Union of Concerned Scientists

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UCS Backgrounder

Chinese Shenzhou 7 Companion Satellite Poses No Military Threat

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News organizations recently reported that as part of their mission, Chinese Shenzhou 7 astronauts this week will release a small soccer-ball sized, "companion" satellite with a camera that will maneuver around the Shenzhou space capsule to broadcast China's first space walk. The satellite will "float several feet away" from the Shenzhou capsule, so that the two crafts orbit in "tight formation."[2]

An article on the Space Travel Web site reported: "Sheng Jie, deputy general designer of the Shenzhou-7 launch system, said the satellite was for civil scientific research to improve China's communication technology. 'The key part of this research is to make sure the small satellite keeps a safe distance from the Shenzhou spacecraft,' Sheng said. Control of the satellite was a challenge for the space survey and control system."[3]

Besides the Space Travel piece, there have been few details in the Western press about the satellite. Nevertheless, Chinese development of a mini-satellite that could maneuver around a larger satellite has raised some questions about its potential military uses.[4] However, a Union of Concerned Scientists (UCS) analysis of the satellite's guidance mechanism indicates that it poses no threat. It can only maneuver at close range around a "cooperative" satellite, and therefore could not be used for "proximity operations" around another country's satellite.

The Shenzhou "CompanionSat"

According to Chinese press reports and animations, the companion satellite will be carried into space mounted on the top of the Shenzhou's orbital module, and will be released by a spring mechanism (Figures 1 and 2). The satellite will carry a camera with a mass of less than 10 kilograms that has wide-angle and zoom lenses that reportedly can take images from distances of 4 meters to 2 kilometers.

Press reports originally said the satellite would be released before the space walk and would broadcast pictures of the walk, but out of safety concerns for the astronaut, it reportedly will not be released until after the space walk.

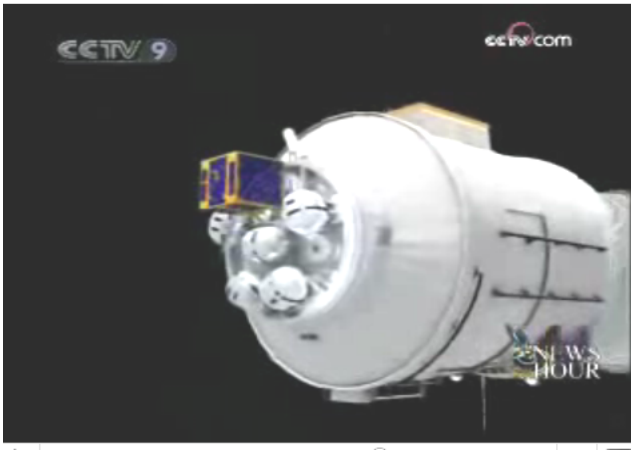

Figure 1: The CompanionSat mounted on the Orbital Module during launch (image credit: CCTV-9, http://www.youtube.com/watch?v=FbJJj2jw8Fc

The satellite appears to be roughly cubical, about 0.4 m on a side; in comparison, a soccer ball has a diameter of about 0.25 m. Its sides are covered with solar panels. Its total mass reportedly is less than 40 kg. It has small thrusters for maneuvering, probably using several kilograms of hydrazine fuel or compressed gas. Based on other Chinese satellites, it probably has eight to 12 thrusters, each capable of providing a less than 1 newton of thrust.

The satellite was designed and manufactured by the Chinese Academy of Science's Satellite Engineering Center. The chief designer is Zhu Gencai.

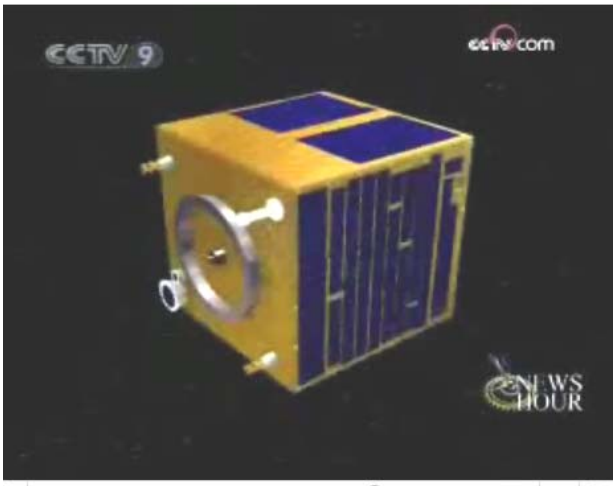

Figure 2: The CompanionSat after being released from the Orbital Module (image credit: CCTV-9, http://www.youtube.com/watch?v=FbJJj2jw8Fc)

Reports in the Chinese press suggest that the satellite will be used as a "client terminal" for China's Tianlian 1 data relay satellite, which China launched into geosynchronous orbit earlier this year. The goal is to have relay communication satellites in orbit allowing China to communicate with its manned spacecraft over a larger part of its orbit around the Earth. Without such satellites, the astronauts would only be able to communicate with ground control when they are in sight of a ground communication station. Since China does not have such stations spread around the globe, without such a satellite any communication with the astronauts would be greatly limited. In previous Chinese space launches, for example, the astronauts reportedly could only communicate with the control center about 12 percent of the time.[5]

China's goal appears to be to develop a small satellite that can function as an additional communications relay node between the space capsule and the ground or the Tianlian 1 satellite.

