3 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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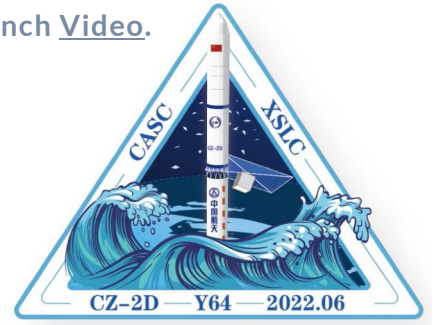
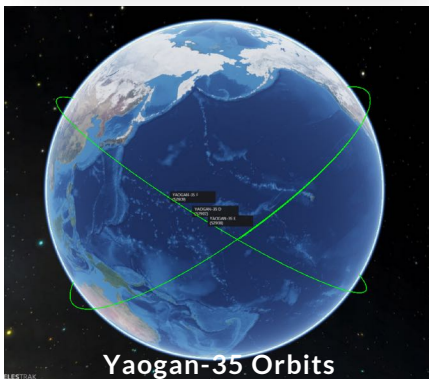
Catalog

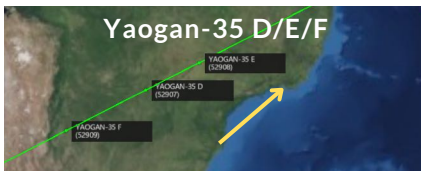
China Launches 2nd Yaogan-35 Triplets

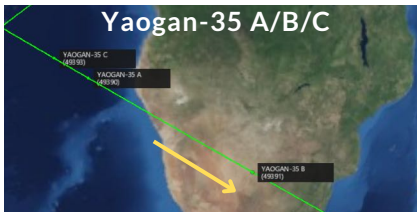
23 Jun 2022: In its second launch of the week, China launched its second batch of Yaogan-35 satellites from the Xichang Satellite Launch Center aboard a Chang Zheng 2D. The satellites, called Yaogan 35 Group 2, are possibly related to another triplet of payloads that launched in November 2021 from the same spaceport on the same rocket. Launch Video.

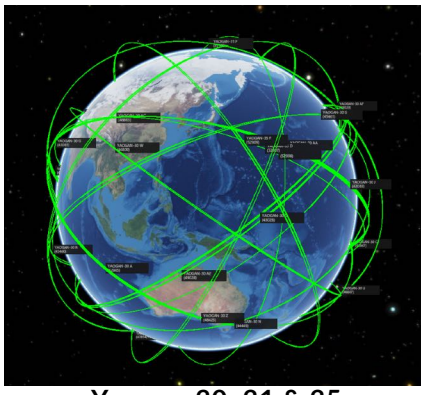


- China reported the satellites would be used for "scientific experiments, land and resource census, and other fields;" however, that generic statement was to not give away the true purpose of the vehicles.
- No details on equipment, mass, or specifics were made public. Based on past missions, they were likely built by DFH Satellite based in Beijing or by the Shanghai Academy of Spaceflight Technology (SAST).
- Yaogan-35 D/E/F satellites are in a similar orbit to their predecessors, in a near circular orbit with an apogee of 503km and perigee at ~489km (e=.002) <See Jack's Astro Corner>. Both sets of satellites are inclined 35°.
- Other Yaogan satellites that deploy in triplets are the Yaogan-30 (30 satellites) and Yaogan-31 (12 satellites).
- Yaogan-30 satellites are believed to be SIGINT satellites and are also in 35 degree inclined orbits.
- Yaogan-30 satellites orbit at ~100km higher altitude and are equally spaced over the earth (separated by 120 degrees).
- Yaogan-31 satellites are also launched in triplets, operate in low earth orbit and within close proximity of one another.
- However, Yaogan-35 is at a different inclination than Yaogan-31 satellites and less than half their altitude. All Yaogan-31 satellites are inclined at 65 degrees and~1100km altitude.
- All other Yaogan satellites operating at ~500km altitude are believed to be imagery satellites & are in sun-synchronous orbits (inclined at ~98 degrees).
- - Yaogan-35 satellites may operate in lead-trail configuration, with the lead satellite potentially cueing the two trailing vehicles.
- The separation between Yaogan 35-A/B/C set differs from the current Yaogan-35 D/E/F formation.
- Yaogan-35 B is 4 minutes ahead of Yaogan-35A which is 1 minute ahead Yaogan 35C.
- Yaogan 35E is only 1 minute ahead of Yaogan-35D which proceeds Yaogan-35F by <1min.
- The time differences are likely to change over time.









Yaogan 30, 31 & 35 Constellations (48 Combined Satellites)

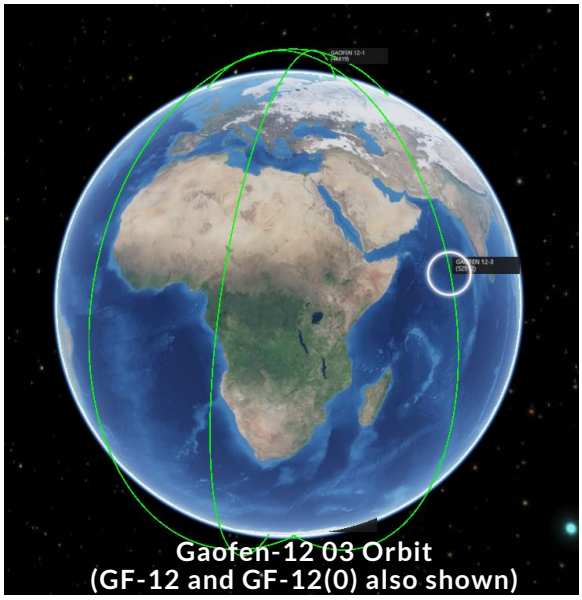
China Launches Gaofen-12 (03) Imagery (SAR) Satellite

27 Jun 2022: China launched the Gaofen-12 03 (GF-12(03)) mission on board a Chang Zheng 4C from the Jiuquan Satellite Launch Center. China declared the launch to be a success minutes after liftoff. GF-12(03) launched into a Sun-Synchronous Orbit (SSO). Both the satellite and the rocket are developed by Shanghai Academy of Space Technology (SAST).

