28 AUGUST 2022

THE FINAL FRONTIER FLASH

Developments & Analysis of the Space Domain

ISR UNIVERSITY

SFA
SPACE FORCE ASSOCIATION

In This Issue

Russia/Iran: Khayyam Satellite Update

China Launches 4th Set of Yaogan-35 Triplets

Chinese Earth Observation Update

China Spaceplane Clues

China Launches Tech Verification Satellite

China Launches New Earth Observation Satellite

Ukraine to Control ICEYE SAR Satellite

Solar Storms Leave Intelsat's Galaxy 15 Inoperable

This Fortnight in GEO

Jack's Astro Corner: Part VI

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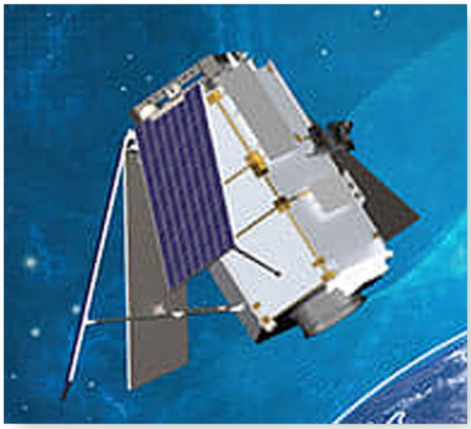
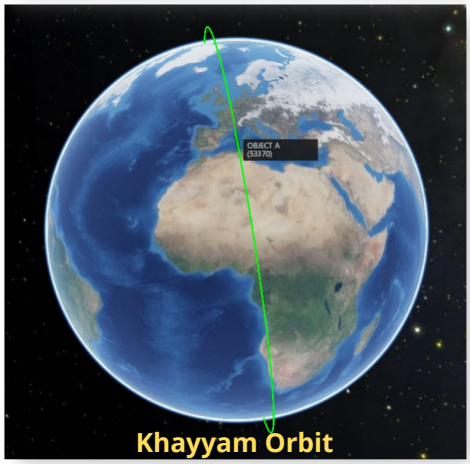
Catalog

Russia/Iran: Khayyam Satellite Update

12 Aug 2022: An Iranian spokesman stated Iran plans to commission three more versions of the Khayyam satellite in addition to the satellite launched on 4 Aug. There were also reports that while Russia will eventually give control of the initial Khayyam to Iran, Moscow intends to use the spacecraft to assist its own war effort in Ukraine first. Iran disputes this, saying they will control the satellite "from day one."



- Iranian spokesman Ali Bahadori-Jahrom stated, "The construction of three other Khayyam satellites with the participation of Iranian scientists is on the government's agenda."
- He said the Khayyam is designed to meet Iran's needs for "crisis and urban management, natural resources, mines, agriculture and so on," and that the Khayyam was built by the Russians under Iran's supervision.
- The Washington Post published an article stating Iran may not be able to take control of the satellite right away.
- Russia, which has struggled to achieve its military objectives in its five-month assault on Ukraine, told Tehran it plans to use the satellite for several months, or longer, to enhance its surveillance of military targets in that conflict.
- The launch is the latest indicator of increased military and political cooperation between Moscow and Tehran. It comes two weeks after a visit to Tehran by Russian President Vladimir Putin for meetings with Iranian Supreme Leader Ali Khamenei, who afterward hailed his government's "long-term cooperation" with Moscow.
- The Khayyam's camera has a resolution of 1.2m, according to Western security officials...That's far short of the quality achieved by U.S. spy satellites or high-end commercial satellite imagery providers, but a substantial improvement over Iran's current capabilities.
- Potentially the most significant benefit will be Iran's ability to "task" the new satellite to conduct surveillance on locations of its choosing, including military facilities in Israel, oil refineries and other vital infrastructure in neighboring gulf states.
- Khayyam is in a 499x501.5km 97.4° sun-synchronous orbit with an orbital period of 94.5 minutes.

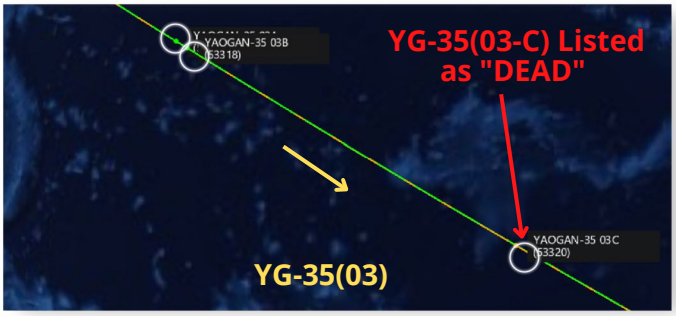


China Launches 4th Set of Yaogan-35 Triplets

19 Aug 2022: Just 2 weeks after launching its third set of YG-35 satellites, China launched its fourth trio of Yaogan 35 (YG-35(04)) military reconnaissance satellites to orbit. Both sets of satellites used a Long March 2D rocket and were launched from Xichang Satellite Launch Center. Details from the Chinese government on the individual satellites' on-orbit operations are sparse. Despite this, spacecraft analysis and comparisons to western missions and previous Chinese launches help to build a gradual understanding. Launch Video.

