17 JULY 2022

THE FINAL FRONTIER FLASH

Developments & Analysis of the Space Domain

ISR UNIVERSITY

SFA
SPACE FORCE ASSOCIATION

In This Issue

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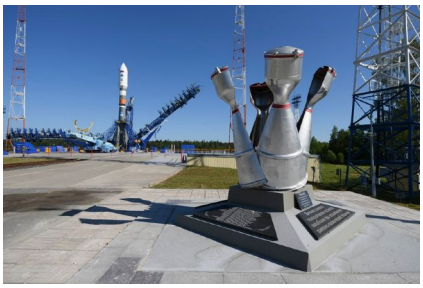
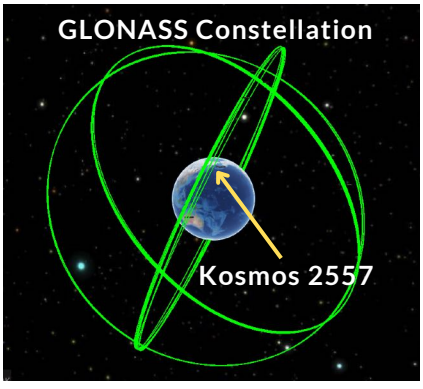
Catalog

Russia Launches GLONASS-K

7 Jul 2022: The Russian Aerospace Forces (VKS) successfully launched GLONASS-K No.16L navigation satellite on a Soyuz rocket from Site 43/4 at the Plesetsk Cosmodrome in northwestern Russia, the fourth in the latest series of GLONASS navigation satellites operated by the Russian Federation. The GLONASS-K satellites are substantial improvements over the previous-generation GLONASS-M constellation, having a longer lifetime and better signals accuracy. Launch Video. Extended Launch Preparation Video Here and Here.

- This marked the ninth launch of the year so far for the Russian Federation, with all of them utilizing various adaptations of the Soyuz launch vehicle. This was the fifth launch of 2022 for the Russian military.
- The Soyuz vehicle used for the mission was the 2.1b variant, which flies with the standard Soyuz 2 booster and core stage engines, but features an updated RD-0124 motor on the Blok-1 second stage.
- The GLONASS-K spacecraft is developed by ISS Reshetnev, with the first being launched in Feb 2011 and others following in Nov 2014 and Oct 2020, respectively.
- GLONASS-K no.16L (Kosmos 2557) will replace Kosmos 2461, a GLONASS-M satellite launched by a Proton-M rocket from the Baikonur Cosmodrome in Mar 2010.
- GLONASS-K No. 16 was completed in the Fall of 2021, or before the new export ban, which was introduced in the wake of the large-scale Russian invasion of Ukraine on 24 Feb 2022, and whose effects were yet to be assessed. At the time, there were eight GLONASS-K and four GLONASS-K2 satellites undergoing assembly at ISS Reshetnev in Zheleznogorsk and the head of Roskosmos, Dmitry Rogozin, promised the launch of "several" GLONASS-K and K2 satellites in 2022.
- Each GLONASS-K satellite weighs in at approximately 935 kg (2,061 lbs) at liftoff — 500 kg lighter than its predecessor in GLONASS-M. The new satellites are able to operate for up to 10 years on orbit (three years longer than GLONASS-M) and have an increased power supply of 1,600 watts.
- GLONASS satellite orbits are arrayed in three planes, separated from one another in right ascension of ascending node by 120 degrees, with eight satellites in each plane. The satellites within a plane are equally spaced, separated in argument of latitude by 45 degrees. Satellites in adjoining planes are shifted in argument of latitude by 15 degrees.
- The satellites are placed into nominally circular orbits with a target inclination of 64.8 degrees and semi-major axis of approximately 25,510 km, giving them an orbital period of about 675.8 minutes. These satellites have ground tracks that repeat every 17 orbits or eight sidereal days.





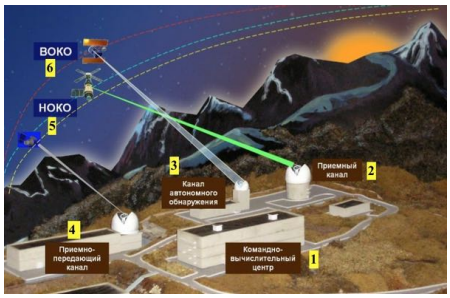
Russian Anti-Satellite Laser Under Development

5 Jul 2022: In his latest open source report, Bart Hendrickx presents strong evidence that a space surveillance complex in Russia's northern Caucasus is being outfitted with a new laser system called Kalina that will target optical systems of foreign imaging satellites flying over Russian territory. Recent Google Earth imagery shows construction is now underway. Kalina will complement a mobile lasera dazzler (Peresvet) that has been operational since late 2019.

- Russia clearly attaches a great deal of importance to denying its enemies the opportunity to image its territory from space. Among the targets of these systems could not only be government-owned reconnaissance satellites but also the numerous commercial optical imaging satellites that are currently in orbit.
- The construction is taking place at the Russian Ministry of Defense's Krona space facility near Zelenchukskaya in Russia's far southwest.

- Analyzing public satellite imagery, solicitation documents from Russian industrial contractors and Russian financial documents, Hednrickx describes the Kalina system, a laser system designed to permanently blind electro-optical imagery satellites.
- Despite having been planned many years earlier, Kalina construction just recently began at an existing space surveillance complex.
- The complex also hosts a lidar ("light detection and ranging") and radar systems designed to help identify targets for space telescopes.

