MUNICH KRAFFT EHRICKE CONFERENCE

China's Space Program—Hare or Tortoise?

by Jacqueline Myrrhe and Dr. William Carey

March 25—In the recent past China has introduced economic and political initiatives which promote its rise as a global power. Embedded in this process is its national space program, allowing the 'Middle Kingdom' to follow a very smart concept for a step-wise build-up. The basic principle is to develop key systems —such as launch sites, launchers—or tracking, telemetry, and control (TT&C) systems—which can be used across the different fields of space exploration: from Earth observation to the manned space program, lunar exploration or other areas. It is maybe a little bit like a Lego system or the menu of a Chinese restaurant.

Hare or Tortoise—Dynamic or Slow?

The hare and the tortoise story is about the proud and idle hare who thought with his long legs he is the fastest animal in the universe and can win any race. Day-by-day he was joking about the tortoise, saying: "You with your short legs will never achieve anything."

One day, the tortoise had enough of this and challenged the hare: "Listen, hare, only because you have long legs, you do not need to be so arrogant. And anyway, how can you know for sure that I am not able to run fast? Let's have a competition!"

In similarity with this fable, China's space program is looked at as being a slowly moving tortoise... Why did this stereotype come into being?

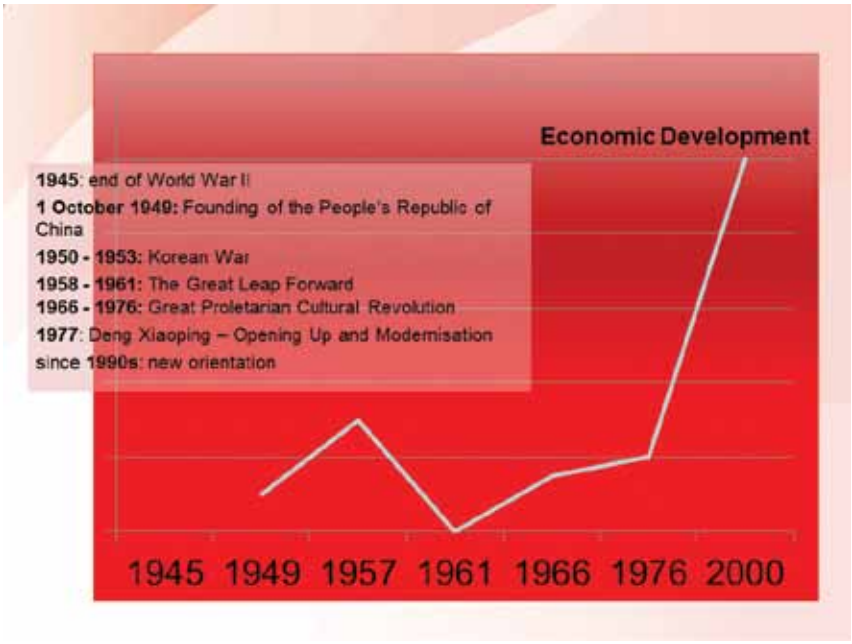
China's space program has the reputation of being:

- **Small:** Yes, it has a relatively small budget. The annual ca. $1.8 billion China spends on space, corresponds to roughly a tenth of NASA's annual budget or 30-50% of the European Space Agency's (ESA's) budget.
- **Slow:** China has not conducted many missions—so far there have been only 6 manned missions with 11 taikonauts involved (two of them flew twice).
- **Technologically less advanced:** It is based on copied Soviet-Russian technology.
- **Not significant enough:** China is not a major space nation because it has not launched relevant science missions, which are the strength of NASA and ESA.
- **And anyway:** China is pursuing military goals, space dominance, space super-power ambitions.

FIGURE 1

Relevant milestones in China's space program: From left: Chang'e 2; Yinghuo 1; Tiangong 1; Shenzhou; CSS.

FIGURE 2
Milestones in China's Societal and Economic Development



So what is it then?

Is China's space program a dynamic hare or a slow tortoise?

Is it a threat to the world?

After a historical overview of the beginnings of the Chinese space program, the second part of the article will focus in on current developments.

Milestones in China's Societal Development

To understand China's space program it is necessary to take the societal and economic context into consideration. This is particularly important from the time after World War II until the turn of the millennium.

At a time when Western nations in Europe, the United States, and Japan enjoyed economic development and prosperity, the Chinese economy rode on a rollercoaster.

Until 1958 the Chinese economy experienced moderate growth. Initiated in 1958, the Great Leap Forward project was supposed to catapult China within 15 years into the league of leading industrial nations. After only 3 years however, the economy of the country was broken. The following Five Year Plan brought some relief, until in 1966 the Great Proletarian Cultural Revolution took its course. The persecution of intellectuals and academics damaged a whole generation of experts, teachers, the scientific elite—most of China's best talent. The economy during the Cultural Revolution did not completely stand still, but progress did. Only after the death of Mao Zedong could the situation halt. China's firsts in space are embedded into these dramatic decades of the nation's post-war development.

