31 JULY 2022

THE FINAL FRONTIER FLASH

Developments & Analysis of the Space Domain

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Catalog

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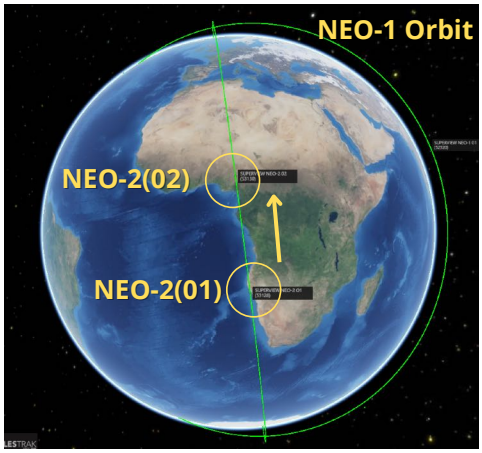
In This Issue

China Launches New SAR Satellites

16 Jul 2022: China launched two satellites onboard a Chang Zheng 2C from the Taiyuan Satellite Launch Center (TSLC). The payloads went to a Sun-Synchronous Orbit (SSO) and are called Siwei Gaojing-2 01/02, or SuperView Neo-2 01/02. The Synthetic Aperture Radar (SAR) satellites were constructed and operated by China Siwei Survey and Mapping Technology Co. Ltd. Launch Video.

- There was initial debate as to whether SuperView Neo-2 satellites are Electro Optical or SAR imagery. Neo-2 are believed to be SAR capable of producing 50cm resolution imagery when operating in spotlight mode.
- The Neo-2 satellites are in SSO as their NEO-1 predecessors which are confirmed high resolution electro optical satellites.
- Both satellite pairs are at similar altitudes and 97.4° inclination.
- The launch time of the NEO-2 satellites places them in a "dawn-dusk terminator" SSO which is more linked with radar/SAR satellites.
- Previously, Siwei launched 2x 30cm resolution SuperView 1 satellites on 29 Apr 2022.
- For their final constellation, Siwei is planning to launch at least 28 satellites which will be divided into three different kinds of satellite systems.
  - 16 Neo-1 satellites provide 20-30cm resolution imagery,
  - 8 Neo-2 satellites provide SAR images with a 50cm resolution.
  - 4 Neo-3 to collect “large swath-width, optical images” with 1m or better resolution. These have a worse resolution than the Neo-1 but can capture a bigger frame for their images. It is not known when the first Neo-3 will launch.
- The final constellation will provide information to a variety of providers in the civil and defense sector for civil mapping, agriculture management, energy and transportation infrastructure, disaster monitoring, and more.
- Siwei Survey & Mapping Tech is technically a commercial company, but is a subsidiary of the China Aerospace Science and Technology Corporation (CASC), which is the main state-owned Chinese contractor for the construction of launch vehicles and rocket systems.

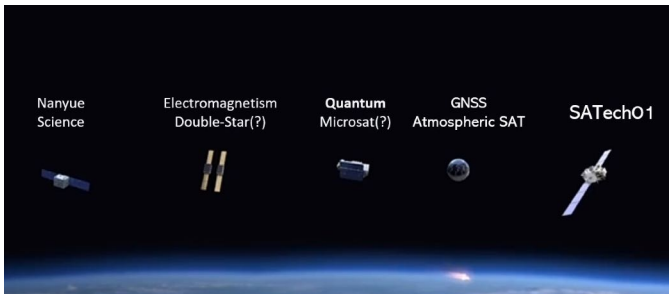


Chinese Company Launches ZK-1A & 6 Satellites

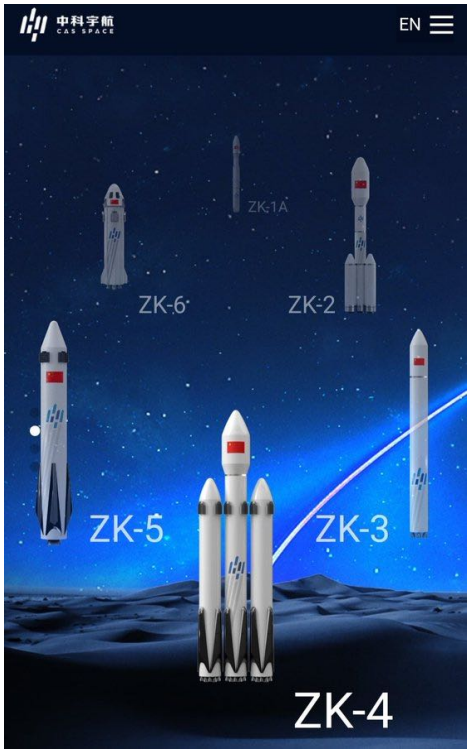
26 Jul 2022: CAS Space launched the most powerful solid rocket built in China, the Zhongke-1A (ZK-1A), from their own newly built launch pad at the Jiuquan Satellite Launch Center. The main payload will be SATech-01, while 5 piggyback microsats shared the ride.

Launch Video & Cool Animation.

- CAS Space, also known as Zhongke Aerospace, is a spinoff company partially owned by the Chinese Academy of Sciences. The company developed the Zhongke-1A vehicle, also known as the ZK-1A or Lijian-1, based on the existing DF-31 road-mobile ICBM. This is one of several Chinese launch vehicles with solid-fueled ICBM heritage.
- The ZK-1A is reportedly capable of lifting 1,500 kg to a 500-km SSO, making it the most powerful solid launch vehicle in China, eclipsing the current Long March 11.
- CAS Space is also working on larger solid rockets and reusable liquid launchers.



- The main payload is SATech-01, also known as SY-01. SY-01 is a new space technology test satellite featuring the High Energy Burst Searcher (HEBS) which is designed to monitor gamma-ray bursts associated with gravitational wave events such as colliding black holes.
- The other spacecraft include the Huawan-Nanyue Kexue science satellite, the Chuangxin-15 satellite, 2 electromagnetism research satellites, and a GNSS atmospheric density measurement satellite. One of the microsatellites reportedly had a quantum key on board, as part of China's work on developing quantum communications.
- CAS Space is planning to fly a medium-lift rocket known as the ZK-2 with a core similar to the ZK-1A plus two solid rocket boosters with the same width as the core. The first flight could occur at the end of 2022.
- A ZK-3 small liquid launcher with greater capability to SSO is also being developed and CAS Space is also developing the vertical takeoff/vertical landing ZK-4, ZK-4A, and ZK-5 rockets with liquid-fueled engines and the ZK-6 suborbital space tourist rocket. The ZK-6 has a marked similarity to Blue Origin's New Shepard, while the ZK-4A and ZK-4 bear some resemblance to the SpaceX Falcon 9 and Falcon Heavy, respectively.