- The most recent imagery of the site is from March 2022, showed a new telescope dome and a tunnel connecting it to the lidar building.
- The Kalina laser facility features a separate tracking system with adaptive optics to help it better mitigate atmospheric disturbance.
- The laser itself features a transmit-receive system to measure laser light reflected back at it from its target in order to better aim directly at the optical systems on its target object.
- Targeting Kalina's laser is likely done manually. Documents describe the capability for the "operator" to simultaneously see the corrected image and the emitted laser beam and then select a spot on the target that needs to be "illuminated".
- The system can be used in day or night.



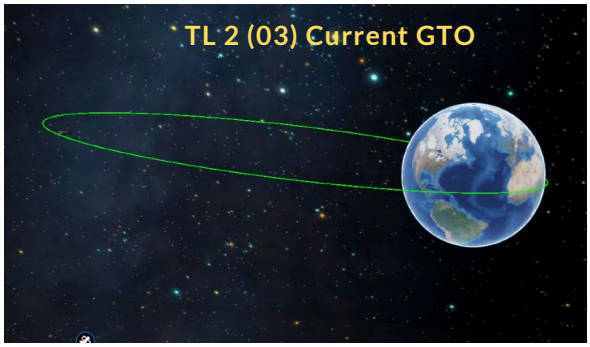
Krona's LIDAR complex

Kalina is one of three laser dazzlers Russia designed to be used against satellites. An airborne system called Sokol-Eshelon has been under development since 2001, but it seems to have been on the verge of cancellation several times and its current status is unclear. The only system known to be operational is Peresvet (internally known as Stuzha-RN or 14Ts034). This is a truck-mounted laser system that is co-deployed with mobile ICBM units and intended to prevent foreign reconnaissance satellites from following their movements.

China Adds another TianLian-2 Relay Satellite

12 Jul 2022: China successfully launched a CZ-3B/E rocket with the third satellite of their Tianlian 2 series of data and relay satellites from the Xichang Satellite Launch Center. The 7 operational Tianlian relay satellites are all located in geostationary orbit. They are similar to NASA's Tracking and Data Relay Satellite network and the European Space Agency's European Data Relay Satellite network. Overall, the Tianlian network consists of 4 first generation and 3 second generation satellites. Launch Video.

- The first generation of TianLian ("sky chain") satellites were built around the DFH-3 satellite bus and were launched between 25 Apr 2008, and 6 Jul 2021 using Chang Zheng 3C rockets from Launch Complex 2 at the Xichang Satellite Launch Center.
- The second generation of Tianlian satellites are built around the DFH-4 satellite bus and have switched to the more powerful Chang Zheng 3B rockets launching from Launch Complex 3 at Xichang.
- The second generation of the satellites introduced multi-targeting ability and improved data transmission rates into the overall network.
- TL-2 uses K-band frequencies (TL-1 satellites used S-band) to enable 1.2 Gbps data transfer rates between the Chinese Space Station and ground control stations.
- The satellites make real-time communications including video possible between the ground and the Tianhe space station module, where three Shenzhou 14 astronauts are currently living and working. See video on China's relay satellite capabilities.
- Previous TianLian 2 launches occurred on 31 Mar 2019, and on 13 Dec 2021.
- TianLian 2 (03) remains in GTO as of 16 July. It is likely destined for China's 10°E GEO slot. China relocated TL-1 (05) closer to TL-1 (03) leaving the 10°E slot vacant.



Quick Look: Chinese Commercial Rockets

6 Jul 2022: Chinese commercial space companies are preparing to flight test newly-developed orbital and suborbital launch vehicles at the Jiuquan spaceport. No launch dates have been set as the Chinese government continues its efforts to foster a developing commercial space sector after opening sections in late 2014. The move has so far brought a proliferation of solid launchers, with mixed success. Liquid launch capabilities would represent a leap for the sector.

Landspace

- Landspace is a Beijing-based launch startup working towards the launch of its Zhuque-2, methane and liquid oxygen rocket.
- The Zhuque-2 mission is expected in the near future and would be the first launch of a liquid propellant launch vehicle by a Chinese commercial space company. See Hot Fire Test from 2021.
- Landspace has constructed infrastructure at Jiuquan to facilitate methane and liquid oxygen launchers.
- According to Landspace the Zhuque-2 will be capable of delivering a 6,000-kg payload capacity to a 200-km LEO, or 4,000 kg to 500-km SSO.
- Zhuque-2 could become the world's first methane-fueled rocket to make a launch attempt, with SpaceX also working towards a full test flight of the much larger Starship.
- The Zhuque-2 will initially be expendable, but Landspace aims to convert it to make the first stage recoverable.

iSpace

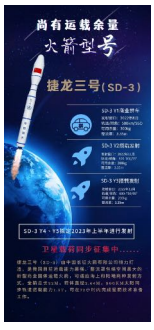
- iSpace is developing its own methalox rocket, the Hyperbola-2. They recently unveiled a first stage test stand at Jiuquan in preparation for hop tests. See animated launch/landing rendition.
- The hop tests will be carried out ahead of a potential orbital launch in 2023, with reusability a key target for the Hyperbola-2.

