All About The Chinese Space Programme

Go Taikonauts!

龙腾太空

Issue 24

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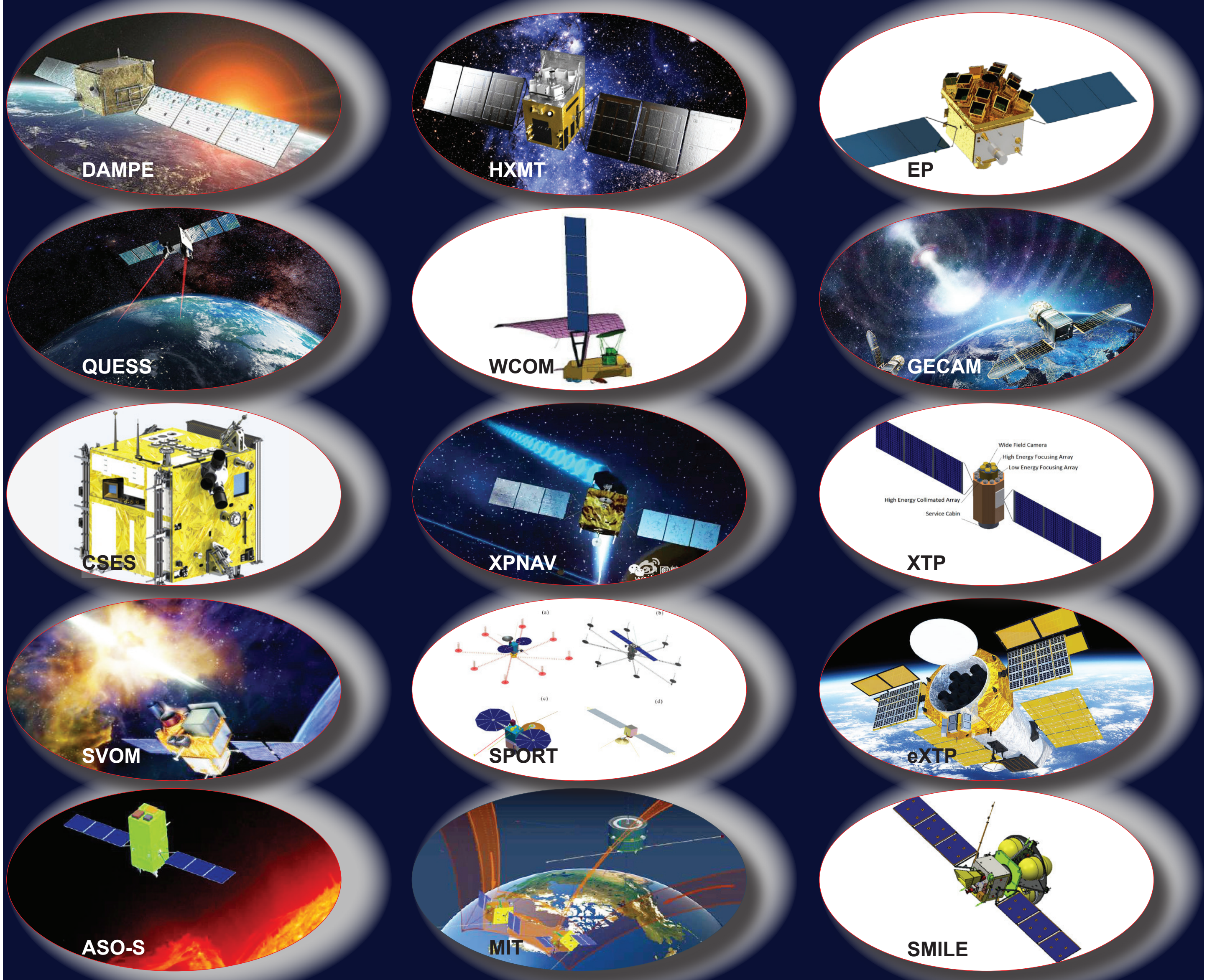

Overview on China's Space Science Missions - see articles on page 18 and 21.

illustrations - credit: CNSA/NSSC/CAS/IHEP/CNES/CSNO/NAO/ESA/ATGMedialab/NASA

Content

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- **UNISPACE50+** of the United Nations in Vienna
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- **3rd/4th Quarterly Reports 2018**

Chinese Space Quarterly Report

April - June 2018

by Jacqueline Myrrhe and Chen Lan

SPACE TRANSPORTATION

CZ-5

In mid-April, the SASTIND (State Administration of Science, Technology and Industry for National Defence) closed the investigation into the CZ-5 Y2 failure. It publicly confirmed the findings of last summer: a quality issue in the structure of the turbopump in the YF-77 cryogenic engines of the core first stage.

The Y3 rocket is being manufactured and will be launched by the end of 2018. The next step will be a Long March 5 Y4 rocket launch of the Chang'e 5 lunar sample return mission.

The CZ-5 improved first stage and the liquid hydrogen and oxygen fuelled core-stage engine has successfully undergone hot-fire ground tests.

CZ-8

Long Lehao, Chief Designer at CALT (China Academy of Launch Vehicle Technology), confirmed during the National Space Day conference "China International Commercial Space Symposium" in Harbin that the two-stage medium-lift CZ-8 carrier rocket will operate with a recoverable first stage. The first stage, which is also the core stage, will be supported by two boosters. They are expected to perform a vertical return landing. The first launch of CZ-8 is planned for 2021.

Bao Weimin, Director of the Science and Technology Commission of CASC (China Aerospace Science and Technology Corporation) said that technologies to control impacting rocket parts are being developed to ensure safety during launches, including those of Long March models with toxic propellants.

CASC's reusability aim in space transportation

Around 2025, reusable suborbital carriers will be successfully developed and suborbital space travel will be realised. Around 2030, rockets with two reusable stages will be developed. Around 2035, completely reusable carrier rockets will enable space tourism.

A future generation of carrier rockets will be put into use around 2040 and hybrid-powered reusable carriers will be developed. Space vehicles will be more diverse, intelligent, reliable, low-cost, efficient and convenient.

Compare "CAST Space Transportation Roadmap" in GT! issue no. 23

A project team with CALT is developing a smart rocket with the ability to receive, judge, and plan flight parameter data during flight and autonomously make adjustments to reach the target orbit or prevent the loss of the carrier. The rocket will be equipped with an advanced reusable power system that can be switched on and off repeatedly.

CZ-3

CALT has developed and tested a wireless information transmission system for rockets. Wireless technology, although technically complicated, is expected to save around 100 kg of mass and could be operational within two years. It can also be used for satellites and robotics.

CALT has already installed and tested a wireless measuring system on its CZ-3B rocket, which launched Apstar 6C in early May. Sensors in the rockets are usually connected by cables.

CZ-2

On 21 May CALT confirmed that the CZ-2C/SMA carrier rocket passed its readiness review before transport to the Taiyuan Satellite Launch Centre. It will launch the CAST-built high-resolution electro-optical Pakistan Remote Sensing Satellite 1 (PRSS-1) (One Arrow-Double Star) and the smaller, experimental PakTES-1A, built by Pakistan's space agency SUPARCO (Space and Upper Atmospheric Research Commission) - with assistance from the Space Advisory Company of South Africa. The launch marks CZ-2C's return to the international commercial launch service market after a break of nearly 20 years.

YUANWANG

Yuanwang 3

From 30 March to 2 April CSMTC (China Satellite Maritime Tracking and Control Department) had Yuanwang 3 (YW-3) and Yuanwang 6 (YW-6) track the re-entry of Tiangong 1 (TG) from 30 March until its re-entry on 2 April.

The ships crews had to determine TG-1's orbit and monitor re-entry conditions during the last 60 min before impact in the South Pacific, the formal end of its seven-year mission. Only 9 days after that assignment, YW-3 performed maritime satellite tracking in support of the launch of Yaogan 31-01 remote sensing satellites and micro-nano technology testing satellite on 10 April from Jiuquan Satellite Launch Centre. YW-3 acquired the data during the initial flight phase of the rocket and satellite and relayed them to the Xi'an Mission Control Centre.

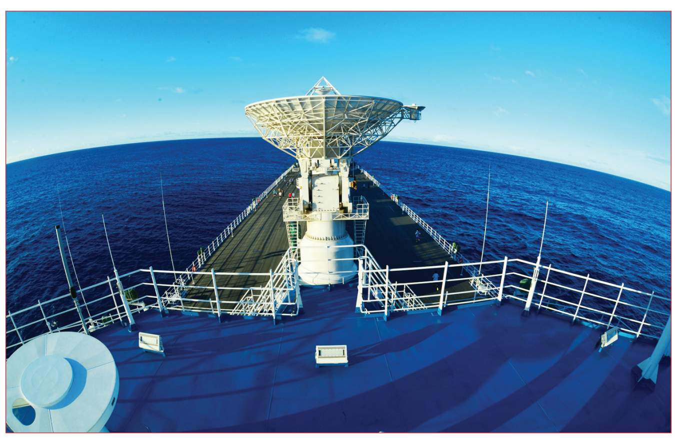
On 25 May, YW-3 returned to its home port at the CSMTC in Jiangyin on the Yangtze river in east China's Jiangsu Province. The crew completed a 70-day maritime space monitoring mission, traveling more than 16,000 nautical miles since its departure on 12 March. All monitoring tasks were accomplished.

Yuanwang 6

From 30 March to 2 April YW-6 and YW-3 were deployed in the Pacific and Indian Ocean in support of the uncontrolled re-entry of the TG-1 space module. After return to port, YW-6 left again on 5 May for the launch of the Chang'e 4 Queqiao communications relay satellite on 21 May. YW-7 and YW-6 were jointly supporting that launch. YW-7 was already in the target area after completion of its support mission for the launch of Apstar 6C. This mission will be the last voyage of the YW-6 tracking ship before it undergoes a technical overhaul.

Yuanwang 7

The YW-7 successfully completed the maritime monitoring and control mission in the South Pacific Ocean, providing important monitoring and control support for the Apstar 6C's accurate orbiting operation on 4 April. After that, YW-7 changed its location in preparation for the launch of the Queqiao satellite on 21 May. YW-7, together with YW-6 performed the maritime telemetry, tracking and command tasks for that launch.



Yuanwang 7 on mission. credit: Science&Technology Daily/China Internet

MANNED SPACE FLIGHT

Tiangong 1 Re-entry

After 2,375 days and 21 hours in orbit and a two-year decay process, the 8.5 t Tiangong 1 (TG-1) space lab re-entered on the early morning of 2 April at 0:16 UTC ±1 min (08:16 BJT) over the South Pacific Ocean at approximately 164.3 W and 13.6 S, between Samoa and Tonga - as reported by Jonathan McDowell. TG-1 missed the official spacecraft cemetery at Point Nemo (the location with the greatest distance of approx. 2,700 km to any land mass on Earth) by 3,600 km. CMSEO (China Manned Space Engineering Office) confirmed that most of the parts burned up during the re-entry process. The chance of a human being struck by debris were estimated to be about 1 in 300 trillion.

TG-1 received a slight life extension due to low solar activity. As a result, the atmosphere was very calm, which made this particular re-entry interesting for experts gathering data to improve modelling processes for re-entry dynamics.

On that occasion, the South China Morning Post (SCMP) revealed that China does salvage space debris on a case-to-case basis, when assets are of high value, contain sensitive technology or intelligence. TG-1 was not such an asset.

TAIKONAUTS

Taikonaut Selection

On 23 April, China finally launched its long-announced selection of the third class of taikonauts. Over a 3-step process, 17 to 18 candidates, male and female, will be recruited to serve the space station project, according to Yang Liwei. China needs spacecraft pilots, space engineers and payload specialists, which calls for aspirants with military background but also from the civil sector, such as engineers and scientists. The taikonaut selection is led by CMSEO and implemented by the China Astronaut Research and Training Centre. *(1998 - 1^{st} group 14 astronauts / 2010 - 2^{nd} group 7 astronauts of which two were woman)*

In April, taikonaut Chen Dong, while attending the Boao Forum for Asia at Hainan Island, said in an interview with CCTV that in the space station era: "... astronauts will stay in space for a longer time with more tasks to be performed. This places higher demands on our physical condition, knowledge, mental status and skills, and create more challenges." Missions for the space station will feature long-term stays in orbit, regular extra-vehicular activities, in-orbit assembling and repair of the station.

Liu Yang addressed the audience at the World Telecommunication and Information Society Day (WTISD) on 17 May in Geneva. She participated in a panel discussion on the topic 'AI-powered Moonshots' and discussed the role of AI (artificial intelligence) in future space exploration.

During the event, ITU Secretary-General Zhao Houlin called upon the Member States to identify, apply and accelerate the use of AI in support of the UN (United Nations) Sustainable Development Goals as well as for the benefit of all mankind.

ACC

1 April 2018 marked the 50^{th} anniversary of the establishment of the Astronaut Centre of China (ACC).

Huang Weifen, Deputy Chief Designer at ACC, announced that the training for the CSS had started, including underwater activities to train EVAs, on-orbit assembly and station maintenance as well as survival training in the desert. Related theoretical courses such as space station technology, robotic arm technology, extravehicular activity technology, medical science etc., are on the agenda, including adaptable diving training, strength and other physical training.

Also, ACC released documentation on the selection criteria, method, implementation procedures for the astronaut selection based on three different types of astronauts - pilots, engineers, and payload specialists.

On 20 April, the Forum on the Development Strategy for Aerospace Medical Engineering took place at ACC in Beijing. In 2014 the centre started its activity with the development of the Feitian underwater training suit used for space station training in the neutral buoyancy water pool at the ACC. On 20 April, it was shown to the public for the first time. Yin Rui, Deputy Chief Commander of the ACC, explained: "The Feitian underwater training suit is developed and produced entirely with digital technologies. Technical challenges such as control of pressure, temperature and humidity, guarantee of efficiency under water, realisation of neutral buoyancy, and collection and transmission of underwater signals such as voice and physiological parameters are addressed. Breakthroughs and proficiency in four key technologies, namely pressure control and monitoring under the water, air exhaust without interference under the water, open immersive heat transfer, and sustaining of neutral buoyancy, were realised." Advanced digital design methods developed by the Shanghai Feitian Zhongzhi Technology Services Co. Ltd. were used in its development.

Underwater training suit for astronauts makes debut in Beijing.

Taikonauts conclude field survival training in desert - A video and photo report.

On 26 May, 15 taikonauts completed a 19-day desert survival training in the Badain Jaran Desert near the Jiuquan Satellite Launch Centre in northwest China as part of their technical space station training. Organised by ACC, each team, all wearing spacesuits, simulated an emergency landing where they had to exit the capsule without external help, report their location and survive in the desert until rescue arrived 48 hours later. The desert survival training tested the allocation of emergency supplies. Chinese astronauts also completed emergency escape training on the Jiuquan Satellite Launch Centre launch pad.

Taikonaut Wang Yaping during survival training on 22 May in the Badain Jaran Desert in the Gansu Province. credit: Xinhua/Chen Bin

CSS

CCTV showed the first video footage of the CSS (Chinese Space Station) core module "Tianhe" in CASC's assembly facility in Tianjin on 1 April. Engineers in Tianjin Space City have been running tests on the core module. The average age of engineers in the space station development is 35. Three young engineers, with an average age of 32, developed and tested a robotic arm.

On the occasion of China's National Space Day, space experts revealed that the CCS will accommodate 10 t of scientific and experimental hardware. The CSS will be equipped with

26 internal payload racks, 67 external attachment points for hosting medium-sized external payloads and four points for large instruments.

Zhou Jianping, Chief Designer of China's manned space programme said that the currently planned mass is 66 t with an option for extension to up to 180 t. The designed life time of 10 years could be prolonged by in-orbit maintenance. Supply operations are expected to be similar to those of the ISS. The CSS may host the first Chinese space tourists and one or two lab modules may be available for commercial activities. Zhou said that detailed guidelines and prices were still being determined. China intends to test the key technologies needed for human deep space exploration, implying that manned space activities would not stop in LEO. China has the technological basis for a manned lunar landing.

Pei Zhaoyu, Deputy Director of the Lunar Exploration and Space Programme Centre of the CNSA (China National Space Administration) proposed - based on China's possibilities - to build an unmanned lunar research station in about 10 years to accumulate technical expertise, and a lunar research and development base around 2050. The base would be permanently operated by robots, and temporarily occupied by humans.

AO for CSS Utilisation by UNOOSA Member States

CMSA (China Manned Space Agency) and UNOOSA (United Nations for Outer Space Affairs) have invited United Nations Member States to apply for the conduct of experiments on board China's Space Station. The Announcement of Opportunity was published during a ceremony on 28 May in Vienna, Austria. The cooperation is open to all countries, all forms of participation are encouraged. Both parties explicitly stated that they would offer support for developing countries. This is the first time that such a project is not linked to any conditionality.

As early as in 2016, CMSA and UNOOSA signed the partnership agreement on offering space-related technological skills and insights to grant UN member states, in particular developing countries, an "Access to Space" to address all 17 Sustainable Development Goals.

Simonetta Di Pippo, Director of UNOOSA, told Xinhua: "China is currently the first contributor to our activities in terms of voluntary contributions, this is quite important, it's a sign of the strong interest of China of collaborating with us, opening up to the entire world the possibility to utilise their facilities." She also mentioned that her office is discussing potential future cooperation with China, especially as far as its lunar programme is concerned.

Following the announcement, UNOOSA sent official letters to all Permanent Missions in Vienna and New York as well as to the offices of the United Nations Development Program, kicking off a three-month application period.

In June, UNOOSA Director Simonetta Di Pippo reiterated that the cooperation between UNOOSA and China also aims at providing flight opportunities for astronauts and payload engineers of UN Member States.

Simonetta Di Pippo, Director of UNOOSA:
"The announcement is open for all Member States. But if you read the announcement you see, we clearly have a preference for developing countries.

AO for the United Nations-China Cooperation on the Utilisation of the Chinese Space Station

LUNAR AND DEEP-SPACE EXPLORATION

Chang'e 3

The satellite tracking website UHF-Satcom.com still receives X-band DSN signals from the Chang'e 3 lander, showing that it is still working after four and a half years at its location in Mare Imbrium on the lunar surface.

Chang'e 4

The LINA-XSAN (eXtra Small Analyzer for Neutrals), an instrument built by the Swedish Institute of Space Physics (IRF), is one of the international payloads for Chang'e 4. It will study the interaction of space plasma with the lunar surface. Originally, the analyser was constructed for the delayed Russian LunaGlob (Luna-25) lander mission. Some components were facing end-of-lifetime, so that IRF decided to transfer LINA-XSAN to Chang'e 4. Russia will still fly a similar analyser on LunaGlob: the Russian ARIES-L instrument.

