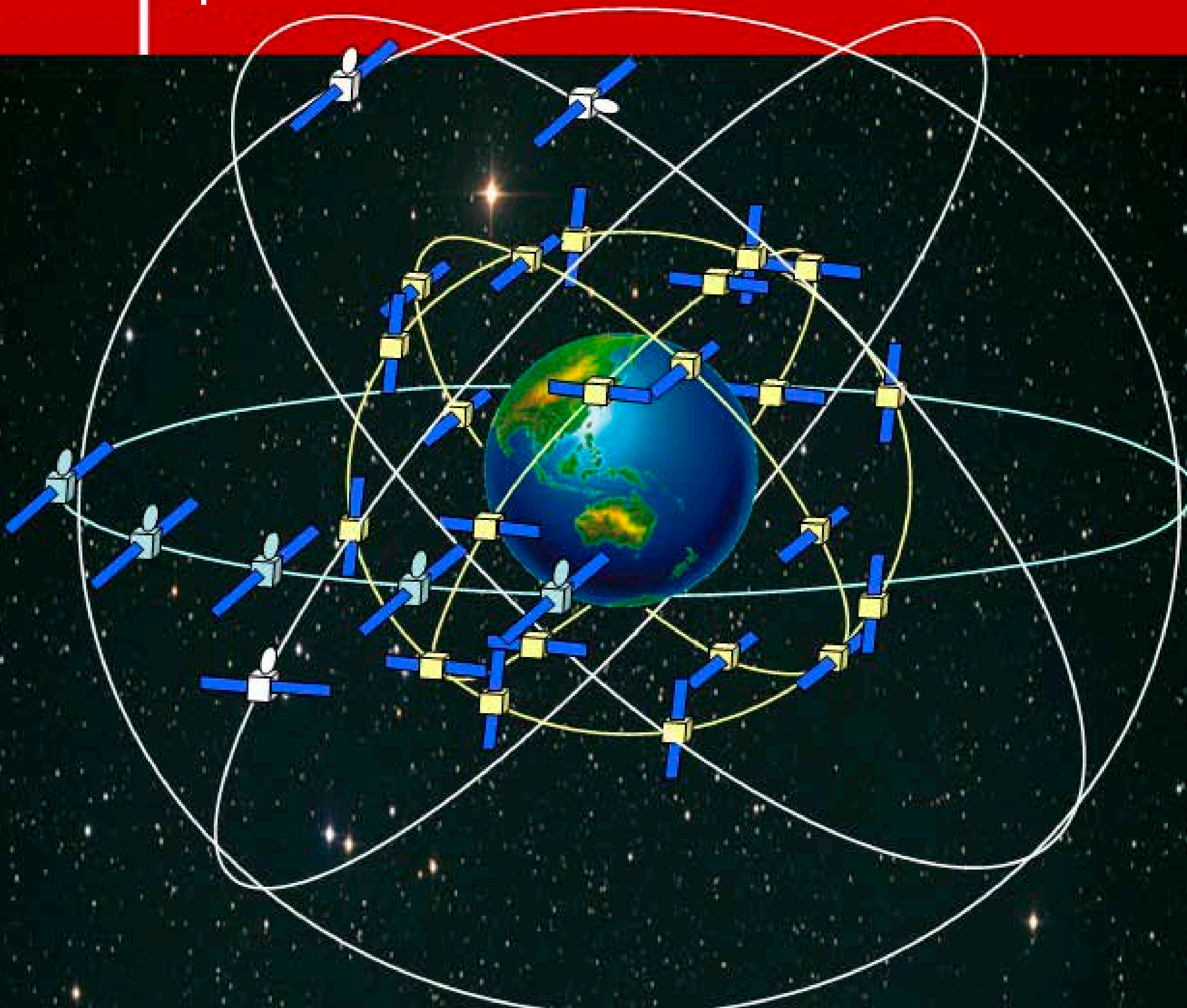
All About The Chinese Space Programme

Go Taikonauts!

龙腾太空

Issue 4 April 2012



Re-invention of Compass

History of the Chinese Beidou Satellite Navigation System

GO TAIKONAUTS!
All about the Chinese Space Programme

Editor's Note

Since Go Taikonauts! started publishing again last August, the Chinese manned space programme has attracted attention all over the world, with the launch of its first space station module and the historic docking mission. ... page 2

Quarterly Report

October - December 2011

Launch Events

The fourth quarter of 2011 was the second busiest launch quarter in Chinese space history. There were eight space launches, just one less than the third quarter of this year: ... page 3

January - March 2012

Launch Events

There were four launches in Q1:

- China's first space launch in 2012 occurred at 11:17, on 9 January. The country's first civil mapping satellite Ziyaun 3 ... page 7

Analysis

No Giant Leap

A Review of China's Space Activities White Papers (2000-2011)

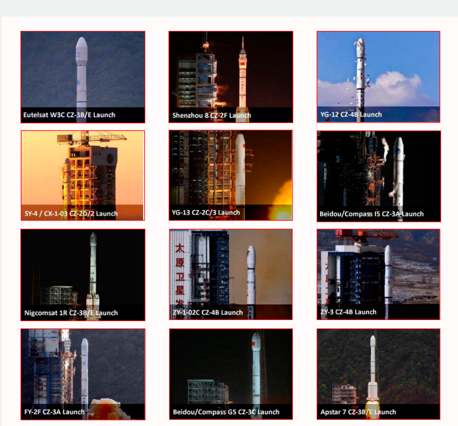
Introduction

On Thursday 29 December 2011, the Chinese government (the Information Office of the State Council) published a White Paper entitled 'China's Space Activities in 2011'. We present here a brief review of the three White Papers (published every five years) in 2000, 2006 and 2011 ... page 25

Gallery

Twelve Launches in Recent Six Months

... page 33



Re-invention of Compass

History of the Chinese Satellite Navigation System

Dual-Sat Concept

China's studies on satellite navigation started very early. Chinese scientists and engineers began to trace technologies and tried to develop receivers of the U.S. Transit navigation system just after it was put into service in the 1960s. In 1983, Chen Fangyun, a CAS (China Academy of Sciences) .... page 11

Interview

ISS - The Bridge Between Atlantic and Pacific?

An interview with Dr. Thomas Reiter, ESA's Director of Human Spaceflight and Operations

The time might soon be right for a Chinese involvement in the International Space Station programme. At the beginning of 2012, voices calling for a Chinese participation in global space efforts are getting stronger. This could start with a Chinese contribution to the ISS. ... page 18

I Found Myself Very Connected With Him

An interview with Mars500 participants Romain Charles and Diego Urbina

In its first issue, GoTaikonauts! published an article on the Mars500 simulation study and an interview with the Chinese participant of the research project, Wang Yue. On 20 March 2012, GoTaikonauts! had the unique ... page 21

Database

Chinese Space Launch History - Part 4

The most detailed Chinese launch record ... page 30

Chinese Launch Sites - Part 4

China has three launch sites in use and one site under construction ... page 32

Editor's Note

Since Go Taikonauts! started publishing again last August, the Chinese manned space programme has attracted attention all over the world, with the launch of its first space station module and the historic docking mission. We have reported these missions in detail in the previous three issues. But in reality, the Chinese space programme is much more than just manned space flight. It's also time for us to switch to other interesting space fields that China is engaging in. The cover story of this issue is for the Beidou Satellite Navigation System, a space infrastructure project representing China's space capability and ambition. It is usually seen as China's challenge to the U.S.'s GPS and Europe's Galileo systems. However, in this article, we will tell readers its opposite side, that the Beidou system is able to, and most likely will, co-work harmoniously with other satellite navigation systems. Imagine an unprecedented combined global navigation system by 2020 with high availability, accuracy and reliability. Is it symbolic for China's integration into the world and strong implication for world peace?

Space cooperation between China and Western countries not only exists in satellite navigation, but also starts to happen in manned space flight. The Mars500 experiment was the first Chinese involvement in an international manned space project. We had an interview with Wang Yue, the Chinese participant, in our first issue. In this issue, we interviewed his two crewmates for their impression on Wang Yue, and the intercultural challenges in long-term space flight. Another interview in this issue is even more interesting. It was only very recently that there were reports on joint China-ESA talks on a possible Shenzhou-ISS docking mission, or a European visit to the Chinese space laboratory. Dr. Thomas Reiter, a former European astronaut who is involved in the Sino-ESA manned cooperation revealed more detailed information in our interview. Will our proposal for a joint Sino-European manned mission (please, see Go Taikonauts! Issue 2) become true? Let's wait and see.

No matter whether the joint manned mission will happen or not, China will move forward on its own track. China has published three space White Papers since 2000, stating its goals and plans in space. People may notice that the plan in these three documents covering more than 10 years are highly consistent. What was accomplished today is exactly what was envisioned one decade ago. Does this show China's capability to execute long-term space projects? Are there any advantages inside China's decision making and planning mechanism? For answers to these questions, please, read the analysis by William Carey in this issue.

Well, with this issue published, we are now expecting the next big mission - the Shenzhou 9 - Tiangong 1 manned docking mission planned within the June to August timeframe. If it's on show in time, we will deliver an exclusive report in the next issue, hopefully.

(Chen Lan)

Imprint

Go Taikonauts! e-Magazine

Go Taikonauts! e-Magazine on iTunes:
http://itunes.apple.com/de/app/go-taikonauts!/id454679742?mt=8

The Go Taikonauts! Team
William Carey - Dave Chen Qing - Chen Lan - Jacqueline Myrrhe

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

Chinese Space Quarterly Report

October - December 2011

Launch Event

The fourth quarter of 2011 was the second busiest launch quarter in Chinese space history. There were eight space launches, just one less than the third quarter of this year:

- The first launch happened at 16:21, on 7 October. A CZ-3B/E blasted off from Xichang and sent the Thales Alenia-built Eutelsat W3C into geostationary transfer orbit. It was the first European commercial satellite China has ever launched.
- On 1 November, at 5:58, the long-anticipated Shenzhou 8 un-manned vehicle was launched successfully by a CZ-2F (Y-8) from Jiuquan. The launch was followed by a flawless space docking with the Tiangong 1 space station prototype two days later, making history.
- On 9 November, at 11:21, a CZ-4B launched from Taiyuan, putting the Yaogan 12 Earth observation satellite and the Tianxun 1 small satellite into space. The 61 kg Tianxun 1 was developed by Nanjing Aeronautics and Astronautics University.
- On 20 November, at 8:15, a CZ-2D, launched from Jiuquan, sent the CX-1-03 and the SY-4 satellites into LEO. CX-1-03 is a small satellite developed by CAS (China Academy of Sciences) for data collection. The SY-4 is a new technology testing satellite. It reportedly uses the first China built space CPU onboard.
- On the last day of November, there was a successful launch from Taiyuan, making another "four shots within a month" after July the same year. At 2:50, 30 November, the Yaogan 13 was lofted to a polar orbit by a CZ-2C. The Yaogan series is considered China's reconnaissance satellite for national defense.
- On 2 December, at 5:07, China's 10th operational Beidou navigation satellite was sent into space by a CZ-3C from Xichang. This satellite, numbered IGSO-05 and put in an inclined geosynchronous orbit, completed the initial constellation of China's second generation regional navigation system.
- On 20 December, at 00:41, a CZ-3B/E was launched and sent another commercial communication satellite, the Nigcomsat 1R into GTO. It is a replacement for Nigcomsat 1 that failed after one year's service. China launched this satellite for Nigeria for free.
- The last space launch of 2011 happened at 11:26, on 22 December. A CZ-4B made a successful launch from Taiyuan and put the ZY-1-02C civil resource satellite into a polar orbit. It should be noted that this satellite does not belong to the Chinese-Brazilian CBERS programme, although previous ZY-1's do.

In 2011, China made 19 space launches, 18 of which were successful. China surpassed the United States of America for the first time in history in the number of space launches.

Launch Vehicle

There was a series of breakthroughs in the Long March 5 development in the fourth quarter:

- The first static load test of the new launch vehicle, a static load test of the 5 m diameter inter-stage segment between the first and the second stage, was completed successfully in mid November. The test was done at the newly completed 2,000-tonne class static load test facility in Tianjin. More static tests are expected in 2012.
- At the end of December, The Factory 211 of CALT (China Academy of Launch Vehicle) completed manufacture of a 20 m long, 5 m diameter hydrogen tank for the Long March 5 vehicle. The tank was welded from eight segments and two end sections. Its manufacture started on 17 November 2011. The tank was considered the most difficult component of the Long March 5 to be manufactured.
- In mid-December, a liquid volume measurement system for the 5 m diameter tanks was delivered and passed acceptance tests in the Tianjin New Generation Launch Vehicle Industrial Base.

In Hainan, relocation of villagers from the new launch site was completed, paving the way for a full-speed-ahead construction of the launch centre. The relocation started in December 2010. It involves 24 villages and 3,400 people. They were moved to about 1,100 newly-built terraced houses and apartments North of the launch site.

There was also progress on the Long March 7 development. In December, the CZ-7 prototype completed a design review by CASC (China Aerospace Science and Technology Corporation) and CALT. All attending the review meeting agreed to proceed with the prototype development in the next step.

CALT hosted a symposium on re-usable aerospace technologies in November. But no information was revealed about China's plan concerning RLVs.

Engine

On 14 December, AAPT (Academy of Aerospace Propulsion Technology, or the Sixth Academy) signed a strategic co-operation framework agreement with Beijing University of Aeronautics and Astronautics (BUAA) on the development of the large thrust staged combustion cycle liquid oxygen kerosene engine, although the news release did not reveal what model of the engine it is. It is believed to be the successor of the YF-100.

Satellites

China's science satellite programmes progressed slowly in recent years. But this situation is expected to change from 2011. After the HXMT (Hard X-Ray Modulation Telescope), the development of the Quantum Satellite and the Dark Matter Exploration Satellite (DMES) were officially kicked-off on 23 December. To be launched in 2016, the Quantum Satellite is to test ground-satellite quantum communication technology developed by the team led by Prof. Pan Jianwei of USTC (University of Science and Technology of China). His team is reportedly the world's leading research team in this area. The DMES has a similar role to the AMS on the ISS, but it is only 1.4 tonnes in weight. Its development involves the USTC, Purple

Mountain Observatory, Institute of High Energy Physics and Institute of Modern Physics, CAS (China Academy of Sciences). Earlier, on 1 December, the DMES programme completed a pre-design review. In addition, on 28-30 December, a symposium on the Magnetosphere - Ionosphere - Thermosphere (MIT) Satellite was held in Sanya. All these science satellite programmes are led by NSSC (National Space Science Centre).

Chinese civil satellite development made some progress as well. Ziyuan 3, China's first civil mapping satellite completed its factory outgoing review on 11 November. In October, the 2nd Academy of CASIC (China Aerospace Science and Industry Corporation) completed China's first rainfall radar, and it passed an acceptance review. The radar will be installed on future FY meteorological satellites and is able to actively detect 3D rainfall data in all weather conditions. In November, NSSC delivered the thermal control article for structure of the scatterometer, the only Chinese payload on CFOS (China-France Ocean Satellite).

There is also news from space. At 6:00, 25 October, the Haiyang 2 ocean satellite completed a successful ground-satellite laser link capturing and tracking test. Later on 10 November, at 16:40, China did its first ground-satellite free space laser communication on HY-2 with downlink rate at 20 Mbps. Two weeks later on 24 November, it achieved high-speed communication with downlink rate of 504 Mbps. It was a milestone for Chinese satellite technology. On 15 November, the Chinasat 20 (ZX-20) communication satellite celebrated its 8th anniversary in orbit. It's another DFH-3 based satellite after ZX-22 and BD-1A, 1B, 1C that reached their 8-year working life. Another satellite celebrating its anniversary in space was the XW-1 student satellite, an amateur radio satellite named HO-68 by AMSAT (The Radio Amateur Satellite Corporation). By 19 November, it had circled the Earth for two years, one year beyond its designed life. According to Chinese media, it still performed normally, thus verifying the CAST100 small satellite bus developed by CAST (China Academy of Space Technology). However, the AMSAT website indicated that the satellite's transponder and repeater ceased working in early 2011, and only its beacon was still active. Meanwhile, a prototype of the second student satellite, XW-2, was completed beginning of December. XW-2 consists of two boxes that are linked by a flexible solar panel. It will test super-capacitor to replace chemical battery. Design of the satellite involves teachers and students from middle schools, which was the first time in China.

A big event in the fourth quarter is about the Beidou Navigation System. China announced that it will begin to provide initial positioning, navigation and timing operational services to China and its surrounding areas from 27 December. During the initial service period, with 10 satellites in orbit, the system provides service to an area from 84°E to 160°E and 55°S to 55°N. Its precision is about 25 m and 30 m in altitude. Its speed precision is 0.4 m/s and time precision of 50 ns. China also released the Interface Control Document (ICD) for equipment developers worldwide. With more satellites launched in 2012, the system's precision will be increased to 10 m. The Beidou navigation system is expected to provide a global positioning service with a constellation of 35 satellites by 2020.

Manned Space Flight

The focus of the Chinese space programme in 2011 was the Shenzhou 8 - Tiangong 1 rendezvous and docking mission. After the successful launch on 1 November (UTC: 31 October), Shenzhou 8 performed a series of manoeuvres to chase the Tiangong 1 space laboratory. On 1 November, the Tiangong 1 turned 180 degrees and aligned its docking port backward. At 23:08, 2 November, Shenzhou 8 reached the first "parking point" 52 km behind Tiangong 1. It then started the approach sequence through another 4 parking points at 5 km, 400 m, 140 m and 30 m where it stayed for a while for verification and adjustment. At 1:29:06, 3 November, the docking ring on Shenzhou 8 contacted the Tiangong 1 and then completed the first Chinese space docking in space. The complete docking process took 7 m 29 s and there was no abnormality reported.

