China's Tiangong Space Station (CSS) and Mengtian Dreaming of Heaven

On Nov. 29, 2022, the Shenzhou 15 mission launched from China's Gobi Desert carrying the second crew of three taikonauts to the now permanently crewed China Space Station (CSS). Six hours later, they reached their destination, China's recently completed space station, called Tiangong, "the heavenly palace". The three taikonauts replaced the existing crew that helped wrap up construction.
With this successful mission, China has become just the third nation to operate a permanent crewed space station.

One month earlier, on October 31, Beijing time, a Long March 5B launch vehicle was launched at the Wenchang Cosmodrome carrying the *Mengtian* laboratory module ("dreaming of the heavens") to the CSS, where it was successfully attached to the axial port multi docking port.
After a relocation maneuver on November 3, the Mengtian module changed the configuration to an T-formation in combination with the Tianhe and Wentian modules.

The repositioning of the Mengtian module marks the assembly completion of the T-shaped Chinese CSS, providing living and working space for the rotating crews.

Station module arrangement *of CSS as of December 2022: A rendering of the station with the Tianhe (core module) at center of picture, a Tianzhou (cargo carrier) on its aft port, the Wentian (lab module) to the left, the Mengtian to the right, and two Shenzhou spacecrafts,on its multi-docking hub.[1]*

Mengtian relocation *after initial docking from an L- to T-configuration:*

Click on Reference [2] and you will see the rotation of the Mengtian into its final position.

The axial port of Mengtian is fitted with rendezvous equipment and first docked to the axial forward multi-docking port of Tianhe. A mechanical arm known as the indexing robotic arm, moved Mengtian to a portside port of the central docking port. In addition to this arm used for docking relocation, the Chinarm on the Tianhe module can also be used as a backup in place of the indexing robot arm.

The Mengtian Module [3]
The Mengtian laboratory module is the third module of the Chinese Space Station and the second scientific experimental module, with a total length of 17.88 meters, a diameter of 4.2

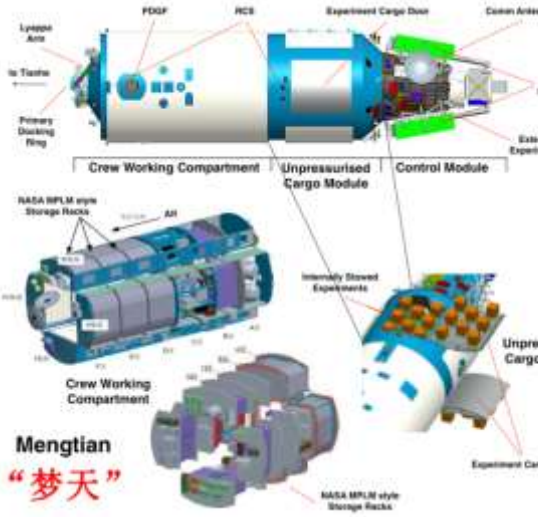
meters, and a launch mass of about 23 tons. The Mengtian module consists of a pressurized crew working compartment, an unpressurized cargo storage area with airlock, and a service control module, with a large area of retractable flexible solar panels for energy supply.
The Mengtian laboratory module is mainly used to conduct scientific and application-specific microgravity experiments and participate in the management of the space station complex. An “auto-door” cargo airlock can support automatic loading and unloading of cargo. The module supports scientific experiments inside and outside the module, and provides the crew with a working space of about 32 cubic meters, containing 13 racks in the pressurized compartment and 37 standardized external multi-purpose containers for application tasks, accessible via the automatic airlock door.

To facilitate the ins and outs of larger cargo and payloads, the unpressurized compartment and airlock cabin of Mengtian is equipped with two square hatches, an internal one and an external one functioning like a revolving door. Plus, the external hatch is electrically driven, which is the first of its kind to be used in global space station history. “This auto-door reduces the astronaut's workload and increases efficiency when transporting cargo out of the cabin”, said Bai Hemin, a designer for the station system at the Shanghai Academy of Spaceflight Technology (SAST).[4] [5]

With this larger door, Mengtian is capable of releasing small satellites into space. "Astronauts can install the satellites on a payload transfer device, depressurize the airlock, and then transfer them out of the cargo bay," said Meng Yao, a designer of Mengtian.

"The robotic arm outside the space station will grab the satellites and then catapult them in specified directions with a spring mechanism," said Meng from the SAST.

Crew of Shezou 14 mission in the Mengtian Lab Module [XU BU/FOR CHINA DAILY]



Right: Mengtian configuration with ISS compatible standard Experiment racks. [1]

Unlike traditional doors with a circular and flat sealing system, the electric outer door has a square sealing structure adapted to the module curvature for the first time (see Mengtian configuration above, right). The auto-door is equipped with a special pull rope. It is non-metallic and has extremely high strength. With the same weight, the tensile strength is about 6 times higher than that of ordinary steel wire.