CAS Space

- CAS Space is a spinoff from the state-owned Chinese Academy of Sciences and is also preparing to launch its ZK-1A (Lijian-1) solid rocket from Jiuquan.
- 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.

China Rocket

- China Rocket is a spinoff from the China Academy of Launch Vehicle Technology (CALT), has conducted a series of tests as it targets a first launch of the Jielong-3 solid rocket no earlier than September. See animated launch rendition.



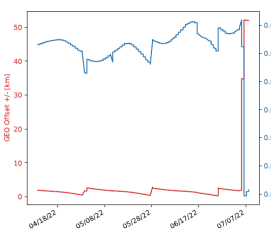
Jielong-3

This Fortnight in GEO

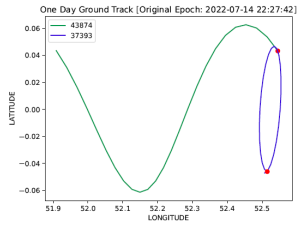
- TJS-3 is relocating westward. As of 15 July, it had drifted ~865 kms from 59° E to 51.2°E. TJS-3 was in proximity with UAE communications satellite, Yahsat 1A, on 14 July 2022.
- SY-12 (02) Continues Eastward Drift. Increased spacing with USA 270. In vicinity of CHINASAT 10 and Beidou 2 G7.

TJS-3:

- In early Jul 2022, TJS-3 increased its altitude 50+ kms and initiated a westward drift.
- As of 16 July 2022, TJS-3 was ~70km above the GEO belt and drifting 1°/day.
- On 14 Jul 2022 TJS-3 was in vicinity of the Yahsat 1A communications satellite.
- 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".



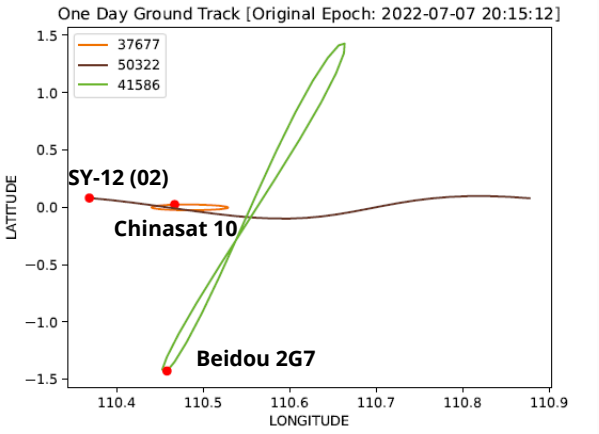
TJS-3 Altitude Changes



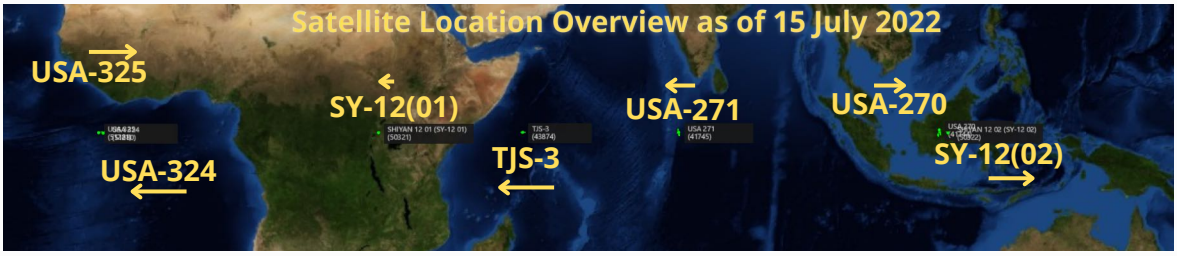
TJS-3 & Yahsat 1A Ground Tracks

Shiyan-12 (02)

- No maneuvers were reported for Shiyan-12(02), it continues to orbit below the GEO belt and drift Eastward.
- On 7 Jul 2022, Shiyan-12(02) was in the vicinity of Chinese satellites, CHINASAT 10 and Beidou 2G7.
- Shiyan-12(02) does not appear to alter its orbit.
- Shiyan-12(02) appears to be drifting East at a faster rate than USA 270.



SY-12 (02), CHINASAT 10 & BD 2G7 Ground Tracks 7 July 2022



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. We'll see how it goes! For this week, orbital information is courtesy of the 2022-07-08 & 2022-07-15, Space Domain Awareness Reports from Palski & Associates Inc. Send a request to david.pierce@palski.com to get added to their distro list!

Saudi Arabia Joins Artemis Accords

14 Jul 2022: In conjunction with US President Joe Biden's visit to the Kingdom of Saudi Arabia, NASA administrator, Bill Nelson, announced that Saudi Arabia became the 21st nation to sign the Artemis Accords.

- The Artemis Accords are an agreement between the Governments of the States participating in the Artemis program. It defines the principles of cooperation and civil activities for the exploration and use of the Moon, Mars, comets and asteroids for peaceful purposes.
- In addition to Saudi Arabia, these are the other Artemis Accord signatories: USA, Australia, Brazil, Great Britain, Italy, Canada, Luxembourg, UAE, Japan, South Korea, New Zealand, Poland, Israel, Mexico, Romania, Bahrain, Singapore, Colombia and France. Ukraine is also a party to the Artemis Accords.
- The Artemis Accords were one of 18 agreements reached during the Presidential visit.

