All About The Chinese Space Programme

Go Taikonauts!

龙腾太空

Issue 18 January 2016

One Track, Two Stations - Proposal for Cooperation on CSS and ISS

Editor's Note

The first issue of the year 2016 is coming along with a reorganisation in the newsletter production. As of 2016 "GoTaikonauts!" will be distributed as a PDF and printed brochure but not anymore as an iPad app. This enables us to streamline the publication process and to add to our portfolio the printed version of the newsletter. Our colleagues and partners of the German space magazine "Raumfahrt Concret" support ... page 3

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October - December 2015

Launch Events

China continued the quick pace of space launches with in total 10 rockets launched in the fourth quarter, equaling the quarterly launch record set in the fourth quarter of 2014. The annual launch rate of 2015 also equals the record of 19 launches that happened in 2011 (including one failure) and 2012. For the second time, China surpassed the United States in the total number of successful orbital launches, though the U.S. made 20 launches in 2015 it included two failures. ... page 4

Book Review

"The Three Body Problem" - author: Liu Cixin

It's been many years since I last read a science fiction novel, my favourite author being Isaac Asimov, especially the Foundation Trilogy, with the intervening years reading being more focused on fiction than science. So it was with a somewhat nostalgic curiosity and hopeful anticipation that I began to read what is being referred to as 'the best selling Chinese science fiction novel' - The Three-Body Problem. First published in Chinese in 2006, and translated by Ken Liu, this first book of a trilogy, was published in English for the first time in 2014. Just as Asimov had won the Hugo Award (for the best science fiction novel published in the previous year) in 1995, Liu achieved the same feat twenty years later, in 2015, so the omens looked good. ... page 27

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Interview

"One Belt, One Road, One Inmarsat"

including an interview with Rupert Pearce, CEO of Inmarsat

"... supporting President Xi's visionary 'One Belt - One Road' strategic initiative."

What a reception! From Buckingham Palace to Westminster, from Downing Street to Chequers Court (the UK's Prime Minister's countryside house retreat), from the City of London to Manchester City Football Club, and from a drive in the royal golden carriage through the streets of London and a grand royal welcome hosted by Her Majesty, Queen Elizabeth II to casual beer-drinking ... page 14

Our Point of View

One Track, Two Stations - Proposal for Cooperation on CSS and ISS

During the International Astronautical Congress (IAC) held last October in Jerusalem, there has been a little-noticed twitter message that was posted by Peter De Selding, a senior space journalist, quoting ESA Director General Johann-Dietrich Wörner as saying he wants China to give up its own space station in favour of joining the ISS. "I told China, we don't need two space stations. How about ISS with China participation?... page 17

Our Point of View

A Foothold on the Moon – But for all Mankind

"Moon Village" – this nebulous term coined by former Head of the German Space Agency DLR, Prof. Dr. Johann-Dietrich Wörner is going around the world since the spring of last year. Prof. Wörner, by profession a civil engineer and with an self-confessed aptitude for constructing, is now Director General of the European Space Agency, but his idea of a "Moon Village" is still with him albeit a bit fuzzy. Prof. Wörner is not shy of talking about concepts before the details are clear. Also, he is not shy of using Germany's biggest tabloid ... page 19

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Cultural Perspective

Popular Symbols and Rituals in Space Exploration in China and their Mediation to Soft Power

Following my work Kul'tura Kosmosa which was about the popular culture of space exploration in Russia, I became aware of a similar but new phenomenon in China. Some of the advertising is shown in Figure 1 from the Shanghai Metro in 2012, but I needed to find some way of understanding what was going on inside this image, what was there and what lay behind it. ... page 24

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The current newsletter comprises – like always – a wide variety of topics. Next to the obligatory Quarterly Report, our readers will find an interview with Prof. Maurizio Falanga, since 2013 the Executive Director of the International Space Science Institute Beijing, who was so kind to complement our article on ISSI's work in Beijing with his valuable evaluation of the progress done so far. We are grateful, that the renowned British Professor and space scientist John Zarnecki, who is since last year, one of the Directors of the ISSI in Bern, Switzerland talked with us about his experience in China. Among his tasks is the support to the ISSI institute in Beijing.

Since July 2015, Prof. Dr. Johann-Dietrich Wörner is the new Director General of the European Space Agency ESA. Wörner is known for his unorthodox way of coming up with new ideas. During the IAC 2015 in Jerusalem, Israel in October 2015 Prof. Wörner spoke about the possibility that China could drop its Space Station in favour of joining the International Space Station, ISS. Also, he promoted his special vision of a global exploration programme that he coined "Moon Village". We are trying to analyse both themes and their consequent options for the future.

Our space journalist colleague Theo Pirard from Belgium has been present during the IAC 2015 in Jerusalem and he shares his impressions from a presentation on the Chinese Manned Space Programme with us. Also, he gives us a glimpse of the Sino-Belgian cooperation on the Global-V satellite for the reconnaissance of vegetation. Theo Pirard attended a workshop end of January in Ghent, Belgium where some details of the project were discussed.

Most of our readers might recall the photos from Chinese President Xi Jinping's State Visit to the UK when he and the Queen were sitting in the Queen's Golden Carriage and driving around London. During his days on the British Isles, President Xi also visited British enterprises, among them the London-based satellite communication provider Inmarsat. We took the opportunity to ask some questions to Inmarsat's CEO, Rupert Pearce.

Last but not least, we have included in this issue an interesting reflection on China's space programme by Andrew Thomas. His richly illustrated article opens a new way of looking at the objectives of Chinese space activities, in particular when culture and art is consulted in support of the interpretation of strategic activities.

The same idea is behind our review of the first part of the science fiction triology "The Three-Body Problem" by the Chinese writer Liu Cixin. Since the book won the 2015 Hugo Award for Best Novel and this was even announced during a live feed from the International Space Station by NASA astronaut Kjell Lindgren, we thought, it would be only fair enough to introduce the book to our readers.

Enjoy reading!

Jacqueline Myrrhe

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Chinese Space Quarterly Report

October - December 2015

by Chen Lan

Highlights

- Jilin 1 launched, faces strong competition from CASC.
- Chinese space science turns a new page with Wukong in orbit.
- China launches the world's first geostationary imaging satellite.
- CZ-5 rolls out for a pad drill, ready for debut in 2016.
- China disclosed plans of two new launchers, NAGA-1 and KT-11.
- New CSS design revealed, man-tended 2 m telescope planned.
- Parachutes of the new generation manned spacecraft tested.
- More details of the Chinese Mars plan revealed.
- CALT tests rocket booster recovery.
- Commercial Space Summit Forum made debut, newcomers in New Space emerge.

Launch Events

China continued the quick pace of space launches with in total 10 rockets launched in the fourth quarter, equaling the quarterly launch record set in the fourth quarter of 2014. The annual launch rate of 2015 also equals the record of 19 launches that happened in 2011 (including one failure) and 2012. For the second time, China surpassed the United States in the total number of successful orbital launches, though the U.S. made 20 launches in 2015 it included two failures.

The Gaofen 4 geostationary imaging satellite and the Wukong science satellite were the most significant space missions launched in this quarter. Gaofen 4 (or GF-4) is claimed as the world's first high-resolution imaging satellite in geostationary orbit, other than meteorological satellites and infrared missile early-warning satellites. With the help of a large aperture camera using a 100 million pixel class sensor, it is able to take pictures with ground resolution of 50 m (optical) or 400 m (infrared). It is also able to update an image of the same area in a few seconds, thanks to high speed imaging using the area array sensor and high data transmission rate at 300 Mbps. The GF-4 launch took place on 29 December at 0:04 in Xichang, when a CZ-3B lifted the 5-tonne satellite into GTO. It was scheduled to reach its GEO position at 105.6°E in early January 2016.

Wukong, earlier called DAMPE (Dark Matter Particle Explorer), was launched by a CZ-2D on 17 December at 8:12 from Jiuquan.

The Gaofen 4 geostationary imaging satellite in a ground testing facility. (credit: Chinese internet)

Strictly speaking, it is China's first proprietary science satellite and this launch turned a new page for China's space science programme. Prior to Wukong, China had only two DoubleStar science satellites (TC-1 and 2) jointly developed with ESA, with the latter providing major scientific payloads. China also flew a few piggyback science payloads on other spacecraft such as Shenzhou and Tiangong, the FSW recoverable satellites and some communication, meteorological and engineering satellites.

Among the other 8 launches, half of them were Earth observation satellites including two for military and two for civil/commercial or dual-use. They are:

- Jilin 1, launched on 7 October at 12:13, is the first of a small satellite constellation to provide a high-resolution commercial imaging service. A technological verification satellite and two experimental video satellites were launched together with the main satellite. While the Jilin 1 satellite worked normally after launch, the two video satellites were rumoured to be lost in November. The launch of Jilin 1 opened up a new commercial satellite market in China but it has to face fierce competition from the beginning (see more in the "Commercial Space" section).
- Tianhui 1-03, launched on 26 October at 15:10 by a CZ-2D from Jiuquan, was the third in the mapping satellite series.
- Yaogan 28, launched on 8 November at 15:06 by a CZ-4B from Taiyuan, was an imaging satellite supposedly for military use.
- Yaogan 29, launched on 27 November at 5:24 by a CZ-4C from Taiyuan, was another imaging satellite supposedly for military use.

There were also four communication satellite launches in the last quarter of 2015, two commercial comsats and two military communication satellites. The Apstar 9 and the LaoSat 1 commercial comsats were launched on 17 October at 0:17 and 21 November at 0:07 respectively, both by the CZ-3B rocket from Xichang. Apstar 9 is based on the DFH-4 bus and has a launch mass of 5,250 kg, one of the heaviest lifted by the CZ-3B. The 4-tonne class LaoSat 1 is the first comsat based on the new DFH-4S bus (also called DFH-3B). The CZ-3B also launched the ZX-2C and the ZX-1C military comsats on 4 November at 0:25 and 10 December at 0:46 respectively. From 12 September to 29 December, the CZ-3B made 7 consecutive launches with turnaround time of 17-19 days. It was a new milestone, representing the great level of maturity achieved by the Chinese launch industry and the capability to conduct commercial comsat launches.

Space Transportation

Development of CZ-5 and CZ-7 have entered their final stages. After completion of modal tests (vibration test) of the first and the second stages in Beijing, the CZ-7 full-rocket modal test started on 7 October in Tianjin and would last more than two months. The CZ-7 test rocket has a height of more than 50 m and a weight of 600 tonnes, and was installed with more than 20 vibration exciters and more than 200 sensors. It moved into the 93-m high vibration tower immediately after completion of the CZ-5 full-rocket modal test. The test was to simulate the launch sequence for more than 100 seconds from launch to booster separation. It was one of the largest scale tests of CZ-7, and was also the final major test before its maiden launch. On 13 October, the dual-engine on the CZ-7 first stage completed a 200-second hot test firing to further confirm its reliability after the earlier pad rehearsal. Also, according to various Chinese reports, all tanks of the first flight model of CZ-7 had completed manufacturing by the end of the year.

On the CZ-5 side, there was also similar progress. By early November, all the 5-m diameter tanks of the first flight model of CZ-5 had been completed. And a series of tests were made in this quarter. In early October, the oxygen tank of the booster, developed by SAST, reportedly completed the low-temperature static load test. In late October, the hydrogen tank of the first stage completed a new low-temperature static load test, followed by the explosion test of the same tank, aimed at obtaining the pressure-bearing limit and failure modes, in December.

However, the most noticeable event in the new launcher development was CZ-5's pad drill at the launch site in Wenchang, Hainan Island. It rolled out in the morning of 23 November. The rocket, with the Chang'e 5 lunar sample return vehicle on top, and standing on the mobile launch platform, moved slowly from the vertical assembly building to the launch pad. It was an integrated pad rehearsal to verify both the launch vehicle and the lunar probe, as well as coordination in launch operation. It returned to the building in late December, marking the start of the second phase drill that was expected to be finished in early January 2016. CZ-5's maiden launch is scheduled for late 2016.

During the 66th International Astronautical Congress (IAC 2015) held in Jerusalem, Israel, 12-16 October, CALT presented a paper introducing a new small launch vehicle under development, named NAGA-1. NAGA-1 is a 2-stage launcher using a YF-100 engine for its first stage and a YF-75 cryogenic engine for the second stage. It has a length of 29.22 m, a mass of 98.23 tonnes and uses a 3 m diameter fairing with a length of 5.28 m. The most interesting aspect is that CALT provided payload capability from four launch sites - Jiuquan in China, Esrange in Sweden, and two further sites in Indonesia and Tanzania respectively, in which the former two are for SSO launches while the latter two for LEO launches. NAGA-1 is able to put 720 kg into a 700 km SSO from Jiuquan, or 500 kg into a 600 km SSO from Esrange. From Indonesia and Tanzania, it is able to launch more than 1,500 kg into a 400 km LEO orbit. A CALT official explained during the IAC 2015 that the new launcher is only for commercial launches, and launching from foreign soil is to get around the ITAR regulations. NAGA-1's launch cost is about 10 million USD, according to the paper. It is obviously a competitor of SAST's CZ-6 vehicle which has similar payload range and performance. It seems an internal CALT project without government funding and guaranteed orders. As a result, CALT has to seek customers on the commercial market to avoid competition with CZ-6.

In early November, Chinese media revealed another new small launch vehicle, this time from CASIC (China Aerospace Science and Industry Corporation). The reported KZ-11 solid-propellant small launcher is a largely upgraded version of KZ-1, the only operational space launcher of CASIC. KZ-11 has a launch mass of 78 tonnes and is able to send 1.5 tonnes to LEO and 1.0 tonne to a 700 km SSO with an estimated launch cost of only 10 million USD. It is another CZ-6 class launch vehicle. The reports also indicated that CZ-11 could be launched from a mobile vehicle without the need of a launch pad. It is scheduled to make its maiden launch at the end of 2016.

Satellites

The dark matter detection satellite "Wukong" (DAMPE) is a milestone for China's space science programme, which is China's first science satellite in the real sense. One day before its launch, on 16 December, CAS (China Academy of Sciences) announced the result of the naming contest for the satellite. It was named after the Monkey King, a character in the Chinese classical novel Pilgrimage to the West who has penetrating insight (indicating the satellite's capability to see dark matter), coinciding with the upcoming 2016, the Year of the Monkey. The naming contest started on 29 September and received 32,517 proposals. On 20 December at 8:45, three days after its launch, CAS's ground station in Kashi successfully established data link with the satellite via X-band. On 24 December at 17:55, CAS's Miyun station received the first batch of science data, marking the start of the 2-month in-orbit testing.

