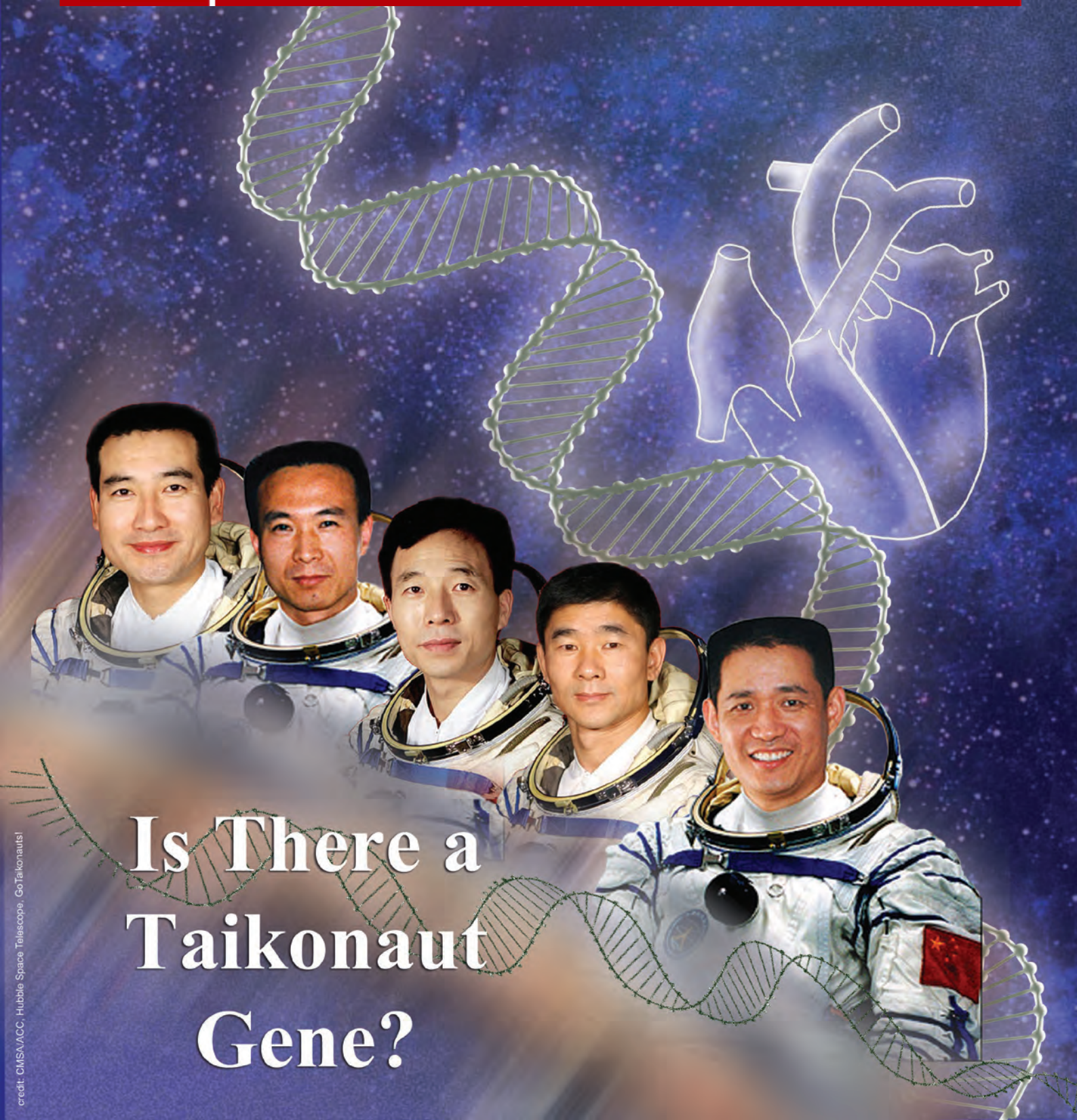
All About The Chinese Space Programme

Go Taikonauts!

龙腾太空

Issue 17 | October 2015



Is There a Taikonaut Gene?

credit: CMSA/ACC, Hubble Space Telescope, GoTaikonauts!

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Go TAIKONAUTS!

Editor's Note

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Quarterly Report

July - September 2015

Launch Events

After two unimpressive quarters with only one launch each, Chinese space launches erupted in the third quarter of 2015 with a total of 30 satellites and seven launches, among which were five launches in September, setting a new record for a monthly launch rate. The most anticipated and impressive launches happened within six days from 20 - 25 September.

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Book Review

A Review of "When China Goes to the Moon…" including an interview with the author Marco Aliberti and ESPI Director Peter Hulsroj

"When China Goes to the Moon..." is a very well-structured, well-written and researched book about China's ambitions in its human space exploration programme, in particular, with respect to its assumed plans for the exploration of the Moon. It provides a detailed background to help understand China's space endeavours, and, based on that understanding, ...

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CZ-6 Maiden Launch

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Is there a taikonaut gene?

including an interview with Prof. Dr. André Aubert

Astronaut, cosmonaut, taikonaut, spationaut, euronaut, austronaut, jaxanaut, afronaut, vyomanaut, brazilnaut. Mind you, there are even reports talking of "castronaut" (Cuban cosmonaut Arnaldo Tamayo Méndez)… and did you know that the Malaysians like it very special? They call their astronauts 'Angkasawan'. It seems that there is no limit to creativity if it comes to finding a fanciful name for a space explorer. The Association of Space Explorers took a smart decision and called them all by the neutral name "space flyers".

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Interview

"You won't change China, China will change you!"

including an interview with Kris Liebaut – Foreign Expert in China

One wonders what such a gigantic nation like China might gain from relationships with a far-away and tiny country such as Belgium. Even within the European context that, Belgium together with its neighbouring countries, The Netherlands and Luxemburg, gets marginalised when the whole region is summarised as BeNeLux. This fact aside, Belgium's cosy capital Brussels is referred to as the 'capital of Europe', hosting the European Parliament and the European Commission. No surprise then that Chinese President Xi Jinping paid a state visit to Belgium and the European...

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Report - Interview

Successful Space Cooperation with China – the British Way

Report from the 10th UK-China Workshop on Space Science and Technology

To most British, the 30.000 population town of Newbury in the South-East of England might be best known for its horse racecourse, or for being the home of Vodafone UK. Without doubt, the hilly, meadow-covered region must be famous for its golf courses, and so one should not be surprised to see that major hotels busily advertise their unbelievably green and well-kept grasslands.

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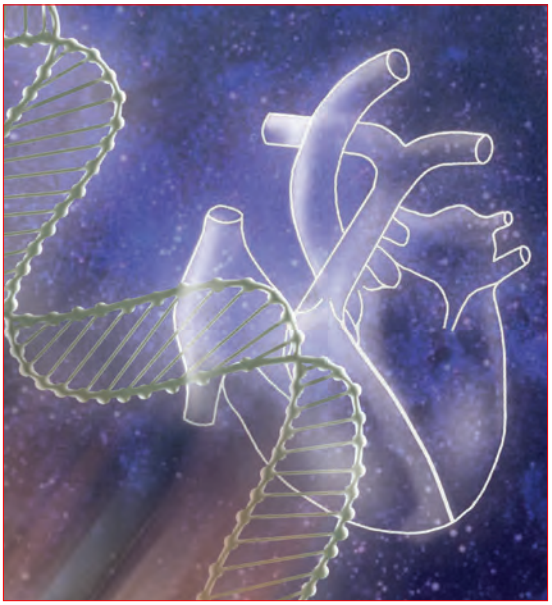

Editor's Note

What can happen when a national giant like China approaches a mini-nation like, let's say, Belgium? There could be reasons for concern and maybe pity for the dwarf nation but the scientific cooperation between Belgium and China is a shining example that win-win and mutual benefit do not depend on territorial dimensions, but certainly political will and personal engagement of the actors. During the last decade, Belgium and China have made remarkable efforts in space cooperation which have now come to fruition.

To illustrate this situation, we took the opportunity to talk to two Belgians – both experts in their fields: Prof. André Aubert and Kris Liebaut.

Prof. Aubert is the principal investigator of a comparative study in space physiology. He had the opportunity to compare medical data of European astronauts with the data of Chinese astronauts. The first results were published in March this year and to most peoples' surprise, the data show that Chinese astronauts seem to cope better with cardiovascular deconditioning after short-duration space missions than European astronauts. This inspired us to the question: is there a taikonaut gene?

Kris Liebaut, on the other hand, has spent six years of his life in China, teaching European languages to aerospace students at Shenyang Aerospace University in the North-East of China. He returned to Belgium with countless interesting impressions and intriguing observations which he was willing to share with us.

Not only Belgium looks at tremendous achievements in space cooperation with China. At the beginning of September, already the 10th UK-China Workshop on Space Science Technology took place in Newbury, a town 100 km West of London. GoTaikonauts! was there and observed a vibrant and highly successful forum in establishing cooperation between British and Chinese organisations.

Late summer, Marco Aliberti of the European Space Policy Institute ESPI, published a comprehensive overview on the Chinese space programme. "When China Goes to the Moon…" This book not only summarises what has happened so far in China, but analyses Europe's stance towards China. Most of all, it is an earnest appeal toward Europe to not miss out on its chance to assist in enabling a new world order. We are reviewing this book.

Additionally, the author gave us in an interview interesting background information on his work for the book, while the Director of ESPI, Peter Hulsroj, explains the Institute's general work but also the specifics in following China's space programme.

Have a good read!

(**Jacqueline Myrrhe**)

Imprint

Go Taikonauts! e-Magazine

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

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Chinese Space Quarterly Report

July - September 2015

by Chen Lan

Highlights

- CZ-6, CZ-11 made debuts - new generation launchers arrive after a long wait.
- First dual-sat Beidou launch successful, two MEO satellites in orbit.
- CZ-5, CZ-7 wound up major ground testing.
- Chinese micro satellites made a giant leap, thanks to the CZ-6, CZ-11 launches.
- Chang'e 5-T1 continues working and producing maps for the sample return mission.
- Yutu continues to send signals.
- China establishes space nuclear propulsion laboratory.
- U.S. and China held the first Civil Space Dialogue.
- NanoRacks to fly the first Chinese experiment on the ISS.
- China interested in purchasing the RD-180 engine from Russia.

Launch Events

After two unimpressive quarters with only one launch each, Chinese space launches erupted in the third quarter of 2015 with a total of 30 satellites and seven launches, among which were five launches in September, setting a new record for a monthly launch rate.

The most anticipated and impressive launches happened within six days from 20 - 25 September. After a one day delay due to an undisclosed technical problem, the CZ-6 new generation launch vehicle lifted-off flawlessly at 7:01, 20 September from a new launch complex (LC 16) in the Taiyuan Satellite Launch Centre and sent 20 small and micro satellites into a Solar Synchronized Orbit (SSO) sixteen minutes later - the number of satellites sent to space is a new record for China. It was the maiden flight of the CZ-6 small launch vehicle as well as the YF-100 and the YF-115 liquid oxygen and kerosene staged combustion cycle engines. The successful launch marked the beginning of a new era of the Chinese space programme with the operation of a new family of launchers using non-toxic, non-pollution propellant and modern onboard and ground support technologies. More details about the CZ-6 and its payloads are in the following sections of "Space Transportation" and "Satellites".

On 25 September, at 9:41, China successfully launched another brand new launch vehicle, the CZ-11 small launch vehicle, from Jiuquan. The four-stage all-solid propellant CZ-11 has a length of 20.8 m, a diameter of 2 m and a launch mass of 58 t, and is able to send 350 kg into a 700 km SSO and 700 kg to LEO. It has also a fast launch preparation cycle of 24 hours. Chinese media also revealed that in a launch drill, it needed only 10 hours from taking the rocket from storage to launch. CZ-11 is allegedly based on the DF-31 strategic missile, so that it presumably has a mobile launch capability from its transportation vehicle. China did not release any official launch photos. But CCTV footage showed that the launcher was mostly encased by a canister during pre-launch testing, with its nose section in a two-piece protective cap. The maiden launch sent the Pujiang 1 main satellite and three CubeSats into orbit (see the "Satellites" section for details). According to the reports, CZ-11 uses the largest solid motor ever developed in China. Its fourth stage was ignited after a period of cruise so that it is more like a perigee kick motor.

The other five launches were:

- On 29 July, at 20:29, a CZ-3B launch vehicle lifted-off from the Xichang Satellite Launch Centre with two new generation experimental Beidou navigation satellites (M1-S and M2-S). Three and a half hours later, the satellites were sent into the medium Earth orbit (MEO) by the YZ-1 upper stage. It was the YZ-1's second flight and the first time it was used in a dual-sat launch.

The 20 small and micro satellites attached on the CZ-6 adapter.
(credit: CCTV)

The CZ-11 launch vehicle at the launch pad.
(credit: Chinese internet)

- On 27 August, at 10:27, the YG-27 satellite was successfully launched from the Taiyuan Satellite Launch Centre by a CZ-4C rocket. The YG-27 optical imaging satellite is the fifth and final one in a series also including YG-8, 15, 19 and 22. Unfortunately, debris of the first stage fell down onto a farmer's house in Xunyang County, Shaanxi Province. Fortunately, there were no fatalities or injury.
- On 12 September, at 23:42, the Tongxin Jishu Shiyan (Communication Technology Test) 1 satellite was successfully launched by a CZ-3B from Xichang. It was reported that the satellite is to test Ka-band broadband communication. It is the first of a series of communication test satellites.
- On 14 September, at 12:42, a CZ-2D rocket took-off from the Jiuquan Satellite Centre, putting the GF-9 high-resolution optical imaging satellite into SSO. Like the GF-8 launched in June, it is not recorded in earlier announced plans (with only GF-1 to GF-7) and is also possibly derived from a YG satellite.
- On 30 September, at 7:13, the second inclined geostationary orbit Beidou navigation satellite (I2-S) was successfully launched. The 4,600 kg satellite (the heaviest Beidou bird) was sent into orbit by a CZ-3B from the newly renovated Pad 3 in Xichang. It was developed by CAST and was the fourth experimental satellite in the Beidou global constellation after the I1-S, M1-S and M2-S. It is reportedly equipped with the domestically made hydrogen atomic clock for the first time. This time again, debris of the rocket damaged a ground object - the car of a farmer. Fortunately, all people including the car owner were evacuated before the launch. The two incidents in a little more than one month show that it had become a serious issue.

In addition to the above seven launches, there was also a foreign launch related to China. It was the Beijing 2 (DMC3) launch by a PSLV-XL launcher from the India's Satish Dhawan Space Centre on 11 July (Beijing Time). Beijing 2, built and operated by the Surrey Satellite Technology Ltd. (SSTL) of Britain, includes three identical imaging satellites with a resolution of 1 m. The Beijing-based Twenty-First Century Aerospace Technology Co. Ltd. (21AT) paid 110 million £ up front to cover most of the system's construction, launch and insurance costs in return for seven years' exclusive use of the imagery. Strictly speaking, it is not a Chinese satellite though it has a Chinese name.

Space Transportation

With its successful maiden flight, the CZ-6 joins the Long March (Chang Zheng) family as the first operational vehicle of the new generation launchers. CZ-6 had been developed by SAST (Shanghai Academy of Space Flight Technology) since 2009. It has a length of 29 m and a diameter of 3.35 m (first stage), 2.25 m (second and third stage) and 2.6 m (fairing). Its launch mass is about 103 tonnes and is capable of putting 500 kg of payload into SSO at 700 km (or 1,000 kg if the third stage is re-ignited). Its first and second stage each have a single YF-100 and YF-115 engine, generating 120 t and 18 t thrust respectively. The third stage has a hydrazine-based engine. All these engines were in their maiden flight. It's faring was reportedly made of a paper honeycomb structure to allow better penetration of radio waves. CZ-6 is assembled, tested and transported horizontally. A specially designed transportation vehicle carries the complete tested rocket and its erector to the launch pad. Its launch pad is also very simple where the erector plays the role of an umbilical pod that is turned down before launch. All this enables fast integration, test, rolling out and launch, which makes CZ-6 a fast responsive launch vehicle whose launch campaign is only 7 days. SAST disclosed that the enhanced model, or medium class CZ-6, had been approved and is scheduled to fly before 2020.

The YF-100 and YF-115 liquid and kerosene engines were core parts of the CZ-6 vehicle with a much longer development history than the launch vehicle itself. China started the study of the staged combustion cycle kerosene engine since the introduction of the RD-120 engine from Russia in the early 1990s. Development of the 120 t thrust YF-100 engine began in 2000 and it made a first hot test firing in 2002. After 15 years, it finally left the ground. Meanwhile, Chinese engineers did not stop improving the technology. Around the end of August or early September, the gas gimbaling assembly developed for the YF-100 made a successful hot test firing in AAPT, paving the way for using after-pump gimbaling technology that will efficiently reduce the size and weight of the engine and improve its performance.

The CZ-6 was just the first of the new generation launch vehicles in China's plan. Within the next year, the CZ-5 and CZ-7 will make their debuts as well. Final testing and preparation for these two larger launchers was in full swing. The following are activities reported in this quarter:

- In late July, the CZ-5 completed the whole-rocket modal test lasting since October 2013. During the test, data of the rocket's mechanical characteristics in 23 working statuses was obtained. The rocket used for the test has a height of 57 m, with four strap-on boosters with a height of 28 m, making it the largest scale and most complicated rocket mechanical / vibration test in Asia.
- On 24 July, at 15:08, the propulsion system of the CZ-5 second core stage made its first test firing. The stage has a diameter of 5 m, a length of 11 m and was installed with the YF-75D expander cycle cryogenic engine. The test firing was performed according to the actual flight

The CZ-11 launch vehicle in pre-launch preparation.
(credit: CCTV)

sequence with an engine re-ignition. On 27 August, at 16:30, it made the second test firing which was also a success. This test firing was the last ground test firing before the CZ-5's maiden flight scheduled for 2016.

