

## EC Knowledge Capture (KC) Series Synopsis

All KC events will be approved for release to the Engineering Academy website using NASA Form 1676.

*This synopsis provides information about the Knowledge Capture event below.*

**Topic:** Chinese Spacesuit Analysis

**Date:** February 18, 2010      **Time:** 12:00-1:00 pm      **Location:** JSC/B4S/R1328

### **Assessment of Export Control Applicability:**

This event was recorded February 28, 2010 at JSC. During this event, Lewis Croog provided an overview of the Chinese EVA Spacesuits after assessing video downlinks during the Chinese EVA on September 27, 2008.

This Knowledge Capture event has been reviewed by the EC5 Space Suit Knowledge Capture Manager in collaboration with the author and is assessed to not contain any technical content that is export controlled. It is requested to be released to the JSC Engineering Academy.

**DAA Form #: 21523**

**Link to presentation material and video:** \\jsc-ifs-02\data\EA\EC\_SHR\Knowledge-Capture\FY10 Knowledge Capture\20100217\_L.Croog\_Chinese Suit\1676 review

**Presenter:** Lewis Croog

**Synopsis:** This presentation will provide an overview of the Chinese EVA Spacesuits that were used last year as China became only the 3rd nation to perform an EVA from a spacecraft. This talk is a follow-on from an AIAA talk given by Chuck Fulcher from Hamilton Sundstrand. An overview of the Chinese spacesuit and life-support system, were assessed from video downlinks during their EVA and from those assessments, spacesuit characteristics were identified and will be provided. The space suits will be compared against the Russian Orlan Spacesuit and the U.S. Extravehicular Mobility Unit (EMU). In addition, China's plans for future missions will be shown.

**Biography:** Mr. Lewis Croog graduated from the University of Bridgeport, Connecticut in 1984 with two Bachelor of Science degrees in Biomedical Engineering and Electrical Engineering. He also entered a Master of Science degree program in Biomedical Engineering at Trinity College in Hartford Connecticut. His work career in space systems started with Hamilton Sundstrand in Windsor Locks, Connecticut and lead to working in Space Life Sciences with Krug International/Wyle Labs at JSC from 1988 through 2005. Projects included Space Motion Sickness Studies, cardiovascular de-conditioning studies from prolonged weightlessness and then onto cellular tissue changes in 0g as the lead electrical designer on the ISS Bioreactor Project. Following post Columbia, he was transferred to Lockheed to support work on RCC repair methods. Eventually he went to work with Jacobs Engineering providing support to EC5 PLSS

hardware development for Constellation, and as a systems engineer with the level 3 EVA SE&I group, performing analysis on EVA spacesuit systems. At the time of this recording Mr. Croog was employed by Jacobs Engineering.

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## U.S. Spacesuit Knowledge Capture (KC) Series Synopsis

**Topic:** Chinese Spacesuit Analysis

This event was recorded February 18, 2010 at NASA Johnson Space Center.

**Presenter:** Lewis Croog

**Synopsis:** In 2008, China became only the 3rd nation to perform an Extravehicular Activity (EVA) from a spacecraft. An overview of the Chinese spacesuit and life support system were assessed from video downlinks during their EVA; from those assessments, spacesuit characteristics were identified. The spacesuits were compared against the Russian Orlan Spacesuit and the U.S. Extravehicular Mobility Unit (EMU). China's plans for future missions also were presented.

**Biography:** Mr. Lewis Croog graduated from the University of Bridgeport, Connecticut in 1984 with two Bachelor of Science degrees in Biomedical Engineering and Electrical Engineering. He also entered a Master of Science degree program in Biomedical Engineering at Trinity College in Hartford Connecticut. His work career in space systems started with Hamilton Sundstrand in Windsor Locks, Connecticut and lead to working in Space Life Sciences with Krug International/Wyle Labs at JSC from 1988 through 2005. Projects included Space Motion Sickness Studies, cardiovascular de-conditioning studies from prolonged weightlessness and then onto cellular tissue changes in 0g as the lead electrical designer on the ISS Bioreactor Project. Following post Columbia, he was transferred to Lockheed to support work on RCC repair methods. Eventually he went to work with Jacobs Engineering providing support to EC5 PLSS hardware development for Constellation, and as a systems engineer with the level 3 EVA SE&I group, performing analysis on EVA spacesuit systems on the Engineering and Science Contract Group (ESCG) at the Johnson Space Center in Houston, Texas.