Wukong is one of 5 projects in the Space Science Pioneer Programme. Except for Wukong and the suspended Kuafu satellites, the remaining three satellites will all be launched within 2016, according to Chinese reports after the Wukong launch. The Shijian 10 recoverable microgravity satellite will be launched in April and recovered in Siziwang Banner (the Shenzhou and Chang'e 5-T1 landing zone) from an orbit with inclination of 43 degrees. In comparison, all previous recoverable satellites were sent into a 57-70 degree orbit and were recovered in Sichuan Province. The QUESS (QUantum Experiments at Space Scale) satellite will be launched before June 2016, followed by the HXMT (Hard X-Ray Modulation Telescope) in the second half of 2016.

Besides the Space Science Pioneer Programme, a few scientific research satellites are also in development. The TanSat is a global carbon dioxide observatory satellite jointly funded by CAS and the Ministry of Science and Technology of China. On 11 November, flight models of two payloads of TanSat completed their thermal vacuum testing and were ready to be delivered to SECM (Shanghai Engineering Centre for Microsatellites), the main contractor of the satellite. TanSat will be launched in the second half of 2016. On 26 October, the University of Leicester announced that it had been chosen by the French Space Agency CNES to develop an innovative new type of super lightweight X-ray mirror with a value of £3.8 M for the Chinese-French SVOM (Space Variable Objects Monitor) astronomical satellite. SVOM is to be launched in 2021. On 21 December, the SMILE (Solar Wind Magnetosphere Ionosphere Link Explorer) mission completed a review on the mission's science objectives and payload configuration. SMILE is a joint CAS-ESA mission selected from 13 proposals in June 2015. No European experts reportedly participated in the review.

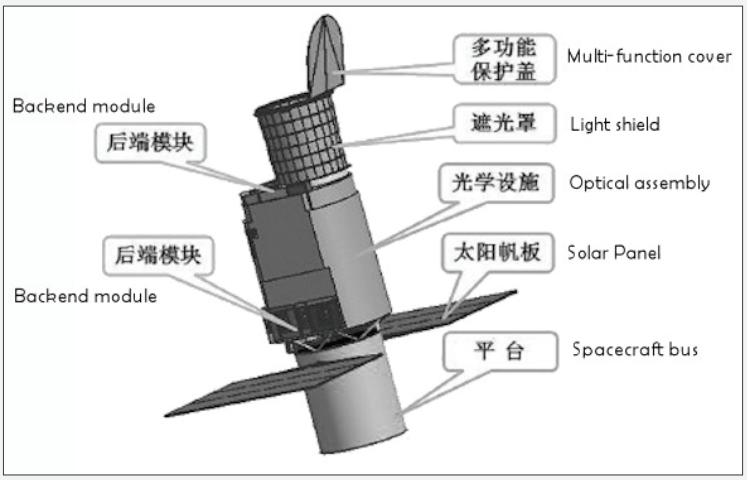
The Tianhui 1-03 cartographic (or mapping) satellite launched on 26 October has joined two existing Tianhui 1 satellites, which greatly enhanced the system's capability. Meanwhile, another cartographic satellite programme run by the National

Administration of Surveying, Mapping and Geoinformation (NASG) was making progress as well. On 20 October, NASG announced that it had started to publicly distribute the DOM (Digital Orthophoto Map) and DSM (Digital Surface Model) products of China generated by its own mapping satellite Ziyuan 3 (ZY-3). It also announced the plan to launch the second ZY-3 satellite in 2016, and the optical and laser altimetric satellite Gaofen 7 in 2018.

In mid- and late October, it was reported that two electric thrusters, the prototype of a 200+ mm ion thruster (presumably an improved model of LIPS-200) and the flight model of the LHT-100 Hall Effect thruster, both of which were developed by the Institute 510 of CAST, completed a series of tests, paving the way for them to be used on satellites.

Manned Space Flight

During the IAC 2015, Chinese scientists and officials revealed more details about the Chinese Space Station (CSS). One significant change from the old design is that the planned large-scale survey telescope at the Experiment Module 2 (Xuntian) was removed from the module and had become a man-tended free-flyer telescope. The telescope has an aperture of 2 m, comparable to Hubble's 2.4 m. It will be launched into the same orbital plane with the station and will be able to dock with the station when needed for maintenance or repair.



The maintainable free-flyer telescope as part of the Chinese Space Station. (credit: CAS)

There were sparse reports on the station's development. In November, it was reported that the Institute 502 of CAST had developed China's largest magnetic torquer with 3,200 ampere square metres. On 9 December, China Space News reported that a prototype of the glove of the new EVA spacesuit was completed and passed a review. Both the magnetic torquer and the spacesuit are supposed for the space station programme. In mid-October, China News Service delivered a report that the window glass to be used in the lighting system of China's space station has been successfully developed by Star Arrow Special Glass in Qinhuangdao, in north China's Hebei Province. During the WRC (World Robot Conference) 2015, held on 23-25 November in Beijing, CAST displayed one of the robotic arms it developed for the CSS. The 10.2 m long, 7 degrees of freedom arm will be installed on the core module (Tianhe). It has a payload capability of 25 tonnes and is able to "walk" with its two ends, similar to the ISS Canadarm 2 and European Robotic Arm (ERA). A second arm developed for the experiment module was not displayed.

In space, the Tiangong 1, a predecessor of the CSS, has worked more than four years since its launch on 29 September 2011. Status checking done on its fourth anniversary showed that the module was in good health and was able to continue carrying out the extended mission. In mid-December, according to USSTRATCOM, it raised its orbit to 388 x 403 km, the first time above 400 km. On the ground, preparation for the Tiangong 2 launch was also underway. In October, CALT completed the first round testing of the CZ-2F to launch the Tiangong 2 laboratory.

In late October or late November, CAST conducted the first air drop test using multiple parachutes. The recovery system consists of three main chutes each having an area of 1,200 square metres, the same as the parachute used by the Shenzhou. The test was performed using an Mi-26 heavy helicopter and was successful. It is believed the test was for the next generation Multi-Purpose Manned Spacecraft.

The parachutes developed for the new generation manned space vehicle in drop testing. (credit: Weibo/CASC)

Lunar and Deep-Space Exploration

The Chang'e 3 lunar probe and the Yutu rover continued to be in a stable status on the lunar surface, though not fully functional. Yutu signaled the Earth again and again every lunar day. On Christmas Eve, it woke up and sent back signals seen as "Christmas greeting". It has become the lunar rover that has lived (not worked) for the longest time on the lunar surface.

On 22 December, Nature Communications published a report by a team of Chinese lunar scientists on the composition of soil along the rim of a 450-m diameter fresh crater at the Chang'e 3 landing site, investigated by the Yutu rover with in-situ APXS (Active Particle-induced X-ray Spectrometer) and VNIS (Visible and Near-infrared Imaging Spectrometer) measurements. Results indicate that this region's composition differs from other mare sample-return sites and is a new type of mare basalt not previously sampled, but consistent with remote sensing.

The Chang'e 5 lunar sample return probe participated in the CZ-5 pad rehearsal in Wenchang starting from November. A team from NSSC (National Space Science Centre, CAS) also participated in the rehearsal as NSSC is responsible for the payload sub-system of Chang'e 5. In December, CAST completed the calibration and darkroom test of the microwave radar to be used in Chang'e 5 lunar orbit rendezvous and docking. The results showed that the system worked well.

An IAC 2015 paper gives more details of the Chinese Mars mission. The mission, planned for 2020, includes an orbiter, a lander and a rover, with a launch mass of 2,350 kg. It will be launched by a CZ-5 and will land on the Martian surface using aerobraking, parachutes and thrusters. In 2028 or 2031 China will then launch a sample return mission re-using Chang'e 5 technology and including a 5,000 kg orbiter, a 2,500 kg lander and ascent vehicle, and a re-entry capsule.

A model of China's Martian probe was displayed at the China International Industry Fair, opened on 3 November in Shanghai. The golden model, which is one third of its real size, is believed to be a design done by SAST. It was rumoured to have lost to the CAST proposal (the latter was once displayed in Airshow China 2014 in Zhuhai). At the WRC 2015 (World Robot Conference) in Beijing, CAST displayed a soil sample capture robot designed for deep-space exploration, together with the space station robotic arm mentioned in the previous section.

Although the 2020 Mars mission is still waiting for the government's approval, work at a certain level is underway. It was reported in mid-October that CAST had completed 30 air drop tests of a "Martian parachute". The tests were carried out from a tower involving 5 different parachute designs.

Advanced Technology

During the IAC 2015, authors from the Qian Xuesen Laboratory of Space Technology, CAST, published two papers about the Space Solar Power Station (SSPS). One of the papers discussed in-orbit assembly of a huge SSPS with two 3-km long solar arrays and a 1-km wide antenna. It would be launched by 200 50-t class heavy launch vehicles (interestingly, it proposed to use Falcon 9 Heavy of SpaceX). An orbit transfer vehicle (for moving parts from LEO to GEO) and two kinds of space robots are designed to carry out the assembly by automatic planning, whose algorithms are also discussed in the paper. Another paper is on thermal control of the SSPS. There have been serious research papers on SSPS in China in recent years. And also, experiments to test relevant components or technologies have also been proposed for the upcoming CSS. The latest papers on IAC 2015 showed that China's study on SSPS is being broadened and deepened.

In late November, CALT conducted an air drop test for the recovery of the rocket stage using multiple parachutes. Valuable data of touch-down velocity and overload have been collected and the feasibility of using multiple parachutes was verified, paving the way for further tests.

The balloon lifting the test rocket stage for a recovery test. (credit: WeChat/CALT)

International Cooperation

During the IAC 2015, China re-iterated the wish for international participation and cooperation in its space station project including extending the station by modules provided by international partners. Twitter messages posted by a European journalist from the Congress, that is still to be confirmed, however, showed a different view from ESA. ESA's new Director General Johann-Dietrich Wörner said he had told China that the world does not need two space stations and will likely persuade China to drop its space station in favour of joining the ISS. On the other side, during the traditional "Heads of Space Agencies Panel" in IAC 2015, NASA Administrator Charles Bolden expressed his belief that the current exclusion of China from the ISS will not last forever.

Though Sino-U.S. cooperation on human spaceflight is still uncertain, a positive move between the two countries has been made, that is the establishment of a space hotline. Western media reported in November that the hotline has been set-up between Washington and Beijing to allow easy sharing of technical information about their space operations, hopefully avoiding any misunderstandings or accidents.

Russia's space agency Roscosmos on 17 December signed a cooperation agreement with the China National Space Administration (CNSA). The document was signed at the 20th regular meeting of Russian and Chinese Heads of Government, during Russian Prime Minister Dmitry Medvedev's three-day visit to Beijing. The two sides agreed to promote the use of "GLONASS" and "Beidou" and their augmentations in their own countries and around the world, expanding the market of navigation services provided by these systems. The two space agencies signed another agreement on the same day on cooperation in the field of space electronics. It was reported earlier that the two countries were discussing a barter deal that Russia will import Chinese space electronic components and will export rocket engines, presumably the RD-180, to China. However, an official statement about the agreement did not mention the engine. Also on the same day, Russian state-owned nanotechnology company RUSNANO and the China Aerospace Science and Industry Corporation (CASIC) signed a strategic partnership agreement.

CNSA also signed an agreement with the Netherlands on 26 October, and a memorandum of understanding with the UAE (United Arab Emirates) on 15 December, on exploration and peaceful use of outer space.

A year after India signed its first space cooperation agreement with China, scientists from ISRO and the Chinese space agency have decided on six major areas of interest, including the hosting of payloads on each other's satellites and inter-planetary missions. The other areas of interest are Earth observation, disaster management, space science and navigation, as the Times of India reported on 5 October.

The Brazilian Ministry of Science, Technology and Innovation announced on 30 December that the sixth CBERS (China-Brazil Earth Resources Satellite) satellite, CBERS-4A, is scheduled to be launched into space in December 2018.

The Planetary Science Institute signed a cooperation agreement with the Qian Xuesen Laboratory of Space Technology (Qian Xuesen Lab), CAST, on 15 December to advance their mutual interests in facilitating the open-ended expansion of the exploration of the solar system and to use the knowledge thus

gained in supporting the expansion of human activity beyond the Earth. Both institutions also wish to advance their common interest in communicating to the public the knowledge and benefits gained through robotic and human exploration of the solar system.

Commercial Space

On 30 October, the China Commercial Space Summit Forum was held in Wuhan, Hubei Province. The forum was organised by the Wuhan Municipal Government, CASC, CASIC, China Electronics Technology Group, China Space Foundation and Chinese Society of Astronautics. Nearly 400 participants from 140 organisations including government bodies, military, universities, internet and investment sectors, as well as media, attended the forum and discussed issues on policy, business model, technology and investment. It was a milestone for commercial space in China and probably indicated the upcoming potential booming of the Chinese commercial space industry.

Information from the forum showed that the Jilin 1 and the follow-up imaging smallsat constellation is not the only imaging satellite constellation. China Aerospace Science and Technology Corporation (CASC) has planned a competing commercial imaging system referred as the "16+4+4+X" constellation that will consist of sixteen 0.5 m resolution optical satellites, 4 high-end optical satellites, 4 microwave (radar) satellites and several video and hyperspectral satellites. The first two 0.5 m optical satellites, Gaojing 1 and 2, will be launched before the end of 2016, followed by Gaojing 3 and 4 at the end of 2017. Completion of the whole constellation is scheduled for 2022. With the rich experience from CAST, its subsidiary, of developing imaging satellites, especially development of the Gaofen satellites, the CASC constellation may be established faster and become more competitive in the market. CASC has set-up a company in September to run the business.

The Collaborative Innovation Centre of Geospatial Technology, located in Wuhan and backed by Wuhan University, CASC, Tsinghua University and Beihang University, proposed a satellite imaging constellation consisting of 24 optical and 6 radar satellites with an overall ground resolution of 0.7 m. It is unclear whether it has connections with the CASC plan.

The CASIC's planned satellite constellation is more ambitious, but is for communication instead of imaging. It plans to launch 156 small satellites to 1,000 km altitude to provide global internet access. The constellation is named Fuxing, or "Star of Happiness". It is the second publicly reported LEO communication constellation in China after the Xinwei/Tsinghua's 64-sat system, whose first demonstration satellite (SCES) was launched in September 2014. CASIC had been seeking external investment and international partners. The effort obviously paid off. Russia's news agency RIA Novosti reported on 8 November that Russian and Chinese experts are discussing the possibility of cooperation on the Star of Happiness project, according to the Director General of the Information Satellite Systems, Nikolay Testoedov. The news did not mention the role Russia plays.

