



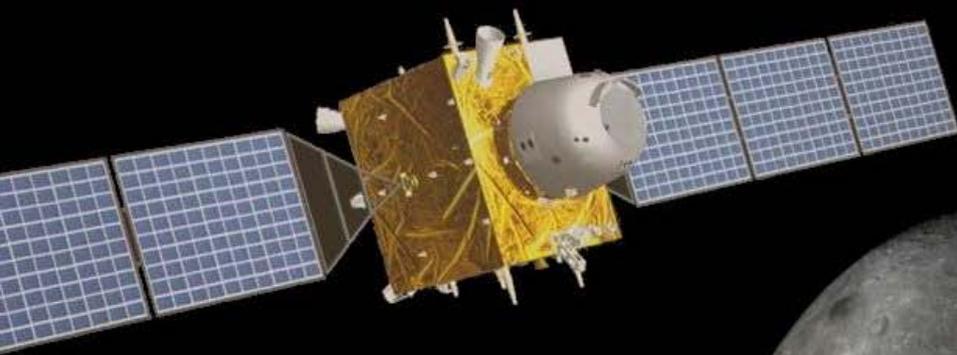
All About The Chinese Space Programme

# GO TAIKONAUTS!

龙腾太空

Issue 14

January 2015



## A Joint Adventure of 4M and 5T1



## Editor's Note

Happy greetings for the New Year 2015 to all our readers! May 2015 be a very successful year for international space efforts including indispensable contributions from China! We would like to start the New Year with an apology ...

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### July - September 2014



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In the subsequent 20 months, some, but not many details of the mission were revealed. The main spacecraft ...

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## On the Spot

### Our World Needs Space: Report from the IAC2014 in Toronto

Toronto – the Canadian metropolis on the North-West shores of Lake Ontario was the host of the 2014 assembly of the International Astronautical Congress - IAC. Downtown Toronto at night looks as futuristic as the Metropolis in the movie of the same name. However, arrival in the city did not make a good first impression - the main road from the airport to the city centre was closed, which meant a zig-zag journey through several side-streets, then downtown Toronto turned out to be a "building-site", and there were some issues with the hotel. At this point, one could be forgiven for feeling that this IAC might not match up to previous experiences. ...

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### Mind the Gap - Missing Space in China, Macao, and Hong Kong

A fortunate accident lead two of our readers on a journey to China, Macao and Hong Kong. Both, dedicated space enthusiasts, used ...

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## Editor's Note

Happy greetings for the New Year 2015 to all our readers! May 2015 be a very successful year for international space efforts including indispensable contributions from China!

We would like to start the New Year with an apology for the long delay in publishing this issue. A high workload on our side prevented us from publishing earlier. But finally we made it and are present with another newsletter full of versatile content.

The cover story reflects on the Chang'e 5-T1 lunar mission - the worldwide-noticed test flight for a lunar sample return mission.

Tightly bound to Chang'e 5-T1 - in the literal meaning of the word - was the 4M project of LuxSpace/OHB. We were glad to get some first-hand accounts from the leading managers of both companies, explaining the 4M mission in the context of being the first private lunar project and their general cooperation with China.

A lengthy report in this issue is dedicated to the IAC 2014 in Toronto, Canada. Although many Chinese could not attend this annual get-together of the space world, for reasons we are explaining in our article, we could still find many Chinese highlights in Toronto.

The IAC is always accompanied by an extensive space exhibition. China was visibly present there. Also in the space exhibition we met Chris Bee, Head of Business Development for the Science Technology Facilities Council - STFC Rutherford Appleton Laboratory in Harwell, Oxford. Following our previous attempts to showcase business opportunities in the space sector with China, we asked him how this is done at STFC. Additionally, we found another gem in Toronto. We felt very honoured to interview Prof. Dr. Weng Jingnong, Vice Dean of the International School of Beihang University, Executive Director of the UN-regional Centre at Beihang University and Director of APSCO Education and Training Centre in China.

Another very interesting and revealing feature is the article "Mind the gap" – an account of two of our readers, Robert Hast from the U.S. and Morris Jones from Australia, on their search for space exhibits in Hong Kong, Macau and Beijing. We would like to thank both for their valuable and unique contribution to our newsletter.

Last but not least important is our interview with European astronaut Paolo Nespoli. He attended the XXVII Planetary Congress of the Association of Space Explorers in September 2014 in Beijing. Paolo Nespoli gives us an exclusive insight in his impressions from the event in China. But he also shares with us his unique experience of working together with Liu Yang, China's first female taikonaut, on the preparation and sharing of one of the Congress' technical sessions. We wish you a good read!

(Jacqueline Myrrhe)

## Imprint

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## Chinese Space Quarterly Report

### July - September 2014

by Chen Lan

#### Highlights

- China launches the first sub-metre resolution civil imaging satellite, GF-2.
- SCES launched, aiming for a Chinese version of Iridium.
- Assembly of the first CZ-7 launcher started.
- Tianzhou cargo ship entered the phase of flight model development.
- Chinese scientists expect Tiangong 1 and 2 to work together in space.
- Completion of Chinese Space Station (CSS) delayed to 2022.
- China will select the third group of taikonauts in 2 years.
- Yutu woke up every lunar day, cause of malfunction initially identified.
- 27th Planetary Congress of the Association of Space Explorers held in Beijing.
- China and India agree for the first time on space cooperation.

#### Launch Event

China made five space launches in the third quarter of 2014. From 9 August to 8 September, SAST made four successful launches within 30 days using its CZ-2C, 2D, 4B and 4C launchers, setting a new record of launch rate in its history. The five launches are:

- On 9 August, at 13:45, the YG-20 reconnaissance satellite was launched on top of a CZ-4C rocket from Jiuquan Satellite Launch Centre.
- On 19 August, at 11:15, a CZ-4B launch vehicle lifted-off from Taiyuan, putting the GF-2 imaging satellite and the Polish BRITE-PL "Heweliusz" smallsat into orbit. GF-2 is the first sub-metre resolution civil imaging satellite (see *Satellites* section for details).
- On 4 September, at 8:15, a CZ-2D launcher lofted two small satellites, the CX-104 and the SCES (Smart Communication Experimental Satellite), into space. The SCES is the first experimental satellite of a 30-satellite LEO communication satellite constellation (see *Satellites* section for details).
- Four days later, on 8 September, at 11:22, another YG series reconstat, YG-21, and the piggyback TT-2 smallsat were launched and put into orbit by a CZ-4B vehicle.
- On 28 September, at 13:13, China launched a new bird in the SJ-11 series satellite. The SJ-11 07 was launched by a CZ-2C from Jiuquan Satellite Launch Centre.

On the other side of the Earth, the rising star of new commercial space, the SpaceX Falcon 9, made two successful launches in about one month, putting two Chinese owned comsats, AsiaSat 8 and AsiaSat 6 into GTO. The launches happened at 16:00 on 6 August and 13:00 on 7 September (all in GMT) respectively. The two 4.4-tonne comsats were built by SS/L and based on the LS-1300LL bus. AsiaSat booked its two SpaceX Falcon 9 v1.1 launches in February 2012 for a price of \$52.2 million per satellite.

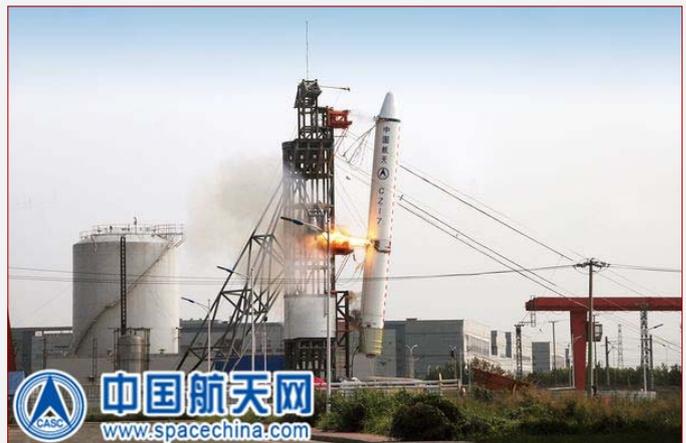
#### Space Transportation

China is developing three new Long March launchers named CZ-5, 6, and 7. In this quarter, all three launchers had development updates that may be summarised as follows:

- On 16 July, the YF-75D expander cycle cryogenic engine, to be used on the second stage of CZ-5, completed a high-

altitude simulated performance calibration test.

- On 18 August, the YF-115 LOX/kerosene engine, to be used at the second stage of CZ-6, made a 1,200-second long duration hot test firing successfully. The engine used in this test has accumulated 3,600 seconds of test fire time since it was installed at the test bed, which paves the way for its final qualification.
- Earlier, at the end of July or beginning of August, the newly developed 1,000 N kerosene/hydrogen peroxide engine, to be used on the third-stage of CZ-6, made its final high-altitude simulated test firing before its maiden flight. The engine restarted in the test.
- On 29 August, the first hot fire test of the CZ-7 second stage propulsion system had a success. It was the last major module of the CZ-7 that made its propulsion test after the booster and the first stage.
- Also in August, the CZ-7 programme made an important test - the booster separation test. The test was conducted in Tianjin and was a success. The booster has a length of about 27 m and is the longest of the Chinese launchers.
- Another ground test of CZ-7, the explosion test of the booster oxygen tank, was also made successfully in early August.



The booster separation test of CZ-7. (credit: spacechina.com)

- As reported in early September, the first CZ-7 launcher has started assembly in CALT. It will be transported to the Hainan launch site for rehearsal.

Although the super-heavy launcher project is still in uncertainty, the pre-development of its engine seemingly went smoothly. On 17 September, the 6th Academy (AAPT) conducted an extreme condition test with the nozzle of the YF-220 cryogenic engine and achieved all objectives.

AAPT also made progress in the development of a new type of rocket propellant. On 20 August, an ignition test using ammonia acetylene as propellant was made successfully. It was the first time for China.

## Satellites

Two satellites launched this quarter received wide coverage on Chinese media. One is the GF-2 civil imaging satellite and the other is the SCES (Smart Communication Experimental Satellite) smallsat. On 20 August at 13:00, just one day after its launch, the two cameras on the GF-2 satellite were turned on. At 15:00, the ground station in Kashi received the first image. On the morning of 21 August, the first panchromatic and multi-spectral fused image was completed. On 29 August, China officially released the first batch of sub-metre images captured by GF-2. The GF-2 satellite is equipped with two identical cameras with one-metre panchromatic resolution and four-metre multi-spectral resolution respectively. In comparison, the SCES is much smaller (135 kg) but received more attention. It was jointly developed by Tsinghua University (satellite bus) and Beijing Xinwei Telecom Technologies (payload). The satellite is to validate a global LEO communication system similar to Iridium and GlobalStar, based on the McWiLL technology. In in-orbit tests after launch, it achieved a bandwidth capacity of 600 kbps using hand-held terminals. It is planned to launch a 64-satellite constellation by 2020 to cover 100 % of the Earth's surface.

On 11 July, the Huajing 1C (HJ-1C) radar satellite was officially delivered to the users, the Ministry of Civil Affairs and the Ministry of Environmental Protection. The satellite was launched on 19 November 2012. It was unusual to spend two



The GF-2 (Gaofeng 2) civil hi-res imaging satellite shown in the Zhuhai Airshow. (credit: Chinese internet)

years to conduct in-orbit testing. Official media disclosed that a high-power microwave switch on the antenna of the SAR satellite malfunctioned in April 2013 and affected image quality. The satellite had to lower its orbit to improve image quality. Meanwhile, the HJ-1A and HJ-1B optical satellites worked normally six years after their launch, three years longer than their expected working life.

Among satellites under development, the following progress was reported:

- The lightning imager is a key payload of the FY-4 new generation geostationary weather satellite. Up to early September, development of the dynamic load test model, the electric model and the qualification model of its camera - have all been completed. The FY-4 ground system construction also went smoothly. The satellite is expected to be launched in 2016.
- The payload sub-system of the Shijian 10 (SJ-10) recoverable microgravity satellite has completed electric system testing. At the end of September, CAS reviewed the Space Science Pioneer Programme and approved the flight model development of the Dark Matter Exploration Satellite. The SJ-10 and the Quantum Satellite would also start flight model development by the end of 2014.

## Manned Space Flight

On 27 August, CAST hosted a review meeting on the Tianzhou space station cargo transportation vehicle, and approved the plan to start the flight model development. Tianzhou development began in July 2012. In just over two years, the electric model, the structural and thermal control model, and the prototype model were all developed and tested. The technical status of the flight model was determined before the review. It is planned to be launched to the Tiangong 2 space laboratory in 2016 or early 2017.

Wang Zhaoyao, Head of the Chinese Manned Space Agency, said on 26 September that there is the possibility that Tiangong 1 will still work after the launch of Tiangong 2. Chinese scientists are expecting through such an opportunity provided by two working orbital stations to do additional research. Tiangong 1



The SCES (Smart Communication Experimental Satellite) in ground testing. (credit: Tsinghua University)

has worked normally for three years since its launch, exceeding its designed working life by one year. Its hyper-spectral imager has captured a huge amount of data and is still working well. In the same interview, Wang disclosed that there will be docking port(s) reserved for international partners but he admitted that the difficulty caused by inclination differences is to be overcome.

On 13 September, Wang Weifeng, Deputy Chief Engineer of ACC (Astronaut Centre of China), said during the Planetary Congress of ASE (Association of Space Explorers, see the *International Cooperation* section for details) that China will complete the selection of the third group of taikonauts in two years. Engineers will be included as candidates for the first time, but no women taikonauts are planned in this group. Two days earlier, Yang Liwei who also attended the ASE, told reporters in an interview that the Chinese Space Station (CSS) will be completed by 2022, two years later than previously announced.

### Lunar and Deep-Space Exploration

Yutu, the first Chinese lunar rover, still woke up every lunar day, although it was unable to move and perform most of the planned scientific work. On 6 September (or the 10th lunar day after Yutu landed), it woke up again. All its scientific payloads continue to work normally, 7 months longer than their designed working life. The lander was reportedly also in good status.

On 24 September, Sun Huixian, Deputy Chief Engineer of the Chinese Lunar Exploration Programme, said in an interview that they have initially identified that high temperature at the lunar surface might have damaged the cable at the rover's wheel and the resulting short-circuit is the cause of the malfunction of Yutu.

### Advanced Technology

China Space News reported on 12 September that CALT has completed the design of a space robotic arm and an assembly test of its joint. The arm has six joints and is able to capture objects in space.