*(At the time of this recording Mr. Croog was employed by Jacobs Engineering.)*

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# Chinese Spacesuit Analysis

Presented by Lewis Croog/Jacobs Engineering/ESCG  
February 18, 2010





# Chinese EVA

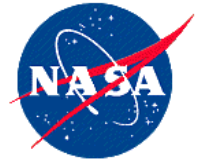


- Immediately following the Chinese EVA on September 27th, 2008 it was noticed that the Feitian (Fa-tien) spacesuit and Russian Orlan were very similar.
- Prior to this EVA there was no information on the Chinese spacesuits.
- The EVA lasted 18 minutes (it was more for a proof of concept and Public Relations)
- Looking like the Orlan suit, (Orlan M) projections can be made on the performance.





# Chinese EVA Suits



- There were two suits involved in this EVA. One was the Chinese Feitian, the other (backup) was the Orlan spacesuit.



- Feitian means flying in the sky (named for a flying Buddhist goddess)
- In April 2004, the Chinese purchased EVA space hardware from Russia.  
According to a contract signed in April, 2004, a Russian company provided three Orlan suits, two low-pressure Launch Entry suits, four suits for underwater training, and four sets of docking systems. The Chinese side is responsible for providing power and communications equipment for the EVA suits.



# Chinese Feitian vs NASA EMU



## Russian Orlan/Feitian Spacesuit comparisons against the EMU

- Russian Orlan spacesuits are one size fits all. They have sizing straps to bring in the arms and legs but that's it. Whereas the EMU can be sized for many different sizes of people.
- Russian suits are certified for 15 uses or 4 years and then they just throw them away. The EMU with maintenance can go a long time (25 years). The Chinese suits used on this mission were discarded before crew descent.
- Nominal pressure is 5.7 psi in the Orlan. So it is assumed as 5.7 psi in the Chinese suits.
- The Life Support System in the Orlan is located inside the suit itself located in the 100% oxygen environment. On the EMU it is outside the suit within the PLSS.
- The Orlan uses an active thermal control system, an LCG, and cools through a sublimator as in the EMU.
- Orlan is made to do an Autonomous EVA and it also has umbilical capability which is what the Feitian used during this EVA.





# Leroy Chiao's visit to China



## American Astronaut Leroy Chiao's Comments on Feitian Suit

Commander and NASA Science Officer on Expedition-10

“ I was impressed with the suit. It has obvious Russian Orlan heritage, with some differences. The Display and Control Module looked similar, as did the pressure regulators and the oxygen injector switch. The hatch latching mechanism also looked similar. So did the umbilical interfaces.

In fact, it is reasonable to assume that the spacecraft interfaces are identical to the Russian system, since the second suit worn by Liu Boming was in fact an Orlan.

There is nothing wrong with this approach. It is arguably optimal to take an existing design and improve upon it, while retaining critical systems that are proven. In my view, China is taking a very logical course in developing their manned space capability.”





# Chinese – Russian EVA Spacesuit Comparison



## How does the Feitian differ from the Orlan?

On Feitian, the suit pressure gauge is on top of DCM (Display Control Module.) It is a mechanical gauge. On an Orlan suit it is located on the arm.



Chinese DCM



Russian DCM





# Chinese Feitian – Russian Orlan Comparison



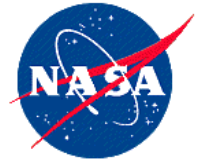
- A sliding handle on Orlan has been replaced with a rotating knob for controlling temperature, though the rest of the architecture looks the same.

Temperature Control





# Difference between Chinese Helmet and Orlan Helmet



- The Feitian visor is larger and wider than on the Orlan helmet
- The Feitian helmet is assumed to be built onto the torso as one piece, just as the Orlan helmet, in comparison against the removable EMU helmet.
- The Orlan-M has a moon roof on the helmet, the Feitian did not.