- On 20 September, the Yuanwang 21 and 22 rocket transportation ships, carrying the CZ-5 rocket for pad rehearsal, departed from Tianjin Port. The two ships arrived in the Wenchang Space Launch Centre in Hainan on 25 September. The launcher will be added with the rehearsal model of the Chang'e 5 lunar probe and will carry out the integrated pad drill.
- In mid-July, the core stage of CZ-7 was lifted by crane from the vibration tower in Tianjin, marking completion of the modal test of the CZ-7 core stage. In mid-August, the first booster was moved into the vibration tower, marking the start of the whole-rocket modal test.
- In late August, the YF-115 engine for the CZ-7 second stage completed the 400-second rated condition hot test firing, winding-up the whole mission profile adaptability test.
- In early September, Chinese Space News reported that a test on CZ-7's transportation environment was done. In this test, a CZ-7 rehearsal rocket (for pad rehearsal) was loaded in a transportation ship with more than 30 measurement points on it and its containers. The result showed that ocean transportation is three times better than train and twice better than highway transportation in terms of overload.

Satellites

The two new launchers, CZ-6 and CZ-11, sent in total 24 satellites into space in six days, which was unprecedented in China's space history. The 20 satellites sent into the SSO by CZ-6 were mounted on three stages on the cone-cylinder shaped satellite adapter:

- At the top of the cylinder was the KT-1 and its sub-sat DCBB. The KT-1 (Kaituo 1) is an 110 kg main satellite (a fast-development, low-cost test satellite extensively using commercial components). The 2 kg DCBB (or CAS-3G), jointly developed by the universities in Hong Kong and Macau, is China's first CubeSat launched into space. Both were developments by the Aerospace Dongfanghong Development Ltd. Shenzhen (short as Shenzhou DFH), a joint venture of CAST, HIT (Harbin Institute of Technology) and the Shenzhou City government.
- In the middle, around the cylinder, there were three individual satellites and a package including six satellites. The three individual satellites included two 12 kg ZDPS (2A and 2B) developed by Zhejiang University to verify MEMS (Micro-electromechanical System) components, deployment of micro structure and formation flight, and the 10 kg XW-2D (CAS-3D) amateur radio satellite developed by the China Spacesat Co., Ltd, the CAST's small satellite subsidiary. The six-sat package included the 20 kg TT-3 (Tiantuo 3, also known as Luliang 1) main satellite, aiming for AIS (automatic identification system for monitoring sea ice and maritime traffic) and ADS-B (the automatic dependent surveillance broadcast for monitoring air traffic flow), and five sub-sats - the 1 kg NUDTPhone sat (also known as Zhineng or CAS-3I) and four 0.1 kg femto-sats, Xingcheng 1 to 4, that are claimed as the smallest operational satellites in orbit. All these six satellites were developed by the National University of Defense Science and Technology (NUDT) and will test formation flight in orbit.
- At the bottom, around the cone, there were three individual satellites and two packages both of which included three satellites. The three individual satellites were the 12 kg Lilacsat 2 (CAS-3H) nano-satellite developed by HIT students for education, amateur radio and technology demonstration, and two 10 kg amateur radio satellites, the XW-2A and XW-2B (CAS-3B and 3C, identical to the XW-2D/CAS-3D) developed by China Spacesat. The first satellite package included three amateur radio satellites, the 25 kg XW-2C (CAS-3C) main satellites and two 1.5 kg sub-sats, the XW-2E and 2F (CAS-3E and 3F), all of which were developed by China Spacesat. The second package included the 20 kg Naxing 2 (NX-2) and the Zijin 1 sub-sat (234 g), both of which were developed by Tsinghua University, and another sub-sat, the Zijin 2 (172 g) developed by Xidian University.

After launch, the 8 sub-sats were released by their main satellite. And the two sub-sats on NX-2 were to be released one month after launch. There were no reports indicating abnormalities during the deployment of the 20 satellites.

The maiden launch of CZ-11 sent the Pujiang 1 main satellite, developed by SAST, and three CubeSats into orbit. Pujiang 1 is a small satellite using a versatile and standardised satellite bus capable of fast integration with payloads. It makes it possible to complete payload integration and testing in one month, launch preparation in one week and in-orbit testing and delivery in one day. It also adopted a series of new technologies like 3D printing, WiFi-based wireless sensors, etc. The three CubeSats are under one designation of STU-2 (STU stands for ShanghaiTech University that is under CAS, or China Academy of Sciences) and also called TW-1 (TW is short for Tanwang, meaning Sky Net in Chinese), among which the 2.9 kg 3U CubeSat STU-2A and the 1.7 kg 2U CubeSat STU-2C were developed by SECM (Shanghai Engineering Center for Microsatellites, CAS) and the third (the 2.2 kg 2U CubeSat STU-2B) was developed by NJUST (Nanjing University of Science and Technology) so that it is also called NJUST 1. Besides their own missions including AIS and ADS-B testing, the three satellites will also test formation flight in orbit. Three European companies, GomSpace from Denmark, Tekever Space from Portugal and NanoSpace from Sweden were involved in the project to provide the satellite platform, the Gamalink inter-sat communication technology and nano-thrusters respectively.

The CZ-6 and CZ-11 maiden launches were not only an historic milestone for the Chinese launch industry, but also the beginning of a new era for China's small and micro satellite development. It has to be noticed that most of the satellites from universities were developed by students. It is reasonable to expect a boom of new satellite applications and a wider market beyond what the traditional Chinese space industry is covering so far.

There also was some news about China's space science missions:

- On 3 July, the Sino-Franco SVOM astronomical satellite completed the system requirement review (SRR) for the Phase B study in Beijing, lasting 5 days. It is planned to complete the study by June 2016.
- In July, the Sun Yat-Sen University started a worldwide recruitment for its Lyra Space Science Mission. The mission aims to find gravitational waves using ground and space based facilities involving three high Earth orbit satellites. The ground research facility will be built in the university's Zhuhai campus in Zhuhai, Guangdong Province.
- On 3 September, the kick-off meeting of the SMILE (Solar Wind Magnetosphere Ionosphere Link Explorer) mission was held in UCL (University College London). The journey of development began.

Other news was from the Gaofen civil high-resolution satellite programme. In early July, the GF-5 (pollution detection satellite) flight model completed the satellite's tracking interface test. And in mid-August, the GF-3 (radar satellite) flight model completed a data transmission test between the satellite and the ground station.

Manned Space Flight

Currently the Chinese manned space programme is at its low tide. There was not much news about it except for a report in mid-August that the CMG (control moment gyro) for the space station has entered the testing phase. It is the largest CMG China has ever developed.

Lunar and Deep-Space Exploration

It has been a long time without messages from the Yutu rover. On 27 August, uhf_satcom, an amateur radio group, tweeted a message saying a nice carrier signal had been received from the Yutu rover on 8462.030 MHz. This group has tracked the Chang'e 5 lander and the rover since its launch. Early this year, it was found that signals from Yutu were getting weaker and weaker. On 27 September, the signals came again. The recent good signal was unexpected. On the other hand, payloads on the lander and the rover had seemingly ceased operation except for the Lunar Optical Telescope (LOT) which is still working. According to a Chinese News Agency report on 9 September, the LOT has accumulated 2,144 hours of sky surveying and 945 hours of observation time on 36 stars. It also captured an image of the Pinwheel Galaxy M101 in February, which was the first time to photograph a galaxy from the lunar surface, and observed an eclipse in April. Also, it found that the density of hydroxyl in the lunar exosphere is 100 times lower than what Hubble detected, indicating the Moon is much drier than previously expected.

During 30 August and 2 September, the service module of the Chang'e 5-T1 photographed the area planned for the Chang'e 5 landing and sampling around 2017. To prepare this task, its orbit was lowered to 30 x 80 km on 28 August. The photographing used the wide and narrow angle cameras at 30 km above the lunar surface and obtained images with a resolution of 1 m. The Chang'e 5-T1 service module had extended its mission for multiple times and completed EM-L1 orbiting and simulated landing and ascending in lunar orbit.

On ground, there was also some news about the Chang'e 5 development in this quarter:

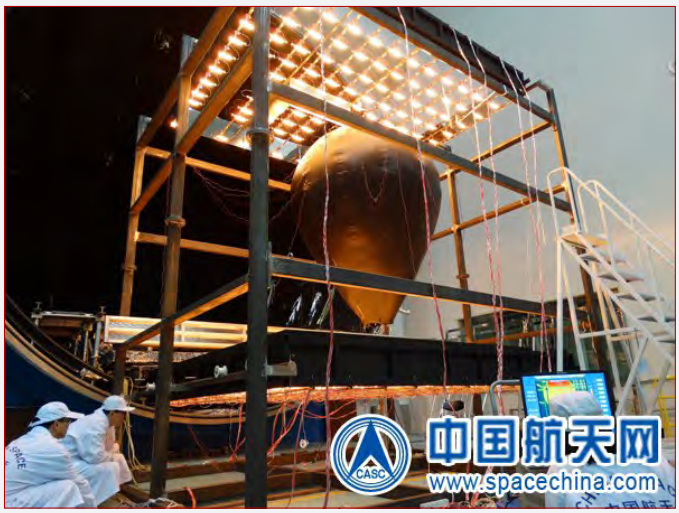
- In early July, the Chang'e 5 completed the landing and launch simulation without engine ignition, paving the way for the later simulation with engine ignited. It was done in the outdoor lunar landing tower built for the Chang'e 3 development in 2011. The facility is able to simulate with high precision the lunar gravity field.
- In mid-July, the Phase 3 full-size plume test of the Chang'e 5 was completed, winding up an important test with all working conditions tested. It was the first time that China used the liquid hydrogen heat-sink system. The successful test paved the way for the ascent vehicle to ignite on the lunar surface in future.
- On 29 July, the propulsion system of the Chang'e 5 lander completed a reliability hot test firing in Beijing. AAPT who is in charge of most of the Chang'e 5 propulsion systems, has completed a string of 12 hot test firings in one month with six Chang'e 5 sub-units including the lander, the ascent vehicle and the orbiter - all were successful.

Work on Chang'e 4 also entered a new phase after the mission objective was set and international cooperation announced in May. On 9-19 July, CNSA and ESA hosted a joint seminar on the Chang'e 4 mission in Beijing. ESA agreed to provide four payloads including the lunar seismograph and the quick flash camera, and plans to deliver them in 2018.

Advanced Technology

On 22 August, the Joint Laboratory for Space Nuclear Propulsion was set-up in Beijing. CAST, China Institute of Atomic Energy and Beihang University are founders of the lab. As the oldest organisation carrying out research on space nuclear propulsion, CAST leads the laboratory.

In early July, it was reported that the Qian Xuesen Space Technology Laboratory, belonging to CAST, completed a successful ground test on thermodynamic characteristics of an aerostat. The report



Ground test of the aerostat developed by the Qian Xuesen Space Technology Laboratory. (credit: spacechina.com)

stated that the technology tested, could be used in deep-space exploration, suggesting a Venus balloon.

International Cooperation

Pursuant to the shared goal of advancing civil space cooperation as agreed upon in the Strategic Track of the U.S.-China Strategic and Economic Dialogue in June 2015, the Government of the U.S. and China convened their inaugural Civil Space Dialogue on 28 September 2015, in Beijing. The meeting was co-chaired by the Department of State for the United States and by the China National Space Administration for China. At the meeting, U.S. and Chinese officials exchanged information on respective space policies and conducted discussions on further collaboration related to space debris and the long-term sustainability of outer space activities. Both sides exchanged views on issues related to satellite collision avoidance. They discussed ways to cooperate further on civil Earth observation activities, space sciences, space weather, and civil Global Navigation Satellite Systems (GNSS). Both sides agreed to hold the second meeting of the Dialogue in Washington D.C., in 2016.

NanoRacks, a Houston based company, has negotiated an historic agreement to fly a Chinese experiment on the International Space Station, a small but symbolic manoeuvre around a law that bans any scientific cooperation between NASA and China. Chinese scientists from the Beijing Institute of Technology, led by Professor Deng Yulin, will pay about $200,000 to NanoRacks for its services. This includes delivery of the experiment to the American side of the Station in a SpaceX Dragon spacecraft and a berth in NanoRacks' orbiting laboratory facilities. In turn the company will send data back to the Chinese researchers.

SpaceNews reported on 29 September that during a presentation to the NASA Advisory Council (NAC) heliophysics subcommittee at NASA's Headquarters in Washington, the new Director of NASA's Heliophysics Division, Steven Clark, mentioned that NASA is considering its participation in the CNSA-ESA Solar wind Magnetosphere Ionosphere Link Explorer - SMILE mission. A final decision is expected as soon as November. According to Clark, one option under consideration is that NASA would deliver hardware to ESA. ESA would do the integration activities in Europe and would be looking at launching off a European launch vehicle.

Interfax reported on 7 July that China is interested in buying Russia's RD-180 dual-combustion chamber 400 tonne thrust engines for its prospective super-heavy-lift launch vehicle. Of the two possibilities of buying ready rocket engines or acquiring a production license, the latter is not favoured by the Russia side, according to a source familiar with the situation.

At the two-day China-Pakistan Economic Corridor forum in Karamay on 11-12 August in Northwest China's Xinjiang Uygur, Ahsan Iqbal, the Federal Minister of Planning, Development and Reform of Pakistan, proposed a space technology cooperation programme between Pakistan and China. He stated that he wanted to see both the countries launch a joint space mission programme with astronauts from both the countries working together, in order to further improve the relations between the two neighbouring countries and increase their efforts for space and technology. The proposal was unanimously adopted at the end of the forum.

On 19 September, the Sixteenth Meeting of the Space Cooperation Sub-Committee of China-Russia Prime Ministers' regular Meeting Committee was held in Moscow. The two sides agreed to actively carry out remote sensing satellite data exchange and also cooperate in the field of lunar and Mars exploration. Russia hopes to use the opportunity of China's Chang'e 4 lunar probe to fly Russian instruments, for which the two sides will study the technical feasibility.

On 13 September, the United Nations Office for Outer Space Affairs (UNOOSA) and the China National Space Administration (CNSA) signed a new agreement in Beijing, through which Chinese satellite Earth Observation data will be harnessed to support the United Nations in the areas of disaster management and disaster risk reduction. Chinese satellites may be tasked with acquiring current imagery over specific areas of interest when relevant for the disaster management cycle.

China also signed space cooperation agreements with Sweden and Sudan in August and September.

On 6 August, the U.S. State Department announced in a statement that the United States, China, Russia, and Laos plan to co-chair a follow-on workshop to explore the benefits of outer space for ASEAN (Association of Southeast Asian Nations) Member States. The workshop will also address current issues facing the space environment, and assess approaches to space security to ensure the benefits for future generations.

Xinhua reported on 15 July that Yinchuan Economic and Technical Development Zone (of Ningxia Province) and China Alliance of Satellite Application Service signed a cooperation agreement on the establishment and operation of New Silk Road Satellite Service Industry Demonstration Area. The demonstration area will become the one and only base for China to provide Arabic countries and regions with satellite communication and navigation services. As planned, the demonstration area will officially start business in 2016.

Commercial Space

There were three commercial communication satellites in development in CAST aiming for launch in the last quarter of 2015 or the first quarter of 2016. The first one is the DFH-4 based Apstar 9. It completed the compact range test in August and was shipped by an Antonov 124 transport plane to Xichang on 27 August. Its launch is scheduled for mid-October by a CZ-3B. The second one is the LaoSat 1 comsat that is the first satellite of the DFH-3B platform. It completed the simulated flight sequence test in August. On 2 September, the rolling out ceremony was held in Beijing, witnessed by The Lao People's Revolutionary Party General Secretary and President, Choummaly Sayasone. It will be launched in mid-November. Finally, the Belintersat 1 comsat completed integration of three modules in August, paving the way for its launch in the first quarter of 2016. Like the Apstar 9, this satellite is also DFH-4 based.

Gilat Satellite Networks Ltd. of Israel, a worldwide leader in satellite networking technology, solutions and services, announced on 12 August that it and the Space Star Technology Co Ltd. will jointly provide the satellite communications network for ChinaSat 16 (ZX-16), the first Ka HTS multi-spot-beam satellite in China.

Miscellaneous

Ground Facility

On 2 August, assembly of the reflecting surface of the FAST, the Five hundred metre Aperture Spherical Telescope, the world's largest radio telescope, started. The first of the 4,450 adjustable panels that form the reflecting surface was installed in position. On 30 September, it completed the installation of the 3.5 km long high-tension electric cables. The FAST is located in Pingtang, Guizhou Province, and started construction in 2011. In addition to astronomical observation, it will also be capable of tracking deep-space spacecraft thanks to these computer controlled adjustable panels. The supercomputer Skyeye-1, capable of a quadrillion computing operations per second, will support space exploration by FAST. FAST needs a strong computing system to support massive data storage and processing. The Institute of Computing Technology under the Chinese Academy of Sciences (CASICT), Dawning Information Industry Co. and China (Guizhou) Skyeye Group, signed an agreement last November to jointly build the Qiannan Super Computing Center in Guizhou. FAST daily peak demand will be above 200 teraflops per second and its first-phase storage demand will be more than 10 petabyte.

In late September, the CZ-7 launch pad in Wenchang Space Launch Centre completed the "level 2" water pouring test (a test to reduce the temperature of the launch pad to protect it from the engine flame). The "level 1" pouring facility is at the ground level while the level 2 is 5 m above ground.

The panels of the FAST are partially installed. (credit: People's Daily)

The level 2 water pouring testing at the CZ-7 launch pad. (credit: CALT/WeChat)

Space Education & Entertainment

On 29 September, at the Purple Mountain Observatory (PMO), CAS, it was announced that it will invite the public to name the Dark Matter Particle Explorer (DAMPE) that is to be launched by the end of 2015. Proposals will be accepted online at http://scitech.people.com.cn/DAMPE until 31 October. Five grand prize-winners will be able to watch the satellite launch in person at the Jiuquan Satellite Launch Center. Besides PMO, University of Science and Technology of China, Institute of High Energy Physics of CAS, Institute of Modern Physics of CAS, National Space Science Center of CAS, University of Geneva and University of Perugia are also involved in the project.