Launch Video.

- Gaofen (meaning "high resolution") is the name for remote sensing satellites that are part of the China High-definition Earth Observation System (CHEOS).
- CHEOS was initiated in 2010 to provide all-weather/day coverage with synthetic aperture radar and EO satellites.
- GF-12(03) is in a 598.4x592.5km orbit with an inclination of 98°.
- GF-12(03) is slightly lower in altitude than previous GF-12 satellites: GF-12 & GF-12(02) (launched in 2019 & 2021 respectively) are at 626.6 x 624.4km and are also in SSO.
- Gaofen 12 satellites are believed to be equipped with high-resolution synthetic aperture radar (SAR), with ground resolution estimated up to the sub-meter level. It is possibly a civilian version of the Yaogan 29.
- Yaogan-29 launched in 2015 is at a similar altitude of 625.4 x 621.8km and is also in SSO.

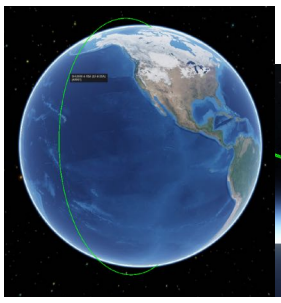
Resolution capabilities and other information has been published for lower numbered Gaofen series satellites. However information for Gaofen satellites numbered 8 and above has not been openly released, suggesting the satellites may support national defense missions.



Mind the Gap: Shijian-6 05A & 05B Closing (Again)

1 Jul 2022: The two suspicious SJ-6 Group 5 satellites continue to orbit near one another. Over the past 3 weeks the distance between the 2 spacecraft has decreased from 4km to 1km.

- The SJ-6 (05) satellites were launched on 9 Dec 2021 and were developed by the China Academy of Space Technology (CAST) and Aerospace Dongfanghong Satellite Co., Ltd.
- Curiously, the orbit for SJ-6 (5) satellites differs from previous SJ-6 missions. Inclination is nearly the same but altitude is ~130km lower.
- The SJ-6 (5) satellites also orbit in closer proximity to each other than previous SJ-6 missions.

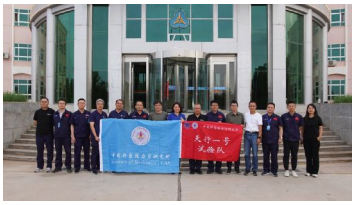


SJ-6 05A Trailing 05B By ~ 10 seconds

- In Feb, analysis from LEO Labs indicated SJ-6 05A and 05B had setup for rendezvous and proximity operations (RPO). LEO Labs detected ingress maneuvers over several weeks resulting in periods of apparent rendezvous mid-Mar.

China: KZ-1A Returns to Flight

22 Jun 2022: ExSpace, a Chinese commercial launch company, launched a Kuaizhou-1A rocket and delivered the Tianxing-1 satellite into orbit. The launch occurred at the Jiuquan Satellite Launch Center and marked a return to flight after its December 2021 failed attempt. The Kuaizhou-1A (KZ-1A) consists of three solid stages and a liquid propellant upper stage. It is capable of carrying 200 kilograms of payload into a 700-kilometer SSO. Launch Video.



Institute of Mechanics Development Team

- The KZ-1A consists of three solid stages and a liquid propellant upper stage. It is capable of carrying 200 kilograms of payload into a 700km sun-synchronous orbit (SSO). Kuaizhou translates to "speedy vessel" in English.
- KZ-1A has now flown 15 times. The previous Kuaizhou-1A flight ended with the rocket's second failure in December 2021. The first launch took place in Jan 2017.
- It is based on the DF-21 Intermediate-range ballistic missile (IRBM) and can use a mobile launch platform as a launch pad, which makes it very flexible in terms of launch area and pad availability.
- Giant state-owned China Aerospace Science and Industry Corporation (CASIC) is the parent company of Expace.
- Little is known about the Tianxing-1 payload. The satellite is said to be used for experiments including "space environment detection," according to Chinese space authorities and media.
- Tianxing-1 was developed by the Institute of Mechanics under the Chinese Academy of Sciences (CAS). It is in a 286x272km 96.8° orbit.
- Tianxing-1 is not high enough to be in an SSO. SSO is common (but not required) for imagery related satellites.

South Korea Conducts First Successful Space Launch

21 Jun 2022: South Korea successfully launched a satellite into orbit on the domestically built Nuri rocket. The rocket lifted off from the Naro Space Center in Goheung and placed a 357-pound performance verification satellite into orbit about 435 miles (700 km) above Earth. The performance verification satellite will provide data to assist future South Korean launches. While in orbit, the satellite will test an antenna, generator, and other equipment. Launch Video.

