.

Hongyun

Zhang Zhongyang, President of the 2nd Academy of CASIC, confirmed on the side-lines of the first session of the 13th National Committee of the CPPCC, that CASIC is working on the Hongyun constellation, a 156 satellite, wideband communication network, operating at an altitude of 1,000 km in LEO. As of 2022, worldwide coverage is planned, including remote areas. Within 2018, an experimental technology verification satellite will be launched.

Xingyun

On 16 March, CASIC founded a new subsidiary, the Xingyun company. Xingyun will build a constellation of 80 small sats to provide space-based internet services to countries along the Belt-and-Road Initiative as the main target market. The first Xingyun satellite (XY-S1 - Xingyun Shiyan 1) was launched on 9 January 2017 onboard a Kuaizhou 1 rocket. The Xingyun company will focus on the research, manufacturing and launch of low orbit satellites, building a network and finally a space-based 'Internet of Things'. Cloud computing and Big Data services will be part of a planned information ecology system to allow world-wide internet access.

Shijian 13 - Zhongxing 16 (ChinaSat 16)

After the successful test of a two-way high-speed laser communication between satellite and ground by a laser communication research team at the Harbin Institute of Technology (HIT), China's first high-throughput communication satellite Shijian 13, became operational on 23 January and was renamed Zhongxing 16 (ChinaSat 16). It achieved an average laser-beam capturing time of 2.5 seconds and an hour-long stable link at the maximum transmission speed of 5 Gbps. ChinaSat 16 has a transfer capacity of 20 Gbps (Ka-band) and a designed orbital life of 15 years. It is positioned in GEO at 110.6° East. It will serve distance education, emergency communication, internet access on planes and high-speed trains with a maximum download capacity of 150 Mbps and an upload capacity of 12 Mbps. According to the medium-to-long-term development plan for civilian space infrastructure, China intends to operate 22 communication satellites by 2025.

CAST Hongyan

CAST plans a 300 satellite LEO constellation, named Hongyan (wild goose), for global communication services, also in remote areas. The first satellite to test the availability of LEO frequency resources and data forwarding services, will be launched this year. Six satellites will follow before the end of 2020 to test a local area network. The whole constellation, along with data processing centres is expected to be completed in 2023 to meet increasing demand for internet services, including faster and more stable global broadband access. The constellation, made up of 54 core satellites and 270 other smaller satellites for coordination, will operate at an altitude of 1,100 km.

ADVANCED TECHNOLOGY

At the end of January, the Financial Times reported that CGWIC is talking with NPO Energomash about the procurement of RD-180 engines, preferably as a licence or the full technology. The RD-180 would help China to improve the development of its own launch systems but also to improve the Russian RD-180 technology and become a competitor on the world market. For

that reason, Russia and China signed an agreement on trade in aerospace technologies, ratified by Russia's parliament, the Duma, in November 2017. A concern is that China is not a member of the Missile Technology Control Regime, a global non-proliferation agreement.

CALT has announced the development of an aerospace vehicle capable of morphing its shape during its flight through the Earth's atmosphere and by doing so reduce air resistance and be more fuel-efficient. The space craft designers took inspiration from the flight dynamic of a bee.

SPACE APPLICATIONS

Technology for encryption and transmission of confidential data, originally developed for space science projects is at the core of an expedited business registration process for entrepreneurs in south China's city of Guangzhou. Combined with artificial intelligence, automated processing, face recognition via mobile phone, the applicants license can be ready within minutes, provided all information is correct and approved. The system was provided by Aisino Corporation in October 2017. The company intends to use space technology also for exit and entry systems, food and drug safety and government affairs.

Chinese scientists are using a high-precision electric motor for the pump of artificial hearts derived from the servo system of space rockets. The "space hearts" have been co-produced by CALT with CASC and are expected to enter clinical trials in a few years. Six sheep survived with the artificial "space hearts" for more than 100 days.

A team at the China Meteorological Administration (CMA) modelled the evolution of smog from 1979 to 2013 and then used ultraviolet sensors on satellites to predict long-term trends and variations. The GEO satellite Fengyun 4, launched in December 2016, can take clear pictures of the movement of smog used for tracking the sources of pollution and improve forecasting. China has started to provide other countries with pollutant monitoring services, helping them establish their own remote sensing networks. The Fengyun series of meteorological satellites cover 42 countries and regions along the Belt-and-Road project. In 2017, CMA trained nearly 400 specialists and awarded 71 scholarships to meteorological and hydrological students from abroad. "We share the same environment and the same Earth. Helping others is actually helping ourselves. That's what 'a community with shared future' means", said Zhang Xingying, Chief Scientist of atmosphere composition remote sensing at the CMA who is also China's Chief Scientist for an EU-funded remote sensing research programme.

CASC weather modification

CASC space scientists designed and constructed a weather modification test system to bring substantially more rain to the Tibetan plateau, Asia's biggest freshwater reserve. The system consists of a network of ten-thousand fuel-burning chambers to produce cloud-seeding silver iodide. As the moist monsoon wind from south Asia hits the mountain, it produces an upward draft and sweeps the silver iodide particles into the clouds to induce rain and snow. The chambers' daily operation will be guided by highly precise real-time data collected from a network of 30 small weather satellites monitoring monsoon activities over the Indian Ocean. CASC signed an agreement with Tsinghua University and Qinghai province on the project. It is not clear whether the government will approve the project, as intercepting the moisture in the skies over Tibet could have a knock-on effect and reduce rainfall in other Chinese regions. The project is controversial and questioned by many Chinese scientists.

COMMERCIAL SPACE

Sea Launch

In February, more details on the sea-launch plans became public. Yang Yiqiang, Commander-in-Chief of the Long March-11 rocket project of the China Aerospace Science and Technology Corporation (CASC) said that 2018 would see the first Chinese sea launch, using the CZ-11 rocket. CZ-11 is booked for five commercial payloads - four launches from land, and one at sea in an area near the Equator for low-inclination orbits. The solid-propellant CZ-11 rockets combine quick-response ability with low prices, for better, competitive services and the adaptation to various launch conditions.

CALT – Micro Launcher

China plans to develop micro solid-propellant carrier rockets for commercial use to meet growing needs for launching micro-nano satellites. CALT said that its subsidiary company, China Rocket, was in the process of evaluating the plan. The micro rockets will be developed with strong abilities, high precision, low cost and a short launch preparation cycle.

OneSpace

At the end of January, OneSpace announced that it is working towards a launch in the first half of 2018. OneSpace's launcher OS-XO is 9 m long and can generate a thrust of 35 t. Testing of the solid-propellant rocket engines was completed by the end of 2017.

OneSpace is taking advantage of the state policy of Military-Civilian Integration and the overall promotion of commercial space start-ups. In cooperation with military enterprises, such as China NORINCO and China Aerospace and Industry, OneSpace was able to develop a cost-effective and highly-reliable carrier rocket. The company's focus is on small launchers for small payloads for an affordable price. Shu Chang, founder of OneSpace, hopes to break-even in 2019. Shu Chang told media that his company has so far received 500 million RMB (80 million USD) in funding. He stressed that he has big hopes for entering the African market, without giving details.

CGWIC - Nigeria

By the end of January, Adebayo Shittu, Nigeria's Communication Minister signed an agreement with CGWIC for two Chinese communication satellites. The total financial volume of 550 million USD will be financed by CGWIC and the China Ex-Im Bank. Instead of repayment, CGWIC will become a shareholder in the governmental company Nigcomsat which is responsible for the management of Nigerian satellite communications. Both parties praised this deal as innovative. The production and launch of the satellites is planned for accomplishment in 2020. The two satellites will provide communication services to other African countries.

CGWI - Cambodia

On 11 January, CGWIC and the investment company Royal Group of Cambodia signed a Framework Agreement for the in-orbit-delivery of the Techo 1 Communications Satellite Project in Phnom Penh, Cambodia. The contract includes ground systems, insurance and technology transfer. The signature ceremony was witnessed by visiting Chinese Premier Li Keqiang and Cambodian Prime Minister Samdech Techo Hun Sen. Techo 1 will become the first integrated satellite communication system for Cambodia, which will greatly enhance the Cambodian communication infrastructure and provide communication and broadcasting services for local users. It will also promote the construction of the Belt-and-Road space information corridor, and improve the interoperability between China and Cambodia

and the ASEAN region. The Techo 1 satellite is expected to be launched in 2021.

NanoRacks

On 21 February 2018, the second meeting of the U.S. National Space Council took place in the high-bay of the Space Station Processing Facility at NASA's Kennedy Space Center, hosted by Vice President Mike Pence.

The Council's theme was "Moon, Mars and Worlds Beyond: Winning the Next Frontier" and included testimonials from leaders in the civil, commercial and national security sectors about the importance of the United States' space enterprise. After the event, policy recommendations were given to the U.S. President for streamlining the regulatory environment for commercial space companies.

One of the invited speakers was Jeffrey Manber, CEO of NanoRacks, which "operates the only commercial laboratory in outer space" and which flew the first Chinese experiment to the ISS in 2017. Jeffrey Manber took the opportunity to make a strong statement before the National Space Council regarding the regulations for U.S. companies intending to work on a commercial basis with China. He said:

... "Finally, as I look overseas, the United States cannot simply ignore China's commercial space ambitions. China is quietly developing a robust commercial space industry. I say quietly because Americans are blinded by our own regulations, and mindset, from participation.

Large Chinese companies are creating commercial launch efforts while young Chinese entrepreneurs are raising funds from Silicon Valley to Hong Kong. On a governmental level, the European Space Agency has astronauts training to visit the planned Chinese space station. But the United States is barred. NanoRacks and others are limited on what we can sell in this marketplace.

Avoiding this emerging marketplace, albeit due to justified concerns over technology transfer and other legitimate challenges, is not the American global leadership that we strive to achieve.

Now, while my time today is brief, I urge us to negotiate a stern but fair agreement with China, and allow U.S. businesses to do what we do best: innovate and compete better than anyone else."

Full text of the statement can be read here:

Kuang-Chi - NanoRacks

At the end of March, Kuang-Chi Science Ltd., and NanoRacks LLC announced a partnership to cooperate on Kuang-Chi's "Traveller" Near Space helium spacecraft. Kuang-Chi's Traveller uses high-altitude helium buoyancy to transport people and payloads into near-space, 25 km above the Earth. The Traveller programme conducted a series of successful test flights in New Zealand and China in recent years. Kuang-Chi and NanoRacks seek to cooperate to establish the Traveller as a commercially viable solution and a platform for scientific research from a number of locations in China and worldwide.

CASIC

CASIC reported that the development of its Kuaizhou 11 solid-fuelled carrier rocket is progressing and that breakthroughs in key technologies relating to the engine have been achieved. In a next step, the integrated system tests will be conducted. The plan is to launch in the second half of 2018. With a lift-off mass of 78 t and a payload capacity of 1.5 t to LEO (or 1 t to SSO) it will become China's largest solid-fuel-propelled carrier rocket and will have a short preparation period of a few days only.

CASIC is developing the "Tengyun Project" (Cloud Riding Project), a reusable space plane for transport of people and payload into LEO (satellites, space station supplies, emergency response) and back. It will be composed of two planes, with the larger aircraft acting as a carrier aircraft. The core technology of the larger aircraft is an air-breathing rocket engine using hydrogen fuel. Zhang Hongwen, Director of the 3rd Research Institute under CASIC stressed that the project is difficult. The research and development of the technology is still at an early stage. "Unlike rocket recycling adopted by the SpaceX, the space plane can take off from an ordinary airport to transport spacecraft into the orbit. It intends to revolutionise the future aerospace transportation," said Zhang. A first test flight is expected for 2030.

CASIC is also researching and developing a solar drone, enabling a local area network in near-space. Test operation of the drone system in limited areas is intended by the end of 2018 or early 2019. The area it covers is not as wide as by satellite, but it is closer to the ground, highly mobile, can stay in the air for a long time, provide internet or telecommunication services unrestricted by regions, and also assist in remote sensing images and meteorological observation. It will provide a suitable way for surveillance or for communication.

