SPACE DEBRIS:

AN EXISTENTIAL THREAT TO HUMAN EXPLOITATION OF LEO

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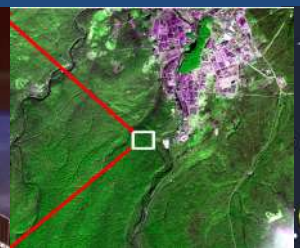

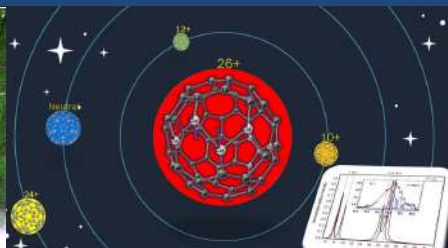

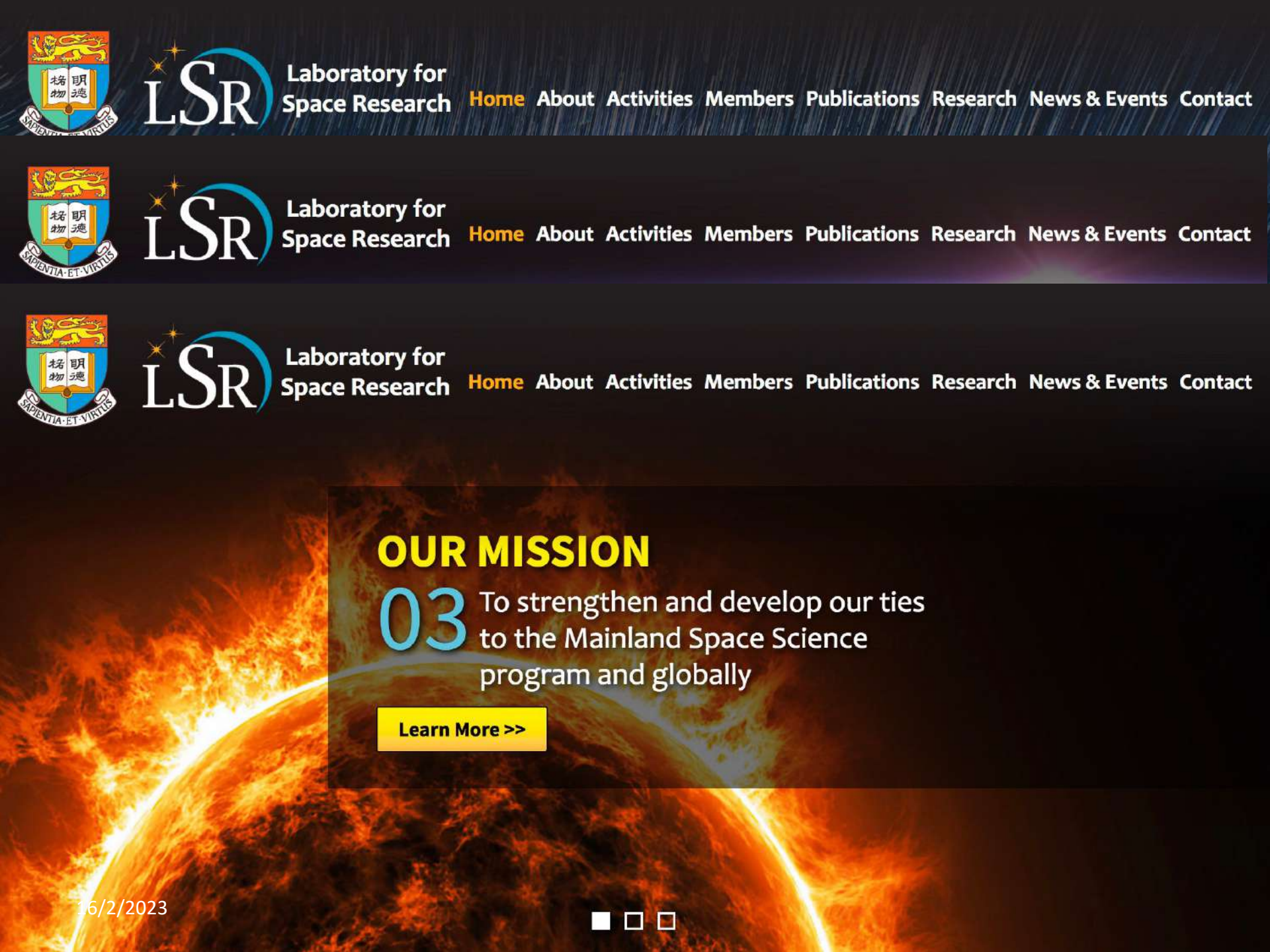
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03
To strengthen and develop our ties to the Mainland Space Science program and globally
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MEMBERS: 65@7/12/22 – 5 depts & 2 faculties

SMT supported!

A free association of scientists, engineers and technologists

No costs to members & no pressure to join

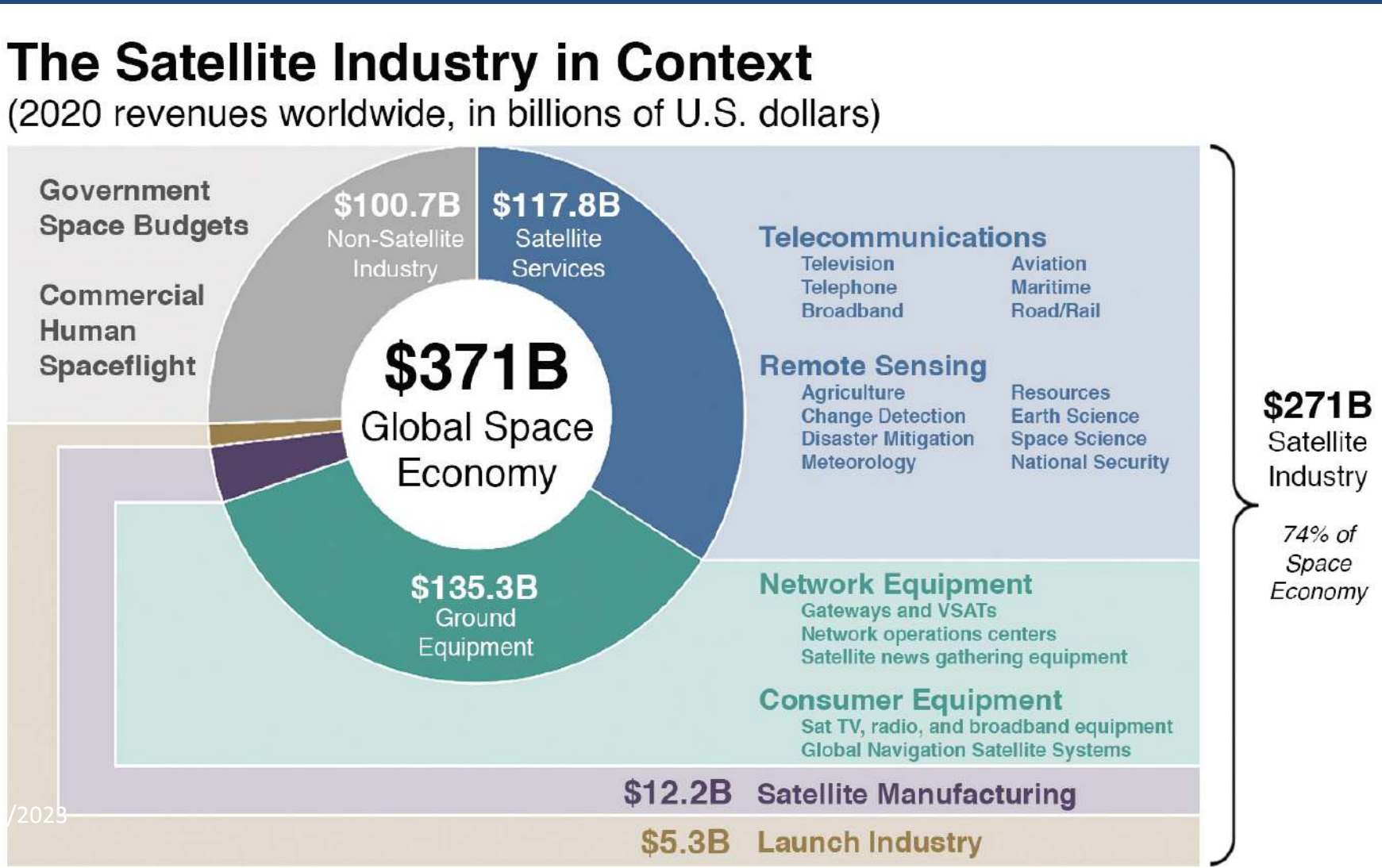
All have a voice: egalitarian, collegiate, respectful