Feitian Helmet



Russian LCG with cap seen on Chinese video



Orlan Helmet with moon roof



According to Liu Guoning, suit designer, the helmet is made of a polycarbonate material and has four layers of protection including a gas filled layer of nitrogen gas. It is heat- and sound-insulating, and protects the astronaut from harm done by possible collisions. It has a ventilation device and a visor anti-fogging coating.



# Chinese IVA and EVA Gloves



Gloves look like Sokol IVA and Orlan EVA gloves.

Feitian IVA Glove



Feitian EVA Glove







## Umbilical and Interface



- Though the Orlan operates autonomously on the ISS, the Feitian used the Orlan style umbilical connection as the nominal EVA umbilical interface. The umbilical provides hardline communications and power. It is claimed to also carry an emergency oxygen supply tube. From a Chinese newspaper article, they describe two umbilicals, one at 8m length, the other at 4m length.
- Russians use a spacesuit interface control panel inside an airlock. The Chinese airlock looks like it has the exact same EVA control panel as the Russians.





# Chinese – Russian EVA Comparison



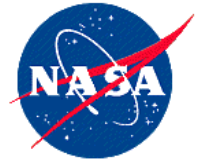
Liu Guoning, a researcher of China's Manned Space Engineering Programme, talks about the extravehicular spacesuit at the Shenzhou VII Manned Space Flight Media Center on September 25, 2008. [Wang Wei/China.org.cn]

**According to Liu, there are differences in technology and reliability, the Chinese "Feitian" is equipped with a number of new features.**

- Firstly, digital technology is extensively applied in the design of Feitian while Orlan-M, researched and designed in the 1970s-80s, only carries simulation technology. For Feitian, image and data transmission and information collection is conducted by digital signals.
- Secondly, CDMA (Code Division Multiple Access network) technology is applied in the Feitian's communication system while the Russian version depends on short-wave communication.
- Thirdly, following the design of the intravehicular spacesuit, the elbow and knee joints of Feitian are softer than those of the Russian version.



# Training Facilities



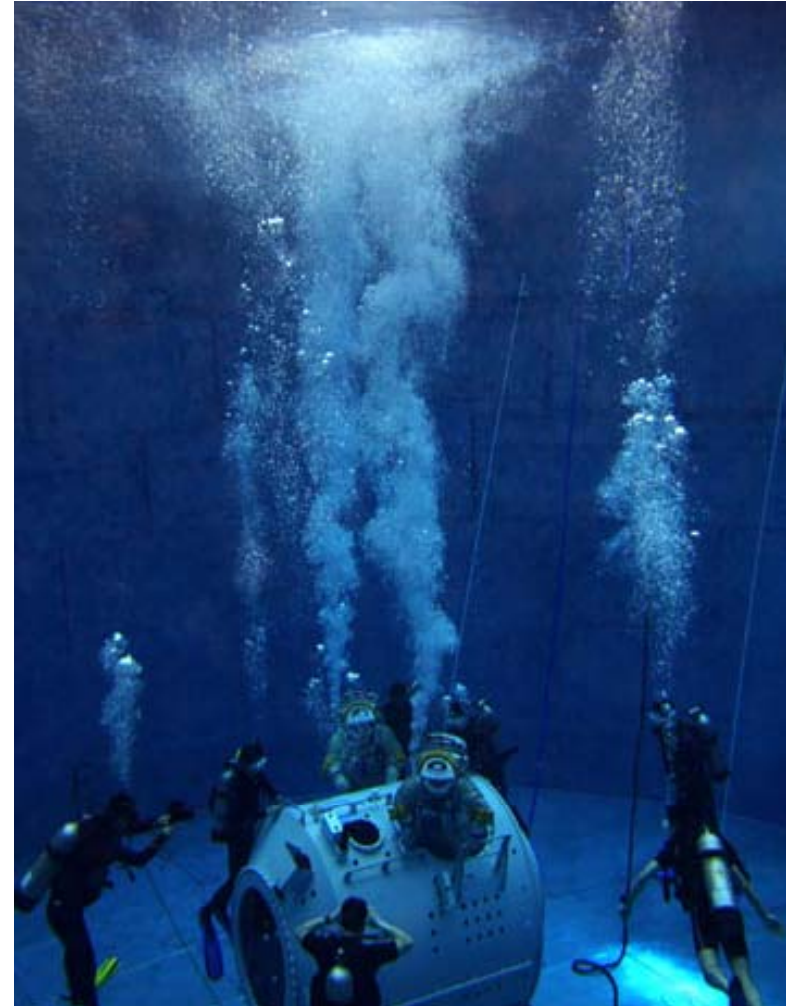
- Training facilities
  - The high fidelity training facilities and simulators are very similar to Russian training facilities.
  - They have thermal vacuum chambers that look the same as the ones in Russia.
  - They built a hydrolab to do their EVA training, very similar to one in Russia. It is 23 meters in diameter and 10 meters deep. It is made to hold larger vehicles and larger mockups for future plans.







