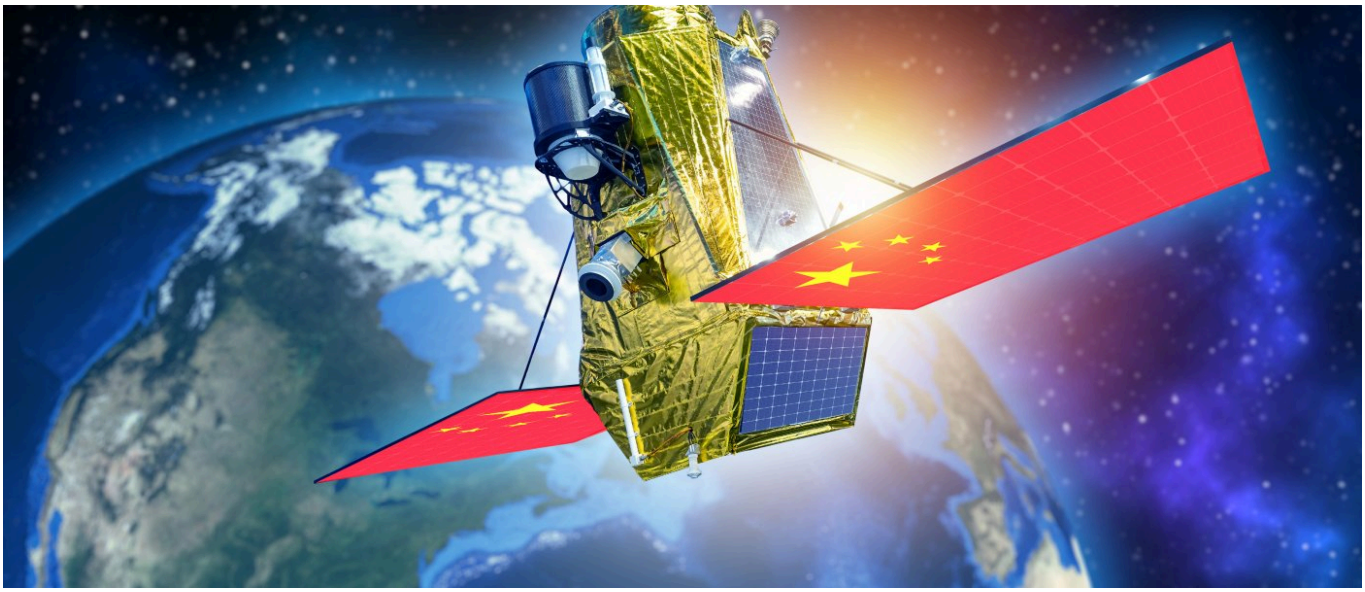
No Place to Hide: A Look into China's Geosynchronous Surveillance Capabilities



Critical Questions by **Clayton Swope**

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China launched a remote-sensing satellite called Yaogan-41 into geostationary orbit (GEO) on December 15, 2023. Analysts expect the satellite to settle into a position that would allow continuous surveillance of the Pacific and Indian Oceans, as well as Taiwan and Mainland China. Paired with data from other Chinese surveillance satellites, Yaogan-41 could provide China an unprecedented ability to identify and track car-sized objects throughout the entire Indo-Pacific region and put at risk numerous U.S. and allied naval and air assets operating in the region.

Q1: What is Yaogan-41?

A1: Officially, the Chinese government says that Yaogan-41 is a civilian high-altitude optical remote-sensing satellite intended for crop yield estimation, environmental management, weather forecasting, and disaster prevention. However, Western observers assess that Yaogan-41 is primarily a military reconnaissance satellite, as the Yaogan program supports the space component of the People's Liberation Army (PLA). China has successfully placed 144 Yaogan surveillance satellites into

orbit since the start of the program in 2006. Translated into English from Chinese, Yaogan literally means remote sensing.

