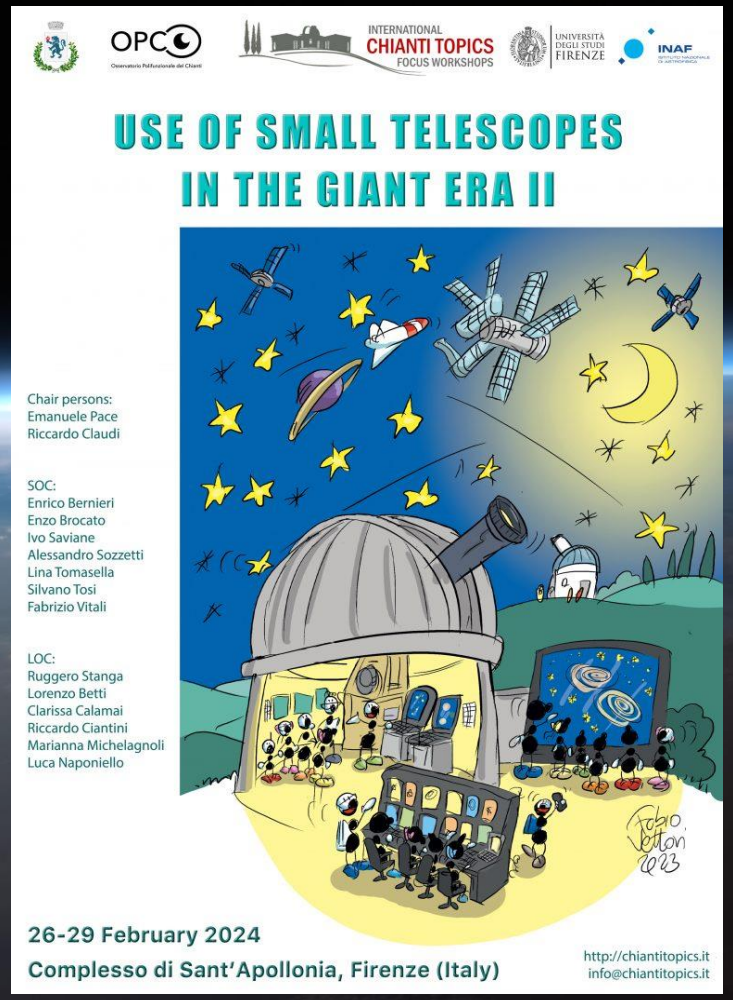
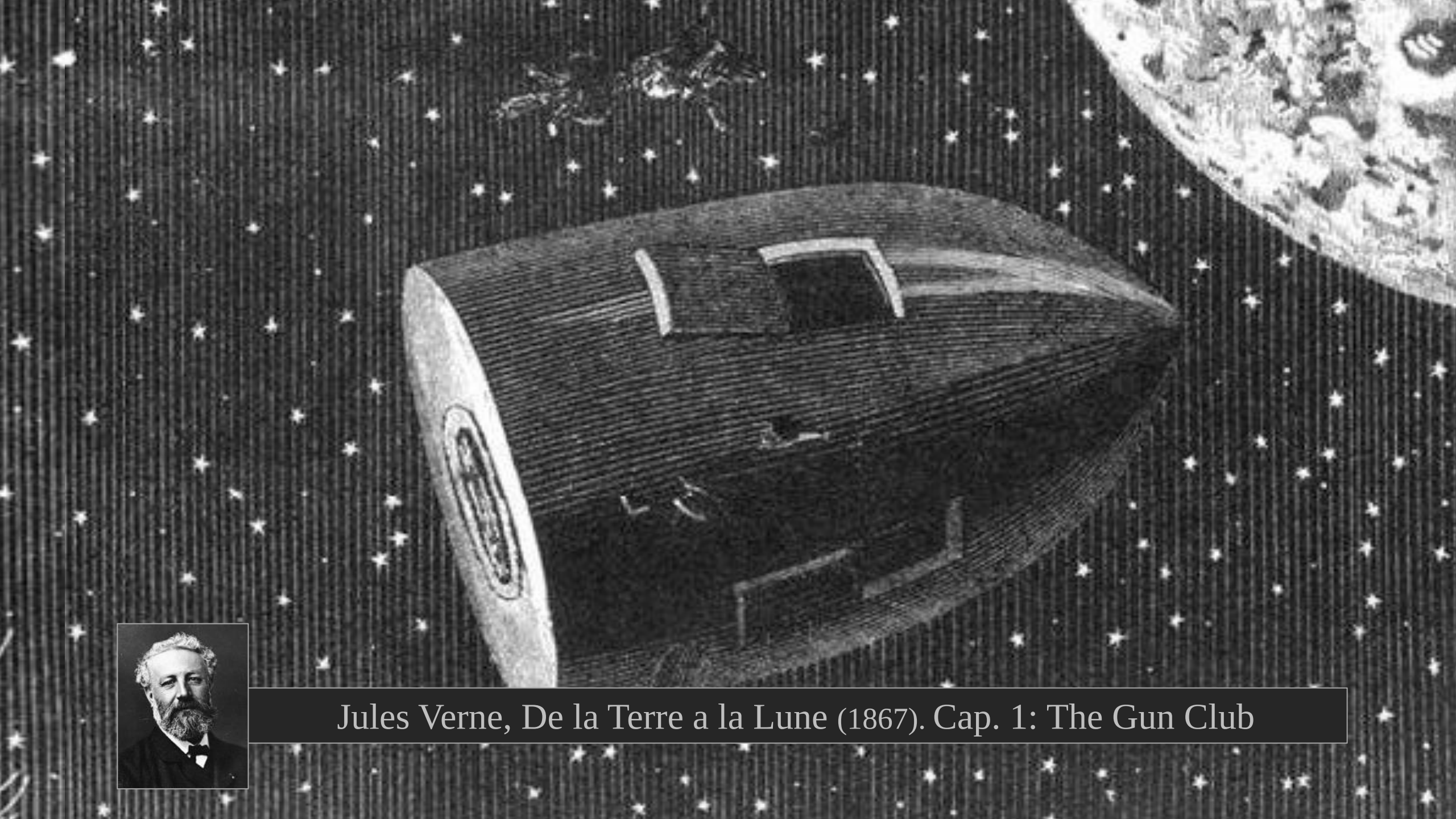



