



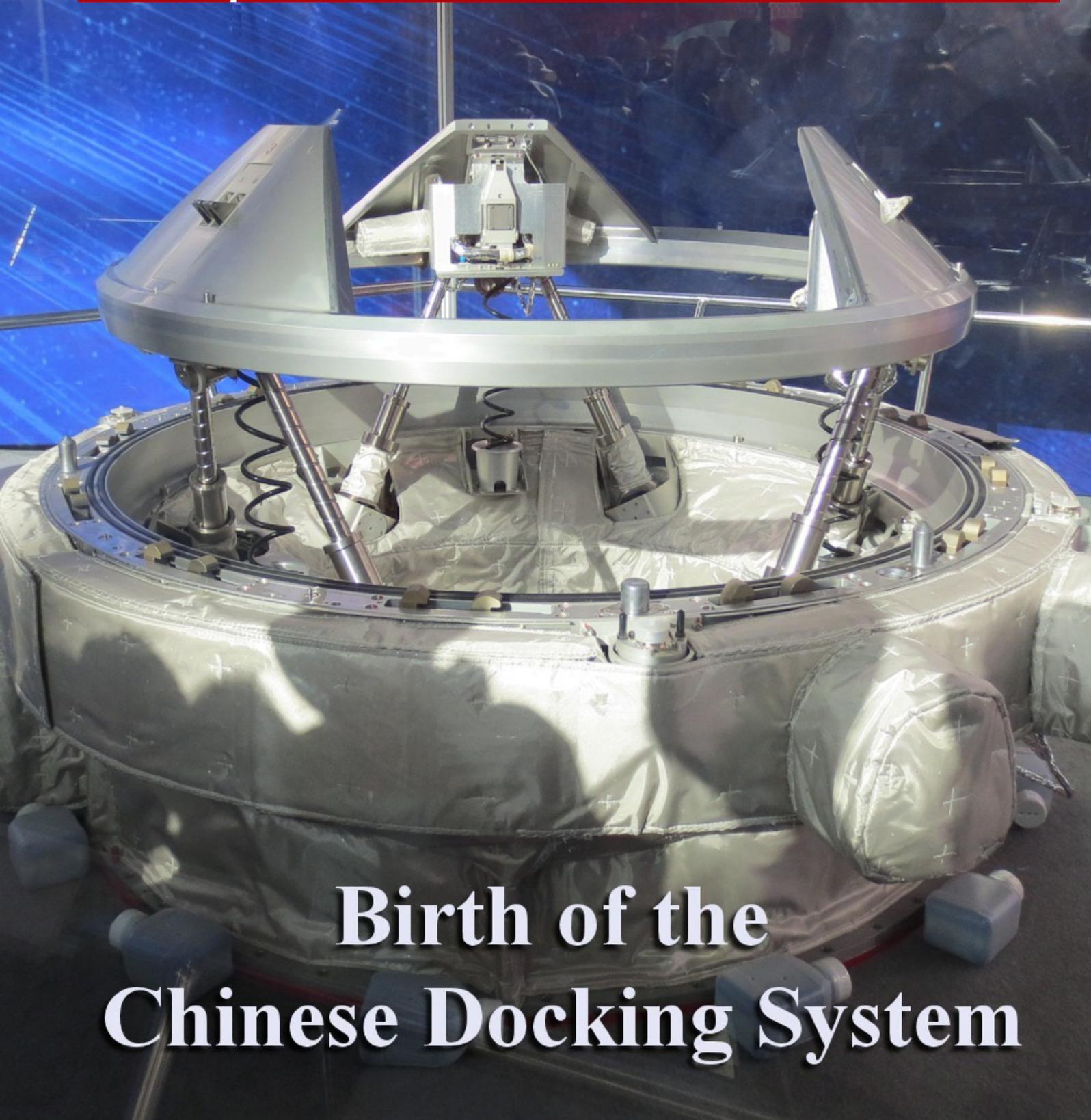
Issue 16

All About The Chinese Space Programme

# Go TAIKONAUTS!

龙腾太空

August 2015



## Birth of the Chinese Docking System



## Editor's Note

China will launch the Tiangong 2 space laboratory next year, followed by the Shenzhou 11 manned mission and the Tianzhou 1 cargo re-supply mission. The docking system in these missions will be upgraded to support liquid propellant transfer. China is also developing a new docking mechanism for the Chang'e, ...

page 2

## Quarterly Report



### April - June 2015

#### Launch Events

It was expected that China would increase its launch rate in the second quarter of 2015. However, the second quarter had almost repeated what happened in the first quarter with a sole launch taking place at the end of the quarter. It made the first half of 2015 the half-year with the least space launches since 2001.

... page 3

## Feature

### “If I could, I would be a space teacher forever.”

One has to congratulate ROOM magazine on this unique and authentic account of a Chinese taikonaut. In a lengthy contribution, China's second woman in space, Wang Yaping, gives a highly personal and in the same way detailed insight into her training as a taikonaut, her mission to space and how life evolved for her after return to Earth.

... page 15

## Gallery

### China's Deep-Space Network ... page 22



## COVER STORY



### Birth of the Chinese Docking System

#### The Development History and Application Status of China's Manned Spacecraft Docking Mechanism

The rendezvous docking technology mission was the key mission in the second phase of China's manned spaceflight project, and the docking mechanism was one of the key technologies. The development history of the docking mechanism of China's Shenzhou spaceship and Tiangong target spacecraft is introduced in this paper, including the details of argumentation, research, designing, testing and so on. The paper also introduces the technical solutions of China's docking mechanism in detail and describes the current application status of China's docking mechanism, together with the flight conditions of Shenzhou 8, and Shenzhou 9 flight missions...

... page 8

## On the Spot

### “There is no other way than cooperation”

#### Report from the British Interplanetary Society London Chinese/Soviet Technical Forum - 19-21 June 2015

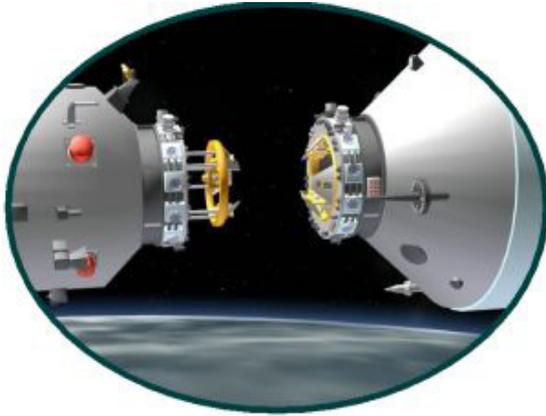
This year marked the 35th anniversary of the forum, which was celebrated by having two key-note speeches on the Friday evening, one by Dr. Helen Sharman and one by Anatoly Pavlovich Artsebarsky respectively. Although the meeting room at the BIS headquarters in central London was quite full, it was a little surprising to see the limited attendance for such an event – by the UK's first astronaut (flying as a UK citizen), and the first time that a cosmonaut has presented at the forum.

Dr. Sharman launched together with Artsebarsky, and Sergei Krikalyev on 18 May 1991 to the Mir space station, and returned with Viktor Afanasiyev and Musa Manarov on 26 May 1991. In a highly entertaining and engaging talk, Dr. Sharman ...

page 17



## Editor's Note



China will launch the Tiangong 2 space laboratory next year, followed by the Shenzhou 11 manned mission and the Tianzhou 1 cargo re-supply mission. The docking system in these missions will be upgraded to support liquid propellant transfer. China is also developing a new docking mechanism for the Chang'e 5 spacecraft to perform lunar orbit rendezvous and docking which will pave the way for the future manned lunar landing. China is now the third country having mastered the rendezvous and docking technology independently. But apart from the fact that it is APAS-like, few people knew any other details of it before the Tiangong 1 and the Shenzhou 8 missions in 2011. What is particular about the Chinese docking system and is it a copy of the Russian system? How did the Chinese master this technology suddenly? What happened during its development?

The cover story of this issue answers all these questions, with authority and a detailed technical description. Its authors are from SAST, developer of the Chinese docking system. The story reveals a long history of the development since 1992 and draws future prospects as well. The article was originally published at IAC 2013 in Beijing. Here we re-publish the information with the author's kind permission.

In mid-June, the BIS's 35th Soviet-China Technical Forum took place in London. Go Taikonauts! was there and seized the moment by interviewing Soviet cosmonaut Anatoly Pavlovich Artsebarsky who shared with us his impressions from his visit to China last year to attend the Association of Space Explorers Planetary Congress in Beijing.

Also, we are grateful for the opportunity to share a unique article by China's second lady in space. ROOM magazine generously allowed GoTaikonauts! to introduce its article "Sowing a New Dream" by Wang Yaping published in no 1 (3) March 2015, to our readers.

Last but not least, in the Gallery section, you will see pictures of the major antennas of the ambitious Chinese deep-space tracking network that is still under construction.

Have a good read!

(Jacqueline Myrrhe, Chen Lan)

## Imprint

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## Chinese Space Quarterly Report

April - June 2015

by Chen Lan

### Highlights

- Gaofen 8 in a surprise launch.
- CZ-5 development made progress.
- China tests coal-based rocket fuel.
- China plans global data collection constellation DSCC.
- China to test 6-hour fast docking during Tianzhou 1 mission.
- Space Station development made progress, new EVA suit in development.
- Chang'e 4 to land at lunar far-side, relay satellite planned, int'l cooperation proposed.
- China plans to jointly develop a small launcher with Europe.
- China and Europe selected SMILE as the joint science mission.
- Jilin Province pushes commercial imaging satellite constellation.

### Launch Event

It was expected that China would increase its launch rate in the second quarter of 2015. However, the second quarter had almost repeated what happened in the first quarter with a sole launch taking place at the end of the quarter.

On 26 June, at 14:22, China launched the Gaofen 8 (GF-8) optical imaging satellite using a CZ-4B rocket from Taiyuan. It was a surprise as China had announced that only 7 Gaofen satellites are in the plan. Later, Chinese media revealed that this satellite was a sister bird of the YG-26 satellite launched last year. The two satellites were developed together by one team and as one project spanning three years. It was unclear if it was the civil version of the military YG satellite, or the GF designation was the cover name of a military bird. It remains unclear if it was planned from the beginning when the Gaofen programme was initiated, or a later decision that came with the YG-26 project.

### Space Transportation

There is a lot of CZ-5 news in this quarter, mostly on ground tests:

- On 2 April, the auxiliary propulsion system of CZ-5 completed a full-system hot test firing. This system is

used for altitude control, end velocity correction, and fuel management during the coasting flight of the second stage.

