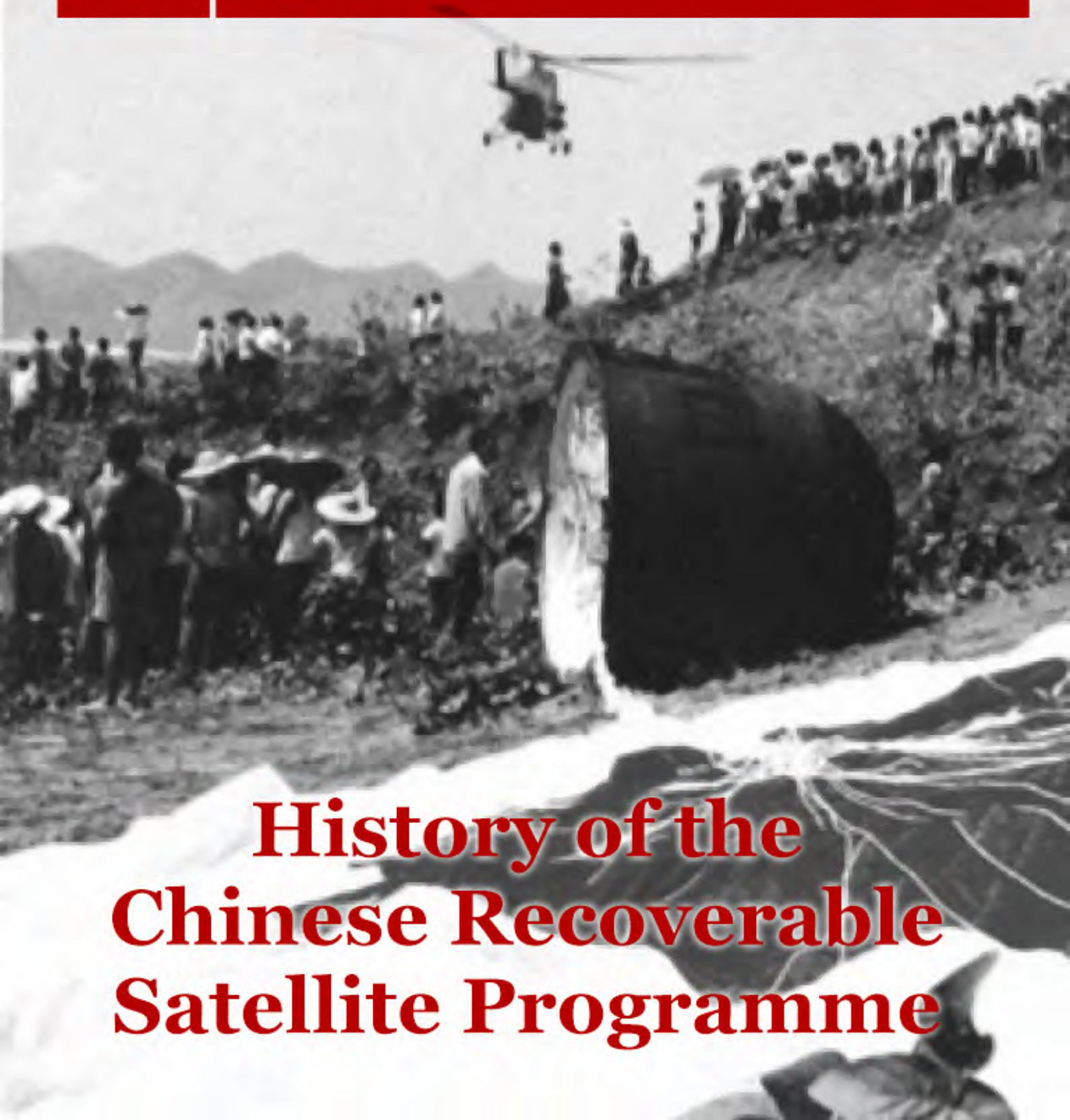
All About The Chinese Space Programme

Go Taikonauts!

龙腾太空

Issue 6 October 2012



History of the Chinese Recoverable Satellite Programme

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Editor's Note

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History of the Chinese Recoverable Satellite Programme

China became the third country to send a human into space in 2003 with its Shenzhou spacecraft. Now, it has a mini space station Tiangong 1. It will complete a more sophisticated modular Space Station in the next few years. These achievements were not made out of nowhere. ... page 7

Interview

The long run for chasing the Sun

Once upon a time there was a tribe of giants living in the mountains of China's North. They were known as warm hearted, busy and brave people. The leader of the giants was Kuafu, the bravest, strongest and friendliest among them. One day the Sun was shining so strong that all life around was about to die. Kuafu was very concerned when he saw his people suffering ... page 21

International Cooperation

Luna meets Chang'e

In the beginning of the space era, the Moon was about to become the domain of the Soviet Union until the United States caught up. Jokes about a "Red Moon" were rigorously wiped out with the manned landings during the Apollo programme. Unfortunately, after the trail blazing human lunar landing the last surface Moon probe was the Soviet Luna 24 which landed 22 August 1976 on the Earth's closest neighbour in space. ... page 26

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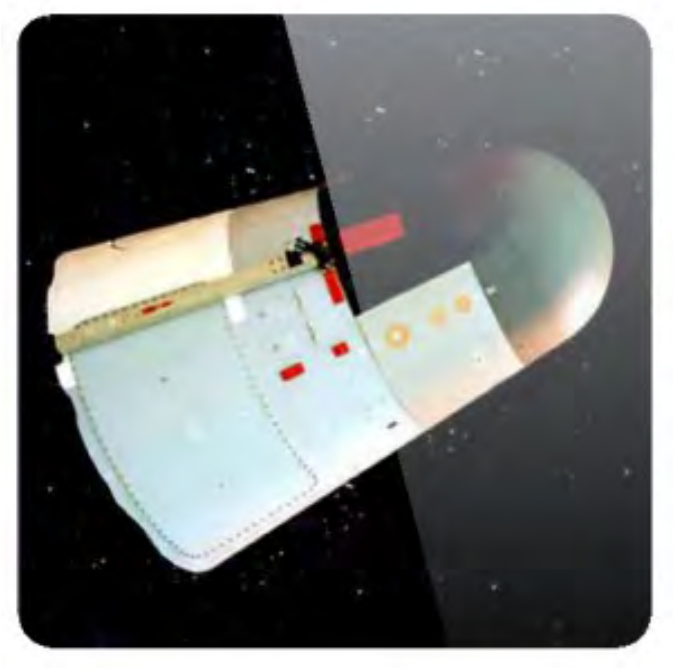

Editor's Note

Not including the current one, we have published five issues of Go Taikonauts! since August of last year. In these issues, four out of five cover stories were related to the Chinese human space flight programme. It shows the significance and influence of the manned programme that cannot be ignored. That's the same for space programmes of other countries. It is also the case for the Chinese space programme even more than 30 years ago. In the 1970s and 1980s, there were many speculations that China would launch a human into space using its own spacecraft and then become the third member in the manned space club after the U.S. and U.S.S.R. It was all because China had launched and recovered the FSW (Fanhui Shi Weixing – Recoverable Type Satellite) satellites successfully since the mid 1970s. Though we now know that the Shenzhou spacecraft is not derived from the FSW, the FSW experience did help the Chinese designers and engineers to master re-entry and landing technologies. This experience has seemingly been forgotten by the media when reporting the exciting docking and station missions recently. But the FSW programme could undoubtedly be considered the prelude of the manned programme and should not be ignored. In the cover story of this issue, we have carried-out a comprehensive review of the FSW programme – since its initiation to its heyday and decline - as well as its new role in the future.

To many people, the FSW story represents something mysterious from the cold war era. However, there is no curtain any more today. The Chinese space programme we see nowadays is very different. It has been more and more open. One of the changes is increasing international cooperation. That is also reflected in this issue of Go Taikonauts! We have a series of reports here, all about international cooperation between China and the West. Two of the reports are about the Chinese participation in the Berlin Airshow (ILA 2012) and the 63rd International Astronautical Congress in Naples, Italy, with the presence of Liu Wang and Liu Yang, China's fresh taikonauts. The other two are about China-ESA space cooperation on the Kuafu mission and the Chang'e lunar mission. The Kuafu project is most interesting because it will be a truly cooperative project with joint development and joint operation. It pushes the China-Europe space cooperation to a new level, while the Double Star Programme one decade ago can be seen as the first level. Now, the cooperation is no longer limited to science missions, it has also been extended to human space flight. The fact is, China is being integrated into the world space activities, albeit slowly. As covered in our report from Berlin, some flags flew on the Soyuz, ISS, Shuttle, and finally Tiangong and Shenzhou, which is quite symbolic. Yes, it is so exciting and may have historic significance. We will keep our eyes open, will try to trace this trend and give our report as much as possible in Go Taikonauts!

As I'm writing this note, the Chang'e 2 probe is approaching a small asteroid. It will become another milestone for China. Let's wait for a historic flyby. This event will not be missed in our next issue. Believe me, it has already been planned, unless 2012 is the end of history.

(Chen Lan)

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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

July - September 2012

by Chen Lan

Launch Event

There were three space launches in the third quarter. It was interesting that August was skipped otherwise there would have been launches in all months. In August 2011, China experienced a launch failure. The three launches were:

- On 25 July, at 23:43, a CZ-3C lifted-off from Xichang Satellite Launch Centre, putting the third Tianlian 1 data relay satellite, TL-1-03, into a transfer orbit. It was positioned at 16.8 degrees East at 23:46 on 30 July. The three Tianlian satellites can now provide nearly 100% coverage for Chinese spacecraft tracking. It is interesting to note that the CZ-3C also carried a Tianlian terminal and was successfully used for space-based tracking for the first time.
- On 19 September at 03:10, the Beidou Navigation System's third and the fourth operational medium Earth orbit satellites, M5 and M6, were launched successfully from the Xichang Satellite Launch Centre by a Long March 3B/E (CZ-3B/E). It leaves the Beidou System only one more step to take (the final GEO sat) to complete an operational regional passive navigation system.
- On 9 September, at 12:12, a CZ-2D launched Venezuela's first remote sensing satellite, VRSS-1 from Xichang Satellite Launch Centre. It was also the first imaging satellite sold by China to an overseas customer. VRSS-1 is based on the CAST2000 bus.

Launch Vehicle

There were extensive activities in Long March 5 development in this period. Around the beginning of July, the initial first-stage hydrogen tank of the launcher completed the helium mass spectrometer leak test, the last of a serious of quality examinations. The 21 m long tank has a volume of 380 cubic metres and a weld-line of more than 300 metres. It is the largest of all the Long March 5 tanks, and also the largest one ever built in China. Two months later, the second first-stage hydrogen tank was also completed in Tianjin. Compared to the first tank, it has 70% less welding flaws. The tank is a test article to be used in simulated flight testing.

In early September, it was announced that a new 70-tonne vibration testing system built by CALT was completed and has been used in testing of the Long March 5 equipment bay – a 5 m diameter and 6.5 tonne object. The vibration system has two 35 tonne electro-dynamic vibration generators and is able to simulate complicated vibrations during the rocket's whole ascent phase.

The engineering model development of Long March 5 will start before the end of the year, CALT announced in a media release in September.

Meanwhile, the Microsoft Bing Map updated new hi-res satellite images of the Wenchang Area, Hainan Island, showing more details and fast construction progress of the new launch site.

In the third quarter, there were also developments in smaller launch vehicles:

- In August, SAST completed a successful low temperature static-load test on the oxygen tank of the Long March 6 small launcher - an important milestone for SAST.
- In Beijing, after a three-year effort, the Factory 211 of CALT applied full automatic welding in manufacturing of the existing Long March tanks. Previously only part of the welding was automatic.
- China Space News revealed on 5 September that the Long March 11 all-solid small launcher has been approved by the Chinese government. The Long March 11 designator and its existence was only revealed in May. We reported it in the previous Quarterly Report in Go Taikonauts! Issue 5.

Propulsion System

It has been a long time without development update on the YF-77 cryogenic engine. In mid-August, there was finally news from the 6th Academy of CASC (or AAPT – Academy of Aerospace Propulsion Technology). The YF-77 engineering model made two successful long duration test firings on 16 May and 17 August with firing times of 520s and 500s respectively. YF-77 development encountered serious technical problems in 2007 when four test firings ended with unsatisfactory results. It was not until the end of 2009 that the engineering model development for the YF-77 was begun. Up to mid-August, it has accumulated a test firing time of more than 22,000 seconds, paving the way for its maiden flight on the Long March 5 in 2014.

On 29 July, the YF-100 engine completed a hot test firing under extreme conditions. The engine used in that test had been stored for three years and had been used in many test firings including two 600s tests. It performed very well.

In this quarter, AAPT also reached another milestone in the Long March 6 Programme. It completed construction and shakedown test of the Long March 6 first stage propulsion system test-bed and delivered the first YF-100 engine for such a test. The first Long March 6 propulsion system test is planned for the near future.

AAPT not only made progress in the current engine development but is also looking to the future. In September, the Institute 11 of AAPT delivered the first marked up 3D design files of the engine for the super heavy launcher. AAPT formed the Integrated Product Team (IPT) in February. It has so far established digital design specification, completed system static parameter calculation, ignition process simulation, 3D modelling and interface size determination for the major components. All of that was done on a computer, making digital synergy and paperless design a reality. The super engines were rumoured to be the 330 tonne and 660 tonne thrust liquid oxygen and kerosene staged combustion engines developed based on experience of the YF-100. On the other hand, AAPT is looking at an alternative rocket fuel. On 24 August, it signed an agreement with China Shenhua

Coal to Liquid and Chemical Co., Ltd. which has the world's largest coal to liquid plant, to explore the possibility using coal based kerosene as rocket fuel.

In August, the 4th Academy of CASC also made progress on solid motor development. It successfully test fired a demonstration motor using a new type of gimballed nozzle.

Satellites

On 30 July and 20 August, the two satellites launched in January were formerly delivered to their customers. They are the Ziyuan 3 mapping satellite and the FY-2F geostationary meteorological satellite. Their customers are National Administration of Surveying, Mapping and Geoinformation and China Meteorological Administration. Both satellites completed in-orbit testing and started service earlier this year.

On the ground, several satellites were in final testing and near to launch. China's first dedicated new technology test satellite, though not yet named, arrived in the Launch Centre late September. Ziyuan 1-03, or CBERS-3, a Sino-Brazil resource satellite, had begun thermal vacuum testing mid-August. By late August, the Huanjin 1C (HJ-1C) satellite completed all major testing including thermal vacuum testing, mechanical and magnetic testing, as well as SAR antenna deployment testing, and was ready to be shipped to the launch site. Another long anticipated satellite, the SJ-9 electrical propelled experimental satellite, was also in final preparation at the launch site. All these satellites are expected to be launched by the end of this year.

China Satellite, a Shanghai listed company and a subsidiary of CASC, announced its plan to raise nearly RMB 1.5 billion from the capital market. It will be used to develop the CAST4000 bus, the integrated system platform for satellite applications, as well as a smallsat production capability.

On 21 September, the annual working meeting for the Space Science Strategic Pioneer Programme of CAS was held in Beijing. The Programme planned five satellites in the Twelfth-Five Year Plan (2011-2015), three of which had already been approved (HXMT - Hard X-ray Modulation Telescope, the Quantum Satellite and the DMES - Dark Matter Exploration Satellite) while the SJ-10 and the Kuafu projects were still to be approved. However, development of the three on-going projects was behind schedule. The meeting urged those involved to take measures to guarantee completion of the 2012 tasks on schedule.

There is also progress on other civil satellite programmes. Preparation work for the Haiyang (HY) 1C, 1D, 2B and 2C have already been underway, according to Chinese media. It also reported on 26 September that the location of six ground stations for China's first carbon dioxide monitoring satellite (TanSat) was recently decided. In addition to the planned TanSat, China will also place carbon dioxide monitoring equipment on the upcoming FY-3 weather satellite. On 27 July, the study of "key technology of the wide field hyper-spectral small satellite payload", led by China Geological Survey, completed a review in Beijing, setting a foundation for the satellite's approval.

Manned Space Flight

On 13 July, the Shenzhou 9 crew completed the 14-day quarantine in the Astronaut Centre in Beijing. On the same day, they met media and answered questions. Their adaptation to the Earth's gravity was smooth and everything went well. About one month later, the crew visited Hong Kong (from 10 to 13 August) and Macau (from 13 to 15 August). They were welcomed by local people and the Chief Executives of the Special Administrative Regions. They also met students and attended academic activities. Interestingly, the display boards brought by the delegation to Hong Kong and Macau disclosed a new space station design, most likely official, that has two pairs of ISS like huge solar panels at the end of two experimental modules.

On 14 September, in a ceremony at the ILA (Berlin Air Show), taikonaut Liu Wang handed over 300 IAF (The International Astronautical Federation) flags to IAF President Prof. Dr. Berndt Feuerbacher. The flags were launched with the Tiangong 1 space laboratory and brought back to the Earth by the Shenzhou 9 crew. The same flags have been on Soyuz TMA-20, ISS and Shuttle Endeavour STS-134, thus became the only object to have flown on all active manned spacecraft on this globe. Wu Ping, Deputy Director General of the China Manned Space Agency (CMSA) also attended the ceremony.