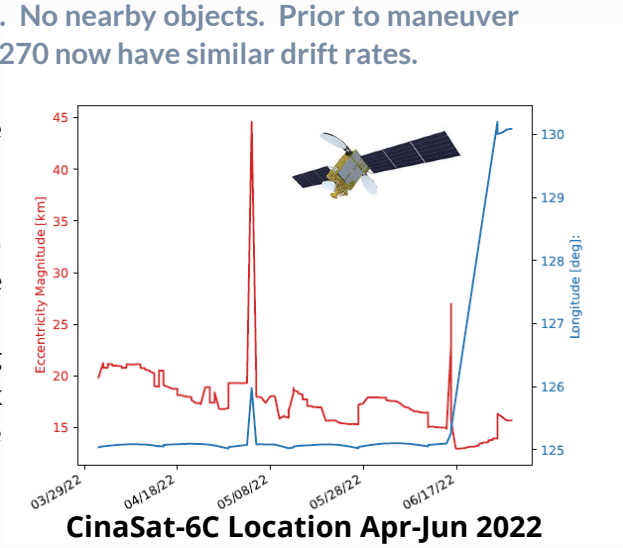
- Reaching orbit is a milestone for South Korea after years of trial and error with its own rocket industry that left it reliant on other nations' technology. Nuri's first test launch last October ended in failure after one of its engines burned out early.
- South Korea is now the 10th nation to send a satellite into space using its own technology. The launch could help South Korea gain footing in the growing global space industry and potentially bolster the nation's national defense arsenal with future spy satellites.
- The verification satellite carried four mini research satellites (CubeSats) each weighing no more than 22 pounds. The CubeSats were successfully deployed on 29 June.

This Fortnight in GEO

- ChinaSat-6C relocated westward 560kms from 125° E to 130°E.
- SY-12 (01) increased altitude ~20km and continues Westward drift. No nearby objects.
- SY-12 (02) Decreased altitude & increased Eastward Drift rate. No nearby objects. Prior to maneuver USA 270 was going to overtake on 26 June. SY-12 (02) and USA 270 now have similar drift rates.

ChinaSat-6C:

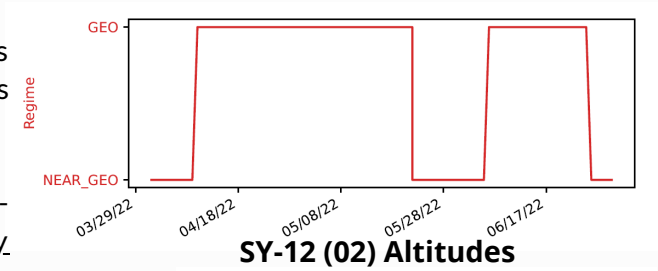
- Zhongxing-6C (or ChinaSat-6C) communication satellite was launched 9 Mar 2019 from Xichang Launch Center.
- It was originally launched into the 130°E GEO slot.
- ChinaSat-6C appears to have lowered its altitude on ~ 15 June, drifted to 130°E and increased altitude on 23 June to slow its Eastward drift.
- The satellite has 25 C-band transponders, supporting high-quality and reliable uplink and downlink transmissions of programs for radio, TV stations and cable TV networks.
- ChinaSat-6C has not been affiliated with national security related missions.



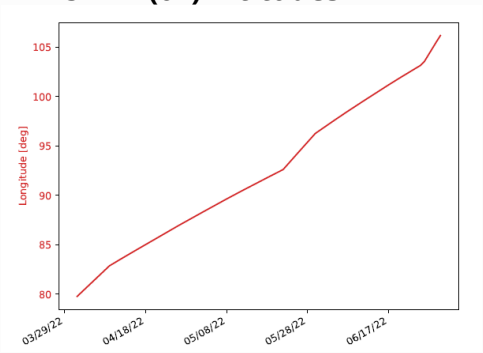
CinaSat-6C Location Apr-Jun 2022

Shiyan-12 (02)

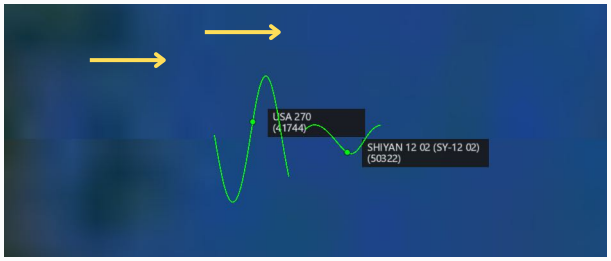
- Shiyan-12 (02) lowered its orbit and increased its eastward drift rate. The maneuvered occurred as USA-270 approached from the west.
- SY-12(02) is currently 43km below the GEO belt.
- Unknown if the maneuver was in response to USA-270 position. SY-12 satellites have previously maneuvered to avoid GSSAP spacecraft.
- SY-12(02) has an inclination of .1273° while USA-270 is 4x greater at .4771°.



SY-12 (02) Altitudes



SY-12 (02) Longitude



USA 270 and SY-12 (02) Drifting East

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 2022-06-24 & 2022-07-01, Space Domain Awareness Reports from Palski & Associates Inc. Send a request to david.pierce@palski.com to get added to their distro list!

Follow Up: Iran Space Launch

26 June 2022: Iranian state television said that Tehran had launched a solid-fueled rocket into space. The launch comes ahead of expected resumption of stalled talks over Tehran's tattered nuclear deal with world powers. A Defense Ministry spokesman stated that the country carried out the 2nd launch of satellite carrier Zuljanah, saying that the launch was sub-orbital and met predetermined research aims. The three-stage carrier has 2 stages of solid propulsion & a single liquid one. Launch Video.