- On 14 April, the separation test of the CZ-5 upper stage, the largest upper stage in China with a diameter of 5.2 m, was completed successfully. On 17 June, the second separation test was made, also with success.
- On 16 April, the 5.2 m diameter hydrogen tank of the CZ-5 second stage completed the low-temperature static-load test in liquid hydrogen mode. It was said to be one of three most important ground tests for CZ-5. The other two are the hot test firing of the first and second stage's propulsion systems and the rehearsal at the Hainan launch site.
- Sometime in May, the oxygen tank of the CZ-5's first stage completed the low-temperature inner pressure qualification and explosion test. It was the last test for this tank, and the tank was qualified for flight.
- In early June, the second fairing separation test was made successfully.
- On 12 June, the second stage for propulsion test was completed and delivered.
- Chinese media reported in mid-June that the modal test of the CZ-5 full-rocket was nearing completion. It had lasted for more than 500 days. The test rocket had the core stage with a diameter of 5 m and a length of 57 m, and four 3.35



CZ-5's second stage built for the propulsion system test was in ground test. (credit: spacechina.com)



CZ-5's second fairing separation test in June. (credit: Chinese internet)



m strap-on boosters with a diameter of 3.35 m and a height of 28 m. There were more than 1,000 sensors and 23 technical statuses to test. All these figures set records in Chinese space history.

- In late June, CALT started the assembly of the rocket for rehearsal in its Tianjin facility. The rehearsal is expected to take place in late 2015.

In mid-June, the CZ-7 development achieved an important milestone. In a review jointly completed by CALT and CASC, it was agreed to begin the CZ-7 engineering model development, marking the completion of all key technological development and major testing and the freezing of the rocket's technical status.

There was also some other interesting news with respect to rocket development:

- On 12 April, an engine using coal-based kerosene as fuel made a successful hot test firing. It was said this was for the first time in the world. The kerosene is produced by the Shenhua Group in its direct coal liquefaction facility in Ordos, Inner Mongolia, which is reportedly the world's first industrial scale coal liquefaction project put into use in 2010.
- It was reported in mid-April that China's first turbopump-fed multiple re-ignitable upper stage engine completed a simulated altitude hot test firing. It will be used in the maiden flight of CZ-7.
- In mid-May, it was reported that CALT would develop a new supporting structure for the CZ-2C vehicle to support a tri-satellite launch.

## Satellites

Gaofen 4 (GF-4) is China's first geostationary high-resolution imaging satellite that is in development. In April, the camera of the satellite completed the thermal environment test. In May, the fuelling test of the propulsion system was also completed. And by end of June, the flight model of GF-4 completed two other tests, the mechanical test and the satellite-launcher separation test, paving the way for its launch in late 2015.

In early June, the project kick-off meeting for the HY-2B/C ocean dynamics satellites was held in Beijing. The HY-2B, the replacement of HY-2A, will be launched into SSO in 2017. The HY-2C will be launched into an inclined orbit in 2018 to provide all-time, all-weather ocean observation. It appears that the HY-2C is newly planned as it had never been reported or announced before.

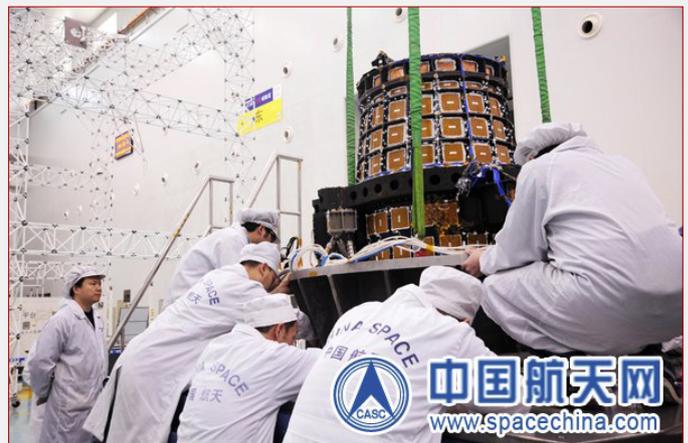
In addition to the GF and HY series, other application satellite developments also made progress. In early June, the FY-4 satellite completed the solar wing deployment test and started thermal control refitting. During the same time period, the government approved funding for the engineering development of the DFH-5 new generation comsat bus. It was planned to complete the prototype development in 40 months with a targeted maiden launch in 2018.

The development of four satellites in the Space Science Pioneer

Program moves forward smoothly. In the time period of 20-22 and 22-24 April respectively, the DAMPE (Dark Matter Particle Explorer) and the QUESS (Quantum Experiments at Space Scale) satellites completed satellite-ground interface tests with the flight models in Sanya. At end of May, the flight models of the payloads of DAMPE were delivered for satellite integration after an intensive integrated payload test in May. These payloads were once sent to CERN near Geneva, Switzerland in November 2014 and March 2015 to carry out photon/electron and heavy ion beam calibration experiments. On 15 May, the first batch of flight models of payloads of the SJ-10 satellite were delivered for satellite integration. By the end of June, 28 of 29 payloads had been delivered.

Besides the above satellites in development, Chinese media also revealed more satellite plans:

- China is planning a new generation of oceanic satellites after HY-1C/D and HY-2B/C. On 25 May, proposals for the new generation of ocean colour satellites and an ocean salinity satellite completed a review and were ready to be submitted to the government for funding. Earlier, on 17 April, the R&D project "key remote sensing technologies for the geostationary ocean colour satellite" under the Program 863, China's national high-tech programme, was kicked-off in Hangzhou. The project is undertaken by the State Oceanic Administration (SOA) and China Academy of Sciences (CAS). It is unclear if this R&D project has links with the planned new generation ocean colour satellites.
- On 5 June, the Atmosphere Environment and Pollution Monitoring Satellite completed an internal review in SAST, paving the way for its formal approval and funding.
- In April, Chinese media reported that China plans to provide a space-based infrastructure (aka. Space Silk Road) for the Chinese government's "One Belt and One Road" initiative ("the Silk Road Economic Belt" and "the 21st Century Maritime Silk Road"). In the plan, the DCSS (Data Collection Satellite System) plays an important role. According to information revealed in a seminar held on 6 February, the DCSS will consist of 40 low Earth orbit satellites to form a global constellation. It will receive information sent from numerous and various types of



The high-resolution camera of Gaofen 4, China's first geostationary imaging satellite, in testing. (credit: spacechina.com)

ground devices or sensors and will provide various services which include among others, data collection, short message communication, information broadcasting, and satellite AIS (automatic identification system).

In space, China's meteorological satellite fleet continued to grow. On 29 April, the FY-2G geostationary weather satellite, launched on the last day of 2014, completed four-months of in-orbit testing and was formally delivered to the user, China Meteorological Administration (CMA). After joining of the new bird, the FY-2 fleet was to be re-arranged to provide better service. According to the plan announced, the 2G will shift to 105E to replace the 2E while the 2E will move to 86.5E to replace the 2D. And the 2D, the oldest in the fleet, was to move to 123.5E. The fourth satellite, the 2F, will stay at 112E. At these positions, the recently launched 2G and 2E will establish a dual-sat operational capability with the 2F to provide enhanced observation. The 2D that had worked for more than 8 years since its launch, much longer than its designed working life, and because its orbit inclination had drifted, entered retirement status. There was also some bad news about the Chinese meteorological satellite, FY-3C. On 31 May, CMA announced, without any details being given, that the FY-3C polar orbit satellite, launched in 2000, had suspended service due to technical issues.

In early May, the object C, one of the SJ-15 satellites launched in July 2013, approached closely to the SJ-7 satellite for the fourth time.

### Manned Space Flight

On 24 April, the Institute 801 of AAPT (Shanghai Space Propulsion Institute, formerly belonging to SAST) delivered the flight model of the propulsion sub-system of the Tianzhou 1 cargo vehicle. The Tianzhou 1 will be launched to the Tiangong 2 space laboratory in 2017 by a CZ-7 from Hainan, after the Tiangong 2 launch and the Shenzhou 11 mission in 2016. It was also reported that the Tianzhou 1 will test a 6-hour fast rendezvous and docking procedure.

The development of China's modular space station is moving forward silently. In mid-May, CAST completed the static-load test of the node module, a segment of the core module of the Station. One month later, in mid-June, CAST completed another test, the mechanical environment test of the Station's robotic arm, a key component for the Station's assembly. Earlier, in mid-April, it was reported that the main airtight layer of an EVA space suit completed the manufacture process review, revealing China is developing a new EVA suit after the Feitian suit used in the 2008 Shenzhou 7 mission. It is supposed to be used on the Space Station.

In early April, Chinese media reported that Yu Tongjie had replaced Wang Zhaoyao as Head of CMSA, China Manned Space Agency. The report did not give the reason for this.

### Lunar and Deep-Space Exploration

As China's most important space exploration mission for the rest of this decade, Chang'e 5 development progressed steadily in this quarter:

- In mid-June, AAPT made a successful plume flow test of the attitude control thrusters on Chang'e 5. It was the first time that China has performed such test in a vacuum environment using a liquid hydrogen heat-sink system with a 1:1 real-scale article.
- In early May, CAST completed the first phase of the landing stability test of the Chang'e 5 lander in a simulated 1/6 Earth gravity environment and verified the lander's performance in 8 status and 18 working conditions.
- In late May, the separation test of Chang'e 5 spacecraft from the CZ-5 launcher was completed.

There was also some operational news from ongoing space missions:

- Ye Peijian, the Chief Designer of the Chang'e programme, said in a lecture on 15 April that Chang'e 2 was at the moment of speaking 100 million kilometres away from the Earth and it is running well.
- On 4 April, the Chang'e 3 lander observed the third eclipse from the lunar surface since its landing more than 15 months before. The Lunar-based Optical Telescope (LOT) worked all the time during the 4 hour 28 minutes eclipse and captured 246 images of the sky without sunshine.
- On 28 May, the Chang'e 5-T1 service module switched on its dual-resolution camera and captured a 2-minute long video of the Earth. Then, up to end of June, it imaged the lunar surface three times and obtained more than 3,000 images with a resolution of 2.5 m. This was an extra test after completion of the extended mission to verify the camera that was based on commercial products.

At the annual session of the United Nations' Committee on the Peaceful Uses of Outer Space (COPUOS) held on 10-19 June, China released details of the Chang'e 4 mission and put forward proposals for international cooperation. According to the plan, Chang'e 4 will be launched between 2018-2019 and will land on the far-side of the Moon. A relay satellite will be launched separately prior to the landing and will enter a Halo orbit around the EM-L2 point with a design life of 3 years. The Chang'e 4 lander and rover are formerly the back-up of Chang'e 3 that will be reconfigured for the new mission. Its name might also be changed. China proposed that potential international partners could launch their own probes to establish a lunar communication network and perform a coordinated landing test and joint exploration, or provide payloads on Chang'e 4, and offer TT&C support, as well as exchange of scientific data and performing joint research.