Experts from ASTRON (Netherlands Institute for Radio Astronomy) tweeted on 24 April that the NCLE (Netherlands Chinese Low-Frequency Explorer) successfully passed the risk assessment review - the last test by the Chinese space agency before launch on board the Chang'e 4 relay satellite.

Biosphere

At a conference on scientific and technological innovation of the Chongqing Municipality in April, the mini-biosphere project designed by 28 Chinese universities under the lead of Chongqing University, was explained: The Chang'e 4 lunar lander will carry a cylindrical, aluminium alloy tin, 18 cm tall, with a diameter of 16 cm, a net volume of 0.8 litres and a weight of 3 kilogrammes. The cylinder will contain seeds of potato and Arabidopsis thaliana, cotton, and probably some silkworm eggs to conduct the first biological experiment on the Moon. Along with the organisms, water, a nutrient solution, air and a small camera and data transmission system will be mounted into the system. A tube will direct the natural light on the surface of Moon into the tin to make the plants grow. The plants are expected to generate oxygen, which is then consumed by the silkworms, which in return produce carbon dioxide for the plant growth.

Queqiao – Chang'e 4

At the opening ceremony of China's National Space Day on 24 April, held at Harbin Institute of Technology (HIT), CNSA announced the name for the Chang'e 4 relay satellite: "Queqiao" - magpie bridge. The two microsatellites for ultra-long-wave astronomical observation of the Moon built by HIT that will launch together with Queqiao were named Longjiang 1 and Longjiang 2 (Black Dragon River – after the Dragon River which flows as Amur from Russia into the Heilongjiang Province).

To raise the interest of the public in space exploration, the Lunar Exploration and Space Programme Centre of the CNSA has invited people to write down their hopes for what they expect from lunar and space exploration, and the relay satellite will carry the names of about 100,000 participants and their hopes into deep space.

21 May

After the launch of Queqiao on 21 May, Zhou Jianping, Chief Designer of China's manned space programme, said that China has the technological basis for a manned lunar landing.

25 May

After 113 hours of flight, Longjiang 2 (LJ-2) successfully completed braking at perilune at 22:00 BJT, entering lunar orbit with a perilune of 350 km and an apolune of 13,700 km, becoming the world's first microsatellite to independently complete Earth-Moon transfer.

LJ-1 failed to enter lunar orbit due to a control failure at the lunar transfer trajectory.

Flying 100 km above the Moon, Queqiao (QQ) received the command by the space control centre in Beijing to decelerate and enter a transfer orbit from lunar orbit to the second Lagrangian (L2) point of the Earth-Moon system. Because of the short time window and limited fuel, only one attempt was possible. QQ is expected to adjust its orbit several times before reaching its position about 455,000 km from the Earth in a halo orbit around the L2 point.

26 May
The low-frequency radio detector on LJ-2, developed by the National Space Science Centre of CAS, was switched on for the first time and began to operate in the 1-30 MHz frequency spectrum and conduct a whole-sky observation.

28 May
The Saudi camera, carried by Longjiang 2, was switched on and took its first photos.

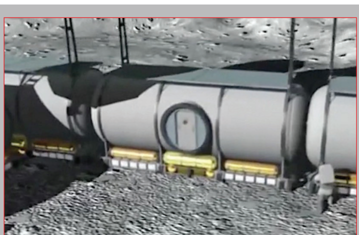
14 June
QQ entered the planned Halo orbit at EML-2, between 65,000 and 85,000 km behind the Moon. Because of accurate orbital manoeuvres, fewer trajectory corrections were needed, which led to fuel savings. This might allow QQ to stay operational beyond its projected lifetime of three years. The complex nature of the Halo orbit requires mission controllers to conduct orbit maintenance every seven days. QQ became the first ever satellite operating in the Halo orbit around the L2 point.

CNSA and KACST (King Abdulaziz City for Science and Technology) of Saudi Arabia co-hosted a ceremony in Beijing to publish three images captured by the Saudi Arabia-developed small lunar optical imaging detector. The two countries will share the scientific data from this cooperation.

Lunar Base

Wang Liheng, a senior space scientist and academician of the Chinese Academy of Engineering, told China Daily it has become the consensus among Chinese space researchers that a manned lunar station is necessary so scientists can deepen their lunar research and explore ways for the exploitation of lunar resources. Such a facility will also help to accumulate experience that can be used for manned missions to Mars, he said.

In a video shown at the National Space Day ceremony in Harbin, CNSA listed the construction and operation of a lunar scientific research station in its development roadmap for the space sector. The video shows the lunar outpost will have multiple, interconnected tube cabins. One of the facility's major energy sources will be solar power, according to the video. The administration did not reveal a schedule for the construction and operation of the outpost in the video.



Moon Base video from 3rd China National Space Day 2018

Call for Ideas for lunar space architecture

One day before the National Space Day, Zhou Jianping, Chief Designer of China's manned space programme revealed a Call for Ideas for the general public to come up with creative approaches for the design of its manned lunar landing and ascent vehicles. With this call, it is hoped to find new and innovative ideas, concepts, approaches, and technology proposals from any person with an interest in space.

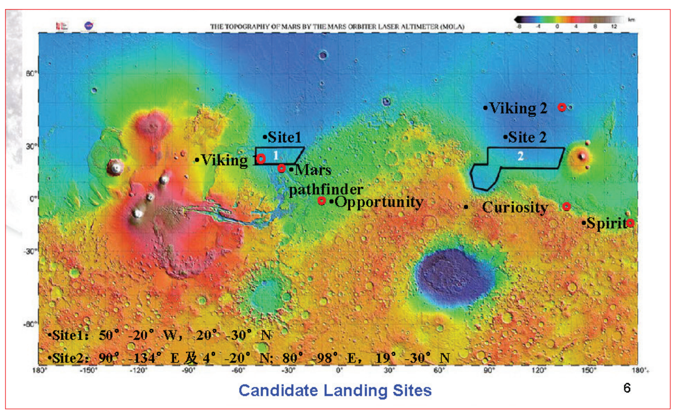
The next day, a video of a manned research station on the Moon was shown during the ceremony on 24 April in Harbin, which was the central location for the 3rd National Space Day activities. Without giving a schedule, CNSA presented a roadmap for the space sector which includes the development of a lunar scientific research station.

Lunar Palace

On 15 May, four students, two males and two females, left the 160 m^2 Yuegong 1 (Lunar Palace 1) simulation habitat at Beihang University after a 110-day stay. They had spent a whole year in a closed base in Beijing and set a new record for the longest stay in a self-contained cabin where oxygen, water and food were recycled by an BLSS (Bioregenerative Life Support System). BLSS is a critical technology for long-term human stays on the Moon or beyond. The Beijing BLSS system is 98% self-sufficient. The volunteers lived on self-grown vegetables and yellow meal worms as well as a small amount of pre-stored pork and chicken. Water was supplied from a purifying machine. The students had access to the internet, could play chess, do yoga and exercise on bikes. They also studied English and listened to the radio. Volunteers had to take psychological and health checks every week. The young crew did consider the simulation challenging but were determined to complete it successfully. The total length of the test, which started on 10 May last year, was 370 days, 5 days longer than planned, with the first group staying for 60 days, the second group for 200 days - breaking the Soviet record of 180 days - and the third group, which was the same as the first group accounting for 110 days. The delay of 5 days for the last group was meant to test the volunteers' psychological states in unexpected situations. After the egress, the crew underwent extensive health checks. The project team will now begin research and development on small bioregenerative life-support instruments to be carried on China's lunar and Martian probes.

MARS

China has selected two preliminary areas on Mars for the lander and roving mission to be launched in 2020 and arriving on Mars in 2021. The locations in Chryse Planitia and Isidis Planitia in relatively low-lying regions on Mars, were shown in the presentation "China's Cooperation Plan on Lunar and Deep Space Exploration" given by Wang Fengyu, Official of the Department of International Cooperation, China National Space Administration, on 27 June at the technical programme of the 61st session of COPUOS (United Nations Committee on the Peaceful Uses of Outer Space) in Vienna, Austria.



COPUOS 2018 presentation by Chinese representative showing Mars landing. credit: UNOOSA/CNSA/CLEP

In May, the Beijing Institute of Space Mechanics and Electronics (BISME - 508th Institute of CAST) performed a functionality and strength test of the parachute for the new-generation crewed spacecraft, the Shenzhou successors. BISME also accomplished crucial tests of an inflatable airbag landing system for spacecraft with an Inflatable Re-entry and Descent Technology (IRDT) demonstrator. IRDT can provide thermal protection and deceleration during the landing phase. It could make a first test flight in 2019.

SCIENCE

QUESS

During the period from May to June 2018, QUESS operation was stable and smooth.

On 29 May, the 19th Meeting of the Academicians of the Chinese Academy of Sciences (CAS) took place in Beijing. Pan Jianwei, academician of CAS and executive vice president of the University of Science and Technology of China, delivered the report "New Quantum Revolution: From Quantum Physics Foundations Test to Quantum Information Technology". He stated that it was promising to establish a complete space-to-ground and wide-area quantum communication network technology system and create a seamless joint between a quantum communication network and a classical communication network within the next 10 to 15 years. Pan Jianwei predicted that the second quantum revolution powered by quantum information technology would also bring about the quantum leap of social civilisation and material civilisation which would turn China into a leader of future information technology.

Parabolic Flight Research

Following the joint proposal GRANULOGY between ESA and CMSA, a meeting of Chinese and European scientists took place on 26 June 2018 in Liège, Belgium. There is a common interest to optimise the use of ISS and CSS resources by sharing the complementary instruments VIP-Gran on the ESA side and a shear instrument from CMSA as well as flight opportunities for mutual scientific benefit.

FAST

A new laboratory for FAST (Five-hundred-meter Aperture Spherical Radio Telescope) was opened by CAS. The laboratory promotes research and technological development of radio astronomy based on FAST's data acquisition. The lab will also promote international cooperation on the Square Kilometer Array (SKA), an international effort to build the world's largest radio telescope using arrays.

Also, a new receiver was installed on FAST to boost its efficiency in surveying the sky. The 19-beam L-band receiver, the first of its kind worldwide, is expected to be put into use in early June and it will increase FAST's survey speed by five to six times. The receiver was jointly developed by scientists from China and Australia. It weighs 1.2 t and cost over 20 m RMB (3.14 m USD).

On 18 April, the U.S. research team at the Fermi Large Area Telescope (LAT) confirmed that the radio millisecond pulsar discovered by China's FAST on 27 February is the unassociated gamma-ray source 3FGL J0318.1+0252 in the LAT point-source list. The now-named PSR J0318+0253, was the first radio millisecond pulsar discovered by FAST and is the first result of the FAST-LAT collaboration outlined in an MoU signed between both teams.

TIANQIN (Heaven's Harp)

The Tianqin project for the detection of gravitational waves, was revealed to the public on 2 April. The Sun Yat-Sen University Guangzhou started the Tianqin project in July 2015.

Three satellites are to be launched around 2030 to measure the change of time and space, said Luo Jun, initiator of the project and an academician of CAS. Luo Jun said he and his team would carry out a four-stage plan over the next 15 to 20 years to detect the waves with three satellites in a 100,000 km orbit. The satellites will establish a network via laser beams. Through laser interference, the distance between the satellites can be measured. The satellite constellation looks like a triangle, like a harp, and the “hands” that are playing it are the gravitational waves. That's why we call it 'Tianqin' (Heaven's Harp), explained Luo.

Space Science Satellites

At the end of April Wang Chi, Director of the NSSC (National Space Science Centre) of CAS told a press conference on the occasion of China’s National Space Day that China is planning for a new batch of science satellites to be orbited around 2020.

The plans include:

- SMILE (**S**olar wind **M**agnetosphere **I**onosphere **L**ink **E**xplorer), a Sino-European joint mission, researching the interaction between the solar wind and the Earth’s magnetosphere.
- Einstein-Probe, aiming at the discovery of celestial bodies that emit X-rays as well as black holes.
- ASO-S (**A**dvanced Space-borne **S**olar **O**bservatory) investigating the interaction of magnetic fields, solar flares, and coronal mass ejections.
- GECAM (**G**ravitational Wave **E**lectromagnetic **C**ounterpart **A**ll-sky **M**onitor), for the search of electromagnetic signals associated with gravitational waves.
- WCOM (**W**ater **C**ycle **O**bservation **M**ission) for the investigation of the Earth's water cycle by measuring soil moisture, ocean salinity, and ocean surface evaporation.
- MIT (**M**agnetosphere-**I**onosphere-**T**hermosphere Coupling Exploration), investigating the interaction between magnetosphere, ionosphere, and thermosphere.

China aims to organise and launch a series of large international science projects, including space science, in the coming years to solve important problems in science. China will organise and launch one or two large international science projects, and foster three to five projects by 2020. Another six to 10 large projects will be prepared until 2035 to increase China's influence in the science and technology field and achieve cost savings, the Ministry of Science and Technology (MOST) said. Areas such as the physical sciences, research on the evolution of the universe and the origin of life were specifically listed as priorities.

SATELLITES

ALCOMSAT-1

On 1 April, the in-orbit delivery ceremony for Alcomsat-1, Algeria's first communications satellite was held at the headquarters of Algeria Space Agency (ASAL). The In-Orbit Delivery & Final Acceptance Certificate was signed. The actual in-orbit delivery occurred already on 1 March.

Alcomsat in-orbit delivery. credit: CGWIC/Xinhua

Gaofen

With the launch of the recent two Gaofen satellites, Gaofen 5 and 6, China established a ground-air high-resolution observation system involving variable space resolutions and cover widths, spectral coverages and revisit periods. Data from Gaofen satellites have largely replaced foreign data, the degree of self-sufficiency is 80 percent. Global Times reported that the performance rate of China's military surveillance and remote sensing is just as high.

China will be able to obtain more than 90 percent of required remote sensing data by home-made satellites.

On 4 April, the first data package of 166.31 gigabytes from the three Gaofen-1 satellites was received by the ground station in Miyun on the outskirts of Beijing, followed by the Sanya and Kashgar antennas which collected real time image data. Kunming and an arctic ground station are also part of the Gaofen network of receiving stations. In late June/early July all sub-system tests should be finished.

Gaofen 6

CAS confirmed that the Miyun ground station successfully tracked and received imaging data from Gaofen 6 on 4 June. The first batch of observation data comprised 40 GB and the mission lasted six minutes.

Gaofen 5

CAS confirmed that its Institute of Remote Sensing and Digital Earth has successfully tracked and received data from the hyperspectral imaging satellite Gaofen 5 via the Miyun ground station on 13 May. The data size was 60 GB and the time frame was nine minutes and 32 seconds.

Zhangheng 1

On-orbit testing of the Zhangheng 1, China's seismo-electromagnetic satellite, was completed successfully by 12 May. By mid-May, Zhangheng 1 had returned a total of 8.22 terabytes of data.

Tianzhi 1

Tianzhi 1, China's first software-based satellite will be launched in the second half of 2018. Tianzhi 1 will carry a small cloud computing platform including four Chinese made smartphones which have strong calculation capability and are energy efficient. The plan is to launch one satellite per year to enhance the system. Tianzhi 2 and Tianzhi 3 are already under development.

Customers can use the satellite platform, which takes advantage of the internet's open sources, to develop, test and debug software. Tianzhi 1 can process data in orbit before sending them back to Earth for different uses, and is capable of automatic operation, which can also reduce the workload of the satellite control system on the ground. A specific user, for example, can rent such a satellite to combine uploaded software and download the results of processed high-definition data of an area of interest.

Fengyun

China plans to send 11 more meteorological satellites into orbit by 2025 to further improve its weather forecasting accuracy and ability to cope with natural hazards, according to CNSA. The planned satellites include three Fengyun 3 satellites in polar orbit, two Fengyun 4 satellites in geostationary orbit, one dawn-dusk orbit climate satellite, one high-precision greenhouse gas detection satellite and one hyper-spectral satellite. There are plans to send a microwave detection satellite into geostationary orbit to enhance its ability to predict and monitor fast-changing typhoons, rainstorms and other extreme weather conditions. The satellite will work with the Fengyun 4 series to improve forecasts of rainfall and climate. There are also plans for a precipitation radar measurement satellite to improve the accuracy of numerical precipitation forecasts.

Fengyun 4A

On 1 May, Fengyun 4A GEO meteorological satellite was handed over to formal operation. The Fengyun series has been included by the World Meteorological Organization (WMO), into the global meteorological satellite series for business applications, becoming part of the global integrated Earth observation system. It is also the on-duty satellite for the International Disaster Chapter Mechanism. The WMO expressed the need for frequent observation of the Indian Ocean region, which could be covered by China's Fengyun satellites. Countries along the Belt-and-Road can trigger the disaster and relief mechanism in case they suffer from natural disasters. In response to that, the China Meteorological Administration would order high-frequency sub-regional observations of the disaster-stricken areas every 5 to 6 minutes through its on-duty Fengyun meteorological satellites, and use the data to create images and quantitative products which would be made accessible to cooperating countries via a specific disseminating and data broadcasting mechanism. Fengyun 4 meteorological satellites currently in use are equipped with HEO (highly elliptical orbit) detectors.

As of midnight, 8 May, Chinese and users in other Asia-Pacific countries can officially receive data from the Fengyun 4A satellite. At the same time, all national weather service platforms have completed the switch from Fengyun 2 to Fengyun 4.

NAVIGATION

Beidou

On 23 and 24 April, the PLA Army held its first technical contest in Nanjing. 210 high ranking officers and cadres from military units competed against each other under simulated battle condition in 11 areas including Beidou-based operations such as positioning, operational command, command, control & communications equipment, remote sensing image interpretation, graph calculation and analysis, and situational mapping.

Hosted by the European Commission (EC), the 3rd International GNSS Monitoring and Assessment (IGMA) of the Seminar of the ICG Working Group S and other series of meetings convened in Noordwijk, Netherlands from 14 to 16 May 2018. The Chinese delegation included experts from the International Cooperation Centre and Evaluation Research Centre of China Satellite Navigation Office (CSNO), the National Timing Centre and the Shanghai Astronomical Observatory of CAS. The purpose of the meeting was to promote the work of various IGMA working groups, and to promote the unification of the format templates and algorithms of the GNSS monitoring assessment products of GNSS, required for the unification and completion of the normative services capabilities of GNSS.

The revision of the BDS Standard System was conducted during the 104th Plenary Meeting of Special Committee 104 of Radio Technical Commission for Maritime Services (RTCM SC-104) from 21-22 May in Harbin. At the meeting, it was proposed to extend the BDS observation codes in the NMEA-0183, RINEX and DGNSS standards and the BDS message compatibility solutions and test plans in the RTCM 10402.4 and RTCM 10403.3 SSR data standards. The RTCM SC-104 working groups are responsible for formulating and revising the work of international general data standards respectively, including DGNSS, RINEX and NMEA-0183.