Reusable satellite

By 2020, China will offer its recoverable satellite capability to commercial customers for scientific research. Zhang Hongtai, President of CAST under CASC told media that retrievable satellites have been one of China's first space projects and have become a proven capability through the successful implementation of more than 20 projects since 1975 and the use in manned space mission. CAST is currently upgrading the technology for better service to commercial customers. Also, CAST intends to build an industrial chain to support the service.

Earth observation

UK satellite company Surrey Satellite Technology Ltd., has signed a 35 million USD (25 million GBP) contract with Beijing-based Twenty First Century Aerospace Technology Co., in Beijing in February. The Chinese commercial satellite operator will lease the high-resolution Earth observation satellite, to be launched by ISRO's PSLV in August, for seven years. Both companies have cooperated since 2011. But that time Surrey Satellite Technology Ltd., built three new satellites, the TripleSat Constellation, for Twenty First Century Aerospace Technology Co., which were launched in 2015, and have provided over the past seven years pictures of land use and landscape changes from space. That contract was closed for 110 million pounds. The new satellite and the triple sat constellation are identical.

(Already in 2017, the China Academy of Space Technology Xi'an and the University of Surrey's Institute for Communications Systems signed a two-year contract to develop high-throughput satellite and 5G mobile satellite systems.)

INTERNATIONAL COOPERATION

APSCO

On invitation of the China National Space Administration (CNSA), an APSCO (Asia-Pacific Space Cooperation Organisation) Delegation witnessed the launch of the CSES - China Seismo-Electromagnetic Satellite or Zhangheng 1 - ZH-1 from Jiuquan Satellite Launch Centre (JSLC).

APSCO Member States will be able to share the ZH-1 remote-sensing data through the newly established APSCO Ground-

Based Ionospheric Monitoring and Information Sharing Platform (GIMISP), and the dedicated web portal containing ionospheric monitoring data processing and analysis tools, for the prediction of earthquakes and for disaster management.

AUSTRALIA

Jan Elizabeth Adams, Australia's Ambassador to China told media in March that the scientists of the FAST project are cooperating with the team of the Parkes radio telescope in Australia: "The FAST telescope in Guizhou and the Australian telescope in Parkes are roughly on the same longitude, but, of course, one in the northern hemisphere and one in the southern hemisphere, so they can work together to look at the same part of the sky at the same time and validate the results. The future already holds even more promise, and we're working together on not just the mechanics of the telescopes, but also the analysis of the data."

FRANCE

At the beginning of January, French President Emanuel Macron paid a 3-day State Visit to China. On 9 January, Jean-Yves Le Gall for French Space Agency CNES and Wu Yanhua for CNSA signed an MoU (Memorandum of Understanding) on climate actions and space exploration. The signature ceremony was witnessed by both Presidents, Emmanuel Macron and Xi Jinping. Under this MoU the two nations agree to widely disseminate CFOSat data and to work towards the creation of a Space Climate Observatory (SCO).

On the same occasion, Dassault Systèmes and CASC signed a strategic cooperation agreement. CASC is interested in Dassault Systèmes' software solution 3DEXPERIENCE to support the digital transformation of CASC and accelerate efficiency and innovation.

On 10 January, during the last day of his stay, French President Emanuel Macron visited the China Academy of Space Technology at its AIT facility in Beijing, where he received a scale model of the China-France Oceanography Satellite co-developed by the two countries and readied for launch this year.

On the conclusion of the State Visit both sides released the "Joint Declaration between the People's Republic of China and the French Republic", which reads under point 17: "China and France intend to continue to deepen their cooperation in the fields of space science and technology and their applications. They wish to actively promote the development of the Chinese-French oceanographic and astronomical satellites with a view to launching them in good condition and according to schedule. They are working to strengthen their cooperation on the joint study of climate change using space technologies and on space exploration." and under 19: "France welcomes the Belt and Road Initiative. China and France agree to explore concrete cooperation projects based on the principle of mutual benefit."

News agency Reuter journalists, who accompanied the French President during this China Academy of Space Technology visit, reported that the President hoped to find French technology used for China's extensive exploration plans. The CAST engineers told him that the space transportation technology is entirely Chinese. Macron was accompanied by the head of CNES, Jean-Yves Le Gall, who felt obliged to tell the President that France is providing all medical instruments for the CSS and that he only quietly added that, by doing so, CNES hopes "to keep a foot in the door".

DBAR

On 30 January, Chinese scientist Guo Huadong published an article on the website of the academic journal, Nature, calling on global scientists to build a digital Silk Road using big data. Guo, an academician with CAS, points out that sharing big data from satellite imagery and other Earth observations across the regions covered by the Belt-and-Road initiative was key to sustainability. Guo has been the chairman of the Digital Belt and Road (DBAR) programme which was initiated in 2016 by Chinese scientists in cooperation with experts from 19 countries and seven international organisations. The aim of the Digital Belt and Road programme is to promote global sharing of expertise, knowledge, technologies and data through Earth observation and big Earth data from satellites and other sources. The information will be applied to research, decision making, project development and monitoring in seven primary areas: environmental protection, disaster risk reduction, water resources management, urban development, food security, coastal zone management and the conservation of natural and cultural heritage.

Innauguration of the DBAR International Centre of Excellence Bangkok. credit: Xinhua/CAS

The National Research Council of Thailand (NRCT) together with the Chinese Academy of Sciences (CAS) announced in Bangkok on 27 February, the establishment of an international centre for the Digital Belt and Road (DBAR) project. The DBAR International Centre of Excellence Bangkok will focus on cooperation on climate change, disaster risk reduction, environmental research and capacity building. Thailand and other Southeast Asian countries have similarities in biological diversity with China's Yunnan, Guangxi and Guangdong, making it easier to develop cooperation.

GERMANY

OHB expands activities in the NewSpace sector with the founding of Blue Horizon Deutschland, researching biological techniques to ensure plant growth on lunar and Mars rock. OHB succeeded in growing higher plants on lunar rocks using a suitable biological technology. These applied biological techniques can be used 1 to 1 to make the deserts green. A cooperation with scientists in China, who work on this topic in Inner Mongolia, is under way.

LUXEMBOURG

On 16 January 2018, the Ministry of Economy of the Grand Duchy of Luxembourg and the National Space Science Center (NSSC) of CAS signed in Beijing, a Memorandum of Understanding (MoU) that provides the framework for the development and implementation of scientific, technical, economic and political cooperation between Luxembourg and China in the exploration and use of outer space for peaceful purposes. The potential cooperation would include economic, legal, regulatory and technological aspects of the utilisation of space resources.

Furthermore, a cooperation agreement was signed to establish a Research Laboratory of Deep-Space Exploration (RLDE) in Luxembourg. The Laboratory would carry out scientific research and technology development including the research of universal interplanetary communications network related technology or advanced deep-space communications technology. The Luxembourg Minister of Economy, Étienne Schneider, also met with senior officials from CASIC and with Ant Financial executives.

DPRK

Kim Jong Un, Chairman of the Workers' Party of Korea and Chairman of the State Affairs Commission of the Democratic People's Republic of Korea (DPRK) paid an unofficial visit to China from 25 to 28 March. During his stay, he showed his admiration for China's accomplishments in the development and innovation of science and technology during a round course of an exhibition showcasing the innovation achievements of the Chinese Academy of Sciences since the 18th National Congress of the Communist Party of China (CPC). Kim left a note in the book of visitors to mark his visit.

DPRK's leader Kim Jong Un shows an interest in China's space science - having a stop at the model of FAST in the CAS exhibition in Beijing. credit: Xinhua

RUSSIA

In March, information emerged that Roscosmos State Corporation is planning for scenarios to work closer with China. Those options would include Russian hardware contributions to the CSS and joint Russian-Chinese projects for human lunar exploration. In June, Roscosmos confirmed a Chinese invitation for participation in the CSS. But its 41-43° orbital inclination, less favourable for launches from Russian territory, has been considered an obstacle. However, a flexible sea launch platform could improve this situation.

Russian space analyst Anatoly Zak wrote at the beginning of March, that Russia might get closer to China's space programme at the cost of its cooperation with the U.S. He noted that Roscosmos State Corporation had begun work on a contingency plan that could shift its human spaceflight cooperation from the U.S. to China. One option could see Roscosmos leaving the International Space Station programme. Zak learned that Russian experts were asked to think of ideas for potential contributions to the CSS and for a joint Russian-Chinese manned lunar project.

Igor Komarov for Roscosmos and Wu Yanhua for CNSA signed on 3 March during the International Space Exploration Forum (ISEF) in Tokyo, the Agreement of Intent for cooperation on the exploration of the Moon and the Outer Space as well as on the creation of a Joint Data Centre on lunar projects. Both sides consider cooperation on the Russian Luna-Resurs-1 (Luna-26) orbital mission in 2022, as well as on the planned Chinese mission for landing in the region of the South Pole of the Moon in 2023.

EDUCATION

China's first Immersive Future Experience Science and Technology Museum in Shenzhen opened on 6 February. The 2000 m² museum emphasises the integration and association of scientific exploration, practical skills, space science, social humanities and artistic aesthetics. The exhibits are mainly interactive to give the visitors an immersive experience of science and art.

For the first time China has admitted foreign students in the aerospace field. The Shenzhou Aerospace Institute under the China Academy of Space Technology enrolled on 19 March, 8 students from Pakistan, Belarus, Kazakhstan, Venezuela and Cambodia for a 2-year Masters Study in aerospace science.

MISCELLANEOUS

The top 10 achievements in China's science and technology in 2017 were elected from among the 270 candidate achievements voted by more than 2,200 academicians of sciences and engineering, experts and scholars. They included the thousand-kilometre-level quantum entanglement distribution, high-speed quantum secret key distribution between the satellite and the ground and quantum teleportation between the ground and the satellite.

Tang Dengjie, Administrator of the China National Space Administration (CNSA) has been appointed to the post of deputy governor of Fujian Province in Eastern China.

Russian cinema movie "Salyut 7", telling the true story of two cosmonauts who repaired the Soviet Salyut 7 orbital module, impressed the Chinese audience and received high ratings from Chinese cinema lovers.

At the Baselworld 2018 Show, an exhibition on China's Lunar Exploration Program (CLEP) was jointly organised by China's Chang'E Aerospace Technology (Beijing) LLC and TAG Heuer, the Swiss watchmaker, strategic partner and official timekeeper of CLEP. Zuo Wei, Deputy Chief Designer of CLEP Ground Application System confirms launch of the Chang'e 4 relay satellite in May 2018 and the launch of Chang'e 5 mission in 2019.

In August 2016, the Swiss watchmaker and China's Mars Exploration Programme set-up a partnership.

ON A SIDENOTE

In March, retired NASA astronaut Scott Kelly spoke to news website "Business Insider" about his one year stay on the ISS but also about his opinion on China's space programme: "I think that China will overtake the U.S. in the space business - if we allow them to. I think we should stay a leader in space. I think it's important. ... International partnership in space is important, and it's one of the great things about the space program. That's one of the highlights of the International Space Station: We were able to do this as a cooperative international effort. A couple of things holding back any kind of partnership with China: issues of technology transfer, arms proliferation, and human rights."

Former NASA astronaut Clayton Anderson promoted in an interview with FOX Business, the idea that more partners and countries should be welcomed on the ISS: "Well I think we need everyone. If I were the king, I would try to negotiate and figure out a way to bring China and India in with us as well. If you work with people in space, you don't fight with them on the ground."

The online news service "Business Insider" also quoted Robert Bigelow, famous for his inflatable space modules and plans for space hotels composed of inflatable structures. Bigelow reflected on China by saying that the current ISS partners are "systematically courted" by China to cooperate on the planned Chinese Space Station: "They're offering very attractive terms and conditions and features that the commercial sector is going to have a horrible time trying to compete with."

The participants of a panel discussion on 12 March at the Satellite 2018 conference in Washington, comprising launch providers Firefly Aerospace, Virgin Orbit as well as rideshare providers Spaceflight, NanoRacks, expect that the development of small launchers in China will lead to a significant reduction in launch costs, satellite development and operations.

