All About The Chinese Space Programme

Go Taikonauts!

龙腾太空

Issue 22

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Chen Dong in Burg Stargard, Mecklenburg, Germany. Credits: Gerhard Rosenfeld, Dr. Lew Tolstong-Riedel, NASA

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Chinese Space Quarterly Report
October - December 2017
by Jacqueline Myrrhe

SPACE TRANSPORTATION

Long March 5 - Y2 failure investigation

During IAC2017, at the end of September in Adelaide, Australia, it emerged that the failure of the CZ-5 was related to the first stage's core engines, the hydrogen propelled YF-77. In October it was reported that China must have searched for rocket parts near the impact area of the CZ-5 first stage in the Philippine Sea, because the Chinese research vessel Xiangyanghong 09, carrying the Jiaolong submarine, was tracked there. Later, spaceflight101.com cited unofficial reports from November 2017 which said that the cause of the failure was pin-pointed to a structural problem in the turbo pump where material broke off and blocked the fuel line.

By the end of 2017, CALT, the manufacturer of the CZ-5 confirmed that the problem was found. Computer simulation-based analysis and ground tests showed a structural fatigue in a turbine exhaust device of the YF-77 engine. Quality improvements and a verification process were being implemented.

Only the CZ-5 uses the YF-77 engine where the pumps for the oxidiser and the fuel are driven by a gas-generator cycle, meaning that some of the fuel goes through a separate pre-burner. The exhaust fumes of the pre-burner cycle are discarded without contributing to the actual combustion process - this allows for a simpler and lighter structure, higher reliability and convenient maintenance. The disadvantage is a lower overall performance.

"Roadmap 2017-2045 for the Development of Space Transportation Systems"

On the occasion of the 60th anniversary of the China Academy of Launch Vehicle Technology (CALT) on 16 November 2017, the China Aerospace Science and Technology Corporation (CASC), published a highly ambitious "Roadmap for the Development of the Space Transportation Systems 2017-2045". The visionary plan calls for the sweeping modernisation of space transportation, embracing commercial utilisation of space resources, diversified means of access to space and the development of new propulsion systems. (see issue no 23)

MANNED SPACE FLIGHT

Taikonauts

In mid-October, China's Central Military Commission (CMC) held a ceremony at the military astronaut unit, where an order signed by President and CMC Chairman, Xi Jinping, was read and a certificate of honour was presented to the unit.

Three-times space flyer (SZ-7; SZ-9; SZ-11) Jing Haipeng, Major General, Member of the Communist Party of China (CPC), and Delegate to the 19th National Congress of the CPC, told media that he would like to be part of another space mission, to show his loyalty to the CPC. According to the CPC Constitution, a minimum of three CPC Members can establish a party group. Already 10 years ago, Yang Liwei told journalists: "If China has its own space station, the taikonauts on mission will carry out the regular activities of a CPC branch in the way we do on Earth, such as learning the Party's policies and exchanging opinions on Party decisions."

Jing Haipeng talking to the media at the 19th NCCPC in October 2017. Credit: Xinhua/www.news.cn

For the first time, the United Nations Educational, Scientific and Cultural Organisation (UNESCO) has awarded the UNESCO Medal on Space Science. It was given to China's first taikonaut, Yang Liwei, and the three other space travellers Valentina Tereshkova, Arnaldo Tamayo Mendez, and Koichi Wakata. Yang Liwei could not attend the ceremony at UNESCO's Headquarters in Paris in person but Shen Yang, Ambassador and Permanent Delegate of the PRC to the UNESCO represented him. The medal is awarded to scientists, public figures and organisations for their contributions to the development of space science in the spirit of UNESCO's priorities.

CSS

As announced by Yang Liwei, China's first taikonaut and Deputy Director of the China Manned Space Engineering Office (CMSA), at the Global Space Exploration Conference (GLEX) in June, the selection of the third batch of astronauts is imminent.

The Ministry of National Defence of China revealed some of the requirements for becoming a flight engineer or payload expert:

- Masters degree in science or engineering;
- body height of 1.6 m to 1.72 m;
- body weight of 55 kg to 70 kg;
- perfect physical condition;
- 100 % cardiac function, central nervous system function and visual performance;
- stress resistance;
- balancing and bearing capacities in low pressure and gravity.

Overall, the psychological and physical requirements are lower compared to the first two taikonaut selections.

At the AirTech'17, Pakistan's largest technical and scientific Olympiad hosted by the Air University from 7 - 10 December 2017, Chief of the Air Staff, Air Chief Marshal Sohail Aman announced that Pakistan will be assisted by China to send astronauts into space within the next two years. That might give Pakistan the chance to become the first foreign nation to visit the future CSS. Marshal Sohail Aman added that China is also providing technical support to Pakistan for launching its satellite programme.

Tiangong 1

In November, ESA started hosting a test campaign by the Inter Agency Space Debris Coordination Committee (IADC) to follow the re-entry of Tiangong 1. IADC, is an international governmental forum for the worldwide coordination of activities related to man-made and natural debris in space. IADC members used the event to conduct their annual re-entry test campaign, during which participants pooled their predictions of the time window, as well as their respective tracking datasets obtained from radar and other sources in order to cross-verify, cross-analyse and improve the prediction accuracy for all members.
CMSA published Tiangong 1 status reports on its website: http://en.cmse.gov.cn/col/col1763/index.html

On 12 December, the Permanent Mission of China to the UN in Vienna issued a notification on the re-entry of Tiangong 1 to the

Committee on the Peaceful Uses of Outer Space - COPOUS: "China attaches great importance to the re-entry of Tiangong 1. For this purpose, China has set up a special working group, made relevant emergency preparedness plans and has been working closely with its follow-up tracking, monitoring, forecasting and relevant analysing. Until 26 November, Tiangong-1 had been orbiting at an average altitude of 296.0 km (perigee: 281.7 km; apogee: 310.2 km; inclination: 42.65°). Currently, it has maintained its structural integrity with stabilised attitude control. According to the latest forecast, its re-entry is expected between the first 10 days of February and the last 10 days of March 2018. ... China will continue to closely track and monitor the operation of Tiangong-1 and will regularly publish relevant information through the website of the China Manned Space Engineering Programme (www.cmse.gov.cn) as well as other relevant media."

Shenzhou 12

Beijing Institute of Control Engineering (BICE), a CAST-institute, started working on upgrades for the guidance, navigation and control (GNC) system of the Shenzhou 12 in preparation for China's next manned mission. The upgrades are needed to enable fast-track rendezvous and docking of manned spacecraft with the future station.

Tiangong 2

The first meeting of the Operation and Management Committee of the Tiangong 2 space laboratory was held at the beginning of December in Beijing. More than 50 experts from relevant institutions participated and confirmed the composition, responsibilities and working mode of the Committee and discussed the main work arrangements for 2018.

Zhang Yulin, Deputy Director of the PLA General Armaments Department and Deputy Commander of China's Manned Spaceflight Programme stressed the importance of quality assurance as the key to the success of the mission.

LUNAR AND DEEP-SPACE EXPLORATION

The Second Joint GSICS/IVOS Lunar Calibration Workshop was hosted from 13-16 November 2017 by the China Meteorological Administration (CMA) in Xi'an, China.

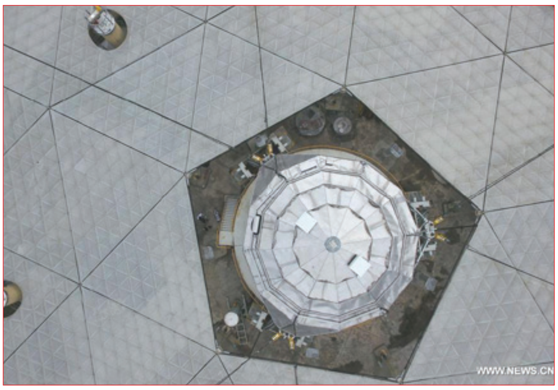
Between 19 December 2017 to 6 March 2018, the Lunar and Deep Space Exploration Centre solicited 20,000 messages via the WeChat account "slecbj". The messages will be sent with the Chang'e 4 relay satellite, to be launched in the first half of 2018.

Jiao Weixin, professor for space science at the Peking University advocated a Moon base which could support bigger, more complicated research and enhance lunar geography studies.

SCIENCE

FAST

FAST, the Five-hundred-meter Aperture Spherical Telescope detected dozens of pulsar candidates during its test and calibration phase since September 2016. Six of 12 new discoveries were confirmed by telescopes in other countries. For outreach purposes, Chinese scientists produced a sound effect of the first two confirmed pulsars, J1859-01 and J1931-01, based on the observation signals received on the nights of 22 and 25 August. One pulsar sends fast and strong signals



Aerial photo taken on 9 August 2017 shows FAST's feedback source cabin. Credit: Xinhua/Ou Dongqu

Lunar Palace 1 - The Lunar Palace 365 experiment

"Yuegong 1" or "Lunar Palace", located at Beihang University, is a 160 m² simulation habitat for the test of long-duration stays of humans in a confined environment. It is the first such facility developed in China and is the world's third closed ground test facility of the Bioregenerative Life Support System (BLSS).

On 9 July, a group of 4 volunteers, students of Beihang University, finished their 60-day experiment which also was the first occupation of the Yuegong facility. Then, eight people entered the research station for a 10-hour transitional phase, to test the system's resilience to high-load human activity in a short time. Still the same day, the second batch of four volunteers, entered the Lunar Palace 1 for living self-sufficiently for 200 days. After these 200 days, the third batch, which is the group from the first 60-days stay, will enter and live for another 105 days to accomplish the 365-day experiment. A successful 105-day trial was conducted in 2014.

The Yuegong facility has three compartments: one 42 m² major living space and two plant cultivation modules, 3.5 m high and 50 to 60 m² ground area.

The main cabin contains four bed cubicles, a common room, a washroom, a waste-treatment room and an animal-raising room. The common room is also the research lab and the simple living area where the volunteers surf the internet, play darts, and train on a bicycle.

In the cultivation modules, the crew grows wheat, potatoes, carrots, green beans, and onions. Liu Hong, professor at Beijing University of Aeronautics and Astronautics and the project's principal architect explained: "We've designed it so the oxygen produced by plants is exactly enough to satisfy the humans, the animals, and the organisms that break down the waste materials. Liu Hong made her PhD in 1994 in the field of environmental protection at the Lomonosov State University in Moscow.

The whole project is about testing a self-sustaining ecosystem that provides everything humans need to survive by recycling everything from plant cuttings to urine. Human waste will be treated through a bio-fermentation process to become, together with other food by-products, the base for growing experimental crops and vegetables. Most of the volunteer's protein intake came from mealworms. They were chosen because they can be fed with non-edible plants, generate the carbon dioxide the plants need, and provide protein for nutrition. The wheat was harvested, threshed, and ground for use in meals.

Yuegong 1 simulation hab. Credit: Beihang University

Liu Hong, Chief Designer of Yuegong 1 - Lunar Palace 1. Credit: Xinhua/Ju Huanzong and the other slow and weak signal, making it comparable to the heartbeats of a young and an old person.

FAST's formal operation starts in 2019. It should be able to discover a hundred pulsars per year, including a pulsar outside the galaxy. It is planned that FAST and the future free-flying space telescope accompanying the CSS can conduct complementary observations.

Gravitational Waves

Chinese scientists were able to contribute to the first time-observation of the "optical counterpart" of gravitational waves coming from the merger of two binary neutron stars. The event was detected by China's survey telescope AST3-2 in Antarctica and also by 70 other telescopes worldwide one day after the gravitational waves from the merger were first recorded by the Laser Interferometer Gravitational-Wave Observatory (LIGO)/ Virgo detectors in the U.S. on 17 August.

The survey telescope AST3-2 in Antarctica.
Credit: Xinhua/Chinese Center for Antarctic Astronomy

Ngari Plan

National Astronomical Observatories of China (NAOC) is building a 12 m optical observatory at an altitude of 5,250 m in Ngari Prefecture, in the southwest of China's Tibet Autonomous Region. The project is included in China's large-scale sci-tech infrastructure plan for 2016 to 2020. Due to constraints on Mauna Kea mountain, on Hawaii, the international community is looking for a suitable, alternative observatory base in the northern hemisphere.

The optical telescope is expected to be installed at the end of 2019 and become operational in 2020.

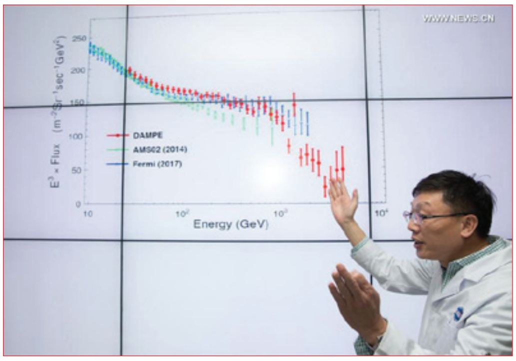
The Ngari site will become the home for an observatory complex to observe primary gravitational waves.

China's current research into gravitational waves includes three programmes: the Ngari Plan, the 500-meter Aperture Spherical Telescope (FAST) and space exploration (including two projects: Taiji and Tianqin), each one under the leadership of a different institute.

View of the landscape at Ngari Prefecture in Southwest China's Tibet Autonomous Region. Credit: Xinhua

DAMPE

The Dark Matter Particle Explorer DAMPE science satellite, also: "Monkey King", has measured more than 3.5 billion cosmic ray particles with the highest energy up to 100 TeV. By sorting the number of particles according to their energy, scientists found an unusual break at around 0.9 TeV and an unexpected spike at around 1.4 TeV on the spectrum. Whether the signals come from dark matter or other astrophysical phenomena is still open. For a solid interpretation of these events, more data is needed.



Chang Jin, DAMPE's Project Scientist and Vice Director of the Purple Mountain Observatory of CAS, is explaining the dataset transmitted by the science satellite. Credit: Xinhua/Jin Liwang

SATELLITES

The island province of Hainan has developed a satellite launch plan to assist remote sensing coverage of the South China Sea. The Sanya Institute of Remote Sensing would start in 2019 launching three optical satellites. After that, it will add another three optical satellites, two hyperspectral satellites and two SAR satellites to complete the Satellite Constellation Programme by 2021, for conducting round-the-clock remote-sensing over the tropical sea area between 30 degrees North and South of the Equator.

The programme would also provide scientific support for the 21st Century Maritime Silk Road and emergency response efforts at sea.

The Innovation Academy for Microsatellites of CAS (IAMCAS) was inaugurated in Shanghai on 26 September. Bai Chunli, Director and Secretary of the Party Committee of the CAS together with Ying Yong, Mayor and Deputy Secretary of the Shanghai municipal committee attended the opening ceremony. The institute is the result of reforming and restructuring of the Shanghai Engineering Centre for Microsatellites (SECM) and will become the engine for China's advanced satellite science and technology innovation as well as the demonstration base for aerospace science and technology achievements and industrialisation.

On 24 October, at the "China Day" during the XIV Plenary of the Group on Earth Observation in Washington, U.S., Yang Jun, Director of China National Satellite Meteorological Centre announced that the data and products of China's latest FY-4 geostationary meteorological satellite and the first Earth observation satellite, monitoring carbon dioxide in Earth atmosphere (Tan Sat) would be freely accessible for global users.

NAVIGATION – BDS-Beidou

On the 31st COSPAS-SARSAT Council Meeting in late October in Montreal, Canada, the Ministry of Transport of China submitted the Beidou Satellite Navigation System's technology and launch plan for search and rescue. By the end of November, Beidou has been included in the global rescue data network that collects signals from persons in distress and distributes data for search and rescue missions. The inclusion supports Beidou's global development as well as its international recognition.

On 4 December, after the Joint Satellite Navigation Meeting held on 29 November in Beijing, the United States and China issued a Joint Statement on Civil Signal Compatibility and Interoperability Between the Global Positioning System (GPS) and the Beidou Navigation Satellite System (BDS):

"In May 2014, China Satellite Navigation Office and the Office of Space and Advanced Technology, U.S. Department of State, jointly established the U.S.-China Civil GNSS Cooperation Dialogue, a bilateral government-to-government mechanism to promote cooperation between the U.S. Global Positioning System (GPS) and the Chinese Beidou Navigation Satellite System (BDS). Over the past three years, representatives and experts from both sides have studied and discussed various topics related to civil service provision and user applications, among which BDS compatibility and civil interoperability with GPS is one of the core focus areas. Both sides have carried out extensive in-depth analysis, and have engaged in persistent discussion and coordination. As a result, the two sides have reached the following consensus regarding compatibility and interoperability between GPS and BDS:

1. Consistent with the bilateral frequency compatibility coordination completed in 2010, GPS and BDS are radio frequency compatible under the framework of the International Telecommunication Union (ITU); and

2. The GPS L1C and BDS B1C civil signals, using two different types of multiplexed binary offset carrier (MBOC) waveforms are interoperable, which means users can receive better service by jointly using these civil signals without a significant increase in receiver cost or complexity.

Both sides agree to continue their consultations and cooperation related to compatibility and interoperability in order to provide better services for global users."

Both sides also held consultations on the follow-up work such as the 3rd Sino-U.S. satellite navigation system meeting.