UN-ICG

From 18 to 22 June 2018, a series of meetings of the United Nations International Committee of Global Navigation Satellite Systems (ICG) were held in Vienna, Austria, including the 20th ICG Provider's Forum and the 2nd ICG-13 Preparation Meeting, chaired by ICG-13 Chair, Ran Chengqi, Director General of CSNO. The ICG-13, the 13th Meeting of the International Committee on Global Navigation Satellite Systems (ICG) organised by the CSNO on behalf of the Government of the People's Republic of China, will be held 4-9 November 2018 in Xi'an, China.

UNOOSA

Lu Xiaochun, Deputy Director of National Time Service Centre of CAS (NTS), gave a report about China Beidou on the 61st Meeting of UNCOPUOS in June in Vienna.

The 9th China Satellite Navigation Conference Convened in Harbin

The 9th China Satellite Navigation Conference (CSNC), one of three major international satellite navigation conferences, was held on 23 May at the Huaqi Entertainment Assembly Hall in Harbin under the motto "Location, Time of Augmentation".

More than 2,500 delegates from China, abroad and the UN attended the event. During the 3-day forum speakers provided information on the integration of space-time enhancement services with mobile communication, the internet, the Internet of Things and big data and their applications in sectors including information, manufacturing and service. Apart from discussions and presentations on the latest technologies, regulations and standards, the results of national innovation competitions were presented and awarded.

The conference was accompanied by the 9th China Satellite Navigation Technology and Application Achievement Exhibition (CSNE) were over 120 exhibitors showed the latest BDS basic products such as antennas, chips, modules, terminals as well as new applications, new products and new ideas arising from the integration of BDS and other technologies were displayed. 100 percent of the key components of the Beidou satellites and the chips for ground-based equipment are produced in China.

Ran Chengqi, Director of CSNO, delivered a report titled Building & Development of the Beidou Navigation Satellite System. He said at the conference that China planned a high precision, national, comprehensive positioning, navigation, and timing (PNT) system, consisting of space segment, the control segment, and the user segment, on the basis of Beidou by 2035. With the completion of the system, China can improve its ability in space and time information service.

He also announced that China intended to launch two back-up satellites for its Beidou 2 system in the next two years to ensure the continuous stable operations of the system and to improve its performance. During the last 5 years of its operation, Beidou has proved stable and never been out of service. The positioning accuracy improved from ten to six meters.

Researchers from Harbin Engineering University introduced their newly developed device for high-accuracy marine positioning with one metre accuracy based on Beidou signals. The experts monitored and collected data from 200 observation stations and independently developed the navigation positioning device. It can fully support domestic high-end devices for oil exploitation, laying pipelines, searching and salvaging, and offshore wind power.

33,500 taxis and 21,000 buses in Beijing, and 40,000 fishing boats off the country's coast are equipped with terminals of the Beidou system. In 2017, China's satellite navigation industry was worth 255 billion RMB (39.9 billion USD).

Beidou - International Cooperation

From 6 to 12 April, CSNO together with its Test and Assessment Research Centre went to Tunisia for exchanges with the Arab Information and Communication Technologies Organisation, Arab Academy for Science Technology & Maritime Transport (AASTMT) and other relevant organisations of the Arab League.

On 10 April, a ceremony for the opening of the China-Arab BDS/GNSS Centre was jointly held by CSNO and the Arab Information and Communication Technology Organisation (AICTO) at El Ghazala Technological Park in Tunis, Tunisia. More than 30 ministerial level officials and 200 representatives of enterprises and scientific research institutes from Oman, Algeria, Nigeria, Kuwait, Sudan, and Iraq attended the ceremony, while a BDS theme report and a BDS Centre special report were presented.

This centre is a result of Chinese President Xi's initiative of "Study the project of the Beidou Satellite Navigation System landing in Arab". It is the first overseas BDS centre and a pilot project in supporting the development of BDS services in the Arab League. The China-Arab BDS/GNSS Centre is a priority cooperation project, jointly constructed and run by the International Cooperation Centre of CSNO and the AICTO. The China-Arab BDS/GNSS Centre integrates functions such as public information and exhibition, application demonstration, testing and evaluation, education and training, and joint research. Five Chinese experts were invited to give a 3-day satellite navigation training course for more than 40 Arab League students.

Ran Chengqi, Director of CSNO, and Muhammad Bin Ammo, Secretary-General of Arab Information and Communication Technology Organisation, signed the "Declaration of Holding the Second Session of China-Arab States BDS Cooperation Forum in 2019 in Tunisia" in Tunisia. By convention, the Chinese Secretariat of the China-Arab Cooperation Forum, Secretariat of Arab League, CSNO, and AICTO will jointly organise the forum in March or April 2019.

An Action Plan 2018-2019 is intend to be signed during the 8th Ministerial Meeting of the China-Arab Cooperation Forum.

Director of China's Satellite Navigation Office, Ran Chengqi (left) and Secretary General of Arab Information and Communication Technology Organisation Mohamed Ben Amor (right) during the inauguration ceremony of the China-Arab States BDS/GNSS Center. credit: africanews.space

Navigation App for mobile users

In May, a Beidou-based navigation app for mobile users providing navigation accuracy to within a metre went online. Latest models of Huawei, Xiaomi, OnePlus, Meizhu, HTC and Nubia have the Beidou chip installed enabling a shift from GPS to Beidou. During the last five years alone, 50 million domestically manufactured Beidou chips have been sold.

TELECOM

At the telecommunications trade show CommunicAsia, end of June in Singapore, China Communication Technology Satcom (CCT), a manufacturer of microwave and satcom equipment, and Zhongshan Tatwah Smartech (Tatwah), a RFID chip manufacturer, said that they entered the satellite communication, broadband, and services business in order to better access the Southeast Asian and overseas markets including Belt-and-Road countries.

SpaceNews reported about a panel discussion during the Casbaa Satellite Industry Forum 2018 in Singapore. Representatives of European and U.S. satellite communications companies Newtec (Belgian - ground systems provider), SES Networks (Luxembourg), North Telecom (Dubai - satellite services provider), LeoSat Enterprises (Dutch-US-American), and Viasat (U.S.), expressed their interest in the Chinese telecom market and in joining Chinese partners to get access to those opportunities.

On 14 May, the State Radio Administration Bureau formally issued the Notice on the Clean-up and Verification of Satellite Earth Stations and Other Radio Stations within the 3,400 - 4,200 MHz and 4,500 - 5,000 MHz frequency bands (National Radio Administration Bureau [2018] No. 4). The notice requested that relevant units, building and using such radio stations as satellite communication receiving stations, satellite radio and television programme Earth stations, microwave stations and radio astronomical observatory stations within these bands, report their information to local radio management agencies before 30 June 2018.

The Ministry of Industry and Information Technology pointed out that the radio stations clean-up and verification was another move by the national radio management agency - after its release of 5G intermediate frequency plan at the end of 2017 - to create favourable conditions for setting up 5G base stations and properly solving coordination and compatibility problems between satellite Earth stations and other radio stations within the same band or adjoining bands.

ADVANCED TECHNOLOGY

During the 3rd Swiss Parabolic Flight Campaign on 12 and 13 June, scientists from the Technology and Engineering Centre for Space Utilisation (CSU) of CAS have tested 3D printing of ceramic cubes. Under the simulated conditions of lunar and Martian gravity, one metal screw and one small metal wrench were manufactured, using 3D printed ceramic moulds. Both experiments were testing technologies for the production of components on China's future Space Station, or building large telescopes in space, or for deep-space exploration such as a Moon base. Raw materials for ceramics production are similar to the silicate particles of lunar dust. The lunar soil also contains metals such as titanium, aluminum and iron. The aim is to manufacture ceramic moulds out of lunar dust, and then cast components by using metals from the lunar soil.

For the first time in China, CASC has successfully validated working principles, working processes and multiple key technologies for inflatable re-entry and descent technology (IRDT), with the aim to use the technology to land heavier spacecraft without heat shields and parachutes, for example on the Moon and Mars. The first in-flight test is planned for 2019, which could be orbital.

A research group at CALT, revealed that it has designed a graphene composite film suitable for use in spacecraft propelled by the radiation pressure of light. Graphene-based spacecraft propulsion technology could be up to 1,000 times more effective than solar sails. The technology is still in its development phase.

COMMERCIAL SPACE

Suborbital Space Tourism

CALT is working on a reusable spacecraft for suborbital space tourism. The fully automated spaceplane would take-off vertically from a launch pad, carry up to 20 passengers to a height of 100 km and would return after approx. 10 minutes of flight via an horizontal landing on a runway. The whole mission would last 30 min. The spaceplane could fly 50 times, with two days of turn-around in between flights. The price per person/flight would be around 200,000 to 250,000 USD. Passengers have to prove a good state of fitness and health and would need to take several weeks of familiarisation training at Chinese space establishments to get accustomed to the acceleration forces and condition of weightlessness that they would experience. CALT said that the spaceplane could be operational as of 2028.

Internet of Things

UK-based nano-satellite manufacturer Sky and Space Global has signed an MoU with Beijing Commsat Technology Development Co., to test and explore how Sky and Space Global's advanced nano-satellite technology can be incorporated into Commsat's IoT service. The intention is to explore the joint provision of IoT and additional narrowband communication services in China. The Chinese IoT market reached 143 billion USD in 2016 and is expected to go beyond 231 billion USD by the year 2020. China's 13th five-year plan laid out the national IoT roadmap and declares the development of narrowband IoT infrastructure as a national strategy.

Space Honor Ltd - iSpace

iSpace have secured a funding of 600 million RMB (90.6 million USD) within a year after Series A funding from investors led by Matrix Partners China.

On 5 April 02:00 BJT, iSpace launched its single stage solid-motor Hyperbola 1S rocket for the first time. The carrier took-off from Hainan island, reaching 100 km with a maximum flight speed of 1,200 m/s.

The flight verified key technologies in design, manufacture, testing, final assembly and for the launch of the Hyperbola rocket itself. Hyperbola 1S is a verification model of the first solid launch vehicle Hyperbola 1.

OneSpace

In an interview with China Youth Daily, Shu Chang, founder of OneSpace Technology said his company might consider Moon exploration and manned space programmes in the future. OneSpace is currently charging 20,000-30,000 USD per kg of payload, but hopes to half this price with its M-series and even reduce it further when a production base is completed in Chongqing. Shu explained that the competitive advantage comes from innovation but also from relatively low costs in the salaries for engineers, for materials, and for land resources. An example for innovation is: a traditional rocket control system weighs approximately 100 kg per one unit, but OneSpace has been able to integrate up to eight units into one and reduce the weight to about 1.8 kilograms, so the rocket can have a higher payload capacity.

On 11 April, OneSpace performed a vertical assembly rehearsal of its OS-X rocket at the manufacturing facility in Beijing. They also tested equipment, transportation and lifting systems, launch pad, as well as rocket assembly, transfer and installation processes. Following which, the rocket was transported to the launch range in the Inner Mongolia autonomous region. There, further testing in preparation for launch was completed.

On 17 May at 7:33 BJT (23:33 GMT; 16 May) the OS-X0 "Chongqing Liangjiang Star" suborbital rocket was launched.

The exact location was not disclosed by the company but it can be assumed that it was at the Jiuquan launch site.

Chongqing Liangjiang Star is named after the state-owned Chongqing Liangjiang Aviation Industry Investment Group, which co-invested in OneSpace's manufacturing facility in

The OS-X rocket launch on 17 May 2018. Onespace's rocket carried a very characteristic logo together with several other signs. It showed the Chinese characters for "Chongqing Liangjiang Star" and two curves embracing the characters. The one in blue representing the Yangtze River and the one in yellow representing the Jialing River - symbolising "Chongqing liangjiang" (Chongqing's two rivers). The colours are a reference to the Chongqing Liangjiang New District, reflecting that this rocket is specially designed for that district. It also carried the insignias of 10 top aerospace universities and the logo of the "Flying Alliance". This advertisement marketing was another success of the flight. credit: Wan Nan/ Chongqing Daily/China Daily

Chongqing. The 9 m-long, single-stage, solid-fuel rocket of 7,200 kg mass reached a height of 38.742 km and a maximum speed of approximately 5.7 times the speed of sound. The launcher was equipped with a wireless communication system for on-board equipment and low-cost and light weight energy system.

The customer was the Shenyang Aircraft Design Institute under Aviation Industry Corporation of China, Ltd. But it was not known which payload was hosted since the objective of the mission was to collect data.

OneSpace plans for 3-4 flights of the OS-X launcher in 2018 and once the rocket is operational, for 10 annual orbital launches.

A portrait of Shu Chang, founder and CEO of OneSpace
"When I saw the arc of the rocket firing, I felt it was so beautiful yet so transient. I was thinking, now that I have taken my first step, I must build larger rockets and launch them even further into outer space," said Shu Chang, founder and CEO of One Space, China's first private technology company manufacturing carrier rockets and other spacecraft.

COMMERCIAL - Diverse

A report by the Beijing-based investment firm FutureAerospace, stated that more than 60 private Chinese companies have entered the commercial space industry over the past three years, focusing on the production and launch of satellites and rockets. Most of the companies are based in Beijing, Guangdong, Shaanxi and Hubei provinces, where the manufacturing industry is more developed.

CAST (China Academy of Space Technology) has a contract with Hong Kong-based APT Satellite Co. Ltd. to produce the Apstar 6D, based on an improved version of the DFH-4 satellite platform.

1st China Space Conference and the 1st China (International) Commercial Space Symposium were held on 23 April in Harbin, northeast China as part of the National Space Day. More than 2,000 aerospace professionals from government, state-owned and private enterprises, and universities attended the event. 12 sessions on aerospace technology development, innovation, military-civilian integration, and education took place.

Magpie Constellation

At the 1st China (International) Commercial Space Symposium, the Huaxun Fangzhou Co. Ltd., the Beijing ZeroG Space Technology Co. Ltd. (or: ZeroG Lab), and the Rocket Force University of Engineering were proposing to design, develop and construct jointly an optical remote sensing satellite constellation of 132 6U CubeSats with 4 m imaging resolution. The constellation, named "Magpie", would operate in a 500 km sun-synchronous orbit for high-resolution global Earth observation with a revisiting time of 12 hours in general, but 30 minutes for key regions. At a later stage, 378 satellites are planned, allowing almost real-time observation (every 10 min) of hot-spot regions. The constellation would consist of clusters of 5 satellites in formation flight, permitting various imaging modes such as wide field imaging and stereo imaging. Each 8 kg, 6U CubeSat structure will host full-colour (RGB) cameras.

ZeroG Lab will equip the satellites with fully autonomous advanced electric propulsion and inter-satellite communication links for attitude control and orbital manoeuvre and in-orbit, inter-satellite data transfer.

ZeroG Lab and Huaxun Fangzhou are also planning a joint CubeSat production facility in Shenzhen, with an annual capacity of 50 sets of CubeSats and components. Two test satellites of the Magpie constellation will be launched within 2018. The first operational satellites are expected within the next two years, with 10 satellites launched by a single rocket. The first phase of the constellation should be completed within 2 - 3 years. Huaxun Fangzhou would be in charge of most of the investment and the overall operation. For the launch service, the Long March 11 carrier rocket is considered as well as cooperation with multiple private rocket manufacturers.

Military-Civil Integration

In support of the strategy of military-civilian integration and to promote the transformation of national defence technologies into civilian services, the Equipment Development Department of Central Military Commission has for the first time declassified 4,038 national defence patents. The declassified patents cover the areas of material science, measurement and testing, radar detection, satellite navigation, and communication technology that can be applied for both military and civilian purposes.

CASIC Space Engineering Development Co

On 26 April, China Aerospace Science and Industry Corporation (CASIC) introduced its new small satellite manufacturing subsidiary in Wuhan, the CASIC Space Engineering Development Co., as part of the Wuhan National Space Industry Base. It used to be the Space Technology Research and Development Centre of the 2nd Institute of China Aerospace Science & Industry Corp. The newly formed company has research and development facilities and a production capacity of 100 satellites annually, with core technologies in the structure and thermal control of satellites.

The CASIC Space Engineering Development Co. also facilitates the development of a new cargo spacecraft using inflatable technology, flexible heat shield technology and composite materials. Spacecraft sections, made of new composite material and new types of environmental control and life support technology will be applied to this unmanned re-entry spacecraft. The first flight is expected for 2019. In the medium to distant future, the spacecraft can support human lunar exploration. It is unclear whether these technologies are independently developed by CASIC or they are involved in joint projects with other space organisations.

Additionally, the company will, with the support of multi-level capital markets, combine capitals and listed companies of various types to form a joint consortium, and set-up portfolio investments combining the primary market and the secondary market, and establish the “Space plus Finance” industry chain and related industrial ecosystem.

RESEARCH AND DEVELOPMENT

Advanced composites manufacturer, Hexcel, has formed a joint venture with Chinese aerospace parts manufacturer Future Aerospace, to establish a materials testing lab in Shanghai-Lingang. Future Aerospace Hexcel Commercial Composite Testing Limited will provide as of September 2018, testing services to commercial aerospace industries in China and the Asia Pacific region.

INTERNATIONAL COOPERATION

ALGERIA - Alcomsat

Algeria's first comsat Alcomsat 1 became operational in April 2018. An in-orbit delivery ceremony was held at the Algerian Space Agency's headquarters in Algiers on 1 April. DFH-4-based, 5.2 t Alcomsat 1 was built by CAST and has a 15-year lifetime. After launch on 11 December 2017, both sides conducted satellite on-orbit testing and completed an on-orbit review. China expects substantive cooperation in other follow-up projects in the field.

APSCO

China will coordinate with the Asia-Pacific Space Cooperation

Organisation (APSCO) to adjust the orbital distribution of its meteorological satellites to better service the members of APSCO.

BELARUS

From 22 - 26 May, for the first time a delegation of the Chinese Academy of Sciences (CAS), visited Belarus. The Chairman of the Presidium of the National Academy of Sciences of Belarus (NASB), Vladimir Gusakov, told the national news agency BelTA that both sides discussed the development of a Belarusian-Chinese satellite and resulting joint projects. During his tour of the National Academy of Sciences of Belarus on 23 May, Bai Chunli, who lead the delegation, expressed China's interest in cooperation with the Belarusian space industry and the advancement of space and other cooperation between both national academies of science. Apart from space exploration, commercial applications of research are areas of mutual interest.

RUSSIA

Within the three weeks since his appointment as Roscosmos' Director General in May 2018, Dmitry Rogozin paid an official visit to China where he met with Vice President Wang Qishan, and familiarized himself with the Chinese space industry's production capacities.

During a summit between Russia's President Vladimir Putin and Chinese President Xi Jinping at the beginning of June in Beijing, the Roscosmos space corporation and CNSA signed agreements on space cooperation following another Memorandum of Intention from 3 March 2018 on Russian-Chinese cooperation in the robotic exploration of the Moon and outer space, and the creation of joint orbital groups. No details were made public. The meeting followed the long-standing habit of almost yearly visits of CNSA to Russia or Roscosmos to China.