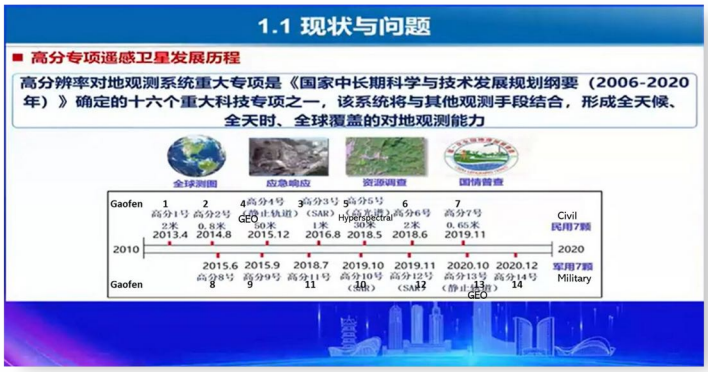
- The new trio join three sets of Yaogan 35 satellite triplets which were sent into orbit by two similar launches in Nov 2021, Jun 2022 and Jul 2022. All twelve satellites are now orbiting at roughly 310 miles (500 km) above the Earth, with an inclination of 35 degrees in order to provide regular, repeated passes over areas of interest.
- The China Aerospace Science and Technology Corporation (CASC), which developed both the rocket and spacecraft for the mission, stated that the satellites would be used for space scientific experiments, monitoring land usage and natural resources, and other scientific purposes.
- The European Space Policy Institute notes in its recently published yearbook on space activities that China's Yaogan series satellites are perceived by analysts to serve both civil and military users.
- As with the earlier pair of Yaogan 35 satellite launches, two of the three satellites were developed by the Aerospace Dongfanghong Satellite Co., Ltd., with the third provided by the Shanghai Academy of Spaceflight Technology (SAST), both of which operate under CASC.
- This mission also included a payload adapter, which serves as an interface between a rocket stage and the spacecraft being sent into orbit, carries a drag sail designed to help deorbit the roughly 660-pound (300-kilogram) adapter much sooner than otherwise. SAST debuted the drag sail on the previous Long March 2D launch.

As of 23 Aug the three YG-35(04) satellites appeared to be maneuvering to the 1 lead 2 trail configuration exhibited by YG-35(01), YG-35(02) and YG-35(03). Recently Spacetrak.org began listing the YG-35(03C) satellite, the lead in the YG-35(03) formation, as "Dead." I could not find any further information related to the status change.



Chinese Earth Observation Update

14 Aug 2022: According to Li Deren, a top scientist of remote sensing in China, China has invested ¥ 50 billion in the China High-resolution Earth Observation System (Gaofen) program and the resolution of civil and military use has reached 0.3m and 0.1m respectively. Interestingly Li presented a slide that explicitly mentioned the Gaofen-8-14 Satellites were "military satellites."



Let's take this opportunity to review the Gaofen series of satellites and their capabilities:

GF-1: Apr 2013, high-resolution cameras (2m resolution panchromatic and 8m resolution multispectral camera).

GF-2: Aug 2014, panchromatic multispectral cameras (panchromatic 1m, substar point 0.8m, multispectral 4m)

GF-3: Aug 2016, C-band multi-polarization synthetic aperture radar (1~500m)

GF-4: Dec 2015, GEO imaging satellite staring camera with visible (50m) & near infrared (400m)

GF-5: May 2018, series of environmental monitoring satellites.

GF-6: Jun 2018, similar to GF-1, GF-6 has high-resolution cameras (2m resolution panchromatic and 8m resolution multispectral camera).

GF-7: Nov 2019, A dual-linear array camera (back sight: 0.65 m, fore sight: 0.8 m); multispectral (back sight: 2.6 m); a laser altimeter (ranging accuracy ≤ 0:3 m) (slope is less than 15 degrees); a footprint camera (≤4 m)

GF-8: June 2015, optical satellite with an high resolution imaging payload developed by the CASC

GF-9: Sep 2014 (1), 2020 (4), series of 5 satellites providing <1m class resolution optical images

GF-10: Aug 2016 (failure) & October 2019, the exact nature of the GF 10 satellite is not known.

GF-11: Jul 2016, Jul 2020, Nov 2021, high resolution optical earth observation satellite, believe to have the military designation is JianBing 16. See previous FFF article

GF-12: Nov 2019, Mar 2021, Jun 2022, high-resolution Earth observation system. It uses a microwave remote sensing system (SAR) with ground resolution up to the sub-meter level.

GF-13: Nov 2020, suspected improved version of GF-4 GEO imager. Likely it is the 15m resolution geostationary earth observation satellite

GF-14: Jun 2020, optical stereo mapping satellite. It can efficiently obtain high precision stereo images globally, draw large scale digital topographic map, produce digital elevation models, digital surface models and digital orthophoto images, and provide basic geographic information.