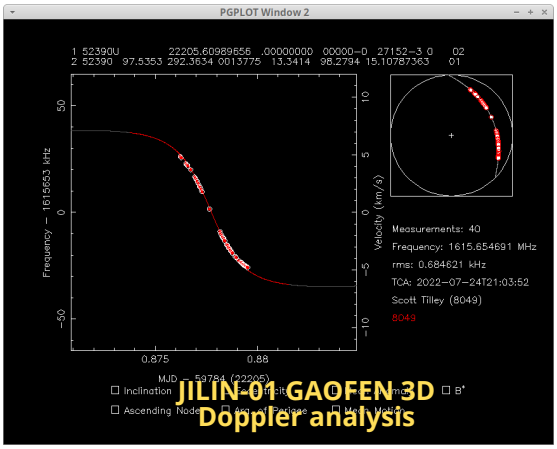


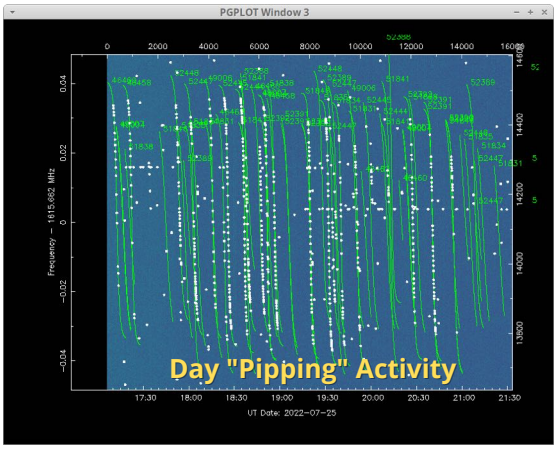
China's state-owned and commercial space entities have been developing a range of solid rockets with varying capabilities in recent years, with the trend seen as an effort to boost the country's overall space capabilities.

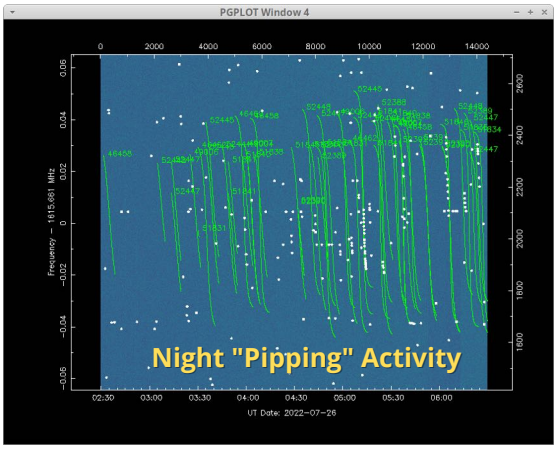
China: Jilin Imagery Constellation Sending Data "Pips"

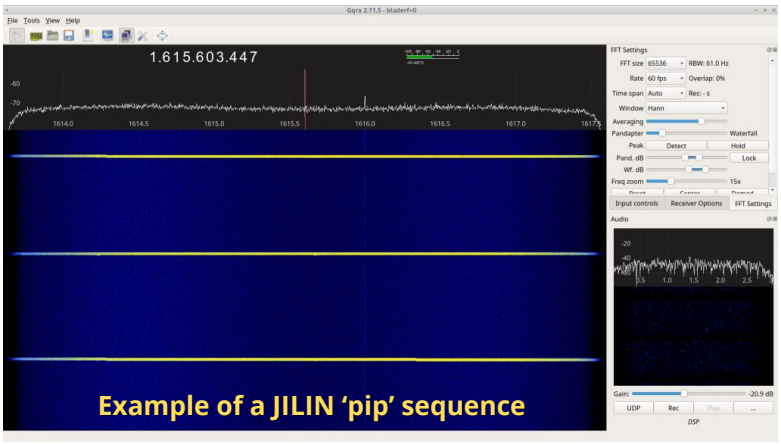
26 Jul 2022: Amateur Astronomer Scott Tilley noted strange wideband data "pips" emanating from the Jilin imagery constellation. With respect to these L-band signals, Jilin is acting like a mobile-satellite communications system. See Video.

- Mr Tilley observed a total of 29 JILIN spacecraft emitting 'pip' emissions between 1613.8-1626.5MHz.
- The 'pips' appear to be about +3MHz in bandwidth and ~0.5 seconds in duration.
- The transmission interval is around 4-10 seconds when they are active but many spacecraft are not active on each pass and when they are they may not 'pip' for the entire pass and may even change their 'pipping' rate.
- The pipping appears to be most pronounced during the daytime. They are active at night but much less so than during daylight.
- Mr Tilley found no reference on ITU filings or in news reports about why there would be data 'pips' coming from the JILIN satellites. He notes the only other service that remotely matches the Mobile-satellite service from China that is presently active is the GEO based TIANTONG system which uses different frequencies.
- The diurnal behavior of the system could mean that it is either driven by human activity (less activity at night) or it could be part of the primary JILIN optical Earth imagery mission, perhaps allowing a client to place a transponder on an asset and have the spacecraft interrogate it and image its location as it moves around...it is possible this could be some sort of asset tracking system.
- The JILIN system is operated by Chang Guang Satellite Technology Company in Beijing. No public references have been found about what these emissions from the satellites purpose is.









China Paper: Shi Jian (SJ) and Shi Yan (SY) Projects

28 Mar 2022: The Chinese Aerospace Studies Institute (part of the USAF Air University), published a short paper describing the history of Chinese experimental SJ and SY satellites up to 2013.

- "Shi Jian" indeed means "practice" but as a noun, such as "best practice", or as in "put into practice."
- Chinese linguists argue against translating "Shi Yan" as "experiment," so "pilot" or "trial" are more applicable.
- Both the SJ and SY series have for decades contributed to what Beijing now refers to as the China High-resolution Earth Observation System (CHEOS).
- SJ satellites have primarily improved methods for radar and infrared payloads and SY vehicles have primarily enabled testing of other optical payloads.
- The SJ series has 30 more years of history and a corresponding larger variety in missions and payloads. For example, it has also regularly played a role in establishing best practices for data transmission and communications, and on-orbit satellite constellation guidance and control.
- In 2013, after being jointly launched, the SJ-15 and Shi Yan-7 conducted their only publicly known rendezvous and proximity operation (RPO), which seemed to be coordinated.
- Information on these early launches illustrates that China's focus for the SJ series was on establishing best practices and operational procedures to enable the development of China's space program.
- To begin professionalizing Chinese space operators, engineers used lessons learned from the first four SJ satellites to publish Mandarin space operations manuals such as the Handbook of the Artificial Satellite Environment and Handbook on Low Earth Orbit Space Environment.