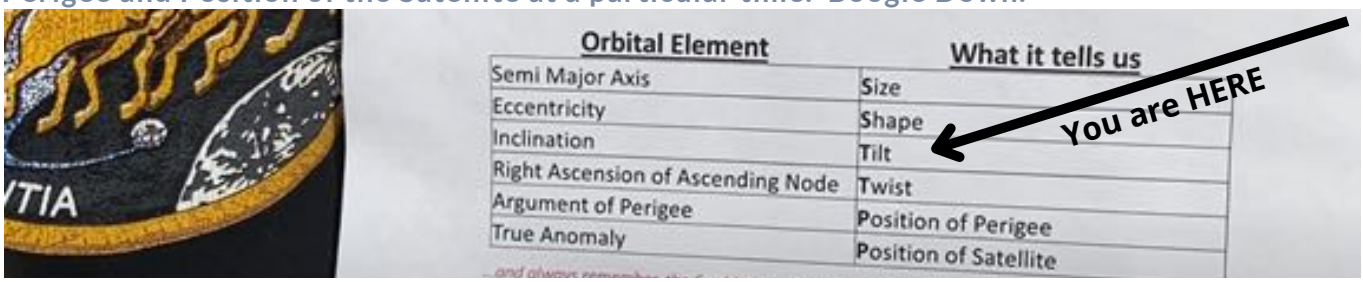
Rogozin Bounced as Roscosmos Chief

15 Jul 2022: Dmitry Rogozin, the blustering head of Russia's state space corporation Roscosmos, is out of the position following a big shake-up in the Russian government. He is being replaced by Yury Borisov, Russian deputy prime minister of space and defense, bringing an end to Rogozin's dynamic reign as general director of the country's space program.

- Rogozin has been a controversial figure for most of that tenure, resulting in strained relations with NASA — Russia's largest partner in space. Rogozin was sanctioned by the United States in 2014 and barred from entering the country due to his time as a deputy prime minister during Russia's annexation of Crimea.
- Rogozin became known for making wildly outlandish statements and threats, many of which put NASA in rather uncomfortable positions.
- When the US placed sanctions on Russian industry during the Crimea invasion in 2014, Rogozin said the move would hurt Russia's space industry and that American astronauts — who relied on Russia to get to space back then — could use a "trampoline" to get to orbit instead.
- More recently he has said NASA astronauts could use "broomsticks" to get to orbit.
- NASA confirmed today that it has finalized an agreement with Roscosmos to perform an upcoming crew swap — where Russian cosmonauts will fly on future SpaceX Crew Dragon missions to the space station in exchange for American astronauts flying on Russian Soyuz capsules to the space station.
- Rogozin's future role in the Russian government is unknown. Rumors have swirled in Russian media that he might find himself in a new position overseeing territories in Ukraine during the invasion.

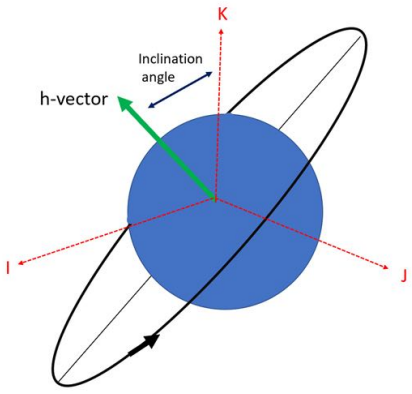
Jack's Astro Corner: Inclination - The Tilted Element (Part III)

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 inclination. 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.



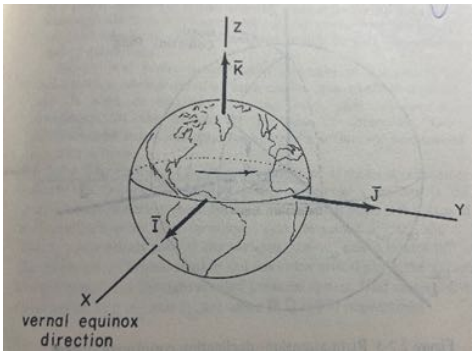
We are now moving into the "T's" of the STP method of remembering the Classical Orbital Elements. TILT is for orbit Inclination. I'm sure by now you have learned the Orbit Element Dance, the dance move for TILT is a crisp bend forward (please mind the hamstrings). To get us started, I'm going to introduce some inclination definitions. I will define several inclination buzz words so you can use them and dazzle friends, family and Generals. We will learn about the significance of the inclination 63.4° as well the many satellites in the vicinity of 98° (no relation to the 1990s Boy Band…which apparently is still going strong).

Most Astro enthusiasts will tell you "Inclination measures the tilt of the orbit away from the equatorial plane." This is about right, but begs the question, "which way do you measure from the equatorial plane to the orbit plane?" As long as you make that clear, you should be OK. Let's look at the REAL definition of inclination and how to solve for its value. We're going to talk vector math….don't panic! I just love vectors (inclination and the remaining 3 orbital elements involve angles between vectors!) Inclination is defined as the angle between the K axis of the Earth Centered Inertial (ECI) coordinate frame and the orbit angular momentum vector, denoted the h-vector. Let me show you in a simple illustration I made where the IJK red coordinate frame is the ECI coordinate frame and the h-vector is shown in green, it's perpendicular to the orbit plane. Do you see the angle between K axis and the H-vector?