Growing brand UDF, BRC and RMGS funding

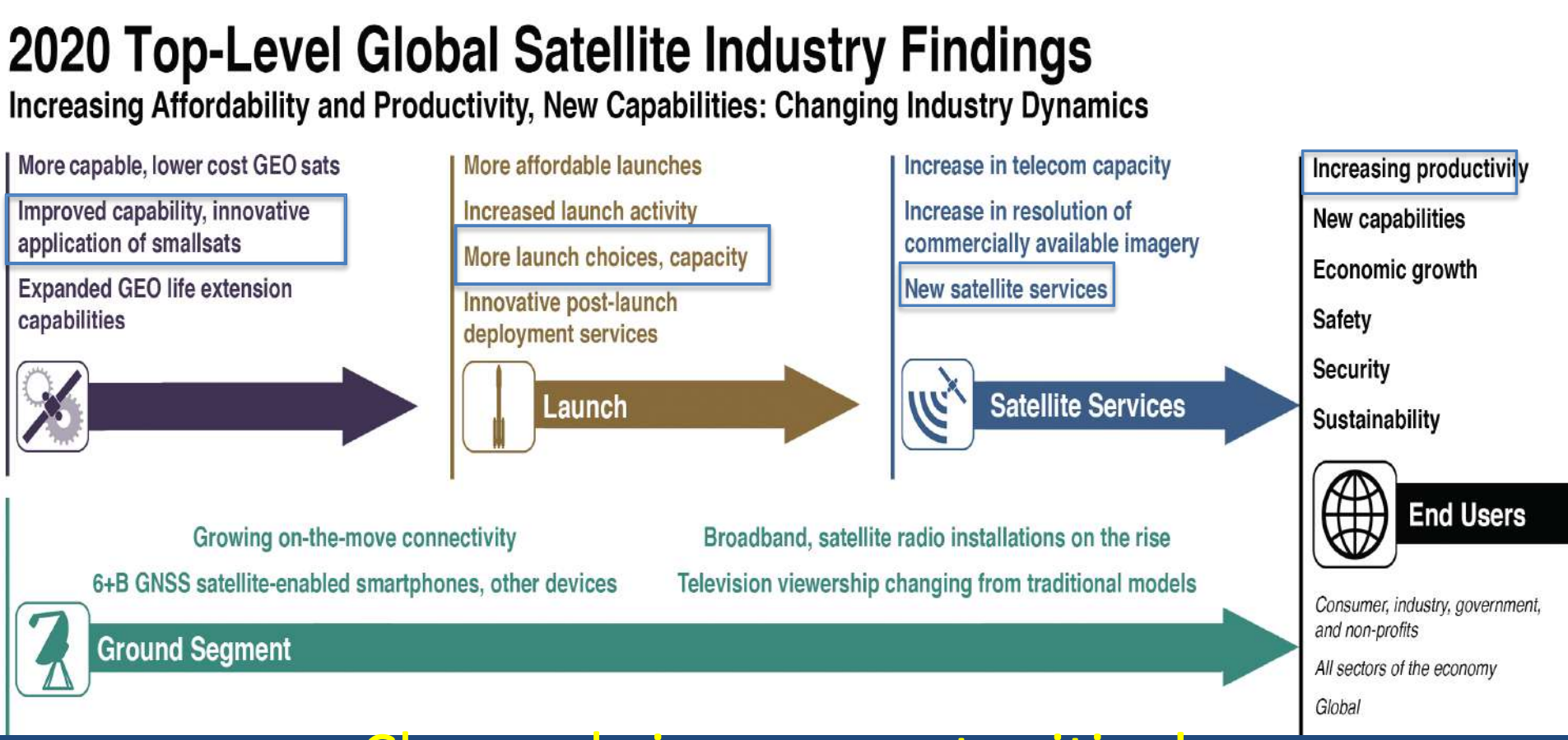
NEW MEMBERS WELCOME

OASA SpaceBiz Breakfast

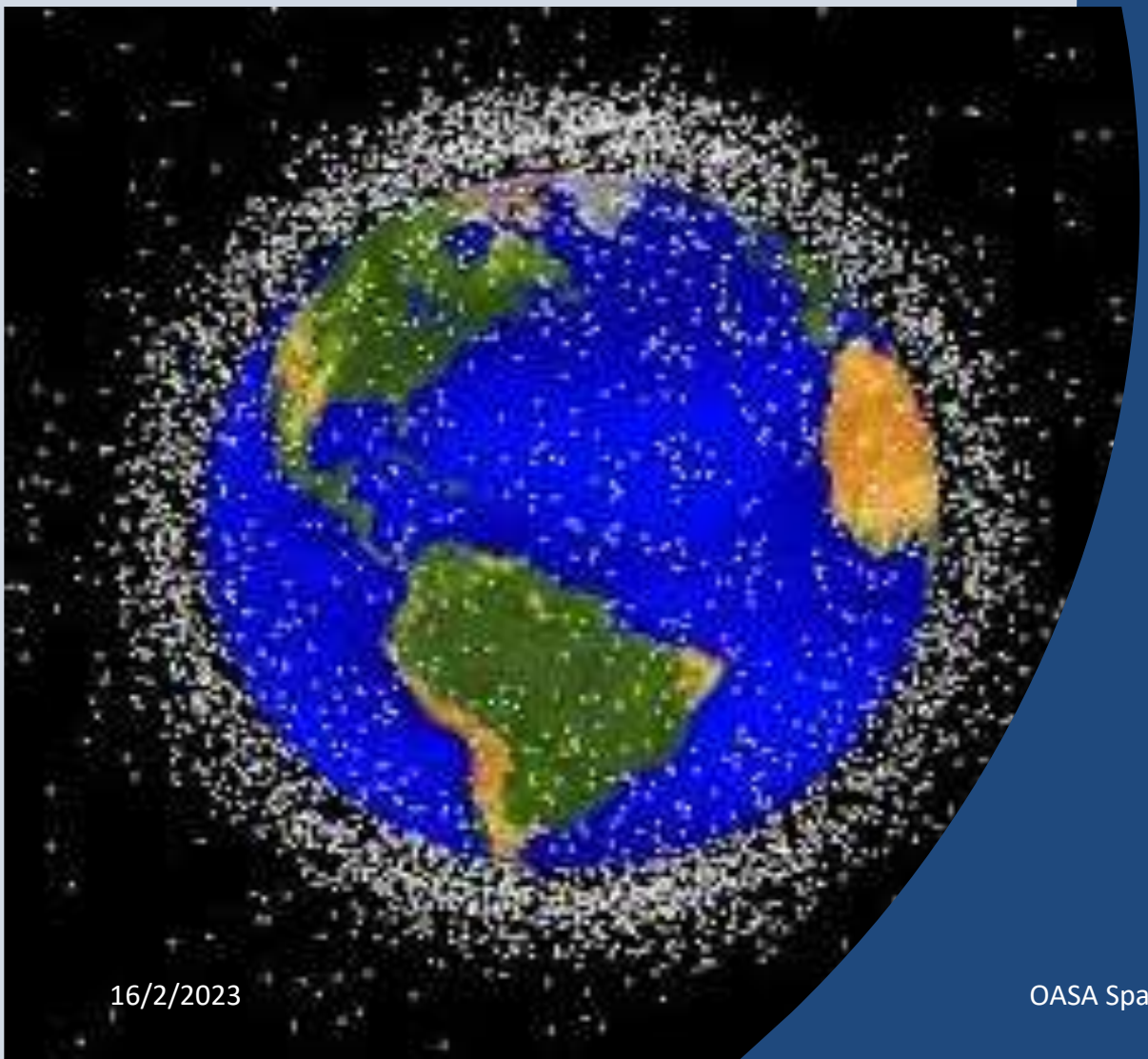
SPACE economy: GLOBAL CONTEXT- much uses Low Earth Orbit… it is not an unlimited resource!



The new reality → rapid change → busier but more challenging



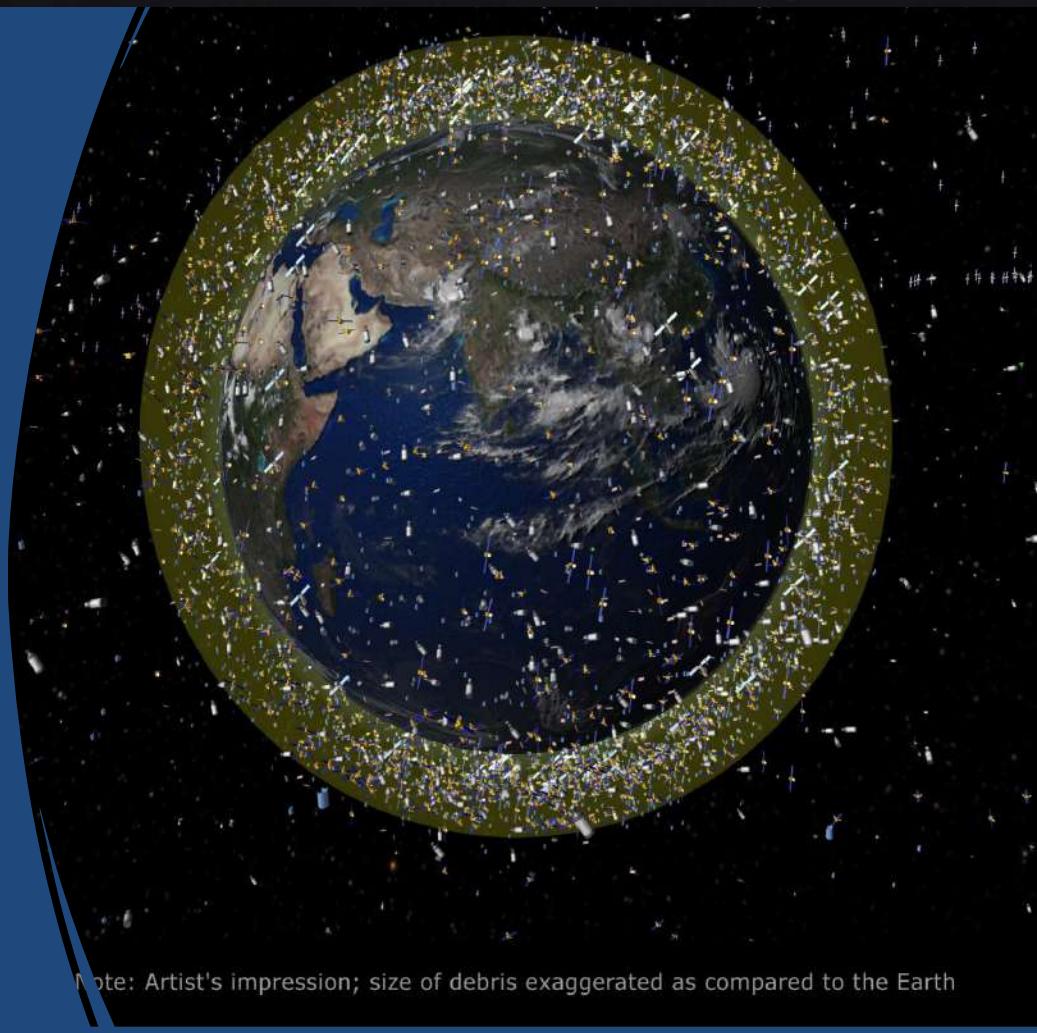
Change brings opportunities!
Money is in the data!



