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China’s SJ-6 Satellites—Tactics, Techniques, and Procedures

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The recent on-orbit behavior of China’s Shi Jian 6 (SJ-6) satellite series, together with newly acquired commercial non-Earth imagery (NEI), helps expand our existing knowledge of the satellite constellations’ tactics, techniques, and procedures (TTPs).[1] As of January 2025, China appears to have completed a nearly ten-month demonstration of rendezvous and proximity operations (RPOs) with mostly three, but at times four satellites, one of which was SJ-6I (49961, SJ-6 05A). In discussion of these RPOs, U.S. Vice Chief of Space Operations General Michael Guetlein stated that the [Chinese] satellites were “practicing tactics, techniques and procedures,” which is consistent with prior research.[2]

This article will cover what we already know about the SJ-6 satellites, in terms of on-orbit behavior and payloads. This article will then present an argument that their recent engagement with the Shi Yan-24C (SY-24C) triplets shares important consistencies with past behavior. An examination across the SJ-6 series reveals similar trends in space environment detection payloads on the larger B satellites, and incrementally improving maneuverability of the smaller A satellites.[i] In particular, SJ-6’s primary mission seems to be TTP development for tipping and queuing for maritime surveillance, based on patent filings and newly acquired NEI. The secondary mission continues to be support of RPO tests for satellites outside the series. These consistencies reveal an evolving challenge, rather than an immediate threat.

The primary takeaway from this effort is that China space watchers need a perspective shift when tracking China’s progress as a pacing challenge.[3] The choice to focus on new launches and new on-orbit behavior in China’s SJ and SY satellites, without also looking back to check for potential similarities, sets one up for overlooking key information. Without identifying past similarities, one is more likely to interpret behavior as a near term threat, rather than an evolving and manageable challenge.[4]

A shift in perspective is necessary, especially in the case of watching China. For example, the eleven-year gap between launches of the last and most recent pair of SJ-6s is simply two Five-Year Plans (FYPs). From China’s perspective, it is absolutely reasonable that Chinese space operators iterated over two FYPs to launch improved payloads for the satellite pairs’ missions in

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[i] The A and B categorization follows the international satellite naming convention. This differs from the NORAD designation used by the U.S. Space Force. See Table 1, column 4.

2021. Whereas in the West, many have assumed eleven years is a sign that there is no relation between the recent and past pairs.[5]

Consistencies across the series

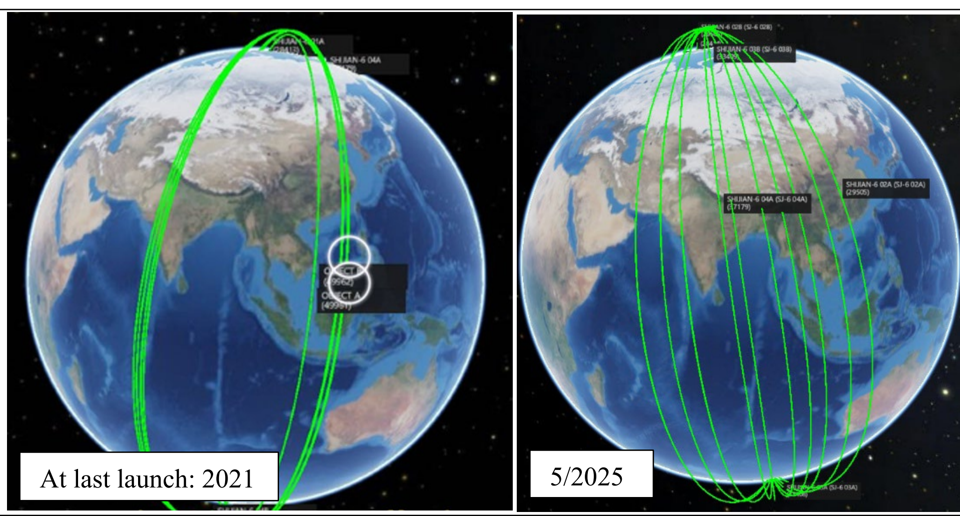
As of December 2021, there are ten SJ-6 satellites, always launched in pairs, for a total of five A satellites and five B satellites. Currently, they are all in a sun-synchronous (SSO) low-Earth orbit (LEO), paired into roughly similar altitudes. China always describes them as space environment detection satellites.[6]