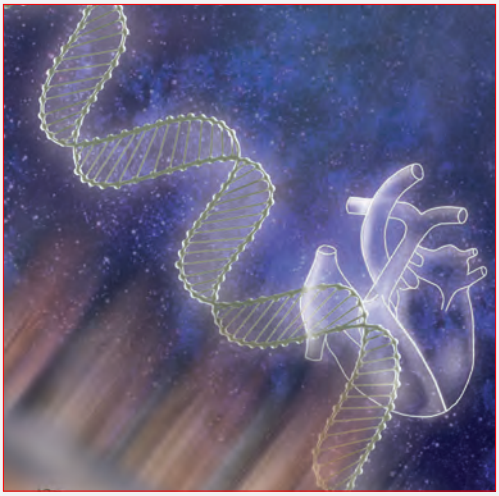
On 16 September, the Wencheng City of Hainan Province announced in a press conference that it welcomes tourists to come and view the maiden launches of CZ-5 and CZ-7. An authorised local tour agency will organise tours for participants to visit the launch site and witness the launches of the new generation launch vehicles.

Chinese writer Liu Cixin has become the first Asian author to win the Hugo Award for Best Novel, receiving the 2015 honour for his Sci-fi book, The Three-Body Problem. The prize was announced by NASA astronaut Kjell Lindgren in a live feed from the International Space Station on 23 August.

(Chen Lan)

Is There A Taikonaut Gene?

by Jacqueline Myrrhe



Astronaut, cosmonaut, taikonaut, spationaut, euronaut, austronaut, jaxanaut, afronaut, vyomanaut, brazilnaut. Mind you, there are even reports talking of "castronaut" (Cuban cosmonaut Arnaldo Tamayo Méndez)… and did you know that the Malaysians like it very special? They call their astronauts 'Angkasawan'. It seems that there is no limit to creativity if it comes to finding a fanciful name for a space explorer. The Association of Space Explorers took a smart decision and called them all by the neutral name "space flyers". After all, they are humans; flying into space – all right so far – mainly circling in an orbit around the Earth. However, doing the same thing might not mean being the same. Maybe it would be an advantage to be a cosmonaut instead of an astronaut? Maybe there is a gene, making it easier for certain ethnic groups to cope with weightlessness? We know that certain ethnic groups excel in the marathon, and others have a natural advantage for gymnastics or weightlifting. Is there maybe something like an astronaut gene?

This is the burning question coming to one's mind after studying the recent paper "Is autonomic modulation different between European and Chinese astronauts?" whose finding is: Yes, for some not (yet) known reason, taikonauts seem to have less problems with the re-adaptation after a short-duration space mission compared to their European colleagues. How come?

Blood circulation in the human body is perfectly designed to function under terrestrial gravity conditions. When standing upright, we can trust that our brain - for some of us up to 2 m in height above the ground - gets as much nutritious blood as the legs, which are closer to the Earth's surface. On the other hand, when sitting or lying down, the head will not be flooded with blood either. This delicate interaction between heart and blood vessels (cardiovascular) is disturbed in weightlessness. Without gravity more body fluid concentrates in the upper part of the body, causing headaches and space sickness, but thanks to the high degree of adaptability the human body will reach a new equilibrium after a few days. Coming back to Earth has the reverse effect: the blood, forced by gravity, will fill again the lower extremities leaving less fluid in brain and trunk before the old balance is established after a few days. This cardiovascular deconditioning occurring in flight, after landing, comes along with a post-flight condition known as 'orthostatic intolerance' - the inability to maintain an upright posture for a longer period of time accompanied by a significant increased heart rate (tachycardia). The underlying pathophysiological mechanisms of orthostatic intolerance have been investigated extensively, but no single satisfactory explanation has yet been proposed. While a high percentage of European astronauts suffer from this condition after short-term space missions, a study by Prof. André Aubert from the University Hospital Gasthuisberg, Catholic University Leuven, Belgium, comes to the conclusion that "post-spaceflight orthostatic tachycardia was significantly reduced in Chinese astronauts."

The study in a nutshell

The comparative study of five European astronauts from three different short-duration space missions to the ISS and five Chinese astronauts from two different short-duration orbital Shenzhou space missions, investigated the cardiovascular control of the autonomous nervous system before and after space flight. The scientists conducted data recording of the beat-to-beat heart rate and finger blood pressure, upper arm (brachial) blood pressure, and respiratory frequency in lying down (supine) and standing positions, before and after space flight. The data for both groups of space flyers were similar in horizontal (supine) position before and after the space missions as well as in standing position before space flight, but did show differences in the heart rate in standing position after the mission. European astronauts showed a significant increase in sympathetic nervous activity (high heartbeat) and a decrease in parasympathetic modulation (opponent to the sympathetic nervous system – slowing the heartbeat) when standing upright – an indication that the autonomous nervous control mechanism worked hard to maintain the cardiovascular balance and blood circulation. The heart rate of Chinese astronauts in standing position was more or less at the same level as before the flight.

Ask the Medicine Man - Prof. Aubert Explains

The human heart is not an isolated organ. It is controlled by the brain through the autonomous part of the nervous system.

This 'autonomic system' is responsible for those body functions that do not need thinking about, like breathing, heartbeat or digestion in your stomach. This is all done automatically and is in contrast to the other parts of the brain that give us consciousness or controls actions which require a command, like lifting an arm. To make it simple, one can say that there are two pathways which are connecting via chemical reactions through the spine, the brain to the heart. One pathway is the sympathetic which is acting as the accelerator and the other one is the parasympathetic pathway, which is acting as the break and makes everything go slower.

Throughout a normal day, there is a delicate balance between

A Tiny Cardiovascular Dictionary

baroreflex sensitivity: relationship between heart rate and blood pressure.

blood pressure variability: blood pressure varies on a beat-to-beat basis and its fluctuations are defined as blood pressure variability.

cardiac output: is the product of the stroke volume with the heart rate.

cardiovascular system: the heart and the blood vessels.

ECG: Electrocardiography

heart rate variability: continuous change of heartbeat from minute to minute; is modulated by the autonomic nervous system. The measurement of the heart rate variability can determine the general condition of a human.

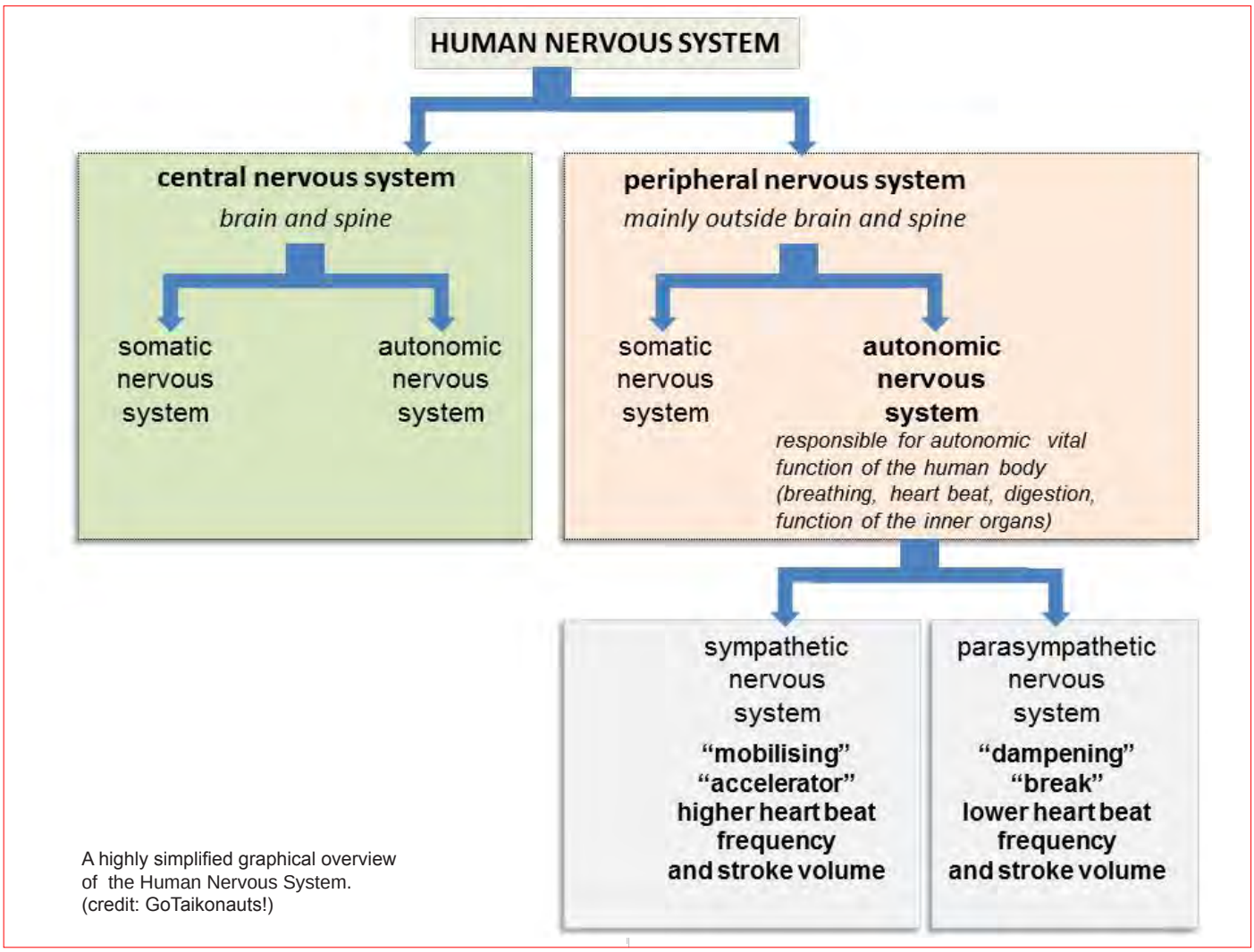
orthostatic intolerance: the inability to maintain an upright posture.

stroke volume: the volume of blood which is expelled each time the heart beats - between 60 to 80 ml of blood. If combined with the heart rate - and considering that a human has 5 to 6 litres of blood - in one minute all of the human's blood is pumped throughout the body under normal conditions.

tachycardia: significantly increased heart rate - caused by an reaction of the sympathetic nervous system which acts as an accelerator for the heart.

both. When we are sitting or lying down, the heart rate is lower and when we stand up we have a control mechanism that tells the heart to increase its performance because the heart has to pump harder against the gravitational pull. When this mechanism is disturbed, people experience difficulties in getting up or standing upright. Also, if you start jogging then the sympathetic response will be higher and as a consequence, the heart rate will go up. When you go to sleep, then the parasympathetic pathway will become dominant. This is a simplified explanation of the processes.

Going into space causes complex changes to the human body. The two main components in space are weightlessness and the radiation environment. Radiation is a problem on its own. Weightlessness has an effect on all weight-bearing parts of the skeleton, including the bones and muscles which become weaker because of off-load. Many of those problems we also have here on Earth. Muscle atrophy, for example, can also be a problem when patients are confined to bed for a long period of time - after an accident or serious illness for example.



A highly simplified graphical overview of the Human Nervous System. (credit: GoTaikonauts!)

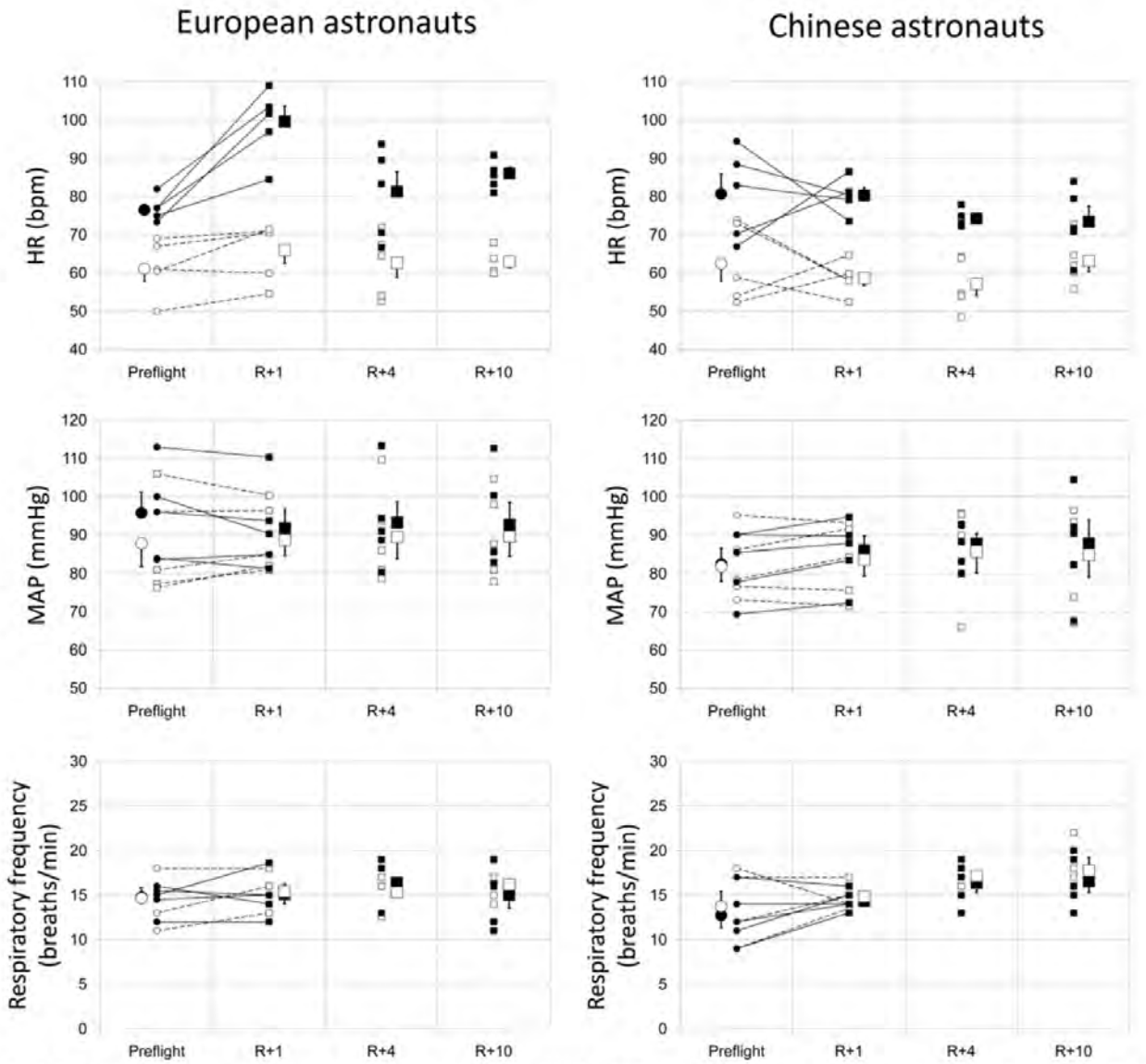


Fig 1. Evolutions in heart rate (HR; top), mean arterial pressure (MAP; middle), and respiratory rate (bottom) before and after spaceflight in the European and Chinese astronauts in the supine and standing position . R+1 = the first day after landing; R+4 = the 4th day after landing; R+10 = the 10th day after landing. ○ (small open circle) baseline individual data in supine position; ● (small black filled circle) baseline individual data in standing position; □ (small open spuare) post-flight individual data in supine position; ▪ (small black filled square) post-flight individual data in standing position; ◯ (large open circle) baseline mean value in supine position; ● (large black filled circle) baseline mean value in standing position; ☐ (large open square) post-flight mean value in supine position; ■ (large black filled square) post-flight mean value in standing position.

doi:10.1371/journal.pone.0120920.g001 (credit: J. Liu, Y. Li, Verheyden, S. Chen, Z. Chen, Gai, J. Liu, Gao, Xie, Yuan, Q. Li, L. Li, Aubert

Evolutions in heart rate (HR; top), mean arterial pressure (MAP; middle), and respiratory rate (bottom) before and after spaceflight in the European and Chinese astronauts in the supine and standing position. R+1 = the first day after landing; R+4 = the 4th day after landing; R+10 = the 10th day after landing.

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- ■ (small black filled square) post-flight individual data in standing position;
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- ☐ (large open square) post-flight mean value in supine position;
- ■ (large black filled square) post-flight mean value in standing position.

On Earth, the orthostatic pressure is much higher in the feet, due to the weight of the fluid column inside the human body. Weightlessness introduces a fluid shift towards the head and trunk. You see that in the face of an astronaut in space when it looks very swollen and his legs are getting pretty thin. This relates to neurovestibular disturbances, cardiovascular deconditioning, dehydration, and also decreased capacity in blood volume or decreased immune response.

Additionally, astronauts lose 2 - 3 kilograms in space, which is mostly due to loss of fluid and lack of drinking during the first days of a space mission.

After a few days, the neurovestibular and cardiovascular systems adapt, and the fluid household of the human body comes to a new – though lower – equilibrium. But the bone and muscle loss continues. It is not far from correct to say that going into space is like getting older and reassembles an accelerated ageing process. Approximately 50 % of our muscles work against gravity, especially in the legs. When we get older there is a deconditioning, not only in the leg muscles, but also in the heart, which is a muscle as well. Those same effects happen during space flight – only faster, and in general the astronauts will readapt again after return to Earth. This is one of the reasons why we scientists are highly interested in studying astronauts: we can observe changes in a healthy human which are similar to aging or sick persons on Earth but – fortunately, the changes in the astronauts are reversible.

Because of the fluid loss in space, astronauts deal with a low blood volume after landing. Next to that, gravity lets the blood circulate through the legs again, which causes some lack of blood in the brain. These circumstances are contributing to orthostatic intolerance after space flight.

Another Physiological Mystery

It is not only that there is no sound explanation yet for the fact that taikonauts seem to have less problems with orthostatic intolerance after a space mission - there is another contradiction space medicine has a big task to find out why it is like that.

The pressure in the whole human blood system is more equal when we are lying down, if we stand up the pressure of the blood column is much higher in the legs.

Going into space relieves the heart, it does not need to pump against gravity. As a consequence the heart rate goes down, just like having a rest or going to bed. The parasympathetic modulation is in control, the sympathetic system has a “break”. Lying horizontally resembles in a certain way the situation in space. That is good news for all of us who are dreaming to be an astronaut – stop dreaming, just go to bed and sleep! “Everybody is an astronaut when you sleep.” – at least from the heart’s point of view, is one of Aubert’s favourite propositions. According to medical textbooks, if the parasympathetic control is dominant the sympathetic activity is reduced. This is the case on Earth. Not so in space. Although astronauts experience a lower heart rate, the traffic in the sympathetic nerves increases. Higher sympathetic activity would normally have a higher heart rate as a consequence. This is a contradiction which is not explained until now.