At the end of June, the Jiamusi deep-space tracking and control station, with support of the National Astronomical Observatories and Shanghai Astronomical Observatory, captured down-link signals from the New Horizons Pluto probe at 4.76 billion kilometres from the Earth, setting a Chinese record. There is a 66 m diameter antenna, the largest one in China, in Jiamusi. This antenna, together with two 35 m antennas in Kashi and one in Nuequen, Argentina that is still under construction, will form China's own deep-space tracking network by 2016, comparable to the DSN of the U.S. (see Gallery in this issue of Go Taikonauts! for more details).

## International Cooperation

During 20-24 April 2015, China participated in the deep-space seminar of the International Space Exploration Coordination Group (ISECG) held in the U.S. China presented the proposal for international cooperation in the Chang'e 4 mission and a panel discussion was held on the mission.

The seventh joint meeting of the U.S.-China Strategic and Economic Dialogue took place in Washington, on 23-24 June. Among the 127 outcome items that the two sides reached, two were related to space. The first is on the establishment of a mechanism of regular bilateral inter-governmental talks on civil space cooperation. The first talk is scheduled for the end of October 2015. The second outcome is to push discussion to avoid orbital collision and guarantee sustainability of outer space activities.

Compared to the U.S., China and Russia were discussing more substantial and long-term space cooperation. According to Chinese media, quoting TASS that reported on 25 May, Russia and China will establish unified technical standards for future manned space flight, including manned lunar missions. The standards will cover docking ports, electrical connectors, cabin atmosphere etc.

Between China and Europe, the most noticeable event was the final selection of the joint science mission. SMILE (Solar wind Magnetosphere Ionosphere Link Explorer) was the winner out of 13 proposals, announced by ESA and CAS on 4 June. SMILE differs from previous missions in that it will study what happens globally in the Earth's magnetosphere as well as the ionosphere, which is closer to Earth. This will provide more detailed information that could help scientists understanding of how the Sun's effect on the Earth's magnetic field influences events on the planet. Previous studies were similar to trying to take a portrait of someone, but including only the ear and some parts of the shoulder, a Chinese scientist described.

A little noticed message was from CALT. CALT had been pushing an international cooperative small launcher project for some time, targeting the international launch market. The project is run by its wholly owned subsidiary APMT (Asia Pacific Mobile Telecommunication Satellite). It had discussions with partners from Sweden, Switzerland and Italy, although the partner's names remained undisclosed, and signed a Memorandum of Understanding with them. ASI, the Italian Space Agency, also expressed support to the project and agreed to sign a government-level framework cooperative agreement in adequate time.

There have been far more bilateral activities than those mentioned above. On 27 May, CNSA Deputy Administrator Wu Yanhua met Jean-Jacques Dordain, Director General of ESA, and exchanged views on possible cooperation in the Chang'e 4 and Mars missions. ESA also delivered ExoMars data to CNSA that will benefit China's future Mars exploration. On 23 June, witnessed by President Xi and King Philippe, China and Belgium signed the Memorandum of Understanding on jointly implementing the concept report of the CropWatch science satellite constellation mission. In April, as a result of a

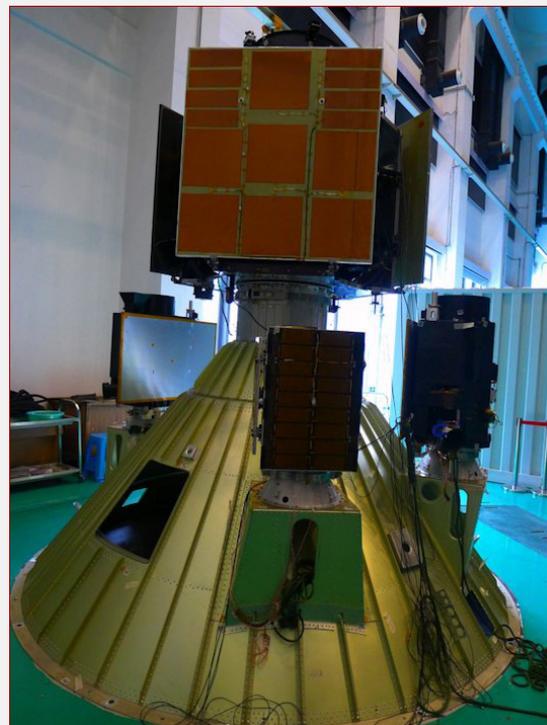
collaboration lasting more than three years, the web site of 'The Sino-Holland Joint-Laboratory of Space Optical Instruments' was put online. The laboratory was established by BISME (Beijing Institute of Space Mechanics and Electricity) and TNO (The Netherlands Organization for Applied Scientific Research) in March 2014.

There are also more and more frequent activities on space cooperation between China and developing countries. On 23 April, China and Brazil signed a supplemental agreement to develop a new Earth resource satellite, CBERS 4A, to be launched in 2018. On 11 May, the first meeting of the Sino-India space cooperation joint committee was held in Beijing. On 21 and 22 May, China signed space cooperation agreements with Mexico and Peru.

A delegation from the School of Aerospace Engineering of Beijing Institute of Technology (BIT) and China Space Sat cooperation visited the Paris Observatory in France and the Institute of Planetary Research Berlin of German Aerospace Agency DLR from 3 to 9 June 2015. The Chinese delegation talked to its French and German counterparts on prospective for cooperation on future asteroid exploration. The Paris Observatory and BIT signed an cooperation framework agreement.

## Commercial Space

The government of Jilin, a northeast province of China, is pushing a commercial satellite project - the Jilin 1 high-resolution civil imaging satellite constellation. The major player behind the project is the Changchun Institute of Optics, Fine Mechanics and Physics, CAS. It began to study the satellite-payload integrated agile imaging satellite technology in 2005 and kicked-off the Jilin 1 development in 2012. In December 2014, Chang Guang Satellite Technology Co. Ltd was formed to run the project on a



Models of the Jilin 1 imaging satellites in integrated testing with the rocket adapter. The larger optical satellite is on top. (credit: Chinese internet)



commercial basis. Its shareholders include the institute, the Jilin government and key persons of the project. It also introduced private investment to the company, which was a move in response to the new policy of the Chinese government to open space industry to the private sector. On 24 April, the key review was completed in Beijing and the satellite entered final stage before launch. The first four satellites including a high-resolution optical imaging satellite (420 kg), a smart-imaging experimental satellite (60 kg), and two smart-video satellites (95 kg each) will be launched in October this year on a single rocket. According to the plan, 12 more satellites will be launched in 2016 to form an initial global constellation that will be extended to 60 satellites by 2020 and 137 in 2030. It is another ambitious global satellite constellation of China after the Beidou navigation system (35 satellites), the LEO comsat constellation developed by Xinwei (64 satellites) and the DCSS constellation (40 satellites).

On 6 May, the ZX-6C (ChinaSat 6C) development formally kicked-off in CAST. It is a C-band comsat to replace the ZX-6B currently in service.

On 23 June, Mr. Thoma Luhaka Losendjola, Deputy Prime Minister of The Democratic Republic of Congo, introduced the CongoSat 1 communication satellite in a press conference. The satellite, equipped with 32 C, Ku and Ka transponders, is based on the DFH-4 bus and will cost USD 330 million to develop. China Great Wall signed the launch contract with the DR Congo side in November 2012. Nearly three years later, the two parties were still negotiating on financing and technical issues. The news conference is an indicator showing that progress may have been made.

By 18 June, Bangladesh's communication regulator had received bids from four contenders for the Bangabandhu 1 communication satellite. They are France's Thales Alenia Space, China Great Wall Industry Corporation, the USA's Orbital ATK, and Canada's MD. The result will be announced in September 2015.

## Miscellaneous

### Ground Facility

In early June, the AIT (Assembly and Integration and Test) centre in Tianjin was put into use when a spacecraft - its

name undisclosed - moved in. The centre was newly built for China's space station programme and other large spacecraft. It has some state-of-the-art facilities including the KM8 thermal vacuum chamber and the 140-tonne vibration test stand.

Chinese media reported in early April that the Donghaijiu 118 (East China Sea Rescue 118) ship was launched in Guanzhou. It is the first of four planned 8,000 KW rescue ships. They will become the workhorses in an emergency sea recovery for future manned space missions.

### Space Education

On 23 May, the award ceremony of the Space Science Experiment Design Competition for Hong Kong Secondary School Students was held. The competition was jointly launched in October 2014 by the Home Affairs Bureau of Hong Kong and the China Manned Space Agency with the Education Bureau of Hong Kong as co-organiser. It was implemented by the Hong Kong Productivity Council (HKPC), AAC (China Astronaut Centre of China), and CAST (China Academy of Space Technology). A total of 70 entries were received from 286 students in 47 secondary schools, covering physics and biology experiments, many are closely related to daily life such as plant growth, animal behaviour, sports and entertainment, as well as food. In March this year, the 20 teams of finalists had face-to-face technical guidance from aerospace experts from Beijing. Following a final assessment through interviews by the experts of the judging panel in May, the Champion, 1st Runner Up, 2nd Runner Up, Most Creative Award and Best Potential Award were selected. The results of the Competition were released online at [spaceexperiment.hkpc.org](http://spaceexperiment.hkpc.org). In the next few months, the HKPC will help construct the winning experiment designs into models that are feasible for being conducted in space. The designs that can pass the testing of the China Manned Space Agency will have the opportunity to be carried onboard Tiangong 2 in 2016 for demonstration by taikonauts in zero-gravity. The awardees will also have the opportunity to visit Beijing Aerospace City or the spacecraft launch centre and meet with space engineers.

(Chen Lan)

## ERRATUM

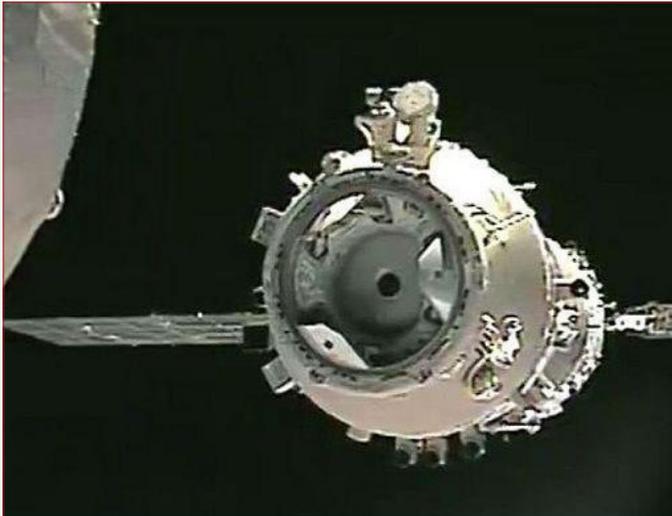
*We apologise for an incorrect information given in issue 15, Chinese Space Quarterly Report October-December 2014 in the section "Commercial Space". We wrongly reported: "In CAST, the Asiasat 9 comsat had started AIT (Assembly, Integration and Test) since October." The correct information is: "In CAST, the Apstar 9 comsat had started AIT (Assembly, Integration and Test) since October." We thank our attentive readers who spotted the error.*



## Birth of the Chinese Docking System The Development History and Application Status of China's Manned Spacecraft Docking Mechanism

by Qiu Huayon, Liu Zhi, Shi Junwei, Zheng Yunqing

Aerospace System Engineering Shanghai, SAST



The rendezvous docking technology mission was the key mission in the second phase of China's manned spaceflight project, and the docking mechanism was one of the key technologies. The development history of the docking mechanism of China's Shenzhou spaceship and Tiangong target spacecraft is introduced in this paper, including the details of argumentation, research, designing, testing and so on. The paper also introduces the technical solutions of China's docking mechanism in detail and describes the current application status of China's docking mechanism, together with the flight conditions of Shenzhou 8, and Shenzhou 9 flight missions.