On 13 October, Russian and Chinese experts in satellite navigation held the "Fourth Conference of the Committee of Sino-Russian Major Strategic Cooperative Projects of Satellite Navigation". The two sides initiated the "Sino-Russian Satellite Navigation Joint Monitoring and Assessment Services Platform" which enables the Beidou and GLONASS System to monitor each other's data and enables the improvement of the precision of satellite navigation systems based on the monitoring results.

The BDS Intellectual Property Right Alliance has been established in Guangzhou, the National IPR Pilot Zone for navigation industry development. It aims at the promotion of the in-depth integration of intellectual property and industry and the improvement of the core competence of the Beidou navigation industry.

On 27 December, a press conference for celebrating the 5th anniversary of the BDS Full Operational Capability (FOC) was held at the State Council Information Office. China Satellite Navigation Office released the Beidou Navigation Satellite System Signal Interface Control Document for B1C (Version 1.0) and B2a (Version 1.0) in both Chinese and English, based on the earlier released beta versions of the documents.

ADVANCED TECHNOLOGY

The China Academy of Launch Vehicle Technology (CALT) has developed 3 upper stages for use on different rockets - the Yuanzheng 1, Yuanzheng 1A, and Yuanzheng 2.
The upgraded Yuanzheng 1A has greater ability than the Yuanzheng 1, with an extended flight time of 48 hours, up from 6.5 hours, and a re-ignition capability of nine times as well as seven times payload release. The older model carried one payload and re-ignited twice. The Yuanzheng 2, mainly used on the CZ-5, has two engines and greater ability in orbit transfers. The Yuanzheng 1S (also: Yuanzheng 1B) is a newer and simpler commercial version of the Yuanzheng 1A applicable for short missions in mid-to-low-Earth orbit or Sun-synchronous orbits. It will debut in 2018 on a CZ-2C. Also planned for 2018 is the Yuanzheng 3 optimised for the use on the Long March 2D and Long March 4B. Yuanzheng 3 can restart 20 times and conduct 10 spacecraft deployments.

Scientists of the Fudan University Shanghai installed several sets of intelligent chips, weighing less than 30 g, on the final stage of the CZ-4C, which launched the Fengyun 3D. After the upper stage released the satellite it transformed into a low-cost science experiment and communication platform, establishing the initial phase of a space-based Internet of Things. The team has named the intelligent chip system "Xinyun" meaning: cloud of chips.

Chinese Atomic Clock

CASIC said that the future CSS will be equipped with a domestically developed active hydrogen atomic clock as a key part of China's space time frequency lab aboard the station. The lab will provide more accurate and stable time frequency signals to improve the Beidou Navigation Satellite System. The active hydrogen atomic clock will weigh about 40 kg and is only one-fifth of the size of a traditional hydrogen atomic clock.

The 2nd Research Institute of CASIC successfully passed the acceptance test of its rubidium atomic clock to be integrated into the second-generation ocean observation and monitoring satellites Haiyang 2B and C.

COMMERCIAL SPACE

CASIC

CASIC plans to launch its Kuaizhou 11 low-cost, solid-fuelled carrier rocket for the first time in the first half of 2018 to place six satellites into orbit. In December, CASIC had completed the launch preparation work. The launch cost for the high reliability and quick response KZ-11 launcher are around 5,000 U.S. dollars per kg of payload.

By December, CASIC has completed component tests for its new solid-propellant motor which is reported to have a diameter of more than 4 m and a lift-off thrust of 1,000 t, which would become the world's largest. (Orbital ATK's motor has a diameter of 3,7 m). CASIC's engineers were proceeding with the assembly of the first rocket motor for ignition tests later in February 2018. They are planned to be used on CASIC's Kuaizhou 21 and Kuaizhou 31 rockets, both new-generation carriers under development.

While KZ-21 will be capable of 20 t to LEO, KZ-31 is supposed to lift 70 t to LEO. The development of the solid-propellant rocket motor required new knowledge in structure, materials and mechanics.

China Space Sanjiang Group, a CASIC subsidiary in Hubei province, said it has submitted a plan on the establishment of a satellite company to tap the space-based communications market for CASIC and is waiting for approval. The new entity would focus mainly on the research, development and launch of small satellites that would operate in low orbit constellations and provide narrowband communications service. The Xingyun network of satellites would offer coverage to users at sea or in remote regions that have poor access to ground-based communications services.

CGWIC

On 27 November, Beijing Tengyuxinwei Technology Co., Ltd., affiliated to CGWIC and Thailand Kasetsart University signed a MoU for the joint development of satellites for the Hongyan satellite constellation, an open commercial satellite system. The contract includes the service for satellite and ground infrastructure construction, constellation application, capability establishment of space technology, big data sharing as well as training for satellite engineering and operations. The project will be initiated in 2018, and the satellite(s) will be put into space starting in 2019.

Foreign launch sites

CGWIC's President Yin Liming said on the sidelines of the 5th China Space Forum, held by the company in Beijing that the company is working with foreign nations to use or construct launchpads or launch centres on foreign territory with geographic advantages close to the Equator. Since such a move would also involve policy and diplomatic issues, it would strengthen China's international space cooperation, Fu Zhiheng, Vice-President of CGWIC pointed out and added that CGWIC is also collaborating with Chinese space authorities to make plans for the construction of a new commercial launch site because the existing four government-run launch centres are too busy to handle the increasing commercial demands. Fu also confirmed that his company has been working with the China Satellite Navigation Office to form a space-based augmentation system for the Beidou positioning and navigation satellites, to enhance the accuracy of Beidou's position and navigation services.

CASC - SEA LAUNCH

On 1 and 2 November, the 2nd China Aerospace Forum and 2017 Annual Symposium of the Chinese Society of Astronautics and China Institute of Space Law took place in Beijing. CASC representatives said that the first Chinese commercial satellite launch from the sea can be expected in 2018. Still in 2017, CASC is starting tests for sea launch key technologies by using solid-propellant Long March rockets with a payload capacity of 500 kg into LEO taking off from a cargo freighter. The price should be in the range of 5,000 U.S. dollars per kg payload.

ExPace

ExPace Technology Co. has raised a RMB 1.2 Billion (US$180 Million) series A round from eight unnamed investors. Those latest funds will be used for the Kuaizhou series of space launch vehicles development, for investments in up-stream and down-stream commercial space industry, and for improvements of the company's assemble line.

OneSpace

On 22 December, OneSpace successfully conducted a 35 second ignition test of its solid-propellant motor at the company's test facility in East China's Jiangxi Province. The test of China's first privately developed rocket motor validated the operation of all major parts, data recording and the overall design of the engine which will be used in the company's OS-X series of rockets but also in other fields such as commercial aerospace products and cutting-edge exploration technology.

Investors from Zhengxuan Investment, HIT Robotics Group, and Chunxiao Capital watched the test run. OneSpace's engineers have finished designing the main body and electrical system for its rocket. The first flight is planned for June 2018.

OneSpace engine test 22 December 2017. Credit: China Internet

SpaceView

The Canadian UrtheCast and its subsidiary, the Earth Observation company Deimos Imaging, signed a strategic cooperation agreement with Beijing Space View Technology Co. on 4 December.

The space assets of the companies are complementary and will ensure a daily global imaging capability, with 17 revisit opportunities per week over any target at mid-latitude. This is key for a wide range of applications, especially those requiring a frequent monitoring over the same area of interest and a real-time response, such as emergency services, border and maritime surveillance and defence and security. UrtheCast acquired access to imagery from Space View's SuperView (Gaojing) constellation of currently two satellites (two were expected within the next weeks and the final configuration includes: "16+4+4+X" = 16 sats with 50 cm panchromatic resolution; 4 SARsats; and several video and hyperspectral sats), and SpaceView (Gaojing) acquired distribution rights for imagery from Deimos 1 and Deimos 2.

left top: Space View and Deimos Imaging's leadership at the China Siwei Headquarters. From left to right: Xu Lily, CEO at Space View, Zhao Jun, Vice President at China Siwei, Xu Wen, President at China Siwei, Fabrizio Pirondini, CEO at Deimos Imaging, Jamie Ritchie, Business Development Director at Deimos Imaging and UrtheCAst. Credit: UrtheCast Corp.

left bottom: Deimos 2 image of launch complex 9 at the Taiyuan Satellite Launch Center on 21 December. Credit: Deimos Imaging, a UrtheCast Company

INTERNATIONAL COOPERATION

Angola

China, along with Argentina, Brazil, Japan and Russia trained 47 Angolan aerospace engineers for the operations of Angola's first satellite, AngoSat-1, which was built by Russian RSC Energia and launched on 26 December 2017 by a Zenit rocket from Baikonur.

APSCO

The United Nations International Conference on Space-Based Technologies for Disaster Risk Reduction "Building Resilience through Integrated Applications" took place from 23 to 25 October in Beijing. The conference was co-organised by the UN-SPIDER Beijing Office of UNOOSA and the Ministry of Civil Affairs of the PRC, in cooperation with APSCO, the Ministry of Foreign Affairs of PRC, the Ministry of Finance of PRC, and the Department of Systems Engineering of CNSA. The World Bank also supported the conference. About 100 participants from governments, industries and academia covering 34 countries and eight regions participated in the conference.

As an extended event to the UN conference, the Secretariat of APSCO organised the "International Training Course on Integration of Multisource Earth Observation Data for Disaster Damage Assessment" jointly with the National Disaster Reduction Center of China (NDRCC), UNOOSA/UN-SPIDER and the UN Regional Center for Space Science and Technology Education in Asia and the Pacific (China) from 25 to 31 October 2017.

The 2nd Working Group Meeting of APSCO Space Education and Curricula Development was held jointly with Beihang University and the APSCO Education and Training Center from 7 to 10 November in Chengdu, China. During the meeting the current status of space education in Member States, its demands and requirements were discussed. More than 24 delegates, professors and experts from APSCO Member States and officials from the Office of the Tianfu New Area and from the APSCO Secretariat actively participated in the meeting.

The 2nd Expert Group Meeting on the Development Plan of Data Sharing Networks and Database Systems of APSCO was held on 21 to 23 November at APSCO Headquarters, Beijing, China. Representatives of all Member States actively participated in the meeting.

The signing ceremony of the contract on the "Implementation of the system design and definition phase (Phase B) of APSCO Joint Small Multi-Mission Satellite (SMMS) Constellation Program" between Asia-Pacific Space Cooperation Organization (APSCO) and China Earth Observation System and Data Center, China National Space Administration (CNSA), was held on 27 November at APSCO Headquarters in Beijing. The project aims at the construction of a small multi-mission satellite constellation including space and ground segments for remote sensing and integrated data collection as well as data acquisition, the development of applications and technical exchanges, appropriate training and cooperation.

The Preliminary Design Review (PDR) for the SSS-1 Microsatellite and the Preliminary Requirement Review (PRR) / PDR for the SSS-2A CubeSat of the APSCO Student Small Satellite (SSS) Project were held from 27 November to 1 December in Beijing. The delegation from the eight Member States Bangladesh, China, Iran, Mongolia, Pakistan, Peru, Thailand and Turkey actively participated in the meeting.

The Intermediate Progress Review (IPR) Meeting and Second Technical Training of APSCO Joint Small Multi-Mission Satellite Constellation Program (SMMS) were held from 27 November to 5 December in Beijing. Representatives of all APSCO Member States and APSCO Secretariat participated in the meeting and training.

The Secretariat of APSCO jointly organised from 11 to 30 December the distance training course 2017-2 "Satellite Communication and Robotics" with Kasetsart University of Thailand in both online and offline modes. The training course is designed to train participants from APSCO Member States for enhancing knowledge of satellite communication and robotics and to introduce the future trends.

Brazil

The China Aerospace Science and Technology Corporation announced that the China-Brazil Earth Resource Satellite-4A (CBERS-4A) will be launched by a Long March-4B carrier rocket in 2019. After CBERS-1, 2, 2B, 3, and 4, it will be the sixth satellite to be launched within the Earth resource satellite cooperation programme of the two nations.

Egypt

End of December, Egyptian parliamentarians approved a law formally establishing the Egyptian space agency, while at the same time announcing a planned research satellite in cooperation with Japan and China. In September, delegates of China and Egypt met on the sidelines of the BRICS summit in Xiamen and signed a MoU between the Egyptian National Authority for Remote Sensing & Space Sciences (NARSS) and the Institute of Remote Sensing Applications (IRSA) of the Chinese Academy of Sciences (CAS), covering China's U.S.$ 45 million commitment to building the satellite with a targeted launch in October 2019. China provided in 2014 U.S.$ 23 million towards Egypt's space programme, mainly for a satellite building and assembly facility. "A delegation of about 20 engineers have been sent for training on how to build satellites in China over the past few months", Dr. Mohamed El Koussy the former head of Egypt's space programme mentioned, "the mission came back about two months ago, and satellite building will proceed for the next 24 months."

The MoU establishes a framework for cooperation in the field of remote sensing applications on the basis of equality, mutual benefit, and reciprocity. The areas of the MoU include:

- Cooperation in remote sensing applications between governmental departments and agencies, and academia;
- Joint research, technology projects and activities;
- Exchange of scientists, engineers and other experts;
- Liaison with industrial, academic, professional and other organisations;
- Exchange of scientific information, data and experimental results;
- Organisation of symposia, seminars, conferences, meetings and special events;
- Education and training; and
- Other cooperation activities that may be decided by mutual consent of the participants.

Also, work has started on a new centre for satellite building in Cairo's Fifth Settlement.

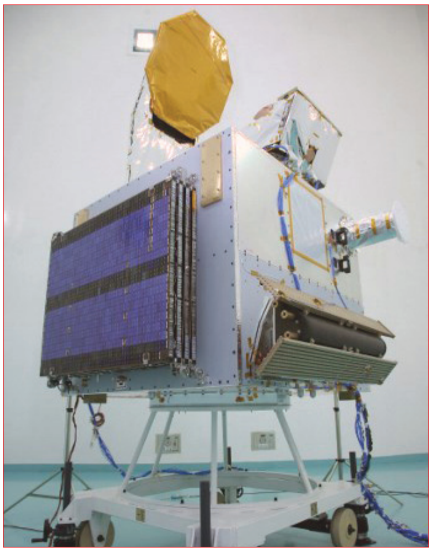
ESA

GomX-4B, a European Space Agency technology test cubesat is scheduled to be launched on a Long March rocket on 2 February 2018, along with GomX-4A, owned by the Danish Ministry of Defence. The pair, flying as secondary payloads with China's Seismo-Electromagnetic Satellite, CSES, will test intersatellite communication links and propulsion while orbiting up to 4,500 km apart.

FRANCE

From 18 to 20 October, 65 French, European and Chinese scientists participated in the 5th CFOSat (China-France Oceanography Satellite) science seminar in Beijing.

The seminar marked a key milestone for the calibration and validation of the satellite data which will enable applications and scientific research. CFOSat is the first direct result of space cooperation between CNES and

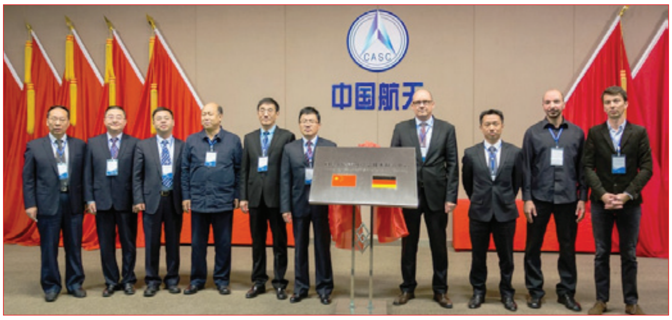


An engineering model of the China-France Oceanography Satellite is seen at the Satellite Assembly Integration and Test Centre in Beijing. Credit: CNSA the China National Space Administration (CNSA). Established in 2007, this project supports bilateral efforts to employ satellite data for environmental purposes.

After the seminar, CFOSat was introduced to the public. It was under testing in the CNSA satellite test centre in Beijing. The 700 kg-satellite will be primarily used for ocean waves monitoring and forecast as well as research in floating ice, polar glacier and ocean dynamics. The satellite will carry a wave-scatterometer spectrometer developed by France and a wind-measurement scatterometer from China. It will be launched by a Long March rocket in the second half of 2018.

GERMANY

On 14 December, German high-tech company Pfeiffer Vacuum signed a strategic cooperation agreement with Lanzhou Institute of Physics (LIP). LIP, a pioneer in vacuum technology in China, is one of the first Chinese institutes being directly engaged in satellite and spacecraft development and became part of the China Academy of Space Technology (CAST) in 1968. Pfeiffer Vacuum and LIP will cooperate in research and development to create vacuum solutions for aerospace applications, vacuum metrology, vacuum calibration and other applications. Before, on 17 October 2017, the LIP-Pfeiffer Vacuum Joint Centre for Vacuum Technology was established in Lanzhou, Gansu province.



Unveiling ceremony of the LIP-Pfeiffer Vacuum Joint Centre for Vacuum Technology. Credit: LIP

From 22 to 26 November, taikonaut Chen Dong and a delegation of CNSA visited the towns of Burg Stargard, Neustrelitz and Neubrandenburg in the North-East of Germany. Chen Dong and the representative of CNSA responsible for international cooperation gave talks to school students and the audience of the 33rd Neubrandenburg Space Days.