However, it became known that four agreements in the area of nuclear energy were also signed on the same occasion. While three agreements support nuclear power plants in China, the fourth agreement concerns the supply of radionuclide heater units (RHU) used as parts of radioisotope thermoelectric generators (RTGs) to power equipment in China's space programme, and for use in lunar exploration in particular, Rosatom said.

Another outcome of the meeting are bilateral talks by mid-July on the possibility of creating a jointly-run orbital station and cooperation for manned programmes.

Anton Shiganov, Executive Director of Roscosmos informed Russian media that the country would aim for cooperation with China on the design of a super-heavy carrier rocket. For the moment, this work is only in the study phase.

In the recent months, observers have noted a gradual shift of Roscosmos toward CNSA. Roscosmos has reportedly drafted a contingency plan in case of deteriorating relationships with the U.S., looking for stronger cooperation with China in the space field.

The Russian Institute of Biomedical Problems (IMBP) in Moscow is cooperating with a partner in China to establish an international rehabilitation centre for astronauts in Sanya on Hainan island and to develop infrastructure for developing space medicine and biology, as well as for the means and methods of rehabilitation, in partnership with relevant Chinese organisations and specialists. The Hainan facility is also planned to become a holiday location for international astronauts.

The Association of Sino-Russian Technical Universities (ASRTU) set-up a joint nano satellite project between Chinese and Russian students. The project is an extension of the previous Lilac Sat Projects, allowing the same teams to now work on the ASRTU project. ASRTU was established in 2011, for the purpose of initiating hands-on projects for students.

FRANCE

On the occasion of the official visit of the French Prime Minister Édouard Philippe to the People's Republic of China from 22 to 25 June, CNES President, Jean-Yves Le Gall, held a first meeting with Zhang Kejian, the new CNSA-Administrator. On 25 June, the two agency heads signed in Beijing in the presence of the French Prime Minister and his Chinese counterpart a specific agreement on implementing the Space Climate Observatory.

This new agreement consolidates space cooperation between France and China and enables new bilateral activities revolving around the Space Climate Observatory (SCO), which was announced at the One Planet Summit in Paris on 12 December 2017. SCO aims at pooling climate data from space and make them readily available to the international scientific community.

After the signature, Jean-Yves Le Gall stressed that he attaches special importance on the implementation of the Space Climate Observatory. LeGall also emphasised that the launch of the CFOSat ocean-surveying satellite is expected in autumn and that China is the guest of honour at the Toulouse Space Show, taking place during the next days.

United Nations World Meteorological Organization (WMO)

On 25 June 2018 the China Meteorological Administration (CMA) set up an operation office for the World Meteorological Centre Beijing (WMC-Beijing) in the National Meteorological Centre of CMA. The main responsibilities of the WMC-Beijing Operation Office is to take on WMC-Beijing's routine coordination and operations support and management, serve as the working connection and communication point with other WMCs and WMO relevant programmes to play a leading role in the Global Data-processing and Forecasting System (an initiative by the UN).

China has established an emergency response mechanism for disaster prevention and mitigation to serve countries along the Belt-and-Road region, said CMA. Under the mechanism, those countries can submit applications to the World Meteorological Organization for starting the mechanism once they encounter typhoon, rainstorm, sandstorm or other extreme weather. Then, CMA would operate on-duty Fengyun satellites for frequent regional observation over the disaster areas every five to six minutes.

SCO - Shanghai Cooperation Organisation

In his speech at the Shanghai Cooperation Organisation Summit on 10 June in Qingdao, Shandong Province, President Xi Jinping offered meteorological services to all parties through its series of Fengyun 2 weather satellites, which are able to cover all Chinese territory, as well as countries involved in the Belt-and-Road Initiative, the Indian Ocean and some African countries. Many of the SCO countries are characterised by high mountains, deserts, oceans and a lack of meteorological information. The number of meteorological disasters in this region is more than double the world average.

In response to a request from the WMO and APSCO, the position of Fengyun 2H, launched on 5 June, was changed 7.5° westward from the original plan. The WMO has included China's Fengyun series of meteorological satellites as a major part of the global Earth observation system. They provide data to customers in more than 80 countries and regions.

At the SCO Summit, President Xi also called for solid cooperation in education, science, technology and disaster relief.

UAE - United Arab Emirates

In QR 3-2017 we reported that the UAE is planning a human space flight programme and aims at partnering with all major space agencies. For the flight of its first professional cosmonaut however, UAE has not partnered with China but with Roscosmos, to use a seat which became available because the U.S. businessman who had booked a flight to the ISS was shifted to a later flight.

APPLICATIONS

Fire protection: Based on spacesuit and navigation technology, CALT developed an intelligent firefighter suit that has cooling capability and can send accurate firefighter positioning information to a background system in real time. The smart suit is currently going through several tests.

AI: China is promoting the development of artificial intelligence (AI) technology for applications in space programmes, Zhang Duzhou, a member of the Chinese Association of Automation and the Chinese Society of Astronautics, said during the National Space Day conference in Harbin. While currently AI technologies are developed for visual image recognition, visual tracking, rendezvous and docking, navigation and positioning, mission planning and spacecraft fault diagnosis, future spacecraft could be capable of self-learning, autonomous perception and planning and self-decision.

Inmarsat: At the end of April, Inmarsat signed a contract with the China Transport Telecommunication Information Group Company Limited (CTTIC) to build a local SwiftBroadband-Safety (SB-S) satellite communication operation platform in China. In addition, Inmarsat, CTTIC and Aviation Data Communication Corporation (ADCC) will jointly provide the advanced SB-S aviation safety service to China's aviation industry. SB-S is also under flight evaluation by Shenzhen Airlines.

Airbus: At the end of May, CTTIC and Airbus Defence and Space inaugurated a remote sensing laboratory in Beijing. Both sides will cooperate to provide more accurate transport information using InSAR data.

Cultural conversation: CALT has developed an advanced book protection system based on aerospace technologies. The structure of special storage boxes is based on rocket heat insulation, honeycomb sandwich structure of the rocket fairing and composite material used in the spacecraft capsule. CALT is planning systems for libraries, museums, archives and temples to help protect cultural relics.

Food safety: Engineers from CASIC's Institute of Radio Metrology and Measurements developed a handheld electronic device which can determine within 10 sec and with an accuracy of 80 to 90%, the freshness of meat. Its sensors and meters are based on space technology. Connected via Bluetooth with a mobile phone app, it detects and measures the presence of ammonia and volatile organic compounds to determine bacteriological activity in uncooked meat.

Airport security: CASIC experts also developed an AI-powered body-scanner for airports, able to detect up to 89 banned items within 0.7 seconds with an accuracy rate of 95%.

Archaeology: A team of Chinese, Tunisian, Italian and Pakistani scientists used Chinese space-based remote sensing technology to discover ten new archaeological sites in the southern provinces of Gafsa, Tataouine and Medenine in Tunisia. The project is part of the Digital Belt-and-Road (DBAR) where one main focus is on Natural and Cultural Heritage, aiming at the preservation, protection and restoration of heritage sites throughout the Belt-and-Road region.

Patent filings: Space-related technology patent applications are on the rise in China, U.S. data analytics firm Govini observed. While in other countries the number of patents filed recently decreased, the number increased in China by 13.3 percent over the last five years.

Wenchang Launch Site: The city government of Wenchang, plans to build an aerospace supercomputing centre and a big data industry cluster project in the near future, promoting the coordinated industrial growth of local information technology, aerospace equipment research and design, as well as life science research through the application of high-performance computing, cloud computing, big data and artificial intelligence. The centre will be crucial for satellite application research and development, the application of high-resolution data and development of a big data industry around spatial information.
Also envisaged are: an industrial platform for spatial big data and a spatial remote-sensing big data cloud platform to serve countries participating in the Belt-and-Road Initiative, an international launch centre, research and development bases and platforms for international exchanges and cooperation. Wenchang is also preparing for an "aerospace plus" industry demonstration park, comprising a space theme-park with tourism activities; applications for space science; research in farming with space-flown seeds; biological, pharmaceutical and aerospace medical research; and innovation development. The projects are open to social and private investments.

EDUCATION

Models of the Long March 2F, 3A, 5 and 7 along with models of the Chang'e 3 Lunar Lander and Yutu Lunar Rover were donated by the China Science and Technology Museum to the Space Exploration Gallery at the Tech Dome Penang in Komtar, Malaysia. For the opening of the exhibition in July, Chinese space experts will give presentations and hold workshops at the Tech Dome.

On 19 June, the first “MSTA series lectures” (MSTA: Major Science and Technology Affairs) was held at Beihang University. The first talk, titled “From Dongfanghong 1 to Manned Spaceflight” was given by Academician and Chinese space pioneer, Qi Faren.

Additionally, Yang Hong introduced the three-step strategy of China’s manned spaceflight project and the difficulties and key problems remaining to be conquered during the process of building China’s space station.

The series of lectures will be continued by inviting scientists and engineering and technical experts who have received national key awards and were witnesses of major science and technology affairs, major science and technology achievements and major science and technology special projects.

MISCELLANEOUS

Space Day - Beijing

On 25 April, a panel discussion to celebrate the 50th anniversary of the founding of the China Astronaut Research and Training Centre took place in Beijing. Along with 12 Chinese colleagues, French astronaut Jean-Francois Clervoy, Russian cosmonaut Yuri Baturin, and Malaysia's astronaut Sheikh Muszaphar Shukor, shared their space experiences and stressed the importance of international cooperation.

With respect to international cooperation in human space flight, Clervoy said that it would make sense to find opportunities on complementary science and hardware development. For that, ESA could provide back-up solutions to critical systems in China's future long-distance, long-duration missions. Baturin said that Russia has accumulated a rich experience in space station construction, and can work with China in fields such as science research and space station operation. Malaysia's first and only astronaut Sheikh Muszaphar Shukor, said that as a surgeon, he noted that China has conducted various cutting-edge research on aerospace medicine and expressed the hope to work with Chinese astronauts to carry out medical experiments. He also looked forward to the chance of participation in China's space station programme.

Space Day - Macao

The 2018 China Space Day Seminar in Macao was held on 24 April at the Macao Science Museum. Zou Yongliao, Director of the Department of Moon and Deep Space Exploration of the Chinese Academy of Sciences, and Xu Ying, a researcher at the Institute of Optics and Electronics of CAS, spoke to nearly 400 high school students about China's Lunar Exploration Project, CLEP, and the Beidou Navigation Satellite System.

Space Day - Taiyuan, Shanxi

During China's National Space Day on 24 April, the Taiyuan Satellite Launch Centre in Shanxi province was open to the public. On 21 and 22 April, Shanxi Science and Technology Museum organised activities on themes that included space robotics, lunar exploration, the dawn of the space century, and Beidou navigation. On 24 April, the National Earth Observation System with High Resolution and Data and Application Centre of Shanxi (or High-Resolution Shanxi Centre) at the Taiyuan University of Technology and the Taichong Exhibition hall was open to the public, introducing satellite remote sensing technologies, satellite models, advanced sensors for extreme environment, data recording equipment and other space facilities to the visitors.

Shanxi province is one of China's important regions with national defence science and technology industry. Future plans are aimed at the establishment of a commercial satellite launch company close to the Taiyuan launch site, along with commercial satellite launch park, satellite and rocket equipment and testing production lines, and an Aerospace Science Museum.

Space Day - Tsang Hin Chi Manned Space Foundation

On the occasion of China's National Space Day, the Tsang Hin Chi Manned Space Foundation, founded by the Hong Kong Goldlion Group, honoured 119 persons with outstanding contributions to China's space missions. The foundation was set up in 2004 by Zeng Xianzi (Tsang Hin Chi) the owner and founder of Goldlion Group. In 2005 the Goldlion Group logo was launched into space on board Shenzhou 6. The awards are given to special talents in China's aerospace sector. So far, 369 astronauts, scientists and project manager were awarded.

Space Day - China Space Foundation

This year, the China Space Foundation has introduced the Space Fund Special Award to reward those who have made outstanding contributions to China's aerospace industry. Six aerospace experts awarded this honour include Zhou Jianping, Zhou Zhixin, Wu Ji, Zhu Kun, Zhu Guangsheng, and Yu Songlin, who received 200,000 Yuan each.

Tracking Station

At the beginning of April, media reported that China may be planning for a space tracking station on the archipelago of Vanuatu which could support future human lunar missions.

On the occasion of its 50th anniversary, the CAST published the "Collection of Space Technology and Scientific Research", a special edition of 23 books, describing major achievements of CASTS's 50-year history, but also outlining directions for the future development of space technology, space applications and space science. It is co-published by the CAST and the Beijing Institute of Technology Press.

PEOPLE cadres

On 24 May, the Chinese government announced the appointment of physicist Zhang Kejian as the new Administrator of CNSA, replacing Tang Dengjie, who was the Administrator until January 2018. Additionally, Zhang becomes Deputy Minister of Industry and Informational Technology (of which CNSA is a part), Director of the China Atomic Energy Authority (CAEA), and Director of SASTIND. Zhang studied high energy density physics at the People's Liberation Army National University of Defense Science and Technology (NUDT), and earned his Master's Degree in Mechanical Engineering from the University of Science and Technology of China (USTC).

At the end of June, 49-year-old He Junke, an aerospace graduate in space technology at the National University of Defence Technology in Changsha and a 14-year veteran aerospace industry technocrat, has been appointed as the Head of China's Communist Youth League. The move is regarded as a consequence of President Xi's focus on the need for young talent "to serve the new era". The fact that China's space scientists are being conferred important political jobs by President Xi Jinping can be seen as an indicator of the importance of aerospace for the Chinese nation.

ON A SIDENOTE

Looking back at his own working experience in NASA, Keith Cowing, now editor of NASA Watch, is providing some interesting food for thought about U.S. cooperation with China. In his comment for NASA Watch, he states: "I was working at NASA in the 1990s when we were tasked with planning to bring the former USSR/Russia into the space station program. Xenophobia abounded. Indeed, you can take everything that circulated back then about how awful the Russians were and just replace that with "China". But we made it work and the ISS is a stunning physical manifestation of what nations can do when they elevate something like space exploration above petty politics. ... A new NASA Administrator and an embryonic space policy being formulated by the National Space Council will have to deal with the issue of China. They have a plan and they are sticking to it with steely determination. Do we just pretend they are not there or do we look back at history's successes and embrace China - and other nations - in the exploration and utilization of space? And for those xenophobes who throw up reasons not to engage with China - just use the word "Russia" instead and then ask yourself if you are being consistent. ... Or we can just ignore China and sit back while they go and develop an extensive international relationship - without us."

International space cooperation is the way forward
Former NASA astronaut Terry Virts and Yang Yuguang from CASIC discussed at China's TV programme space exploration. Yang said that inviting other countries into the programme is a win-win game for both China and the world, as it can not only help China's space programme grow faster, but also bring opportunities to other countries for their science experiments. Virts said that his favourite part of being an astronaut is embracing different life styles in space.

In a commentary for "The Diplomat", senior analyst and author Namrata Goswami shared her observations: "In my several interactions with the space community in the United States, there is a tendency to underplay Chinese space developments as things the U.S. achieved decades ago, with China only now catching up. ... Consequently, when significant advancement is registered by China, space policy makers in the United States are taken by complete surprise."

left: A photographic portrait: A woman in no man's land - Wang Yaping's terrestrial taikonaut training

The Moon is still strategic - a comment by Morris Jones
"Decades after the Moon became covered in American flags and footprints, the nearest world in space is becoming strategic again. Recently, China launched a satellite to orbit the L2 Earth-Moon Lagrange point. This is not the first time China has launched something to the Moon, but it's a harbinger of a space program that seeks to outstrip all international rivals in the decades ahead. Later this year, a Chinese robot lander will touch down on the far side of the Moon, becoming the first spacecraft in history to land there safely. It will deploy a small rover and conduct scientific experiments, including a small biological laboratory. ... Becoming the first nation to land on the far side of the Moon is a grand achievement, but the best is yet to come."

LAUNCHES

2018-034A
2018-034B
2018-034C
2018-034D
10 April 2018 - 04:25 UTC (12:25 BJT)

launch site: Jiuquan Satellite Launch Centre; LC43, Pad94
launcher: Chang Zheng 4C
payloads:
Yaogan-31 01-1 (YG-31 01-1)
Yaogan-31 01-2 (YG-31 01-2)
Yaogan-31 01-3 (YG-31 01-3)
Weina 1B

The main payload for the CZ-4C was the first identical triplet of the new 31-series of Yaogan remote sensing satellites.
All three YG-31-01 satellites were launched into a 1,100 km, 63.4 degrees inclined orbit, similar to the Yaogan 9 series. They were built by China Spacesat (formerly Aerospace DFH), a subsidiary of CAST. Their task is to conduct electromagnetic environmental probing of the oceans and other related technological tests. There is very limited information available on these satellites.

The Weina 1B micro-nanosatellite for technology experiments was an secondary payload. It is owned by MicroStar Technology Co. Ltd. Weina 1B joined the first satellite of this type launched in January. Five more Weina satellites are expected in 2018.

2018-040A
2018-040B
2018-040C
2018-040D
2018-040E
26 April 2018 - 04:42 UTC (12:42 BJT)

launch site: Jiuquan Satellite Launch Centre; mobile platform
launcher: Chang Zheng 11
payloads:
Zhuhai 1-02-1 (OVS-2)
Zhuhai 1-02-2 (OHS-01 - Qingkeda 1)
Zhuhai 1-02-3 (OHS-02)
Zhuhai 1-02-4 (OHS-03 - Guiyang 1)
Zhuhai 1-02-5 (OHS-04)

The CZ-11 released one video (OVS) and four hyperspectral (OHS) satellites into a 500 km, 97.4 degrees inclined orbit. All satellites were built by Zhuhai Orbita Aerospace Science and Technology Co. Ltd. They belong to Zhuhai Orbita's Zhuhai 1 commercial remote sensing satellite constellation, which will provide satellite big data service for agriculture, forestry, animal husbandry and fishing, land and water resources, environmental protection, transportation, smart cities and modern finance industries all over the world. Zhuhai aims to deploy 34 video, hyperspectral, and small personal satellites (OPS) over the next few years.

The 90 kg, box-shaped OVS-2 has a video imaging resolution of 0.9 m. The video sequences are 120 sec long. It is equipped with a three-part solar cell delivering 100 to 180 W. OVS-2 is the improved version of the prototype video satellites Zhuhai 1A and 1B (resolution: 1.98 m), launched in June 2017. The video swath covers an area of approx. 22.5 km x 2.7 km, roughly 67.5 km^2.

