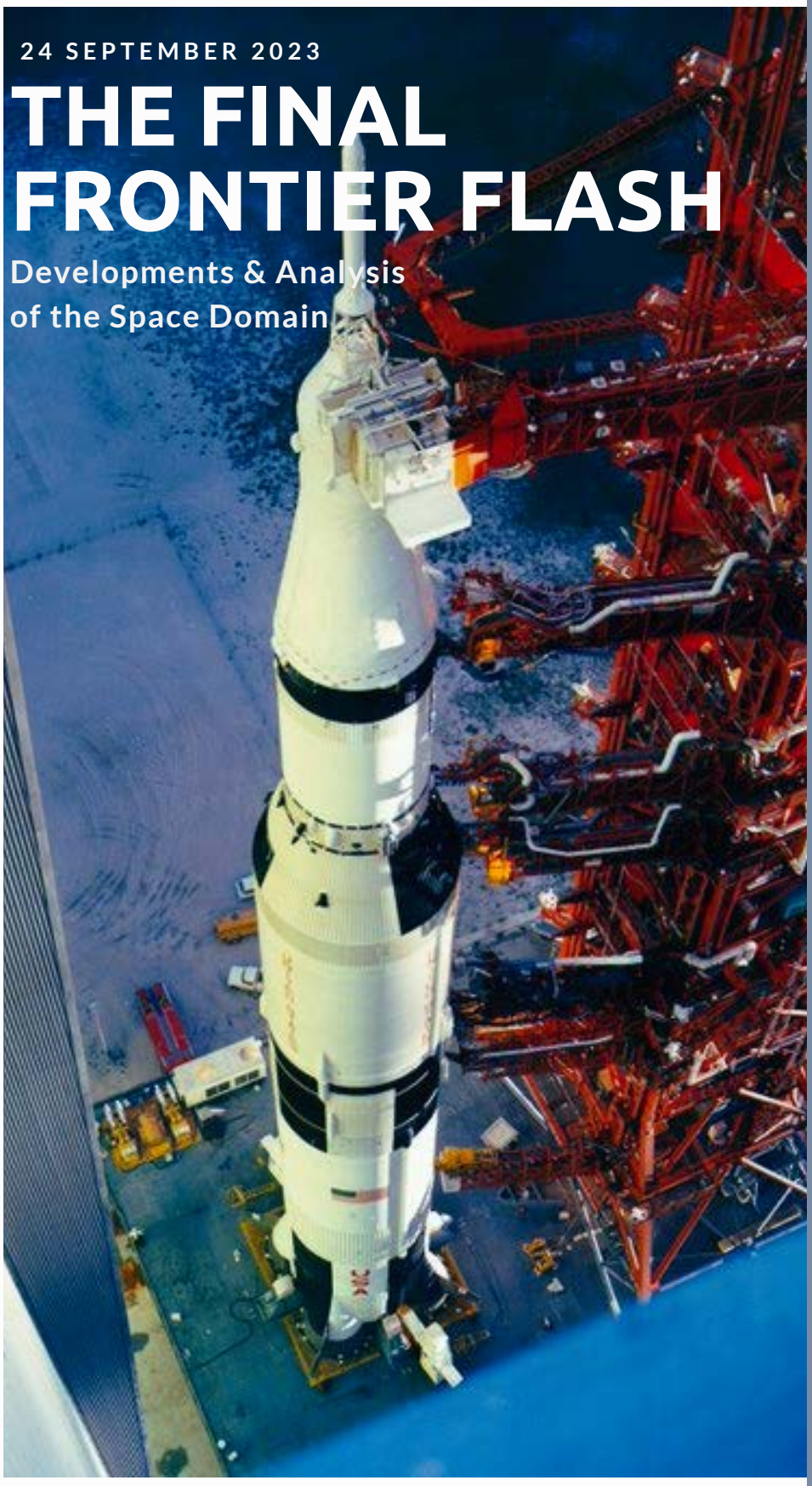
24 SEPTEMBER 2023

THE FINAL FRONTIER FLASH

Developments & Analysis of the Space Domain



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SFA SPACE FORCE ASSOCIATION

In This Issue

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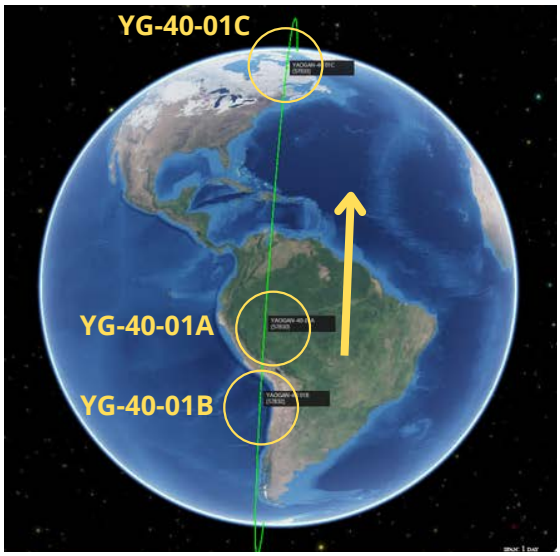
Catalog