China's Firsts in Space: The East Is Red—DFH 1

As an outcome of the Korean War, China felt under nuclear threat and asked the Soviet Union for technical assistance in the development of its own nuclear capabilities including long-range missiles. The Chinese request was granted.

The launch of Sputnik 1 on October 4, 1957 by the Soviet Union sincerely impressed the "Great Helmsman," Mao Zedong. Such a satellite he wanted to have for his own nation, preferably with the support of the Soviet Union. China's space ambitions were not driven by a race. For China, the underlying principle was to catch up with leading technology developments in the world.

The Chinese Academy of Sciences (CAS) set up a task force for the technical and scientific development of an indigenous satellite connected to a long-term and comprehensive national satellite program. CAS was fully aware of the relevance of satellites for future national scientific and technical development. Chairman Mao advised his comrades:

> If we're going to throw one up there then throw a big one, one that weighs two tons. Of course we start throwing small, but with one that is at least two tons. Something like that chicken egg of the Americans, I won't do it!

Despite the Soviet Union supporting China's military missile program, there was no assistance in the civil space sector.

Worse, because of the Great Leap Forward, too few allocated resources and materials, and too small a work force made it impossible for CAS to succeed with a national satellite. Lack of progress and missing know-how made the Chinese experts realise that they had to start from scratch: developing sounding rockets first.

FIGURE 3

China's firsts in space are embedded in the dramatic decades of the nation's post-war development.

And they did!

In 1961, after the Great Leap Forward, the Chinese leadership focussed on the so-called "Four Modernizations," among which was science and technology. The satellite work group within the CAS was still struggling. The Director of CAS's Geophysical Institute, Zhao Jiuzhang, saw the big progress the military made with the development of missiles and wrote a letter to the party leaders in which he suggested to:

> … combine the tests of our ballistic missile program with launching a satellite, and get the benefit of hitting two birds with one stone.

In 1966, the 'Cultural Revolution' deeply impacted the Chinese society and shook its foundations. Intellectuals were targeted and scientific institutions became places of conflict and violence. Under those circumstances, CAS and other institutions involved in space developments asked the Communist Party to protect their institutions with the help of the military. Mao approved and since that moment the Chinese space program and the People's Liberation Army have been tied together and have remained in tandem until today.

After 12 years of hard work, impacted by economic and technical constraints and political and societal interference, China launched its first satellite DFH 1 on April 24, 1970 (in the middle of the chaos of the 'Cultural Revolution'). China thus became the fifth nation in the world to do so. The 173 kg (not 2 tons) singing satellite was more of a propaganda instrument than the starting point for a solid, sustainable science program.

For comparison: 1970 was the year when Lunochod 1 explored the Moon, Venera 7 soft-landed on Venus, and Apollo 13 was able to make it home to Earth.

China's second civilian satellite was launched in 1975, carrying some of the payloads originally intended for DFH 1.

Although most Chinese satellites even today are based on the DFH bus, the actual intention of the scientists and engineers to aim for a long-term program only began to evolve in the 1990s.

China's Firsts in Space: Geostationary Satellite

In March 1974 three young telegraph workers wrote a letter to the government pointing out to the Chinese leaders that positions in geostationary orbit can only be assured by actually placing an object there.

In 1976 Mao—shortly before he died—approved the project and China notified the ITU—International Telecommunication Union—that it was going to place a telecommunications satellite into geostationary orbit by 1980.

After the end of the 'Cultural Revolution' in 1976, Deng Xiaoping was responsible for education, science, and technology—one of the four 'modernizations' that he thought to be the most important.

Deng became famous in illustrating his idea in a 1978 meeting when he tried to persuade his comrades to go for a communications satellite program in this enthusiastic way:

> If we invite a good teacher to give a lecture in the Great Hall of the People only 10,000 people can hear it, but if the same teacher were to give that lecture on television, and everyone had the equipment to receive it, that's a classroom of unlimited size.

It was also decided to develop a cryogenic upper stage, which led to a delay in the overall program. At a certain point Deng wanted to buy a communications satellite from the U.S.A., however this initiative did not work out and the self-set deadline for a launch in 1980 was slipping.

As before with the Soviet Union, the insight prevailed that instead of relying on support from other countries, China has to find and go its own way:

> If we buy, we can buy one or two, but we can't

go on buying indefinitely. So, we have to do this ourselves.

In the second half of 1983, China accomplished the five major systems needed:

- Launch vehicle
- Satellite
- Launch site
- The tracking and telemetry equipment
- A network of ground stations.

On Jan. 29, 1984, the first launch failed because of problems with the cryogenic upper stage.

The second attempt on April 8, 1984 was more or less successful. Problems with overheating batteries were solved by adjusting the satellite's attitude.

To recapitulate: in 1984 the Salut-7 space station was operational and the third Space Shuttle was put into service.

It took China 10 years to become the 5th geostationary nation in the world.

China's Firsts in Space: Manned Space Program

The most patience went into the Chinese manned space flight program.