LAOS

Sonexay Siphandone, Vice Premier of Laos, visited on 14 December the exhibition hall of the ground station of the Laos Asia-Pacific Satellite Co. Ltd. for the LaoSat 1 communication satellite and the satellite observation and control centre located in the south of Vientiane, capital of Laos. LaoSat 1 was the first satellite that China built for an ASEAN Member State. The Vice Premier thanked the China-trained Laotian engineers for their work and stressed the importance of the national satellite observation and control centre, enabled with China's support.

NGO

Stephen Hawking spoke via a video address at Tencent's We Summit, an annual gathering for sharing ideas on science and technology. He promoted the Breakthrough Starshot project, initiated by himself and Russian entrepreneur Yuri Milner, which aims on building a laser beam-propelled "nanocraft" that can travel at 20 percent of the speed of light. Pete Worden, Executive Director of the Breakthrough Starshot programme and former Director of NASA Ames Research Center told the audience that the project team is looking forward to working closely with Chinese experts and institutes.

RUSSIA

During the 22nd meeting of the Heads of Government of Russia and China, Director General of Roscosmos, Igor Komarov and Tang Dengjie, Head of CNSA signed on 1 November in Beijing the awaited cooperation programme for Lunar and Deep-Space Exploration. The cooperation comprises the areas of lunar and deep-space research, cooperation for joint spacecraft design, for electronic hardware and space materials, cooperation in the field of Earth observation, space debris monitoring, electronic components, communication satellite system, long-term cooperation in satellite navigation, and cooperation within the community of BRICS countries.

At its meeting on 29 November, the upper house of the Russian parliament, the Council of the Federation, ratified an intergovernmental agreement with China to protect space exploration technologies, which was already signed on 25 June 2016 in Beijing. The purpose of the agreement is "to create an organisational and legal basis for preventing unauthorised access to and transfer of protected technologies, in particular with regard to cooperation in rocket and space activities, including the creation and operation of launch vehicles and ground-based space infrastructure." The agreement also regulates the extent of and the procedures for access to technical data and hardware for joint projects.

UK

Professor Dame Jocelyn Bell Burnell led a Scottish science delegation to China, which met with leaders of national academies and institutions. The two sides identified areas of beneficial cooperation: space science, big data, renewable energy, robotics.

UKRAINE

Ukraine and China approved, during the 4th meeting of the Sub-Commission on Cooperation in the Space Sector of the Ukrainian-Chinese Intergovernmental Commission, an update of their space cooperation plans from 2016 - 2020. The long-term space cooperation programme lists the joint implementation of more than 70 projects. Most of them are related to rocket and space technologies, China's Lunar Exploration Programme and a mission to study the planets of the solar system, as well as cooperation in the field of creating new materials and Earth remote sensing. On that occasion, interim results of the implementation in 2017 were discussed and both sides praised the positive dynamic in space cooperation between the two nations. The new areas of cooperation were not revealed.

UNITED NATIONS

The Committee of Disarmament and International Security of the 72nd Session of UN General Assembly on 30 October approved two draft resolutions on the prevention of an arms race in outer space: "No first placement of weapons in outer space" and "Further practical measures for the prevention of an arms race in outer space." Both incorporated the concept of building a "community of shared future for mankind", first proposed by Chinese President Xi Jinping. On 18 January 2017, Xi delivered a keynote speech entitled "Work Together to Build a Community of Shared Future for Mankind" at the UN Office in Geneva, Switzerland, calling for global solutions for global problems.

During the 21st IAA Human in Space Symposium from 27 to 30 November in Shenzhen, Romanian cosmonaut and former President of the Association of Space Explorers Dumitru-Dorin Prunariu told media that for the first time in the history of the UN, China proposed to the UN Office for Outer Space Affairs (UNOOSA) an agreement for the selection of experiments from developing countries to be conducted in the Chinese space station for free. The move "proves that China considers the

UN as highly important in international cooperation," and that "no other nation has ever signed such an agreement," Prunariu pointed out.

UNITED STATES

On 29 November, China and the U.S. held a satellite navigation meeting in Beijing led by Li Wang, Chairman of the China Satellite Navigation System Committee, and Jonathan Margolis, Assistant Secretary of the US Department of State. Changfeng Yang, Chief Architect of the Beidou System, Director Chengqi Ran and Deputy Director Jiaqing Ma of China Satellite Navigation Office (CSNO), Deputy Director Qi Yu of the International Cooperation Department in the China National Space Administration, Deputy Director David Turner of the Space and Advanced Technology Office, the US Department of State, attended the meeting. (more in the section: "Navigation")

On 30 November, China and the U.S. held the 3rd meeting of the Intergovernmental Civil Space Dialogue in Beijing. The two sides introduced their space policies and space exploration plans, and exchanged views on strengthening cooperation in deep-space exploration, space security, Earth science and space science, and commercial aerospace. Tian Yulong, Secretary General of the China National Space Administration CNSA, and Jonathan Margolis, Assistant Secretary for the U.S. Department of State, co-chaired the meeting.

The two sides agreed to continue to strengthen bilateral exchanges and cooperation in policy, safety standards and data and operations. The two sides believe that space technology is an effective measure to prevent and mitigate natural disasters. China and the United States should consider the advantages of their space technologies to promote space technology to cope with major natural disasters, data sharing and applications and research cooperation.

The two sides agreed to use the dialogue mechanism to establish a multi-level cooperation channel to support the communication and exchanges between Chinese and U.S.-American aerospace NGOs, to explore commercial space cooperation, and to encourage scientists from both countries to hold regular scientific meetings and to actively participate in the activities of international multi-lateral organisations, such as the Charter on Space and Natural Disasters, the United Nations Committee on the Peaceful Uses of Outer Space, and the International Space Exploration Coordination Group (ISECG).

The establishment of the China-U.S. civil space dialogue mechanism is one of the results of the 7th round of the China-US Strategic and Economic Dialogue. The 1st and 2nd meetings were held in 2015 and 2016 in Beijing and Washington, respectively.

During the 3rd meeting of the Intergovernmental Civil Space Dialogue in Beijing. Credit: CNSA

EDUCATION

On 2 October, Shenzhou 11 taikonauts Jing Haipeng and Chen Dong handed over worms of the second generation of the six space silkworms which in 2016 spent 30 days in the Tiangong 2 space laboratory, to students of the Christian and Missionary Alliance Sun Kei Secondary School in Tseung Kwan O in Hong Kong. The silk worm experiment was suggested by them and it turned out that the silk spun in space was stronger. The students will continue to study the worms to see if the favourable variation will be inherited.

MISCELLANEOUS

With the launch of Fengyun 3D on 15 November (local time) and the three Jilin satellites on 21 November from the Taiyuan Satellite Launch Centre, the site has improved its efficiency in launch preparation and shortened the launch interval from 20 to 7 days. Taiyuan mainly accommodates polar and sun-synchronous launches.

On 17 November, the founding scientist of the Five-hundred-meter Aperture Spherical Radio Telescope (FAST), Nan Rendong, was posthumously awarded the title of "role model of our times." Nan had led the team who selected the site for FAST and oversaw its construction since 1994, before his death due to sickness in September at the age of 72. He was also honoured for his strong personal qualities as a dedicated and selfless scientist and a sincere person.

Space Applications

Engineers at the Second Academy of China Aerospace Science and Industry Corporation developed a 5 kg robot arm device based on space technologies, bionics and biomimetics. The robot is able to autonomously move around on smooth surfaces, from slippery architectural glass to a slithery ship's hull, or a high-rise signal tower, and can perform cleaning, inspection or rust-removal operations, or operate in the chemical industry or energy sector.
The academy is currently also developing a firefighting drone, which can launch a rocket filled with a fire-suppressing chemical agent into rooms of high-rise buildings.

On A Side Note

During the daily press briefing by the Ministry of Foreign Affairs of China on 12 December, Chinese foreign ministry spokesperson Lu Kang answered a question by a journalist:

Q: U.S. President Donald Trump yesterday announced plans to send a man back to the Moon, and possibly to Mars. In one of his comments, President Trump said that space has so much to do with many other applications, including military applications. Is China concerned that this renewed interest by the U.S. government in space could mean that the U.S. will militarise space for its own purposes?

A: China is pleased to see the scientific and technological progress in the exploration and peaceful use of outer space by various countries. We believe that continuous progress in the peaceful use of outer space will benefit humankind as a whole ultimately, and China stands ready to step up cooperation with the rest of the international community in this regard.
As for your second part of your question, I need to check and verify what was said by President Trump. Yet I think you must be aware that China's position on preventing the weaponisation of outer space is distinct and consistent. As early as in the disarmament talks in Geneva, China has clearly expressed its hope that various parties of the international community will reach the consensus of committing to an early conclusion of a treaty that aims for the prevention of weaponisation of outer space.

LAUNCHES

2017-060A
9 October - 04:13 UTC (12:13 BJT)

launch site: Jiuquan Satellite Launch Centre JSLC, LC43
launcher: Chang Zheng 2D
payload: VRSS-2 Antonio José de Sucre

After Venesat 1 in 2008 and VRSS-1 in 2012, China launched with VRSS-2 the third satellite for Venezuela. VRSS-2, also named "Antonio José de Sucre" or in short: "Sucre", after the Venezuelan independence leader and President of Bolivia and Peru, Antonio José de Sucre is the improved successor of Venezuelan Remote Sensing Satellite VRSS-1 "Francis Miranda". The owner is the Venezuelan space agency ABAE (Agencia Bolivariana para Actividades Espaciales).

Sucre is a cube-shaped, CAST 2000-based satellite with two deployable solar panels and a mass of 942 kg. Built by CAST and DFH, its mission life is expected to be five years. Sucre's imaging equipment is capable of taking 1 m panchromatic and 4 m multi-spectral images. An additional infrared camera provides data in the short wave range (SWIR) with a 30 m resolution and in the long wave range (LWIR) with 60 m resolution. The IR-camera allows the capture of images day and night at the required temperature of minus 215 degrees centigrade. The remote sensing data will be of use for different Venezuelan government agencies in the areas of land resource inspection, environmental protection, disaster monitoring and management, crop yield estimation, city planning and by the defence authorities for border protection.

Venezuelan President Nicolas Maduro thanked China in a televised speech for the successful launch of the satellite.

The contract for the in-orbit delivery was signed in October 2014 in Caracas by CGWIC and the Venezuela Ministry of People's Power for Science, Technology and Intermediate Industries (MPPCTII).

Venezuelan professionals are preparing for the launch of the "Satellite Sucre" on 9 October, from the Jiuquan Launch Center, in the People's Republic of China. Credit: Agencia Bolivariana para Actividades Espaciales ABAE

2017-069A
2017-069B
5 November, 11:45 UTC (19:45 BJT)

launch site: Xichang Satellite Launch Centre LC3
launcher: Chang Zheng 3B (YZ-1)
payload: Beidou 3M1 / Beidou 3M2

The launch of the two 3rd generation navigation satellites - the first of their type - continues China's efforts in the assembly of the global navigation network, adding the 21st and 22nd satellites to the operational constellation. The Long March rocket used the YZ-1 upper stage for placing the satellite duo into medium Earth orbit (MEO) at 21,500 km, inclined by 55.5 degrees.

The CAST-built and DFH-3-based new satellites hold search-and-rescue services, improvements in the inter-satellite links, laser communication devices and higher-performance rubidium and hydrogen atomic clocks which lead to a higher spatial signal accuracy, better stability and signal clarity. The atomic clocks were developed by the Xi'an Institute of the 5th Institute of China Aerospace Science and Technology Corporation.

Each box-shaped satellite has a mass of 1,014 kg, and a dimension of 2.25 x 1.0 x 2.2 m. The phased-array antenna unit is completed with two deployable solar arrays. Additionally, the satellites carry laser retro-reflectors for the high-precision location determination.

The satellites are also named Beidou 24 (PRN 1) and Beidou 25 (PRN 2) and have an expected lifetime of 12 years. They follow five experimental Beidou-3 satellites (launched 2015 and 2016) which verified the new technologies and are able to operate autonomously for 60 days without ground control support. Beidou is interoperable with U.S., Russian and European navigation networks. Beidou's B1-signals are transmitted at 1,561048 to 1,57592 GHz and are almost equivalent to the GPS-L1 and Galileo-E1 signals.

Until 2020, the modernised network of Beidou's phase 3 will consist of 27 MEO and 5 GEO satellites. The navigation accuracy for users is around 5 m compared with 10 m in the past.

2017-072A
2017-072B
14 November - 18:35 UTC (15 November - 02:35 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC; LC9
launcher: Chang Zheng 4C
payload: Fengyun 3D / HEAD-1

With FY-3D, the NSMC (National Satellite Meteorological Centre) is using after Fengyun-3C (launched in 2013) another polar-orbiting (98.66 degrees) meteorological satellite of the 2nd Fengyun generation which provides global three dimensional all-weather and multi-spectral remote sensing images. It constitutes a major part of the global space-based meteorological observation system.

The CAST/SAST-built satellite is three-axis stabilised and box-shaped with a dimension of 4.4 m x 2.0 m x 2.0 m in the stowed configuration and of 4.4 m x 10 m x 3.8 m when the single 22.464 m^2 solar panel (2.480 W) is deployed in flight configuration. The energy supply is supplemented by two NiCd batteries. The total spacecraft launch mass is 2,450 kg and the designed life time is five years.

The ground swath of the onboard optical-mechanical scanners covers 3,000 km with a 250 m resolution in the High-Resolution Picture Transmission (HRPT) mode. The satellite has two X-band transmitters (one real-time and one delayed) and an L-band transmitter (real-time).

The instruments cover three main tasks: sounding, ozone and imaging. Data of FY-3D support weather forecasts in the medium-and-long range numerical weather prediction (NWP) model, enabling high-impact weather forecasts for up to a week in advance. The satellite is equipped with greenhouse gas probing instruments, carries hyper-spectral greenhouse gas monitoring sensors and can monitor global greenhouse gas emissions such as carbon dioxide, methane, and carbon monoxide with high accuracy. Its data will help to shorten the interval between world weather forecast updates from six hours to four hours and double the frequency of updates for weather disaster monitoring.

Fengyun 3D will undergo a six-month period of on-orbit testing before it will be jointly operated by the China Meteorological Administration (CMA) and China's National Satellite Meteorological Centre (NSMC).

China plans to launch another four Fengyun 3 satellites between 2018 and 2021 including a morning orbit satellite and an afternoon orbit satellite with improved remote sensing instruments. The other two Fengyun 3 satellites are a meteorological satellite and a low inclination, nearly circular orbit, precipitation measuring satellite which operate in the dawn-dusk orbit.

At the beginning of December, the Chinese weather satellite Fengyun-3D returned its first high-quality image which shows a true colour image of the Leizhou Peninsula (the regions from the South China Sea to northwest China) taken by the medium-resolution spectral imager.

The launch also orbited a secondary payload, the small commercial imaging satellite HEAD 1 for HEAD Aerospace Technology Co. of Beijing. The 45 kg, 3-axis stabilised HEAD 1 satellite was built in cooperation with SAST. It is box-shaped and equipped with two solar panels. HEAD 1 is the first commercial AIS (Automatic Identification System) satellite in China. The maritime tracking satellite can register 2 million messages from 60,000 ships per day. Its lifetime is around 2 to 3 years and is the demonstration satellite for the planned 30 satellite network of the Skywalker Constellation. HEAD Aerospace Technology Co. is also the operator of the satellite.

Scientists at Shanghai Fudan University used the upper stage of the Long March 4C rocket for testing new technology. The stage was fitted with intelligent, 30 g-chips to establish the initial stage of a space-based Internet of Things.

2017-074A
2017-074B
2017-074C
21 November 2017 - 04:50 UTC (12:50 BJT)

launch site: Taiyuan Satellite Launch Centre - TSLC; LC 16
launcher: Chang Zheng 6
payloads:
Jilin 1-Shipin 4
Jilin 1-Shipin 5
Jilin 1-Shipin 6

With the launch of the three, small, high-definition video and imaging satellites, the Changguang Satellite Technology Corp. (CGST) in Harbin, Jilin province, continues the assembly of a global commercial remote sensing constellation of 60 satellites by 2020 facilitating revisits every 30 minutes, and of 138 satellites by 2030 for revisits every 10 min. The swath width of the on-board camera is 19 km x 4.5 km producing a resolution of around 1 m. Together with the five previously launched Jilin 1 satellites the additional three reduce the current Jilin 1 network's revisit time from three days to one day. The first image was sent 9 hours after the launch.

The 95 kg-Jilin satellites, named after the north-eastern Jilin province, are box-shaped probes with a fixed solar panel unit and two solar arrays. Life time in a sun-synchronous 535 km orbit is 3 years.

Jilin 1 satellites are also named: Lingqiao 1-04 to 1-06, Changgauang 1-01 to 1-03 and Shipin 4 to 6. Once the constellation becomes fully operational, it will service a wide range of civilian and business fields such as land resources monitoring, mineral exploitation, geographical mapping, agricultural estimation, environmental inspection, disaster relief and emergency response.