# SPACE SURVEILLANCE

## an opportunity for small telescopes

ettore perozzi
Direttorato Scienza e Ricerca

Agenzia Spaziale Italiana

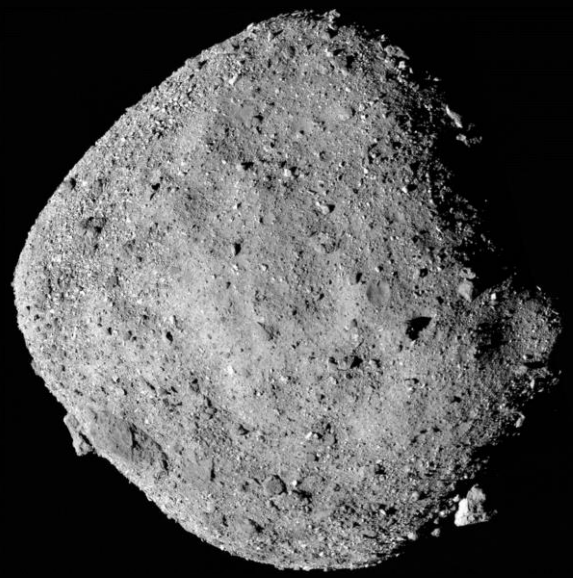




Jules Verne, De la Terre a la Lune (1867). Cap. 1: The Gun Club