“However”, adds Aubert, “we do not have much data on that yet, because such data recording requires sensors and measurements directly in the legs and to measure the pressure in the heart requires a heart catheter which was done only once during a Space Shuttle flight, when a medical doctor was on board.”

There is something else, that Prof. Aubert regrets: “There is always a problem with medical data from space flights. One has to take into account the different conditions for space missions. Standardised protocols could help a lot. Unfortunately, we are not there yet.”

“When we sleep we are all astronauts!”

No, listening to Prof. Aubert will not make you sleep! Not at all! Prof. Aubert is a lively speaker with a passion for his research. His knowledge and interest is enormous and so is his enthusiasm for his work, for the future and opportunities in life. This might explain why, although he studied and gained

Prof. Aubert in the entrance hall of the University Hospital Gasthuisberg of the Catholic University Leuven in Belgium. (credit: GoTaikonauts!)


Prof. Aubert explains the smart, colour-marked signpost systems that helps visitors and staff to find their way within the enormous hospital campus. (credit: GoTaikonauts!)

his PhD in physics, he soon added to this unanimated science the study of physiology. Aubert not only speaks English, Dutch, French, German, and Hungarian but is also interested in history, literature, society and being Belgian – in good food.

Often he says: “I was very lucky!” But there was a moment when he was not lucky at all. He applied for the European astronaut selection by the end of the 1970-s and made it under the last dozen of finalists. The chosen three were Ulf Merbold, Claude Nicollier, and Wubbo Ockels. Aubert said, he did not regret too much to have failed in the final round but he should have continued with space physiology already by that time. Only later, when he was already in the middle of his professional career in experimental cardiology at the University Hospital Gasthuisberg, did he resume his interest in space physiology with the participation in several of ESA’s Parabolic Flight Campaigns. The universal question, Prof. Aubert has been asking throughout his research in space physiology has always been: “Which role does microgravity play in the process of cardiovascular deconditioning and alterations in autonomic cardiovascular control?” His triple simple methods of research have continuously been: ECG, finger cuff or upper arm cuff, and respiratory recording to look into the heart rate variability along with the blood pressure variability. From the beginning he maintained an extensive international network for the exchange of research and to get inspiration from colleagues in related areas. Also, he has been always educating the next generation of space physiology researchers by teaching the development of humans understanding of human physiology in weightlessness and the state-of-the-art in that field of research at the “Physiology of Weightlessness” course at the Catholic University Leuven’s Master in Space Sciences programme. Regularly he has been inviting international students, in particular from Eastern European countries, to his research laboratory at the University Hospital Gasthuisberg in Leuven. In 1984 Prof. Aubert was honoured by the Belgian Minister of Foreign Affairs for his pioneering role in building bridges between the East and the West.

In 2002, Prof. Aubert was lucky again. He replied to an ESA Announcement of Opportunity and was able to “fly” his experiment during Frank De Winne’s first mission to space, the Belgian “Odissea” short-duration mission to the International Space Station. One can feel Aubert’s happiness when he explains that “physiology research is a discipline where you have to interact with your subjects a lot. You are really close to the astronauts. They would also come after the mission to the hospital for data recording and this gives always the opportunity for some personal contacts. In this respect, human physiology is very rewarding.” Aubert is attached to humans and sincerely interested in other people and the work of his colleagues. Vividly he remembers a recent Parabolic Flight Campaign jointly organised by ESA, DLR, CNES - the European, German, and French space agencies, saying: “The best experiment was during the joint Parabolic Flight Campaign where we had different levels of gravity. It was so nice to work together with colleagues from all over Europe. Usually, DLR has its own campaign, CNES has its campaign and then ESA too. But during the joint one we all flew at the same time. We all loved it so much!”

Aubert takes pleasure in little details, for example he will always remember that Frank De Winne was born two weeks after Yuri Gagarin’s flight. And in a way, De Winne’s very successful “Odissea” mission was the starting point of more follow-up research on further European short-duration missions and six long-duration missions to the ISS as well as participation in the Mars500 simulation study. Most important, data from the short-duration missions to the ISS became the foundation for Aubert’s, and in a wider sense Belgium’s, cooperation with China.

Maybe Aubert was simply lucky again, but maybe it was also this unbeatable combination of excellent scientific work and openness to new developments and other cultures which paved the way for Aubert’s involvement in China’s way into the cosmos.

Right after the “Odissea” mission and at the time when China launched its first manned mission into space, a Chinese PhD student joint Aubert’s team in the Leuven hospital. (see below for more details in the interview with Prof. Aubert) This was perfect timing! It was time enough to get warm with the idea of trying a comparative study for the Shenzhou 6 mission in 2005

In the hall ways of the University Hospital Gasthuisberg of the Catholic University Leuven is a detailed scale model of the hospital campus displayed. Prof. Aubert knows his way around the territory. (credit: GoTaikonauts!)

Prof. André Aubert and taikonaut Fei Junlong, Shenzhou 6 space craft Commander, shaking hands in the Microgravity Science Glovebox of a ground model of the European Columbus laboratory. (credit: André Aubert)

and the Shenzhou 7 mission in 2008.

"The cooperation between my institute and China was in the framework of scientific cooperation between Belgium and China. I had national funds from Belgium and the Chinese paid in kind and took care of my local expenses in China. It went all very well." Also, the Chinese would come over to Belgium and it was quite an event when Chinese astronaut Fei Junlong was welcomed in Leuven. Beneficial for this scientific cooperation has always been the strong support from the Belgian government and the personal engagement of the Belgian Kings. In 2005, Prof. Aubert was part of an official delegation to China, led by the then Belgian King Albert II. That visit also marked the renewal of closer ties between the two countries after a break of 24 years. "Last year", Aubert recalls, "the new Chinese President Xi Jinping visited Belgium and to my surprise I got an invitation for the State Dinner in the Royal Castle of Laeken. It was a great honour. Such close relations open doors."

One can only wish Prof. Aubert that the doors not only get wide open but also stay open for a long-term continuation of this intriguing scientific research.

INTERVIEW

GoTaikonauts!: Prof. Aubert, you have been working at the University Hospital Gasthuisberg of the Catholic University Leuven since a long time. What exactly was your research area?

Prof. Andre Aubert: I was working here in Leuven in experimental cardiology what means in the laboratory. I have seen patients only on special occasions. My special interest has always been in non-invasive research what is all kind of research for which you do not need surgery. The methods are very versatile: you can listen to the heart by recording ECG, an electrocardiogram, by heart sound, or displacement echo cardiography. Then I came to the study of patients of 'syncope' which is a very special condition: when the patients are sitting nothings happen, but the moment when they get up they can fall. There might be a 100 different reasons why this occurs to them.

The most obvious reason is that the heart rate should raise when you stand up, but when this does not happen, you collapse. In these patients you would implant a pacemaker and the patient is healed. By coincidence I realised that when astronauts come back from space they also have difficulties to stand upright. That is how it came that I studied astronauts. In the beginning of my scientific career, I focussed all my energy on cardiology and came to space physiology a bit later.

Prof. André Aubert together with the first Chinese taikonaut Yang Liwei who flew on the Shenzhou 5 mission. (credit: André Aubert)

GoTaikonauts!: How did it come that you made the connection with normal patients in a hospital and astronauts?

Prof. Andre Aubert: This was my idea. I did some literature research and also, I had already some experience with ESA Parabolic Flight Campaigns where I could conduct cardiovascular research. In the preparation for the Belgian short-duration flight to the ISS end of 2002, ESA issued an Announcement of Opportunity. I applied and my experiment was accepted.

Shortly after that time we also had our Chinese doctoral student Jiexin Liu. Often, he had to go to the Chinese Embassy for paperwork. Occasionally, I joined him. At the Embassy, there was a Consul Attachè responsible for science and he was also involved with the Chinese space programme. As you see, life is sometimes full of coincidences. So we ended up sitting with the Attaché having a cup of tea and he gave us advice on whom to talk to. I must say, I was lucky. Without the help of my Chinese student it would not have been possible. This was in 2004, 11 years ago. I was among the first to cooperate with the Chinese. A little time later, I could show already the first results from my research from the European flights.

The first Chinese flights were also short-duration missions. That made it easy to compare both. The only disadvantage was that for the European flights I could take measurements before, during and after the flight. But for the Chinese astronauts I could only take measurements before and after the flight, since for the very first Chinese space flights, no equipment for the data recording was in space.

What made it easy for comparison was the fact that short-duration missions do not involve 'counter measures'. For long-duration missions the astronauts on board the International Space Station have to exercise up to two hours a day for training the muscles and the heart. Therefore, astronauts coming back to Earth after six months in space are in a very good condition. But for short-duration missions there is no exercise programme. This is one of the reasons why ESA astronauts returning from short-duration missions are in a worse physiological condition than after long-duration missions.

GoTaikonauts!: Did the study results surprise you?

Prof. Andre Aubert: Initially, I really did the research purely out of scientific curiosity. I did not expect that there would be major differences between the two groups. The starting point was that we could have two homogeneous groups of European and Chinese astronauts. That constellation made the whole research interesting. I wanted to see how the data compared.

The only difference I knew before was that in the Western world the population is eating too much fat and therefore they have problems with heart disease. But in the Far East they eat too much salt, so they die from CVA - a high blood pressure related disease.

But this is in the general population. Also, the body height in the astronauts was not too much of a difference, what could be the case since the general population in the West is taller. Somebody told me that the ratio between the arm length and body height is different between European and Chinese - the Chinese have longer arms. I did not know that before.

So we found out that the Chinese astronauts have a better condition than the Europeans after their return from space. This finding surprised me. My Chinese PhD student incorporated this research into his PhD thesis.

But why this is, is still a question mark. We can only make some suggestions. My Chinese colleagues claim, that one of the reasons might be due to nutrition and Chinese traditional medicine, which includes acupuncture as well as herbal medicine. There might be something in it. The first drug in cardiology, at the end of the 18th century was from a flower – the Foxglove or by its botanical name: Digitalis. So, we cannot reject this because it is an idea from China. But we have to look at it carefully.

At this stage the most reasonable conclusion could be the fact that the Chinese astronauts are all fighter pilots and they are used to high g-acceleration. However, in the European comparison group there are also military pilots. On the other hand, two of the Chinese astronauts also had a very slight increase in the heart rate but it is much less than with the European astronauts. Three even had a decrease in heart rate, which none of the European astronauts showed.

The major point of concern is that the number of subjects is relatively small to say something definite about the results and to draw firm conclusions. So we should have more flights. And also, I hope, that when the Chinese start with longer-duration flights, that they also will have physical exercise to counteract the effects of microgravity and then of course it will not be the same situation any more.

GoTaikonauts!: But this means, you are continuing your research?
Prof. Andre Aubert: Yes. I am going to discuss the on-going research by the end of August when I am back in China together with Chinese colleagues and my former PhD student Jiexin Liu. Like most Chinese, he is very good in networking. Now that he is back in China, he is working in the International Friendship hospital in Beijing.

GoTaikonauts!: Would it make sense to look into old data?
Prof. Andre Aubert: Yes, these data exist - surely tomes of data - but since this is operational medicine and it is personal data these records are confidential and even scientists cannot get access to it.

GoTaikonauts!: Are the space agencies interested in your work?
Prof. Andre Aubert: In general my research is highly valued within ESA. In its brochure "Columbus – Research and Results from Columbus and the ISS" it is written about my ISS experiment 'Cardiocog': "Cardiocog was the foundation of ESA's cardiovascular research on the ISS and helped to increase the understanding of orthostatic intolerance."

Also, the Chinese are very much interested. They even asked me to give a lecture about my work to the astronauts and to the Chinese Academy of Science. This is all planned for my next visit to Beijing.

GoTaikonauts!: Apart from this cardiovascular research with taikonauts, do you also have other projects together with Chinese scientists?
Prof. Andre Aubert: Yes, there is the bed-rest study. The results in the Chinese bed-rest study were very similar to the results from our European bed-rest studies. By the end of summer, I am expecting a paper coming out on this. [*Orthostatic Intolerance Is Independent of the Degree of Autonomic Cardiovascular Adaptation after 60 Days of Head-Down Bed Rest*]

GoTaikonauts!: How is the working atmosphere in China? How were you supported by your Chinese colleagues?
Prof. Andre Aubert: The Chinese are very, very, hospitable. The first time I went there I was invited to a special dinner with interesting eating habits. You know these round tables and whatever is in front of you, you would eat from. Also the drinking habits are unusual, but I have experience in cooperation with the Russians, and this was a good training for my China experience. It was always a very special experience.

Also, I visited several centres for medical space research. The centre for basic research is in Beijing but there is also a centre in Xi'an.

My Chinese colleagues have always considered me as their colleague. They openly discuss all questions with me. I have to mention, that most of the time, the discussions are going via a translator. This all takes time for the talk. My Chinese colleagues show me their results, they ask me questions – so in that way we have a normal professional relationship.

The only exception is that I had no direct medical access to the Chinese astronauts. In China, like in the Soviet Union, astronautics is very much a military domain. I could enter everywhere, but for example, for the European astronauts I was also responsible to place the electrodes on the body. With the Chinese astronauts this was not possible. So I had to explain where I would like to have the electrodes placed and the Chinese doctors would do it. I was waiting in a room next to the actual medical room and in case of problems the Chinese doctor would come and would ask me. But they showed me the results immediately and if I was not happy they did it again. It is just a question of a different approach.

On the other hand, after the data recording, we would have dinner together and shake hands, but scientifically, I cannot apply the electrodes onto them. That is the only restriction which occurred to me.

GoTaikonauts!: What are the advantages in cooperation with China?
Prof. Andre Aubert: With respect to space: China is doing its projects in time. After they have announced a programme, they stick to the timeframe. Look at the human space flight programme. They had the first flight, a solo flight, then the two-person flight, the flight with three crew members, the EVA, and now we have the space lab and will soon see the station

emerging in the future. Of course, it is not always so easy, but they follow the programme. And if they want to cooperate they do it. They also approached NASA for cooperation on the ISS. Unfortunately it did not turn out and they decided to go their own way. Maybe things are changing now that everybody can see that China has solid projects and funding for the programmes.

GoTaikonauts!: From your point of view what are the difficulties in cooperating with China?
Prof. Andre Aubert: Difficulties can arise if you have to take the centralised system into consideration. Because of this hierarchical structure you might need a decision from a higher level, which takes time. It is not so much because of the State system, it is simply how the Chinese society works. I think this is where one can easily fail. You need to know where you have to go and whom to address.

There is also a certain degree of flexibility required. For example, if I would have insisted on having in-space measurements, my project would have needed approval from a much higher level. I did not insist on that. But in the way we did it, it was more a cooperation among scientists what worked out very well. And of course, having some personal contacts makes everything much easier.

And there is one more fact to take into consideration: I could work through the Belgium-China scientific framework agreement, that gave the whole project a financial base.

GoTaikonauts!: What could be the areas of cooperation for the future?
Prof. Andre Aubert: Maybe a mission to the Moon? But at the end the objective should be a mission to Mars. Humans need a goal, something they can strive for. At the moment there is not so much enthusiasm for space in the general public. The reason for that might not always be the costs. It is obvious that all the money spent in the space industry and space research is spent here on Earth. Also, space technologies have a strong influence on many areas of life. Who would like to live without space technologies for a day?

GoTaikonauts!: If you think 5-10 years ahead from now: What is your personal wish, where would you like to be in your research and in your cooperation with China?
Prof. Andre Aubert: In my cardiovascular research, I wish we can have larger numbers of subjects from all over the world and that we have standardised methods. Because then we could have, with very fundamental measurements, a larger database from which scientists could gain for their very different research areas.

Above all, I wish for more cooperation in space between the spacefaring countries. Also, I would prefer to see that there are less bilateral projects, but far more multi-national projects. With respect to Europe, clearly, ESA should take the lead in the cooperation with partners outside Europe.

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Fei Junlong (Shenzou 6) together with Prof. Aubert in the old city centre of Leuven in Belgium. (credit: André Aubert)

"You won't change China, China will change you!"

An interview with Kris Liebaut – Foreign Expert in China from 2008 to 2014

by Jacqueline Myrrhe

Goliath meets David

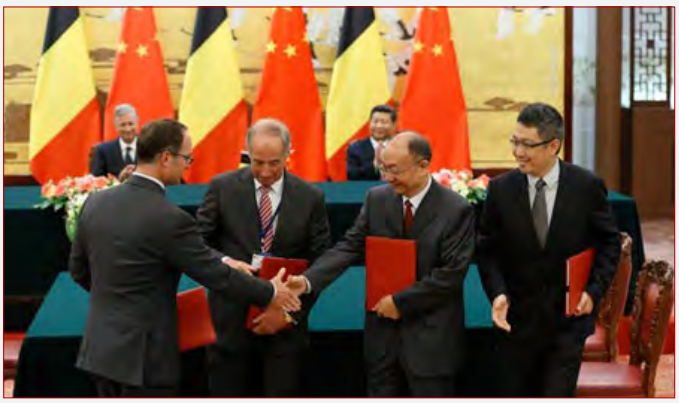
One wonders what such a gigantic nation like China might gain from relationships with a far-away and tiny country such as Belgium. Even within the European context, Belgium together with its neighbouring countries, The Netherlands and Luxemburg, gets marginalised when the whole region is summarised as BeNeLux.

This fact aside, Belgium's cosy capital Brussels is referred to as the 'capital of Europe', hosting the European Parliament and the European Commission. No surprise then that Chinese President Xi Jinping paid a state visit to Belgium and the European Commission last year from 30 March 2014 to 1 April 2014. As recent as 29 June 2015, Chinese Premier Li Keqiang participated in the 17th bilateral EU-China summit in Brussels. His visit saw the signing of the Collaborative Research Arrangement between the European Commission Joint Research Centre and the Chinese Academy of Sciences Institute of Remote Sensing and Digital Earth.

With respect to Belgium, as early as 1979 a bilateral agreement on economic, industrial, scientific and technical cooperation between the Belgium-Luxembourg Economic Union (BLEU) and the People's Republic of China was signed. From that starting point, scientific and space cooperation between Belgium and China grew steadily. Most projects do not fall under any federal-level framework.