- There is little information available regarding the launch on altitudes or rocket performance.
- There is no reporting of any payload associated with the launch. The launch was sub-orbital, Iran claims this was intentional.
- State television aired footage of the launch, which appeared to proceed without trouble, but there was no confirmation whether it was successful.
- The launch comes after weeks of speculation as satellite images had appeared to show that Iran was preparing for a launch at the Imam Khomeini Spaceport in the province of Semnan.
- The first launch of Zuljanah satellite carrier was made on 1 Feb 2021 from the Semnan Space Center.
- The Zuljanah's primary mission is to place a satellite with a weight of about 220 kg or 10 lighter satellites with a weight of 20 kg into 500 km orbit.
- The latest launch of Zuljanah – which is named after the horse of the third imam in Shia Islam, Imam Hussein – comes months after the Islamic Revolutionary Guard Corps (IRGC) successfully put a second military satellite, called the Noor 2, into orbit in Mar 2022.
- Noor 2 remains in a 517x480km orbit.
- Iran's launched Noor - its first military satellite - in 2020. That vehicle decayed from orbit on 13 Apr 2022.

Over the past decade, Iran has sent several short-lived satellites into orbit and in 2013 launched a monkey into space. The government appears to have recently sharpened its focus on space and in November 2021, Iran's Supreme Council of Space met for the first time in 11 years.

Iran Supreme Council of Space Nov 2021

Explosion at Chinese space launch center

10 Jun 2022: Space enthusiast Harry Stranger posted evidence of a late October 2021 explosion at China's Jiuquan Satellite Launch Center. High-resolution imagery from Airbus and CNES show the facilities, which were possibly used for testing solid rocket motors, intact in October 2021. The apparent aftermath of an explosion is visible in an image from November 2021.

- The incident occurred at facilities constructed around 16km to the southwest of Jiuquan's two main launch complexes.
- Further satellite imagery from Planet's Super Dove satellites seen by SpaceNews indicates the explosion occurred between 0316Z on Oct. 15 and 0407Z Oct. 16.
- China's Shenzhou-13 crewed mission lifted off from Jiuquan at 1623Z, 15 Oct (12:23 PM Eastern), suggesting the blast had little or no impact on CASC, the country's main space contractor, and its major activities.
- There is no indication that the explosion was reported by Chinese media. It is thus somewhat unclear what the facilities were used for and what caused the explosion. Given the profile of launches at Jiuquan it is likely that the structures were related to testing and assembly of solid rockets operated by non-CASC entities.

India Demonstrates New On-Orbit Capabilities

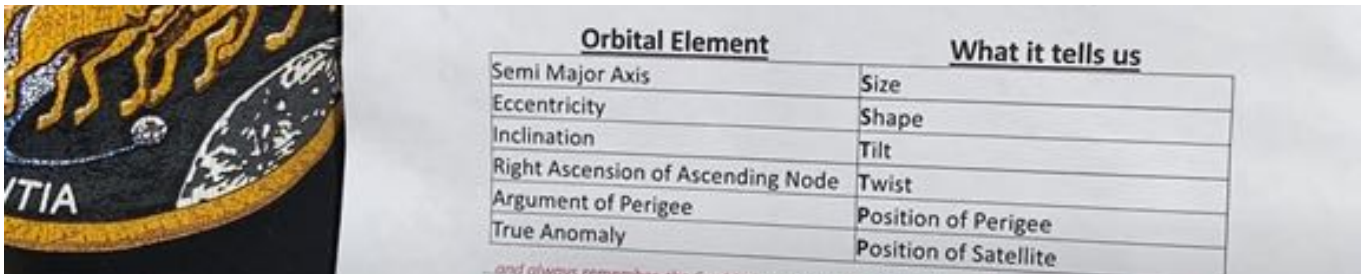
30 Jun 2022: India launched its 55th Polar Satellite Launch Vehicle (PSLV) – in its Core Alone (CA) configuration – carrying nine payloads to a low Earth orbit (LEO). The PSLV's fourth stage carried an orbital experimental module that served as a hosted payload bus. Launch Video.

- This was the second orbital launch for India in 2022 and the 15th launch of the PSLV-CA variant.
- On top of the fourth stage was the PSLV Orbital Experimental Module (POEM).
- POEM will perform in-orbit scientific experiments using the PS4 stage as an orbital platform. This will test the PS4 as a possible platform to house experiments for long-term missions. For this mission POEM carried six payloads.
- Of the three satellites not on POEM the largest was the 365kg electro-optic DS-EO Singaporean Earth Observation satellite.
- The launch also contained the NeuSAR Singaporean Synthetic Aperture Radar (SAR) Earth Observation satellite. NeuSAR is the first small Singaporean SAR satellite, and has a mass of 155 kg.

India has several missions scheduled in the coming months. After PSLV-C53, the next mission is the maiden launch of the SSLV rocket. SSLV is India's newest rocket and the first dedicated small satellite launcher. It is set to launch no earlier than (NET) August with the Earth Observation Satellite (EOS)-2 payload

Jack's Astro Corner: Shaping up with Eccentricity (Part II)