### International Cooperation

On 10 September, the 27th Planetary Congress of the Association of Space Explorers (ASE) was opened in Beijing. Chinese Vice Premier Ma Kai attended the opening ceremony. A total of 93 astronauts from 18 countries, including Alexey Leonov, the first person to walk in space, Valentina Tereshkova, the first female astronaut, and Buzz Aldrin, the second person to land on the Moon, attended the six-day event.

China and the U.S. continued their talks on global satellite navigation. During 19-27 August, the second Coordination Meeting on Satellite Network between China and the United States was held in Washington. It was reported that the two sides completed partial coordination work related with Beidou and GPS. China was also pushing cooperation on satellite navigation with other countries. On 20 September, the China Satellite Navigation System Management Office and Geoscience Australia met in Beijing and discussed possible cooperation on Beidou applications in Australia.

China became more and more active in international space

cooperation. In this quarter, there were some government level activities, as listed below:

- On 18 September, witnessed by Chinese President Xi Jinping and Indian Prime Minister Narendra Modi, CNSA and ISRO signed an MOU on the peaceful use of outer space. This is the first time the two countries have come together on space cooperation.
- On 19 July, the third meeting of Sino-European Joint Committee on Space Cooperation was held in ESA headquarters in Paris. The two sides set down the cooperation plan for the 2015-2020 timeframe.
- Two days later, the third coordination meeting for Sino-Italian Space Cooperation was held in Rome. Heads of CNSA and ASI, the Italian Space Agency, attended the meeting, reviewed status of the current projects and exchanged views on future cooperation.

Besides the above activities, there are also many media reports on cooperation on specific space missions:

- During 23-25 September, the second workshop on the Sino-European Joint Space Science Mission was held in Copenhagen, Denmark. Scientists from Europe and China presented various proposals for the mission and discussed their scientific objectives, technical designs and cooperation plans. The formal request for proposal will be released at the end of 2014 or beginning of 2015. The spacecraft of this mission is expected to be launched into space in 2021.
- On 24 September, the APSCO Joint Satellite Constellation Programme was approved in the 8th Council Meeting of APSCO in Lahore, Pakistan. The programme was to provide APSCO member countries capabilities to monitor natural disasters. It evolved from the APSCO Multi-role Small Satellite Programme initiated more than a decade before.
- During 22-23 July, the International Space Science Institute Beijing ISSI-BJ, held the forum on the STEP (Search for Terrestrial Exo-Planets) mission. Experts from UK, France, Germany, Austria, U.S., and China attended the forum and discussed the scientific objectives, overall design and key technologies of the mission, as well as the possibility for international cooperation. ISSI-BJ has successfully held forums on multiple Chinese space science missions including the XTP/GRAVITAS, Space-VLBI, MIT and SPORT and would hold two more forums on the ASO-S and WCOM missions in 2014.
- In early August, CNSA and CNES signed an agreement on the SVOM mission. According to the agreement, the SVOM astronomical satellite will be launched in 2021. It is another delay.
- On 23 September, a representative from the UK Embassy in Beijing visited the National Observatory and was briefed on the progress of the Einstein Probe (EP) mission. The University of Leicester (UK) has been involved in the EP Project. Further inter-government cooperation on the project was also discussed during the visit.

### Commercial Space

On 21 July, China and Venezuela signed an agreement on the

in-orbit delivery of the VRSS-2 remote sensing satellite. China Great Wall will be the prime contractor responsible for the satellite's design, manufacture and launch, ground facilities and data processing system, as well as related training and service. China launched Venezuela's first remote sensing satellite, VRSS-1, on 29 September 2012.

## Miscellaneous

### Ground Facility

Although Hainan Island was hit by the strongest-ever typhoon in its history on 19 July, construction of the Wenchang Space Launch Centre was not influenced. In mid-September, the CZ-5 and CZ-7 launch platforms assembly was completed. The work took about 9 months.

In late July, the CZ-5 rocket transportation vehicle completed a test with the rocket stage container and the trailer. The vehicle and the container are specifically developed to transport the 5 m-diameter CZ-5 stages by highway. The container has a size of 36.2 m x 6.4 m x 6.6 m and was claimed as the world's largest transportation container.

Also in late July, a new 25 m diameter antenna of the Xinjiang Observatory was installed as planned. As part of China's deep-space tracking network, the Xinjiang telescope has been reconstructed since early 2014. Also, the location of the planned QTT (Qitai Radio Telescope) was selected at 43°36'4".03 N and 89°40'56".99 E (the site is at an altitude of 1,760 m, and 46 km away from Qitai County Town). The 110 m diameter QTT will be the world's largest movable antenna telescope.



The largest-ever rocket stage container designed for CZ-5. (credit: spacechina.com)

## A Joint Lunar Adventure of 4M and 5T1

by Jacqueline Myrrhe, Chen Lan



200 km x 41,300 km lunar fly-by and free return orbit.

Around 11:30, 27 October, Chang'e 5-T1 flew to a position 60,000 km from the Moon and entered the so-called gravitational sphere of influence of the Moon. It then started the 32-hour lunar fly-by. On 28 October, Chinese official media announced that Chang'e 5-T1 had completed the fly-by smoothly, and had left the lunar gravitational sphere of influence and entered the return trajectory on the same day.

Chinese media neither made a live broadcast of the launch, nor had extensive reports on the internet or in paper media. But on 28 October, China released three images taken by Chang'e 5-T1 of the rear of the Moon, at a distance about 12,000 km. These images included a stunning picture showing the Moon in the foreground and the Earth in the background. It was reported that CAST had planned this photographing opportunity since 2012 and had studied all previous joint Earth-Moon images taken by other countries in order to make it with the best visual result.

Just after the launch, the third rocket stage performed a manoeuvre that raised its perigee to more than 80,000 km and inclination to 50 degrees, so as to avoid a possible uncontrolled re-entry. As a result, it was behind the Chang'e 5-T1 for thousands of kilometres and also made a lunar fly-by on 28 October.

### 4M + 5T1 = (Surprise)<sup>2</sup>

When LuxSpace, a Luxembourg-based micro-satellite manufacturer, issued its press release on 18 September 2014, only a few realised the big sensation: not only that LuxSpace wanted to fly the first commercial Moon project, but also the obvious question which sprang into mind was: If they want to launch towards the Moon, who is giving them a hitch-hiking opportunity? There was only one imminent Moon mission on the global exploration timetable: the expected Chinese Chang'e 4 mission. But Luxembourg and China - in a joint lunar mission, could that be for real? Also, nothing was known about the launch date for the Chinese mission but a report on the LuxSpace press release mentioned 23 October. Finally, Chang'e launched - on the 23 October (UTC). But it was not Chang'e 4. On the Long March 3C/G2 rocket was the first Chinese lunar round-trip mission bound for the first Chinese high-speed re-entry into the Earth's atmosphere, and surprisingly named Chang'e 5-T1. China and Luxembourg together wrote space history, both realised technology testing and demonstration with their respective missions, and both, consciously or not, gave a surprise gift in deep-space exploration to the world.

The 4M - Manfred Memorial Moon Mission - is a lunar mission project dedicated to the founder of OHB Bremen, Prof. Dott.-Ing. h.c. Manfred Fuchs. Manfred Fuchs was an enthusiastic promoter of lunar exploration plans. Already in 2006, he led the design of a German lunar surface mission, named "Mona Lisa". The German Aerospace Centre DLR, which ordered the mission

### The Pathfinder Mission

It was a little unexpected when China announced in March 2013, that an experimental lunar fly-by and re-entry vehicle would be launched before the Chang'e 5 lunar sample return mission, to verify the high-speed skip re-entry technology that China has never mastered. The experimental spacecraft was tentatively called the Chang'e 5 Pathfinder in official reports.

In the subsequent 20 months, some, but not many details of the mission were revealed. The main spacecraft (referred to as the "service module") is based on Chang'e 2, or the proven DFH-3 bus. A mini version of the well-tested Shenzhou space capsule from the manned space programme was mounted on the satellite bus. The advantage was, that the re-entry parameters of the Shenzhou capsule are well known. This helped to obtain useful data and to validate the heat shield design under these special conditions and trajectory design for a future Moon landing by Chang'e-5. The spacecraft carried 1,065 kg of propellant and the 330 kg capsule. The launch vehicle was the CZ-3C/G2 (G means "enhanced") that has a 1.5 m stretched core and two 0.8 m stretched boosters, increasing the GTO capacity from 3.8 tonnes to 3.9 tonnes. The spacecraft would land in Siziwang Banner where Shenzhou landed. In October 2012 and November 2013, there were reports with photos about the sled test and air-drop test of the Chang'e 5 capsule. As the capsule design would not be changed for Chang'e 5, all these tests can be seen as part of the "Pathfinder" mission.

China announced the launch date on 22 October, two days before the event and kept media reporting low profile. The mission was officially re-named to "Re-entry Flight Test of the Lunar Exploration Programme", for short, as Chang'e 5-T1.

At 2:00, 24 October, Beijing Time, the CZ-3C/G2 lifted-off on time from the Xichang Satellite Launch Centre in China's Sichuan province, just after a thunderstorm. 1,170 seconds later, the spacecraft and the third-stage of the rocket entered a

study never made use of this idea.

When Fuchs, aged 75, unexpectedly died on 26 April 2014, the international space community lost one of its most valuable members. In memory of Manfred Fuchs, an innovative, low-budget lunar project was perceived. The technical mission management and the manufacturing of the probe was under the responsibility of LuxSpace of Luxembourg, a subsidiary of OHB AG Bremen.

## Xiao Fei Coming Home

According to the flight plan, Chang'e 5-T1 needed six mid-course orbital corrections. Thanks to the precise control of the first two corrections however, the third (just before the lunar fly-by) and the fourth (just after the fly-by) corrections were canceled. The sixth and final correction was done on 30 October. It was critical to determine the landing precision or even the success of the landing.

The scaled-down Shenzhou capsule on Chang'e 5-T1 was nicknamed "Xiǎo Fēi" (Little Flyer) by the Chinese internet community. However, Chang'e 5-T1 mission did not reach the popularity of the previous mission which included the Yutu rover. Chinese TV broadcaster CCTV did not cover the landing, as it did for its launch. Xinhua News Agency and CCTV made some news flashes, but details of the landing were given hours and even days later.

At 5:53, 1 November Beijing Time, at around 5,000 km above the ground and at a speed of 10.8 km/s, the Xiao Fei capsule separated from the main spacecraft (service module). Three minutes later, the service module made an attitude adjustment. And eight minutes later, fired its engine to raise itself into a higher orbit to avoid possible collision with the capsule.

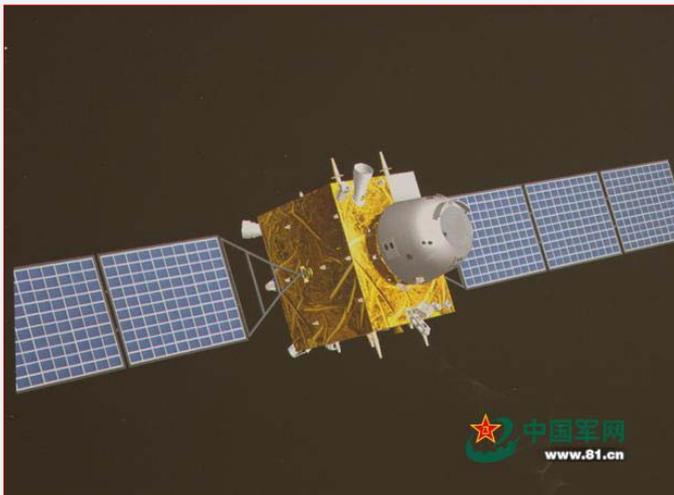
At 6:11, the capsule established the correct attitude for re-entry, which caused relief to the people in the control room. Two

minutes later, the capsule entered the 3-minute long blackout which is the most critical moment for the mission. The main objective of the mission was to test the so-called skip re-entry technology which predicts that the capsule will "bounce back" into space at the upper edge of atmosphere, so as to lower the final re-entry velocity. If it does not bounce back into space in this period, the capsule would plunge into the Indian Ocean at high speed, may exceed the limit of its heat shield, and the whole mission would be considered a failure. Fortunately, at 6:17, it was reported that lift control was completed as expected and the capsule had started the phase of free flight. Then the applause burst out in the control room.

At 6:23, the capsule performed lift control again and entered blackout again. Then everything looked as a repeat of a normal Shenzhou landing. At 6:26, it established communication with the ground. At 6:31, at 10 km above the ground, the cover of the parachute bay was jettisoned, followed by deployment of the drag parachute and the main chute. At 6:42, Xiao Fei landed safely in Siziwang Banner, situated in the central region of North-China's Inner Mongolia Autonomous Region, about 500 km from Beijing. The rescue team found the capsule 15 minutes later.

From the landing images released later, the Xiao Fei capsule looked more scorched than her big brother, the Shenzhou capsule. But there was no obvious trace of burning on the other side of the capsule, showing that the attitude control worked very well upon re-entry. Another interesting finding was at the half edge of the heat shield where it seemed made from a lighter colour material, different from the honeycomb structure seen on most of its heat shield and on Shenzhou. It is probably a new ablative material being tested for future missions.

The capsule was transported to Beijing by a Y-8 transport plane on the same day. On 2 November, the capsule was opened in CAST. Its payloads including seeds, lactic acid bacteria and interestingly, moon cakes, were retrieved.



Artist's impression of the Chang'e 5-T1 spacecraft. It was essentially a DFH-3 satellite (Chang'e 1 and 2) with an additional re-entry capsule. (credit: Chinese internet)



The Chang'e 5-T1 re-entry capsule in sled test. This photo was released in October 2012. (credit: China Space News)



The Chang'e 5-T1 re-entry capsule in an air-drop test. This photo was released in November 2013. (credit: spacechina.com)



The Chang'e 5-T1 re-entry capsule in ground testing. This photo was released in June 2014 and was the first time the Chang'e 5 capsule was shown publicly. (credit: spacechina.com)

The successful landing marked the first mission to the Moon and back since the Soviet Union's Luna 24 mission in 1976. China became the third nation to do so after the former Soviet Union and the United States. The bounce on the upper layers of the atmosphere was one of the biggest challenges. An error of only 0.2 degrees would have made the mission fail. China's space engineers and scientists collected a wealth of technical and scientific data which will lay the foundation for future missions. Chang'e 5-T1 also served as a test for ground stations and recovery operations but also supported the development of new materials and innovative space equipment design.