On board were also the four box-shaped OHS-01/02/03/04 satellites from the OHS-2 series, each with a mass of 80 to 100 kg. They are equipped with hyperspectral cameras and two solar panels providing 100 to 180 W. 32 spectral band sensors gather imaging with a resolution of 10 m and cover an area of 140 km x 0.24 km, around 33.6 km^2. The revisiting time is every five days. Two of those satellites were given names by its sponsors. Qingkeda 1 was developed in cooperation with the Qingdao University of Science and Technology. Guiyang 1 resulted from a government supported partnership between industry and academia.

2018-041A
03 May 2018 - 16:06 UTC (04 May - 00:06 BJT)

launch site: Xichang Satellite Launch Centre; LC2
launcher: Chang Zheng 3B/G2
payload: Apstar 6C (Yatai 6C)

The Apstar 6C communication satellite, based on the DFH-4 satellite bus, is equipped with 26 C-band and 19 Ku/Ka-band transponders. Particular Ku-band capacities are reserved for East-China and Mongolia. The box-shaped satellite has a size of 2,36 x 2,10 x 3,60 m. Two 6 m-long solar panels provide 10.500 W, 20 % more compared with Apstar 6. At the same time the capacity of the available upstream-downstream channels was increased by 371%.

Manufactured by CAST for Hong Kong-based APT Satellite Co. Ltd., Apstar 6C has a designed life of 15 years. It will be positioned in GEO to provide high-performance services such as TV transmission, communication, internet and multimedia services to customers across the Asia-Pacific region.

By 14 May it had moved to its working location at 136.5°E where it will replace the still operating Apstar 6 satellite. Already on 30 May, Apstar 6C took over some operations for Apstar 6 which encountered some problems with its solar panels. The official hand-over of operations from CGWI to APT was on 7 August 2018 (BJT).

Apstar 6C is China's 10th commercial communication satellite for export, and the 2nd entire Chinese satellite sold to an international satellite operator. Also, it is the 12th satellite within CGWIC's in-orbit delivery programme. The contract with APT Satellite was signed on 17 October 2015, making it the 2nd communications satellite for the Hong Kong telecommunications operator after Apstar 9.

CAST has a another contract with APT to produce the Apstar 6D, an improved version of the DFH-4 satellite platform.

left: Launch of YG-31. credit: Xinhua/China internet

below: The Long March 11 rocket's payload fairing is positioned over the Zhuhai 1 Earth observation satellites before launch. credit: Zhuhai Orbita

2018-043A
08 May 2018 - 18:28 UTC (09 May 02:28 BJT)

launch site: Taiyuan Satellite Launch Centre; LC9
launcher: Chang Zheng 4C
payload: Gaofen 5 (GF-5)

The Gaofen 5 high-resolution hyperspectral imaging satellite for environmental monitoring was launched into a 700 km SSO. The satellite is capable of obtaining spectral information from ultraviolet to long-wave infrared radiation. For that, it is equipped with six advanced observation payloads: the Advanced Hyperspectral Imager (AHSI), Visual and Infrared Multispectral Sensor (VIMS), Greenhouse-gases Monitoring Instrument (GMI), Atmospheric Infrared Ultraspectral (AIUS), Environment Monitoring Instrument (EMI) and Directional Polarization Camera (DPC).

The main payload, AHSI, works with 318 channels providing 20 to 40 m resolution, VIMS has 12 channels and AIUS four.

The Hefei Institutes of Physical Science, the Shanghai Institute of Technical Physics and the Anhui Institute of Optics and Fine Mechanics (AIOFM) contributed to the instrument's development.

GF-5 has the highest spectral resolution among China's remote sensing satellites. The set of sensors allows for comprehensive environmental monitoring, including air pollutants, greenhouse gases, and aerosols. It is the world's first full-spectrum hyperspectral satellite for land and atmospheric observation, allowing the investigation of material composition.

Developed by SAST, the 2.700 kg mass GF-5 satellite is based on the SAST-5000B bus and is fitted with one deployable solar array. It designed life time is eight years.

Gaofen satellites are part of the China High-Resolution Earth Observation System (CHEOS) - a near-real-time, all-weather, global surveillance network of seven satellites for agricultural planning, disaster relief, environment protection, and security purposes.

CHEOS is combining data collected on several platforms: satellites, airplanes and stratosphere balloons. The primary data users are the Ministry of Land and Resources, the Ministry of Environmental Protection, and the Ministry of Agriculture.

It is planned to launch Gaofen 6 and Gaofen 7 this year.

CNSA released an international cooperation plan for GF-5, specifying fields that will be open for cooperation and commercial service and for countries along the Belt-and-Road Initiative.

During the launch of GF-5, the Long March 4 launcher used for the first time a new technology to reduce the load caused by lateral high winds. The rocket carried an integrated navigation system developed by SAST which adds a Beidou navigation modus to the GPS and GLONASS modes.

On 13 May, the Miyun ground station received during a 9 min, 32 sec-long downlink the first 60 GB of data from GF-5, which were transmitted to the Institute of Remote Sensing and Digital Earth (RADI), CAS for post-processing.

Gaofen 5 satellite. credit: CCTV

2018-045A
2018-045B
2018-045C
20 May 2018 - 21:28 UTC (21 May - 05:28 BJT)

launch site: Xichang Satellite Launch Centre; LC3
launcher: Chang Zheng 4C
payloads:
Queqiao (QQ)
Longjiang 1
Longjiang 2

In preparation of the Chang'e 4 landing mission on the far side of the Moon - to be launched in December 2018 - the CE-4R (Chang'e 4 Relay) deep-space communications relay satellite, called "Queqiao" (Magpie Bridge) was launched into lunar transfer trajectory to be positioned in a Halo orbit around Earth-Moon-Lagrange point 2 (EML-2).

Queqiao is based on the CAST 100-bus. Its launch mass is 448 kg. It is a box-shaped satellite with two solar panels and a 4.2 m foldable parabolic antenna, deployed after launch. For orbital manoeuvring, QQ is equipped with a 130 N engine.

QQ uses X-band for the communication with the Chang'e 4 lander and rover, and S-band for the signal transmission between Earth and satellite. Its life time is five years. QQ has also low-frequency antenna on board. QQ reached its working position 65,000 to 85,000 km behind the Moon on 14 June.

Along with QQ travelled two lunar micro-satellites built by the Harbin Institute of Technology: DSLWP A1 and A2 (**D**iscovering the **S**ky at **L**ongest **W**avelengths **P**athfinder), also called Longjiang 1 and Longjiang 2. Each weighs 45 kg and has a dimension of 50 x 50 x 40 cm and can navigate independently. On 25 May it was confirmed that Longjiang 2 successfully entered lunar orbit, sending Earth rise photos, while the contact with Longjiang 1 was lost on 21 May.

Both satellites were registered in the OSCAR-Network for Radio Amateurs: Lunar OSCAR 93 (LO-93) for Longjiang 1 and Lunar OSCAR 94 (LO-94) for Longjiang 2. Only LO-94 is active.

In our next issue we will have a detailed report on the Chang'e 4 mission.

2018-048A
2018-048B

02 June 2018 - 04:13 UTC (12:13 BJT)
launch site: Jiuquan Satellite Launch Centre, LC9
launcher: Chang Zheng 2D
payloads:
Gaofen 6 (GF-6)
Luojia 1-01 (LJ-1-01)

Gaofeng 6 is a high-resolution imaging satellite based on the CAST-2000 bus. It is box-shaped with a size of 1,56 x 1,56 x 1,87 m and has a mass of 1,064 kg. Solar panels on the outside of the satellite body and one foldable panel deliver 1,000 W. GF-6 was built by China Spacesat (formerly Aerospace DFH), a subsidiary of CAST. The cameras came from Changchun Institute of Optics, Fine Mechanics and Physics. It carries one 2 m-panchromatic/8 m-multi-spectral camera and one 16 m-multispectral medium-resolution, wide angle camera. The wide-angle swath is 800 km while for the other cameras it is 90 km. Its data will be used for the monitoring of natural

Gaofen 1-01	**2013**, 26 April	**Gaofen 10**	**2016**, 31 August
Gaofen 2	**2014**, 19 August	**Gaofen 1-02**	**2018**, 31 March
Gaofen 8	**2015**, 26 June	**Gaofen 1-03**	**2018**, 31 March
Gaofen 9	**2015**, 14 September	**Gaofen 1-04**	**2018**, 31 March
Gaofen 4	**2015**, 28 December	**Gaofen 5**	**2018**, 08 May
Gaofen 3	**2016**, 09 August	**Gaofen 6**	**2018**, 02 June

disasters, the evaluation of agricultural projects and the survey of forest and wetland resources. Positioned in a 645 km high, 98 degrees inclined orbit, GF-6's expected life time is 8 years.

The first 40 GB-data package was received by Miyun ground station during a 6 min-long downlink stream on 4 June.

GF-6 will replace GF-1, launched in 2013. It is the 12th Gaofen ('high resolution') satellite for the CHEOS China High-Resolution Earth Observation System. All are in sun-synchronous orbit (SSO) except for the geostationary GF-4.

Luojia 1 (Luojia 1 = science experiment satellite 1), a secondary cubesat payload from Wuhan University was also deployed. The 10 kg, 6U cubesat carries a low light level imager with 100 m resolution for studies of the illumination on the Earth's night side. Luojia 1-01 is a prototype for a network of 60 to 80 of those satellites. The second test cubesat is under development.

2018-050A
05 June 2018 - 13:07 UTC (21:07 BJT)

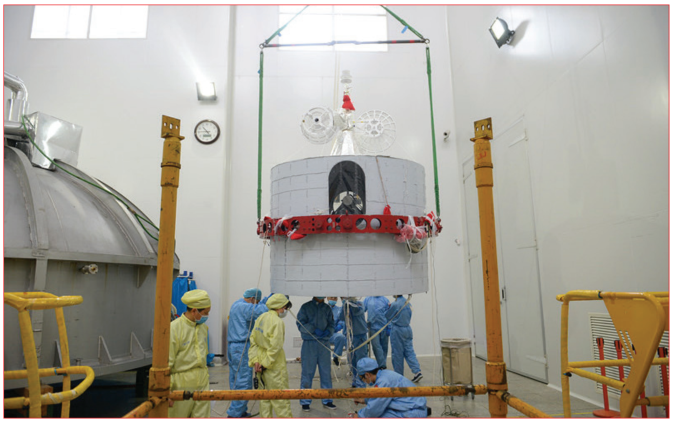
launch site: Xichang Satellite Launch Centre; LC2
launcher: Chang Zheng 3A
payload: Fengyun 2H (FY-2H; FY-2-09)

FY-2H was launched 5 days ahead of schedule which originally had the date set for 10 June.

The three-axis, spin-stabilized (100 rpm) GEO meteorological satellite is cylindrically shaped with a diameter of about 2.1 m, a height of 4.5 m and a mass of 1,380 kg. The take-off mass is including a disposable engine - the on-orbit mass of FY-2H is 680 kg. The satellite's solar cells, wrapped around the drum-like body, deliver 300 W. Despite its continuously improved performance, it is the last in the FY-2 series of Chinese spin-stabilized geostationary meteorological satellites. It will be replaced by China's next-generation geostationary meteorological satellites, the Fengyun-4 series (first was launched in 2016) and by the Fengyun-3 series for polar orbits.

It was developed by the Shanghai Institute of Satellite Engineering (SISE) under CAST with a designed life of 4 years. Fengyuns are operated by the China Meteorological Administration (CMA) and the National Remote Sensing Centre of China (NRSCC).

After four months of in-orbit tests, FY-2H will provide real-time cloud and water vapour images, along with space weather information, to countries across Asia-Pacific. Its payloads include DCS (Data Collection Service), a Stretched Visible and Infrared Spin Scan Radiometer (S-VISSR) with one visible light and four infrared channels, which will be able to monitor floods and flood-related weather hazards such as typhoons. The satellite also carries a Space Environment Monitor (SEM), and a Solar X-Ray Monitor (SXM).



The Fengyun-2H weather satellite during space environment testing. credit: CASC

In response to a request from the World Meteorological Organisation (WMO) and APSCO, the position of FY-2H will be changed from the original location of 86.5°East longitude to 79°East. The WMO has included China's Fengyun series into the global Earth observation system.

The satellite will not only cover Belt-and-Road countries, and the territory of APSCO Member States, but also the Indian Ocean and most African countries.

Data will be free to Belt-and-Road countries and APSCO member countries. The Belt-and-Road region, characterised by high mountains, deserts and oceans, lacks meteorological information. Damage from natural disasters, especially meteorological disasters, in this region is more than double the world average. China has helped establish ground stations to receive the data in some APSCO member countries, including Pakistan, Indonesia, Thailand, Iran and Mongolia. China plans to upgrade the stations and provide training to technicians in those countries.

According to the Medium- and Long-Term Development Plan for China's Civil Space Infrastructure (2015-2025), China has planned 11 satellites related to the meteorological service, including three FY-3 satellites, two FY-4 satellites, and one twilight orbital climate satellite, one high-precision greenhouse gas detection satellite, one hyperspectral satellite, as well as one newly developed geostationary orbit microwave detection satellite and two precipitation radar satellites.

2018-054A
2018-054B
27 June 2018 - 03:30 UTC (11:30 BJT)

launch site: Xichang Satellite Launch Centre; LC3
launcher: Chang Zheng 2C
payloads:
Xin Jishu A (XJS A)
Xin Jishu B (XJS B)

Xin Jishu A and B are two technology satellites for testing intersatellite communications and for conducting new technology tests for Earth observation. Not many details became known on this pair of satellites. They were built by DFH Satellite Company under CAST. One satellite is bigger than the other - both are equipped with solar panels. CALT confirmed that both satellites were arranged in a special launch configuration on top of the lengthened version of the CZ-2C launcher, so that a special payload fairing had to be used. The engineers also modified the payload separation mechanism to guarantee a low-shock deployment in a 485 km, 35 degree orbit.

Jonathan McDowell reported that the two satellites' name 'xin jishu shiyan' A and B translates to: New Technology Test Satellite A and B. Satellite A made small orbit corrections from 29 June to 3 July and was taking the lead for satellite B by 1,100 km.

Launch preparation of iSpace' Hyperbola 1 on Hainan island. (see page 9)
credit: iSpace/Chinese internet

Jonathan McDowell reported in his Space Report No. 751 from 28 July 2018:

"Tiangong 2

China's Tiangong-2 spacelab was used for a single human expedition in 2016; China has announced that no further visits are planned. Since Shenzhou 11 left in Nov 2016, TG-2 has made small reboost manuevers on 2017 Mar 5, Apr 5-6, May 13, Jun 17-20, Sep 17, and Nov 4. The Tianzhou-1 freighter docked with it several times between Apr and Sep 2017 and transferred an unknown amount of propellant. The freighter carried about 2000 kg of propellant in eight 250 kg tanks, half of which were for its own maneuevers. I am guessing each of the three propellant transfer exercises that were carried out involved one tank's worth.

On 2018 Jun 13 at around 0645 and 0735 UTC the lab made a two-impulse manuever to lower its orbit from 388 x 391 km to 293 x 299 km. It seemed as if this might be a precursor to a deorbit burn, but on Jun 22 at about 0117 and 0202 UTC a second two-impulse manuever restored the orbit to 390 x 399 km. The full sequence used about 330 kg of propellant.

If we assumed Tianzhou left the 1000-kg-capacity tanks full, that leaves about 670 kg. Total mass of Tiangong-2 including propellant is probably now around 8500 kg. At least 250 kg of propellant is required to safely deorbit the vehicle at end of mission.

As of Jul 26, Tiangong-2 remained in a 386 x 395 km orbit."

Meet the man leading the way for China's space exploration

Yang Hong is the Chief Architect of the space lab system for China's Aerospace Science and Technology Corporation. From the spacecraft Shenzhou 1 to Shenzhou 5, he has witnessed the country's milestones in manned space missions. Yang leads a dynamic team, which average age is 34 years. He believes that everyone played an important role in the smooth running of China's space programmes

Young Female Welder Devoted to Aerospace Industry

Wang He is one of China most skilled welders for aerospace components, having won several welding competitions. She works as a spacecraft circuit board welder for the electronic fitting centre of the Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, and has welded hundreds of spacecraft components and parts in the past 12 years. Wang was involved in the Shenzhou, Tiangong and Chang'e space programmes. "Welding is like sewing and welding for spacecraft is like making embroidery which requires high accuracy in temperature and skill," Wang said.

__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*

ACC	Astronaut Centre of China
AI	artificial intelligence
AICTO	Arab Information and Communication Technology Organisation
APSCO	Asia-Pacific Space Cooperation Organisation
ASTRON	Netherlands Institute for Radio Astronomy
BDS	BeiDou satellite navigation Systems
BJT	Beijing Time
BLSS	Bioregenerative Life Support System
CALT	China Academy of Launch Vehicle Technology, 1st Academy of China Aerospace Science and Technology Corporation CASC
CAS	Chinese Academy of Sciences
CASC	China Aerospace Science and Technology Corporation
CASIC	China Aerospace Science and Industry Corporation
CAST	China Academy of Space Technology
CFOSat	China-French Oceanography Satellite
CGWIC	China Great Wall Industry Corporation
CLEP	China's Lunar Exploration Programme
CMA	China Meteorological Administration
CMSA	China Manned Space Agency
CMSEO	China Manned Space Engineering Office
CNES	French Space Agency
CNSA	China National Space Administration

COPOUS	Committee on the Peaceful Uses of Outer Space
CSES	China's Seismo-Electromagnetic Satellite
CSMTC	China Satellite Maritime Tracking and Control Department
CSNO	China Satellite Navigation Office
CSS	Chinese Space Station
CSU	Technology and Engineering Centre for Space Utilisation
CTTIC	China Transport Telecommunication Information Group Company Limited
CZ	Long March, Changzheng
DAMPE	Dark Matter Particle Explorer
EC	European Commission
ESOC	European Space Operations Centre
FAST	Five-Hundred Metre Aperture Spherical Radio Telescope
GEO	Geostationary Orbit
GMT	Greenwich Mean Time
GNSS	Global Navigation Satellite System
IAMCAS	Innovation Academy for Microsatellites of CAS
IGMA	International GNSS Monitoring and Assessment
IRDT	inflatable re-entry and descent technology
IRF	Swedish Institute of Space Physics
ITU	International Telecommunication Union

KACST	King Abdulaziz City for Science and Technology
KZ	Kuaizhou
LHAASO	Large High Altitude Air Shower Observatory
LINA-XSAN	eXtra Small Analyzer for Neutrals
LJ-2	Longjiang 2
NCLE	Netherlands Chinese Low-Frequency Explorer
NSSC	National Space Science Centre
PLA	People' s Liberation Army
QQ	Queqiao
SAST	Shanghai Academy of Spaceflight Technology
SASTIND	State Administration of Science, Technology and Industry for National Defence
SCO	Shanghai Cooperation Organisation
SECM	Shanghai Engineering Centre for Microsatellites
SUPARCO	Space and Upper Atmospheric Research Commission
SZ	Shenzhou
TG	Tiangong
UN	United Nations
UNOOSA	UN Office for Outer Space Affairs
UTC	Coordinated Universal Time
WMC-Beijing	Meteorological Centre Beijing
WMO	World Meteorological Organization

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Wu Ji and Chinese Space Science

by Brian Harvey

A cult of personality is not one of the defining characteristics of the Chinese space programme. It is not well known for its personalities, although there are exceptions: the chief designer, Tsien Hsue Shen (1911-2009); the original space scientist, Zhao Jiuzhang (1907-1968); and of course, its astronauts like Yang Liwei and Liu Yang. Other names appear from time to time, like rocket designer Long Lehao and lunar evangelist Ouyang Ziyuan and they are often quoted in newspaper interviews or for their scientific papers. Any space programme, though, is affected by its key personalities and understanding them, the role they play, their influence, importance and approach, is a part of understanding the programme as a whole. In China, a key emerging personality is Wu Ji, whose modest manner is eclipsed by his ambition for what Chinese space science could achieve. He came to prominence in the scientific publishing world in 2018 when Springer published his short but landmark book *Calling Taikong - a strategy report and study of China's future space science missions* (1).