Operation of the CompanionSat

After the astronauts release the satellite from the Shenzhou space capsule, it reportedly will move away to a distance of 100 to 200 km from the spacecraft. When the astronauts are ready to return to Earth, the spaceship will split into three parts: the re-entry module, which carries the astronauts back to earth; the orbital module, which is where the astronaut exits for the space walk; and the service module, which is attached to the opposite end of the re-entry module and contains the main propulsion system for the space capsule. After separation, the orbital and service modules eventually will decay and burn up during re-entry into the atmosphere. Neither will be carrying large amounts of toxic chemicals.

Once the orbital module is separated from the re-entry module, the ground station will command the CompanionSat to maneuver back to the orbital module and maneuver around it. At the end of the mission, it also will burn up during re-entry.

For a satellite to be able maneuver around another satellite at close range, it needs very accurate information about its position relative to that second satellite so that it can calculate how to maneuver. In this experiment, it appears that relative information is determined in the ground station by differential GPS, which means comparing signals from GPS receivers on the two satellites.[6] The GSP signals from the CompanionSat and the orbital module will be sent to the ground station, which by comparing them can determine the relative position of the two objects to an accuracy of centimeters or better -- much better than it can use the GPS signals to determine the absolute position of either satellite. The ground station then calculates the required maneuvers and sends them to the CompanionSat.

As a result, the relative guidance requires active communication with or between the two satellites, and the CompanionSat cannot carry out the relative guidance on its own, which is what it would need to do if it were maneuvering around a non-cooperative satellite. Therefore, this kind of guidance procedure cannot be used for high-precision guidance to attack or maneuver closely around another country's satellite.

Testing of this kind of cooperative maneuvering is relevant not only to data relay, but Chinese reports say that it is also relevant to the next two Shenzhou missions, which will involve docking with an orbital module as part of establishing an orbiting space lab.

Appendix: The HummerSat-1A Nano-satellite

We know more about another small maneuvering satellite that China is developing, the HummerSat-1A, than the CompanionSat.[7] The HummerSat-1A is a 30-kg satellite equipped with a camera and on-board propulsion, which was developed as part of a experiment to demonstrate formation flying between satellites. It was built by a unit of the Chinese Academy of Space Technology (CAST), which also developed the Shenzhou space capsule.[8] The satellite is an octagonal cylinder (see Figure 3) with a diameter of 0.4 m and a height of 0.175 m, making it roughly the size of soccer ball (which is approximately 0.25 m in diameter).

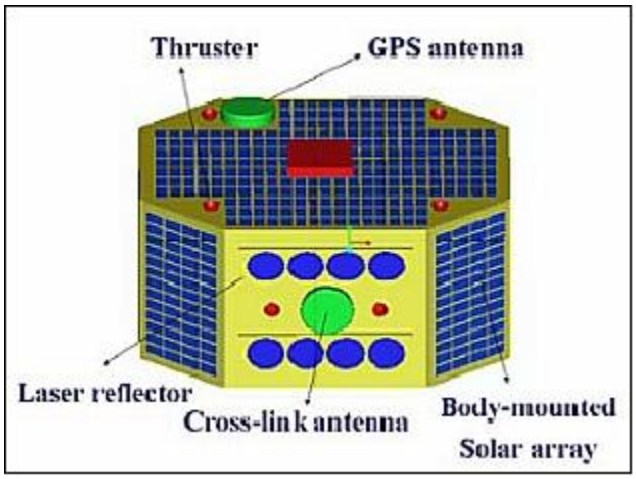

Figure 3: The HummerSat-1A (image credit: DFHSat)

For maneuvering and controlling its orientation, the HummerSat-1A has 12 small thrusters, each capable of providing a tiny 0.03 newtons of thrust. It has surface-mounted solar cells that reportedly give an average power of about 5 watts.

The satellite is intended to be part of the HummerSat-1 mission[9] (named after "hummingbird" and formerly called Minisatellite-1), in which the 130 kg HummerSat-1 satellite releases the smaller satellite and then flies in close formation with it to test crosslink communication between the two satellites, as well as relative navigation, guidance and control. There is considerable interest in many countries in developing the capability to have satellites fly in formation, since collections of small satellites may be able to carry out the functions of a large satellite, but with various advantages. For example, if one satellite in the formation fails, the rest could continue to operate, and the failed satellite could be replaced much more easily and cheaply than having to replace one larger satellite.

