The Chinese Space Program

Where are they headed? Why are they going? How will they get there? What does it matter?

James Oberg
According to legend, the first man to try to ride a rocket was Wan Hu (XIVth century AD)
Yang Liwei
Shenzhou-5
Shen-Zhou (Heavenly Vessel)

Unmanned flight tests began in Dec 1999
Shenzhou’s CZ-2F Booster (‘Shenjian’)

(Chang Zheng = Long March)

9 tons to LEO (more power than Russian ‘Soyuz’)
Preparing for the breakthrough trip

‘Yuhangyuan’ – not official
‘Hangtianyuan’ – used in industry
‘Taikongren’ – commonly used
TAIKONAUT – Anglicized term
The Launching – Never ‘Routine’

Some unusual images: jettisoning protective covers; reddish smoke
Shenzhou ascent and landing tracks

Orbit = 42 degree inclination
Amazing Openness About Spacecraft

It took many years before the USSR released this level of technical detail about ‘Vostok’ and ‘Soyuz’
On Orbit

Yang remained in his seat the whole flight, radioed greetings, showed the Chinese and UN flags, tried space food and took space naps, looked out the window, and above all – made manned spaceflight REAL to China.
Approximate locations of Yuanwang ships

Location of Yuanwang-3 matches official Chinese account of when Shenzhou was over its horizon

Shenzhou Orbits and Tracking Ships
Visually tracking Shenzhou-5

A fortuitous coincidence of orbital plane and sunlight allowed Shenzhou to appear as a moving star in the predawn sky along arcs across the northern hemisphere (below).

CCD image (top) was made by Paul Maley, one of the world’s most avid amateur satellite observers, after an all-night car chase across the midwest. Such observations often give critical information on the space missions.
Shenzhou ‘Orbital Module’ Free Flight

With its own solar panels, the OM can continue in space for research or for re-docking by later missions.
Returning to Earth. . . .

Shenzhou performs de-orbit burn (left), separation, and entry (right); as viewed from launch site, SM disintegrates while CM fireballs home.
Shenzhou Parachute Landing

[top] Russian Soyuz landing

[left] Chinese Shenzhou spacecraft descending on parachute
[upper center] Firing of soft-landing engines prior to impact
[lower center] Shenzhou parachute spread out on ground
Astronaut extraction – Shenzhou vs. Soyuz

Once recovery forces arrive at landing point, Shenzhou command module (left) is fitted with platform/slide like the design used for Soyuz (right)

Note how Shenzhou appears to be a bit larger than Soyuz – and it is.
Shenzhou vs. Soyuz
A Family Resemblance??

Shenzhou (Chinese) vehicle (top L, R)

NY Times (Jan 3, 2003): “The Shenzhou spacecraft are converted Soviet capsules from the 1960s….”

Agence France Presse: “Little more than a slightly modified version of the old Soviet workhorse of space, the Soyuz.”

Soyuz (Russian) vehicle (lower left, lower right)
Some systems clearly were 100% Derivative: E.G., In-cabin pressure suits

Shenzhou

Soyuz
Some were very similar:
e.g., Launch-Escape-Tower

Test firing of Shenzhou launch escape tower

[Top] Spacecraft with aero shroud and ‘escape tower’: left, Russian Soyuz; center & right, Chinese Shenzhou.

Huang Chunping on stabilization flaps: “This is the most difficult part of the escape system. We once wanted to inquire about it from Russian experts, but they set the price at $10 million. Finally we solved the problem on our own.”
Shenzhou, Soyuz CM shape similarities

Shenzhou (left top/bottom), Soyuz cutaway (right),

Chinese small recoverable satellite (below right)
Parachute compartments of Russian ‘Soyuz’ (left) and Chinese ‘Shenzhou’ (right).
Close-up of ‘recoverable satellite’ recently when it hit a house
Moscow Cosmonaut Training (1996-7)

Li Qinglong and Wu Jie learn what Russia has to teach about human space flight. They graduate (below) with full certificates.