Yang Yuguang, Senior Researcher at CASIC, told China Daily that Chinese space workers appreciate SpaceX's spirit of innovation and creativity and are determined to continue to explore their own road maps toward success. "The rapid rise of SpaceX can't be copied in China because NASA has granted it

an unprecedented level of support, ranging from infrastructure and technology to experience," he said. "That is why it has been able to grow so fast. By comparison, we have to accumulate experience and technology on our own." However, some of the US company's technical approaches can be considered by Chinese researchers as a reference, Yang said, noting China should particularly research and learn its expertise in producing and optimising rocket engines.

LAUNCHES

2018-002A
2018-002B
9 January - 03:24 UTC (11:24 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, LC9
launcher: Chang Zheng 2D
payload: Gaojing 1-03 / Gaojing 1-04 (SuperView 1-03/04)

For the further assembly of its commercial, high-resolution Earth remote sensing network, Beijing Space View Tech Co. Ltd., launched another pair of Gaojing (SuperView) imaging satellites into a 500 km sun-synchronous orbit. By joining the first pair of satellites, phased 90° from each other, they combine to form the initial SuperView 1 constellation. The final multi-sensor configuration, will consist in 2022 of 24 satellites (16 optical (0.5 m resolution) + 4 super-high-resolution of less than 0.5 m + 4 VHR X-band SAR satellites + additional micro video and hyperspectral satellites). It is a state-certified satellite system, managed by the Siwei Survey and Mapping Company. The Gaojing satellites are built by the CAST/DFH Company and based on the CAST3000B bus, featuring low mass (560 kg), high agility, high image quality, advanced AOCS and a highly integrated electronic system. The projected operational life is 8 years. One Gaojing satellite has an onboard data store capacity of up to 2 terabytes and can image an area of 700,000 km² per day. The panchromatic resolution is 0.5 m and multi-spectral imaging (in blue, green, red, and near-infrared) resolution is 2 m with a 12 km swath width. The cameras can operate in nadir mode, rolling imaging, long strip mode, multiple strip collection (high-res and large swath), multiple point target collection and stereo imaging. The maximum single scene is around 60 km x 70 km.

The SuperView constellation can offer remote sensing data for land and resource surveys, mapping, environmental monitoring, finance and insurance as well as for the internet industry.

China Great Wall Industry Corporation (CGWIC) is the prime contractor of the SuperView 1 satellite programme, and China Siwei Surveying and Mapping Technology Co. Ltd., Beijing (Space View's sister-company) will be the owner and operator. SuperView 1 satellites are designed and developed by the China Academy of Space Technology (CAST)/DFH Company. CGWIC, Siwei, CAST and SAST are all subsidiaries of China Aerospace Science & Technology Corporation (CASC).

Originally, the launch was planned for 25 December 2017 but was postponed to give priority to the launch of a Yaogan triplet.

2018-003A
2018-003B
11 January - 23:18 UTC (12 January - 7:18 BJT)

launch site: Xichang Satellite Launch Centre - XSLC, LC2
launcher: Chang Zheng 3B/YZ-1
payload: Beidou 3M7 / Beidou 3M8

Three hours after lift-off, the Yuanzheng 1 (YZ-1) upper stage positioned the navsat pair into a circular medium Earth orbit at 21,500 km, inclined by 55.5°. The two 3rd generation navigation satellites are also named Beidou 26 and Beidou 27, indicating that they are the 26th and 27th satellite in the Beidou family.

The box-shaped satellites have a mass of 1,014 kg and a dimension of 2,25 x 1.0 x 2,2 m. Their projected lifetime is 12 years. The phased-array antenna unit is completed by two deployable solar arrays. Additionally, the satellites carry laser retro-reflectors for high-precision location determination. Beidou 3rd generation satellites are designed for long-endurance, are based on a lightweight satellite platform, are equipped with an intersatellite data link system and advanced self-navigation technology. The signals are synchronised by rubidium atomic clocks, transmitted in the B1 frequency band (1,561048 - 1,57542 GHz). Signals in the B2 and B3 frequency band are also operational.

Both satellites were built by the Shanghai Innovation Academy for Microsatellites of the Chinese Academy of Sciences. Media have stressed that 90 % of the key components were developed by China. In 2018, it is planned to launch 18 Beidou-3 satellites to cover the Belt-and-Road region. By around 2020, the modernised network with 27 MEO and 5 GEO satellites will enable global coverage. The launch was delayed from 2017 because of problems with the CZ-3 rocket.

2018-006A
13 January - 7:10 UTC (15:10 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC, LC 43
launcher: Chang Zheng 2D
payload: LKW 3 - Ludikancha Weixing 3

The 3rd LKW 3 very high-resolution Earth observation satellite was added to a constellation in a 500 km polar orbit. LKW 3 is 45° apart from LKW 1 and 2. The LKW satellites are based on the CAST2000 bus, have an elongated, hexagonal satellite body with three deployable solar panels. No detailed information was published. Officially declared for remote sensing, LKW satellites may serve military purposes.

2018-008A 2018-008C 2018-008E
2018-008B 2018-008D 2018-008F
19 January - 4:12 UTC (12:12 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC, mobile
launcher: Chang Zheng 11
payload: Jilin 1-Shipin 07 / Jilin 1-Shipin 08 / KIPP / Huai'an / Quantutong 1 / Hunan Xiangjian Xinqu

The third CZ-11 flight lifted two more Jilin 1 video satellites and four small satellites into orbit. The launch was also the 100th orbital launch from JSLC.

The two commercial Jilin 1 video satellites were built and are owned by Chang Guang Satellite Technology Co., (CGSTL) in Changchun, Jilin province.

Jilin 1-07 was named "Deqing 1" (DQ-1) and Jilin 1-08 "Linye 2". Both video satellites produce high-resolution (92 cm) remote sensing imagery for government and industry users. The Jilins are box-shaped satellites, with a mass of 95 kg and are equipped with an objective and two solar panels. The initial Jilin constellation in 500 km SSO will consist of 12 satellites. More launches are planned for 2018. Also compare 2017-074A/B/C in issue 22.

The 4 cubesat payloads

Xiaoxiang 2 (TY-2, Tianyi 2) and Xiaoxiang 5 (TY-5, Tianyi 5)

Both these 6U cubesats were developed by SpaceTY Aerospace Co. at the Tianyi Research Institute in Changsha, Hunan province. The 8 kg Tianyi 2 (also: Hunan xiangjiang xinqu hao weixing, named after Hunan Xiangjiang New Area) is equipped with four technology experiments: testing optical fibre sensing technology, space radio software, amateur radio and image stabilisation. SpaceTY operates Tianyi 2 on behalf of the Changsha Gaoxinqu Tianyi Research Institute. It is the 2nd satellite of a commercial series of nanosats in preparation for future astronomical missions using smallsats.

Quantutong 1 (also Tianyi 6) serves for search-and-rescue service experiments for the Beijing-based Quan Tu Tong Co., (All Graphic Location Network Co.) It carries navigation, communication, micro remote sensing cameras, AIS, and

amateur radio payloads. Danish GomSpace contributed a number of components.

KIPP (named after the fictional robot from the movie 'Interstellar') or Kepler 1 is a 3U cubesat built by Scotland's Clyde Space for Kepler Communications of Toronto, to serve as a technology demonstration for the planned Ku-band telecommunications constellation of 10 to 15 satellites in polar orbits. It is designed for a 2-year operational life. The satellite stores and forwards data, is able to connect marine vessels, oil & gas platforms, mines, agriculture fields, and other businesses without real time requirement. Kepler says its satellite will eventually be able to connect to other satellites, space stations and space transport vehicles.

KIPP is the first Canadian satellite launched on a Chinese rocket and also the first commercial low-Earth-orbit satellite to use Ku-band frequencies. Delft-based Innovative Solutions in Space (ISIS) arranged the launch.

Huia'an hao Enlai xing (Huaian 1 - HA 1), is a 2 kg, 2U cubesat built by 20 undergraduate students at Huai'an Youth Comprehensive Development Base in Jiangsu province, and named in honour of former Chinese Premier Zhou Enlai, who was from the area. Equipped with a HD optical camera, the satellite can take pictures of the Earth's surface and hosts a voice transmission and a deorbit experiment.

2018-011A 2018-011C
2018-011B 2018-011D
25 January - 05:39 UTC (13:39 BJT)

launch site: Xichang Satellite Launch Centre - XSLC, LC 3
launcher: Chang Zheng 2C
payload: Yaogan 30-01 (Chuangxin 5-10) / Yaogan 30-02 (Chuangxin 5-11) / Yaogan 30-03 (Chuangxin 5-12) / Weina 1A (Chuangxin 6-6)

The fourth triplet of identical Yaogan 30 remote sensing satellites was the main payload on this launch. They complement the network of nine in 2017 launched satellites in similar 600-km, 35° inclined orbits. The satellites, built by Microsatellite Innovation Institute under the Chinese Academy of Sciences (CAS), will conduct electromagnetic environmental probes and other experiments. There is very limited information available on these satellites.

The Weina 1A nanosatellite for technology experiments was an additional payload on this launch. It is owned by MicroStar Technology Co. Ltd. Currently, no further information is given but it was reported that six more Weina satellites will be launched in 2018.

2018-015A 2018-015C 2018-015E 2018-015G
2018-015B 2018-015D 2018-015F
2 February, 7:51 UTC (15:51 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC, LC 4
launcher: Chang Zheng 2D
payload: Zhangheng 1 / GomX-4A (Ulloriaq) / GomX-4B / ÑuSat-4 (Ada) / ÑuSat-5 (Maryam) / Shaonian Xing / Fengmaniu 1

ZH-1, also named ESEM (ESEM - Experimental Satellite on Electromagnetism Monitoring) or CSES-1 (China Seismo-Electromagnetic Satellite), was placed in a 98° Sun-synchronous circular orbit at an altitude of around 500 km. It is based on the CAST2000 satellite bus, has a mass of 730 kg, is cube-shaped (1,4 m), and equipped with one three-segment solar panel and six long booms which will deploy and keep electromagnetic detectors more than 4 m away from the satellite. CNSA, together with the China Earthquake Administration and the Italian Space Agency (ASI) are jointly operating ZH-1. The expected operational lifetime is 5 years.

ZH-1, named after Zhang Heng (78-139), a Chinese polymath, astronomer and seismologist of the Han-Dynasty, carries six instruments to detect and measure high-energy particles, plasma, and electric and magnetic fields: a search-coil magnetometer, an electric field detector, a high-precision magnetometer and a GNSS occultation receiver. It is also equipped with a Langmuir probe, a plasma analyser, and a tri-band beacon to measure in-situ plasma and ionospheric profile. While the High-Energy Particle Detectors are an Italian contribution, the High Precision Magnetometer is a China-Austria cooperation. The same type of magnetometer will be also be used for ESA's Jupiter mission JUICE in 2022.

The satellite is mainly known as an experimental seismo-electromagnetic probe to monitor and study the ionospheric perturbations which may possibly be associated with earthquake activity, especially with those of high magnitude. The aim is to find factors which would enable short-term earthquake forecasting.

But the instruments will also contribute a wealth of data on the space environment of the Earth's electromagnetic field, ionospheric plasma and energetic particles and try to understand the possible impact of human activity on the Earth's near-space environment. Data will also allow for studying solar-terrestrial interactions and phenomena including Coronal Mass Ejections and solar flares and may also serve aerospace and navigation communication purposes.

Zhangheng 1will run in-orbit tests for about six months to assess its data quality before it is formally put into service. A second seismo-electromagnetic satellite is under evaluation in China.

The piggy-back payloads

The two 8 kg, 6 U cubesats **GomX-4A and 4B** were built by the Danish company GOMSpace.

GomX-4B has 6 payloads. It will test S-band inter-satellite and High-Speed satellite-to-ground links with high data rate capacities. Also, on board is a cold gas micro-propulsion unit (developed by Sweden's NanoSpace) for orbit controlling during formation flight with GomX-4A at a distance of 100 to 4.500 km. GomX-4B carries the Cubesat Highly Integrated Memory Radiation Assurance experiment (Chimera) for testing of COTS components in the space environment. Additionally, it hosts two new optical devices from the Netherlands; the 45-channel HyperScout Hyperspectral Camera from Cosine and a Star Tracker developed by ISIS.

GomX-4A, named "Ulloriaq", will be operated by the Danish Ministry of Defence for technology demonstration and surveillance of the Arctic. It is fitted with radio receivers capable of capturing position signals from ships and aircraft.