In another Sino-Russian commercial space project, China will play the role of the investor. On 13 October at the second Chinese-Russian Expo in Harbin, the Chinese investment fund, Cybernaut, signed an agreement with the Russian space technology company, Dauria Aerospace, to invest $70 million to develop 10 satellites as part of the Urban Observer project to conduct daily imaging of the world's 100 largest cities with a resolution of 0.7 meters per pixel. A joint venture will be created in Hong Kong.

In the area of traditional commercial space, the China Great Wall Industry Corporation (CGWIC) is the only Chinese player on the international market. In October, it lost the bid for the first Bangladeshian geostationary communications satellite, Bangabandhu 1. Thales Alenia Space of Italy won the contract. It was reported that CGWIC had the highest stipulated costs in the bidding. But there was also some positive news for the Chinese company. On 17 October, it signed the contract with APT Satellite to launch the Apstar 6C comsat by 18 March 2018 and in-orbit deliver by 1 May 2018. Apstar 6C will be based on the DFH-4 bus with 45 C/Ka/Ku transponders onboard. It was also followed by a framework agreement signed on 12 November for in-orbit delivery of the Apstar 10 comsat. CGWIC also started discussion with Nigeria on NIGCOMSAT-2 and -3 comsats worth 700 million USD. China built and launched the DFH-4 based NIGCOMSAT-1 (which failed in orbit) and 1R (its replacement) in 2007 and 2011 respectively.

The so-called New Space (or private space, differs from traditional commercial space focusing on satellite applications), has also appeared in China, but in a very early stage of development. Except for LinkSpace (formerly Lingke Aerospace) that was founded two years ago and is developing sounding rockets, there have been a few newcomers. OneSpace, a start-up company invested by Chun Xiao Capital, Legend Star (a Lenovo controlled angel fund) and HIT Robot Group, founded before the end of 2015, is one of them. It aims to develop launch vehicles for small satellites. On its web site (www.onespacechina.com), it claims to make the first launch with its small launcher in 2018 that has a LEO capacity of 500 kg and an SSO capacity of 350 kg, followed by a medium-sized launcher in the mid-2020s. LandSpace (www.landspacetech.com) is another new and mysterious start-up that appeared near the end of 2015, aiming to develop an "affordable and reliable launch vehicle". It states on its website that it offers space transportation solutions covering technical, logistics, commercial and insurance aspects by cooperating with key launch vehicle manufacturers in China, indicating a strong background link to China's existing space industry. In early December, it was circulated on the internet that Zhou Hongyi, founder of Qihu 360 Technology and an internet tycoon in China, had planned to launch the "China's first private rocket" in January 2016. It is believed to be a sounding rocket.

It is too premature to determine if all of the above projects are serious and will eventually bear fruit. While in the near-space area, it is much easier to see some results, though strictly it has nothing to do with space. On 13 October, the Yuan Meng, a 18,000-cubic-square helium "near-space" airship took-off in Xilinhot, Inner Mongolia, and completed a test flight up to 20,000 m altitude lasting 48 hours. The Yuan Meng was jointly developed by the Beijing Nanjiang Space Technology, Beihang University and the Xilingol League of Inner Mongolia. In mid-December, the "Jump From Edge of Space" project was put online on a Chinese crowd-funding website in the hope of recruiting volunteers to challenge the high-altitude parachuting record of 41,419 m. The project is sponsored by Space Vision, a start-up company to provide near-space tourism. The president of the company, Jiang Fang, is also the first Chinese citizen who booked a suborbital flight in 2005.

Miscellaneous

Ground Facility

Construction of the FAST (Five-hundred-metre Aperture Spherical Telescope) made fast progress. Chinese media released a photo taken on 16 December showing the assembly

site of the telescope in Pingtang, Guizhou Province, where 2,059 of the total 4,450 reflector panels had been installed. The telescope is expected to complete panel installation in April 2016 and put into use in September 2016.

Space Education & Entertainment

China's Central Bank released a special set of commemorative bank notes and coins on the 26 November to celebrate the country's space achievements and progress. The set includes a 100 yuan bank note and a 10 yuan coin, featuring the DFH-1 satellite, the CZ-2F rocket, Shenzhou 5, Tiangong 1 - Shenzhou 9 docking, Chang'e 1 lunar probe, Yutu lunar rover, and the Chinese Space Station to be completed by 2022.

An exhibition, themed on the life of Qian Xuesen, the Father of Chinese Rocketry, was staged in California Institute of Technology (Caltech) on 2 October 2015. Marking the 60th anniversary of Qian's return to his homeland from the U.S. in 1955, the exhibition features numerous archives, documents and images of the scientist throughout his life and career. Qian was a Caltech alumnus and one of the founders of the Jet Propulsion Laboratory (JPL). Qian Yongzhen, Qian Xuesen's daughter, and Dr. Thomas F. Rosenbaum, president of Caltech, attended the opening ceremony of the exhibition. It was sponsored by the Qian Xuesen Library, Shanghai Jiao Tong University, Caltech, Shanghai Municipal Education Commission and Chiao-Tung (another spelling of Jiao Tong) University Alumni Association in America (CTUAAA).

Who Said that China is not up to Space Science?

by Jacqueline Myrrhe

Among chocolate, precision watches and other noble and interesting things, Switzerland is famous for its cheese with big-big holes in it. What is lesser known about Switzerland is the existence of its academic environment and space science expertise. But still, it was Professor Johannes Geiss, a Swiss scientist who drove the establishment of the International Space Science Institute in Bern.

In the late 1980s, the international exploration of Comet Halley, involving the big space agencies of that time lead to a big success but also a wealth of data. Together with his colleagues, Prof. Geiss wanted to make best use out of those collected valuable information, and looked for ways to utilise the results in an interdisciplinary way - coordinated and across the different fields of science. So what might be good for Swiss cheese - having big holes and gaps - is not at all desirable in scientific research.

Since the establishment of ISSI in Bern in 1995, several means of scientific interaction and intellectual exchange were successfully introduced. The office is open to **Visiting Scientists** by invitation "to work on scientific subjects at the forefront of research in areas of the international space science communities."

But there are also **International Teams** formed after applications originating from an Annual Call. Typically, the International Teams are "composed of about 8-15 scientists of different laboratories, nationalities and expertise. They hold a series of two to three one-week meetings over a period of 12 to 18 months".

Another ISSI tool are **Working Groups**, which "are set up for specific tasks, also of technical nature. The results of the Working Groups activities are published as volumes of ISSI Scientific Report Series or in the scientific literature".

ISSI's Science Committee recommends up to five topics per year, studied during a one-week long **Workshop**. The Workshops "can be attended by 40-45 invited scientists and experts. The results of the Workshops are published as refereed papers in issues of Space Science Reviews and in parallel as volumes of the Space Science Series of ISSI".

And last but not least, once a year, ISSI invites 25 leading experts for a two-day **Forum** where "informal and free debate ... on open questions of a scientific nature or of science policy matters" can take place in Bern.

ISSI Bern's website (*http://www.issibern.ch/index.html)* explains in clear and good detail the conditions and options for taking part in those activities. Also, on the website are well-sorted links to ISSI's publications, although only the outreach publications (Annual Report, ISSI presentation, Spatium magazine) are for free download.

"I wish science could be a tool, just like sport, to break any political barrier and bring people to work together"

interview with Prof. Maurizio Falanga, Executive Director of International Space Science Institute Beijing

For the past two decades, China has been greatly looking to the stars. In 1992, China started the implementation of a strong space programme, which resulted in the development and launch of the Shenzhou spacecraft and the Long March launcher, the first taikonaut in space in 2003, as well as the orbiting space station Tiangong 1 in 2011. Meanwhile, China has sent various satellites to space, including the lunar probe Chang'e, to

On 16 July 2013, Professor Rafael Rodrigo, Executive Director of the International Space Science Institute ISSI and Professor Wu Ji, Chairman of the Board of Trustees of ISSI-Beijing and Director General of NSSC, jointly inaugurated the International Space Science Institute-Beijing. ISSI Beijing is hosted at the National Space Science Center NSSC of the Chinese Academy of Sciences CAS.
(credit: ISSI/NSSC)

ISSI Beijing's science publication "Taikong"
(credit: ISSI/NSSC)

The success of ISSI, did not echo throughout Switzerland only. ISSI Bern earned European-wide, actually world-wide recognition. In autumn 2011, the Director General of China's National Space Science Center, NSSC, Prof. Wu Ji visited the Bern institution and what he saw inspired him to the idea to "export" ISSI's structure, tools and working mechanisms to Beijing. Later on he recalled: "The idea to establish ISSI-BJ goes back to my visit of ISSI Bern in October 2011. It surprised me that a small organisation, with less than 20 staff members, has such a good performance attracting nearly 1,000 top-level scientists from all over the world every year in different disciplines of space science to do cutting-edge research and to discuss the frontier topics together. Of course, my positive impression also came from the institute's outstanding outcomes of both publications and reports, which has a significant influence on the space science communities. During this visit, I proposed the initiation of establishing a branch in Beijing. I discussed with Professor Roger-Maurice Bonnet, then the Executive Director of ISSI. We both agreed that such a new institute could contribute to the international space science community, to the development of space science in China and of course to the development of ISSI itself."

In the "Annual Report 2013/2014 of International Space Science Institute Beijing (ISSI-BJ)" Wu Ji, describes what then followed after his trail-blazing visit.

Already in February 2012, Mr. Simon Aegenter, at that time Chair of the ISSI Board of Trustees, and Professor Roger M. Bonnet, the Executive Director of ISSI flew to China's capital to meet Wu Ji at his home institution, the National Space Science Center (NSSC) in Beijing. Here the group discussed the implementation of ISSI in Beijing and the two parties signed a MoU for cooperation, which was approved by the ISSI Bern's Board of Trustees in June 2012. After the adoption of the proposal in November 2012, preparation of the new institute started straight away. Wu Ji again: "In April 2013, the ISSI Board confirmed the status of ISSI-BJ and agreed that ISSI-BJ can share the name, the logo and the tools with ISSI." Just as ISSI's tools would be shared and implemented mirroring the Bern institutional environment. But most importantly Prof. Wu stressed: "ISSI-BJ quickly became an ISSI-like institute but with its own characteristics. ... [The] new institute, the International Space Science Institute - Beijing, was inaugurated on July 16, 2013. Since then, we have seen ISSI-BJ growing well and becoming a wonderful platform for the international space science communities, which is both the objective of ISSI in Bern and also this institute in Beijing."

While ISSI-Beijing's first Executive Director, became Professor Maurizio Falanga, the function of the Chairman of the Board of Trustees of the International Space Science Institute Beijing, was given into the trustworthy hands of Prof. Wu Ji - a scientist who has gained extensive working experience in Europe and is like nobody else predestined and experienced to drive China's science onto the global stage. He stated in ISSI-Beijing's Annual Report 2013/2014: "The message I would like to impart to you here is, that what you have seen till now is just the beginning. There is still a great potential for development. On the one hand, China is developing very fast which provides great opportunities to invest in space science satellite missions. On the other hand, a fast-growing space research community in China needs to talk with their colleagues abroad. The most efficient way is to go to ISSI-BJ. For the same reason, space researchers outside of China may find new opportunities here with both missions and people. I would like to express, that everyone is welcome at ISSI-BJ. It is a purely international, and multi-lateral, platform. Science is freely discussed without disturbances. Please come to visit us and give your contributions on space science."

For all who cannot so easily come along to Beijing, ISSI Beijing's website is worth a side trip. One can find the download link for the Taikong magazine, published by ISSI Beijing. The Taikong brochure constitutes the output of the Forums organised at ISSI-Beijing. It reports the content of the forums

explore our solar system more intensely. Future missions are already planned: the Chinese nation continues its "space dream". Prof. Maurizio Falanga, Executive Director of ISSI Beijing was so kind to give more detail on the involvement of his institute in progressing the current situation.

GoTaikonauts!: What is your evaluation of the work of ISSI Beijing during the first two and a half years of its existence?

Prof. Falanga: I would say that ISSI Beijing was established at the right moment in the appropriate country. There are two reasons behind it: 1. ISSI Beijing is an international cooperative platform for space science research. 2. China is now developing space science missions quickly.

It is not only an important platform of international cooperation for Asian space science, but also an important window of making Chinese space science missions open to the world and making scientists all over the world know Chinese or Asian space science missions.

The programme of ISSI covers a widespread spectrum of disciplines including the physics of the solar system and planetary sciences to astrophysics and cosmology, and from Earth sciences to astrobiology. Already during the first two and a half years of its existence, ISSI Beijing was able to invite world-leading space science scientists and Principal Investigators. ISSI Beijing is developing into an institute of excellence in Beijing and is also able to strengthen the relations between Asian/Chinese scientists and foreign scientists, such as ESA and NASA, etc.

GoTaikonauts!: Which of ISSI Beijing's tools are in particular successful and why?

Prof. Falanga: ISSI Beijing is an international, neutral and non-profit institute to serve the space science communities. ISSI Beijing's mission objectives are quite unique, since it is an institute to serve the space science communities in multi-lateral and multi-disciplinary activities. ISSI-Beijing is open to support projects from any Asian or international scientist or institute; therefore, ISSI Beijing is able to attract Asian as well as international scientists to work together in Beijing. Its main objective is to deepen the understanding of space science and technology for future Chinese space missions and to study the results of past missions through multi-disciplinary research. To achieve this, the Institute organises equally useful forums, workshops, meetings for international teams, etc.

GoTaikonauts!: What are the long-term objectives of ISSI Beijing?

Prof. Falanga: NASA (National Aeronautics and Space Administration of the U.S.A.) and ESA (European Space Agency) cut some financial resources, but China has a remarkable space programme. Before, Europe used to look at the United States for international cooperation, now

and reflects, in a neutral way, the Forum's discussions and advice from all the participants.

Also on the website are information on all the past and upcoming activities, organised in Beijing. An interesting and innovative activity in Beijing is "Understanding Science" co-organised by the UK Royal Society of Chemistry RSC, the Institute of Physics IoP and the International Space Science Institute in Beijing. Through scientific lectures in the English language, a broader public is made aware of today's accomplishments in research. During its past events, Swiss astronaut Prof. Claude Nicollier or even Prof. Wu Ji himself have used this opportunity to get in direct contact with the young generation of Chinese scientists.
It is worth stressing that the already mentioned "Annual Report 2013/2014" is an informative and revealing read. On page 15 - 16, Visiting Scientists Professor Mario J. Pinheiro, University of Lisbon, Portugal and Vittorio De Falco, Ph.D. candidate, University of Basel/ISSI, Switzerland, share their rich experience about their work in ISSI-Beijing and their experiences in China.