# Training at Hydrolab in China





# Chinese EVA



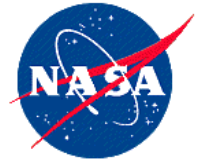
- Video of the EVA can be seen on these links:
- <http://www.youtube.com/watch?v=UhjnT8Oqhjk>
- <http://www.youtube.com/watch?v=0UJJp6AWZfw>

## Notes from video:

- He is struggling with the hatch. Crewmember does not have anything to hold onto while he is grabbing the hatch handle.
- Bad planning with the shortage of handholds.
- EVA mirror on wrist like on the EMU to see the DCM controls and gauge.
- Even a slight air pressure on the door makes it hard to open.
- Lots of stuff flying out of the airlock.
- Russian hatch has two handles in the middle to grab onto. The Chinese hatch has different handles.



# Chinese EVA



Chinese taikonaut Zhai Zhigang getting the test sample of solid lubricant placed outside the orbital module



Note: There are many cables from the Orbital Module to the Descent Module which some may have to be disconnected before undocking.



# Chinese Spacesuit Characteristics

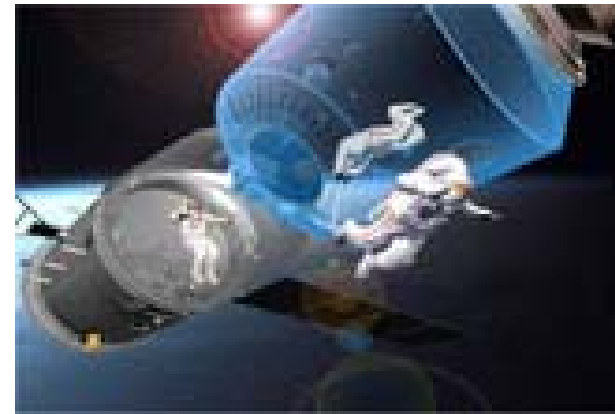
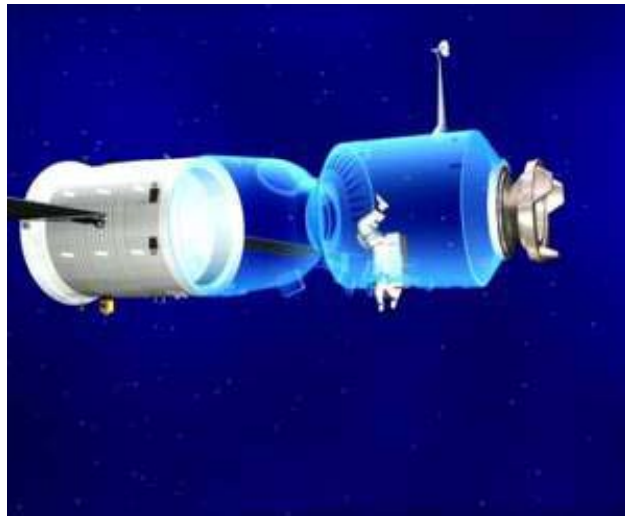