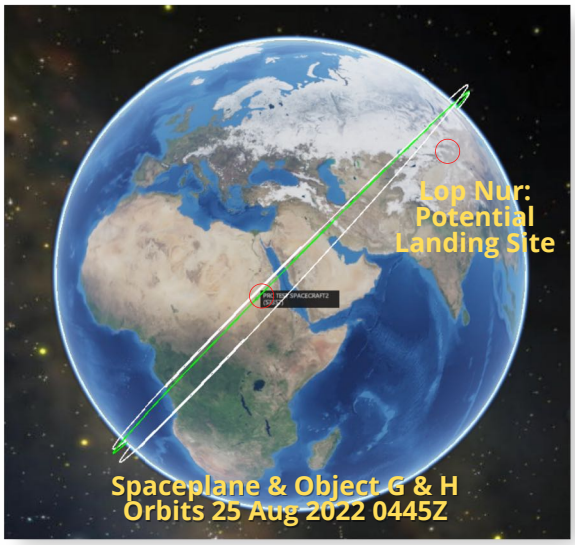
For those who really want to go deep, take a look a the 8 Apr 2022 "An Introduction to the Chinese High-Resolution Earth Observation System: Gaofen-1~7 Civilian Satellites" white paper.

Finally, please take a look at a 2020 interview with Li Dereng in which he describes China's goal to develop an integrated PNTRC concept (Position, Navigation, Timing, Remote sensing, Communications), in three steps: first, a local coverage of the Chinese coasts with 20 LEO sats and three GEO relays, to get a revisit every 15 minutes. Then, a regional coverage of China and the Belt & Road countries with 50 optical, 50 radar and 150 communication satellites. Finally, a global coverage every 5 minutes, with 200 EO and 300 communications satellites.

China Spaceplane Clues

16 Aug 2022: China's reusable experimental spacecraft remains in orbit and recently increased its altitude from 346x593km to 351x595km. While the launch and payload have remained shrouded in secrecy, China has publicly displayed the modified fairing from the launch. See TikTok Video.

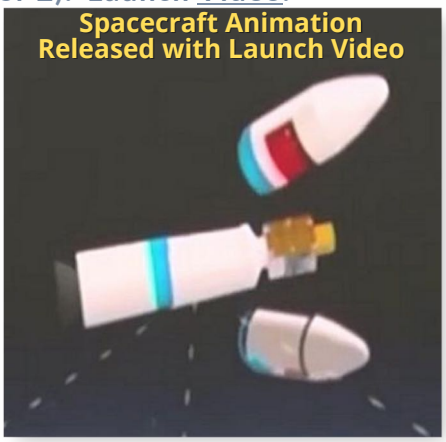
- China's most secretive but not quite hidden spacecraft is shattering the country's previous known record for flight of an unmanned spaceplane.
- The size of the rocket fairing as well as amateur sightings and tracking by the US Space Force all point to a vehicle similar to the American X-37B built by Boeing but smaller.
- If the bumps are spare spaces for wings, the vehicle's wingspan could be larger than fairing's diameter 4.2m.
- Just as with the 2020 spaceplane mission, it appears that at least one smaller satellite was also released alongside the spaceplane.
- When it does land, the spaceplane is expected to touch down horizontally at a landing strip near Lop Nur. Satellite imagery shows recent activity near the landing strip. Lop Nur was the landing site thought to have been used by the 2020 flight.
- While there is little information about the mission, the project appears to fit into space transportation development plans outlined by CASC, China's main space contractor, and its major subsidiaries.
- CASC has previously iterated plans to develop low-cost, reliable access to space, including reusable launch vehicles and a spaceplane. The project, as described, would need to be scaled up dramatically from the test spacecraft currently in orbit.
- A once-every-five-year space "white paper" released by the State Council Information Office in Jan 2022 stated China would, "continue to strengthen research into key technologies for reusable space transport systems, and conduct test flights accordingly."
- Long Lehao, a veteran chief designer of the Long March rocket series, last month presented a range of space transportation concepts during a public lecture, including a spaceplane render, see Video.



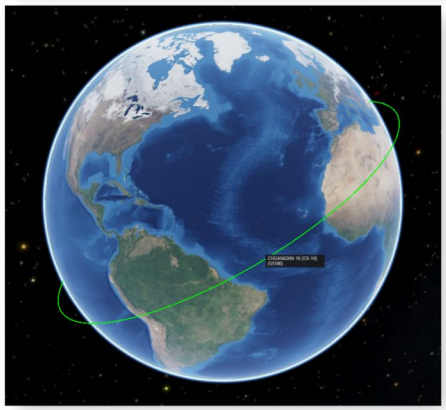
Long Lehao presenting space transportation concepts at public lecture

China Launches Tech Verification Satellite

23 Aug 2022: CASC subsidiary, ExPace, launched a Kuaizhou-1A from Xichang carrying the Chuangxin-16 payload onboard, developed by the Chinese Academy of Sciences (CAS). The spacecraft will reportedly be used for verification of new technologies. There is some confusion over the number of satellites carried to orbit (either 1 or 2). Launch Video.