China: Yaogan 40 Triplets Launched into New Orbit

10 Sep 2023: China launched a LM-6A Y5 from Taiyuan Satellite Launch center with 3 Yaogan 40 satellites. Chinese sources stated only that the purposes of the satellites was for "electromagnetic environment probing." The satellites are in a ~800 km orbit with 86° inclination. Launch Video.

- YG-40-01A/B/C orbit is significantly different than those of other recent Chinese launch trios (YG-35, YG-36 and YG-39).
- As of 16 Sep 2023, all three satellites are continuing to maneuver, and their positions relative to one another will change. Currently YG-40-01A & B have nearly identical semi-major axis (SMA): 847.6 and 849.4 km respectively. These two satellites have increased SMA since arriving in orbit. YG-40-01C's SMA is ~60 km less than A & B at 787 km. All three share the same 86° inclination.
- YG-40-01 is the first of the Yaogan satellite family to operate in this unique orbit, which appears to be unlike all other Chinese satellites.
- Shiyan 20A/B and C orbit at a similar altitude (SMA), but are inclined 60°.
- The Fengyun-3 environmental monitoring satellites also operate at a similar altitude, but again the inclination is different (98.8° for FY-3s).
- There are no Gaofen or Shijian satellites operating in anything similar to this orbit.
- Taiyuan Satellite Launch Center has hosted 22 separate Yaogan launches, all for imagery satellites (either Electro-Optical or Synthetic Aperture Radar). Yaogan-40-01 launch was the first Yaogan launch from Taiyuan since 2015.
- YG-40-01 is the first Yaogan launch to use an LM-6 booster.
- The LM-6A is a two-stage rocket loosely based on LM-6, but modified in many ways. It can lift 5 metric tons into a polar orbit, and is usually 50 m tall with a diameter of 3.35 m. This specific launch used the Y5 variant, which appears to be closer to 55 meters in total length.

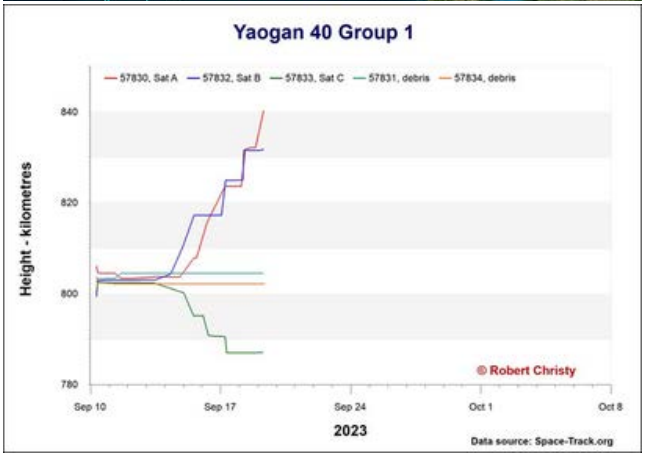


Yaogan-40-01 Triplet Formation

Comparison between LM 6A Y5 and Y1 shows Y5 has a special long fairing that makes it taller, nearly 55m tall while Y1 and Y2 were about 50m

Yaogan 40: Similar Profile as YG-31 ELINT Triplets?

19 Sep 2023: Robert Christy of Orbital Focus noted similar characteristics between the deployment of Yaogan-40A/B/C and Yaogan-31A/B/C satellites. If the pattern holds and the YG-40 triplets assume a similar formation as YG-31, it will be a strong indicator YG-40 spacecraft are designed to intercept radio signals & calculate their point of origin.



- Yaogan-31 satellites were launched between 2018 and 2021. There are 12 YG-31 satellites flying in 4 orbits, with 3 satellites in each orbit, operating in a precise triangular formation.
- The Yaogan-31 triplets closely resemble the architecture of the original version of the U.S. Naval Ocean Surveillance System (NOSS). Using three satellites in a precise formation allows them to intercept radio signals from the ground, calculate and track warship positions in the world's oceans, and study their activity based on their radio emissions.
-Shortly after YG-31-02A/B/C launched in 2021, one satellite moved to a higher orbit and the other two dropped by a similar amount. The singleton in the higher orbit started falling back from the other two. After the pair lapped the singleton twice, the YG-31-02A/B/C satellites slid into formation for the active mission.
-The effect of being at two slightly different orbit heights is that the two orbit planes move at different rates, with the lower orbit moving faster. By the time the three YG-31 satellites came together, the singleton's orbit was about 110 km east of the pair.
-By spacing the pair about 125 km apart from each other along the same track, and having the outlier traveling at the same speed, the three vehicles will spend most of their lifetime operating in a near-equilateral triangular formation.
- The YG-31-01A/B/C triad suggests a possible maneuver model and timeline. Two moved to the higher orbit, with the singleton moving lower, taking it ahead of the others and coming up on them from behind. The on-orbit 'catchup' process for that mission took the 'usual' four weeks to perform before the three vehicles settled into close formation.