The Kessler Syndrome & is there a cure?

Why is space junk dangerous?

- Kessler Syndrome
  - Once past a certain critical mass of the number of debris, the total amount of space debris will keep on increasing. It is a chain reaction to create more debris by collision



https://www.esa.int/Enabling_Support/Space_Engineering_Technology/The_Kessler_Effect_and_how_to_stop_it

What is the Kessler Syndrome? – Let's check Wikipedia!

Kessler syndrome

Article Talk

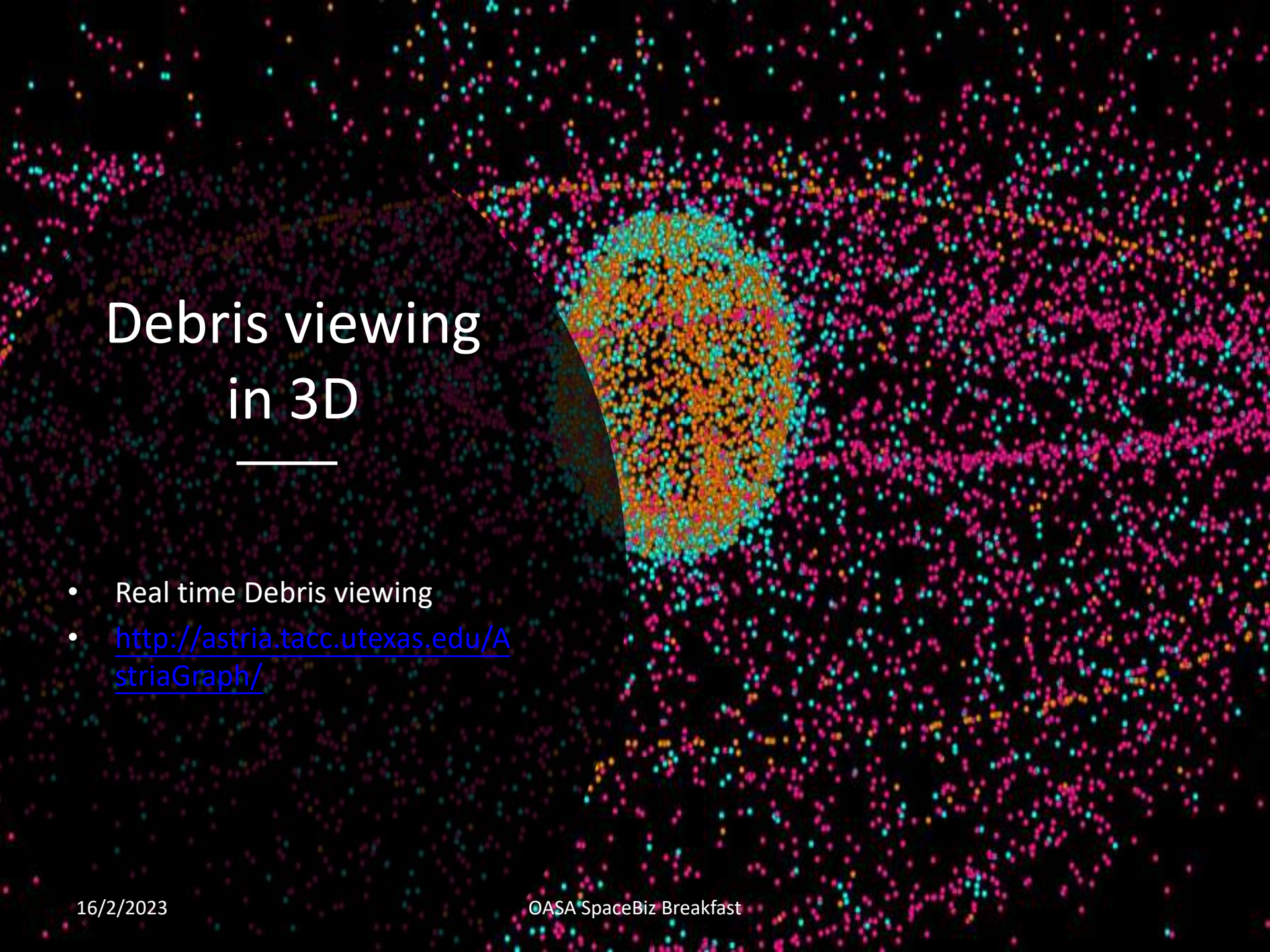
From Wikipedia, the free encyclopedia

The **Kessler syndrome** (also called the **Kessler effect**,[1][2] **collisional cascading**, or **ablation cascade**), proposed by NASA scientist Donald J. Kessler in 1978, is a scenario in which the density of objects in low Earth orbit (LEO) due to space pollution is high enough that collisions between objects could cause a cascade in which each collision generates space debris that increases the likelihood of further collisions.[3] In 2009 Kessler wrote that modeling results had concluded that the debris environment was already unstable, "such that any attempt to achieve a growth-free small debris environment by eliminating sources of past debris will likely fail because fragments from future collisions will be generated faster than atmospheric drag will remove them".[4] One implication is that the distribution of debris in orbit could render space activities and the use of satellites in specific orbital ranges difficult for many generations.[3]

Where does space debris come from?

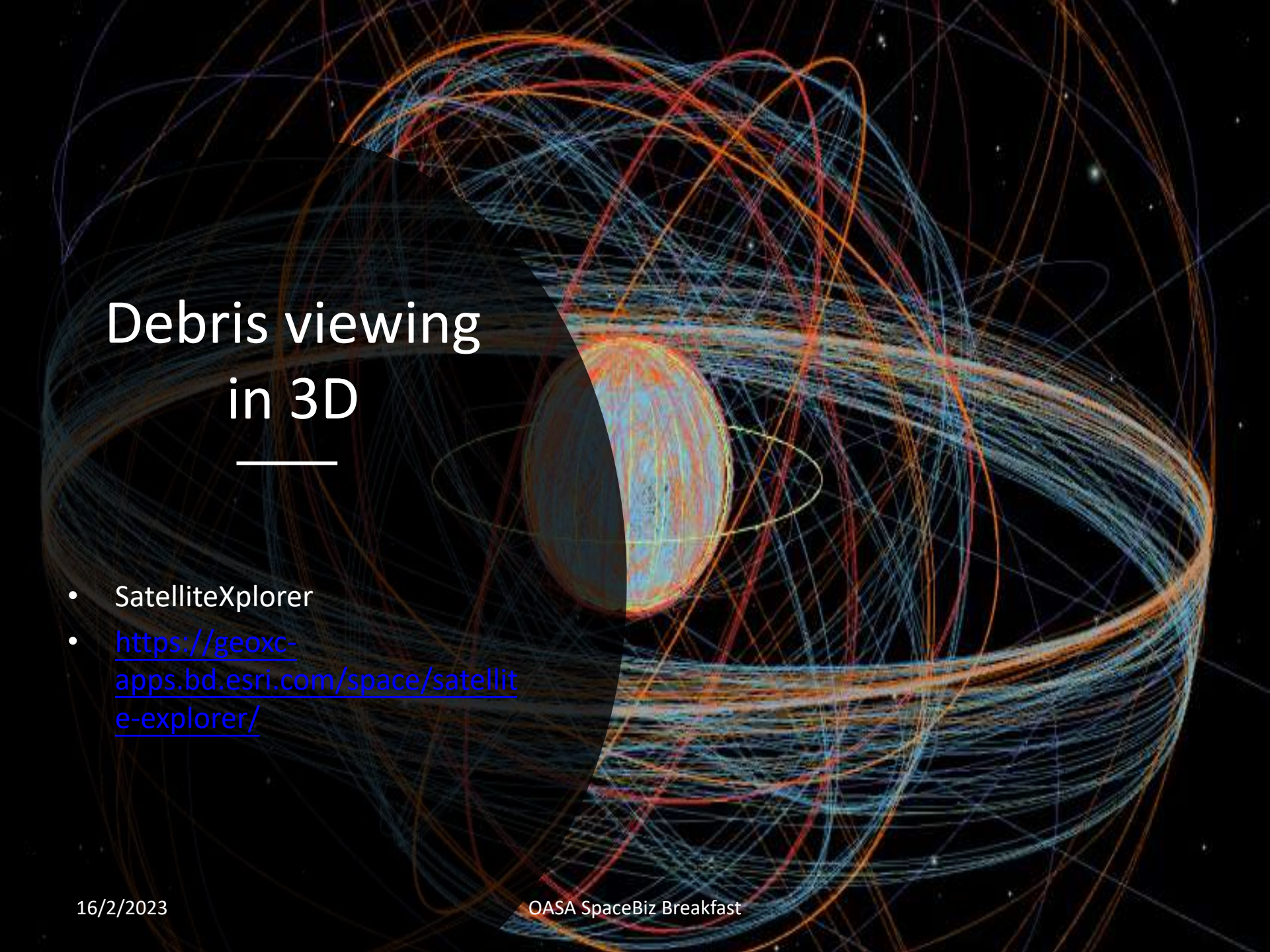
- Over last 60 years >11,140 satellites sent into earth orbit
- A total of over 8,261 satellites are currently orbiting but only ~4852 satellites (around 58%) are currently still active – the rest are effectively space junk
- In 2020 alone, 1283 satellites sent into lower earth orbit
- The debris includes paint flakes, rocket remains, small metal pieces, fragments of solar panels etc, etc etc…