After the historic docking, the Tiangong 1 took over control of the combination and started a series tests during the following 10 days. On 13 November, at 19:53, the Shenzhou 8 undocked from Tiangong 1 and retracted back to the parking point at 140 m. It then re-approached Tiangong 1 and re-docked at 20:22. The un-docking and approaching was done in sunshine and the re-docking happened just after sunset. It was to test sensors on both spacecraft with possible interference by sunlight. On 17 November, the Shenzhou 8 undocked once more. It then started the re-entry sequence and finally landed in Inner Mongolia. On 18 November, Tiangong 1 performed two engine firings, raised its orbit altitude from 337 km to 382 km and switched to long-term management mode, waiting for the manned Shenzhou 9 and 10 in the next year.

At the same time of the Shenzhou 8 launch, China's first "Space Post Office" was opened for service. It provides a service for issuing space philatelic covers to be carried and recovered by Chinese spacecraft and online posting of the "space letter" that is generated with an electronic form on-board the spacecraft and then printed and posted to any address at ground. It was assigned the post code of 901001. China's first taikonaut Yang Liwei was appointed as its first postmaster.

In early December, it was found that a mystery philatelic cover on a European collectibles web site revealed names of the second taikonaut group, including two female candidates. The cover is signed by seven candidates, Wang Yaping (female), Liu Yang (female), Zhang Hu, Chen Dong, Cai Xuzhe, Tang Hongbo and Yi Guangfu. Date of the stamping on the cover is 10 May 2010. As both the names and the date are coinciding with few previously revealed pilot names and the date of the official establishment of the second taikonaut group, the information is considered very reliable.

On 5 December, Wang Yue, the Chinese Mars500 participant, together with the other five crew members from Russia and Europe, completed their 520 day simulated mission to Mars. After one and half years isolated in limited space, he had lost 10 kilograms in weight, but still looked in good spirits. Wang Yue was back home in Beijing two days later and was welcomed by his family members, colleagues and officials.

On 28 December, the Shanghai based Jiefang Daily reported that China will build a space telescope on its modular space station to be launched around 2020. The 2 m aperture optical and infrared telescope will be placed in one of two experimental modules. It will be a little smaller and with less space resolution than the Hubble Space Telescope but it will have a larger viewing field.

Lunar and Deep Space Exploration

On 9 November 2011, at 00:16:03 Moscow Time, a Zenit 2 carrying the Russian Phobos-Grunt Phobos sample return spacecraft and China's first Mars probe, the Yinghuo 1, took-off from the Baikonur cosmodrome in Kazakhstan. 11 minutes after lift-off, the spacecraft separated from the second stage of the rocket and reached its initial parking orbit of 347 x 207 km. However, the Fregat upper-stage did not fire as planned shortly before completing the second orbit to insert the spacecraft into a Mars-bound trajectory. Ground control then lost contact with Phobos-Grunt. The rescue campaign after the accident had not saved the spacecraft stranded in low Earth orbit, though signals had been received by ESA and Russian ground stations since 22 November. It was expected that the Phobos-Grunt and the Yinghuo 1 would re-enter atmosphere in mid of January.

On the other side, there was more positive news. There were breakthroughs in the development of China's Chang'e 3 lunar lander and rover:

- The rover of the Chang'e 3 lunar mission, sometimes called the Lunar Surface Rover, completed field testing in a remote site near Lop Nur in the Kumtag Desert, Qinghai Province. The testing started on 5 October and ended in early November. To support the testing, there were 9 special-purpose and refitted vehicles and a team of about 100 people from CAST and contractors. The rover weighs 120 kg and is able to travel as much as 10 km within 3 km from the lander.
- On 29 December, it was announced that the Chang'e 3 had completed some major testing including the lander hover and obstacle avoidance testing, indoor and outdoor field-testing and the integrated testing of the lander.
- On 31 December, in a meeting held at NSSC, the Chang'e 3 payload sub-system completed the review for the engineering model development. All experts attending the review meeting agreed and approved development of flight models of the payload sub-systems on the Chang'e 3 lander and rover.

In October, Xinhua reported that China plans to build a 110 metre movable dish telescope in Xinjiang to support future deep space tracking and astronomical observation. Currently China has four large telescopes in Beijing (50 m), Kunming (40 m), Shanghai (25 m) and Urumqi (25 m) that form China's VLBI observation network. Another telescope in Shanghai with a 65 m dish, and two large antenna specially for deep space tracking and control - a 35 m one in Kashi, Xinjiang and a 64 m one in Jiamusi, Helongjiang - are under construction. China is also building the world's largest 500 m diameter fixed telescope (FAST) in Guizhou Province that can also be used for VLBI tracking. The new 110 m telescope, located in Qitai County, North-East of Urumqi, will become the world's largest movable telescope. It will largely enhance China's deep space tracking capability.

Miscellaneous

In October, the International Academy of Astronautics (IAA) has attributed the Theodore Von Karman Award for 2011 to Prof. Liu Jiyuan, in recognition for his life-long service to the aerospace profession in government, industry, and the international community; for his outstanding contributions to human space flight programmes; for his role in the development of the Long March launch vehicles; and for his dedicated leadership of IAA as Vice President for Publications and Communication. The Von Karman Award, created in 1983, recognises outstanding lifetime-achievements in space related scientific activities. It is awarded annually. Prof. Liu Jiyuan served as Vice Minister of the Ministry of Astronautics Industry (MOA), President of China Aerospace Corporation (CASC), Administrator of China National Space Administration (CNSA), Deputy Chief Commander of China's Manned Space Flight Programme, and President of Chinese Society of Astronautics (CSA). He is currently the Vice President of IAA and the Honorary President of CSA.

The ESA/DLR delegation headed by Thomas Reiter and Gerd Gruppe witnessed Shenzhou 8 launch in Jiuquan. Shenzhou 8 carried the German SIMBOX biological experiment and it was reportedly completed successfully. In Q4, there were also two other events in the field of international cooperation. On 23 November, the Italian Space Agency (ASI) President, Enrico Saggese, signed a cooperative agreement in Beijing with the China National Space Administration (CNSA) President, Chen Qiufa. The deal covers science and exploration, space transportation, Earth observation, telecommunications, satellite navigation, and education, according to an ASI press release. On 25 October, the American Institute of Aeronautics and Astronautics (AIAA) signed a Memorandum of Understanding with the Chinese Society of Aeronautics and Astronautics (CSAA). Both sides emphasised that it would strengthen the contact and friendships between both societies, while creating many opportunities for technical and scientific exchanges between Chinese and American engineers and scientists working in the aerospace field.

In November, a breakthrough was made in the Compass/Galileo navigation frequency negotiation. In an interview with the German space magazine "Raumfahrt Concret", European Commission Vice President Antonio Tajani announced that the European Commission had signed an agreement with China which settled the controversy on the frequency overlapping between Galileo and Compass. But no details of the agreement were revealed.

There was also news on commercial space aside from, i.e., the two Long March commercial launches in this quarter:

- On 5 November, China officially delivered the PakSat-1R communication satellite and the ground station in a ceremony in Pakistan. The satellite was launched by a CZ-3B on 12 August.
- On 11 November, Asia Satellite Telecommunications Company Limited (AsiaSat) and Space Systems/Loral (SS/L), the leading provider of commercial satellites, announced the signing of two construction agreements for two communications satellites, AsiaSat 6 and AsiaSat 8. AsiaSat 6 will have 28 high-power C-band transponders, while AsiaSat 8 will have 24 Ku-band transponders, and

a Ka-band beam. The high-power transponders on the satellite will enable the use of small antennas on the ground. AsiaSat is Asia's leading satellite operator based in Hong Kong. Its major shareholders are CITIC (China International Trust and Investment Corporation) and General Electric.

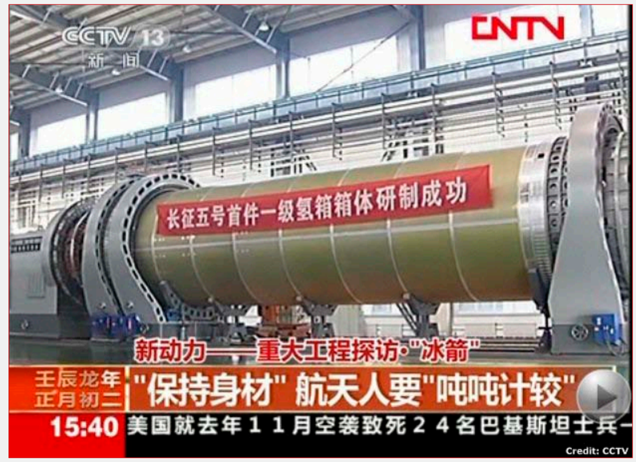
- Just two weeks later, AsiaSat reached another milestone. On 26 November, at 03:10:34, An ILS Proton Breeze M vehicle lifted-off from Baikonur, Kazakhstan, sending the AsiaSat 7 communication satellite into GTO. Built by Space System/Loral, the SSL1300 based AsiaSat 7 has 28 C-band and 17 Ku-band transporters. It would be placed at 105.5°E to take over the AsiaSat 3S that would be retired soon.
- On 5 December, the China Great Wall Industry Corporation (CGWIC) signed an agreement with Thales Alenia Space to launch Turkmenistan's first NSSC (National System of Satellite Communications) satellite by a CZ-3B. A separate agreement was signed on 18 November between Turkmen Ministry of Communications and Alenia for the latter to build and deliver the satellite in orbit. The satellite is expected to weigh about 4,500 kilogrammes at launch, provide 10 kilowatts of power to the payloads, and to carry an undetermined number of Ku-band transponders. It will be launched in August of 2014 and will be stationed at the Monaco-registered 52 degrees East for its 15-year service life.
- On 12 December, China Great Wall singed a framework agreement with Indonesia's PT Pasifik Satelit Nusantara (PSN) to build and launch a DFH-4 based communication satellite at 146°E. On the same day, PSN also assigned an agreement with China Satellite Communication Corporation to rent transponders on ChinaSat 5B for use before the new satellite is put into service.
- On 26 December, it was announced that the China Great Wall Industry Corporation (CGWIC) had been re-organised from a state-owned company to a limited company 100% owned by CASC (China Aerospace Science and Technology Corporation). The objective of the re-organisation is to introduce strategic investors.

On 14 December, the Yuanwang 4 tracking ship was officially de-commissioned. Yuanwang 4 was formally an ocean survey ship. It was converted to a space tracking ship and re-named Yuanwang 4 in 1999. It was the third Yuanwang retired from ocean-going. Yuanwang 1 is now in China Ship Museum in Shanghai (formerly China Ship Pavilion in Expo 2010). While Yuanwang 2 is parked in its base in Zhangjiagang, to serve as a fixed tracking station for satellite operation. However, there was report that it will be relocated to the space theme park near the Hainan Launch Centre in Wenchang, Hainan. Yuanwang 3, 5 and 6 are still in active status.

In early December, CASC formed two research laboratories named after Qian Xuesen, the father of the Chinese space programme. They are Qian Xuesen Space Technology Laboratory under CAST and Qian Xuesen Launch Vehicle Laboratory under CALT. The two laboratories will be open to the international space community.

On 29 December, China issued a White Paper on the development of space industry since 2006 and the major tasks for the next five years. The White Paper titled "China's Space Activities in 2011" was the third space White Paper following the one in 2000 and another in 2006. There are not many new plans in the activities it outlined, but it has a strong consistency with the previous two White Papers, showing China's capability to execute long-term space programmes.

(Chen Lan)



top: CZ-5 first stage hydrogen tank

right: Tianxun 1 satellite

bottom: Chang'e 3 rover test field

very bottom: Yuanwang 1 in museum

Chinese Space Quarterly Report

January - March 2012

Launch Event

There were four launches in Q1:

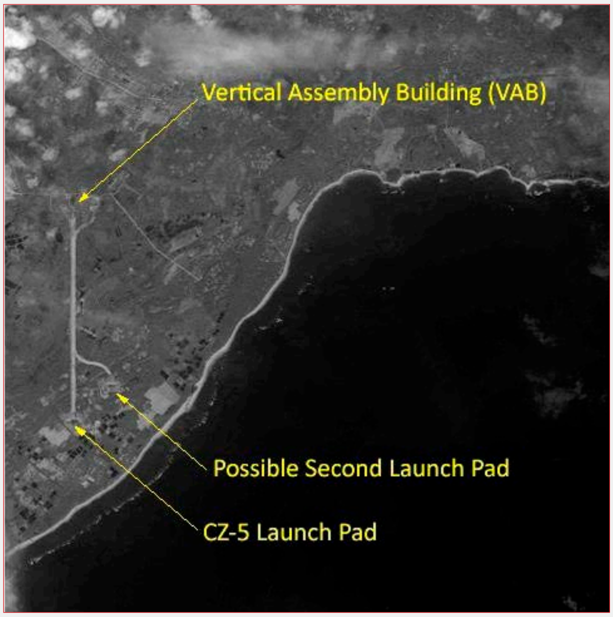
- China's first space launch in 2012 occurred at 11:17, on 9 January. The country's first civil mapping satellite Ziyaun 3 (ZY-3) was sent into a polar orbit by a CZ-4B rocket from Taiyuan. The 2,640 kg satellite is equipped with a set of TDI CCD cameras with best resolution of 2.5 m. The rocket also carried a piggyback small satellite, VesselSat2, built by the Luxembourg-based LuxSpace for the U.S. company Orbcomm for Automatic Identification Service (AIS) - used for ship tracking and other maritime navigational and safety efforts.
- Four days later, on 13 January, at 8:56 Beijing time, a Long March 3A (Y22) lifted-off from the Xichang Satellite Launch Centre, sending the FY-2F geostationary meteorological satellite into GTO. It was the first of three planned Block 3 FY-2 satellites. Two Block 1 satellites, FY-1A and 1B, are experimental. Three Block 2 satellites, 1C, 1D and 1E are operational satellites. FY-2F reached its GEO position at 112°E on 18 January.
- On 25 February, at 0:12, the Beidou/Compass G5 satellite was launched on top of a CZ-3C vehicle from Xichang. It was the 11th operational satellite and the 5th GEO bird in the 14-sat Beidou 2 regional navigation system. It manoeuvred to its geostationary slot at 58.75°E on 13 March.
- On the last day of Q1 (31 March), China made its first commercial launch in 2012. At 18:27, a CZ-3B/E (Y22) lifted-off from Xichang and sent the Apstar 7 communication satellite into GTO. The 5,054 kg Apstar 7 is the seventh Thales Alenia Space-manufactured satellite launched by Long March launch vehicle. It has 56 operational transponders (28 C-band and 28 Ku-band) on board, and will replace the current Apstar-2R satellite at 76.5°E.

Launch Vehicle

In a review in January, the main target of the Long March 5 new generation launch vehicle development in 2012 was set to complete the prototype development and start the engineering model development within the year. It asked for completion of 36 large-scale tests on the prototype including static load tests, strap-on booster separation test, electrical matching test and electromagnetic conformance test, etc. It achieved a milestone in February. CALT (China Academy of Launch Vehicle) completed an all-digital assembly of the CZ-5 prototype - the first ever in Chinese space history. The first static load test article of the 5.2 m diameter faring and isolating layer on the first test article of the 5 m diameter tank were also completed in March. It was reported that the highly-risky strap-on booster separation test was planned for the end of March. But there was no reports indicating this was accomplished.

At the end of January, CASC (China Aerospace Science and Technology Corporation) announced that the Phase 1 construction of the Tianjin New Generation Launch Vehicle Industrial Base was almost fully completed. It now has the capability to manufacture, assemble and test the new generation launch vehicle. The Phase 1 construction of the Base includes 29 facilities with 200,000 square metres, in which 28 were completed and the final one, the full-vehicle vibration test tower, will be completed by September 2012. The Phase 2 facilities will have 300,000 square metres and will be constructed in the next few years.

Meanwhile, China announced that the Hainan Launch Centre has entered full-scale development. All major facilities have started construction and will be completed by the end of 2012. It is expected to be ready for a launch rehearsal in 2013. A recently published DigitalGlobal satellite image shows completion of major transport pathways and roads, suggesting two launch pads in the new centre.



Satellite image of the Hainan launch site

There was also progress on existing launch vehicles. The Factory 211 of CALT completed the building of an oxygen tank on the second stage of the CZ-3B using the friction stir welding (FSW) technology. This activity marks the maturation of the FSW technology as it has been applied on all CZ-3 models built by CALT. SAST (Shanghai Academy of Spaceflight Technology) also started use of the FSW technology on a CZ-2D, launched on 20 November 2011.

Engine

The YF-100 engine achieved two successes in bi-directional gimbaling, and double engine parallel firing test on 15 January and 8 February, paving the way for final delivery of the liquid oxygen kerosene staged combustion engine for the new generation launch vehicles. The YF-100 engine development has accumulated almost 20 years. In early March, a full-system, flight status YF-100 in single engine configuration for the CZ-6 first stage made a successful manufacture-processing verification test firing. This marked the engine as ready for flight. Below are the major milestones in the YF-100 development.