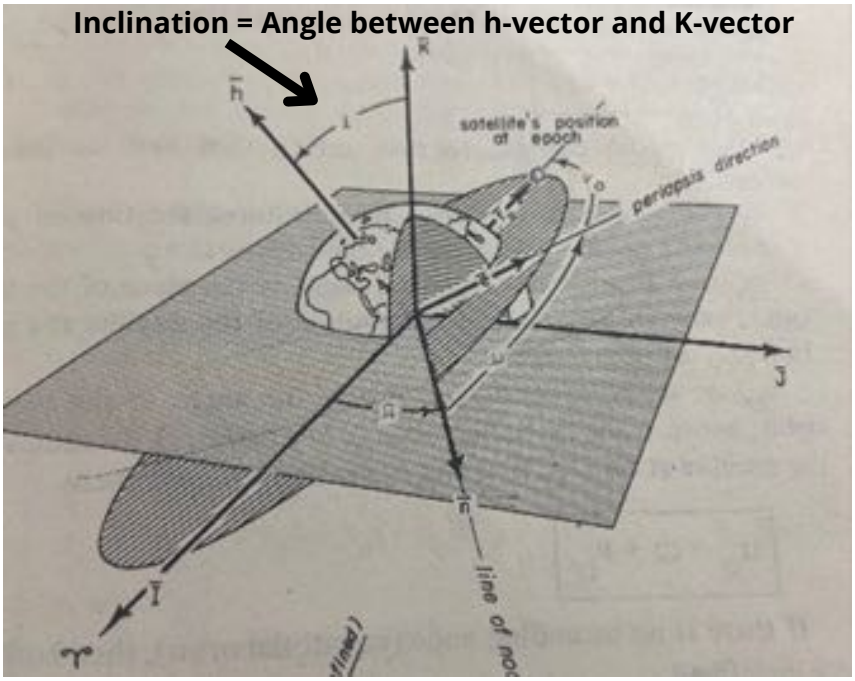


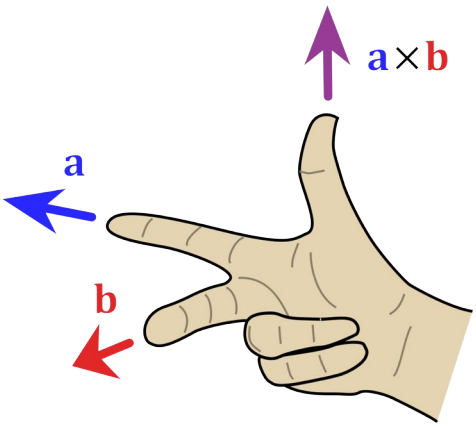
Jack's Astro Corner: Tilt (Cont)

Here are two illustrations from my favorite astrodynamics book by Bate, Mueller and White "Fundamentals of Astrodynamics", fondly called BMW (it was recently updated, Bill Saylor is the 4th author now). You'll see the ever popular Earth Centered Inertial coordinate frame. Look close at the I and J or X and Y axis. They form the fundamental plane, it's the equatorial plane. The K axis is the Earth's spin axis, it is perpendicular to the equatorial plane. There's a lot more science and details to this, but this is the basic stuff of ECI. Remember the K axis, because we are now going to introduce the h-vector.



What's this h-vector? It's the angular momentum of the orbit. Here's where you get to demonstrate your right-hand rule "astro gangster" sign. If you take your right hand and form a two finger and thumb coordinate frame you are cool! Then if you curve your fingers in the direction of orbit travel, your thumb will point in the direction of the h-vector. Here below is an illustration from BMW that shows angle between h-vector and k-vector.

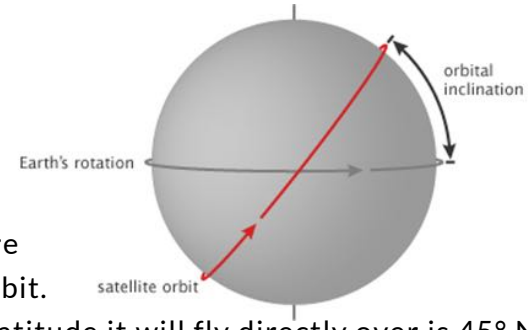




You'll see the Astro smarties doing this all the time. It shows the right-hand coordinate system. Here I am a few years back with several Weapons School/Astro experts showing off the right-hand rule also known as the "Astro gangster" sign.

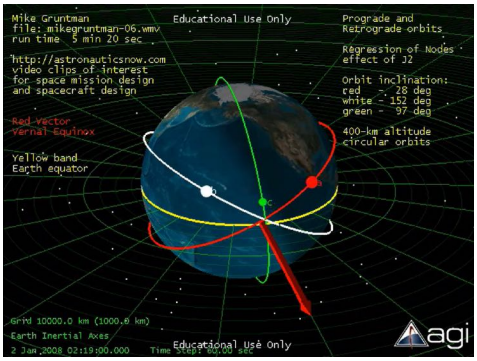
I can see you are itching to learn how to calculate the angle between 2 vectors. The dot product of two vectors equals the Cosine of the angle between them. Let's try it. In vector notation, K-vector is simply [0, 0, 1), h-vector of the orbit is [-1, +2, -0.3]. What's the angle between them? (Checkout this online tool. What answer did you get? (answer: 97°)

Jack's Astro Corner: Tilt (Cont)



If you ask around or surf the internet you'll probably get a few different explanations for inclination. I'll use the NASA drawing to show this. It shows Inclination is the angle between an equator's plane the Earth Centered Inertial (ECI) coordinate frame and the orbit's plane. Here we see a straight on view of the ascending node of the orbit. To me this looks like a 45° inclined orbit. The maximum latitude it will fly directly over is 45° North and South. Make sure you keep track of the ascending node passage and which way the satellite is heading; 45° and 135° can look alike. With the h-vector definition previously explained this is clearer. No worry, you'll figure it out, right Bueller?