Ref: https://www.geospatialworld.net/wp-content/uploads/2022/11/3d-rendering-planet-earth-broadband-internet-system-mee
needs-consumers-1920x1440.jpg



Debris viewing in 3D

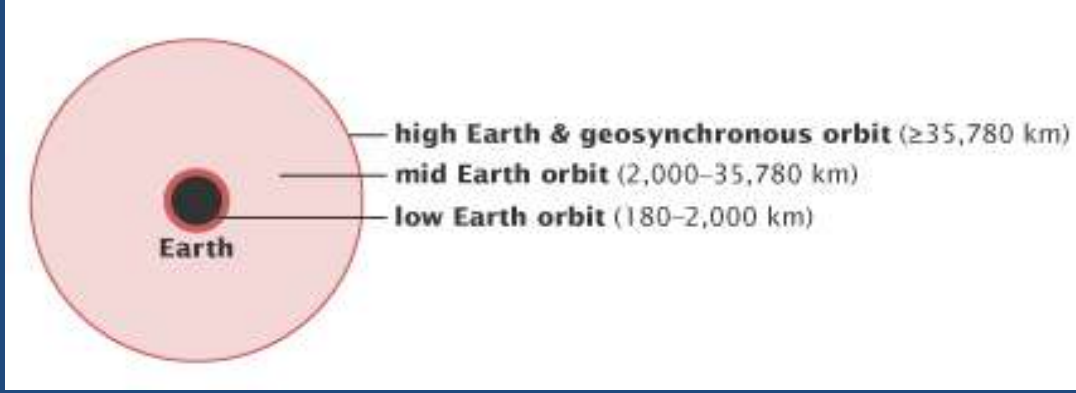
- Real time Debris viewing
- http://astria.tacc.utexas.edu/AstriaGraph/



Debris viewing in 3D

- SatelliteXplorer
- https://geoxc-apps.bd.esri.com/space/satellite-explorer/

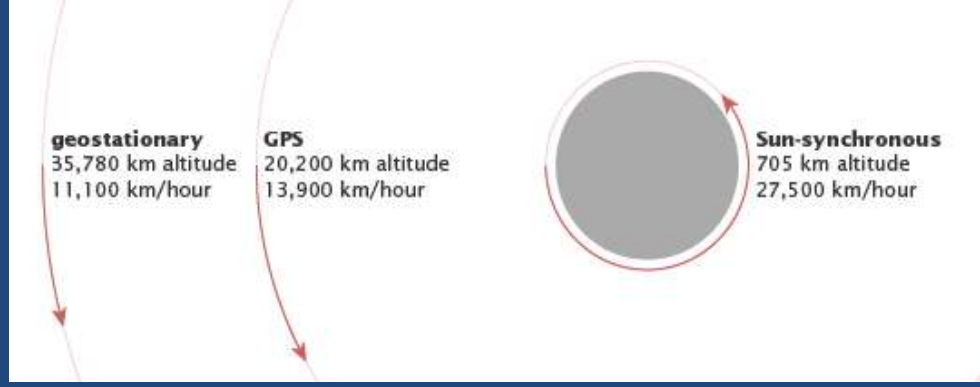
Main Orbit categories



- Low Earth Orbit (LEO) → this is the key concern
  - Between 180km-2000km altitude (in general)
  - At around 7.8 km/s
  - Take about 90 mins to complete one round trip (Travel about 16 times a day)
- Medium Earth Orbit (MEO)
  - Between 2000km-35780km altitude (in general)
  - Example, Semi-Synchronous Orbit for GPS (at 20,200 km altitude, rotate the earth for every 12hrs roughly.)
- High Earth Orbit (HEO)
  - Bigger than 35780km altitude (in general)

Ref: https://earthobservatory.nasa.gov/features/OrbitsCatalog

Orbit categories(others)



- Geo-Synchronous (GSO)
  - Take 23hr 56mins 4.09 sec to complete one round trip
  - 3km/s at 35786 km altitude
  - If you look up, the satellite never move
- Geo-Stationary Orbit (GEO)
  - Same as GSO except it is at the equator
- Polar Orbit
  - LEO with the orbit close to 20-30 degree of North and South pole
  - 200-1000 km altitude
  - Travel at around 7.6km/s (27,500 km/hr)
- Sun-synchronous Orbit (SSO)
  - Polar Orbit where it synchronizes with the Sun
  - E.g., passing Hong Kong everyday at noon exactly
  - i.e., take satellite images and compare the image over time
  - Travel at 7.6km/s

 Ref: https://earthobservatory.nasa.gov/features/OrbitsCatalog

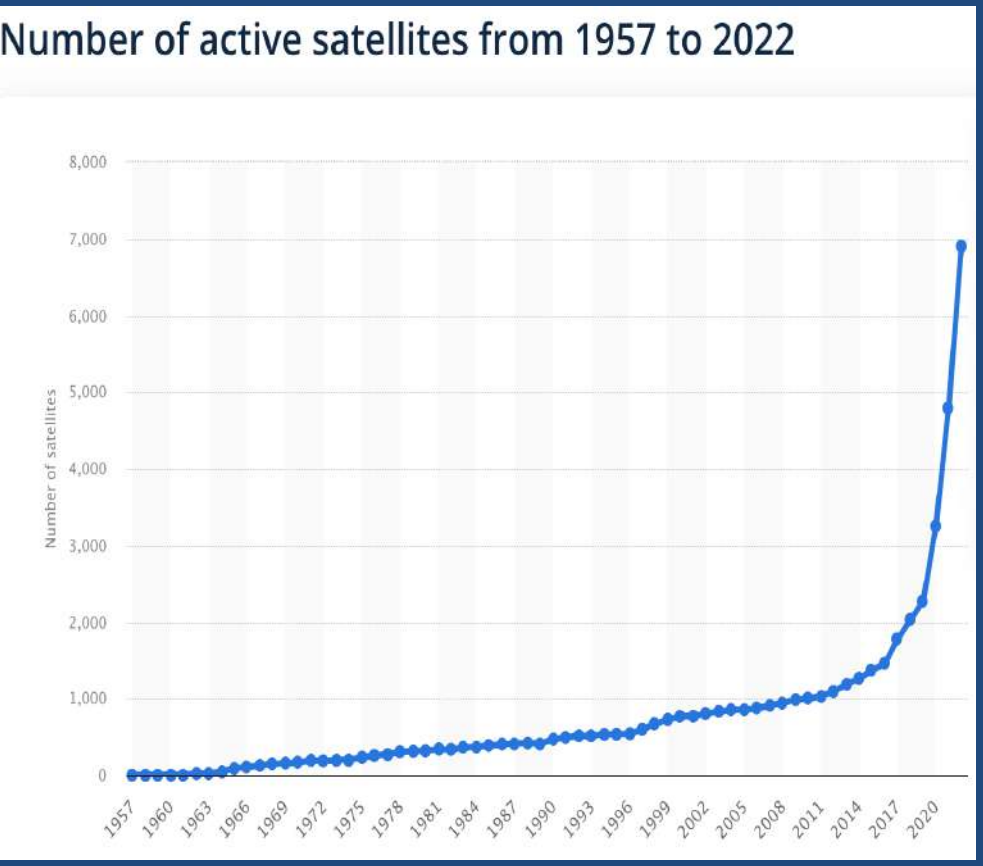
How much space debris currently in Earth orbit? – this is not a static number!