@Neil Costa
Russian space tradition: autograph the guest-room door

Since the very first flight, cosmonauts autographed the door of their quarters at the launch site (left); aware of the tradition, Yang Liwei did the same (right). It remains unclear whether he also repeated the Gagarin tradition about the tire on the bus to the launch pad (below).
Open credit to Russian help

*Liaowang* magazine (Xinhua News Agency), 2002: “After China and Russia signed a space cooperation agreement in 1996, the two countries carried out very fruitful cooperation in docking system installations, model spaceships, flight control, and means of life support and other areas of manned space flight. *Russia’s experience in space technology development was and is of momentous significance as enlightenment to China.*”

[For perspective, it should also be pointed out that the docking mechanism on American space shuttles is also based on this same Russian design]
Technology Acquisition Issues

- Commercially purchased
- Cooperatively learned
- Openly researched
- Surreptitiously obtained
- Domestic transfers
- Specific R&D
How Do We ‘Find Out’ About Chinese Space?

- Official announcements
- Press Accounts
- Personal conversations
- Implications of released information
- Non-Chinese government statements/leaks
- Non-Chinese private observations
- Analogies with Soviet ‘space race’
Significant openness about personnel

Luan Enjie, Director, China National Aerospace Administration
Qi Faren, ‘General Designer’ of Shenzhou spacecraft
Yuan Jiajun, ‘Chief Director’ of Shenzhou program operations
Zhang Qingwei, ‘General Manager’ of ‘whole manned space industry’
Wang Yongzhi, ‘Chief Designer’ of entire manned program
Li Jinai, ‘Commander-in-Chief’ of manned spacecraft project
Yuan Jie, Director, Shanghai Aerospace Bureau (builds the Shenzhou)
Su Shuangning, ‘Chief Director/Designer’ of astronaut systems
Gu Yidong, ‘Commander and Chief Designer’, application systems
Zhao Jun, ‘Commander and Chief Designer’, landing systems
Huang Chunping, Commander-in-Chief of SZ-2F booster program
Liu Zhusheng, ‘Chief Designer’ of Shenzhou carrier rocket system
Zhou Jianping, ‘Chief Designer’ of the ‘launch system’
Xie Guangxuan, ‘Chief Designer’ of CZ3 booster
Sun Baosheng, ‘Deputy Chief Designer’, telecommunication system
Ouyang Ziyuan, ‘Chief Scientist’ of lunar projects
Much more information than Soviet-style ‘Space Race’ secrecy (EG, names of candidate astronauts available)

Leaked to press in mid-2003:
Chen Quan, Deng Qingming, Fei Junlong, Jing Haipen, Li Buoming, Li Qinlong, Li Wang, Nie Haishen, Pan Zhanchun, Wu Jie, Yang Liwei, Zhai Zhigang, Zhang Xiaoguang, Zhao Chuandong
**“The continuous development and application of space technology has become an important endeavor in the modernization drive of countries all over the world.”**

**“The Chinese government has all along regarded the space industry as an integral part of the state's comprehensive development strategy.”**

**“A number of satellite application systems have been established and have yielded remarkable social and economic benefits.”**
Applications satellites

(left) DFH-1 (top), -2 (center), -3 (bottom) commsats (Dongfanghong = ‘East-is-Red’)

(right top) Zi-Yuan Chinese-Brazilian Earth Resources Survey Satellite (two launched)

(right bottom) Bei-Dou navigation sat

(below) Feng Yun (FY-2A) “Wind-Cloud” geosync metsat, launched 1997 to 105° E
‘Space White Paper’ on Central Control

"The state guides the development of space activities through macro-control, makes overall plans for the development of space technology, space applications, and space science, promotes the R&D and system integration of important space technologies and the application of space science and technology in the fields of economy, science and technology, culture, and defense."

“The state's supervision over space activities is being continuously strengthened."
Dependence on Omniscience ‘At The Top’

“China's various types of artificial satellites, in their research and manufacture, are all under unified national leadership...” that will “correctly select technological paths, strengthen advanced research, and constantly initiate technical advances. We must constantly select development paths where the technological leaps are the greatest.” Strict funding constraints require selecting “limited goals and focus[ing] on developing the ... satellites urgently required by our country,” and on determining which satellites “are most crucial to national development.”

-- Xu Fuxiang (February 2001)
Ideological Idiom:

“Concentrating superior forces to fight the tough battle and persisting in accomplishing something while putting some other things aside.”
Skepticism of tightly-focused control

Dr. Joan Johnson-Freese:

“They are not building the science/technology infrastructure necessary for a broad program," a "critical” issue.