### Tiny But Hard to Miss

4M is a lunar fly-by of a small spacecraft, weighing merely 14 kg and having the size of a computer screen or briefcase, if you want – just 50 x 30 x 10 cm. It was attached to the last stage of the Long March 3C rocket which lifted-off with Chang'e 5-T1's night launch. 20 minutes after launch, the main payload, the Chinese Chang'e 5-T1 satellite, separated from the upper-stage. Both followed a trajectory around the far side of the Moon. The 4M probe, remaining attached to the upper stage, was switched on. 4M was equipped with a radio amateur beacon, call sign WSJT JT65B, which re-transmitted on 145.980 MHz in a continuous loop 2,500 pre-recorded messages, each 13 characters long. The first radio amateur received the signal 1 hour 20 min after launch in Brazil. During its whole journey, the messages were received by at least 29 radio amateur stations around the globe. Astrophysicist, Nobel Prize laureate, and amateur radio enthusiast Joe Taylor, call sign K1JT, developed a version of his free weak signal communication software WSJT especially for 4M. The software allows the extraction of information even from very weak signals. The International Amateur Radio Union - IARU, supported the experiment.

In parallel, the radio beacon was used for testing a new approach to locate the spacecraft through inverse triangulation. Another instrument on-board, provided a large volume of data on radiation measurements throughout its trajectory around the Moon. Although the experiment stopped working during

the second passage of the Van Allen Belt after 215 hours of operational time, the data are currently being investigated by LuxSpace. Jochen Harms, Managing Director of LuxSpace told the press, that the radiation data will be openly shared.

Lunar fly-by occurred, nominally on 28 October. The Chang'e 5-T1 capsule re-entered Earth's atmosphere on 31 October (UTC). Initially, it was planned that 4M would also make a re-entry and burn up. But a late orbital trajectory change by the Chinese engineers caused the upper stage to remain in a highly-elliptical Earth orbit with an apogee of 386.000 km, and a perigee of 85.000 km. The orbital period is 14 days. The main battery was only designed to provide power for 10 days, although it may last longer. Because the LuxSpace experts "found" a solar panel in storage which was consequently mounted on 4M before launch.

On 4 November 2014, LuxSpace announced the successful end of the mission after 250 hours of mission operations. LuxSpace reported: "After 438 hours of continuous operation, 4M's primary batteries are empty. Depending on illumination, 4M may wake up from time-to-time and restart transmitting. Given the temperature conditions, 4M operated four times longer than the designed lifetime."

### Mission Extended

One more surprise came at 17:00, 2 November when BACC (Beijing Aerospace Control Centre) announced the start of the half-year long Chang'e 5-T1 extended mission. The plan was for the service module to go to the Earth-Moon L2 point and circle the point for 3 times and then return to the Moon, working in a lunar orbit. One scientist said in an interview that the spacecraft's good performance in its primary mission had left enough propellant, around 800 kg, providing a solid base for the extended mission.

After it released the re-entry capsule, the service module did two orbital burns and entered an orbit of 600 x 540,000 km orbit. Again, it sailed to the Moon.

At 16:00, 9 November, the module traversed to its apogee 540,000 km from the Earth and took a photo with the Earth and the Moon in one frame. This time the Earth was in foreground and the Moon, 920,000 km away from the camera, was in background. It was taken with one shot, without any processing. It was also claimed as the world's first Earth-Moon photo taken from such a position. Indeed, it is as stunning as the photo taken 12 days earlier.

On 23 November, it flew-by the Moon and did a lunar gravity assist manoeuvre that was also the first time for China. On 27 November, it finally entered a Lissajous orbit around the Earth-Moon L2 point with a period of 14 days. There were reports indicating that Chang'e 5-T1 service module was to act as a relay satellite for future lunar missions. But from the announced official plan of this mission and future missions, there was no such possibility. The official objective of this mission was to test orbital tracking and control, but it could also be a technical validator for future lunar communication satellites.

The story continued. It was again back to the proximity of the Moon after entering the New Year. On 4 January, the service module left the orbit around the EM-L2 point, and on 11 January at about 3:00 (Beijing Time) made a lunar orbit insertion burn, entering a 200 x 5,300 km lunar orbit. It was followed by two other burns on 12 and 13 January and finally entered a 200 km orbit around the Moon with an orbital period of 127 minutes. According to the official plan, in February and March 2015, it will make a remote guidance test for the Chang'e 5 lunar orbit rendezvous and docking, and from April, it will start to image the lunar surface planned for the Chang'e 5 landing. Obviously, the extended mission was planned early in the mission definition phase. It also reflected the philosophy of the Chinese planners to make full use of a spacecraft for long-term targets. We have already seen the same philosophy in the design connection between the Chang'e 3 and Chang'e 5.

Where will the Chang'e 5 T-1 go after the six month extended mission? Will it be the second Chang'e 2 that will bring us more exciting surprises? Time will tell.

## MMMM – So What?

The idea to transmit messages from space is a little bit like recalling the Sputnik moment from 1957, when the first Soviet satellite would not stop beeping. It might also remind one of the Dong-Fang-Hong satellite transmitting the legendary song "The East is Red." Maybe LuxSpace and Chang'e 5-T1 do carry a little bit of a Sputnik moment of the 21st century. The whole mission set-up not only demonstrated technology, but demonstrated far-reaching consequences. One of those is the enormous capacity of private companies to perceive successful missions, even a deep-space mission at an incredibly fast pace and within a reasonable budget. ESA as well as NASA would have taken years for the whole process from mission definition to launch into space. The costs for 4M are revealed to be approximately 400.000 Euros. The mission showed in the middle of space sanctions against Russia and still existing sanctions against China, that common sense does not tolerate a limited political horizon.

Also, LuxSpace issued a wake-up call that precious science can be done with mini payloads. Jochen Harms called it democratisation of space research. China, on the other hand, made a point by showing how easy international cooperation could be if the will for success exists. And maybe, as it might seem, isn't the LuxSpace approach to go for proven technologies to implement improvements in incremental steps a little bit copied from China?

## Path Found

Chang'e 5-T1 was as successful as 4M. The primary mission objective for Chang'e 5-T1 was the test of re-entry and landing while returning with high-speed from a lunar trajectory. China has never done that before. The test is needed for the accomplishment of the third and final step in the Chinese Lunar Exploration Programme, which after the accomplishment of orbiting and landing, foresees the return of lunar samples to Earth. The actual Chang'e 5 mission in 2017 is supposed to bring up to 2 kg of lunar rock and regolith (soil) back to Earth.



The Chang'e 5-T1 re-entry capsule, integrated with the service module, in final ground testing. (credit: CCTV)



The Chang'e 5-T1 re-entry capsule, packed in a specially designed container, in preparation to be transported to the launch site. (credit: Chinese internet)

It is planned to take samples from a depth of 2 m under the surface. The biggest technological challenges will be sample collection, launch from Moon's surface, and rendezvous in lunar orbit. If successful, China will become the third nation to do so, another historic moment for the Middle Kingdom. Eventually, it will lead to a Chinese manned landing on the Moon.

Chang'e 5-T1 and 4M were real pathfinders that made not only way for China's future lunar probes but also a new way of international cooperation.

Additionally, with Chang'e 5-T1, China took a certain shortcut. Initially, it was expected that the back-up spacecraft for the Chang'e 3 mission, Chang'e 4, would make its journey before the third phase for CLEP would start. Like some other Chinese space missions, Chang'e 5-T1 came with some surprises, which makes following the Chinese space programme real fun. What will be the next? Probably it will be Chang'e 4 which is still sitting in one of China's cleanrooms waiting for a mission designation.



The Chang'e 5-T1 in the hatch opening ceremony after it was transported back to Beijing on the same day of its landing. (credit: Chinese internet)



CAST staff opening the hatch of the capsule to retrieve payloads. (credit: Chinese internet)

## 4 for 5 - 4M lunar mission on Chang'e 5-T1

by Jacqueline Myrrhe  
including interviews with Dr. Fritz Merkle and Jochen Harms

*The 4M - Manfred Memorial Moon Mission - is a lunar mission project dedicated to the founder of OHB Bremen, Prof. Dott.-Ing. h.c. Manfred Fuchs. Manfred Fuchs was an enthusiastic promoter of lunar exploration plans. Already in 2006, he led the design of a German lunar surface mission, named "Mona Lisa".*

*When he unexpectedly died 26 April 2014, the international space community lost one of its most valuable members. In memory of Manfred Fuchs, an innovative, low-budget lunar project was perceived. The technical mission management and the manufacturing of the probe was under the responsibility of LuxSpace of Luxembourg, a subsidiary of OHB Bremen, Germany. GoTaikonauts! had the opportunity to talk with the representatives of the two involved companies: Dr. rer. nat. Fritz Merkle, Member of the Executive Board of OHB AG, Bremen, Germany and Jochen Harms, Managing Director of LuxSpace, Betzdorf, Luxembourg.*

### “The attitude to say, they are just copying is not helpful.”

Interview with Dr. rer. nat. Fritz Merkle, Member of the Executive Board of OHB AG, Bremen, Germany



Dr. Fritz Merkle (credit: GoTaikonauts!)

**GoTaikonauts!:** *Dr. Merkle, how did the idea for the 4M project come up?*

**Dr. Fritz Merkle:** To begin with, I have to say that the 4M project was technically coordinated by our colleagues in the company LuxSpace, in Luxembourg. Jochen Harms is the lead, the head, there.

But indeed, Moon activities originated in Bremen. However, our subsidiary in Luxemburg has good contacts to China Great Wall Industries. Those contacts resulted from an earlier project, the launch of VesselSat 2. VesselSat is a small satellite for AIS, and it was launched by China Great Wall Industries. The relationship with them is still existing and currently characterised by the intention to realise more and other programmes. During the on-going discussions between Jochen Harms and our Chinese partners, it was the Chinese side who offered a piggy-back opportunity on the Chang'e 5-T1 mission. The overarching objective on our side is, to find out whether it would be possible to go alternative ways. We have been looking at spaceflight activities from three different perspectives. The first aspect is the classic area of manned space flight, which we consider as

the prime discipline. Then there are the standard applications like communications, navigation and Earth observation. Finally, we are convinced that a third segment is about to develop. It is not quite clear yet, which direction this segment will take. Obviously, this is the area companies like Google or Facebook are interested in. Included in this are the cubesats for which one can buy kits for a few thousand dollars. And we are asking: What will that trend become in the future? We are both convinced that those activities are not short-lived exotics, appearing here and there, but that this is a development of a certain industrial activity area. How this will look like in detail, is hard to predict today. Another important question must be considered: is this activity area still interesting for big companies? For big enterprises, the volume of turnover is crucial. And if a company is used to 200 Mio-programmes but has to substitute such big projects with, let's say 400 small satellites, the question then comes up, who are the customers? This could mean that the new segment is rather a business for small start-up companies, used to working with lower turnovers.

Even for OHB, and we are a smaller company, this is a limited business. Companies like Airbus, dealing with turnover in the range of billions of Euros would accomplish such programmes in less than 6 months. Even we as OHB often get confronted with the question whether small sats are still attractive for us? They are! On the other hand, you can expect that in 10 years from now we will not only be building cubesats. But within the company group we are developing the ideas for that in Luxembourg. The team in LuxSpace under the lead of Jochen Harms, is in an excellent position for that.

**GoTaikonauts!:** *At OHB, do you also have direct contact with Chinese colleagues?*

**Dr. Fritz Merkle:** Yes, currently, we do have a concrete cooperation programme. It is about the development of an environmental satellite, the CarbonSat. Through this programme we are having an intensive contact with Chinese colleagues. The idea emerged already years ago. But there was an intermediate time when the project was running on a lower level.

However, four weeks ago, a Chinese delegation was visiting us in Bremen. We are making use of the Bremen Economic

Development GmbH (compare GT! Issue no. 13; p. 23/24) and their office in Shanghai. We are grateful for the support by Ms. Chen who is keeping the contact for us with our Chinese partners.

**GoTaikonauts!: What are your direct experiences in contact with Chinese colleagues? You know there are a lot of prejudices. What is your point of view?**

**Dr. Fritz Merkle:** Our experiences are actually good. For quite a while, we even had a Chinese colleague in our company whose expertise convinced us. Of course, it is always a bit difficult to make the first contact. There is the language barrier, which is not so easy to take. Often we have to talk with the help of a translator, which makes it more difficult to have a discussion.

However, I am a strong believer in communication. One has to talk with each other to get known to each other. Of course, we do have to follow certain conditions because we are also working for the German Armed Forces. A Chinese visitor, for example, cannot access all our floors or offices.

Also, our company has to defend against hacker attacks. We do not know for sure, whether those attacks are originating in China, or whether they are routed via China. In the end, such attacks could come from anywhere. But if we could work with China on the CarbonSat, this would be a magnificent project. For that, the work by Ms. Chen in the Shanghai Office is very important. In principle, we already agreed on a cooperation a certain time ago, but then the Chinese ran out of money, and finally also the German counterpart.

In Germany, it is still difficult to get financial support for small studies with respect to cooperation with China. Fortunately, the

situation within the German Aerospace Centre DLR is changing right now. Touching on this point, I must not forget to mention our good contacts with China in the area of Life Sciences. We work together with an institute in Xi'an. Prof. Slenska is the expert on the German side of the project. He is very knowledgeable in the field of regenerative systems, of oxygen generation, and of the use of photosynthesis for energy generation.

**GoTaikonauts!: Are you not afraid of losing your technological solutions to the Chinese who will copy them and use them for their own benefit?**

**Dr. Fritz Merkle:** In a controlled cooperation you have influence on the outcome. If you really want to cooperate for a project, you have to adapt the infrastructure accordingly, to avoid misunderstandings. If, in the future, Chinese engineers would work with us, we would introduce a special access area. In my opinion such measurements are no obstacle for cooperation. Although, we did not get so far yet.

**GoTaikonauts!: Do you think, it is worthwhile to make such a high effort? Please, give us a little outlook to the future with respect to cooperation between OHB and China.**

**Dr. Fritz Merkle:** I am really positive. China will become, in certain areas of astronautics, a really important player. We must learn to deal with that. The attitude to say, they are just copying is not helpful. Otherwise China will leave Germany and Europe behind. Therefore we are supporting such projects like that started with the 4M project.