# space situational awareness

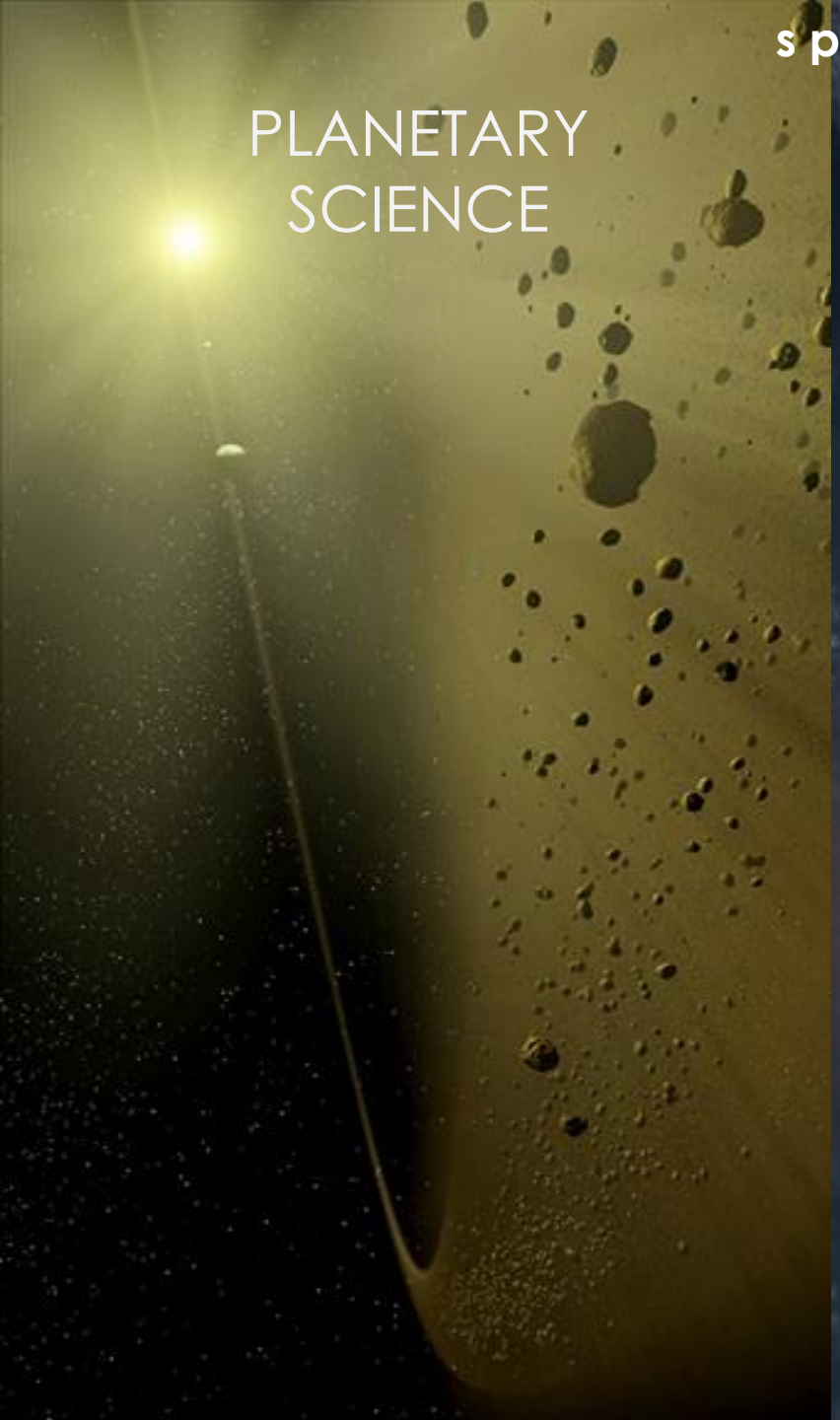
## ASTEROID HAZARD



## SPACE WEATHER

## SPACE DEBRIS

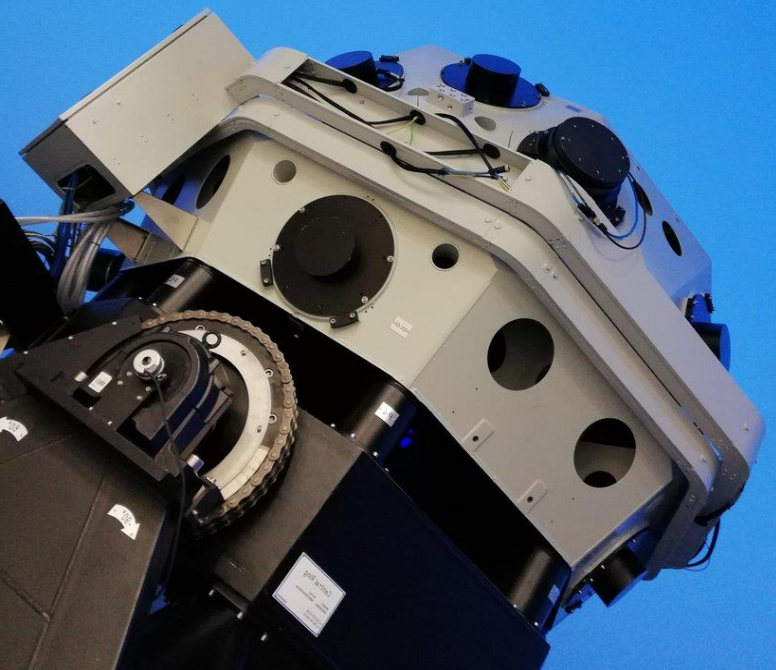
# space situational awareness



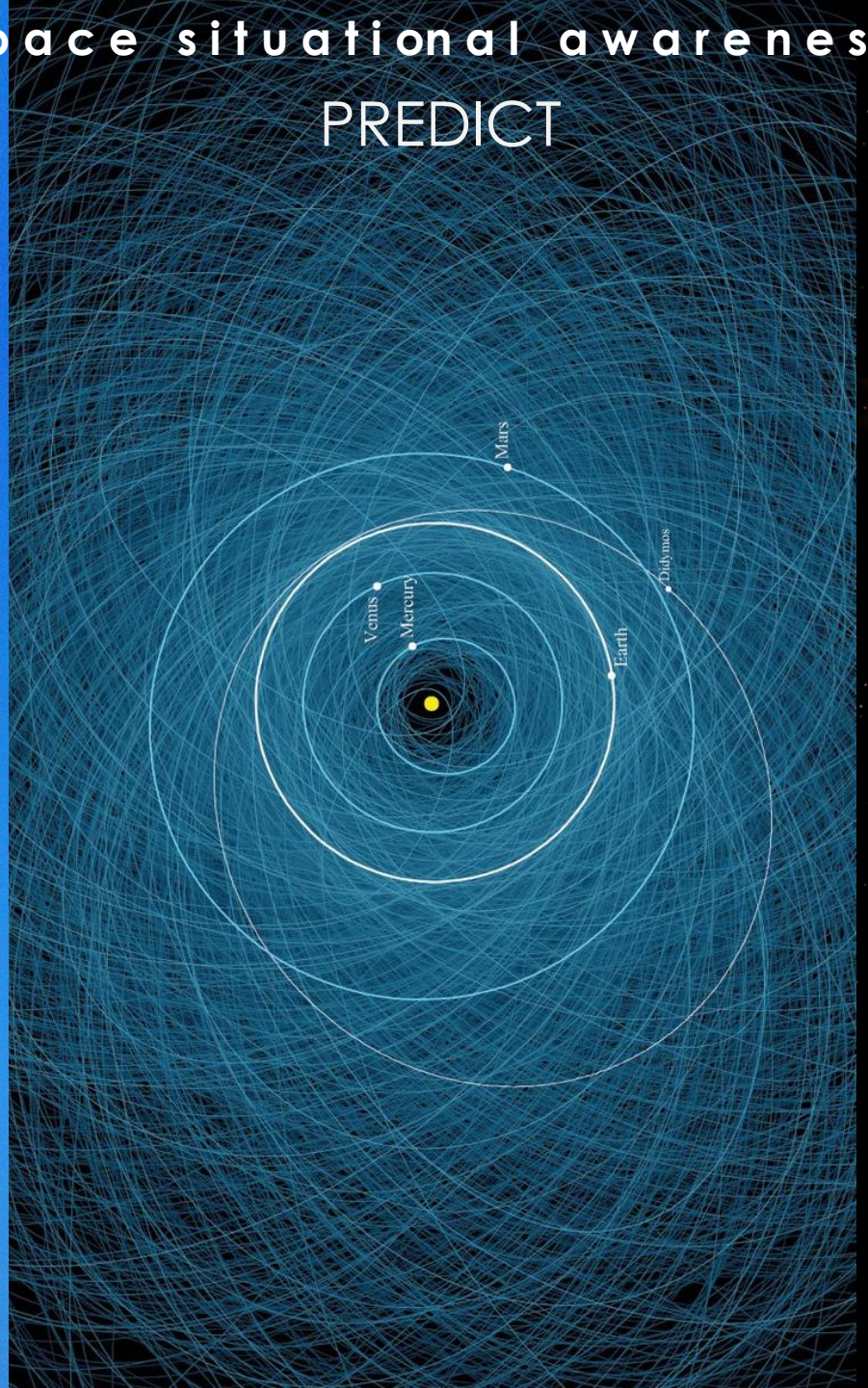