The life expectancy of both nanosatellites is 3-5 years. They will be fully operated by GomSpace.

ÑuSat-4 and ÑuSat-5 (Ada / Maryam) The two Earth observation satellites are the fourth and fifth satellites for the commercial Aleph 1 constellation of Argentinian Satellogic S.A. Aleph 1 will consist of up to 25 satellites. Satellogic have launched before on the Long March rocket, indicating the launch cost of between 1-2 million USD per satellite. For 2018, three more satellites are planned.

The two satellites were named "Ada" after Ada Lovelace and "Maryam" after Maryam Mirzakhoni. The body-shaped, 37 kg remote sensing satellites have a dimension of 40 x 43 x 75 cm with an integrated telescope. The optical imager delivers 1 m resolution panchromatic data, the infra-red sensors image with a 90 m resolution and the multi-spectral data are of 30 m resolution.

Juvenile 1, a 3 kg, 3U observation cubesat, was built and tested by Beijing CommSat Company, for space education and outreach. It is designed for wireless storage and transmission of radio waves at UV frequency, space imaging and the verification of user

links to the Internet of Things (IoT). Shaonian Xing is also called Young Pioneer 1, Junior Star, Teenager Satellite, Youth Satellite or Ministar 1 reflecting on its origin within the school project "SatChina", engaging in a way more than 1,000 primary and secondary schools from across the country. Data from the satellite is open to all schools in China equipped with adequate facilities.

FengMaNiu 1 is a 3U, 4 kg cubesat, built by LinkSpace Aerospace Technology. It is a technology testing satellite for, among others, an optical camera unit and an amateur radio. Fengmaniu means "wind mill".

2018-018A
2018-018B
12 February 2018 - 05:03 UTC (13:03 BJT)

launch site: Xichang Satellite Launch Centre – XSLC, LC2
launcher: Chang Zheng 3B/YZ1
payload: Beidou 3M3 / Beidou 3M4

Another pair of Beidou navigation satellites of the 3rd generation, also named Beidou 28 and Beidou 29, were launched into MEO. Three hours after lifting off, the satellites entered the circular target orbit of 21.500 km. Both satellites were built by CAST. For more details on the Beidou satellites also compare: 2018-003A / 2018-003B and Quarterly Report 2017-4 in issue 22.

2018-025A
17 March - 07:10 UTC (15:10 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC, LC 43-94
launcher: Chang Zheng 2D
payload: LKW 4 - Ludikancha Weixing 4

LKW 4 is another satellite in the constellation of very high-resolution Earth observation satellites. Limited information concerning the LKWs is published. Also compare 2018-006A - above. It is believed that the LKW satellites serve military purposes.

2018-029A
2018-029B
29 March - 17:56 UTC (30 March - 1:56 BJT)

launch site: Xichang Satellite Launch Centre – XSLC, LC2
launcher: Chang Zheng 3B/YZ-1
payload: Beidou 3M9 / Beidou 3M10

Two more navigation satellites, the number 30 and 31 of all Beidou satellites since 2000, entered their pre-set orbit in the A plane of the constellation after more than three hours of flight. After initial testing, the navsat twins joined the 6 previously launched satellites in the Beidou-3 satellite network. The now eight BDS 3 sats form the simplest global system and will undergo integrated test operations. The new generation satellites were developed by the Innovation Academy for Microsatellites Shanghai.

For details on the 3rd generation Beidou satellites also compare: 2018-003A / 2018-003B and Quarterly Report 2017-4 in issue 22.

2018-031A
2018-031B
2018-031C
31 March - 03:22 UTC (11:22 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC, LC9
launcher: Chang Zheng 4C
payload: Gaofen 1-02 / Gaofen 1-03 / Gaofen 1-04

The three civil high-resolution optical remote sensing satellites will join the 2013 launched GF-1-1 satellite on a 3+1 network. The new triplet provides a 2-day revisit coverage and a 15-day global coverage, but will improve to a 11-day global coverage within the 3+1 network.

Each satellite, based on the CAST 2000 small satellite bus and designed by China Spacesat, has a launch mass of 805 kg and an operational lifetime of 6 years. The box-shaped Gaofens of 1,56 x 1,65 x 1,87 m in size, are equipped with two solar panel wings, each with three solar panels, providing 1.000 W performance. For the Earth monitoring tasks within CNSA's CHEOS programme, each GF-1 is equipped with a 2 m resolution panchromatic CCD camera, an 8 m resolution multi-spectral imager, and a 16 m resolution wide-field multi-spectral imager for simultaneous observations.

China Spacesat Co. Ltd., is the commercial subsidiary of CAST.

The Gaofen constellation is part of China's civil space infrastructure, to be completed in 2025. The data will serve fields such as disaster prevention and mitigation, environmental protection, urban and rural development, transportation, emergency management.

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

http://news.xinhuanet.com
http://spaceflight101.com/china/
https://www.nasaspaceflight.com
http://www.spaceflightinsider.com
https://spaceflightnow.com
http://www.planet4589.org/space/jsr/jsr.html

ACC	Astronaut Centre of China
AAPT	Academy of Aerospace Liquid Propulsion Technology
APSCO	Asia-Pacific Space Cooperation Organisation
BDS	BeiDou satellite navigation Systems
BISME	Beijing Institute of Space Mechanics and Electricity
BJT	Beijing Time
BNU	Beijing Normal University
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
CFOSat	China-French Oceanography Satellite
CGWIC	China Great Wall Industry Corporation
CLEP	China's Lunar Exploration Programme
CMA	China Meteorological Administration
CMC	China's Central Military Commission
CMSA	China Manned Space Agency
CMSEO	China Manned Space Engineering Office

CNES	French Space Agency
CNSA	China National Space Administration
CPC	Communist Party of China
CPPCC	Chinese People's Political Consultative Conference
CSES	China's Seismo-Electromagnetic Satellite
CSMTC	China Satellite Maritime Tracking and Control Department
CSS	Chinese Space Station/China Space Station
CZ	Changzheng, Long March
DAMPE	Dark Matter Particle Explorer
DBAR	Digital Belt and Road
DPRK	Democratic People's Republic of Korea
DSLWP	Discovering the Sky at Longest Wavelengths Pathfinder
ESOC	European Space Operations Centre
ESA	European Space Agency
EVA	Extravehicular Activity
FAST	Five-Hundred Metre Aperture Spherical Radio Telescope
FHR	Fraunhofer Institute for High Frequency Physics and Radar Techniques
GDP	Gross Domestic Product
GEO	Geostationary Orbit
GNSS	Global Navigation Satellite System
HIT	Harbin Institute of Technology
HXMT	Hard X-ray Modulation Telescope

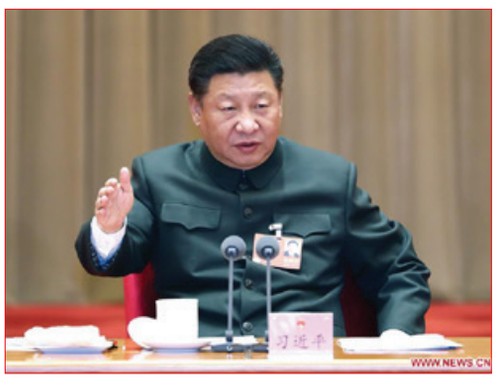
IAC	International Astronomical Centre
IADC	Inter Agency Space Debris Coordination Committee
IAMCAS	Innovation Academy for Microsatellites of CAS
IADC	Inter Agency Space Debris Coordination Committee
IHEP	Institute of High Energy Physics
LLR	Lunar Laser Ranging
MoU	Memorandum of Understanding
NAOC	National Astronomical Observatories of China
NORINCO	China North Industries Group Corporation Limited
NPC	National People's Congress
NSSC	National Space Science Center
PLA	People' s Liberation Army
R&D	Research and Development
SJ	Shijian
SKA	Square Kilometre Array
SOA	State Oceanic Administration
SZ	Shenzhou
TG	Tiangong
TIRA	Tracking and Imaging Radar
UAE	United Arabic Emirates
UNOOSA	UN Office for Outer Space Affairs
UTC	Coordinated Universal Time
QTT	Qitai 110-meter Radio Telescope

China's new buzz phrase: integration of military and civilian development

by Jacqueline Myrrhe

At the 18th National Congress of the Communist Party of China in November 2012, the integration of military and civilian development was declared a national strategy. Considering this process as crucial for China's prosperity, Chinese President Xi Jinping put this topic on his personal agenda. In March 2015, Xi reiterated his commitment to turn this long-term mechanism into reality and he established under his leadership the Central Commission for Integrated Military and Civilian Development in January 2017.

President Xi identified sea, outer space, cyber space, biology and new energy as the core areas for the integration development. On the civilian side, the "Four Civil Industries": civil aerospace, civil aircraft, civil nuclear power and high-tech shipping, are in the focus. On the military side, military high-tech industries such as satellite navigation and remote sensing application, ocean engineering and scientific equipment, network information security, smart city development are relevant.



President Xi Jinping leads the 1st Plenary Session of the 19th China's Central Military-Civilian Integration Development Committee in March 2018. Credits: Xinhua

In this whole process the proven method of combining state guidance with the market's role is applied. It is recognised that over the last decades, China has poured substantial resources into the development of the military sector and military high-technologies. The size of China's military occupies a significant number of talents, just for the only purpose of national defence which was until now a closed sector.

One of the results of the military-civilian integration is to make those resources, paid by the taxpayer, directly accessible and benefitting the taxpayer with significant gains for the overall economic and societal development.

There is also the awareness, that feeding the limited national social resources organically into the society can translate into "twice the benefit with half of the investment". In particular, the application of military technologies to the civil sector should boost the national economy. But this is not a one-way road because also, the reverse dynamic should work: advanced civil technologies support the military industry. Once this two-way process gains momentum, the military-civilian integration has come to fruition, the two parts mutually promote, interact, blend and support each other to narrow the gap between the Chinese and leading nations in the world. As a consequence, the two objectives of "making the country rich" and "making the military strong" can be achieved.

In March 2018, the first Plenary Session of the 19th China's Central Military-Civilian Integration Development Committee hosted by President Xi Jinping passed a series of relevant decisions.

The meeting deliberated and adopted a guideline on military-civilian integration, a working plan of the central commission for integrated military and civilian development in 2018, and a plan for building innovation demonstration zones of national military-civilian integration with a list of the zones. The meeting also reiterated the combination of top-level plans with local research to achieve progress in mechanism, policy, and development mode innovation.

Chinese military-civilian integration is still at the transitional stage from initial integration to deep integration, along with some structural conflicts, institutional handicaps, policy problems etc. Much can be achieved, once a functioning information exchange system has been established between military and civilian entities. There are concerns that it might be difficult for the older generation of military to show an open mind to those changes and that both sides will take some time to understand each others requirements. Also, coordination and sharing of resources as well as the modernisation of policies, regulations, management mechanisms and institutional structures are a challenge. Civil enterprises wish to get easier access to licences and procurement processes. For military departments is it hard to judge the maturity of civil technologies. A good idea is the establishment of a demonstration project of military-civilian integration from which others could learn.

In April 2018, the Central Military Commission has for the first time declassified and published 4,038 national defense patents in the field of aerospace.

What China is testing, is not unprecedented. The internet, the Global Positioning System GPS, nuclear power and space technology are just a few examples of dual-use technologies and prove how integrated military and civilian development has been improving people's lives across the globe.

GPS was originally developed by the U.S. Department of Defense and operated by the U.S. Air Force. Only in 1996, U.S. President Bill Clinton signed a policy document, which allowed for the civilian use of certain GPS signals. Also, today's internet is based on a military technology. In the 1960s, the Advanced Research Projects Agency, ARPA, of the U.S. Department of Defense financed the Advanced Research Projects Agency Network ARPANET which later opened up to civil use.

The example of the Cold War shows how the investment of national resources into the military field has been an immense burden for the economies of the Soviet Union but also for the U.S.

After the break-up of the Soviet Union, Russian military enterprises established cooperation and applications while using military technologies such as microelectronic, computer, radar and nuclear technologies.