## Spacesuit Characteristic Claims

1. The suit, weighing 120 kilograms (264 pounds), is made of "advanced synthetic fibers" and is so supple that an astronaut could bend over and pick up a coin while wearing it, Chinese state-run media reports have said.
2. Chinese spacesuit, cost up to 4.4 million dollars each.
3. "The surface material, made up of advanced synthetic fabric, boasts characteristics such as fire and radiation resistance that meet spacewalk requirements," the newspaper quoted Pang Zhihao, a Chinese space expert.
4. The surface material should protect astronauts from extreme heat on the side exposed to the sun at temperatures more than 200 degrees Celsius, and extreme cold on the shaded side, said Pang. The material can also protect astronauts from injury from floating micro-meteoroids in space, Pang added.
5. With a flexible limb joint design, the suits can be donned by occupants ranging from 1.60 to 1.80 meters tall (5'3" – 5'11").
6. It took 11 hours for unpacking and assembling of the EVA suits in the orbital module. Pre-breathe time is approximately 100 minutes.



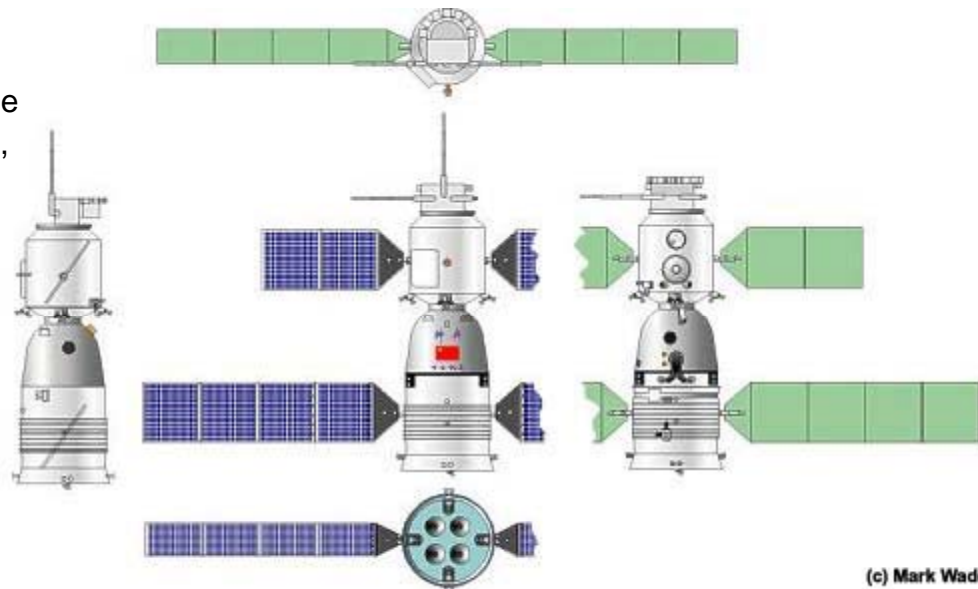
# Shenzhou spacecraft



Chinese taikonauts move from the re-entry module of the Shenzhou-7 spacecraft to its orbital module, starting preparations for China's first space walk.

## Shenzhou spacecraft

The Long March 2F has improved guidance and control equipment. They've upgraded the engines and have new computer systems onboard.



(c) Mark Wade





# Shenzhou 7 vs. Soyuz



- Shenzhou (meaning “Divine Vessel”) is based on the well-proven Russian Soyuz design. Like the Soyuz, the Shenzhou too consists of three modules. A service module with the spacecraft’s propulsion systems, instrumentation and a set of solar panels come at the rear. In the middle is the re-entry capsule in which up to three astronauts can travel to and from space. Right in front is the orbital module that provides living space for the astronauts during the mission.
- But the Shenzhou is not a copy of the Soyuz. It is larger , and the spacecraft and its systems have been designed and manufactured by the Chinese to meet their requirements. For instance, its orbital module, unlike that of the Soyuz, is equipped with a propulsion system and solar panels. So even after the astronauts return to the earth in the re-entry capsule, the orbital module can be operated from the ground by remote control for several months more.



# Launch Entry Suits



- The Chinese crew launch in the Sokol launch entry suit.