"Asian programs generally are weakest on the systems engineering issues, those which require 'big picture' orientation. The Japanese are at least aware of that weakness and try to compensate -- the Chinese, less so."

"It is likely that [this weakness will catch up with the Chinese] at some point."
Shenzhou-6 – when and what?

Early expectations of rapid-fire sequence of missions not fulfilled by slow, methodical approach

China has fourteen astronauts in training; they plan to try a spacewalk (below) ‘soon’ but not on next mission.
(Top) First tests will probably involve short-range redocking with detached Orbital Module.

(Center) Later a test flight would chase down a module left in orbit previously.

(Right) Artist concept (unofficial) of ‘module train’ of small units to build up room & power in orbit for brief visits.
Shenzhou Military Applications?

Photographs of equipment associated with the Orbital Module suggest usage for image & electronic reconnaissance, and maybe others.
Puzzle over forward-mounted module (sub-satellite?)
Modular concept displayed at European trade fair, 2000


Artist concepts of station (below) and Shenzhou docking (above).
Caution – Art Often is Direct Rip-Off

Much of the art published during recent enthusiastic press coverage is merely Western space hardware with Chinese flags painted on.
Will China Have A Role on the International Space Station?

Shenzhou vehicles could visit, and could ferry supplies and personnel to the ISS and back within a few years.

Tracking site recently completed in Namibia is directly below normal landing path BUT return from ISS orbit passes too far south for tracking
Wu Ji (Deputy Director, Chinese Academy of Sciences' 'Center for Space Science and Applied Research’, declared that Chinese Moon probes will aim at questions not addressed by previous missions, stressing the importance of doing "something unique“.

Other sources states that Chinese probes will study the geological evolution of the lunar soil, its interactions with the solar wind and will analyze its chemical composition.

Most interviews and published accounts of lunar applications appear to be derivative of the existing Western literature (e.g., ‘helium-3’) and not a reflection of any approved domestic program.
Booster choice for initial lunar missions

Yu Menglun: Research on a Chinese Lunar Probe Launcher; Aerospace China, No. 11, 2002

Comment: This paper reveals details on the Chinese lunar launchers. Due to its injection accuracy, it appears that a CZ-3A based launcher (i.e. a CZ-3A, -3B or -3C) would be the best choice. The paper publishes the following payload characteristics for several Chinese launchers

<table>
<thead>
<tr>
<th>Launcher</th>
<th>to Lunar Orbit</th>
<th>to Lunar Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>CZ-3A</td>
<td>1700</td>
<td>500</td>
</tr>
<tr>
<td>CZ-3B</td>
<td>3400</td>
<td>1250</td>
</tr>
<tr>
<td>CZ-3C</td>
<td>2400</td>
<td>800</td>
</tr>
<tr>
<td>CZ-5 &quot;light&quot;</td>
<td>4400</td>
<td></td>
</tr>
<tr>
<td>CZ-5 &quot;medium&quot;</td>
<td>8100</td>
<td></td>
</tr>
<tr>
<td>CZ-5 &quot;heavy&quot;</td>
<td>10600</td>
<td></td>
</tr>
</tbody>
</table>
Cheng-Eh Lunar Probe

Lunar orbital probe (left) is to be built on basis of DFH-3 communications satellite (lower left)

"Chang'e" is a character who flies to the Moon in the Huai Nan Zi fairy tale, 4th C. BC.

Typical trajectory of simple lunar probe shows checkout, transfer, and arrival.
Chang-Eh Moon Satellite’s Technology Base (DFH-3) Was (According to Cox Report) Largely Western

Cox: “DFH-3 commsat (1994) had its development time cut in half by use of a large number of Western components”:
* Central processor was built by Matra-Marconi;
* The solar panel substrates provided by Messerschmitt-Boelkow-Blohm, which also performed final fabrication;
* The antenna assembly, consisting of a deployable dual gridded reflector, feed, and interconnecting structure, was built by Daimler Chrysler Aerospace Group
* IR Earth sensor (attitude control) built by Officine Galileo;
* Payload test equipment consisted of five racks with 80% US equipment; racks provided by German corporation.
Other moon proposals

Tsinghua University’s “LunarNet” -- a polar orbiter equipped with sixteen 28 kg landers, to be released in equally spaced areas on two mutually perpendicular orbital planes. The landing system, probably using airbags, would ensure surviving a landing at speeds between 12 and 22 m/s. Each lander will carry a camera, temperature sensors, cosmic ray detectors, a penetrometer, an instrument for the measurement of soil magnetic properties and other instruments. Use relay satellite for earth comm.