In China, the space industry is the most apparent beneficiary of the military-civilian integration. Until recently, only Chinese state-owned firms were permitted to build, launch and operate satellites. In 2014, new regulations allowed private companies to participate.

On 5 September 2018, iSpace became the first Chinese commercial provider to launch a suborbital rocket from the Jiuquan Satellite Launch Centre since it began operation in 1958. Only two days later, OneSpace, which is supported by the state defence contractor Aviation Industry Corporation of China, successfully completed its first suborbital rocket launch from Jiuquan. This is a concrete measure towards the implementation of the strategy of military-civilian integration.

Connected with China's move for integration of military and civilian development is the hope that economic growth in the 21st century is no longer defined by expansion of production but rather by expansion of knowledge which enables innovation and efficiency for smart and green growth.

"Our top goal was to be committed to one hundred percent quality..."

interview with Prof. Dr. Bernd Madauss

Prof. Dr. Bernd Madauss is a renowned international expert on project management in the aerospace sector. He started his professional career in the Hanseatic city of Bremen, Germany, where he completed his engineering studies in naval architecture. In the late seventies he finished his studies for a Master of Business Administration (MBA) at the Pacific States University (PSU), Los Angeles, U.S.A. In the mid-eighties, Bernd Madauss finished his PhD studies at PSU. The University appointed him to a full professorship two years later.

He was involved in aircraft and rocket design, project planning and control, acquisitions including requests for proposal (RFP) and proposal preparation, contract management, cost control management, documentation and configuration control and risk management. He gained his project management experience as project control manager at ELDO Paris and MBB Munich and thereafter as Senior Program Manager at SES Astra, Luxembourg.

Since 2004, his expertise was requested by many of the leading European space enterprises which included Airbus, MT Aerospace, OHB Bremen, IABG, Yuzhnoye, and institutions such as the German Aerospace Centre, DLR. His vast amount of international space project management (PM) experience and his capability in PM training became known also outside of Germany. He performed PM-training in China, Oman, UAE and Ukraine. In 2007 he was employed as Corporate Advisor by Yahsat, UAE, were he also took over the position of acting CTO.

Prof. Madauss lectured project management at some renowned universities across Europe and is Visiting Professor and Faculty Member of the International Space University (ISU) in Strasbourg, France.

As of today, he has accumulated more than five decades of professional experience in project management and engineering of international space projects.

Prof. Madauss is the author of numerous articles and book contributions and is the author of the handbook "Project Management", of which the 7th edition has been published in 2017.

GoTaikonauts! had the opportunity to talk with him about his experience in project management training and project management activities in China.

GT!: You were involved in the project management for Chinese State-owned space companies. How did this happen?

Prof. Madauss: In 1998 I provided a training course for project management in Toulouse. Some Chinese engineers from China Great Wall Industry Corporation (CGWIC) attended the course. They liked the training and therefore one of them approached me and asked whether I could give such training also to his colleagues in China. One year later, in 1999, I trained personnel of CGWIC in project management.

Almost a decade later, in 2011, I met again with one of the participants of the 1999 training course at the CABSAT Expo in Dubai. His colleague, a CGWIC manager asked me whether I would mind to come again to China in order to give a PM training course in Beijing. I happily agreed and I received an invitation for the PM training course at CGWIC, Beijing.

During my stay in China, I had discussions about the possibility that my company "Angermann Consulting and Training GmbH - ACT" may perform in the name of the Bolivian Space Agency ABE a monitoring function for the production process of the Bolivian satellite TKSat-1 - Túpac Katari 1. TKSat-1 is a geostationary telecommunication satellite, which was built, launched and delivered into orbit by Chinese companies.

I wrote an offer for field office activities and formed a team of five highly qualified space engineers and colleagues which I knew from my earlier work for the German space company Messerschmitt Bölkow Blohm MBB in Munich.

Throughout the year 2012 we had several rounds of negotiations until we got the contract.

The ACT Team. From the left: Arnold Jablonski, Victor Billig, Klaus Polzer, Bernd Madauss, Hans-Jürgen Tscheulin. credit: Bernd Madauss, book on project management, 2017

I always had the feeling that the Chinese liked the name of my company which reads "ACT" and can be interpreted as "active".

After contract signature, ACT immediately started with the monitoring tasks. The launch of the satellite was set for 21st December 2013. The date was the wish of Evo Morales, President of Bolivia. The tight deadline was very challenging for the Chinese engineers. Before sending the satellite to the launch site a Pre-Shipment Review (PSR) had to be performed. The ACT representative in China demanded that the data package for the PSR had to be presented in the English language.

GT!: Which problems did you encounter during the management of the project and how did you resolve them?

Prof. Madauss: Our top goal was to be committed to one hundred percent quality to guarantee that the TKSat-1 satellite will remain fully functioning in orbit for at least fifteen (15) years. This is the hallmark of my company and the characteristic of the performance of our team. We knew that the first Nigerian satellite, built by CAST, encountered technical problems in orbit. That gave us some headaches. Therefore, ACT encouraged the Chinese colleagues to improve the quality assurance (QA) aspects. The project manager approached ACT, since he realised that we were hesitating and he asked for support. As a consequence, Professor Victor Billig, the ACT colleague in charge at that time, set-up a two-day training on QA, to help them to understand the situation and the processes involved. All Chinese team members participated in that training course. Thereafter, ACT issued a certificate for the successful completion of the training.

In November 2013 ACT participated in the PSR for TKSat-1. Four parties had to confirm and sign the PSR readiness documents: namely CAST (the satellite manufacturer), CGWIC (the Chinese management company), ABE (the Bolivian Space Agency), and ACT (the management and field office consultant). The responsible ACT colleague had concerns because some documents were missing or written in the Chinese language. The documents were really crucial for the judgement that everything was OK for shipment to the launch site. Some of those documents would contain changes which he had initiated and without those documents he could not know whether the changes were implemented or not. He assumed that the Chinese colleagues had not the same understanding as ACT about the relevance of those documents. Then, literally overnight, all missing documentation were translated into English and handed over to ACT.

I have to admit, that for a short moment we were also thinking about what would have happened if we had not counter-signed the PSR document. Fortunately, we did not have to worry about this because all four parties involved jointly concluded to give green light for shipment of the satellite to the launch site. All agreed: 'Let's go!'

What is important to add is the fact, that we had throughout the whole satellite production process an open dialogue with all Chinese colleagues who were building the satellite and full access to all relevant documents. On-site at the CAST satellite factory in Beijing, ACT had full visibility as required for the monitoring tasks. As far as I can judge and as far as it was important for our work all important information were provided to ACT.

GT!: How have you experienced your Chinese colleagues? Which strengths are Chinese space experts contributing to international projects?

Prof. Madauss: In all my business visits to China I have experienced a constructive and very friendly atmosphere. All were cooperative and contributed to a good work environment. On special occasions we were invited for a typical Chinese dinner sitting at a round table. Everybody at the table could try out all of the different dishes. It was also very popular to speak a toast. For that, all would cheer with a small glass of spirit and that was the way to celebrate brotherhood. It was everybody's turn.

We also appreciated the patience of the Chinese colleagues and their listening skills.

During my project in China I have not experienced any hiding of important information. We experienced a very open and transparent atmosphere and all required technical documentation and information were accessible to the ACT personnel.

GT!: Is there anything European companies could learn from China?

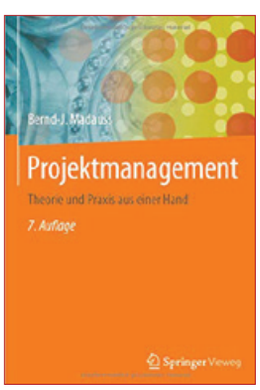
Prof. Madauss: First of all, the general idea of establishing a friendly human relationship. In some situations, I have applied this also to other projects, for example in the cooperation with my colleagues in Europe and the U.S. To start a project in a friendly environment is helpful for managing complex international projects. This is especially true for building a bridge to another culture. Therefore, and that is what we learned in China, one should invest in some warm-up time prior to starting the project. Also, my ACT colleagues enjoyed their stay in Beijing and we learned how to eat with chopsticks. Secondly, we learned that it is good to take some time for solving critical aspects without rushing. Europeans sometimes have the tendency to be too fast because we assume efficiency means: working as fast as possible.

GT!: You are the author of the seventh edition of the textbook "Project Management", which also provides some information about the project management experience in China?

Prof. Madauss: Yes. The book is a compilation of 26 project management topics, containing also two chapters in the English language. Prof. Victor Billig, a member of the ACT team wrote about the developments in space since the launch of Sputnik. He also wrote about the special experience made in China. The photo (previous page) shows the five ACT members which provided the TKSat-1 field office support in Beijing.

GT!: How do you assess China's current space ambitions?

Prof. Madauss: China is very determined to catch-up with Western competitors in Europe and the U.S. and in recent years much progress has been made in the space domain of China. I therefore consider any reservations and limitations in cooperation with China as short-sighted. I am looking respectful to the space developments in China as a future competitor with products as good as the Western products. The Chinese are smart people. At the moment they may miss in special areas some space experience but this is just a matter of time to become fully competitive reaching a world class standard.



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The Túpac Katari communications satellite in the space testing facilities of CAST. credit: CAST

The TKSat is mounted in a protective cover, sitting on top of its launcher, the CZ-3B. credit: Xinhua

Bolivian President Juan Evo Morales Ayma delivers a speech after the successful launch of the Bolivian communications satellite Túpac Katari at the Xichang Satellite Launch Center (XSLC), in China's southwestern Sichuan Province, on 21 December 2013. credit: Xinhua/Yan Yan

left: Túpac Katari launched from the Xichang Satellite Launch Center (XSLC) on 21 December 2013. credit: Xinhua/Yan Yan

Túpac Katari 1
TKSat-1

Iván Zambrana, Executive General Director of the Bolivian Space Agency (ABE) and Yin Liming, President of China Great Wall Industry Corporation (CGWIC) signed on 13 December 2010 in La Paz, a contract for the in-orbit delivery of the Túpac Katari 1 communications satellite and the delivery of the relevant ground application system to Bolivia. The spacecraft, named after the national hero, Túpac Katari, who fought off the Spanish conquistadors, is the first communications satellite for Bolivia serving its 11 million inhabitants. For CGWIC it was the sixth communications satellite in-orbit delivery contract with an international customer.

Túpac Katari is based on CAST's DFH-4 satellite bus and has a projected service life of 15 years. The satellite is 2.36 m long, 2.1 m wide and weighs 5.3 tonnes. Launched on 21 December, it was positioned in GEO at 87.2° W. It is equipped with 26 Ku-band, 2 C-band and 2 Ka-band transponders. It will not only provide communications and broadcasting services to the whole territory of Bolivia and the surrounding areas, but also facilitate the development of civil projects like remote education and telemedicine. The 302 million US-dollar programme cost (other sources say: 295 million) was covered with 85 % financing from the China Development Bank and with the Bolivian government contributing 15 %. ABE did not disclose the specific terms of its China Development Bank loan, but it can be assumed that the funds were advanced at low interest rates, with repayment starting only after the satellite became operational in orbit.

After its testing phase, the satellite entered its operational life and was handed over to Bolivia on 1 April 2014. Two years after the launch of TKSat-1, ABE said that 75 % of the spacecraft's transponders have been sold, all to Bolivian government and commercial entities. The state-run National Telecommunications Company (Entel) is the main user of the satellite, which occupies about 50% of the capacity. That percentage is used to expand coverage in mobile telephony, satellite television, telecentres and Internet services. Nearly two million people in rural areas benefited from the services. Iván Zambrana of ABE said at the end of 2018 that internet access doubled in the last five years thanks to the satellite Túpac Katari, from 30% of Bolivians who had that service in 2013, to 64% in 2018. TKSat's capacity enabled national TV channels Bolivisión and ATB to make use of high definition broadcasting, beginning 1 November this year. At the same time, the satellite's revenues are close to 100 million US-dollar. Over the satellite's 15-year life, its total revenue is estimated to be around $500 million, a level that ABE said is sufficient to justify a replacement. Already before the launch of TKSat-1, Bolivian media reported that the country intends to purchase another satellite from China, but an Earth observation satellite which would be named after the wife of Túpac Katari, Bartolina Sisa.

left: Bolivian President Evo Morales speaks at the satellite hand over ceremony in April 2014.
credit: cochabandido blog

right: Bolivian President Evo Morales is presented with a model of the Túpac Katari communications satellite.
credit: CGWIC

A Historic Day for Chinese NewSpace

by Chen Lan

Launch Site in the Desert

On 27 October, invited by MinoSpace, a Chinese start-up satellite company, I went to the Jiuquan Satellite Launch Center (JSLC) and witnessed the inaugural launch of the LandSpace Zhuque 1 (ZQ-1) solid fuel small launcher. It was not only the first orbital launch by LandSpace, China's leading private rocket company, but also China's first private rocket to be launched into orbit. The payload on top of this rocket was the first deliverable by MinoSpace - the Weilai 1 (Future 1) educational satellite developed for CCTV (China Central Television).