- The KZ-1A is capable of flying payloads up to 300kg into low Earth orbit. This launch delivered its payload into a 600 x 594km 29° inclined orbit.
- Reports indicate the Chuangxin-16 payload is actually two satellites, named A and B. Because only one object has been tracked so far in orbit, the two satellites may separate in the future, have failed to separate as designed, are not meant to separate, or that this satellite will be followed by the its "twin" in a separate launch — as CAS describes this payload as "an assembly of two satellites" and this, in the past, has been used to indicate individual launches.
- The Chuangxin (translated as "innovation") payload is meant for technology research...one possible demonstration would be automated undocking, rendezvous, and re-docking of these two satellites. However, it remains to be seen what the ultimate mission plan will be for the payload.
- The flight marked the 16th launch of the Kuaizhou-1A series, with 14 of these launches being successful. This launch was also the first ExPace launch from Xichang, with most of its previous launches being from Jiuquan and others being from Taiyuan.
- See new video showing entire KZ-1A launch sequence.



China Launches New Earth Observation Satellite

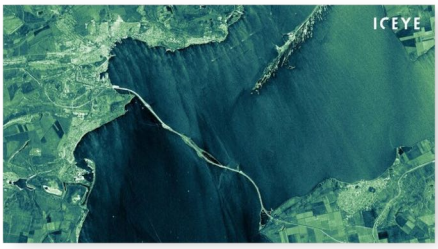
24 Aug 2022: One day after the KZ-1A launch from Xichang, China also launched a LM-2D with the Beijing-3B Earth Observation satellite from Taiyuan. BJ-3B reportedly is capable of .5m resolution imagery. Twenty First Century Aerospace Technology Co., Ltd (21AT),a commercial space company, operates the satellite along with it's BJ-3A predecessor. Launch Video.

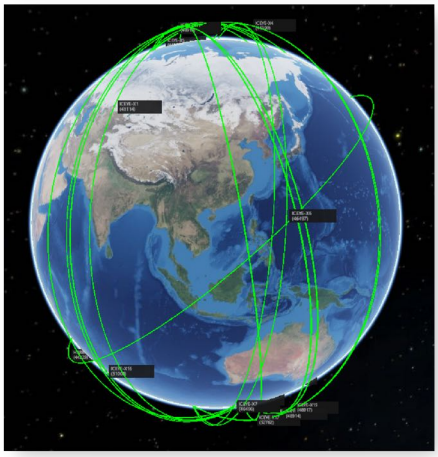
- BJ-3B is in a polar SSO at 596 x 615 km & 97.9° inclination.
- BJ-3B is designed to provide high-resolution remote sensing data products, its optical system is capable of 0.5-meter resolution.
- The initial Beijing-3 satellite, BJ-3A was launched in November 2021 and carries two imagers: a full color imager with a resolution of 0.5m and a multispectral imager with a resolution of 2.0m.

Beijing-3 is the country's most agile satellite built to date, and can photograph such large areas in record time, thanks to the use of onboard AI technology for stabilization. It can also plan its flight route independently, while monitoring up to 500 areas of interest as it zooms around the globe nearly 100 times each day.

Ukraine to Control ICEYE SAR Satellite

23 Aug 2022: ICEYE signed a contract with the Serhiy Prytula Charity Foundation which will provide the Government of Ukraine with ICEYE's Synthetic Aperture Radar (SAR) satellite imaging capabilities. ICEYE will transfer full capabilities of one of its SAR satellites already in orbit for the Government of Ukraine's use over the region.





- The SAR satellite will be operated by ICEYE. In addition, ICEYE will provide access to its constellation of SAR satellites, allowing the Ukrainian Armed Forces to receive radar satellite imagery on critical locations with a high revisit frequency.
- The Serhiy Prytula Charity Foundation is an organization established by a Ukrainian actor to provide drones, armored vehicles and humanitarian aid to the Ukrainian Armed Forces in response to the Russian invasion. In a statement, Prytula called the agreement with Iceye "a significant step in responding to the Government of Ukraine's urgent request for critical Earth observation data and it will greatly benefit our Armed Forces."
- Iceye has launched 21 satellites since the company was founded in 2014. Not all of the spacecraft remain in operation, but the company doesn't disclose exactly which satellites are still gathering data. Still, Iceye claims to operate the world's largest constellation of SAR satellites.

Solar Storms Leave Intelsat's Galaxy 15 Inoperable

23 Aug 2022: Intelsat lost communications with of one of its satellites after it was presumably disabled by space weather (see video). Intelsat is attempting to regain control of the Galaxy 15 broadcast satellite after a disruption on 19 Aug. Intelsat said that a geomagnetic storm likely "knocked out onboard electronics needed to communicate with the satellite." The satellite, launched in 2006, experienced a similar outage in 2010.