Wu Ji. Credit: Brian Harvey

Wu Ji is very much one of the modern generation of leaders of the Chinese space programme. The original leadership was born early in the 20th century, studied in the United States, Soviet Union and Europe in the 1930s and helped establish the programme after its formal foundation on 8th October 1956. Most of them lived to a very old age, several passed a hundred and some are even still alive. Wu Ji was born after the space programme was established, in 1958 in Beijing and graduated in electrical engineering.

Like many of the early leadership, he studied abroad, but in the new Europe. He obtained his PhD at the Technical University of Denmark and then worked in the European Space Agency (ESA) European Space Research and Technology Centre (ESTEC) on multi-beam antennae for communication satellites. He became an expert in antennae, ocean and land microwave remote sensing and space weather, taking a senior role in the Tan Ce, Chang'e and Yinghuo missions. In the last case, he specifically helped to design a mission which he considered would fill an important gap in Martian studies, namely its atmosphere and why its water was lost which had been neglected in favour of surface landers and rovers. Yinghuo (2011), unfortunately, was lost on the doomed Russian Phobos-Grunt Sample Return mission, but the idea of studying the atmosphere was subsequently taken up by the American MAVEN (2013) and Europe's Exomars Trace Gas Orbiter (TGO) (2016).

Zhao Jiuzhang. Archive photo

At the Moscow 2017 conference to mark the 60th anniversary of Sputnik, Wu Ji delivered a wide-ranging talk on the topic of space weather and the potential consequences of Earth being affected by a knock-out blow of solar radiation. He is increasingly well known internationally and is a vice-president of the international committee on space research, COSPAR. He has been a president of the International Lunar Exploration Working Group (ILEWG).

Wu Ji has been known for his critical approach to the country's space programme. According to him, China's space programme was good on engineering and applications, but science lagged and lacked a mandate or a budget. Science had been, for many years, the poor relation of the Chinese space programme and one of its lowest priorities. China's first satellite, the Dong Fang Hong, was originally to be a scientific satellite, but the instruments were taken out in favour of a tape recorder playing *The east is red*. The next satellite, though, was scientific, Shijian 1 (1971), with a basic suite of instruments (cosmic ray detector, x-ray detector, magnetometer). It successor, Shijian 2 (1981), was a more ambitious three-in-one mission with no less than thirteen instruments.

Space science, though, languished from this point and the programme turned to the challenge of recovering satellites from orbit in the 1970s and the first communications satellites in the 1980s. Shijian was in effect the programme's scientific series, but Shijian 3 was cancelled and the small Shijian 4 and 5 radiation satellites had to wait until 1994 and 1999 respectively. Many scientific projects were proposed, such as the Tianwen orbiting astronomical observatory, which dated to 1976. The project was largely completed when it was cancelled in 1985, although some of its instruments found their way into the new manned space programme on board Shenzhou 2. The idea of a solar telescope was resurrected in 1992 but was not funded until 1997 and then redefined in 2011 but is still on the ground. Two recoverable Shijian missions, with biological and materials processing cargoes, were delayed for some time. Occasionally, instruments were able to hitch a lift on Fengyun weather satellites.

Being a space scientist must have been a discouraging profession then, with few missions flying and others delayed or disappearing. It was probably not much consolation that space scientists elsewhere fought similar battles for priority in their space programmes too, Russia being a prime example. The only bright spot during this period was the Tan Ce or Doublestar mission, with launches in 2003 and 2004, carried out in cooperation with ESA, one with a huge scientific haul of over 2,300 papers published by European and Chinese scientists.

2009 was the landmark year in which everything began to change and, one suspects, the government and governing bodies of the space programme finally listened to the critical comments of Wu Ji and his colleagues. That year, the Academy of Sciences published *Science and technology* *in China - a roadmap to 2050: strategic general report of the Chinese Academy of Sciences*, a monumental report outlining China's scientific future until the year 2050 under a broad range of headings, such as energy, information technology, synthetic biology, brain function, ecological agriculture, predictive health, security and genetics. It was self-critical, describing how China had become a scientific backwater. Never again, it said and China must be the world's leading scientific nation by the year 2050 in discovery and invention and publishing more scientific papers than any other nation (there is a problem about the last commitment, for it was met by 2018). The report singled out 22 technology areas for development, such as photosynthesis, geothermal energy, nanotechnology, regenerative medicine, synthetic biology and mathematics. This report was completely missed by western countries, maybe because it fell outside the conventional narrative of what they normally wanted to hear about China.

The academy report was not a government report, but it can be assumed that its approach was broadly supported and approved by government, much as would be the case in other countries. Here, the most interesting feature was that space science was the focus of one of the 18 working groups for the roadmap, which published its own sub-report, *Space science and technology in China - a roadmap to 2050*. The editor? Wu Ji, with a colleague, Guo Huadong. This dedicated roadmap was the outcome of a working group of forty specialists, institutes, study bodies and space centres. The critical tone of the *Roadmap* was remarkable, repeatedly emphasizing the gap between China and other countries: China's record in space science did not match its status as an emerging space power, it said. Although China had invested ¥900m over 1996-2005, China's contribution to scientific papers worldwide was 'a very small portion'. Space telescope technology lagged 'far behind the international level'. This time, someone in Springer picked up the report and had it published in English (2).

In 2016, Nature magazine included Wu Ji into its top 10 list of most important scientists.

The space science *Roadmap* was a real turning point, for it led to the Strategic Priority Plan on Space Science (SPPSS) and the founding of the National Space Science Centre (NSSC), both in 2011. The idea of the strategic plan was to get rid of the old idea of individual space projects that struggled case-by-case to get funding year by year and might be eventually launched. Instead, there would be priorities, lines of development, themes and timeframes, the time periods coinciding with the national five-year plans. Four or so projects would be agreed and carried out, while in the background, feasibility studies would be undertaken for a batch of new projects. The idea was to have four or so missions for each five-year period while study began on a new set of missions, which would then find their way into the next five-year periods (14th plan, 2021-2025; 15th plan, 2026-2030) and so on. The earlier chaos would give way to an orderly system, timetable and pipeline for selecting missions for preliminary study, more detailed design study, approval, development and eventual launch. Not only that, but each mission would have a Principal Investigator (PI), the team leader responsible for the proposal, payloads and analysis and two chiefs - a chief project manager and chief designer. Similar systems were well known and long known to space science management in Europe and the United States, but when applied to China at last gave the programme a sense of purpose.

In 2011, China's new National Space Science Centre was set up to take responsibility for planning space science, with Wu Ji as its founding director. The NSSC took over the former Centre for Space Science and Applied Research (CSSR), in turn constituted from Zhao Jiuzhang's Institute of Applied Geophysics (1958) which later became the Institute of Space Physics and the Centre for Space Science and Technology (1978). The old CSSR held the China Space Science Data Centre and was responsible for a collection of institutes and facilities, such as the Miyun ground receiving station, Hainan ionospheric observatory, the Beijing cosmic ray observatory, the Beijing super neutron monitor, the sounding rocket base in Hainan and the space plasma environment test laboratory, but it had little profile within the programme or abroad. It may have been best known as the home of the China committee of the international committee on space research, COSPAR.

The important point, though, was that a single, unified National Space Science Centre put space science centre stage in the programme for the first time, which held out the promise that it would now be properly planned and obtain its fair share of the budget. It was formally charged with responsibility for research, design, assembly, coordination and scientific support and included postdoctoral students. In 2011, the NSSC was allocated a budget of ¥300m (€38m), later expanded to ¥700m, a staff complement of 450, including 50 scientists and subsequently built a 19.4ha, ¥914m, €100m campus. The staff complement was built quickly and is now 507. The NSSC received in 2017 a visit from the journal *Nature*, whose Jane Qiu reported it smelling of fresh paint, kitted out with new furniture, a hive of activity, with engineers running mission simulations, film crews making documentaries and motivational slogs on the walls (e.g. *Be diligent and meticulous!*) (3).

The Strategic Priority Plan meant the setting down of 14 lines of development (black holes, astro-oscillations, astrophysical objects, exo-planets, the Sun (micro and panorama), space weather, micro-satellites, solar system, fundamental physics, extraterrestrial life, life sciences and material processing), each heading with an assigned set of missions. Five science missions were identified in the first set of 2011 approvals, while four more were identified for study for development over 2016-2020, while another group of four was identified to follow.

A key element was funding, with the budget rising from ¥3.5bn (€437m) in 2011-15 and set to rise to ¥5.9bn (€737m) in 2016-2020 to ¥8.6bn (€1.075bn) in 2021 and ¥11.6bn (€1.45bn) in 2026-2030. The low starting of €437m was low compared to the space science budgets of other countries and was behind the United States (€4.5bn), Europe (€800m), Japan (€900m), Russia (€550m) and ahead of India (€40m), but will eventually overtake all but the United States. It started at about 10% of the programme as a whole. In 2016 Wu Ji reported on progress in *Prospects for Chinese space science, 2016-2030*, published by the Academy of Sciences. The real test of the new system, though, was would these new missions actually fly?

First up was the Dark Matter Particle Explorer (DAMPE) in December 2015, named *Wukong* on reaching orbit and which within two years collected a vast set of data on gamma rays, high-energy particles and cosmic rays. The delayed Shijian 10 recoverable mission flew in April 2016. Next was Quantum Experiments at Space Scale (QUESS) in August 2016, named *Micius*, which caused a sensation in the communications world by setting up a photon-based secure communications link between China and Austria. Then came the Hard X-ray Modulation Telescope (HXMT), a project devised in the 1990s but which had languished for many years. Launched in June 2017 and named *Huiyan*, it quickly began to trap x-ray radiation as its camera scanned the heavens.

Only one of the planned missions in the first, 2011-15 timeframe set did not fly, *Kuafu*. This was a long-standing European-Chinese mission to study the Sun, design of which had reached an advanced stage even before 2010. *Kuafu* collapsed suddenly during the ESA ministerial conference in Naples in November 2012. The reasons are obscure and unlikely to be found in any published document. *Kuafu* may have become caught up in China's proposal to join the Galileo navigation satellite programme, which the Americans successfully opposed. Canada, an ESA associate member, withdrew from *Kuafu* (likely political reasons in the form of prime minister Stephen Harper's antipathies to China) and then ESA found itself without a budget for the mission. It was, despite this unsettling experience, replaced by a lower-cost (€100m) mission, Solar wind Magnetosphere Ionosphere Link Explorer (SMILE) to fly soon after 2020.

Although the *Kuafu* project fell through, several other science projects which were not formally part of the list did fly. These were the small XPNav, an intriguing test of the possibility of using pulsars for deep space navigation (November 2016); a carbon observatory called Tansat (December 2016); and the Experimental Satellite on Electromagnetic Monitoring (ESEM), named *Zhangheng*, an Earthquake-detection satellite with Italian participation (2018). In addition, two collaborative missions with France have made progress: the Chinese French Oceanic satellite, launched in 2018 and Space Variable Object Matter (SVOM) (due 2021).

Tansat was interesting because it had its origins in the project 863 horizontal science funding programme. It progressed from study (2010) to preliminary design review (2012) to launch (2016) in only six years, probably an indication of the emerging priority of environmental issues. Likewise, *Zhangheng* emerged quite quickly, having been announced only in 2014 and may have been funded by or through the Institute of Geology in the China Seismological Bureau. *Zhangheng* built on Russian research dating to the 1980s, whereby Sergei Pulinets and his colleagues found that it was possible to detect electrical waves 90 - 120 mins from orbit before Earthquakes struck, but this had been dismissed in the west as 'quack science'.

The next box of missions, awaiting approval and if successful, launch after 2020, are the Einstein Probe (EP); Water Cycle Observation Mission (WCOM); Magnetosphere Ionosphere Thermosphere (MIT); and the Advanced Space Based Solar Observatory (ASO-S), the latter two dating back a number of years but which now have the prospect of progressing at last. The following box, now in early study, but expected to progress design over 2020-4 and fly after 2025, are the Solar Polar ORbit Telescope (SPORT); X-ray Timing and Polarization mission (XTP); Space Millimetre VLBI Array; and Search for Extra Terrestrial Planets (STEP).

Further details of China's space science ambitions were published in *Calling Taikong*. Wu Ji outlined a set of prospective new scientific missions far beyond the original *Roadmap 2050*, likely to see their way onto the manifests some time in the 2020s. These cover such areas as gravitational waves (the Taiji, Tianqin and Ali missions); microgravity (Qingying, Quingyang, Qingyan and Tengyun); the energy cycle (six satellites); biochemical programme (two satellites); the search for extra-terrestial life (Jupiter/Earth twin Exoplanets and Exo-zodiacal Dust Imager and Spectrometer (JEEEDIS)). Individual missions were listed in the field of deep-space observations (Space Ultra Low Frequency Radio Observatory (SULFRO); Ultra Violet Emission Mapper (UVEM); COsmology and Molecule Explorer (COME); the Sun (Deep-space Solar Observatory (DSO); Solar Polar Region Explorer (SPORE); Super High Angular

Science missions 2015 - 2017

2015	Wukong - Dark Matter Particle Explorer DAMPE
2016	Shijian 10
2016	QUESS-Micius - Quantum Experiments at Space Scale
2017	HXMT-Huiyan - Hard X-ray Modulation Telescope

Smaller ad-hoc missions

2016	XPNav	using pulsars for deep space navigation
2016	Tansat	carbon observatory
2018	ESEM	Experimental Satellite on Electromagnetic Monitoring - Zhangheng
2018	CFOSat	
2021	SVOM	Space Variable Object Matter

2020 - 2025 batch

EP	Einstein Probe
WCOM	Water Cycle Observation Mission
MIT	Magnetosphere Ionosphere Thermosphere
ASO-S	Advanced Space Based Solar Observatory
SMILE	Solar Wind Magnetosphere Ionosphere Link Explorer
GECAM	Gravitational Wave Electromagnetic Counterpart All-sky Monitor

2025 - 2030 batch

SPORT	Solar Polar ORbit Telescope
XTP	X-ray Timing and Polarization mission
STEP	Search for Extra Terrestrial Planets
Space Millimetre VLBI Array	

resolution Principle for coded mask x-ray imaging (SHARP-X); Solar Radio Array at extremely Low Frequency (SRALF), Stereoscopic Polarization Imagers for Explosive Sun (SPIES), Solar Energetic Emission and Particle Explorer (SEEPE) and Multi-layer Exploration of Solar Magnetic and Velocity Field (MESMV)). There will be four successors to SMILE: China Geomagnetic Satellite (CGS); Meridian Chain Nanosats for the Magnetosphere; Small Satellite for the Equatorial Ionosphere; and Micro-satellite Fleet for the Geomagnetic Field and Radiation Belt. These names may be a mouthful to digest, but they indicate the scale, ambition and distinct fields of the space science programme.

Almost ten years since the 2009 *Roadmap*, the reorganization of Chinese space science with a national institute, framework programme and funding, appears to be succeeding, the launch record so far being the best possible evidence. Although internal attention inevitably focusses on the Chang'e lunar missions and the upcoming space station, the number of new missions flying and timetabled indicate that Chinese space science may have at last found a place in the space programme that Zhao Jiuzhang would have approved. Much of this should probably be attributed to Wu Ji.

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Overview on China's Space Science Missions

by Dr. William Carey

DAMPE

DArk **M**atter **P**article **E**xplorer

The name in Chinese is 'Wukong' which means 'understanding the space' which for this mission has the primary scientific objective of measuring electrons and photons at higher resolution than current experiments to identify sources of Dark Matter (DM).

The specific research goals are:

- to study DM particles through the high-resolution observation of high-energy electrons, gamma-ray spectrum and its spatial distribution;
- to study the origins of cosmic-rays via observation of the high-energy electron spectrum and anisotropy in the TeV energy region; and
- to study the propagation and acceleration mechanisms of cosmic-rays through the examination of their heavy ion spectra.

The total payload mass of ~1,480 kg of the DAMPE telescope consists of four components:

- a double-layer of Plastic Scintillator Detector (PSD);
- a Silicon-Tungsten Tracker Converter (STK);
- an imaging calorimeter constructed of 14 layers of Bismuth Germanium Oxide (BGO) bars; and a Neutron Detector (NUD) consisting of sixteen scintillator plates, each read by a photomultiplier.

The DAMPE satellite was launched from the Jiuquan Satellite Launch Center on 17 December 2015 at 08:17 Beijing Time, into a Sun-synchronous orbit at an altitude of 500 km. It reached its anticipated lifetime of three years in December 2018, when its operational lifetime was extended by two years, as it remained in good condition and is currently continuing to collect key scientific data.

The mission is an international cooperation between institutes from China (four institutes under CAS, including NSSC Beijing, and the Hefei University of Science and Technology of China), Switzerland (University of Geneva), and Italy, (Universities of Bari, Lecce and Perugia), together with other numerous universities and particle physics institutes (including CERN).

QUESS

QUantum **E**xperiments at **S**pace **S**cale

The nickname for this satellite is 'Micius', after a fifth-century BC Chinese scientist named Mozi (or Micius in Latin) who discovered that light travels in straight lines. The satellite is a proof-of-concept mission to enable long-distance quantum optics experiments to further the development of quantum encryption and quantum teleportation technologies.

The scientific objectives are:

- the implementation of a long-distance communication network that is based on high-speed Quantum Key Distribution (QKD) between the satellite and the ground station;
- to achieve major breakthroughs in the realisation of practical space-borne quantum communications;
- and to investigate quantum entanglement distribution and quantum teleportation on a space scale;
- and perform fundamental tests of the laws of quantum mechanics on a global scale.

The QUESS satellite has a total mass of ~640 kg, and consists of a highly stable mini-satellite bus for precise pointing, so that the ground stations can lock-on to the optical link from the satellite.