Figure 1

Figure 2

- The SJ series improved methods for satellite control after launch, a general requirement that is especially necessary for enhanced imagery with two satellites flying in formation.
- The first Shi Yan was initiated and designed by the Harbin Institute of Technology and launched in 2004, nearly 30 years after the start of China's space program.
- Shi Yan-1 was China's first stereoscopic imaging satellite for terrain mapping, and the first ten years of the series saw Shi Yan 1-5 focused on piloting as many payloads as possible, probably optical sensors, on one satellite close to 200 kg.

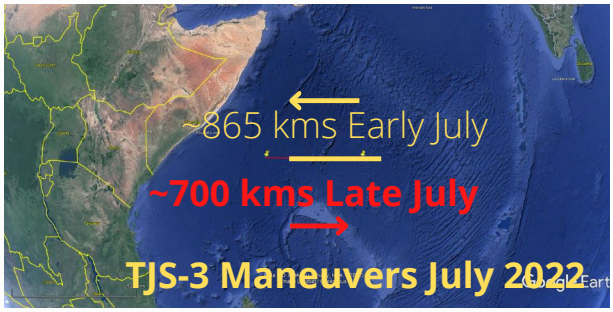
China has historically used the SJ series to establish operational best practices and procedures for systems or techniques already adopted. The SY satellites appear to play an earlier role in the space systems development process. China has used the SY series to pilot multiple new technologies on one satellite bus specifically to develop a platform for efficient payload integration, as well as to determine the applicability of the payloads.

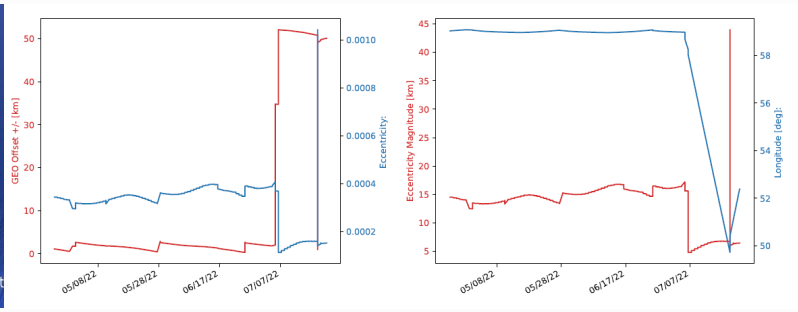
This Fortnight in GEO

- TJS-3 reversed course and is now drifting eastward towards its original position in early-July.
- Tianlian-2 (03) relay satellite circularized its orbit and is now at 10°E.
- Russian Luch/Olymp Satellite initiated 2° per day westward drift, now 2,900kms from previous station.
- SJ-17 reduced altitude and initiated .48° per day westward drift. Briefly in vicinity of Fengyun-2F.

Forget Something? TJS-3 Reverses Course:

- In early July TJS-3 was at 59°E when it increased its altitude and began a westward drift.
- TJS-3 proceeded to 51.2°E, ~900km from its original position earlier in the month.
- On 22 July TJS-3 decreased its orbit ~100km and reversed its drift. It is now back to 57.5°E and continuing to drift east <1°/day.
- Soon after its launch in Dec 2018 TJS-3 conducted a series of maneuvers with the TJS-3 AKM. Watch Video.
- Chinese news media reported TJS-3 will test "double satellites co-position communications" as well as "multi-frequency and high speed comms".





Tianlian-2(03) Update

As anticipated the new Chinese data relay satellite, Tianlian-2(03), circularized its orbit and has settled into China's 10°E GEO slot.

- China recently relocated TL-1 (05) closer to TL-1 (03) leaving the 10°E slot vacant.
- Tianlian-2(03) is the most inclined of China's 2d generation relay satellites. TL-2(03) is 3° inclined, .TL-2(02) is 2.4° and TL-2(01) is only .1° inclined.
- China has 7 current data relay satellites. Four are first generation TL-1 satellites and three are the second generation TL-2. China's first TL-1 is in a supersynch orbit and no longer active.

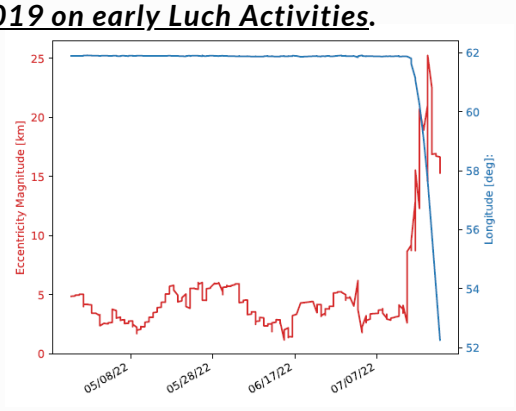
This Fortnight in GEO (cont)

Russian Luch/Olymp Initiates Westward Drift

- Prior to 21 Jul 2022 Luch/Olymp maneuvered to decrease its orbit ~140km resulting an a 2° per day westward drift. It has now drifted from 61.8°E to 35.8°E (~2,900km).
- Over the past 2 weeks Luch/Olymp has been in the vicinity of SKYNET 5D (UK 39034) and PAKSAT 1R (PK 37779).
- Prior to the maneuver Luch/Olymp had been in vicinity of Intelsat-33 since October 2021.
- During its eight years on orbit, Luch has parked near more than two dozen commercial communications satellites for periods ranging from a few weeks to nine months and typically close enough to be within the typical ground terminal uplink window.

Watch most outstanding COMSPOC video from June 2019 on early Luch Activities.

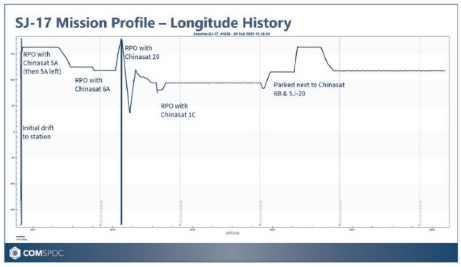
Luch/Olymp Heads West



Luch/Olymp Longitude

Hello Old Friend: SJ-17 Maneuvers

- SJ-17 decreased its altitude ~34 km and is now drifting west at ~.48° per day. It relocated from 117.5°E to 111.31°E and continues to drift westward.
- SJ-17 was periodically in the vicinity of Fengyun 2F, a Chinese weather satellite, early on 29 July.