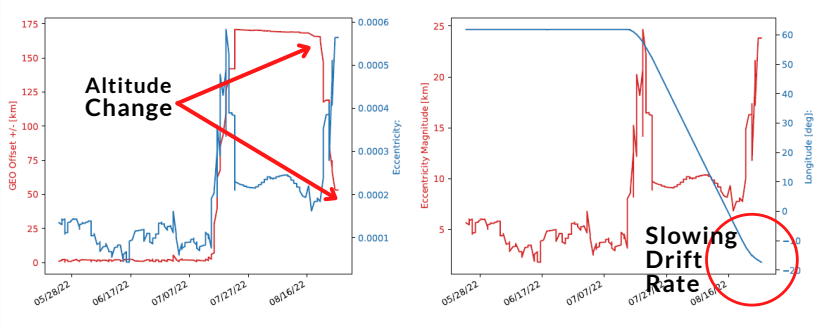
- The satellite is otherwise operating nominally, keeping Earth pointing with all payload operations nominal.
- Intelsat is offloading Galaxy 15 customers onto other satellites so they can continue to try and regain command. The plan is to then deorbit the satellite.
- Galaxy 15 operates in a geostationary orbit over 133° W and provides media coverage to the Americas.
- In 2010, the company lost contact with the satellite for over eight months before it began accepting commands from Intelsat's control center after its batteries fully drained and prompted a reset.
- The U.S. National Oceanic and Atmospheric Administration (NOAA) issued a warning(opens in new tab) on 16 Aug for a category G3 geomagnetic storm, writing that "impacts to our technology from a G3 storm are usually minimal."

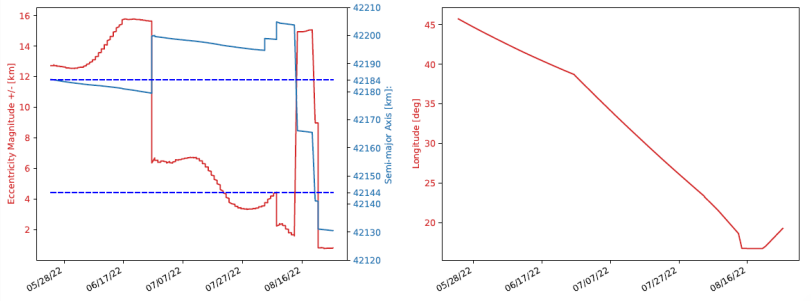
Throughout 2022, solar activity has generated large solar flares and coronal mass ejections (CMEs), suggesting that the sun is "waking up" from a more dormant phase of its 11-year cycle of activity.

This Fortnight in GEO

- Russia's Luch/Olymp decreased altitude 115km to slow westward drift (see graphic below).
- TJS-3 continued to drift eastward towards its early-July position. Briefly in vicinity of Russian ELEKTRO-L3, a second generation of Russian geostationary meteorological satellite.
- SY-12(01) decreased its altitude and reversed drift. It is now drifting eastward and will be in vicinity of Astra 1L, 1M and 1N communications satellites (see graphics below).
- SY-12(02) continued its eastward drift and was not in the vicinity of other satellites during this period.
- SJ-20 maintained its position at 33.5°E.
- SJ-17 continues westward drift.

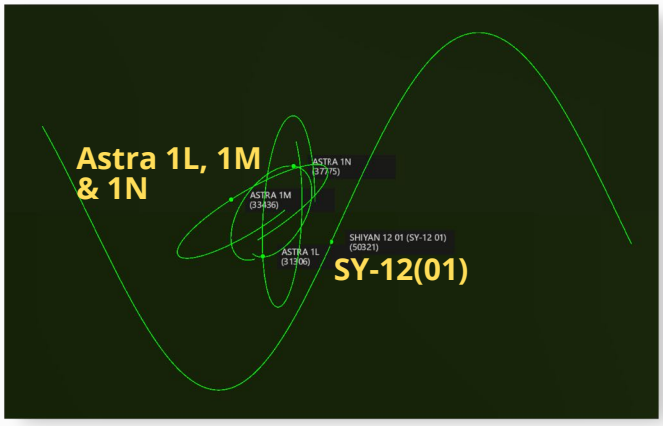
Russian Luch/Olymp (Right) decreases GEO offset by 115kms and begins to slow westward drift rate.





China's SY-12(01) (left) decreases altitude and reverses drift. Satellite is now drifting eastward.