Table 1: China's SJ-6 Satellites 5/1/2025*

Launch	Name	NORAD	International	Altitude	RAAN	Inclination	RPO Participant
12/2021	SJ-6 05A (SJ-6I)	49961	2021-122A	575	104	97	Yes
	SJ-6 05B (SJ-6J)	49962	2021-122B	537	110	97	
6/2010	SJ-6G	37179	2010-051A	532	124	97	
	SJ-6H	37180	2010-051B	573	115	97	Yes
10/2008	SJ-6E	33408	2008-053A	532	133	97	
	SJ-6F	33409	2008-053B	560	127	97	Yes
10/2006	SJ-6C	29505	2006-046A	533	152	97	
	SJ-6D	29506	2006-046B	576	146	97	
9/2004	SJ-6A	28413	2004-035A	557	141	97	
	SJ-6B	28414	2004-035B	534	137	97	

* Data collected from CelesTrak and represents same day, same time

Image 1: SJ-6 Series Orbital Setup During 2021 Launch and 5/1/2025*



* Images from spaceaware.io

All A satellites, manufactured by the Shanghai Academy of Space Technology (SAST), are smaller and have all significantly maneuvered while in orbit.[7] These maneuvers are probably related to the satellite's mission relative to the B satellite, rather than orbit maintenance maneuvers. On the other hand, all B satellites, manufactured by the China Academy of Space Technology's subcontractor Aerospace Dong Fang Hong Satellite Company (DFH), are larger and do not significantly maneuver while in orbit. They maintain their orbit.[ii] One or both of the A and B satellites has always had a payload from the China Electronics Technology Corporation (CETC), a company that specializes in electronics generally, not space electronics specifically.[8] China built the first six pairs of SJ-6s at the same time, based on Chinese media interviews with the Commander in Chief, Lu Zili [陆子礼], and probably only made minor hardware and some software modifications prior to their early launches.[9]

Like China's use of other SJ satellites, the SJ-6s have played a role in developing operational and systems best practices for national, not just military, satellites. Indeed, past research which used a linguistic analysis of the Mandarin characters for the SJ satellites also showed that the words used to describe the SJ series indicate that they are likely for TTP development.[10] The words used to describe the SY series, on the other hand, indicate that they are used for earlier-stage technology demonstrations, not later stage TTPs.[11] The same study found SJ and SY satellites launched before 2013 demonstrated on-orbit behavior consistent with the naming convention.[12]

Examining the SJ-6 series with this logic, the first six satellites probably enabled Chinese satellite operators to improve the two-satellite coordination of CETC and other companies' payloads for their primary mission. Then, after China launched the fourth pair of satellites in 2010, Chinese space operators proceeded to use the presumably newly integrated payloads to develop TTPs for LEO RPOs. In this case, the SJ-6 B satellites from the third (SJ-6F, launched 2008) and fourth (SJ-6H, launched 2010) pairs both held steady for a different satellite, SJ-12, to conduct less than 1 km RPOs in August 2010 and December 2010, respectively.[13] As a result of SJ-12 visiting two different SJ-6 B satellites, Chinese operators could certainly compare the improved 2010 payloads with the older 2008 payloads for future development.

The above review of previous SJ-6 behavior shows that there are important consistencies between the past and most recent (2021) pair. The three important consistencies across all SJ-6s include:

- The A satellite maneuvers more than the B satellite.
- The B satellite acts as a target for another satellite's maneuvers, either in series or out of series.