It was a nice day with comfortable temperature and a clear blue sky. Our bus departed from Jiayuguan before sunrise and started a 4-hour journey through the Gobi Desert. In the beginning, the bus ran on a section of desert expressway. Along the expressway, greens, villages and farmlands were occasionally seen between sand-stabilised facilities. And we saw a beautiful sunrise. However, after about three-quarters of the journey, an immense flat bare desert was suddenly before my eyes. All living things were gone, replaced with sparsely located strange facilities. The two-lane highway goes straight into the distance, with a railway accompanying it on the left-hand side. I felt that the atmosphere became serious, with a little excitement. Finally, I discovered the familiar launch towers and the VAB (Vertical Assembly Building) on the horizon that I saw hundreds of times in photos and on TV. At about 11:00 h, we reached the checkpoint to enter Dongfeng, the so-called "space city".

Highway to the launch center. (credit: Go Taikonauts!)

Dongfeng is a clean and silent small town. There are many old-era low buildings among golden autumn woods, but with only sparse pedestrians and vehicles. We seemed to have arrived in the middle of the last century. It is said that all its residents are launch centre staff or their family members. From the bus, I saw some foreign faces walking along the street. They may be from France or Belarus, as two days later on 29 October, the Sino-France CFOSat ocean satellite and a piggyback Belorussian small satellite would be launched here.

After a quick lunch, we headed to the launch site. It was not too long before we got to the gate of the fenced launch centre. After we entered the area, our bus reduced speed and then passed by the VAB. I saw the mobile launch platform for CZ-2F sitting in front of the huge building on two rails, 20 metres apart. I noticed the base on top of the platform was blackened. Without stopping, the bus then slowly approached the Pad 921 from where the Shenzhou spaceships depart. When the launch tower got closer and closer, I remembered the first time I saw it 19 years ago when the first two photos of the Chinese manned space programme were leaked on the internet. The bus turned around at the bottom of the tower, soon drove out a small gate, and then went East. After driving for a few kilometers, I saw a white-red colored small rocket standing on a small flat concrete ground, without an umbilical tower or any tall supporting structure.

The CZ-2F manned launch tower in JSLC. (credit: Go Taikonauts!)

A public space sculpture in Dongfeng City. (credit: Go Taikonauts!)

This is a simple launch facility for mobile small launchers, and is a fenced area as well, but much, much smaller than the one we just passed by. We entered the launch area while eight buses that took us to the site and a few more light vehicles parked outside. When approaching, I found that the Zhuque 1 rocket was actually standing on a blue-colour mobile platform that includes the erecting mechanism and the flame diversion baffle. Not far away, there are two lightning towers and a white low building with unknown purpose. It was to my surprise that we were allowed to go near to the rocket so very closely - it was almost touchable! Zhuque 1 is a 3-stage solid fuel launcher with a length of 19 metres, a diameter of 1.35 metres and a launch mass of

From left: Dr. Enyu Gao (co-founder and CEO of MinoSpace), Dr. Shufan Wu (co-founder and Board Director of MinoSpace, co-founder of LandSpace), Changwu Zhang (co-founder and CEO of LandSpace) (credit: LandSpace/MinoSpace)

The Zhuque 1 launcher, taken 2 hours before launch. (credit: LandSpace)

Close-up of the third stage of Zhuque 1. (credit: Go Taikonauts!)

27 tonnes. It has a lifting thrust of 45 tonnes and is capable of putting a 300 kg payload into LEO and 200 kg into SSO. The Weilai 1 satellite, based on MinoSpace's MN-10 bus and integrated with an in-orbit experiment and imaging payloads, was supposed to be sent into a 500 km SSO with a working life of 2 years.

People crowded around the rocket and enjoyed being there. Other people stood a little further away and talked to each other. They all took a lot of photographs. It was more like a tourist attraction. After staying for about 20 minutes, the bus took us back to the launch centre.

A Beautiful Launch

After another short but close visit to the Pad 921 where Shenzhou manned spaceships take off, at about 15:00 h, we were transferred to an open space around 2 km away from the ZQ-1 rocket, waiting for its launch. There were about 200 people, mostly staff of the two companies wearing the space-blue uniform and the guests they had invited. The CCTV "Go to the Future" programme crew occupied an exclusive space because the Weilai 1 satellite was specially designed to serve this TV programme. At such a distance, the rocket could hardly be seen. There was a happy and relaxed atmosphere. People were enjoying the unique scenery of the desert under a blue sky. Some even went out of the specified viewing area to take photographs. It was also to my surprise that, unlike previously rumoured, we were allowed to carry our mobile phones and use them all the way. The 4G signal at the launch site was also quite strong.

When a string of vehicles evacuated from the distant launch pad and came close to us, and another string of fire engines and ambulances came from the opposite direction, I realised that the launch was imminent. The launch was scheduled for 16:00 h Beijing Time and it was T-30 minutes at that moment. People became calm. There was only the countdown voice from the loudspeaker. A drone was hovering over our heads. At T-10 seconds, people started to shout out loud: ten, nine ... zero! But there was no sign of life from the tiny rocket on the horizon. About four or five seconds later, maybe shorter but for me it seemed so long, a bright flash came to my eyes followed by smoke rising from the ground. All happened in silence until a few seconds later when I heard a not-so-loud rumbling sound. I even felt the sound was quite enjoyable. The small rocket went up faster and faster. It was hardly visible, only a bright flash with a long white trail of smoke extending behind the flash light. The rocket went over our heads and then flew south. As the sound faded, it finally disappeared high up in the sky. But the long white smoke, which became twisted by high altitude winds, lingered in the blue sky for a long time. It was the most beautiful scene of the day.

Close-up of the mobile launch platform. (credit: Go Taikonauts!)

The wind was writing on the sky. (credit: MinoSpace)

The Zhuque 1 launch. (credit: LandSpace)

People on the ground were excited. They cheered loud and threw their colleagues high up. We gathered around Dr. Shufan Wu, co-founder of MinoSpace and co-founder of LandSpace. He had the latest information on his mobile phone from the control room. All looked perfect. First stage separation and second stage ignition, fairing jettison, second stage separation and third stage ignition, all went well. We were anxiously waiting for the payload separation, the final signal to claim success. However, Dr. Wu's face got serious and then he left. An investment guy told me that he felt that something may have gone wrong. About a dozen minutes later, we got a clue via a mobile phone as someone had already posted a message on the internet saying that the third stage lost attitude and failed to enter orbit.

Mission Almost Accomplished

Back in Dongfeng for dinner, people, including those from the two companies and their investors, were a little upset but still congratulated LandSpace and encouraged each other. Many people compared it with the first three failed launches of the SpaceX Falcon 1. The fact is that this first private space launch has completed most steps and only failed in the final stage. It was almost successful. History has already been made. Undoubtedly it was a milestone in Chinese commercial space activities.

Dr. Wu came at the end of the dinner. He confirmed the launch failure and told us that the third stage and the satellite had reached an altitude of nearly 340 km and a velocity of more than 6.2 km/s, both are records in China created by a private rocket. In fact, the ZQ-1 launch has made another achievement. Compared to development and assembly of the rocket, acquiring the orbital launch permission from the government and setting up the procedure for private companies to enter the national space launch centre were more difficult and complicated. With full support from its cooperation partners, LandSpace finally made it after months of long hard work. LandSpace was the first Chinese private company who obtained the orbital launch licence. At the end of September 2018, the first ZQ-1 was transported to JSLC. Having the rocket in Jiuquan - ready for launch - has already been a big success. The ZQ-1 has already accomplished its mission before launch, said Zhang Changwu, LandSpace co-founder and CEO.

Four days later, LandSpace released the preliminary result of the failure investigation with exactly the same information that Dr. Wu had revealed at the end of the launch day. The cause of the failure was suspected to be a broken pipe at one attitude control thruster. It happened at T+402 seconds when the third stage motor had already worked for 37 seconds. Final results pending further investigation will be released later. LandSpace responded to the accident very quickly, showing the company's good business sense and PR capability.

Reaction from the public and media was also quite positive. Most people understand the risks in space exploration. On the internet, they gave LandSpace a lot of support and encouragement. Mainstream state media including CCTV, the customer of the launch, also gave simple but positive reports. Many people knew at this time that China has private companies developing space rockets.

There were even salutes from competitors. Shu Chang, founder and CEO of OneSpace, another startup rocket company, said on WeChat, "….it was a special day for Chinese commercial space. It was a great attempt. Exploration is without end. Never give up!". "Whatever the result was, today is memorable as it was the first orbital launch attempt by a private company", said Hu Zhengyu from LinkSpace.

NewSpace Pioneers

Though the ZQ-1 failed to reach orbit, the launch was still considered a great achievement, made by LandSpace. As a pioneer, the company encountered a lot of difficulties and setbacks before this day. LandSpace was founded in 2015 and is the earliest private rocket company in China. In early 2017, LandSpace signed a contract with the Denmark based GomSpace to provide a commercial launch service using its solid launcher LS-1. Unfortunately, the deal was suspended because LandSpace's solid motor supplier CASC, the state-owned space giant, ceased execution of the agreement signed with LandSpace of providing solid motors, giving as reasons sensitive technology control. This forced LandSpace to independently develop a liquid engine to get rid of the external reliance. The future Zhuque 2 (ZQ-2) liquid-fueled medium launcher will be LandSpace's flagship product while the solid-fuel small launcher plays only a transitional role.

ZQ-2 is a two-stage launcher with LEO payload capability of 4 tonnes and an SSO capability of 1.8 tonnes. It has a length of 48.8 m and a diameter of 3.35 m, and a launch mass of 216 tonnes. Four Tianque methane engines at its first stage provide 268 tonnes of ground thrust. And the second stage is equipped with a 10-tonne class (vacuum thrust) Phoenix engine. The development of LandSpace's liquid oxygen and methane engines have made fast progress since then. On 9 October, the Tianque 1 80-tonne class (vacuum thrust) engine made a successful chamber hot test firing in LandSpace's Huzhou-based test and manufacturing facility.

Dr. Wu Shufan in front of LandSpace's banner poster. "Land your dream in space" - China's NewSpace demonstrates that PR is not alien - even not in the deepest desert. (credit: MinoSpace)

In parallel, LandSpace managed to get a new solid engine from another channel. The result is Zhuque 1, and this launch story.

In comparison, the journey of MinoSpace, founded in August 2017, was much smoother. In just about one year since its establishment, the company has secured satellite deals valued more than 200 million RMB (USD 30 million). It not only showed that China has a large requirement for small satellites, but also proved that MinoSpace has a strong competitive power. Its founder and board director Dr. Shufan Wu had worked in Europe for 17 years, including 12 years working in ESA, and was former CTO of Shanghai Microsatellite Engineering Centre, CAS. While the other co-founder, MinoSpace CEO Dr. Enyu Gao is from CAST, China's most renowned satellite developer.