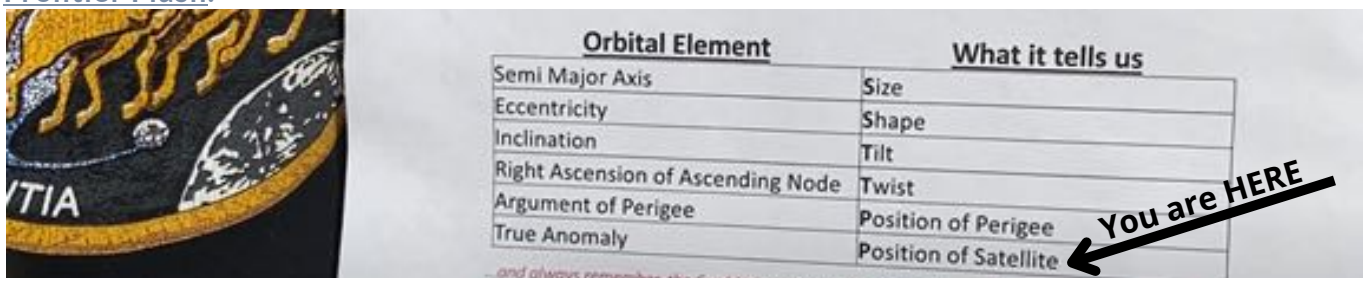
China's SY-12(01) (left) in vicinity of Astra 1L, 1M and 1N communication satellites on 26 Aug 2022, 0918Z.



Editor's Note: Thanks to weekly reporting from Palski & Associates Inc, we're going to try to keep track of maneuvers of select spacecraft in GEO. For this week, orbital information is courtesy of the 2022-08-19 & 2022-08-26, Space Domain Awareness Reports from Palski & Associates Inc. Send a request to david.pierce@palski.com to get added to their distro list!

Jack's Astro Corner: True Anomaly – "Where are we?" (Part VI)

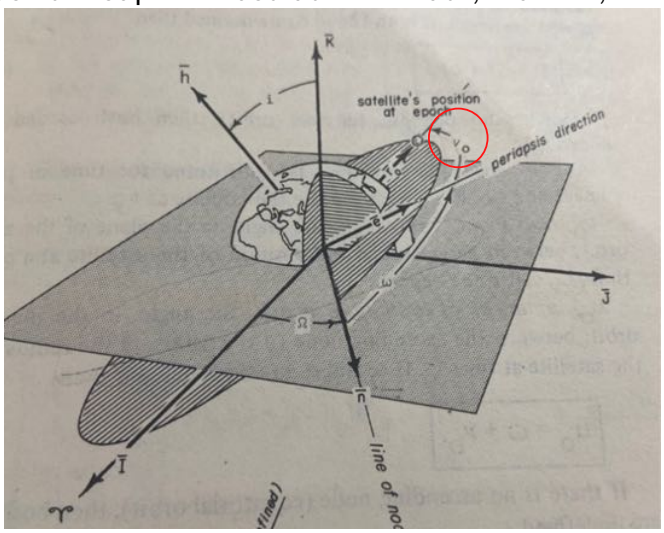
Over the summer, Jack Anthony will break down each of the six orbital elements required to uniquely identify a specific orbit and satellite in that orbit. This week we examine the final element, True Anomaly. For those who may have missed the previous articles, please visit Jack's "Orbit Element Dance" on YouTube" or check out the previous 5 editions of the Final Frontier Flash.



We now move to the second P of my STP method of learning and remembering the Classical Orbital Elements. This is the final essay of the 6-part series on the Classical Orbital Elements. I hope you have learned a lot and also mastered the Orbit Element Dance! Recently I spoke with 10 high school students who were "over the Moon" about space.Some said they saw my YouTube video....one even got up and showed me the dance! I did it for them and it took a while before they stopped laughing. They sure will remember the orbital elements!

We are now going to learn about the orbital element called the True Anomaly. Hey wait a minute, we got an "anomaly" in the orbital elements? Is this an orbital element "Apollo 13" situation. Nope! Well, here's the scoop on why the angle is called an "anomaly." According to my 1980-81 Grad School thesis advisor and awesome teacher Dr. Bill Wiesel, the use of the term "anomaly" is owed to this guy named Ptolemy who lived around 100 AD. He was an Egyptian mathematician, astronomer and a lot more. He surmised that the Earth was the center of the universe, let's just say it's not.BUT, he came up with the concept of eccentric motion of the planets. His work would be refined by Johann Kepler who would come up with the 3 laws of planetary motion. For non-circular motion the angle describing position would not increment or move uniformly as it would in a circle, so Professor Ptolemy called it an "anomaly" and over time the name stuck.

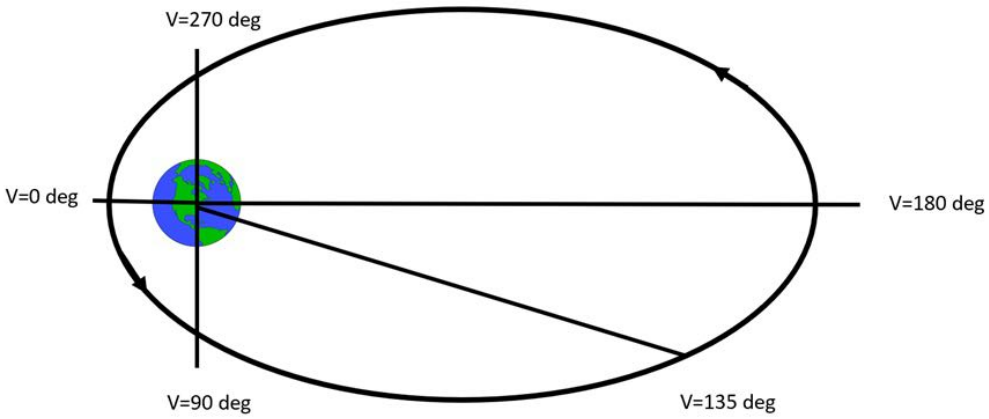
Once again, I am going to use the superb illustration in Bate, Mueller, White & Saylor:



Jack's Astro Corner: True Anomaly (Cont)

Last time we learned about the Argument of Perigee which is denoted using ω, “small omega.” It is the angle between the Node vector and a vector pointing to where perigee is.Perigee is the closest point to the Earth of the orbit. You’ll see the vector pointing towards perigee is denoted “e”. I bet you remember that is the “eccentricity vector.” That is the starting reference for True Anomaly. What’s the other reference? Answer: It is the satellite’s position vector. Its where the space object is at the time noted. The time noted is called the Epoch Time. The True Anomaly angle is noted using the Greek letter “Nu” and represented with a small v.

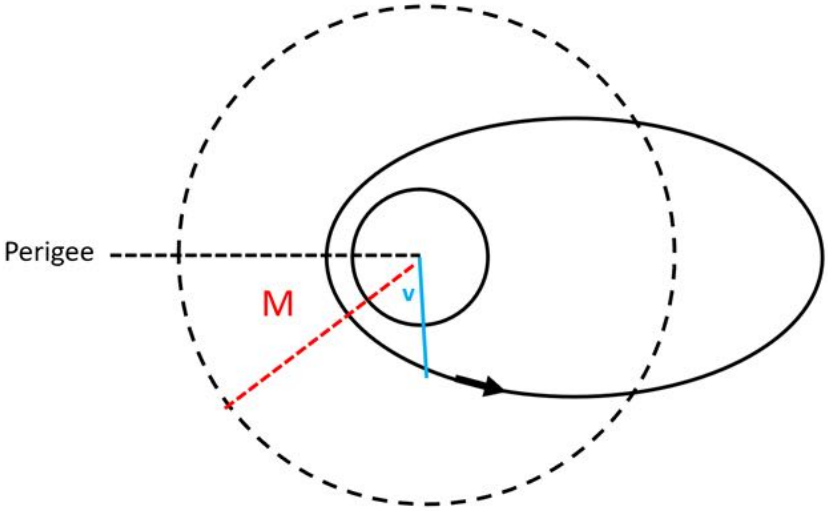
OK, so let’s see what the True Anomaly can tell us about the orbit and specifically where the space object is in the orbit. If v is zero degrees, that means the object is at perigee. What if v is 180 degrees? Let’s ask Barney Fife who is here for a refresher Astro class. Barney bursts forth with the answer. “It’s at apogee” and goes on to dazzle all of us with additional information “Its going the slowest in its orbit at apogee.” Right you are Barney. Here’s an illustration below that shows some different values of True Anomaly in the orbit.



LPop quiz! At v=135 degrees, is the satellite speeding up or slowing down? How about at 270 degrees? Answers: slowing down, speeding up. Good job!This is based on Kepler’s second law.

One more thing before we wrap up our 6-part series on Orbital Elements. In the Two-Line Element (TLE) Set they list Mean Anomaly as one of the 6 orbital elements. It’s a teammate of the Mean Motion which you learned about in the semi-major axis article.It moves at the angular rate of Mean Motion. Mean Anomaly is the angle where the space object would be if it was travelling on a circular path with the same semi-major axis (and therefore period). It is a “fictious” angle and unlike true anomaly, mean anomaly increases at a constant rate. Hummm, let’s look at an illustration I made that shows both true and mean anomalies.

Jack's Astro Corner: True Anomaly (Cont)



Mean Anomaly will always be less than True Anomaly when traveling to apogee, so it lags. They are equal at apogee. Then on the way back to perigee, Mean Anomaly leads True Anomaly and is then equal again at perigee. For circular orbits Mean and True Anomalies are equal.

Well, this concludes the 6-part series on the 6 classical orbital elements. I hope you enjoyed it, I tossed in some extra astrodynamics stuff along the way. Maybe your interest is piqued where you can learn more though formal Astro education, pestering an astrodynamics expert (they love it), or doing a self-study.