Shenzhou Pressure Suits



Soyuz Sokol Suits

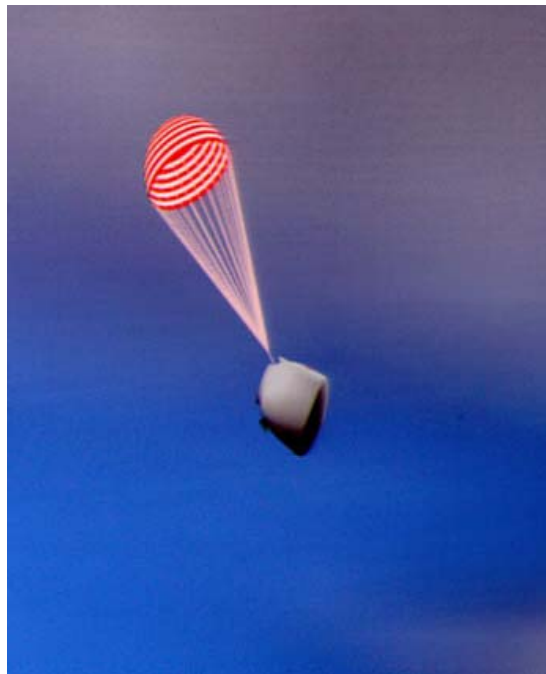




# Earth Entry



- China mobilized about 300 search and rescue workers, including air and land forces, to meet the Shenzhou-7 crew at the main landing zone on Sunday.





# Landing



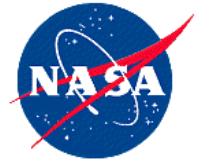
- Module parachuted down on a grassland at Siziwang Banner at 5:37 p.m., soldiers and experts were already on the way to the landing site by car or by helicopter.



China's Shenzhou-7 spacecraft's re-entry module lands safely in north China's Inner Mongolia Autonomous Region.



# Re-entry module on ground



Technicians help the three Chinese taikonauts get out of Shenzhou-7 re-entry module





# Re-entry module on ground



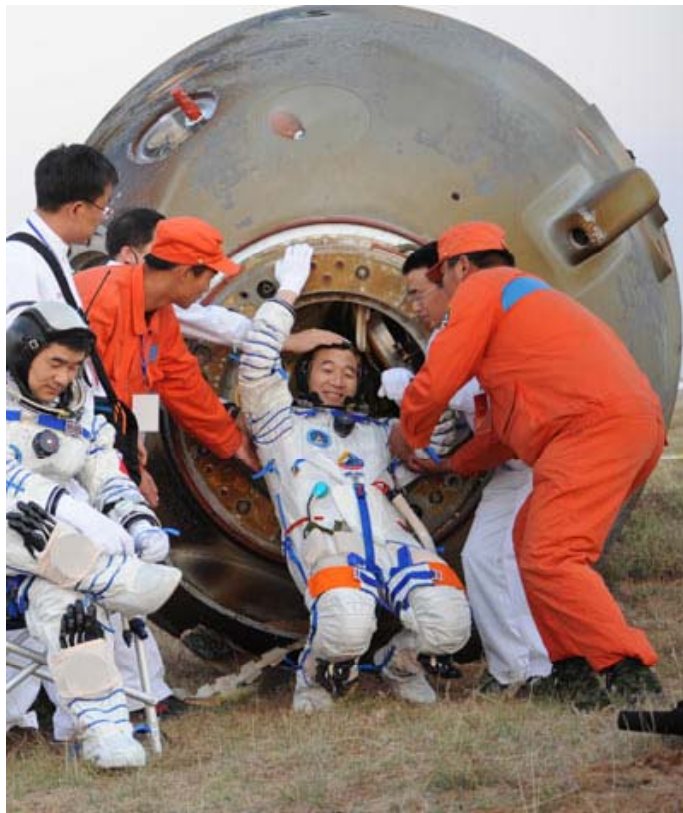
Chinese taikonauts get ready to get out of Shenzhou-7 re-entry module







# Re-entry module on ground





# 13 Monitoring Stations



- The network is made up of thirteen monitoring and controlling stations and ships, deployed in different parts of the world. They include four "Yuanwang" vessels on the three big oceans, five stationary measuring stations in the territory of China, one mobile measuring station and three monitoring and controlling stations in other countries, including a new one in Malindi of Kenya. The additional Malindi station in the monitoring blind zone between Namibia and Karachi will help increase the monitoring time by about four minutes.