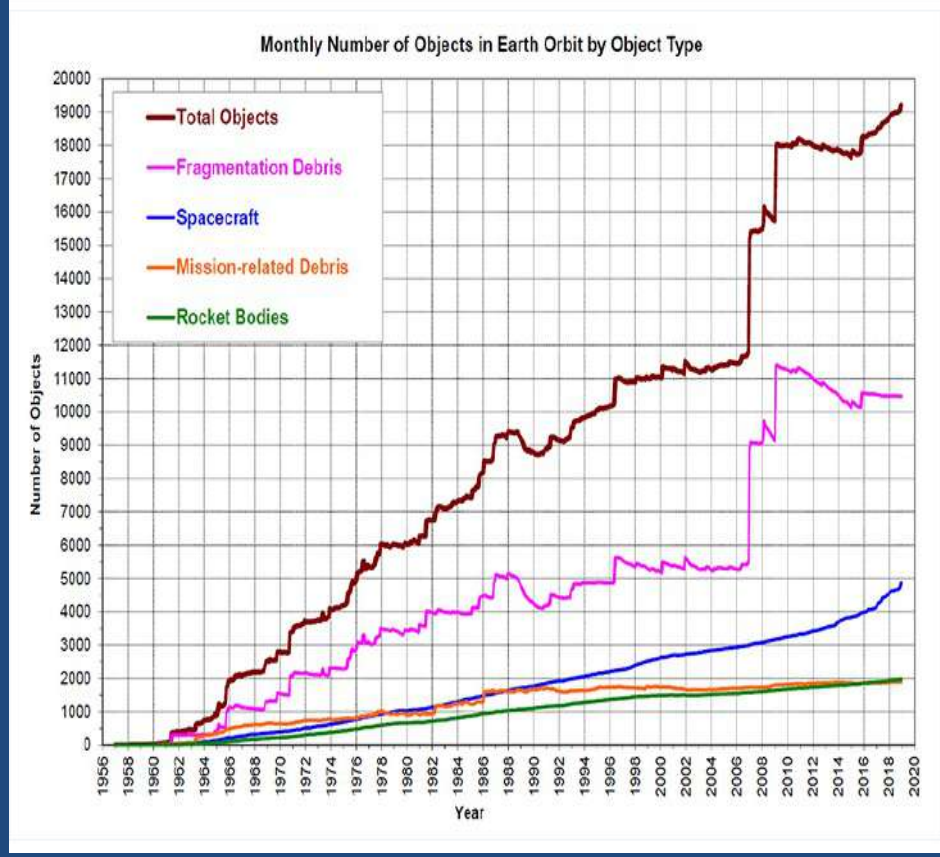
European Space Agency (Update on 22 Dec 2022) report that there are:

- ~36500 items of space debris >10 cm
- ~1,000,000 pieces space debris 1 - 10 cm in size
- 130 million pieces space debris between 1 mm to 1 cm in size

Ref:
https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

Number of Debris pieces increases every year





Ref: https://en.wikipedia.org/wiki/File:LEO-SpaceDebris-Nov2020.png

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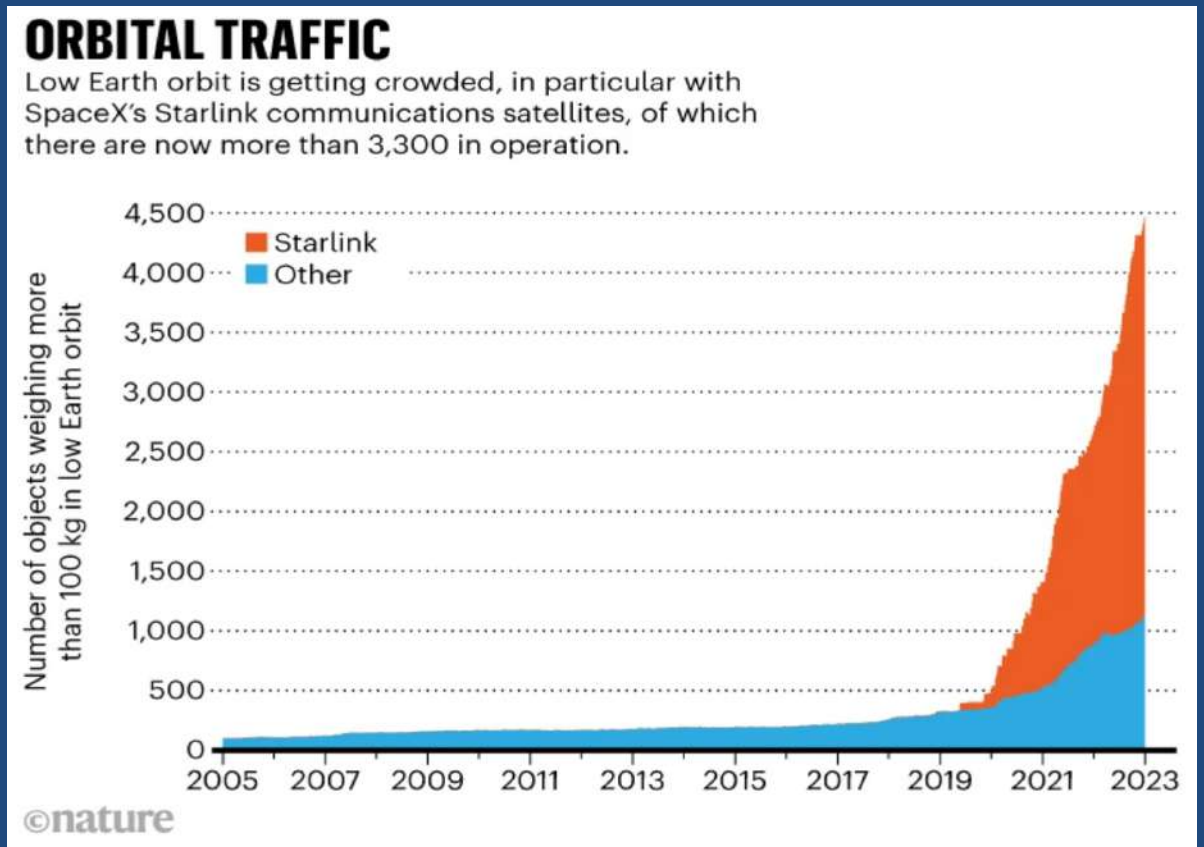
Its getting very crowded in low earth orbit and increasingly difficult to manage…



There are now >3,300 operational Starlink satellites in orbit, the largest by any one operator by a larger margin. The growing congestion means that, between 2020 and 2022, SpaceX has had to move its satellites out of the way more than 26,000 times to prevent collisions with space objects.

Urgent international regulation is needed!

It can no longer be allowed to be the wild west up there!

16/2/2023

ELSEVIER

Advances in Space Research

Available online 4 July 2022

In Press, Corrected Proof ⓘ What's this?

Improving international governance of space debris in the era of large constellations of small satellites and China's response

Kuan Yang [1], Yulin Wu

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https://doi.org/10.1016/j.asr.2022.06.061 Get rights and content

Abstract

The rapid development of large constellations of small satellites will inevitably lead to a sharp increase of space debris, and thus brings about great threat to space safety and space environment. This poses severe challenges to the current international governance of space debris. The existing space debris mitigation guidelines are neither adaptive nor effective in dealing with the space debris problem in the era of large constellations of small satellites. Under such background, it is indispensable to establish an innovative space debris governance mechanism combining rules both concerning space debris mitigation, prevention, and more importantly, space debris active removal. In this regard, China has been improving its domestic space legislation regarding space debris management at the domestic level. On the other hand, China shall continue to promote the innovative development of space debris governance mechanism at the international level, so as to cope with the conundrums resulting from the development of large constellations of small satellites.

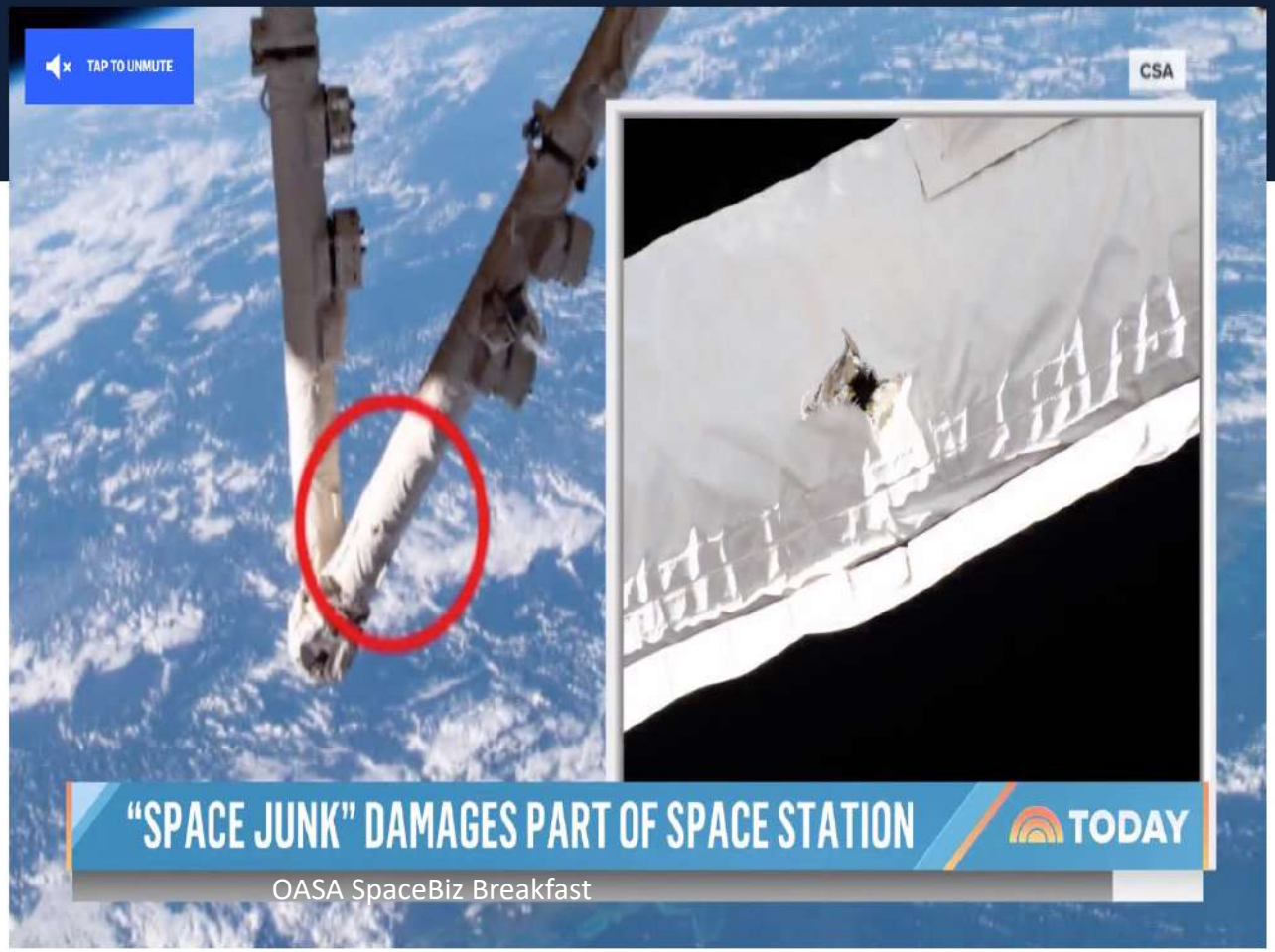
The threat of the impact of debris and space junk is very real.