Prof. Falanga was right when he emphasised the fact that ISSI Beijing "was established at the right moment in the appropriate country." A recent interview with Chinese physicist Pan Jianwei by science weekly "Nature", revealed that China is in the middle of getting rid of its past reputation of not investing sufficiently in space science.

Pan Jianwei from the University of Science and Technology of China in Hefei is leading a satellite project aimed at setting-up a quantum communications link between Earth and space to be launched in June this year. When "Nature" magazine asked him whether basic-research satellites are a new trend for China, he answered that previously only the army and the Ministry of Industry and Information Technology were able to transport payloads into space: "So scientists had no way to launch a satellite for scientific research. ... We at the Chinese Academy of Sciences CAS really worked hard to convince our government that it is important that we have a way to launch science satellites. In 2011, the central government established the Strategic Priority Program on Space Science, which DAMPE and our quantum satellite are part of. This is a very important step." Pan Jianwei went on to explain that also for the future Chinese Space Station, the signs look promising for science: "The mechanism to make decisions for which projects can go to the [Chinese] space station has been significantly changed. Originally, the army wanted to take over the responsibility, but it was finally agreed that the Chinese Academy of Sciences is the right organisation. We will have a quantum experiment on the space station and it will make our studies easier because we can from time to time upgrade our experiment (unlike on the quantum satellite). We are quite happy with this mechanism. We need only talk to the leaders of CAS - and they are scientists, so you can communicate with them much more easily."

Pan Jian Wei's words illustrate clearly that ISSI Beijing was indeed established in the right place at the right time - offering potential benefits for the science community all over the world.

the attention of U.S., European and Japanese scientists moved to China for future space missions, they even come to Beijing at their own expense, to take part in our international and neutral platform to do research, to bring their contribution and to discuss about future missions.
I wish science could be a tool, just like sport, to break any political barrier and bring people to work together on science. China contributes significantly to this process and ISSI Beijing should give its small contribution.

GoTaikonauts!: What do you personally like best about your work in Beijing - with Chinese colleagues, in a Chinese environment?

Prof. Falanga: China nowadays opens its doors to all and this Institute is a small part of this new philosophy: be open to other countries, to welcome scientists here to work together with Chinese colleagues to facilitate international cooperation in space research. So, all what is organised here, must be international, multi-disciplinary, and informal. This is a neutral area where scientists meet just for the sake of scientific research.

Links:
ISSI Beijing: *http://www.issibj.ac.cn/*
Taikong magazine: *http://www.issibj.ac.cn/Publications/Forum_Reports/201404/t20140404_119042.html*

The article is based on information from ISSI Bern and ISSI Beijing website and the "Annual Report 2013/2014 of International Space Science Institute - Beijing (ISSI-BJ)" The interview by science magazine "Nature" with physicist Pan Jianwei can be found at: http://www.nature.com/news/china-s-quantum-space-pioneer-we-need-to-explore-the-unknown-1.19166

"We hope that our institute will become an integral and important part of the Chinese space institutional environment."

interview with Prof. John Zarnecki

Go Taikonauts! spoke with Prof. Dr. John Zarnecki at the 10th UK-China Workshop on Space Science & Technology in September 2015 in Newbury, UK.

GoTaikonauts!: Prof. Zarnecki, I understood that you – despite being retired – are very-very busy again?

Prof. Zarnecki: I always have listened in disbelief to those old people who claim that they have never been so busy since they retired. Now I find, that I am saying that.

GoTaikonauts!: How does it feel?

Prof. Zarnecki: I took the right decision. After having taught students for 35 years, I do, again, interesting things. I work part-time at ISSI, the International Space Science Institute. ISSI was established in 1995 in Bern, Switzerland. One of ISSI's strengths is to bring people from all over the world together - in a multi- and interdisciplinary way – to address open scientific questions. At the end of this process which can take up to a week, the experts produce an output in the form of a scientific paper, or we have a series of books published by a renowned international science publisher.

The brain behind ISSI was Swiss Professor Johannes Geiss who is a very eminent space scientist now approaching the age of 90. He was responsible for the first experiment deployed

by the Apollo astronauts on the surface of the Moon. In the late 1980s, he saw that available data from excellent science missions, such as the space mission to Halley's Comet, could be used for further processing in an inter-disciplinary approach. He realised that this opportunity did not yet exist and he wanted to close the gap. ISSI was funded by the Swiss authorities, with grants from Swiss industry and ESA. It is by many people regarded as very successful.

Nowadays, we have typically 1,000 people per year pass through the doors of ISSI, either in groups or as individual scientists. We have various tools, as we call them: we have working groups which meet two or three times over a two-year period, we have a workshop which is an intensive one-off one week meeting or forums which are higher-level discussions of scientific strategic issues.

A few years ago, there was a discussion between Wu Ji - Head of the National Space Science Centre (NSSC) of the CAS and the former ISSI Executive Roger M. Bonnet. Prof. Wu Ji was very impressed with what he saw and therefore he wondered whether it could be mirrored with a similar institution in China. This request was considered and positively viewed by the ISSI Board of Trustees and therefore it was agreed that there would be an ISSI Beijing set-up. It is indeed a mirror of the Bern institution with the same scientific committee and activities.

In Bern we have a Science Committee that chooses the themes and the workshops. This process is a peer-reviewed process and is very competitive. We have the same Science Committee that assesses applications in both places. Considering that our Science Committee has always been truly international, this works very well.

And ISSI Beijing which officially started in 2013 essentially follows the same format, it uses the same tools, it is open to scientists from around the world, but obviously being in Beijing the focus is more on the Asia-Pacific region but the international approach is dominant.

We had already a series of workshops and forums in ISSI Beijing. On the well-maintained ISSI Beijing's website you can see all the details. ISSI Beijing is located in the NSSC building, however NSSC is just the host providing some in-kind contribution like the rooms and some administrative support, but ISSI Beijing is an independently acting institution.

The scientific disciplines covered, range from Earth Observation through to the edge of the universe, cosmology and everything in-between.

The driving factor is space data, data taken by space vehicles but those data could be combined by observations from the ground, modelling, laboratory experiments, but there has to be a space component.

GoTaikonauts!: What is your specific function?

Prof. Zarnecki: My personal role is that I am one of the Directors of ISSI in Bern. We have an Executive Director and three Directors of which two are part-time. In Beijing they have an Executive Director from ISSI Bern on a part-time basis, Prof. Maurizio Falanga, and a Chinese Administrative Director, Prof. Xiaolong Dong.

As a Member of Staff in Bern I go sometimes to Beijing. We assess collectively the programme in the two places [Note: ISSI Beijing has an independent science programme from Bern, and it is not assessed by the ISSI Directors but by the Science Committee members]. We hope that our institute will become an integral and important part of the Chinese space institutional environment. I would say, our Chinese science colleagues see the ISSI Beijing as another step to internationalise their activities and to compare their research not only on a national but also international level.

GoTaikonauts!: What are your expectations for the next five years?

Prof. Zarnecki: I would like to see us to have far too many applications which of course in a way is sad because you have to disappoint people but it would be a mark of success. If in five years from now we would have three times as many applications it would tell us we are going in the right direction.
Another issue is funding: we would like to see secure funding. At the moment we cannot complain, but we look into the future and would hope for secure long-term funding.
We were very pleased for any support from industry, Chinese or Asian industry. We are looking into this right now, but for the moment it is limited to agencies or institutions for in-kind support. Interestingly, Russia, for example, is providing small financial support for ISSI in Europe.

GoTaikonauts!: Was the workshop useful for you?

Prof. Zarnecki: This workshop is related to British-Chinese cooperation. So my aim was not to directly promote ISSI. But I could learn here about specifics in cooperation with China. One of the challenges we have in China is to make the ISSI facilities and tools known. There we have to do more outreach. Also, we do some interesting activities in Beijing, like an initiative called "Café Scientifique – Understanding Science" where you have a meeting in a cafe. We usually have around 50 Chinese students. In this informal environment we present an international speaker and have a lively discussion. You might be aware of the fact that in particular, Chinese students are hesitant to debate in the presence of authority figures, however, if you choose an informal, relaxed environment you have really interesting and good debates. So, this is an interesting cultural experience, highly enjoyable for me.

left: Prof. John Zarnecki, Director of the International Space Science Institute ISSI Bern. (credit: ISSI Bern)

right: Prof. John Zarnecki was during the 10th UK-China Workshop on Space Science & Technology in September 2015 in Newbury, UK the lead and rapporteur for the space science session. He is giving the results of the presentations and discussions during the summary presentation. (see: GoTaikonauts! issue no 17) (credit: GoTaikonauts!)

"One Belt, One Road, One Inmarsat"

by Jacqueline Myrrhe

What a reception! From Buckingham Palace to Westminster, from Downing Street to Chequers Court (the UK's Prime Minister's countryside house retreat), from the City of London to Manchester City Football Club, and from a drive in the royal golden carriage through the streets of London and a grand royal welcome hosted by Her Majesty, Queen Elizabeth II to casual beer-drinking at a countryside bar with Prime Minister David Cameron - the Chinese President Xi Jinping and his wife were hosted during the state visit to Great Britain with formidable honour, respect and welcoming warmth. British media could not publish enough colourful photos, labelled the state visit to Great Britain as "historic" and celebrated the event with superlatives each day of its duration from 20 to 23 October 2015.

China's Foreign Minister Wang Yi said at the end of Chinese President Xi Jinping's four-day stay on the British Isles that the event has opened a "golden era" of bilateral relations and a new chapter of China-West exchanges. On the European continent however, it came a bit as a surprise, that the European Union country with the most significant relationship with China is actually the United Kingdom. While Europe is still struggling to find common grounds towards China, last October the UK might have done a lot of good for the entire Union of European Nations. The UK not only became the first European Union Member State to establish a comprehensive strategic partnership with China, it is also the first Western country to issue RMB sovereign bonds and the first major Western country to apply for full membership of the China-initiated Asian Infrastructure Investment Bank AIIB. Since recently, it is also a leading offshore RMB trading centre after Hong Kong.

Minister Wang stressed that China-Britain cooperation should be embedded into the exchange on all levels between China, as the Central Asian power house, and the whole of Europe, creating a "community of shared interests", a key concept mentioned often by the Chinese President during his UK trip. Minister Wang told British media that the European Union wants to deepen and strengthen cooperation with China not only in the international fight against global warming, but also in infrastructure to revive and enliven their economies. For the moment, the UK and China are entering "a golden era in their relations featuring enduring, inclusive and win-win cooperation" and building a "global comprehensive strategic partnership for the 21st century."

Those strategic aims are strongly accompanied by Sino-British business relationships. During his days in Great Britain, President Xi took the opportunity to visited British enterprises, among them the London-based satellite communication provider Inmarsat on 22 October 2015.

Rupert Pearce, CEO of Inmarsat showed the Chinese President around the companies' headquarters and explained Inmarsat's work as the world leader of providing global mobile satellite communication services. Particular emphasis was on Inmarsat's support to the "One Belt - One Road" infrastructure project for reviving the ancient Silk Road by connecting Eurasian countries via a land and a sea route, initiated by President Xi in 2013. In the Network Operations Centre, real time network traffic was demonstrated and explained to the supreme Chinese visitor.

Inmarsat is no stranger to the Chinese market. Since decades it is serving the Chinese government. China was a founding member in 1979 when INMARSAT - International Maritime Satellite Organization - was created as a non-profit intergovernmental organisation to establish and operate on behalf of the United Nations a satellite communications network for the maritime community to provide safety and distress communication. Later on, the mandate was extended to aeronautical communications. In April 1999, INMARSAT was succeeded by the International Mobile Satellite Organization IMSO and the operational unit was privatised, becoming the UK-based company Inmarsat Ltd. Aside from its commercial services, Inmarsat still provides the global maritime distress and safety services GMDSS to ships and aircraft at no charge, as a public service.

After using Inmarsat's SwiftBroadband connectivity service already for a while, the Chinese airline Air China and Inmarsat - through Honeywell Aerospace - agreed in February 2014 to test Inmarsat's Global Xpress Aviation high-speed global broadband connectivity services with a seamless performance of 50 Mbps on its A330 aircraft.

Recognising the rapidly growing demand for satellite communication services in China, Inmarsat opened its first office in Beijing shortly after, in August 2014. Being recognised by the central and provincial governments in China as "the standard" for communication during emergencies and natural disasters gives Inmarsat a privileged positioning.

British Prime Minister David Cameron and Chinese President Xi Jinping having a pint at a pub near Chequers, Buckinghamshire, north-west of London, UK on 22 October 2015. (credit: EPA)

The Beijing office includes a demonstration lab that supports product demonstrations and end-user training, and promotes closer collaboration between Inmarsat partners and their customers to develop solutions in China for China. All of the Inmarsat terminals are fully mobile – reflecting Inmarsat's unique capabilities and allowing the Beijing office team and Inmarsat partners to provide a 'fly-away' demonstration capability at customer locations anywhere in China.

Inmarsat's operational partner in China is Beijing Marine Communication and Navigation Co. MCN (owned by: China Transport Telecommunication & Information Center CTTIC) to serve customers like Air China, China COSCO, China Shipping Container Lines, China National Petroleum Corporation, China Central Television and Xinhua News Agency. This relationship with MCN dates back to 1979, when INMARSAT was founded. MCN also owns and operates for Inmarsat a satellite access station established in Beijing in 2014 – the only station in China for a foreign operator. The Beijing satellite access station handles all traffic from China over the Inmarsat network, enabling Inmarsat to deliver its complete range of solutions to the Chinese market. The Chinese local manufacturer of Inmarsat terminals is the company Spaceon in Chengdu, Szechuan Province.

After the successful initial Global Xpress test phase, Inmarsat and MCN signed in April 2015 four new Value Added Reseller (VAR) agreements for Inmarsat's Global Xpress, a globally-seamless available, superfast mobile broadband service in the Ka-band spectrum for commercial and public sector organisations across China. Inmarsat's Global Xpress programme is a US$1.6 billion investment project. Global Xpress services will be supported by an operational constellation of three Inmarsat-5 Ka-band satellites in geostationary orbit above the Equator (with a fourth satellite current planned to be an operational spare). Global Xpress operates with a combination of fixed narrow spot beams that enable Inmarsat to deliver higher speed through more compact terminals and additionally steerable beams for providing capacity directed and in real-time to where it is needed. Global Xpress will deliver global broadband connectivity services for the 'One Belt – One Road' economic corridor project. The underlying MoU with CTTIC was signed short before President Xi's visit to Inmarsat's headquarters. Through the MoU between Inmarsat and CTTIC, both companies are intensifying their cooperation for the provision of global aviation passenger connectivity and the next generation safety services to Chinese airlines. Additionally, Inmarsat has worked with its Chinese partners to integrate its satellite communication services with China's BeiDou Navigation Satellite System.