China Launches New Space Tracking Ship to Serve Shenzhou VII



## Future Plans of Chinese Space Program



- The nation plans to set up a "simple" space lab in 2011 and a manned space station in 2020.
- There are preparations for a moon landing, which they consider a political strategic move.
- Coming up in the near term will be two unmanned docking missions, and then a manned docking mission.



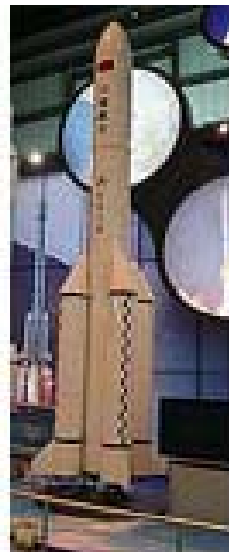


# Future Plans of Chinese Space Program



- **China's New Carrier Rocket To Debut In 2014**

China's new generation of carrier rocket, the Long March 5, with a maximum payload capacity of 50,000 lbs, (same as Space Shuttle) will come into use in 2014, said an official with the China Academy of Launch Vehicle Technology on Sunday. The rockets will be made in Tianjin and launched in Hainan, said Liang Xiaohong, vice president of the academy and a member of the 11th National Committee of the Chinese People's Political Consultative Conference (CPPCC), the top political advisory body.

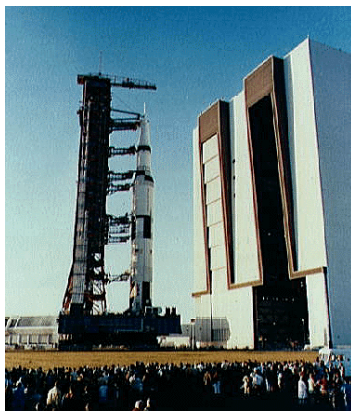




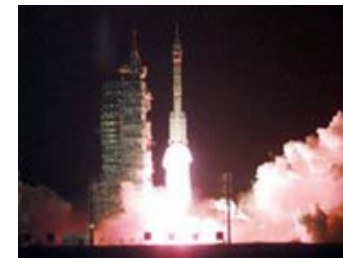
# Vehicle Assembly Building



Chinese VAB

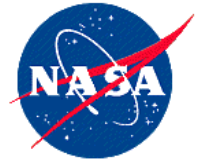


NASA VAB





# Launch Rocket



Chinese Long March Rocket compared to Russias Soyuz Rocket  
are similar in design



Chinese Long March Launch System



Russian Soyuz Launch System



# Chinese EVA Mission Specifics



- **Official Name:** ShenZhou 7
- **Mission Crew:** ZHAI Zhigang, JING Haipeng, LIU Boming
- **Launch Vehicle:** CZ-2F
- **Launch Site:** Jiuquan Satellite Launch Centre
- **Launch Time:** 25 Sept 2008 21:10:04 Beijing Time (01:10:04 GMT)
- **Landing Location:** Siziwang Banner Landing Site
- **Landing Time:** 28 Sept 2008 17:38 Beijing Time (09:38 GMT)
- **During:** 68 hours 27 minutes
- **No. of Orbits:** 45

The spacesuit can support an EVA mission of up to four hours and can be re-used at least five times.

Russian advisers were involved in the EVA training and also provided technical assistance during the EVA mission.



# Future Plans of Chinese Space Program



- **Griffin Predicts Chinese Moon Mission By 2015.**
- [Flight International](#) (1/21, Coppinger) reports, "China could attempt a manned circumlunar flight in 2015, says outgoing NASA administrator Michael Griffin." Griffin made the comments while addressing employees. Griffin "was asked about the likelihood of the Chinese going to the Moon -- and whether that could encourage the US government to increase NASA's funding." Griffin reportedly declined to comment on the funding issue. "Griffin said he could envisage a Chinese Moon mission by 2016 that uses the country's new Arianespace Ariane 5-like Long March 5 rocket in a double-launch scenario. ... They would dock in LEO and the Earth departure stage would send the Shenzhou round the Moon."



# Future Plans of Chinese Space Program



**01 March 2009**

## China Moon Probe Ends Mission: *Space Station Plans detailed*

China's first probe sent to the Moon has ended its mission.