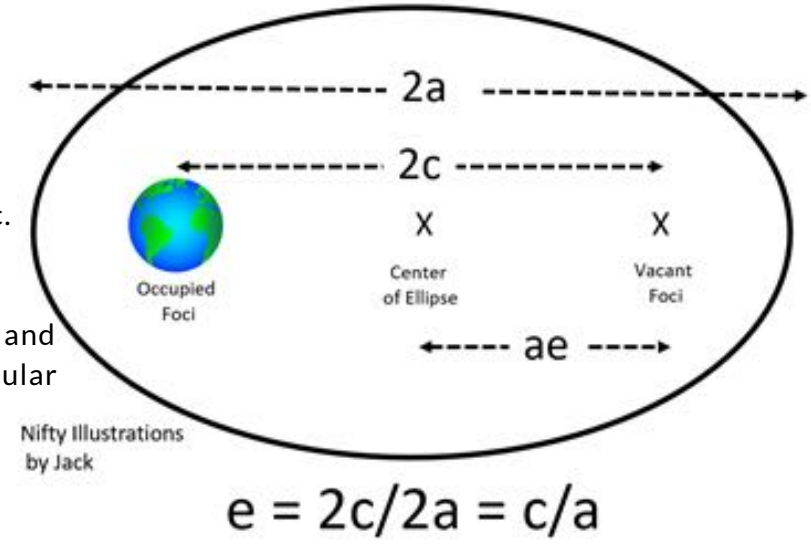
Over the summer, Jack Anthony will break down each of the six orbital elements required to uniquely identify a specific orbit and satellite in that orbit. This week we examine eccentricity. For those who can't wait the entire summer, please visit Jack's "Orbit Element Dance" on YouTube" and you'll find 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.



The second "S" in my "STP" way of remembering the 6 Classical Orbital Elements is SHAPE. The shape of an orbit is described by the ECCENTRICITY orbital element (denoted as "e") and is the focus (see what I did there) of this week's "Astro Corner." I like to say eccentricity is the oddity of the orbit or how eccentric it is. A circular orbit has a eccentricity of 0. For closed ellipses orbiting the Earth the values for eccentricity are 0 to less than 1. If an orbit has an eccentricity of 1, it is a parabola; and if great than 1 it's a hyperbola. Good news, we will just focus on the e < 1. If eccentricity is up there around .7 to .99, its an elongated orbit…very eccentric. In this article we will look at my favorite high eccentricity orbit that has an eccentricity of .737.

Eccentricity is a parameter that can be used with semi-major axis in a simple equation to answer some key questions about the orbit. First, let's learn what your geometry teacher would introduce as "what is eccentricity?

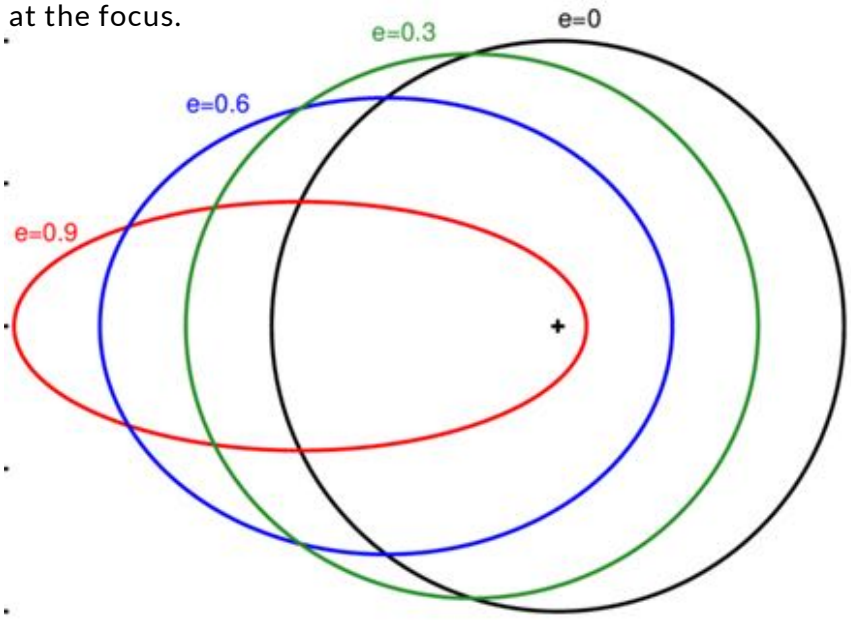
Let's look at the geometry of the orbit ellipse. You can see the major axis 2a and also the distance between the two foci of the ellipse, 2c. These are what is used to determine eccentricity. If the orbit is circular, the foci are right on top of each other and 2c = 0, hence the eccentricity of a circular ellipse is 0.



$$e = 2c/2a = c/a$$

Jack's Astro Corner: Shaping Up (Cont)

Here's an illustration to show what I mean by "oddity" of the ellipse, the eccentricity increasing. Remember the Earth, that big ole gravitational body making all the stuff in orbit stick with us orbiting the Earth at the focus.



Let's see what we can learn when we have both a and e. Given e and a, what can you tell about an orbit? Well, let's do some math! You can calculate the radius of perigee (closest approach to Earth) and also the radius of apogee (the furthest). Then you can subtract out the radius of the Earth (which is 6378 km) and have the altitude of perigee and apogee (we assume a spherical Earth)

Here's the equations for finding these good to know min and max distances of an orbit:

Radius Perigee = a times (1-e) Radius Apogee = a times (1+e)

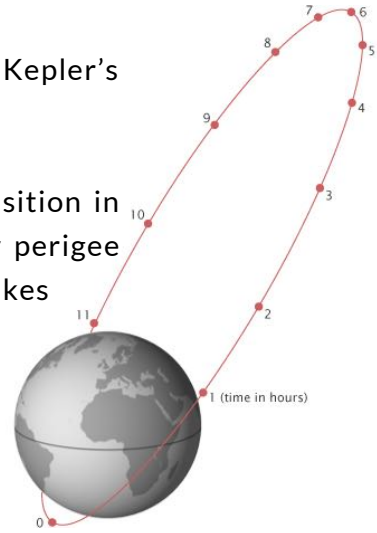
Altitude Perigee = Radius Perigee - 6378 Km Altitude Apogee = Radius Apogee - 6378 Km