Date	Model	Duration	Note
16/05/2002	Prototype		First complete engine test firing
05/01/2005	Prototype		New test bed verification
30/10/2005	Prototype	300	Long duration gimbaling firing
27/12/2005	Prototype	400	Long duration gimbaling firing
03/07/2006	Eng. Model	600	Long duration gimbaling firing
12/09/2007	Eng. Model	400	Bi-directional gimbaling firing
07/07/2009	Eng. Model	280	Longest gimbaling firing
11/11/2010	Eng. Model		First double engine parallel firing
23/11/2010	Eng. Model		First double engine parallel firing with gimbaling
13/09/2011	Eng. Model		Long duration gimbaling flight verification
15/10/2012	Eng. Model		First bi-directional gimbaling, double engine parallel firing
08/02/2012	Eng. Model		Second bi-directional gimbaling, double engine parallel firing

Also, the CZ-6 third stage engine made a successful full-system test firing, with an engine restart, in late March. Unconfirmed sources indicate that the re-ignitable engine uses hydrogen peroxide and kerosene and has a designator of YF-85. It is developed by the Institute 11 of the Academy of Propulsion Technology.

In late February, the vacuum pumping system on the CZ-7 engine was successfully tested. Such a system was used on Chinese engines for the first time. The report did not indicate the engine model. CZ-7 uses YF-100 and YF-115 engines.

Satellites

After the successful launches on 9 and 13 January, the ZY-3 mapping satellite and the FY-2F geostationary meteorological satellite both started their in-orbit testing. ZY-3 sent back its first image on 11 January with a better resolution (2.1 m) than the designed 2.5 m. Since then, it has provided more high-resolution images and made them available on the MapWorld (or Tianditu) website - a Chinese counterpart of the Google Map, run by the National Administration of Surveying, Mapping and Geoinformation. The FY-2F sent back the first optical image on 19 January. This was followed by receipt of the first 5-channel image and the first infrared image on 6 February. The testing was expected to last till early April and then would replace the FY-2C that is currently active.

On 2 March, the Haiyang 2 (HY-2) ocean satellite completed its in-orbit testing and was finally delivered to its end user, the State Oceanic Administration (SOA). HY-2 is China's first ocean dynamic environment satellite that was launched in August 2011. The satellite failed after the launch and was rescued after a 50-day rescue campaign. It is also equipped with China's first free space laser communication payload that was successfully tested last year. At the end of March, SOA announced that it has started to provide ocean dynamic data products to the public.

Aside from the above three in-orbit satellites, there was also news on various satellite programmes:

- In early January, the first FY-3 data receiving system in a high-attitude area was completed and delivered for use. It was located in Sweden, near the Arctic Circle.
- In mid-January, the Institute 203 of the Second Academy under CASIC (China Academy of Science and Industry Corporation) delivered the last two Rubidium atomic clocks for the Beidou/Compass satellites. The institute supplied 12 on-satellite clocks in six batches for the 14-bird Beidou 2 regional constellation.
- The Sino-Brazilian CBERS 3 resource satellite has successfully passed its final test and also passed compatibility testing with the ground segment. The test was done between 29 February and 7 March. CBERS 3 is to be launched by the end of 2012.
- During 12-15 January, a co-ordination and planning meeting for the Dark Matter Exploration Satellite (DMES) was held in Purple Mountain Observatory in Nanjing. The meeting was focused on the payload-satellite bus interface and set a solid foundation for the satellite design and other works in 2012.
- On 28 February, the GEO Millimetre Wave Atmosphere Temperature Sensor, developed by the Mirslab (Key Laboratory of Microwave Remote Sensing) of NSSC (National Space Science Centre), completed a review by the expert group from the Ministry of Science and Technology. It was reportedly the word's first full-size prototype that is able to obtain temperature data with ground resolution of 50 m from geostationary orbit.
- In early March, SAST completed the development of the electrical model and preliminary design review of the FY-4 weather satellite prototype. FY-4 (Fengyun 4) is China's first 3-axis stabilised geostationary meteorological satellite due to be launched in 2016.

Manned Space Flight

In mid-February, there were reports on Chinese media that the Shenzhou 9, to be launched later this year, would still be un-manned and would repeat the un-manned docking with Tiangong 1. This indicated that something abnormal had happened during the Shenzhou 8 docking in November 2011. The China Manned Space Engineering Office (CMSEO) immediately denied the report. The CMSEO spokesman announced on 17 February that the Shenzhou 9 will dock with the Tiangong 1 with three taikonauts onboard. It will be launched in the June to August timeframe. China will also test manual docking in this mission. More information was revealed in early March during the annual session of China's National People's Congress. It was reported that both the Shenzhou 9 manned vehicle and the CZ-2F launcher had completed assembly in Beijing. The Shenzhou 9 will carry butterfly live eggs and pupae as part of a student programme. Taikonauts, including two females, were in training for the docking mission, but it was still too early to confirm if the Shenzhou 9 crew will include a female member or not. Chinese space officials also revealed that Tiangong 1 and its onboard experiments were working normally. On 23 March, China announced that the Shenzhou 9 vehicle has completed the system level review for shipment to Jiuquan.

According to U.S. USSTRATCOM data, Tiangong 1 raised its orbit again from 339 x 355 km to 354 x 364 km. Its last orbit-raising was in mid-November, just after completion of the Shenzhou 8 docking mission.

On 2 February, CAST signed an agreement with Tianjin City to settle a series of projects in the Tianjin Binhai New Area. The most significant project is the space station AIT (assembly, integration and test) centre. Tianjin Municipal government expressed full support to the projects.

Lunar and Deep Space Exploration

On 6 February, China released the 7 m resolution full-Moon image composed of 746 lunar images and also provided a web site (http://159.226.88.30:8080/CE2release/cesMain.jsp) for interactive 2D and 3D browsing with lower resolution. The images were taken by the Chang'e 2 orbiter during 24 October 2010 and 20 May 2011. It was reportedly the world's highest resolution full Moon image. The total data size of the image exceeds 800 GB. Meanwhile, Chang'e 2 has been working normally at the Sun-Earth L2 point for six months.

On 13 March, China announced that the Chang'e 3 lunar lander/rover had started engineering model development after the completion of reviews of five major sub-systems and breakthroughs of a series of key technologies. Earlier the same month, the Chang'e 3 lunar rover completed mechanical environmental testing in Suzhou, Jiangsu Province. The rover weighs a little more than 100 kg and is designed to work for three months. It is equipped with a 360 degree panorama camera, infrared spectrometer and X-ray spectrometer to analyse lunar soil, and with a microwave radar at its belly to explore the inner structure of the Moon. There are also solar panels and a communication payload to link to the lander and the tracking station on Earth directly. It was also revealed that it is to be named later by a public competition.

On 22 February, a team from Shanghai Engineering Centre for Microsatellites visited the Purple Mountain Observatory in Nanjing. They discussed design and implementation issues on China's first asteroid probe.

The ill-fated Russian Phobos-Grunt spacecraft crashed into the Pacific Ocean, off the coast of Chile, around 17:45 GMT on 15 January. China's first Mars probe, Yinghuo 1, carried inside Phobos-Grunt, also ended its mission, without even being activated.

Miscellaneous

On 17 January, a new book, Mars500: *Return of Wang* (here Wang also means king in Chinese), written by the Chinese Mars500 participant Wang Yue, was published in Beijing. Wang Yue, taikonaut Fei Junlong, and Chen Shanguang, Director of ACC (Astronaut Centre of China), attended the book launch ceremony.

In mid-February, 50 Venezuelan space engineers arrived in China to receive training in satellite technology. China has signed a contract to build and launch Venezuela's first remote sensing satellite, VRSS-1, or 'Francisco Miranda'. VRSS-1 is manufactured by CAST and completed partial electrical testing by mid-February. It will be launched by a CZ-2D in late 2012. The President of Venezuela, Hugo Chavez, met the engineers before their departure.

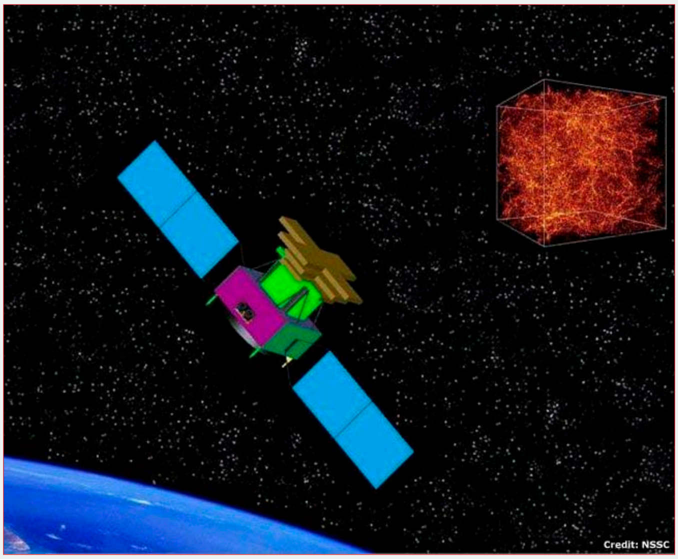
On 19 March, the Nigcomsat 1R communication satellite was officially delivered to its user, Nigerian Communications Satellite (NIGCOMSAT) Limited. The DFH-4 based satellite was launched by a CZ-3B/E on 20 December 2011 to replace the failed Nigcomsat 1, another DFH-4 comsat.

The Barcelona Moon Team, a Spanish team in the Google Lunar X PRIZE, has signed an agreement in mid-March with China Great Wall Industry Corporation to launch the Barcelona Moon Team spacecraft into lunar orbit, from where it can deploy a robot to the lunar surface. To win the Google Lunar X PRIZE, a privately-funded team must successfully place a robot on the Moon's surface that explores at least 500 meters and transmits high-definition video and images back to Earth. The Barcelona mission has been designed not to have American components that may interfere with the International Traffic in Arms Regulations (ITAR) so that it can be launched by a Chinese launch vehicle. Chinese media reported that the launcher for the Barcelona lunar lander will be a CZ-2C. It will mark the return of the CZ-2C to the international market. To send the spacecraft to the lunar orbit, China will provide an upper stage that has not been disclosed.

On 14 February 2012, the 14th China-EU Leaders' Meeting was held in Beijing, China. Chinese Premier Wen Jiabao, Chairman of the Council of Europe Herman Van Rompuy, and the President of the European Commission, Jose Manuel Barroso, attended the meeting. In the Joint Press Communique, the two sides committed to continue their Galileo cooperation under the 2003 agreement. They also supported the establishment of China-EU dialogue mechanism of space science and technology, and the EU-China Space Science and Technology Cooperation Conference.

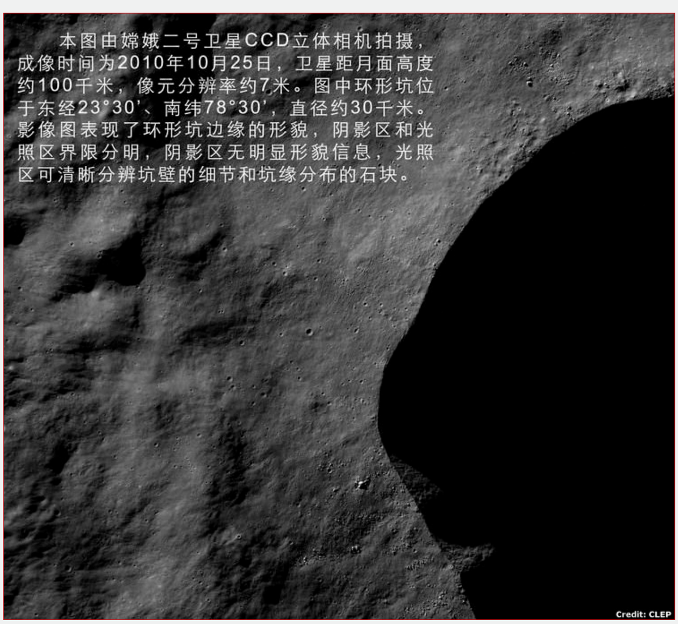
On 23 March, the Chinese government announced that Wang Zhaoyao had been appointed Director General of the China Manned Space Engineering Office (CMSEO). On the same day, he headed a delegation to ESA's Guiana Space Centre in Kourou and witnessed the launch of the ATV 3. He also had talks with European Space Agency Director General Jean-Jacques Dordain. The BBC, Aviation Week and other international media interviewed Wang during his stay in Kourou. Aviation Week reported on 26 March that Wang Zhaoyao and Jean-Jacques Dordain had discussed future cooperation in the field of manned spaceflight, including the potential for a Chinese Shenzhou spacecraft to dock with the International Space Station (ISS). Wang admitted that currently Shenzhou is unable to dock with the ISS because of system differences, but experts from both agencies are expected to establish a working group that will meet in Paris in April to discuss Shenzhou's compatibility with a planned ISS common docking mechanism. Mr. Dordain stated that the two sides are discussing a range of collaborative opportunities in the area of manned spaceflight, including astronaut training, life-support systems and utilisation of each other's space station facilities.

(Chen Lan)



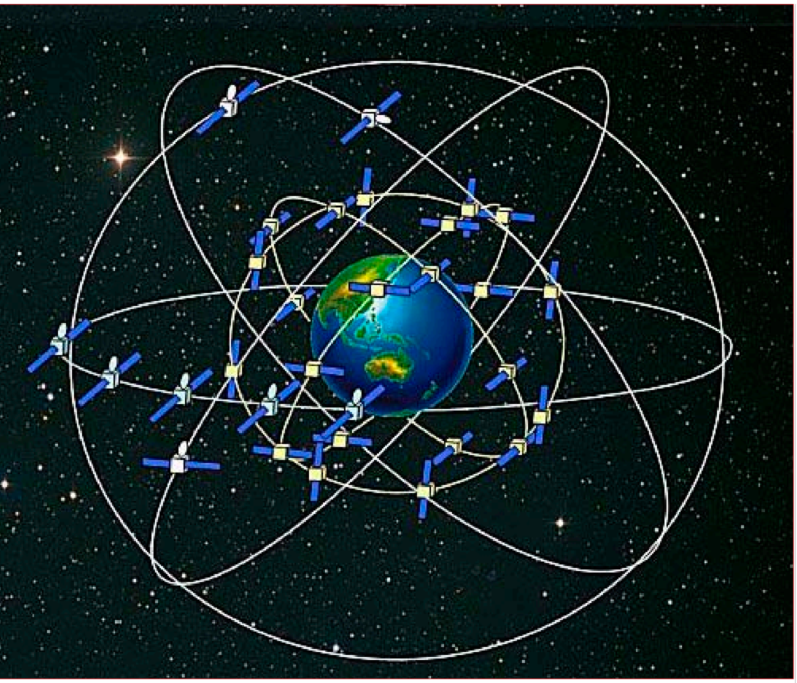
Dark Matter Exploration Satellite

Shenzhou 9 arrived in Jiuquan.



Chang'e 2's 7 m resolution lunar image

Re-invention of Compass
History of the Chinese Satellite Navigation System


Beidou CP III Constellation (credit: Chen Lan)

Dual-Sat Concept

China's studies on satellite navigation started very early. Chinese scientists and engineers began to trace technologies and tried to develop receivers of the U.S. Transit navigation system just after it was put into service in the 1960s. In 1983, Chen Fangyun, a CAS (China Academy of Sciences) Academician, and Liu Zhikui proposed to develop a dual-satellite, regional navigation system. Such a concept is actually very similar to the U.S.-Europe Geostar-Locstar project, a private satellite navigation system that was operational in the late 1980s and early 1990s and bankrupted later due to competition from GPS and mobile communications.

The principle of dual-sat positioning is quite straightforward. It can be simply described as "three-sphere intersection". The system consists of two geostationary orbit (GEO) satellites whose longitudes are 60 degrees apart, a ground control centre, a number of calibration stations and user terminals. The system measures the distance from the satellites to the user terminal, which results in two spheres with the satellites at their centres and the satellite-terminal distances as radii. They intersect at a circle. The circle also intersects with the ground sphere, which results in two points at each side of the Equator. As the system services only the Northern Hemisphere, the North Point becomes the user's position. More exactly, the ground sphere is not a smooth sphere. It is a digital map with surface altitude, or digital terrain model, stored in the control centre. As the satellites' positions are known, it is easy to calculate the coordinates of the intersecting point, or location of the user terminal. Such kind of navigation is also called the Radio Determination Satellite Service (RDSS).

In contrast to GPS's simplicity, the proposed dual-sat system works in a complex way as follows:

1. The control centre sends periodically signals to two satellites.
2. The satellites receive the signal and broadcast it to its service area.
3. The user terminal picks up the signal from one of satellites, and sends the response (positioning request) to two satellites simultaneously.
4. The satellites receive the request and forward it to the control centre.
5. The control centre receives the user request from the two satellites and calculates the coordinates of the user terminals according to the two-way transmission time of two signals (from two satellites), known satellite positions the terrain model, and known delays in devices and atmosphere, then send the result to the satellites.
6. The satellites relay the coordinates received from the control centre to the user.

Thanks to the dual-sat system's two-way transmission capability, it has a unique feature that GPS does not have, and that is the short text messaging. Similar to GPS, it also has a time synchronisation function.

After years of studies, the dual-sat concept was tested and demonstrated in 1989 using two communication satellites (presumably two DFH-2As). It was reportedly tested again in 1993. Test results were encouraging. It proved the feasibility of the system and paved the way for the project's approval. During the Gulf War in 1991, the United States' extensive use of space-based infrastructure including GPS deeply impressed the Chinese leadership, which may have helped the decision-making for many strategic projects. The Beidou (which means The North Dipper in Chinese) navigation system, based on the dual-sat concept, finally received approval in 1994.