President Xi's visit just emphasised the importance of Inmarsat's service to Chinese entities as well as the intercontinental 'One Belt One Road'-infrastructure for which Global Xpress will become the backbone for its connectivity. Proudly, Inmarsat gave the prestigious visit the motto: 'One Belt One Road One Inmarsat'. In an interview with the Chinese news agency Xinhua, Rupert Pearce stressed: "China is already making substantive commitments to realizing the initiative and it is clear that foreign investors too see the long-term benefits of this globally important initiative." Like Pearce, there are others who could anticipate that the 'Belt and Road'-initiative, which is not only centered around an economic but also a cultural and political vision, could become the neo-Marshall Plan of the 21 century. It corresponds to the new reality of China's economic standing, and its will to take increased responsibility for peace and welfare. CEO Rupert Pearce expresses his confidence when talking to Xinhua: "We see Global Xpress ... support China's strategic ambitions. ... But we can go much further than that. There is absolutely nothing to prevent these collaborations expanding around the world. Many Chinese companies are now global companies, leading the world in the market they serve. And we are very proud to serve them anywhere in the world."

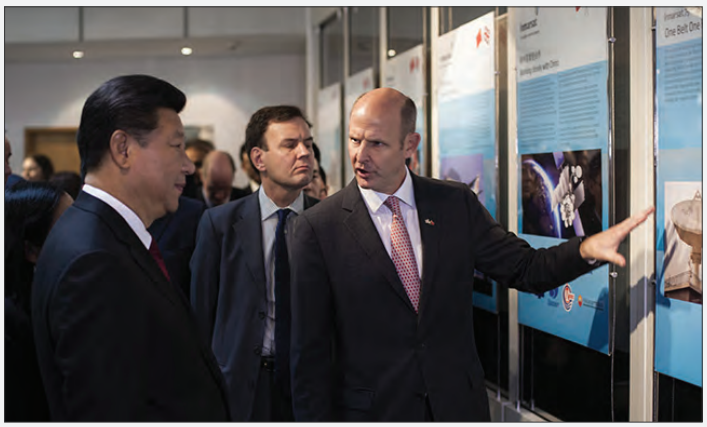
"…supporting President Xi's visionary 'One Belt - One Road' strategic initiative."

Interview with Inmarsat CEO, Rupert Pearce

GoTaikonauts!: The signing of the Memorandum of Understanding MoU, between Inmarsat and China Transport Telecommunication & Information Centre - CTTIC is a very impressive and future-oriented act. Does Inmarsat feels like a trail-blazer, in the sense of pioneering a highly prestigious, highly visible and very important cooperation on the global scale?

Rupert Pearce: Inmarsat is delighted to have signed the Memorandum of Understanding - MoU with China Transport Telecommunication & Information Centre - CTTIC. As the leading provider of global mobile satellite communications, we continually invest in both enhancing our satellite communications infrastructure and in broadening the use of our mission critical services.

Chinese President Xi Jinping (centre) viewing satellite coverage screens in the Network Operation Centre control room with Rupert Pearce (right), CEO of Inmarsat, during his visit to Inmarsat in London on 22 October 2015. Inmarsat's technology was used in the search for the missing Malaysian Airline flight MH370. Inmarsat worked close with the Chinese government to help to pinpoint the southern corridor flight path taken by the Boeing 777. (credit: Reuters)



From left to right: President Xi Jinping, Rt Hon Greg Hands MP, Chief Secretary to the Treasury, Rupert Pearce, CEO of Inmarsat. (credit: Inmarsat)

At the end of 2015, we completed the roll-out of our more advanced service – Global Xpress – a new satellite constellation which is the world's first globally available Ka-band, high-speed broadband network delivered through a single operator.

The MOU we signed with CTTIC last year established a new strategic partnership between Inmarsat and China, through which to deliver our revolutionary Global Xpress mobile satellite broadband service throughout China and the 'One Belt - One Road' - OBOR region. The MoU creates the framework for an exclusive strategic relationship between Inmarsat and CTTIC to develop business opportunities in China and OBOR for CTTIC's Chinese government and enterprise customers. It also provides a framework for the two organisations to establish a partnership to provide global aviation passenger connectivity and next generation safety services to Chinese airlines.

GoTaikonauts!: What are the benefits of cooperating in the field of space with China? Are there disadvantages?

Rupert Pearce: Inmarsat provides its services to governments and commercial organisations around the world. China is one of Inmarsat's biggest markets, delivering double-digit growth in the last five years for both voice and broadband services. We see many benefits – both to Inmarsat and China through this new era of enhanced cooperation.

GoTaikonauts!: What is your overall impression of your cooperation with China? Is it difficult or easy and what are the specifics of doing business with China?

Rupert Pearce: China was instrumental in the foundation of Inmarsat in 1979 and, since that time, we have enjoyed a long history of cooperation together. Through this experience we have learnt that building business relationships in China is about trust, understanding and openness. In developing a long-term relationship we feel both - Inmarsat and China - are able to benefit, making the most out of the positive outcomes of such a long history together, both now and in the future.

GoTaikonauts!: What is your experience in cooperation with Chinese colleagues - meaning: what are, from your point of view, the differences or difficulties in business relationship and culture?

Rupert Pearce: We believe that Inmarsat has a good working relationship with China - both commercially and in terms of our relationships with government. Of course, as with all relationships, the key is identifying the mutual benefits that exist and we believe that, over the past thirty-seven years of our history together, we have an understanding of China's business culture.

GoTaikonauts!: In an interview with Xinhua you spoke about future perspectives of cooperation, such as using Chinese launchers or even getting satellites manufactured in China. How realistic are these ambitions? How much is ITAR in the way of such visions for the future?

Rupert Pearce: Inmarsat is committed to strengthening its partnership with its long-established channel partners in China and to supporting President Xi's visionary 'One Belt - One Road' strategic initiative. We only have to look at our recent successes together, from the creation of the Beijing satellite access station, to the opening of our new, state-of-the-art marketing and service facility in Beijing to see that our joint ambitions can become reality.

Of course, we are mindful of the international regulatory environment, but over the course of time we believe these ambitions are realistic.

From left to right: Rupert Pearce, CEO of Inmarsat, HRH The Duke of York, President Xi Jinping, Andy Sukawaty, Chairman of Inmarsat, Rt Hon Greg Hands MP, Chief Secretary to the Treasury (credit: Inmarsat)

One Track, Two Stations

Proposal for Cooperation on CSS and ISS

by Chen Lan

During the International Astronautical Congress (IAC) held last October in Jerusalem, there has been a little-noticed twitter message that was posted by Peter De Selding, a senior space journalist, quoting ESA Director General Johann-Dietrich Wörner as saying he wants China to give up its own space station in favour of joining the ISS. “I told China, we don’t need two space stations. How about ISS with China participation? Not sure how they’ll react”, he said. The message has not been confirmed by other news reports but considering Peter De Selding’s standing and credibility and ESA’s attitude on cooperation with China, it is very likely true.

Prof. Wörner’s idea is indeed in the interests of mankind and out of good intention. Undoubtedly a single station built by all space-faring countries perfectly represents peace, harmony and unification of the world and reflects on a long-held dream of mankind. However the reality has a large gap with the ideal. We have to be aware of the following situation:

- It is too late now. The Chinese government approved the Chinese Space Station (CSS) plan in 2010. Five years later, the design has been frozen, hardware development has been in full-swing, supporting projects like new launchers and launch site are near completion. There are only less than three years left before the launch of the core module in 2018. Also, China has a very good track record in executing its long-term space plan. Abandoning the current plan or significantly changing it, means not only a great loss of all that has been invested, but also a major shift in the course of the long-term plan. It would cost too much. If it had happened 15 years, or even 10 years ago when the CSS was still in its conceptual phase and China’s long-term station plan only an outline, it would have been very welcomed by the Chinese side. In fact, China expressed the willingness to join ISS many times during those days but all attempts were rejected by the U.S. side.
- China must have concerns about its independence and the planned retirement of the ISS in 2024 or as late as 2028, if lucky enough. It would be too risky to bind China’s future human space flight activities with the ISS. Russia’s plan to separate its segment from ISS and the problems caused by the Ukraine crisis, also reminds the Chinese not to repeat Russia’s path. There are potential conflicts of interest, global or regional, between China and U.S. and China may face a similar or more serious situation than Russia is facing today.
- The United States of America (U.S.), more exactly the U.S. Congress, is always the main obstacle for China to join the ISS, and there is no sign that the situation will change in the near future. As long as China continues to grow in its current direction, the Congressmen and - women will not change their minds. ESA may be able to influence NASA, but not the Congress.

Based on the above three points, we can draw a conclusion with certainty that China will not give up its space station that is almost ready to go to space. No, it will never happen, though joining ISS with limited resources is possible, for example, sending a small module to the ISS, if the U.S. finally agreed. But it’s not what Prof. Wörner expects.

Is there still a chance to cooperate with China on the space station programme? We think the answer is “Yes!” and time would also allow so. This is the proposal we present here - a “coordinated space station formation” (or group, fleet, column, queue, whatever it is called) consisting of two space stations, the ISS and the CSS, and more in the future.

The concept is such that the two stations fly in the same orbit, the 51.6 degree ISS orbit, with a certain distance apart, say 100 km. Either station runs independently but can also work jointly to support each other. Visiting vehicles, with equipment/supply and crew inside, can move quickly and easily from one station to another. This “multi-station formation” has the following major advantages that a standalone station does not have:

- **Mutual rescue**: in case of an emergency of one station when its rescue vehicle(s) are damaged, as long as one manned transportation vehicle at any of the stations is available, it would be possible to transfer the crew to another station, to wait for later vehicles to bring them back to the Earth. The two stations provide a shelter for each other, which is extremely important for the aging ISS and the Chinese who have little experience on long-duration space station operation. It would be a capability never before realised in the history of space flight and will provide a doubled safety guarantee to both crews.
- **Mutual support**: the two stations provide redundancy on many basic capabilities and can also support each other, especially when there is something one station lacks. For example, sharing of the orbit re-boosting vehicles, storage space and supplies, ground-station data links, onboard medical support, and back-up docking/berthing ports, etc. The Chinese free-flyer telescope can also be serviced by the ISS, if needed. Without such mutual support capability, as currently on ISS, the same job will cost more and even need a new launch to complete.
- **Joint experiment**: it enables experiments relying on two stations, for example, laser communication and long baseline astronomical observation. And also, the dual-station makes it possible to do the same experiment simultaneously on two stations for comparison. In fact, it opens a door for innovative experiments we have never imagined before.
- **Manned formation flying**: in the early days of space flight, there have been two manned spacecraft flying closely. But they all were short-duration flights. Manned formation flight may be valuable for future manned deep-space missions. It provides more redundancy and flexibility for long-duration missions. This proposal provides a chance to experiment with this concept.

Implementing such a space station formation will be much easier for the Chinese than giving up the CSS and joining the ISS. But still, a lot of work needs to be done:

- China has to launch the CSS into the same orbit as the ISS. The ISS orbit is a circular orbit at about 400 km with an inclination of 51.6 degrees instead of the CSS’s planned 42-43 degrees. All visiting cargo and crew vehicles have also to be launched into this orbit. The CZ-5B launcher that is to lift the station modules, is able to send 23 tonnes to a 200 x 400 x 42° orbit. While the planned modules have a mass of 20-22 tonnes each, there is only 1-3 tonnes margin left to raise the orbital inclination from 42 to 51.6 degree. It might not be enough. One possible way is to

launch them into a lower, say 300-350 km, orbit (Shenzhou and Tiangong orbits) but still in the same orbital plane. Once assembled (in 2022), one or more cargo ships would then lift it to the ISS orbit. This would mean that equipment/supply and crew transfer between the two stations in the first four years (from 2018 to 2022) will need more fuel. It is acceptable. If ISS can be lowered to about 350 km as it was before 2011, it will significantly reduce the gap and remove the four-year transitional period. At the same time, cutting fuel and removable equipment in the modules to reduce launch mass could also help. As the gap of the launch mass is probably minor or does not exist at all, we believe there will be solutions possible. For the Tianzhou cargo ship and the Shenzhou crewed vehicle, the problem is less serious. Removing a little cargo (from Tianzhou) and onboard equipment/supply (from Shenzhou where full supply and even the fully-functional orbital module is not required in station ferry missions) would easily solve the problem.

- The inclination change would present another problem, caused by the fact that the locations of current Chinese tracking stations are not suited for a 51.6 degree trajectory, especially during the ascent and re-entry phases. For launches from Wenchang on Hainan Island, reallocating the tracking ships may solve the issue easily. But there will still be Shenzhou launches from Jiuquan because China's new generation multi-functional manned spacecraft that could be launched from Wenchang will be put into use after 2020. For the 51.6 degree orbit, a north-bound launch from Jiuquan will put its downrange within Mongolia. China may have to launch the Shenzhou in its descending orbit phase (southwards). So, one or more new tracking stations have to be built to the southeast of Jiuquan, in central China. Similarly, to support re-entry and landing from a 51.6 degree orbit, two new tracking stations would have to be built southwest of the landing zone (probably in Qinghai and Tibet) to replace the Jiuquan and Kashi stations. Tracking ships would have to be deployed in the Indian Ocean to replace the Malindi and Karachi stations. The Tianlian data relay satellites may reduce the number of new stations to be built, and it could be further improved if there was support from the EDRS, or even NASA's TDRS and Russia's Luch systems. All these have no technical barriers but need time and investment to build.
- For landing from the 51.6 degree orbit, the Inner Mongolian primary landing zone in Siziwang Banner can still be used, but the back-up one in Jiuquan would no longer be useful. China would have to establish a new back-up landing zone southwest of Siziwang Banner for the case of ballistic re-entry. Also, all emergency landing sites worldwide would have to be re-planned and prepared.
- Besides, both sides need to make the plan together and do the necessary technical work, such as making docking/berthing mechanisms compatible, integrating the data communication systems, establishing a coordinated mission management and control system, etc. For all this kind of work, experience from the ISS would help a lot.
- Optionally, new modules for each other's station can be developed and launched, if political and financial conditions allow. China may send a module to the ISS, and the ISS partners (most likely ESA) send a module to the CSS, and crew can be exchanged between the two stations.