This automatically operating electric door is the first of its kind and is operated by a controller in the module. To open, the square door is rotated approximately 90 degrees around the central axis to ensure the cargo passage is fully open. After the cargo is released, the door closes automatically.

Mengtian Research
Eight scientific laboratory standard racks for 7 research areas were developed by the Chinese Academy of Sciences:
(1) Supercold atomic physics, (2) High-precision time-frequency, (3) High-temperature materials science, (4) Two-phase flow cooling system, (5) Fluid physics, (6) Combustion science, and (7) Online maintenance and tuning.

Three first experimental projects are carried out in cooperation with ESA using the innovative two-phase flow cooling system rack to expand the international influence and enhance application research of the Chinese space station.

The measurements of high-precision time-frequency laboratory rack will be integrated into the world's most accurate space-time-frequency system operating in orbit by combining atomic clocks with different properties.
In the future, scientists will be able to use ultra-high-precision time-frequency signals to conduct basic physical research and support corresponding theoretical investigations such as the theory of relativity. In addition, by comparing and measuring atomic clocks on Earth, the accuracy of China's atomic time system can be improved. Chinese scientists can also participate in the calibration of the world’s atomic clock time signals. It is intended to close the technical gap in comparing intercontinental terrestrial optical clocks and to support the change in the definition of the unit of time "second".

The combustion experimentation system installed in the module can support combustion experiments with three types of fuels: liquid, solid and gas. The combustion science experimentation system will be the first worldwide to detect velocity fields in a microgravity environment.

The high-temperature materials science rack can carry out scientific experiments on growth and development of high-temperature metals and alloys, advanced semiconductor materials and functional crystal materials. Among them, real-time observation of X-ray transmission imaging is another innovative feature of the laboratory rack.
It is the first time that an X-ray experimental device is operated on a space station, enabling dynamic real-time imaging and observation of the melting and solidification process of materials.

In order to be able to better investigate the law of motion of liquids in the microgravity environment, the Mengtian experimental module is specially equipped with a specialized fluid physics laboratory rack.

Liu Guoning, deputy chief engineer of the space application system of the Chinese Academy of Sciences, said these eight scientific laboratory cabinets allow scientists to conduct research in areas such as microgravity fundamental physics. It is expected to achieve international-level scientific achievements in the above areas, promote application and technology transfer, and further improve the overall level of China's space science.

Comparison of Mengtian with Columbus

Type	Mengtian	Columbus
Length	17.88 m	7 m
Diameter	4.2 m	4.4 m
Total mass	23,000 kg	10,300 kg
Payload total mass		2,500 kg
Total on-orbit mass		12,800 kg
Experiment racks	7 (1) Supercold atomic physics (2) High-precision time-frequency (3) High-temperature materials science (4) Two-phase flow cooling system (5) Fluid physics (6) Combustion science (7) Online maintenance and tuning	4 (1) Fluid science lab (2) EU physiology modules (2) BioLab (4) EU drawer rack (5) EU storage rack
External Experiments:	37	15

In summary, China developed with the China Tiangong Space Station (CSS) a permanently crewed laboratory at eye level with the International Space Sation (ISS) and is promoting international cooperation.

China is implementing its first batch of international cooperation programs on board the Tiangong CSS, and has uploaded some experiments already, like the experiment POLAR-2, an international effort led by the University of Geneva to study distant gamma-ray bursts, arranged through a United Nations program called "Access to Space for All,"
Foreign astronauts are welcome to Tiangong "*to make greater contributions to the shared future of mankind*", Chinese Foreign Ministry spokesperson Wang Wenbin said in an interview (April 2022) "*which cannot be achieved without the cooperation of countries around the world*".

"China has always adhered to the principles of peaceful and mutual-beneficial use and common development of space, signed cooperation agreements with France, Germany, Italy, Russia, Pakistan, as well as space agencies and organizations such as the United Nations Office for Outer Space Affairs (UNOOSA) and the European Space Agency", Wang said. "China's space station is the first project of its kind that is open to all UN member states", Wang further noted, "and there are already nine projects involving some 17 countries and 23 entities selected among the first batch of scientific experiments to be carried out on the station". [6]

References:
[1] Figure of CSS station elements as of December 2022
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[4] Auto-door design http://en.qstheory.cn/2022-11/01/c_826032.htm

[5] Auto-door: https://news.cgtn.com/news/2022-11-01/China-Space-Station-What-s-new-for-Mengtian-1eBwCwSXT8I/index.html
[6] Summary Status and Interview https://www.globaltimes.cn/page/202204/1259653.shtml