Once Yaogan-41 reaches its intended position it will become the fourth Chinese optical surveillance satellite in GEO. Notably, Yaogan-41 is much larger and heavier than its three optical predecessors. Whereas these other satellites were launched by the Long March 3B rocket, capable of lifting 2,000 kilograms (kg) into GEO, Yaogan-41 used China's largest rocket, the Long March 5, capable of launching a 4,500 kg payload. Additionally, Yaogan-41's payload fairing was 50 percent longer than the usual Long March 5 fairing, making the particular Long March 5 that launched Yaogan-41 China's tallest rocket.

Experts assume that Yaogan-41 is also more capable than its three GEO peers, whose highest optical resolution is believed to be around 15 meters. This resolution is enough to detect and likely classify large ships. If Yaogan-41's builders were able to incorporate technology Chinese researchers expected to perfect by 2020, the optical resolution of Yaogan-41 might approach 2.5 meters. This resolution would be enough to identify and track car-sized objects, the equivalent to seeing a strand of hair from 800 meters away.

Q2: How is Yaogan-41 different from most surveillance satellites?

A2: Most remote-sensing satellites, including those from the United States, Europe, Russia, and China, operate in low Earth orbit (LEO), which is up to 3,000 kilometers (km) in altitude. The majority of satellites currently in orbit and the bulk of surveillance satellites operate in LEO because it is much easier and cheaper to launch satellites into LEO than into higher orbits. Additionally, for an equivalently sized sensor, placing that sensor in LEO produces sharper resolution because it is closer to the objects on Earth. LEO satellites, however, lack one characteristic that can be crucial to surveillance: persistence.

A typical satellite in LEO orbits the Earth in less than two hours, thus only seeing a given spot on Earth for a few minutes. Additionally, due to orbital mechanics, it may take hours or days for that satellite to revisit the same spot again. Though a constellation of satellites at lower orbits can provide persistency by reducing the revisit time, satellites in GEO orbit at the same rate as the Earth, which means they view the Earth as if it is not moving. Only GEO provides a satellite, like Yaogan-41,

with a persistent view of the same place. An additional advantage is that a GEO satellite can see almost half of Earth's surface from its 36,000 km altitude.

There are dozens of geosynchronous weather satellites, which are effectively very low-resolution remote sensing systems optimized to track large cloud formations and storms. However, only China and India operate high-resolution optical GEO satellites, but India's system carries a multi-spectral payload and not a visible light optical imager like its Chinese peers.

Q3: What are China's other GEO remote sensing satellites?

A3: China operates three other optical surveillance satellites in GEO. These three satellites are part of the Gaofen program, which has 29 satellites operating in LEO for a total of 32. Gaofen, which means high resolution, is part of the China High-resolution Earth Observation System (CHEOS), an ostensibly civilian initiative to assist in agriculture, disaster response, and environment monitoring activities. In addition to satellites, CHEOS operates near-space, airborne, and ground-based data collection and processing systems.

Though China provided significant details about the payloads for the first seven Gaofen satellites, which often included multiple sensors, including optical, hyperspectral, multispectral, and SAR capabilities, it has provided little information about subsequent satellites. The three Gaofen satellites operating in GEO are Gaofen-4, Gaofen-13, and Gaofen-13-02. Launched in 2015, Gaofen-4 was equipped with a 50-meter resolution electro-optical sensor and could capture three images per minute. While unconfirmed by China, experts believe that Gaofen-13, launched in 2020, and Gaofen-13-02, launched in 2023, can capture images with a resolution of 15 meters. Yaogan-41 is believed to be the successor to Gaofen-13 satellites.

In addition to these optical surveillance satellites, China operates one synthetic-aperture radar (SAR) satellite in GEO, called Ludi Tance-4 (Land Exploration-4 in English). Launched in August 2023, it is the world's first and, currently, only GEO satellite with a SAR payload. The resolution of Ludi Tance-4 is 20 meters. The advantage of SAR is that it can see through clouds and at night. Like the three Gaofen satellites and Yaogan-41, China claims that the Ludi Tance-4's mission is

purely civilian and aimed at providing information about land resources, disaster prevention and response, and forestry applications.