### I. INTRODUCTION

In September 1992, the China Central Committee decided to implement the manned space flight programme and approved a "3-step" development strategy. The critical mission of the second step was to achieve the technology of rendezvous and docking of two spacecraft, which was a necessary condition for subsequent construction of the space station. One of the cores of space rendezvous and docking technology is the development of a docking mechanism. The docking mechanism is designed to achieve the docking of a chaser spacecraft to the target vehicle under the expected initial contact conditions, maintaining mating and the safe separation of the two spacecraft.

The Shenzhou 8 unmanned spaceship successfully docked with the Tiangong 1 space lab on 3 November 2011.

The Shenzhou 9 manned spaceship successfully docked with Tiangong 1 on 18 June 2012. After many years of endeavour, the docking mechanism has been successfully put into use, with perfect performance in many docking processes. This paper mainly introduces the development and detailed technical solutions of docking mechanisms.

Combined with the on-orbit mission situation, this paper also describes the application of the docking mechanism in China.

### II. THE DEVELOPMENT PROGRESS OF CHINA'S DOCKING MECHANISM

The Aerospace System Engineering Shanghai (ASES, affiliated to Shanghai Academy of Spaceflight Technology) began the project of docking mechanism demonstration in 1996. In April 1997, the symposium on docking mechanism was convened by the experts demonstration group of manned space rendezvous and docking project. At that meeting, the Androgynous Peripheral Assembly System (APAS-89) was determined to be China's project implementation plan considering that this programme could achieve a great-leap-forward development in technology and it could be compatible with the international trend of developments in this field.

The development of the docking mechanism lasted 16 years and covered: demonstration phase, the key technology research phase, engineering development phase, flight initial model phase and flight formal model phase. Currently, 19 sets of active or passive docking mechanism have been developed and built, such as a principle prototype, research prototype of the critical technologies, engineering development units, and flight prototypes. Additionally, significant design, analysis, simulation and a variety of experimental validation have also been completed.

#### II.I Demonstration Phase (1996-2000)

##### Main Events

In 1998, the first original prototype of a docking mechanism and its test equipment was developed, as shown in Figure 1.

In 1999, improvements for the buffer system of the prototype were completed.

In 2000, docking function tests of the original docking mechanism prototype were completed.

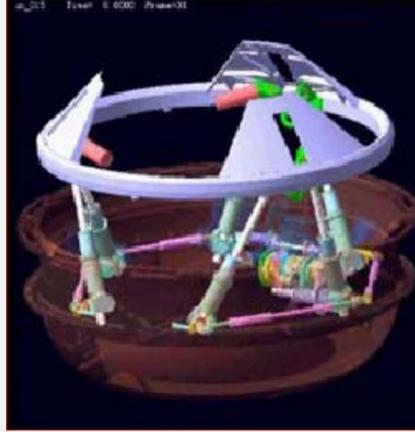
##### Technical Achievements

With the development of the original prototype, the initial overall design and preliminary docking dynamics simulation analysis of the docking mechanism was completed, and the overall concept verified.

#### II.II The Key Technology Research Phase (2000-2005)

##### Main Events

In November 2001, research on the key technologies of the



left - Figure 1:  
The original prototype of docking mechanism and test equipment

top - Figure 3:  
The digital prototype of docking mechanism (docking dynamics simulation model) (2004)

docking mechanism was officially launched according to the requirements in the documentation launched from the demonstration phase.

In November 2003, the assembly of the docking mechanism research prototype of the critical technologies was completed, as shown in Figure 2.

In January 2004, the mechanical characteristics test of the docking mechanism research prototype was completed.

In October 2004, the docking capture buffer tests of the docking mechanism research prototype were completed.

Technical Achievements

During work on the key technologies, especially on prototype research, development and validation testing, the following technical achievements were achieved:

The overall design technology of the docking mechanism achieved a break-through and was mastered. The basic parameters and structural dimensions of the docking mechanism were determined.

The technology of the docking dynamics simulation achieved a break-through and was mastered. The established docking dynamics model is shown in Figure 3. The difficulties of docking collision, friction, mechanical transmission clearance and other issues in this model were overcome.

The results of simulation and experiment were interactively corrected with each other.

The docking mechanism key components, such as capture mechanism, differential mechanism, screw assembly, the drive mechanism and other core components were successfully developed, as shown in Figure 4.

The high-precision processing technology for complex parts,



left - Figure 2:  
The research prototype of docking mechanism (2003.12)

top - Figure 4: The core components of docking mechanism (2003)



Figure 5:  
Mechanical  
Characteristics  
Test-Bed  
(2003.12)



Figure 6:  
Docking Buffer  
Test-Bed (2004)

and the high-precision assembly debugging technology for complex space mechanisms achieved break-throughs and were mastered.

The preliminary ground testing technique was mastered, and two pieces of ground test equipment of the docking mechanism were developed. One is the mechanical characteristics test-bed, as shown in Figure 5, and the other is the Docking Buffer Test-Bed, as shown in Figure 6. The revised simulation model, based on a large amount of data obtained in research prototype verification testing, set the direction for the subsequent design improvements.

### II.III The Initial Phase Of Project Development (2005-2006)

#### Main Events

In March 2005, the docking mechanism project entered into the project development phase and the work for the primary programme design began. The determined docking target is that of an 8-tonne manned spaceship docking to an 8-tonne target spacecraft. (The previously identified docking target was that of an 8-tonne manned spaceship docking to a 2-tonne target spacecraft).

In June 2006, the final assembly of the docking mechanism programme prototype was completed.

In August 2006, the capture and buffer test of the prototype began, and was completed in November the same year.

In September 2006, the rigid join and separation test of the prototype began and was completed in January 2007.

#### Technical Achievements

The following technical achievements were obtained:

For the latest 8 t - 8 t docking target, the overall design of the docking mechanism was completed, and the structural configuration and key performance parameters (such as buffer

performance parameters) were determined.

The technical modification of the Docking Buffer Test-Bed was completed by means of transferring the original 8 t - 2 t docking simulations to 8 t - 8 t docking simulations, as shown in Figure 7. The parameter validation was then completed using this test-bed.

The docking mechanism design process had been further improved, and the iterative feedback correction relationship between the design, simulation, and experiment was established, as shown in Figure 8. The technique flow of the full cycle of development was determined.

The product support and cooperative units were identified.

### II.IV The Prototype Phase Of Project Development (2006-2010)

#### Main Events

In September 2006, the docking mechanism project turned into the prototype phase.

In October 2007, the assembly of the first set of product (for mechanical and thermal testing) was completed.

In June 2008, acceptance of structural thermal product and validation test was completed.

In November 2008, the second set of the docking mechanism (docking capability product) was built, and the docking and separation performance verification test begun. This product set was specifically designed for the docking performance verification test, as shown in Figure 9.

In May 2009, the third set of product (for space qualification testing) was built, as shown in Figure 9.

#### Technical Achievements

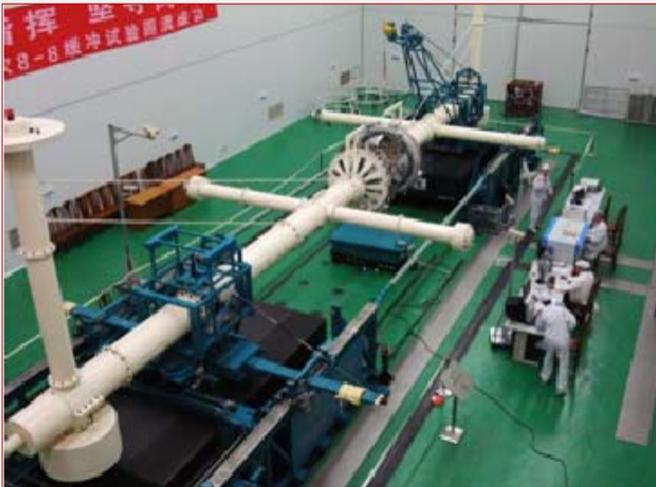


Figure 7: The Docking Buffer Test-Bed modified (2006)

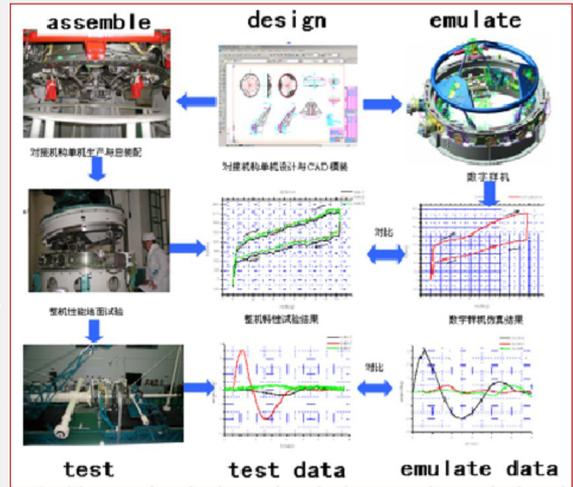


Figure 8: Shows the design, simulation, testing relationship of docking mechanism

During the prototype phase, the following technical achievements were obtained:

The docking performance of the docking mechanism was fully validated, including the capture buffer performance and separation performance. The key factors that influence the docking performance and separation performance were mastered.

Mechanical products and avionics instruments have passed all the required qualification tests, and the docking mechanism design further verified.

The design and verification of the docking mechanism thermal control was completed.

The interfaces with overall and other sub-systems were verified in various tests of the overall spacecraft.

The docking mechanism's ground test technologies were comprehensively mastered. Two other docking mechanism ground test-beds were developed. One is a six degree-of-freedom general docking test stand, as shown in Figure 10, and the other a thermal vacuum docking test stand, as shown in Figure 11.