“Lunar Rabbit” -- This 330 kg probe will cost as little as $ 30 million and will be launched on a geostationary transfer orbit from the Xichang space center. Insertion into a lunar transfer orbit will be carried out on the following day using the on board bipropellant engine. At the time of the third apogee the probe will be inserted in a 100 to 200 km high lunar orbit where it will split into two components. The first, apparently based on the Double Star scientific satellites, will carry out an orbital mission, using a CCD camera, an infrared camera, a radar altimeter and a radiometer. The second will head for a lunar landing. This lander, braked by a solid propellant engine, will carry only a camera and will test optimal control algorithms discussed in some length in Chinese literature. Once on the surface the lander will release a 60 sq. meters Chinese flag.
“Moon Rabbit” small lander (based on ‘Double Star’ payload) and trajectory plans
Lunar Rovers and Samplers

Soviet precursors such as Lunokhod (top) and sample return (bottom) show capability of CZ-5-class boosted payloads.

Toy ‘moon-buggies’ (above) now are widely sold in China; but sometimes a space toy is just a space toy (below).

Theoretical flight path studies show interest, not intent.
Numerous ‘rover’ models studied in university engineering class projects
Mars

May 2002: a prototype Mars rover unveiled at the China Sci-Tech Week held in Beijing. The "Mars Explorer" rover was said to be based on NASA's Mars Exploratory Rovers, and had six wheels, a square-shaped body and a sensor "head" weighing around 20 kg. Each of its six wheels is powered by two independent motors for redundancy. Between the rover body and wheels is a mechanical arm, able to crush stones and perform chemical analyses. See below:

Plans for the CZ-5 Booster

Officially-described vehicle for heavy commsats and for large manned space station.

Ariane-5-class vehicle is a major quantum-jump in the ‘Long March’ family and presents very formidable engineering challenges.

Designed for sea transport and launch only from new Hainan Island site (right)
Manned Lunar Flight?

“China intends to conduct a mission to circumnavigate the Moon in a similar manner as was carried out by Apollo-8 in 1968. This mission will apparently involve a modified Shenzhou spacecraft and will be launched around 2006.” FUTRON Corporation, China and the Second Space Age, October 15, 2003, p. 7.

Two different possible flight plans are a simple swing-by (left, as with Soviet ‘Zond’) and orbital (right, as with Apollo-8). Simpler variant could be carried out with a single CZ-5 launching; orbital profile could require two launches.
Classic ‘Lagrange points’ were associated with planetary orbits. Space probes make use of the Sun-Earth L1 (right) and L2.

Earth-Moon system also has ‘Lagrange points’ (left) that have been suggested for lunar exploration support. All ‘local’ Lagrange points are shown below:
Moon as a backdoor to any other orbit of interest

Case study: Hughes commsat rescue to GEO

Translunar opens way to undetected access to GPS (12-hr), GEO, retro-GEO, unexpected low-altitude passes, etc.
Chinese Astronauts on the Moon?

@ Mark Wade

These dioramas at a Chinese trade exhibit in Germany in 2000 seem to only be copies of US Apollo hardware with flags added. There is little if any credible evidence that such hardware is even being designed in China for actual human missions to the Moon.
‘Shenzhou’ versus ‘Constellation’

Both China and US are now developing human space vehicles for use in low earth orbit and then eventually beyond; the Chinese vehicle already is flying, the US vehicle has more experience to support its development.

Both vehicles can carry 3 or more crew, are launched on expendable boosters, have launch-escape-systems, can rendezvous and dock in orbit, and return on dry land. Both promise to outstrip capabilities of the Russian ‘Soyuz’ vehicle, just as Russia wants to replace it.
Strategies: Copying versus Innovating?

• a) Have any indicators appeared that China may be implementing some kind of strategic plan to "get on top of the US" in space by developing capability to operate in (or even dominate) cis-lunar space and key regions such as L points and orbits above GEO?