YG-40 appears to be following the same pattern as YG-31/01A/B/C, with two satellites maneuvering to higher orbits with the third decreasing its altitude. In their current altitudes YG-40-01C, operating at an altitude ~49 km lower, will "lap" YG-40-01B & C for the first time on 28 Sep 2023. It will lap them a second time on ~3 Oct 2023.

Yaogan-39-01 Takes Shape

16 Sep 2023: After its 31 August launch, YG-39-01 A/B/C appears to be operating in formation, though the configuration appears to differ from previous YG-35 and YG-36 triplets.

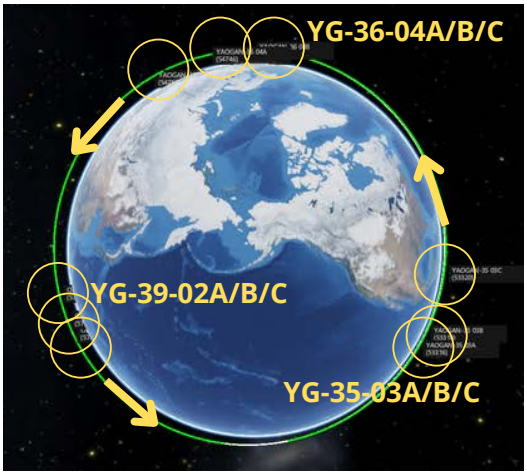
As shown here, YG-39-01 has two satellites in "Lead" position (Lead1 and Lead2) and one in Trail (Follower1). YG-35 and 36 typically (but not always) have a single "Lead" and two in Trail.

This is an initial analysis, and will likely change over time. We'll likely learn more if China launches additional YG-39 triplets...*oh wait, this just in...*

That was Fast: China Launches Yaogan-39-02 Triplet

17 Sep 2023: Less than 3 weeks after launching it initial batch of three Yaogan-39 satellites (YG-39-01 launched 31 August) China launched YG-39-02 from Xichang, also on an LM-2D. As with its predecessor as well as the 30 YG-35/36 satellites, the YG-39-02 trio is in a ~500 km orbit with a 35° inclination. Launch Video.

- YG-39-02A/B/C satellites are co-planar with YG-35-03 and YG-36-04. All of the YG-35/36 and 39 satellites are co-planar with other satellites of this family.
- YG-39-02A/B/C are still conducting initial maneuvers, and it is too early to assess formation.
- The YG-39-01 triplet (A/B/C) is grouped with YG-35-02A/B/C and YG-36-02A/B/C.
- Here are the other current pairings: 1) YG-36-01 & YG-35-01; 2) YG-36-03 & YG-35-05; 3) YG-36-04 & YG-35-03; and 5) YG-36-05 & YG-35-04.



YG-39-02, YG-35-03 & YG-36-04 as Viewed from North Pole

Mission Patches YG-36-05 (left), YG-39-01 (center) & YG-39-02 (right)

YG-39-02 en route to launch

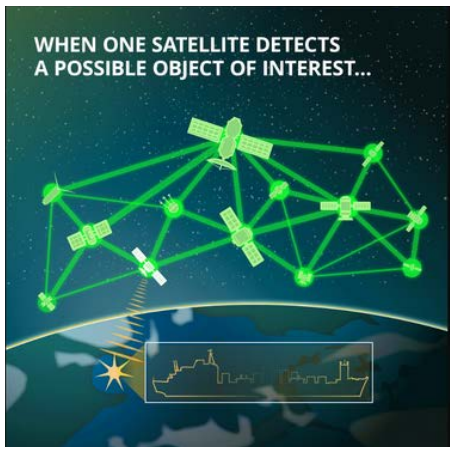
US: Sandia Labs Researching Teaming Satellites

14 Sep 2023: Sandia National Laboratories announced that for the past six years, its researchers have been working on an autonomy project, led by the Air Force Research Laboratory, to enable relatively small and inexpensive satellites clusters to work together as a single, autonomous unit. The project could improve the U.S.'s ability to conduct national security missions, including intelligence, surveillance, reconnaissance (ISR), climate monitoring, and emergency response.