The Chinese Delegation coming to the Berlin Airshow ILA 2012 was announced as a Delegation of CMSA - China Manned Space Agency. Go Taikonauts! assumes that there was a change in the English translation for the China Manned Space Engineering Office (CMSEO) because the delegation also came with a new logo. However, the Chinese name for the organisation has not changed, only the logo and the English name.

New CMSA logo.

In July, in a forum held in Shanghai, Zha Xuelei, from SAST and Deputy Chief Designer of China's cargo spacecraft, revealed more details about the planned cargo ship and the Chinese Space Station CSS. The cargo spacecraft will have a diameter of 3.35 m and launch mass of 13 tonnes. Its payload capacity is 6 tonnes, comparable to ATV and HTV. Its development went smoothly, according to Zha. On the other hand, in China's modular Space Station project, SAST is still responsible for the power, communication and docking sub-systems, with similar role in the Shenzhou spacecraft. In addition, SAST will develop one of two 20-tonne class experimental modules independently.

However, it's CAST that takes over most of the work of the Space Station project. It revealed in early September that CAST has won out in the station's robotic arm bidding, beating SAST and some universities. Another progress for CAST in the Station project was on 7 September in Tianjin Binhai New Area where there was a ground-breaking ceremony of the AIT (assembly, integration and test) Centre for space station modules and other large spacecraft. The AIT Centre was designed to assemble 6-8 large spacecraft yearly. It occupies 100,000 square metres and is planned to complete construction by August 2012 and delivered for use by August 2014. CAST and Tianjin Municipal government signed the agreement for the Centre in February.

Lunar and Deep Space Exploration

Development of Chang'e 3, China's first lunar lander and rover, has entered the critical phase. By late September, it had reportedly completed the following tasks:

- SAST had delivered the flight model of the Chang'e 3's propulsion sub-system. It was transported from Shanghai to Beijing for spacecraft integration.
- A launch site rehearsal had already been made to prepare for the launch in 2013.
- Electrical testing of the flight model of Chang'e 3 had started.
- The flight model of the landing mechanism of Chang'e 3, developed by the Institute of Solid State Physics of CAS, had completed the acceptance review.
- The National Space Science Centre (NSSC) had completed a specific quality review for the software used on Chang'e 3.

While Chang'e 3 is getting more and more ready for launch, Chang'e 5&6 lunar sample return vehicle, the third and final stage in China's robotic lunar exploration plan, had begun some early work silently. Institute 25 of the 2nd Academy, CASIC started development of the microwave radar for lunar orbit rendezvous and docking in early 2012 and had made some achievements in smaller size, lighter weight and lower power improvements on the basis of the Tiangong-Shenzhou system. Also, the proposal for the flame deflector system on the lunar ascent stage of the Chang'e 5&6 had passed a review, paving the way for the next step in testing.

On 19 September, the Purple Mountain Observatory and Southeast University, both located in Nanjing, Jiangsu Province, discussed the proposal of an asteroid sample return mission. It is unclear if it is only a proposal by these academic organisations, or it is part of China's overall deep space exploration plan.

Research and Development

In September, a banner appeared at the campus of the Northwestern Polytechnic University. It was dedicated to the celebration of a successful test flight of a "high-tech" demonstration project. It was rumoured on the Internet that this flight was a hypersonic test flight, most likely a test related to scramjet.

International Cooperation

In late July, Argentina and China signed an agreement to build a ground tracking antenna in the Province of Neuquen, Argentina to support China's lunar and deep space exploration. It will allow China to have a tracking station in the Southern Hemisphere from 2014. Argentina will share the use of the facility for the benefit of their national space programmes. The agreement was signed in Beijing, by representatives of the National Commission on Space Activities of Argentina (CONAE) and the China Satellite Launch and Tracking Control General (CLTC).

On 4 September, the International Lunar Observatory Association (ILOA) of Kamuela, Hawaii signed a Memorandum of Understanding with the National Astronomical Observatories (NAOC) of the Chinese Academy of Sciences to use the Chang'e 3 lunar lander to conduct astronomical imaging from the lunar surface. The lander carries an ultraviolet telescope on-board that will be operated by NAOC.

On 11 September, Thomas Reiter, ESA's Director for Human Spaceflight and Operations said ESA is exploring the possibility of joint space missions with China. "I would welcome a European astronaut flying aboard a Chinese spaceship," he stated in a media interview during the ILA Berlin Air Show. He said that ESA is hoping to deepen space cooperation with China and could aim for joint missions in "the second half of this decade." "In fact, some of our astronauts have started Chinese language training," he said. Reiter added that ESA would also like China to become a member of the International Space Station programme if US objections can be overcome.

China and Europe reached an agreement on 20 September during the EU-China Summit in Brussels, Belgium, between China and the 27-nation European Union, to take the satellite navigation frequency dispute to the International Telecommunication Union (ITU) by the end of this year. Besides, a joint statement issued after the Summit said that the two sides "expressed common willingness to enhance cooperation in the field of space technology, and on the civil aspects" of their navigation systems.

Daily News, a Sri Lankan newspaper, reported on 5 July that there is a possibility for a Sri Lankan citizen to be sent into space by a Chinese spacecraft in less than four years. It is connected with Sri Lanka's first satellite project undertaken by the Sri Lankan company SupremeSAT. On 14 August, SupremeSAT signed a joint investment agreement with China Great Wall Industry Corporation (CGWIC) and Sino Satellite Communications Company Ltd. for the setting up of Sri Lanka's first ever Space Academy and Satellite Ground Station in Sri Lanka within the Pallekele BOI Zone in Kandy. According to Chinese media, the facility will provide a tracking service to Chinese satellites including the Beidou navigation system. Also, the agreement to build Sri Lanka's first satellite, based on the DFH-4 bus and to be launched in 2015, would be signed in October in China and President Rajapaksa, who initiated this move, is expected to witness this ground-breaking event. However, there was no mentioning later that China would provide a seat in future Shenzhou missions as part of this satellite contract.

Ma Xingrui, General Manager of CASC, visited Belarus and Turkmenistan early August, and was welcomed by the Presidents of the two countries. China is to build two communication satellites for these two countries and launch them in 2014.

Commercial Space

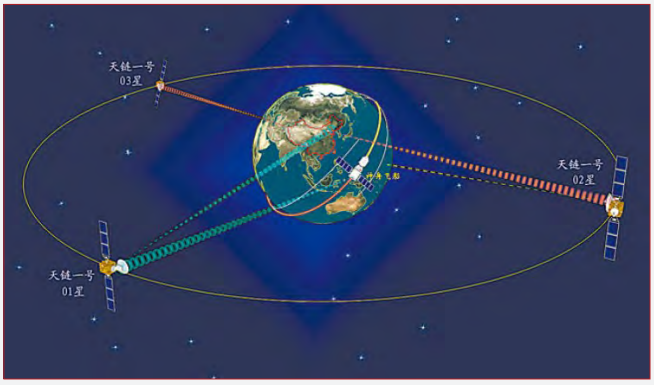
China inked two smallsat launch deals in this quarter. On 3 August, China Great Wall signed a launch service contract with GSMR (Galactic Suite Moon Race) that is the Barcelona Moon Team competing for the Google Lunar X PRIZE. The GSMR lunar probe will be launched by a Long March 2C/CTS in the second half of 2014. The second one is the Memorandum of Understanding on the QB50 Project, signed between the China Asia-Pacific Mobile Telecommunications Satellite, a subsidiary of CALT, and the von Karman Institute for Fluid Dynamics (VKI). The QB50 Project, funded by the European Commission,

is to design and launch a network of 50 miniaturised satellites to study the lower layers of the thermosphere/ionosphere. They would be launched from China in the timeframe of 2014-15. CALT will also provide launch opportunities for two other satellites for the Belgian institute using its newly-developed launch vehicle in the next 10 years.

On 11 July, witnessed by Chinese President Hu Jintao and President of Laos Choummaly Sayasone, China and Laos signed a loan agreement for the Laos Satellite Project, paving the way for the satellite project's implementation. The Export-Import Bank of China (China Exim Bank) will provide a loan to a Sino-Lao joint venture between Lao government and China's APMT, to build, launch and operate the satellite. It will be a DFH-4 based comsat with 22 transponders and will be placed at 128.5 degree East, an orbital slot owned by the Lao government, in 2015.

APT Satellite announced on 29 September that the assignment of its rights and liabilities under the Apstar 7B satellite procurement contract and the APSTAR 7B satellite launch services agreement to China Satcom had been completed on 26 September 2012. A total sum of around US$129 million had been paid by China Satcom to APT pursuant to the terms of the cooperation agreement as consideration for the assignment. The Thales Alenia Space built Apstar-7B was a replacement of the Apstar 7 comsat. It has been renamed to Chinasat 12 after the transfer. It was transported to China by an Antonov 124 late September to prepare its launch in December.

Wenchang construction progress: the launch tower is taking shape. (credit: Chinese Internet)



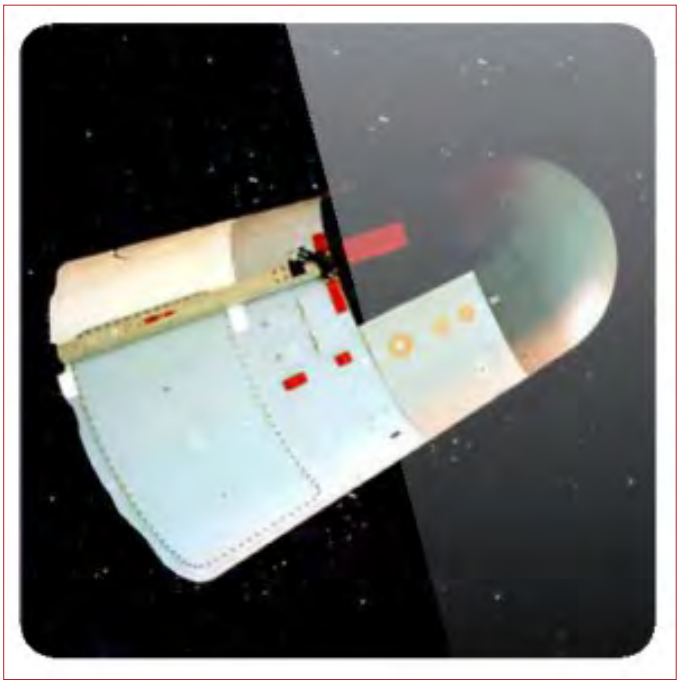
Three Tianlian data relay satellites in orbit. (credit: Chinese Internet)

YF-77 test firing. (credit: Chinese Internet)

New design of the modular Chinese Space Station CSS. (credit: Chinese Internet)

History of the Chinese Recoverable Satellite Programme

by Chen Lan



China became the third country to send a human into space in 2003 with its Shenzhou spacecraft. Now, it has a mini space station Tiangong 1. It will complete a more sophisticated modular Space Station in the next few years. These achievements were not made out of nowhere. If one takes a look at the history of China's space programme, it can be seen that the FSW recoverable satellite programme played a very important role, and set a solid foundation for the later manned space programme. This article reviews this important programme that started during the Cold War era, appeared to fade away, but may sustain much longer.

Starting From Scratch

China started its satellite programme in 1965. The 173 kg DFH-1 satellite was launched into space in 1970, at which time China became the fifth member of the exclusive "space club". In early 1966, only months after starting of the DFH-1 programme and four years before the first satellite launch, the second satellite development programme began. It was a more ambitious programme that asked for the launching and soft-landing within Chinese territory of a 2-tonne class satellite. This is the FSW (FSW – Fanhui Shi Weixing, meaning recoverable type satellite) programme. The 8th Design Institute of the 7th Ministry of Machinery (now CAST, or China Academy of Space Technology) was responsible for the programme, which was led by Wang Xiji and Sun Jiadong.

Compared with DFH-1, FSW was technically more challenging. It was not only heavier and larger, but also involved a lot of new technologies, many of which were completely new to China at that time, e.g. hypersonic aerodynamics, the three-axis stabilisation attitude control system, large satellite structure, heat control system, retro motor and recovery system, as well as sophisticated payload system (terrain and stellar cameras). But the most difficult task for the Chinese engineers was the re-entry and landing technology.

In the 1960s, China had no high-speed computers and had not yet mastered hypersonic aerodynamics theory, especially the newly established "computational fluid dynamics". The engineers had to rely on wind tunnel tests, and after more than one thousand such tests, they selected the best shape design from among seven proposals. The thermal protection system development was not smooth in the early stages. The test article of the spherical nose broke apart during a thermal vacuum test in August 1971. Finally, Chinese engineers developed a carbon-based composition ablative material called "XF" whose details are still undisclosed. The satellite's skirt (i.e. the sidewall subject to less heating) and bottom part uses a molybdenum skin and silicon rubber coating as thermal protection material. At the same time, the retro-motor development made good progress. From March 1968 to May 1971, the FG-14 motor made a series of ground test-firings and most of the problems were solved. In August 1971, the overall specifications of the satellite were adjusted and the motor had to be re-designed. Development of the improved motor was completed before the end of 1974. There were also many problems in the FSW recovery parachute development. As this was one of the largest parachutes ever developed in China and without any previous experience, all drop tests failed in July and October 1970, mostly due to insufficient strength. It was not until the end of this year that the Chinese engineers had their first success, but there were still a lot of problems to overcome. After more than 50 air drop-tests supported by the PLA Air Force, the parachute system design was finalised around 1973.

Besides re-entry and landing technologies, the three-axis stabilisation attitude control system (ACS) was another technical area to master. The ACS was developed by the Beijing Institute of Control Engineering. Its gyros, borrowed from ballistic missiles and the infrared Earth-sensor, were developed by the Shanghai Institute of Technical Physics. Two prototype sensors were tested on a T7A sounding rocket in July 1969 and both were successful. Using cold gas thrusters, the attitude control system achieved a precision of 1-2 degrees.

In parallel with the FSW development, important test equipment was also being built. Initial FSW satellites were tested in the 3.6 m diameter KM-3 thermal vacuum chamber, while a larger 7 m diameter KM-4 was still in construction at that time. The satellite was also tested on China's largest 200 kN electric-magnetic vibration test stand. To support tracking, control and recovery of the satellites, additional tracking stations, and landing zone facilities were built, together with an upgrading of the control centre.

Birth of the First Generation

The first generation FSW, or FSW-0, has a blunt conical shape, very similar to the U.S.'s early Discoverer capsule, but larger.

FSW-0 is 3.1 m in length and 2.2 m in diameter (bottom). It weighs about 1,800 kg at launch. The FSW-0 satellite has two modules, an instrument module and a re-entry module. At the bottom of the re-entry module, there is a solid propellant retro-motor. During ballistic re-entry, the satellite endures more than 3,000 degrees of high temperature. At about 16 km above the ground, automatically triggered by the atmosphere pressure sensor, the re-entry motor and bottom of the capsule is jettisoned which exposes the parachute compartment, followed by parachute deployment.

The film canister of the first FSW. (credit: Chinese Internet)

FSW-6 recovery. It was sunken in the Tuo River and found 8 days after landing. (credit: Chinese Internet)

A PLA Black Hawk Helicopter was lifting a FSW-1 type capsule in 1980s. (credit: Chinese Internet)

Close-up of burnt exterior of a recovered capsule. (credit: Chinese Internet)

FSW-0 was designed as a film-return photographic reconnaissance satellite. It carries a prism-scanning panoramic camera and a stellar camera in the instrument module. After exposure, the film rolls into a canister in the re-entry module through a channel between the two modules. The cameras were developed by a team from the Changchun Institute of Optics, Fine Mechanics and Physics, the Institute 811 of the Ministry of Public Security and the Beijing Industrial College. In July 1967, the cameras were tested on two T7A sounding rockets. Ground images taken at 12-85 km altitude were successfully retrieved. As this was the first time China had developed such a large camera, a series of difficulties were encountered. But finally all problems were solved.

Making it through the chaos of the Cultural Revolution and after working hard for many years, engineers finally managed to deliver the first satellite. The satellite was transported to Jiuquan Satellite Launch Centre on 8 September 1974. On 5 November 1974, it was launched by the first CZ-2 rocket. However, 20 seconds after lift-off, the launcher lost stability and was self-destroyed. The rocket exploded and crashed 300 m away from the launch pad. Subsequent investigation showed that the failure was caused by minor wire damage on the second stage.