# space situational awareness

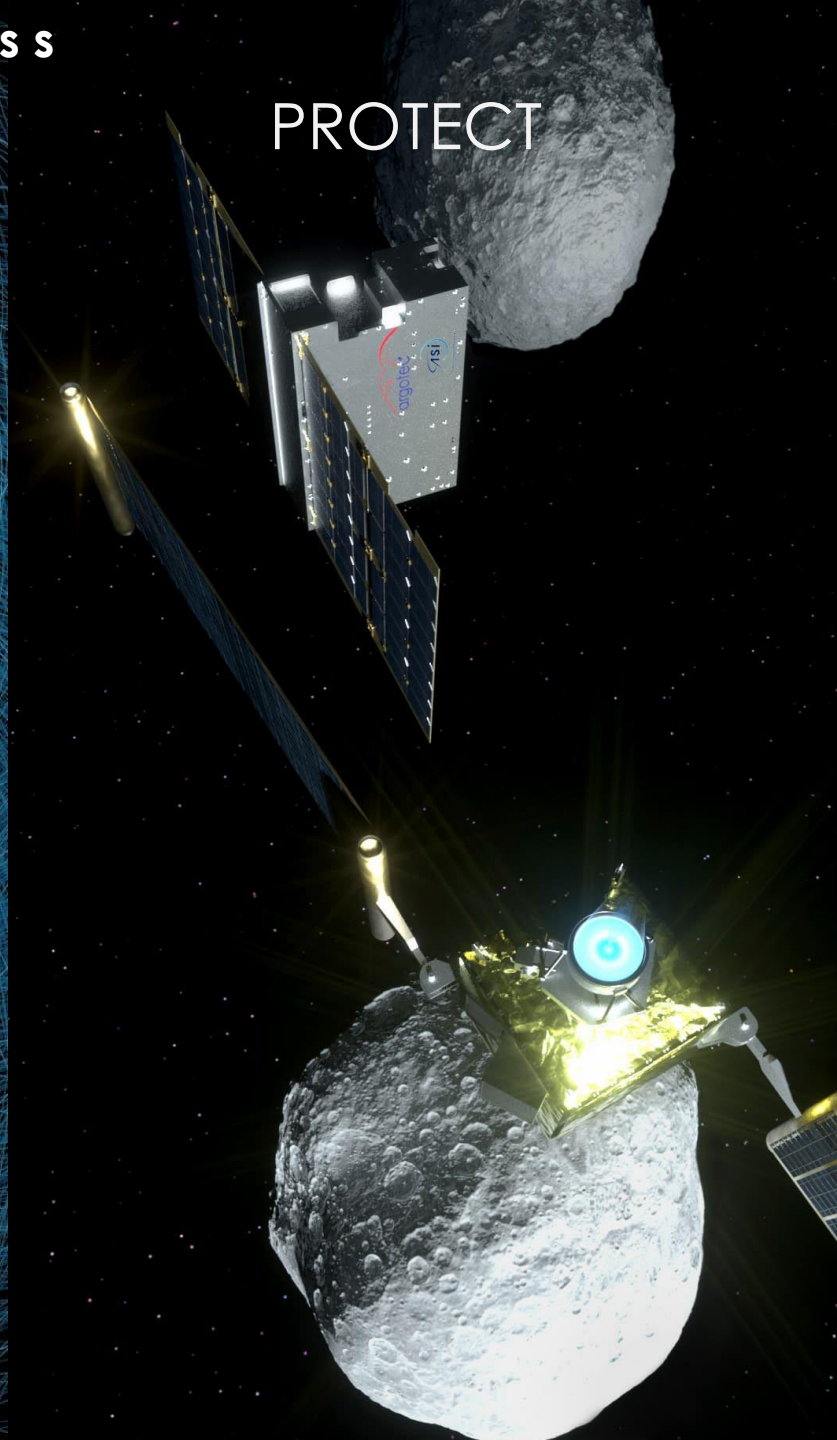
## OBSERVE



## PREDICT




## PROTECT



## OPERATIONS

PROJECT MANAGEMENT

SW ENGINEERING

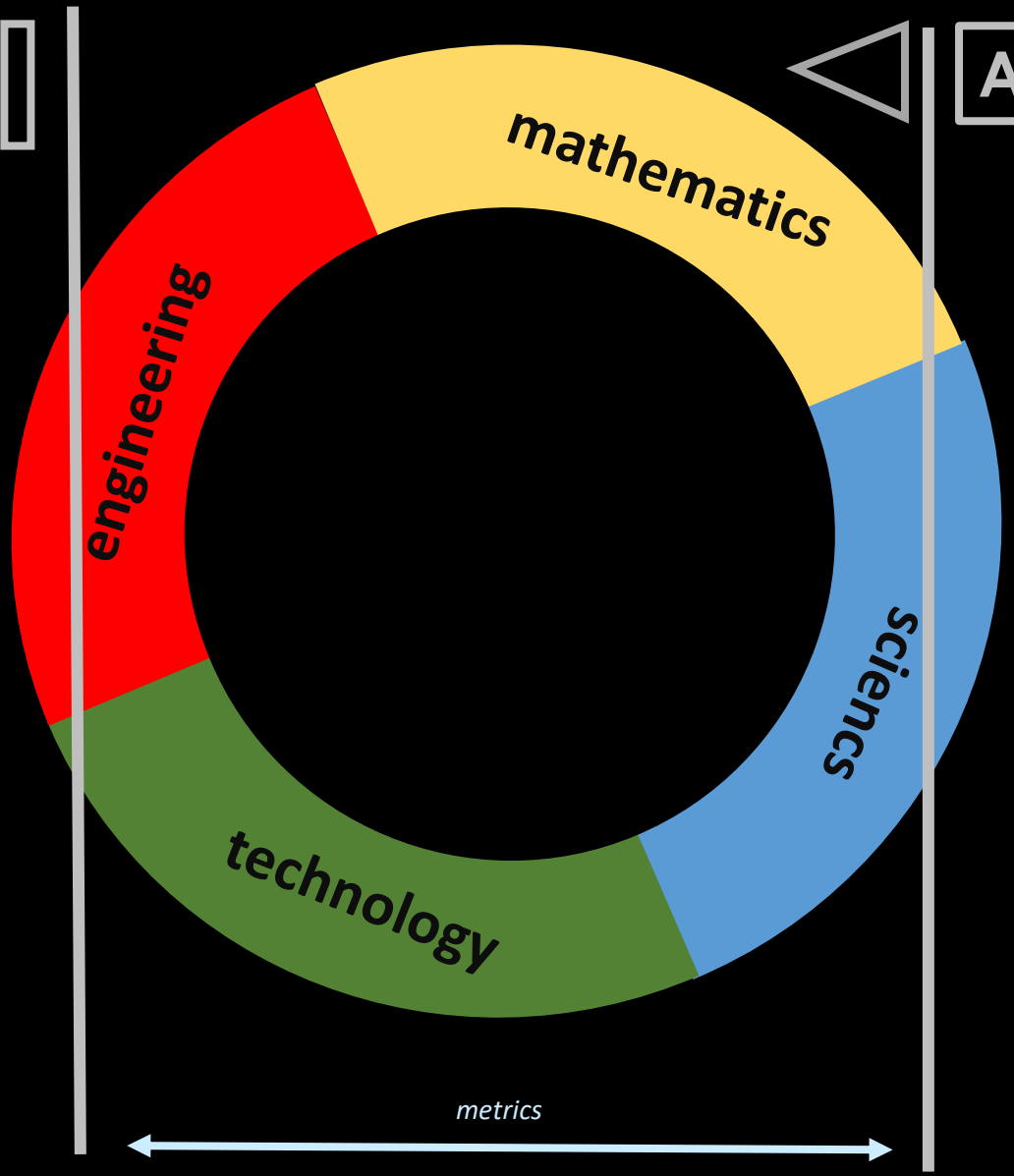
CONFIGURATION CONTROL

OPERATIONS

SERVICES

USERS

LIABILITY