[ii] The most recent B satellite raised its orbit to realign with the rest of the SJ-6 constellation, which is not the same as leading a maneuver to engage in an RPO. It is, however, the most the satellites have had to adjust their orbits after launch.

- The SJ-6 pairs contribute to RPO TTPs for a satellite outside of their series. For example, SJ-12, and more recently SY-24C.

Differences in SJ-6I's (SJ-6 05A's) on-orbit behavior

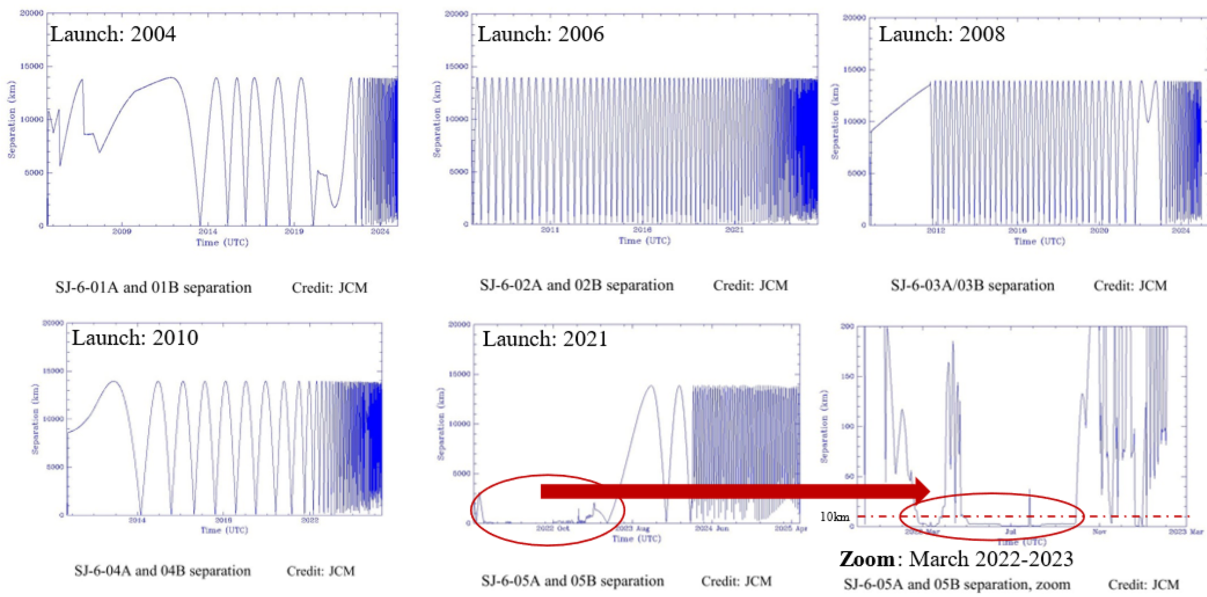
China launched the most recent pair of SJ-6s in December 2021, and initially into a lower orbit compared with the past SJ-6 launches. The newest satellites started off at approximately 470 km altitude and as of May 2025, are approximately 100 km higher, similar to the rest of the constellation, as shown in Table 1. In 2022, the A satellite (SJ-6I) practiced what would be the first less than 10 km intra-series RPOs for the SJ-6s. While in the past, the A satellite maneuvered relative to the B satellite, it did not, however, limit the separation distance to less than 10 km, as it did in 2022.

For example, Image 2 compares distances between the A and B satellites across each pair of SJ-6s. Jonathan McDowell of the Harvard-Smithsonian Center for Astrophysics provided two plots for the 2021 pair. The first mirrors the axis of the other launch charts. The second zooms in so that the axis shows more discrete distances. The red lines emphasize the zoomed timeframe and when the distance between the satellites was less than 10 km.

As can be seen, in 2022, the smaller maneuverable A satellite (SJ-6I) approached the larger B satellite (SJ-6J) within less than 1 km proximity several times over multiple months.[14] This is not different on-orbit behavior, it is an expansion of prior behavior. As discussed above, the A satellite has historically maneuvered relative to the B satellite, and it recently has moved much closer than in the past.