On 23 November, a press conference was held in Changguang Satellite Technology Co., Ltd in Changchun. The first images were introduced to the public and it was announced to launch 10 more satellites in 2018.

2017-075A
2017-075B
2017-075C
24 November 2017 - 18:10 UTC (25 November - 2:10 BJT)

launch site: Xichang Satellite Launch Centre - XSLC; LC 3
launcher: Chang Zheng 2C
payload: Yaogan-30 02-1 / Yaogan-30 02-2 / Yaogan-30 02-3

China successfully launched a set of three remote sensing satellites, developed by the Innovation Academy for Microsatellites of the Chinese Academy of Sciences (former SECM). The satellites will conduct electromagnetic probes and other experiments. There was no further confirmed information available.

2017-077A
3 December - 04:11 UTC (12:11 BJT)

launch site: Jiuquan Satellite Launch Centre - JSLC; LC43
launcher: Chang Zheng 2D
payload: LKW-1 - Ludikancha 1 (Yaogan Weixing-31)

China launched the high-resolution imaging satellite, Ludikancha Weixing-1 (LKW 1, Land Surveying Satellite 1), into a 500 km, 97.46 degree polar, sun-synchronous orbit. It serves within the Land Resources Exploration Satellite Constellation for the "remote sensing exploration of land resources." It is the starting point for a network of Earth observation satellites.

The LKW-1 satellite has a hexagonally shaped, elongated satellite body with three deployable solar panels - a common configuration for LEO satellites. LKW-1 is a CAST-built probe based on the CAST-2000 bus.

Launch of the LKW-1 land exploration satellite into a pre-set orbit from the Jiuquan Satellite Launch Centre in the Gobi Desert, northwest China's Gansu Province, on 3 December 2017. Credit: Xinhua/Zhen Zhe

2017-078A
10 December - 16:40 UTC (11 December - 00:40 BJT)

launch site: Xichang Satellite Launch Center - XSLC; LC2
launcher: Chang Zheng 3B-G2
payload: Alcomsat 1

Algeria's first communication satellite is also China's first international and commercial high-throughput satellite and represents the first Algeria-China space cooperation project.

Alcomsat 1, based on the DFH-4 platform, was developed and built by CAST. It has a lift-off mass of 5,225 kg and a design life of 15 years. It is a box-shape construction with two solar panels (minimum of 19.5 kW).

The satellite is equipped with 33 operational transponders (19 in Ku-band, 12 in Ka-band and 2 in L-band for satellite navigation) as well as military-operated payloads in X-Band, EHF- and UHF. On 18 December, after eight hours of operations, the satellite was positioned at 24.8° West longitude in the geostationary orbit. The Algerian Space Agency (ASAL - Agence Spatiale Algérienne) takes over the operation of the satellite from its operations centres in Medea and Algiers for broadcast, emergency communications, tele education, e-government, enterprise communications, satellite broadband, and satellite-based augmentation system applications. Tunisia, the northern Chad and the North Sudan will also make use of the satellites broadcast and internet services.

CGWIC managed the contract, signed in December 2013, for the design, manufacturing, assembly, test, launch, and in-orbit delivery to ASAL as well as other ground deliverable items necessary for the satellite's operation and application. China Satcom assisted with the Alcomsat 1 programme, including frequency coordination, defining the system and gauging user needs. For this mission specifically, China has helped Algeria develop a training programme for local engineers related to the design and construction of Alcomsat 1.

Members of Alcomsat 1's team from China and Algeria pose with the spacecraft before launch. Credit: Algeria Press Service

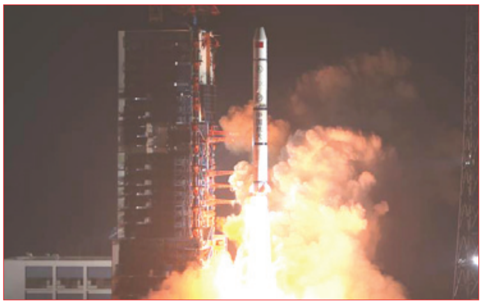
2017-084A
23 December - 04:14 UTC (12:14 BJT)

launch site: Jiuquan Satellite Launch Center - JSLC; LC 43
launcher: Chang Zheng 2D
payload: LKW-2 - Ludikancha 2 (Yaogan Weixing-32)

China launched its second high-resolution imaging satellite, Ludi Kancha Weixing 2 (LKW-2, Land Surveying Satellite 2) three weeks after orbiting LKW-1 and put it into the same 500 km sun-sync orbit but phased 180 degrees away. The LKW satellites are hexagonal shaped with three deployable solar panels on the one end of the elongated body and a thruster on the other. It is based on the CAST-2000 bus of China Academy of Space Technology (CAST). The satellite is mainly used for remote sensing exploration of land resources.

2017-085A
2017-085B
2017-085C
25 December 2017 - 19:44 UTC (26 December - 3:44 BJT)

launch site: Xichang Satellite Launch Centre - XSLC; LC3
launcher: Chang Zheng 2C
payload: Yaogan-30 03-1 / Yaogan-30 03-2 / Yaogan-30 03-3



A Long March-2C carrier rocket is lifting-off from Xichang Satellite Launch Center with three Yaogan satellites. Credit: Xinhua/Liang Keyan

As the third batch of the Yaogan 30 surveillance constellation, the satellites (also called: Chuanxin) will conduct electromagnetic environmental probing and other experiments.

The 3 identical satellites joined a larger Yaogan 30 satellite launched in May 2016 (2016-029A) and the two other triple-sets of remote sensing satellites launched on 29 September (YG-30 01-triplet 2017-058A / 58B / 58C) and 24/25 November (YG-30 02-triplet 2017-075A / 75B / 75C) into the same type of orbit in around 600 km height and with a 35 degree tilt against the Equator. The satellites form a global surveillance network, consisting of network nodes where three satellites fly in triangular formation. (There are also other observers on the internet who mention that the satellites were distributed over the orbital plane, separated by 120 degrees.)

The Yaogan 30 (03) trio of Earth observation satellites with two deployable solar arrays were developed by the Innovation Academy for Microsatellites of the Chinese Academy of Sciences (CAS) in Shanghai (former SECM).

This last launch of 2017 was the 18th Chinese launch (including Kuaizhou and Kaituozhe launches). Initially, China planned for 30 rocket launches but the problems with the Long March 3 in June and the Long March 5 failure in July interrupted the schedule.

Ralf Hupertz and Arno Fellenberg kindly contributed information to the section Chinese Space Launches. Other sources of informations are:
http://news.xinhuanet.com *https://www.nasaspaceflight.com* *https://spaceflightnow.com*
http://spaceflight101.com/china/ *http://www.spaceflightinsider.com* *http://www.planet4589.org/space/jsr/jsr.html*

APSCO	Asia-Pacific Space Cooperation Organisation
BDS	BeiDou satellite navigation Systems
BICE	Beijing Institute of Control Engineering
BJT	Beijing Time
BLSS	Bioregenerative Life Support System
BRICS	Brazil, Russia, India, China, South Africa
CALT	China Academy of Launch Vehicle Techno-logy, 1st Academy of China Aerospace Science and Technology Corporation CASC
CAS	Chinese Academy of Sciences
CASC	China Aerospace Science and Technology Corporation
CASIC	China Aerospace Science and Industry Corporation
CAST	China Academy of Space Technology
CBERS	China-Brazil Earth Resource Satellite
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
CNES	French Space Agency

CNSA	China National Space Administration
COPOUS	Committee on the Peaceful Uses of Outer Space
COSPAS-SARSAT	International Satellite-based Search-and-Rescue Initiative
CPC	Communist Party of China
CSES	China's Seismo-Electromagnetic Satellite
CSNO	China Satellite Navigation Office
CSS	Chinese Space Station
CZ	Long March, Changzheng
DAMPE	Dark Matter Particle Explorer
ESOC	European Space Operations Centre
FAST	Five-Hundred Metre Aperture Spherical Radio Telescope
GEO	Geostationary Orbit
GLEX2017	Global Space Exploration Conference 2017
GMT	Greenwich Mean Time
GNC	Guidance, Navigation and Control
GNSS	Global Navigation Satellite System
IADC	Inter Agency Space Debris Coordination Committee
IAMCAS	Innovation Academy for Microsatellites of CAS

ISECG	International Space Exploration Coordination Group
ITU	International Telecommunication Union
KZ	Kuaizhou
LIGO	Laser Interferometer Gravitational-Wave Observatory
NAOC	National Astronomical Observatories of China
NDRCC	National Disaster Reduction Center of China
NSMC	China's National Satellite Meteorological Centre
PLA	People' s Liberation Army
SAST	Shanghai Academy of Spaceflight Technology
SECM	Shanghai Engineering Centre for Micro-satellites
SMMS	Small Multi-Mission Satellite
SZ	Shenzhou
TG	Tiangong
UNESCO	UN Educational, Scientifiic and Cultural Organisation
UNOOSA	UN Office for Outer Space Affairs
UTC	Coordinated Universal Time
VRSS	Venezuelan Remote Sensing Satellite

Hard Road to Commercial Space
- The Past of the Chinese Commercial Launch Service

by Chen Lan

Decisions

About 40 years ago, China started an historic transition from the Stalin-style centrally planned economy to the market economy, which was known as "reform and opening up". The country shifted its focus to economic development. It had a great impact on the space programme. Many military and scientific space projects were cancelled or postponed. Only application satellite programmes and launch vehicle development survived. Government funds flowing to the space programme were significantly reduced. Space organisations had to produce non-space products such as refrigerators and motorcycles to get revenue to support their operations. At the same time, space launch services had become a profitable business in the West. The European Ariane rocket carrier and the U.S. Space Shuttles were the only players in this small but fast-growing market. Some people inside the Chinese space industry with profound insight realised that China could be able to play a role in the field of commercial space launch service. One of them was Liu Jiyuan, Deputy Minister of the Ministry of Astronautics at that time.


Liu Jiyuan. Credit: China internet

On 8 April 1984, China launched its first geostationary communication satellite, the DFH-2, using the new Long March 3 (CZ-3) rocket. It was a milestone in Chinese space history and laid the foundation for the commercial launch business. Immediately after the DFH-2 launch, in late April, Liu held a meeting to discuss the possibility for China to provide a commercial launch service for other countries. Despite suspicions and oppositions, a consensus was reached among high-level officials. Shortly after, Liu formed a team to investigate the market and study the approach and allocated 300,000 RMB (about 45,000 Euros at the current rate) to it. The team was led by Liu himself and had ten members including Wu Keli and Huang Zhuoyi.

At the end of 1984, a proposal for a commercial launch business was submitted to COSTIND (Commission of Science, Technology and Industry for National Defense). On 2 April 1985, the feasibility study of the business was reviewed. The conclusion was positive and the first decision was made. In May and June, China revealed the message at the Paris Airshow and at several international conferences that China is ready to provide a launch service. These 'trial balloons' received a lot of attention in the international community. On 27 October 1985, the Chinese state news agency Xinhua made the first official announcement that China plans to use its Long March rocket to launch commercial satellites into space.

For Liu Jiyuan and his supporters, it was very encouraging that such a target was reached smoothly in only one and a half years. However, they never realised that it was just the beginning of a long and difficult road filled with obstacles, and even tears and blood.

First Steps

Up to mid-1985, China had made only 13 successful space launches. The new CZ-3 that was able to launch communication satellites had only one successful launch by then. In addition, Chinese space officials had no knowledge of the market and business. They even did not know what 'bidding' meant. Without a good track record and without any international business experience, to promote the Long March rocket to foreign customers seemed much more difficult than putting a satellite into space.

Of course, China's launch service had one important competitive advantage - that was and is its low price. The Chinese experts initially set the price 15% lower than its Western competitors for the same payloads. First contacts with some foreign customers were made in mid and late 1985, but none of them went very far.

The breakthrough was made by coincidence. In November 1985, a delegation from the Swedish Space Corporation (SSC) requested to have a look at Chinese launch vehicles. After the visit to the rocket assembly facility in Beijing, the Swedish expressed their wish to use the Chinese CZ-2C launch vehicle to launch their Mailstar store-and-forward LEO communication satellite. It was a surprise to the Chinese team. Two months later, a launch reservation agreement was signed on 23 January 1986. A partial reason as to why the CZ-2C was chosen among all the other competitors was actually a very personal one. Sven Grahn, a project manager of SSC (later Vice President), is a member of the well-known Kettering Group and had tracked satellite radio signals since the 1960s. He also tracked almost every Chinese satellite and was very familiar with the Chinese space programme. His trust in Chinese launch vehicles made the negotiation very smooth. The Chinese commercial launch business made its first step forward.

Five days after the first contract was signed, the U.S. space shuttle Challenger STS-51L exploded 73 seconds after lift-off, followed by a string of launch accidents involving Titan, Delta and Ariane. The commercial launch market suddenly changed and this gave the Long March a very good opportunity. In the first half of 1986, it was decided to put the commercial launch business under the China Great Wall


CZ-3 launch vechicle. Credit: CGWIC/China internet

Industry Corporation (CGWIC), the international business arm of China's space industry. The new launch service department was led by Wu Keli. Later in the same year, a representative office was set-up in Los Angeles. Huang Zuoyi became the only full-time staff of this office. In this year, they visited many potential customers in the United States. Their efforts paid off. In just one year from January 1986 to January 1987, two contracts and five reservation agreements were signed, though most of them later turned out to be disappointments. Among them, the most dramatic one was the Westar 6. It was a Hughes 376 comsat recovered from orbit by STS-51A in 1984 and was just within CZ-3's 1,400 kg GTO capability. But after the reservation agreement was signed, Western Union, the satellite's owner, was re-organised and the satellite was purchased by the Houston-based Teresat. Again, a launch agreement was signed with the latter in June 1986 and the formal contract on 28 January 1987. Teresat was closed shortly afterwards. Just one month later, another short-lived company who took over the satellite, signed the contract with China, and terminated it shortly afterwards too. It was on 2 January 1989 when Asiasat signed the launch contract with CGWIC that the satellite's fate was finally decided – still to be launched by the CZ-3 as originally planned. By that time, Asiasat is a consortium of Hong Kong-based Hutchinson Telecommunications, the UK's Cable & Wireless, and the China International Trust and Investment Corporation (CITIC), and pioneer of satellite communication in China and Asia.

As Asiasat 1 was a U.S.-made satellite, an export license needed to be issued by the U.S. government, which became a difficulty. The U.S. side had two major reasons to refuse such a license, one is that Chinese launches are sponsored by the government and is therefore unfair to its competitors, the second is that when a U.S. satellite is on Chinese territory, there would be a risk of leaking sensitive technologies. China's position was that a Chinese launch service is only a supplement to the international market and therefore no threat to the major players. At the same time, China would take all measures to guarantee the protection of U.S. secrets. To solve the problem, the two governments had two rounds of difficult negotiations and finally signed three MoUs on technology safeguarding, launch responsibility and international trade issues in November 1988 and January 1989. According to the agreements, China would be allowed to launch no more than 9 U.S.-made comsats within the following 5 years. However, the Tiananmen Square incident in June 1989 interrupted the process. After a long time of hard negotiations, the Bush administration decided to review the export license case-by-case and granted a waiver to export the Asiasat 1 on 21 December 1989, less than four months before the scheduled launch.

On 12 February 1990, the satellite arrived in the Xichang Launch Center, together with the Hughes launch support team and U.S. government security guards. On 7 April 1990, history was made. The CZ-3 lifted off and sent the Asiasat 1 into GTO accurately. China had entered the international commercial launch market. It was also the first time a recovered satellite had returned to space.

When Asiasat 1 opened the new page, the first contract signed with the Swedish Space Corporation was still awaiting its execution. In 1987, the Mailstar project was cancelled due to fast growing VSAT systems. To utilise the launch opportunity, SSC decided to launch a scientific satellite, Freja, instead. A launch contract was signed in 1988. In 1992, Freja was successfully launched by a CZ-2C, as a piggyback payload together with the main payload, the FSW-13 recoverable satellite.

New Launch Vehicles

Early in 1986, Huang Zuoyi had already dreamt of a heavy launch vehicle, a strap-on version of the CZ-2C, to launch the largest comsat in the market. The idea gained support from many people, including Liu Jiyuan and the CALT Director, Wang Yongzhi. The idea also attracted Hughes and Aussat (later Optus), the largest Australian satellite operator. In October 1986, Hughes visited China for the first time. In January 1987, the Ministry of Astronautics briefly agreed to the plan to develop the CZ-2E to launch commercial payloads. On 5 February 1987, a reservation agreement was signed with Hughes. In January 1988, Hughes won the bid of Aussat to build two HS-601 model satellites, the largest communication satellite at that time. On 31 October 1988, the formal contract to use CZ-2E to launch the Optus B1 and B2 comsats was finally signed. It was a great achievement for the Chinese negotiators because when the contract was signed, the new launch vehicle was still on the drawing board.

The contract was also a great challenge for Chinese. It asked for a test launch before 30 June 1990. If China failed to meet the schedule, the contract would be terminated and a fine of one million U.S. dollars would be imposed.