Now let's look at the good ole HEO where eccentricity stands out as a "hey, now that's different". Let's look at the Molniya orbit. It's a HEO! What's HEO? "Bueller, Bueller, Bueller?" It means Highly Elliptical Orbit. I've seen it stated as Highly Eccentric Orbit also. We'll see that the Molniya orbit is very eccentric, around .737... wow, that's up there on the eccentric scale of 0 to <1. It has a low perigee and a far-out apogee. Let's look at the numbers to see what I mean. The Russians introduced this orbit in the 1960's. Their access to geosynchronous orbits from the high latitude launch sites was a propulsive challenge, so they came up with the Molniya or "Lightning" orbit.

Jack's Astro Corner: Shaping Up (Cont)

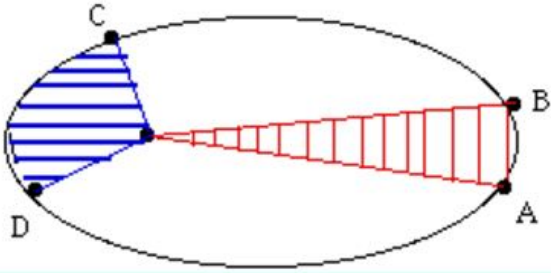
Here's a HEO orbit I'll use to let you test your awesomeness with the equations above: a = 26600 km (which if you use the nifty orbit period equation from last time you get 720 minutes or 11.99 hr orbital period), e=.737 (yup, it is very eccentric), and inclination 63.4 deg. Note: Next Astro Corner we'll be diving into inclination (the orbit TILT) and you'll learn this 63.4 deg inclined orbit is called a critical inclination, we'll learn why. Pop Quiz: Calculate the altitude perigee and apogee (answer: perigee altitude = 618 Km and apogee altitude is 39826 Km).

Let's take a closer look at the HEO orbit like this and introduce Kepler's Second law of orbital motion.



OK, see the tick marks with elapsed time in hours. These show position in the orbit every 1 hours. Notice that this HEO satellite whizzes by perigee area in less than 2-hrs.From perigee to reach apogee for this orbit takes 6 hrs. What Kepler's Second Laws says is if you made a triangle type figure it sweeps out "equal area in equal time." Thus, you are slowest at apogee and fastest at perigee. I call the HEO orbit the "hang time" orbit. Do you see that the "hang time" above the northern hemisphere is more than 10 hours.

Here's an illustration of Kepler's Second Law. Kepler's is a Astrodynamic Dictator, his 3 laws are solid, you can't change them!



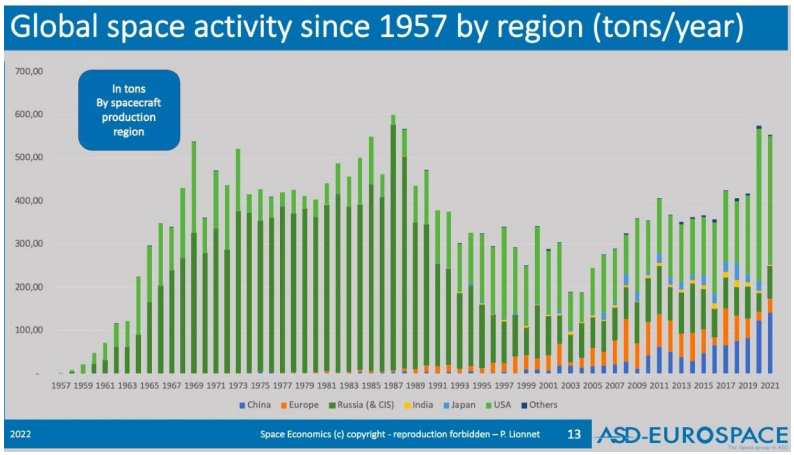
Illustrating Kepler's 2nd law: segments AB and CD take equal times to cover.

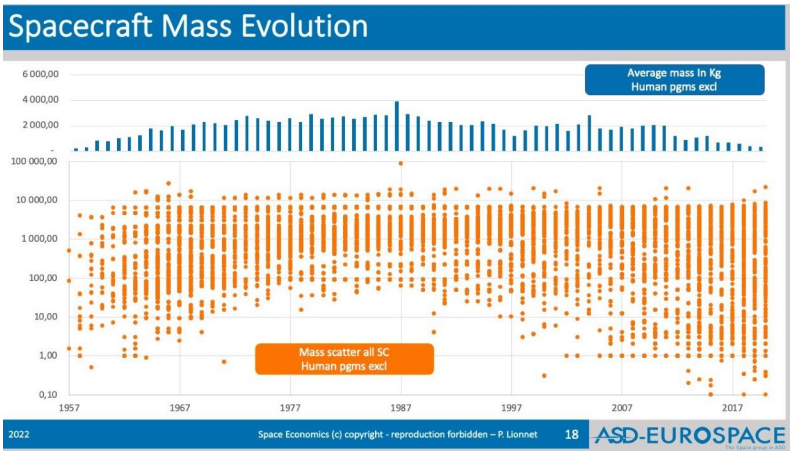
The HEO orbit is an excellent example of a highly eccentric orbit. There's another non-circular orbit that's pretty interesting. It's called the Tundra Orbit. It's a geosynchronous orbit, that it has a orbit period of 23 hr 56 minute 4 seconds. It's semi major axis is 42164 Km and eccentricity varies between .2 and .3. It too has an inclination of 63.4 deg. That is a special inclination...I'll explain it next time. So, since you are versed in calculating perigee and apogee distances, what are the altitudes of these?