To complete the above work within three years is not an easy job. But if CSS joins ISS, as Prof. Wörner suggested, all the above work still exists, and there would be many more additional challenging jobs. We believe that this proposal is the most realistic, lowest cost and easiest to implement solution. Once completed, it can be seen as an integrated "virtual" space station playing many roles one station normally plays. In future, new stations such as the Bigelow commercial station could also join the formation. It requires not only the two stations running in one physical orbit, but also all participants working on the same track. This is exactly the spirit of cooperation we have seen on the ISS. We believe it will achieve the same objective as the ISS does. We think ESA is in the best position to lead this project. However, there is not much time left. It needs strong will and a resolute decision from both sides with which all challenges can be overcome. We hope that CNSA, ESA and NASA take some action quickly to grab the chance, and then again, after the ISS, change the history of human space flight of several decades from now on.

A Foothold on the Moon – But for all Mankind

by Jacqueline Myrrhe, Dr. William Carey

"Moon Village" – this nebulous term coined by former Head of the German Space Agency DLR, Prof. Dr. Johann-Dietrich Wörner is going around the world since the spring of last year. Prof. Wörner, by profession a civil engineer and with an self-confessed aptitude for constructing, is now Director General of the European Space Agency, but his idea of a "Moon Village" is still with him albeit a bit fuzzy. Prof. Wörner is not shy of talking about concepts before the details are clear. Also, he is not shy of using Germany's biggest tabloid newspaper to talk about his "Moon Village" to the widest possible audience. Despite not sparing any effort, his idea has not gripped the masses but rather leaves room for questions and interpretation.

Let's get together!?

What is known though is that Prof. Wörner is looking for nothing less than inspiring ideas for the next large-scale, global and sustainable endeavour after the ISS, but building upon the ISS legacy. According to him, it would be good if that activity could engage stakeholders beyond the current space community, if it would inspire the general public and advance mankind as a whole. The core concept is that a location on the Moon would be identified and any potential participant to the "Moon Village" would join with contributions according to capability and interest. During the IAC 2015 in Jerusalem he said: "some people are coming together, some nations are coming together." However, is this sufficient enough to make something decent out of it?

There is no existing logic that the idea of a single person can become an ESA-wide idea and finally a programme supported by ESA-Member States and consequently a global space exploration programme. But this seems to be a prerequisite to get started at all. Furthermore: Is ESA in the position to take up a leadership role? If not, can a "Moon Village" function rather on the basis of a self-managing community than on the conventional model of leader and followers? Maybe the concept would represent more a "Moon Community" than a "Moon Village"? If Wörner's approach is intended to be global, sincerely global, how do we overcome the global split between space-faring and non-space-faring nations? If this remains unconsidered, the majority of countries in the world will not be able to contribute and the "Moon Village" would sadly lack a truly global attribute. It might be worth remembering that the "European" Space Agency has been for the biggest part of its history a "West European" Space Agency ignoring the expertise and capabilities gained from Berlin to Moscow from Warsaw to Bucharest. Also, if commercial entities are involved as self-responsible actors, do we run into the danger of just extending the more or less successful terrestrial (business) models to deep-space? If we do not dare to leave the old path of business-as-usual, would really all of mankind benefit or just the few capable of doing so and have always done? How then could mankind advance as a whole? And last but not least: Is the ISS project really the best possible reference project?

This question is legitimate, considering that ESA is a junior partner in the ISS programme, a project which might have only 8 years of lifetime left. Only by the end of this year will we know whether the ESA's Member States are willing to support the continuation of the ISS's lifetime. The chances of additional funding for a "Moon Village" in parallel to the ISS are almost zero. But most importantly, the ISS is currently a closed club, limiting the partners to the signatories of the Intergovernmental Agreement which is the legal foundation for the ISS Project. Looking back at the time period when the ISS was conceived, one has to admit that that era has been characterised by the Cold War, followed by the break-up of the Soviet Union and the epoch-making events in all East-European socialist States. The ISS, like the Apollo Programme, has been embedded in the social context of its time. The world has significantly changed since then. A "Moon Village", scientifically and technologically undisputed, has to find it societal justification, has to satisfy the needs of the 21st century – a world shaken by crisis and a growing divide between developed and underdeveloped countries and between poor and rich. Paul Weissenberg, Deputy Director General of the European Commission stated already in January 2014 during the International Space Exploration Forum in Washington DC, U.S.A.: "Exploration continues to happen. Fortunately! But let's face it! The strategic and geopolitical environment in which we operate has changed. The world has become smaller – not just financially. Less and less nations are exploring space for national pride reasons. … Competition yes, but competition has reached its limits. Ambitious space exploration programmes are beyond individual capabilities of most countries." Certainly, the ISS Project has advanced technological, operational and scientific knowledge of the participating States. But, has the ISS really done good for all of mankind, has it contributed to growth and prosperity in non-space fairing countries? No, it has never been its objective – but this was back in the 1980s. The same is true for NASA's Apollo Programme. The theory was about to come "for all mankind" but the real objective was to be on the Moon before the Soviet Union. It is not about questioning the Apollo or ISS programmes, they have been both correct at the moment they were conceived, but has Apollo or the ISS lived up to the expectation of a dramatically changed world of the New Millenium?

The ground is paved

The United Nations have recognised that basic conditions have to be in place to enable nations to become space nations. Without a rocket, one cannot get into space. Money could buy you a rocket but without money, skills, and capabilities one cannot even think of sending any sort of payload into space. Inverting the argument also works: education and training will provide skills, knowledge and capabilities for social, economic and cultural development, which at the end of the day can elevate any nation up to wealth, space and even farther.

The United Nations Office for Outer Space Affairs - UNOOSA has run since 2010, the HSTI programme - the Human Space

ESA has been looking into the feasibilty of building a future lunar base by using 3D printing and lunar local materials. (credit: ESA/Foster + Partners)

Technology Initiative. HSTI provides a platform to exchange information between all UNOOSA's Member States – currently 77, plus numerous intergovernmental and non-governmental organisations having observer status. The three main pillars of the HSTI are: international cooperation, outreach, and capacity building. The most important characteristic is the emphasis on "capacity building". HSTI offers the inexperienced aspirants the opportunity to learn and use the expertise of the experienced players: a necessary step if the aim is to narrow the divide between technologically developed and developing countries.

It is important to recognise that China has been offering its soon-to-be-assembled Chinese Space Station to UNOOSA for use within HSTI. During the 58th COPUOS session in Vienna last year, the Deputy Director of the Scientific Planning Bureau of China Manned Space Agency, Xiaobing Zhang reiterated in his presentation "China Manned Space Programme", China's offer for sharing its station with international partners and open it "to all UNOOSA Member States and in particular developing countries" through the UNOOSA-HSTI. According to Director Zhang, China could support: "space science experiments and applications onboard [China's Space] Station, astronaut selection/training/flight, and application of human space technology."

One of the slides from Xiaobing Zhang presentation during the 58th COPUOS. (credit: CMSA, UN)

The first step comes before the second

China has rightly recognised that infrastructure is a prerequisite for development in each respect. Providing infrastructure empowers people and nations to find their own - independent way into the future. The opposite is also true: poor infrastructure will keep people at home and will deprive them from advancing. Not only does China's offer to the HSTI go in this direction, but also its "One Belt - One Road" initiative. The revival of the ancient Silk Road is aimed at the economic, societal and cultural development across the Eurasian Region and beyond - in the economic arena. "One Belt - One Road" enables mutually beneficial cooperation rather than old-fashioned confrontation, a new type of international relations, and features win-win cooperation and creates an inclusive community of common destiny for mankind. And China is not shy of taking a leadership role.

Looking at the United Nations HSTI closely, reveals crucial overlaps with Prof. Wörner's "Moon Village" initiative. If ESA would not be shy of aligning with UNOOSA to turn the "Moon Village" idea into real action, ESA could gain enormous non-monetary benefits and financial savings at the same time. ESA's Member States would be - together with the UN - in the position to share their resources and play an active role in overcoming the global split between space-faring and non-space-faring nations. Through just one common exploration activity, not only an unprecedented international cooperation could be achieved, but could - as a side effect - trigger broader development programmes, e.g. a "Marshall Plan for Africa", in the fields of technology, education, science and economy. A societal justification par exellence. If most - preferably all - nations of the world could obtain access to the "Moon Village" the people in each nation would sense a certain degree of ownership of the Moon, which leads naturally to a global awareness. Keep in mind, that probably all ethnicities have been associated with the Moon through ancient legends, traditions, religious rituals and even architectural monuments. To revive this cultural heritage through public outreach would open any people's hearts and souls in favour of lunar exploration, and connect them closely to the lunar legends of our modern times. If the participation of non-space faring nations in the "Moon Village" programme could be established, the "Moon Village" would become a tool to elevate all of Mankind to a higher level. Past losers get a sincere chance to become winners. Past winners get a sincere chance to share. We have just one Moon! There is no second chance. The way we make use of this single and unique opportunity will forever determine the way that mankind explores and conquers the cosmos. It would be worth the effort!

But still, Prof. Wörner's "Moon Village" idea could turn out to be more suitable as a second step – only after a first one has been taken. Maybe, at this moment in time, it could seem to be more attractive to take an interim milestone, i.e. to make a dress rehearsal before the global journey to the Moon could eventually begin. It is a fact that the ISS is in place and the CSS will be quite soon. A fact also is that the HSTI is real, and so is China's readiness to share its CSS with all 77 UNOOSA Member States, most of them non-space fairing nations, but also involving all space nations. Why not use existing resources first in order to prepare for embarking upon a "Moon Village"?

Our colleague Chen Lan has outlined a proposal to combine the missions of the ISS and the future CSS. Chen Lan's suggestion, to use both stations for formation flights, joint experiments, mutual support and rescue operations, would breathe new life into the ISS and give the CSS a higher aim. East and West could cooperate in space and test new territories. And they could do it now! (see pages 17/18) By involving the HSTI of UNOOSA, possibly the European Commission and U.S.-American Institutions also South and North of the globe would be on board. ESAs Member States would not need to count every penny but most objectives of the "Moon Village" could be achieved by a possible pre-cursor CSS-ISS Project much faster and more efficient and lay the foundation for a future "Moon Village". It would be honest to admit that by offering its Space Station to UNOOSA, China has already paved the way for such a kind of global-wide space activity. If the West would join with its ISS, it could become sincerely global. And yes, it would just be the first step. "Wörner's Moon Village" as the next step then, could become the masterpiece - for all of mankind.

The Chinese are fond of saying "Where there is a will there is a way", but for those of us in the West, a slight modification of this phrase is needed, and would read "Where there is a political will, there is a way". Construction of this political will – not the hardware – is the biggest obstacle standing in the way of making Prof. Wörner's concept become something far more tangible – but obstacles are there to be overcome. While ESA might have difficulties to fill a leadership role in the infrastructure construction of a possible "Moon Village", ESA has proven its strength in building bridges between nations and continents. ESA should not be shy of being bold!

China Manned Space Agency CMSA Presentation at IAC 2015, Jerusalem: Worldwide Scientists Welcome into Modules of the Chinese Space Station CSS !

by Theo Pirard, Space Information Centre Belgium

During the 66th IAC 2015 (International Astronautical Congress), which took place from 12 to 16 October in Jerusalem, Israel, China showed high-level dynamism in manned spaceflight operations. China declared consistently its willingness to open them to international co-operation, with an invitation to countries around the globe. In the framework of the GNF (Global Network Forum) sessions, CMSA (China Manned Space Agency), represented by Dr. Zhou Jianping, Chief Designer of China Manned Space Programme, gave a long and informative statement about the current development of systems towards the CSS (China Space Station) facility, open to users in the world.

The go-ahead decision to build this modular facility, along with a planning schedule and with specific uses, was taken by the government of Beijing in September 2010 as the 3rd step in the strategy of the China Space Programme. The aim is to make available within ten years the China Space Station infrastructure. Planned to be available at the beginning of the 2020's, the station will allow China "to master long-term human spaceflight technology independently, to acquire the abilities of long-term man-tended space science and technology, to test and exploit the resources of space environment comprehensively", as stated by Dr. Zhou Jianping.

The basic ideas of the main project in the space programme of China are:

- to demonstrate full abilities of building large-scale space facilities, of mastering on-orbit operations with manned spacecraft;
- to focus on benefits of applications by achieving great innovation progress on systems in space;
- to operate economically through sustainable development;
- to carry-out international co-operation as the contribution of China to peaceful exploration and to space resources for mankind.

The design specifications for the CSS are:

- the core element with three experiment modules (science, applications, technology);
- 42°-43° inclined orbit at an altitude of 340-450 km;
- a lifetime of some 10 years;
- a permanent crew of 3 people, up to 6 maximum.

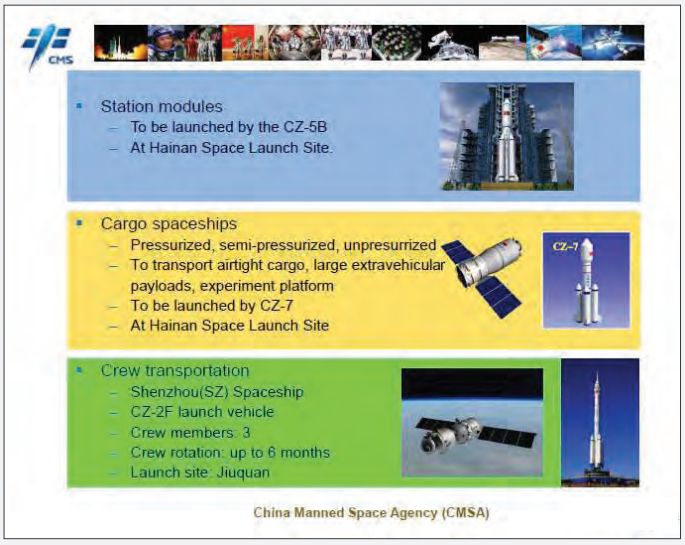
Dr. Zhou Jianping noted: "According to future requirements for utilisation and international co-operation, newly built modules can be added and onboard payload experiments can be exchanged".

As a key preparatory mission for the construction of the CSS, the TG-2 (Tiangong 2) laboratory will be launched by CZ-2F (from Jiuquan) in 2016, before the end of the first half of the year. Visits of TG-2 will be made during the following months by one manned Shenzhou (SZ-11) spaceship also launched by CZ-2F (from Jiuquan), then automatically by one cargo spacecraft, named Tianzhou 1 (TZ-1), launched by new CZ-7 (from Hainan launch site). The first Tianzhou has to verify the cargo transportation system, including on-orbit propellant re-supply.

Towards 2022 as the first CSS year!