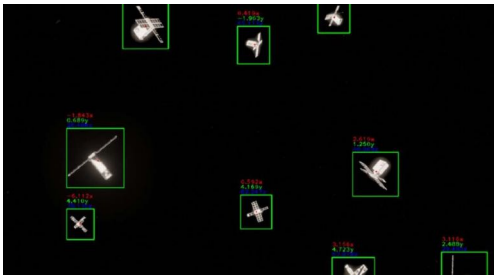
The longitudinal history of the SJ-17 satellite since launch in 2017, including major RPOs with other satellites. Image credit: COMSPOC Corporation.

SHIJIAN-17 is an experimental satellite that carries an electric thruster test package, a type of propulsion system that could give the spacecraft great maneuverability to efficiently adjust its orbit and move around the geostationary belt. General James Dickinson, then Commander of U.S. Space Command, stated in Congressional testimony that the SJ-17 also carried a robotic arm that could be used for dual use capabilities. Watch another awesome COMSPOC Video on SJ-17.

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 2022-07-22 & 2022-07-29, Space Domain Awareness Reports from Palski & Associates Inc. Send a request to david.pierce@palski.com to get added to their distro list!

Commercial: SCOUT to Develop On-Orbit SDA

22 Jul 2022: SCOUT Space won a Phase 2 Small Business Innovation Research contract from the U.S. Space Force to augment military systems with commercial data from space-based sensors. SCOUT wants to demonstrate that commercial data collected by sensors in space combined with data from traditional ground sensors can improve the accuracy of space debris tracking and can help predict collisions.

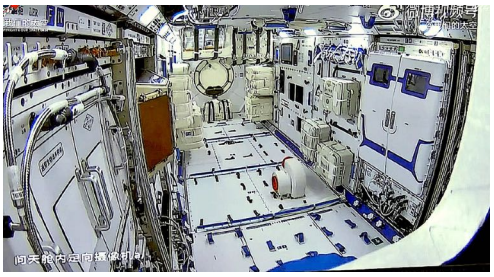


- SCOUT's data will augment the military's space catalog with commercial data that can be shared with international partners.
- The company's software will be tested by the operators from Space Delta 2, a Space Force unit that focuses on space domain awareness, and the Air Force Research Laboratory's intelligence systems division.
- SCOUT developed a sensing payload called SCOUT Vision that uses computer vision and guidance software to enable better navigation and threat avoidance. The first one launched in June 2021 on an Orbit Fab's on-orbit refueling spacecraft and is currently in operation.

China Adds Wentien Module to Space Station

24 Jul 2022: China launched the Wentian experiment module on a Long March 5B rocket from the Wenchang spaceport on the southern Chinese island of Hainan, with crowds watching on from nearby public beach areas. The LM-5B first stage will likely re-enter Earth's atmosphere on 31 July.

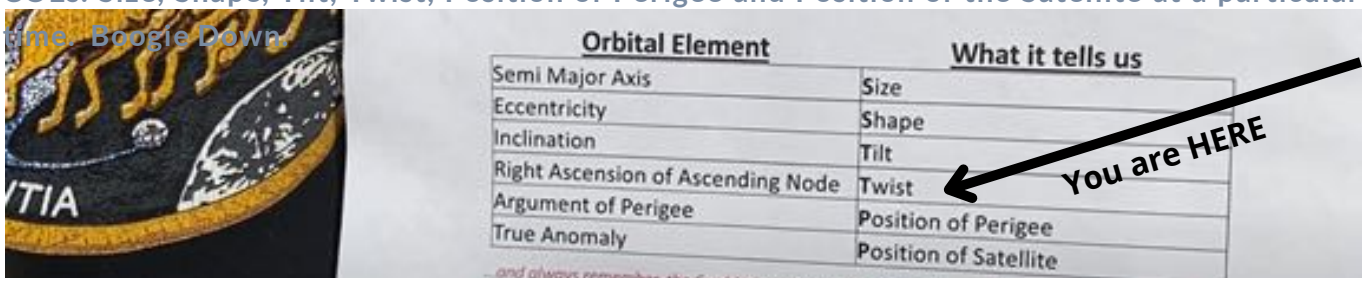
Watch Launch. Watch Video Describing Wentien.



- Wentian ("Quest for the Heavens") is a laboratory cabin module (LCM), and one of the three major modules of the Chinese Space Station. It will not only provide science space for the station, but also additional navigation capabilities, avionics, propulsion, and orientation control.
- The Wentian module had a mass at takeoff of 23,000 kilograms and is designed to host a range of science cabinets for on-orbit experiments.
- Wentien also provides backup life support and propulsion for Tianhe, which launched in Apr 2021.
- The country has now successfully launched eight space station-related missions for the project, including two modules, three cargo spacecraft and three crewed missions. A third module, named Mengtian, is expected to launch in Oct.
- While the launch and docking were successful, the large first stage of the Long March 5B rocket, which entered orbit along with Wentian will re-enter Earth's atmosphere on 31 Jul.
- The re-entry will be uncontrolled and location of the debris field unknown. The previous LM-5B left debris fell into the Indian Ocean (no damage was reported).

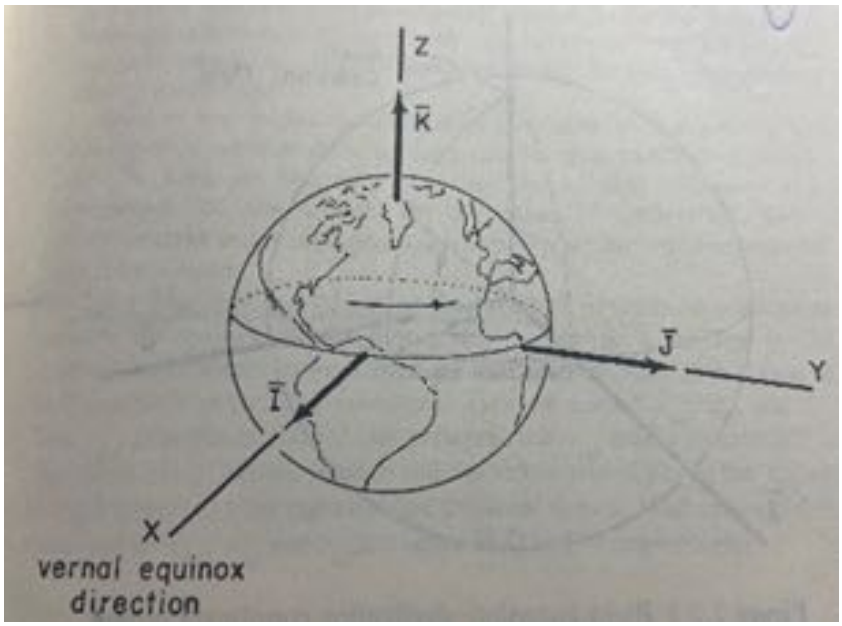
Jack's Astro Corner: Right Ascension of the Ascending Node (RAAN) - Let's Do the Twist (Part IV)

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 Right Ascension of the Ascending Node (RAAN). For those who can't wait the entire summer, please visit Jack's "Orbit Element Dance" on YouTube" and you'll find a 1:02 video featuring Jack in his driveway demonstrating this highly effective way to learn about the 6 classical orbital elements (COE). Each movement ties to an important astrodynamics principle. Below is a screen grab from this video. As you can see, Jack uses the STP method of remembering the 6 COEs. Size, Shape, Tilt, Twist, Position of Perigee and Position of the Satellite at a particular time. Boogie Down.