Inside the Chinese decision makers, there were also strong objections. Meetings, held in September 1988 in Huairou and in November 1988 in Daxing (both in the sub-urban area of Beijing) saw intense debates. CZ-2E was not foreseen in China's original plan and it would take resources and funds from other projects. It was also risky because it sharply increased the LEO capacity from 2 t to 9 t. The brand new heavy launcher, all necessary new test facilities and a new launch pad had to be completed within only 18 months. The meetings had no conclusions. On 14 December 1988, the State Council held a meeting especially on that issue. Premiere Li Peng, Vice-Premiere Yao Yiling, officials from the Ministry of Astronautics, the Ministry of Foreign Affairs and COSTIND attended the meeting. The CZ-2E development was finally approved but without any funds allocated. The development cost was estimated about 350 million RMB (45 million Euros at current rate). Liu Jiyuan made considerable effort to raise the money and finally allocated 20 million RMB from inside the space budget to CALT to kick-off the development. All of the rest of the money was later loaned from banks. The CZ-2E development was led by Wang Yongzhi (later Chief Engineer of the manned programme).


CZ-2E launch vechicle. Credit: CGWIC/China internet

18 months later, a new rocket was erected at the new launch pad. It was a miracle, not only in Chinese space history but

also in world space history. The maiden launch of CZ-2E was on 16 July 1990. The CZ-2E launch vehicle was successful but the simulated Optus payload failed to reach the transfer orbit because the perigee kick motor (PKM) failed. Nevertheless, it paved the way to launch the two HS-601s in 1992. Also, it has to be mentioned that the CZ-2E was an important milestone in Chinese space history. It later evolved into the CZ-2F, the manned launch vehicle. In fact, just two months after the CZ-2E's maiden flight, the Chinese government approved the manned programme - the Project 921. Without CZ-2E, there would have been no Shenzhou 5 manned flight 11 years later.

During this time, China developed a new GTO launcher, the CZ-3A. It had a newly developed cryogenic engine, increasing the GTO capacity from 1.4 t to 2.5 t. The plan also asked for a new heavy launcher called CZ-3B which combined CZ-3A's core stage and CZ-2E's strap-on boosters. For a long period of time, the CZ-3B was China's largest launch vehicle with a GTO payload capacity of 5 t.

Failures and Successes

Symbolically, like the whole commercial launch programme, the CZ-2E's road to space was not smooth. The Tiananmen Square incident interrupted all commercial and technical coordination between China, Hughes and Optus. It was not until 30 April 1991 that the U.S. government lifted the ban of exporting satellites to China. On 22 March 1992, the first launch attempt was terminated immediately after ignition. Fortunately, the launch vehicle and the satellite both stayed intact. The cause was a piece of additional material on the ignition device leading to a short circuit, which had shut down one of the four engines. Five months later, the third CZ-2E successfully launched the Optus B1.

At the end of that year, the Chinese commercial space programme experienced another mishap - a real failure. The Optus B2 was launched but the satellite was lost. Although its replacement, the Optus B3 was launched smoothly 18 months later, it was actually the start of a string of failures in the Chinese commercial launch service. In January 1995, the fourth CZ-2E exploded after launch. The Apstar 2 comsat was lost and six nearby villagers were killed. The most serious accident happened on 14 February 1996 when the new 3-stage CZ-3B made its maiden flight. Because of the malfunction of a control unit, the rocket changed its attitude from vertical to horizontal just after lift-off and hit a hill 1.85 kilometers away. Six people, including a senior rocket engineer, were killed. (for an in-dept analyses on the accident, see cover story in GoTaikonauts! issue no. 8: "Mist around the CZ-3B Disaster"). In August, the CZ-3's upper stage prematurely shut down the engine, leaving the Hughes built Chinasat 7 in a lower orbit.

CZ-3B launch vehicle. Credit: CGWI/China internet

In the period from 1992 to 1996, China successfully launched 6 commercial communication satellites. They are Optus B1 and B3, Apstar 1 and 1A, Asiasat 2 and Echostar 1. There was also progress on securing new contracts. The largest contract in this period was the Iridium launch deal that could be seen as an exchange of Chinese investment into the Iridium Programme. But failures had already cast a shadow on Long March's path to the market. At least 3-4 signed contracts were cancelled. They included Echostar 2, Asiasat 3, Globalstar.

In August 1997, China resumed commercial space launches by putting the Philippine's Agila 2 comsat into orbit using an improved CZ-3B. Two months later, it launched Apstar 2R. The CZ-3B made two more successful launches in 1998, sending two domestic commercial comsats into orbit. From December 1997 to June 1999, China made 6 launches, putting 12 Motorola/Iridium LEO communication satellites in orbit. Although China achieved a record high market share of over 10% of the world market during this period, these consequent successes did not strengthen China's market position. China's commercial launch business dropped suddenly after 1998. There were two major factors for this, one being a change in the market situation. At the end of 1990s, the requirements for the GEO comsats slipped and the LEO comsat market collapsed. At the same time, cheap Russian launch vehicles entered the market. For example, ILS's Proton and Sea Launch's Zenit-3S. Long March's cost advantage disappeared. Another factor was and still is international politics. After 1996, the Sino-U.S. relationship became more and more stressed. China 'threats' became a hot topic of bipartisan politics. Hughes and Loral were accused of having leaked sensitive technologies to China during the CZ-2E and CZ-3B failure investigations. Lockheed Martin was suspected to have helped China to develop the Smart Dispenser transfer stage for Iridium launches, which was considered as having military potential. China, of course, denied all these accusations. In 1998, the Cox Report, a report on Chinese spying on U.S. technologies, was published. As a result, the control of satellites export and space technology exchange was getting stricter and stricter. From that time on, U.S.-made satellites and satellites with U.S.-made components became impossible to be launched by any Chinese launch vehicle.

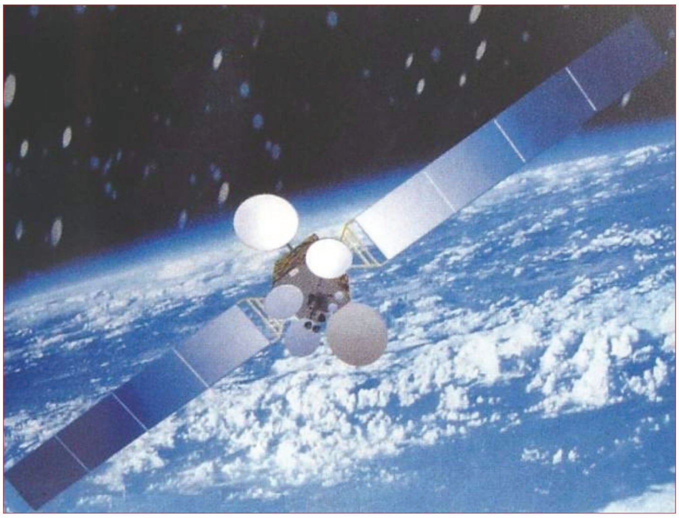
China however, continued their efforts. They signed a few contracts with non-U.S. satellite manufacturers in the late 1990s and early 2000s. For example, the Atlantic Bird 1 and two HKSATs, made by Europe and Israel respectively, as well as a Korean small satellite. However, because all had U.S. made components, the contracts were never executed. They were either switched to other launch providers such as Ariane or cancelled.

Return to the market

Facing an unfavourable market environment, China changed its strategy after 2000. The first move was to switch to European satellite manufacturers. But the removal of all U.S. components from a high-performance communication satellite was a difficult decision for all satellite operators unless the satellite had to be launched in China. As a result, the strategy was only partially successful. The Apstar 6, made by Alcatel and owned by the Hong Kong-based APT communications, was the first communication satellite without U.S.-American components launched by a Chinese launch vehicle. It was launched on 12 April 2005 by a CZ-3B from Xichang, marking China's return to the market after six years of silence. Following the Apstar 6, the domestic operator Chinasat signed two contracts with Alcatel to manufacture Chinasat 9 and Chinasat 6B. They were launched by the CZ-3B on 9 June 2008 and 5 July 2007 respectively.

The second strategy was more substantial and has been showing long-term influence. That is bundling together the launch service with the satellite export, which is also a common practice called “in-orbit delivery” used by major satellite manufacturers such as Hughes and Lockheed Martin for many years.

In an interview, Fu Zhiheng, the Vice-President of China Great Wall Industry Corporation gave to GoTaikonauts! (compare: issue no 10) in September 2013 in Beijing, he said: “China Great Wall Industry Corporation is the commercial arm for China’s space industry with respect to international business. Our main business comprises launch services, commercial satellites, including telecommunication and remote-sensing satellites. Also, we are engaged in promoting international collaboration in the space area not only for commercial reasons, but because we are authorised by the Chinese government to do this kind of activity. Indeed, we are the only commercial organisation in China to do that. … our priority is to promote a package solution to the customer. We use Chinese satellites, Chinese launchers, and Chinese ground infrastructure. We put it all together into a package and promote it to our potential customers. In this way, there is no ITAR issue.”



DFH-4 communication satellite. Credit: CAST/China internet

China put its hope on the domestically-developed DFH-4 communication satellite bus. By that time, the DHF-4, developed by CAST (China Academy of Space Technology) was China’s largest satellite. Its performance is equivalent to Boeing’s HS-601. The project was kicked-off in the late 1990s and has been one of China’s most important spacecraft projects during those years. The following are its major characteristics:

- Bus mass: 5,100 kg (launch mass, including the apogee kick engine and fuel)
- Payload mass: more than 600 kg
- Solar panel area: 62 m^2
- Backup battery: 54 units of H_2Ni batteries
- Output power: 10,500-13,000 W (at beginning and end of working life)
- Output power to payload: 8,300-7,830 W (at beginning and end of working life)
- Attitude control: three-axis stabilised
- Attitude control precision: +/- 0.06^O (pitch and roll), +/- 0.2^O (yaw)
- Station keeping precision: +/- 0.05^O (at both longitude and latitude)
- Working life: 15 years

Unlike the DFH-3, the first DFH-4 satellite was a commercial satellite. Named as Sinosat 2, it was purchased by Sino Satellite Communications and became China’s first direct broadcasting television satellite. It was launched on 28 October 2006. Unfortunately, the first DFH-4 comsat, Sinosat 2, resulted in a disaster. The satellite managed to manoeuvre to the geostationary orbit but failed to fully deploy its solar arrays. China made great efforts to overcome the difficulties, but finally it gave up.

So, the contract with the Nigerian National Space Research and Development Agency (NASRDA) for in-orbit delivery of the NigComSat 1 became critical for the Chinese commercial space programme. The NigComSat 1 became the second DFH-4 based comsat, with 28 C-, Ku-, Ka- and L-band transponders. The contract was signed in December 2004, and NigComSat 1 launched successfully on 13 May 2007 from Xichang. In July 2007, CGWIC handed over the satellite to the Nigerian Communications Satellite Ltd. (NigComSat Ltd.) along with a ground station in Abuja, Nigeria. A 15-year operational support service and a comprehensive training program have also been provided as part of the contract. Unfortunately, in November 2008, the satellite failed in orbit. This time again, the problem was also caused by the solar panel mechanism.

As Chinasat, Sinosat and Apstar all have Chinese government shares, the Sinosat contract is not considered as a real breakthrough for DFH-4. While the NigComSat contract shows that the low-cost Chinese-made communication satellite is attractive to developing countries. Encouraged by the first success, China signed the second contract 11 months later. This time with Venezuela.

China in-orbit delivered the VeneSat 1 or “Simon Bolivar”, which was also the third DFH-4 comsat, to Venezuela in 2008 after its launch on 29 October 2008. It was a total success, demonstrating the maturity of the bus. The contract, signed in November 2005 between the Venezuelan Ministry of Science and Technology and CGWIC, was the first one with a Latin American customer and the first cooperation project between China and Venezuela. The satellite was equipped with 14 C-band, 12 Ku-band and 2 Ka-band transponders and four shaped communication antennas. In December 2008, the VeneSat 1, two Venezuelan ground stations in Bamari and Luepa and an additional teleport in Bamari were handed over to the Venezuelan authorities.

The PakSat 1R contract, signed in October 2008 with Pakistan Space & Upper Atmosphere Research Commission (SUPARCO) was the third communications satellite contract CGWIC signed with an international customer and the first in-orbit delivery contract for an Asian customer. The DFH-4-based PakSat 1R housed 12 active C-band and 18 active Ku-band transponders. It was successfully launched on 10 August 2011. The handover to SUPARCO was in November the same year, together with ground stations in Lahore and Karachi.

In spring 2009, the Nigerian Federal Ministry of Science and Technology, NigComSat Ltd. and CGWIC agreed for a replacement of NigComSat 1, the NigComSat 1R.

2010 and 2011 were very fruitful years for CGWIC. It could book contracts for a total of 4 in-orbit-deliveries. One of the 2010-contracts was the LaoSat 1 for the China Asia-Pacific

Mobile Communications Satellite Company Limited (APMT), which was launched in November 2015. Laos is the first ASEAN customer for China. The other one was the 30-transponder satellite Túpac Katari 1 for the Bolivian Space Agency, launched on 20 December 2013. The China Development Bank gave a loan for the financial realisation of the project, which also included the required ground application system. LaoSat 1 and Túpac Katari are DFH-4 based satellites.

The two satellites contracted in 2011 were the Belintersat 1 for Belarus and VRSS-1 for Venezuela. Belarus became China's first European customer for in-orbit-delivery. Belintersat 1 is a DFH-4-based communication satellite with 38 transponders. It launched on 15 January 2016 and was handed over in May 2016. Half of the satellite's capacity is leased to external customers with NigComSat being the partner for all African operations.

The VRSS-1 satellite is a CAST 2000-based satellite for Earth observation, a first for China's in-orbit-delivery initiative. It launched on board a CZ-2D in September 2012 and was handed over to the Ministry of People's Power of Science and Technology and Intermediate Industries of Venezuela in the beginning of 2013.

By the end of 2013, a long-standing customer turned to CGWIC with a special order. APT Satellite Company Limited for the first time ordered a Chinese-built communication satellite including the ground structure for satellite operation. Apstar 9, a DFH-4 platform-based satellite, launched on 16 October 2015 with a CZ-3B from Xichang and in January the following year, the hand-over took place.

Up to early 2018, at least 20 DFH-4 based satellites have been launched, with no further satellite failure. The competitive advantages of the DFH-4 satellite bus could be proven with numerous launches for the domestic and international customer alike.

Meanwhile, an advanced, ultra-high-performance satellite bus, the DFH-5 platform is about to be tested in 2018. Originally, the first DFH-5-based satellite should have been in space in 2017. The second launch of the new generation launch vehicle CZ-5 from the just opened launch site Wenchang Satellite Launch Center on 2 July 2017 ended in a failure and the innovative experimental DFH-5-based communication satellite Shijian 18 was lost. The replacement satellite, Shijian 20, is expected to be lifted by the third launch of the CZ-5 in the second half of 2018. The Long March 5 rocket will significantly enhance China's launch capability and competitiveness with a maximum GTO capacity of 14 t enabling not only a commercial launch service but also future robotic deep-space exploration and the assembly of the Chinese Space Station.

A challenging future ahead

The outlook for China's launch business remains difficult despite growing successes. As long as the political relationship between China and the United States stays unchanged, China's access to the core market will still be hampered. Additionally, economic pressure through U.S.-President Donald Trump's "America First" strategy and tariffs on aerospace hardware will not ease the access to the U.S. market for a Chinese launch service provider.

In the long term, a commercial space launch service remains an important field of China's ambitious space plan. The timely strategy changes and the adaptability to global trends in the last decades has enabled China to secure its modest place on the launch market. There are several directions, China is following. Already in 2013, Fu Zhiheng, the Vice-President of CGWIC mentioned: "In the meantime we also have our eye on the small satellite market. Nowadays there are more and more countries which are capable of developing small satellites, mini or microsatellites. But access to space is the big obstacle for them, so we believe we can use the capability of the Chinese launchers."