- Scenario: a satellite observing ships on the ocean. As it takes pictures of each ship, an algorithm decides what kind of vessel it is. But one sneaky sailor paints a pattern on the deck that confuses the satellite, so it can't decide what it's looking at.

-Solution: The confused satellite could communicate its problem to others in the network, which could straight away point their sensors to the same spot, combine their data and make a positive identification.

- The current project aims to connect up to about a dozen satellites, though researchers say further development could lead to connecting much larger networks.



-"The ultimate idea is to scale up to constellations that might cover virtually the entire globe — and to potentially coordinate data collection even with non-space assets," like sensors on the ground or on planes, said Drew Woodbury, a senior manager in Sandia's space programs.

-Sandia has been heavily involved developing machine learning and autonomy algorithms, radar sensors, computer models, communications protocols, and flight software. Researchers have been building specialized space hardware, where budgets for size, weight and power are commonly tighter than on the ground. Notably, they have adapted distributed software to operate on multiple satellites without conventional, land-based communications.

<Editor's Note/Rant: Collaborating constellations is the future of space operations. China has announced intentions of moving in this direction. Please read an interview with Li Dereng, a Professor at Chinese Academy of Sciences and Engineering. In "From Earth Observation Satellite to Earth Observation Brain," Li describes how China is moving to an integrated PNTRC concept (Position, Navigation, Timing, Remote sensing, Communications). The U.S. DoD acquisition community is organized around specific weapon system capabilities (Comm, PNT, EO Imagery, SAR, SIGINT) which has a chilling effect on its ability to rapidly develop a multi-phenomenology constellation.>

LEO Labs Reports Near Miss

13 Sep 2023: A derelict Soviet-era payload (Cosmos 807) had a conjunction with a Chinese rocket body. The miss distance was 36 m (± 13 m) and the probability of collision was 1E-3 (i.e., 0.1% or 1/1,000). Cosmos 807 and CZ-4C had a combined hard body radius (HBR) of 5.6 m. This contributed to the relatively large probability of collision (PC) value. If these two objects had collided, the number of resulting cataloged fragments would have likely been ~3,000. By comparison the 2021 Russian ASAT test resulted in ~1,800 total cataloged fragments over time.

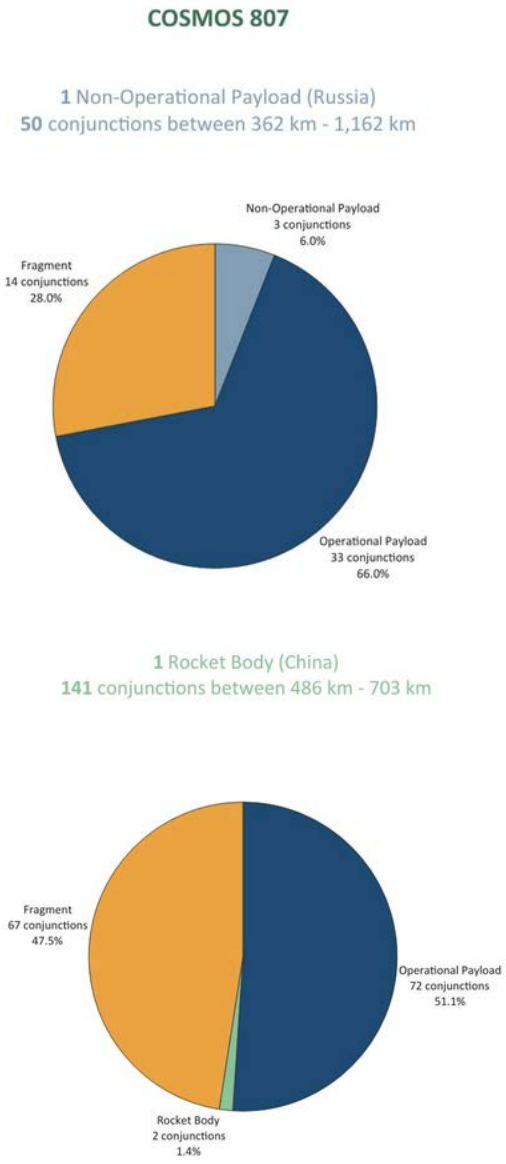
- Cosmos 807 is a 400 kg payload launched into an elliptical orbit in 1976. It's likely Cosmos 807 has had many close encounters with other objects over time.

-Cosmos 807 has an apogee of 1,126 km and a perigee of only 366 km... it is regularly traversing 760 km of trafficked space.