Back in 1966, a feasibility study investigated the option to use synergies from the first satellite program for a human spaceflight program. In 1970—the Cultural Revolution was in full swing—"Project 714," aimed at launching a Chinese astronaut by 1973, was approved. A first group of candidates was sent for training to Star City, near Moscow.

In 1971, Mao disbanded the astronaut group again:

> We should take care of affairs here on Earth first, and deal with extraterrestrial matters a little later.

Deng Xiaoping, who after the Cultural Revolution was responsible for space activities, was interested in space applications, but officially closed the manned space project in 1976: China "should not participate in the space race" and instead we should "focus our energies on urgently needed practical satellite applications."

On March 23, 1983, U.S. President Ronald Reagan delivered his SDI speech. In China this speech led to discussions on what role science and technology should play in a country's national development.

Again, a letter was written. In the beginning of 1986, four senior scientists wrote to Deng Xiaoping, pointing out that China needs to make concentrated efforts in the area of technology and technological breakthroughs.

In April 1986, the legendary document, "An Outline for National High Technology Planning," the "Plan 863," was published, and in October of that same year, the plan was approved and budget allocated.

As was previously the case, the goal of the Chinese human spaceflight program was not to race with, or surpass other nations, but rather to stop the process of falling too far behind. China was in need of an ambitious project that would develop a national space industrial infrastructure and promote the education of the needed talent and specialists.

A debate over serious differences as to whether China should go for a space shuttle design or the space capsule technology, caused the delay of "Plan 863" for more than five years.

Finally, the Standing Committee of the Politburo approved the space station plan on Sept. 21, 1992, and declared that the Chinese Space Station (CSS) was to be the core of China's human spaceflight efforts.

Despite lessons from the past, in the mid-1990s, China considered purchasing a complete Soyuz spacecraft from Russia. After lengthy negotiations, the Chinese scientists and engineers only "got bits and pieces, here and there" from their Russian counterparts and, in the end, the Chinese experts realised once more that they had to do the bulk of the work themselves.

Although the launch vehicle, the Long March 2F (LM-2F), was ready in time, the Shenzhou capsule was behind schedule.

Only on Nov. 20, 1999, the unmanned Shenzhou 1 lifted off, followed by three more automated test flights.

Interestingly, the systems on the last unmanned mission, the Shenzhou 4 flight, were equipped to support a mission with two taikonauts who would spend three days in space. The flight of Yang Liwei with Shenzhou 5 on Oct. 15, 2003 was a one-crew mission that lasted 21 hours and made China the third country in the world capable of human spaceflight.[1]

1. For more on these historical aspects of China's first steps into space, it is highly recommended to study the paper by Gregory Kulacki and Jeffrey G. Lewis, "A Place for One's Mat: China's Space Program, 1956-2003." American Academy of Arts and Sciences, 2009.

Caesura—The Economic Boom

The economic success at the turn of the millennium not only provided China with the self-confidence and self-esteem to proffer big societal concepts, but was also the point in time to give science and technology—and with it space—a fundamental new orientation and direction to meet the needs of the future of the nation.

White Papers

Since 2001, in parallel with the respective five-year plans, China has issued its "White Papers on Space Activities." The prevailing tone of all White Papers has remained the same until today:

> The Chinese government has all along regarded the space industry as an integral part of the state's comprehensive development strategy, and upheld that the exploration and utilization of outer space should be for peaceful purposes and benefit the whole of mankind. …
>
> The role of space activities in a country's overall development strategy is becoming increasingly salient, and their influence on human civilization and social progress is increasing.

The defined key principles for the development of space activities are:

- Maintain and serve the country's overall development strategy.
- Uphold the policy of independence and self-reliance.
- Maintain comprehensive, coordinated and sustainable development.
- Adherence to the policy of opening up to the outside world.

> China's space strategy has three major characteristics:
> 1. *consistency*,
> 2. *consistency,* and
> 3. *consistency*.

The strategy at the highest level remains consistent, i.e. incremental progress is achieved step-by-step.

No giant leaps forward!

China is more than willing, indeed actively seeking, international cooperation.

Roadmap—A Schedule Up to the Year 2050

Additionally, the scientific community underwent a fundamental and tightly organized discussion on a roadmap for space science and space technology up to 2050. At the end of this process of stocktaking, analyzing, and evaluating the tasks for the future, the document *Space Science and Technology in China: A Roadmap to 2050* was published in 2009.

The *Roadmap 2050* analyzed the flaws and strengths of China's science community and the worldwide trends in space and technology, and came up with long-term and far-sighted goals and steps in achieving them.

The roadmap activity aimed at predicting the future developments of science and technology in accordance with the needs of the Chinese nation for the next 20-30 years,

> to address the needs of both the nation and society, the continued growth of economy and national competitiveness, the development of social harmony, and the sustainability between man and nature.

Furthermore, it was concluded that growth by purely extending the economic production has reached its limit!