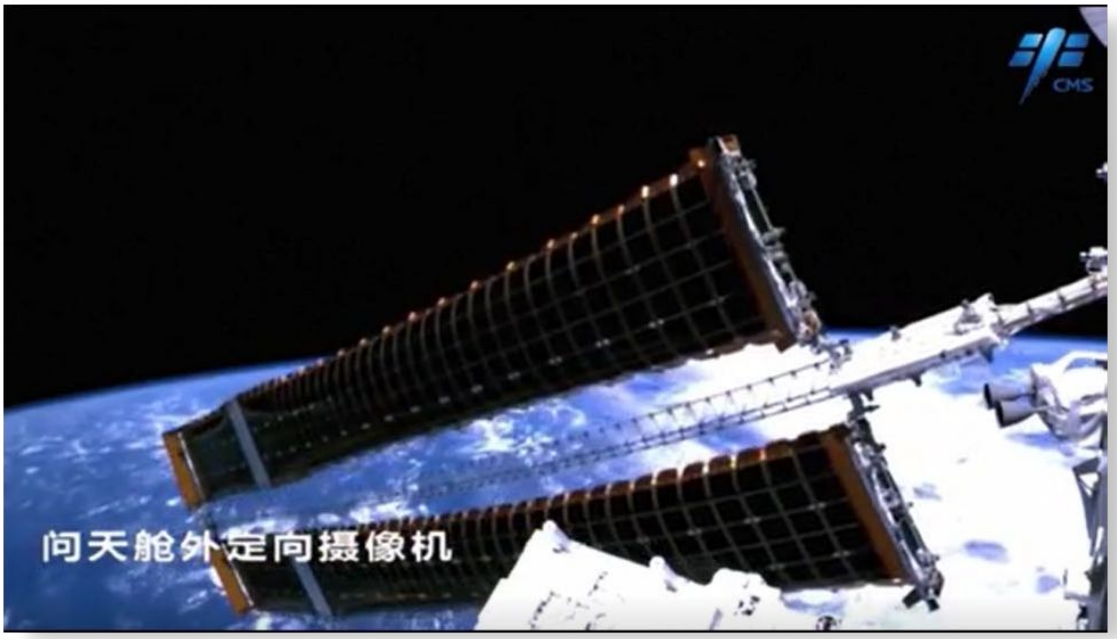
You can reinforce your knowledge by learning the orbital element dance. It will also get you cool points with family and friends. Remember the STP method: Size, Shape, Tilt, Twist, Position Perigee, Position Satellite.

Having completed the 6-part series on Orbital Elements entitles you to a graduation certificate, please see next page 😊

“Congratulations, thank you for learning the 6 Orbital Elements…
….say, let’s see your Orbital Element Dance!
Ferris Bueller & Barney Fife

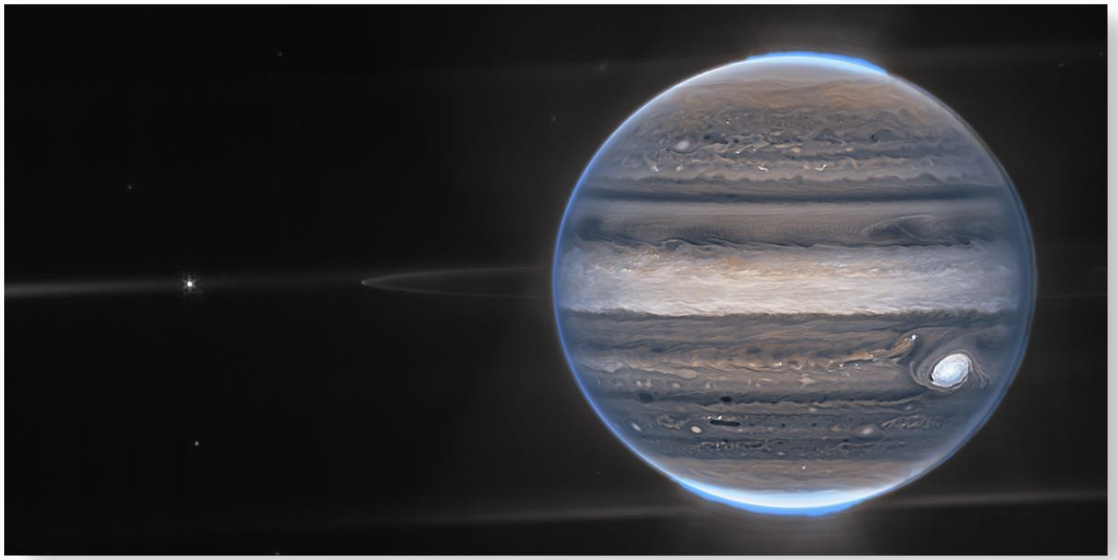
Pics o' the week!

Lenticular cloud floats above the Gemini Observatory in Maunakea, Hawai'i



New Solar Panels Extended Outside Chinese Space Station

Because Rockets...



JWST's Latest Image of Jupiter (and moons)

Space Debris Finds a New Home in Australia

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SP480 - Intelligence Support to Space
Continuing Education
SP101 - Introduction to Space Operations
SP102 - Introduction to Space
SP103 - Math for Space
SP201 - Space Race 2.0
SP202 - Advanced Orbital Mechanics
SP203 - Joint Planning Process
SP204 - Space Surveillance Network/Object Surveillance & ID
SP301 - Electromagnetic Warfare
SP302 - Cyberspace
SP303 - Anti-Satellite Weapons
SP304 - Interference Detection, Attribution & Geolocation

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