Beidou 1 System

The Beidou 1, officially referred to as Beidou Experimental Navigation System, consists of two operational and one spare satellites and provides positioning, two-way messaging and time synchronisation services.

China launched its first two navigation satellites, Beidou 1A and 1B, on 31 October 2000 and 21 December 2000 on CZ-3A rockets. It was a pity that the CAS Academician Chen Fangyun could not see it happen. He passed away one year ago. The third and the in-orbit spare satellite, Beidou 1C, was launched on 25 May 2003. Orbital slots of the three satellites are at 140°E, 80°E, and 110.5°E respectively.

Beidou 1 satellites are based on the DFH-3 bus that was developed for China's second generation GEO communication satellites. In 1994, 1997 and early 2000, three comsats based on the DFH-3 bus were launched. Beidou 1 satellites' primary parameters are as follows:

- Bus mass: 2,320 kg (launch mass, including the apogee kick engine and fuel)
- Payload mass: 168 kg
- Size (excluding antenna): 2,000 x 1,720 x 2,200 (mm)
- S/L-band antenna size: 2,600 x 2,440 (mm)
- Solar panel span: 18,096 (mm)
- Solar panel area: 22.7 m^3
- Backup battery: two 45Ah Cd-Ni batteries
- Output power: 2,049-1,688 W (at beginning and end of working life)
- Propulsion: one 490 N apogee kick engine, fourteen 10 N attitude control (station keeping) thrusters. All use MMH/MON-1 (N_2O_4) as propellant.
- Attitude control: three-axis stabilised
- Attitude control precision: ±1.5°(pitch and roll), ±0.48°(yaw)
- Station keeping precision: ±0.1°(at both longitude and latitude)
- Working life: 8 years

Compared to the GPS system, the dual-sat navigation system requires a much simpler satellite payload and does not need inter-satellite links. The communication transponders developed for DFH-3 can be easily modified for Beidou satellites. The Beidou 1 system uses ground atomic clocks. There is no atomic clock on the satellites. The spare Beidou 1C is reportedly installed with a laser reflector to help precise measuring of the satellite's space position in centimetres.

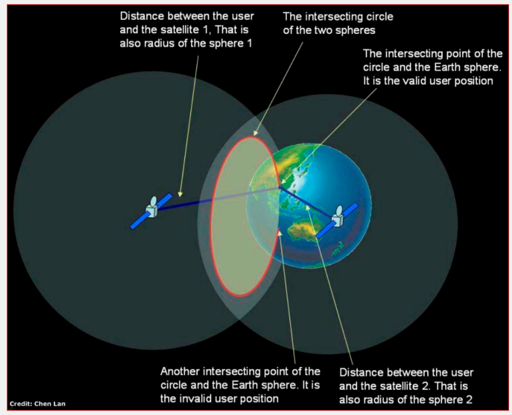
Unlike GPS, the Beidou control centre is critical for the whole system. All positioning calculations have to be done in the control centre. The ground segment also includes a number of calibration stations to help maintain system precision.

Beidou user terminals are also different from GPS receivers. It has to transmit radio signals to the geostationary satellites 36,000 km above the ground. As a result, they are larger, heavier and consume more power than GPS receivers. China has developed a series of Beidou terminals including those for mobile vehicles and ships, handheld terminals, as well as special purpose terminals used for rescue, communication and time synchronisation.

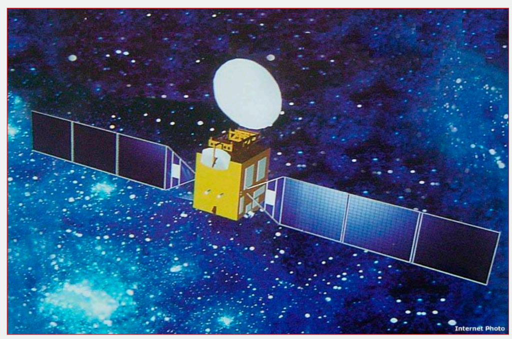
According to Chinese publications, Beidou 1 is an all-weather, all-time regional positioning system. Its detailed characteristics are as follows:

- Service area: 70-145°E and 5-55°N, mostly in China and nearby Asian countries.
- Positioning precision: 20-100 m (horizontal). With differential positioning, it can be improved to within 20 m.
- Short message length is normally limited to 36 Chinese characters (equivalent to 72 ASCII characters). Authorized users can send concatenated messages up to 120 Chinese characters (240 ASCII characters). Messages are encrypted.
- Time synchronisation precision: 100 ns (one-way) or 20 ns (two-way).
- System response time: 1-5 seconds depending on precision.
- Success rate of one-time request: 95%
- Registered frequencies in ITU (International Telecommunication Union): L-band (1610-1626.5 MHz) for uplink, and S-band (2483.5-2500 MHz) for downlink.
- Maximum system capability: one million users.
- Maximum processing capability: 150 requests per second.

The Beidou 1 system is incompatible with GPS, GLONASS and Galileo. But it can co-exist with GPS. Reports indicate that by

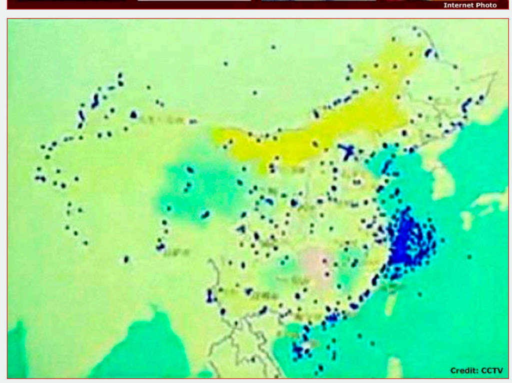


Dual-sat concept



Artist's impression of the Beidou 1 satellite

Beidou 1 terminals



Beidou 1 user distribution

using differential positioning, it can be used to refine GPS's C/A precision from 100 m-level to metre-level.

Beidou 1 Commercialisation

The basic Beidou 1 system was established at the end of 2000. But it was claimed "operational" only after the spare satellite was launched in mid-2003. In fact, all satellites have worked normally and smoothly since their launch, but the application process is much slower than planned.

It is believed that during 2000 to 2003, the system was mainly used for testing and by a few "group users" – most likely including military users. However, the Beidou 1 system has fatal flaws for most military applications. Its terminal has to transmit signals and the whole system relies on a centralised control centre. It does not support positioning off the surface and in high-speed. Obviously Beidou 1 is only a transitional system in Chinese military strategy. On the other hand, the Beidou 1 system naturally matches many civil applications such as transportation fleet tracking and off-shore applications, because the Beidou control centre maintains position data of each terminal, and also provides two-way messaging between terminals and the control centre.

It seems that a decision was made between 2000 and 2003 to commercialise the Beidou 1 system. The business model the Chinese government adopted was to issue a "Beidou operator license" to commercial companies. The first operator is Beijing BDStar Navigation Tech. Co., Ltd. It received the operator license in late 2002. Up to 2011, seven companies have received the commercial license. BDStar is still the largest one and holds the most market share of Beidou applications.

BDStar was formerly a COSTIND (Commission of Science Technology and Industry for National Defence) company specialised in satellite navigation. It was spun-off in 1999 and was privatised in 2000. From 15 December 2003, BDStar provides user registration, positioning, messaging and time synchronisation services, as well as billing. It also distributes user information to control rooms of group users through PSTN, Frame Relay, DDN, VSAT and Internet. BDStar is not only a service provider, but also an equipment (user terminals) supplier and system integrator. In other words, it provides one-stop service. Users need to pay the registration fee and also usage charges. In 2005, one-time positioning/messaging cost about RMB 0.1-0.2 (0.01-0.02 Euros). BDStar is targeting group users who are 60 km offshore where there is no GSM and CDMA coverage.

After around eight years of commercial operation, by the end of 2011, the Beidou 1 has accumulated about 100,000 users among which half are government and military users and half are commercial users. And among the commercial users, about 30,000 are in fishing and marine industry. It's not an impressive figure. Beidou 1's claimed maximum capability is one million users! Many analysts conclude that Beidou 1's poor market is due to entering later into the market (i.e., 10 years later than GPS), and that Beidou 1 lacks competitive advantages over GPS. Beidou's terminal price and service charge, terminal size/weight and power consumption, the altitude limitation, and other inherent flaws, are the bottleneck of its popularisation. However, it is still attractive to certain users such as governmental group users who require both positioning and secured messaging.

Emerging of Compass

As discussed above, the Beidou 1 system has inherent drawbacks that largely reduce its value in military applications, for example, missile guiding. The Chinese fully understand these weaknesses. Their studies on passive global satellite navigation system started as early as in 1999. In 2004, the development of the second generation satellite navigation system was officially kicked-off. The new system was named as Beidou Satellite Navigation System, with the word "experimental" removed when compared to the official name of the first generation system. It was also given an official English name "Compass" and is often unofficially called Beidou 2.

Some media reports indicate that suspension of the cooperation with Europe in the Galileo Programme forced China to develop its own global navigation system. This is obviously wrong. China officially joined the Galileo programme in October 2004 and signed a series of contracts in 2005 and 2006. It was only after 2006 that the cooperation stalled when the Beidou 2 development had already entered its third year.

China registered four geostationary geosynchronous orbit slots with the International Telecommunications Union (ITU) in April 2000 under the name of 'Compass'. But it went almost unnoticed by the rest of the world. It was in early 2005 when the Beidou 2 plan was revealed for the first time by the Chinese media. The plan revealed in 2005 consists of a constellation with 4 geostationary Earth orbit (GEO) satellites, 12 inclined geo-synchronous orbit (IGSO) satellites and 9 medium Earth orbit (MEO) satellites at orbital altitude of 22,000 km. It uses exactly the same principles as GPS for passive navigation. Since then, the constellation design has been changed a lot. The final configuration asks for 5 GEO satellites, 3 IGSO satellites and 27 MEO satellites, from which we can see clearly increasing global capability comparing to the initial design.

China has defined three phases for the Beidou system development as follows:

- Compass Phase I (CP I): an active regional experimental system to service China. It is Beidou 1 that is categorised as Radio Determination Satellite Service (RDSS).
- Compass Phase II (CP II): a passive Regional Navigation Satellite Service (RNSS) to service the Asia-Pacific region. It includes a constellation of 14 satellites and is targeted for completion in 2012.
- Compass Phase III (CP III): a passive Global Navigation Satellite Service (GNSS) with regional enhancement consisting of 35 satellites to be ready around 2020.

It is interesting to note a unique feature of the Beidou global constellation - its mixed orbit types. The Beidou MEO orbit is quite similar to that of Galileo and Glonass. It is the so-called Walker 24/3/1 constellation which has three orbital planes with inclination of 55 degrees and RAAN (Right Ascension of Ascending Node) difference of 120 degrees. In each circular orbit with an altitude of 21,500 km, 9 satellites (one of them is spare) are evenly located. Besides the MEO orbit that is intended to provide global coverage, there are also three IGSO satellites whose orbit is in the same plane as a MEO orbit. The GEO satellites are located at 58.75°E, 80°E, 110.5°E, 140°E, 160°E. Both GEO and ISGO satellites are for regional enhancement on positioning accuracy and point-to-point short messaging.

As a transitional phase from Beidou 1 (CP I) to the final global system, the CP II passive regional system consists of 5 GEO satellites (at slightly different orbital slots as compared to CP III), 5 IGSO satellites and 4 MEO satellites. Two more IGSO satellites (i.e., more than the final global system) are added for increasing robustness of the system.

Table 1:
Major characteristics of Beidou open service in the three phases

	CP I 2000	CP II Trial 2011	CP II 2012	CP III Regional 2020	CP III Global 2020
Positioning Accuracy (m)	20-100	25	10	2.5	10
Altitude Accuracy (m)	10	30	10	4	15
Differential Positioning Accuracy (m)	20		1	1	
Timing Accuracy (ns)	20-100	10-50	10-50	10	20
Speed Accuracy (m/s)		0.4	0.2	0.1	0.2

Compass CP II satellites are based on the DFH-3 and the improved DFH-3A bus. As this bus has only a working life of 8 years, and there are significant differences between the current regional CP II system and the future global CP III system, all satellites for the CP III will be designed and launched separately later in this decade. Even in the same phase, there are some differences between the MEO, IGSO and GEO satellites. To have a smooth transition from Beidou 1, some satellites are still equipped with the Beidou 1 RDSS system which needs the satellite to have a large S/L-band antenna (cf. Table 2 for details of all types of satellites).

All CP II and CP III satellites are (and will be) equipped with a domestically developed Rubidium atomic clock for high-precision timing. The atomic clocks were developed by the Institute 203 under the Second Academy of CASIC (China Academy of Science and Industry Corporation) that was reportedly selected from many organisations competing for the on-board atomic clocks on Beidou 2. Another interesting point is, that China has considered two options for the CP III MEO satellites; one based on CPII MEO satellite that has its own apogee kick engine; and the other, based on a new bus, has to be sent into the 21,500 km orbit by an upper stage.

During the development of the new generation Beidou satellites, China also made a series of breakthroughs in recent years, including precise orbit determination, precise time synchronisation, inter-satellite links and autonomous satellite guidance, etc.

The Compass system uses three frequency bands referred to as B1 (1559.052 - 1591.788 MHz), B2 (1166.22 - 1217.37 MHz) and B3 (1250.618 - 1286.423 MHz). In CP II (passive regional system), three carrier frequencies are used: 1561.098 (B1), 1207.14 (B2) and 1268.52 (B3). In future CP III (passive global system), the carrier frequencies are 1575.42 (B1), 1191.795 (B2) and 1268.52 (B3). Both phases support open (B1, B2) and authorised (B1, B3) signals which provide different positioning precision to civil and military/security users. It should be noted that signals in B1 and B3 overlap with the Galileo signal, which caused some difficulties between China and Europe.

Table 2: Beidou 2 satellite parameters

	CP II MEO	CP II ISGO	CP II GEO	CP III MEO 1	CP III MEO 2	CP III IGSO	CP III GEO
Bus	DFH-3	DFH-3	DFH-3A	DFH-3		DFH-3B	DFH-3B
RDSS	No	No	Yes	No	No	Yes	Yes
Launch mass (kg)	2,160	2,300	3,050	2,200	1,000	4,200	4,600
Payload mass (kg)	249	247	350				
Size (m)	2.2x 1.72x 2.0	2.2x 1.72x 2.0	2.2x 1.72x 2.4				
S/L antenna size (m)	N/A	N/A		N/A	N/A	D=4.2	2.4x3.2
Battery	40AH NiH2	40AH NiH2	60AH NiH2				
Power (end of life) (W)	2,005	2,065	2,500	3,000	3,000	6,200	6,800
Working life (year)	8	8	8	10	10	12	12
Launch Vehicle	CZ-3B (dual-sat)	CZ-3A	CZ-3C	CZ-3B / CZ-7 (dual-sat)	CZ-3B (dual-sat) / CZ-5 (quad-sat)	CZ-3B / CZ-7	CZ-3B / CZ-7

Transition to a Global System

In 2007, the first two Beidou 1 satellites were quite close to their working life of 8 years. China had planned a smooth transition from Beidou 1 to Beidou 2 without affecting existing users. But it was still years away from the establishment of the new system. China decided to launch a new spare satellite to support longer operation in case the two old satellites failed. The new satellite and the Beidou 1C, launched in 2003, would totally replace the Beidou 1A and 1B launched in 2000. On 3 February 2007, Beidou 1D was launched by a CZ-3A from Xichang. But contact was lost just after launch. Some reports indicated the problem was related to the deployment of the solar panels. The rescue work achieved a success in mid-February when the satellite's solar panel deployed and contact was re-established. The satellite, stranded in the geostationary transfer orbit, was then raised slowly and finally reached its geostationary slot on 11 April. Unfortunately, it lost control again in less than two years. It was observed in early 2009 that the satellite was drifting from its position at 86°E. By the end of 2008, all other three Beidou 1 satellites worked well at the 8 years of life mark. Very fortunately, they continued to work for three more years up to the end of 2011, guaranteeing a smooth transition to Beidou 2.

On 14 April 2007, the first Beidou 2 satellite, the Compass M1, was launched. It was an experimental satellite with a similar role to GIOVE in Galileo for in-orbit validation, and also a role

Table 3: Beidou Launch History

Date	Launcher	Satellite	Orbit	Status
10/31/2000	CZ-3A	Beidou 1A	GEO 59°E	Out of service
12/21/2000	CZ-3A	Beidou 1B	GEO 80°E	Out of service
05/25/2003	CZ-3A	Beidou 1C	GEO 110.5°E	Out of service
02/03/2007	CZ-3A	Beidou 1D	Supersync orbit	Out of service
04/14/2007	CZ-3A	Compass M1	MEO 21,500 km / 55°	Testing only
04/15/2009	CZ-3C	Compass G2	Drifting	Satellite failure
01/17/2010	CZ-3C	Compass G1	GEO 144.5°E	In service
06/02/2010	CZ-3C	Compass G3	GEO 84.6°E	In service
08/01/2010	CZ-3A	Compass I1	IGSO 118°E / 55°	In service
11/01/2010	CZ-3C	Compass G4	GEO 160°E	In service
12/18/2010	CZ-3A	Compass I2	IGSO 118°E / 55°	In service
04/10/2011	CZ-3A	Compass I3	IGSO 118°E / 55°	In service
07/26/2011	CZ-3A	Compass I4	IGSO 80-112°E / 55.2°	In service
12/02/2011	CZ-3A	Compass I5	IGSO 79-110°E / 55.2°	In service
02/24/2012	CZ-3C	Compass G5	GEO 58.75°E	In service
04/2012 (Planned)	CZ-3B	Compass M3 Compass M4	MEO 21,500 km / 55° MEO 21,500 km / 55°	
(Planned)	CZ-3B	Compass M2 Compass M5	MEO 21,500 km / 55° MEO 21,500 km / 55°	
(Planned)	CZ-3C	Compass G6	GEO	

for securing the frequency filings. The M1 completed its role successfully, establishing bargaining power when China began negotiating with Europe on frequency overlap.