*Note: AIS - Automatic Identification System, automatic tracking system mounted on ships and vessels*

**OHB website:** <http://www.ohb.de/>

## “We hope to have a further mission to the Moon with the Chinese.”

Interview with Jochen Harms, Managing Director of LuxSpace, Betzdorf, Luxembourg



Jochen Harms (credit: ESA/LuxSpace)

**GoTaikonauts!: Even for insiders, the 4M project has been a big surprise. Who had the idea and what is special about the mission?**

**Jochen Harms:** In the beginning of the year 2014, China Great Wall Industries had offered to us the option to launch with them. We had launched our satellite VesselSat 2 with them before.

When Prof. Manfred Fuchs, who was a big promoter of lunar exploration, died in April, I have been talking with Marco Fuchs, his son and successor at OHB Bremen. Marco Fuchs agreed.

**GoTaikonauts!: What were the technical criteria and constraints when you designed the mission hardware?**

**Jochen Harms:** The main criteria were time and budget as well as reliability. We are extremely success oriented.

**GoTaikonauts!: The 4M is a low-budget, short development-time project. How could this be achieved?**



**Jochen Harms:** We had a small and dedicated team and tried to keep technical challenges under control by using our heritage in terms of technology, subsystems and partners.

One must not forget, that LuxSpace is specialised in these kind of special projects. Already before, we have been able to build and launch VesselSat 1 and 2 within a year. When we started 4M, we could make use of those experiences and partly could make use of existing technologies. The base of our work and the success is our highly focussed team and technologies which are simply good and functioning.

**GoTaikonauts!: China has a certain reputation in the high-tech area which is not always positive. Was the Chinese partner the first choice for you?**

**Jochen Harms:** LuxSpace is working since years on a base of mutual trust with CGWI (China Great Wall Industry). For us, China is the first choice if it comes to reliability and professionalism.

**GoTaikonauts!: What are your experiences in cooperation with Chinese colleagues? What are the advantages, and what are the difficulties?**

**Jochen Harms:** The Chinese space actors are very reliable and things are done in a very professional manner. It took quite some time to get their confidence in our solutions, but I hope we have achieved this now. If there is any difficulty it is mainly related to the language.

**GoTaikonauts!: Which technical and which intercultural challenges did you encounter during the project work? How did you solve problems?**

**Jochen Harms:** The main problem was the schedule. In fact, nobody really believed that we would get a tested spacecraft made in a few months. It is always interesting to see that we come with two engineers, where on their side are several times more.

**GoTaikonauts!: Apart from commemorating Manfred Fuchs, the small payload also had a scientific task. What was it about?**

**Jochen Harms:** We had an offer from Spain to fly a radiation experiment. This experiment was developed through an ESA study. The sensor proved to be good. We have received very interesting results.

**GoTaikonauts!: Can you already comment on the first results from the 4M mission?**

**Jochen Harms:** We have quite a number of results, direct measurements but also what we should do better next time. What we certainly need next time is a dedicated ground station network for measuring the position of the spacecraft.

**GoTaikonauts!: You also issued a competition to radio amateurs to receive the signals. How was the participation?**

**Jochen Harms:** Absolutely amazing! To be honest, we would have not expected such a high level of feedback. We thought,

maybe 10 stations would record the signals. But at the end, we got confirmation from 29 stations. Among them were radio amateurs with big antennas from all over the world and many radio amateurs who received a few messages.

**GoTaikonauts!: Did the satellite re-enter the Earth's atmosphere or where is it now?**

**Jochen Harms:** At the moment [end of November], the satellite is still flying but we do not have contact. The payload is mounted on the upper stage and therefore might not get sunlight. Most likely it will re-enter soon.

**GoTaikonauts!: There are critical voices, doubting that the 4M project can be counted as the first commercial Moon project. Would you agree with those criticisms?**

**Jochen Harms:** There are always critical voices in whatever you do or achieve. We are quite happy with what we have made, my team was enthusiastic, we received a huge interest from the global radio amateur community and a large press coverage. This is what we hoped for.

**GoTaikonauts!: Do you have plans for the future which involve cooperation with China?**

**Jochen Harms:** Yes, we hope to have a further mission to the Moon with the Chinese in 2017. We just need a sponsor for our next ideas.

*This interview was done in cooperation with the German space magazine "Raumfahrt Concret".*

## About LuxSpace

LuxSpace was founded in November 2004 as a daughter company of OHB AG Bremen, Germany. It is located on the SES campus at Betzdorf in Luxembourg. Although belonging to the international network of companies within the OHB group, LuxSpace acts fully independently and provides know-how, expertise as well as products and services to the European and global institutional and industrial market in the fields of space and defence system engineering and application development. The company employs currently roughly 50 experts from 15 countries. LuxSpace achieves a turnover of approx. 10 million Euro annually. The main business areas are micro-satellites, as well as sub-systems for the OHB SmallGEO product line. Additionally, LuxSpace is very active in customer service for maritime applications like AIS (Automated Identification System) and in Earth observation.

More information on the company LuxSpace:  
<http://www.luxspace.lu>

More information on the 4M project:  
<http://moon.luxspace.lu/>

4M blog:  
<http://moon.luxspace.lu/blog/>

## Cooperation is Key to Our Future

XXVII Planetary Congress of the Association of Space Explorers in Beijing, China, 10 - 15 September 2014  
 “Cooperation - Realising Humanity’s Space Dreams Together”

by Jacqueline Myrrhe  
 including interview with ESA astronaut Paolo Nespoli

For the first time in the 27-year-long history of the global professional and educational organisation of space travellers - The Association of Space Explorers - its prestigious annual meeting, the Planetary Congress, took place in China.

From 10 to 15 September 2014, Chinese astronaut Yang Liwei and the China Manned Space Agency hosted one of the biggest gatherings of astronauts, cosmonauts, taikonauts and other international space explorers in China’s capital Beijing. While the main conference venue for the 6-day programme in the Beijing Friendship Hotel included one keynote meeting and three technical sessions, the space fliers also toured around Beijing’s Space City, and were involved in outreach activities with university and primary school students in Beijing, Shenzhen, Xi’an, and Tianjin.

In his opening speech, ASE President Dumitru-Dorin Prunariu stressed the reason behind the intentional choice for China: “The 27th Congress of the Association of Space Explorers is taking place in



Poster of ASE’s 27th Planetary Congress in Beijing, China. (credit: ASE/CMSA)

the country with the most numerous population, with one of the most significant contributions to rocketry and to the evolution of flight, with exceptional economic progress, as well as outstanding scientific and technological achievements, a country which, over the last decades, has become one of the most prominent participants in manned and unmanned space exploration.”

This year’s theme: “Cooperation - Realising Humanity’s Space Dreams Together” expressed the long-standing wish of China’s space community to be closely connected with the world if it comes to activities in space. Prunariu, in his function as President of ASE, underlined in his opening address, the importance of the motto: “By choosing this topic, in a world full of controversies and confrontations, our Association intends to make its contribution to a better human understanding, to the peaceful cooperation needed to fly into the space and to use space for the benefit of all beings on our planet.”

China’s Vice Premier, Ma Kai, who



Group photo of all participants of the 27th Planetary Congress in Beijing, China. (credit: ASE/CMSA)



officially welcomed the noble audience of 93 space explorers from 19 nations on the first day of the Planetary Congress, took the opportunity to convey the viewpoint of the Chinese government: "Exploring and making full use of outer space is a right shared by all countries. China takes it as a basic principle to peacefully utilise space resources to promote human development. China holds that we should enhance international cooperation and exchanges to promote the development of manned space flight, and benefit all human beings on the basis of mutual benefits, peaceful utilisation of space and common development. The Chinese government is pleased to cooperate with the international community to facilitate technological advances, maintain a peaceful and clean outer space and contribute to scientific and civilisation development of mankind."

One visible sign of the desire of international cooperation is the fact that all 10 taikonauts, flown in space to date, are members of ASE. Therefore, it should not have come as a surprise that cooperation was the overarching motto of the conference week in China. During the keynote meeting on the first conference day, taikonaut Nie Haisheng gave an overview on the achievements of China's Astronaut Research and Training Centre with respect to international cooperation. He laid out that China is interested in joint manned space missions and joint space science research as well as the use of space applications: "We can take advantage of China's astronaut selection and training facilities and technologies to select and train astronauts for other countries and provide flight opportunities to jointly promote human space development."

Those offers were widely welcomed by the attending space fliers. Dumitru Prunariu expressed towards Chinese media: "Now China will build its own space station in 2022. We heard with great interest that China is inviting the international community to be part of experiments on board the new space station. We are glad that China [...] showed us so many things here and is so open to international cooperation." According to Chinese media outlets, "Prunariu added that further cooperation on manned space programs requires more support at the state level as well as agreements with China in economic and scientific cooperation."

Russian cosmonaut Sergei Avdeev mentioned: "We are quite willing to cooperate with Chinese. In terms of the space station programme, the two sides can cooperate in biology, space science and technology, life support systems and others." Even JAXA's astronaut Koichi Wakata, who became the first Japanese commander of the International Space Station beginning 2014, became enthusiastic about the prospect of flying to space again: "I'm looking forward to flying to China's space station. Now I have to learn Chinese, although it is difficult."

The 1st Technical Session was held in Tsinghua University on the second conference day, 11 September. The session under the topic "International Space Programs Review" was chaired by Russian astronaut Oleg Novitskiy and Japanese astronaut Soichi Noguchi. The space fliers exchanged opinions on the topic of space education and international cooperation and met with students from Tsinghua University.

The 2nd Technical Session, entitled "Future International Cooperative Space Programs" was chaired by U.S.-American astronaut Bonnie Dunbar and Russian cosmonaut Alexander Alexandrov and took place in Beijing's Space City on 13 September. The space fliers discussed topics like the prospect of human space development, communication and cooperation, space medicine and security.

On 14 September, the 3rd Technical Session taking place in Beijing, was chaired by China's first female taikonaut, Liu Yang, and Italian ESA astronaut Paolo Nespoli. Under the theme "Cooperation in Human Spaceflight", the space fliers had an open discussion on the prospect of international cooperation and the expansion of fields for cooperation. Liu Yang introduced a guessing game with which she tried to motivate the space fliers to guess the meaning of Chinese words for technology and space terms. At the end of this session, China's first taikonaut Yang Liwei, together with support from the Astronaut Centre of China, invited all space nations to participate in the Chinese space exploration programme.

During the closing ceremony, Wang Yongzhi, the first Chief Designer of China's manned space programme and Academician of the Chinese Academy of Engineering, received



The audience is listening during the presentations in Space City, Beijing. (credit: CMSA)



The panellists of the 2nd Technical Session "Future International Cooperative Space Programmes" in Space City, Beijing. (credit: CMSA)

the “Crystal Helmet Award” – the highest honour given by ASE. In recognition of his pioneering role for China’s conquest of space, taikonaut Yang Liwei was presented with the “Leonov Medallion”. The community of space flyers voted for the Wang Yaping presentation to be honoured with the “Best Technical Report Award”.

Also, for the first time in its history, The General Assembly of the Association of Space Explorers elected an Asian space flier as the President of the organisation. During the closing ceremony Dorin Prunariu handed over presidency to Japanese astronaut Soichi Noguchi, who, at the age of 49 years, is also the youngest astronaut to serve as ASE President. Soichi Noguchi explained during a press conference in Beijing, that his election was a consequence of the appreciation of the global space community for Japan’s contributions to spaceflight. Also, he took the opportunity to refer to the growing presence of Asian nations in the process and expressed his hopes for a greater role by China in international space exploration efforts.

The Association of Space Explorers came to life out of a strong human desire of care for and the concern about our planet. In 1983, a small group of Soviet cosmonauts and U.S.-American astronauts were talking about their personal commitment and

responsibility for the preservation and protection of planet Earth. Recognising, that the few humans who had the privileged opportunity to see the globe from outer space are united by this exceptional experience, this handful of space fliers – as they call themselves - decided to found a non-governmental professional organisation with the aim to spread the message and to engage with the young generation all over the world. Without the support of their governments, Soviet and U.S.-American space fliers took their fate in their own hands and ASE came into place in 1985 in France.

As if history is repeating itself, the strong message echoing from Beijing is that the concern about our planet is still dearly needed. Also, space fliers are still the small privileged group of humans who know best how vulnerable our home planet is. The added urgency of the 21st century is, that the care for our planet is not only a matter of space fliers but does need to be taken seriously by governments across the globe. There is hope that the impulses from the 27th Planetary Congress will advance cooperation to realise humanity’s dreams together.

*special website about the 27th Planetary Congress:*  
<http://en.cmse.gov.cn/list.php?catid=211>

## “I was curious about China.”

**Interview with ESA astronaut of Italian nationality, Paolo Nespoli, on his impressions during his participation in the XXVII Planetary Congress of the Association of Space Explorers in Beijing, China.**

**GoTaikonauts!: How did it come about that you participated in the Association of Space Explorers Planetary Congress 2014 in Beijing?**

**Paolo Nespoli:** The annual Planetary Congress is the main annual event of the Association of Space Explorers. It is our global meeting, where the members get together to meet, discuss space issues and socialise. It’s essentially the annual reunion of space travellers from all over the world.

This year was particularly special because, if I’m not wrong, there were more than 90 between space travellers, cosmonauts, astronauts and taikonauts, plus their accompanying guests. This means that, so far, it was the Planetary Congress with the highest number of participants.

**GoTaikonauts!: What particularly motivated you to go to China?**

**Paolo Nespoli:** Well, I have

been to the last several Planetary Congresses and, as far as I’m concerned, I will always try not to miss any since it’s the only place where I can see together so many friends and catch up with the latest family and professional news. For this particular year, the bonus was that it was in China and that, I heard, most of the taikonauts would be present – in fact, all of them showed up! Also, China is a country I’m very curious about, especially after the quick - and only - touch-and-go trip I did a few years ago. My wish was to be able to meet some of my fellow Chinese astronauts, learn and experience a bit more about China and the Chinese people and possibly learn about its history and culture. And yes, get to taste “real” Chinese food!

**GoTaikonauts!: What was your overall impression of the Congress - what was your overall impression of China?**

**Paolo Nespoli:** I would say that the host organisation put a lot of efforts in the Congress and it showed: the logistics and all activities were impeccable and things ran very smoothly. All the main events were efficiently located in the compound where our hotel was and there were some visits to outside institutions and universities. I was impressed by what I saw



Liu Yang and Paolo Nespoli - the two Chairs for the 3rd Technical Session “Cooperation in Human Spaceflight”. (credit: Paolo Nespoli)

in the places we visited and everybody was very courteous and seemed to genuinely enjoy our visits. It was obvious to me that not only the Chinese wanted to proudly show us their best hospitality, places and institutions, but that also they had real gems to show. I was very impressed by what I saw, by the university, the labs, by the people and the organisation, and by how things were done.