## AWARENESS

SCIENCE

RESEARCH

APPLIED RESEARCH

PROTOTYPNG

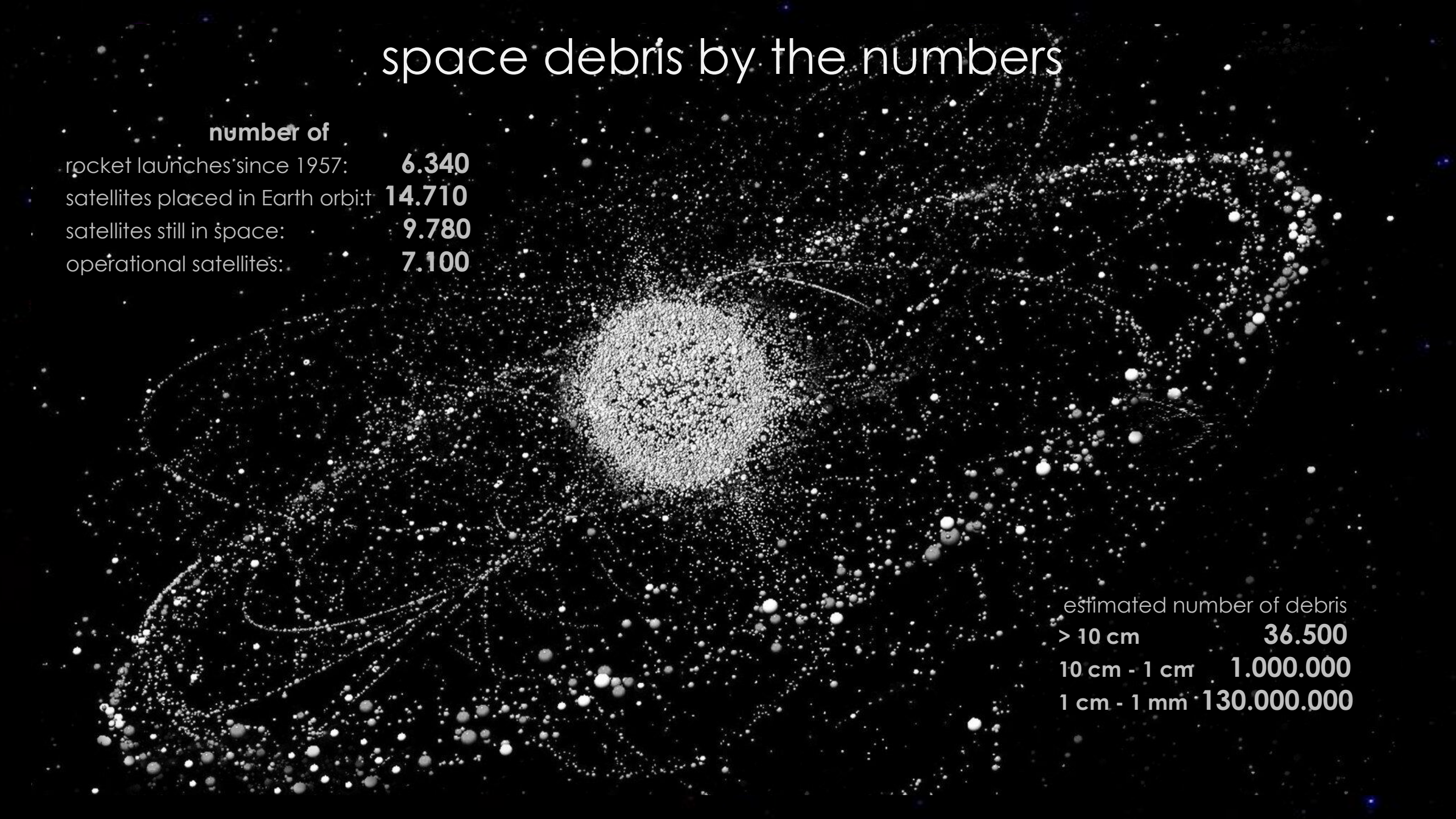
AUTOMATION

# space surveillance

# space surveillance

Je veux dire qu’il ne suffit pas d’envoyer un projectile et de ne plus s’en occuper ; il faut