The in-orbit validation lasted for about two years. In April 2009, the next Compass satellite was launched but it was a failure. The G2 satellite reached the geostationary position at 84.6°E and lost control shortly afterwards. It has been drifting since then.

China quickly resumed Beidou constellation construction in January 2010 and successfully placed three satellites in orbit in eight months. The two GEO satellites and one IGSO satellite established what is the so-called 2+1 constellation. It was not enough for positioning but was ready for system testing and evaluation. About another eight months later, in early April 2011, the 3+3 constellation was formed with launches of one more GEO satellites and two more IGSO satellites. Such a system was able to be used to provide initial passive positioning capability in the Asia-Pacific region. From April to December 2011, Chinese engineers made extensive testing and system optimisation. In July and December, China launched the two more IGSO satellites (all spares) for the CP II constellation, completing the initial passive regional navigation system.

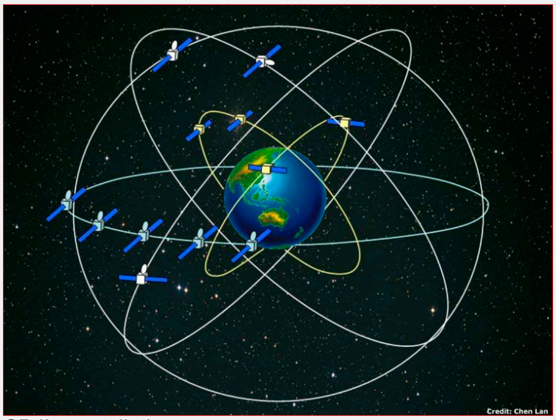
On 27 December, China announced that it will begin to provide trial positioning, navigation and timing services to China and its surrounding areas from 84°E to 160°E and 55°S to 55°N. China also released the Interface Control Document (ICD) with B1 frequency coding information for equipment developers worldwide. It was reported that release of the ICD had oppositions from local manufacturers who are able to access ICD information through internal channels.

At the same time, the Beidou 1 system completed its historic role. The 1A and 1B satellites were moved to graveyard orbits around the end of November and early December. All Beidou 1 users were supposed to have switched to the new system during April to December as the latter is also compatible with the Beidou 1 RDSS, including short messaging.

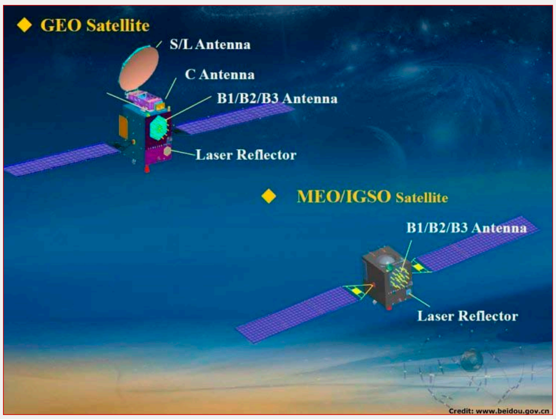
In 2012, China plans to launch six more Beidou CP II satellites, including two GEO satellites, one of which is to replace the failed G2, and four MEO satellites. One of them, the G5, was already launched in February. The first dual-sat launch for MEO satellites by a CZ-3B is scheduled in April. With all these launches completed, the trial service will be upgraded to formal service with better accuracy. For China, its focus will be moved to the CP III global system to be ready by 2020.

Harmony in Space

Unlike GPS and Glonass, all newcomers of GNSS face a very tough and complicated issue - the frequency overlap with existing systems. Galileo had this issue with GPS many years ago. Beidou/Compass met the same problem. Frequency overlapping not only increases risk of signal interference but also causes a more serious problem – each side could not jam the signal of the other without also jamming its own encrypted, security-related signals as well. Just after China announced the plan for the second generation Beidou, the frequency issue emerged. Unfortunately, all frequencies China filed to the ITU have overlap with Galileo's. The Beidou B1 band has overlap with the Galileo E2 band, the Beidou B3 overlaps with Galileo



CP II constellation



CP II satellites

Beidou 2 satellite in testing

Beidou 2 atomic clock

E6, and the Beidou B2 also overlaps with the Galileo E5a. Galileo PRS (Public Regulated Service) uses E2 and E6, while Beidou Authorised Service uses B1 and B3. As a result, these two restricted services will both be disabled by hostile jamming from any one side during a potential conflict. Beidou B2 / Galileo E5a overlapping has less problems as both are for open civil service.

It is technically possible to avoid interference between two systems. For example, the European Community and the U.S. signed an agreement in 2004 for Galileo to use BOC (Binary Offset Carrier) modulation that is able to achieve good inter-system compatibility. On the other hand, frequency overlap has also its positive side that provides a good opportunity to realise interoperability between systems. Fortunately, all major GNSS systems, including Compass, have agreed on right-hand circular polarisation, CDMA modulation, and common frequencies. This allows use of common analogue receiver components for each of these signals. It will benefit end-users because it not only increases accuracy with signals from more visible satellites, but also enhances service robustness.

Early negotiation between China and Europe did not make progress at all. China insisted that under ITU policies, the first nation to start broadcasting in a specific frequency will have priority to that frequency, and any subsequent users will be required to obtain permission prior to using that frequency, and otherwise ensure that their broadcasts do not interfere with the original nation's broadcasts. The fact is that China launched the Compass M1 on 14 April 2007, much earlier than the first Galileo IOV (In-Orbit Validation) satellite. Soon after the M1 launch, researchers at the French Space Agency CNES and Stanford University in the USA not only detected its signals on the Galileo E2, E5B, and E6 bands, but also completed decoding of the signals.

China also participates in the ICG (International Committee on GNSS), an organisation one of whose roles is to coordinate multiple GNSS systems for compatibility and interoperability. China made a small step forward in July 2010. During the workshop of the ICG Working Group A – Compatibility and Interoperability (WG-A) held on 30-31 July in Vienna, China proposed to change almost all of its signal modulation on CP III satellites from Quadrature Phase Shifting Keying (QPSK) to BOC. Though also overlapping with Galileo frequencies, it provides better compatibility and possible interoperability.

Since 2010, the joint workgroup established by China and Europe have participated in at least seven meetings to discuss the problem, but have still failed to resolve the issue. It was in November 2011 that a breakthrough was made. In an interview with the German space magazine "Raumfahrt Concret", European Commission Vice President Antonio Tajani announced that the European Commission had signed an agreement with China which settled the controversy on the frequency overlap between Galileo and Compass. Details of the agreement have never been released. There was no indication of possible compromise from one side on the jamming issue. And also, many Compass Phase II satellites using QPSK modulation were manufactured and launched before the agreement. Therefore, the significance of the agreement may be more for the CP III constellation.

Beidou B1 for CP II is also very close to the GPS L1 band (1575.42 Mhz) which GPS uses for civil signal and planned to use for the military M-code signal. Also, China planned to use 1575.42 Mhz (B1) and 1176.45 Mhz (B2) in its CP III global system that are exactly the same used by the GPS's L1 and its planned L5 civil signal. This raised the compatibility issue between China and the U.S. However, as these two frequencies are planned by ICG for open service interoperability between major GNSSs, it can also be seen as China's efforts to make Compass interoperable with other GNSS systems

China and the U.S had met for five times since June 2007. It was reported that an agreement was signed in September 2010 on Compass/GPS compatibility and interoperability. On 24-25 May 2011, during a workshop on Global Navigation Satellite Systems held jointly by the U.S. National Academy of Engineering (NAE) and the Chinese Academy of Engineering (CAE) in Shanghai, more positive signs were shown. Both the China and the U.S sides expressed a strong will for interoperability and the government's responsibility to protect the navigation frequency band against illegal interference. As Beidou B1 and GPS L1 has close frequency and similar modulation, it is even possible to achieve interoperability in the Compass Phase II. A Chinese company show-cased a deeply integrated Compass/GPS dual constellation receiver in the workshop that has already been used in China. Chinese experts also presented a transition plan from the near-term interoperability to future BOC interoperability. There was also a proposal for the Chinese GEO satellites to broadcast error corrections messages for other GNSS to provide cross-constellation integrity assistance, which is a capability GPS does not have.

Beidou is China's independent global satellite navigation system to avoid reliance on the U.S. GPS system. But it will also benefit users all over the world. The frequency overlap has turned out to be a common basis for cooperation. The NAE President, Dr. Vest, stated in the 2011 Shanghai workshop "We have one world, and only one set of global resources. It is important to work together on satellite navigation. Competing and cooperation is like Yin and Yang. They need to be balanced." Besides foreseeable compatibility and interoperability between GPS, Galileo and Beidou, Glonass has also planned to transit to the CDMA modulation. Japan and India are also developing compatible augmented navigation systems. We have strong reasons to expect an unprecedented combined global navigation system by 2020 with high availability, positioning and timing accuracy, as well as reliability and system robustness. It will be a new milestone in the history of navigation after the invention of the compass in around 200 B.C. and the GPS in 1993. It has also great consequences for world peace when major players co-exist and co-work harmoniously in space.

(Chen Lan)

ISS - The Bridge Between Atlantic and Pacific?
An interview with
Dr. Thomas Reiter, ESA's Director of Human Spaceflight and Operations

The time might soon be right for a Chinese involvement in the International Space Station programme. At the beginning of 2012, voices calling for a Chinese participation in global space efforts are getting stronger. This could start with a Chinese contribution to the ISS.

Let's briefly recapitulate: China has always stated its interest in the ISS programme. Mainly political realities have prevented this to date. There is the US-American International Traffic in Arms Regulations (ITAR) on the one hand, and the so-called 'Wolf Clause' on the other, which is preventing NASA from any cooperation with China. (cf. GoTaikonauts! Issue No. 2 "Learning Rendezvous and Docking").

Despite these unfortunate circumstances, NASA Administrator Charles Bolden and his colleagues paid a visit to China in October 2010, from which he and his delegation returned noticeable impressed.

Also, the German Aerospace Centre and the European Space Agency welcomed Chinese delegations on several occasions.

At the end of June 2011, Prof. Dr. Berndt Feuerbacher, President of the International Astronautical Federation (IAF) handed over a small parcel with 300 IAF flags to taikonaut Zhai Zhigang, and partners of the Chinese Association for Astronautics. These flags were flown last autumn on-board of Shenzhou 8 to the Chinese Tiangong 1 space station.

Later in the year, in December 2011, the ESA Director General Jean-Jacques Dordain published his "Agenda 2015", a strategy paper for the four years of his term. On page 37 it reads: "ESA should be ready for increased cooperation with China in the domain of human spaceflight.", and on page 55: "Significant cooperation should be developed between ESA and China, in particular in scientific missions and in human spaceflight, with the objective to reinforce the current ISS partnership." Dordain even proposes on page 41 of his document: "docking a European vehicle to the Chinese space station". It is not a secret that ESA will fly ATV 4 and 5 in 2013 and 2014 but would not have further vehicles for such activities available after 2015. Therefore the question comes to mind how this could work out.

At the beginning of this year, on 26 January, the Head of the German Aerospace Centre, Prof. Dr. Johann-Dietrich Wörner, gave a press conference in Berlin. Like Dordain, Wörner found clear words, when talking about China. He said: "China is strong in the field of aerospace. So far, China was not considered for involvement in the International Space Station. I have said in my testimony to the Augustine Commission back in 2009, that it would be better to involve China in the ISS programme. Of course this has to be done with caution and with attention to the human right situation, and to the protection of technological rights. I am not naïve. But to leave China out is not the right way to go. With the SIMBOX project we have done the first step in this direction. China's involvement in the ISS would also make sense to prevent a new space competition. We have seen in 1975 when the Soyuz and Apollo spacecraft not only met in space but also docked. The astronauts and cosmonauts did not have passports with them, but it was still possible. And remember, this was at the time when the relationship between East and West has been at least as tense as it is between China and the rest of the world today. Actually, the tensions between the US and the Soviet Union have been worse. And dammit!, sorry if I say so, but why should this not be possible today? Cooperation does not mean automatically that I do not care about human rights and other issues. Also, not to talk to somebody I have controversies with, is not a solution for the future."

On 1 February 2012, the German online issue of "Der Spiegel" magazine published an interview with ESA's Director of Human Spaceflight and Operations, Dr. Thomas Reiter, in which he strengthened the position of his boss when confirming the idea of the docking a European space vehicle to the Chinese space station, or the docking of the Chinese spacecraft to the ISS. Dordain took his turn again during the press conference after the Heads of Agencies Meeting (means the Head of ISS Partner Agencies) in Quebec, Canada, on 1 March 2012, when he explained after being asked about the cooperation with China: "Myself, I am in favour of trying to see how we can work together with China. As I said, this ISS partnership will not be fruitful if this was a closed partnership. This is not a closed partnership, it's an open partnership and we have to see, as Mr. Popovkin was saying, anyone which can help and support this partnership is more than welcome. … I think that at the end, this is a laboratory of the future world, and that laboratory is such that I am convinced that we shall build a collective future together. So yes, I am sure that we shall work with China. It will take some steps, but it will come, I am sure of that." While the Heads of Roscosmos and CSA could agree, NASA and JAXA did not comment.

Another milestone was reached when Jean-Jacques Dordain invited his Chinese counterpart Wang Zhaoyao, Director General of the China Manned Space Engineering Office (CMSEO) to follow the launch of ESA's ATV 3 on 23 March 2012 from Kourou in French-Guiana. On 26 March, Aviationweek reported about this meeting, and that ESA and CMSEO had discussed the option of docking a Chinese spacecraft to the ISS.

GoTaikonauts! in cooperation with the German space magazine "Raumfahrt Concret" wanted to know the details and asked Dr. Thomas Reiter, ESA's Director of Human Spaceflight and Operations, what is the latest situation on this topic?

GoTaikonauts!: *We would like to turn to a topic which is currently in the public eye: Chinese space activities and related European cooperation. In an interview with Spiegel Online International in February this year, you made an announcement, comparable to Kennedy's Moon-ward-ho! speech: Before this decade is out, a European spacecraft is going to dock to the Chinese space station, or a Chinese spacecraft will dock to the*

Dr. Thomas Reiter during his interview with Raumfahrt Concret/GoTaikonauts! on 12 April in Berlin. From the left: Bernd Ruttmann (Raumfahrt Concret), Thomas Reiter, and Uwe Schmaling (Raumfahrt Concret).

Conceptional projection of ESA's Advanced Re-entry Vehicle approaching the Chinese Space Station.

Mr. Thomas Reiter, Director of ESA's Directorate of Human Spaceflight and Operations, said it's a great honour of the delegation to be invited to watch the launch process of Shenzhou 8. Reiter considered that the visit is helpful to enhance mutual understanding and mutual trust, and is also positive in deepening the cooperation and exchange between the two sides.

People in the picture:

◦ First from left: Wang Zhaoyao, Director of the China Manned Space Engineering Office.
◦ Second from left: Karl Bergquist, ESA's Administrator for International Relations at ESA HQ
◦ Fifth from left: Thomas Reiter, ESA Director for Human Spaceflight and Operations
◦ Middle: Niu Hongguang, Deputy Commander CMSEO
◦ Fifth from right: Gerd Gruppe, Member of Board of German Aerospace Agency DLR and Director of Space Management
◦ Third from right: Christoph Hohage, Space Administration in DLR's Directorate of Space Projects
◦ Second from right: Yang Liwei, Deputy Director CMSEO
◦ First from right: Dr. Peter Preu, Head of Department for Microgravity Research at DLR

International Space Station. In case of the European vehicle docking to the Chinese space station, would this be an ATV, or were you relating to an ATV successor? What was this announcement about?
Dr. Thomas Reiter: I consider this a feasible scenario. China is taking big steps in its manned and un-manned space activities. Soon we will witness the next manned launch, the launch of Shenzhou 9. I am confident that the manual docking to the Chinese space station module, Tiangong 1, will be as successful as the automated docking with Shenzhou 8 last year.
China is occupied with a wide range of space activities: scientific missions, Earth observation missions, classic commercial applications and exploration. From my point of view, I think it is obvious to include China and to look for cooperation. We are on the way! Provided we can get the political mandate of our Member States, indeed, I could imagine a cooperation project which aims towards the docking of a European spacecraft to the Chinese space station towards the end of this decade. The European spacecraft would be a further development of the current ATV.

***GoTaikonauts!:** ESA's Director General has given strong support in his "Agenda 2015" for the promotion of the cooperation with China. Are there already some plans outlined, in particular in the area of manned space flight?*
Dr. Thomas Reiter: Together with our Chinese colleagues, we have been looking at several starting points for our discussions. We are going to meet for a joint workshop in the beginning of May, during which we will talk with our Asian counterparts about rendezvous and docking. The Chinese will report about the Shenzhou 8 mission, and we are going to explain our experiences with ATV. By the end of the year, an exchange in the area of astronaut training is planned. We will welcome the Chinese astronauts and astronaut trainers for a visit, and later on, we will reciprocate the visit and go to the Chinese astronaut training centre. Most likely not this year anymore, but for sure next year, we will also have an exchange on the topic of life support systems. Since China intends to set-up a bigger space station, they have to advance in the further development of life support systems. This is almost asking for cooperation. All these activities are first contact opportunities and we hope that concrete cooperation could emerge from that.