China's economic and social development will largely depend on science and technology through scientific discoveries, through the realization of so-called mega-projects (Beidou, High-Res Earth observation network, ground station network), and through new inventions and technological innovation.

The strategic aims of the roadmap reflect the principles of the White Papers.

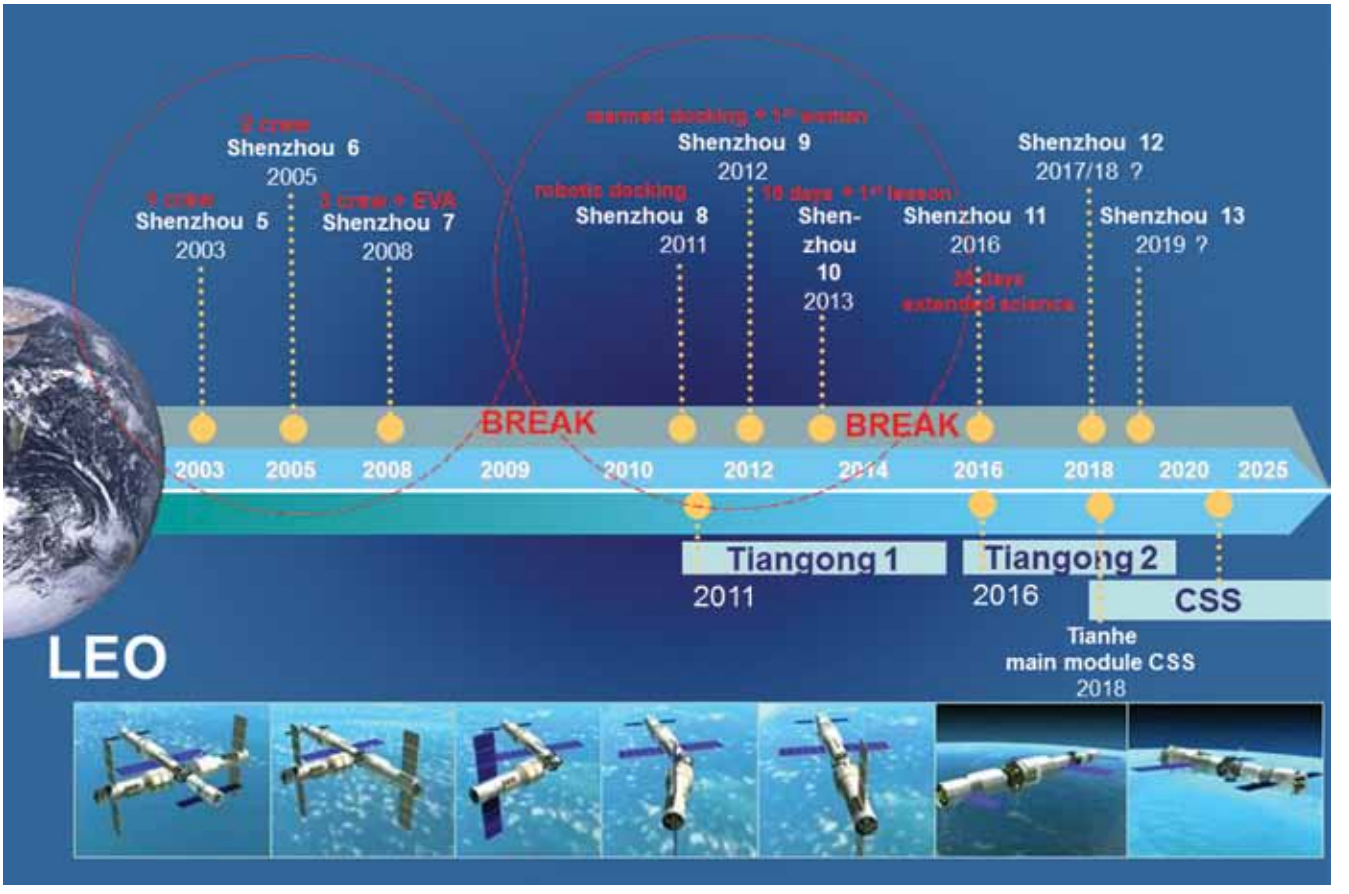
And another conclusion was drawn during the roadmap process:

> The past 250 years' industrialization has resulted in the modernization and better-off life of less than 1 billion people, predominantly in Europe, North America, Japan, and Singapore. The next 50 years' modernization drive will definitely lead to an improved life for 2-3 billion people, including over 1 billion Chinese, doubling or tripling the economic increase over that of the past 250 years.

- For that, space will be one of the leading areas.
- *Space activities are encouraged and supported by the government;* important are *independence, self-reliance and self-renovation* while promoting *interna-*

FIGURE 4

Timeline of Shenzhou and Tiangong Missions



tional exchanges and cooperation; the modernization of space technology is combined with technology imports based on win-win deals.