After the A satellite (SJ-6I's) completed its RPOs with the B satellite (SJ-6J) in October 2022, the two gradually raised their orbits.[15] They are now at similar altitudes with the rest of the constellation, as shown above in Table 1.

Image 2: Comparison of SJ-6 A/B Pair Separation Distance After Launch

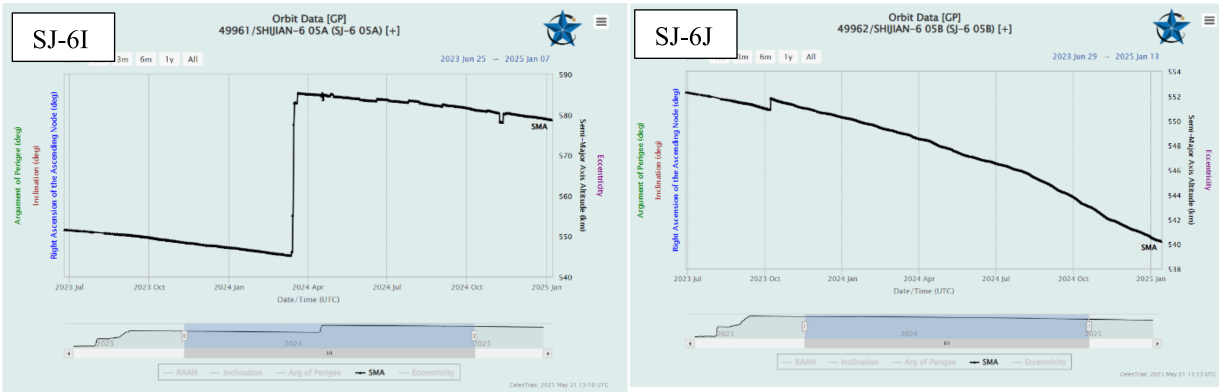


*Jonathan McDowell prepared the tables. CASI put them side-by-side with red emphasis.

An additional expansion of prior behavior occurred in 2024 when SJ-6I contributed to inter-satellite RPOs with the SY-24C triplets. Recall that it is not new for the SJ-6s to participate in RPOs with a satellite outside of their series. Rather, it is an expansion of behavior for the RPO participant to be the A satellite, not the B, and for the A satellite to engage in RPOs with more than one satellite outside the series.

Starting in early 2024, SJ-6I (the maneuverable A satellite) departed its proximity operations with SJ-6J, based on United States Space Force data.[16] It then maneuvered into proximity with the Shi Yan-24C (SY-24C) triplets.[17] See CelesTrak charts below that show the altitude changes of SJ-6I (aka SJ-6 05A) and SJ-6J (aka SJ-6 05B) between July 2023 and January 2025. In that timeframe, both satellites started at approximately 552 km altitude. Then in March, SJ-6I left SJ-6J behind at approximately 548 km to orbit raise to approximately 580 km. Depending on one's definition of "close proximity," with SJ-6J 40 km away and continuing to gradually drop its orbit, it is debatable if it played a role in SJ-6I's engagement with the SY-24C triplets.

Image 3: SJ-6 I and J Altitude July 2023-January 2025



* Images from https://celestrak.org/

From there, SJ-6I and two, and sometimes all three, of the SY-24C triplets engaged in RPOs of less than 1 km for many months, according to U.S. commercial LEO space situational awareness (SSA) firm LeoLabs.[18] As of January 2025, China appears to have completed the nearly ten months RPO demonstration. See details in Table 2, based on LeoLabs analysis.

