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China Can Track GSSAP

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A Chinese technical assessment of the U.S. Geosynchronous Space Situational Awareness Program (GSSAP) satellites from 2023 revealed China's deepening analysis of U.S. space domain awareness (SDA) capabilities. The Chinese have moved beyond describing U.S. SDA systems, and have begun analyzing GSSAP satellites' on-orbit behavior in academic journals. In a recent example, Western media in 2023 flagged a Chinese language article that published a list of close approaches between GSSAP and Chinese satellites; the article's authors also simulated one of GSSAP's optical payloads, at varying distances.[1]

When compared with other Chinese evaluations of GSSAP's pattern of life, China's ability to track GSSAP is improving in two noteworthy ways. First, the People's Liberation Army (PLA) was able to track GSSAP-3, despite limited Western data. This probably indicates PLA progress in fusing its own SDA data with Western SDA data. Second, China's space practitioners are becoming more confident in publicizing approaches involving GSSAP and Chinese satellites that occur within 100 kilometers (km), probably because they can build off of research openly published by the PLA. Another likely reason for Chinese academics' forward leaning assessments of close approaches is that earlier this year, China implemented its national standard for space object orbital data, which is designed to enable deeper international engagement. Armed with their own analysis and empowered to publicize it, Chinese experts appear to be preparing to fill the gap in international discourse around GSSAP operations which is lacking in public U.S. and international forums.

This paper describes China's improving ability to track GSSAP and their willingness to discuss these efforts, based on data PLA and technical experts have used to analyze the six GSSAP satellites' on-orbit behavior. According to the U.S. Space Force, GSSAP declared initial operating capability in 2015. GSSAP satellites collect space situational awareness data and "operate near the geosynchronous belt and have the capability to perform rendezvous and proximity operations (RPO). RPO allows for the space vehicle to maneuver near a resident space object of interest, enabling characterization for anomaly resolution and enhanced surveillance, while maintaining flight safety."[2]

Gaining a better understanding of GSSAP's pattern of life has probably helped the Chinese develop satellite software to autonomously detect and command the satellite to

maneuver when its sensors notice anything similar to GSSAP's historical approaches. For example, in February 2022, a pair of Chinese satellites in geosynchronous Earth orbit (GEO) called Shiyan-12 01 and 02 either autonomously detected or Chinese operators correctly anticipated, GSSAP-3's approach, according to Western media.[3] In that instance, Shiyan-12 01 and 02 detected a GSSAP satellite, separated, and turned, probably to take a picture of GSSAP-3 with favorable lighting conditions. The Chinese on-orbit systems that probably contributed to this enhanced ability is the subject of a future paper.[i]

Growing body of Chinese analysis

In April 2023, Chinese research organizations associated with the Chinese Academy of Sciences (CAS) in Changchun, Jilin Province and the state-owned enterprise China Academy of Space Technology (CAST) built on earlier PLA and CAST analysis of GSSAP. As stated above, Western media in May 2023 noted that the joint CAS and CAST paper simulated GSSAP's imagery resolution for close satellite inspection, up to 10km. This was an improvement built on the PLA Aerospace Force Space Engineering University's (SEU's) July 2019 simulation up to only 50km, but with different solar phase angles. The same media reports also highlighted CAS and CAST's chart of GSSAP's close approaches with Chinese satellites. Importantly, that chart's examples overlapped with and extended the timeline from an earlier graphic which CAST published in 2019. In both cases, CAST received the examples of close approaches from the Russian-led International Scientific Optical Network (ISON), a benefit probably resulting from the fact that multiple Chinese sensors contribute to ISON.[4]

2019 and 2023 International Scientific Optical Network (ISON) Charts

2019

表 1　GSSAP 卫星曾接近的目标

Table 1　Targets that GSSAP had ever approached

时间	接近目标	所属国家	最近距离/km
2016-09-13	通信技术试验卫星一号(TJS-1)	中国	15
2017-07-13	快讯 AM-8(Express AM-8)	俄罗斯	10
2017-09-14	射线卫星(Luch)	俄罗斯	10
2017-09-21	巴基斯坦-1R 卫星(Paksat 1R)	巴基斯坦	12
2017-0929	尼日利亚通信卫星-1R(Nigcomsat 1R)	尼日利亚	11
2017-10-05	钟鸣(宇宙-2520)(Blagovest (Cosmos 2520))	俄罗斯	14
2017-11-17	虹-1M 3(Raduga-1M 3)	俄罗斯	12
2018-05-14	虹-1M 2(Raduga-1M 2)	俄罗斯	13