***GoTaikonauts!:** Do you think that China is technologically mature enough to enter the International Space Station project?*
Dr. Thomas Reiter: Technically, China might not be mature enough today, but if you consider how successful the first demonstration mission for automated docking has been, I am convinced that China will certainly be able to join the ISS programme in a few years from now, and also to conduct research on the ISS. With respect to the Chinese cooperation in the ISS project, there is mainly political resistance in the US. We have to work on a solution for this problem. Russia, along with Europe, is supportive to the Chinese involvement in the ISS. Last year, when we have been for the launch of Shenzhou 8 in China, we could get a first-hand impression of China's space capabilities. We could see the satellites currently under assembly in the integration halls. It seems to us, that China is on a comparable level to the US, Europe or Russia. Therefore, I am convinced that China could be an excellent partner for the future. It goes without saying, that big exploration projects, no matter whether they are manned or un-manned, can only take place in an international context. And for that, every partner who can contribute significantly is welcome. Considering this, China's performance is already remarkable. We are looking forward to this cooperation.

***GoTaikonauts!:** You have been mentioning already that on the political level, a lot of work still needs to be done. The US attitude is reminiscent of the 1980's, when the Eastern Block was boycotted and technology export was not possible. Do you have an idea why the US is blocking the cooperation with China?*
Dr. Thomas Reiter: From my point of view, this is purely politically motivated. Apparently, my colleagues in NASA have no principle objections against a potential cooperation with China. They do understand that the extension of the ISS cooperation to China would be beneficial for all partners. Also, if you want to talk about a manned mission to Mars within the next two decades, global cooperation would become highly important. I consider it important that all space nations of the planet would work together on such a project to keep the load on each partner bearable. I think, the political hurdles can be taken. Of course, cooperation with China does need careful consideration. It is true that China is very much interested in taking over technologies which they do not yet master. This is also a matter of discussion during our first contacts. The three examples I have given to you are the starting point to get known to each other, to understand better what everybody is actually expecting from each other. Where are the partner's strengths and weaknesses? Where could we help each other? Any partnership should be based on mutual support. The upcoming discussions are expected to evolve into a process, in which all ISS-members are involved. I am convinced that in this way we can master any obstacle which might still be existing in the US.

***GoTaikonauts!:** In other words: political development and rapprochement is required on both sides. Actually, is there political resistance in Europe? Your Director General, and you yourself, are definitely in favour of cooperation with the People's Republic of China, but how is the general political situation in Europe?*
Dr. Thomas Reiter: I am not aware of any fundamental political resistance within Europe - quite the opposite. There is political support to carefully pave the way for cooperation in the area of spaceflight. We all know that during the progress of any international project, problems with its implementation might arise. This is even a fact for the ISS project where 15 partners are involved. Every now and then, certain issues required detailed discussions. But this is exactly the characteristic of such a kind of partnership. We simply have to face cooperation with China and look for real projects. We can debate for ever about the Chinese technological capabilities in spaceflight. Unless we are starting a project, these debates are purely academic.

***GoTaikonauts!:** Would you like to fly again into space? Maybe you could fly to the Chinese space station, expected around 2020. John Glenn also dared to fly to space at the age of 77 years. So plenty of time for you!*
Dr. Thomas Reiter: This dream still exists, in particular if you have been in space before. But looking at it realistically, I have to say that we have recruited six new astronaut candidates recently. It is up to these six young people to fly their missions. As much as I wish I could fly again, I know it will remain a dream.

I Found Myself Very Connected With Him

An interview with Mars500 participants Romain Charles and Diego Urbina

In its first issue, GoTaikonauts! published an article on the Mars500 simulation study and an interview with the Chinese participant of the research project, Wang Yue. On 20 March 2012, GoTaikonauts! had the unique opportunity to talk to the two ESA-supported participants of the Mars500 simulation study, Romain Charles (French) and the Diego Urbina (Italian). The two young men are currently in the post-simulation phase and are based in ESA-ESTEC Noordwijk, in The Netherlands. ESA has requested them to write a final report of the study and next to that, they are still undergoing medical checks, or are involved in follow-up experiments, e.g., in May 2012, when all six Mars500 crew members will participate in ESA's 57th Parabolic Flight Campaign in Bordeaux, France.

In the interview, GoTaikonauts! asked the two Marsonauts about their intercultural experiences and their interaction with Wang Yue.

GoTaikonauts!: How was your overall experience during the simulation study? How would you summarise it?

Diego: It was a hard experience but a very enriching experience.

Romain: To summarise it, I would talk about how it ended: we were still a crew of six together, working efficiently together. I would say this was the main success of this experiment.

GoTaikonauts!: However, you were a crew of six, composed of highly different cultures with crew members from, so to say, three continents. How did this work out? Was this something special?

Diego: For us, this was mostly an advantage because it added some variety to our daily lives: we had different topics to speak about, about things we didn't know before. If we would have been all from the same country, maybe we would have easily run out of topics to talk about.

Romain: Well, the main thing was that we had common things to talk about like education, work, food, traditions – all those things that make a country, we could share them between us. Sometimes it would be quite hard to understand exactly the meaning of those traditions, but it was overall an advantage.

GoTaikonauts!: For some reason the Chinese participation in the Mars500 programme emerged pretty late. How did you react when you heard about a Chinese participant for the simulation study?

Romain: For me it was quite straightforward because I did the medical check with the Chinese participants, so from almost the beginning, I have been together with the Chinese. It seemed normal to me.

Diego: I think it was a very positive thing having a crewmember from another, completely different country as opposed to having four Russians and two Europeans. It adds a little bit more variety, and this is definitely something that you want when you are in isolation and monotony.

GoTaikonauts!: You both stressed the very positive aspects of the international composition of the crew. But what were the intercultural challenges, in particular if you think about the Asian culture coming into your crew?

> "I wanted to learn Chinese but one year and a half was not long enough for this."

Diego: A big challenge is the food, because the food from the West is very different from the Eastern food. In the East, they like more spicy food. They like a very particular kind of food that was not always available during the simulation. I think this was a challenging thing. And other than that? I think you have to recognise the way things are done differently in different countries, and you have to get used to them or try to handle them. Well, you have basically to get used to it. That is also a challenge.

GoTaikonauts!: You have pointed to the food and that this was a challenge for Wang Yue, the Chinese participant. But was there also an intercultural challenge for you personally in the interaction with your Chinese colleague?

Diego: For me there was no challenge at all – not because of the fact that he is Chinese or because of his personality. I found it very easy to interact with him. I found myself very connected with him. Therefore I did not feel any particular challenge.

GoTaikonauts!: Romain, how was this with you? Was it a challenge for you to interact with a crewmember from Asia?

Romain: Look, he is a friend. I mean: a friend. As Diego said, Wang was very outgoing and we could talk with him very easily. We went along quite well together.

GoTaikonauts!: Romain, I saw you on one of the photos in the Mars500 gallery learning Chinese. How is the progress in learning such a difficult language?

Romain: I learned a few words in calligraphy and a few sentences in Chinese, but I would not say that I speak Chinese. I focused mainly on Russian because this was one of the official languages. After that I wanted to learn Chinese, but one year and a half was not long enough for this.

GoTaikonauts!: Diego, I saw you in one of video diaries from the Mars500 study when you were doing some filming. I saw you approaching the cabin of Wang Yue. From what I could see on the video was that you very respectful when you were entering the cabin. You first asked: 'May I come in?' and you pointed out that you were doing some recording and you reassured again: 'Do you mind?' Do you

top left: The Mars500 crew is posing in Halloween mood. In the front row to the left is Romain to be seen. Standing behind are Diego in the middle and Wang Yue to the right.

top middle: Romain is tasting Korean space food.

to right: Wang Yue is using a portable electronic book reader inside the Mars500 facility with Diego Urbina in the background.

Celebrating the Chinese New Year.

think that respect and mutual understanding are the key factors for such an international cooperation?

Diego: Definitely! I would say respect in a confined space with people from different cultures is one of the most important things, if not the most important thing. You have to learn to tolerate things that maybe you are not used to, because the other people are also tolerating things from you that they are not used to. So, it is like a mutual exchange.

GoTaikonauts!: Was learning from each other and respecting each other something coming easy to you?

Diego: I have already been working with international groups of people. Therefore, I knew a little bit how to deal with them. But also I think that the people they have chosen for Mars500 - all of them had a tendency to be very respectful. That is the main common thing I can find in all of us. So, it came very natural for us.

GoTaikonauts!: Do you remember something what you could learn from Wang Yue, something like a tradition, a phrase or a particular behaviour and what you liked?

Diego: Surely! For example, I liked to see him constantly reading and reading and learning about new things in his spare time. You see that he is doing that and then you want to do that as well. And also his patience was remarkable. Sometimes he said: O.k. Diego, be patient. You have to be patient with this. It will be o.k. This was another thing what I could admire from his culture.

GoTaikonauts!: And you Romain, apart from Chinese, could you learn something from Wang Yue?

Romain: I learned from Wang Yue a lot about Chinese history. He loved history and he was proficient in Chinese history, so he taught us a lot about his history.

GoTaikonauts!: What did impress you the most about Chinese history?

Romain: It was from the early Chinese Empire. They were so much advanced in science. They had all those power struggles. To listen to this was even very entertaining sometimes.

"He had a lot of surprises for us…"

GoTaikonauts!: Do you remember a pleasant surprise while working with your Chinese colleague?

Romain: He had a lot of surprises for us actually. He had a lot of small gifts which he would keep under his bed and all of the sudden for a birthday or for the Chinese New Year he would come up with a gift saying: 'This is for you. This is for you. Happy New Year!' or 'Happy Birthday!' This was very nice!

GoTaikonauts!: Diego, what do you remember about Wang Yue?

Diego: The approach of the Chinese to learn English is different from ours. I guess it is because we have common words in English, Italian or Spanish, so we tend to use the words we have in common more often. But as with the Chinese language, Wang Yue ended up learning some strange words, very specialised words. As a consequence, he started sometimes talking like a scholar with very advanced English and he left us surprised: 'Oh, Wang Yue it sounds so elegant talking like that!' Every once in a while he would surprise us with something like that.

GoTaikonauts!: I assume, you are still in contact with all of your crewmembers?

Diego: Yes, we write each other very often e-mails.

Romain: Yes, I can confirm this. We still have a distribution list and we receive often the same e-mails. But also, there are post-simulation activities ongoing. For example, few weeks ago we could see the Russian crew in Germany. It was nice to have a talk with them and spend some time with them again. And hopefully we will see everybody in a few weeks from now in Moscow. I want to know what they will become in the future in their respective countries.

GoTaikonauts!: This sounds a little bit like you might be defined for the rest of your lives through the Mars500 study?

Diego: Well, I don't know if defined is the right word, but it is like one of the strongest experience that we have had in our life. So for sure we will not forget it. But of course, life goes on. Now we move on to new things. But this is an experience that for sure will mark us somehow.

GoTaikonauts!: Is this the same for you, Romain? Is it a lifetime experience?

Romain: Yes, definitely.

GoTaikonauts!: The last question drifts away from your personal impressions. But if you look at your very valuable experience and your big expertise in intercultural interaction with other humans and take this view to look at China: Can you imagine something where you could see the strength of China within the space area, no matter what it might be?

Diego: China has a huge momentum right now. They have a huge impulse to go on to explore and to catch-up with the technologies which were already developed in the West. They are doing it at a very fast pace. I can see them doing really, really nice things in the very next few years.

Romain: I think they will be part of the big players. I mean, they already are. Only three nations sent humans into space with their own means and China is one of them.

(Interview: Jacqueline Myrrhe, William Carey)

Wang Yue is teaching Romain Chinese calligraphy.

"... we were still a crew of six together, working efficiently together. I would say this was the main success of this experiment."

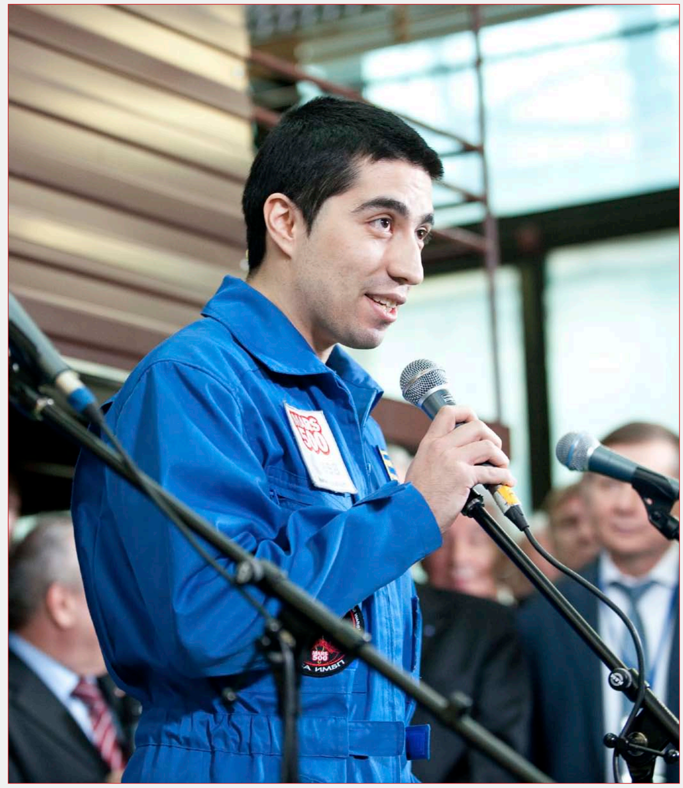
Wang Yue and his crewmates exit the simulation facility.

Diego's anniversary with calligraphic birthday greetings.

Romain Charles studied Mechanical Engineering from 1999 to 2004 in Clermont Ferrand, France. He earned his Master's degree in Engineering from the French Institute of Advanced Mechanics in 2004. Following his university education he gained professional experience in the car industry. Already during his study he worked as support for Quality Engineering with companies such as Mclaren, Aston Martin and Tesla Motors. This followed a spell as a Quality Engineer for the automotive components company Mann + Hummel in 2004. Romain Charles was also involved in projects for the Nissan company. Before joining the Mars500 simulation study he was assigned to the post of Quality Manager for the Sotira (part of the SORA group of companies) company, which produces composite panels.

He would like to continue his professional carrier in the field of space. He hopes to contribute with his unique experience and the valuable insights gained throughout the last two years to the advancement of European and global space activities.

In his spare time Romain likes reading books and going to the cinema. He enjoys the broad possibilities of the internet, as well as swimming, running and scuba diving.



Diego Urbina studied Electronics Engineering at the Politecnico di Torino, in Turin, Italy. Here he got his Bachelor's and Master's degrees in Electronics. Diego also holds a Master's degree in Space Studies from the International Space University, in Strasbourg, France.

In 2008, during his time at university, he was assigned as Attitude and Orbit Control Systems researcher for the Aramis nanosatellite at the Politecnico di Torino. From May to August 2009, Diego served as an operations and astronaut training intern at the Neutral Buoyancy Facility of ESA's European Astronaut Centre in Cologne, Germany. In the same year, he could also participate in the 'Image Reversal In Space' (IRIS) experiment for the ISS, supporting numerous measurements for baseline data collection and testing the experiment during ESA's 50th Parabolic Flight Campaign in Bordeaux. Following his graduation, Diego spent time as an outreach and educational activity organiser in the developing world. Another activity brought him in the beginning of 2010 to the waste planes of the Utah desert. He was a crewmember at the Mars Society's Mars Desert Research Station in Utah, USA. For two weeks he could conduct research on the growth of tropical plants and spacesuit constraints.

He would like to continue his professional carrier in the field of space. He hopes to contribute with his unique experience and the valuable insights gained throughout the last two years to the advancement of European and global space activities.

In his spare time Diego enjoys scuba diving, graphic design, drawing, fitness training and football.

No Giant Leaps
A Review of China's Space Activities White Papers (2000-2011)

Introduction

On Thursday 29 December 2011, the Chinese government (the Information Office of the State Council) published a White Paper entitled 'China's Space Activities in 2011'[1]. We present here a brief review of the three White Papers (published every five years) in 2000[2], 2006[3] and 2011 respectively, covering space activities in China.

The overall structure of the papers throughout this period has remained the same. i.e.:

- **I.** Stating the principles and strategy behind the paper.
- **II.** Summarising the current status and major events that occurred during the previous five years.
- **III.** A review of the planning for the upcoming five years.
- **IV.** A statement of the policies and measures defined to ensure completion of the goals and tasks.
- **V.** The status of China's cooperation at international level.

We will now take a quick look at each of these five main sections in each paper, to try and understand how they have developed over the last decade. In just reviewing these papers, which are all in the public domain, what is immediately observed is the extremely broad range of space activities that China is now engaged in.