How's your Orbit Element Dance confidence? I'm excited to hear reports like "my crew is doing the dance, we can't wait to show you." Now these are some pretty hip Guardians! In the STP way of remembering Orbit Elements, we are up to the second "T", the Twist of the orbit, which is Right Ascension of the Ascending Node (RAAN). Like I stated in the Inclination article, these last 3 orbital elements are angles between orbit-related vectors.

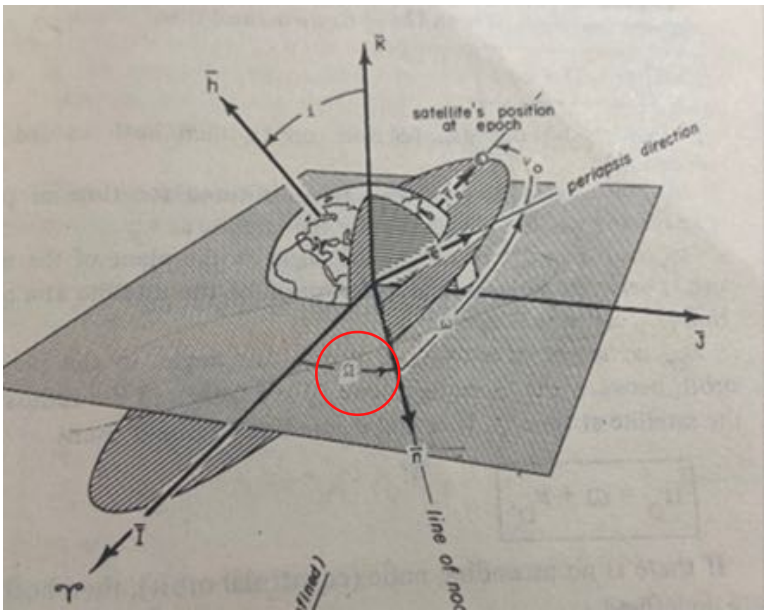
The Ascending Node is where the satellite passes through the equatorial plane as it ascends from the south hemisphere to the north. Remember the ECI coordinate frame from the Inclination essay? Here again the illustration from BMW the shows what the ECI frame is.



Jack's Astro Corner: Twist (Cont)

The principal axis of this coordinate frame is the I or X axis. That is the reference we'll use to determine RAAN. It points towards the Vernal Equinox. Overall, it points to a place way, way out there in space that is not moving relative to Earth and is fixed to the stars. Well, it's sort of moving about 1 degree per 72 years. Why? Due to the Earth's axis precession, this reference point has shifted over the centuries from Aries to Pisces and is heading to Aquarius. Despite how it is sometimes depicted, the Vernal Equinox is a direction and not tied to any geographic point on Earth. There a lot of science that goes into tracking the exact position of the Vernal Equinox and this point in the star background. Many times, an ECI coordinate frame will have a date associated with it. Pretty exact stuff!

The other vector needed to determine the orbit RAAN is the Node Vector. It's actually a vector in ECI pointing to the Ascending Node of the orbit. In your Orbit Element Dance practice, the move after saying "Twist" is a dramatic dance move (like John Travolta...who knows who he is?) where we identify the Ascending Node and point to create a Node Vector. It's my favorite move in the dance. Here again is the BMW illustration that shows inclination from last time, and the three remaining orbit elements RAAN, Argument of Perigee, and True Anomaly. Look closely and find the I axis and then the Node Vector. It will say "line of nodes." The angle between them is RAAN and is denoted Ω. It's Greek and is stated as large Omega.

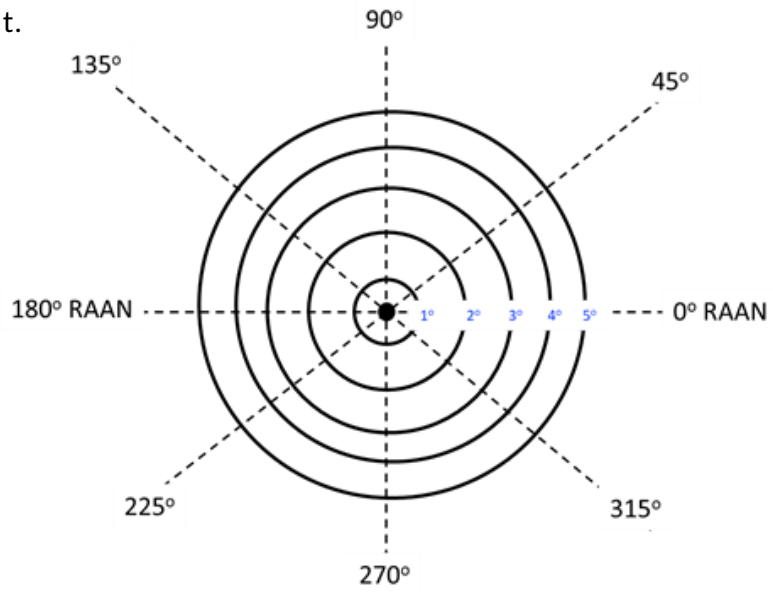


Looks to me that the RAAN is about 35 degrees or so, do you agree? As you can see, the RAAN can have a range of values of 0 to 359 degrees. It's the twist or swivel of the orbit plane. We measure eastward from I-axis, which is per the Right-Hand Rule. To show that put your thumb in the K-axis direction, curl your fingers and that's which way we measure.

Jack's Astro Corner: Twist (Cont)

RAAN is relative to the ECI frame, it is not tied to the longitude of the Earth, it is an inertial reference not a geographic reference. Some folks call it the Longitude of the Ascending Node, even BMW does. They are referring to the "celestial longitude." It is a measurement in the ECI frame. So, when you are in a discussion about "longitude of the ascending node," make sure everyone understands if it's RAAN (inertial) or some reference to a geographic longitude on Earth. You'll be an astrodynamics super hero if you step up and verify this point!