In October 2004, the Belgian Federal Science Policy Office - BELSPO and the Chinese Ministry of Science and Technology - MOST issued a call for proposals at the 15th Meeting of the China-Belgium Joint Commission for Scientific and Technological Cooperation. The selected 10 projects also included space research projects. As a continuation of that work, the 16th Meeting of the Joint Commission in March 2007 in Beijing awarded funding to the space cooperation through the STEREO programme - a national Earth Observation research programme for a broad-range of projects - and to programmes within Belgium's ESA membership. Between 2011-2013, BELSPO cooperated with MOST, the Institute of Atmospheric Physics, CAS and the Belgian Institute for Space Aeronomy - BIRA on the evaluation of the role of biogenic volatile organic compound - VOC emissions on air quality in China. The Flemish Institute for Technological Research - VITO develops remote sensing projects, related to the design of monitoring tools for desertification and land cover changes in North West China, agro-environmental monitoring using satellite data in Harbin, crop growth monitoring in Hubei, and integrated water resources management in Xinjiang.

The latest initiative between the two countries shows how the decade-long cooperation laid a solid foundation for future projects to build upon. On 24 June 2015, State Secretary of Science Policy, Elke Sleurs, signed in Beijing a Memorandum of Understanding MoU between the Belgian Federal Science Policy Office and the China National Space Administration - CNSA in the field of space sciences, technologies and applications. Increased collaboration between Belgium and China in the field of satellite technology can put both nations "at the forefront" of delivering vital information globally, stated Elke Sleurs after the signature ceremony. The MoU is on an Earth Observation programme, which aims to design and build a joint Belgian-Chinese satellite mission "with the full potential to put both nations at the forefront in delivering exclusive agricultural and environmental information worldwide," said Sleurs to the Chinese news agency Xinhua. She also stressed that since more than 20 years, BELSPO has supported and funded research projects between Belgian and Chinese universities as well as joint research projects with the Chinese Ministry of Science and



A MoU between the Belgian Federal Science Policy Office BELSPO and China National Space Administration CNSA in the field of space science, technologies and applications was signed on 23 June 2015 at the Great Hall of the People in Beijing. The signature ceremony was witnessed by Chinese President Xi Jinping (in the background to the right) and King Philippe of Belgium (in the background to the left). (credit: CNS)

The President of Chinese Academy of Sciences CAS Bai Chunli (left) signed a cooperation agreement with Vincent Blondel, President of the Catholic University of Louvain of Belgium (right), at the CAS in Beijing on 24 June 2015. (credit: Xinhua/ Jin Liwang)

Technology: “I hope that more initiatives will follow, so that both nations can demonstrate their unique competencies to Europe and the international world.” Belgium has put more and more focus on remote sensing technologies, and the development of applications to monitor the state of the environment and agricultural land use. “Belgium has set an objective of increasing the economic efforts of space research by enhancing SME [small and medium enterprises] participation in the space industry via technological and scientific support programmes,” said Sleurs, and added that Belgium’s space sector accounts for an annual turnover of 350 million Euros and creates 2,000 high-tech jobs. In 2014, the aeronautics and space industry in Belgium grew by 6 %, while the federal government aims to devote 3 % of its GDP to research and development.

Sleurs was part of a delegation to China, headed by King Philippe of Belgium. During his stay in Beijing, King Philippe was not only welcomed by President Xi Jinping, but also invited to the Chinese Academy of Sciences – CAS in Beijing, where he was greeted by Bai Chunli, the Academy’s President. The focal highlight of the King’s visit to CAS was his speech in front of the academics. Later during the day, CAS President Bai Chunli and Vincent Blondel, President of the Catholic University of Louvain, Belgium, signed a cooperation agreement at the CAS in Beijing. The Belgian space company AMOS wrote on its website after the highly successful visit in China: “AMOS has signed two agreements with major Chinese players in the field of optical instrumentation for space applications: a Strategic Cooperation Agreement with China Aerospace Science and Technology Corporation - CASC, and a Joint-Laboratory Agreement with the Beijing Institute of Space Mechanics and Electricity - BISME. These agreements set a strong framework for future Sino-Belgian collaboration in the fields of space instrumentation development, in-orbit performance simulation, and precise optical manufacturing and metrology. After the signing ceremonies, in the presence of King Philippe and President Xi Jinping, the CEO of AMOS, Philippe Gilson, said: “We feel honoured to have been chosen by two of the most prestigious space institutions in China to support their development of

STEREO

Already in the late 1970s and 1980s, Belgium participated in Earth observation programmes with France (SPOT satellites), the European Space Agency - ESA, the European Organisation for the Exploitation of Meteorological Satellites - EUMETSAT, and the European Centre for Medium-Range Weather Forecasts - ECMWF. It was by then, that also the importance of remote sensing applications became clear and Belgium decided to strategically develop autonomous Belgian Earth observation expertise of an international standard as a contribution to the national goal of a knowledge economy.

The first programme period from 1984 to 2000 was called Telsat, but continued as STEREO I from 2001-2006, STEREO II from 2006-2014 and STEREO III from 2014 to 2020.

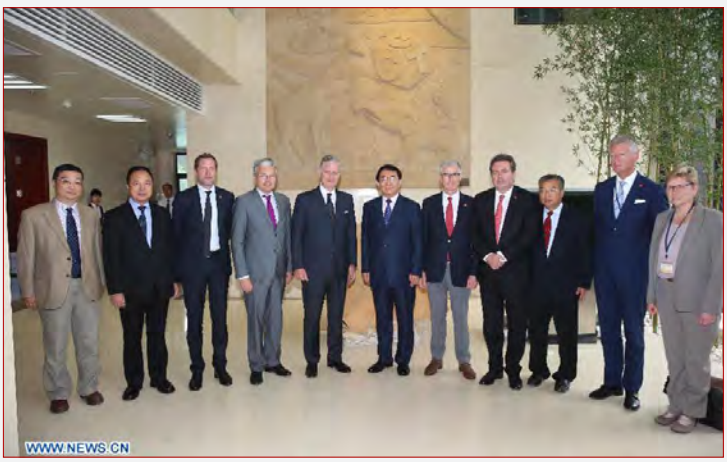
“STEREO II and III are expected to maintain and develop high-quality scientific expertise gained by Belgian universities and research laboratories during the STEREO I programme. STEREO II and III also seek to strengthen the integration of Earth observation Belgian activities into programmes and activities developed at European (including GMES) and global (including GEOSS) levels. A particular focus was given to establish international cooperation links and to develop applications.” The Belgian government provided funding of 54.445 Mio Euros for the 14 years period until 2020.

The four research themes are:

- Global monitoring of vegetation and changes in large terrestrial ecosystems;
- Environmental management (water, soil, forests, agriculture, coastal areas, urban and suburban areas);
- Health and humanitarian aid;
- Security and risk management.

web resources:
http://www.belspo.be/belspo/space/stereo_en.stm#stereo
http://www.belspo.be/belspo/fedra/prog.asp?l=de&COD=SR

The President of Chinese Academy of Sciences Bai Chunli (right) welcomed King Philippe of Belgium (left) for a visit to CAS on 24 June 2015 in Beijing. King Philippe of Belgium delivered a speech to the academics. (credit: Xinhua/Jin Liwang)



Group photo of the visit by the Belgian Delegation led by King Philippe of Belgium (5th from left) to CAS. In the middle: the President of Chinese Academy of Sciences Bai Chunli; far right: State Secretary of Science Policy Elke Sleurs. (credit: Xinhua/Jin Liwang)

space optical instrumentation. This confirms the growing international recognition of our expertise, and enhances the potential for growth of AMOS activities in this domain." The Flanders-China Chamber of Commerce reported that in total, 12 cooperation agreements were signed covering areas such as space, customs, science and technology, nuclear fuel and education: "China supports connectivity between its western region and Antwerp", President Xi emphasised, inviting Belgium to back Chinese enterprises to join the investment plan for Europe and participate in the construction of a railway network across the continent. He also highlighted areas for cooperation, including high-end manufacturing, environmental technologies and sustainable development, as China is carrying out its innovation-driven development strategy. King Philippe said his country would use its advantages and act as a bridge by which China can enter Europe. "Belgium appreciates China's Belt and Road Initiative and would like to make an effort to link those plans with the investment plan for Europe", he added.

About the person: Kris Liebaut

Kris Liebaut is a 43-year old Belgian from Aalst, East-Flanders. He has quite versatile interests and hobbies, reaching from aerospace and astronomy to travelling, archaeology and science.

As a 14-year old boy, he was already member of JVS Sirius/Aalst, the local youth branch of the Belgian Astronomical Association in Flanders (VVS). Later on, he became actively involved in Sirius' umbrella organisation, Murzim/Aalst and other associations in Ireland and Spain.

Next to his scientific interests, Kris is talented in languages - with his mother tongue Dutch and fluent knowledge of French, English, German, Spanish and some basic Chinese. His professional background is a unique combination of business administration/ languages and electronics.

From 2008 to 2014 he stayed as an "Foreign Expert" in China, mainly teaching European languages to Chinese students in aerospace and engineering at the Shenyang Aerospace University - SAU and the University of Science & Technology Liaoning - USTL in Anshan.
During his time as a university teacher, he also organised aerospace exhibitions and was a (guest) lecturer on various space topics.

Kris has a Chinese wife and a 4-year old son. The whole family returned to Belgium only last year, so parts of Kris' mind and maybe heart still stayed in China.

From the Middle of Europe to the Middle Kingdom

It should not come as a surprise that Belgium and China developed close ties in the field of space science. Although not commonly known, it is a fact that Belgian missionaries, scientists and engineers have been in China already centuries ago, as 43-year old Belgian Kris Liebaut pointed out to GoTaikonauts! According to him, the most famous among them might be Ferdinand Verbiest (Nán Huáirén).

Verbiest, a Flemish Jesuit missionary, was one of the first official Foreign Experts at the court of the famous Chinese Emperor Kangxi during the 17th century. He worked as a diplomat, cartographer, translator and engineer. But he was most famous as an accomplished mathematician and astronomer in which he corrected the Chinese calendar and was later asked to re-build and re-equip the Beijing Ancient Observatory (Běijīng Gǔ Guānxiàngtái). This observatory and its instruments are still on display just south of Jianguomen in Dongcheng District, near Beijing Railway Station (Běijīng Huǒchēzhàn).

Interested in history, astronomy and space, Kris Liebaut surely could lecture on historical links between China and Belgium for hours with increasing enthusiasm. And if one is willing to take his point of view, one can say that Kris followed in Verbiest's footsteps back in 2008 to teach for six years European languages at universities in China's Northeast.

GoTaikonauts! met Kris in Brussels and Aalst to learn from his experiences and listen to his lectures on Chinese space activities. He gave us a unique account on his time in China and his knowledge of cultural competence, science and human relationships.

Kris Liebaut among his Chinese students in the class room. (credit: Kris Liebaut)

At the Shenyang Aviation Museum. (credit: Kris Liebaut)

At a Chinese flight simulator... (credit: Kris Liebaut)

Posing in front of a mock-up of an early Chinese jet plane at SAU's campus. (credit: Kris Liebaut)

GoTaikonauts!: How did it come that you left for working in China?
Kris: I was already involved in facilitating business contacts between Europe and China via my jobs at Flanders Investment & Trade - FIT, the EU-China Business Association – EUCBA and Flanders-China Chambers of Commerce - FCCC. So in a way, I was already part of the "inner circle" of people involved in Sino-European business relations.

It was during that time I met my future wife who worked as a Chinese interpreter at a business meeting in Antwerp. As we both had some common friends, there was already a "network bridge". We both agreed to follow the one who found a job for the other first… As I could not compete with my future wife's "China speed", it resulted in a "one-way ticket to China" and the start of a new life.

My first working place was at the Shenyang Aerospace University in Liaoning Province, Northeast China. My exact position there was "Foreign Expert", in my case that meant: university teacher in European languages. So, most of the time I was teaching Chinese students English, French and German.

GoTaikonauts!: Was it difficult to start your work once you arrived in China?
Kris: Well, I really had to adapt to the "China speed". All the administrative and medical procedures went very fast, done in a few days! Once that finished, I was granted my own university apartment, just outside the campus. When I just moved in, I had to start teaching right away … and it worked perfectly! So when in China, you must improvise and be prepared for the unexpected!

GoTaikonauts!: How big were the classes?
Kris: This depended very much of the major. For my course aerospace English, I had around 20 to 25 students. In other classes there were 40 or 45 students, which made teaching a foreign language quite a challenge!

GoTaikonauts!: You have been teaching at an aerospace university. Maybe future taikonauts were sitting in your class?
Kris: Maybe in the future… who knows! But I assume that

Shenyang Aerospace University - SAU

Shenyang Aerospace University is situated in the Northeast region of China in Shenyang city, approximately 900 km from Beijing. Shenyang is the capital of Liaoning Province and the largest city in Northeast China with its 8 million inhabitants. The whole region used to be the centre of China's heavy industry - "China's Ruhr region" - showing all the associated negative effects like air, soil and water pollution. In the last 15 years, enormous efforts have been made to counteract this situation and create a more sustainable development.

Liaoning Province is also the birthplace of China's first taikonaut, Yang Liwei, who was born in Suizhong County.

The province, and more particularly Shenyang, always played an important role in the development of China's aerospace sector with the Shenyang Aerospace Corporation (Shěnyáng fēijī gōngsī) and the Shenyang Aerospace University - SAU. SAU's scale is enormous, a truly "University City" in the North of Shenyang, at Shenbei New District. Founded in 1952, the university campus comprises today 20 ha of landscaped gardens, university buildings with 600,000 m^2 of floor space and a library with more than 2 million books! It has 1,600 staff members of which more than 50 % academics who are responsible for 20,000 Chinese and 200 international students.

SAU belongs to the Top 5 of Chinese aerospace universities. In the past it was one of the 6 universities operated by the Chinese Ministry of Aviation, but is now jointly operated by Liaoning Provincial Department and the Chinese Ministry of IT. Although SAU is traditionally very strong in engineering and pilot training, nowadays its students can also choose other majors like international business, tourism, …

It is worth having a look at SAU's website to get a grasp of the university's campus and its academics. check: http://en.sau.edu.cn/

With a Chinese H-5 jet plane at SAU's aviation garden.
(credit: Kris Liebaut)

SAU's space expo with a mock-up of China's lunar satellite Chang'e-1.
(credit: Kris Liebaut)

most of them are now working as an engineer or technician in the Chinese aerospace sector as quite a lot of them did their practical training at AVIC, the Aviation Industry Corporation of China. So it's quite possible that some of my old students are now making or designing the Chinese space planes or rockets of the (near) future …"the right stuff" that makes taikonauts! :-)

GoTaikonauts!: Did you also have to train Chinese pilots?
Kris: Yes, but only the basic theoretical training in English. Normally, they only needed to learn some technical knowledge, but I also added communication and social skills as they are equally important. In my view, it is not only important to fly an airplane or spacecraft, but also to interact with your crew and ground control.

GoTaikonauts!: How did you do that?
Kris: For the theoretical training, I had to use a lot of PowerPoint slides and movies in order to let them understand how the theory works in practice … a lot of research for sure!

Now and then I let them go out of the classroom and went to some old aeroplanes at the university campus. Looking at the real thing, showing and naming the different parts of a plane and their functions in English were integral part of my course. The students later told me that they did appreciate this new way of teaching as most Chinese teachers are only teaching by the textbook. Hopefully my English course of aerospace was giving them some airspace to study and fly with a smile …

GoTaikonauts!: Did you have to consider special aspects when teaching your pilot students?
Kris: Seems to me that the first and most important step of recruiting pilots in China is a strict physical examination - e.g.: 100 % perfect eyesight, strict diet and heavy physical tests every day, which means constant fitness. Sometimes my English courses were scheduled after intensive physical training such as 10 km of swimming or 20 km of running.
In that case, I did spare my "Chinese Spartans" by doing some "lighter stuff" such as an English word game, a pilot quiz or a role-play …

GoTaikonauts!: How did you interact with your students?
Kris: According to the principle: what you teach is not a goal but a tool in a students' future professional life.

Most Chinese university students already have a strong theoretical language background, so I rather focused on their practical use. Like most universities worldwide, Chinese teaching is very much a one-way story: teacher gives information and asks questions - student listens and replies questions.

What makes language teaching in China so difficult is the student's silence: nobody wants to speak up, afraid to make mistakes and loose face in front of the whole class and the teacher.

Foreign Experts in China

Although China has always been open for foreign exchanges via its famous "silk route", there have been periods in the past as well as in recent history that China locked itself away from any external influence. To give an example in 1979, only 117 Foreign Experts were registered in China.

However, since the 1990's economic boom, the reforms in opening-up and moving towards a market-oriented society, the demand for Foreign Experts grew substantially. China saw an explosive increase not only in numbers but also in type of Foreign Experts.

Still, in 1991 a little bit more than 600 Foreign Experts were staying in the country, while in 2013 China counted an impressive 610,000 Foreign Experts on its territory. These experts can be found in various sectors such as science, education, business and industry.

This trend will continue in the near future, although there is more a shift towards quality before quantity. In 2011, the China Foreign Expert Bureau initiated the "Top Foreign Expert Program" including the "1000 Foreign Experts plan", also called the "Thousand Talent Plan". Its objective is to employ in 10 years 500-1000 "Top Foreign Experts".

More information:
http://1000plan.safea.gov.cn/
http://en.safea.gov.cn/

Visiting the Chinese Long March rocket family and a lonely American Saturn rocket at the Shanghai Science & Technology Museum.
(credit: Kris Liebaut)

So as a language teacher, I first created a relaxed, cosy atmosphere. A friendly facial expression, a relaxed voice and the fact that I looked a bit like Mr. Bean was certainly a help.

The first weeks, I allowed enough time to my Chinese students to prepare their assignments. Later on, I also made some calculated mistakes or telling them I didn't know in order for the students to react and realise that making mistakes or not knowing something is not bad, as long as you correct your mistakes and learn the things you do not know …

At the end, I let the students talk in front of the class, first in a group, later on alone. Mistakes in speaking I only corrected after the student had finished and I tried to keep the corrections in general terms. The same principle I worked out for my written and more theoretical courses.

Very much appreciated was my "walk talk", were I went with my students outside the classroom and talked and discussed in English what we saw on the campus … With these "peripatetic" lectures, walking as teaching, I have also introduced an ancient Greek teaching method which was quite common in the Athens of Aristotle (around 335 BC). Maybe this method should be re-introduced in our Western schools and universities again…

Anyway, at the end of each semester, most of my students considered me more as a guide than a teacher. And isn't this the essence of teaching?