On 26 November 1975, a second FSW-0 launch was attempted, and this time it was a success. The satellite entered a 181 x 495 km orbit with an inclination of 63 degrees. But during its initial few orbits, it was observed that the pressure of the instrument module was constantly decreasing. There was a proposal made to retrieve it ahead of schedule so as to avoid further problems, but the final decision was to keep the original plan of a three-day flight. At the 10th orbit, the pressure indicator was stabilised. At 10:50 h on 19 November, a temporary tracking station in Xinjiang tracked the satellite and sent the attitude adjustment command. Soon afterwards, the Jiuquan station commanded the satellite to separate the two modules. Re-entry and landing appeared nominal. However, it continued along its re-entry trajectory, passing over the planned Suining landing zone in Sichuan Province. It was forecast to land in Guizhou Province, but with all the recovery team in Sichuan, ground control lost contact with the satellite. No one knew where the satellite landed or what its status was. About six hours later, a report from Guizhou was received stating that an unidentified object had crashed in Liupanzhi, Guizhou, about 400 km away from the planned landing zone. The recovery team rushed to the site immediately and found the satellite roughly intact, although its skirt was seriously damaged by the heat generated during re-entry, and the parachute was also burnt. It was indeed a hard landing. Fortunately the film was undamaged and the image quality was very satisfactory. So, the flight was considered a success. China announced the news and became the third country capable of recovering a satellite.

The first FSW-0 showed two major problems, the large landing precision error and faulty thermal protection system. So the next satellite had a re-designed skirt whose metal skin was replaced

by the “XF” material, the ablative material used by the satellite’s nose. It was delivered on 19 October 1976 and launched on 7 December. Three days later, it landed in the middle of Sichuan Province, as planned. This time all systems worked perfectly.

During 1978 to 1987, China launched seven more FSW-0s, all without failure. Since 1982, the satellites orbital life has been extended from three to five days, and helicopters used for recovery. Also since 1982, images returned by the FSWs were used in civilian areas such as resources, agriculture and environment investigations, archaeological survey, city planning, etc. Besides its major task of photographic territory survey, China has also used the FSW-0 satellites to test new technologies. For example, there were four FSWs, each carrying a CCD imaging system and data relay system.

After the first FSW launches, some Western analysts suspected that China would develop its own manned spacecraft based on FSW, and then send the first Chinese taikonaut in the late 1970s or early 1980s. This was not true. Many years later, declassified information shows that China’s first manned space programme, Shuguang, had nothing to do with the FSW. It looked more like the American Gemini.

Maturing the Technology

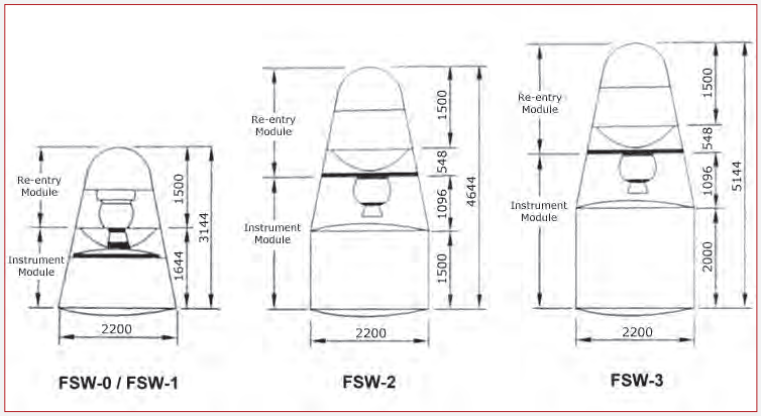
FSW-1 is an improved model based on FSW-0. Its external size is the same as the FSW-0 but with the launch mass increased to 2,100 kg. Significant improvements included the newly-developed digital three-axis attitude control system which increased control precision. It also used a digital data transmission system and an in-cabin pressure control system. Its orbital lifespan extended to 8 days.

Payloads of the FSW-1s are different from that of FSW-0s. It carries a frame metric camera with much better geometric precision but lower resolution. As a result, it was mainly used as a cartographic satellite. Since 1987, FSWs have been used as a microgravity and space science platform. The FSW-9 for the first time carried a number of microgravity experimental payloads including two commercial piggyback payloads from the French company Matra Marconi and a Chinese GaAs crystal growing experiment. It was China’s first commercial space activity, more than two years before China’s first commercial satellite launch in 1990. The microgravity experiment in orbit was successful. However, an overload as high as 20 g during re-entry is not favourable for some experiments. After this, there were only two more international piggyback payloads, one from Germany in FSW-11 (1988) and another from Japan in FSW-17 (1996).

It is also interesting to mention that the most popular piggyback payloads in FSWs are plant and vegetable seeds. Although still controversial, many Chinese scientists believe that space environment, such as strong cosmic rays, could change genetic characteristics of the seeds, so that it is a more efficient way to create better species than on the ground. In 1990, the FSW-12 carried out China’s first space biological experiment on higher animals by sending two guinea pigs into space. Another space biological experiment on FSW was in 1996 when the FSW-17 carried a number of animals including mice, insects, silkworms, and a tortoise.
In total, five FSW-1s were launched. But the FSW-15, launched on 8 October 1993, did not return as planned. When retrofiring occurred, the satellite was unfortunately aligned in the wrong direction. As a result, the retro motor pushed it into a higher orbit. It remained in orbit until 12 May 1996 and became a hot topic on world media before its natural decay. This is because a satellite with a thermal protection system could survive the re-entry, and possibly cause ground damage in an uncontrolled re-entry. Fortunately, it crashed harmlessly into the North Atlantic Ocean. The FSW-15 accident actually disappointed a few people who paid for carrying their private items inside the capsule. The 235 private items included a 10 cm diameter gold badge of Mao embedded with 44 diamonds to coincide with the 100th birthday of Mao Zedong, two gold statues of Buddha, 3,000 commemorative covers, a gold watch with diamonds, CDs and LDs, marriage photos, gold rings, credit cards, a Rolls Royce keychain, a pager and some name cards, etc. Most of them were said to be from Hong Kong customers.

Larger and Heavier

FSW-2 is a major milestone in FSW history. It is China’s second-generation territory survey satellite after FSW-0. Its launch mass is increased to nearly three tons. But its most notable exterior change was the addition of a 1.5 m tall cylinder at its



FSW satellite size. (credit: Go Taikonauts!)

FSW satellite comparison. (credit: Chinese Internet, Go Taikonauts!)

bottom. In FSW-2, the retro motor and landing system was relocated to a new segment between the re-entry capsule and the instrument module, which gave the capsule more internal space for payloads. Upon re-entry, the retro motor is jettisoned immediately after retrofire so that the capsule re-enters with less useless mass.
Other improvements included the new three-unit hot-redundant

FSW satellite launch configuration comparison (left to right: FSW-0/1, FSW-2. FSW-3). (credit: Chinese Internet, Go Taikonauts!)

FSW-20 landed into a residential house. The white cloth covered capsule can be seen at the bottom right corner in the image. (credit: Chinese Internet)

on-board computer, better attitude control system, and a new mono-propellant orbit control system. The latter gave the satellite limited orbital manoeuvring capability which could be used to adjust its final orbit to make the re-entry more precise. Its orbit life was extended to more than 15 days. FSW-2's main payload also had a significant upgrading. The satellite was equipped with a high-resolution nodal panoramic camera developed by CAST. FSW-2's image resolution, amount of film, and efficiency of film usage were considerably increased.

Because FSW-2 is much heavier than its precursor, its launch vehicle switched to the SAST (Shanghai Academy of Spaceflight) developed CZ-2D. From 1992 to 1996, three FSW-2s were launched and recovered. But after the final FSW-2 launched in October 1996, there was a large gap of seven years without any FSW launch. In comparison, from 1974 to 1996, there were 18 FSW launches, resulting in a launch rate of about one satellite per year. Analysts believed that the absence of new FSWs was a result of electro-optical imaging satellites taking over the role of FSWs.

China started the development of the ZY-1 resource satellite programme (China-Brazil Earth Resource Satellite, or CBERS) in late 1980s and the purely domestic, military ZY-2 programme later. The Sun-synchronisation orbit ZY-1 has best ground resolution at about 20 m. The lower orbit ZY-2 should have better resolution.

Although the first ZY-1 and ZY-2 satellites were launched and put into use in 1999 and 2000, there were rumours that China was developing a new-generation FSW satellite. Some even thought that the new FSW would have multiple recoverable film canisters, a technology that has been used by both, US and Russian space craft to extend the satellite's operational life.

Modernised Bird - Obsolete Duty

After seven years of silence, China launched the first of the new-generation recoverable satellites on 2 November 2003, from a new launch pad in the Southern Launch Centre, JSLC. The FSW-18 was recovered after 18 days in space. In 2004 and 2005, four more new-generation FSW-3 satellites were launched, at a rate of one pair each year. This set a new record for the FSW launch rate with five FSWs in 22 months. All five satellites were successfully recovered. But the FSW-20 landing was not perfect. The FSW landing zone is in Suining District, Sichuan Province. When it was planned and established, it was a remote area without many residents. Nearly 40 years later, as a result of fast growing economy in recent years, the area's population and building density has been significantly increased. The FSW-20 capsule unexpectedly landed in downtown of Daying County, smashing the roof of a two-storey building and finally came to rest on the building's second floor. Fortunately, no people were injured. It took about five hours for the recovery team to move the satellite out from the damaged building.

The new FSW, unofficially called FSW-3, is the latest upgrading since FSW-2. Its mass is increased to about 3,600 kg, almost double of the first-generation FSW-0. Its height is increased to 5.144 m with a stretched cylinder section about 2 m tall. FSW-3 upgraded its tracking, telemetry and control system and its communication system with the introduction of the Unified S-Band System (USB) which was first used by the Shenzhou manned spacecraft. The new lithium battery extends the spacecraft's orbital life to about one month. FSW-3 has also a better attitude control system with unspecified precision and better internal heat control system with precision of 0.2 to 0.3 degrees (in comparison, FSW-0 is about 5 degrees and other models are 2-3 degrees). Also, it needs to be mentioned that FSW-3's instrument module has limited independent orbital operation capability, similar to the Shenzhou orbital module. It allows the FSW orbital module to work as a scientific satellite for about three days after separation of the re-entry capsule.

In fact, the five satellites, launched from 2003 to 2005, belong to two variants. FSW-18, FSW-20 and FSW-22 were launched by CZ-2D/2 (a stretched version of CZ-2D), with a mission duration of about 18 days, and in orbits of about 200 x 320 km. All of them were launched without fairing, like all previous FSWs. FSW-19 and FSW-21 were launched on top of the CZ-2C/3 (a new variant of the workhorse CZ-2C, with stretched stages and four fins at the bottom) and inside the fairing to protect the satellite during ascent. Their orbits are about 170 x 510 km and their orbital life is extended to a maximum of 27 days. Recent publications indicate that the former variant (with

FSW Specifications				
	FSW-0	**FSW-1**	**FSW-2**	**FSW-3**
Launch mass (kg)	1,800	2,100	2,800-3,100	~3,600
Payload mass (recoverable) (kg)	260	260	400	
Payload mass (non-recoverable) (kg)	340	450	500-600	
Volume (m^3)	7.6	7.6	12.8	
Height (m)	3.14	3.14	4.64	5.14
Diameter (m)	2.2	2.2	2.2	2.2
Microgravity level (g)	10^{-3}-10^{-5}	10^{-3}-10^{-5}	10^{-3}-10^{-5}	
Orbital life (day)	3-5	8	15-17	16-27
Attitude control precision (roll/pitch) (degree)	±1	±0.7	±0.3	
Attitude control precision (yaw) (degree)	±2.2	±1	±0.4	
Heat control precision (°C)	5	2-3	2-3	0.2-0.3

higher perigee) is used for cartography and the latter (with lower perigee) for territory survey, similar to the roles of FSW-1 and FSW-0 respectively. Both variants have no multiple recoverable film canisters as speculated before.

According to Chinese reports, the original FSW-3 programme includes only the above five satellites and gives no clue to show that China has any further plans on film-return photographic reconnaissance satellites. It is quite natural to understand because this kind of satellite has limited orbital life and limited amount of films. When Chinese electro-optical imaging satellites, firstly the ZY-1 and ZY-2, and later the Yaogan series, became mature, it became very clear that the FSW's imaging role can be totally replaced.

A New Chapter

A new type of imaging satellite does not mean the FSW story has now come to an end. On 9 September 2006, another FSW, the SJ-8 (Shijian 8) satellite lifted-off from Jiuquan. Shijian is the name of a Chinese technical and engineering test satellite series. SJ-8 gets the name because its major role was to carry 225 kg plant and vegetable seeds to be exposed to the space environment, so it is also called the "Seed Satellite", actually, a long-anticipated project since the late 1990s. This was the first time an FSW was publicly given a specific mission designator and did not carry a ground observation camera. To fully utilise the opportunity, CAS (Chinese Academy of Sciences) proposed to outfit its orbital module (or instrument module) into a remotely-controlled scientific lab. At last, in total 500 kg of experimental payloads were carried inside this newly converted "lab". The mission was successful. Clear images were transmitted to the ground from the second day of the flight and the module continued to work for three more days after the re-entry capsule was recovered. The FSW-3 orbital module's independent operational capability was practiced for the first time on SJ-8.

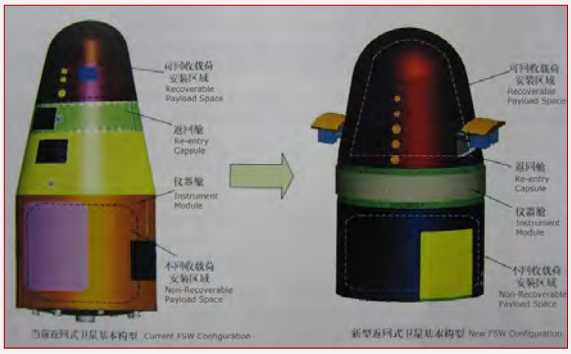
As a market-driven project, SJ-8 was not previously in the plan. It was proposed in the late 1990s and was finally realised after eight years of political and financial efforts. But it will inevitably be an important turning point in FSW history. A new roadmap had been set for the FSW programme by Chinese space planners. FSW would become a scientific platform with a focus specifically on microgravity activities. There are more and more domestic requirements in this field. And it also eyes the international commercial market for microgravity applications in the post-Shuttle era.

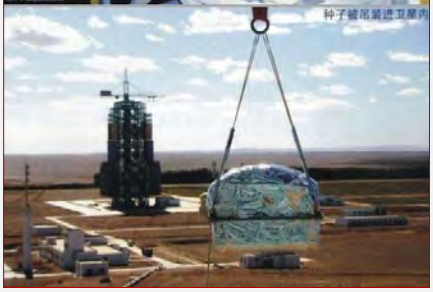
SJ-10 (Shijian 10) was the first one within this strategy, and was announced in March 2007, just a few months after the SJ-8 mission. CAS took the responsibility to plan and develop its payloads. It was listed in its Eleventh-Five Year Plan of space science. Early in 2006, China and France started a collaborative microgravity research project. The French-Chinese IMPACHT (Interface Microgravity PhAse Change Heat Transfer) joint experiment was one of the payloads to fly on SJ-10. SJ-10 was originally expected to be launched in 2009, and later in 2011, and now it is becoming uncertain. In August 2012, it was reported that the NSSC (National Space Science Centre of CAS) was still pushing for the approval of the SJ-10 programme. It reflected a long-term dilemma that space science has a low priority in the Chinese space programme. In recent years however, China has increased the budget for space science missions. For example, the Hard X-ray Modulation Telescope (HXMT), the Quantum Satellite and the Dark Matter Exploration Satellite (DMES) were approved in a short time-period, which was the first time in almost a decade after the Sino-ESA DoubleStar project. SJ-10's fate may improve if this is a sign of the coming of a Golden Age for Chinese space science.

It is believed that the SJ-10 will still be based on the FSW-3 platform. However, there is sparse information, some from exhibition boards, indicating that a new-generation FSW is underway. In an early revealed rendering, a pair of solar panels was added at its instrument module. A later revealed design shows a larger re-entry capsule and solar cells at the exterior of the instrument module. Its recoverable payload capacity was reportedly increased to 600 kg. While the addition of solar cells indicates the requirement for longer flight duration (including independent flight of the instrument module, or the "lab"), which is a good news for microgravity experiments.

Since its first launch, FSW has had a long history of nearly 40 years. It is the oldest Chinese satellite platform still in use. Its evolution may become slower after it gets a new role. But it will definitely continue to contribute to the Chinese space programme, similar to the Soviet/Russian Vostok/Zenit/Foton spacecraft projects.

Please, go to the gallery for more photos.





top left: Part of Shijian 8 payloads. Two black boxes are the data recorder (left) and the primary controller (right) of the microgravity experiment. (credit: Chinese Internet)
2nd top left: Seeds were packaged and installed in the Shijian 8 satellite. (credit: Chinese Internet)
top right: In-orbit images of Shijian 8: germination of a seed. (credit: NSSC)
left bottom: Comparison of the current FSW and the new design of FSW. (credit: Chinese Internet)

COSIMA 1 - Protein Crystallisation on FSW-11

By Jacqueline Myrrhe

Summer 1988: On 5 August 1988, the German experiment payload COSIMA 1 launched on-board the FWS-11 re-entry capsule on top of the Long March CZ-2C rocket from the Juiquan Space Launch Centre in the Chinese Province of Inner Mongolia. The experiment facility was carrying its poetic name for good reasons: the Greek originated name of Cosima is the female form of Cosmo, which can be translated into “order” or even “beauty”. And exactly this is what the interdisciplinary group of international scientists fully supported by German research funds was looking for: the order and beauty of protein crystals.