Payloads include:

- a quantum key communicator,
- a quantum entanglement emitter,
- a quantum entanglement source,
- a quantum experiment controller and processor,
- and a high-speed coherent laser communicator.

The launch from the Jiuquan Satellite Launch Center, took place on 15 August 2016, and placed the satellite into a Sun-synchronous orbit at an altitude of 500 km.

Two secondary payloads on this launch were:

- the Lixing-1 microsatellite; and
- the six-unit cubesat 3Cat-2.

QUESS had an anticipated operational lifetime of two years, which was extended by another 2 years.

Operated by the Chinese Academy of Sciences (CAS), the QUESS satellite mission is a joint Chinese-Austrian cooperation between CAS and the University of Vienna together with the Austrian Academy of Sciences (AAS).

ESEM

Experimental **S**atellite on **E**lectromagnetism **M**onitoring

The ESEM satellite is also on occasion referred to as ZH-1 (named after Zhang Heng (78-139), a Chinese polymath, astronomer and seismologist of the Han-Dynasty), or the China Seismo-Electromagnetic Satellite (CSES-1).

The ESEM satellite has the primary objective of studying the ionospheric disturbances (i.e. earthquake precursors) induced by seismic activity and evolving earthquake mechanisms. Specifically, to analyse the temporal correlation between seismic events (especially those of high magnitude) and electromagnetic perturbations in the upper ionosphere - the aim being to identify observations which would enable short-term earthquake forecasting. Collected data will also facilitate the study of solar-terrestrial interactions and solar physics phenomena including Coronal Mass Ejections (CMEs), solar flares, and cosmic-ray solar modulation, and also on the space environment of the Earth's electromagnetic field, ionospheric plasma and energetic particles and try to understand the possible impact of human activity on the Earth's near-space environment.

Based on the CAST2000 satellite bus, ESEM has a total mass of ~730 kg, and incorporates six deployable booms that will maintain the electromagnetic detectors at a distance of more than 4 m from the satellite. In order to detect and measure the high-energy particles, plasma, and electric and magnetic fields, ESEM accommodates the following instruments:

- a search-coil magnetometer,
- an electric field detector,
- a high-precision magnetometer,
- a GNSS occultation receiver,
- a Langmuir probe,
- a plasma analyser, and
- a tri-band beacon (to measure in-situ plasma and ionospheric profile).

While the High-Energy Particle Detectors are an Italian contribution, the High Precision Magnetometer is a China-Austria cooperation. The same type of magnetometer will be also be used for ESA's Jupiter mission JUICE in 2022.

ESEM was launched from the Jiuquan Satellite Launch Center on 2 February 2018 and placed in a 98-degree Sun-synchronous circular orbit at an altitude of 500 km. The anticipated lifetime is 5 years. There were six secondary payloads on the launch which included: Fengmaniu 1, GomX-4A (Ulloriaq), GomX-4B, Nusat 4 (Ada), Nusat 5 (Maryam) and Shaonian Xing.

The mission is a Chinese-Italian cooperation between the China National Space Administration (CNSA) and the Italian Space Agency (ASI). ESEM was developed by the China Earthquake Administration (CEA) and the Italian National Institute for Nuclear Physics (INFN) together with numerous Chinese and Italian universities and institutes.

SVOM

Space-based Multiband Astronomical **V**ariable **O**bjects **M**onitor

A joint Chinese-French astronomy mission between the China National Space Administration (CNSA) and the Centre National Etudes Spatiales (CNES), with a primary objective to detect and study Gamma-Ray Bursts (GRBs) generated by the explosion of massive stars or the merger of neutron stars or black holes.

There are a number of lower level specific objectives related to cosmology, fundamental physics and high-energy astrophysics, and to achieve these objectives, the operations strategy involves a combination of space-based observation with coordinated ground-based measurements.

The payload consists of four instruments:

- the ECLAIRS Large Field Telescope,
- the MXT Narrow Field Telescope,
- the GRM Gamma Detector,
- and the VT Narrow Field Telescope.

SVOM is scheduled for launch in 2021 into an orbit at an altitude of 600 km, and has an anticipated lifetime of 3 years.

HXMT

Hard **X**-ray **M**odulation **T**elescope

HXMT, also: ‘Insight’, is China’s first X-ray astronomy satellite.

The main scientific objectives of the Insight mission are:

- to scan the Galactic Plane to find new transient X-ray sources and to monitor known variable sources;
- to observe X-ray binaries to study the dynamics and emission mechanisms in strong gravitational or strong magnetic fields;
- to find and study gamma-ray bursts.

There are three main scientific payloads:

- a high-energy X-ray telescope (20-250 keV),
- a medium-energy X-ray telescope (5-30 keV),
- and a low-energy X-ray telescope (1-15 keV).

HXMT was launched on 15 June 2017 from the Jiuquan Satellite Launch Center, and following a 5-month period of commissioning, began operations on 30 January 2018.

HXMT is jointly funded by the CNSA and CAS.

GECAM

Gravitational Wave **E**lectromagnetic **C**ounterpart **A**ll-sky **M**onitor

The GECAM mission is a Chinese space telescope for detecting X-rays and gamma-rays.

This mission arose due to the historic detection of gravitational waves by the U.S. ground-based Laser Interferometer Gravitational-Wave Observatory (LIGO) in February 2016.

It consists of two micro-satellites (GECAM-A and GECAM-B) in low Earth orbit placed on opposite sides of the Earth, to detect gamma-ray bursts in the energy range of 8 keV to 2 MeV.

Currently in ‘Phase A’ it is planned to start operations in the latter half of 2020. In combination with coordinated ground-based measurements, the mission may shed light on the debate of whether the merger of black holes also produce electromagnetic radiation, in addition to the merger of neutron stars (which has been observed).

Although a wholly Chinese mission, potential cooperation would be with ground-based detectors.

XPNAV-1

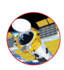
X-ray **P**ulsar **NAV**igation Satellite-1

The XPNAV-1 mission is the first satellite of a three-step experimental programme to observe X-ray pulsars. XPNAV-1 is a mini-satellite of 270 kg developed by CAST, featuring a three-axis attitude stabilisation mode having the capability to point to a defined inertial position (on demand) to an accuracy of up to 2 arc-minutes with up to 90 minutes sustained observation (limited by the power supply).

The primary objective of this first satellite is to validate the capability to observe X-ray pulsars, using X-ray instruments developed by CAST. This first mission will be followed by the launch of a medium sized satellite (within 2-3 years) to accumulate additional X-ray data, and to test pulsar navigation algorithms (once 3-5 pulsars have been accurately timed). The third step is to build a constellation system to demonstrate navigation and time services using X-ray pulsars.

The main payload complement consists of two X-ray devices: a Time-resolved soft X-ray spectrometer (TSXS), and a High Time resolution Photon Counter (HTPC). The TSXS utilises a Wolter I type lens of four nested mirror shells (collection area 30 cm^2) to focus the incoming X-ray photons within the 15 arcminute Field of View (FoV) onto a Silicon Drift Detector (SDD). A GPS-calibrated Rb clock is included to provide accurate timing, and a quasi-parallel optical star used to assist the inertial pointing. The TSXS device provides a 1.5 μs time resolution and a 180 eV @ 5.9 keV energy resolution in the 0.5 to approx. 10 keV energy band. The HTPC device uses the collimator to confine the FoV to 2 degrees and the Micro-Channel Plate (MCP) X-ray detector to count the X-ray photons in the 1 to approx. 10 keV energy band from the pulsar. Compared to the TSXS, the MCP of the HTPC has a higher time resolution of 100 ns and a bigger collecting area of 1,200 cm^2. In addition to the main payload, there were two secondary payloads: Xioaxiang-1, a 6U cubesat (8 kg) developed by the Changsha Gaoxinqu Tianyi Research Institute in Hunan; CAS 2T & KS 1Q, a 2U cubesat that remained attached to the upper stage of the CZ-11.

XPNAV-1 was launched on 10 November 2016 from the Jiuquan Satellite Launch Centre, into a 500 km SSO orbit (97.4 degree inclination), using a CZ-11 launch vehicle. The satellite completed its test phase on 17 November 2016 and entered into its observation phase. To help achieve the primary objective, the Crab pulsar was selected a calibration target as it is a bright source of X-rays and well-studied. The results of 162 observations of the Crab (each lasting between 10 and 90 minutes) confirmed the capability to observe pulsars in the soft X-ray band, implying that primary objective of the mission had been achieved. Observations looking for weaker X-ray sources continues.



eXTP

Enhanced **X**-ray **T**iming and **P**olarimetry Mission

The eXTP mission has been developed to study the state of matter under extreme conditions of density, gravity and magnetism.

The primary goals are:

- the determination of the equation of state of matter at supra-nuclear density;
- the measurement of QED effects in radiation emerging from magnetised stars; and
- the study of the dynamics of matter in the strong gravity field regime: “one singularity (black holes), two stars (neutron stars and magnetars) and three extremes (gravity, magnetism and density)”.

The mission will carry a unique and unprecedented suite of state-of-the art scientific instruments, enabling for the first time, simultaneous spectral-timing-polarimetry studies of cosmic sources in the energy range 0.5 to 30 keV (and above). The major payload elements consist of:

- Spectroscopic Focusing Array (SFA): A set of 9 X-ray optics operating in the 0.5-10 keV energy band with a field-of-view (FoV) of 12 arcmin each and a total effective area of ~0.8 m² and 0.5 m² at 2 keV and 6 keV respectively. The telescopes are equipped with Silicon Drift Detectors offering <180 eV spectral resolution.
- Large Area Detector (LAD): A deployable set of 640 Silicon Drift Detectors, achieving a total effective area of ~3.4 m² between 6 and 10 keV. The operational energy range is 2-30 keV and the achievable spectral resolution better than 250 eV. This is a non-imaging instrument, with the FoV limited to <1 degree FWHM by using compact capillary plates.
- Polarimetry Focusing Array (PFA): A set of 4 X-ray telescopes, achieving a total effective area of 900 cm² at 2 keV, equipped with imaging gas pixel photoelectric polarimeters. The FoV of each telescope is 12 arcminute and the operating energy range is 2-10 keV.
- Wide Field Monitor (WFM): A set of 3 coded mask wide field units, equipped with position-sensitive Silicon Drift Detectors, covering in total a FoV of 3.7 steradian and operating in the energy range 2-50 keV.

Currently the launch date is scheduled for 2025, on a CZ-7 launch vehicle. The proposed orbit is an altitude of 550 km with 2.5 degree inclination. An extended Phase A was scheduled to be completed by the end of 2018.

The eXTP mission is a major international programme led by China, and currently supported by CAS and CNSA, executed under the NSSC within the framework of activities of the CAS Bureau of Major R&D Programs. CAS's Institute of High Energy Physics (IHEP) in Beijing, leads the science consortium and is coordinating science payload contributions from China and international partners. ESA/NSSC/CAS have initiated a joint study to examine a potential ESA contribution through a 'mission of opportunity', and the Italian Space Agency, ASI, have initiated the coordination of anticipated European contributions.

Einstein Probe

The EP mission will perform systematic all-sky surveys via a wide-field X-ray telescope to discover high-energy transients of various types over a wide range of timescales at a high cadence. Any newly discovered transients will be immediately observed via a narrow-field X-ray telescope, and a fast-alert system will also allow additional follow-up observations by multi-wavelength facilities around the globe. This mission may shed light on questions such as the origin and evolution of black hole populations, the generation mechanism of gravitational waves, and their effects and life-cycle of the first generation of stars, during re-ionisation in the dark early Universe.

The primary scientific objectives are:

- Reveal quiescent black holes at almost all astrophysical mass scales and study how matter falls onto them by detecting transient X-ray flares, particularly stars being tidally-disrupted by otherwise dormant massive black holes at galactic centres.
- Discover the X-ray photonic counterparts of gravitational-wave transients found with the next generation of gravitational-wave detectors and determine their precise location.
- Carry out systematic and sensitive surveys of high-energy transients, to discover faint X-ray transients, such as high-redshift Gamma-Ray Bursts (GRBs), supernova shock breakout, and new types of transients.

EP will carry two scientific instruments:

- a Wide-field X-ray telescope (WXT) with a 60 degree by 60 degree field of view (FoV), and
- a Follow-up X-ray telescope (FXT) of 1 degree by 1 degree FoV, together with a fast-alert downlink system.

Novel Micro-Pore Optics (MPO) is used (for both instruments) in the lobster-eye configuration to achieve a wide FoV and X-ray focusing. This approach, can achieve a FoV of thousands of square degrees with very little weight - unique for wide-field X-ray imaging. The nominal bandpass of WXT is 0.5-4.0 keV.
The payload has a mass of 150 kg and power consumption of 200 W - easily accommodated by one of the micro or small satellite platforms readily available in China.

The mission is currently scheduled for launch in 2020 timeframe into a circular orbit at an altitude of 600 km, inclination around 30 degrees (or less), and a period of 97 minutes.
The mission was conceived by the CAS institutes NAOC and IHEP and the Tsinghua University, and is open to international collaboration (mainly UK presently).

WCOM

Water **C**ycle **O**bservation **M**ission

The WCOM will be the first Earth Science driven satellite mission for China, with the most synergetic capabilities for global water cycle observations, and will provide unprecedented, accurate observations through simultaneous monitoring of key water cycle elements, e.g. soil moisture, snow water equivalent, surface ice, ocean salinity, atmospheric water vapour, precipitation and other associated parameters. The resulting datasets will enable the refinement of long-term satellite observations made during the past decades, and to represent the changing trend in hydrological elements needed for global change studies.

The mission concept of the WCOM satellite is a combination of active and passive microwave remote sensors with a wide frequency coverage. The satellite payloads (~450 kg) consist of an Interferometric Microwave Imager (IMI), a Dual-frequency Polarised microwave Scatterometer (DPS) and Polarimetric Microwave Imager (PMI).

Currently in the engineering phase, WCOM is scheduled for launch around 2020, into a sun synchronous orbit at 600 km altitude, and inclination of 97.8 degrees, and has a projected lifetime of 3-5 years.

WCOM was initiated jointly by the Institute of Remote Sensing and Digital Earth and the National Space Science Centre with the Chinese Academy of Sciences (CAS). CAS will cooperate with U.S. and European research teams to initiate a satellite constellation based on WCOM, with the aim to form a global water cycle observation network.

MIT

Magnetosphere-**I**onosphere-**T**hermosphere Coupling Small Satellite Constellation

The MIT mission will investigate the coupling (i.e. physical processes) between the magnetosphere, ionosphere and thermosphere.

The primary scientific objectives being:

- to study the origin of the outflow ions and their acceleration mechanisms;
- to understand the impact of the outflow ions on magnetic storm development;
- to characterise the ionosphere and thermosphere storms caused by magnetic storms; and
- to explore the key mechanisms for the magnetosphere, ionosphere and thermosphere coupling.

The constellation is composed of four small satellites (MA/MB and the ITA/ITB) orbiting the Earth at three different altitudes. The satellites will carry a total of 9 identical instruments each, and include particle detectors, electromagnetic sensors, auroral imagers and neutral atom imagers.

Spacecraft MA and MB will be in a polar orbit of 8 Earth radii, but phased so that while MA is at perigee (1 Earth radii) MB will be at apogee (7 Earth radii). The other two satellites (ITA and ITB) will be in a 500 km x 1,500 km polar orbit and have a period of 1/9 of the other two spacecraft. This orbital phasing approach (4 spacecraft at 3 different altitudes) in the polar region will provide optimum coverage for the targeted observations.

The launch of this mission is currently expected in the 2019-2022 timeframe.
The Chinese MIT mission anticipates international cooperation on the MA/MB spacecraft.

ASO-S

Advanced Space-based **S**olar **O**bservatory

The ASO-S mission, as the name suggests, is a mission to study the Sun, the primary focus being to understand the relationship between the solar magnetic field, solar flares and Coronal Mass Ejections (CMEs), which may be abbreviated as '1M2B', i.e. one Magnetism plus two Bursts (flares and CMEs).

The mission's four major scientific goals are:

- to simultaneously observe non-thermal images of solar flares in hard X-rays, and the formation of CMEs;
- to simultaneously observe the full-disc vector magnetic field, energy build up and release of solar flares, together with the initiation of CMEs;
- to observe the response of the solar atmosphere to eruptions;
- and to observe eruptions and evolution of the magnetic field (to assist in the forecasting of solar weather).

To address those science goals, ASO-S will carry three payloads:

- a Full-disk solar vector MagnetoGraph (FMG),
- a Lyman-alpha Solar Telescope (LST), and
- a Hard X-ray Imager (HXI).

The mission is currently expected to launch in 2022 on a CZ-2D launch vehicle, in order to cover the peak years of the (11 year) solar cycle, having a nominal mission design lifetime of approx. 4 years. ASO-S will have a sun synchronous orbit at an altitude of 720 km, and an inclination angle of 98.2 degrees. ASO-S could become the first Chinese solar mission in orbit when launched, and was formally approved by the Chinese Academy of Sciences (CAS) under the Strategic Priority Research Program on Space Science in June 2017.

SPORT

Solar **P**olar **OR**bit **T**elescope

SPORT is intended to be the first mission from a polar orbit around the Sun to measure solar high-latitude magnetism leading to eruptions and the fast solar wind, and to image interplanetary propagation of Coronal Mass Ejections (CMEs) in the ecliptic plane.

SPORT has four top-level scientific objectives:

- characterise CME propagation through interaction with the inner heliosphere;
- investigate the solar high-latitude magnetism associated with eruptions and variation of the solar cycle;
- investigate the origin and properties of the fast solar wind;
- and observe the acceleration, transport, and distribution of energetic particles in the corona and heliosphere.

The SPORT mission will carry a suite of remote sensing and in-situ instruments among which are tentatively,

- an EUV imager (121.6 nm),
- a magnetograph,
- a coronagraph,
- a heliospheric imager,
- a synthetic aperture radio imager,
- a solar wind plasma analyser,
- a magnetometer,
- a radio and plasma wave instrument, and
- an energetic particle detector.

A CZ-5E launch vehicle with upper stage is foreseen to place SPORT into an orbit similar to that of Ulysses around 2020, with its perihelion at 0.7 AU from the Sun, aphelion at 5 AU, and inclination angle of about 75 degrees with respect to the ecliptic plane.

Originally proposed in 2004 by the National Space Science Center, Chinese Academy of Sciences (and later studied jointly by the University of Science and Technology of China, the National Astronomical Observatories of CAS, as well as the China Aerospace Science and Technology Corporation), the mission is now under scientific and engineering background study in China.

International partnerships for instrumentation designs and scientific collaborations are welcomed.