- China *selects a limited number of projects that are of vital significance to the national economy and social development*.
- Space activities are evaluated according to economic efficiency criteria.
- China is sticking to *integrated planning* by combining long-term development and short-term development, combining spacecraft and ground equipment, and coordinating development of space technology, application and science.

China's space activities are *long-term, stable, and sustainable* development to benefit the strategy of *revitalizing the country* with *science and education and that of sustainable development*, as well as in economic construction, national security, science and technology development, and social progress.

LEO—Efficiency Is Key

Is there a specific reason why the Chinese space program seems to be on a slower pace as compared to the leading space nations, the Soviet Union and U.S.A.?

In order to find an answer to this question, a closer look at China's Shenzhou program might be helpful.

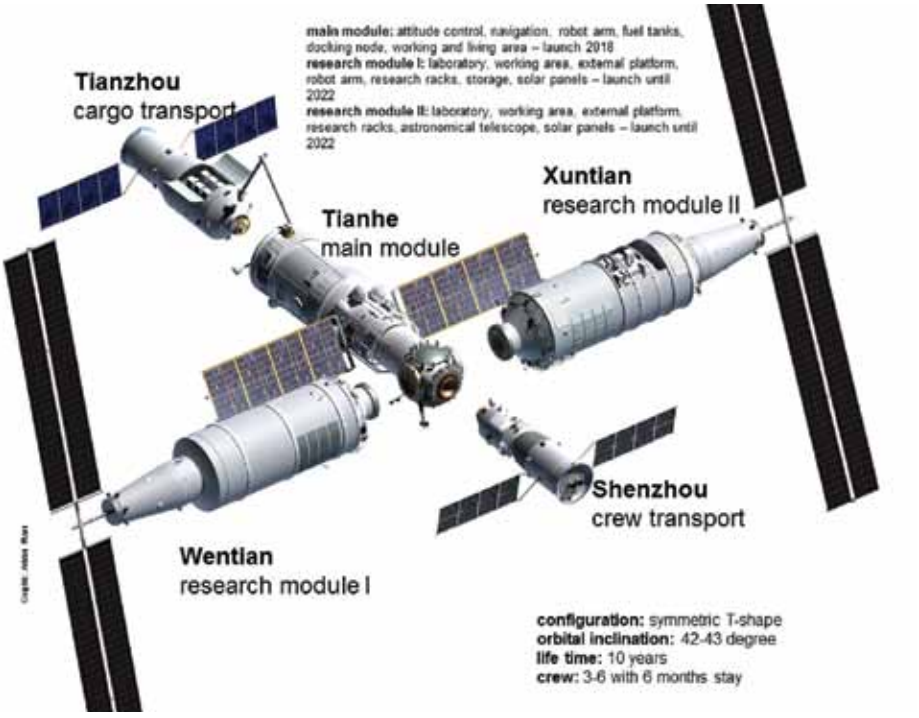
The low number of manned missions is characterized by a specific approach.

In 2003 Shenzhou 5, with one person on board, was launched. Two years later saw the two-crew mission with Shenzhou 6, and 3 years later, a three-taikonaut crew conducted the first Chinese EVA on Shenzhou 7.

The space community expected that more missions would happen, however, what we observed was a 3-year break until 2011. We assume that this break was used to learn, analyze, and improve, before going on! China had to learn fundamental space technologies for its manned space program.

Also, the next three Shenzhou missions again formed a kind of cluster.

FIGURE 5



Older conceptual illustration of the future Chinese Space Station (CSS), but it clearly emphasizes that the size will be manageable with indigenous capabilities.

In October 2011, the Shenzhou 8 craft performed an automatic rendezvous and docking with Tiangong 1. Only 7½ months later, Shenzhou 9 docked with TG-1. Among the three crew members was China's first female taikonaut. And again, one year later, in June 2013, the next Chinese human mission, Shenzhou 10, took place. Female crew-member Wang Yaping succeeded in fulfilling Deng Xiaoping's vision of a classroom of unlimited size when she delivered a lesson to 60 million Chinese students from space.

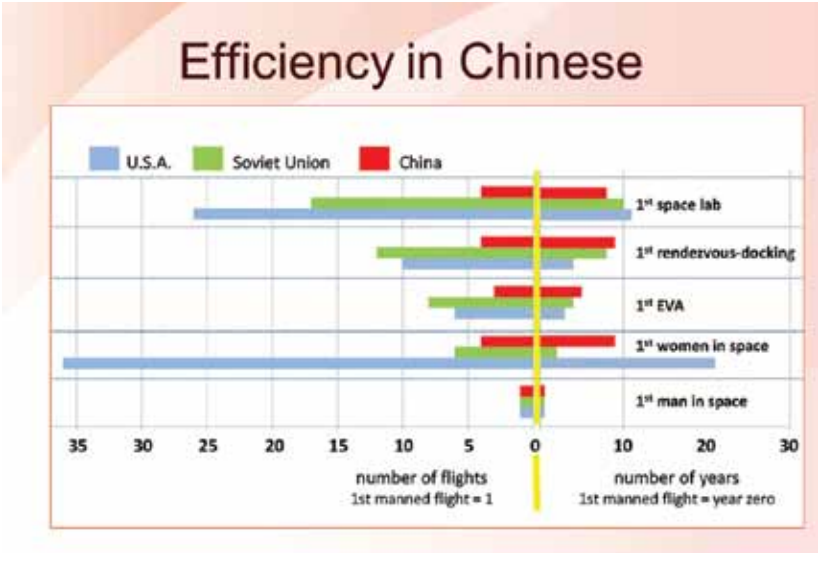
Again a three-year break took place, giving China time to learn, analyze, and improve what has been achieved so far. The last manned mission, a 30-day extended stay in space took place from October to November 2016.