**GoTaikonauts!: When you say you were impressed, what specifically impressed you?**

**Paolo Nespoli:** The people were both, friendly and curious. The facilities were pretty nice. I thought the environment for the people to study was good. People seemed to be busy in their work but fairly relaxed at the same time. I saw everybody was pretty eager to show us around and to talk to us, and to learn from us. This all made an interesting situation.

**GoTaikonauts!: Did you also have interaction with your Chinese colleagues, the taikonauts?**

**Paolo Nespoli:** Yes. With Liu Yang, the first Chinese female taikonaut, I co-chaired one of the technical sessions. This was an interesting experience! For several weeks before the Congress I tried to get in touch with her but could not manage. Then, just prior to the Congress, I learned that with the help of a Chinese colleague, she had already organised everything... So, I requested a meeting as soon as I arrived in China to discuss the plan and give my comments. I thought I was going to get a hard time to get my inputs in, but, instead, I found Liu and her team really open and flexible: they immediately changed things to accommodate my suggestions and were open to changes, even some last minute changes. Liu Yang and her team was very professional and it was a pleasure to work with them.

**GoTaikonauts!: Do you think that cooperation with China would fit into the international working environment for space exploration?**

**Paolo Nespoli:** Well, judging from my limited experience acquired during the Congress, I can say that it seemed that the Chinese have already thought about things and have their own way of doing things, but that they are ready to listen and change things if it makes sense. Also, it seems they have the resources and the capabilities, and, most important, the will to go forward. We have a little bit more knowledge and experience and, in some aspects, a different way of looking and doing things. I believe it will be a win-win situation if we would put all of this together to really go forward as a human race. By the way, during the session I co-chaired with Liu Yang, the Chinese delegation put forward a request for international cooperation in the field of space scientific research.

**GoTaikonauts!: Did you encounter any particularly memorable situation?**

**Paolo Nespoli:** While some excursions to historical sites were organised for family members, for us participants this Congress was pretty much marching, marching, marching, and I almost did not get the chance to get out of the compound where we stayed. This was a pity since I would have loved to see again at least the Great Wall of China. Fortunately, I was lucky enough to be chosen to go to Xi'an for the outreach day. There we had a very

nice visit to one of the local universities, but also the chance to spend a couple of hours at the site of the Terracotta Warriors, escorted by some Chinese students who really took care of us. This side trip alone made the trip to China worthwhile!



Paolo Nespoli is presenting during the 2nd Technical Session "Future International Cooperative Space Programmes". (credit: CMSA)



Outreach Day in Xi'an. 3rd from the left: European astronaut Paolo Nespoli, next: Soviet-Russian cosmonaut Alexander Ivanchenkov, 3rd from the right: NASA astronaut Clayton Anderson. (credit: CMSA)



Outreach Day in Xi'an: European astronaut Paolo Nespoli, Soviet-Russian cosmonaut Alexander Ivanchenkov, and NASA astronaut Clayton Anderson. (credit: CMSA)



## Impressions of Toronto Our World Needs Space

Report from IAC2014 in Toronto

by Dr. William Carey



Toronto – the Canadian metropolis on the North-West shores of Lake Ontario was the host of the 2014 assembly of the International Astronautical Congress - IAC. Downtown Toronto at night looks as futuristic as the Metropolis in the movie of the same name. However, arrival in the city did not make a good first impression - the main road from the airport to the city centre was closed, which meant a zig-zag journey through several side-streets, then downtown Toronto turned out to be a “building-site”, and there were some issues with the hotel. At this point, one could be forgiven for feeling that this IAC might not match up to previous experiences. However, by the time of the Opening Ceremony on Monday, a change of room and familiarity with navigating the building-site, led to an improvement of mood.

### Opening Ceremony

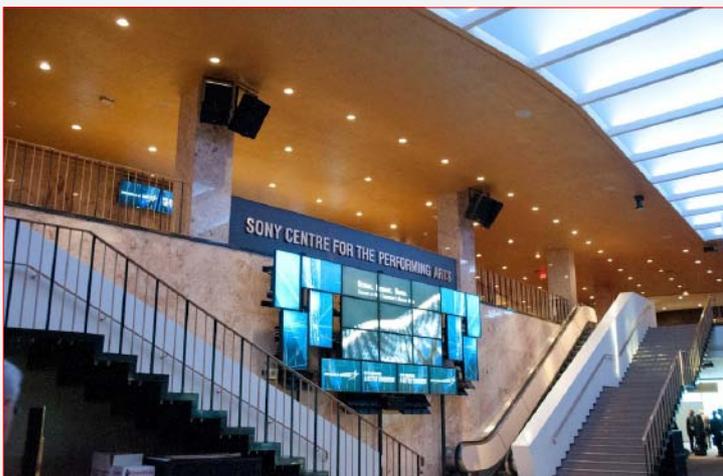
The 65th IAC began with an opening ceremony at the Sony Centre for the Performing Arts in Toronto on Monday, 29 September.

The expectations were high following the opening ceremony of the 64th IAC last year in Beijing (who can forget that incredible sand-drawing), especially as Cirque de Soleil was to be in the programme. Compered by two Canadian astronauts, Jeremy Hansen and David Saint-Jacques, the performance was not only highly interesting and entertaining but also peppered with fancy visuals and stunning screen projections. The presentation by the Canadian duo centered around the theme “Spotting Your Collaborator”, which focused on entrepreneurs, academics, government, retirees and enthusiasts. For a typical representative of the retiree group of course, it had to be, Chris Hadfield. It was interesting to note that the symbol for the enthusiasts was Dr. Who’s time machine (old-fashioned English police telephone kiosk). To make particular reference to the “enthusiast” group was very refreshing, as this community is often overlooked in discussions concerning stakeholders who have an interest in promoting space, and it could arguably be the most effective one. Getting back to the Cirque de Soleil: the two interludes were artistically brilliant but appeared a bit lost in the frame of this programme.

The actual IAC took place in the incredible Metro Toronto Convention Centre, in the closest neighbourhood to the landmark CN Tower. The generous conference location offered convenient access to meeting rooms of which most were situated on the same floor that made it easy to commute from one presentation to the next. The modern and high-quality installations guaranteed the smooth running of the sessions. From that perspective, it was a real pleasure to attend the IAC2014.

### Plenary 1: Heads of Agencies

The moderator, Berndt Feuerbacher, began the session by congratulating India on its Mars Orbiter Mission (MOM), Mangalyaan, highlighting the fact that this was the first Mars



Performing Arts Entrance (credit: GoTaikonauts!)



Spotting Your Collaborator with Jeremy Hansen and David Saint-Jacques (credit: GoTaikonauts!)



Plenary 1 Panel Members from left to right: Walter Natynczyk (CSA), Francisco Javier Mendieta Jiménez (Mexico), Koppillil Radhakrishnan (ISRO), Naoki Okumura (JAXA), Charles Bolden (NASA) and Jean-Jacques Dordain (ESA) (credit: GoTaikonauts!)



Walter Natynczyk, Head of the Canadian Space Agency (credit: GoTaikonauts!)

mission ever to be successful at its first attempt. The “usual” format for most of the remainder of the session was followed, with each HoA giving a short summary of the key events of their Agency during the past year. Coming about two months too soon, Jean-Jacques Dordain was unfortunately not able to report on the hugely successful and unique ESA Rosetta/Philae cometary mission, which took place in early December this year, but did however, note the Alexander Gerst and Samantha Cristoforetti missions on the ISS, together with Gaia, Sentinel-1A satellites and Galileo navigation system were notable achievements for ESA in 2014. Naoki Okumura noted that JAXA plans to launch Hayabusa 2 (an asteroid sample return mission) in late 2014 that will rendezvous with its target asteroid in 2018. Koppillil Radhakrishnan continued the deep-space exploration theme stating that the Chandrayaan 2 lunar mission (featuring a lander) is on schedule, and announced that an ISRO un-manned crew module will be used to study re-entry characteristics for future possible human spaceflight. Charles Bolden focussed on NASA’s commercial activities of the last year, and their work aimed at sustaining human life on Mars, and their progress on Orion in partnership with ESA. Francisco Javier Mendieta Jiménez emphasised Mexico’s long history of involvement in space activities, and mentioned that technology transfer and capacity building was important to his Agency, and the utilisation of space technology to address global environmental problems. He also reminded the audience that Guadalajara will host the IAC in 2016. Walter Natynczyk of CSA, noted that this year, was the 25th anniversary of the Canadian Space Agency, saw the launch of the Cassiopeia mission, and publication of a new government space policy framework.

During the Q&A session that followed, the question (from Go Taikonauts!) as to how a panel discussing global space cooperation could take place without representatives of Russia and China was one of the first questions, as both Denis Lyskov - Deputy Head of the Russian Space Agency, and Xu Dazhe - Head of the Chinese Space Agency - were conspicuous by their absence from the panel. Berndt Feuerbacher responded: ‘This is not our intention... They were foreseen to be here with us, they have been with us in the past, and they will be with us in

the future. It is just unfortunate, due to problems especially in the visa area, that we couldn’t have these nations here. I apologise for this.’ Several Russian and Chinese participants had been refused visas by Canada it transpired. Walter Natynczyk of CSA was unable to explain what had gone wrong, as he had only been alerted to the problem a couple of days before.

Less than a month after the IAC, Walter Natynczyk, appointed in August 2013 as Head of CSA, left the Agency (around 14 months in post) to become Deputy Veterans Affairs Minister from November 2014. Personally, I will miss his presence, attending the last IAC where his “booming” voice did not even need a microphone to be heard by an audience of around 3,000 delegates, he made quite an impact, and especially as he was honest enough to admit that as far as space was concerned he was “the new kid on the block”. His leadership of CSA will be hard to replace, but he does leave the Agency in a better position than when he arrived according to some Canadian media reports – I can believe it.

## Plenary 6: ISS and Beyond

The plenary session “ISS and Beyond - the Future of Human Activity in Low Earth Orbit” was moderated by Norbert Frischauf, in which the panellists discussed visions for the use of LEO in the next decade and beyond. This was a highly interesting and very well-moderated event.

Mike Gold when speaking about commercial spaceflight stated, ‘For many it’s difficult to see at this point, but if you look back at satellite development then you can see how it has quickly developed into an industry generating hundreds of millions of dollars and technologies that impact us every day, every hour of our life. We must overcome barriers that separate us as countries and since this is the IAC it must begin at a global level. There are a variety of situations around the world that prevent us from coming together but these things can change.’, and added, ‘I foresee a future of multiple stations, some of which may be government and some of which may be commercial.’ William Gerstenmaier observed, ‘One of our primary goals is to



Plenary 6 Panellists from left to right: Hansjörg Dittus (German Aerospace Centre), Mike Gold (Director of Operations and Business Growth, Bigelow Aerospace), William Gerstenmaier (Associate Administrator for Human Exploration and Operations, NASA), Ernst Messerschmid (Professor University of Stuttgart) (credit: GoTaikonauts!)



Plenary 7 Panel Members left to right: Chiaki Mukai (Astronaut and Director of Centre for Applied Space Medicine and Human Research, JAXA), Susan Chodakewitz (President, Tetra Tech AMT and Chair Women in Aerospace), Pascale Ehrenfreund (President Austrian Science Fund and Professor George Washington University), Colleen D'orio (Director General Programs and Integrated Planning, CSA), Simonetta Di Pippo (Director United Nations Office for Outer Space Affairs) (credit: GoTaikonauts!)

expose as many terrestrial companies as we can to the benefits of space.', and added, 'We have really got a finite window with the Space Station to establish a market in LEO. We need to let industrial companies see that there is a real benefit to doing research in space. So part of our primary purpose in the near term is to expose as many peripheral countries as we can to the benefits of space, and let them discover what they can get for research, let them see this huge potential and then, with enabled transportation, they can then go operate in orbit.'

### Plenary 7: Global Societal Challenge

The plenary session "Global societal challenge as the key driver for space activities: the imperative for a new way to engage stakeholders" was moderated by Johann-Dietrich Wörner.

Johann-Dietrich Wörner introduced this session by noting that although the space community itself understands the value of space activities, '... outside of this community the perception is different, which results in a growing pressure to justify the funding of space activities. We need a new way to communicate the contribution of space to global society challenges, and politics and strategies that could be effective in this context.' Chiaki Mukai commented on the limited amount of access to space that exists today, 'If there is no access it takes the motivation away. At present I would have to say that space access is very limited. We need to think about how we can increase the access. We also have to increase the opportunities for education, research and jobs.' Chiaki Mukai went on to propose that an organisation such as the UN could be a suitable organisation to provide a gateway for people to access space who currently cannot.

Simonetta Di Pippo, Director of United Nations' Office for Outer Space Affairs (UNOOSA), confirmed that 'From the United Nations' standpoint, space is a driver for socio-economic and sustainable development.', and added: 'The more we have people and satellites in space, the more we have an increased number of stakeholders supporting space as a tool. Our objective is to try to have space underpinning all the main goals

of the future.'

### Global Networking Forum GNF - Heads of Agencies Press Conference

In the Heads of Agencies Press Conference, again moderated by Berndt Feuerbacher, the visa issue was again raised by several of the journalists present, as did the effect of political issues on cooperation. One delegate asked if any clarification could be given on the visa issue. Walter Natynczyk of CSA stated that he was not the right guy to ask this question to, as he did not have any information, and could not comment further, confirming that he had only become aware in the last 48 hours. Another delegate (Go Taikonauts!) asked if political decisions interfere with the daily work in their agencies, how do they deal with this. Walter Natynczyk of CSA responded by clearly stating that the reality is that space requires cooperation. In his Agency he has total flexibility, but does have to take the geo-political situation into account on a case-by-case basis. Charles Bolden remarked that yes, cooperation can continue, and gave the ISS as a good example of working together with Russia. The restrictions that NASA are currently under in cooperating with



Heads of Agencies Panel for the Press Conference (credit: GoTaikonauts!)

China are restricted to human spaceflight, but NASA are actively pursuing cooperation with China in the area of science.