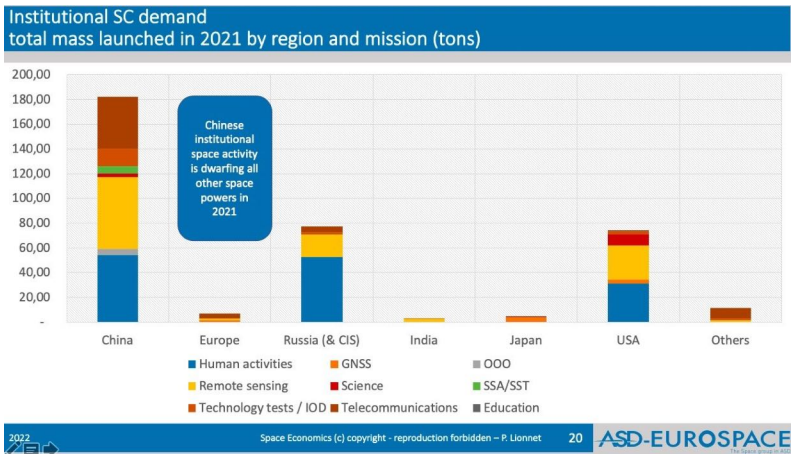
Interested in learning more about the Tundra orbit, surf the Internet, there's lots of info on it out there.

Next time we learn about Tilt of an orbit, it's inclination

Pics o' the week!