China plans to start the construction of its 10-year modular space station in 2018 with the launch of the Testing Core Module. The modules will be launched by powerful CZ-5B from Hainan Island. Subsequent Tianzhou cargo vehicles - each consisting of pressurised, semi-pressurised and un-pressurised parts - will be put into orbit by CZ-7 launchers from the Hainan launch site. However, the manned Shenzhou spaceships, each with up to 3 taikonauts, will continue to be launched by CZ-2F from Jiuquan. Rotation of crews will be achieved every 6 months. "Several manned spaceships and cargo spacecraft will be launched to visit the Testing Core Module, in order to conduct key technology tests such as on-orbit assembly, EVA, long-term flight, etc."

Once the core module has been tested with successful results, two Experiment Modules 1 and 2 will dock with it by using lateral ports. The CSS in its final configuration - a total of 3 modules - will



(credit: CMSA)

(credit: Theo Pirard)

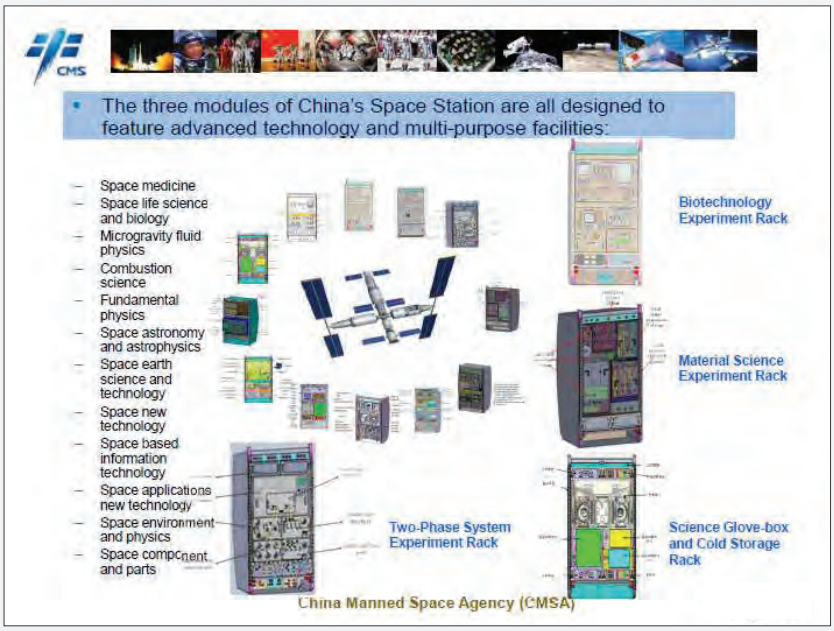
be put into operational status around 2022. “The three modules of CSS are all designed to feature advanced technology and multi-purpose facilities.” Specific racks will equip the modules used as laboratories.

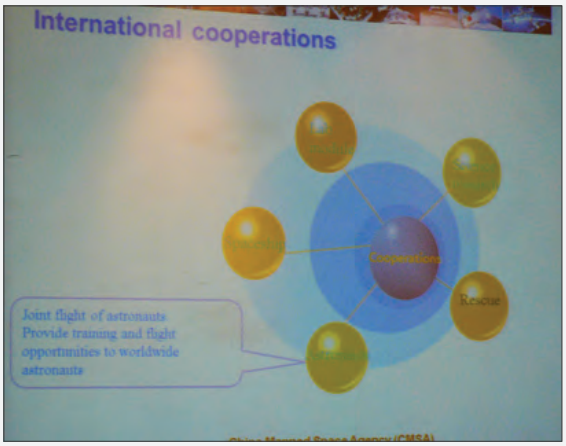
They are described with the use of English acronyms:

- For space life sciences and biotechnology: ESER (Ecology Science Experiment Rack), BER (Biotechnology Experiment Rack), SGRR (Science Glove-box & Refrigerator Rack);
- For microgravity fluid physics and combustion: FPER (Fluid Physics Experiment Rack), TSER (Two-phase System Experiment Rack), CER (Combustion Experiment Rack);
- For materials science in space: MFER (Material Furnace Experiment Rack), CMER (Container-less Material Experiment Rack);
- For fundamental physics and microgravity processes: CAER (Cold Atom Experiment Rack), HTFR (High-precision Time Frequency Rack);
- As multi-purpose facilities: HMGR (High Micro-gravity Level Rack), VGER (Varying-Gravity Experiment Rack), RACK (Modularized Experiment Rack), IMOR (In-situ Maintenance & Operation Rack), etc.

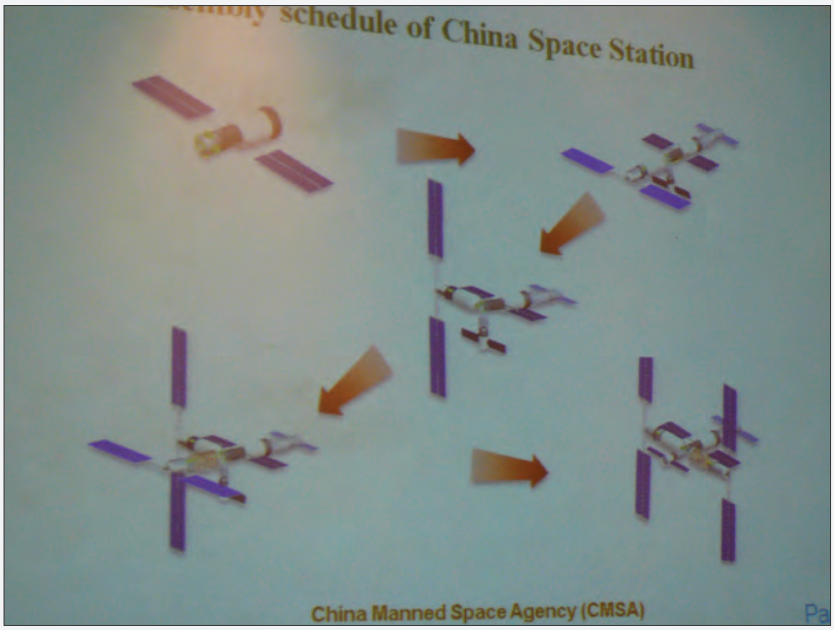
Dr. Zhou Jianping gave a detailed description, with drawing, of each rack currently in development. The most surprising element projected for use with the CSS is the Space Telescope module whose maintenance will be achieved within the inhabited station: dedicated to astrophysics observations, dark energy and dark matter research and cosmology investigations, it will function autonomously and will dock regularly to the CSS for the updating of the science instrumentation.

Concluding his presentation of CSS, Dr. Zhou Jianping insisted on the benefits of the station to mankind, through agreements to be signed with space agencies. An invitation was addressed to men and women of the world for activities in the orbital complex of CMSA (China Manned Space Agency). His message, consistent with the presentation given by the Chinese representative Xiaobing Zhang during the 58th COPUOS session last June in Vienna, was clear: “It is certain that China will never halt its footsteps in human space exploration and will continue to explore the vast space, deeper and further!”





(credit: CMSA/Theo Pirard)



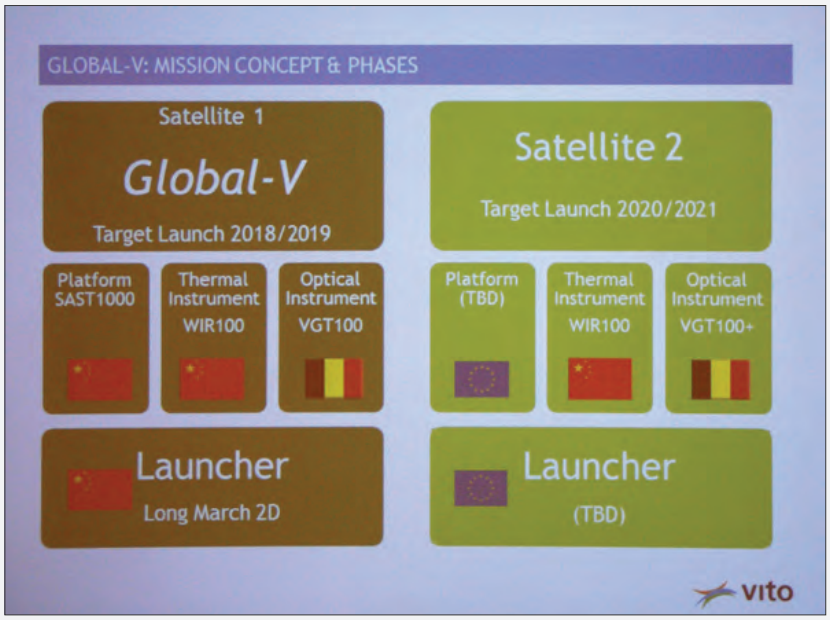
Global-V in 2018:
Sino-Belgian Satellite to Monitor the Global Biosphere Every two Days

by Theo Pirard, Space Information Centre Belgium

Through the ESA technological programme, Belgium developed the PROBA-V(egetation) spacecraft having great autonomy for in-orbit operations but no manoeuvering capability. The 138-kg Earth observation micro-satellite developed by QinetiQ Space in Belgium and launched by a Vega rocket in May 2013, is the continuation of the Vegetation system which was initiated in the 1990's by the European Commission with the support of France and the Belgian government. Vegetation consists of a multi-spectral imager with wide viewing swath of 2,250 km, to achieve a global monitoring of our biosphere within 48 hours. It can be considered as a precursor for the Copernicus system, which deploys a constellation of Sentinel spacecraft dedicated to global monitoring for environment and security. The data of PROBA-V - images of up to 100 m for ground resolution - are collected by Earth stations in Sweden, Alaska and Canada, then transmitted to VITO (Flemish Institute for Technological Development) in Mol (Belgium) for processing and archiving.

PROBA-V demonstrated its essential role as the observer of vegetation resources on the Earth and as a first access to remote sensing data for many applications (agriculture, forestry, ecosystem vulnerability, disaster management, etc.). The small and compact satellite using miniaturised opto-electronics of Belgian company OIP Sensor Systems, is functioning very well in sun-synchronous orbit at 820-km altitude, under the control of ESA Redu Centre in the Belgian province of Luxemburg. In 2015, its mission nominal lifetime of 2.5 years was extended to 5 years, in order to remain operational until late 2018. The community of Vegetation users exceeds some 2,200 in 91 nations. The first three countries for the number of users are Belgium, Italy and China! The current PROBA-V archive rises to 465 TB (Terabytes) at the end of 2015.
In order to avoid an interruption in the continuously updated collection of Vegetation imagery, Belgium had to look for a successor. The solution comes from China, an important customer of the Vegetation images to currently evaluate crop growth and problems. Since 2015, The RADI or Institute of Remote Sensing & Digital Earth) of CAS (Chinese Academy of Sciences) has a Memorandum of Understanding with VITO to co-operate around the use of Vegetation data. It was the basis for further co-operation with the development of a Sino-Belgian satellite, under the name of Global-V.

In June 2015, Belgium and China signed an agreement for the joint development and utilisation of Global-V. This Earth observation satellite of 400-500 kg, planned for a CZ-2D launch in 2018, will combine the SAST 1000 platform of the Shanghai Academy of Spaceflight Technology with the Belgian Vegetation instrument (compact) and with a "Made in China" thermal infrared sensor (heavy). Its development was presented on 25 January at Ghent, Belgium to the community of Vegetation users, the day before the PROBA-V Symposium, which was attended by a delegation of Chinese engineers and scientists. Following some participants, many questions remain unsolved about the partnership for the development of Global-V. However, it is crucial to go ahead with this venture: because what will happen if the unique PROBA-V satellite stops suddenly to function because of electronic failure in the payload or because of collision with a piece of orbital debris? The future needs to be secured.



(credit: VITO/Theo Pirard)

Popular Symbols and Rituals in Space Exploration in China and their Mediation to Soft Power

Notes from a presentation at POLITSCI-15, Istanbul, Turkey, 11 December 2015

by Andy Thomas

Following my work Kul'tura Kosmosa which was about the popular culture of space exploration in Russia, I became aware of a similar but new phenomenon in China. Some of the advertising is shown in Figure 1 from the Shanghai Metro in 2012, but I needed to find some way of understanding what was going on inside this image, what was there and what lay behind it.

Figure 1: Chinese product advertisement with a space theme

Figure 1b: Advertisement block accompanying Shenzhou commemorative Maitai liquor (brochure found in Beijing, 2015)

But I became aware that in the literature the majority of commentators talked of competition between China and the West, and mostly between China and the U.S.A. I needed to find some other theory to cover what existed in popular culture, what the symbols are, and secondly to find out how we come to know and understand them. So after spending some time looking at the Realist school of foreign policy, I settled on the works of Jacques Derrida and followers, who spoke of communication, both intentional and unintentional, and from this communication we can see a relationship of power.

The text is in two parts:

- Firstly, I am going to take a leaf from the Realist book and show how the physics of space exploration give a new and previously undiscovered understanding of some of the strategic impulses of Chinese international relations.
- Secondly, I am going to look at how the signs and symbols which are embedded in this description give us a wider communication (both intentional and unintentional) and from this a deeper understanding of the relation of popular participation to power.

Figure 2 shows how China's space programme (an example from space science) extends outside China's borders in both latitude and longitude. In fact of course the action is polycentric, multi-polar and extends upwards into space.

Figure 2: Meridian Space Weather Monitoring Project of the Chinese Space programme

Looking at the parameters of the orbit of the Chinese Space Station Tiangong-1, the ground-track is always between 42 degrees North and 42 degrees South. This determines Chinese activity on the ground, for example, the tracking stations used are the Chinese facility at Swakopmund in Namibia, and the use of the Italian Space Agency facility at Malindi in Kenya.

Figure 3: Ground track of the descending node from 42.8 degrees North of the Tiangong-1 Space Station. The Southerly extent is 42.8 degrees South, thereby covering the continent of Africa.

Some commentators have referred to the new importance of Africa to China. Illustrating this via instruments of popular culture, Figure 4 shows two postage stamps commemorating the Chinese painter Qi Baishi. The one on the left is from of the Soviet Union of 1957, and the other one in 2001 from the Republic of Ghana in West Africa. Note how the foreign friends of China have changed from Russia to Africa.

Figure 4 (a) and (b): Images of the Chinese artist Qu Baishi from the Soviet Union in 1957 (Left) and Ghana in 2014 (Right).

Looking now at the location of Chinese launch facilities, and the direction that the rocket takes from Jiuquan, for example, one can see that the launch trajectory not only overflies Hainan island, but also over the disputed territory of the Spratley Islands – where China needs telemetry tracking stations.