Many other questions were answered in a way that stressed the fact that the agencies represented by the panel have in the past, are now, and will in the future, cooperate extensively. Jean-Jacques Dordain of ESA when asked if the sanctions on Russia affect the ESA-Russia relationship, stated that there is no interference in ESA's cooperation with Russia. The ESA Member States have not given any guidelines, and there have been no comments from Russia on restricting their cooperation on the ISS. So the cooperation with Russia is okay, and he gave the progress on ExoMars as an example of this situation. Jean-Jacques Dordain went on to say that there are three main benefits from working together on the ISS. One is that it is a science laboratory; two, that it provides good learning environment on how to work together, as working with NASA is very different from working with Roscosmos; three, the ISS is a test bed for going beyond Low Earth Orbit. He then added a fourth benefit: astronauts. Noting that the press in general mentions ESA under three circumstances: when ESA performs a space first, when there is an astronaut involved, or when there are problems. So this was emphasising that astronauts are another benefit, and act as ambassadors to the younger generation.

### Global Networking Forum GNF - Space Education and Programmes on Space Applications

The GNF session on Space Education and Programmes on Space Applications was organised by the Chinese Society of Astronautics and Beihang University. The Programme on Space Applications was established by UNOOSA in 1971, and has since brought together many space experts from developed and developing countries, with a focus on education and training in space applications. This GNF event provided an opportunity to review space application education in general, and to consider the future role of space education within the framework of the UN, particularly the Programme on Space Applications. The session was moderated by Prof. Tao Zhi (Vice President of Beihang University, and Chair of the National Key Laboratory on Aero-Engine Aero-Thermodynamics) who also made a short presentation to the session, stressing the importance of applications in today's world, and noted that the UN has strongly



Prof. Weng Jingnong (credit: GoTaikonauts!)

encouraged the exploration and peaceful use of outer space for a long time. He went on to note that Beihang University started teaching in English as early as 1993, and is the leading institute of science and technology in China. Beihang established the International Space Education and Training Centre in 2004, and Master and Doctoral programmes respectively in 2004 and 2013. A new centre, the "Asia-Pacific Regional Centre for Space Science and Technology Education" will be initiated in November 2014.

Prof. Weng Jingnong (Director of the APSCO Education and Training Centre, Beijing, and Vice Dean of the International School, Beihang University) gave a presentation on "International Space Education: Opportunities and Challenges". He noted that Beihang was in 1952 the first aerospace university in China and supported by CNSA, has engaged in international space education since 2000, and have had international students from over 90 countries. The Beidou International Exchange and Training Centre was setup in 2012, and in 2013, the APSCO Education and Training Centre in China. Good progress in education has been made through initiatives of the UN Space Application Programme (SAP) and ISU Space Studies Programme (SSP). For the future, MOOCs (Massive Open Online Courses) will be established, together with a new UN Regional Centre in 2015 covering Master and Doctoral



The panel during the GNF session on Space Education and Programmes on Space Applications (credit: GoTaikonauts!)



Attendees of the GNF session on Space Education and Programmes on Space Applications (credit: GoTaikonauts!)



## United Nations entrusts Beihang University in Beijing with space education task

In case you fancy long acronyms and long titles, this is the place to be: United Nations Regional Centre for Space Science and Technology Education in Asia and the Pacific (China) at Beihang University Beijing or in short: UNRCSSTEAP (China).

On 17 November, the Head of China's National Space Administration (CNSA) Xu Dazhe and the Director of the United Nations Office for Outer Space Affairs (UNOOSA) Simonetta Di Pippo, inaugurated UNRCSSTEAP (China). The ceremony was hosted by Wu Yanhua, the Vice Administrator of CNSA.

Xu Dazhe focussed in his speech on the fact that the UNRCSSTE institution will become a beacon of knowledge, education and cooperation for all countries in the world, but especially for the nations in the Asia and Pacific region. Through education and training in space science and technology and through China sharing its space knowledge with the world, the national level of aerospace capabilities everywhere around the globe will be elevated.

Simonetta Di Pippo recalled the starting point of the establishment of the centre in her opening speech: 'It was less than 14 months ago when an international Evaluation Mission, facilitated by the Office for Outer Space Affairs and composed of experts nominated by Member States of the United Nations Committee on the Peaceful Uses of Outer Space, met here in Beijing to assess a proposal by the Government of China to establish a new Regional Centre at Beihang University. The Evaluation Mission recommended the establishment of the Regional Centre and its affiliation to the United Nations.'

She then continued, by saying: 'This Regional Centre for Space Science and Technology Education in Asia and the Pacific (China) will join the network of Regional Centres established in Africa, Asia and Pacific, Latin America and the Caribbean and Western Asia. These Centres develop, through in-depth education, an indigenous capability for research and applications in the core disciplines of:

- Remote Sensing and Geographical Information Systems;
- Satellite Communications;
- Satellite Meteorology and Global Climate;
- Space and Atmospheric Sciences; and
- Positioning, Navigation and Timing.

In addition a dedicated curriculum on space law has recently been developed for inclusion in the education programme of the Centres.'



Simonetta Di Pippo and Xu Dazhe opening the UNRCSSTEAP at Beihang University, Beijing. (credit: CNSA)

Simonetta Di Pippo expressed that: 'The Office for Outer Space Affairs is confident that the infrastructure and the quality of the academic research and facilities at Beihang University, as well as the governmental and institutional support provided by the Government of China, will allow the Centre to fulfil its role to contribute to building regional capacities in space science and technology for peaceful purposes. ... In line with the requirements for affiliation of a Regional Centre with the United Nations, the Government of China has concluded bilateral agreements with several Member States in the Asia and the Pacific and

in other regions in support of the work of the new Regional Centre and has also established a Governing Board for the Centre.'

At the end of her speech, Simonetta Di Pippo put emphasis on the benefit of the centre for the United Nations: 'Today's inauguration of the Regional Centre for Space Science and Technology Education in Asia and the Pacific (China) represents a new starting point for cooperation between China and the United Nations in the field of space activities. We at the United Nations Office for Outer Space Affairs are very much looking forward to working together with the newly established Centre and its Member States to realise our common vision to bring the benefits of space activities to all humankind.'

The same day before the inauguration of UNRCSSTEAP, a UN/China/APSCO workshop on space law was opened. The 4-day workshop, hosted by CNSA was conducted under the theme "The Role of National Space Legislation in Strengthening the Rule of Law".

level programmes. He concluded by stating that Beihang will continue to contribute to International Space Education, working with UNOOSA, APSCO, SGAC (Space Generation Advisory Council), and existing and future member states of UN Regional Centres.

After the event, Prof. Weng Jingnong was ready to give an interview to GoTaikonauts!

*Please read the separate article "Interviews at IAC 2014" for the interview with Prof. Weng Jingnong.*

## The Technical Sessions

In the technical sessions GoTaikonauts! had identified a total of 35 individual papers and multiple papers in two sessions as being of particular interest for our magazine prior to going to Toronto. Of these, 21 papers were either cancelled prior to the Congress, or were affected by the visa issue, so from this perspective it was extremely disappointing. The Moon Exploration session contained three papers from China. Shuwu Dai presented two: "Overview of Chinese Yutu Lunar Robotic Rover Payloads" and "Overview of Chinese Lunar Lander Payloads", and Ming Li one, "Overview of the Chang'e 3 mission and Development of Follow-on Mission". Although all three were interesting, none offered any new information to the GoTaikonauts! team members present.

In the technical session "Regional cooperation in space: policies, governance and legal tools" there were three papers of relevance:

1. "New Space Development: The Political and Economic Landscape for Emerging Actors" presented by Tanay Sharma, who considered the space programmes in Brazil, Mexico, India and China, noting that a growing number of countries in Asia and Latin America are becoming interested in space development and the application of space-based utilities for national development. These countries have demonstrated the ability to collaborate regionally in, for example, disaster management, national/regional security, and socio-economically beneficial space applications. The conclusions included: geographic solidarity in space cooperation is increasing through bilateral agreements; both Asia and Latin America share key drivers for national space activities; and the BRICS Development Bank could potentially enable new entrants.
2. "The Similarities and Differences of APSCO and ESA in the Rules and Practice - Analysis from Policies, Governance and Legal Tools" by Prof. Haifeng Zhao from the Harbin Institute of Technology. Prof. Haifeng began by observing that APSCO was the second intergovernmental regional space cooperation organisation in the world, ESA being the first, and is now entering its sixth year. APSCO has organised 5 international symposia during this period. After comparing APSCO and ESA in several areas, Prof. Haifeng proposes the establishment of an Asia-Pacific Centre for Space Law within the framework of APSCO.
3. "Space Cooperation in Asia - a Mystery" by Du Rong from the University of Hong Kong, summarised the status quo of Asian space cooperation, aspects of the co-existence of different cooperation initiatives, interactions between APSCO and APRSAF (Asia-Pacific Regional Space

Agency Forum - initiated by JAXA) and prospects for a regional space organisation. Concluding that several sub-regional initiatives cannot equal the significance of a single regional organisation. As the integration of APSCO and APRSAF is not feasible, a substantial cooperation between China, India and Japan is needed.

In the technical session "International Space Exploration Policies and Programmes", two papers were of interest.

1. "Perspective for International Cooperation on China Space Station" by Zhou Lini from the Centre for National Security and Strategic Studies, National University of Defence Technology. Although well-presented, the content of this paper did not provide any new information or additional insight regarding the title of the paper provided.
2. "Non-Governmental Organisations Importance and Future Role in Space Exploration" presented by Max Grimard, Airbus Defence and Space. This presentation observed that space exploration is mainly politically-driven and conducted by space agencies at national and international level, primarily through the International Space Exploration Coordination Group (ISECG) at agency level, the International Space Exploration Forum (ISEF) at the political level, and the International Academy of Astronautics at (IAA) at the individual level. However, despite this attention, there is no consensus on the way forward beyond ISS, especially in terms of implementation and programme decisions, due to a lack of political and public support rather than budget capability. Two slides were then shown showing that space exploration is not so expensive when compared with public expenses and household expenses - this was quite revealing. Max Grimard then went on to argue that there is a strong need to revive attention and support from the public and from politicians, and one approach would be to involve NGOs, arguing that those NGOs currently active in the space domain are "too self-focused", addressing primarily space fans and the space community, suffer from "space egocentrism", with no coordination of activities or goals. He then goes on to propose a "Global Space Exploration Network (GSEN)" through involvement of non-space NGOs, i.e., to get out of the space community and reach a broader public.

In the technical session "Small Earth Observation Missions", one paper, "GF-1 Satellite High Resolution & Wide Swath Mission Design and Technology Characteristics" by Lu Chunking, of the Dong Fang Hong Satellite Company Limited, did provide some good technical details. The GF-1 is a new generation small satellite that includes two high-resolution (HR) cameras and four wide field of view (WFOV) cameras, with a planned lifetime of 5 to 8 years, and was launched in April 2013.

## Exhibition Area

Certainly smaller than the exhibition area of IAC 2013 in Beijing, the area was nevertheless a big attraction for the delegates attending the Congress, and included several of the "big" western companies and organisations such as Lockheed Martin, Boeing, SpaceX and DLR. The big companies from China were also present however, represented by the China Aerospace Science and Technology Corporation (CASC), the



The APSCO stand (credit: GoTaikonauts!)



Tiangong 1 space lab (credit: GoTaikonauts!)

China Great Wall Industry Corporation, the Asia-Pacific Space Cooperation Organisation (APSCO) and by China HEAD Aerospace Technology Company. In addition to models of the Long March series of launchers, the CASC stand also displayed a model of the Chang'e 3 lunar lander and small rover Yutu. Although targeted for Sinus Iridium, the actual landing occurred in Mare Imbrium, and although the rover's wheels got stuck after only 120 m, both lander and rover continue to transmit data.

Here in the exhibition area we met Chris Bee, Head of Business Development for the Science Technology Facilities Council - STFC Rutherford Appleton Laboratory in Harwell, Oxford, UK. He was willing to share with us insights into the British strategy of scientific cooperation with China and why he thinks business, scientific and technology engagement in China is not only worthwhile but in the first place a future oriented activity.

The large presence of British companies and organisations gave the impression that the UK understands the immense

cooperation opportunities that China harbours and is already now in a pole position for sustainable future space exploration projects to be materialised in the mid-term future. Chris Bee explains these opportunities in the interview with us.

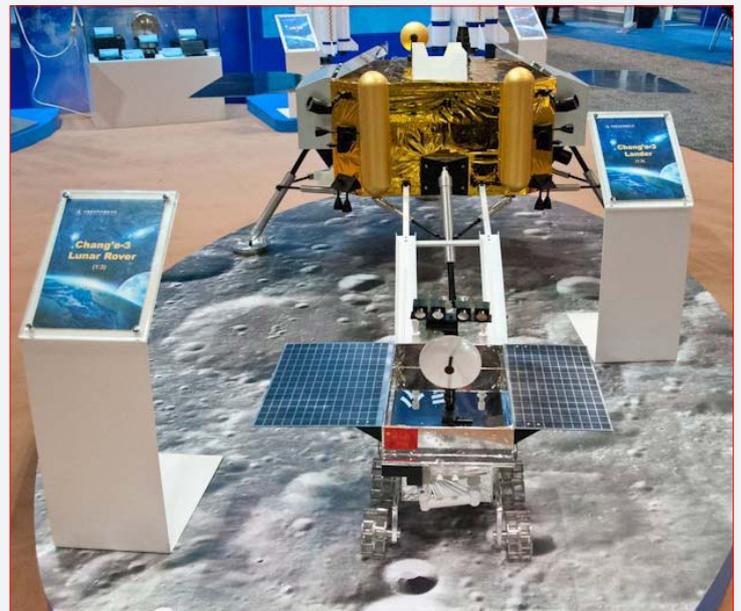
*Please, read the separate article "Interviews at IAC 2014" for the interview with Chris Bee.*

### Late Breaking News Event

The Late Breaking News session on the final day of the Congress focused on ESA's Rosetta/Philae mission - noting a final choice of the landing site on the comet would be made in the week after the Congress; and India's Mars Orbiter Mission, (Mangalyaan) where Koteswara Rao (Scientific Secretary of the Indian Space Research Organisation - ISRO) reiterated a number of firsts for India: first mission to Mars, first interplanetary mission, and of course, a success at the first attempt.



Long March 3 (left) and Long March 5 (right) at the CASC stand (credit: GoTaikonauts!)



Chang'e 3 and Yutu rover (credit: GoTaikonauts!)