For the investigation of the structure of protein crystals it is necessary to expose them to X-ray diffraction. X-ray analysis, however, can only be done, if the crystals are big enough and stable enough for this procedure. By that time, the growth process for protein crystals was not very well understood. In particular it was not clear which role gravity plays, but it was considered to be a disturbing factor. Experiments, conducted during the Spacelab 1 mission did not generate satisfactory results. To get a better insight into the crystallisation process under microgravity conditions, the COSIMA payload, a 22 x 21 x 15 cm box accommodating 101 experiments of 25 different biological macromolecules was sent into a 319.5 km x 205 km orbit.

Out of the 101 samples, 45 did not show any crystal growth and 27 did not yield crystals sufficiently large for X-ray analysis, neither in the microgravity experiments nor in the control experiment on the ground. A total of 29 samples from nine different proteins yielded crystals which were analysed in their home laboratories. From seven of these proteins results could be obtained. The final report about the experimental results, published in 1989 in the December issue of “FEBS Letters” (Vol. 259, 1), stated: “From the results obtained we conclude that under microgravity conditions crystal growth can only be expected under those crystallisation conditions which also permit crystal growth on Earth. A number of space-grown crystals were larger in size and of a better quality in their ability to diffract X-rays than the corresponding ground control crystals grown at the Chinese launch site. However, the space-grown crystals have not reached the X-ray diffraction quality of the crystals obtained under optimal conditions in their home laboratories.”

One member of the COSIMA research team was Ada Yonath. By that time she was a Research Fellow at the research group for structural molecular biology at the German electron synchrotron DESY in Hamburg. Later, when she became the Director of The Kimmelman Centre for Biomolecular Structure and Assembly at the Weizmann Institute in Rehovot, Israel, she explained the several space experiments, including the research on FSW-11: “...the aim of our space experiments was to improve the quality of our ribosomes crystals. If successful we intended to use the improved crystals for X-ray crystallography experiments for the determination of the ribosome structure (these experiments are performed on Earth) and subsequently learn about its function. We got only a tiny indication in a space mission run by a Chinese company, before we joined NASA’s experiments, but we could not repeat it in NASA mission mainly because NASA’s experimental design was less suitable for our aims.”

Although the COSIMA experiment in 1988 did not provide good enough results for solid clues on protein crystallisation, against all odds, Ada Yonath went on with her interest in the study of protein structures. For more than 15 years she tried to unveil the spatial structure of ribosomes until she made a breakthrough in 2000 - after more than 25,000 attempts in ribosome crystallisation. Finally, at the age of 70, Ada Yonath together with Venkatraman Ramakrishnan and Thomas A. Steitz was awarded the Nobel Prize in Chemistry in 2009 “for studies of the structure and function of the ribosome”.

The Journey of the Flags

by Jacqueline Myrrhe

Taikonaut Liu Wang (left), CMSA Deputy Director Wu Ping (middle), and IAF President Berndt Feuerbacher (right) showing one of the flown IAF flags to the media. Credit: Bernhard Tiedt

Sending a letter has always been a risky business. It might happen that the letter is heavily delayed because of detours or missing address details; sometimes the mail gets damaged along the way and sometimes, the letter never even reaches the intended recipient.

Prof. Dr. Berndt Feuerbacher, President of the International Astronautical Federation must be an optimist through and through. He dared to conceive of a great mailing adventure and luckily, he made it! 300 yellow-blue flags went a long way to get back to where they started from. On the occasion of the 60th anniversary of the foundation of the International Astronautical Federation - IAF, Feuerbacher, together with his colleagues had a brilliant idea to commemorate this event: What if we send a symbolic item, let's say the IAF flag, across the universe? O.K., let's say across space in low Earth orbit and after return, consider the flag as a birthday present to the members of the federation. Finally, it was decided to pack 300 mini versions of the IAF flag - sufficient to provide one to each of the 227 members of the organisation, with some spare - and to fly the neatly-tied package on all globally available human space flight systems in operation by that time. How else could the message connected with the flags be better expressed: "Through their travel aboard spacecraft belonging to all nations with an active human spaceflight programme, the flags represent the unique global reach of the IAF." Such an epic journey took some effort and some time.

First stop ISS

It started on 15 December 2010 when the Soyuz TMA-20 launched into the Winter night sky from the famous Baikonur cosmodrome, nestled down in the wide frozen plains of the Kazakh Steppe. From the legendary launch site, which had already seen the unforgettable space pioneer Yuri Gagarin soaring into space, that night, Russian cosmonaut Dmitry Kondratyev, along with NASA astronaut Catherine Coleman and European Space Agency astronaut Paolo Nespoli, took the precious goods with them to the International Space Station - another symbol of peaceful cooperation for the benefit of man.

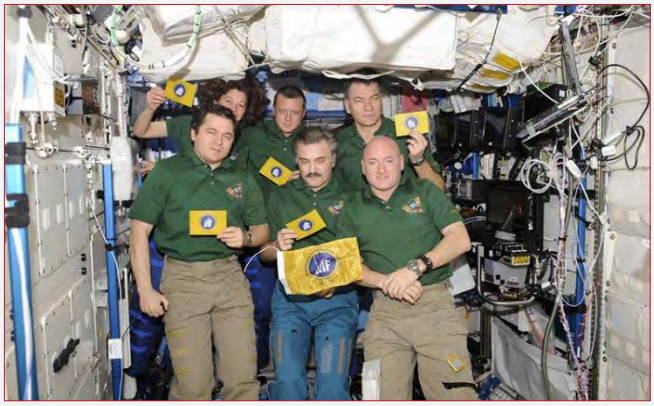
The crew of three international astronauts carefully deposited the little package on the ISS and took care of it until its return tour half a year later. That moment arrived on 30 May 2011, when the IAF flags were handed over to the crew of the Space Shuttle Endeavour before undocking from the Station. The IAF package was now destined to make it back to Earth with Endeavour. Coming home with STS-134 meant that the flags were not merely passengers but also witnesses of space flight history. When STS-134 Endeavour touched down on the Florida runway in the early-morning hours of the 1 June 2011, the space ferry completed its 25th and final mission into space. While Endeavour after landing ended up in a museum for display as a showcase, the IAF flags headed on to the next leg of their journey.

Next stop - a glimpse of the Moon and Mars

The unloading from the payload stowage in Endeavour was handled quickly and without problems, because the 300-piece cargo had to rush back to Europe. After arrival in the French city of Bordeaux, more famous for its high-quality red wine then its relationship with space, the flags took-off for another special mission. Accompanied and safe-guarded by two experienced space travellers, ESA astronaut Jean-François Clervoy and Romanian cosmonaut Dumitru-Dorin Prunariu, the flags flew on-board the A300 ZERO-G airplane of the French company Novespace into another historic first of space activities. Novespace is the European company operating Parabolic Flight Campaigns on the continent. On this occasion, in the second week of June 2011, three European space agencies - the French CNES, the German DLR and the European Space Agency - booked the A300 ZERO-G to conduct for the very first time, parabolic flight manoeuvres which not only mimicked microgravity, but also the gravity conditions on the Moon and Mars. Together with numerous scientific experiments inside the A300, the 300 IAF flags had a gravitational experience of 0 g, as in low Earth orbit, of 0.16 g corresponding to the level of gravity on the Moon, and of 0.38 g - the gravitational environment on Mars.

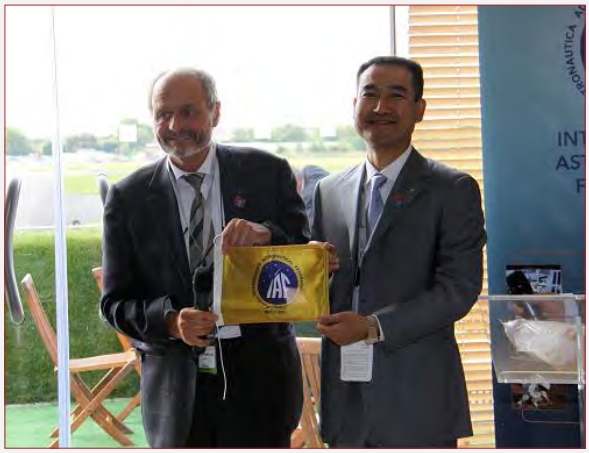
From Bordeaux in the South of France the yellow package made its way to Paris. During the 50th International Paris Air Show at Le Bourget, taikonaut Zhai Zhigang got the responsible job of transporting the parcel to the Far East into the north-western territories of China to get it to the Jiuquan Satellite Launch Centre. On the evening of the 29 September 2011 the Long March 2F rocket carried the experimental docking target Tiangong 1, China's first space module into orbit. This historic moment was the last milestone for the cosmic parcel delivery

The flag of the International Astronautical Federation – IAF. Credit: IAF



IAF flag with members of Expedition 26 crew aboard the ISS. Front row from left to right: Oleg Skripochka, Alexander Kaleri, Scott Kelly - back row from left to right: Catherine Coleman, Dmitry Kondratyev, Paolo Nespoli. Credit: NASA

The IAF flags on Novespace A300 ZERO-G flight with Jean-François Clervoy, ESA astronaut and former President of Novespace (left), and Dumitru-Dorin Prunariu, Romanian cosmonaut and former Chairman of COPUOS (right). Credit: IAF



50th International Paris Air Show Le Bourget - Prof. Dr. Berndt Feuerbacher hands the flags over to Zhai Zhigang, the first space walking taikonaut (also see Go Taikonauts! Issue no. 2) Credit: IAF

service. The IAF package containing a set of 300 flags stayed on-board Tiangong 1 until the arrival of the first visiting crew. That crew of 3 launched on 16 June 2012 with Shenzhou 9 to dock with Tiangong two days later. Commander Jing Haipeng, Pilot Liu Wang and first female taikonaut Liu Yang had no difficulties to find the pack and get it ready for its final journey to the Earth on 29 June 2012, when the crew landed after a successful mission with Shenzhou 9 in Siziwang Banner, in the Chinese province of Inner Mongolia.

On 14 June 2012 Prof. Feuerbacher received it all back - each piece, certified and in perfect shape. During a festive ceremony at the Berlin Airshow, ILA 2012, Chinese astronaut Liu Wang and Wu Ping, Deputy Director General of China Manned Space Agency (CMSA, formerly CMSEO) handed over to President Feuerbacher the highly precious cargo, for which he never lost faith in getting it returned after being flown on all possible space systems and having been part of several historic space flight moments. He said: “I would like to express my sincere thanks to our Chinese friends for carrying these flags into space and bringing them back to us. I would like to give my congratulations to the great achievements of the Chinese nation in space. I regard this as a token of friendship and peaceful cooperation in space. Thank you very much!”

The Chinese guests thanked Prof. Feuerbacher for the invitation and expressed in their inspiring speeches their heartfelt wish for extended space cooperation in the future. (Please, see in the boxes the transcripts of the three speeches delivered by: Deputy Secretary General of the Chinese Society of Astronautics Mrs. Gong Jinyu, Deputy Director of CMSA, Mrs. Wu Ping, and Taikonaut Liu Wang).

ESA’s Director General Jean-Jacques Dordain also contributed to the refreshing optimistic atmosphere when he shared his dream with the audience: “For the 70th anniversary of the IAF, I hope that my dream might become true. I wish that these flags will fly from a European station to a Chinese space station without coming back to Earth, to have a direct connection between the different stations. This is certainly one of my dreams.”

In a panel discussion following the handover ceremony, ESA’s Director for Human Spaceflight and Operations, Dr. Thomas Reiter, also took the opportunity to express his support for future cooperation with China in the area of human space flight. Astronaut and Director Thomas Reiter was noticeably

proud when one of the new ESA astronaut recruits welcomed the Chinese colleague on stage in Mandarin. Thomas Pesquet, part of the group of recently selected ESA astronauts is currently undergoing Chinese language training and he took the opportunity to show that he is determined to get on with this rather difficult language. Ulrich Bobinger, the moderator of the panel discussion, involved Liu Wang in an interesting round of questions and answers. First of all Bobinger wanted to know, what is the Chinese secret of the countries recent success is space? Liu Wang showed off with a lot of humour and he exposed the inside of his jacket and his pockets while he was explaining with a big smile that there is no secret involved. He became serious again when he explained in simple words: “We work hard. The spaceship and the other equipment is very good. We developed the spacecraft gradually from Shenzhou 1 to Shenzhou 9. All people in the space sector work hard, they are making even over-hours without compensation. We work long hours every day or even the night.” The moderator then wanted to know whether it was difficult for Liu Wang to wait such a long time for his first space flight. Liu Wang said: “I love manned space flight and I like my job. In English you have a saying: Where there is a will, there is a way.” When Liu Wang got asked about cooperation the pilot became enthusiastic: “We have many cooperation agreements with ESA and DLR but also with France, Belgium, Switzerland. But as a taikonaut I hope we can achieve together more if we work together, no matter whether it is in Tiangong or Columbus. We can even go together to the Moon.” This was the point when the moderator turned to the Chinese space traveller to get some information on how it will go on in the future. Also for this question, Liu Wang had a prompt answer: “We will continue launching our spaceship and cargo ship and build our space station. I heard the news about landing on the Moon, but I think in the future we should first land on the Moon and later on Mars.”

Final destination - all around the globe

After Berlin, IAF President Prof. Feuerbacher himself took over the role of postman to carry the set of 300 yellow-blue flags to Naples in the South of Italy. In the first week of October, the 63rd International Astronautical Congress, themed “Space science and technology for the needs of all”, took place. As promised, the flags were framed, packed and distributed as a birthday present to more than 227 members of the IAF in 59 countries. They can now be found in the offices and showrooms of space organisations, space companies and space institutions all over the world. Mission accomplished!

As it seems, Feuerbacher is not only a gifted president - he is an integrator across borders. Maybe he knows from his personal experience how important it is to keep talking, even if the circumstances are difficult. Born during the heyday of World War II in Leipzig, his family left the Eastern part of Germany after the war. Many of his colleagues in Germany remember him when in 1990, he supported the integration of the Institute of Cosmic Research of the Academy of Science of the German Democratic Republic into the new scientific structures of the reunited Germany. Through his efforts, two new DLR Institutes in Berlin-Adlershof were founded and consequently the expertise of cosmic research at that location maintained. By that time, not many people were far-sighted enough to see such potential worth preserving for the future - Feuerbacher did.

Taikonaut Liu Wang (left) and IAF President Berndt Feuerbacher are presenting the IAF flag to the media and the audience during the event at ILA 2012. Credit: Go Taikonauts!

IAF President Berndt Feuerbacher (left), Taikonaut Liu Wang (middle), and CMSA Deputy Director Wu Ping (right) are checking the content of the package flown on the Tiangong1/ Shenzhou 9 mission. Credit: Go Taikonauts!

Prof. Dr. Berndt Feuerbacher, President of the IAF is thanking the Chinese Delegation for their efforts. Credit: Go Taikonauts!

The Chinese Delegation is watching the video presentation. From the left: Deputy Secretary General of the Chinese Society of Astronautics Mrs. Gong Jinyu, Taikonaut Liu Wang, Deputy Director of CMSA Mrs. Wu Ping. Just a little side note: 2/3 of the Chinese delegation was female: a nice contrast to all the other male participants of the event. Imagine the same photo if Liu Yang instead of Liu Wang would have attended the event ... Credit: Bernhard Tiedt

In a way, the flags accomplished a bigger mission than just travelling 444 days in space and having seen all active manned transportation systems by the time of flight.

Clearly, the IAF project could only become a success because NASA, Roscosmos, ESA, and CMSA took an active part in that space project. In a way, maybe the Feuerbacher Project will go down in history not only as the best organised cosmic mail delivery, but as the first US-China space cooperation in manned space flight?

A sequence from the Chinese space video, showing the crew of Shenzhou 9 with the IAF flag in the Tiangong 1 space module. Credit: Bernhard Tiedt

Deputy Director of CMSA Mrs. Wu Ping is giving her speech during the Berlin Airshow event for the handover of the IAF flags. Credit: Go Taikonauts!

After the panel discussion the astronauts joined together for a group photo. From the left: ESA astronaut Dr. Ulf Merbold, ESA astronaut and ESA Director for Human Spaceflight and Operations Dr. Thomas Reiter, ESA astronaut Thomas Pesquet, taikonaut and pilot Liu Wang, ESA astronaut Dr. André Kuipers. Credit: Bernhard Tiedt

ESA Director General is talking to the audience about his vision for the future. Credit: Bernhard Tiedt

Nǐhǎo! ESA astronaut Thomas Pesquet is welcoming taikonaut Liu Wang in Mandarin. Credit: Bernhard Tiedt

ESA astronaut Dr. Ulf Merbold found clear words for the unacceptable situation that the US has to buy flight opportunities for their astronauts in Russia. Credit: Go Taikonauts!

Taikonaut Liu Wang is explaining to the audience: I love my work. He is also giving clear reasons for the success of the Chinese space programme: “We work hard.” Credit: Go Taikonauts!