que nous le suivions pendant son parcours jusqu’au moment ou il atteindra le but.

# space debris by the numbers

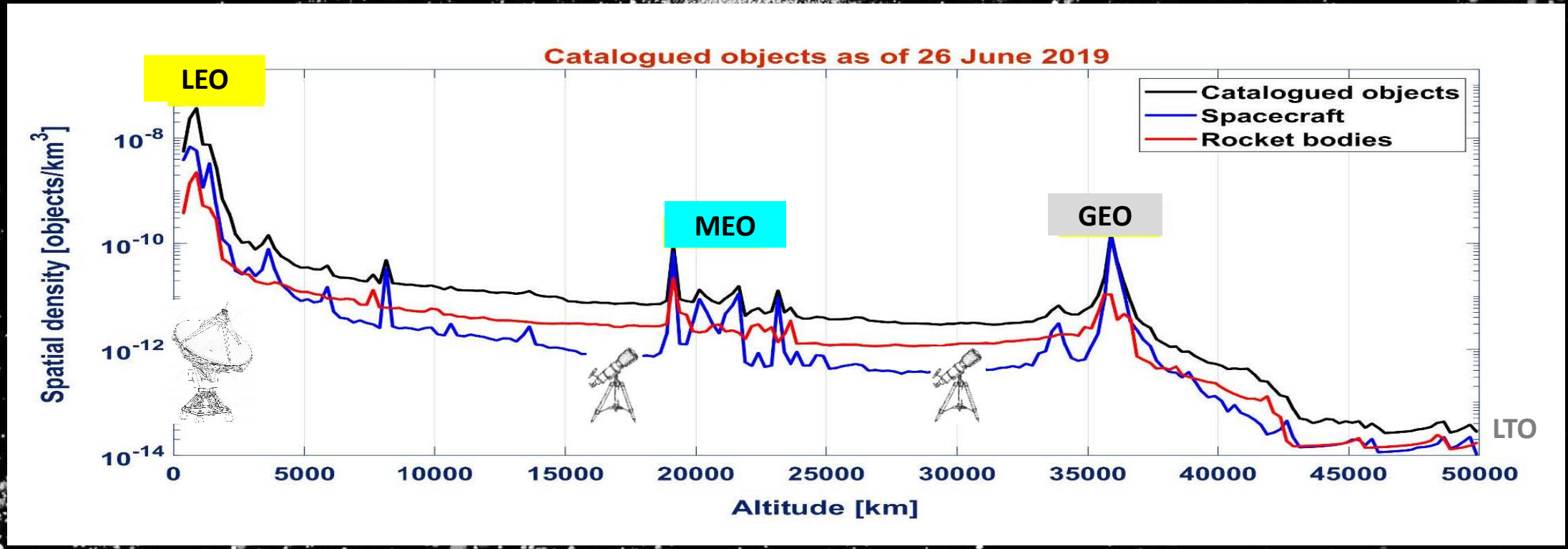


| number of | |
|---|---|
| rocket launches since 1957: | **6.340** |
| satellites placed in Earth orbit: | **14.710** |
| satellites still in space: | **9.780** |
| operational satellites: | **7.100** |

| estimated number of debris | |
|---|---|
| **> 10 cm** | **36.500** |
| **10 cm - 1 cm** | **1.000.000** |
| **1 cm - 1 mm** | **130.000.000** |