2023

表 2 被 GSSAP 抵近侦察的卫星

Tab.2 Satellites being closely scouted by GSSAP

Date	Satellite approached	Country	Range/km
2016-09-13	TJS-1	China	15
2017-07-13	Express AM-8	Russia	10
2017-09-14	Luch	Russia	10
2017-09-21	Paksat 1 R	Pakistan	12
2017-09-29	Nigcomsat 1 R	Nigeria	11
2017-10-05	Blagovest	Russia	14
2017-11-17	Raduga-1 M 3	Russia	12
2018-05-14	Raduga-1 M 2	Russia	13
2020-08-23	SJ-20/Chinasat 6 A	China	24
2022-01	SJ-12 01, SJ-12 02	China	73

An examination of the data the Chinese authors used to establish a close approach with GSSAP is summarized below to show not only the types of data, but also the ultimate cohesion

[i] These two papers dive deeper into the initial analysis presented at the biennial China Aerospace Studies Institute Conference May 20204, accessible here: https://www.airuniversity.af.edu/CASI/Display/Article/3850446/chinese-research-in-space-based-space-surveillance/.

across separately analyzed timeframes (2015-2023).[ii] The list includes the joint CAS and CAST paper together with earlier and more recent reports, in chronological order.

- PLA SEU, in July 2019, published GSSAP-3's orbital inclination and semi-major axis for two months, from November 1, 2018 to December 19, 2018.[5]
- CAST, in December 2019, published GSSAP-1 and 2's altitude, period, eccentricity, and inclination. They provided GSSAP-1 data for four years between March 2015 to March 2019, and GSSAP-2 data for three years between July 2016 to July 2019.[6]
- SEU and the PLA Aerospace Force Unit 32027, in late 2021, published an updated assessment of the then all orbital GSSAPs (1-4), to include their proximity to other countries' satellites, over the year 2020. They not only referenced using the American company Ansys STK's software, but also using the U.S. Space Force's (USSF's) space-track.org.[7]
- CAST, in June 2022, examined GSSAP-3 and 4's inclination, semi-major axis, longitude and eccentricity, every two months for two years from September 12, 2019-September 12, 2021.[8]
- CAS and CAST, in April 2023, extended China's publicly available timeline of the first four GSSAPs' orbital maneuvers, examining their longitude and altitude from November 2019 to November 2022. The authors also updated the PLA's assessment of the solar phase angles during select close approaches with Chinese satellites. Importantly, CAS and CAST included the first known chart on GSSAP-5 and 6's longitude and altitude, from April 2022 to September 2022.[9]
- CAST in November 2023 published the first publicly known example of what they claim is GSSAP-5's close approach with ShiJian-23 (SJ-23), data which they illustrated with a chart displaying longitude and inclination from Jan 10, 2023 and March 21, 2023.[10]

Improving ability to track GSSAP

According to the above Chinese language technical reports, it is clear that China is leveraging publicly available data. The Chinese are not alone in their improving ability to track GSSAP. Western amateur astronomers using ground-based radio and optical instruments have improved tracking and analysis capabilities with technology advances and strengthened partnerships; and the U.S. has made more information available as well. China's tracking data of GSSAP 1 and 2 as early as 2015, eight months after its launch, is mostly consistent with amateur satellite trackers.[11] China's tracking data of the most recent GSSAPs (5 and 6), just a few months after their launch, is consistent with publicly available websites that primarily ingest USSF data.[12]

China's independent ability to track GSSAP is best understood with two other indicators. The first indicator is the PLA's GSSAP-3 data from 2019. The timeline they investigated is

[ii] This paper is written for readers who are already familiar with orbital elements. For the non-space operator readership, the orbital elements are described here (https://www.amsat.org/keplerian-elements-tutorial/ or https://catalina.lpl.arizona.edu/faq/what-are-orbital-elements), and how the elements make up the TLEs is described here: (https://www.space-track.org/documentation#/tle).

earlier than that displayed in a commonly accessed public website, and more granular than readily available amateur astronomer publications.[13,iii] What the PLA published is still 28 months after GSSAP-3's launch, however, possibly indicating that the PLA worked to merge disparate data points, combining its data with Western analysts' partial collections, which would still be a major feat, even if they largely relied on others' data. The delay in publication could also be completely unrelated to the PLA's SDA capabilities, and more a concern about classification.