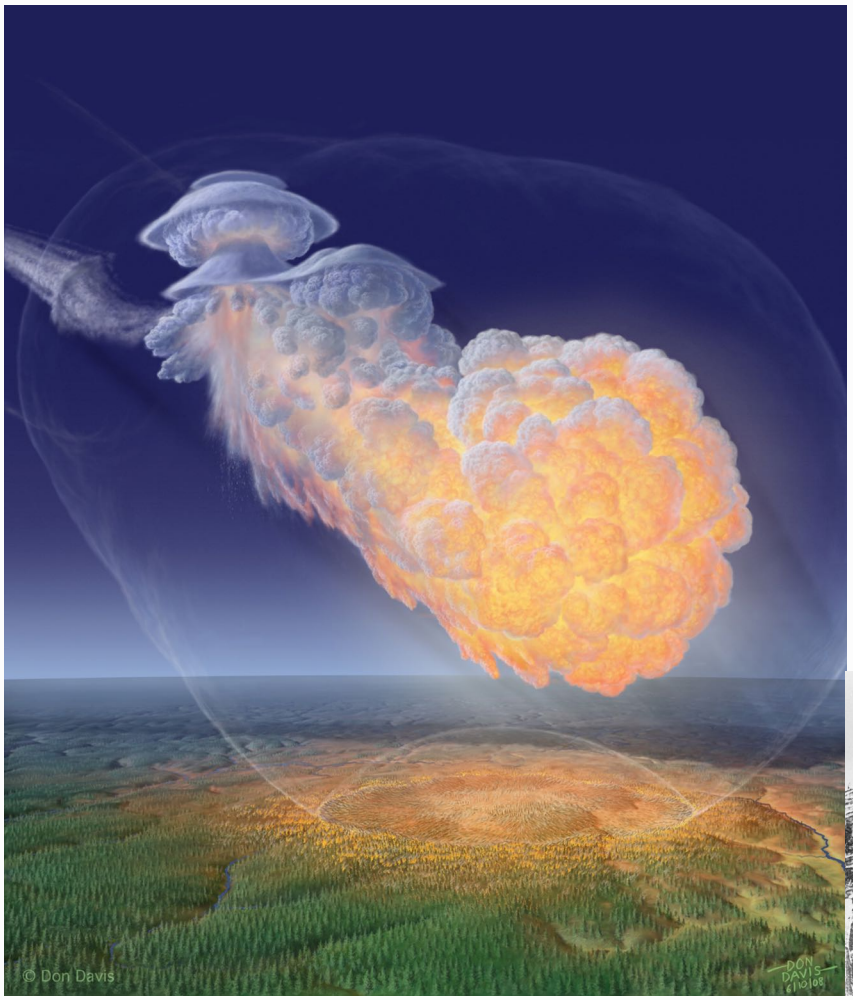




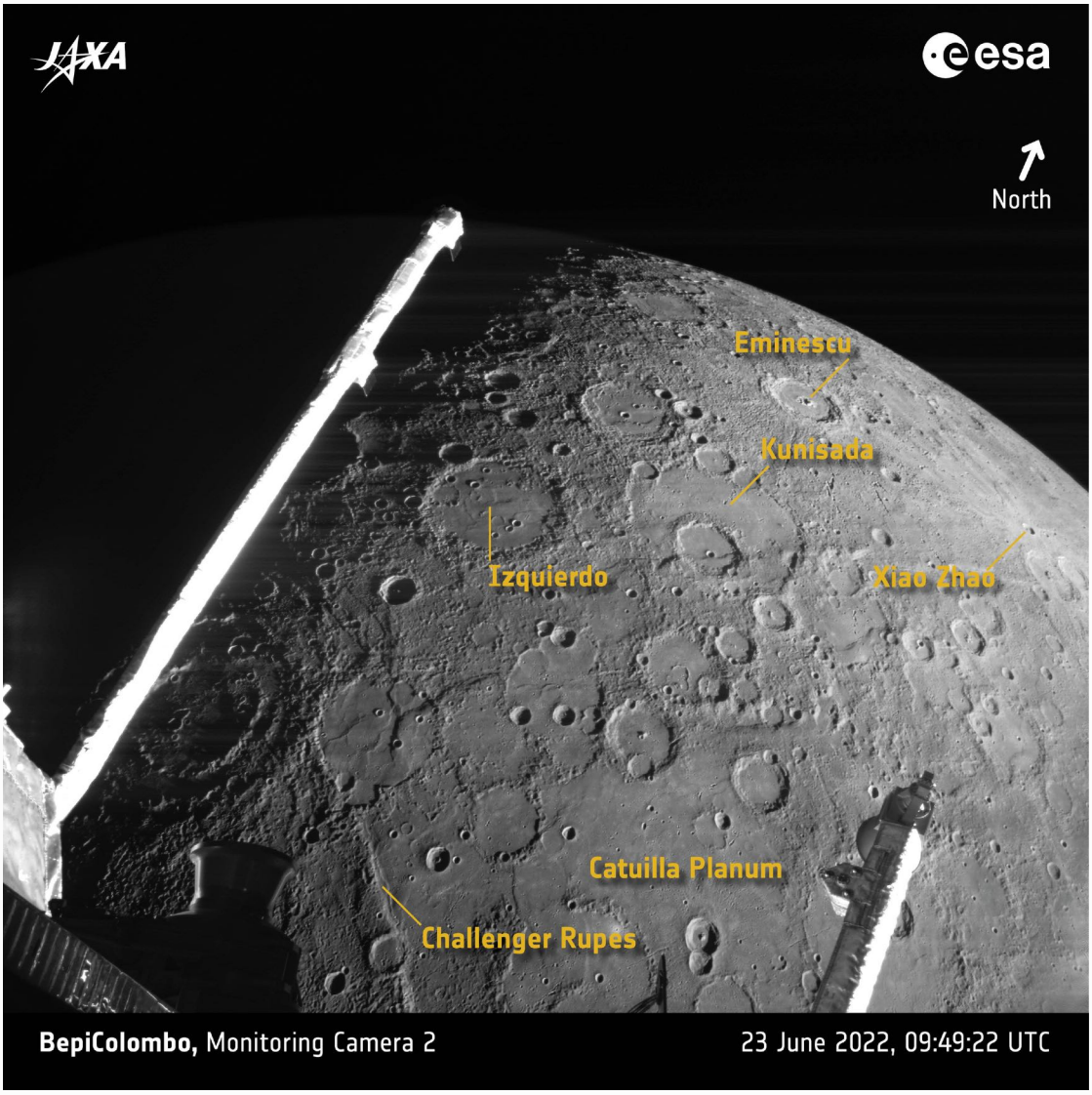


Excellent Info Graphics from ASD-EUROSPACE

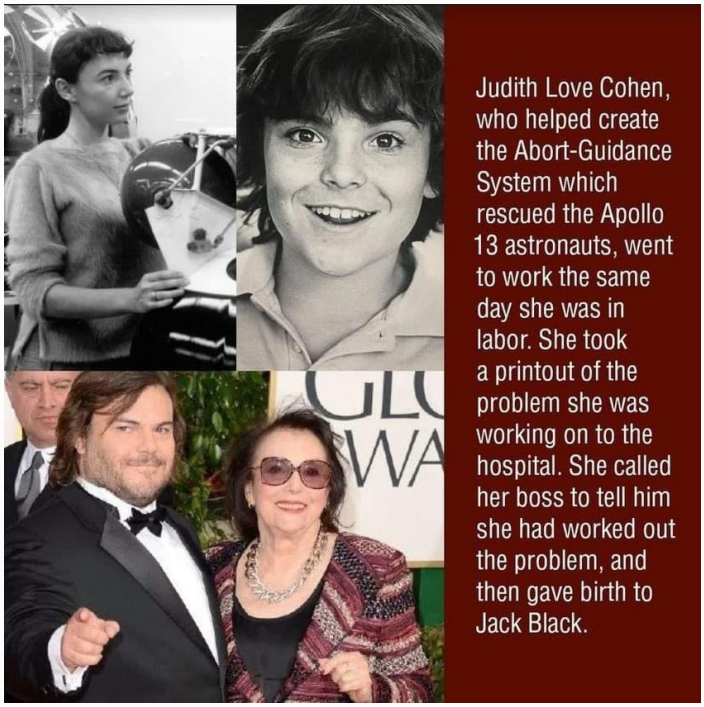
Logo of a Chinese commercial satellite company owned by SAST...Alyssa, seem familiar?



On June 30, 1908 the Tunguska event took place. It exploded in the atmosphere and sent a careening fireball angling toward the ground then billowing upwards. A shock wave slammed into the forest, stripping branches from trees directly below and knocking trees flat for miles.



BepiColombo ~920km over Mercury during its second of six flybys. The spacecraft will begin orbiting the planet in December 2025.



This I didn't know...
proving <again> women are far tougher

ISR UNIVERSITY

1411 Frontier, Suite 1A
Spring Branch TX 78070

isruniversity.com
integrityisr.com

#WeKnowISR

SFA
SPACE FORCE ASSOCIATION

555 E. Pikes Peak Ave
Colorado Springs, CO 80903

ussfa.org

#WeKnowSpace

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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611519 (Other Technical and Trade Schools)

DDTC/ITAR Registered

Facilities Clearance:
Top Secret

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U.S. AIR FORCE

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.