Table 2: 2024 RPO Participants

Satellite Name	NORAD ID	Pair/Triplet	Launch Date
SJ-6I	49961	A	12/2021
SY-24C 01	58650	1	12/2023
SY-24C 02	58651	2	12/2023
SY-24C 03	58652	3	12/2023

- 13 March - 28 April: SJ-6I and SY24C (01/02/03) performed multitude of RPOs at <1 km separation.
- 29 Aug. - 23 Sept.: SY-24C 02 and SY-24C 03 RPO at <1 km separation.
- 27 Nov. - 2 Dec.: SJ-6I and SY-24C 03 RPO at <1 km separation.

The most recent SJ-6 on-orbit behavior shows important consistencies with past behavior and is an incremental advancement for improved payload testing and TTP development. Before moving on to examine information on what is known about the payloads, the important two ways SJ-6's on-orbit behavior has evolved include:

- Chinese space operators continue to use the SJ-6 series to advance other satellites' RPO tests as a secondary mission, before returning the satellites to their primary mission.
- The maneuverability of the A satellite is getting better, and observers should expect to see related advancements if China launches another SJ-6 pair in the future.

What we know about payloads

The B satellite developer, Aerospace Dong Fang Hong Satellite Company, (DFH), filed telling invention patents in 2008 and 2009. DFH continues to pay the patent fees to ensure they stay active until 2028 and 2029, respectively. Based on the satellites that the company developed in the early 2000s, and other satellites on-orbit, there is good reason to consider that the below patents are for the B satellite's payload.[iii]

- DFH in January 2008 and July 2009 filed invention patents for a SSO LEO satellite that would orbit at approximately 500-550 km altitude. That satellite would use a "side swing" maneuver to expand the viewable range of the satellite's electronic payload.[19] This maneuver is not obvious like an altitude change, but would most likely be observed as a change in reflected light. According to DFH, it improved the swing method used in two optical imagery satellites (Zi Yuan-1 and "XX-3") and adapted the method to an "all weather satellite" like a "microwave or signals satellite."[20,iv] The 2009 patent specifically refers to satellites with "dual-orbit coverage," which probably refers to synthetic aperture radar (SAR) techniques to capture multiple signals to form an image. It could also be referring to coordination with a second satellite, but the patent information is unclear.
- DFH in October 2009 filed a third invention patent specific to an "agile satellite," that can demonstrate an "agile attitude maneuver."[21] In spacecraft engineering, "attitude" roughly refers to the direction the satellite is pointing, and is related to a "side swing" maneuver. Again, most attitude adjustments are a maneuver that would not necessarily be detected.

In addition to DFH, CETC contributed antennas to every SJ-6 pair.[22] Unlike in the case of DFH's patents, that clearly indicate the technology is focused on LEO SSO satellites, CETC's patents, in the pertinent timeframe, do not clarify an orbit.[23,v] However, given that CETC in 2012 described that the patent was for tipping and queuing optical imagery, and that China did not launch its first GEO imagery satellite until 2015, this research assumes that these patents refer to LEO satellites.[24]

- CETC in December 2007 and May 2008 filed invention patents, the first of which remains active, for satellite-based phased array radars to enable ground-based mobile vehicle, ship, air, and missile mounted communications and navigation.[25]

[iii] Most Yao Gan (YG) satellites are not in SSO, but YG-3, YG-11 (2010), and YG-12 (2011) are in SSO.
[iv] "XX-3" probably refers to the SSO Yao Gan-3 from 2007.
[v] CETC's early satellite antennas were in support of China's 331 Program for communications satellites and developing positioning, navigation, and timing for China's Beidou satellites. Additionally, one of the Deputy Commander in Chiefs of the first six SJ-6 A satellites, Yang Zhihao [杨之浩] from SAST, also participated in China's 311 Program, which might mean CETC's payload is on the A satellite.