Now that you know what inclination is, let's learn the "lingo" of this "tilted" orbit element called inclination. For orbits with an inclination of more than 90° we call them retrograde. If less than 90 degrees, we have a prograde or direct orbit. If the inclination is zero degrees, we call that an equatorial orbit. Very popular for the geosynchronous satellites. I mentioned 90 degrees earlier, that's a Polar orbit. The polar orbit has a ground track that flies over the poles. Here's a weird one nobody has tried, an inclination of 180 degrees. It is called a retrograde equatorial orbit. Have you ever heard of a sun-synchronous orbit? Well, hang on, we first must learn about some orbit perturbations that affect an orbit and that can be used to create an orbit of great operational benefit.

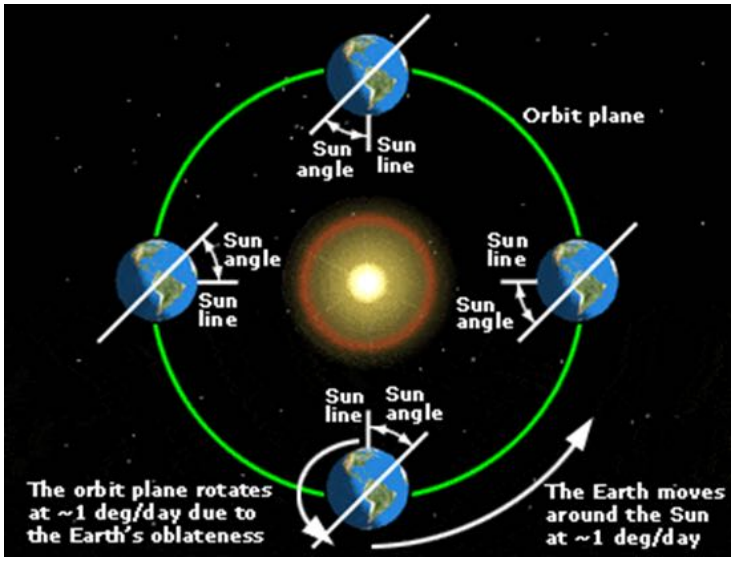


The central gravitational force of the Earth is what makes satellites orbit the Earth. We assume a spherical Earth and that's pretty good for starters. But in reality, it's not a spherical point source of gravity. The Earth has oblateness, that is it's squished a little and football shaped, wider at equator and shorter to the poles. Can't really see it, but this is true. This causes some additional forces to be put on an orbiting satellite. The biggy Earth oblateness effect is called the J2 effect. It has an effect mostly the right ascension of the ascending node (RAAN) (twist) and the Argument of Perigee (defines where the closest approach to Earth is). You can get a constant change over time in those orbit elements; it's called a secular perturbation. The equation that determines the motion of perigee due to J2 can be solved to find the inclination where perigee will not drift. There are two specific inclinations where the rate of change of perigee movement due to J2 is zero. Holy cow, now that can be helpful. The answer is 63.4 and 116.6 degrees and it's called the critical inclination. Remember the HEO orbit? Well, if you launched into 63.4-degree inclined orbit and had perigee positioned in the southernmost part of your orbit, then it would not drift away from there and rotate away from this southernmost point. That's helpful for keeping the "hang time" part of the orbit (apogee) over the northern hemisphere. Remember that from the Eccentricity article?

Let's look at another source of forces on a satellite in its orbit: The Sun and the Moon gravity. For the GEO satellites, the Sun and Moon's gravity play a big role in what happens to their inclination.

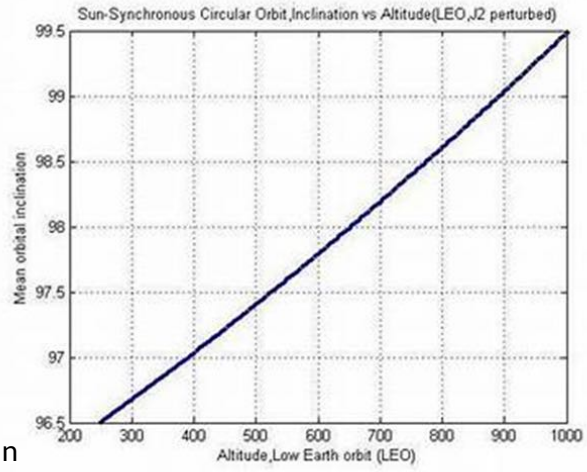
Jack's Astro Corner: Tilt (Cont)

These gravitational bodies are far away, but do "pull" on the GEO birds and thus create something called the 54-year cycle. If the orbit inclination is left to its own, that is not "north-south" controlled, the inclination will go through a 15-degree span in 54 years. Again, it can get really complicated as to how this plays out, but inclination goes for a 15-degree cycle in 54 years. Most GEO satellite operators don't allow this to happen. They activate their propulsion systems to keep the inclination at zero or within certain limits. Last thing, remember I mentioned sun-synchronous orbit? Well, let's learn what inclinations support that orbit. It is a VERY popular orbit for Earth observing space systems (imagery). Here's superb illustration courtesy of Technobytes.org, it shows what's going on with the sun-synch orbit.