- In the last 20 months, LEO Labs has observed 50 high-PC (i.e., PC > 1E-6) conjunctions involving Cosmos 807. While the majority were with operational payloads, 14 included fragments — six of which were from the fragment cloud generated after Russia's 2021 ASAT test.

-The Chinese CZ-4C Rocket Body (R/B) is a 2,000 kg object abandoned five years ago — and it's already been involved in 141 high-PC conjunctions, split almost equally between fragments and operational payloads.

-The CZ-4C R/B has an apogee of 682 km and a perigee of 553 km.



Near Miss Between 400kg Cosmos 807 and 2,000kg CZ-4C Rocket Body on 13 September 2023

US DoD Releases a Plan for Protecting Space Assets

15 Sep 2023: The U.S. Department of Defense (DoD) released an unclassified whitepaper, *Space Policy Review and Strategy on Protection of Satellites*. The 19 page document <Editor's note: recommend reading this yourselves> provides a review of space policy, and describes the DoD approach to protecting and defending space systems while protecting the Joint Force from adversary hostile use of space.

- The *2022* and *2023 National Defense Authorization Acts* (NDAA) mandated U.S. space policy review. The report outlines the United States' preparations to defend its space assets from attack if war breaks out in space. DoD Assistant Secretary for Space Policy John Plumb noted releasing the report in an unclassified format is "a key step towards normalizing space as an operational domain."

- The report identifies DoD's key priorities in regards to space systems:
  1. Assure critical space-based missions by accelerating the transition to more resilient architectures and by protecting and defending critical systems against counterspace threats
  2. Strengthen the ability to detect and attribute hostile acts in, from, and to space (improve Space Domain Awareness)
  3. Protect the Joint Force from adversary hostile uses of space.

- The document identifies China as the strongest adversary and risk to U.S. operations in space, followed by Russia. Both nations have extensive counterspace capabilities, including direct-ascent anti-satellite (ASAT) weapons and jamming technology. Importantly, the report also addresses adversary use of their own space systems to threaten allied forces operating in other domains.

- As potential adversaries increase their use of space-based services to support their combat capability, operations to deny hostile use of space could reduce an adversary's ability to conduct attacks against the U.S., its allies, and partners.

- Specific to China the report notes: The PRC is building a space architecture to enhance its ability to fight and win a modern military conflict. The PLA owns and operates roughly half of the world's space-based intelligence, surveillance, and reconnaissance (ISR) satellites. Recent improvements to the PLA's ISR fleet enhance its ability to monitor forces across the globe, including U.S. expeditionary forces, increasing the PLA's ability to conduct long-range strikes against U.S. and allied forces. The PRC likely intends to leverage these advancements to challenge the U.S. military's ability to conduct joint operations in the Indo-Pacific region.

- Joint Force space operations could deny an adversary's space and counterspace capabilities and services, using a variety of reversible and irreversible means to reduce the effectiveness and lethality of adversary forces across all domains. Operations to deny adversary hostile use of space could originate in any domain, and target on-orbit, ground, cyber, and/or link segments to reduce the full spectrum of an adversary's ability to exploit the space domain.

- The report states "DoD will leverage a breadth of options across all operational domains to deter aggression and, if deterrence fails, to prevail in conflict."

Germany Signs Artemis Accords

14 Sep 2023: Germany signed the Artemis Accords, adding one of Europe's largest space powers to a document outlining best practices for sustainable space exploration. Germany became the 29th signatory country during a ceremony at the German ambassador's residence in Washington, DC. Walter Pelzer, German Space Agency Director General at the German Aerospace Center (DLR - Deutsches Zentrum für Luft und Raumfahrt), signed on his country's behalf.

- Germany is also one of the biggest European space nations, committing €3.5 billion ($3.7 billion) to the European Space Agency (ESA) at last November's ministerial summit – more than any other member. Five of the six largest contributors to ESA — Germany, France, Italy, the United Kingdom and Spain — have now signed the accords, along with several other members.
- German officials did not publicly state why they waited until now to sign the accords. In a statement, DLR said that the accords "reaffirm" their commitment to the 1967 Outer Space Treaty and related international agreements. Backers of the accords have long argued the document is intended to "operationalize" the Outer Space Treaty, by explaining how member parties and signatories should carry out certain principles.
-DLR added it continues to support new, binding space treaty development, potentially on utilization of space resources, one of the topics covered in the Artemis Accords.