For the HummerSat mission, the small satellite has a structural mass of 25 kg and carries a 5 kg camera.

In the HummerSat experiment, the relative guidance also is handled by differential GPS. In this case, the guidance is done on the larger HummerSat-1, as shown in Figure 4. This diagram shows that the smaller satellite sends the information from its GPS receiver through the cross-link to the larger satellite. The larger satellite compares that information with its own GPS receiver, computes the maneuvers the smaller satellite should make, and sends that information back to the small satellite's thrusters. As a result, the HummerSat-1A, like the CompanionSat, does not have the ability to do its own guidance and control calculations.

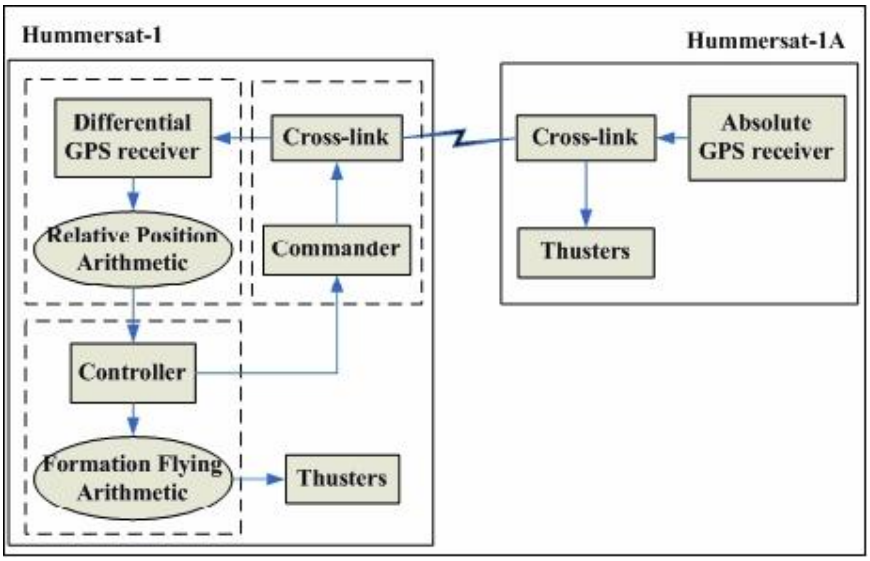

Figure 4: Guidance process for the HummerSats (image credit: DFHSat)

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Founded in 1969, the Union of Concerned Scientists is the leading science-based nonprofit organization working for a healthy environment and a safer world. The organization is headquartered in Cambridge, Massachusetts, and also has offices in Berkeley, Chicago and Washington, D.C. For more information, go to www.ucsusa.org.

Endnotes

[1] David Wright is co-director of and a senior scientist in the Global Security Program at the Union of Concerned Scientists. Gregory Kulacki is a senior analyst and China Project manager for UCS's Global Security Program.
[2] See, for example, M. Magnier, "China's latest manned rocket mission to include spacewalk," Los Angeles Times, September 25, 2008. www.latimes.com/news/printedition/asection/la-fg-space25-2008sep25,0,7772496.story; G. Covault, "U.S. and China Resume Space Cooperation Talks, Aviation Week and Space Technology, September 5, 2008, www.aviationweek.com/aw/generic/story_generic.jsp?channel=awst&id=news/aw090808p2.xml&headline=U.S.%20and%20China%20Resume%20Space%20Cooperation%20Talks; L. Hidalgo Whitesides, "The New Red Scare—Avoiding a Space Race With China," http://blog.wired.com/wiredscience/2008/09/the-new-red-sca.html.
[3] "Experts dismiss concerns over China's manned space program," Space Travel, September 23, 2008, www.space-travel.com/reports/Shenzhou_Astronauts_Arrive_At_Launch_Center_999.html.
[4] D. Cyranoski, "China's third manned space shot prepares for launch," Nature, September 22, 2008, www.nature.com/news/2008/080922/full/news.2008.1123.html?s=news_rss.
[5] Tianlian-1, http://en.wikipedia.org/wiki/Tianlian-1.
[6] Differential GPS is a technique in which two GPS receivers can compare their signals and determine the relative position of the two receivers to much higher accuracy that either receiver can determine its absolute position. Differential GPS can give relative locations of two objects to centimeter accuracy or better, depending on the separation of the two objects.
[7] H.J. Kramer, "HummerSat-1," http://directory.eoportal.org/presentations/6146/15541.html.
[8] The unit that develops and builds small satellites is DFHSat (DFH Satellite Co.).
[9] Xiaomin Zhang et al., "First micro-satellite and new enhanced small satellite series in DFH Satellite Co. Ltd.," *Acta Astronautica* 61 (2007), 234-242.