• b) Are there any reasons to suspect that China may be pursuing some kind of space architecture that would be fundamentally different from the "traditional" architectures developed over the years by the US and Russia?

• [E.G., a strategic shift towards networked constellations of microsats in lieu of large sats for C4ISR operations, and/or the development of some kind of highly flexible, rapid launch infrastructure.]

• c) What indicators should we be watching for that China may be pursuing these kinds of strategies (or others for that matter).
What indicators proved helpful in forecasting (even in hindsight) 1960’s Soviet space?

- Public statements
- Public silences
- Unmanned test flights
- Infrastructure construction
- Acquisitions menu for shopping abroad
- Scientific theoretical papers
- Crew training (e.g., helicopters)
- Artwork
Rationale for >> $1 Billion per year

"China certainly has the political will to forge ahead with its space program. It recognizes all the internal and external prestige-related benefits of space that the U.S. and the FSU did in the 1960s, as well as the technology-industrialization-economic benefits that pushed Europe into space later."

"From a science & technology perspective, the experience of developing and testing a manned spacecraft will be more important to China's space effort than anything that their astronauts can actually accomplish on the new spacecraft. This is because it will raise levels in areas such as computers, space materials, manufacturing technology, electronic equipment, systems integration, and testing as well as being beneficial in the acquisition of experience in developing navigational, attitude control, propulsion, life support, and other important subsystems, all of which are vitally necessary to dual-use military/civilian projects.”

-- Xiandai Bingqi magazine (June 2000)
Increased launch rate already being seen

Figure 1: Chinese Government Launches (1970-2021).
Future Launch Projection from Futron's ASCENT Study
For China, space is the stage for the future

China’s public morale has responded proudly to the news stories about space activities
China uses ‘space militarization’ as diplomatic lever
The “Treasure Fleet” of Admiral Zheng He (Cheng Ho)

The Chinese decision to terminate these expensive voyages may have been rational in the short term but it led to half a millennium of grief.
Understanding comes through people -- and the loss of Iris Chang diminishes our ability to understand

http://www.irischang.net/
Chen Lan’s Unofficial Chinese Space Website

http://www.geocities.com/CapeCanaveral/Launchpad/1921/

Also: www.fas.org and www.spacetoday.org

www.spectrum.ieee.org/WEBONLY/publicfeature/may01/china.html & dec01/space.html (two Oberg articles)
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... And books as well
Star-Crossed Orbits -- Inside the US-Russian Space Alliance

• Richard Truly, former astronaut and NASA Administrator: “Clear-eyed, cold-blooded look at the real costs and benefits of this joint endeavor. Don't miss this one!"

• Gene Kranz, Apollo Flight director: “A great piece of investigative journalism... A must read for program managers, engineers and scientists engaged in present and future projects with Russia. ”

• Sci-Tech Books: “Oberg combines riveting personal memoir with top-notch investigative journalism to tell the complete untold story of the U.S.-Russian space alliance. ”

(more)
Star-Crossed Orbits (continued)

- Harrison ‘Jack’ Schmitt, Apollo moon walker and US Senator: “This remarkable book is must reading for anyone who wishes to understand the culture with which one must deal when attempting to cooperate with Russia”

- *American Scientist*: “His sleuthing and story-telling abilities make this a gripping narrative”

- Walt Cunningham, Apollo astronaut: "Finally, someone is telling it like it is about the Russian manned space program - the good, the bad and the ugly. I have relied on Jim for years because no one knows it or tells it like he does.”

- Gregory Bennett: “Riveting prose that grabs your attention and won't let loose”
Jiu-Quan Space Center, Gansu Province

41°N, 100°E
Formerly known as Shuang Cheng Tzu
First launches, 1960

Mainly to launch scientific & recoverable satellites into low or medium earth orbits at high inclinations.
“Long March” ("Chang Zheng") Boosters

Remarkably unified basic design with many varieties of strap-ons and stretches
“Father of Chinese Missile/Space Program”, Qian Xuesen (Tsien Hsue-Shen)

(Left) In charge of missile program;
(Below) Retired in Beijing in 2002
Qian (Tsien) in America

Tsien with US Army V-2 inspection team in Germany (1945), working at Jet Propulsion Laboratory, teaching at Caltech (late 1940’s).
“Find the differences” – Means What?
Future Crews