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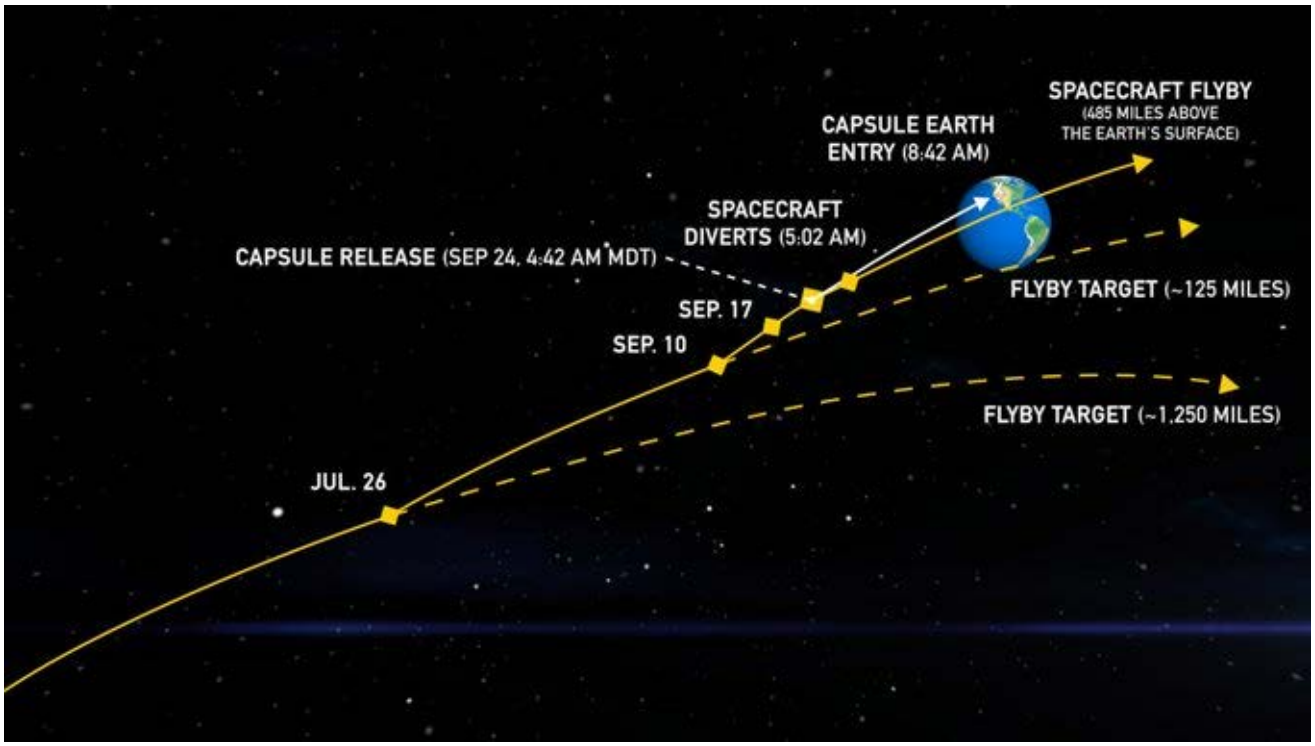
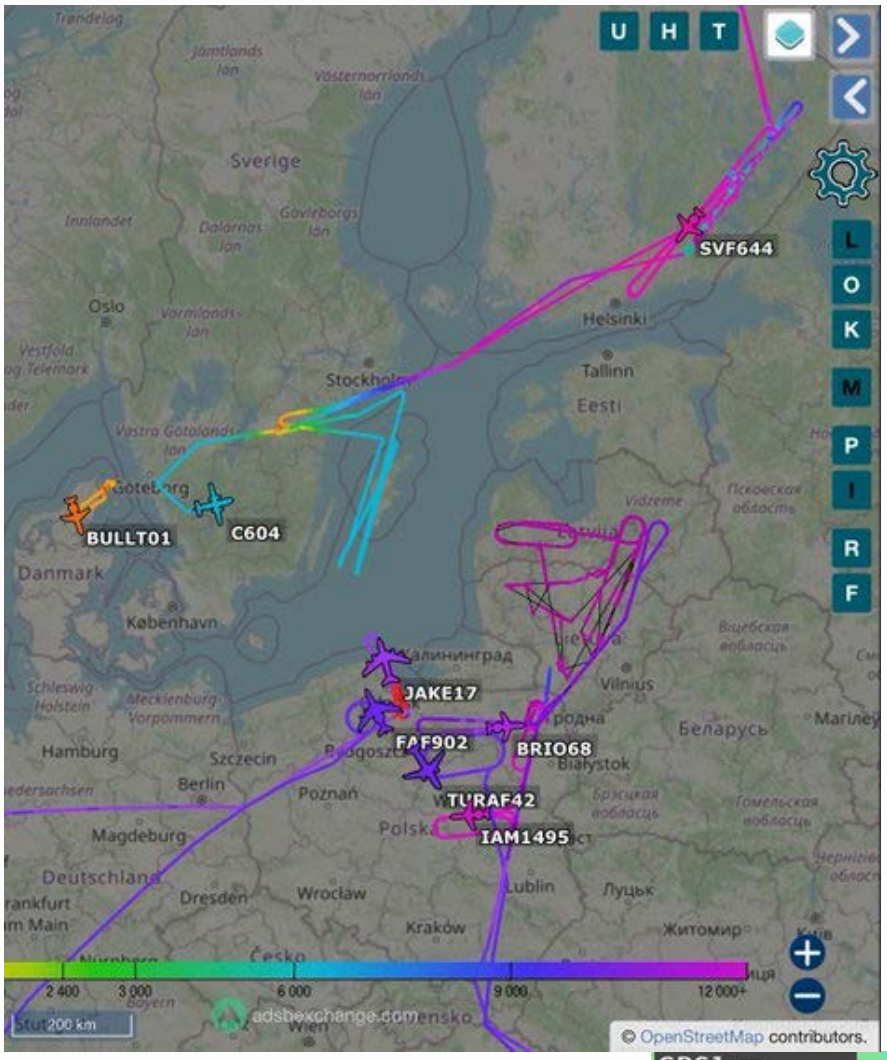
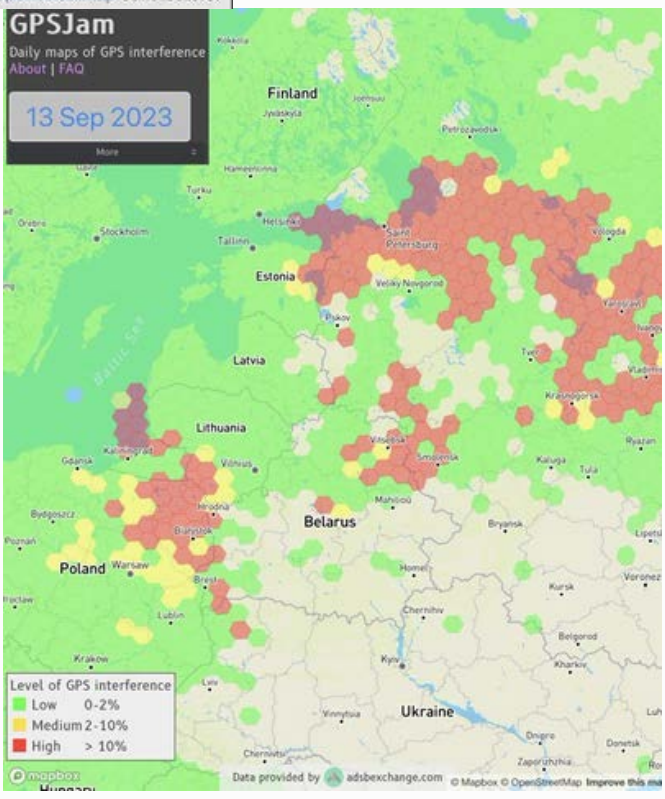
Pics o' the week!