Figure 5: China's satellite launch sites

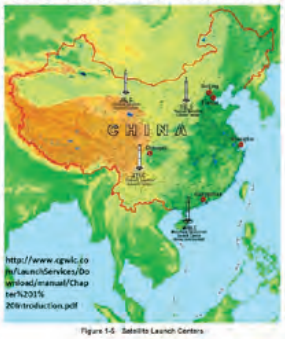


Figure 6: Satellite launch from Jiuquan

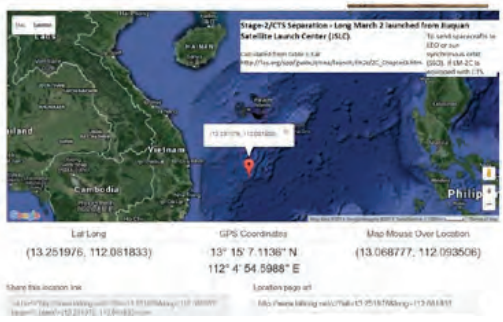
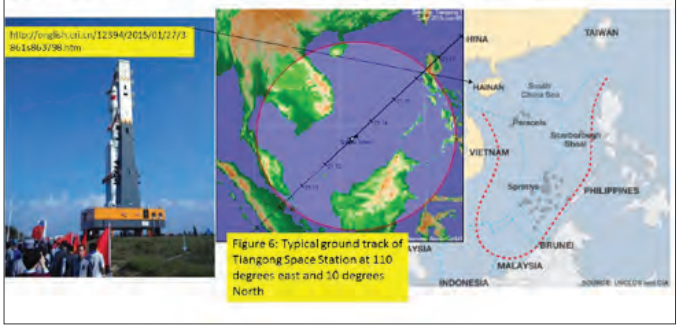


Figure 7: Long March-7 rocket to be launched from Hainan



From an understanding of the ground-tracks then, we can understand not only Chinese interest in Africa, but also in the disputed areas of the South China Sea.

We can apply this approach also to the example of the Nigerian satellite Nig-Com-Sat-1R, built by China on a standard DFH-4 bus, which although the satellite may be physically in orbit over Africa, it can be controlled from Kashi in western China. Is this a strategic asset for Nigeria, for China, or for both?

Figure 8: Asia Beam from NigComSat 1R

Returning now to communication and Jacques Derrida: the attraction, to me, of using cultural materials is that it allows two things:

- the transfer of unintentional communication; and
- its role in the promotion of power.

Looking again at the use of postage stamps, Figure 9 shows a Chinese one from 1953 showing the legend of Qu Yuan. This is a civilizational legend. It was his suicide as a protest against corruption that is immortalised in the Dragon Boat races of early July in China.

Figure 9 (a): the "Four Giants of World Culture" stamp issue of Qu Yuan 1953.

Figure 9(b): Dragon Boat commemorative postage stamp of 2001

This civilizational legend is promoted actively in China, and Figure 10 shows a blackboard in a school classroom.

Figure 10: Classroom Blackboard drawing 黑白报 of the Dragon Boat Festival

This legend may also be found in the manned spaceflight of Shenzhou 10 (Figure 11); we can note that there was a cost and timing element to the decision to do this: in which the space flight was organised to take the opportunity of this event in popular culture. It conveys, I consider intentionally rather than unintentionally, messages about the longevity of the country and the power of the leadership.

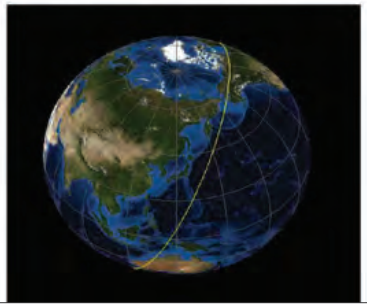
Figure 11: "Caption: "This video grab taken from the screen at the Beijing Aerospace Control Center shows Chinese astronauts on the Shenzhou-10 spacecraft greeting the nation and the Chinese in the global for the Dragon Boat Festival, on June 12, 2013. The words on the paper read "Happy Dragon Boat Festival!" (Xinhua/Wang Sijang)"

Another example using postage stamps; Figure 12 shows a joint issue between Hong Kong and Australia, which reminds us of the space between these two points on Earth.

Figure 12: Dragon Boat stamps issued by Hong Kong and Australia

I call it the Chinese hemisphere (Figure 13).

Figure 13: The "Chinese Hemisphere". The yellow line is the ground track of a polar-orbiting satellite.



An unfamiliar view of the Earth to those of us in the West (the line is the sub-satellite path of a polar orbiter).

Finally I would just like to examine the imagery of the Chang'e missions to the Moon.

In the first image (Figure 14a) from China TV in 2007, Chang'e is a satellite, a piece of electronic equipment, and in the second image (Figure 14b) from a shop in Shanghai in 2012 – the figure is the subject of a civilizational legend.

Figure 14 (a): Photograph on Chinese TV (CCTV Channel 1) of the Chang'e mission, 4 November 2007 (Author's collection).

Figure 14(b): Chang'e, as found in Shanghai, 2012.

But, in two images from Beijing in 2015, the image of the bird near the Moon (Figure 15b), resembling the satellite by the Moon in a postcard from the Space Post Office (Figure 15a), conveys a quotation from Chairman Mao Zhedong. A message of aspiration and achievement: "Vying with the sky for height/ Vying with heaven in stature"

Figure 15: Images taken July 2015. a) left: The image of the Lunar Mission, Chang'e 3 published by the China Space Post Office in Haidan, Beijing;
b) right: Advertisement (photographed through glass) at Guomao 国贸站 Metro station, Beijing. The vertical text on the right reads: Yù yǔ Tiān gōng shì bǐ gāo 欲与天公试比高 and is a well-known quotation from Mao's poem "Snow", 1936)
Vying with the sky for height/Vying with heaven in stature.
It is one of the series of public advertisements created by the China Photographers' Society, known as *China Dream advertising*

Conclusion:

- China's strategic activities can be interpreted directly as an exercise of power in pursuit of its space programme.
- "Soft Power" - both domestically and internationally - is integral to this activity.
- Post-structuralist analysis of the cultural discourse acknowledges cultural messages in the implementation of soft power.

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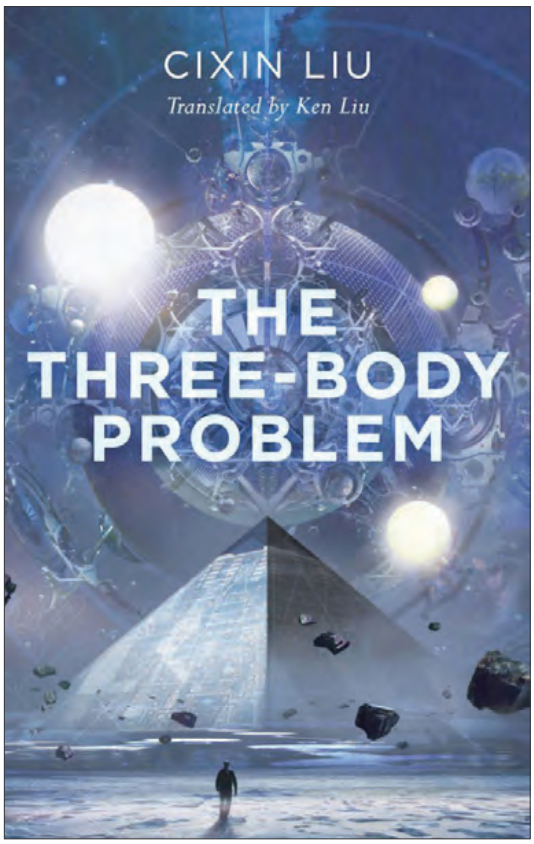
"The Three Body Problem" - author: Liu Cixin

A Review by Dr. William Carey

It's been many years since I last read a science fiction novel, my favourite author being Isaac Asimov, especially the Foundation Trilogy, with the intervening years reading being more focused on fiction than science. So it was with a somewhat nostalgic curiosity and hopeful anticipation that I began to read what is being referred to as 'the best selling Chinese science fiction novel' - The Three-Body Problem. First published in Chinese in 2006, and translated by Ken Liu, this first book of a trilogy, was published in English for the first time in 2014. Just as Asimov had won the Hugo Award (for the best science fiction novel published in the previous year) in 1995, Liu achieved the same feat twenty years later, in 2015, so the omens looked good. Similar to a long slow anticipatory climb to the top of the first peak of a long roller coaster ride, the first part of the novel introduces the main character, or should I say more correctly, one of the main characters, Ye Wenjie. Her father, a famous physics professor is brutally murdered by a group of red guards. This is China in 1967, during the period of the Cultural Revolution, and the action initially described is rather bleak. Two years later, betrayed and imprisoned, Ye Wenjie ends up on the mysterious Radar Peak, where the novel notes "…this event in 1969 would be recorded as a turning point in the history of humankind". So, the scene is set, and the reader enters the core of the story which continues from a point forty-odd years later.



Two of the other main characters, Wang Miao (a researcher in nanotechnology) and Shi Qiang (a bad-cop type figure) are introduced in the next part of the story. Joining a group known as 'Frontiers of Science', Wang starts to see what turns out to be a 'countdown' in his vision. Several scientists, members of the Frontiers of Science organisation have committed suicide, which is how Shi Qiang comes into the plot. Wang then gets involved in an online virtual reality game called three-body, where it appears that the objective is to understand the events that occur, to find some explanation of what is going on. Wang tries the game five times, encountering many historical scientific figures, including notable scientists in the process. A broad range of scientific domains are introduced throughout the novel, extending from the very small (quantum theory) to the very large (orbital mechanics), and in a rigorous manner. A comparison can be made here with the technical accuracy of 'The Martian', but in this case the canvas covered is much larger.

Even at this stage in the story the reader is not quite sure of the overall message, of where it is going, as the characters and events, seem somehow disconnected, at least in my case. It was difficult for me to try and tie the various strands of the story together, to make something consistent out of the numerous threads, even beyond half-way through the novel it was a little confusing for me. However, it does all come together in the end - and persistence pays off, to reveal a novel of exceptional depth, especially with respect to the big question of: what is likely to happen if/when we eventually make contact with an alien civilisation?

I will not reveal the rest of the story, but leave for the reader to discover for themselves. The roller-coaster ride picks up speed rapidly, as the disperate threads eventually come together, leaving considerable tension, which one assumes will be answered in the subsequent two books.

The author's postscript is also an interesting read, as it summarises how Liu Cixin's curiosity in science was ignited when, as a seven year-old boy in Henan Province, he saw in the night sky, China's first satellite, Dongfanghong-1 (launched in 1970), and how his upbringing during turbulent times in China has influenced his writing.

The translation by Ken Liu successfully achieved a fine balance between avoiding submerging the style and meaning of the author, while making the text understandable and to 'flow' for the Western reader, although many western readers may find the text somewhat 'clunky'. The addition of numerous (but not too numerous!) footnotes explaining specific Chinese cultural references greatly aids the understanding.

The 'Three Body Problem' is a science fiction novel, but with definite 'Chinese characteristics'. One which I can thoroughly recommend, and if this first of the trilogy is anything to go by, the remaining two novels, when they are eventually published in English, are likely to be just as satisfying a read.

P.S.: "The Dark Forrest", the second book of the trilogy was published in English on 22 October 2015.

Gallery - CZ-7 and CZ-5 Debuts

CZ-7 in the vertical assembly building before rolling out for a pad drill in early 2015. (credit: CAN Photo)

CZ-7, standing on the mobile platform, on the way to the launch pad for a drill. (credit: Chinese internet)

CZ-7, standing on the mobile platform, on the way to the launch pad for a drill. (credit: Chinese internet)

CZ-7 at the launch pad in a pad drill in early 2015. (credit: CALT)

Gallery - CZ 7 and CZ 5 Debuts

CZ-5 rolling out from the vertical assembly building for a pad drill on 23 November 2015. (credit: Chinese internet)

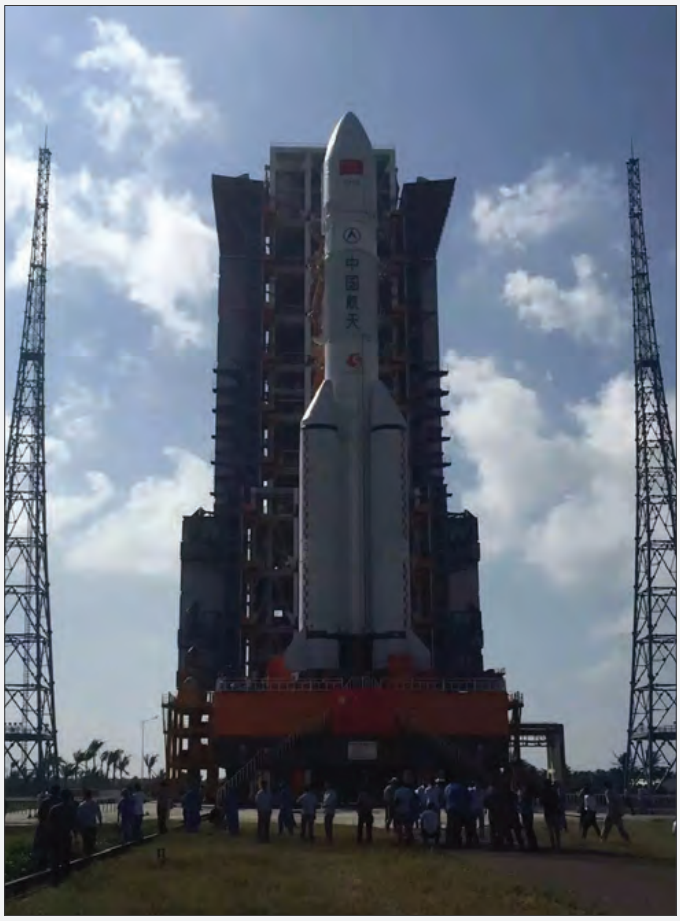
CZ-5 rolling out from the vertical assembly building (in background) for a pad drill on 23 November 2015. (credit: Chinese internet)

CZ-5, standing on the mobile platform, rolling out for a pad drill on 23 November 2015. (credit: Weibo/Bigfoot Tangpopo)

CZ-5, standing on the mobile platform, rolling out for a pad drill on 23 November 2015. (credit: Weibo/Bigfoot Tangpopo)

Gallery
CZ-5 and CZ-7 Debuts

CZ-5, standing on the mobile platform, rolling out for a pad drill on 23 November 2015. (credit: Chinese internet)



CZ-5 at the launch pad on 23 November 2015. (credit: Chinese internet)

CZ-5 at the launch pad on 23 November 2015. (credit: Chinese internet)

Distant view of the CZ-5 rolling out on 23 November 2015. (credit: Chinese internet)

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