Event occurred on or before May 2021

Over the station's 23 - year orbital lifetime, there have been about 30 close encounters with orbital debris requiring evasive action.
Most debris is too small to track

Space junk damages International Space Station's robotic arm

The wayward object punctured a hole in Canadarm2's protective thermal covering, but the robotic arm remains functional.



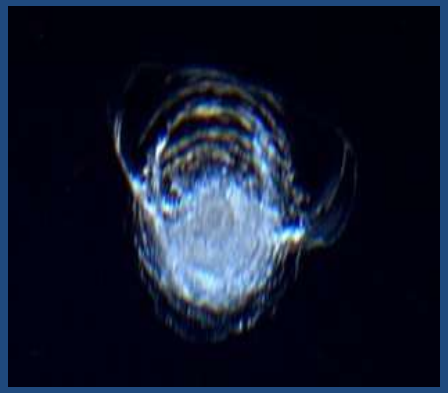
Damage example

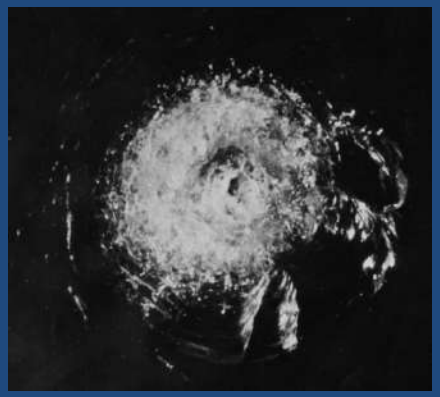
- 0.2-millimeter paint debris at 7.06 km/s has the same destructive force as a hand grenade

https://www.esa.int/Space_Safety/Space_Debris/European_conference_on_space_debris_risks_and_mitigation

Damage to the Space Shuttle & ISS

- An object hit and damaged the Space Shuttle mission STS-7 in 1983
- That object believed to be fleck of paint smaller than a few thousandths of a millimeter across
- Similar paint fleck damaged the viewing Cupola of the ISS in 2016
- 7mm-diameter circular chip gouged out!
- Anything bigger than 1cm could penetrate the shields/windows
- Anything bigger than 10 cm could shatter the spacecraft



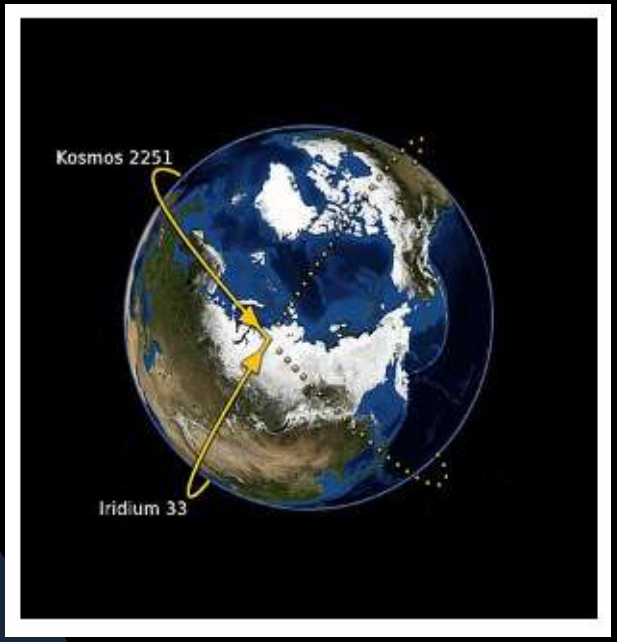


Several space shuttle windows replaced because of damage caused by material shown to be paint flecks. Millimeter-sized orbital debris represents the highest mission-ending risk to most robotic spacecraft operating in low Earth orbit.

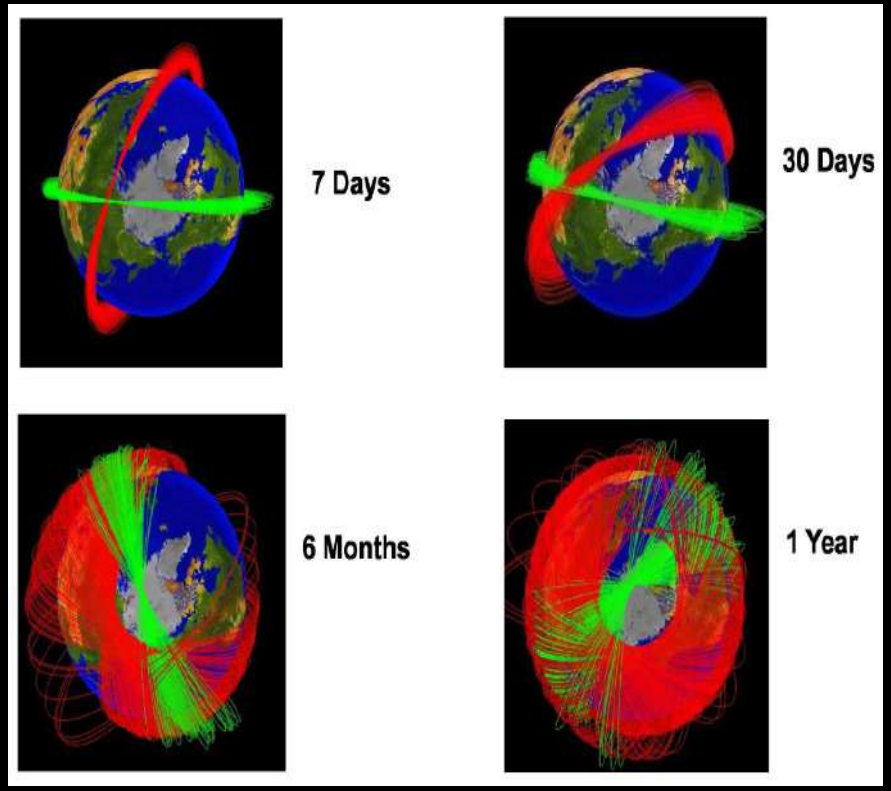
Ref: https://www.esa.int/ESA_Multimedia/Images/2016/05/Impact_chip

Past major Debris collisions

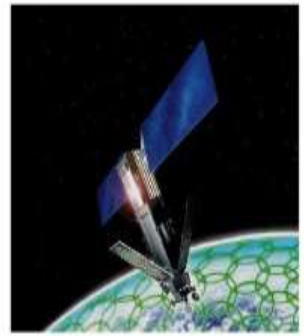
- In 2009, an Iridium satellite was hit by an inactive satellite "Cosmos" with a relative velocity of 35,890 km/h
- The collision created >1800 pieces of new sizeable debris pieces



https://en.wikipedia.org/wiki/2009_satellite_collision



https://ntrs.nasa.gov/citations/20100002023



Iridium 33

Cosmos 2251

Mysterious Russian satellite breaks up in orbit, generating cloud of debris

By Mike Wall published 1 day ago

Kosmos 2499 broke apart in early January, according to the U.S. Space Force.