Through various tests, the design was further improved and the final design determined.



Figure 9: Left is the second set of product docking capability pieces (2008), Right is the third set of product qualification pieces (2009)

Figure 10: Six degrees of freedom Docking General Test Stand (2008.6)

## II.V Flight Model Phase (2010-2013)

### Main Events

In January 2010, the docking mechanism project entered the final phase.

In June 2010, the assembly of Shenzhou 8 / Tiangong 1 flight product was completed.

In February 2011, the acceptance test of Shenzhou 8 / Tiangong 1 flight product was completed, and the products delivered to the spacecraft department.

In August 2011 and January 2012, the acceptance test of Shenzhou 9 flight product and Shenzhou 10 flight product were completed, and the products delivered to the spacecraft department.

### Technical Achievements

The main task of the final phase was to complete the development and delivery of the flight product, and to further improve the product's reliability. The main technical achievements were as follows:

Further improvement of the product's reliability, and of a number of details in the product design was achieved.

In order to verify the stability of the docking mechanism product technology, the product reliability information was accumulated, and the

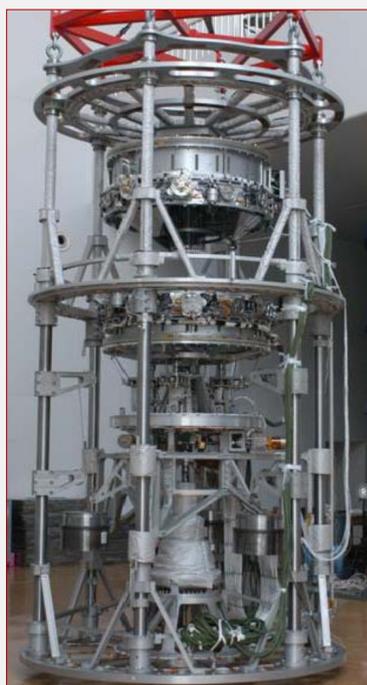




Figure 11: Thermal Vacuum Docking Test Station (2009.10)

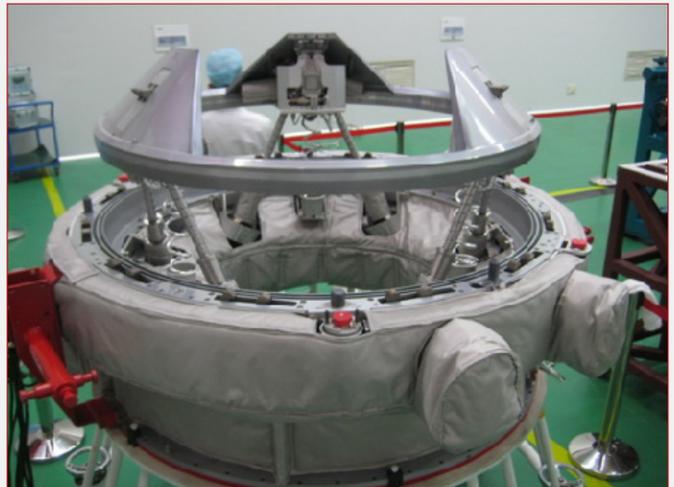


Figure 12: Flight docking mechanism product of Shenzhou 8 manned spaceship (2010.6)

reliability test put into operation.

The technical information was further confirmed.

### III. THE TECHNICAL SOLUTIONS OF CHINA'S DOCKING MECHANISM

The development process of China's docking mechanism is described above, so this section will introduce the technical solution of the docking mechanism with flight test status, which is the technical solution of the docking mechanism in the Shenzhou spaceship and Tiangong 1 target spacecraft.

#### III.I Docking Mechanism Functional Components

The docking mechanism on the Shenzhou 8 spacecraft is intended to be active, which was installed in front of the orbital module. While the corresponding mechanism on the target spacecraft (Tiangong 1) is typically passive, and was installed in front of the experiment module.

The Shenzhou 8 docking mechanism sub-system is composed of an active docking mechanism (of about 310 kg) and 3 avionics

instruments. The Tiangong 1 docking mechanism sub-system is composed of a passive docking mechanism (of about 200 kg) and 2 avionics instruments.

The primary components of the active docking mechanism are a structural base ring housing 12 pairs of structural hooks (1 active, and 1 passive per pair), an extendable guide-ring with 3 petals, a motor-driven capture latch within each guide petal, 3 ball screw/nut mechanism pairs connected via a common linkage, and 5 fixer mechanisms (that allow for only x-axis movement of the guide-ring).

The passive docking mechanism whose guide ring is locked in place, is a simplification of the active one.

The avionics instruments are designed to achieve docking mechanism drive control and status measurements.

The docking mechanism sub-systems of the two vehicles work together, and are designed to achieve the capture, dynamic attenuation, alignment, and hard-docking of the spacecraft through the use of essentially identical docking mechanisms attached to each vehicle.

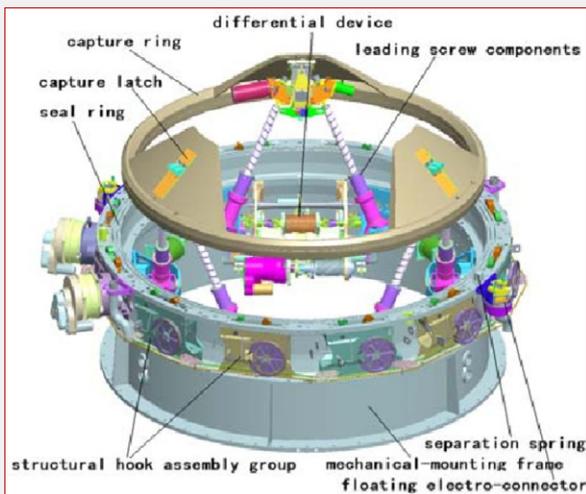


Figure 13: Shows the docking mechanism of Shenzhou 8 spaceship

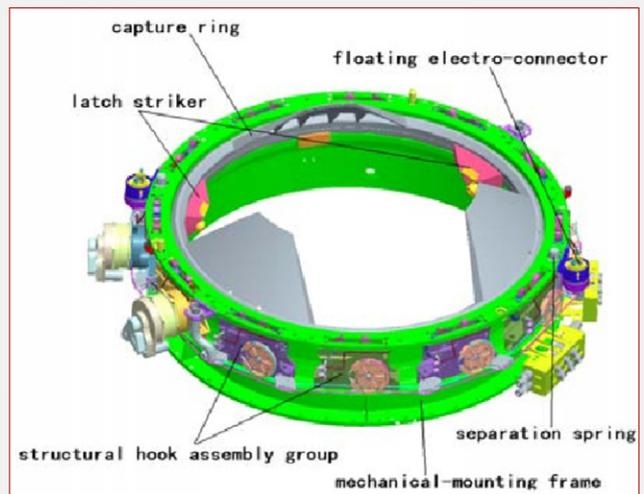


Figure 14: Shows the docking mechanism of Tiangong 1 target spacecraft

The docking mechanism of the Shenzhou spaceship is shown in Figure 13. The docking mechanism of the Tiangong 1 target spacecraft is shown in Figure 14.

### III.II Docking Mechanism Functions

#### The Capture Function

The chaser vehicle moves into a capture envelope at a certain relative speed. Docking begins when the chaser is manoeuvred to bring the interfaces of the active docking mechanism in contact with the target vehicle passive mechanism.

During docking, the guide petals are the first element to make contact. The active docking ring then responds to correct the lateral and angular misalignment between the two opposing interfaces.

The initial capture of the docking vehicles is established when the active mechanical latches capture the passive latch strikers on the opposing capture ring and the two rings are in contact.

#### The Extending and Retraction Function

The active docking ring is extended to the ready-to-dock position or ultimate position, or retracts to bring the two hard-capture interfaces into hard-capture range by means of driving six screws.

#### The Buffering and Alignment Function

At the completion of the capture, dynamic energy and residual motion of the separate vehicles is absorbed by the springs, damping and friction element etc. of the active docking mechanism. Then the active docking ring aligns the two mating vehicles.

#### The Rigid Join Function

Structural attachment occurs at the completion of the docking ring retraction process. Twelve active structural hooks located at the structural interface are grouped into two separately activated

gangs of six hooks each. An immobile passive hook is located next to each active hook. The structural latches are engaged to provide a rigid structural interface, to compress and pre-load the seals to facilitate the maintenance of a pressurised volume which can be pressurised for crew and cargo transfer for joint mission operations.

#### The Sealing Function

At completion of the hard-docking, the seal mounted on the mating interface is compressed to create a sealed docking channel between the two docking mechanisms. Meanwhile, the floating electro-connector is automatically connected to implement circuits and signal connecting between the two spacecraft.

#### The Separation Function

At the end of the mission, the chaser active latches are unhooked after the docking channel is depressurised, after which the preloaded separation springs “push” the vehicles apart at low velocity. After it reaches a safe distance from the target vehicle, the chaser performs a separation manoeuvre.

In emergency situations, detonating explosive devices can be used to unlock the hook, to achieve separation.

#### The Control Function

Both automatic and manual docking control modes (mutually exclusive) are set up for use. It is readily available for other operations to deal with the docking and undocking process failures of the docking mechanism sub-system, such as necessary remote control, program control, and manual docking instructions.

## IV. THE APPLICATION STATUS AND PROSPECTS OF CHINA'S DOCKING MECHANISM

### IV.I The Application Status

In November 2011, the Shenzhou 8 spaceship successfully



Figure 15: Docking in orbit



Figure 16: China's Probe-and-Cone docking mechanism

conducted rendezvous and docking with the Tiangong 1 target spacecraft (shown in Figure 15), which was China's first rendezvous and docking mission. In this mission, two sets of docking and un-docking operations were performed.

In June 2012 and June 2013, both the Shenzhou 9 and Shenzhou 10 spaceships (each with three astronauts on board) successfully conducted a docking with Tiangong 1. Two sets of docking and undocking operations were carried out in both missions. During the Shenzhou 10 mission, the astronauts have given students on Earth a lively space physics class from Tiangong 1.

All docking and separation processes, including capture, buffering, correction, extending, retraction, rigid join, seal, and separation of the docking mechanisms and other functions were verified. The implementation of the functions met the requirements. The entire docking process took approximately 7 min 30 s, and the whole separation process took about 3 min 30 s. Telemetry displayed that the working status were normal, and performed flawlessly.

#### IV.II The Prospects

Docking technology is one of the cornerstones of China's manned space station construction. The successful development of China's docking mechanism and multiple in-orbit applications is a giant leap forward in space technology for China, and an important milestone in the development of China's manned space project. In September 2010, the China Central Committee approved the implementation of China's manned space station project, where the docking technology will enter the practical stage.