## Lasting Impressions

Coming back to the initial perception that this IAC might not match up to previous years experiences – unfortunately that was confirmed.

The visa issue clearly had a negative effect. The momentum around international cooperation that one felt building-up towards the end of last year (see issue 10 of GoTaikonauts!) and the beginning of this year (IAA Space Exploration Conference, Heads of Space Agencies Summit and the International Space Exploration Forum – see issue 11 of GoTaikonauts!) appears to have stumbled a little with this action. As both Walter Natynczyk and Charles Bolden pointed out however, unfortunately terrestrial geo-politics is a fact of daily life, a fact that they, as Heads of Agency have to deal with as the best they can. The result being that IAC2014 felt somewhat “flat”, especially as there seems to be a considerable amount of activity in many regions of the world at this time focused on cooperation at regional and international level. An impression was that the IAC was somehow out of touch with all of this.

The lack of Chinese and Russian delegates was very noticeable, and not only in the Plenary sessions, but also in the technical ones. One also had the perception that the quality of technical papers, at least in those sessions attended, was not as high as in previous years. Often topics were presented by persons without first-hand expertise. Also, IAF should observe carefully

that the IAC will stay a forum with high-standards set by professionals rather than amateurs or hobbyists. This is not to say anything against space enthusiasts, but they have their own forums. Making all the effort to go to an IAC, no matter where in the world it is taking place, means to get the best possible information on the advertised topics from the related experts in the field. Something the IAF needs to keep a close eye on.

A certain diluting of the quality standards of the content presented during an IAC was a great pity because the event itself was extremely well-organised and efficient – for which the local organisers have to be commended. The venue, Toronto, proved itself to be a very friendly, dynamic and welcoming city, and first impressions of Toronto itself quickly faded.

The Congress theme of “Our World Needs Space” is certainly true, but so is the reverse, “Space Needs the World”. From the plenary, GNF and even technical sessions, this is a key lasting impression, and strong “take-home” message from IAC2014. International cooperation may have stumbled temporarily, but it will keep moving forward, that much is also clear.

And finally - After a hectic first four days of the Congress, it was a real pleasure to have a relaxing evening meal at the impressive CN Tower with our friends and colleagues from the journalists’ branch. For GoTaikonauts! this was one of the most important results from Toronto – reinforcing the bonds between the expert authors on Chinese space activities.



Andrea Accomazzo, Rosetta Flight Director, ESA  
(credit: GoTaikonauts!)



Koteswara Rao, Scientific Secretary of the Indian Space Research Organisation - ISRO  
(credit: GoTaikonauts!)



From left to right: Clive Simpson (UK), William Carey (Netherlands), Jacqueline Myrrhe (Germany), Theo Pirard (Belgium) and Brian Harvey (Ireland). (credit: SharpShooter)



## Interviews at IAC 2014

Interview with Prof. Dr. Weng Jingnong,

Vice Dean of the International School of Beihang University, Executive Director of the UN-regional Centre at Beihang University and Director of APSCO Education and Training Centre in China

**GoTaikonauts!** *What is the meaning of your International Programme at Beihang University?*

**Weng Jingnong:** We focus on Remote Sensing and Geographic Information System, Satellite Communication, and GNSS. We have also extended it to cover Space Law and Small Satellite Technology.

**GoTaikonauts!** *You mentioned in your presentation MOOC - Massive Online Open Course. How are you using that tool and how is your university contributing?*

**Weng Jingnong:** China has a MOOC platform on the national level. Beihang University is one of the major part of the platform and we will integrate our courses into this national infrastructure. From there it is shared with the public.

**GoTaikonauts!** *In your programmes are Chinese and international students learning together?*

**Weng Jingnong:** Our programmes are open to international and Chinese students.

**GoTaikonauts!** *Do you have difficulties to find interested and talented young people to take up your studies?*

**Weng Jingnong:** Not really, we have more and more people joining our programmes.

**GoTaikonauts!** *We in Europe have the big problem, that the young people are not any more interested in science, mathematics and complex studies. Young people in Europe prefer to become bankers, lawyers or simply celebrities. How is the situation in China?*

**Weng Jingnong:** The good situation in China is that we have far more students. Also, most students really want to join the university. But of course we also have the phenomena that many young people become interested in social sciences. However,

for the moment we still have enough students interested in natural sciences.

**GoTaikonauts!** *Since your students are coming from different countries, having a different background and joining your programme with a different level of education, how do you manage to make them study from the same education level?*

**Weng Jingnong:** We try to get the students having the same level of education and to merge them into one group. If they can't satisfy the required education we give them additional training. After that we can accept that student to join the study group. But of course we are doing interviews beforehand to see what preconditions the students bring with them.

**GoTaikonauts!** *How is the success rate of your studies? How many students are passing your programmes?*

**Weng Jingnong:** I estimate that 20 to 30 % of the students applying for the programme drop out after the initial interview. By having a harmoniously composed student group we hope that most students will accomplish the programme, but roughly 10 % of our students cannot pass the examination and do not get the degree.

**GoTaikonauts!** *What is your wish for the next 10 years? Where would you like to be 10 years from now?*

**Weng Jingnong:** First of all we should focus on our advantage fields: Global Navigation Satellite System, Remote Sensing and GIS - because we have rich resources in these fields. And also with the rest of our education programmes we can extend to other related areas such as Space Law, and Small Satellite Technology. We also plan to extend our scale in terms of number of students. Also, we should try to bring the benefit to more countries.

*website:*  
<http://is.buaa.edu.cn/English>

Interview with Chris Bee,  
Head of Business Development for the Science Technology Facilities Council -  
STFC Rutherford Appleton Laboratory in Harwell, Oxford

**GoTaikonauts!** *What are your responsibilities within the company?*

**Chris Bee:** I am Head of Business Development for the Science Technology Facilities Council - STFC Rutherford Appleton Laboratory in Harwell, Oxford, but I worked as the business development manager for the space department within STFC prior to my current role. I am reasonably familiar with the space

community. I still get involved in space development and in general for STFC.

We have two space laboratories in the UK, the Rutherford Appleton Laboratory, where we have 200 scientists and technologists who are part of RAL space. We also have in Edinburgh the Royal Observatory, which is part of STFC as well. It is for all our ground-based astronomy programmes.

**GoTaikonauts!: We are aware that you have cooperation projects with China. Which projects do you have and why? What is the purpose of it and what do you intend to gain from it?**

**Chris Bee:** The background to that is that the UK is cooperating with China academically since a long time - 20 to 30 years - where the science programmes have gone hand-in-hand for some time. We have visiting professors from the UK to China, for example Prof. Richard Holdaway who is a visiting professor at the Beihang University, in the Astronautics and Aeronautics Department of the BUAA. We have very good relationships with Beihang. There is a reciprocal relationship with them. A few years back, they send us a student who spent 18 months at RAL and was working on cold atom technology. We have seen a lot of cooperation in that area. There even has been a joint UK-China laboratory facility on terahertz technology in Beijing. A lot of that is using the Rutherford Appleton Laboratories, the terahertz componentry and terahertz understanding.

**GoTaikonauts!: How is that laboratory staffed?**

**Chris Bee:** Since it is a cooperation between the different parties, there is equal involvement on both sides.

**GoTaikonauts!: How is the laboratory run?**

**Chris Bee:** There are research programmes that run along. The selection criteria of the research programmes is based on the usefulness for the UK as well as being educational for China. In China it is all about relationships. We keep the relationship going with regular cooperation workshops. We are now on the 9th joint UK-China Workshop on Space Science and Technology. It is an activity which is run by Prof. Holdaway and involves a lot of the UK community. The recent one was end of May in Shanghai. The workshops alternate between China and the UK. The next one will be in about one year's time.

**GoTaikonauts!: So, you have been in China?**

**Chris Bee:** Yes, in the meanwhile I have been six or seven times in China. It has always been very interesting and rewarding.

**GoTaikonauts!: What is in particular interesting for you about China? What is your general experience?**

**Chris Bee:** Chinese are very hospitable. It is great fun building a working relationship with them. It is a very different way of doing business. But it is a very trusting, a very much more emotionally involved way of doing business than we are used to do in the West.

**GoTaikonauts!: The Germans always say it is very hard to set up a business relationship with Chinese partners. What do the British say?**

**Chris Bee:** We say it takes patience and perseverance. You need to understand what the issues of the strengths and the weaknesses are perhaps, than you would need to do in signing a simple piece of paper or contract.

**GoTaikonauts!: But does it pay off at the end and if so how?**

**Chris Bee:** It has for us. Although it has taken a while we are now seeing the benefits in terms of the connections that we are making into China in particular within the Chinese Space Agency. So the scientific cooperation on future missions seems to come to a point now where we are building a relationship.

**GoTaikonauts!: Could I summarise the objective of the whole set-up to get used to the environment in China and to be prepared for the moment once big space missions come up and to be ready to contribute to that?**

**Chris Bee:** Yes, one could say it in this way. One example is Prof. John Zarnecki from the Open University in Milton Keynes. He has a joint appointment as well in China.

We worked very much with John and with some of our solar physicists. They have been working on various mission concepts and one of them looks like very close to fruition.

**GoTaikonauts!: But this also means there is not a real project until now?**

**Chris Bee:** On the science side this is true. On the technology side, through things like this joint laboratory, this is not necessarily the case.

**GoTaikonauts!: You also need finances to keep such projects going. How does this work?**

**Chris Bee:** Yes. We are lucky in the UK that we now have a programme called Newton-Fund which is allowing us to work - not directly in space - but in some spin-off areas from space. That is focussed on agro-tech. We are using technology developed from space and work with those technologies on some of their local problems related to agriculture, such common problems such as crop disease, crop monitoring, that sort of thing, which is very important to the Chinese economy. In this area we are having good support from the UK. It is early days but we are optimistic.

**GoTaikonauts!: Now looking at the human relationship: working with your Chinese colleagues, what are your experiences? How are your Chinese partners on the human basis and how on the business basis?**

**Chris Bee:** There is a lot of learning around the cultural prospective. It starts with simple things like when you go to dinner, there are some local customs which are very interesting in their own way. The Chinese make you feel very welcome. Consequently there is learning on both sides. We can be a little bit insensitive some times what can introduce some surprise.

**GoTaikonauts!: How do you handle such insensitive situations?**

**Chris Bee:** We try to use tact and diplomacy if we can. It is inevitable that when such different cultures working together, occasionally, even if you are making allowances, it could turn into miscommunication.

**GoTaikonauts!: And on the business side? I could imagine that the approach to work is completely different from the**

**European or British approach to work?**

**Chris Bee:** The Chinese seem to work very hard, from what I have seen. The working hours seem to be very long. They are very committed to what they are doing.

**GoTaikonauts!:** *Chinese are perceived as not being very efficient. Can you confirm that?*

**Chris Bee:** I think this is not a fair assessment. There are different stages in the process. For example in the Chinese business culture they very often like to see an MoU. While perhaps we within the Western culture might see an MoU as a less important document. It is very much put on a pedestal in the Chinese culture as a statement of intent. So, it is important to go through the MoU process to get to the other side.

**GoTaikonauts!:** *What do you expect from the future? Will the relationship last?*

**Chris Bee:** We will see innovativeness on both sides. Perhaps the Chinese view on innovation is slightly different from ours. Innovation takes two forms: it is either something truly ground-breaking, or you are doing something what you are already doing a little bit better. And I think the Chinese tend to focus a little bit more on doing the things a little bit better. While perhaps our innovation focus in the West is generally much more on the

ground-breaking. The ground-breaking in the Chinese seems to be more curiosity-driven. So, it's about marrying those two things up. But certainly the drive for innovation growth is shared across the world now because of the current economic environment. And I think, looking into the future, that is not going to go away. The growth rates within China are certainly very attractive. We would all like to be a part of that. Therefore it is good if we are working with people who are driving innovation, then that is also good for those on the other side.

**GoTaikonauts!:** *What is your personal wish for the next years?*

**Chris Bee:** We would love to go for some new destination with the Chinese.

**GoTaikonauts!:** *Should it be the Moon or Mars?*

**Chris Bee:** Well, Moon seems to be the thing to do within 5 years. I think we should look further out into the future. Who knows? We could all put in a vote for where. To align better with the sense of exploration that would be a great thing.

**GoTaikonauts!:** *This sounds all very positive!*

**Chris Bee:** Yes, it is!

website Science and Technology Facilities Council - Astronomy and Space Science:

<http://www.stfc.ac.uk/683.aspx>

more information on the 9th UK-China Workshop on Space Science and Technology held in Shanghai on 28-29 May 2014:

<https://www.gov.uk/government/publications/uk-china-workshop-on-space-science-and-technology/uk-china-workshop-on-space-science-and-technology>

more information on the Newton Fund with respect to China:

<https://www.gov.uk/government/priority/promoting-economic-development-through-research-and-innovation>

## Mind The Gap - Missing space in China, Macao, and Hong Kong

A fortunate accident led two of our readers on a journey to China, Macao and Hong Kong. Both, dedicated space enthusiasts, used their time in East Asia to search for traces of the Chinese space programme in public places. **Robert Hast**, a retired airline employee from the U.S., went to China and Hong Kong in spring this year, while **Morris Jones**, Australia's leading independent space analyst, used a stopover on his way home from the IAC2014 in Toronto to Australia, to visit Hong Kong and Macao. Both made the same experience: China should no

longer hide its space achievements but show case everything it can. Also, China should not only invite its own citizen for the celebration of its space programme, but make it easier accessible for foreigners. By doing so, the picture how China is seen by the world could become more colourful, interesting, and impressive. GoTaikonauts! is very grateful to Robert Hast and Morris Jones, that they agreed to share their space-hunting experiences and for taking over a pathfinder role for our readers!

### “Keep an open mind, and enjoy the differences, that’s why you go.”

by Robert Hast



The National Museum of China at the East side of Tiananmen Square. (credit: Robert Hast)

Our family has established a tradition. Two years ago we took our oldest daughter to Sydney, Australia as her grade school graduation present. This year, my youngest daughter's graduation was approaching and her wish was "to go to China". So, we packed and went on a holiday to China.

#### Beijing

From the beginning, I hoped to use this occasion to see some real Chinese space hardware, regardless of whether it would be in an exhibition, public outdoor place or wherever. I have been interested in manned spaceflight since grade school. The Apollo Moon flights I thought were, and still are, the greatest thing mankind has ever done. I would become interested in the U.S.S.R./Russian programme as well - partly because information was so hard to come by in the early days. In 1995 I had the opportunity to go to Baikonur to see a Soyuz launch.