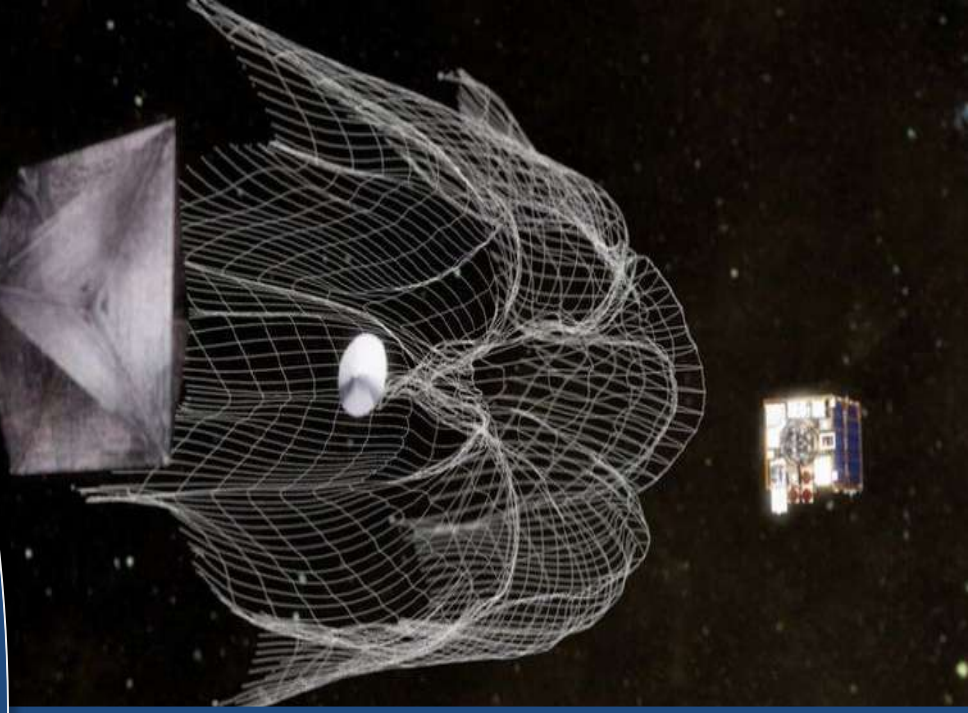
Comments (2)

Artist's illustration of a satellite breakup in Earth orbit. (Image credit: ESA/ID&Sense/ONiRiXEL, CC BY-SA 3.0 IGO)

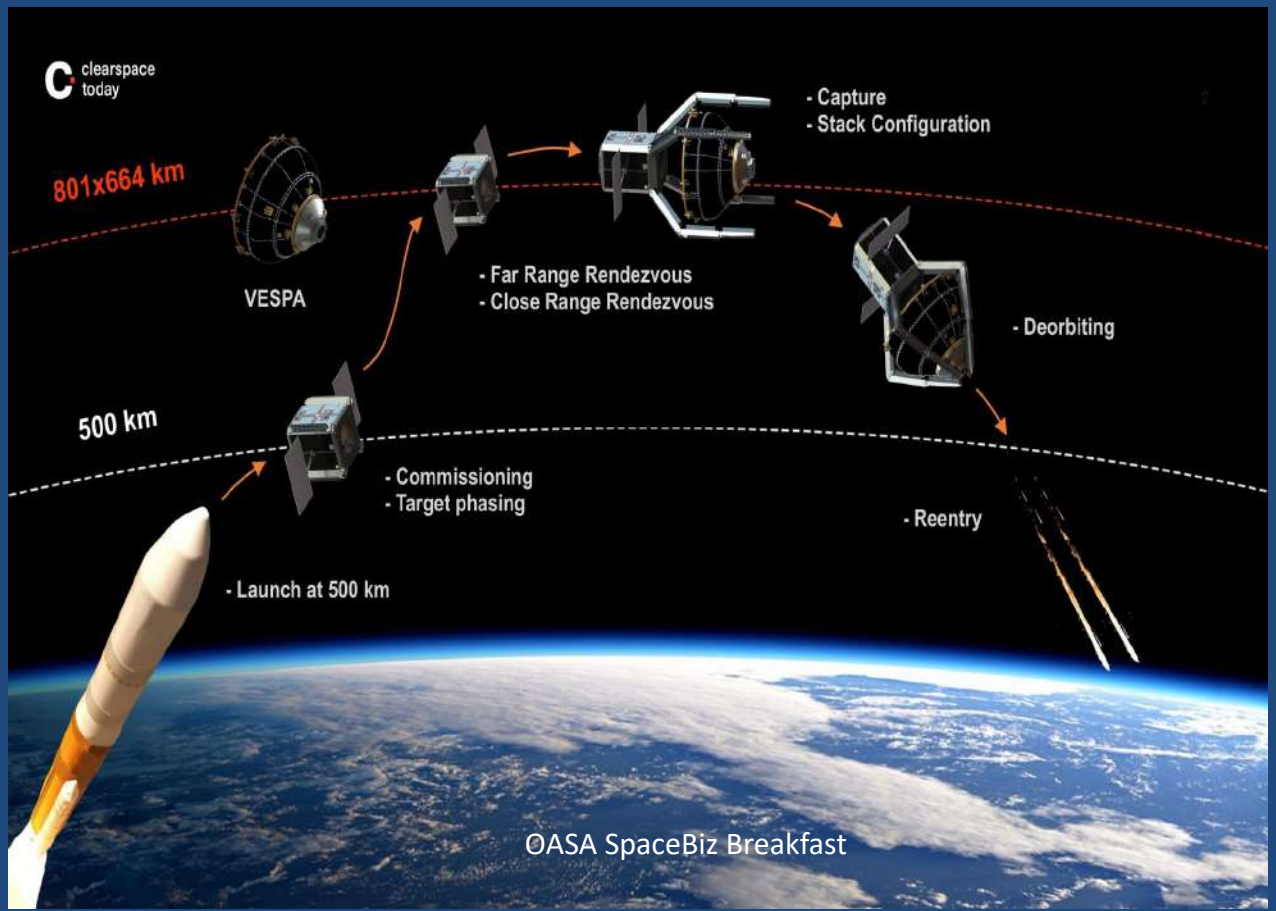
Broke-up Jan 4th 2023
Creating 80 major pieces of potentially damaging pieces of debris and who knows how many more small pieces….

Are we doing anything about it?

- If the debris is at LEO, the debris will eventually drop back to earh due to the drag
- In 2018, a satellite named “RemoveDEBRIS” shot a net to catch a dummy satellite
- And shoot a harpoon towards a debris



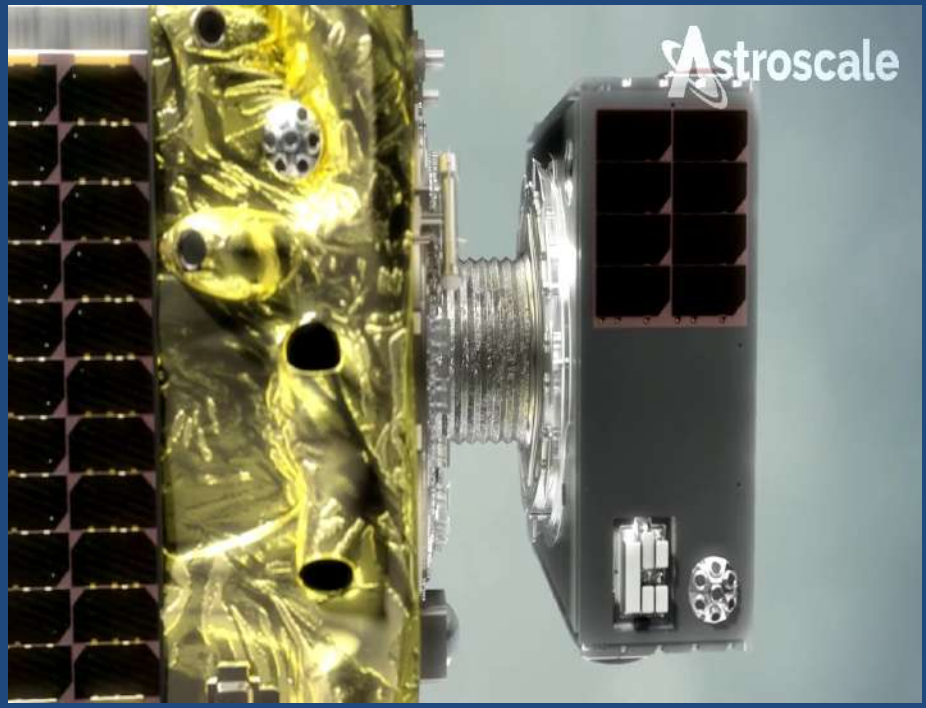
- In 2025, a satellite called “ClearSpace” will try to retrieve 100kg debris using claws supported by European Space Agency