I. Principles and Strategy

The first part of each White Paper reiterates the key objectives and principles underpinning the Chinese strategic approach to their space activities. Already in the 2000 White Paper it was clear that China viewed the space domain as a critical strategic element, as the paper begins with the paragraph, '*The Chinese government has all along regarded the space industry as an integral part of the state's comprehensive development strategy, and upheld that the exploration and utilization of outer space should be for peaceful purposes and benefit the whole of mankind. As a developing country, China's fundamental tasks are developing its economy and continuously pushing forward its modernization drive'*. The three key elements in this paragraph are repeated in the 2006 and 2011 publications: Space remains an integral part of strategic planning; space should be for peaceful purposes; and technological developments in space have a positive effect on China's economic and social development - clear and consistent primary objectives. In addition, in 2011, it is noted that the influence of space activities on China's economical and societal development is increasing. A strong point is that the space programme is embedded in the economic development of the country. Space is used as a driver for societal development, something that would not work in the same way for a free-market society.

Although the detailed wording of the content of the 'Aims and Principles' section has been modified in each publication, the key principles remain more or less the same, i.e.:

1. Maintain and serve the country's overall development strategy.
2. Uphold the policy of independence and self-reliance.
3. Maintain comprehensive, coordinated and sustainable development.

An addition in the 2006 and 2011 papers was a reference to the *'Adherence to the policy of opening up to the outside world'*.

II. Progress Made (Since Last White Paper)

1. Space Transportation Systems

This title appeared for the first time in 2011, in the previous 2000 and 2006 WPs, it was termed *"launching vehicles"*. Note also that the complete section title *"Space Technology"* has been removed completely.

1956-2000 Launches: In the 44 year period between 1956-2000 China accomplished 63 Long-March launches, with 21 consecutive successful flights in the period October 1996 to October 2000. Included in these Long-March launches, in the period 1985 to 2000 a total of 27 foreign commercial satellites were launched.

2000-2006 Launches: In this 5-year period the Long-March launch vehicle achieved 24 consecutive successful flights. Mention is made of *"smooth progress"* in R&D for a 120-ton thrust liquid-oxygen/kerosene engine and a 50-tonne thrust hydrogen-oxygen engine.

2006-2011 Launches: In this 5-year period Long-March vehicles achieved a total of 67 successful launches.

This section clearly reflects the dramatic increase in China's launch capacity in the period 2000-2011.

2. Man-made Earth Satellites

In 2000, the development of four series of satellites was reported:

1. Recoverable remote sensing satellites.
2. Dongfanghong (DFH) telecommunications.
3. Fengyun (FY) meteorological.
4. Shijian (SJ) scientific research and technology.

In 2006, the addition of a further two series was reported:

1. Ziyuan (ZY) Earth resources.
2. Beidou navigation/positioning.

The 2011 paper additionally identified Haiyang (ocean), Yaogan (remote sensing) and Tianhui satellite series, together with *'a constellation of small satellites for environmental and disaster monitoring and forecasting'*.

The 2011 paper also noted that *'In 2010, China formally initiated the development of an important special project - a high-resolution Earth observation system'*.

The 2011 paper identified four classes of man-made satellites, i.e., Earth Observation, Communications & Broadcasting, Navigation & Positioning and Scientific/Technological.

Throughout the period covered by the papers, the series of satellites has been extended, with particular emphasis on the consolidation of the Beidou constellation. The reference to the high-resolution Earth Observation system as a special project is also interesting. Although it is difficult to be certain, it would appear that no satellite series have been cancelled or otherwise abandoned, and such a reference is not likely to appear in a White Paper in any case. The overall message however, is one of steady growth and consolidation.

3. Human Spaceflight

The 2000 paper reported on the accomplishments of its manned programme, initiated in 1992, primarily manned spacecraft and reliable launch vehicle. China's first unmanned experimental spacecraft Shenzhou, was successfully launched and retrieved in 1999. The 2006 paper reported that a further three unmanned Shenzhou launches were successful. The 2006 paper also noted Shenzhou V in 2003, and Shenzhou VI in 2005. Unsurprisingly, neither Yang Liwei, the first Chinese Taikonaut of (Shenzhou V) or Nie Haisheng and Fei Junlong (Shenzhou VI) were mentioned by name in the white paper. The reports of both of these major milestone missions for China were typically understated.

The 2011 paper reported the success of Shenzhou 7 mission, noting China is the third country in the world to master EVA technology. Again, neither taikonaut was identified by name. Also reporting of the Tiangong 1 / Shenzhou 8 unmanned rendezvous and docking demonstration was made. The importance of this technology in the construction of laboratories and space stations in the future was clearly made. It should be noted however, that within China, all of the taikonauts flown to date have become well-known hero's, especially Yang Liwei, and all are having the task to engage the general public, as is done in the West.

4. Deep Space Exploration

This area of space activity did not appear in the 2000 paper, and was only very briefly mentioned in the 2006 paper. The 2006 report stated *'..studies and engineering work of the lunar-orbiting project has been conducted, making important progress'*. The 2011 paper summarised the achievements and significance of the Chang'e 1 mission in 2007, specifically noting that China was now capable of performing deep-space exploration. The paper also noted the Chang'e 2 launch in 2010, and extension of the mission to the SEL2 Lagrange Point. Again emphasising the importance of these missions for the future exploration of deep space.

5. Space Launch Sites

The 2000 paper reported the setting-up of three launch sites in China, Jiuquan, Xichang and Taiyuan. 2006 and 2011 noted the continuing construction of these three sites, and in addition, 2011 reported the building of a fourth launch site in Hainan, *'to accommodate the launch of new-generation launch vehicles'*.

6. Space Telemetry, Tracking and Command (TT&C)

The establishment of this TT&C network was first reported in 2000. Its improvement and expansion was noted in 2006, together with its support of un-manned and manned spacecraft throughout their mission profile. Further improvement of ground stations and ships was noted in 2011, including an expansion of the network from ground-based to space-based, and from geo-space to deep-space, and the capability to support human spaceflight and deep-space exploration.

7. Space Applications

This activity area appeared already in the 2000 paper, and specifically noted that *'China attaches importance to developing all kinds of application satellites and satellite application technology, and has made great progress in satellite remote-sensing, satellite telecom and satellite navigation'*. Details of the activities in each of these three areas were then given, with remote sensing and telecommunications accounting for just over 2/3 of the total number of satellites launched to this point in time.

The 2006 paper reported on:

1. The *'taking-shape of a national satellite remote-sensing application system'*. These systems performed regular operations in the fields of meteorology, mining, surveying, agriculture, forestry, land mapping, water conservancy, oceanography, environmental protection, disaster mitigation, transportation and regional and urban planning.
2. The initial *'shaping'* of a satellite telecommunications and broadcasting industry. Specific mention is made of satellite radio and television broadcasting services leading to increased coverage and quality all over China, but particularly in the countryside. Mention is also made of the establishment of a world-wide maritime satellite communications network.
3. The paper notes the great progress made in satellite navigation and positioning technologies, and the use of such technologies in the fields of transportation, basic surveying and mapping, project surveys, resources investigation, earthquake monitoring, meteorological exploration, oceanic surveys, etc.

The 2011 paper reports on the continued development of the applications in the three areas of Earth Observation, Communications and Broadcasting, and Navigation and Positioning.

8. Space Science

The 2000 paper reported broadly on the utilisation of the 'SJ' series of satellites, without any details of specific missions.

The 2011 paper addressed four categories:

1. Sun-Earth exploration. The 2006 paper reported on the Double Star cooperative mission with the European Space

Agency (ESA). Additionally, the 2011 paper noted the implementation of the Double Star programme in concert with ESA's Cluster Programme.

2. Lunar scientific research. 2011 highlighted the achievements of China's lunar exploration projects.
3. Microgravity science and space life science. Both the 2006 and 2011 papers reported briefly that many space life science, space materials science and microgravity science experiments were performed using a combination of Shenzhou spacecraft and recoverable satellites.
4. Space environment exploration and forecasting. 2006 noted important progress in the observation, reduction and forecasting of space debris.

9. Space Debris

Space Debris. For the 2011 paper, space debris was given a category of its own, where progress in monitoring of space debris was reported.

III. Planning for the Following Five Years

In the 2000 paper, the following targets (for the subsequent 10 years) were identified:

- To build-up an Earth Observation system for long-term stable operation.
- To set-up an independently-operated satellite broadcasting and telecommunications system.
- To establish an independent satellite navigation and positioning system.
- To upgrade the overall level and capacity of China's launch vehicles.
- To realise manned spaceflight and establish an initially complete R&D and testing system for manned space projects.
- To establish a coordinated and complete national satellite remote-sensing application system.
- To develop space science and explore outer space.

And with respect to the long-term (for the subsequent 20 years or so):

- To achieve industrialisation and marketisation of space technology and space applications.
- To establish a multi-function and multi-orbit space infrastructure composed of various satellite systems.

Concerning the first set of bullets above, and comparing with the progress reported in the subsequent papers of 2006 and 2011, all of the points identified have appear to have made significant progress. The last two bullet points have a timescale of 20 years, but here also, considerable progress does seem to have been achieved.

In the 2006 paper, the following statement was made:

"The Outline of the 11th Five-Year Program for National Economic and Social Development" and "The National Guideline for Medium- and Long-term Plans for Science and Technology Development (2006-2020)" formulated by the Chinese government in 2006 put the space industry in an important position. Based on the above two documents, the Chinese government has drawn up a new development plan for China's space industry, defining development targets and major tasks for the next five years or more. According to this plan, the country will launch and continue key space projects, including manned spaceflight, lunar exploration, high-resolution Earth observation, new-generation carrier rockets, and a group of priority projects in key sectors. It will also strengthen basic research, make arrangements ahead of schedule, develop frontier space technology, and accelerate progress and innovation in space science and technology."

The wording of the above paragraph tends to suggest that although China fully appreciated the importance of space activities in its overall development strategy from the very beginning in 2000, the significant global impact that these activities had on the rest of the world during the period 2000-2006, caused them to rethink their planning in 2006.

Following the introductory paragraph, the 2006 paper identified a number of development targets, which fully reflected the priorities outlined in 2000. In addition however, specific targets were:

- To enable astronauts to engage in extravehicular activities.
- Achieve spacecraft rendezvous and docking.
- Realise a lunar-orbiting probe.
- Make important and original achievements in space science research.

Certainly the targets identified in the first three bullets have been very successfully achieved indeed. In the case of the last bullet, however, although some 'important and original' achievements may have been demonstrated, as with the vast majority of scientific research, these achievements do not receive the same level of 'communication' to the general public as for example, a rendezvous and docking mission shown live on television. This is a problem well-known to those scientists performing research using facilities on the International Space Station. It is sometimes felt that only a Nobel Prize will be an adequate demonstration of 'good' science.

Major targets (tasks) in 2006 were identified as:

- To develop new generation, non-toxic, pollution-free, high-performance, low-cost and powerful thrust rockets.
- To start and implement a high-resolution Earth Observation system.
- To define a plan for the development of a satellite remote-sensing ground-system, and an application system.
- To develop and launch geostationary orbit telecommunications satellites and Direct TV broadcasting satellites.
- To improve the Beidou navigation satellite test system, and launch and implement the Beidou navigation satellite system project.
- To develop and launch new-technology test satellites.
- To develop and launch the *'breeding'* satellite (related to agricultural science research).
- To develop scientific satellites.
- To enable astronauts to engage in extravehicular operations; and conduct experiments on spacecraft

rendezvous and docking; carry out research on short-term manned and long-term autonomously orbiting space laboratories.
- To realise a lunar-orbiting probe; develop and launch Chang'e 1.
- To increase the comprehensive experimental ability and returns of spacecraft launch sites.
- To advance the technology and capability of the TT&C network.

Looking at some of the above bullets, the achievements can be summarised as follows:

- The development of non-toxic rocket motors appears to be making good progress.
- The announcement of the initiation of the *'special project'* on a high resolution Earth Observation system was initiated in 2010.
- The *'improvement'* of the Beidou system has definitely been achieved with several more satellites added during the 2006-2011 timeframe.
- Demonstrations of EVA (in 2008) and Rendezvous and Docking (late 2011) have been significant notable achievements for China.

Instead of the list of bullet points in the 2000 and 2006 papers, the 2011 paper identified the major tasks for the subsequent 5 years by category, i.e.:

- Space Transportation System
- Man-made Earth Satellites
- Human Spaceflight
- Deep-Space Exploration
- Space Launch Sites
- Space TT&C
- Space Applications
- Space Science
- Space Debris

This structure now reflects the structure of section II, so if maintained in future White Papers, will enable a rapid assessment of whether the targets have been achieved or not.

Some notable key targets are:

- The launching of Long-March series 5, 6 and 7 launch vehicles, together with initial activities on heavy-lift launchers.
- Emplacement of a suite of satellites:
  - A high-resolution Earth Observation system (all-weather, 24-hour, multi-spectral, various resolution).
  - Develop a higher capacity/power platform for GEO communications and broadcasting.
  - Following a three-step plan (experimental, regional, global) complete the Beidou navigation/position satellite system by 2020 (5 GEO and 30 non-GEO satellites).
  - Launching a range of scientific/technological satellites (including Shijian 9).
- Launching of Shenzhou 9 and Shenzhou 10, and achieve manned or unmanned rendezvous and docking with Tiangong 1.
- Launch space laboratories and space *'freighters'* and make progress in several key technologies associated with medium-term human space flight.
- Conduct studies on preliminary planning for a human lunar landing.
- Following a three-step strategy, orbiting, landing and returning, continue lunar exploration.
- Conduct a special demonstration in deep-space exploration, and advance exploration of planets, asteroids and the sun.
- Continue to enhance all of its launch sites, and complete the construction and initiate service of Hainan.
- Improve TT&C capabilities across the board.
- In the area of Space Applications:
  - In addition to general improvement of ground facilities, implement application demonstration projects.
  - Expand value-added business (services) in satellite communications.
  - Further commercialise satellite communication.
- Promote further use of Beidou in various fields of Chinese economy.
- In the area of Space Science:
  - Make in-situ analyses (in landing and roving areas) on the Moon.
  - Make Moon-based astronomical observations.
  - Perform astrophysics and microgravity research.
- Continue work on monitoring and mitigating space debris.

IV. Development of Policy & Measures

This section identifies the policies and measures that should be taken to ensure completion of the overall goals and specific tasks identified. In all three papers, a policy which clearly stands out relates to effective planning and *'rational'* deployment of space activities, i.e., the overall development of China's space industry is well planned, but more importantly well-coordinated. In this regard, the 2011 paper states *'...give priority to applied satellites and satellite applications'*, even ahead of human space flight.

There is also a consistent reference to:

- The *'development of talented people'*. China appears to fully appreciate and understand the importance of having the right (knowledgeable) individuals in the right place at the right time.
- A statement that is rarely, if ever these days, spoken of in the West, i.e., a guarantee of suitable and steady financial investment.
- An encouragement to *'people in all walks of life'* to participate in space-related activities.

One noticeable addition in the 2011 text, is a reference to the *'... strengthening of innovation capability'*.

V. International Cooperation

All three papers exhibited a consistent set of guiding principles in this area. A consistent theme here is the emphasis on space cooperation in the Asia-Pacific region, together with a focus on interacting with developing countries. Organisations within

China are strongly encouraged to engage in international cooperation over a broad range of topics, but should be in line with state policies.

The 2011 paper provides an impressive list of bilateral and multilateral activities, including a reference to a limited number of commercial activities.

Key cooperation areas identified in the 2011 paper for the upcoming five years are:

- Scientific research in a number of areas.
- Applications of Earth Observation satellites.
- Applications of communications satellites, primarily in broadcasting and television.
- Applied technological cooperation (R&D, development of ground facilities, industrial services) in the navigation field.
- Technological cooperation on a space lab and a space station (human spaceflight).
- Space TT&C cooperation.
- Commercial launch services, including satellite application facilities and related services.
- Personnel exchanges and training.

Worthy of note here is the emphasis on *'applications'*. In the previous White Papers the emphasis was more on the development of knowledge and the building-up of capabilities and infrastructure. It appears now that China is ready to put their systems to good use.

It is also evident that when China is involved in a successful international cooperation with another entity, e.g., the European Space Agency on the Double Star project, the positive experience engenders trust and a willingness to extend or otherwise develop the cooperation. It is critical for China however, that cooperation by definition, must be characterised by 'mutual benefit', i.e. a win-win situation for both parties, or for all parties in a multilateral engagement.

Summary

From a Go Taikonauts! perspective, what is the most impressive aspect highlighted by this brief review is the commitment by China to building its strategy on a foundation of clearly-defined principles. This is a word that is seldomly heard of now in the West, and if it is, it is usually in derogatory terms. The principles form a common silken thread running through all of the White Papers. The strategy at the highest-level remains consistent, i.e. incremental progress achieved step-by-step. No giant leaps! At the lower level, the prioritisation of the various space activities does change, in response to internal or external events, but the overall direction is maintained.

China's strategy has three major characteristics; consistency, consistency and consistency.

Another *'take-home'* message from the review is that China is more than willing, indeed actively seeking, international cooperation. It is hard to imagine a more reliable partner than one who bases their cooperation around the principle of *'win-win'*, and who shows long-term stability in their approach.

A final (and personal) observation from the review relates to China's modesty. Despite all of the considerable achievements, in general, but specifically in the space domain, China continues to refer to itself as a *'developing country'*[4]. This attitude, apart from being enormously refreshing, can only drive China to more and more success in the long-term.