STEP

Search for **T**errestrial **E**xo-**P**lanets

STEP is a mission to detect Earth-like planets.
The primary scientific objective is to use differential astrometry to complete the measurements obtained by other techniques in order to lower the threshold of detection and characterisation down to the level of an Earth mass in the habitable zone of each system. The intent is to explore in a systematic manner all solar-type stars (i.e. of spectral type F, G, K) up to 20 parsecs from the Sun. The high-precision astrometry technique is ideal for the terrestrial exo-planet detection.
The spacecraft will have a 1.2 m primary mirror with focal length of 50 m, and field of view (FoV) of 0.44 degrees, and achieve a 0.5 micro arc second astrometric precision (ideal for the detection of eco-planets). The data rate will reach 65 Gb/day requiring the use of a 64 m antenna for 1.8 hours each day. The final data processing work will last one year after mission completion, but intermediate solutions are expected to be delivered during the observations.

The satellite will be placed at L2, and have a projected lifetime of ~5 years, and international partnership is welcomed.

SMILE

Solar Wind **M**agnetosphere **I**onosphere **L**ink **E**xplorer

The SMILE mission will investigate the connection between the interaction of the solar wind with Earth's magnetosphere via simultaneous observations of the magnetosphere and North Pole aurora, while monitoring the in-situ plasma environment.

The primary scientific objectives of the mission are:

- Explore the fundamental modes of the dayside solar wind/magnetosphere interaction;
- understand the sub-storm cycle;
- and determine how Coronal Mass Ejection (CME) driven storms arise and develop.

Four payloads will be installed on the SMILE satellite:

- the Soft X-ray Imager (SXI) will provide the X-ray image of the dayside magnetopause;
- the Ultra Violet Imager (UVI) will provide the global distribution map of polar aurora;
- together SXI and UVI will coordinate to observe the solar wind-Magnetosphere Ionosphere interaction;
- two other instruments, the Magnetometer (MAG) and Light Ion Analyser (LIA) will measure the magnetic field and plasma in the upstream solar wind and magnetosheath in-situ in real time to determine the original driver.

The 2,200 kg spacecraft is scheduled to be launched by a European Vega-C rocket or Ariane 6-2 in 2023, and subsequently be placed in a highly inclined elliptical orbit. Every 51 hours, SMILE will fly out to 121,000 km, giving it a prolonged view of Earth's northern polar regions. It will then return to within 5,000 km of Earth for data transfer to an ESA ground station in Antarctica and the CAS ground station in Sanya, China.

NSSC/CAS is responsible for the spacecraft platform (built by IAMC/CAS), spacecraft testing, and mission and science operations. ESA is responsible for the payload module, spacecraft test facilities, launcher, launch campaign, and the primary ground station, and will share science operations with CAS. SMILE is an international cooperation project led jointly by CAS and ESA.

2019 in Chinese Space

by Blaine V. Curcio

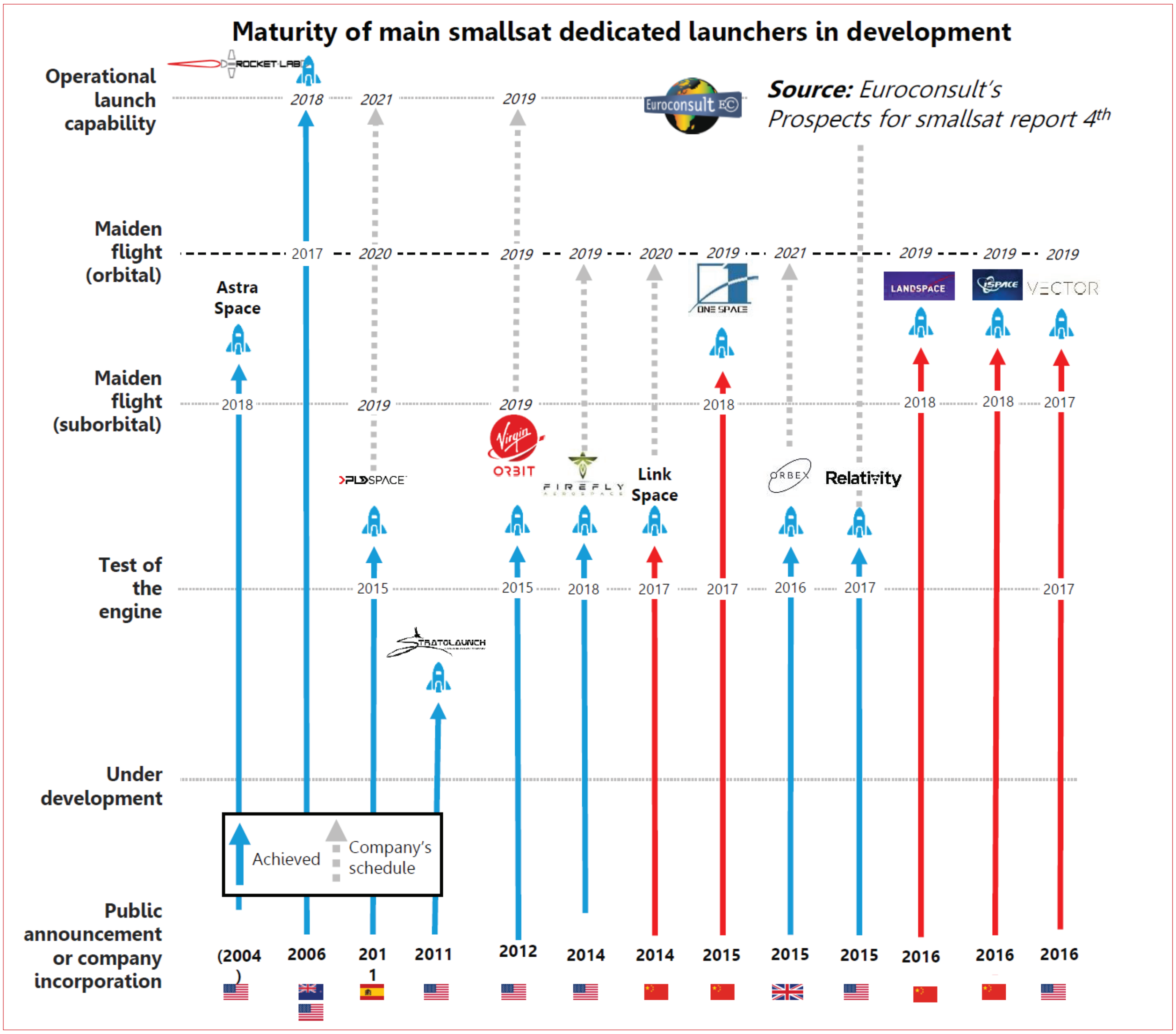
2018 was a monumental year in Chinese commercial space, from the perspective of fundraising, company formation, rocket engine tests, and indeed, English-language media coverage. We saw hundreds of millions of USD pledged to private companies, and the continued development of state-owned projects with budgets in low single-digit billion USD range. With all that being said, the year was not one for execution. Most of the developments in 2018 were for companies or projects in early phases. As these projects start to develop, 2019 will be a year of firsts, and a year when various projects start to achieve very tangible advancements. While always hard to predict, some things to look out for in space in China in 2019 include:

- *Private Launch Companies Achieve Liftoff*
- *Satcom Market May See Deregulation*
- *The Chinese LEO Space Gets Really Interesting*
- *Satellite Integrators Becomes an Industry that Defines China's Advantage in Space*
- *More HTS Enters the Market, Which May Push IFC Regulators*

Private Launch Companies Achieve Liftoff

Private launch companies in China had a significant 2018, and the year was expected to be capped off by the first orbital launch from a Chinese private launch company (Landspace). However, the October 2018 launch ended in a third-stage anomaly, thus causing the satellite to crash into the Ocean. Shortly after the launch failure, Landspace announced a new round of US$ 43 million funding, signaling a degree of resilience, but the implications beyond this are that the title of "first private company to successfully achieve orbital launch" remains up for grabs.

This will likely change in 2019, with multiple private companies planning for their first orbital launch. OneSpace and iSpace - both companies being beneficiaries of >US$ 100 million of



Euroconsult overview on status of global commercial launcher developments. credit: Euroconsult/Blaine Curcio funding- are planning their first orbital launches in H1 2019. One or more of the private launch companies will join Expace (a nominally private launch company that is largely funded by CASIC) and the traditional state-owned aerospace companies as being capable of launching payloads into orbit.

Other developments in the launch industry in China in 2019 will likely include continued advancement on a variety of engines. There are currently around 20 private launch companies in China, though with some limited to the development of a specific engine or component. Ultimately, there are likely to be advancements made in specific areas across a number of niche startups, with the challenge then being how to quickly incorporate these advancements into the state-owned companies that would be the prime contractor for most space projects. Smaller launch companies such as DeepBlue have made advancements in liquid engines and have attracted funding from some of the same VC firms as the larger launch companies.

Satcom Market May See Deregulation

The satellite industry in China has historically been an effective monopoly, with China Satcom and APT Satellite, both under the CASC umbrella, controlling the majority of the market. The advent of HTS, and the subsequent new applications that can be enabled by satellite, may push the market towards some degree of deregulation, with this allowing for more innovative and competitive solutions. This would importantly not only benefit the domestic Chinese satcom industry, but would also allow for more competitive turnkey solutions for satellite export, i.e., if China Great Wall Industry Corp (CGWIC) were to sell a HTS to a developing country for the purposes of connecting 10,000 schools to the internet, the business case would be even easier to sell if CGWIC could also include the equipment needed for 10,000 schools, due to this having also been done in China as a test case.

Other specific HTS verticals that would benefit dramatically from deregulation include in-flight connectivity (IFC). IFC is seen as a huge potential market in China, but one that is hamstrung by regulations for domestic flights, and by the conservative nature of the state-owned airlines that dominate the aviation industry, according to a senior Air China representative in late 2018. Separate to this, Chinese companies that may be eyeing a Southeast Asia, or South Asian satellite targeting mobility or other verticals, would likely have an easier time closing a business case if they were also granted access to China, a point not likely to be lost on the Chinese regulators.

Ultimately, this may lead to 2019 being a year of some deregulation for the satcom industry for companies either based in, and/or operating in China. This could include more companies obtaining licenses and/or offering services for connectivity via satellite, more companies announcing plans to procure a satellite over China and some other Belt and Road region, or in a less likely scenario, more foreign companies selling satellite capacity into China.

The Chinese LEO Space Gets Really Interesting

The last 2 months of 2018 saw some tantalizing developments among the several prospective Chinese LEO constellation companies. In the private sector, Galaxy Space, a private constellation company with funding from Shunwei Capital (the VC of Xiaomi Founder Lei Jun), announced a round of funding in November that valued the company at RMB 3 billion (US$ 450 million). While the value of the funding round itself was not made public, industry rumors indicated at least US$ 100 million of funding. The company later saw Lei Jun, Founder of Xiaomi and almost deca-billionaire as of January 2019, visit their facilities, where he learned about the Galaxy Space project and urged the company to work towards integrating their LEO constellation with 5G and IoT.

2019 is likely to see the launch of Galaxy Space's first LEO communications satellites to an orbit of 1,200 km. Separate to Galaxy Space, a number of programs have been pushed by China's SOEs for LEO constellations, notably *Hongyun* and *Xingyun* from CASIC, and *Hongyan* from CASC. These constellations are well-funded, with CASIC having earmarked RMB 100 billion (US$ 16 billion) to a series of five projects, of which two are a narrowband and a broadband LEO constellation (the others are hypersonic planes, high altitude platform systems (HAPS), and UAVs), indicating a likely budget of at least RMB 30 billion (US$4.5 billion) for the two projects. CASC likewise announced in December 2018 funding of RMB 20 billion (US$ 3 billion) for its *Hongyan* project, a LEO broadband constellation that eventually plans to have 300 satellites. In 2019, both CASC and CASIC are likely to deploy multiple LEO satellites, following the successful first launch of *Hongyan* in December 2018.

Ultimately, 2019 will see multiple Chinese LEO constellations start to deploy. As constellations such as OneWeb start to deploy concurrently, 2019 may also see a pivot by some Chinese constellations into different frequency bands than Ka-band, given the fact that multiple western constellations will have access to that spectrum. One of the more intriguing to watch on the private side will surely be Galaxy Space, given the company's relationships, albeit indirectly, with Xiaomi, one of the world's largest manufacturers of "things", electronic devices that may continue to become more integrated with the Internet as part of the IoT (smartphones, a variety of other electronics, and household appliances, all of which form a sort of "Xiaomi Ecosystem"). Other private constellations such as Commsat

Xiaomi CEO Lei Jun visiting Galaxy Space in December 2018. credit: China Internet

Zero Gravity Labs website of Cubesat components looking like an online shopping experience credit: China Internet and Spacety are also expected to launch more satellites in 2019, with this being the year of the constellation in some respects.

Satellite Integrators Becomes an Industry that Defines China's Advantage in Space

Over the past several years, as launch costs have started to decline, and as smaller satellites have become likewise cheaper and more accessible, a new breed of company has started to emerge. "Satellite integrators" are companies that can provide a variety of services, including launch integration (i.e. buying a launch from a launch company, then selling spots of the launch to companies or universities that want to launch small satellites), building of smallsats, etc.

In China, one such company already exists; Zero Gravity Labs. Zero Gravity Labs is a cubesat and smallsat manufacturer, though the company has a rather unique value proposition. It's website resembles an e-commerce website, complete with a variety of photos, prices, and specifications for components of smallsats. The company has vertically integrated to some extent, inking a deal with iSpace in 2018 for launch services. In this way, Zero Gravity Labs aims to offer a fully integrated service for companies to design, build, and launch smallsats and cubesats. While the end customer for now remains a relatively niche customer segment of universities and companies, if launch costs and component costs continue to decline, the addressable market in five years may be significantly larger.

In this way, the satellite integrator is likely to be a type of company to which operating inside of China is in some ways an advantage, particularly at the lower end of the market in terms of technology. China's competitive advantages include a huge electronics manufacturing supply chain, as well as an equally huge number of qualified engineers who are capable of creating new technologies. The city of Shenzhen, in the heart of China's electronics supply chain, is home to vast markets of electronics subcomponents, with these markets having, in more recent years, attracted an increasing number of Chinese and foreign tinkerers - people who are putting themselves at the center of the world's electronics supply chain and building unique and hi-tech products at a rapid pace. While the space industry in China has yet to reach this level of scale, efficiency, consolidation of supply chain, and indeed technical mastery, it is not far off. Many of China's space industry startups work at the same blistering pace of the nation's tech companies - the phrase 9-9-6 is common in China, referring to startup working hours of 9am to 9pm, 6 days per week- and the pace of technological advancement is impressive.

China's entire space industry will benefit from these inherent advantages - cheap and plentiful engineering talent, fast and cheap electronics supply chains, and scale of demand - but in particular, companies such as satellite integrators will benefit, particularly at the lower end of the market, where demand from Chinese universities, companies, and, at a certain price point, enthusiasts, will be significant.

More HTS Enters the Market, Which May Push IFC Regulators

Late 2019 is expected to see the launch of Apstar-6D, a Ku-band HTS that, when launched, will represent what may be the largest non-NBN satellite over Asia-Pacific today, at around 50 Gbps. While not the first HTS in Asia (this honor goes to Thaicom's IPSTAR, launched all the way back in 2005), Apstar-6D represents a major Ku-band payload coming over Greater China. The satellite's owner, APT Mobile Satcom and its parent company, APT Satellite, have already agreed to a deal with Panasonic Avionics - one of the world's leading In-Flight Connectivity (IFC) service providers - for multiple GHz of Ku-band capacity to be utilized for IFC over Greater China and the Pacific.

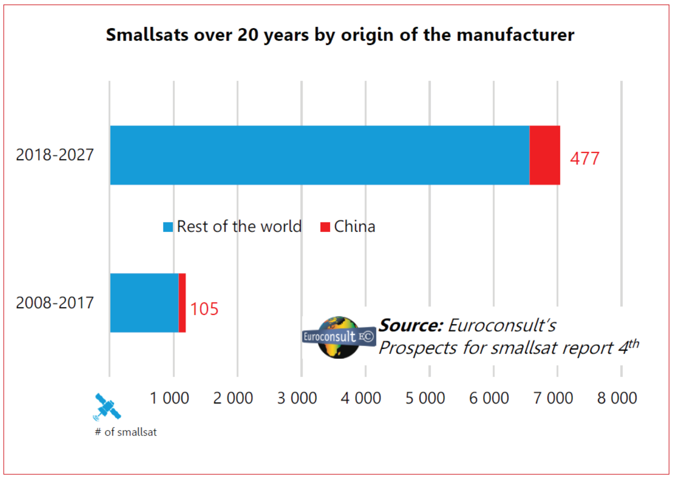
However, IFC remains prohibited on flights within China, a regulation that is expected to change sooner rather than later. The launch of Apstar-6D in late 2019 would provide an additional reason for the regulators to open the IFC market, given the huge amount of capacity coming over the country. Separate to IFC, the launch of Apstar-6D represents the first of what was originally planned to be three HTS satellites launched globally by APT. The second and third satellite remain under review given current market conditions, however the Apstar-6D satellite will nonetheless by itself multiply the amount of sellable capacity by APT Satellite/Apsatcom Shenzhen by a factor of up to 10x.

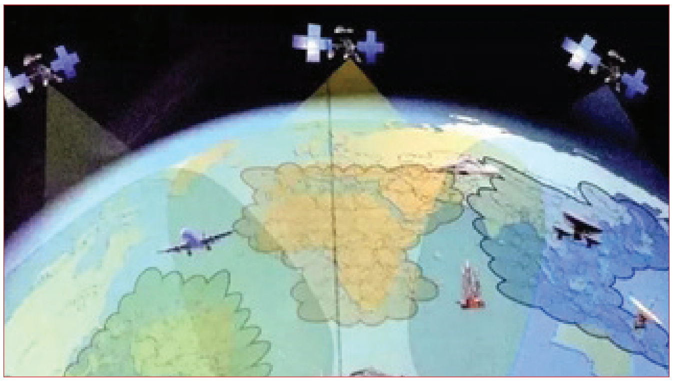
Conclusions

The Chinese space industry saw a monumental 2018, with a record amount of private fundraising, new company formation, technological development, and a fair share of political intrigue.

2019 will be a pivotal year for Chinese space. After the fundraising of 2018, expectations for companies to deliver will be significantly higher, and several companies will achieve notable firsts over the coming 12 months. Constellations will begin to deploy, satellite telecommunications may start to blossom with the increased advent of HTS and potential market opening, and the Chinese export machine will likely ink another one or two turnkey satellite packages to be sold to developing countries.

As China begins to play a more leading role on the global stage, its status in emerging industries will become more important, particularly when those industries are ones that truly capture our imagination and push the boundaries of human capability, industries such as space. Moving forward, Chinese companies, state-owned or private, will continue to develop competitive technologies with speed and scale, in a way that is motivated by both profit and country.





Original constellation plans for APT Satellite/APT Mobile Satcom
credit: China Internet


Thinking
in
visions!
E = m x rc²