- CETC in July 2012 filed an invention patent, which may have expired, for a method to use its on-orbit phased array radar antennas to collect maritime electronic signals for tipping and queuing an optical payload. CETC described that the method would detect maritime moving targets and schedule follow-up on-orbit optical imagery. It is unclear if the patent is describing tipping and queuing within a satellite with both signal and imagery payloads, or two satellites with separate payloads.[26]

The research did not find any relevant patents from the A satellite manufacturer SAST. One of the Deputy Commander in Chiefs of the first six SJ-6 A satellites, Yang Zhihao [杨之浩] from SAST participated with CETC in China's 311 Program, which might mean CETC's payload is on the A satellite.[27] China's 331 Program kicked off China's development of communications and navigation satellites.

Crosschecking with NEI

Commercial NEI from two different companies further buttresses the above argument that the SJ-6 series' primary mission seems to be TTP development for tipping and queuing for maritime surveillance, with the secondary mission of supporting other satellites' RPO tests. In general, one would expect even medium quality NEI to be useful in determining the relative size between the A and B satellites. Other detectable information would be if one of the satellites had a large deployable antenna separate from its solar panels. This would be useful context given the above patent references to "signals and microwave" satellites, and that separately, some space watchers have alleged that the SJ-6s support electronic signals intelligence.[28] Depending on the type of electronic intelligence, the antenna could range from a large parabolic antenna to a low profile phased array antenna.

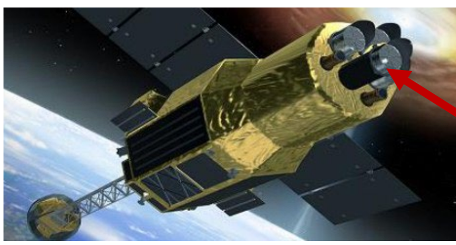
This report was able to further enhance the usefulness of commercial NEI by requesting a pair of early SJ-6s and the most recent pair of SJ-6s. This enabled comparative imagery analysis of size and payloads. Analysis is ongoing to explore advancements that the Chinese developers have made in the payloads. In the meantime, the initial analysis reveals important consistencies and strengthens the argument that space watchers should continue to view at least the SJ-6 satellites as an evolving series with the same mission.

In the first example below, a U.S. commercial firm imaged the 2006 pair of SJ-6s (29505 and 29506). In the second example, the Australian firm HEO imaged the 2021 pair (49961 and 49962). Indeed, the imagery can confirm that both the past and the most recent SJ-6s follow the convention that the more maneuverable A satellite is smaller than the less maneuverable B satellite. Both images show that the A satellite has fewer solar panels than the B satellite, which is an indicator of size and power requirements. In further confirmation, HEO's image directly measures the A and B satellite.

There is not enough information in either image to compare the A satellites and determine its payload. Therefore, it remains an open question as to if the A satellite receives tips from the B satellite for follow up imagery. The U.S. firm's image also reveals some side-mounted antennas, which could be for standard telemetry, tracking, and control or scientific measurements of the space environment, as described in each of China's launch announcements.[29]

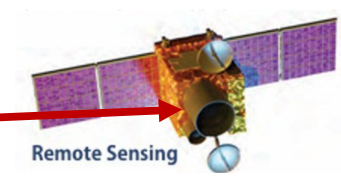
Coincidentally, both images of the B satellite are better and support deeper exploration into the possible "signal and microwave" antenna payloads, as DFH described in the patent filings. The U.S. firm's image clearly shows that the 2008 SJ-6 has an Earth facing (Nadir) antenna on the right. On the left, there appears to be a scientific payload like an x-ray detector or solar ultraviolet imager; it may also be a general remote sensing payload.[30] See Image 4 for a comparison of other on-orbit satellites with similar looking payloads.