GoTaikonauts!: How was the success rate in your class?
Kris: Yes, the success rate was pretty good as most Chinese students are really learning hard. Of course, on giving marks you must realise that most Chinese students are not grown up with English via media, TV, movie, internet, etc., so on average their English level is a bit lower. However, what I have noticed during the years is that the English level of Chinese students is increasing rapidly: they understand its importance for a good career or as a handy tool during a holiday abroad.

GoTaikonauts!: How did it come that you and your students even prepared an exhibition on European space flight activities?
Kris: During my years of teaching in China, I found that my Chinese students at the Shenyang Aerospace University - SAU lacked some practical and hands-on experience.

Therefore I wanted them to do something practical for them which would open their minds and enable them to be a creative team player.

The exhibition "Belgium: Heart of Europe" at the Shenyang Aerospace University - SAU. (credit: Kris Liebaut)

In 2011, the Belgian Embassy in Beijing invited Belgian expats in China to organise activities related with the celebration of 40 years diplomatic relations between China and Belgium.

Connecting both, I suggested SAU's Board of Directors to organise an exhibition about Belgium at the university campus. After several meetings, it was agreed to have this expo called: "Belgium: Heart of Europe" which would be held from 19 to 26 April 2011 at the Friendship Villa of the SAU area. Together with my Chinese students, we worked out the concept, collected the materials, translated the texts and let the students themselves decide what to do and how to do it. In order to streamline all this, I had to put it all in a "roadmap" which included actions done and still to do. When all was ready, me and my students set-up the expo the day before the opening ceremony which was hosted by SAU with keynote speakers from the Belgian Embassy and Bekaert, a large Belgian steel company.

The expo was really a great success with both Chinese and foreign students from SAU and other universities visiting it. No wonder! I think that Belgium was in fact the first foreign country on display during an expo at a Chinese university! Readers can always correct me, of course.

Besides tourism, education and history there was an important part reserved for Belgian aerospace, including the Belgian space missions of Dirk Frimout and Frank De Winne. Most Chinese students were astonished that a small country like Belgium had already 3 manned space missions and the fact that it played such an important role within the International Space Station ISS which they really found "cool". Through this exhibition I realised how much my Chinese students were eager to learn more about foreign countries' science, technology and culture. In a way I let Belgium come to China and let them realise that by learning a language, you will better understand the world "outside the Great Wall"…

GoTaikonauts!: What was the most interesting or surprising experience you had?

Kris: There were so many interesting and surprising experiences I could write a dictionary full with them! In all, I would say that Chinese university students have more respect for teachers than in the West.

I remember that I once failed a student and explained him why. He thanked me and said: "Yes you were right, these are the marks I deserve. You let me open my eyes and I will work harder and prepare better next time". Do you think a Western student would react that way?

GoTaikonauts!: Do you think you made a difference to your students?

Kris: I really think so. Chinese students are mostly very excellent in memorising, reciting and preparing for exams. In Western eyes, you would consider them as "nerd herds", as most of them did not develop their own ideas or social skills and are very much "family-fenced".

They are also missing some self-confidence. Most of the blame is to the Chinese "tiger (grand)parents" who are often over-criticising their (grand)child. They often say: Oh, you only have 99 %, where is the missing 1 %?

This is what I consider as one of the most important tasks of a teacher in China – to encourage the students to focus on their strengths, let them be more creative, social and communicative. So, being a teacher in China is for me like being a gardener: you can really make the difference by giving them the sun of creativity, the water of knowledge, the soil of learning and the communication of talking to grow even better.

GoTaikonauts!: It must have been hard for you to leave China after all that time and all this success?

Kris: Yes, being a Foreign Expert in China was quite a rewarding chapter in my life. I now live in Belgium, but I regularly return to China, visiting my family-in-law and some Chinese friends … So don't worry, China is far but not forgotten…

One of the exhibition panels, showing examples of Belgian aerospace achievements and portraits of Dirk Frimout and Frank De Winne. (credit: Kris Liebaut)

One of the exhibition panels, showing historical and modern connections between Belgium and China. (credit: Kris Liebaut)

GoTaikonauts!: Can you make use of the things you have learned in China?
Kris: Of course! And I am still learning every day, thanks to my Chinese wife and family members! But for me, it's not so much a question of 'making use of' but rather 'being influenced by' the things I have learned in China...

All in all I have become more global-minded, communicative and confident. These skills I apply daily in my current professional and private life here in Belgium. Combining both my China experience and years-long interest in space and astronomy, I am regularly writing articles and giving lectures about Chinese astronomy and space travel. If interested, feel free to contact me! :-)

GoTaikonauts!: In one of your presentations you said: You will not change China but China will change you! This is a very strong statement. What do you think is the most important consideration in dealing with China?
Kris: Due to its huge size and population, you can not expect that everything will go your way. You must accept to follow the "Chinese way", not straight like our Roman alphabet but rather like the curves of a Chinese character. It's quite funny that Chinese might say to you: "When in China, do as Romans do." [rù jìng wèn sú, rù xiāng suí sú]

In China, it is all about people:

- You must take your time to know the right people.
- Use your time wisely and build up a network of people you can trust.
- These connections or guanxi are the key to your success in China.

Once done, fasten your seatbelts as you are in for a rollercoaster ride at lightning speed!

GoTaikonauts!: From your point of view, what could be the future prospects of cooperation with China?
Kris: I would say there are lots of opportunities for companies in the field of avionics and space travel. I know that Boeing and Airbus are already producing (parts of) airplanes in China and native Chinese aircraft companies are continuously looking for foreign cooperation. I also predict opportunities for companies specialised in Air Traffic Control systems for civil aviation.

About space travel, I am really looking forward to the renewed Sino-Belgian cooperation on space science. You also don't have to be a "big boy" to be active and successful in China.

A good example is the Belgian SME Newtec who has an office in Beijing and are producing satellite terminals for the Chinese market.

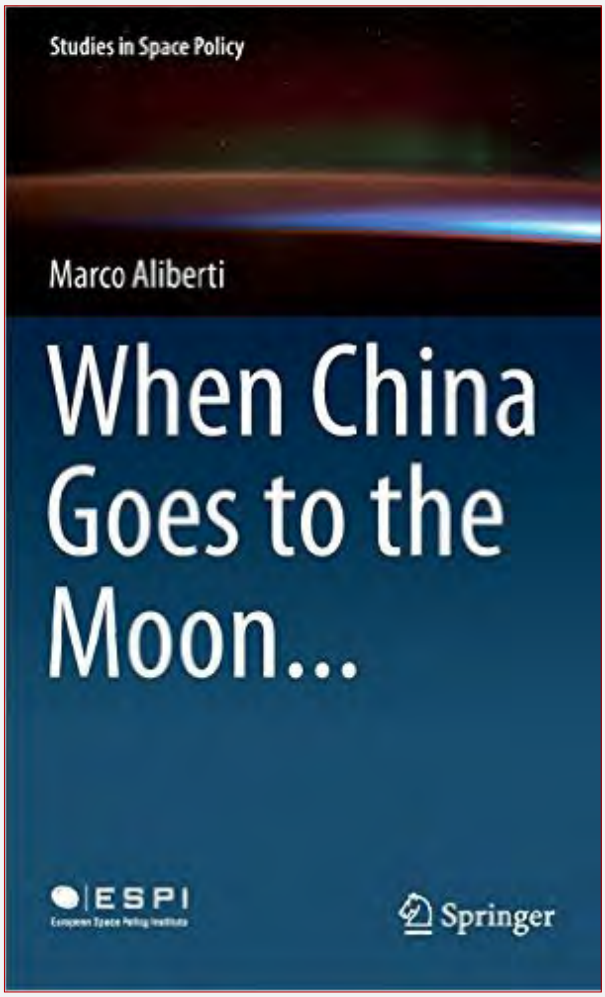
There are also many other promising products/services for the Chinese market. My golden rule is: look for a niche market and "cross the river by touching the stones" like former Chinese leader Deng Xiaoping used to say.

Kris and his Chinese students welcoming Mr. Michel Gerebtzoff of the Belgian Embassy and Mr. Lian Yong from Bekaert at the official opening of the expo "Belgium: Heart of Europe". (credit: Kris Liebaut)

A Review of "When China Goes to the Moon …" by Marco Aliberti

reviewed by Dr. William Carey

"When China Goes to the Moon..." is a very well-structured, well-written and researched book about China's ambitions in its human space exploration programme, in particular, with respect to its assumed plans for the exploration of the Moon. It provides a detailed background to help understand China's space endeavours, and, based on that understanding, identifies potential roles for Europe in defining the future exploration of space, specifically the Moon, and the potential changes to the geo-political landscape depending on which role Europe chooses.



It is not only in good comedy that timing is the secret. In the space world also, timing is a critical parameter for success, as ESA's Rosetta mission has convincingly demonstrated. To arrive successfully at the specified comet, Cheryumov-Gerasimenko, the launch window (in March 2004) needed to be precisely met. In addition, the long journey to the comet included a number of fly-by gravity-assists by using the gravitational attraction of Mars and the Earth. Even then, additional orbit corrections were needed either side of each fly-by to ensure that Rosetta would meet up with its target in 2015. Similar launch windows exist to go to the International Space Station, the Moon and to Mars. So what have timing (launch windows) got to do with Marco Aliberti's book? Well, anyone reasonably familiar with launching a spacecraft to rendezvous with a specific target will know, such windows are finite in time, they do not last forever, and may take a long time to come around again. Windows of opportunity have a similar characteristic, but additionally may not ever appear again. The conclusions of "When China Goes to the Moon…" include actions to be taken by Europe, which are highly time-critical.

The title of the book appears carefully crafted, as "when" is used and not "if", even though China has not formally announced a human lunar programme as yet, although strong indications are there. The Moon is presumably chosen because it is potentially more short-term than humans going to Mars. Also, the inclusion of the dots after the word Moon is also indicative of an unfinished story. At least, this is our interpretation, and we believe intentional on the part of the author.

A key point is already made in the Foreword by the Director of the European Space Policy Institute, Peter Hulsroj, when he highlights the fact that Chinese exceptionalism is culturally non-expansionist, a difficult concept for us in the West (particularly in the U.S.) to fully grasp due to our societal structure and history. And he goes on to note a fundamental message of Aliberti's book which is that if we can recognise and understand this fundamental difference in viewpoint, then an opportunity exists (a window of opportunity) for cooperation rather than confrontation, and cooperation in the exploration of space could provide a solid foundation stone on which to build the future. The book is not only aimed at the space community itself but "seeks to reach out far beyond the traditional space community - to the geostrategists, overall policy makers, and interested general public." In this respect it admirably achieves its objective as it succinctly summarises and analyses China's exploration of space.

Chapter two is devoted to an overview of the Chinese space programme with respect to organisation, funding and policy. Concerning organisation, a constant theme reiterated in the West is that it is not always clear whom one should be or is talking to. This overview confirms a complex interwoven governance in which it is more often than not, difficult to bring into clear focus what is civil, what is military, academic or commercial, but concludes with an organigramme that can be used as a helpful guide, at least starting point - for newcomers and "old-hands" alike. The pertinent observation is also made however, that such ambiguity is not conducive to the implementation of international cooperation! This organisational complexity unfortunately also adds to the difficulty in clarifying the space budget of China, and thus, in providing a comparison with other nations, but the figures provided indicate that China will likely become second only to the U.S. in terms of overall expenditure within the next decade. It is also shown that in comparison to organisation and budget, China's space policy is more transparent, mainly due to the level of information provided in their Space White Papers (5-year plans).

"Why the Moon?" (chapter three) examines the range of rationales and objectives for why China would send its taikonauts to the Moon, but does so by looking through Chinese glasses - unsurprisingly, these are shown to be complex and multifaceted. Arguments are presented for China achieving its objective of showing leadership more completely through cooperation than by going it alone, and in the process, avoid any interpretation of a "space race" between China and anyone else, particularly the U.S. This chapter contains an interesting quotation that President Kennedy (and we are reminded that "ironically" he was the initiator of the U.S.-Soviet space race) made to the United Nations shortly before his death, *"Why should the United States and the Soviet Union, in preparation for such expeditions, become involved in immense duplications of research, construction, and expenditure? Surely we should explore whether the scientists and astronauts of our two countries - indeed of all the world - cannot work together in the conquest of space, sending some day in this decade to the Moon not the representatives of a single nation, but the representation of all of our countries."* A statement that is even more pertinent to today than when it was first uttered, only with China substituted for the Soviet Union. Aliberti goes on to suggest that "…a cooperative undertaking to the Moon in which China would take the lead could really act as a powerful turning point for the creation of a new space consensus - the Beijing space consensus - in the perception of future generations, making China the indispensable pillar for building the global partnership required to achieve the ambitious goals of future space exploration." Why the China-U.S. relationship plays such a critical role in China's ambitions is examined again in chapter six.

In the fourth chapter "China's Way to the Moon", it is (thankfully) made clear that China does not yet have a formally-approved human lunar programme. Considerable confusion surrounds this issue, especially when statements from individual leading scientists are taken out of context, or represent purely personal wishes. We are reminded that two key documents accurately reflect Beijing's current planning: the report "Science and Technology in China - A Roadmap to 2050" published in 2009; and the third Space White Paper "China's Space Activities in 2011". The former, produced by the Chinese Academy of Sciences (CAS), while not being a formal policy document, carried significant weight, and provided an extensive range of topics for Beijing to ruminate upon. The White Paper, as a formal policy document, published two years later, for the first time identified that "China will conduct studies in the preliminary plan for a human lunar landing". It is then hypothesised that such a decision by China on a formal human lunar programme will likely be announced in a future White Paper either in 2021 or 2026. The 2016 White paper is considered too premature, and will allow time for China to assemble the necessary technologies required. The individual silken threads are in advanced preparation, they only need to be finalised and woven together into a lunar cloth.

The numerous economic, political, social, and technological "conditioning factors" are assessed in chapter 5, the conclusion of which is that China is manifestly looking for cooperation and not confrontation. It is noted that in addition to inherent political motivations, a cooperative human lunar endeavour would benefit China through a sharing of the economic costs, would aid global stability, increase robustness and reduce programmatic risk.

Chapter six, "China, the Moon, and the World" makes very interesting reading, looking at a number of alternative bi-lateral or multi-lateral cooperation scenarios that China could adopt for going to the Moon, and their subsequent impact on the geo-political landscape. Both space-faring and non space-faring nations are addressed, with the U.S., Russia and Europe (through ESA) being the most attractive to China. The possibility of a G2 (U.S. and China) is discussed. With respect to Sino-U.S. relations in the space domain, although there have been some small advances recently, the current situation, due to the "Wolf Ammendment" in particular, is stifling constructive dialogue between Beijing and Washington. While not fully in harmony with China's desires, one clear conclusion from the analysis of this chapter is that a bi-lateral cooperation between China and Russia could be a distinct possibility if the existing geo-political climate does not change, and so become the default option. The final sentence of this chapter however, notes that "Europe's posture could eventually become a key variable in solving Beijing's strategic equation on the space chessboard". So, a possible significant role for Europe then?

The "Europe and China in Space: Constraints, Opportunities, and Options" chapter examines what this role for Europe could be in helping to solve this geo-political puzzle. This chapter highlights that the definition of Europe, as defined from a space policy perspective, is somewhat out of focus, consisting as it does of the European Union (EU), the European Space Agency (ESA), and the Member States of both these entities. Although not yet fully-focused, thanks to the Lisbon Treaty, the enlargement of ESA in moving towards bringing in all EU Member States, and closer cooperation between the EU and ESA, the image of a single entity is gradually becoming much more visible. Recounting the recent developments in the broader political relationship between the EU and China, together with an analysis of the historical long-term European-China cooperation in space activities, culminate in a SWOT (strengths, weaknesses, opportunities and threats) analysis that identified four potential policy options for Europe with a number of recommended actions. These four options were:

- Europe as a Strategic Partner: Although this could bring extensive benefits to Europe, it was not seen as a particularly viable option due to the potential geo-political disturbance, and the difficulty of aligning all European stakeholders.
- Europe as Competitor: As an independent human spaceflight programme would go against the grain of current European stakeholder consensus, and an alignment with either the U.S. or Russia could have some deleterious geo-political consequences, and so the political effectiveness of this option was felt to be low.
- Europe as a Limited Partner: An option primarily lead by ESA supported by the EU, but felt to be too limiting for Europe globally.
- Europe as a Bridge-Builder: Europe to provide the interface to enable cooperation between China and the U.S. - a potential game-changing role!

The final option was assessed as the best option from an overall European perspective. Concerning this option, and coming back to timing (launch windows), it becomes clear that in order to provide a timely lift-off for Europe's Bridge-Builder role, Europe must act quickly before the window of opportunity closes, if it

has not done so already. It cannot move as slowly as it has done in the past - the world is moving on - and fast. The "elephant in the room" in all of these deliberations however, remains the U.S., as although the ball is in Europe's court, the rules of the game are still defined by the U.S.

For anyone interested in space, and especially for any European citizen interested in space, this book should be required reading, referencing sources from many highly competent experts (e.g. Chen Lan, Gregory Kulacki, Joan Johnson-Freese, Brian Harvey, etc.). The accumulation of this expert knowledge and its in-depth analyses is of particular relevance for this moment in time. It will provide the reader with a clear understanding of where we stand today and the potential consequences of choices now made on the future geo-political landscape.

"When China Goes to the Moon...", Studies in Space Policy series, Vol. 11, Springer International Publishing, 2015. [ISBN 978-3-319-19472-1]. 149 US-$ / 118 Euro

"Paradigm-changing initiatives must thus be taken…"

interview with Marco Aliberti, author of the book "When China Goes to the Moon…"

GoTaikonauts!: Who had the idea for the book "When China Goes to the Moon..." and why?
Marco Aliberti: Like other ESPI projects, the idea of the book was spearheaded by ESPI Director, Peter Hulsroj, building on the insight given by our Editorial Advisory Board, a group of renowned personalities that provides guidelines with respect to the research and network activities of the Institute. China's space programme has advanced at an astonishing rate in recent years, and a comprehensive reflection on how Europe could best deal with – and benefit from – its growing ambitions was perceived to be of utmost importance for a pan-European think tank like ESPI.