China has now formally and comprehensively launched the engineering development of China's Space Station, and all the following tasks: the manned spaceship Shenzhou series, cargo spacecraft, space station cabin, etc., will need to use the docking mechanism to complete in-orbit docking and assembly tasks.

Based on the existing configuration, the active docking mechanism will be modified with the addition of 3 electromagnetic brakes (dampers) to enhance the energy buffering capacity in

order to accommodate larger tonnage docking conditions.

We are also active in other types of docking mechanism development work, such as the Probe-and-Cone docking mechanism (shown in Figure 16), and low-impact docking system, etc.

The successful development of the docking mechanism has created opportunities for China's cooperation to international space docking. In October 2010, the International Docking System Standard (IDSS) was released, and also provides a platform for China's participation in docking mechanism international standardisation. A set of proposals for IDSS interface definition document (IDD) were presented in 2011.

#### V. CONCLUSION

Shenzhou 8, 9, and 10 spaceships' successfully docking in orbit with the Tiangong 1 target spacecraft, marks a break-through in the key technologies of building a space station. China became the third country in the world that mastered rendezvous and docking technologies. This has laid a solid foundation for the subsequent development and construction of the space station. As China's aerospace development continues, the technological achievements from the research and development of the docking mechanism will also be widely used during the development of the subsequent products. Having these technical reserves is a strong guarantee in follow-up missions, especially in the completion of China's Space Station mission.

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## ROOM for Space

by Jacqueline Myrrhe

Since more than a year now, a new space magazine in solid printed format and with bold ambitions is enriching the difficult market for space publications. 'ROOM - The Space Journal' is produced right in the centre of Europe, in Vienna. Editor-in-Chief, Igor Ashurbeyli, aims at nothing less than publishing "a highly professional, scientific and, at the same time, popular journal, one that will not confound the general reader."

At this moment, we will see the fourth issue coming out, offering a stable quality in content which includes among others, some interesting and rarely read views from the Russian space community. It is refreshing to see that the ROOM team is preferring in-depth reflections on a wide range of space topics, in a healthy distance from the mainstream (space) web portals. In this sense, the magazine might find its audience, in particular if it will be possible to engage readers on a global scale, as stated by Ashurbeyli: "The journal will become a meeting place, a discussion forum for intellectuals and experts directly and indirectly affiliated with the space community from all around the world. The discussion will happen in real time on

our website: [www.room.eu.com](http://www.room.eu.com). Members of the international expert community will hold a biannual gathering at the 'ROOM' conference. The papers presented will be published in the 'White Book of Aerospace Exploration'. All of this will enable us to bring together an international, non-governmental expert council on space matters - the Socium, as we like to call it." The subscription price for ROOM is very moderate for what it is, however financing and enduring quality journalism, in particular quality space journalism, is not that easy to achieve. This might explain, why also aeronautical articles are included, trying to attract more than just the tiny space community. Experience from other publications show that this might become a too difficult balancing act without compromising the space audience. We will see whether ROOM can manage this type of split successfully.

ROOM magazine generously allowed GoTaikonauts! to introduce its article "Sowing a New Dream" by Wang Yaping published in issue no 1 (3) March 2015 to our readers.

### "If I could, I would be a space teacher forever."

Wang Yaping seen by Jacqueline Myrrhe

One has to congratulate ROOM magazine on this unique and authentic account of a Chinese taikonaut. In a lengthy contribution, China's second woman in space, Wang Yaping, gives a highly personal and in the same way detailed insight into her training as a taikonaut, her mission to space and how life evolved for her after return to Earth.

Also, the tone of her expressions is pleasant, standing in stark contrast to the me-me-messages often conveyed by Western people. Would somebody insist that it is wrong to strive for ideals, detached from personal objectives? Wang Yaping is not shy is telling us about her ideals. For sure this is one of the best records by a taikonaut published in the English language and a worthy read.

To begin with, Wang Yaping is giving her answer to the question, why women at all should fly into space: "... without the participation of women, the human space programme is incomplete, the space family is missing something." On a more substantial ground she continues: "Women are just as capable of taking responsibility, energizing their colleagues, and taking on serious and tough missions with spirit and harmony. Not to mention the fact that the participation of women makes it possible to study the physical and psychological

differences between how men and women are affected by going into space." Surprisingly unexpected for a Chinese military, Wang Yaping is showing a deep sense of humour when she concluded: "Last but not the least, my body weight is less than most male taikonauts, which makes me a fuel-saver."



(credit: CCTV)

She continues by describing her upbringing in the North of China and talking about her childhood dreams for life: "I never thought the sky would call to me. My dream was much more simple: to go beyond the mountains and to pay back all that my parents had given me." Wang Yaping had in mind to become a lawyer or a teacher and was finally glad, to end up as "a special kind of teacher, one who brings knowledge of space."

She also gives an interesting insight into China's taikonaut training and the handling of female taikonaut candidates: "Becoming a qualified taikonaut is never easy, especially for a woman." To understand this, one must consider that "...in space, you can't catch a break simply for being a woman. So the training subjects, training content and test standards for women are almost identical to those of male taikonauts." These circumstances qualify female taikonauts

equally and should guarantee them due respect. It sounds like a confession when Wang Yaping stresses: "That means that we women often have it much harder." A moment later, she puts Neil Armstrong's famous quote into context with her experience: "But I also feel that one small step in space means a huge leap to an individual life. The experience, the feeling and the value given to our life by spaceflight is precious and irreplaceable."

Then, Wang Yaping recalls her mission tasks during the Shenzhou 10 mission in June 2013: "Of course, I was also responsible for routine spacecraft status monitoring, equipment operation, and space experiments, not to mention manual rendezvous and docking. The space class was unique... When teaching was assigned to me, I was excited and nervous. I have never been a teacher before and I was not entirely confident in my abilities. To make the space class interesting, I spared no effort. For instance, I watched teaching videos made by our foreign colleagues and studied the teaching methods and skills of professional teachers. Moreover, I tried to change my role from teacher to student, watch my teaching videos and pinpoint my own shortcomings." But the real big thing for her was coming home after 60 million Chinese children saw her space lesson: "After return to Earth, I established teacher-student relations with many children and received many letters from them. One child wrote to me..., 'Teacher Wang, I saw you floating in Tiangong, like Chang'e, and I really envy you.' ... I was very touched that many children wrote at the end of their letter things like, 'I will study hard and I want to be an astronaut in the future, to explore the beauty of space. I want to be of use to our country and to our world.' Every time I saw such words, I was deeply moved."

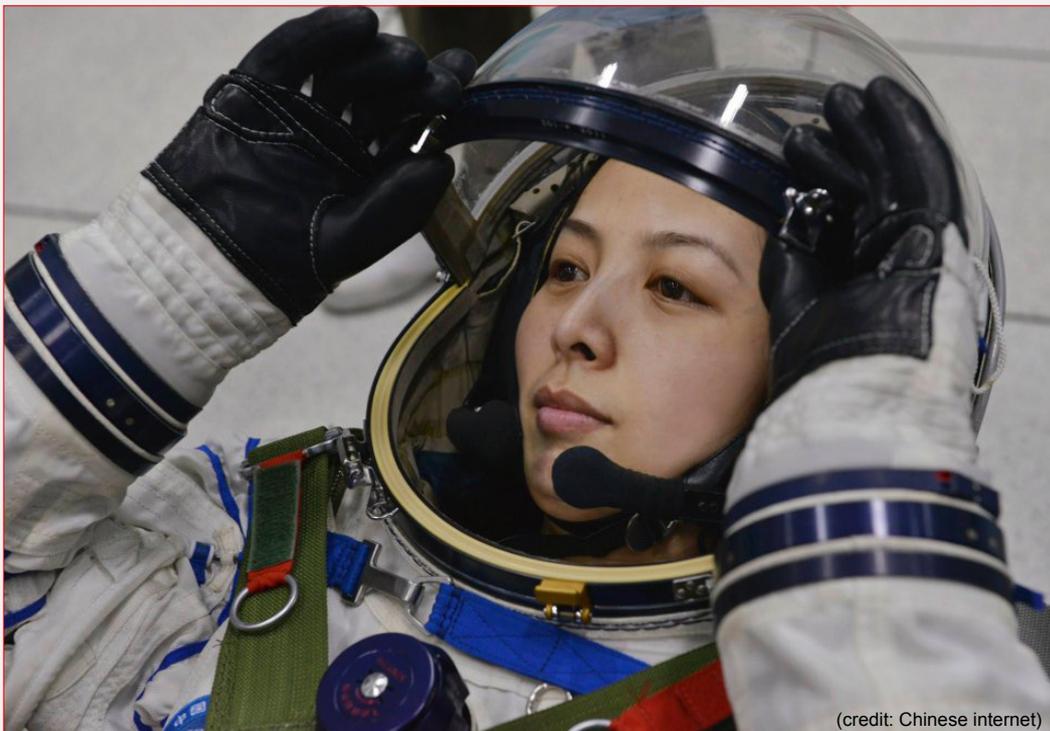
But in reality, her mission might never end. Her space lecture

had such an enormous impact on a whole generation of school students, that Wang Yaping might always be remembered for her performance in the Tiangong 1 space lab. "After my return to Earth, I have been to dozens of schools. I spoke to many children and saw first-hand their yearning for a new world. Children have an unlimited imagination, which, in turn, makes for unlimited motivation. I never expected that a short space class could have such a great impact on them. I have to say that it changed me too. I love science, outreach programmes, and love every aspect related to space science." Very remarkable is that her space class not only affected the children on Earth but also changed Wang Yaping herself: "I even felt that being a teacher while up in space brought me more honour than my career as a taikonaut."

After the gigantic success of Wang Yaping's work during the Shenzhou 10 mission, it should not come as a surprise that she gets asked about her future ambitions: "I still remember how someone asked me 'What is your next dream?' during a media interview after my return. My dream is to go further and further in this career. Yes, this is just the beginning. Space exploration is endless. I hope that I can make more contributions to human space flight and outreach programmes, taking advantage of my space class experience and the identity of an astronaut. If I could, I would be a space teacher forever."

For the full article by Wang Yaping, please, consult: ROOM - The Space Journal, issue no 1 (3) March 2015 or the online link: [http://room.eu.com/article/Sowing\\_a\\_new\\_dream](http://room.eu.com/article/Sowing_a_new_dream)

For the report on the Shenzhou 10 mission, also compare: Go Taikonauts!, issue no 9



(credit: Chinese internet)

## “There is no other way than cooperation” Report from the British Interplanetary Society London Chinese/Soviet Technical Forum - 19-21 June 2015

by Dr. William Carey

This year marked the 35th anniversary of the forum, which was celebrated by having two key-note speeches on the Friday evening, one by Dr. Helen Sharman and one by Anatoly Pavlovich Artsebarsky respectively. Although the meeting room at the BIS headquarters in central London was quite full, it was a little surprising to see the limited attendance for such an event – by the UK’s first astronaut (flying as a UK citizen), and the first time that a cosmonaut has presented at the forum.