**According to the Xinhua news service, Chang'e-1 smashed into the lunar surface under remote control at 3:36 p.m. Beijing time on March 1st.**

Chang'e-1 -- named after a legendary Chinese moon goddess -- was dispatched to the Moon on October 24, 2007 -- billed by China as the first phase of a three-step Moon exploration strategy. The planned impact of the lunar orbiter on the Moon has helped hone skills needed for a follow-on robotic landing upon the lunar surface.

Xinhua noted sources within the State Administration of Science, Technology and Industry for National Defense concerning the impact time of the craft on the Moon, carried out by two Earth observation and control stations in China.

China's lunar plans call for a soft-landing on the Moon of a rover around 2012. A third phase of the plan would use another rover to snag lunar samples then return those materials to the Earth in 2017.

Chinese space scientists were delighted with the success of Chang'e-1. Part of its scientific output was to relay a first full map of the Moon.

Meanwhile, both India and Japan continue to have active spacecraft in orbit around the Moon. NASA's Lunar Reconnaissance Orbiter is now targeted for launch on May 20.

It has also been reported that China will launch a space module in late 2010 -- calling it "Heavenly Palace-1" -- a step toward building a larger space station. The module would weigh over 8 tons, according to news sources in Beijing, with a Shenzhou-8 spacecraft docking to the Heavenly Palace-1 early in 2011.



# Future Plans of Chinese Space Program



## Reports: China to Launch Second Moon Probe in 2009

China is planning to launch a second spacecraft to explore the moon even as its first lunar orbiter continues to map the lunar surface, the country's state-run media has reported.

The new probe, Chang'e 2, is slated to launch sometime in 2009, according to reports by the *Xinhua News Agency* and *China Central Television*. Ye Peijian, lead designer and commander of China's Chang'e 1 lunar orbiter currently circling the moon, announced plans for the second mission, but provided little additional details, *Xinhua* reported.

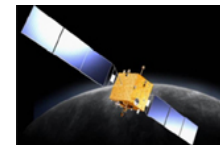
Chang'e 1 is a [5,180-pound \(2,350-kg\) satellite](#) that launched Oct. 24 from China's Xichang Satellite Launch Center in the southwest Sichuan Province to spend about one year mapping and studying the moon. The spacecraft is based on China's Dongfanghong 3 telecommunication satellite platform and equipped with eight primary instruments, though Ye did not state whether its Chang'e 2 successor would be based on a similar design.

But the [success of Chang'e 1 to date](#), especially its survival of a Feb. 20 eclipse that starved its power-generating solar panels of sunlight, have been under discussion, according to a series of reports by *Xinhua* and other outlets.

"Chang'e 1 passed the test," *Xinhua* quoted Ye as saying after last month's total lunar eclipse. The eclipse forced the lunar orbiter to consume about 40 percent of its overall battery power, less than the 60 percent expected before the eclipse, and left it out of contact with flight controllers in Beijing for about 49 minutes, *Xinhua* reported.

The eclipse left the lunar probe without direct sunlight for about 80 minutes, though it did fire its rocket engine to tweak its orbital path to minimize the time in shadow, Gu Shen, deputy director of Chang'e 1's measurement and control systems, told *Xinhua*.

China's Chang'e 1 spaceflight is part of a [three-stage plan](#) to explore the moon with orbiting spacecraft, rovers and ultimately a sample return mission.







# Sokol / Shenzhou LEA Suit



- Electrical cables are mounted on the right abdomen of the suit; on the left abdomen there are separate hoses for air and oxygen. Normally, an electric blower ventilates the suit with cabin air through the larger hose at the rate of 150 litres (5.3 cubic feet) per minute. If the cabin pressure drops below (8.7 psi) the air supply is automatically replaced with oxygen from pressurized bottles. Both air and oxygen exhaust through the blue pressure relief valve at the centre of the chest, this valve also regulates the pressure of the suit. This has the advantage of simplicity; the disadvantage of a high rate of oxygen consumption is considered acceptable given that it is only intended for emergency use.



Sokol Suit



Chinese Shenzhou LEA Suit