GoTaikonauts!: Who chose the title of the book and does it have any particular meaning?
Marco Aliberti: We had the title in mind since the very inception of the project. "When China Goes to the Moon…" is a potentially misleading title, yet – I think – highly thought provoking. It triggers a reflection on how the future in space might look like and makes the case for the global space community to address China's space ambitions in a timely manner even more compelling.

GoTaikonauts!: Your book is a tremendous effort in research, analysing and writing. Why did you decide to take on this hard work?
Marco Aliberti: Asian affairs have always been at the very heart of my interests and research activities since I was a student, and the opportunity to work on this project was simply invaluable for me! While aware of the inherent complexities surrounding the topic, I was strongly motivated by the will to propose a novel way of thinking about Beijing's space endeavours and ultimately contribute to promoting a better understanding of China's posture and ambitions in space.

GoTaikonauts!: Your overall look at the opportunities for Europe on cooperation with China tends to be positive. In the last chapter, Chapter 8, you refer to "windows of opportunities" which might not stay open forever. What is your take on that? Would you dare to estimate a timeframe in which the window of opportunity for space cooperation with China is going to close?
Marco Aliberti: The possibility of successfully crafting a major cooperative undertaking in the field of space exploration – be it an exchange of astronauts between the ISS and the upcoming Chinese station, or the joint exploration of the Moon – will depend on a number of critical factors. Time is certainly one of those factors. It is quite evident that the more Europe indulges in adopting a firm pro-cooperative policy action, the more Chinese space ambitions will take their own path. China has repeatedly emphasised its willingness to cooperate with the West, but it is tired of having the doors slammed in its face by the U.S. In other words, should China's overtures continue to be snubbed by the West, it will be certainly pushed to go to the Moon on its own, or with alternative partners, such as Russia. And if such a pathway materialises, the global space community will almost certainly slide into a competition scenario, a new space race.

Paradigm-changing initiatives must thus be taken before such an unfortunate path takes root. Ideally, concrete plans for cooperation with China should be advanced within the next few years. The potential for cooperation on board the ISS might be possible, yet a number practical hurdles would have to be overcome to make that a reality; it should thus be addressed no later than the next International Space Exploration Forum, which will gather in 2016 or 2017.

GoTaikonauts!: What would you like to see as a consequence of publishing this book? What would you like to achieve?
Marco Aliberti: In the book I have tried to underpin the case for a major cooperative undertaking in human spaceflight and to explain why Europe should become a trailblazer of such a challenging, yet highly promising, endeavour. There are great potentials that need to be harvested and I really hope to have succeeded in communicating this message. Even more so, I hope that the ideas of the book will reach far beyond the traditional space community; that the general public and overall policy makers in Europe will become more aware of the opportunities at stake. Eventually, it is the aim of ESPI to create more awareness and stimulate further discussions on the topic and, as an essential element to achieve this goal, we are currently promoting the book among key stakeholders. I really hope they will reflect on its ideas and that they will eventually decide to firmly commit to the realisation of a global initiative in human space exploration.

GoTaikonauts!: Will the topic of Europe-China space cooperation continue to be important for you?
Marco Aliberti: On both sides there is the will – and in a sense the need – to further cement space cooperation in terms of policy dialogue, data and information exchange, and joint space activities. The scope and relevance of space cooperation could likely deepen in the future, but for bolder initiatives a broader international alignment is needed. Europe needs to foster a process of real and enduring inclusion of China within the international space community, an inclusion that would, in turn, facilitate an overall cooperative approach to space activities.

"We should aim high…"

interview with Peter Hulsroj, Director of the European Space Policy Institute, ESPI in Vienna

GoTaikonauts!: ESPI is a rather young institute, founded in 2002. Why was it set-up, what is the main objective of your activities?
Peter Hulsroj: ESPI was set-up by a decision of the ESA Council because it was felt that Europe needs an independent think tank on space policy. To safeguard the independence of ESPI it has been established as an association under Austrian law. ESPI has 15 members, including all the large space agencies of Europe, a few of the smaller ones, the European Commission, and the large manufacturers and operators.

GoTaikonauts!: How is the work in ESPI done? How do you observe trends and how do you analyse those tendencies?
Peter Hulsroj: Our analytical work is done primarily by our Resident Fellows, of which Marco is one. Resident Fellows can be seconded by the members or directly paid by ESPI. Every year we define a work plan, approved by our General Assembly, where 3-4 topics are identified for in-depth analysis. The result of our analysis is captured in our reports, which can be downloaded free-of-charge from our website www.espi.or.at, or in our books.

GoTaikonauts!: Does your institute actively observe Chinese space activities?
Peter Hulsroj: Yes, we have invested significant time in this, since China is becoming such a powerful actor in space – and that in all domains!

GoTaikonauts!: What is your evaluation of China's space potential?
Peter Hulsroj: Present Chinese capabilities are very impressive, indeed. To have built up a human launch ability so quickly is a sign of this, as is the progress on the Chinese space station. And, in normal circumstances, China will go from strength to strength. A growing economy, as that of China, has great potential for funding space activities. It is not obvious that the other existing major space powers have completely grasped how determined and capable China is and will be in space.

GoTaikonauts!: What are China's strengths and which of those strengths could become disadvantageous or interesting for Europe?
Peter Hulsroj: China is capable in all domains, and hence could largely go it alone. Still, China is spread thin, so cooperation is welcome. But cooperation is probably most welcome because China wants to be seen as having 'a seat at the table' of the major space powers. Space is increasingly becoming geopolitical - in addition to provide very concrete utilitarian benefits.

GoTaikonauts!: Which position should Europe take in this current scenario of unsettled concepts for cooperation with China?
Peter Hulsroj: Europe should make sure that the potential of space to be an instrument of peace and harmonious co-existence is exhausted to the maximum extent. In the past, this has been a role for space, and it should serve in that function again.

GoTaikonauts!: What would you recommend to ESA, the EU and the European Member States on how to deal with China's space ambitions?
Peter Hulsroj: Europe should take seriously the offers of cooperation extended by China. In the first instance this means that Europe should seek to get cooperation going between the ISS and the Chinese space station (which should be ready by 2022). Taikonauts should be welcomed onboard the ISS and astronauts on the CSS. At the end, Europe should seek to foster a true spirit of cooperation on exploration between all major space powers – exploring the Universe as a common task of humankind!!

GoTaikonauts!: Do you think your work can facilitate closer European-Chinese cooperation?
Peter Hulsroj: I most certainly hope so!! But not only European-Chinese cooperation. We should aim high and try to be a catalyst for Sino-American-European cooperation, and we should seek to get India and others to join in as well.

When Europe wakes up too late ...

a commentary by Jacqueline Myrrhe

Positive surprises often come unexpected! The just-published book "When China Goes to the Moon... " is not only a treasure but it is a dramatic call addressed to the international space community, but in particular to Europe, to get into gear with respect to space cooperation with China. Recent developments are not really hopeful, and the danger that Europe might become the big looser is real. It is, indeed, five to twelve!

This August, the commercial U.S.-American space company NanoRacks signed an agreement with the Beijing Institute of Technology to fly the first Chinese experiment to the International Space Station.

A first which was previously hoped could have been enabled by Europe, the European Space Agency. Now it is a commercial company! One can only congratulate NanoRacks on this achievement. However, this fact of having a "commercial" agreement adds a bitter note to the efforts for space cooperation at agency level. Remember, there is a law in force, prohibiting NASA from bilateral cooperation with China. The Head of NanoRacks is Russian-proofed, former MirCorp President Jeffrey Manber, the chap who almost bought the Mir space station back in 2000. That Mir space station - the most emblematic symbol of Soviet grandeur and leadership! The new Russia was about to sell it during those days! If China is able to get with money what it needs, where is the role for space agencies? Where is the added value of nation-to-nation cooperation – a moral and highly immaterial duty to the world's citizens? Where is Europe

- the bridge builder, the role Europe always liked to play with virtue and used to be so proud of?

But the sensation of disappointment goes on: A flight by a Chinese astronaut to the International Space Station - ISS might be enabled rather by Russia than by Europe. Enjoying just 8,3 % utilisation rights of the ISS would have been enough to share with China, but the longer Europe hesitates, the easier it becomes for others.

Still there is the hope, that a European could become the first astronaut on the Chinese Space Station. But is there enough time left for making it happen? Already in November 2013, Pakistani Major General Ahmed Bilal, Chairman of the Pakistan Space and Upper Atmosphere Research Commission expressed his country's honest hope: "If China starts taking foreign astronauts to outer space, we would like to be the first candidate." – a position reiterated during the China-Pakistan Economic Corridor forum in Karamay, China in August 2015. Pakistan is not only cooperating with China on the Beidou Navigation System but enjoys since long a special relationship with its big and strong neighbour.

Another interesting development, hardly noticed in the space community, are China's offers to the United Nations. During the 58th session of COPUOS - Committee on the Peaceful Uses of Outer Space of UNOOSA - United Nations Office for Outer Space Affairs - in June 2015, Zhang Xiaobing, the Deputy Director of the Scientific Planning Bureau of the China Manned Space Agency presented China's idea on international cooperation within the framework of its future Space Station. It was very clearly shown that China encourages the UN Member States, in particular developing countries, to come on board the Station project. The offer on the table is for astronaut selection, training and missions, experiments, and space applications. The UN HSTI - Human Space Technology Initiative - would be the programmatic framework to make it happen. Should work, shouldn't it?

There is nothing wrong in being careful! ESA's Director for Human Spaceflight and Operations, Thomas Reiter, explained during his annual press conference in January 2014 what his understanding of being careful regarding ESA's cooperation with China is: "I think that also in the past I have been emphasising, that the initiation of such a type of cooperation is a process, which we have just nudged. We are still in the middle of getting to know each other. ... However, we are advancing by taking logical steps. Of course, we have to do that with prudence, but we do that."

Again: there is nothing wrong in crossing the river by touching the stones - as China expert Kris Liebaut in the interview in this issue illuminatingly described. However, touching the stones and being happy with the realisation that there is a stone is not good enough. The stone must become a stepping stone!
Has ESA lost it - ESA, an agency, looking already a decade-long for its mission and its vision for the future? Not knowing what one wants is not helpful in defining the future, in defining its place in the international arena.

In July 2015, new ESA Director General Johann-Dietrich Wörner advocated in an interview with the BBC, a truly international Moon village to be built in a concerted international activity. "We should have international cooperation, without any limitations, with any countries of the world," Wörner said. "We have enough Earthly problems between different nations – space can bridge these Earthly problems and the Moon seems to be a good proposal. Isolating a country is not the right way, a much better solution is to find ways to cooperate in space to strengthen ties between humans on Earth." Sounds good! Could it work?

However, as stated in Marco Aliberti's book, there are two dimensions: "real political will" - which ESA can collect only to a certain degree. The actual institution for political will on the European level is the European Parliament and the European Commission, while ESA is more the practical institution, managing even European Union space programmes. This maze of responsibilities faces the centralised nation China - a solid rock in Asia. And soon this rock might merge with the Russia boulder.

Has Europe lost it? Europe, which in its self-esteem, was always so proud of building bridges between cultures, nations, continents…

The other dimension is "time" - "windows of opportunity" which do not stay open forever. What China-time is it? How much time is left? True, China does not appear to be in hurry, but standing still gives even a snail enough lead.

And then there is still the third dimension, hard to grab, hard to seduce, not to buy in the supermarket – it is called: trust. It is not only China, most countries in Asia cannot do business without trust. Westerners are astonished again and again, how important trust in the Eastern world is. How can trust be ensured in a monetary, suspect world into which the West has been sliding over the last few decades?

While the book remains optimistic there are indications that it might be already too late for Europe? "The world needs a new departure, not a reiteration of history", as Aliberti rightly appeals. Is a Europe, caught between the political dynamics of the 21st century and busy with sorting out itself, prepared and mature enough for a "new departure"? Maybe the new departure is already taking place – but in Asia?

When China goes to the Moon "hand-in-hand" with Russia, Europe will know it has been sleeping far too long.

Successful Space Cooperation with China – the British Way

Report from the 10th UK-China Workshop on Space Science and Technology

by Jacqueline Myrrhe

To most British, the 30.000 population town of Newbury in the South-East of England might be best known for its horse racecourse, or for being the home of Vodafone UK. Without doubt, the hilly, meadow-covered region must be famous for its golf courses, and so one should not be surprised to see that major hotels busily advertise their unbelievably green and well-kept grasslands.

It has a certain charm to discover that Newbury is almost in the middle between the British capital London, 100 km to the East, and the ancient World Heritage Site of Stonehenge, 70 km to the West. At the same time, the academic centre of Oxford can be reached in less than an hour's drive, as well as Swindon, the hometown of the UK Space Agency's headquarters. Though Newbury is even closer to Harwell - the modern and growing Science and Innovation Campus of the British Isles. All these considerations must have provided a good reason for choosing Newbury to host the anniversary workshop, the 10th UK-China Workshop on Space Science and Technology.

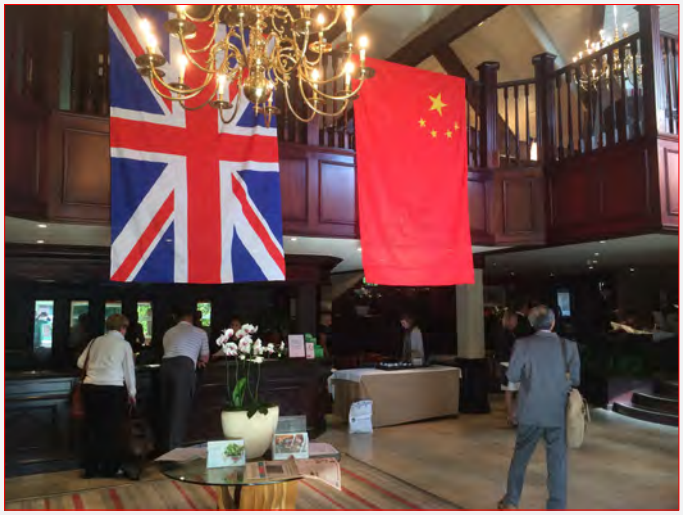
During the three days from 7 to 9 September, the Donnington Valley Hotel provided a friendly atmosphere shared between golfers and space experts. And no, there was no time to play golf for the over 100 workshop participants - approximately 40 Chinese and almost 70 British. The workshop programme was packed from its beginning on Monday morning until Wednesday afternoon with a plenary session, six themed work group sessions running in parallel, and visits to Rutherford Appleton Laboratory RAL and the Satellite Applications Catapult in Harwell. Workshop Chairman Chris Bee, Head of Business Development for the Science Technology Facilities Council - STFC Rutherford Appleton Laboratory RAL - did an excellent job to make the national and international guests alike feel welcome.

One would not expect – but be rather pleasantly surprised, however, to witness the remarkable progress, the UK has made within such a short time in the set-up of space cooperation relationships with the Middle Kingdom. (also compare: interview with Chris Bee Head of Business Development for STFC-RAL in GoTaikonauts!, issue no 14, p. 27-29) What was started by an accidental, although, Ministerial casual remark, turned into a decade of success and as Prof. Holdaway states in his interview with GoTaikonauts! (see: end of article), there has been a big interest from both sides from the very beginning. Since then, the workshop has been taking place in alternating locations in China or the UK.

Success has many parents - and it is the same here. To spread the news about existing opportunities and to bring potential partners together can be hard work. The UK chose to rest that work on several shoulders, with a significant share of the work done by the Science Technology Facilities Council STFC - Rutherford Appleton Laboratory RAL, the UK Space Agency, UK Trade & Investment, and in the Foreign and Commonwealth Office, UK Embassy in China with Karen Maddocks as the Head of Science and Innovation Network Beijing.

Additionally, the workshop initiative fits into the GREAT Britain campaign, "the Government's most ambitious international promotional campaign ever, uniting the efforts of the public and private sector to generate jobs and growth for Britain. ... [of which the] aim is to encourage people around the world to think and feel differently about modern Britain." Sophie Boldon, Head of Market Development, UK Trade & Investment, took this as the departing point for her presentation and recalled, that the government of Great Britain wishes to promote commerce in 8 great high-tech sectors. It is planned to achieve a market growth from 3.1 billion £ to 40 billion £ in 2030. One of the 8 high-tech sectors is space. The UK would not be the UK if the overall focus

Group photo of the participants of the 10th UK-China Workshop on Space Science and Technology. (credit: STFC-RAL)



The national flags not only welcomed the workshop participants but also created a suitable atmosphere. (credit: GoTaikonauts!)

On Monday morning, the plenary took place. (credit: GoTaikonauts!)

wouldn't be on business opportunities. Therefore, there was a lot of talk on applications - satellite applications which generate markets, jobs and turnover. One might think of this concerted activity as a sound, long-term strategy and one might be right.

The 10th workshop saw six themes of discussion, split into programme sessions and applications sessions. The first group comprised Earth Observation, Space Science and Skills and Training, while the second included Space Technology, Newton Network, and Data Exploitation.

Space Science

During the summary presentation, Prof. John Zarnecki from the Open University reported on the results of the Space Science session. His co-chair was Wang Chi of the National Space Science Centre, Chinese Academy of Science. Although the presentations and discussions covered a broad range of topics, 3 areas of potential large interest for collaboration were highlighted. The first is the ESA-China space mission, SMILE - Solar wind Magnetosphere Ionosphere Link Explorer. It is a truly cooperative work from the very beginning and the UK is well represented here by its contributions through ESA. Both scientific principal investigators - Graziella Branduardi-Raymont from the Mullard Space Science Laboratory, University College London for the European side and Wang Chi from the State Key Laboratory of Space Weather, NSSC, CAS, for the Chinese side were present during the workshop.

The second highlight area was the curation and analysis of samples from space. Curation? You think it is simple? Think again! The UK has nearly 50 years of experience in curation and analysing of various samples and has developed specialised techniques to handle and to store those very rare materials. Of course, Prof. Zarnecki stressed, that it would be nice to get access to Chinese lunar samples and to exchange know-how.
The third area of interest was exo-planet research with a view to a possible UK participation in Chinese missions under study but not yet approved.

Skills and Training

This session was chaired by Anu Ohja of the National Space Academy, together with Yu Junsheng of the Beijing University

Karen Maddocks, the Head of Science and Innovation Network Beijing, was presenting which kind of support the Embassy in Beijing can give for cooperation efforts. (credit: GoTaikonauts!)