Osiris-REX Scheduled to Return Asteroid Material on 24 Sep 2023

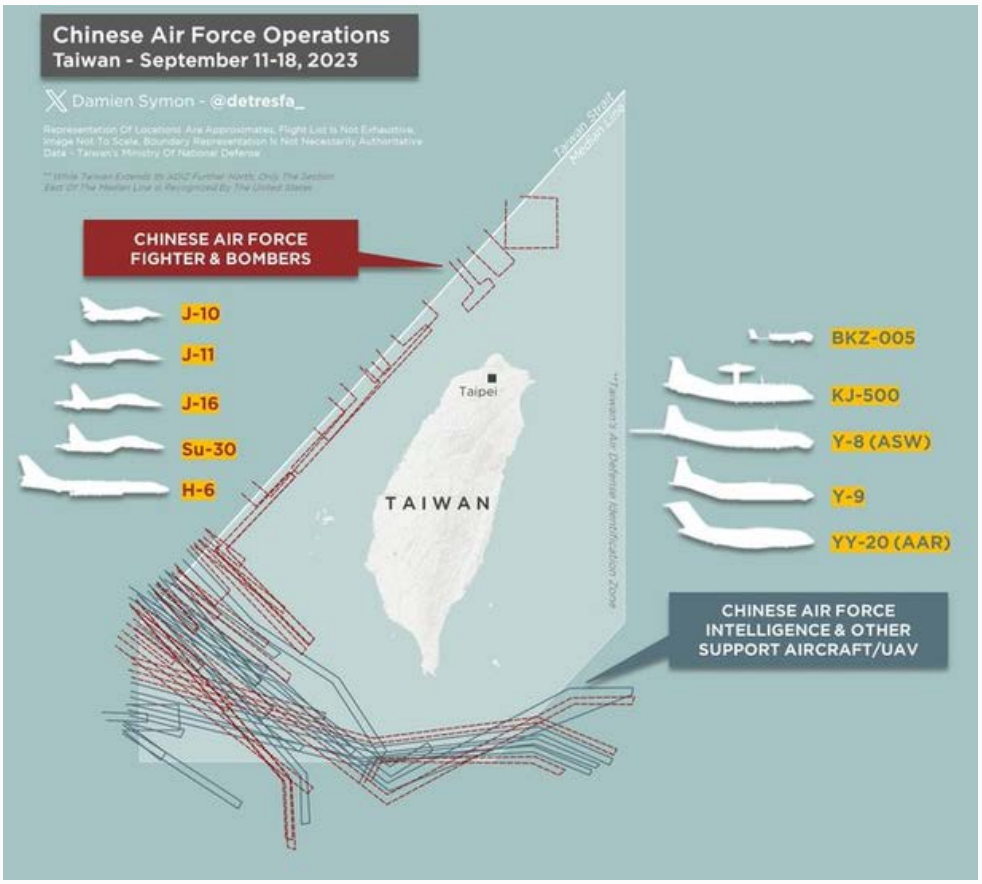
Osiris-REX Preparing to Scoop asteroid Bennu on 20 October 2020