Two pilots in an expert’s discussion: taikonaut Liu Wang (left) and ESA astronaut Dr. Thomas Reiter. Credit: Bernhard Tiedt

Two pilots in an expert’s discussion: taikonaut Liu Wang (left) and ESA astronaut Dr. Thomas Reiter. Credit: Go Taikonauts!

Dr. Ulf Merbold (right) - ESA astronaut, pilot and physicist is talking to taikonaut Liu Wang (left). President of the IAF, Prof. Dr. Berndt Feuerbacher is joining the conversation of the two space travellers. Credit: Bernhard Tiedt

Address by the Deputy Director General of the China Manned Space Agency, Ms. Wu Ping, at the IAF Flag Handover Ceremony during the Berlin Airshow, ILA 2012

The Honorable Mr. Feuerbacher
Ladies and Gentlemen,

Good Morning!

It is great pleasure for Chinese astronaut, Mr. Liu Wang, my colleagues and I to attend the IAF Flag Handover Ceremony held here, Berlin of Germany. To begin with, please allow me, on behalf of Mr. Wang Zhaoyao, Director General of China Manned Space Agency as well as the staff of CMSA, to extend our warm congratulations to the success of the flag-carrying mission and the wonderful organisation of Berlin Air Show. And also we would like to express our heartfelt appreciation and gratitude for the attention and supports that IAF has been giving to China's manned space programmes.

As a renowned NGO in the international astronautical fields, IAF has been playing an important role in pushing the cooperation and exchange among the aerospace institutions and organisations around the world, so as to develop the human spaceflight technologies. The flag-carrying mission is one of the IAF's concrete acts in promoting mankind's peaceful use of outer space and pushing space international cooperation. The mission was approved and paid great attention to by Chinese government. Under the elaborate organisation of CMSA, the mission was carried out smoothly and successfully. In June 2011, the CMSA sent its delegation to the IAF Spring Meeting in Paris and attended the 60th anniversary celebrations. During the event, the flags were handed over to Chinese delegation by IAF President, Mr. Feuerbacher. In July 2011, a special ceremony was held in Jiuquan Satellite Launch Center by CMSA to stow these flags in the Tiangong 1 space target module. Tiangong 1 target module was blasted-off on September 28th 2011, and made a precise entry into its target orbit. In June 2012, Shenzhou 9 manned spacecraft and Tiangong 1 successfully conducted space dockings automatically and manually, separately. The Shenzhou 9 space crew took the IAF flags out of Tiangong 1 and landed on the Earth on June 29th 2012. Then, another ceremony was held by the CMSA on July 1st to celebrate the successful return of Shenzhou 9. A postbag (China Post ID Number: TGDZ-01) was unloaded from the re-entry module, in which the IAF flags were stowed. Having witnessed the entire process, Beijing Fangyuan Notary Office issued a notarial certificate.

We truly appreciate this flag-carrying activity initiated by IAF. We think highly of its unremitting efforts in advancing the mankind's peaceful use of outer space and in promoting the international exchange and cooperation of manned space programs. I believe that the completion of the flag-carrying mission is just the inception of a further cooperation between the two sides. We are looking forward to more bilateral communication and cooperation in the future. Meanwhile, we make a sincere appeal to those countries and organisations in the world that commit themselves the peaceful use of outer space resources to, under the principle of mutual respect, equality and mutual benefits, carry out more international communication and cooperation for the noble purpose of making positive contributions to the development of manned space technologies as well as to the wellbeing of all mankind.

Thank you very much!

(Photo credit: Bernhard Tiedt)

Speech by Astronaut Liu Wang at the IAF Flag Handover Ceremony

The Honorable
Mr. Feuerbacher,
Ladies and Gentlemen,

I feel very pleased to attend such a wonderful air show today in this beautiful city of Berlin. It is my honour to attend the IAF flag handover ceremony on behalf of the Chinese astronauts.

As we all know, during the last 60 years since its establishment, IAF has been serving as a bridge connecting all the space agencies around the world. It has been making continuous efforts and contributing a lot to the development of human space cause. Today, we are handing over to IAF nearly 300 flags, which entered the preset orbit in September 2011 boarding Tiangong 1 target module to continue its space travel, after their space flight aboard the Soyuz Spacecraft, International Space Station and Space Shuttles respectively. On June 16th, 2012, Shenzhou 9 manned spacecraft sent me, together with astronauts Jing Haipeng and Liu yang, into space from Jiuquan Satellite Launch Center. After our country's first space automatic rendezvous and docking test, I had the honor to control the Shenzhou spacecraft and completed China's first manual rendezvous and docking test. During the flight of the combined unit, we showed to the whole world one of the IAF flags, which then were sent back intact to the Earth within the Shenzhou 9 re-entry module.

As a member in exploring the space, after witnessing the space flight of the IAF flags, I was deeply impressed by the appeal of the International Astronautical Federation in the world astronautical field and its continuous contributions to the development of human space cause. The IAF flags witnessed the confidence and courage of human in space exploration during each rocket launch, and appreciated the peace and beauty of our Earth home during each orbital flight. These flags will be delivered to every IAF member organisation during this year's International Astronautical Congress. I firmly believe that they will be the most precious gifts for all the space agencies around the world. IAF flags have witnessed the process of the human peaceful exploration and use of space, and will also witness more international space cooperation in the future to jointly develop the world's manned space technologies.

Facing the unbounded galaxy and our peaceful Earth home during my first space flight, I deeply felt that I was not only carrying out the mission for my own country, but also exploring the unknown world on behalf of humankind. Before ending my presentation, please allow me to cite the words of the famous American Astronaut Armstrong who has just passed away: "This is one small step for a man, while one giant leap for mankind". We Chinese astronauts are willing to cooperate and share our achievements with other astronauts from the world, and make our own contributions to the common cause of our human being, to "the peaceful use of outer space and the welfare of all mankind".

(Photo credit: Bernhard Tiedt)

Address by Mrs. Gong Jinyu, Deputy Secretary-General, Chinese Society of Astronautics

Respected CMSA Deputy Director-General , Mrs. Wu Ping,
Respected IAF President Berndt Feuerbacher,
Respected Director General of ESA and IAF Vice-president Mr. Jean-Jacques Dordain,
Distinguished ladies and gentlemen,

Good morning!

I feel honoured to be a part of the IAF flag handover ceremony held today at ILA. On behalf of the president of the Chinese Society of Astronautics, Professor Ma Xingrui, and its Secretary-General, Mr. Yang Junua, I express my heartfelt congratulations to the IAF flag handover ceremony and sincere gratitude to all the attending guests.

CSA has been an IAF member organisation for over 30 years. We therefore have a long-term relationship of friendship and a history of cooperation with the Federation. Arranged by the IAF President and Executive Director, under the leadership of the China Manned Space Agency, with support from the China Association for Science and Technology and the China Aerospace Science and Technology Corporation, CSA has actively participated in the organisation and coordination of the travel of the IAF flag aboard China's manned spacecraft. We were also a part of the previous handover, when the Chinese delegation first received the flag. We also witnessed the entire process during which the flags were carried aboard China's first target space station Tiangong-1.

We would like to sincerely thank CMSA for their great support and outstanding work on the travel of the flag. They have been outstanding from beginning to end: from the sending of a dedicated delegation to the IAF Secretariat in Paris to receive the flags and bring them to Beijing; arranging that the flags are carried aboard Tiangong-1; and finally, when Shenzhou-9 and Tiangong-1 successfully docked and safely returned, notarising the flags. Today, led by Deputy Director-General Mrs. Wu Ping, they arrived from Beijing to Berlin specifically to return the flags to IAF. This fully shows that CMSA has attached great importance to the IAF, has given their support to CSA and dedicated all efforts to strengthen the international exchanges and cooperation in the field of space.

We would like to sincerely thank the IAF for investing their wisdom and efforts in this innovative activity. The IAF flags that have been flown in space symbolise that space exploration is a dream shared by all people in the world and the peaceful utilisation of space is our common goal. This innovative activity will have a profound impact on the international space exchange and cooperation. We believe and wish that IAF flag will fly forever in the minds of the peace-loving people of the world space community.

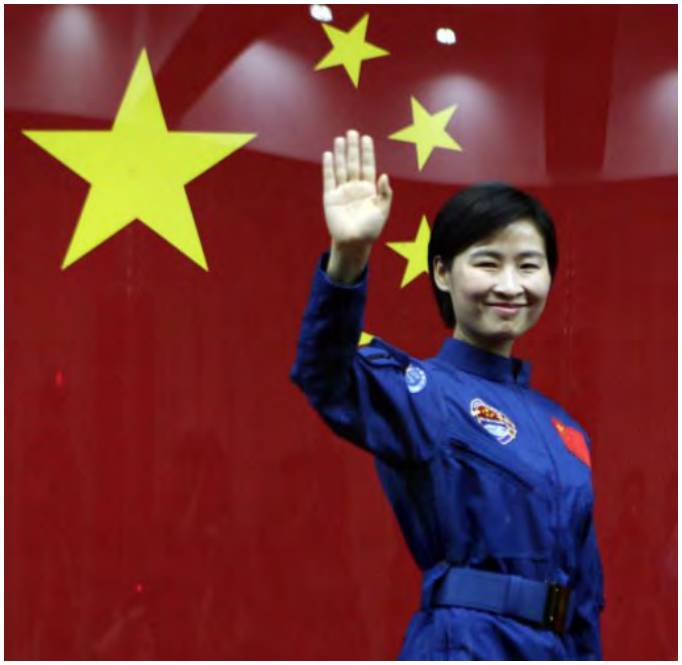
Thank you!

Jinyu GONG
Deputy Secretary-General
Chinese Society of Astronautics

(Photo credit: Bernhard Tiedt)

Ladies First

by Jacqueline Myrrhe, with contributions from Brian Harvey



No doubt: she is a star! China did right in selecting Liu Yang to become the first Chinese woman in space. She is a fresh addition to her female colleagues in the world: friendly, open, warm, and a women with a message: Let's work together in space! During the 63rd International Astronautical Congress at the beginning of October in Naples, Italy, Liu Yang made her European debut on the conference stage, and she made it with style and élan. Now that we, outside China, know her, we are curious to see what else China has in its pocket. If the other female taikonauts have similar personalities, the space community will soon become much richer.

"I have met many new friends from the international space family.", Liu Yang stated at the beginning of her Naples presentation about her flight on-board the Shenzhou 9 spacecraft. She said that she was responsible for over 30 space medical experiments and for the support to control and maintain the spacecraft, as well as supporting the docking manoeuvre. She described her impressions very vividly: "I think it is the same for all newcomers in the outer space, I also enjoyed the wonderful experience of space flight in addition to the hard work. In order to reduce the effect of microgravity on the body, I did exercise every day like riding the bicycle. I even played Tai Chi in orbit – it's awesome." Liu Yang stressed "awesome" with a lot of joy so that the audience had no doubt that she really meant what she said. Then she went on:

"What touched me the most was that upon entering the Tiangong 1, I was so surprised and excited to find an album of all our taikonauts and a panda doll prepared long before our mission by the ground support team. They even prepared the thread for me to make a Chinese knot during my spare time. Looking down at our mother Earth from space for the first time, I was really astonished by the beauty of the blue planet. It is a treasure that glows too and that should be cherished and protected by all human beings. I am looking forward to the next flight. I am also looking forward to the cooperation with other countries' astronauts. Taikonauts are willing to cooperation with astronauts or cosmonauts all over the world and to make our due contribution to the peaceful utilisation in the outer space for the benefit of mankind."

After her speech, the media representatives got an opportunity to ask questions to Liu Yang and her boss, the Director General of China's Manned Space Agency - CMSA (former CMSEO), Dr. Wang Zhaoyao.

In answer to a question about her next flight, Liu Yang answered Solomon-like by saying: "My flight schedule is closely connected with the country's programme developments. The next mission will soon come, and no matter whether I am selected for the next mission - all our taikonauts are all the time prepared for the country's selection." Then she explained that her job for the coming years is to do more training and more preparation work. "And beside that, I have one duty in addition and that is to exchange experiences with other taikonauts and to learn from each other because I have the flight experience. I think now more of my duties are still to train to be ready for future missions", she added. Liu Yang became very philosophical when she was asked whether she knew about the other people staying in orbit on-board of the International Space Station at the same time when she was flying in low Earth orbit. She answered smiling: "I think we could sense all the others in the universe, and during our mission, I and all the other taikonauts sensed the other astronauts in orbit. We also sent our greetings to them during our mission in orbit." Wang Zhaoyao answered the last three questions of the session. He showed some humour when he replied to the question about the second female taikonaut possibly on the Shenzhou 10 mission: "The crew for Shenzhou 10 has not been decided yet. We have certain selection criteria. As long as the taikonauts are matching the selection criteria, they will be able to be selected. And we also have a selection criteria that says: Ladies First!" But on the question about European experiments on Shenzhou 10 mission, Director Wang did not give much additional information but saying: "For our next mission there is a certain involvement of foreign space agencies, including the European."

Unfortunately the web streaming of the press event on Wednesday 3 October early in the morning did not give the translation for the presentation held by Dr. Wang Zhaoyao, Director of China's Manned Space Agency. According to the press release issued later by the IAF, he gave an illustrated overview of the flight, covering mission planning and implementation. Dr. Wang revealed that the Chinese Space Station is expected to be completed and fully operational around 2020, and added that China intends to strengthen international exchange and cooperation in its future development and operation. "During the operational phase, the Space Station will conduct long-term man-tended operations with the nominal status of three crew who will alternate every half year", he explained. Dr. Wang also said that the construction phase would see intermittent visits and stays depending on mission requirements and that some

EVAs would be performed.

During the question and answer session, Wang Zhaoyao explained the technical objectives for the Shenzhou 10 mission in the following way: "The main objective is to further test and certify our technologies and experiences on rendezvous and docking. As you all may know the rendezvous and docking technology is a ‘must have’ for our future construction of the space station. For the better execution of future missions we will try our best to make good use of the Tiangong docking target to test and verify our rendezvous and docking capabilities. We also hope to use the Tiangong 1 during the Shenzhou 10 mission to verify some future technologies that will be needed for our Space Station, such as in-orbit repair and in-orbit refuelling." Again, he did not give much information away when asked about the expected number of flights in 2013. "So far we have scheduled only one mission to Tiangong 1 - the Shenzhou 10 mission."

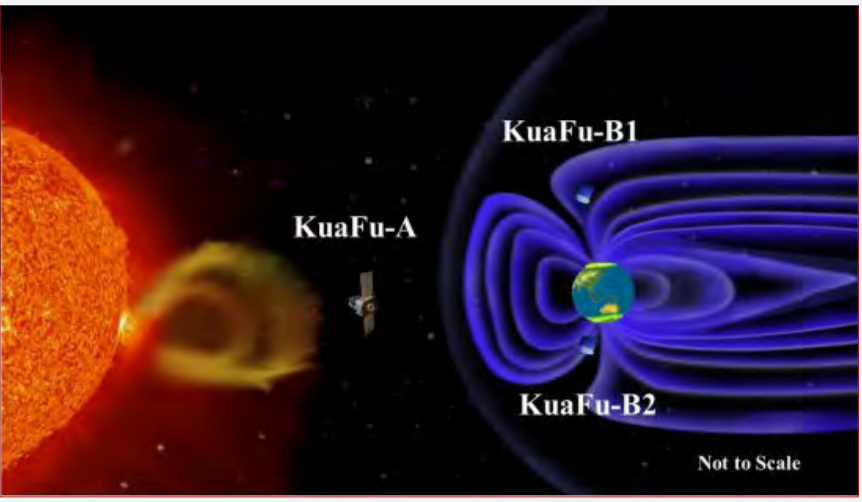
Go Taikonauts! had the opportunity to talk to Brian Harvey from Dublin, Ireland, about his personal impressions during the 63rd IAC. Mr Harvey is an expert for Chinese space activities with a particular focus on the scientific programme. He has just now finalised his latest book about Chinese space projects, entitled: "China in Space: The Great Leap Forward" – anticipated to be published by Springer New York by the end of this year or beginning of next year. Brian Harvey could not only attend the morning event but also some other presentations on Chinese lunar exploration during the 63rd IAC. Following those lectures, he took some more technical details home. The space expert thinks that the one manned mission in January 2013, Shenzhou 10, will do '10% new things', what could be translated into a manual docking first. He also got the impression that there would certainly be a woman on-board the next Shenzhou spacecraft. After listening to the presentation in Naples, he expects that Tiangong 1 will be de-orbited in 2013 and Tiangong 2 will fly in the 2014 to 2016 timeframe. There will be longer occupancy by crews and it will test the unmanned freighter version of Shenzhou, comparable to the Russian Progress cargo spaceship. Brian Harvey pointed out to Go Taikonauts! that the Chinese delegation gave some illustrations of the early stages of the construction of the 2020 space station, and that Wang Zhaoyao showed some designs of 'equipment modules' to dock with the Chinese Space Station using the Long March 7 rocket.