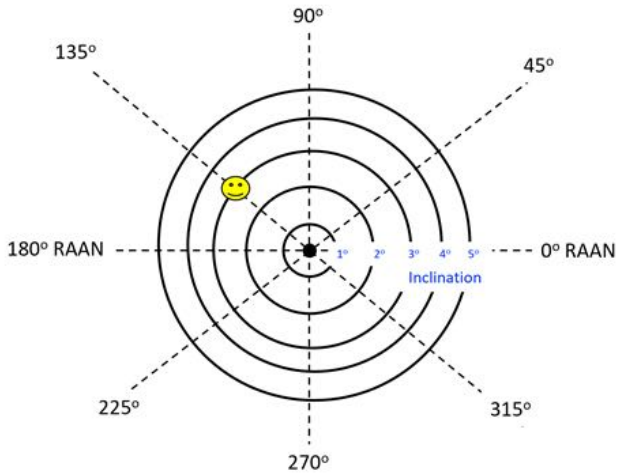
OK, so we got the RAAN definition down. Hooray! Now I'd like to introduce you to the Polar Plot used by GEO satellite operators and orbit planners. It combines information on Inclination and RAAN in one nifty display. Inclination and RAAN are the two orbital elements define the orbit plane. You need BOTH of these elements to define the orbit plane. Here's a illustration I made to introduce the Polar Plot.



Jack's Polar Plot

As you can see, I have limited PowerPoint skills, but the circles radiating out are inclination, the dot in center is inclination zero. The RAAN is also depicted. For this plot we start at the 3 O'clock position and proceed counter-clockwise and make a 360-degree circle. I've labeled the RAAN for every 45 degrees. So, if your GEO spacecraft was launched into a GEO orbit with inclination of 3 degrees and RAAN of 135 degrees where would it be shown in the Polar Plot? "Ah, yes, Mr. Bueller, you have raised your hand, what do you say?" (before Bueller speaks, where would you put the "smile face dot" defining your satellite's orbit plane location? <Play TV show Jeopardy music here>

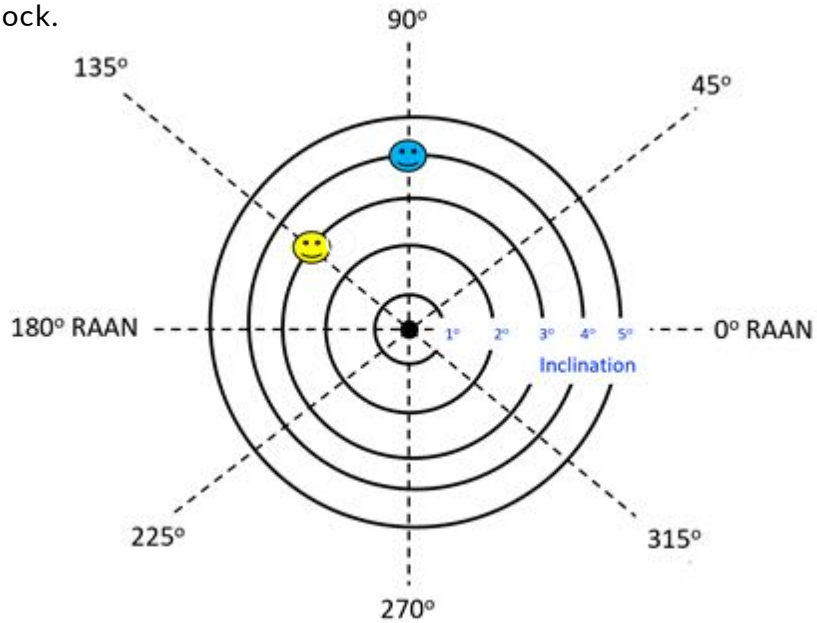
Jack's Astro Corner: Tilt (Cont)



This “smiley face” defines your orbit plane, the inclination and RAAN. It’s important to know BOTH are needed to define the orbit plane. I can’t emphasize that enough.

Now, I’m going to talk you through an realistic example problem involving maneuvering your GEO satellite. Let’s have you be in charge of a GEO satellite that is a refueler. We’ll call it the Guardian Gas-n-Go satellite.You have been asked to rendezvous and dock with a Client satellite at their location in GEO. They are paying you in In-and-Out Burger Coupons, a lot of them, plus you get a special pass to go to the head of the line! In this example I’ll drive home the importance of fully defining your orbit plane with inclination and RAAN, not just inclination!

Guardian Gas-n-Go satellite must complete an RPO with the Client and then Dock with the client who needs to be refueled. Your client satellite is in an orbit with inclination of 4 degrees and RAAN of 90 degrees. Here’s the Polar Plot with you and the client’s orbit plane is defined with a blue smile face. Your maneuver task is to match the orbit plane of the client before closing in on them for RPO and Dock.



Jack's Astro Corner: Tilt (Cont)

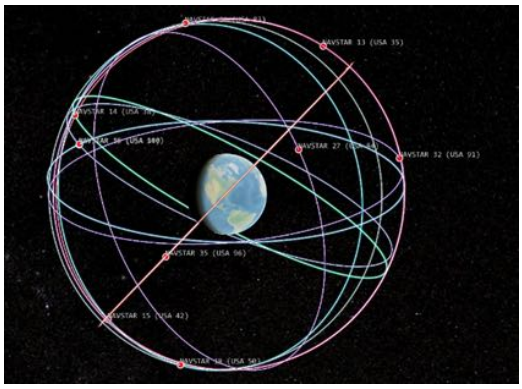
How do you get your refueler satellite to the client? Well, you have to execute an orbit plane change, get in their orbit plane. After doing that, there is additional maneuvering to close the distance and meet up with the client and dock with them to dock and refuel them. We'll not play through that, we will just do the orbit plane matching stuff.

The Delta-V to do this orbit plane change to match the client is a combined single burn to increase the refuler inclination by 1 degree to match client's inclination. ALSO, the refueler must rotate the RAAN from 135 degrees to 90 degrees, that's a 45 degree change in RAAN. I've got a nifty spreadsheet tool to calculate that Delta-V to do that combined single maneuver to re-align your orbit plane to the Client's orbit plane. We find that 152 m/sec is needed to do that orbit plane match.