Dr. Sharman launched together with Artsebarsky, and Sergei Krikalyev on 18 May 1991 to the Mir space station, and returned with Viktor Afanasiyev and Musa Manarov on 26 May 1991. In a highly entertaining and engaging talk, Dr. Sharman recounted her experience of the preparation for and participation in the ‘Juno’ mission, and in particular of her relationship, and enduring friendship with Artsebarsky, whom she calls until today “Tolja”.

Regardless of her mission success, Dr. Helen Sharman established two firsts by flying into space: becoming the first British in space and having for the first time in space history the situation that the first representative of a nation in space is not a man - like all the times before - but a woman.

Both, Sharman as well as Artsebarsky have been participating in the 27th Planetary Congress of the Association of Space Explorers in September 2014 in Beijing. Both stressed their positive impressions gained during the week in China. Towards the end of her talk Dr. Sharman remarked, “Last year I have been with Anatoly Artsebarsky in Beijing for our annual meeting of the Association of Space Explorers. The Chinese astronauts have been very pleased not only in telling us what they have done but also what they hope to do in the future. And it was

interesting to hear just this week, a plea from one of the Chinese taikonauts that they wanted to use the ISS that is currently in orbit. It is interesting to see them reach out for some sort international cooperation, interesting to see what that would be, and how much they are making use of. So what we need to do is start to develop a second international space station. That is on the cards.”

For one of the GoTaikonauts! team present, one of the ‘failed’ last 32 of the selection process for the Juno mission, it was a pleasure to finally have a personal copy of Helen’s book ‘Seize the Moment’ signed by her, and a little surprising at the realisation that this event had occurred 25 years ago!

Anatoly Artsebarsky’s presentation, given through an interpreter, provided an overview of his experience as Commander of the Soyuz TM-12 which carried him together with Sharman and Krikalyev to the Mir station, and as Commander of Mir-9 from mid-May through early October 1991. It was during this time that the crew, although shielded to some extent by their ground support team, became aware of the collapse of the Soviet Union. Something which clearly had a profound effect on the cosmonauts. In total, Artsebarsky and Krikalyev performed six EVA’s. During the sixth and final EVA on 27 July, which lasted for 6 hours and 49 minutes, they added 11 segments to the Sofora girder, and in an unplanned activity, attached a Soviet flag in a metal frame to the top of the girder.

As Dr. Sharman before, Artsebarsky gave his interpretation of the 27th Planetary Congress, stating “Last year I have been in China for the 27th Planetary Congress of the Association of Space Explorers. We also went to schools and there I was really



Helen Sharman (right), together with Anatoly Artsebarsky (left) and Alistair Scott, President of the British Interplanetary Society. (credit: GoTaikonauts!)



Philip Mills presented during the forum his exceptional collection of Chinese space craft. (credit: GoTaikonauts!)

surprised about the high level of education which seems to me similar to what we had in the Soviet Union, only that in China it is now on a different technological level. Even the style of school uniforms including the red scarf reminded me of Soviet times. But in the first place I was impressed by the school student's knowledge and that they were keen on asking questions. One can say that they will have a great future. Let's see how quickly China will advance in the time to come." He went on to say, "I remember the first group of Chinese cosmonauts coming to Star City in the 1970-s. Those astronauts never flew but they got a full training. The second group prepared in 1996. But only seven years later China had its first astronaut in space. But by now they have 10 astronauts in space and among them were even two women. I do not go into details on those developments since you have seen much about those flights in the newspapers and on TV. For me it is just very interesting to see how the Chinese establish a big goal and then they follow this big goal to fulfill a dream. It really reminded me of the Soviet Union 30 years ago." He concluded by noting that, "Nowadays there is a joke told among Russian cosmonauts: China has been the third nation to launch a manned mission into space. They will be the second nation landing on the Moon and the first to land on Mars."

The vast majority of the presentations at this year's forum were focused on Soviet topics, with only three talks relating to China. Two by Bert Vis on the 'Taikonaut Selection Process' – summarising the four phases of selection and comparing to Russian and American selection: and 'China's Pathfinder Astronauts' – an investigation into the first two taikonauts which underwent training in Russia.

The third by Gurbir Singh 'India & China: The Race to Mars', in addressing three major questions: why India went to Mars, how did it get there, and what the impact of going to Mars was; concluded that without the Chinese Yinghuo-1 failure, India would not be at Mars today.

A particularly interesting presentation was made by Phil Mills entitled 'Russian designs, inventions, ideas and technical innovations taken up by US commercial space companies'. As is common knowledge within the space community, the Russian RD-180 engine is currently used on the U.S. (United Launch Alliance - ULA) Atlas V launch vehicle. As such, its use has been heavily debated over the past year, primarily due to deteriorating relations between the U.S. and Russia. This talk demonstrated that contrary to the commonly-held belief that Russia (i.e. the U.S.S.R.) in general copied innovations made in the West, there is evidence to show that American commercial companies are copying many innovations made by the Soviets/Russians.

As with the other recent forums that GoTaikonauts! have attended, the topics presented this year were interesting and well-researched, despite the very limited emphasis on China. It was also an acknowledgement of the standing of the BIS in the international space community that they managed to be successful in inviting both Helen Sharman and Anatoly Artsebarsky to this year's forum. And the Russian cosmonaut joke, begins to sound less of a joke, and more an almost certain prediction of the future, despite some failures along the way.



Helen Sharman is presenting during the Chinese/Soviet Technical Forum. (credit: GoTaikonauts!)



Anatoly Artsebarsky included in his presentation a photo showing Helen Sharman and Wang Yaping during the ASE's 27th Planetary Congress last year in Beijing. (credit: GoTaikonauts!)

## “We need to proceed from the base of common sense” interview with Soviet cosmonaut Anatoly Pavlovitch Artsebarsky

**GoTaikonauts!:** In your presentation right now during the BIS Soviet-Chinese Technical Forum, you stressed the importance of international space cooperation. Why?

**Anatoly Pavlovitch Artsebarsky:** Yes, working together in space is very important. New projects will cost more than all the previous ones, and we would need money on a scale, no country alone can afford - not even the United States of America, Russia or China. Only in international cooperation would it be possible to study and explore new space projects. I probably sound like I am being awkward, but we can only manage everything all together.

The MIR Space Station and the International Space Station are good examples of how successful we can be when we work together. The ISS is a mega-international cooperation between Russia, the U.S.A., Canada, Japan and European countries through the European Space Agency. This is a great project and irreplaceable experience.

We must not suspend work because of any political complexity. It is necessary that politicians come to an agreement, and we work together including China, India and Brazil. It will help us and our planet to progress in future studies, and in the understanding of near-Earth space.

**GoTaikonauts!:** Do you think you can do anything to support international cooperation? You, personally?

**Anatoly Pavlovitch Artsebarsky:** I am no one of importance. But...

**GoTaikonauts!:** But you are an astronaut or to be precise: a cosmonaut.

**Anatoly Pavlovitch Artsebarsky:** I do my best to voice my opinion and to explain how important it is that we should explore near-Earth space together. Our Earth is a spaceship that is flying in the Universe. This spaceship needs more than just protection. Outer space should bring nations together to explore our near-Earth environment. If we work together, we shall never fight against each other, and this is the most important thing!

That is why, when I visited China, I told the students at the university that we could make it, but all together. When I speak to the pupils in Russia, I say the same. We are strongest when we work together.

Our history demonstrates some good examples. When people had been exploring the oceans a long time ago, they shared their experience with other explorers, because there was a marine brotherhood. To share experiences and knowledge meant they were able to prevent ships from making the same mistakes and avoid people suffering or dying. The sailors who navigated the way successfully before, should share their experience and knowledge.

Space is another ocean, which is why, by sharing our experiences, we can be an organic unity. Only together can we understand what is going on around our planet, around our Solar System, around our galaxy, and so on and so forth - endlessly.

**GoTaikonauts!:** You visited China last year. What did you

like most of all in this country?

**Anatoly Pavlovitch Artsebarsky:** Yes, it was my first time visiting China. I was very impressed with how well organised it was, by how we were met and accommodated. Every day was carefully planned with some really interesting excursions. We met the American astronauts and the Russian cosmonauts were present. The Chinese taikonauts managed everything.

It occurred to me that they were all the same, whether an astronaut, a cosmonaut or a taikonaut, the titles are the only difference. All the minds are attuned to wanting to know and learn more about space. When something new is learnt, we should waste no time in sharing this information and knowledge to move forward together.

For example, since the U.S.-Americans flew to the Moon 46 years ago, what is the reason for them to fly to the Moon again now? Of course, there is no sense. But they are interested to fly to Mars, it is only that this will cost a fortune.

By working together, we could help the U.S.-Americans. For example, the Russian spacecraft Soyuz and Progress serve the International Space Station mainly for the reason that the U.S.-American Dragon doesn't fly very often. The Dragon is useful and helpful of course, but the main cargo traffic relies upon Russia nowadays, especially since the Space Shuttles stopped flying. This knowledge could help us getting to Mars, but it will take cooperation and communication.

This is why we should prepare ourselves beforehand. The technologies we use to explore outer space, should be general and cross functional. They should be transparent, open and available for everybody. Any country should be able to use the achievements of those states that have achieved it already in the past. There should be no business, no trade, no commerce or secrets. We should share the received information with everybody using the general planetary approach. If we get some information about the state of the surface of the Moon, for example, regardless who: the Americans or the Chinese – we should share that knowledge. Now the Japanese are working on the same matter too. All this data and these databases should be brought together. It will help to develop the most accurate and fullest database of the Moon, for example; in a similar way this could also be done for Mars or Venus.

There is no reason to think that if somebody was the first to launch a Mars rover, or conduct more research, then this somebody would have priority over the others. Of course, we understand that money has been spent and invested. However, next time, any other country can spend more money under a different set of conditions.

We need to proceed from the base of common sense and best value for money being used for space exploration together! And share all the information!

**GoTaikonauts!:** Those are highly interesting concepts and one can only agree to your ideas. The best about your vision is that it is inclusive, leaving out nobody. This is what our world really needs...

**Anatoly Pavlovitch Artsebarsky:** In addition to my earlier comments regarding the Chinese astronautics I would like to add that during the Planetary Congress of the Association of Space Explorers, the Chinese astronauts informed all interested states that China was creating a new Chinese Space Station. Any new ideas, or offers are welcome, including the intention of any country to develop a separate module. For example, the Republic of Kazakhstan could finance their own module that would become a part of the Chinese Space Station, and the same would be possible for a Russian or Japanese module. We need to come to an agreement, to understand that everything is being done in the best interests of the whole of humankind, not for the benefit of only China. For example, there should be no commerce. The science, research and exploration must have priority over business or money. Maybe one can compare it to the very situation we all are in now – we are sitting in an impressive library. The majority of mankind’s knowledge of the universe is kept here. It is very important that anybody can come here, take a book and read.