The 64th annual conference of the International Astronautical Federation will take place from 23 to 27 September 2013 in Beijing. One can expect that China will use this occasion to showcase their space flight achievements of the past and exploration strategies for the future. Certainly, Naples 2012 was interesting, however, one can be sure: Beijing 2013 will be “awesome”.

Note: The presentation by Wang Zhaoyao and Liu Yang was streamed on the internet and can be found either on the IAF website or on YouTube.

The long run for chasing the Sun

by Jacqueline Myrrhe



Artist impression of the Kuafu mission constellation with Kuafu A in the Sun-Earth L1 Lagrangian point, what means in 1.5 Mio km distance from Earth and the two Kuafu B space probes located in the same Molniya orbit, but phased 180 degree apart. Credit: ESA

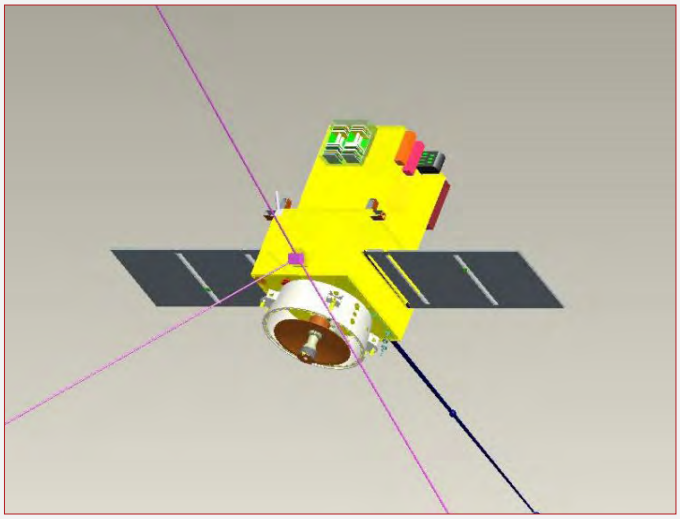
Once upon a time there was a tribe of giants living in the mountains of China's North. They were known as warm hearted, busy and brave people. The leader of the giants was Kuafu, the bravest, strongest and friendliest among them. One day the Sun was shining so strong that all life around was about to die. Kuafu was very concerned when he saw his people suffering from the heat. Therefore, he decided to catch the Sun to make it listen to the needs of the people. Next morning he waited for the Sun to rise and started running in that direction. Then he had to follow the star moving across the sky. He ran and ran until the Sun began to set. Just at the moment the Sun wanted to disappear behind the horizon, Kuafu got so close to the Sun that he wanted to embrace the star. Unfortunately, the Sun was so hot that Kuafu felt extremely tired and thirsty. He needed to drink. He drank all the water from the Yellow River, but it was not enough to make him feel satisfied. He found the Wei River and drank its water up to the last drop. Still this was not enough, and he wanted to run North to drink the water of the Big Lake, but he could not reach the lake anymore and died on the way. Shortly before he died he felt sorry for his people, because he could not help them. He threw his wooden stick in the direction of the place where his tribe used to live to send a last greeting. Kuafu died, but at the place where the stick reached the ground a forest of peach trees started to grow. Over time the trees became more and more, and the fruits of the trees served the travellers coming along as a refreshment. This is why Kuafu is still living in the hearts of the people today.

This is the short version of an ancient Chinese legend. There are many other versions of the story around, and the Chinese today still enjoy telling this more than 2000 year-old fairy tale with the sad ending.

Kuafu's legacy

Although Kuafu died, the name of the brave giant is still remembered and the modern Kuafu has not yet given up chasing the Sun. The Kuafu of today is an ambitious space mission which intends to do something never done before: to systematically collect data of the Sun-Earth environment, by observing the complete chain of solar effects starting at the solar atmosphere up to geospace, including solar flares, coronal mass ejections, interplanetary clouds, shock waves, and their geo-effects, such as magnetic storms and auroras.

The mission will consist of three satellites: Kuafu A and Kuafu B1 and B2. Kuafu A intends to host solar instruments for the continuous observation of solar activities and will be located at the Lagrangian Point L1. Kuafu B1 and B2 are planned to be located in highly-elliptical polar Earth orbits to watch auroras in the Northern Hemisphere. The best thing about this mission, is that the international science community is joining together in this challenging project to bring the best out of Kuafu.



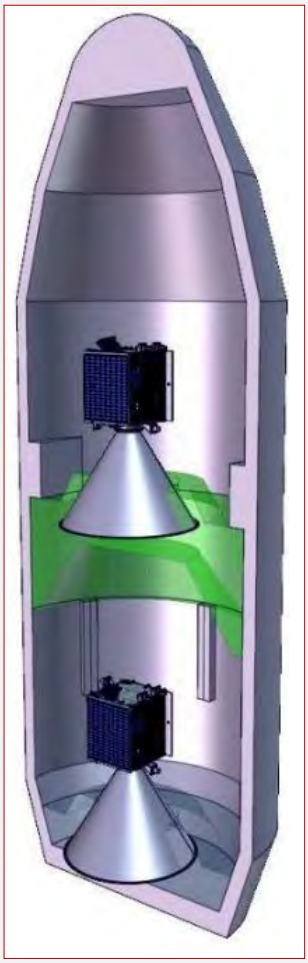
Kuafu A, located in a halo orbit at the Sun-Earth L1 Lagrangian point, is supposed to continuously observe the Sun, providing an early warning about Coronal Mass Ejections and measurements of the Interplanetary Magnetic Field. Credit: ESA

The beginning

The Kuafu Programme was already initiated at the beginning of 2003 when the Beijing University and China Academy of Sciences came up with the idea of a space weather explorer concept during a Space Weather Group meeting of the National Natural Science Foundation of China - NSFC. NSFC supported the Kuafu project from 2004 onwards and in October 2004, the Kuafu pre-study phase received approval as a key science project. Since its very beginning, the Kuafu Project has been open to the international science community. Scientists from various European countries and Canada have been heavily involved in the project from the very beginning.

The first international meeting of the Kuafu pre-study team was held on 9 December 2004, in Frankfurt, Germany. At that time, the Canadian 'Ravens' project was merged with Kuafu. The second international meeting of the Kuafu pre-study team, and the first international symposium on the Kuafu project were held in Beijing from 19 to 24 May 2005.

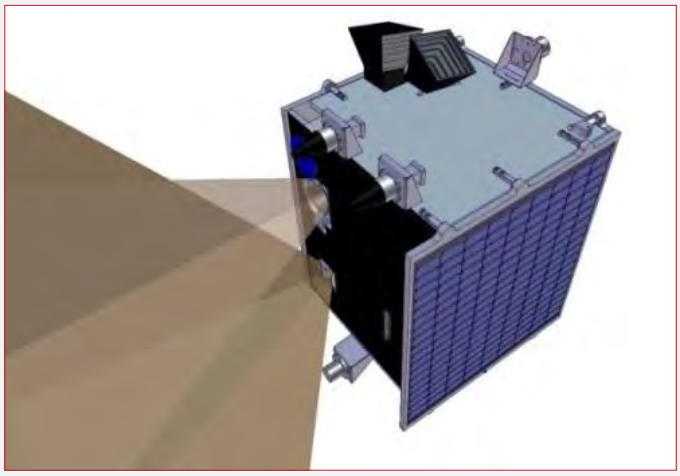
On 28 July 2005, a national trilateral cooperation agreement was signed by the China Meteorological Administration CMA, the Peking University PKU and the China Aerospace Science and Technology Corporation CASC.



The two Kuafu B spacecraft will be launched by a single Long March 2C/SM rocket provided by China. Credit: ESA

Two months later, on 16 September 2005 the Chinese solar-terrestrial research community jointly decided to support Kuafu as the only solar-terrestrial mission to be submitted to the China National Space Administration CNSA. Kuafu merged with the Solar Wind and Auroral Storm Explorer SWASE, a project of the Chinese Academy of Sciences CAS. With this merging, CAS became one of the key members of the Kuafu project, and a Kuafu Coordination and Planning Committee KCPC was introduced for the coordination of the domestic and international cooperation of the Sun chaser project. The Kuafu Scientific Committee was placed in charge of all scientific activities.

From 22 to 23 July 2006, the 4th ILWS General Meeting was taking place in the Friendship Hotel in Beijing. During that conference, the Kuafu payloads experienced endorsement.



Possible design of the Kuafu B spacecraft. The satellites are dwarf satellites, but the performance and significance they could achieve will be gigantic. The brave giant Kuafu has found an appropriate successor. Credit: ESA

At the end of that year, the KCPC drafted an International Coordination Plan aimed at inviting representatives from related European national agencies, the Canadian Space Agency CSA and ESA to discuss cooperation on the mission, including intentions, cooperation mechanism, funding possibility, and, if needed, the publication of Announcements of Opportunity.

From 14 to 19 January 2007 CMA hosted the 2nd International Symposium on the Kuafu Project (ISKP-II) and 5th Kuafu Team Meeting were held on Hainan Island, in the South of China.

Keep chasing the Sun

In June and September 2007, the Kuafu Project passed two critical reviews on its scientific objectives and payload systems, and scientific and engineering feasibility.

By 2008 the satellite design for Kuafu A was on the way and the project team was looking for a launch in 2012 to meet the solar maximum.

However, since China always hoped for a broad international cooperation in the realisation of this ambitious concept, it took some more years to get the mission set-up within an international cooperation framework. This also meant that the projected launch date of 2012 could no longer be met. Missing one solar maximum must not mean missing the next one. However, with a little bit of patience, a little bit of endurance and a little bit of optimism – some very Chinese characteristics which have already led to the success of other projects - Kuafu can be helped with its long run of chasing the Sun.

Go Taikonauts! was very lucky to be able to talk to the ESA Programme Manager for the Kuafu mission, Bruno Gardini, who expanded on the details of the mission, and gave an overview on the current status of this international project.

Interview with Bruno Gardini, Programme Manager for the Kuafu project in the Directorate of Human Spaceflight and Operations at the European Space Agency ESA in Noordwijk, The Netherlands

Bruno Gardini, ESA's Programme Manager for the Kuafu project in his office in ESA-ESTEC.
Credit: Go Taikonauts!

GoTaikonauts!: What is the mission profile of Kuafu?

Bruno Gardini: We are currently working on the finalisation of the Programme Proposal for the Ministerial Council. To describe it briefly: it is a three spacecraft configuration which we intend to accomplish in cooperation with China. Here on the ESA-side we are also lining-up with ESA's Science Directorate, a mandatory programme for all ESA Member States. First of all, there is the Kuafu A space probe which will be positioned in the Earth-Sun Lagrangian Point L1. And if you look at the configuration of the spacecraft you will see that it is very similar to SOHO. Of course, Kuafu compared with SOHO, will have far more advanced and very interesting scientific experiments. But please, keep in mind that SOHO is already an "oldie". It was launched in 1995 and experienced several mission extensions, the last one until 2014. Therefore, Kuafu has the chance to continue the pioneering data acquisition of SOHO.

As you can imagine, the payloads on Kuafu will be mostly Chinese payloads. They will be designed and built in China, launched by China and operated in China. But we will also have two European instruments from Germany and Switzerland. KuaFu-A is really a key component of the whole mission, because with its position in the Langrange Point, the spacecraft can give us an early warning of Coronal Mass Ejections or changes in the interplanetary magnetic field, events which are the starting point for electro-magnetic storms affecting us here on Earth. Kuafu would provide us with near real-time data for space weather services, which could then warn the satellite operators and all these kind of things, where space weather could do quite some damage if the disturbances are not known in time.

I should not forget to mention that there is also a very large scientific interest in the mission and an involvement of European scientists at the level of contributions as Co-Principal Investigator for the set of Chinese instruments. In practice this means that the Principal Investigator is Chinese but they are open to cooperation. In our recent agreement, which has been signed by our Director for Human Spaceflight and Operations, Thomas Reiter, and the Director of the National Space Science Centre of the Academy of Science of China, Prof. Wu Ji, both parties agreed to apply an open data policy. China is really very open on that. Our Asian counterparts know that it is a sensitive thing, of course, but we are having a very good relationship with them. And it is an extremely efficient relationship by the way! During a couple of meetings we could agree on the main features of the mission and it was all well prepared. We sent questions in advance and the Chinese came to the meeting and were absolutely well prepared and cooperative.

So this is the one spacecraft. Then we have two more spacecraft which are in Near Earth orbit. We have selected the Molniya orbit because it is not only a highly-stable orbit but it gives us the maximum coverage of the Northern Hemisphere which is the most important one for commercial and other applications. The two spacecraft are phased 180 degrees apart. With that configuration one can gain a complete coverage of the Northern Hemisphere, and even with some overlap, for the time that both spacecraft are moving through the northern part of their orbit. When they are opposite, the spacecraft can collect data on the Aurora Borealis and at the same time also some measurements of the Aurora Australis. It is not the same coverage in the South, because the perigee in the Southern Hemisphere is relatively low giving us a less beneficial opportunity for measurements than in the North. The characteristics of the orbits go from 1.8 Earth radius at perigee to an apogee of approximately 7 Earth radius.

These two spacecraft will be developed by us with European experiments. If I say "us" this also includes Canadian contributions because Canada is an associated member state of ESA. The Chinese side has expressed their interest to fly two of their experiments on our spacecraft as well. This spacecraft would be operated by ESA and we would also provide ground station support to operate Kuafu A. In fact our ground stations nicely complement the Chinese ground station network and by combining our space tracking capabilities we can guarantee the important 24 hour coverage of Kuafu A at the Lagrangian Point L1. As I explained before, the spacecraft in the Lagrangian point has the early warning function of telling us whether there is a Sun event that would affect the Space Weather conditions on Earth. Kuafu A is providing us with that specific data.

To keep the cost of the mission and the small spacecraft within reasonable limits, we have given attention to existing qualified European platforms, although some other possibilities exist. For the spacecraft design, we have to take into account the Molniya orbit, and also the fact that these space probes will be launched by the Chinese Long March 2C/SM rocket, and therefore have to fulfil the Export Regulations, essentially they have to be ITAR-free. We have now to elaborate and modify the design of the selected platform to ensure that we can launch under these conditions. Taken all together, this is a tremendous opportunity for Europe. Out of this mission we will get the space weather data of Kuafu A, and can analyse the effects of space weather on the Earth's magnetosphere and other near-Earth effects - so we have a complete chain of data acquisition, and we will get this full set of usable space weather and scientific data in exchange

for our contributions. After all, the Kuafu mission is indeed also a scientific mission. If you think about the investment we are making and compare it with what we get for it this is a fantastic win-win situation for both sides. Otherwise, if Europe would have to go it alone - building a spacecraft for the Langrange Point position, providing two launchers, setting up the full operations - it would be an investment of several hundred Million Euros. But for a fraction of the cost, we will get all the data we need.

GoTaikonauts!: What will be the life time of the spacecraft?

Bruno Gardini: The lifetime of Kuafu A is expected to be in the 10 years range. For the Kuafu B spacecraft, the problem is, that the highly elliptical Molniya orbit reaches up to the Van Allen belts which the spacecraft have to cross regularly. Here, we are facing rather high levels of radiation which are of course cumulative. But also typical for these small platforms is an average design lifetime of two years. And this applies basically to all of them: SSTL, Proba, or TET - the new German platform. So nominally, we should consider two years of operation, although they usually last much longer. Our planning and financial envelope is based on two years of operations.

As I mentioned before, this programme is also financed from the mandatory space science programme. We, our Directorate, would provide the spacecraft platform - the flight segment so to say. The operational costs would be covered by the mandatory space science programme, with the payloads of instruments being nationally funded.

So for the space segment, which is covered by the SSA optional programme, it would demand 70 Million Euros of budget, the two years of operation would demand another 20 Million of financial commitment. And this means the operations for three spacecraft, also for Kuafu A. I think this is a very interesting constellation. The mission has also strategic value, because it would be the first project in full cooperation with China. We had Double Star and we had cooperation for the ground segment but those contributions remained rather limited.

The remarkable thing is that the initiative came from China, from the Chinese Academy of Science. Our Chinese colleagues asked our Science Directorate to develop this mission together. The proposal went to the Science Programme Committee and the scientists concluded, yes, this mission is interesting, but only on the level of a mission of opportunity, meaning the Science Directorate would not finance the whole mission alone. This proposal was then moved to the Programme Board Space Situational Awareness, because it also included the aspect of space weather as an important element. And since Space Situational Awareness is hosted in our Directorate, it ended up with us. And this is where we are today.

GoTaikonauts!: Will it not create a political problem now that the mission is assigned to the Space Situational Awareness programme - a programme with some aspects of dual use and of a sensitive character?

Bruno Gardini: There are different elements to Space Situational Awareness, one of them being Space Surveillance and Tracking, and this is a bit controversial. But this is only one component. The other component is NEO, the detection of Near-Earth objects. And the third part of the programme is Space Weather. Space weather is not controversial and we had very positive reactions.

GoTaikonauts!: It sounds as if the chances for getting the proposal for the Kuafu mission approved during the ESA Council at Ministerial Level by the end of November are not too bad?