Now, this is the most fuel-efficient way to do this orbit plane match. One Delta-V that changes both Inclination and RAAN in one maneuver.Let's say the mission director's name is Barney Fife. So what if Barney said we just needed to increase our inclination 1 degree. He's been to the Mayberry School of Orbitology. Uh, did Barney forget RAAN? Let's say that happened. We'd find that my nifty spreadsheet tool would tell us that 54 m/sec is all that's needed to increase our inclination 1 degree.Barney is thrilled, Deputy Mission Director Andy Taylor is not. He explains to Barney "You matched the client's inclination, BUT, failed to match the RAAN." You are NOT going to be able to rendezvous because you are in a different orbit plane.Matching the orbit plane is needed to subsequently maneuver close and stay in formation. You can't be zig zagging out of plane trying to do that.

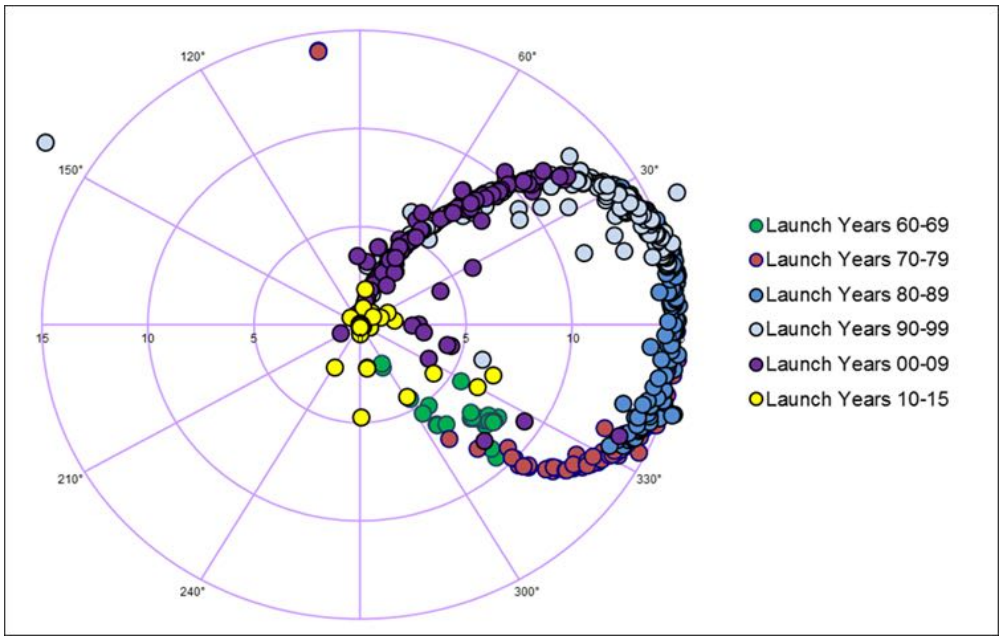
What can they do? The Guardian Gas-n-Go spacecraft must to do a second Delta V and twist the orbit plane over the 45 degrees to match the client's RAAN. That would require a second burn of 164 m/sec...yikes this mistake is costing us big time. Instead of a single 152 m/s Delta V, you would have to do two burns and they would total to 218 m/s. Gosh Barney, that "forgot RAAN" cost you 66 m/s extra. How you going to explain that to General Raymond, General Dickinson, Lt Gen Shaw or Lt Gen Whiting? I hope you followed this example problem, the bottom-line is the orbit plane is defined by Inclination and RAAN, and to just change inclination is inadequate to match the orbit planes and then set up your rendezvous and refueling mission. Remember RAAN is a partner of Inclination when it comes to defining the orbit plane!

I asked my good friend and fellow Astro engineer David Pierce of Palski & Associates "how can I really drive home the inclination & RAAN define the orbit plane?". He shared a MEO example. This screenshot below of the GPS satellites. They orbit the Earth every 12 hrs and each has an inclination of about 55 degrees, but do you see the many orbit planes? Well, that's because they have different RAANs. Thank you, David.



Jack's Astro Corner: Tilt (Cont)

Let's get back to GEO. OK, one more thing now that you are all RAAN smarties to the max. Remember the 54-year cycle where inclination goes through a 15-degree cycle? We introduced that in the Inclination Astro Corner.Well, using the Polar Plot we can "see" this cycle happening over time. Here's an illustration courtesy of Palski & Associates, a premier team supporting all things space range and RPO, amazing folks.



Let's look close at this "Conga Line" of satellites in the 54-year cycle. Take time to digest this because what you see is the cycle happening, it's going clockwise. This Polar Plot is current around 2015. See those purple dots? Those are GEO satellites that started at zero inclined and that are NOT controlling their inclination (keeping it at or near zero). They were launched in the 2000-2009 timeframe. The are on the 54-year cycle. Where are they going? We'll let's look at the GEO birds launched in 1960's, see the green dots? Well, they have been on a journey that the purple dots will be following. See what I call it a "Conga" line...LOL. The Polar Plot with Inclination and RAAN depicted is the "bread and butter" (or as Forrest Gump would say "peas and carrots") of GEO operators and orbit engineers.

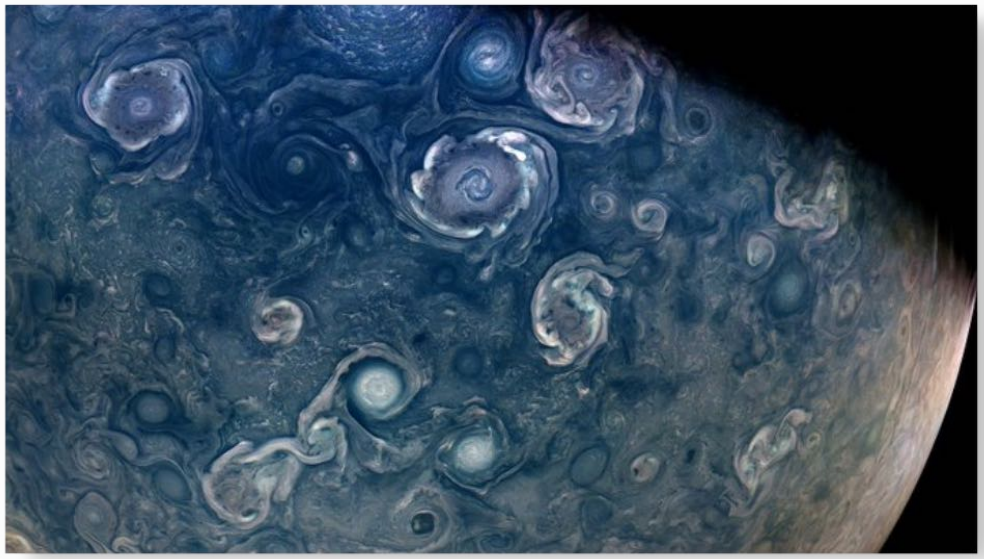
In conclusion, RAAN is the angle between the I-axis of the ECI frame and the Ascending Node vector of the Satellite's orbit. The Polar Plot is a tool for keeping track of your orbit plane. If you can digest what it is and understand it, you'll be deemed an Astro dynamo...and that's cool! Next time Argument of Perigee, another angle between two vectors and guess what, one of them is going to be the Ascending Node vector.