The orbit plane maintains it's orientation to the Sun. This is helpful since you can fly over a place of interest every day at the same local time and have the same Sun illumination orientation of the place below, photo analysts dig that. This is orbit plane movement caused by the J2 perturbation. Let's look at an example below.

What are the sun-synchronous orbit inclinations? Here's a plot that helps answer that. Thank you SpaceDaily.com for this plot. Let's say you are in an 800 Km circular altitude orbit, well, if you launched into a 98.6 degrees inclined orbit, your orbit plane will remain in the same orientation to the Sun. You set your launch time to get the timing you want. Why does this happen? Well, you get the RAAN to drift about +1 deg/day. This is about how much the Sun moves about the Earth per day. So, the angular relationship holds steady as the earth orbits the Sun and your orbit plane moves +1 deg/day. Now you know about the sun-synchronous orbit. Pop quiz, what is the inclination needed for a 400 km circular orbit altitude? "Anyone, anyone? Bueller?"



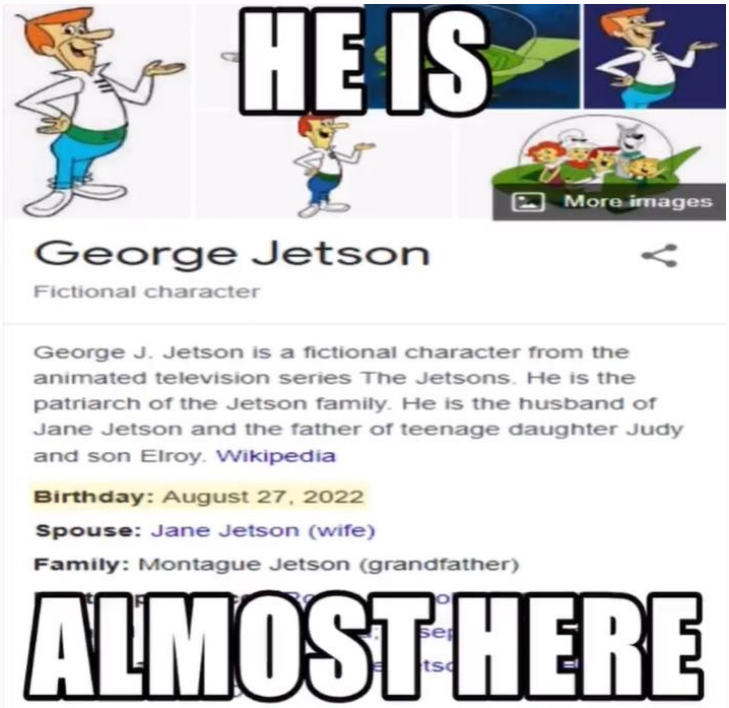
Next time we'll learn about TWIST, the Right Ascension of the Ascending Node (RAAN). Be sure to practice your orbit element dance. I'm sure your Guardian shipmates will value you demonstrating it, maybe during a senior office visit to your unit. I want to thank 3rd Test & Evaluation Squadron Commander Anna "Sumo" Gunn-Golkin for reviewing a draft of this article. She was a great Astro teacher at USAF Academy and today leads the premier test squadron in Space Force. Yay Anna! Finally, General Willie Shelton also took a look and helped tweak this essay.

Pics o' the week!

Saturn's Aurora

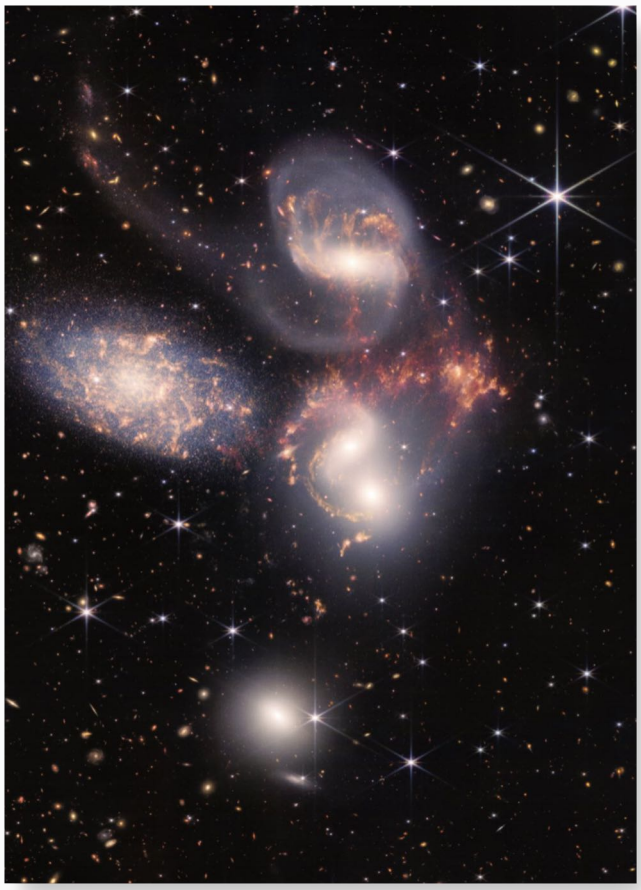
The Apollo "Rubber Room" at LC-39. A bunker is located 40 feet beneath the launch pad. Dome-shaped, built on springs and shock absorbers, to be used in the event of an imminent Saturn V explosion with workers at the pad.