Image 4: Comparison of On-Orbit Space Environment, Science, and Remote Sensing Payloads



ASTRO-H is a Japanese X-ray astronomy satellite

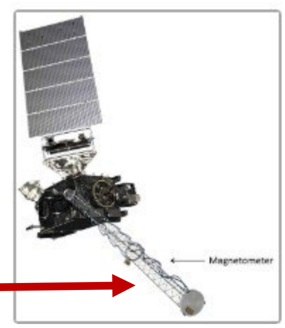
Lenses for science or imagery



General remote sensing satellite

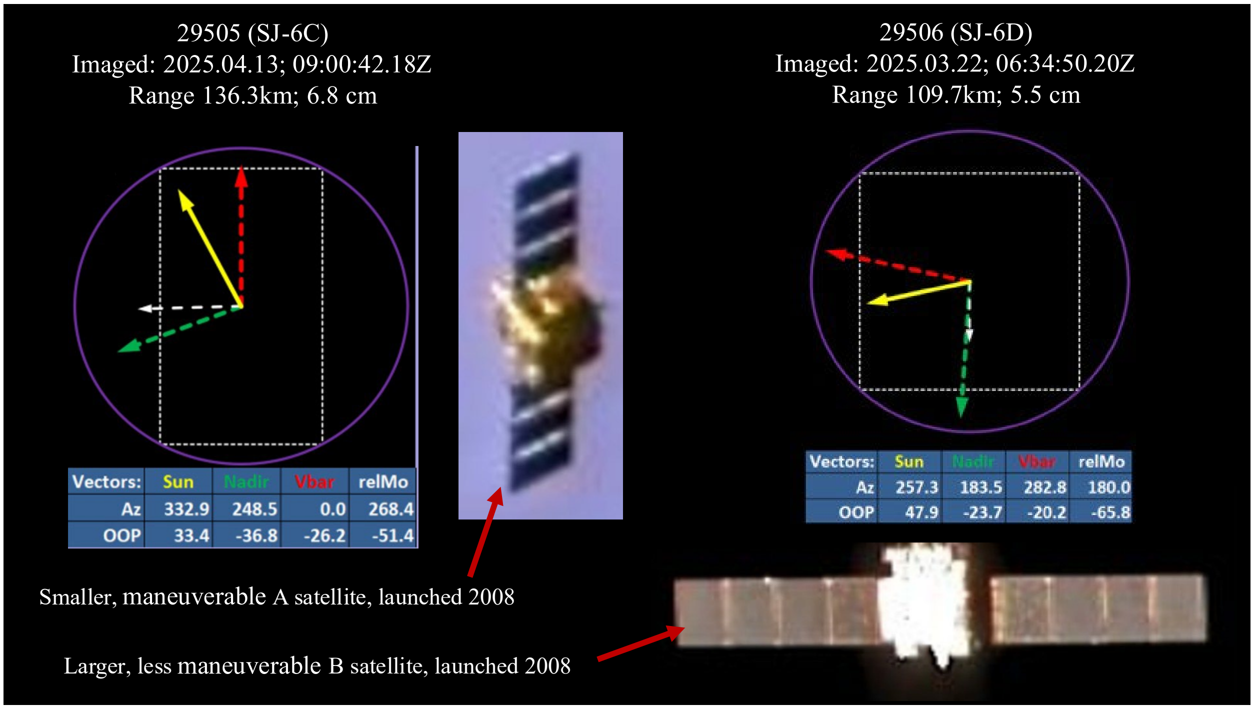
METOP A is a European meteorological satellite