Pics o' the week!

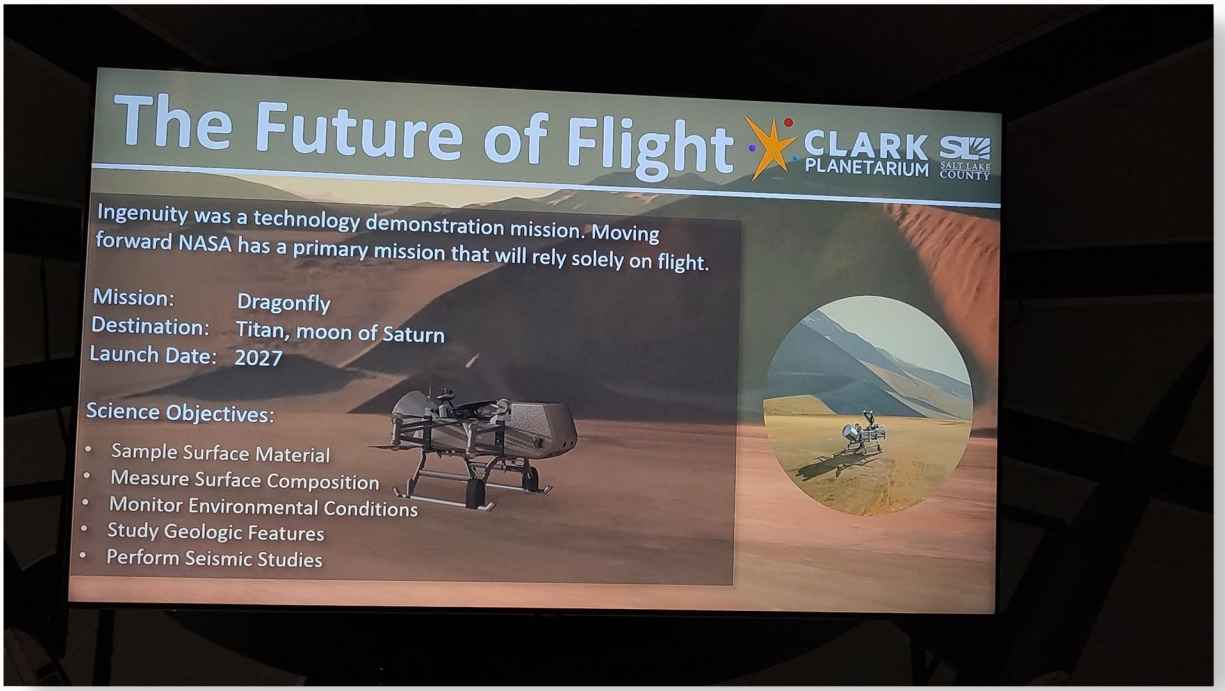
US Air Force space tracking center (early 1960s)

JoAnn Morgan was the only woman working in the launch firing room for Apollo 11, which landed on the Moon 20 July 1969. It would be one of many ceilings Morgan would break during her 45 years at NASA.

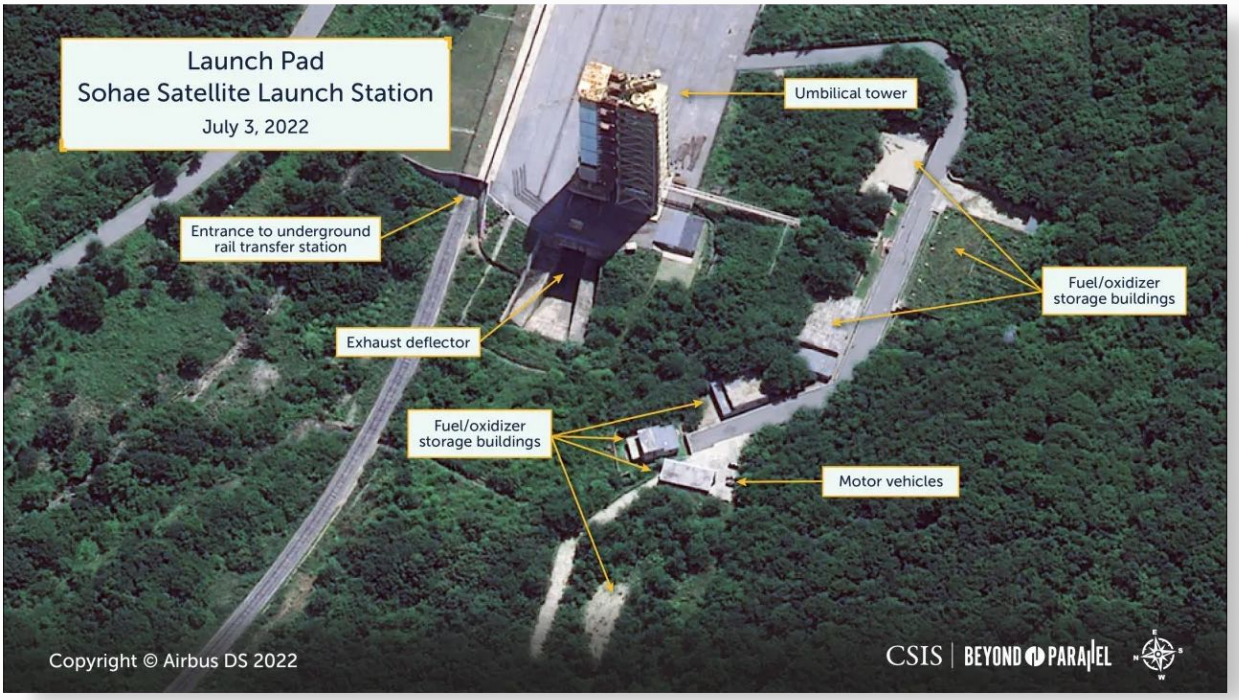
"Movie Poster" of New KZ-1A Booster



Jupiter's North Pole imaged by @NASAJuno on 5 July 2022



So this...this is COOL. We're sending an octo-copter to one of Saturn's moons, Titan. Titan has an atmosphere about 4x denser than Earth.



Not nearly as cool...North Korea begins first stages of construction to modernize the Sohae Satellite Launching Station

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