And there is one more interesting efficiency fact to be noticed: Initially, Tiangong-1, 2, and 3 were planned. Since TG-1 could successfully fulfill many additional technology tests, many objectives for Tiangong 2 were accomplished earlier. Once planned tests for Tiangong 3, such as a long-term stay in space, had been achieved already with TG-2, TG-3 became redundant and the assembly of the CSS will be initiated after TG-2.

Figure 5 shows an older conceptual illustration of the future Chinese Space Station (CSS). It is designed as a Mir-class orbital complex which, in full contrast to the International Space Station (ISS), can be operated and maintained within national space flight capacities.

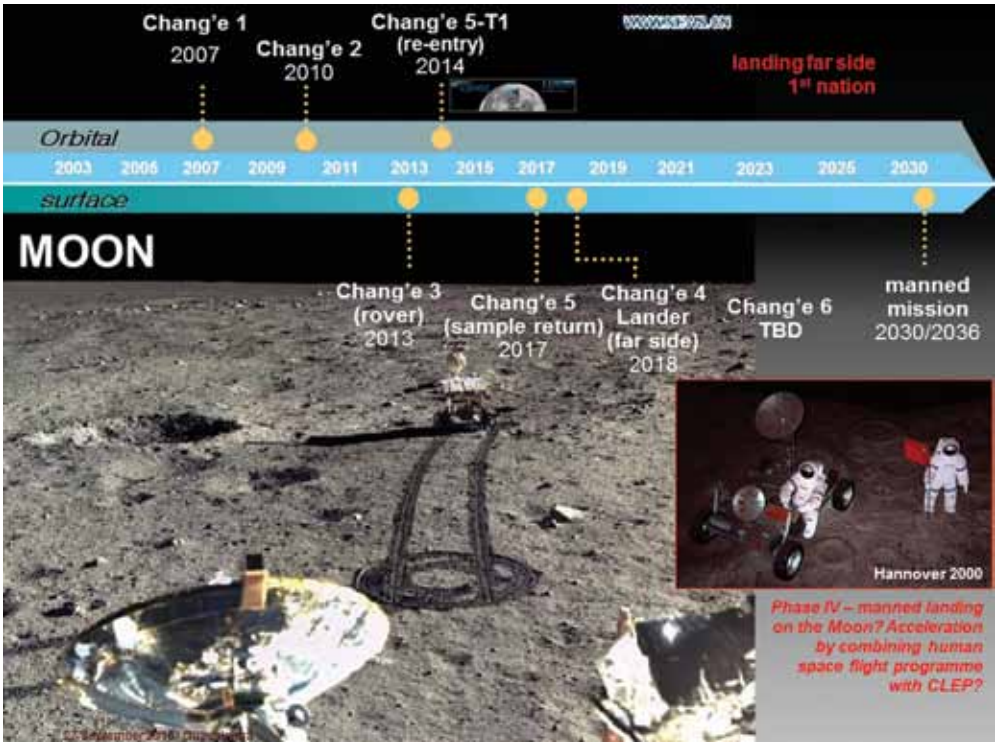
What the observation of the Chinese space program has proven, is that time is not the main criterion for China—efficiency is. The diagram in Figure 6 illustrates that compared with the Soviet Union and the U.S.A., China has not been faster in the achievement of its firsts in space. However, China's strength and spe-

FIGURE 6



Efficiency in Chinese: Comparison of space achievements by the U.S.A., Soviet Union, and China.

FIGURE 7
Timeline of CLEP



cialty is its efficiency. The first woman in space, the first EVA, the first rendezvous-and-docking, the first space laboratory have been achieved with fewer flights as compared with the Soviet Union or the U.S.A.

For example, China achieved its first EVA during its third manned mission, while the Soviet Union accomplished this feat on its eighth flight and the U.S.A. on its sixth flight.

Or: the first female astronaut flew on China's fourth manned mission, while in the Soviet Union it was on the sixth national mission and in the U.S.A. it was on the 36th manned mission.

China might move slowly, but with respect to efficiency and performance, it is a global champion.

CLEP—China's Lunar Passing Lane

CLEP—China's Lunar Exploration Program—is China's test case for future deep-space exploration.

CLEP was planned in three phases—orbiter, lander, sample return mission. To each phase, two missions were assigned, allowing a step-wise build-up of capabilities: infrastructure, technology and resources.