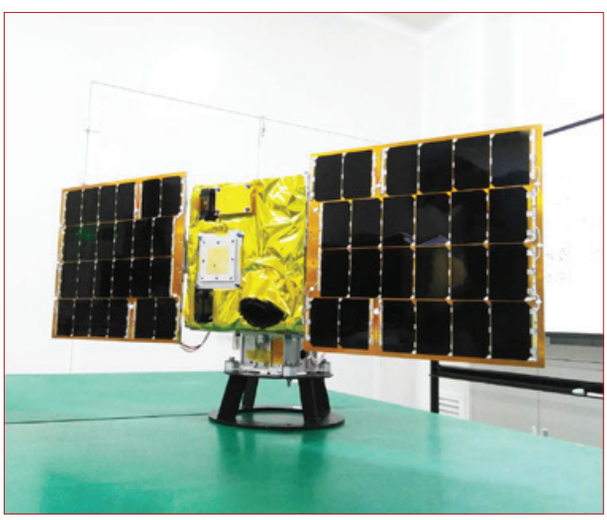
LandSpace and MinoSpace represent the fast-growing private space sector in China. They are pioneers in China's NewSpace. Meanwhile, more than 100 startup space companies have emerged in China these years. LandSpace's private competitors include OneSpace, Interstellar Glory (or Space Honor or iSpace in another translation), Galactic Energy, Jiuzhou Yunjian, LinkSpace, Dragon Drive, S-Motor and Space Engine, etc., the latter two currently focusing on space propulsion systems. MinoSpace has also a lot of competitors including SpaceTy, CommSat, SpaceOK, Chang Guang, etc. There are more satellite operation and application companies. They all are supported by private capital. It is expected that many of them will not survive but the remaining companies will have a chance to become great companies like SpaceX.

One interesting fact from my observation on LandSpace and MinoSpace is that the staff of these two companies are very young. They are energetic and passionate. Many of them have Western education and working background. And of course, professionals from Chinese state-owned space giants (CASC and CASIC) played a very important role in these companies. In the 21st century, talent is the most important resource. Are these young and talented people an implication of the future of the Chinese NewSpace?

The next day after I returned home, MinoSpace announced that a satellite with two sub-systems provided by MinoSpace was successfully launched into space with the CFOSat, the Sino-France Oceanographic Satellite. One week after the ZQ-1 launch, a partner from Essential Capital that financed Galactic Energy, another private rocket company, told me that they had just test-fired China's largest privately developed solid motor with a thrust of 60 tonnes.

The story of Chinese NewSpace has just started.

This reporting about China's NewSpace will be continued in the next issue of GoTaikonauts!



Flight model of the Weilai 1 (Future 1) satellite. (credit: MinoSpace)

The solid motor of Galactic Energy. (credit: Galactic Energy)

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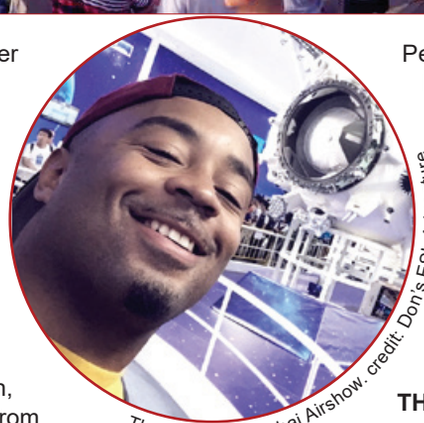
‘First’ Flight: Aviation, Air Defence, Space Exploration & More on Display at China’s 2018 Zhuhai Air Show

by Donovan Cosby (www.Donesladventure.com)

I just might be the luckiest expat in China. After all, over the past 7 years I’ve had the most incredible experiences that I never could have imagined before stepping foot in the country. And truth be told, many of them - scratch that, the *majority* of them, have actually been a ‘first’.



The author at Zhuhai Airshow. credit: Don’s ESL Adventure

For instance, I caught my first ever space rocket launch at Hainan Island’s Wenchang Satellite Launch Center. Now *that* was epic. Let’s see, I’ve watched my first ever live dragon boat race in Fenghuang Ancient Town, hopped aboard my first international cruise from China to Japan, and heck, I even played badminton for the first time. I can’t think of ever seeing anyone play that back in the US!

What’s more, I’ve recently added a new event to my ever-expanding list: I visited my very first air show - China’s much talked and hyped about 2018 Zhuhai Air Show, and like many of those awesome first experiences, this too would turn out to be an experience of a lifetime.

COUNT ME IN

It was Nov. 11th - Veteran’s Day back in the States. But in China, this particular day held another, yet, similar commemorative purpose: It was the 69th anniversary of the creation of the People’s Liberation Army Air Force, or PLA Air Force. In other words, it was time to celebrate!

So, open up an airbase, put on some well-crafted aerial stunts featuring China’s latest fighter jets, and throw in a bunch of cool displays showcasing the world’s second largest economy’s stronghold on modern and futuristic aircraft, comprehensive air defence systems, and yet-to-be-revealed space-tech? Well, that’s an easy guess - count me in!

THE CROWDS

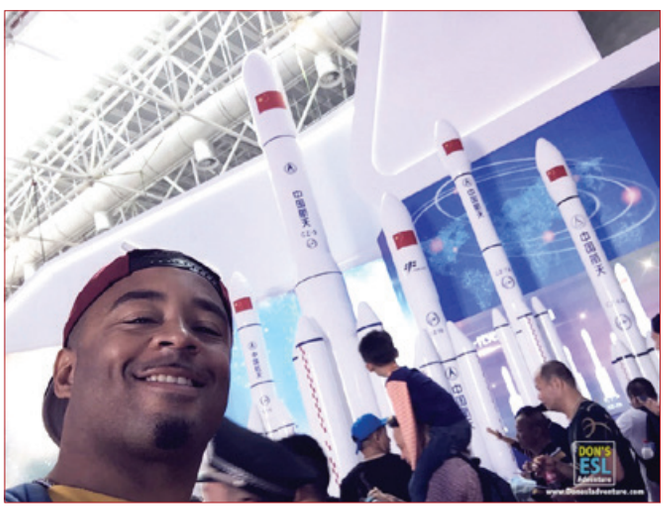
First up, you should know that I’ve travelled far and wide across China, and in a land filled with 1.3 billion people, never had I ever seen so many people gathered together at once. Ever.

No kidding, the crowd size itself was a spectacle of its own merit. Forget Shanghai’s Bund during Golden Week, or Beijing’s Great Wall on *any* holiday, the Zhuhai Air Show’s numbers, at the very least, were in the tens of thousands. And you know what? It was all for good reason.

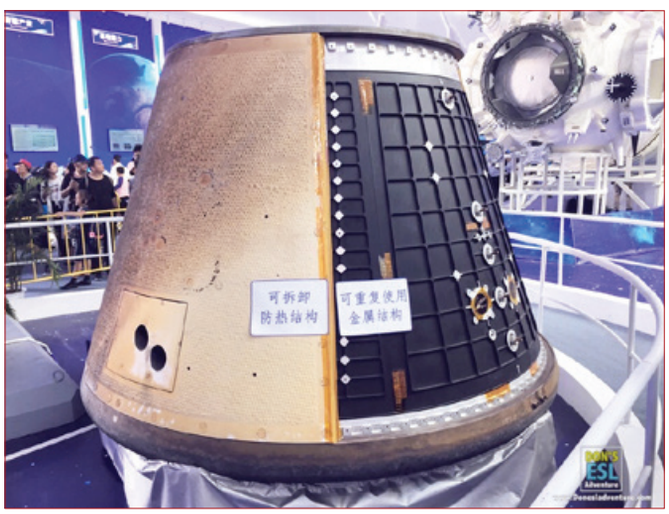
AERIAL STUNTS

It was early morning and I arrived just in time. Five Chinese fighter jets had just flown across the sky in sequence and at

The full-scale model of the core section of the Chinese Space Station. all photos credit: Don's ESL Adventure/www.Donesladventure.com



The author in front of the Long March models.



A full scale model of the next generation Shenzhou manned space craft.

break-neck speeds, leaving behind a mile-long smoke trail of the most vibrant colors I'd ever seen a few hundred meters up. "What an entrance!," I thought.

They went up, down, around, and zigzagged over our heads nearly a dozen times. On their own, they'd twirl 360-degrees, shoot high into the sky at 90-degrees, and then swoop down and zip pass one another at close range - head on and at full speed. It was incredible!

What's more, the jets produced the loudest, most deafening sounds I had ever heard. In fact, they were so loud that I felt my entire body tremble and the ground shake beneath my feet each time the planes roared by. I could only imagine how it'd feel to sit in the cockpit!

There were back-to-back shows afterwards, too, complete with various styles of aircraft and plenty of 'oohs' and 'ahhs' from the crowd. But on ground level, what really stood out was the strong sense of nationalistic pride I could feel streaking across the air, literally. This was China at its best, and at the same time, it was only a small snippet of what's yet to come in the near-future.

AVIATION

Spread out across the lot were some of China's best homegrown aircraft, along with a few exceptions provided by the international community. I spotted everything from gliders, gyroplanes, seaplanes, and landplanes, to helicopters, drones, amphibious planes, and military air power.

And you know what? Those weren't even the hottest items in my book. Instead, the coolest aircraft on deck had to be the *Blade Runner*-esque, flying car and hovercraft prototypes of the future. Ah, if they only offered free test-drives!

There were some other standout vehicles thrown into the mix. A couple of new-aged fire trucks and bulldozers, high-end tanks, and even a few military-grade naval speedboats.

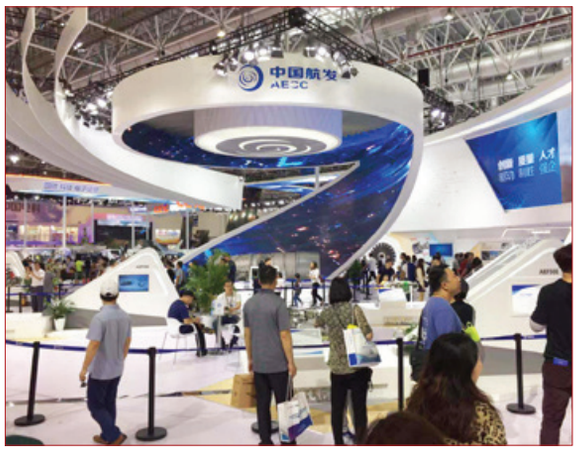
It was enough eye-candy scattered around to see for days - 6 days to be exact. And guess what? That was only *half* of what the air show would offer!

AIR DEFENCE

How would modern day China defend itself against foreign threats? More specifically, how would it engage enemies from the air, and what type of network was required to protect its airspace? Hey, this was the 69th anniversary of the PLA Air Force - any and every angle had to be covered.

And therein lay these bunkers, huge bunkers, sprawling with all kinds of sophisticated tech and powerful military arsenal used to detect threats and fend off attacks from the air. And in this day and age, drones and ground-based air-defence systems - radar, anti-aircraft, and missile interceptors - proved king.

I saw drones big and small, from skateboard-sized reconnaissance bots to plane-sized attack weapons. There were a bunch of jeeps and Humvees too, decked out in military camouflage patterns and stocked with radars, heavy machinery,



and massive anti-missile silos. It was awesome!

Additionally, the exhibition housed plenty of charts detailing China's comprehensive network and strategic action plan to safeguard its airspace, which also included communication and detection satellites, command centres, and naval craft.

Jeez. If China's goal was to showcase how meticulous, organised, and fully prepared they are to defend its borders, then, (*claps hands*) job well done!

SPACE EXPLORATION

And finally, the 'one.' The 'big Cahoona.' The 'Crème de la crème' of sections. The ... well, you get the picture. It was China's space industry on full display.

Let's see, I'd already seen a rocket launch. Check. Back in 2017 I visited the Five-Hundred Meter Aperture Spherical Telescope in Guizhou. Double-check. And this time around? I'd lay eyes on a full-sized replica model of the Tianhe core module belonging to China's Tiangong Space Station, which is estimated to be completed in 2022. I repeat: the luckiest expat in China.

It was unveiled for the very first time, too - the centerpiece for which Chinese astronauts would live, control, dock, and conduct experiments onboard their space station. At 16.6-meters long and 4.2-meters at its widest, the core module was easily the hottest item in the room, so much so that it was an unwritten rule to not leave without snapping a selfie in front of it.

There were other displays in the room to satisfy my inner-space geek as well. Across from the module sat 10 small-scale models of rocket ships - mostly members of China's Long March family - that have blasted Chinese satellites and taikonauts into space.