When the Chinese Shenzhou programme started, well, that caught my interest too. Whenever I travel somewhere - I spent 30 plus years working for a major U.S. airline, so am able to travel almost anywhere - I try to find space-related sites near where I/ we will be. Now, I will admit to dragging my wife and daughters to some obscure sites that they'd rather not be at, just to take a

quick picture or two of something that caught my interest. But in China, I got frustrated trying to find space hardware. There isn't a lot of information out about what capsules are where, or what is on display where. And, of course, some sites I just couldn't gain access to. But, we did see Shenzhou 5, along with Yang Liwei's spacesuit. That was the only Shenzhou I found. But let me explain step-by-step.

General sightseeing in Beijing is really rewarding. We had arranged for a tour to the Great Wall at Mutianyu. It was incredible and certainly one of the highlights of our stay in China. The benefit of an arranged tour is that you can bombard your tour guide with plenty of questions and all in English. Our guide spoke beautiful English. At the hotel, restaurants, etc., we got by... by pointing. After the Great Wall, we also went to the China Aviation Museum - row after row of older MiG fighters. Although the China Aviation Museum did not display any space hardware it did have some beautiful "taikonaut" figures.

Our tour also took us to the 2012 Summer Olympics site, which is worth seeing. Now, we - on our own - went to Tiananmen Square - very impressive too. Also, the Forbidden City is very beautiful, and the National Museum of China. I wanted to go the National Museum in the hope that a Shenzhou capsule might be on display, and - of course - we "found" Shenzhou 5 there. Over the Shenzhou 5 was hanging a Chang'e 1 model. Also, I wanted to see the other displays in the museum - I had read how the museum had just re-opened after a year's long remodelling. It was a very beautiful building, and the displays of Chinese history were very compelling. As far as other exhibits, other than the photo references to the DF-2A nuclear test at the Lop Nur desert in the Xinjiang province, and to the DFH-1 first satellite launch, there was an artistic impression of Shenzhou in a large wall mural.

The CASC has a museum in Beijing that is supposed to contain at least 2 Shenzhou capsules, however I was unable to gain access to it. (compare report by Theo Pirard in GT! no 10, page 13/14)

But, at the CCTV tower in Beijing we found a large model of Tiangong 1. It was sitting in the lobby as we headed to the elevators. It was unexpected, as was a space theme park I saw from the high-speed railway train window on the way out of Beijing. We took the bullet train to Hong Kong, which made it a 10 hour long ride.

## Hong Kong

In Hong Kong, we visited the Science Museum and the Space Museum. Both lacked any Shenzhou capsules or other actual hardware. Though the Space Museum did have some manned space-related murals, among them Yang Liwei's blue flight suit. A big advantage of Hong Kong is that English was spoken by just about everybody we came into contact with, or at least understood.

Of what we saw, I got the most satisfaction from Shenzhou 5 in the National Museum of China - now this may be because we traversed the entire building looking for it - the museum didn't have any directional signs - and it was literally the last thing we saw. I had almost given up hope of finding it.

I thoroughly enjoyed China. Our trip was a great adventure. There wasn't anything I didn't like, though I think the train ride from Beijing to Hong Kong was a favourite highlight as it allowed us to see 1,500 miles of China's countryside. I will say, my girls did not like being the object of countless photographs, some people asked, but most did not. I tried to tell them that 'different' was one reason you travel - not sure if they were convinced.

In case I would be asked for advice, I would tell people going to China the same thing I tell people traveling anywhere: keep an open mind, and enjoy the differences, that's why you go. I always felt safe in China, enjoyed the interaction with people - even though I didn't speak the language, and found the thousands of years of history to be remarkable.



Photos in the National Museum of China showing DFH-1 and the DF-2A, China's first nuclear ballistic missile test at Lop Nor in 1966. (credit: Robert Hast)



DF-5 ICBM. National Museum of China. (credit: Robert Hast)



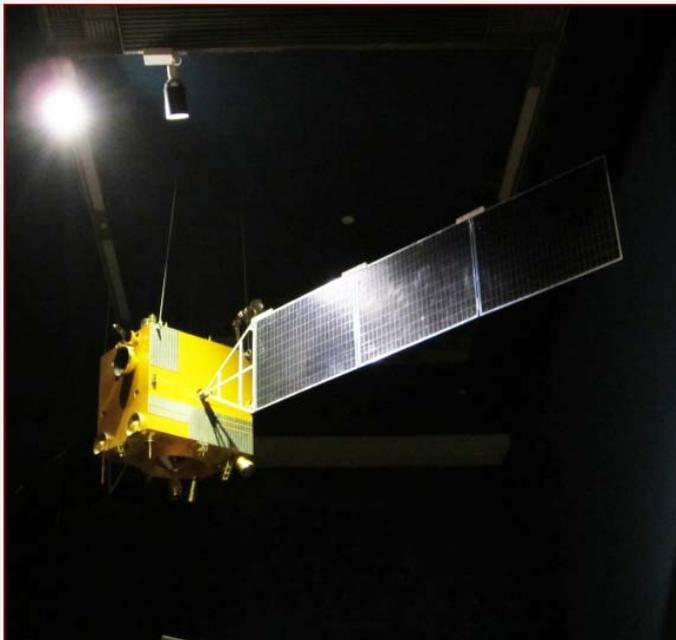
Information mural at the Hong Kong Space Museum. (credit: Robert Hast)



An artistic impression of Shenzhou in a large wall mural in the National Museum of China. (credit: Robert Hast)



Space and aviation monument in front of the China Aviation Museum in Beijing. (credit: Robert Hast)



The model of the Chang'e 1 lunar space probe hanging over the Shenzhou 5 capsule in the National Museum of China. (credit: Robert Hast)



The Tiangong 1 space lab model in the foyer of the CCTV tower in Beijing. (credit: Robert Hast)

## Looking For Space in Hong Kong and Macau

by Morris Jones

### Hong Kong

A space enthusiast would expect Hong Kong and Macau to be well-stocked with exhibits from China's advanced space programme. Hong Kong even has its own dedicated "Space Museum" on the tip of Kowloon peninsula. There are space attractions in both territories, but overall, it is disappointing to see that China's space programme is under-represented.

The Hong Kong Space Museum has operated for decades, and features a planetarium theatre alongside some museum exhibits on astronomy. It's fairly small and low-key. There's a full-scale replica of the Space Shuttle flight deck and "hands-on" experiment displays. Temporary exhibitions of Chinese space hardware appear periodically, but the permanent exhibits really don't match expectations.

There's a small exhibit of a Chinese flight suit, small models of Chinese launch vehicles and a scale replica of the Shenzhou 5 spacecraft. A flag of the Hong Kong Special Administrative Region that flew on a Shenzhou test flight is also displayed. Recently, the museum has also added a model of the Tiangong 1 laboratory docking with a Shenzhou spacecraft. As far as Chinese space hardware goes, that's about it. No representation of the lunar programme is there at all!

Hong Kong also has a Science Museum that doesn't really deal with space.

### Macau

The Macau Science Center can be reached by taking a one-hour ferry ride from Hong Kong followed by a short bus or taxi ride. It's a more general science museum aimed at young people. A space enthusiast will find more here than in the whole of Hong Kong. There's a full-scale model of the Shenzhou 7 spacecraft. Spacewalker Zhai Zhigang's moment in history is captured with a replica of an astronaut in a Feitian EVA suit, complete with a Chinese flag in his glove.

The Shenzhou model isn't exactly as high-fidelity as other replicas displayed in mainland Chinese museums, but you can walk up a spiral corridor and see the model from different perspectives. This gives excellent views of the Feitian suit, which seems to be reproduced with more detail than the spacecraft itself.

A replica of China's first satellite also hangs beside Shenzhou.

The museum also has a small "space" hall amongst other halls dealing with other scientific themes. It contains a Shenzhou simulator as well as a "mission control" game and a remote control Moon rover. It would have been interesting to try these attractions, but they were either under repair or unstaffed. General displays on spaceflight, including samples of space food and a space toilet, are also here. It's a fairly large hall, but the whole display is so poorly managed by the Museum itself that it's almost pointless to walk through it.

The museums feature gift shops. It would be nice to buy souvenirs of the Chinese space programme such as models and patches. Unfortunately, they are not available. It's probably easier to buy these things on ebay than in the museums themselves!

Overall, it is surprising that China's space programme is so poorly presented in these museums. This represents a lost opportunity for space enthusiasts and young people who could be inspired to study science and technology by better displays.



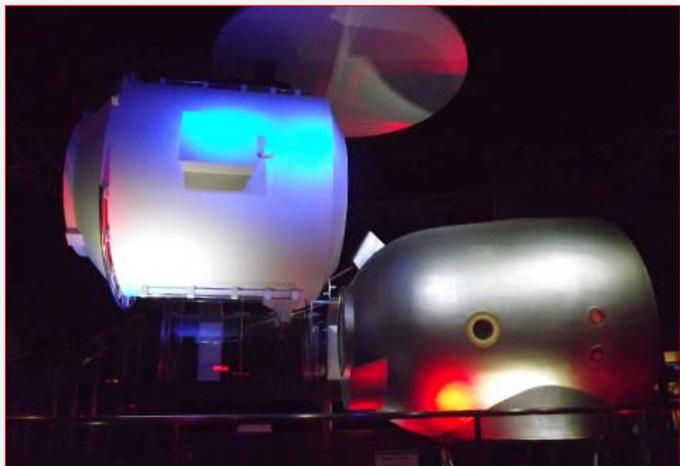
The entrance area of the Hong Kong Space Museum on the tip of Kowloon peninsula. (credit: Morris Jones)



The Macau Science Center. (credit: Morris Jones)



Shenzhou 7 model in Macau Science Center. (credit: Morris Jones)



Shenzhou simulator in Macau Science Center. (credit: Morris Jones)



Extravehicular activity from Shenzhou 7 in Macau Science Center. (credit: Morris Jones)



Simulated space station module in Macau Science Center. (credit: Morris Jones)



Hong Kong Space Museum at night. (credit: Morris Jones)



Mission Control Simulator in Macau Science Center. (credit: Morris Jones)



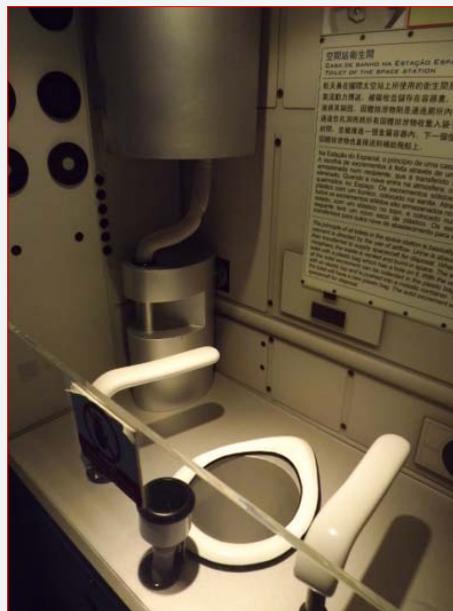
Chinese Spaceflight Exhibit in Hong Kong Space Museum. (credit: Morris Jones)



Yang Liwei model in Macau Science Center. (credit: Morris Jones)



Shenzhou and Tiangong replicas in Hong Kong Space Museum. (credit: Morris Jones)



Space Toilet in Macau Science Center. (credit: Morris Jones)

## Gallery Chang'e 5-T1



The CZ-3C/G2 rocket, with Chang'e 5-T1 on top, standing at the launch pad in Xichang Satellite Launch Centre. (credit: Chinese internet)



The Chang'e 5-T1 launched from Xichang Satellite Launch Centre by a CZ-3C/G2 launch vehicle at 3:00, 24 October 2014. (credit: Xinhua)



A helicopter lifting the capsule from the landing site. (credit: Xinhua)



The Earth and the Moon in a single frame, taken by Chang'e 5-T1 on 28 October at far side of the Moon during its lunar fly-by. (credit: CLEP)



Another Earth-Moon joint image taken by Chang'e 5-T1 on 9 November on the way to the Earth-Moon L2 point after the re-entry capsule had landed successfully. (credit: Chinese internet)



At 6:42, 1 November (Beijing Time), the Chang'e 5-T1 re-entry capsule, nicknamed Xiao Fei, safely landed in Siziwang Banner, Inner Mongolia. Technicians were checking the status of the capsule. (credit: Xinhua)



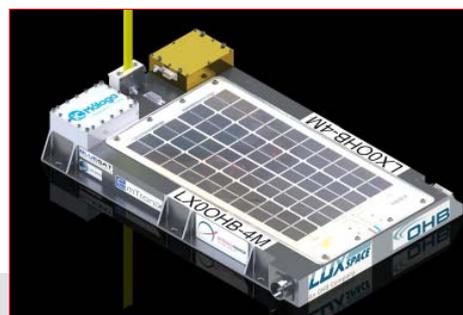
The Chang'e 5-T1 re-entry capsule. This photo shows that its heat shield was scorched much more than its sister Shenzhou. Note that at upper edge of the shield, it was made using a lighter coloured material. (credit: zz.81.cn)



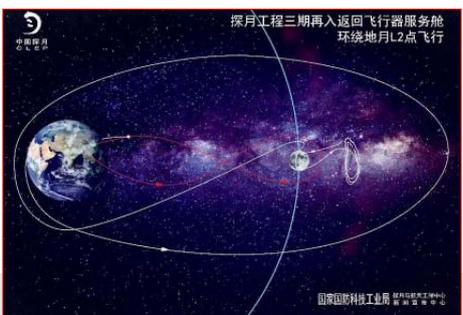
Close-up view of the Xiao Fei capsule. Note stripes in a slightly different colour at the side of the capsule, indicating different ablative materials were used. (credit: Xinhua)



The Chang'e 5-T1 capsule was moved into a Y-8 transport plane, to be returned to Beijing on the same day of landing. (credit: Chinanews)



Model of the 4M payload, developed by LuxSpace and launched with Chang'e 5-T1. (credit: LuxSpace)



Chang'e 5-T1's full trajectory from launch, lunar fly-by, the capsule's re-entry, EM-L2 point orbiting and the final lunar orbit. (credit: CLEP)



A composite photo taken by Chang'e 5-T1 from the Lissajous orbit around the Earth-Moon L2 point, showing different phases of the Moon. (credit: CLEP)