Time for a photo - many workshop participants, like here Chris Bee and Fang Baodong, became acquaintances. (credit: GoTaikonauts!)

of Posts and Telecommunications. Also here, broad and high-quality presentations and discussions reporting on successes in cooperation, characterised this session. Romain Charles of ESA, one of the Mars500 simulation participants gave an exceptional talk providing deep and valuable insights into intercultural phenomena. The many questions by the audience showed how curious people are about human interaction, in particular when the cultures are highly different, and how much people were willing to learn from Romain Charles' experience. Those cultural and human stories of success, said Ohja, give the framework for when we will work together more closely in the future. As an outcome of the different inputs during the session, he suggested the establishment of a "multi-disciplinary consortium of UK providers and present this to the Chinese collaborators who will work over a long period of time to see if we can sustain and build on these individual programmes to weave them together as a direct part and direct outcome of the UK-China workshops." The idea is to take advantage of the "strengths and opportunities from both sides, the traditional Chinese system of education and the traditional UK approach, and it would be desirable to synthesize the best from both systems." As a consequence, the National Space Academy UK could transfer its projects to the National Space Academy China to have a joint programme for space science education at all levels - fundamental to higher level - schools to universities.

Earth Observation

The Earth Observation session was chaired by Andy Shaw of Terreflexion Consulting Ltd. The well-attended programme saw a wide range of talks whose main themes were based on technology associated with LIDAR, SAR and the use of SENTINEL missions. The follow-up activity resulting from this session will be in finding ways of making these data sets available to China.

Newton Network-AgriTech

The Newton Network-AgriTech session was under the lead of Hugh Mortimer, RAL Space STFC, together with Xu Lijun of the Beihang University of Aeronautics and Astronautics BUAA. As before, the wide range of excellent talks covered diverse and interdisciplinary topics.

The overarching focus has been on the Newton Fund programmes. Since its inception, almost a year ago, 20 projects which involved 26 UK participants and 23 Chinese partners in industrial and academic research, could be financially supported. The AgriTech sub-set promotes the use of satellite-enabled technologies and data from satellites and modelling helping Chinese agriculture in becoming more efficient. The whole theme of agricultural monitoring from space was split into four areas:

- How can Earth observation data be used to monitor climate change;
- how will feedback from climate change impact agricultural processes;
- precision agriculture: how can technologies be used to enable better monitoring, better mapping, and better preparation of the landscape we are using;
- sustainable intensification: the ability to use less products to improve yields, to monitor pests and diseases, from space.

These areas require a range of expertise from biologists to data modellers. In the week after the workshop, an MoU would be signed for the AgriTech project and an £ 8 million Joint Open Call; £ 4 million from the UK and 4 from China, would be announced by STFC and NSFC in the middle of October. (http://www.rcuk.ac.uk/international/newton/)

Space Technology

Sarah Beardsley of RAL Space and Li Feng from the China Academy of Space Technology CAST, oversaw the Space

NEWTON FUND

The Newton Fund is part of the UK's official development assistance. Its aim is to develop science and innovation partnerships that promote the economic development and welfare of developing countries.

The fund is £75 million each year from 2014 for 5 years, and we expect that the UK funding will lead to extra funding from:

- Partner countries;
- private foundations;
- multi-lateral organisations;
- corporate partners.

The UK-China Research and Innovation Partnership Fund is part of the UK's Newton Programme. The China partnership has a total value of £200 million over five years. Both the UK and China will contribute equally to the fund.

Within this the UK and China have identified a number of joint priority areas which they are looking to support:

- Health.
- Environmental Technologies.
- Food and Water Security.
- Urbanisation.
- Energy.
- Education.
- Creative Economy.

This is an exciting new model of collaboration, which builds upon the excellent relationship that the UK and China already have on science and innovation. This is the first time any country has had a dedicated matched funded budget with China for science and innovation collaboration.

In addition to the Newton Fund, the Science and Innovation Network undertakes a broader programme of work with UK and Chinese partners to drive high-quality strong collaborations. The Science and Innovation Network works closely with the Research Councils Office and British Council in China.

sources:

UK government website
https://www.gov.uk/government/publications/newton-fund-building-science-and-innovation-capacity-in-developing-countries/newton-fund-building-science-and-innovation-capacity-in-developing-countries

Newton Fund is launched - Science and Technology Facilities Council website:
http://www.stfc.ac.uk/news/newton-fund-is-launched-a-new-initiative-intended-to-strengthen-research-and-innovation-partnerships-between-the-uk-and-emerging-knowledge-economies/

Technology sessions. As Sarah Beardsley reported on the Wednesday morning, it was challenging to bring all presentations and discussions which covered many different activities together into a coherent theme. However, with respect to collaboration opportunities, the talk by Liu Zhiyong from CAST was useful in that it included an extensive list of possible areas. Just alone, this list of ideas for potential collaboration activities could be worth a workshop on its own. Still, during the workshop, an MoU on the joint development on a millimeter and sub-millimeter wave receiver front-end was signed.

Data Exploitation

One tends to agree with Philip Davies of Deimos Space UK Ltd., when he, as the Chair of the Data Exploitation session, presented his session as the arguably most important of all sessions, since the discussions were aimed at making use of all this "fabulous data" from the other sessions. The highly different talks covered any use of space data with a focus on Earth observation data. The topics presented were as versatile as high performance computing, use of Earth observation data for mapping applications, simulations and other purposes, as well as the commercial space industry in China. Philip Davies summarised two main areas for follow-on collaborations. One area is Earth observation applications work making use of data from UK and/or European assets together with Chinese assets. "Earth observation applications do not care where the data come from." Much of the research projects between the UK and China could be applied in each other's regions, similar to the AgriTech approach. Understandably, a big interest in this respect is the potential commercial exploitation. It would be desirable to follow-up on the presentation on meteoroid/debris impact on the solar panels of Eureca and the Hubble Space Telescope, to identify joint efforts for a better protection of future space systems.

It is admirable how, with a combination of tactical skill and long-term strategic approach, the UK has gone into the field of space cooperation with China. The numerous signed MoU's and agreements (at least 9 during the workshop and several more after the event) speak a language on its own.

Additionally beneficial are the strong and serious British intentions for overall cooperation with China. The UK Chancellor George Osborne visited China in late September for participation in the 7th UK-China Economic and Financial Dialogue in Beijing, where 53 agreements were signed and sealed. Osborne became very enthusiastic about the prospects of the bonds between the two countries when he stated that the City of London should be "China's bridge into Western financial markets. ... And make no doubt about it, I want the UK to be the natural Western hub for renmimbi trading." Also, it was the UK which became the first major Western country as a founding member of the Asian Infrastructure Investment Bank (AIIB). London's surprise move prompted other European countries to also sign up. China's President Xi Jinping is scheduled to visit the U.K. later in October where the inputs from the UK-China Workshop on Space Science and Technology will feed into a framework for cooperation.

Newton AgriTech Programme

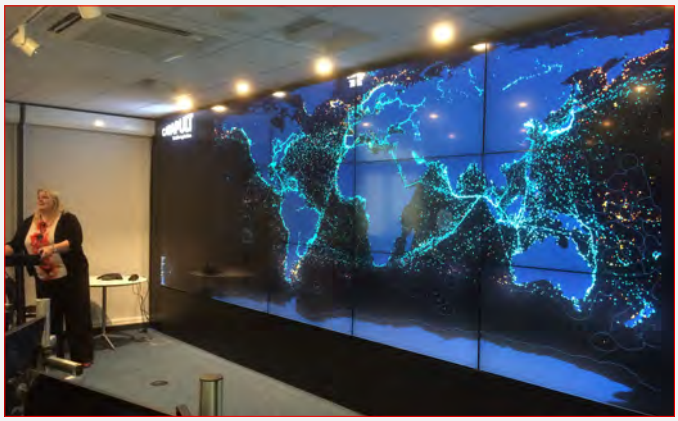
STFC RAL Space is delivering a 12 million £ Newton programme of research and innovation in the area of Agricultural Technology (AgriTech) between UK and China. This novel programme holds significant international and strategic importance to the UK having direct provenance and endorsement from the highest level of UK Government.

The purpose of the programme is to stimulate partnership and collaboration between the UK and China, exploiting advances in satellite remote sensing, Big Data modelling and enabling robotic and autonomous technologies to address critical agricultural issues in China. No programme of this type has been tried before.

Further novelty exists in the means of delivering the programme. STFC have delegated responsibility for programme design and delivery directly to RAL Space under the leadership of Dr Hugh Mortimer. RAL Space requires expert technical support in the areas of space remote sensing, agricultural science, programme design and delivery.

source: UK China Agri-Tech Workshop on Precision Agriculture and Soil Management
http://www.cittc.net/sites/english/forumDetail.html?id=1366

The Chinese guests followed the explanation of the AIS ship identification system application on the impressive screen wall of the Satellite Applications Catapult. (credit: GoTaikonauts!)



For Wednesday afternoon a tour to Harwell was organised. The workshop participants were shown RAL Rutherford Appleton Laboratory and the Satellite Applications Catapult at the Harwell Science and Innovation Campus. (credit: GoTaikonauts!)

The numerous agreements underline the success of the workshop. (credit: GoTaikonauts!)

During his banquet dinner address, Prof. Holdaway, who just retired as the years-long Director of RAL Space, envisioned a human mission to Mars. Even though he sees in NASA the natural leader for such an endeavour. Crucial contributions would come from all over the world, including China and the UK. A human mission to Mars would certainly fit into the overarching goal of the UK-China strategy, which could not have come more to life than through the series of UK-China workshops. It all fits nicely together.

also compare:
UK-China Cooperation in Space: Two Perspectives with the same Objective, GoTaikonauts!, issue no 10, p. 34-38

Interview with Chris Bee, Head of Business Development for the Science Technology Facilities Council - STFC Rutherford Appleton Laboratory in Harwell, Oxford, GoTaikonauts!, issue no 14, p. 27-29

"And this has to be good!"

interview with Prof. Richard Holdaway, retired Director of RAL Space and driving force of the UK-China space relationship

GoTaikonauts!: How did the UK-China Workshop initiative come into place and how did you decide to set-up such a series of workshops?

Prof. Richard Holdaway: It started in 2005, when an intergovernmental meeting between the UK and China took place. This meeting was not specifically on space but on science and technology cooperation. It was led by our then Minister for Science and Technology, David Sainsbury. I was part of that delegation going to Beijing. During the meeting it became clear that there were a number of areas in science and technology which were interesting for both sides, for example, medical research, IT, energy, and nanotechnology. The Minister then turned around to me and asked: "What about space?" It was obvious that the UK has a space programme and the Chinese have a space programme, so when the Minister addressed me with this question, I could hardly say: "Not a good idea, Minister!" This is how this initiative was born. There was funding from both governments to set-up a series of workshops. One of which was about space. I took about 30 academics and industrialists over to Beijing for the first workshop. At that time, we really had no idea what response we would get from China. But in fact we got something like 500 interested Chinese turning up. We covered astronomy, solar physics, planetary physics, Earth observation, climate change and some very basic technologies. We covered all those topics on a very top level in that workshop. Of course there is an issue in terms of export control of technology. But because there was such a big interest we decided to have a second workshop which was held here in Harwell at the RAL laboratory. Then, further workshops were hosted alternately in China and the UK. We have run some training courses, and have had numerous visits from Chinese delegations here and UK delegations over there. We have also had student and staff exchanges. In total we have probably had an involvement from approximately 2000 - 3000 people from both countries on all levels, from government, industry, academia, and space agencies. We've had pretty much the same themes ever since, looking at opportunities in science collaborations, outward-looking and downward-looking, joint technologies developments, and commercial opportunities in both directions. The Chinese are more open now to collaboration than they were even 10 years ago.

One of the things which made a big difference last year was the agreement signed as a result of the visit by our Prime Minister David Cameron to China in December 2013. The agreement was signed by the UK and the Chinese Prime Minister, for a programme which became known as the Newton Programme. We put together a proposal for a joint programme with China on using space technology, but on the ground or in the air, but not in space, for improving agriculture in both countries. That proposal was in fact the largest funded programme of all programmes, not just space programmes. That is why we have a Newton session here which is run by Hugh Mortimer. That gives an extra dimension to the whole interest in the Chinese space programme which is not just space for space but space technology for other purposes, using robotics, using the UAVs [unmanned aerial vehicles], using data processing, using some of the sensors in space but using them either on the UAVs or on the ground. So there is a lot of interest and as you know very well, the Chinese have a massive space programme. They have their own taikonaut programme, they have their own space station they are building, they have been to the Moon, they have continuous developments and plans for the Moon including commercial developments. They plan in due course a mission to Mars. And the interesting thing is whether or not by the time there is a manned mission to Mars whether by then, leading up to this mission there will be opportunities for China not just to work with the European Space Agency - as it has done before - but to work with NASA too, what is not possible right now. But if you think back to the Cold War, between the East and the West,

there were two things that linked Russia with the West: one was soccer and the other one was the space programme. Those two things continued all the way through the Cold War. NASA and the predecessor of Roscosmos worked very closely in space. Personally, I think it is inevitable that the same thing will happen eventually in the space programme with China. There have been and will be for some considerable time still, concerns about sensitive technology in working on that with China in the same way as there is with Russia. But the protections on those technologies are very well established as they are with a number of other countries. China is not unique in that respect. So provided you work within the confines of allowable technology discussions there is no reason on Earth why China could not be brought into the fold for human exploration of space beyond Earth orbit.

GoTaikonauts!: What do you think are the strengths the UK could bring into cooperation with China?
Prof. Richard Holdaway: There are two particular strengths: one is in payloads. The other one is the ability to do things quickly. This goes back to the initiative by Daniel Goldin who used to be Head of NASA: faster, better, cheaper! It is the sort of thing that Surrey University does very well with micro-sats, the sort of things that RAL Space does very well with its instruments - Surrey are world leaders in micro-sats, RAL Space are arguably world leaders in instruments, as they have had 212 instruments launched into space. Many of them are unique instruments in that they are new developments, new technologies and so on. But most of them have been built very quickly, more quickly than a large space agency can do so. Those are the real strengths: Innovation in the UK and the ability to build in particular, world leading payloads.

GoTaikonauts!: After ten years, are you happy with the results?
Prof. Richard Holdaway: Yes, it takes a long time. The culture in China, which is highly dynamic, nevertheless is very different to the culture in the West, combined with the fact that it takes a long time to get to know people - the issue of trust is much more important - and getting to know people is much more important. This is not only valid for China but for all of Far East Asia, including countries like Japan. So, it does take time! The collaborations have been growing all the time. At RAL we have been working with the Chinese for 40 years! The first 25 - 30 of those years we were working on science, but we have been working with the Chinese on technology for the last 10 to 15 years. We have been always thorough and are still restricted in the technology that we can discuss with China and we can develop with or for China. But the same is true when we work with Russia. We have been working with Russia for many years and there are some other countries where we have very different restrictions. We can work within these constraints and it is ok. The Chinese have a lot to offer: they have got launch vehicles, they are building their entire space station, they have offered us payload space on their lunar mission, and on their Mars mission. They are much more open to collaboration than they ever were.

GoTaikonauts!: China is seriously planning for an international cooperation on a Mars mission? China is that far already?
Prof. Richard Holdaway: Oh, yes - it is for a robotic mission. We are actually not participating in this Chinese Mars robotic mission because we could not get the funding in the UK as a high enough priority. The offer from China was: you provide payloads that do interesting science and we fly for free.

GoTaikonauts!: Looking into the future: 10 years from now, how would you like to see the cooperation with China evolving?
Prof. Richard Holdaway: There already is scientific cooperation in space missions between the European Space Agency and China and therefore the ESA Member States and China. We in the UK do some work with China on nation-to-nation agreements. I am sure - all of those things will continue to expand. And likewise: there is nothing to stop China and ESA and Russia and India and Japan to work together on a human space mission. What is not possible at the moment is to have China working with the United States. That - I think - will change eventually. There is an opportunity, a UK mission called Lunar Mission One, which is going to the Moon and the Chinese have been and will continue to be invited to be involved in the science and educational part of that, possibly also the technology - who knows. That is an unmanned mission - nevertheless it is supposed to be a joint mission to the Moon. I think that there is a very-very high likelihood that by the time humans are going to Mars - in a controlled way - I am not talking about these one way tickets to Mars - when there is a properly funded US mission to Mars - and I think it has to be led by the US - I think by then the Chinese will have been invited to participate in some shape or form. And this has to be good!


View to the hilly golf course at the Donnington Valley Hotel with art sculpture. (credit: GoTaikonauts!)


UNESCO World Heritage Site, Stonehenge. (credit: GoTaikonauts!)

Gallery

CZ-6 Maiden Launch

far left: CZ-6 in a pad drill in 2013. This picture was released at the end of 2013. (credit: Chinese internet)

left: CZ-6 in a pad drill. This is a newly-released image showing that the erector (umbilical pod) had left the rocket. (credit: SAST/WeChat)

The YF-100 engine. A single YF-100 is used on the first stage of CZ-6. (credit: Chinese internet)

CZ-6 in rocket - satellite horizontal mating. This was the flight model launched on 20 September. Note that all follow-up images show the flight model. (credit: SAST)

CZ-6 was hoisted onto the transportation vehicle. (credit: SAST/WeChat)

CZ-6 and its erector on the transportation vehicle. The picture was taken during the rolling out. (credit: SAST)

CZ-6 and its erector on the transportation vehicle. The picture was taken during the rolling out. (credit: SAST)

CZ-6 being erected at the launch pad. (credit: SAST)

CZ-6 sitting at the launch pad. The erector was partially put down. (credit: SAST)

At 7:01 Beijing Time, 20 September, the CZ-6 made its successful maiden launch and sent 20 small/micro satellites into orbit. This picture shows the moment of ignition. (credit: SAST)

At 7:01 Beijing Time, 20 September, the CZ-6 made its successful maiden launch and sent 20 small/micro satellites into orbit. This picture shows an overview of the new launch pad with CZ-6 in ascent. (credit: SAST)

At 7:01 Beijing Time, 20 September, the CZ-6 made its successful maiden launch and sent 20 small/micro satellite into orbit. This picture shows the rocket in ascent. (credit: SAST)