(William Carey)

References:

1. China's Space Activities in 2011 (http://www.china.org.cn/government/whitepaper/node_7145648.htm). Information Office of the State Council of the People's republic of China. 29 December 2011.
2. China's Space Activities (2000) (http://english.gov.cn/official/2005-07/27/content_17656.htm). Information Office of the State Council of the People's republic of China. November 2000.
3. China's Space Activities in 2006 (http://www.china.org.cn/english/features/book/183672.htm). Information Office of the State Council of the People's republic of China. October 2006.
4. China's World View: A Long Way to Go. Simon Rabinovich. http://blogs.ft.com/beyond-brics/2012/04/25/china%e2%80%99s-world-view-a-long-way-to-go/#axzz1t3QyN0FN

Chinese Space Launch History (Part IV: 2007 – 2010)

#1	#2	Date	Time (UTC)	ID	Model	LV S/N	Launch Site	Launch Pad	Payload		Orbit				Remark
									Name	Weight	Type	Perigee	Apogee	Inclination	
105	95	2/2/2007	16:28	07003	CZ-3A	Y12	Xichang	2	BD-1 04	2320	GTO				
106	96	4/11/2007	3:27	07010	CZ-2C/3	Y18	Taiyuan	old	HY-1B	442	LEO	798		98.5	
107	97	13/4/2007	20:11	07011	CZ-3A	Y13	Xichang	3	BD-1 M1	2160	MEO	200	21650	55	
108	98	14/5/2007	8:01:02	07018	CZ-3B	Y9	Xichang	2	Nigcomsat 1	5100	GTO	209	41951	25	
109	99	25/5/2007	7:12	07019	CZ-2D/2	Y8	Jiuquan	603	YG-2						
									PX-1	2.5					
110	100	1/6/2007	16:08	07021	CZ-3A	Y15	Xichang	3	Chinasat-5C	2200	GTO	205	42123	25	
111	101	5/7/2007	12:08	07031	CZ-3B	Y10	Xichang	2	Chinasat-6B	4600	GTO	206	50030	2.43	
112	102	19/9/2007	3:26:13	07042	CZ-4B	Y17	Taiyuan	old	ZY-1 02B		LEO	738	750	98.5	
113	103	24/10/2007	10:05	07051	CZ-3A	Y14	Xichang	3	CE-1	2350	HEO	205	50930		
114	104	11/11/2007	22:48	07055	CZ-4C	Y3	Taiyuan	old	YG-3						
115	105	25/4/2008	15:35:11	08019	CZ-3C	Y1	Xichang	2	TL-1 01	2480	GTO	210	41795	18.5	
116	106	27/5/2008	3:02:33	08026	CZ-4C	Y2	Taiyuan	old	FY-3 01	2200	SSO	815.6	821.7	98.78	
117	107	9/6/2008	12:15	08028	CZ-3B	Y11	Xichang	2	Chinasat-9	4500	GTO	214	49887	24.2	
118	108	6/9/2008	3:25	08041	CZ-2C/SMA	Y1	Taiyuan	old	HJ-1A		LEO	647		98	
									HJ-1B		LEO	642		98	
119	109	25/9/2008	13:10	08047	CZ-2F	Y7	Jiuquan	921	Shouzhou-7		LEO	200	347	42.4	
									BanXing-1	40	LEO				
120	110	25/10/2008	1:15	08053	CZ-4B	Y22	Taiyuan	New	SJ-6 03A		LEO				
									SJ-6 03B		LEO				
121	111	29/10/2008	16:53:43	08055	CZ-3B/E	Y12	Xichang	2	Venesat-1	5100	GTO	208	41929	24.78	
122	112	5/11/2008	0:15	08056	CZ-2D/2	Y12	Jiuquan	603	SY-3		LEO				
									CX-1 02	200	LEO				
123	113	1/12/2008	4:42	08061	CZ-2D/2	Y9	Jiuquan	603	YG-4		LEO				
124	114	15/12/2008	3:22	08064	CZ-4B	Y20	Taiyuan	New	YG-5		LEO				
125	115	23/12/2008	0:54	08066	CZ-3A	Y20	Xichang	3	FY-2 06	1390	GTO				

#1	#2	Date	Time (UTC)	ID	Model	LV S/N	Launch Site	Launch Pad	Payload		Orbit				
									Name	Weight	Type	Perigee	Apogee	Inclination	Remark
126	116	14/4/2009	16:16	09018	CZ-3C	Y3	Xichang	2	BD-2 G2	3050	GTO				
127	117	22/4/2009	2:55	09021	CZ-2C/3	Y19	Taiyuan	old	YG-6		LEO				
128	118	31/8/2009	9:28	09046	CZ-3B	Y8	Xichang	2	Palapa D	4078	GTO	221.1	21135.3	22.3	Partial failure. Apogee lower than target orbit.
129	119	12/11/2009	2:45	09061	CZ-2C/3	Y21	Jiuquan	603	SJ-11 01		LEO				
130	120	9/12/2009	8:42	09069	CZ-2D/2	Y10	Jiuquan	603	YG-7		LEO				
131	121	15/12/2009	2:31:05	09072	CZ-4C	Y4	Taiyuan	New	YG-8	1040	LEO	1183.7	1193.4	100.5	Orbit data: USSPACECOM
									XW-1	60	LEO	1090.3	1204.4	100.5	Orbit data: USSPACECOM
132	122	16/1/2010	16:12	10001	CZ-3C	Y2	Xichang	2	BD-2 G1	3050	GTO				
133	123	5/3/2010	4:55:05	10009	CZ-4C	Y5	Jiuquan	603	YG-9 A		LEO				
									YG-9 B		LEO				
									YG-9 C		LEO				
134	124	2/6/2010	15:53	10024	CZ-3C	Y4	Xichang	2	BD-2 G3	3050	GTO				
135	125	15/6/2010	1:39	10027	CZ-2D/2	Y15	Jiuquan	603	SJ-12		LEO				
136	126	31/7/2010	21:30	10036	CZ-3A	Y16	Xichang	3	BD-2 I1	2300	GTO				
137	127	10/8/2010	22:49:05	10038	CZ-4C	Y6	Taiyuan	New	YG-10		LEO				
138	128	24/8/2010	7:10	10040	CZ-2D/2	Y14	Jiuquan	603	TH-1		LEO				
139	129	5/9/2010	16:14	10042	CZ-3B	Y13	Xichang	2	Chinasat-6A		GTO	213	42061	25.2	
140	130	22/9/2010	2:42	10047	CZ-2D/2	Y11	Jiuquan	603	YG-11		LEO				
									PX-1A	3.5	LEO				
									PX-1B	3.5	LEO				
141	131	1/10/2010	10:59:57	10050	CZ-3C	Y7	Xichang	2	CE-2	2480	TLO	2128	365996	28.5	
142	132	6/10/2010	0:49	10051	CZ-4B	Y23	Taiyuan	New	SJ-6 04A		LEO				
									SJ-6 04B		LEO				
143	133	31/10/2010	16:26	10057	CZ-3C	Y5	Xichang	2	BD-2 G4	3050	GTO				
144	134	4/11/2010	18:37	10059	CZ-4C	Y7	Taiyuan	New	FY-3 02		SSO				
145	135	24/11/2010	16:09	10064	CZ-3A	Y21	Xichang	3	Chinasat-20A		GTO				
146	136	17/12/2010	20:20	10068	CZ-3A	Y18	Xichang	3	BD-2 I2	2300	GTO				

Note:

1. #1 and #2 are flight numbers of all launches and launches per vehicle respectively.
2. Last digit in CZ-2C/2, CZ-2C/3, CZ-2D/2 designators is unofficial and refers to "block n".

Sources:

1. CGWIC website: http://cn.cgwic.com/LaunchServices/LaunchRecord/LongMarch.html
2. Chinese Internet forum: http://www.9ifly.cn/thread-407-1-1.html (author: heito, darklighter, liss, zhaoyublg)
3. Jonathan McDowell, History of Space Flight, http://www.planet4589.org/space/book/index.html
4. Wikipedia, http://zh.wikipedia.org/wiki/中国运载火箭发射列表

Chinese Launch Sites
(Part 4 - Wenchang Satellite Launch Centre)

Launch Site Name:
Hainan Wenchang International Commercial Satellite Launch Centre, or simply Wenchang Satellite Launch Centre (WSLC)

Location: 19.62°N, 110.96°E

Brief History

Aimed at launching China's next generation of space rockets, a new space port is under construction in Wenchang, Hainan Province on Hainan Island in the South China Sea. The new launch site has certain advantages over China's other space launch sites: e.g., low-latitude location, wider launch angles and sea transport capability. The site will be able to launch CZ-5 class heavy launch vehicles as well as manned space missions.

After years of feasibility study and preparation, official construction started on 14 September 2009. Phase I of the construction will build at least one launch pad and technical facilities to support both manned and unmanned space launches. The first launch of a CZ-5 is expected to take place sometime in 2014.

Sources:
1. 百度百科 , http://baike.baidu.com/view/25207.htm
2. CGWIC, http://www.cgwic.com

Facilities

- Launch Pad #1 and possibly Launch Pad #2
- General Vertical Assembly and Test Facility
- Horizontal Transport Preparation Facility
- Payload Assembly and Test Facility
- Payload Propellant Loading and Fairing Assembly Facility
- Command and Flight Control Centre

Other Facilities:

- A telemetry station
- A dedicated terminal in West Qinglan Sea Port
- A Space Theme Park, planned to open to the public in 2014

Milestones

September 2007: WSLC construction plan was approved by The State Council of China

14 September 2009: Official groundbreaking of WSLC and core facilities

Late 2013: Completion of WSLC phase I

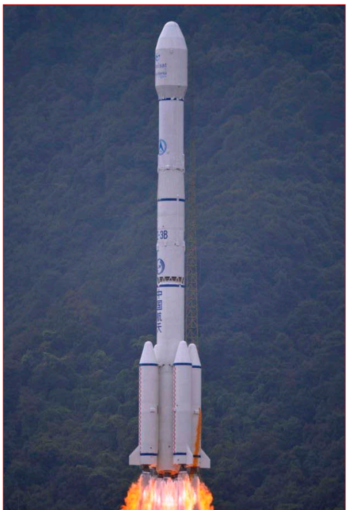
2014: First launch (most likely a CZ-5)

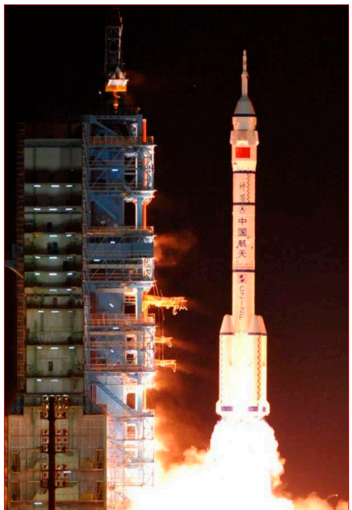
Corrections
Issue 2
article "Dawn of the Chinese Space Station Era" in the:
• 2nd paragraph of the section "A Mini Man-tended Space Station", "The resource module has a diameter of 2.8 m, with a usable interval volume..." should be "The resource module has a diameter of 2.8 m. The experimental module has a usable internal volume..."
• 3rd paragraph of the section "A Mini Man-tended Space Station", "Ka-band" should be "Ku-band".
• 6th bullet ("upgradable software") following the 4th paragraph of the section "A Mini Man-tended Space Station", "of any sub-system" should be "of a sub-system".

Issue 3
Quartely Report (July - September 2011) in the:
• first paragraph of the section "Manned Space Flight", "On the same day, another CZ-2F for the Shenzhou 8 arrived in JSLC." should be "On the same day, the Shenzhou 8 spacecraft arrived in JSLC."

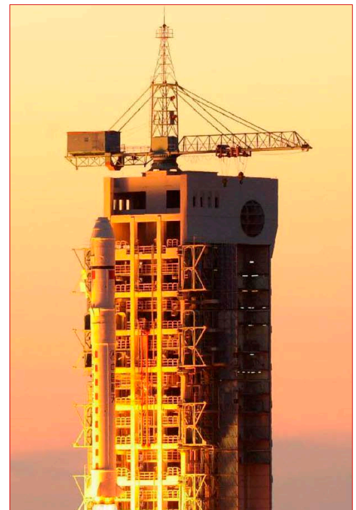
Gallery

Twelve Launches in Recent Six Months


Eutelsat W3C was launched by a CZ-3B/E (Y18) at 16:21 BJT, 7 October 2011 from Pad 2, Xichang Satellite Launch Centre. (credit: Xinhua)

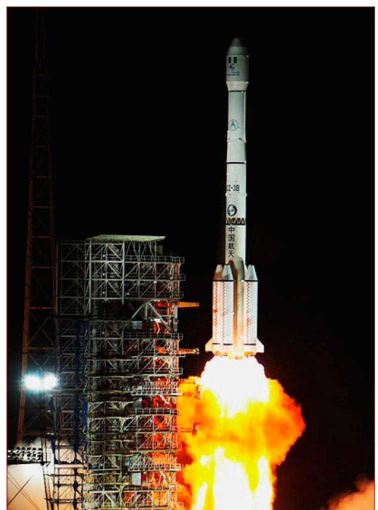

Shenzhou 8 was launched by a CZ-2F (Y8) at 5:58 BJT, 1 November 2011 from Pad 921, Jiuquan Satellite Launch Centre. (credit: Xinhua)

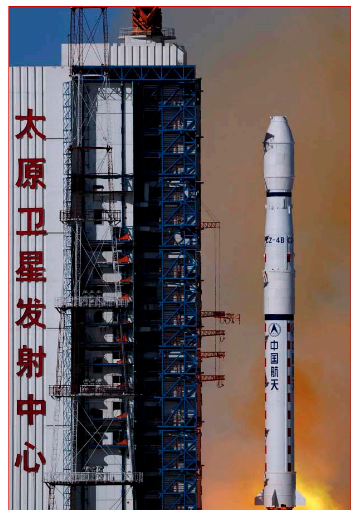

Yaogan 12 was launched by a CZ-4B (Y21) at 11:21 BJT, 9 November 2011 from the New Pad, Taiyuan Satellite Launch Centre. (credit: Xinhua)


CX-1-03 / SY-4 was launched by a CZ-2D (Y19) at 8:15 BJT, 20 November 2011 from Pad 603, Jiuquan Satellite Launch Centre. (credit: Xinhua)


Yaogan 13 was launched by a CZ-2C/3 (Y20) at 2:50 BJT, 30 November 2011 from the New pad, Taiyuan Satellite Launch Centre. (credit: Xinhua)

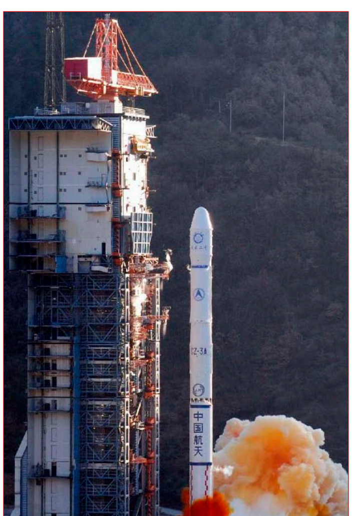

Beidou/Compass IGSO-5 was launched by a CZ-3A (Y23) at 5:07 BJT, 2 December 2011 from Pad 3, Xichang Satellite Launch Centre. (credit: Xinhua)

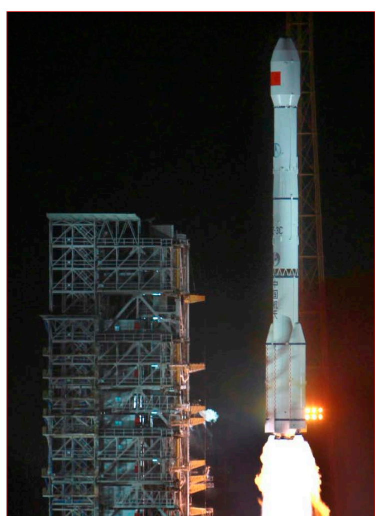

Nigcomsat 1R was launched by a CZ-3B/E (Y21) at 0:41 BJT, 20 December 2011 from Pad 2, Xichang Satellite Launch Centre. (credit: Xinhua)

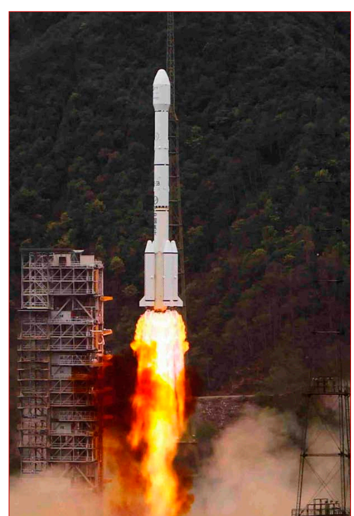


ZY-1-02C was launched by CZ-4B (Y15) at 11:26 BJT, 22 December 2011 from the New Pad, Taiyuan Satellite Launch Centre. (credit: Xinhua)


ZY-3/VesselSat-2 was launched by a CZ-4B (Y26) at 11:17 BJT, 9 January 2012 from the New Pad, Taiyuan Satellite Launch Centre. (credit: Xinhua)


FY-2F was launched by a CZ-3A (Y22) at 8:56 BJT, 13 January 2012 from Pad 3, Xichang Satellite Launch Centre. (credit: Xinhua)


Beidou/Compass G5 was launched by a CZ-3C (Y6) at 0:12 BJT, 25 February 2012 from Pad 2, Xichang Satellite Launch Centre. (credit: Xinhua)


Apstar 7 was launched by a CZ-3B/E (Y22) at 18:27 BJT, 31 March 2012 from Pad 2, Xichang Satellite Launch Centre. (credit: Xinhua)