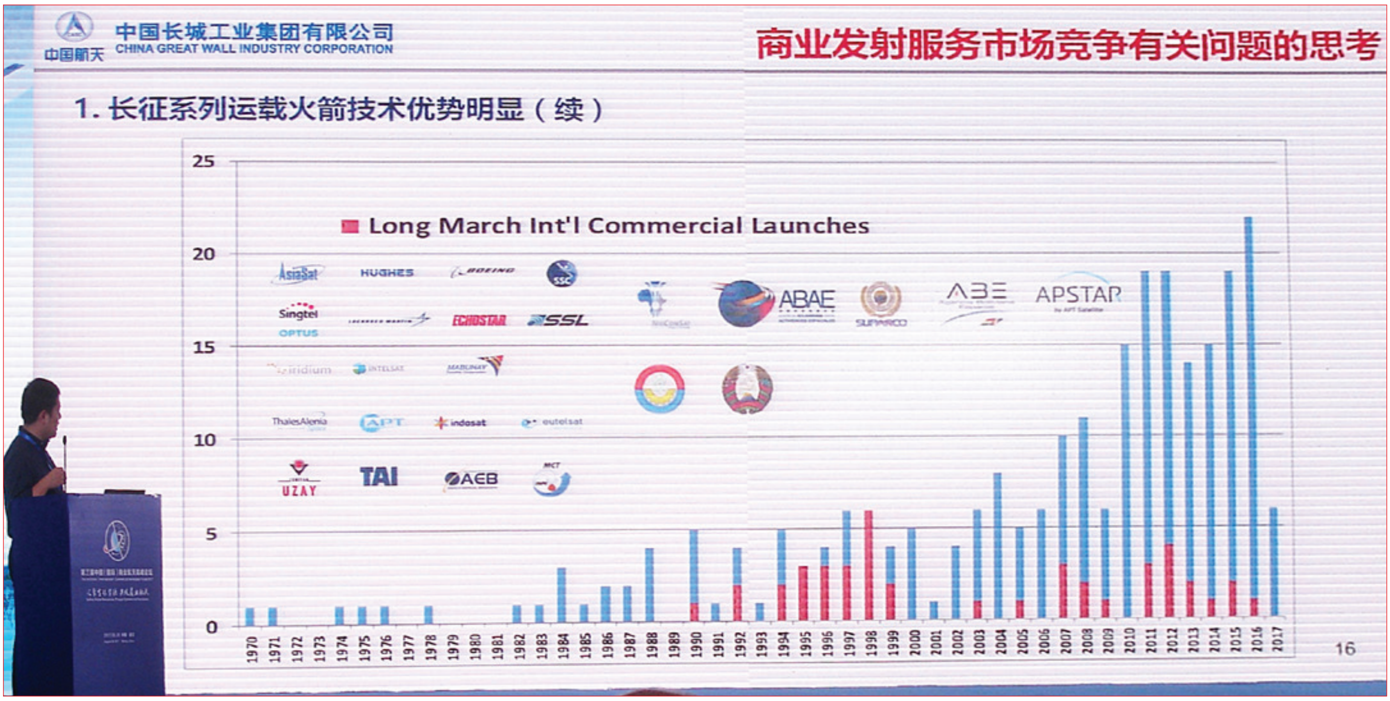
The capability for multiple launches on a single carrier has been first tested in September 1981, when China successfully launched and deployed three satellites. For a commercial customer this feat was used – although unsuccessful – nine years later, in the summer of 1990, when the Optus mass simulator and Pakistan's Badr 1 lifted-off on a CZ-2E. Until 2017, China has launched 11 foreign satellites as piggyback payloads and a multiple launch capacity was indispensable for the six double launches of the Iridium satellites in the 1990s. Also, the first commercial lunar payload, the 4M test radio beacon and the experimental payload PS86X1, rode piggyback with Chang'e 5-T1, mounted in the equipment bay of the third stage of the CZ-3C launcher.

Further improvements to the Yuanzheng upper stage allowed for extended operations time and re-start capability. On 26 April 2013, the Turkish Turksat 3USat, the Argentinian CubeBug-1 and the NEE-01 Pegaso from Ecuador shared the CZ-2D rocket with the Chinese Gaofen 1 remote sensing satellite. In June 2017, the Chinese flagship science mission HXMT Hard X-ray Modulation Telescope offered an additional travel opportunity for the Argentinian smallsat ÑuSat 3'Milanesat' and two domestic commercial satellites, the OVS-1A and OVS-1B by Zhuhai Orbita Control Engineering Ltd.

The other pathway to the commercial market is CGWIC's strategy to continue the delivery of package solutions for international customers and serve China's soft-power diplomacy. Mainly developing countries in South-America or Africa, such as Venezuela, Bolivia, Uruguay, Argentina, Nigeria are using China's lower cost offer of becoming the owner of a national satellite. Apart from Pakistan, more countries in China's nearer neighborhood, like Laos or Indonesia, Sri Lanka, Cambodia, Thailand are also making use of in-orbit-delivery packages. The December 2017 launch of Algeria's first communication satellite, Alcomsat 1, set a precedent for strengthening south-south cooperation but even more so for space cooperation between China and Arab countries, a market CGWIC is targeting in recent times. At the end of November 2017, Fu Zhiheng, Vice-President of China Great Wall Industry, said on the sidelines of the Symposium on International Space Cooperation Promoting Economic and Social Development of Developing Country in Beijing: "In addition to traditional clients, we pay great attention to finding new customers. For instance, we are striving to tap the space market in the Middle East that is dominated by the United States and European firms. What I can tell you now is that we have made substantial progress in this region."

The importance that China attached to the Alcomsat 1 launch can also been seen in the fact that Chinese President Xi Jinping and Algeria's President Abdelaziz Bouteflika exchanged congratulatory messages to each other over the phone after the successful launch.

It can also happen that the commercial aspect is secondary, since CGWIC clearly has the governmental mandate for promoting international cooperation and creating win-win-situations. In this regard, the China-Brazil Earth Resource Satellite (CBERS) with the sixth satellite expected to take-off in 2019 is one of the most successful and longest lasting projects which included even technological cooperation. But also, when



Si Yuan, General Manager of the Americas for the China Great Wall Industry Corporation showed at the 3rd China (International) Commercial Aerospace Forum 2017 in Wuhan a balance of the commercial launches by Long March. The diagramme clearly indicates the fluctuation in the number of launches. He concluded that China has a matured technology already in place. However, launch services alone is becoming less and less attractive. The current main business focus is the delivery of turn-key satellites to customers. credit: CGWI/GoTaikonauts!

China builds ground stations in the respective countries, this operations infrastructure also serves China's space operations.

A very new idea which has been heard recently, is China's intention to use launch sites outside China or built space ports in regions close to the Equator. Such a move would give China greater flexibility in using launch sites closer to the coast and avoiding the current problem of over-land drop-off zones for rocket stages, but would also give China a margin in avoiding U.S. export regulations. Also, in 2018 it even became clear, that the four big space ports are becoming more and more busy with China's ambitious science, manned and military missions. CGWIC stated, that it would like to have another launch site in China to serve the segment of small sat launches for national commercial customers.

On a final note, it should be mentioned that China is about to enter another dimension of commercial space activities, enabled by its launch capabilities and space technological advancements: With the successful commissioning of the Beidou Satellite Navigation System for users in the Asia Pacific and for users in countries along the Belt-and-Road and with a global coverage by 2020, China is also tapping into the commercial market of space applications – a wide area of unprecedented growth and perspectives.

The Belt and Road Spatial Information Corridor, which stretches along emerging and developing countries, as well as the cooperation within APSCO, BRICS, SCO, ASEAN and the UN will play a strategic role for China's commercial launch services as well as versatile space application services.

After going through hard transition phases and recovering from heavy failures, China has been able to reinvent its ambitions for commercial launch services again and again. It started as a simple launch service provider, enhanced its capabilities with multiple launch and piggyback opportunities, aimed at small-sat launches and comprehensive package solutions. Nowadays, even domestic demand apart from the military is emerging: more commercial customers from within China order satellites and need a launch service. And there are the commercial launch service provider start-ups which will take over certain segments of the launcher market.

Despite the diversification of launch providers which we will see in the years to come, the overall envelope of Chinese commercial launch activities, supported by new technological breakthroughs in low-cost launch vehicles, new upper stage and a re-usable space transportation system, can open up completely new avenues for space businesses.

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top: A banner with congratulations after the successful launch of VRSS-2.

left: The team of experts responsible for VRSS-2. Credit for both photos: Bolivarian Space Agency of Venezuela

Table 1: Chinese commercial launch history (short version)

date	satellite (bus)	date	satellite (bus)
1990, 7 April	AsiaSat 1 (HS-376)	2011, 19 December	NigComSat 1R (DFH-4)
1990, 16 July	Optus B mass simulator, Badr 1	2012, 9 January	Vesselsat 2
1992, 13 August	Optus B1 (HS-601)	2012, 31 March	APStar 7 (SB-4000)
1992, 6 October	Freja	2012, 29 September	VRSS 1 Miranda (CAST-2000)
1992, 21 December	Optus B2 (HS-601)	2012, 27 November	ChinaSat 12 (SB-4000)
1994, 21 July	Apstar 1 (HS-376) (later renamed: Chinasat 5E)	2012, 18 December	Göktürk 2
1994, 27 August	Optus B3 (HS-601)	2013, 26 April	TurkSat 3USat; NEE 01 Pegaso; CubeBug 1 El Capitán Beto
1995, 25 January	Apstar 2 (HS-601)	2013, 1 May	ChinaSat-11 (DFH-4)
1995, 28 November	AsiaSat 2 (LM-7000) (later renamed: AMOS 5i, AsiaSat 2)	2013, 9 December	*) CBERS 3
1995, 28 December	EchoStar 1 (LM-7000)	2013, 20 December	Túpac Katari 1 (DFH-4)
1996, 14 February	Intelsat 708 (SSL-1300)	2014, 19 August	BRITE-PL2 Heweliusz small sat.
1996, 3 July	Apstar 1A (later renamed: Chinasat 5D)	2014, 4 September	Ling Qiao
1996, 18 August	ChinaSat 7 (HS-376)	2014, 23 October	4M; PS86X1
1997, 19 August	Agila 2 (SSL-1300)	2014, 7 December	*) CBERS 04
1997, 1 September	Iridium simulator A & B	2015, 7 October	Jilin 1 (4 sat cluster)
1997, 16 October	APStar 2R (SSL-1300)	2015, 16 October	APStar 9 (DFH-4)
1997, 8 December	Iridium 42 & 44	2015, 20 November	LaoSat 1 (DFH-3B)
1998, 25 March	Iridium 51 & 61	2016, 15 January	Belintersat 1 (DFH-4)
1998, 2 May	Iridium 69 & 71	2016, 30 May	ÑuSat 1 & 2 'Fresco & Batata'
1998, 30 May	ChinaStar 1 (LM-2100) (later renamed: Chinasat 5A, APStar 9A)	2016, 6 August	Tiantong 1
1998, 18 July	SinoSat 1 (SB-3000) (later renamed: ChinaSat 5B) → PSN 5)	2016, 15 August	3Cat-2 Cubesat
1998, 19 August	Iridium 76 (Iridium 3) & 78	2016, 9 November	XiaoXiang 1; LiShui 1
1998, 19 December	Iridium 11A & 20A	2016, 28 December	Gaojing 1-01 & -02 (CAST-3000)
1999, 11 June	Iridium 92 & 93 (14A & 21A)	2017, 9 January	Jilin 1-03; Xingyun Shiyan 1; Caton 1
1999, 14 October	*) CBERS 1 and smallsat	2017, 2 March	Tiankun 1
2003, 21 October	CBERS 2	2017, 12 April	Shijian 13/ChinaSat 16
2005, 12 April	APStar 6 (SB-4000C2)	2017, 15 June	ÑuSat 3'Milanesat'; OVS-1A; OVS-1B
2006, 28 October	SinoSat 2 (DFH-4)	2017, 18 June	ChinaSat 9A (DFH-4)
2007, 13 May	NigComSat 1 (DFH-4)	2017, 9 October	VRSS 2 'Antonio José de Sucre' (CAST-2000)
2007, 31 May	SinoSat 3 (DFH-3) (later renamed: ChinaSat 5C, Eutelsat 3A, Eutelsat 8 West D)	2017, 14 November	HEAD 1
2007, 5 July	ChinaSat 6B (SB-4000)	2017, 21 November	Jilin 1-04, -05, -06
2007, 19 September	*) CBERS 02B	2017, 10 December	Alcomsat 1 (DFH-4)
2008 - cancelled	Apstar 6B (DFH-4)	2018, 9 January	Gaojing 1-03 & -04 (CAST-3000)
2008, 9 June	ChinaSat 9 (SB-4000)	2018, 19 January	Jilin 1-07 & -08; Hunan-Tianyi 2; Quan Tu Tong 1-Tianyi 6; KIPP
2008, 29 October	VeneSat 1 Simon Bolivar (DFH-4)	2018, 2 February	ÑuSat 4 & 5 'Ada & Maryam'; GOMX 4A & 4B; FengMaNiu 1; Juvenile-1 (piggy back on CSES)
2009, 31 August	Palapa D (SB-4000B3)	2018, 4 May	APStar 6C (DFH-4)
2010, 4 September	Chinasat 6A (DFH-4) (SinoSat 6)	2018, 20 May	LongJiang-1/2 / Lunar Camera Payload (piggy back on Queqiao)
2011, 20 June	ChinaSat 10 (DFH-4) (SinoSat 5)	2018, 2 June	Luojia 1-01 (piggy back on Gaofen 6)
2011, 10 August	Paksat 1R (DFH-4)	2018, 9 July	PRSS 1 (CAST 2000) (PakTES-1A)
2011, 7 October	Eutelsat W3C (SB-4000)		

*) Note: CBERS is a government funded programme and not a fully commercial programme. CBERS launch arrangements were also different from "standard" commercial practice. Therefore, one can debate whether the CBERS programme can be considered a commercial activity. For the sake of completeness, we are keeping it in our list.

Table 2: Chinese commercial launch manifest (short version)

date	satellite (bus)	date	satellite (bus)
Mid-2018	Jilin-1 09-12	2019	NicaSat 1 (DFH-4)
Mid-2018	Jilin-1 Optical-B; Xiangrikui 1A; Xiangrikui 1B; Ouke-Micro 1; TY 4; Zhongwei 1	2019	Hongyan satellite constellation (DFH-4)
Mid-2018	SupremeSAT 2 (DFH-4)	2020	Recoverable satellite
2018, September	CFOSat	20??	Palapa-N1 (DFH-4)
2019	CBERS-4A	20??	PNS-7
2019	Chinasat 18	2021	TECHO 1
2019	APStar 6D (DFH-4E)		

For the extended version of both tables (including launcher and owner/operator) please, go to our website and download the PDF. Data as of 18 August 2018

Commercial Space Takes Off in China (Part 2)

by Chen Lan

Chinese commercial space activities have a long history dating from the late 1980s, but there has been no private space sector at all until recent years. In the first part of this article, the latest changes, especially SpaceX's impact and the emergence of private space start-up companies, have been reported. Twelve Chinese commercial space companies in the fields of launch vehicle and remote sensing satellites were reviewed in Part 1 of this article. Part 2 continues the review for companies involved in the development of communication satellites and satellite busses, as well as miscellaneous space businesses. It also discusses problems and difficulties, and also the potential of the emerging Chinese commercial space industry.

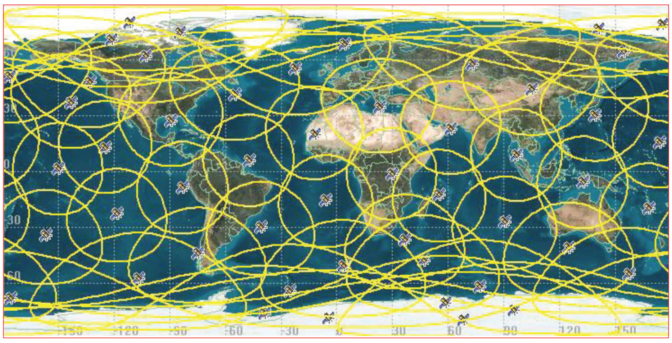
Major Players (continued)

*(Please note that those with * are state-owned companies, or mixed ownership companies whose major shares are state-owned).*

Communication Satellite

CASC/CASIC LEO Comsat Projects*

Both state-owned industrial giants have planned their own commercial LEO comsat constellations. CASC's plan is to launch a 60 satellite-constellation named "Hongyan" (Swan Goose) that supports data collection and exchange, AIS and ADB-S with a future extension to 270 satellites to support broadband and voice communication. While CASIC intends to provide narrowband and broadband services via two constellations. The "Xingyun" (Flying Cloud) is an 80 satellite-constellation to support space-based IoT (Internet of Things). And the "Hongyun" (Rainbow Cloud) constellation will consist of 156 satellites to form a global broadband network. Currently CASIC is leading the race. It has already launched the Xingyun Test 1 and the Tiankun 1 demonstration satellites (for "Xingyun" and "Hongyun" respectively) in January 2018 and March 2017. It has also established two companies, Aerospace Xingyun and CASIC Space Engineering, with investment from the Hubei Province to run the two constellations commercially. CASC plans to launch the Hongyan demonstrator in late 2018. It has not yet formed any commercial entity to run the project but it is unavoidable.



Coverage of the CASC Hongyan constellation. Credit: CASC/China internet

HEAD Aerospace

HEAD Aerospace, founded by Zhou Dachuang, is one of the earliest private space companies in China that started with traditional trading in 2007 relying on Zhou's broad connections within the international space community. It has some subsidiaries in Europe and successfully launched a few Sino-European joint projects, e.g., the China-Italy Joint Laboratory on Electric Propulsion. It has planned the 24 satellite "Skywalker AIS"-constellation that also carries SAR and hyper-spectral imaging payloads. On 15 November 2017, the 45 kg HEAD-1 commercial AIS demonstrator was successfully launched into an 808 km-orbit. There is no report on external funding of the company.