Bruno Gardini: I believe we have a good starting position. The main problem we have, is that, if we want to limit the cost of the mission, we essentially have to use an existing platform, although as mentioned before other possibilities exist. Now, existing platforms means a significant contribution from the country where the prime contractor is located. This is the biggest challenge at the moment. Once we have selected the platform, we will have a mission, but today we expect the decision can only be taken at the Ministerial Council.

GoTaikonauts!: One of the existing platform is the German TET spacecraft that was launched successfully on the 22 July this year: is TET ITAR-free?

Bruno Gardini: No it is not. But none of the mentioned platforms is ITAR-free for a simple reason: if you want to develop a low cost platform, you rely on American electronic components which are easily available and for a low price. In the meanwhile, we, and also industry, made an analysis to see which modifications and exchange of parts we would need. There are a lot of items needing replacement, starting with the solar arrays, batteries, or electronic parts. On top of that we need to change the design for this mission because for orbital transfer, we need a propulsion system which none of them have. The initial perigee provided by the Long March 2C/SM rocket is only about 200 km and we have to bring the spacecraft to the final perigee. We also need to go to the X-band communication system with a coherent transponder. Normally the small platforms use GPS receivers, which may not work at the high apogee and are a ITAR sensitive item. But if we use a coherent transponder we do not need GPS. At the end we are left with a number of modifications, but this is also an opportunity for several other countries to participate.

GoTaikonauts!: Are you not running out of time for this mission? The latest launch target was 2012 to meet the upcoming solar maximum?

Bruno Gardini: The launch date for Kuafu A is now 2017, so in good time for the next solar maximum.

In China the mission is already fully approved. But Kuafu A is essentially a science mission, so our colleagues in China look at the whole mission as a “package”. They provide the launcher for our spacecraft free of charge and we have to contribute the spacecraft.

GoTaikonauts!: What is the percentage of the number of items you have to replace to make the platform ITAR-free?

Bruno Gardini: The ITAR items comprise all electronic components. We have a cost estimate and now we have to see what needs to be done. There are some specific items which are more important than others, for example the power supply, which

will require a redesign of the box. The solar arrays and battery would also need to be exchanged completely. It is clear to us that a substantial part of the money goes into the modifications.

However, we should also keep in mind another factor which is the commercial aspect of this mission: if we end up with a platform which is ITAR-free to carry a sizable payload of experiments – in other words an inexpensive platform which can be launched in China with a cheap launcher, I think this is also a market opportunity. I know it is not a big market, but nevertheless.

GoTaikonauts!: Is the mission embedded into a bigger framework of existing or future missions?

Bruno Gardini: Yes, Kuafu will complement existing missions. Missions like SOHO, ACE and other spacecraft are all well beyond their design lifetime. SOHO is even at the end of its second life, if you want to put it that way. So we need a replacement. We all hope that SOHO continues for many more years. But still, we are looking for data which we can put together in a systematic way. We already have a space weather service in Belgium, where we distribute space weather warnings to our customers via the internet. We would like to do that now in a more systematic way. The service is almost operational. Kuafu would be the first dedicated mission for this system. The next step would be to have a fully operational system where you can guarantee the delivery of certain data at a certain time under certain conditions. We cannot do this today, but this is the idea for the future. And there is an interest by the Chinese to get access to our space weather service as well. There are interesting combinations possible for this kind of application. This is a big potential for the future.

GoTaikonauts!: During the process of the project you have been in China. What was your impression?

Bruno Gardini: The most impressive is to see how and at which speed things are progressing in China. Not a new discovery, but nevertheless still interesting. And I think Europe should really take this opportunity to extend our cooperation with China as a first step to even bigger projects in the future.

GoTaikonauts!: Thank you very much for your time and highly interesting information.

Luna meets Chang'e

by Jacqueline Myrrhe

In the beginning of the space era, the Moon was about to become the domain of the Soviet Union until the United States caught up. Jokes about a "Red Moon" were rigorously wiped out with the manned landings during the Apollo programme. Unfortunately, after the trail blazing human lunar landing the last surface Moon probe was the Soviet Luna 24 which landed 22 August 1976 on the Earth's closest neighbour in space. For 14 years it became pretty quiet around the lunar orbit. Only with the launch of the Japanese Hiten spacecraft in 1990, lunar exploration has been becoming increasingly versatile and international. Hiten was followed by NASA's Clementine and Lunar Prospector, by ESA's SMART-1 in 2003, JAXA's Selene in 2007 and eventually China's Chang'e 1 in 2007 as well as India's Chandrayaan 1 mission one year later.

Only three years after Chang'e 1 China launched Chang'e 2. These two lunar missions contributed a lot to the surprise effect the Middle Kingdom offered to the space world throughout the last decade. Chang'e 1 and Chang'e 2 were not only a wake-up call for the established space players but also helped China enormously to earn the deserved respect from the leading space nations on the planet.

Although China challenged the Moon after its neighbour Japan and considering that China, Japan and India have similar lunar exploration plans based on the orbiter-lander-sample return-approach, it looks now as if China is on the passing lane. While JAXA's Selene 2 and ISRO's Chandrayaan 2 were planned for 2012 only Chang'e 2 launched. Chang'e 3 with a rover on-board is almost on its way for a launch in 2013 while the next Japanese and Indian missions are scheduled for 2014. It should not be left without notice that the Google LunarX prize is also still not won, quite the opposite. Originally, the time frame was set for the end of 2012 or until the end of 2014 for the decreased prize money. Now the deadline is set for the end of 2015 but the prize will fall by 5 Million US-Dollars if a governmental mission makes it in the meantime to the lunar surface and roams around. Chinese engineers are about to spoil that competition a little bit.

Helping, succeeding and sharing

Part of the recent success in lunar exploration, China owes to the European Space Agency ESA. By the time of the mission planning for Chang'e 1 China did not possess sufficient deep space communication capabilities for the operation of its Moon mission. An initial request to NASA to help out was refused.

Instead, the European Space Agency stepped-in and offered its deep space network to China for spacecraft and ground operations support services.

Already in preparation for this cooperation, ESA took its SMART-1 mission in 2003 as a test case and provided details of the spacecraft's position and transmission frequencies to the Chinese mission controllers at BACC, the Beijing Aerospace Command and Control Centre. With the help of these data, the colleagues in East Asia could test their tracking stations and ground operations before launching Chang'e 1.

For the Chinese mission, ESA eventually provided its 15 m European Space Tracking (ESTRACK) network stations at Maspalomas (Spain) and Kourou (French Guiana) which were complemented later by ESTRACK's DSA 1 - the giant 35 m deep-space station at New Norcia, Australia. The three antennas shared tracking operations during Chang'e 1's cruise to Earth's natural satellite and were also on duty during the critical orbit insertion manoeuvres.

ESA's ground stations are remotely controlled from the ESTRACK Control Centre - ECC at the European Space Operations Centre - ESOC in the city of Darmstadt in the Southwest of Germany. Under nominal routine operation conditions the antennas are not manned but for supporting China's first lunar rendezvous, ESA's engineers were busy on-site to provide a quick response in the event of any technical problems. Those problems did not arise and the intensive preparation work finally paid off. The Chinese scientists shared their data obtained dur-

ESA's 15 m European Space Tracking (ESTRACK) network station in Kourou, French Guiana. (Credit: ESA)

ESA's 15 m antenna in Maspalomas on the Canary Island of Gran Canaria. The dish operates for arriving signals in S- and X-Band and transmits radio waves in S-Band. (Credit: ESA)

The New Norcia station DSA 1 (Deep Space Antenna 1) is situated in 140 km distance north of Perth. The site hosts a 35-metre deep-space antenna with transmission and reception in both S- and X-Band. (Credit: ESA)

ing Chang'e 1 flight with their European colleagues. Also, scientists, engineers and ground control experts from ESA's ESOC and China's BACC have held a series of joint meetings in Beijing and Darmstadt, conducted joint testing, upgrading of station software and participated in simulations.

"ESA's expertise in tracking Chang'e 1 sets the stage for future cooperation with China. The Agency's tracking station network, ESTRACK, is a resource that benefits not only the Agency but also all space science through such international cooperation," explained Erik Soerensen, Head of the System Requirements and Validation Section at ESA's European Space Operations Centre on the ESA website after the mission. During the 12th International Conference on Space Operations from 11 to 15 June 2012 in Stockholm, he together with his colleague Gerhard Billig, reported on the details of the operations for Chang'e and explained in depth the reasons why the cooperation with China worked perfectly.

Hermann Opgenoorth, Head of ESA's Solar System Missions Division could add to that prospective by expressing: "Participation in Chang'e-1 gives European scientists and ESA experts a welcome opportunity to maintain and pass on their expertise and to continue their scientific work. Based on the experience gained with this first mission, we intended to cooperate on the next missions in China's Chang'e line of lunar explorers."

And indeed this cooperation found its continuation during the Chang'e 2 mission and will experience its revival during the upcoming Chang'e 3 and Chang'e 4 lunar surface exploration project when ESA's New Norcia antenna will link up with the Kashgar 35 m antenna and the Jiamusi 64 m dish.

At home in the Solar System

Detlef Koschny is ESA's jack-of-all-trades. Having a background in science and engineering, he incorporates the perfect mix of skills it needs to manage with ease a wide range of planetary missions. From the European Rosetta mission to ESA's flight to the Moon with SMART-1 or the highly successful mission to our neighbour planet Mars Express, or even to the field study Desert RATS 2011, Dr. Koschny is the "man for all missions". Also, he is enthusiastic about his profession - something what shows after seconds of talking to him and this is something what might get infectious if you only stay long enough with him in his small but cosy office in the main building of ESA's ESTEC branch in Noordwijk, The Netherlands. If you are lucky he will open his drawers and you have the rare chance to touch something extra-terrestrial. No, Dr. Koschny is not hiding little green men but some other treasures like meteorites which he might invite you to lift because he enjoys seeing your surprised face when struggling with the heavy weight. But as soon as one of his colleagues comes along to discuss a problem, you understand, that Detlef Koschny currently covers the function as Head of the Near-Earth Object segment of ESA's Space Situational Awareness programme.

In his spare time, if Detlef Koschny is not watching the night sky through his telescope in the garden next to the famous bulb fields of Holland, he is also playing in the jazz band, called "The TBDs". As a drummer he is giving the rhythm what might have

Experts at the Beijing Space Command and Control Center are conducting real-time monitoring of the launch 24 October 2007. (Credit: Xinhua).

China's first lunar orbiter Chang'e I and technical graphs are shown on the screen at the Beijing Space Command and Control Center, which is conducting real-time monitoring of the launch 24 October 2007. (Credit: Xinhua)

Experts at the Beijing Space Command and Control Center are conducting real-time monitoring of the launch 24 October 2007. (Credit: Xinhua)

Scientists get ready to observe the launch of Chang'e 1, China's first lunar orbiter at the Urumqi Observatory in Northwest China's Xinjiang Uygur Autonomous Region, 24 October 2007. (Credit: Xinhua)

predestined him to lead different project teams, but also to look into techniques and solutions provided by other teams to learn from them. His team spirit might also have been a reason why ESA has chosen him to become the Project Scientist for the cooperation with China on the Chang'e 1 mission.

Go Taikonauts! had the opportunity to talk to him recently about his 2007 project.

GoTaikonauts!: How did you become involved in the Chang'e project?

Detlef Koschny: I have been interested in small bodies in the solar system for a long time. I started at ESA working in the team of the Rosetta Project Scientist, but got involved in the Smart-1 mission to the Moon very soon. I was helping to set up the Science Ground Segment, i.e. the group that coordinates the operations of the payload. Smart-1 successfully arrived at the Moon in December 2004 and we did some excellent measurements there. A few years later Europe was asked by India to support them in their lunar mission Chandrayaan-1. I consulted them in setting up their operations and archiving system. Since a number of European instruments were selected to fly on the mission and part of their funding came from ESA, I was nominated to be the European Project Scientist for Chandrayaan-1.

So, one led to the other. When China was proposing a collaboration on their lunar mission Chang'e, I was again nominated Project Scientist...

GoTaikonauts!: What were your tasks?

Detlef Koschny: Europe provided support for their navigation and flight dynamics. In return, we were promised access to the full dataset of the mission. We did not contribute any hardware to the mission or had any ESA-funded scientific instruments aboard. So my only task was to ensure that we would get access to the data - which we did.

GoTaikonauts!: Why was ESA interested in a cooperation with China in the field of lunar exploration? Has China capabilities which are interesting enough for ESA?

Detlef Koschny: This cooperation came up as logical extension of previous scientific collaborations between ESA and China. It was a recognition by China of ESA's operational capabilities, which could be used for their mission while at the same time, pursuing ESA's scientific interest regarding the Moon after Smart-1.

GoTaikonauts!: What could ESA gain from the cooperation on this project?

Detlef Koschny: The returned data quality is very good. It allows us to enlarge our database about the Moon, thus enhancing the European scientific knowledge in this domain.

GoTaikonauts!: Was it a success for both sides?

Detlef Koschny: In the end the contact with my Chinese counterpart was not so intense, thus it is difficult for me to judge how the Chinese side assessed our collaboration. But we were recently asked to work together with China on the Kuafu mission, so this I see as a confirmation that our previous collaboration - not only on Chang'e - was a success.

Detlef Koschny in September 2011 at ESA's ESTEC establishment in the Netherlands during a simulation of a future mission to an asteroid. For that simulation, the international team of experts in ESTEC linked up with astronauts roaming over the simulated surface of an asteroid which was in reality the wide plain of the desert near Flagstaff in Arizona, USA. Credit: ESA

GoTaikonauts!: Could you work with your Chinese colleagues face-to-face or how was the work organised?

Detlef Koschny: Our division did not have any dedicated budget for this support, and I only spent a small part of my time on this mission. Thus we reduced any travel as much as possible. Most of our interaction was via e-mail.

GoTaikonauts!: You have experience in working with Chinese and Indian scientists. Can you spot any differences?

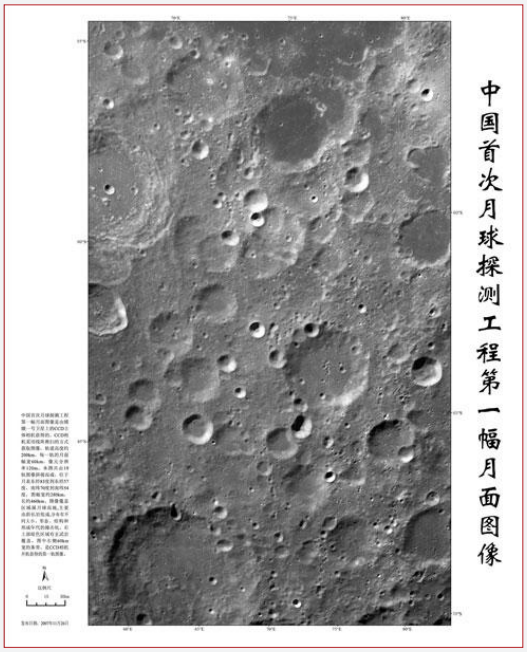
Detlef Koschny: Yes - but I can't put them in words. All cultures are different - I have been a German living in the Netherlands for almost 15 years now and still stumble over cultural differences, even though our countries are physically very close to each other. My son has moved to Ecuador for one year just a few weeks ago. In a recent telephone call I again felt that he is now exposed to a very different culture. But I have to admit that I find it difficult to phrase what these differences are. I just try to accept them and live and work with them.

GoTaikonauts!: Were there any surprises in the cooperation with your Chinese counterparts?

Detlef Koschny: No, not at all. Both sides performed their work very professionally, and - given the cultural differences - within the expectations.

GoTaikonauts!: Have you been to China in the context of the Chang'e project or on any other occasion? What was your impression?

Detlef Koschny: I have not yet been in China. I was planning to go to the General Assembly of the International Astronomical Union in Beijing this year, but then in the end could not for



First picture of the Moon captured by Chang'e-1. (Credit: Xinhua)

Artistic impression of the Chang'e 1 lunar orbiter. (Credit: CLEP)

Chinese Premier Wen Jiabao (right) unveils the Moon image captured by China's lunar orbiter Chang'e-1 during an unveiling ceremony at the Beijing Aerospace Control Center in Beijing, capital of China, 26 November 2007. China published the first picture of the Moon captured by Chang'e-1, marking the success of the country's first lunar probe project. (Credit: Xinhua).

personal reasons. I regret that a bit, I missed a chance to see a country which I haven't experienced yet.

GoTaikonauts!: Are there any follow-up projects with China in the area of scientific exploration?

Detlef Koschny: There are discussions on-going. I have mentioned the Kuafu mission, where both ESA's Space Situational Awareness programme and our Science Programme would be a potential contributor. Right now we are just a few weeks before our next ESA Council Meeting on Ministerial level, where we will see how much money we will really have available for which programme for the next years. Therefore, at this moment in time, all statements I could make on a collaboration would be premature.

GoTaikonauts!: Within your life time, do you think you will see humans back on the surface of the Moon?