In front of the module sat a real taikonaut spacesuit that reached parts of Earth's outer atmosphere that I might never have had the chance to see in this lifetime. And on another end? Television screens, props, and more models covering China's ambitious goals for lunar exploration, satellite mapping and navigation, and even commercial space flight.

Growing up in the States, I'd always hear of the history, accomplishments, failures, and zealous aspirations of countries like the USA and Russia in their unrelenting quest to reach the cosmos. Having lived in China for the past 7 years, not only has it been an incredible journey laying witness to its emergence as a powerful player on the world stage - it's also been thrilling to learn and observe first hand, China's progress, growing expertise, and enhanced technical prowess in the race to 'conquer' space. Hmm ... I wonder what kind of space achievements they'll unveil at next year's air show?

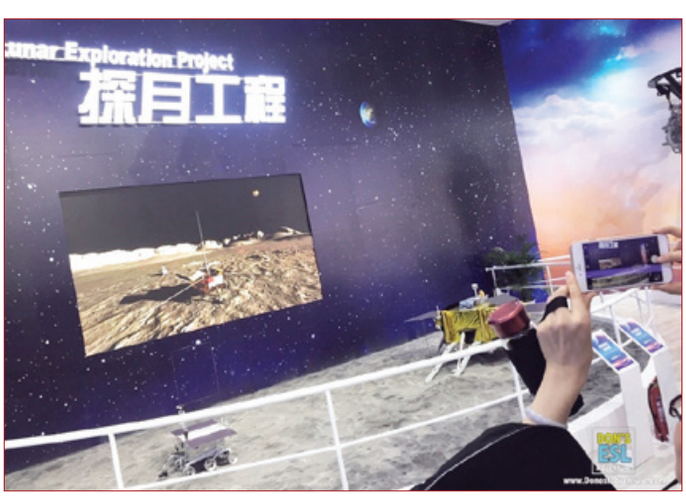
THAT'S A WRAP

And well, that was the last stop on my tour of China's 2018 Zhuhai Air Show. It was everything I hoped it would be: Air stunts, aviation displays, cool tech, military weapons, space components – I discovered more about China's grasp on these industries than I ever could have imagined.

And you know what? That's not bad for a 'first' time. Safe & happy travels!

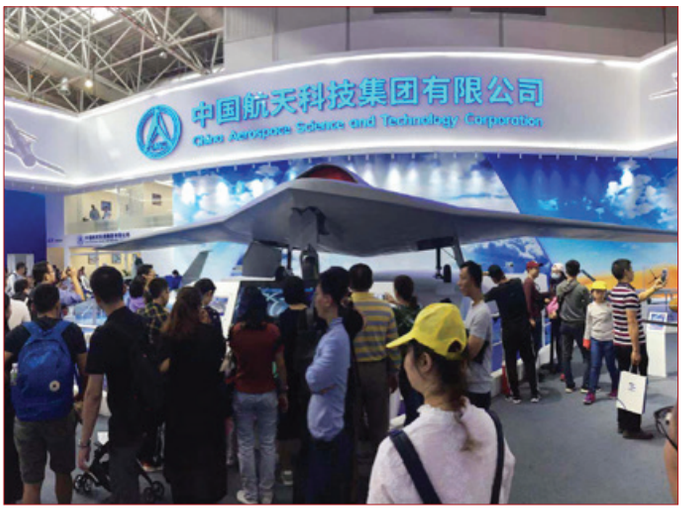
How to get to the Zhuhai Air Show?

1. The Zhuhai Air Show is located at the China International Aviation & Aerospace Exhibition, which is about 10-15 minutes from Zhuhai Jinwan Airport by car. Stay at a hotel in the area and grab a taxi or Didi.



A model of the Chang'e 3 lander and rover.

The Beidou Satellite Navigation Constellation.



top left: The exhibition of CASC.
top right: The 10 variants of the Long March rocket family.
right: The core module of the Chinese Space Station with EVA suit (far right).
all photos credit: Don's ESL Adventure/www.Donesladventure.com

2. There's not much to do around the airport, so if you're looking to stay in a busier district of Zhuhai, I highly recommend crashing near Zhuhai Railway Station (not Zhuhai North Railway Station), which you can reach by airport shuttle bus for less than 30 RMB. The great thing is that the Zhuhai Air Show offers free shuttle buses from the railway station directly to the venue. You'll need to make reservations for seats via mobile registration, but if you can't read Mandarin or have no Chinese friends to help, don't worry; I saw plenty of people registering on the spot!

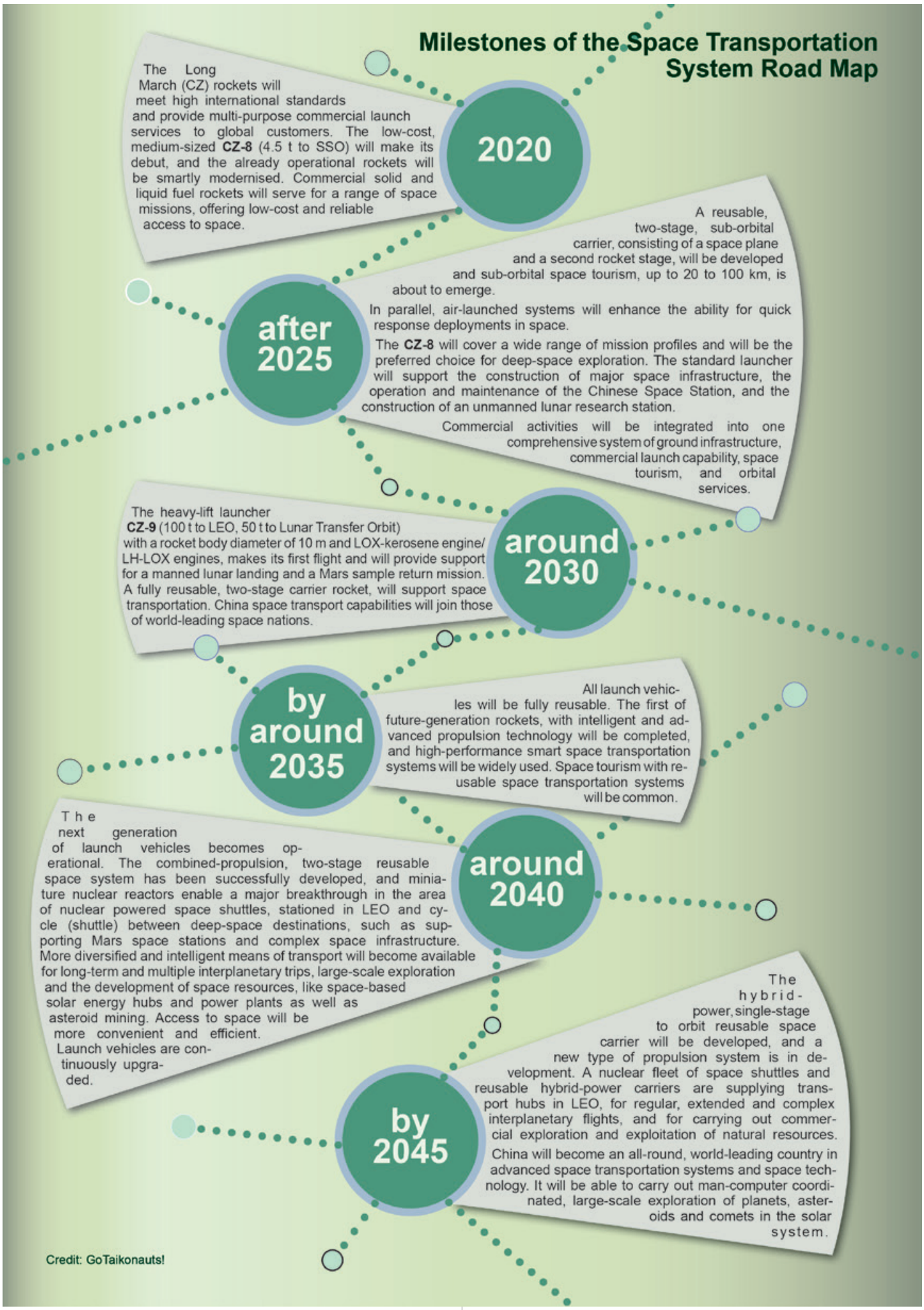
   Furthermore, if you're not able to catch the venue shuttle, I suggest taking the airport shuttle bus from Zhuhai Railway Station to Zhuhai Jinwan Airport, then catching a taxi.

for more photos, please visit the travel blog of our author:
https://www.donesladventure.com/china-blog-china-attractions-china-things-to-do-live-in-china/first-flight-aviation-air-defense-space-exploration-more-on-display-at-chinas-2018-zhuhai-air-show

3. I purchased my tickets for the 2018 Zhuhai Air Show via Trip.com. The air show website: http://www.airshow.com.cn - provided the QR code, I scanned it using the Trip.com app, and was able to buy my tickets from there (485 RMB). Remember, you'll need to present your physical passport to get in.
4. There were huge food tents setup at the air show that offered Chinese meals in addition to KFC, Burger King, and Subway. The venue also supplied a bunch of power banks that could be used after placing a deposit, but you'll need to have WeChat or Alipay.
5. Every hotel in Zhuhai may not accept foreigners, even though their business is listed on hotel booking websites. If you can, try calling your intended hotel ahead of time to confirm.

a short video, nicely reflecting the atmosphere at the airshow, can be found here:
https://www.youtube.com/watch?v=nt6r4ho9OP0

all photos on pages 24, 25, 26, 27: Don's ESL Adventure/www.Donesladventure.com


Milestones of the Space Transportation System Road Map
2020
The Long March (CZ) rockets will meet high international standards and provide multi-purpose commercial launch services to global customers. The low-cost, medium-sized CZ-8 (4.5 t to SSO) will make its debut, and the already operational rockets will be smartly modernised. Commercial solid and liquid fuel rockets will serve for a range of space missions, offering low-cost and reliable access to space.
after 2025
A reusable, two-stage, sub-orbital carrier, consisting of a space plane and a second rocket stage, will be developed and sub-orbital space tourism, up to 20 to 100 km, is about to emerge.
In parallel, air-launched systems will enhance the ability for quick response deployments in space.
The CZ-8 will cover a wide range of mission profiles and will be the preferred choice for deep-space exploration. The standard launcher will support the construction of major space infrastructure, the operation and maintenance of the Chinese Space Station, and the construction of an unmanned lunar research station.
Commercial activities will be integrated into one comprehensive system of ground infrastructure, commercial launch capability, space tourism, and orbital services.
around 2030
The heavy-lift launcher CZ-9 (100 t to LEO, 50 t to Lunar Transfer Orbit) with a rocket body diameter of 10 m and LOX-kerosene engine/ LH-LOX engines, makes its first flight and will provide support for a manned lunar landing and a Mars sample return mission. A fully reusable, two-stage carrier rocket, will support space transportation. China space transport capabilities will join those of world-leading space nations.
by around 2035
All launch vehicles will be fully reusable. The first of future-generation rockets, with intelligent and advanced propulsion technology will be completed, and high-performance smart space transportation systems will be widely used. Space tourism with reusable space transportation systems will be common.
around 2040
The next generation of launch vehicles becomes operational. The combined-propulsion, two-stage reusable space system has been successfully developed, and miniature nuclear reactors enable a major breakthrough in the area of nuclear powered space shuttles, stationed in LEO and cycle (shuttle) between deep-space destinations, such as supporting Mars space stations and complex space infrastructure. More diversified and intelligent means of transport will become available for long-term and multiple interplanetary trips, large-scale exploration and the development of space resources, like space-based solar energy hubs and power plants as well as asteroid mining. Access to space will be more convenient and efficient. Launch vehicles are continuously upgraded.
by 2045
The hybrid-power, single-stage to orbit reusable space carrier will be developed, and a new type of propulsion system is in development. A nuclear fleet of space shuttles and reusable hybrid-power carriers are supplying transport hubs in LEO, for regular, extended and complex interplanetary flights, and for carrying out commercial exploration and exploitation of natural resources.
China will become an all-round, world-leading country in advanced space transportation systems and space technology. It will be able to carry out man-computer coordinated, large-scale exploration of planets, asteroids and comets in the solar system.
Credit: GoTaikonauts!