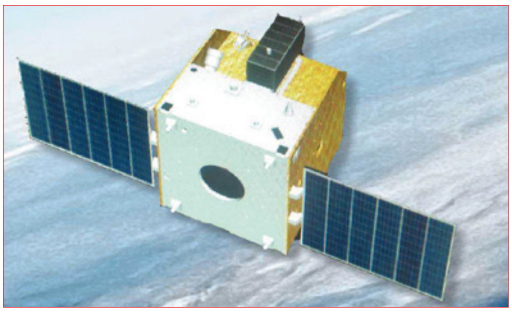
A model of the HEAD-1 satellite. Credit: HEAD/China Internet

CommSat

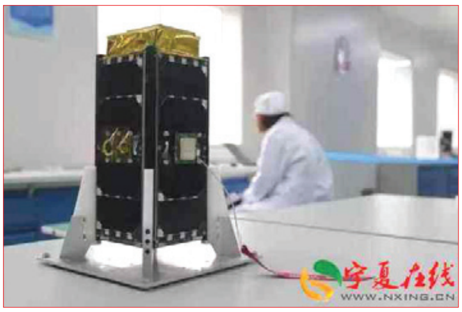
CommSat is a company with focus on "space IoT" and space education. It plans to establish a space IoT constellation with more than 60 micro-satellites in the 50 kg-class. Its first batch of satellites is scheduled for launch in late 2018 to initiate a trial service. While its first educational satellite TeenSat 1 was already launched on 3 February 2018 and many schools in China have received its signal and used (or will use) it for experiments. CommSat will launch more commercial educational satellites as well as entertainment satellites in the future. For example, it has designed a so-called "selfie satellite" for commercial service. CommSat is one of the companies favoured by the capital market. It has obtained three rounds of funding before 2018. In February 2018, it received a 100 million RMB investment led by Ameba Capital and Junzi Capital. On the other hand, reports indicate that CommSat has already realised revenue of several dozen million RMB.

SpaceOK*

SpaceOK is a so-called "mixed ownership" company. It was founded by a subsidiary of CAS (China Academy of Sciences) and Orbita, a Zhuhai-based private company (see Part 1 of this article in GT! issue no. 21). Its core team was from state

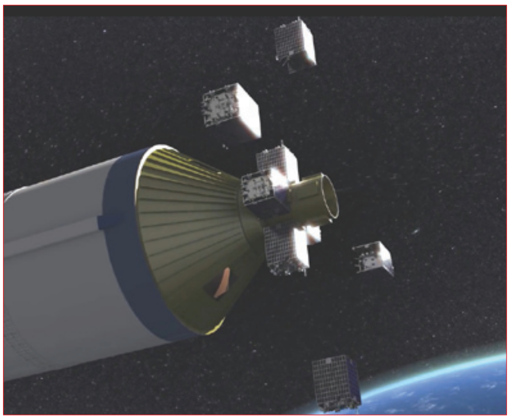


CASIC's Tiankun 1 satellite. Credit: CASIC/China internet



Test of CASIC's Xingyun 1 satellite. Credit: CASIC/internet

CommSat's YouthSat. Credit: CommSat/internet



Deployment of the SpaceOK satellite. credit: SpaceOK/internet

Caton 1 satellite. Credit: Caton/China internet

A portrait of
“China’s Unlucky Tycoon: The ‘Canal Madman’ Keeps finding Trouble“
by Blake Schmidt and Pei Yi Mak
https://www.bloomberg.com/news/articles/2017-11-27/china-s-unlucky-tycoon-the-canal-madman-keeps-finding-trouble

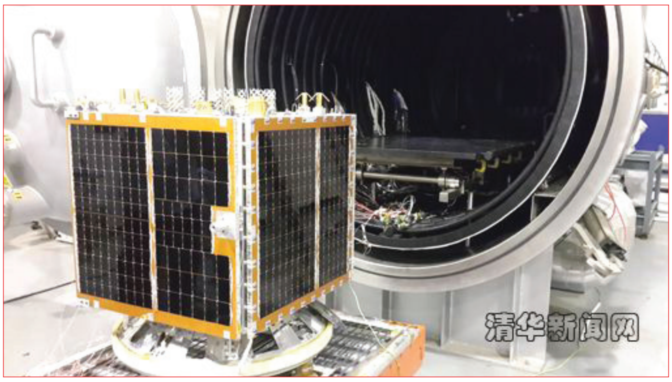
space organisations including Shanghai Engineering Centre for Microsatellites, CAS. It plans to launch a 64 satellite M2M (machine-to-machine)-constellation by 2022. It has already completed its first satellite Jiading 1 (Jiading is the name of the district in Shanghai where the company is located) based on its Q-SAT satellite bus. The launch is expected in late 2018 by a CASIC Kuaizhou 11. In October 2016, Orbita left the company with its share transferred to an individual investor.

Caton

Caton Global Technology is an established company with a focus on maritime products and services. VDES (VHF Data Exchange System, a new generation system to replace AIS) satellites are a new area for the company. On 9 January 2017, the Caton 1 experimental VDES satellite was launched into space by a KZ-1A launcher. It was claimed as the world’s first VDES satellite. Caton 1 was co-developed by CommSat (see above). There are no reports about its follow-on plan on satellites and commercial service. There was investment from a stock exchange-listed company but it may not be related to the satellite project.

Xinwei

Xinwei is a stock exchange-listed telecommunication company since the mid-1990s. It developed the SCDMA and McWill technology that once had a certain success in the Chinese market. In 2010, businessman Wang Jing controlled the company and started a series of bold moves including the plan to launch a 32 satellite-LEO comsat constellation using McWill technology. On 4 September 2014, the 130 kg-Smart Communication Experimental Satellite, jointly developed by Xinwei and Tsinghua University, was launched into an 800 km-SSO. It was claimed as China’s first LEO comsat. Tests showed that the satellite was successful but there have been no reports about the satellite and Xinwei’s plans since then. Wang is famous for his plan to build the Nicaragua canal where he earned his nickname “Canal Madman”. His other two projects related to space are the Nicaragua 1 comsat and the SpaceCom purchase. The latter was canceled because of the Falcon 9 / SpaceCom AMOS-6 explosion in September 2016. In recent years, Xinwei was in trouble due to the scandal in the stock market. Its space programmes are very likely in trouble also.



The Xinwei SCES satellite in front of the vacuum test chamber. Credit: Xinwei/internet

ChinaSat*

ChinaSat is China’s state-owned comsat operator and is the earliest commercial space company in China. It has merged two much smaller comsat operators (Sinosat and ChinaStar), controlled the Hong Kong-based Apstar, and finally manifested its monopoly position in the Chinese market. ChinaSat once belonged to China Telecom and then became an independent company. In a re-organisation in 2009, its space segment was moved under CASC and the ground segment under China Telecom. ChinaSat owns a series of DFH-based comsats and a few foreign made satellites. It has submitted its application to be listed at the stock market in Shanghai or Shenzhen.

StarTime*

Beijing StarTime Telecommunications Technology (BST) is a product of Military-Civil Integration. It is a mixed ownership company founded by China Great Wall Industry Corporation (a CASC company marketing Chinese launchers and satellites), China Mobile and private investors. It plans to launch the Startime 1 and 2 HTS (High-Throughput Satellite) satellites. The Startime 1 satellite is a 70 Gbps-HTS satellite based on the DFH-4E bus, and is to be launched in 2019. Media reports indicate that the satellite will be ordered by Thaicom (Thailand) and its full capacity will be leased to StarTime. This is probably an arrangement due to the shortage of orbital slots. Startime 2 is also reportedly a joint project with Measat of Malaysia running in a similar model.

Platforms & Miscellaneous

SpaceSat / Aerospace DFH*

SpaceSat is a spinoff of CAST (5th Academy of CASC) focused on small satellite development, and has been a stock exchange-listed company since 2002. It also established a joint venture with HIT (Harbin Institute of Technology) and Shenzhen Academy of Aerospace Technology (backed by the Shenzhen Government, HIT and CASC) - Aerospace Dongfanghong Development Ltd., Shenzhen. SpaceSat was intended to be a commercial space company but in its early days, almost all of its orders were still from the national, governmental plans. In recent years, China’s small satellite market took shape and SpaceSat became the largest and most competitive player in this sector. It also exported its satellites to overseas customers, for example, the VRSS-1 imaging satellite was built for Venezuela.

far left: Spacety satellite. Credit: Spacety/China internet

left: The Spacety team is a group of very young space experts. Credit: Spacety/China internet

Its product line includes the CAST100, CAST968 (CAST1000) and CAST2000 smallsat buses that meet the requirements of Earth observation, communication and space science missions.

Spacety

Spacety was founded by two space professionals who had been involved in many national space projects. Spacety provides low-cost, short development cycle, small satellite platforms to users for scientific research and engineering test purposes. It has developed and launched four satellites since November 2016 (up to April 2018). The satellites are all 6U cubesats. It is reported that Spacety's satellite bus and components are from ISIS (Innovative Solutions In Space) in the Netherlands. In April 2017, it secured the A-series funding of nearly 100 million RMB from multiple investors.

MinoSpace

MinoSpace was founded in 2017 by Wu Shufan, one of the LandSpace founders, former ESA engineer and former CTO of SECM (Shanghai Engineering Centre for Micro-satellites, CAS). Its products include satellite platforms (buses) and satellite components, as well as small satellites and satellite communication solutions. It is expected that MinoSpace's first satellite launch takes place in late 2018, followed by four more launches. At the end of 2017, MinoSpace received a "10 million RMB-class" investment from multiple investors.

Kuang-Chi Science

Kuang-Chi was founded in 2006 by Liu Ruopeng and four other partners. It started with a WiFi antenna but then extended its business into various areas including aerospace. It acquired Martin Aircraft of New Zealand (famous for Martin Jetpack) in 2014 and a controlling interest in SolarShip of Canada (transportation airship) in 2015. It kicked off the "near-space tourism" project in February 2015. It plans to use high altitude helium balloons to carry six people to about 20-24 km above the ground (Kuang-Chi defines 20-100 km altitude as "near-space"). Its first test balloon, Traveller 1, flew on 6 June 2015 in New Zealand and reached an altitude of 21 km. On 25 October 2017, the Traveller 3 reached again 21 km in Xinjiang, carrying a living tortoise to "near-space" which was recovered after landing. In March 2018 Kuang-Chi and the U.S. company NanoRacks agreed to use the balloon for worldwide customers. Kuang-Chi Science is a Hong Kong-listed company.

Aerospace Maker

Aerospace Maker is a space education startup company. Its founder, Geng Saimeng has a rich experience in education and also space technology. Before Aerospace Maker, he founded a STEM (Science, Technology, Engineering and Mathematics) education company in the area of robotics. But the crowded market forced him to switch to space. So far, the company has developed a full spectrum of courses and teaching aids, suitable for students from primary school to high school, on satellite design, telemetry, remote sensing and sounding rocket design, as well as lunar exploration. The company supported China's first "middle school student satellite" Bayi Shaonianxing, launched on 28 December 2016. There is limited information revealed about its funding but it reportedly has already a positive cash flow.

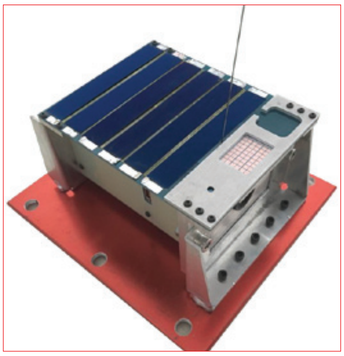
KCSA

KCSA (Ke Chuang Space Agency) is, strictly speaking, not a commercial space company. Instead, it is a non-profit internet community focusing on space technologies. It started with a space board in a BBS web site in 2003. In 2011, the "Agency" was established and it started to manage amateur rocket development. Unfortunately, all rocket launches were not so successful (including those launched by the team led by Hu Zhengyu, later LinkSpace founder). Since 2014, it started the

far left: The helium balloon spacecraft "Traveller" of Kuang-Chi Science.

left: The "Traveller" cabine. Credit for both photos: Kuang-Chi Science/China internet

The KCSA team. Credit: KSCA/China internet



KS-1Q. Credit: KSCA/China internet

Hands-on activity with Aerospace Maker.
Credit: Aerospace Maker/China internet

One of the education classes of Aerospace Maker. Credit: Aerospace Maker/China internet

"open source" micro-satellite project. On 10 November 2016, the KS-1Q, a 2U cubesat developed by KCSA that is sometimes claimed to be an educational satellite, was successfully launched by a CZ-11. It was so far the most important achievement by KCSA. Donation is the only way it is funded. Although KCSA is not a commercial space company, it inspired many people and is more or less influential in Chinese commercial space circle.

Growing Pains

The commercial space idea has never played a significant role in the Chinese space industry. But the development in recent years was really impressive. No one had expected that so many private start-up companies would shoot out of the ground like mushrooms - almost overnight. However, it has also shown its negative side. Dreams usually come with crucial reality. Passion is often mixed with opportunism. Hot money always lacks rationale.

Although commercial space has been in sight in China for only a few years, the market has already shown signs of overheating. In the field of LEO small satellite constellation, there have been nearly 20 LEO satellite constellations (more than 1,000 satellites) proposed by more than a dozen companies, among which about 10 constellations are for narrowband communication (data collection and exchange, AIS/VDES/ADS-B, IoT, M2M etc.). Is there a real demand? Of course not. There are bubbles. It is believed that the actual demand for small satellites will be several times smaller than the above numbers suggest and most start-up satellite companies will disappear in a few years. It is normal, and similar to what has been seen in the internet industry. There are at least 7 launch vehicle companies competing for the small satellite launch market. They will also suffer from the smallsat bubble. In contrast, companies in niche markets, for example, Spacety, who only target research satellites, will have more chances to survive. In three to five years, we will see the result.

It seems that the government is also not so well prepared for the new development. There are a lot of new policies, for example Military-Civil Integration, PPP and Mixed Ownership Reform. But they all have separate targets and scopes. There is not a specific policy for commercial space existing. Old policies still lag behind new realities. The failed contract between LandSpace and CASC was a typical example. There is also no government purchase schema on the table, like NASA did on ISS cargo and crew transportation. This is a special problem that does not exist in the U.S. or within the European space industry. China has two established state-owned space giants (CASC and CASIC). When they go commercial – as they are doing right now – they are able to get much more resources than real private companies can get, including funding from state-owned banks and investment companies, as well as local governments. There are still no policies to balance those state-owned monopolists and the much smaller private start-ups. In addition, space law is also a vacancy in China. A legal guarantee would avoid problems like that one Landspace met. In fact, there are many things the government needs to do. The faster the government responds to the market, the better it will be for the future of the Chinese commercial space industry. It remains to be seen.

For small start-up companies, the most common problems are the shortage of technology, and qualified people. There are still many restrictions that prevent technology and people transferred from state-owned companies and national organisations to the private sector, though it is improving over time. These companies themselves have also problems. Some companies overstated their capability and are keen on media publicity which is suspected as a tactic for funding - and their final objective is to get money instead of their space projects. LinkSpace and Dragon Drive are examples and it cannot be ruled out that there are more companies, especially smallsat companies, having such motivations.

Investment companies actually are accustomed to such a situation but they still pour financial support into this market. It has to be admitted that there is also a lot of opportunism in their motivation. Of course, the projected huge potential of the market is the main reason for them to come in. The problem is, investors are unfamiliar with space - they are mostly good at internet and traditional industry investment. As a result, blind investment has become quite popular in the commercial space arena. Investment companies need to take certain responsibility for the bubbles.

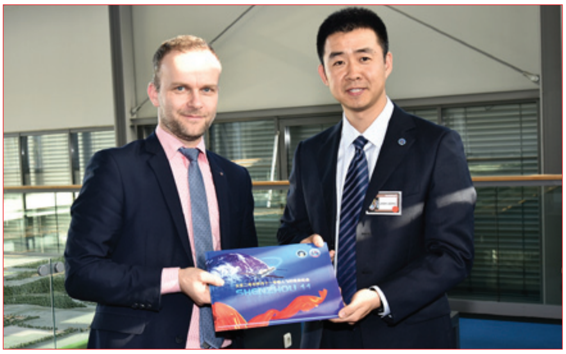
Although so many problems come with the fast growth of the new industry, they are all "growing pains". The foundation built by the Chinese space programme in the last half century, the huge domestic market and inherent future demand, and the largest talent pool in the world predict that the Chinese commercial space arena will have a bright future in the long term, just like the Chinese internet has proven before. Great Chinese space companies like a Chinese SpaceX, or a space Alibaba may be just around the corner.

To Mons Rümker and back with Chang'e 5 - Visit by taikonaut Chen Dong to Neubrandenburg Space Day 2017

by Jacqueline Myrrhe

In the countryside of the Mecklenburg region in the North-East of Germany there is a tiny town. It is named Burg Stargard, after its medieval fortress "Stargard" whose main tower is overlooking the hilly terrain dominated by fields, forests and grasslands. And there is the local ice cream shop, which is well-known among ice cream lovers. But this is as far as it goes with notability. Last year the local authorities added another tourist attraction which could evolve into something bigger than ice cream and castle fame.