Detlef Koschny: It is not yet known if this will be part of the plans of China in the future. I am working on the robotic exploration of the solar system, but I think it would be a great achievement of humankind to see a strong international human exploration undertaking. However, to make this happening within my lifetime, there are only about 25 years left. At least in Europe, we'd need some drastic changes in political interest to make this happen.

COMMENTARY

Some lunar confusion

Until recently, things were more or less clear: the Chinese Lunar Exploration Programme (CLEP) synonym for the Chang'e programme of robotic lunar exploration was divided into three phases:

Phase I would comprise an orbital mission, the Chang'e 1 lunar orbiter. After the big success of that mission, the engineering model was named Chang'e 2 and it also made it to the Moon and even further.

Phase II is planned to see a soft landing on Earth's closest cosmic neighbour and the space craft is about to release a rover for the investigation of the surface. That mission, Chang'e 3 is about to be launched next year, very likely in the second half of 2013. The information on Chang'e 4 are for the moment limited, but it is to expect that Chang'e 4, the back-up model of Chang'e 3, will be of good use and will be launched as soon as the Chinese are confident, that Chang'e 3 is a success story.

Phase III is defined as sample return mission. Chang'e 5 and certainly also Chang'e 6 will be designed for the accomplishment of an automated sample return.

For the moment we know that China has successfully concluded Phase I and the country is staying steadily on the course to accomplish Phase II and III.

Already in 2008 Chinese rocket scientist Long Lehao together with Rong Yi, published a paper in the China Academic Journal which analysed manned lunar mission scenarios aiming at landing a Chinese on the Moon "and return to the Earth safely before 2030." Last year in December, with the release of the White Paper on China's Space Activities in 2011, for the first time an official governmental paper stated that "China will conduct studies on the preliminary plan for a human lunar landing." Since that time, speculations about China's ambitions for a manned lunar exploration are continuously present in the media and the space community.

On 19 September this year, China's state media Xinhua quoted the leading Chinese lunar scientist, Ouyang Ziyuan, who was giving hints on a "manned lunar mission in the future". In a report delivered at the 12th General Conference and its 23rd General Meeting of the Academy of Sciences for the Developing World being held in Tianjin, China, the Chief Scientist mainly explained the plans for the Chang'e 3 mission. But Ouyang also said. "The hope is that China completes the three-phase unmanned lunar probe projects of orbiting, landing and returning in 2017, so as to pave the way for a manned lunar mission in the future," said the Chief Scientist.

see:
http://news.xinhuanet.com/english/china/2012-09/19/c_131860764.htm

Maybe for insiders no surprise, but for the first time a document states that "China's lunar exploration is divided into two stages: unmanned lunar exploration and manned lunar landing exploration." as the interested reader can find in the paper by Ouyang Ziyuan compiled in the abstract book of the 12th General Conference and its 23rd General Meeting of the Academy of Sciences for the Developing World, Tianjin 2012.

see:
http://twas.ictp.it/news-in-home-page/common/files/files-press/abstracts_tianjin2012/view

One day later, on 20 September Xinhua published another news on the speech by Ouyang Ziyuan with the focus on the fact "that China has not yet created a timetable for its manned Moon landing program." According to Xinhua the three phases of China's lunar exploration programme are now defined a little bit different: "Ouyang said China's lunar probe projects currently consist of unmanned moon exploration, a manned moon landing and the building of a moon base. "China is currently in the first stage," Ouyang said, adding that the first stage involves the orbit, landing and return of lunar spacecraft.

see:
http://www.chinadaily.com.cn/china/2012-09/20/content_15769517.htm/p>

One begins to wonder whether Ouyang Ziyuan has taken over a kind of function as the spokesperson for the Chinese lunar exploration programme? Whatever it was what motivated him – he, the leading lunar scientist in China, the perspective of a lunar base sounds only too good. Although this news is highly inspirational, it also contributes to some confusion.

Also looking at the existing space exploration roadmap, which was published 2009 in the book "Space Science & Technology in China: A Roadmap to 2050" does not really contribute to more enlightenment. That roadmap does indicate a manned lunar landing for 2030 and a manned Mars landing for 2050 but the text also states that the roadmap, compiled in 2008, intends to give guidelines for long-term strategic thinking with respect to long-term and unconventional science and technology predictions. Prof. Dr.-Ing. Yongxiang Lu, President of the Chinese Academy of Sciences says in the introduction to the book: "The point is to emancipate the mind and respect objective laws rather than indulging in wild fantasies."

However, maybe all this is only confusing for outside observers, but not surprising at all to insiders and Chinese experts which explain that an official decision for a manned lunar mission could be expected around 2017 at the earliest. After all, the logo of the CLEP programme has incorporated straight from the beginning the footsteps of a human. Was this a hint to the Chinese intention for manned lunar exploration right from the start?

China's Recoverable Satellites

Satellite	Bus	Launch Vehicle	Launch Date/Time (UT)	Landing Date/Time (UT)	Flight Duration (dd:hh:mm)	Launch / Recovery Mass (kg)	Orbit (Perigee/Apogee /Inclination) (km/degree)	Primary Mission	Note
FSW-0	FSW-0	CZ-2	11/05/1974 09:40			1790		Territory survey	Launch vehicle failure
FSW-1	FSW-0	CZ-2C	11/26/1975 03:29	11/29/1975 03:00	2:23:31	1790 / 600	181 x 495 / 63	Territory survey	Hard landing
FSW-2	FSW-0	CZ-2C	12/07/1976 03:46	12/10/1976	~3	1790 / 600	172 x 492 / 59.5	Territory survey	
FSW-3	FSW-0	CZ-2C	01/26/1978 04:27	01/29/1978	~3	1810 / 650	169 x 488 / 57	Territory survey	
FSW-4	FSW-0	CZ-2C	09/09/1982 07:18	09/14/1982	~5	1780 / 610	177 x 407 / 63	Territory survey	
FSW-5	FSW-0	CZ-2C	08/19/83 06:00	08/24/1983	~5	1840 / 630	175 x 404 / 63.3	Territory survey	
FSW-6	FSW-0	CZ-2C	09/12/1984 05:43	09/17/1984 04:32	4:22:49	1810 / 620	178 x 415 / 68	Territory survey	
FSW-7	FSW-0	CZ-2C	10/21/1985 05:04	10/26/85	~5	1810 / 620	175 x 409 / 63	Territory survey	
FSW-8	FSW-0	CZ-2C	10/06/1986 05:40	10/11/1986 03:20	4:21:40	1770 / 610	176 x 402 / 57	Territory survey	
FSW-9	FSW-0	CZ-2C	08/05/1987 06:37	08/10/1987 06:30	4:23:53	1810 / 650	172 x 410 / 63	Territory survey	French microgravity payload
FSW-10	FSW-1	CZ-2C	09/09/1987 07:15	09/17/1987 05:00	7:21:45	2070 / 610	208 x 323 / 63	Cartography	

Satellite	Bus	Launch Vehicle	Launch Date/Time (UT)	Landing Date/Time (UT)	Flight Duration (dd:hh:mm)	Launch / Recovery Mass (kg)	Orbit (Perigee/Apogee /Inclination) (km/degree)	Primary Mission	Note
FSW-11	FSW-1	CZ-2C	08/05/1988 07:28	08/13/1988	~8	2130 / 640	208 x 326 / 62.8	Cartography	German microgravity payload
FSW-12	FSW-1	CZ-2C	10/05/1990 06:14	10/13/1990 05:00	7:22:46	2080 / 650	206 x 308 / 57.1	Cartography	
FSW-13	FSW-2	CZ-2D	08/09/1992 08:00	08/25/1992	~16	2060 / 600	211 x 315 / 63	Cartography	
FSW-14	FSW-1	CZ-2C	10/06/1992 06:20	10/13/1992 04:20	6:22:00	2590 / 640	175 x 353 / 63.1	Territory survey	Dual-sat launch (Freja)
FSW-15	FSW-1	CZ-2C	10/08/1993 08:00	03/12/1996 16:09	886:08:09	2100 / (650)	214 x 317 / 56.9	Cartography	Retrofire failure. Natural decay in North Atlantic Ocean
FSW-16	FSW-2	CZ-2D	07/03/1994 08:00	07/18/1994 03:35	14:19:35	2760 / 770	178 x 333 / 62.9	Territory survey	
FSW-17	FSW-2	CZ-2D	10/20/1996 07:20	11/04/1996 02:59	14:19:39	2970 / 770	176 x 354 / 63	Territory survey	Japanese microgravity payload
FSW-18	FSW-3	CZ-2D/2	11/03/2003 07:20	11/21/2003 02:04	17:18:44	~3600	193 x 324 / 63	Territory survey	
FSW-19	FSW-3	CZ-2C/3	08/29/2004 07:50	09/24/2004 23:55	26:16:05	~3600	167 x 552 / 63	Cartography	
FSW-20	FSW-3	CZ-2D/2	09/27/2004 08:00	10/15/2004 02:43	17:18:43	~3600	205 x 319 / 63	Territory survey	Landed in downtown Daying
FSW-21	FSW-3	CZ-2C/3	08/02/2005 07:30	08/28/2005 23:38	26:16:08	~3600	166 x 552 / 63	Cartography	
FSW-22	FSW-3	CZ-2D/2	08/29/2005 08:45	09/16/2005 03:28	17:18:43	~3600	204 x 323 / 63	Territory survey	
FSW-23 (SJ-8)	FSW-3	CZ-2D/2	09/09/2006 07:00	09/24/2006 02:43	15:19:43	3400	177 x 445 / 63	Microgravity	The “Seeds Satellite”

China's Communication Satellite

Satellite	Bus	Launch Vehicle	Launch Date	Launch Mass (kg)	Payload (trans-ponders)	Orbital Position	Note
DFH-2-0	DFH-2	CZ-3	01/29/1984	910	4 C-band		Failed to reach GTO due to second stage problem
DFH-2-1	DFH-2	CZ-3	04/08/1984	910	4 C-band	125°E	
DFH-2-2	DFH-2	CZ-3	02/01/1986	917	4 C-band	103°E	
Chinasat 1	DFH-2A	CZ-3	03/07/1988	1024	4 C-band	87.5°E	
Chinasat 2	DFH-2A	CZ-3	12/22/1988	1024	4 C-band	98°E	
Chinasat 3	DFH-2A	CZ-3	02/04/1990	1024	4 C-band	115°E	
Asiasat 1	HS-376	CZ-3	04/07/1990	1247	24 C-band	105.5°E	Formerly Westar 6, retrieved by Shuttle from space.
Chinasat 4	DFH-2A	CZ-3	11/28/1991	1024	4 C-band		Failed to reach GTO due to second stage problem
Apstar 1	HS-376	CZ-3	07/21/1994	1385	24 C-band	138°E	
DFH-3	DFH-3	CZ-3A	11/30/1994	2232	24 C-band		Failed to reach GTO due to satellite failure
Apstar 2	HS-601	CZ-2E	01/25/1995	2830	26 C-band 6 Ku-band		Launch failure
Asiasat 2	AS-7000	CZ-2E	11/28/1995	3379	24 C-band 9 Ku-band	100.5°E	
Apstar 1A (Chinasat 5D)	HS-376	CZ-3	07/03/1996	1400	24 C-band	134°E	
Chinasat 7	HS-376	CZ-3	08/18/1996	1384	24 C-band		Failed to reach GTO due to second stage problem

Satellite	Bus	Launch Vehicle	Launch Date	Launch Mass (kg)	Payload (trans-ponders)	Orbital Position	Note
Chinasat 6	DFH-3	CZ-3A	05/11/1997	2200	24 C-band	125°E	
Apstar 2R	FS-1300	CZ-3B	10/16/1997	3700	28 C-band 16 Ku-band	76.5°E	
Asiasat 3	HS-601HP	Proton	12/28/1997	3400	28 C-band 16 Ku-band		Launch failure. Transferred to Hughes and saved by a lunar flyby
Chinastar 1 (Chinasat 5A)	A-2100	CZ-3B	05/30/1998	2917	24 C-band 24 Ku-band	87.5°E	
Sinosat 1 (Chinasat 5B)	SB-3000A	CZ-3B	07/18/1998	2820	24 C-band 14 Ku-band	110.5°E	
Asiasat 3S	HS-601HP	Proton	03/21/1999	3465	28 C-band 16 Ku-band	105.5°E	
Chinasat 22	DFH-3	CZ-3A	01/25/2000	2300		97.8°E	Aka. FH-1, military tactical comsat
Asiasat 4	HS-601HP	Atlas 3B	04/11/2003	4137	28 C-band 20 Ku-band	122.2°E	
Chinasat 20	DFH-3	CZ-3A	11/14/2003	2300		103.3°E	Aka. ST-1, military strategic comsat
Apstar 5	FS-1300	Zenit 3SL	06/29/2004	4640	38 C-band 16 Ku-band	138°E	
Apstar 6	SB-4000C2	CZ-3B	04/12/2005	4680	38 C-band 12 Ku-band	134°E	
Chinasat 22A	DFH-3	CZ-3A	09/12/2006	2300		98.2°E	Aka. FH-1A, military tactical comsat
Sinosat 2	DFH-4	CZ-3B	10/28/2006	5100			
Sinosat 3 (Chinasat 5C)	DFH-3	CZ-3A	06/01/2007	2200	10 C-band	3°E	

Satellite	Bus	Launch Vehicle	Launch Date	Launch Mass (kg)	Payload (trans-ponders)	Orbital Position	Note
Chinasat 6B	SB-4000C2	CZ-3B	05/07/2007	4600	38 C-band	115.5°E	
Asiasat 5	FS-1300	Proton	08/12/2009	3760	26 C-band 14 Ku-band	100.5°E	
Chinasat 9	SB-4000C2	CZ-3B	09/06/2008	4500	22 Ku-band	92.2°E	
Chinasat 6A (Sinosat 6)	DFH-4	CZ-3B	09/05/2010		24 C-band 8 Ku-band 1 S-band	125°E	
Chinasat 20A	DFH-3	CZ-3A	11/24/2010			130.1°E	Aka. ST-1A, military strategic comsat
Chinasat 10 (Sinosat 5)	DFH-4	CZ-3B/E	06/20/2011	5220	30 C-band 16 Ku-band	110.5°E	
Chinasat 1A	DFH-4	CZ-3B/E	09/18/2011	5320		129.9°E	Aka. FH-2, military tactical comsat
Asiasat 7	FS-1300	Proton	11/26/2011	3813	28 C-band 17 Ku-band 1 Ka-band	100.2°E	
Apstar 7	SB-4000C2	CZ-3B/E	03/31/2012	5054	28 C-band 28 Ku-band	76.5°E	
Chinasat 2A	DFH-4	CZ-3B/E	05/26/2012	5320		98.3°E	Aka. ST-2, military strategic comsat

Note:

1. Comsats transferred from operators of other countries are not included. All listed here are Chinese owned comsats when launched.
2. Military comsats are owned by the military but operated by Chinasat.
3. Sinosat and Chinastar have been merged into Chinasat. Chinasat is also a major shareholder of Apstar. Asiasat is a partially Chinese-owned company.

Gallery

Chinese Recoverable Satellite

Debris of China's first recoverable satellite launched and recovered in 1975. Film canister, retro motor and the parachute can be seen.
(credit: Chinese Internet)

A FSW-0 or FSW-1 capsule landed in farmland.
(credit: Chinese Internet)

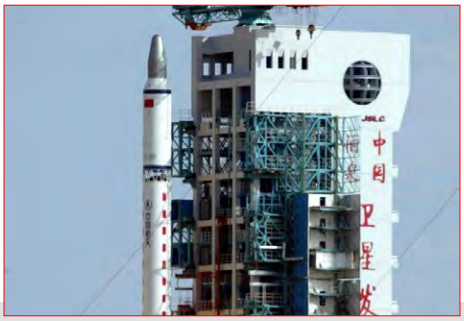
A FSW-0 or FSW-1 capsule in display in the China Military Museum in Beijing,
(credit: Chinese Internet)

A FSW-0 or FSW-1 in assembly before launch.
(credit: CMSEO)

A FSW-2 capsule in assembly.
(credit: china-defense-mashup.com)

A FSW-3 in final testing before launch.
(credit: Chinese Internet)

FSW-17 was launched by a CZ-2D on 20 October 1996, from Jiuquan. It was the last time using the Jiuquan North Launch Centre and the original Long March 2D version.
(credit: Chinese Internet)



FSW-18 was launched by a stretched CZ-2D on 3 November 2003 from Jiuquan. It was the first time using the new launch pad (Pad 603) at Jiuquan South Launch Centre and the CZ-2D/2.
(credit: Chinese Internet)

Shijian 8 (SJ-8, or FSW-23) capsule landed in farmland on 24 September 2006.
(credit: Chinese Internet)

Shijian 8 landing site. There were many nearby farmers at a close distance from the capsule when it was recovered.

A Mil-171 helicopter was to lift the Shijian 8 capsule. The landing site looked to be near a small village.
(credit: Chinese Internet)

A model of the future recoverable satellite in display at the Zhuhai Air Show 2010. The new design has a large re-entry capsule and solar cells at the exterior of the instrument module.
(credit: Chinese Internet)