https://www.thesun.co.uk/tech/13304034/esa-space-junk-

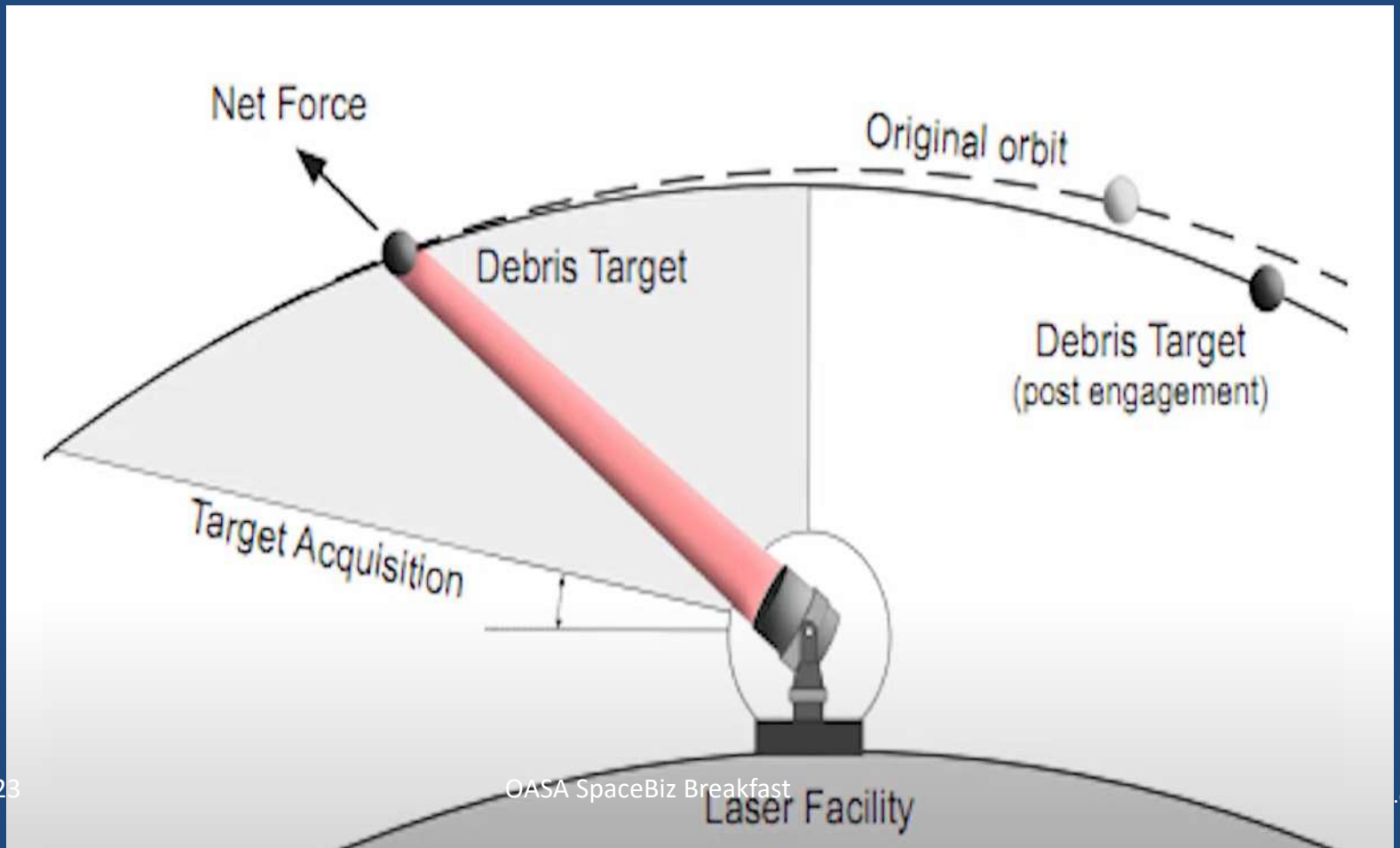
Are we doing anything about it?

- Magnetic Capture from Astroscale
- Using magnetic tugboat debris capture system
- Successful demo mission on August 25, 2021



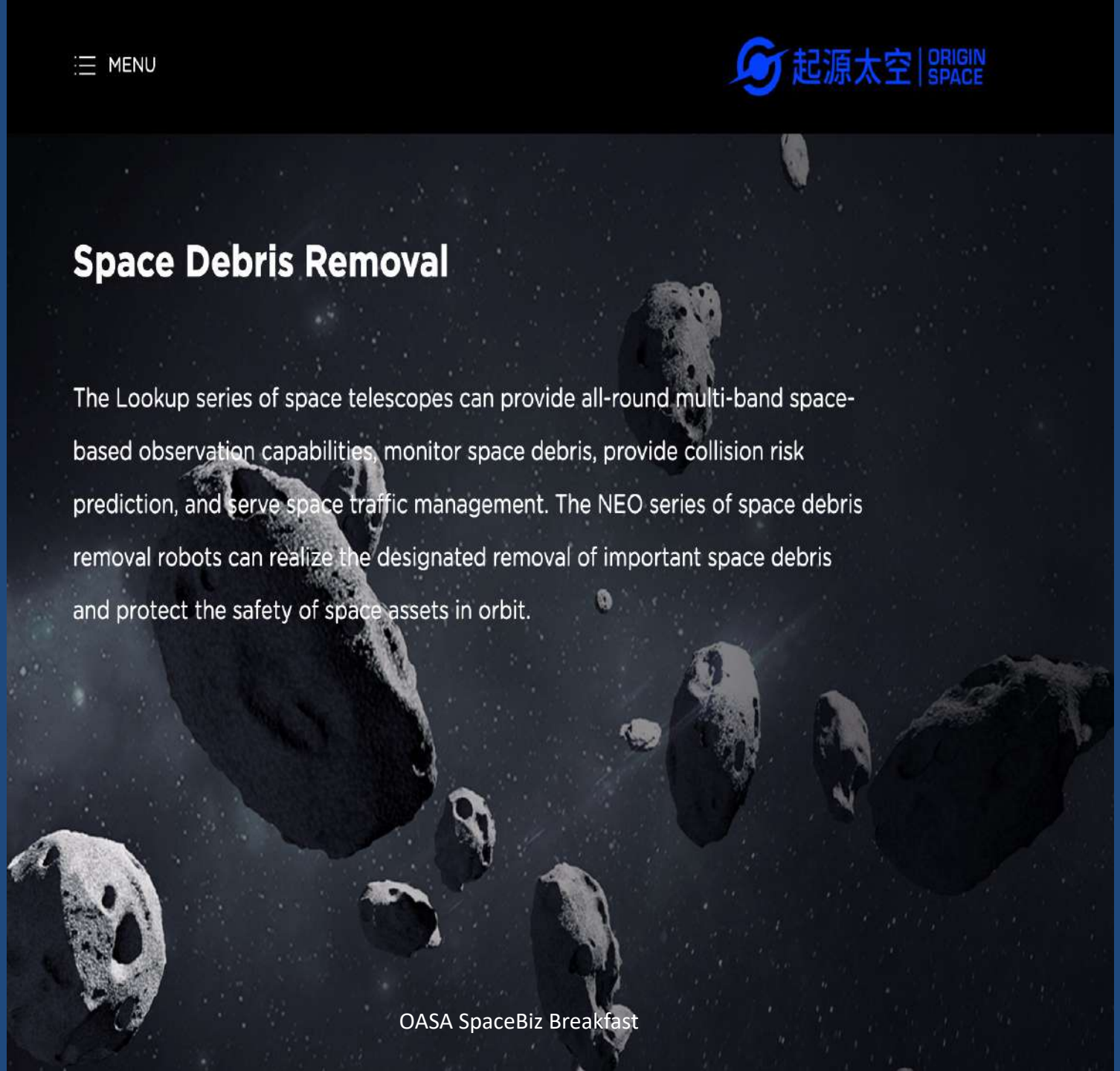
https://www.youtube.com/watch?v=VIeRpePrWN8

- Laser Broom
- Burn or push the debris away



Space Debris Removal technology

Strong market demand for space debris removal, the company Origin Space (CEO LSR dep director Meng SU) has independently developed a number of core technologies such as space-ground integrated detection, space target rope net/manipulator capture, etc., breaking a number of world records in the field of commercial aerospace. The “NEO-01” satellite has completed the simulation of asteroid target release and flying net capture experiments, as well as related technical verification of space debris removal. The project achieved similar goals at only one-tenth of the cost of international benchmarking projects.


MENU
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Space Debris Removal
The Lookup series of space telescopes can provide all-round multi-band space-based observation capabilities, monitor space debris, provide collision risk prediction, and serve space traffic management. The NEO series of space debris removal robots can realize the designated removal of important space debris and protect the safety of space assets in orbit.

NEO-02 Concept Model : A Self-developed Space Debris Removal Robot

The project plans to complete active removal of 100Kg level space debris in Low Earth Orbit

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References

https://www.geospatialworld.net/prime/business-and-industry-trends/how-many-satellites-orbiting-earth/#:~:text=According%20to%20the%20Index%20of,objects%20launched%20into%20the%20space

https://www.youtube.com/watch?v=eeQnv_IWttw

https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

Top debris creation events

Object	Year	Pieces	Notes
Fengyun-1C	2007	3,549	Intentional collision (ASAT)
Kosmos 2251	2009	1,716	Accidental collision with Iridium 33
Kosmos 1408	2021	1,562	Intentional collision (ASAT)
STEP 2 Rocket Body	1996	756	Residual propellant explosion
Iridium 33	2009	659	Accidental collision with Kosmos 2251
Kosmos 2421	2008	511	Disintegrated *citation needed*
SPOT 1 Rocket Body	1986	506	Residual propellant explosion
Parus	1981	482	Battery explosion
OV2-1 Rocket Body	1965	473	Engine explosion
Nimbus 4 Rocket Body	1970	465	Residual propellant explosion
NOAA-16	2015	458	Battery explosion
TES Rocket Body	2001	373	Residual propellant explosion
CBERS 1 Rocket Body	2000	344	Residual propellant explosion
Fregat tank	2020	338	Residual propellant explosion
Ablestar	1961	320	Residual propellant explosion
Delta 2910	1975	313	Residual propellant explosion
Solwind	1985	289	Intentional collision (ASAT) [7]

https://en.wikipedia.org/wiki/List_of_space_debris_produ