The next phase can only start if the objectives of the previous phase have been accomplished and the corresponding resources have been established step-by-step.

Phase 1 started with the Chang'e 1 orbiter, orbiting the Moon and impacting at the end of the mission.

Chang'e 2, again an orbiter, flew an extended mission, reaching the Earth-Sun L2 Lagrange point and rendezvoused with asteroid Toutatis. Chang'e 2 is still active and supports tests for China's deep-space network.

Phase 2 started with the Chang'e 3 mission, comprising a Moon lander and the Yutu lunar rover. Then Chang'e 4 was expected. But China surprised the world.

Instead of Chang'e 4 (back-up of Chang'e 3), in preparation of Phase 3, Chang'e 5-T1—a test re-entry mission with Xiaofei, a downscaled Shenzhou capsule as re-entry body—was launched and returned to Earth, testing high-speed re-entry into the Earth's atmosphere.

And there was another surprise: The first commercial lunar payload—the Luxembourg-German 4M Manfred Memorial Moon Mission (with a *radio and dosimeter*) was on board of 5-T1.

We are now expecting in November the Chang'e 5 sample return mission, planned to bring 2 kg of Moon material to China.

Chang'e 4 will not end up in the museum; rather it will be repurposed with a new mission profile of landing on the far side of the Moon. There will be international and commercial cooperation for this mission. And China will write space history with the first ever landing of a human-made body on the lunar far side.

At this stage it might be fair to claim that China did very well in getting rid of its tortoise image.

Science on the Horizon—Mars and Beyond

Slowly but surely, China's space dream is beginning to embrace space science.

With respect to future space exploration, there is a firm focus on Mars. Chinese space experts are emphasizing that Mars exploration is based on the results and experiences of the lunar program. The engineering team from CLEP is involved in the Mars exploration project.

Having learned enormously from CLEP, China's first Mars mission goes bold: launching in 2020 with arrival at Mars in 2021, the Mars probe will accommodate lander, rover, and orbiter—all in one mission. If China succeeds, the tortoise image might be gone forever.

But already the recent Chinese science missions have earned worldwide respect. In December 2015, the dark matter particle explorer **DAMPE-Wukong** was launched. April 2016 saw the **Shijian 10** retrievable science satellite and August 2016 the **QUESS-Mozi** project, testing quantum communication.

For the near future, more and highly ambitious missions are in the pipeline:

- **HXMT**, a hard X-ray telescope
- **SMILE** for the observation of solar activities and space weather
- **MIT** for Magnetosphere-Ionosphere research
- **WCOM** for remote sensing of soil and oceans
- **ASO-S**, a Solar Observatory
- **Einstein** for the investigation of black holes
- **Missions to Jupiter** and/or **asteroids**.

Political Context: BRICS, SCO, and One Belt One Road

Space and politics are not always best friends but there is no denying that they interfere with each other.

Next to Brazil, Russia, India, and South Africa, China is one of the BRICS member states—an association of emerging economic powers finding its place in a multi-polar world.

While in 2015 the option of a joint BRICS space station was briefly discussed, there is now a realistic cooperation project in the area of Earth observation under way. Igor Komarov, Director of Roscomos State Corporation, explained in May 2016:

> The practical initiative, on which we are now working together with the BRICS countries, is a data exchange in distanced probing of the Earth, which will help in quicker responses to emergency situations, natural calamities, pollution and other aspects. I believe, it will find rather prompt and very important practical use for the BRICS countries.

I would also like to point to the existence of the Shanghai Cooperation Organization (SCO). As the biggest regional organization, its objectives are comparable to the Helsinki Accords/Organization for Security and Cooperation in Europe (OSCE). SCO and BRICS are important for the China-led New Silk Road Economic Belt and Maritime Silk Road (One Belt One Road, OBOR): a mega-project of economic and societal development, aiming at the revitalization of the ancient Eurasian Silk Road model to create a bridge between Asia and Europe.

"The Belt and Road is China's initiative, but it belongs to the world. The idea came from China, but the benefits will flow to all countries." stressed China's Minister for Foreign Affairs Wang Yi, when he pointed to the Belt and Road Forum for International Cooperation that China is hosting in Beijing in May 2017.

One Belt One Road will be supported by the Digital Silk Road. Comprehensive space infrastructure—like the Chinese Beidou satellite navigation system and the Russian GLONASS—are ready to feed space applications, essential for the realization of the One Belt One Road endeavor. At this moment it is hard to predict how big the market for OBOR space applications will become, but it is certain that it will be enormous.

The One Belt One Road initiative is also complementary to the Eurasian Trade Zone, an initiative by Russian President Vladimir Putin. On several occasions he confirmed: "For us, China is a key partner in the region."

Embedded in the strategic environment for open international cooperation is the Chinese initiative within the frame of the United Nations. In March 2016, the United Nations Office for Outer Space Affairs (UNOOSA) and the China Manned Space Agency (CMSA) signed a framework agreement and a funding agreement to develop the space capabilities of UN member states via opportunities on board China's future space station.