The second indicator is the PLA's report in 2021, which included analysis on a close approach not listed in the updated ISON list, which probably indicates the PLA used its own data. The PLA report concluded that the closest GSSAP came to another satellite in 2020 was 8.71 km. The PLA detailed the specific case, but did not list the satellite's name; they identified GSSAP-2 as the second satellite, with the close approach occurring February 11, 2020 at UTC 20:52:20.000. Given that Chinese academics historically have built directly off of PLA reports, and the joint CAS and CAST list did not include this example, the unnamed satellite is probably an uncatalogued object. According to the paper's pie chart, GSSAP spent most of its time in 2020 in close approach with U.S. satellites. Chinese satellites are ranked second.

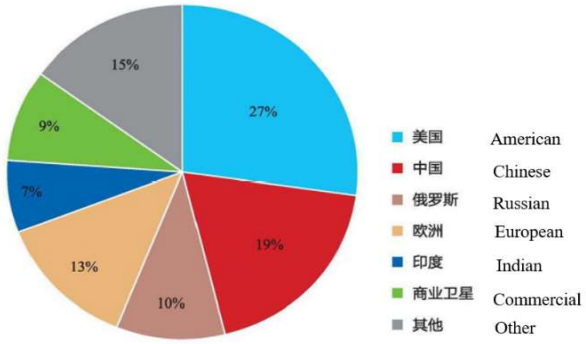

图 9 卫星所属国抵近次数分布图
Distribution of Approached Satellites

Filling the discourse gap on GSSAP operations

GSSAP's mission and the orbital elements of its current location are not classified; U.S. government and Western experts just don't often talk about it. Consequently, the Chinese and others are filling the vacuum. A "GSSAP" keyword search in Google Scholar shows that the majority of academic research in English is by Chinese researchers. Moreover, as the PLA improves the quality and availability of its domestic space object catalog, to at least domestic scholars, Chinese space experts will continue to publicize GSSAP's approaches with Chinese and other satellites that are closer than 100 km. As an example, in November 2023, CAST described the first publicly available example of GSSAP-5's close approach with China's SJ-23, just after it reached orbit.

[iii] It is also possible there are other resources, about which the author is unaware. For example, the author found one reference to GSSAP-3 drifting in 2019 in a British Interplanetary Society publication. The report stated that the data was from amateur astronomers. (https://www.bis-space.com/membership/spaceflight/2019/SpaceFlight-v61-no09-September-2019_f094jh.pdf)

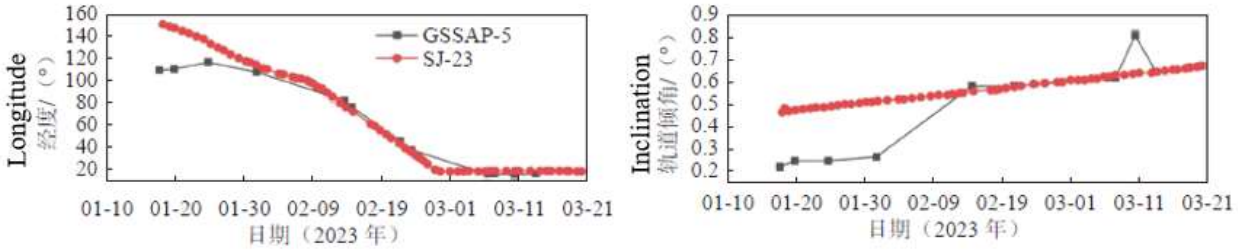

图 6　美国 GSSAP-5 卫星接近我 SJ-23 号卫星情况

Fig. 6　American GSSAP-5 satellite has been approaching Chinese SJ-23 satellite since January 2023

Armed with their own data and a temporally cohesive analysis of GSSAP 1-6's pattern of life, Chinese space experts are readying to meet calls from the Chinese Communist Party, PLA, and the China National Space Administration to enhance China's "voice and influence in the international rules system."[14] In particular, the PLA seeks to address what it has referred to as "GSSAP's one-way transparency," which according to them allows the U.S. to have more information than other satellite operators.[15] The major impetus for China's early 2024 publication of its national standard for space object orbital data was to strengthen sharing among agencies and scholars, and to participate in international governance. The standard's preface states, "appropriate openness and transparency of information on space objects on the basis of independent control is a necessary condition for participating in the [international] governance of outer space security."[16] Space industry watchers and the international community should only expect more Chinese analysis on satellites' pattern of life.

Endnotes

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