On 17 November, Tilo Lorenz, the Mayor of the town of Burg Stargard together with taikonaut Chen Dong, revealed an information display to commemorate Carl Rümker (also: Christian Karl Ludwig Rümker or: Charles Rümker). As it turned out in June 2017, China, the Moon, Rümker and Burg Stargard are about to join together in a close relationship. But why? In the Europe of the 19th century, several persons contributed to the domain of practical astronomy without having studied that science. By that time, patience in the observation of the night skies and precision in recording observational data where crucial skills to make significant contributions to astronomy. This is what Carl Rümker was also good at. He lived an adventurous and restless life too and this started early. A few years after Carl's birth on 18 May 1788 in Burg Stargard, the Rümker family moved to the nearby, bigger town of Neubrandenburg where Carl Rümker's father was appointed as the court administrator. But Carl did not stay long in Neubrandenburg either. He left for Berlin to acquire a higher education and to study architecture at the academy. Soon, he went on, taking up different, challenging professional occupations in several towns in Europe and Australia. He joined the English merchant navy, the Royal Navy, became Director of the School of Navigation in Hamburg, and later astronomer in Australia, then went back to Hamburg to take over the Hamburg Observatory, and finally settled in Lisbon Portugal, his final stop before he died in 1862. Carl Rümker contributed with star observations and star catalogues to the astronomical research of his time. He was a member of some renowned scientific academies, among which the Royal Astronomical Society London (RAS) is the most important. The RAS awarded him its gold medal. In 1935, the International Astronomical Union, named a volcanic crater area on the Moon after Carl Rümker - "Mons Rümker".



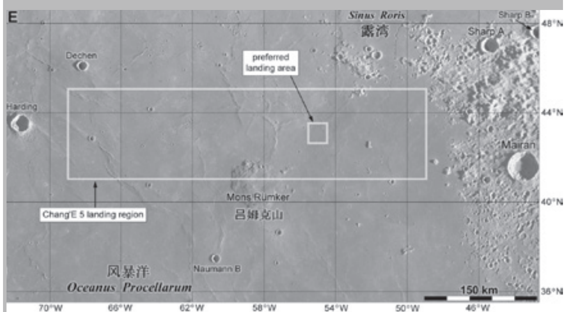
Chen Dong (right) and the Mayor of Neubrandenburg. Credit: G. Rosenfeld

The Head Mayor of Neubrandenburg, Silvio Witt, explains the town model to Chen Dong. Credit: Gerhard Rosenfeld

Mons Rümker

Mons Rümker is an extended irregular volcanic terrain of approximately 70 km diameter in the North-western part of the Moon's near side, stretching between 41-45°N and 49-69°W. Its 22 volcanic domes tower up to 1,300 m above the mare surroundings of the Oceanus Procellarum – the largest lunar plane. The robotic mission Surveyor 1 and 3 as well as Luna 9 and 13 touched down in Oceanus Procellarum, as did the manned Apollo-12 mission – but all those landing sites were closer to the lunar Equator.

Scientists assume that the basalt material in the Eastern Rümker region may represent different stages of early, lunar volcanic activity, including very young magma, around 2 billion years old. This would be in contrast to the samples, brought back by the Apollo mission, which originates from geologic similar regions of similar older age. To close the knowledge gap on the formation of Earth's neighbour, lunar samples from the Mons Rümker region could contribute to new insights into the early lunar vulcanism and the determination of the Moon's age. Scientists around the world are eagerly waiting for this opportunity.



On 6 June 2017, during the Global Space Exploration Conference, GLEX 2017, Liu Jizhong from the Chinese Lunar Exploration Programme, CLEP, announced that the landing site for its lunar sample return mission, Chang'e 5, would be the region of Mons Rümker. Originally planned for launch on 30 November 2017, Chang'e 5's flight would have coincided with the yearly Space Day event in the town of Neubrandenburg, the home town of Carl Rümker's parents and Rümkers childhood home, and just 10 km away from Rümker's birthplace Burg Stargard.

This fact was the inspiration to invite a taikonaut to join the Neubrandenburg Space Days, an international space conference which attracts an audience of space enthusiasts from all over Europe, representatives from space industry, space science institutes, students, and the interested general public. The objective of the conference is to showcase the peaceful characteristics of space flight activities. The organisers strongly believe that the future of mankind is connected to international cooperation and harmonious development. In particular the younger generation needs visions and inspiration. Space is the best tool for that. So far, 46 cosmonauts and astronauts from 15 different countries have visited Neubrandenburg.

In close cooperation with the Chinese Embassy in Berlin, CNSA and the Astronaut Centre of China (ACC) the organisers of the Neubrandenburg Space Day event welcomed, from 17 to 19 November 2017, taikonaut Chen Dong for a visit to Burg Stargard, Neubrandenburg and the DLR establishment in Neustrelitz. He became Neubrandenburg's 47th visiting space traveller.

At the conference, Chen Dong spoke about his first mission

During the conference. Gan Yong of CNSA is on the microphone (far left) and to the very right is Li Xiaohe, the personal translator of Chen Dong. Credit: Gerhard Rosenfeld

to space, the 33-day flight together with his commander Jing Haipeng on board of Shenzhou 11 to Tiangong 2 that took place from mid-October to mid-November 2016. He was responsible for 38 experiments, exercising a multitude of skills either as engineer, farmer, pilot, doctor or handyman, depending on the experiment requirements. In his talk, he stressed the importance of the Cardiospace experiment, a cooperation between China and France. Cardiospace was launched mid-September on board of Tiangong 2. It is a Doppler laser and ultrasound scanner that measures micro-circulation and macro-circulation, to see how the taikonauts' cardiovascular system adapts to microgravity conditions and the degree of deconditioning upon their return to Earth.

Chen Dong was also very attached to the educational experiment by students of the Christian and Missionary Alliance Sun Kei Secondary School in Tseung Kwan O in Hong Kong. They had proposed to breed silkworms in space. The longer-term stay during Shenzhou 11 allowed observation of the life circle of six silkworms under microgravity conditions. Chen Dong told the audience in Neubrandenburg that the worms produced stronger silk in space compared to the silk worms in the ground experiment. One year later, in October 2017, Jing Haipeng and Chen Dong handed over worms from the second generation of the space silkworms to the students in Hong Kong. The students will continue to study the worms to see if the favourable variation will be inherited.

Gan Yong, Deputy Head of the International Cooperation Division of CNSA, also accompanied taikonaut Chen Dong to Germany. He gave a comprehensive overview on all parts of China's

Giving signatures is one of the hardest but very important task of any astronaut. Credit: Gerhard Rosenfeld

Chang'e 5

Historically, China has a rich heritage of lunar fairy tales and legends. However, it has no tradition as a strong player in modern space science or even lunar science. Taking this into consideration, the last two decades have seen China leapfroging in this respect, and the global community of lunar scientists might welcome this dedicated and determined move.

The Chang'e 5 Moon mission is a significant milestone and of high importance for the further course of China's Lunar Exploration Programme (CLEP) and the future alignment of the Chinese manned space programme.

Chang'e 5 is designed for launch with the heavy-lift carrier rocket CZ-5 from Wenchang Space Launch Centre in Hainan province. Initially planned for 30 November 2017, the launch needed to be postponed until 2019 because of problems with the CZ-5 maiden launch in July 2017. The mission's objective is to bring 2 kg of lunar soil and rock samples back to Earth. It will be the first lunar sample return mission since Luna 24 in 1976, which brought back material from Mare Crisium. The complete Chang'e 5 mission is planned to take one month, becoming China's most sophisticated lunar expedition with demanding flight manoeuvres and challenging conditions on the landing site in the region of Mons Rümker.

Europe's mission control centre, ESOC in Darmstadt, Germany, is prepared to provide operations support for Chang'e 5. In particular the launch and early operations phase (LEOP) will make use of ESA's antennas in Kourou (French-Guyana) and in Maspalomas (Canary Islands).

Chinese experts will be present at ESOC and the Chinese Deep-Space network is on stand-by as a back-up option for the LEOP phase before China takes over the majority of the mission operations.

The 8.2 t lunar probe is composed of 4 units: orbiter/service module, lander, ascent unit and return/re-entry module. After Chang'e 5 reaches lunar orbit, the 4 components will separate into two sections, with the orbiter and re-entry module staying in lunar orbit while the lander and ascender, aided by small retro-rockets, soft-land on the Moon's surface, at Mons Rümker. On the Moon, a driller is programmed to automatically collect sub-surface samples and a mechanical arm will be deployed to scoop the surface regolith material. The samples will be stored in the ascent unit.

After two days, the ascender is scheduled to launch back into lunar orbit to rendezvous and dock with the combination service module/re-entry module. This flight manoeuvre would be the first automated rendezvous around a celestial body other than the Earth and would be a test-case for a future Mars sample return mission as well as human lunar expeditions to the Moon.

In lunar orbit, the collected samples will be transferred for transport to Earth to the Earth return-module. The return vehicle will then separate from the orbiter/service module unit and re-enter Earth's atmosphere applying the 'skip re-entry' manoeuvre, already practised during the Chang'e 5-T1 flight.

Like China's Shenzhou crewed spacecraft, Chang'e 5 is expected to land in Siziwang Banner, in the Inner Mongolia Autonomous Region. From the landing site, the lunar samples will be brought to the research and storage facilities of the National Astronomical Observatories in Beijing.

The samples are intended for research and investigation in China and the world-wide science community.

A successful Chang'e 5 mission would conclude the 3rd phase of CLEP and pave the way for China's future manned Moon exploration. The cost for the Chang'e-5 lunar sample return mission is estimated at 20 billion RMB (3 billion U.S. $).

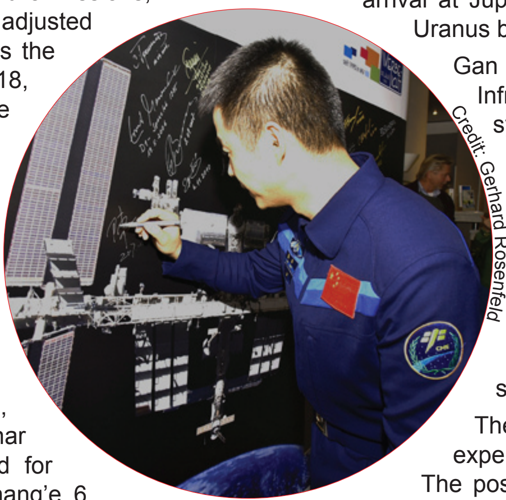
The 4th phase of CLEP will start with the launch of the Chang'e 4 probe in 2018, aiming at the world's first soft-landing on the far side of the Moon. China also plans to explore the lunar pole in the near future, signalling the start of the extended phase of CLEP around 2020.


The highest-ranking member of the historical folk dance group is presenting a souvenir to taikonaut Chen Dong. Credit: Dr. Lew Tolstong-Riedel


Chen Dong (to the left of the information stand) and the Mayor of Burg Stargard, Tilo Lorenz. (to the right of the display). Credit: GoTaikonauts!


Chen Dong next to the memorial display for Carl Rümker in Burg Stargard. Credit: Dr. Lew Tolstong-Riedel

national space programmes. Bearing in mind the connection between China's Moon programme and the home region of Carl Rümker, his presentation included many details about China's Lunar Exploration Programme (CLEP). Gan Yong presented the results of the Chang'e 1, 2, and 3 missions and gave a preview on the Chang'e 4 and 5 missions, and even beyond. He confirmed that the adjusted plan for the launch of Chang'e 4 includes the lift-off of the relay satellite in May 2018, and of the actual Chang'e 4 lunar far-side mission in December 2018. The landing site is situated at 45.5ºS, 178ºE in the Von Kármán Crater, within the South Pole's Aitken Basin. One year later, in 2019, the launch of the lunar sample return mission, Chang'e 5, is planned for touchdown in the region of Mons Rümker.


Credit: Gerhard Rosenfeld

The CNSA expert also spoke about the lunar South Pole exploration mission, projected for 2023, and the follow-up lunar South Pole exploration mission, planned for 2027. Gan Yong also mentioned the Chang'e 6 mission, on the CLEP schedule for 2024 encompassing the second lunar sample return mission.

Also of interest, details for China's first Mars mission, to be launched mid-2020. The mission profile includes an orbiter, which should stay operational for at least 1 Martian year and a rover on the planet's surface, roving around for 90 Martian days. The second step of China's Mars exploration roadmap includes the 3-year Mars Sample Return mission by around 2028. Another ambitious exploration mission will be the asteroid mission, scheduled for mid-2024. It will be designed to explore 2-3 asteroids in one mission and will fly-by, touch down or even bring back an asteroid sample.

The Chinese science exploration roadmap also contains a combined deep-space mission to be launched in 2030, with arrival at Jupiter by 2036, at Saturn in 2045 and at Uranus by 2048.

Gan Yong also mentioned the Civil Space Infrastructure, consisting of different systems. The High-Resolution Earth Observation System is one part of it. For that, GaoFen-5, GF-6, GF-7 satellites will be launched before 2020. For the ocean remote sensing part of the Civil Space Infrastructure, satellites HaiYang-1C/D and HY-2 B/C are approved, and will be launched in 2020. Furthermore, 10 land observation satellites are approved.

The visit of the Chinese delegation of space experts has been an interesting experience. The postponement of the launch of Chang'e 5 has added an unfortunate note to the event but the citizen of Burg Stargard and Neubrandenburg look forward very much to next year, when Chang'e 5 is heading to the Moon and back. During the festive ceremony of the revealing of the Carl Rümker memorial display, the Mayor of Burg Stargard shared his dream with his Chinese guests when he said that he would be thrilled to get hold of a few grains of lunar soil from the Mons Rümker region for the local museum. He would not mind to come to China to pick up the mini-lunar sample in person, but also: Chen Dong would be most welcome to visit again.

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Go Taikonauts! team
Dr. William Carey - Dave Chen Qing - Chen Lan - Jacqueline Myrrhe
V.i.S.d.P.: Uwe Schmaling

Contact: info@go-taikonauts.com
Web site: www.go-taikonauts.com

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The Indian Space Programme - India's Incredible Journey From the Third World Towards the First

by Jacqueline Myrrhe

Does it make sense to offer to readers, interested in the Chinese space programme, a review of a book on the history, past and future of India's efforts in space? Why could such a publication be of relevance for understanding China's space ambitions? These are legitimate questions, in particular since there is no governmental agreement between the two Asian giants India and China in place for cooperation in space - not yet.

In any case, one cannot overlook that both countries have shown a similar approach in the early phase of its space efforts because both countries understood straight from the beginning that space technology and space research are the basis for applications that benefit the national economy, governance and the society as a whole. Like China, India is using space technology as a tool to drive a developing nation into the 21st century, making a super-population of more than 1 billion citizens fit for the challenges of today's modern world.

Both space nations have big plans for the exploration of space, and both of them have already overlapping interests in the use of space and space technologies. Also, the current shift from the dominance of a traditional space nation to new constellations of cooperation and partnerships makes it more relevant to keep an eye on India's space developments and achievements. Not to forget that India and China are co-founders and active Member States of the BRICS organisation, working together on the exchange of Earth observation data and a virtual remote-sensing satellite constellation by combining the existing resources of each partner.

Similarly important, both countries are active Members within the United Nation Office for Outer Space Affairs (UNOOSA), contributing to advances of space law, the sustainability of the space environment and the prevention of an arms race in space – areas of far reaching consequences for the future use of outer space.

And after all, China and India are neighbours, even big neighbours, with strong ties to Russia, another significant space nation. So, the prospects of cooperation could be enormous if the lack of direct cooperation of the two neighbour nations can be overcome.

Observing these aspects, the knowledge of what India is up to in space is of high relevance for categorising and positioning China's efforts in space. India and China are two Asian power-houses, their relationship with each other will shape the future of the continent and the future of the world. The two countries together can change the course of the world, but in a scenario where the three nations of Russia, China and India join forces - space forces - they should be unbeatable.

The book by Gurbir Singh reflects on all these aspects. For the first time, he was able to give a complete overview on all areas of Indian space efforts by looking at old traditions in Indian science and astronomy, describing the early attempts to set-up a national space programme and develop indigenous space hardware for launchers, telecommunications, navigation, science and manned space flight activities, as well as giving an outlook to what to expect from India in the years to come - all in one place.

The book is written by a space enthusiast, who actually is an outsider with no direct connection to any Indian space organisations. With a lot of effort, countless interviews of Indian key figures, and many visits to locations and witnesses in India, Gurbir Singh has collected over a time period of 6 years, meaningful material and new knowledge about forgotten details, such as the circumstances of awarding the Nobel Prize to Chandrasekhara Venkata Raman, or the biography of India's first rocketeer, Stephen H. Smith. His research is combined with his deep knowledge of international space programmes, an excellent education in history, and a sincere understanding of Western and Indian culture. No-one else has done this before.

Gurbir Singh is a talented writer. Reading the text is pleasant and it shows that the author enjoys writing. As a result, not only is the content Indian, but also the style, the description and respectful dealing with persons - Indian culture at its best. The book might mainly target the non-specialist, but considering the fact that it is the first and most comprehensive account on India's space efforts, it is of benefit to anyone that needs to know about it.

"The Indian Space Programme - India's Incredible Journey From the Third World Towards the First" is a 645 page-publication, supplemented by 29 tables, 9 appendices, more than 140 illustrations (some images published for the first time) and complemented by over 1,000 references, is available in ebook and paperback from Astrotalkuk Publications.

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