NATO ISR Flights (above).
Russian GPS Jamming (right).
<u>This much GPS jamming over Poland is very unusual in terms of area affected, number of aircraft affected, and duration</u>.

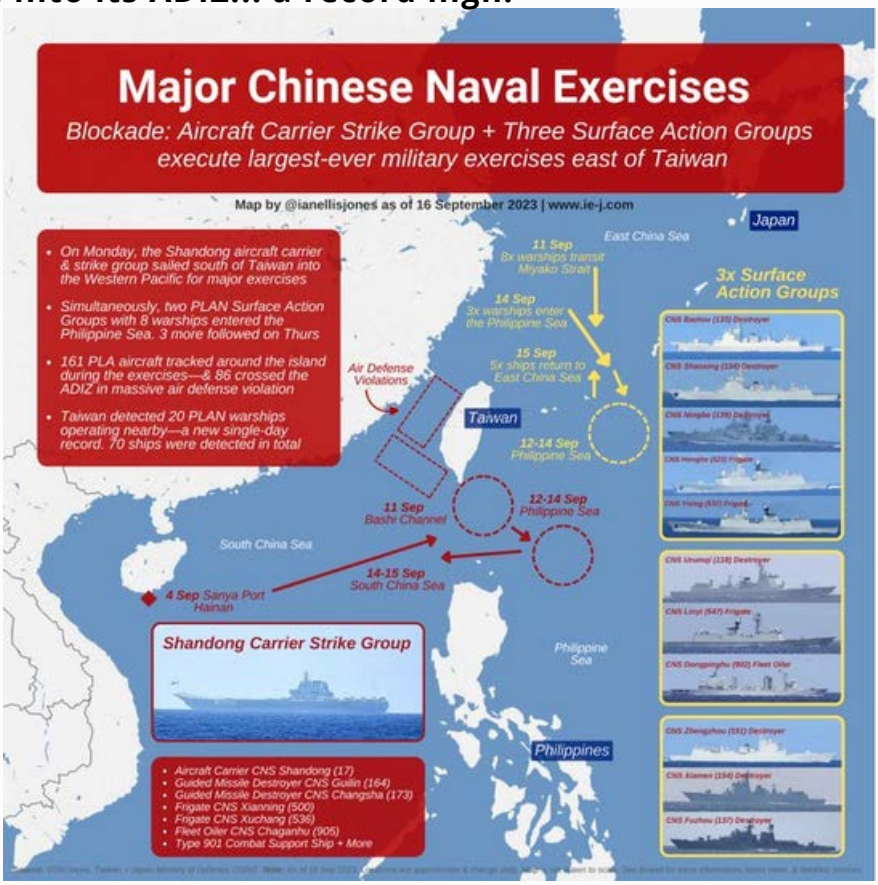
Intensified <u>GNSS-jamming around Baltics</u>. The Kalingrad blobs north and south came about Sep 9th, first day of large NATO naval exercise.



Big Chinese Show of Force around Taiwan. China's use of Space to support its Air and Naval Operations is currently unknown.

Infographic of recent Chinese Air operations towards Taiwan 11-18 September 2023. Taiwan detected 103 PLA aircraft, many crossing the into its ADIZ... a record high.

China's Navy <u>conducted its largest-ever naval exercises in the Western Pacific</u>, east of Taiwan—unscheduled, unannounced, & unprecedented. The PLAN deployed 20+ warships to the waters around Taiwan, a new daily record, & likely simulating a blockade.



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