Albert Einstein and Marie Curie chatting by a lake circa 1929.

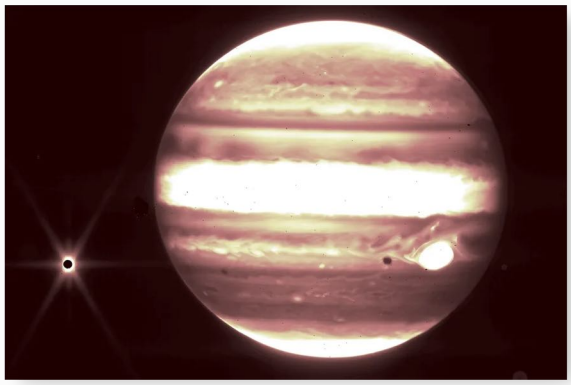


For those of us who grew up in the 70's.

Fun Fact: After Space Shuttle Discovery's External Tank was damaged by woodpeckers, NASA did undertake a task to stop it happening again... by deploying these bird deterrent balloons. And it worked!



From this moment on you will always be able to tell the difference between a Hubble image and a JWST image:
<u>Hubble stars have four spikes in a cross. JWST stars have six in a snowflake.</u>



And JWST is just getting started!

Breath Easy Dad
April 1944 - July 2022

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ISR UNIVERSITY TRAINING
FOR SPACE PROFESSIONALS

Over the past half century, continuous improvements in technology and globalization of services led to the development and proliferation of advanced space systems across the commercial, civil, and military sectors. Space is no longer the domain of the most technologically advanced countries; people worldwide rely on services provided by, or dependent upon, space assets. Space capabilities underpin infrastructures and services for nearly all human activities, including commerce, agriculture, humanitarian- and disaster-relief efforts, financial transactions, social networks, and national defense. Recognizing the importance of understanding space operations, ISR University offers a series of space and critical thinking courses--inspired by courses we created and taught to the US Space Force and US Air Force-- to develop the next generation of space professionals!

SPACE COURSES

Space 100: Space Operational Environment

Space 105: Introduction to Space

Space 150: Space Systems Design

Space 200: Space Operations Planning

Space 300: Adversary Space Capabilities

Space 350: Adversary Space Capabilities II

Space 900: The Space Domain (Executive Seminar)

CRITICAL THINKING AND ANALYSIS COURSES

CT 100: Foundations of Critical Thinking

CT 200: Critical Thinking for Analysts

CT 300: Advanced Critical Thinking for Analysts

CT 500: Leading Critical Thinkers

CT 700: Critical Thinking for Executives

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ISR UNIVERSITY'S INNOVATIVE APPROACH TO VIRTUAL LEARNING

ISR University leverages decades of operational, in-classroom, and individualized training experience to maximize student-based learning and knowledge-sharing in a virtual setting. We optimize the same instructional best practices that have made us thought leaders and expert practitioners in C4ISR in-person training. These allow us to engage students on a higher level, delve deeper into concepts, and impart knowledge not just information.

OUTCOME-BASED APPROACH Integrity ISR uses an outcome-based approach that designs a curriculum to meet organizational desired learning objectives that are specific, measurable, and relevant and allow us to translate these objectives into real-world application of concepts and wisdom.

ACTIVE LEARNING The onus for learning is on the student. Instructors are facilitators, who help build wisdom through interactive live-virtual lessons. We use the Socratic method and thought-provoking discussions/exercises from targeted readings and assignments to aid discovery/deeper exploration of concepts.

SYNCHRONOUS AND ASYNCHRONOUS LEARNING We employ a variety of synchronous and asynchronous learning techniques to maximize facilitator to student interaction and increase retention.

- **Live-Virtual Instruction:** Our expert instructors actively teach students using videoconferencing for up to two hours per module.
- **Micro-Learning:** Each module has micro-lessons that break down difficult or overarching topics into smaller chunks.
- **Gamification:** We leverage embedded games to help students retain information. Their scores are recorded on a class leader board, spurring their desire to repeat the game until they get a high score.
- **Practical Application:** We use meaningful practical exercises and assessment devices designed to translate into higher order capabilities of application, evaluation, synthesis, and analysis.

CRITICAL THINKING Our courses fundamentally build critical thinking skills through interactive learning and application assessments. We use an in-depth, tailorable, critical thinking rubric to meaningfully evaluate students and provide opportunities for growth.

COHORT-BASED LEARNING Cohorts play an incredibly important role in knowledge retention and the development of long-term professional relationships. Our faculty is experienced in developing strong academic and cohort ties in the virtual environment. In our virtual setting, discussion boards and blog posts require students to respond to each other's thoughts and ideas and defend their own.