Magnetometers to detect space environment

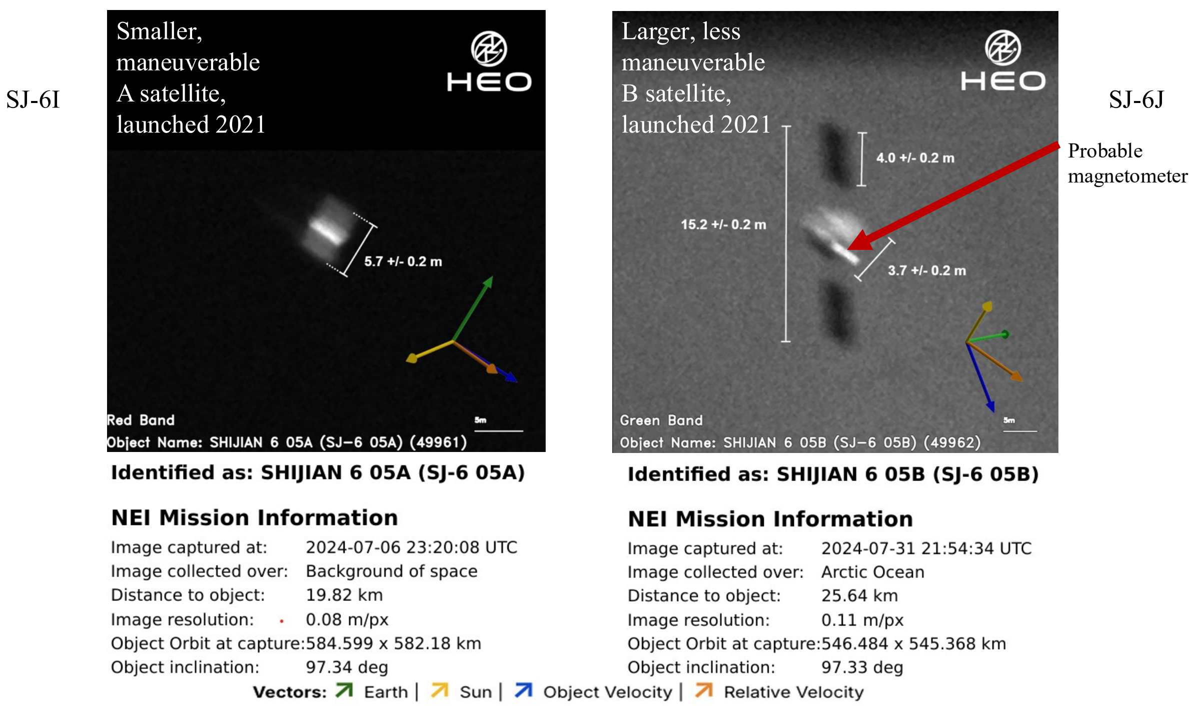


GOES is a U.S. meteorological satellite

HEO's image clearly captures what is most likely a sensor called a magnetometer, which is common on meteorological and some navigation satellites.[31] This may also be on the 2008 SJ-6 B satellite, just not captured on the face in the U.S. image. Magnetometers measure the space environment magnetic field, a measurement which China has included in its descriptions of "space physics environment satellites," like SJ-6.[32] Different types of advanced quantum magnetometers already have commercial application, and can be used for signals intelligence, at least in terrestrial applications.[33]



*A U.S. firm provided the imagery and the metadata. CASI added the size and maneuverability.



*HEO provided the imagery and the metadata. CASI added SJ-6 I/J convention, maneuverability, and magnetometer flag.

Conclusion

The primary takeaway from this effort is that Western space watchers need a perspective shift when tracking China's progress as a pacing challenge. The choice to focus on new launches and new on-orbit behavior in China's SJ and SY satellites, without also looking back to check for potential similarities, sets one up for overlooking key information. Without identifying past similarities, one is more likely to interpret behavior as a near term threat, rather than an evolving and manageable challenge.

This shift is necessary, especially in the case of watching China. For example, the eleven-year gap between launches of the last and most recent pair of SJ-6s is simply two FYPs. From China's perspective, it is absolutely reasonable that Chinese space operators iterated over two FYPs to launch improved payloads for the satellite pairs' missions in 2021.

This article provides evidence that the SJ-6 series' primary mission is probably TTP development for tipping and queuing for maritime surveillance, with the secondary mission of supporting other satellites' RPO tests. China has advanced the B satellites "signals or microwave" antenna as described in DFH's patents. A major gap is that we continue to have a poor understanding of the A satellites' payloads. This research does however show that the A satellite's on-orbit behavior is an incremental evolution from the past to continue advancing its secondary mission of supporting other satellite's RPO capabilities.

Endnotes

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