Money should not be the first thing considered. If we want to create something great, there is no need to think about money or business, the idea is the most important thing to think about - for the benefit and progress of humankind and future developments.

**GoTaikonauts!: One can only agree to this. What about you, would you like to participate in a Chinese space mission or to fly onboard a Chinese spacecraft?**

**Anatoly Pavlovitch Artsebarsky:** Well. China has their own very good taikonauts who are very capable people. Let them work, and let the most worthy of them fly into space. If a situation arose when somebody asks for help - but I don't think this would happen - I would of course agree to fly. I am acquainted with many, very hard-working Chinese taikonauts who have been trained but never flew, or with those who are training now: let

them all fly!  
 I know many Russian cosmonauts who have been trained but never flew. It is a very difficult situation to go through, to live with the fact that you had trained for so many years, but never had a chance to fly.  
 That is why I would never want to take a seat away from a Chinese taikonaut.

**GoTaikonauts!: Another question, maybe a bit out of context after so many inspiring thoughts by you. How did you get used to the zero-gravity? And how did you adjust to normal life after the flight, to normal gravity on Earth?**

**Anatoly Pavlovitch Artsebarsky:** I can briefly tell you. It was rather easy for me because there had been already many other cosmonauts and astronauts who flew before me. I was the 71st Russian cosmonaut after Yuri Gagarin. The 71st, can you imagine? That is why, the experience of our medical professionals and other specialists was so enormous. I fully relied upon them without any hesitation. I complied fully with the instructions of our medical staff. Thanks to that, I never suffered from difficulties with vestibular disturbance when we were already onboard the Station. We trained a lot on the Earth, including the vestibular system. The American astronauts do not train in this way, they take some medical drugs to block vestibular disturbance, while the Russian cosmonauts are specially trained to reduce the negative effect.

I would like to mention that of course, that test pilots are easier to train, especially those pilots who flew a lot and experienced g-loads and brief weightlessness. Training and tests on Earth are more difficult for those who have never flown before.

The requirements of a mission commander should always be higher than that of the crewmembers. Crewmembers have different responsibilities but take no part in the vehicle control. The commander should meet targets regardless of his/her state, knowledge, wishes, or health: for example, to deliver the crew onboard, to dock, or to return the crew. That is why, until now,

at least, the highest requirements are set to a mission commander both on the Space Shuttle and the Soyuz spacecraft.

The most important thing to know is that it is possible to get used to the condition of weightlessness. It takes about one week. For example, take a pen; can you see it on the table? In space, I hold a pen and when I release it, it will fly. It will hang like this in the microgravity, I can hardly find it or see it because it will not be a pen any more, but a point. Only a point!

There are a lot of other examples about how a person must adjust to zero-gravity. It takes about one week to understand that if you push yourself off, you will fly in the direction you want to and not an uncontrolled direction. It is important to fly in the right direction through the whole



During the interview with Anatoly Artsebarsky (right) in the library at the headquarters of the British Interplanetary Society in London. Anatoly Artsebarsky was accompanied by Alexej Loktinov, who helped with translation throughout the forum. (credit: Gurbir Singh)



Station, because you should not accidentally touch anything. There are a lot of different objects onboard, which are fixed using Velcro tape or rubber bands, if you touch something, it will fly after you and get lost inside the Station. You will never find it afterwards.

At the same time the zero-gravity relaxes you. You feel good. And it is very difficult to force yourself to do something, to train and load yourself, for example, to run using a training bike simulator, to cycle or use a running machine, or train your arms. In other words, you need to force yourself. Actually, you want to do nothing. If you weren't returning to the Earth later on, you could do nothing at all, but you know that you must return.

We know of some examples when the U.S.-American astronauts had got into problems after 400 days and nights of work in space. Our cosmonauts too, there was a case that after 18 days and nights spent onboard, the cosmonaut had serious problem upon landing. Because during his stay in space he had to work onboard a vehicle which was not equipped with any running machine or bike simulator. The blood-vessels suffer most notably without training on board. At the end, the crew could not move unaided upon return to Earth.

This understanding helps to force ourselves to train for 2 hours every day: one hour running before lunch, one hour training on the bike simulator in the afternoon. During my mission, we had only one free day per week, sometimes two. We hated doing exercise, but we knew we had to.

Just imagine please, you put on a 30 kg backpack here on the Earth and you need to run with it somewhere. You would say: "No, I do not want to!" but you must do it in space because you understand that if you do not do it, you would come back to Earth and be unable to take care of yourself.

I am amenable to discipline and trained a lot. That is why when I returned to the Earth, I had some difficulties with my blood, but otherwise I managed to recover quickly. I did everything we were instructed to do, sometimes I slept less, but I always kept up my training. I could even play football within a week of being back on Earth. This was my personal approach, but each crew has its own approach. Every man is the architect of his own future.

24 years have already passed since I flew. Sometimes I think that if I had controlled myself as I did onboard the station, I would have probably have achieved more in my life. You feel more relaxed on the Earth. Nobody sees you, hears you, pays attention to you, and you can allow some weakness.

When you are flying in the space, you always know that the medical staff are controlling you. The Mission Control Center

is doing the same. You are motivated and want to meet the requirements you agreed to before your flight.

That is why, it is rather important to keep working before, during and after the flight to override the negative effect of microgravity upon the human body.

**GoTaikonauts!: This was very interesting. Thank you so much!**

**Anatoly Pavlovitch Artsebarsky:** I would like to add something. Probably, it will not be so interesting, but I think it is worth to mention. Among the cosmonauts and astronauts who trained together in the 1960s, 70s and 80s, there is still a strong bond. The crews, having been trained in the former Soviet time, are still on visiting terms with each other. The cosmonaut flow was less in those days in comparison with what Star City experienced later. Especially when the Space Shuttles still flew, there were many crews trained. They flew together for one week and parted company afterwards, and that's it, everything was forgotten. I am told that nowadays that new crews are trained, then they fly, complete their work, and go every which way.

However, we are different, we still keep congratulating each other on birthdays. Ryoko, for example, a Japanese astronaut who had been trained with us, the Austrian and German astronauts, we all are still in touch. I really like to meet cosmonauts and astronauts and keep on communicating. I think it is important.

I would like to share a belief of mine with you. I think, that the training, especially difficult parts, brings out not only the soul, but the true character of a person, of a Russian man I mean. Helen [Sharman] noted, that she learned what the enigmatic Russian soul meant. She said it after working together with me, Sergey Krikalev and some other Russian cosmonauts. She knew that we would always be there to help and support each other.

We are told that we want to attack Europe. Sheer stupidity! Nobody wants to do it. There has been no Soviet Union for 25 years, but Europe is still scared that Russia will attack it. Think about it: Russia is also a part of Europe. I absolutely agree with the words of our President that we should work together, instead of inventing new enemies. In fact Russia is neither an aggressor nor an enemy. We are fully for peace.

**GoTaikonauts!: Thank you very much. It was quite a revelation talking to you. All the best for the future!**

*GoTaikonauts! wishes to thank Svetlana Saburova for the transcript and translation of the interview.*

## Gallery China's Deep-Space Network



The 18 m diameter antenna in Qingdao tracking station. This antenna, together with the same type of antenna in Kashi, was completed in 2007 to support the Chang'e 1 lunar mission. They are for the first time equipped with an X-band telemetry, tracking and communication system and were tested during the Chang'e 1 mission. These two 18 m antennae built the foundation for China's deep-space tracking network established thereafter. (credit: Bando.cn)



The 66 m diameter antenna under construction in Jiamusi. China began building its own deep-space tracking network after the Chang'e 1 mission. The network includes three stations in Jiamusi, Kashi and Nuequen, Argentina. The Jiamusi antenna, with support of S/X bands, was completed in 2012 and is the largest antenna in China. (credit: Chinese internet)



The 66 m diameter antenna in Jiamusi after completion. As the backbone of China's deep-space network, it supported the Chang'e 2 extended mission (EM-L2 point orbiting and Toutatis fly-by), Chang'e 3 and the Chang'e 5-T1 missions. In June 2015, it captured signals from the New Horizons Pluto probe from 4.76 billion kilometres away from the Earth. (credit: Chinese internet)



The 35 m diameter antenna in Kashi. Equipped with the S/X/Ka tri-band system, it was also completed in 2012 and supported the Chang'e 2 extended mission and follow-on lunar missions. (credit: China.com)



A similar 35 m diameter S/X/Ka tri-band antenna is under construction in Nuequen, Argentina. This picture was taken in early 2015. At the top-right of the picture is the antenna to be installed, and at the bottom-right is a display board at the construction site showing the appearance of the antenna. (credit: Chinese internet/Weibo)

In addition to the dedicated deep-space tracking network, China has established a VLBI (Very Long Baseline Interferometry) astronomical observation network to precisely measure the spacecraft's position. Currently it includes 5 radio telescopes located in China. This picture shows the 25 m diameter radio telescope in Nanshan, Urumqi, completed in 1994. (credit: Chinese internet)



The 25 m diameter telescope in Sheshan, Shanghai. It was completed in 1986. As the oldest member of the Chinese VLBI network, it participated in the tracking of all Chinese lunar missions since 2007. (credit: Chinese internet)



The 40 m diameter telescope in Kunming. This telescope and the 50 m telescope in Beijing were both completed just before the Chang'e 1 mission in 2007. (credit: Chinese internet)



The 50 m diameter telescope in Miyun, Beijing. This telescope and the 40 m telescope in Kunming were both completed just before the Chang'e 1 mission in 2007. (credit: NAOC)



The newest member of the Chinese VLBI network, the 65 m diameter "Tianma" radio telescope in Tianmashan, Shanghai. It was completed in 2012. As Asia's largest radio telescope, it supported the Chang'e 2 extended mission and all follow-up Chinese lunar missions. (credit: Chinese internet)



FAST, the Five hundred metre Aperture Spherical Telescope, will be the world's largest radio telescope. It is located in Pingtang, Guizhou Province, and started construction in March 2011. In addition to astronomical observation, it will also be capable of tracking spacecraft thanks to its computer-controlled adjustable panels (4,450 in total). Once it is completed, China will possess a significant capability in deep-space tracking and control. This picture is the artistic impression of FAST. (credit: Chinese internet)



FAST in construction. This photo was taken in early 2015 when its circular girder, six feed towers and the flexible net under the reflector surface had been completed. On 2 August 2015, the first of the 4,450 adjustable reflector panels was installed. (credit: Chinese internet)