China offers to UNOOSA member states:

- The use of the CSS for experiment payloads or joint research
- The development of modules, subsystems, components, or other platforms
- To train and to fly astronauts
- To share technical know-how.

FIGURE 8

China's Proposals for UNOOSA's Human Space Technology Initiative (HSTI)

China's first taikonaut, Yang Liwei, stressed on April 24, 2016—when China first celebrated its national space day:

> Payload has been reserved in the Chinese space station, due to enter service around 2022, for international projects and foreign astronauts. Upon request, China will also train astronauts for other countries, and jointly train astronauts with the European Space Agency. . . . The future of space exploration lies in international cooperation. It's true for us, and for the United States too. China will not rule out cooperating with any country, and that includes the United States.

It might be that the Chinese Space Station has the potential to become the World's Space Station.

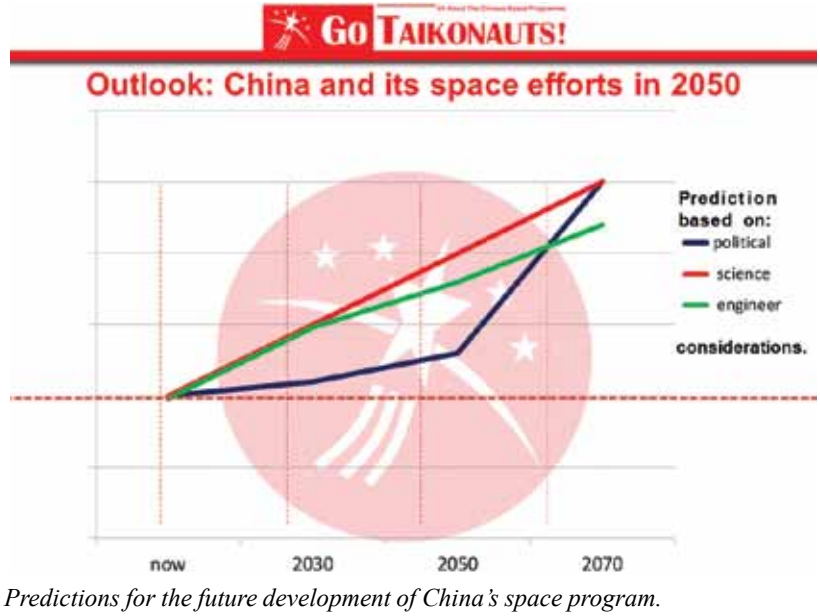
How the Future Might Look

Predictions about the future of the Chinese space program are rare. The authors of this paper are part of the Sino-European GoTaikonauts! team, which has closely observed China's space efforts for the last decade. Having seen its dynamism, inspiration, modesty, and perseverance, each one of us was looking at China's space dream from a different angle and dared to make predictions for its future development (see Figure 9). Although we are all convinced that Chinese space activities will increase and grow, we diverge a little bit on the speed and pace of how this will happen. However, we do agree that we will see China becoming the second space power after the United States.

The **science**-based considerations (red) say: Space exploration will remain important in China. The efforts will continue to grow linear because space science and technology is considered to be a tool for the development of the overall society. Space is a fundamental desire of mankind. It has the image of being a high-tech area. It is extremely difficult and by challenging space, any society can demonstrate its capabilities.

The **societally** focussed opinion (blue) says: Space exploration in China will remain important, but other issues (climate change, energy, social welfare, infrastructure projects—also on a global/Asian/African scale) will require more resources. Once the creation of a harmonious, possibly global, society is achieved,

FIGURE 9



Predictions for the future development of China's space program.

space exploration will experience a renaissance.

The **engineering** considerations (green) say: China has a good track record to complete its space plans, which have been demonstrated in the manned space flight, lunar exploration, Beidou navigation system, and other civil and military programs. So it is very reasonable to see that China will continue its fast expansion in space, but with a pace consistent with the slightly slowed down growth rate of its economy. Although there are many challenges ahead, we will see China become the second space power after the United States.

China's Space Program Is Neither Hare nor Tortoise

In the beginning, it has been slow. However, if the frame is set and decisions are taken, things speed up and the tortoise might convert into a hare.

Leaps forward are possible and will advance the whole process. Leap-frogging is a Chinese specialty.

And something else is characteristic of China's space program:

A guest in a Chinese restaurant is often taken by surprise when studying the gigantic menu. The trick is: a set of basic components can be combined for an almost unlimited number of dishes. China's space program often works in the same way.

So, the next time you sit in a Chinese restaurant, please think of the Chinese space program … frogs and frogs.

FIGURE 10

Neither hare nor tortoise—China has its own pace of space.

Note

This article is a summary of the IAC2016 paper (IAC-16,E3,2,5-E3.2-29th IAA Symposium on Space Policy, Regulations and Economics) with the same title. For better detail, please, consult the paper.

Acknowledgement

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