Q4: How will China use the Yaogan-41 capability?

A4: Unlike the United States, Europe, and Russia, China has emphasized the development and expansion of a high-resolution GEO optical and SAR surveillance capability. While there are civilian applications for such capabilities, those applications can generally be served by satellites operating at lower altitudes, which are easier and cheaper to reach and provide higher resolution images than GEO alternatives. Additionally, civilian applications such as agriculture, environmental monitoring, and disaster preparedness do not typically necessitate the extra costs associated with persistent coverage, as these applications have no movement detection and tracking requirements. Take for instance, the equivalent civilian U.S. and European satellite programs, Landsat and Copernicus, respectively, which both operate satellites in LEO.

Beijing, which probably assesses the greatest threats to its security and freedom of movement will come from the Indo-Pacific, has determined that it will pay a premium to obtain persistence and the ability to detect change in near-real time across the region. Using 50-meter resolution data from the Gaofen-4 satellite during a presentation at the International Astronautical Congress in 2016, China demonstrated it could identify ship trails, which form when ship exhaust interacts with clouds in the lower troposphere. Persistency also allows for real-time tracking, meaning that whatever China identifies it could track using the same capability.

Paired with its existing GEO optical surveillance capabilities, Yaogan-41's increased resolution means that China will be able to more easily identify and track U.S. and allied naval forces in the Indian and Pacific Oceans than it ever could before. This increased resolution may give China the ability to identify and track even smaller objects, not just ships, but airborne assets like fighter aircraft and bombers as well. While stealth technology can help aircraft evade detection by radar, it is less effective against optical sensors, as demonstrated when a Google Maps user spotted a B-2 stealth bomber flying over Missouri. Pairing data from Yaogan-41 and China's legacy GEO surveillance satellites with trained artificial intelligence (AI) algorithms would likely automate and speed up identifying objects of interest. For example,

the *New York Times* has already used a similar approach, pairing satellite imagery and AI technology to identify bomb craters in Gaza.

In addition to its optical and SAR GEO remote sensing satellites, China operates around 300 other surveillance satellites in lower orbits. China could use its persistent, GEO surveillance capabilities to locate, identify, and track U.S. and allied naval forces operating in the Indo-Pacific region. In real time, such tracking information could be used for tasking China's LEO surveillance satellites, which possess better resolution than GEO system, other intelligence collection platforms to gain more insights, or for targeting of long-range missiles, such as China's DF-21 and DF-26 anti-ship ballistic missiles.

Q5: What does this mean for U.S. national security?

A5: PLA leaders, whether for defensive or offensive planning purposes, seek to know the real-time locations of allied naval and air forces operating in the Indo-Pacific theater. Recognizing the limitations of ground-based radar, China has built up a capability over the last decade using GEO optical and SAR satellites—a combination unique to China and tailored to China's security concerns—for identifying and tracking threats. Yaogan-41 may significantly improve China's ability to detect and track not just naval vessels, but also aircraft. Paired with AI algorithms and sufficient computational resources, capabilities afforded by Yaogan-41 will make it more difficult for the United States and its allies to hide vessels larger than an automobile in the Indian and Pacific Oceans, other than submarines.

The United States and its allies have assumed China already maintained space-based surveillance capabilities that could keep fairly accurate tabs on large surface ships in the region. Going forward, they should consider that China might also be able to detect and track aircraft, even those far out into the Pacific Ocean and those designed to evade radar. Though GEO systems would be sitting ducks in any conflict, they could serve a vital role in a first-strike scenario by locating and aiding in targeting of key U.S. and allied platforms. While clouds will still obscure optical space-based systems and AI algorithms make mistakes, relentless advances in Chinese surveillance capabilities could soon produce an Indo-Pacific region where there is no place to hide.

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Tags

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