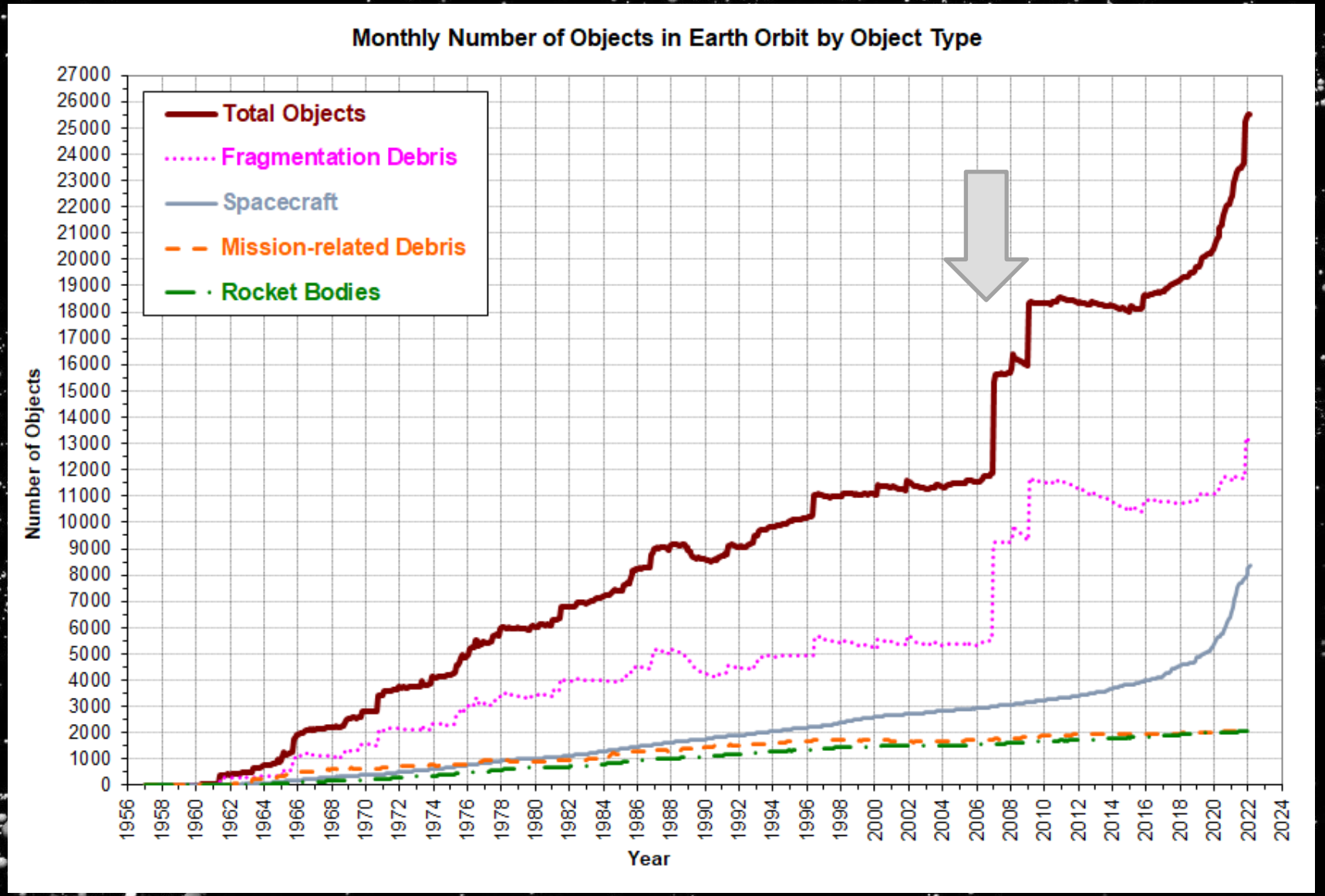
# orbital regimes and spatial density

**LEO** Low Earth Orbits < 2000 km: *Earth observation, scienceetc*
***MEO*** Medium Earth Orbits 20000 km: *navigation constellations*
**HEO** High Eccentricity Orbits : *high latitude telecom satellitesetc*
**GEO** Geostationary Orbits 36000 km: *telecommunications, weather forecasting etc*




**LTO** Lunar Transfer Orbits < 400000 km; > LEO: lunar exploration

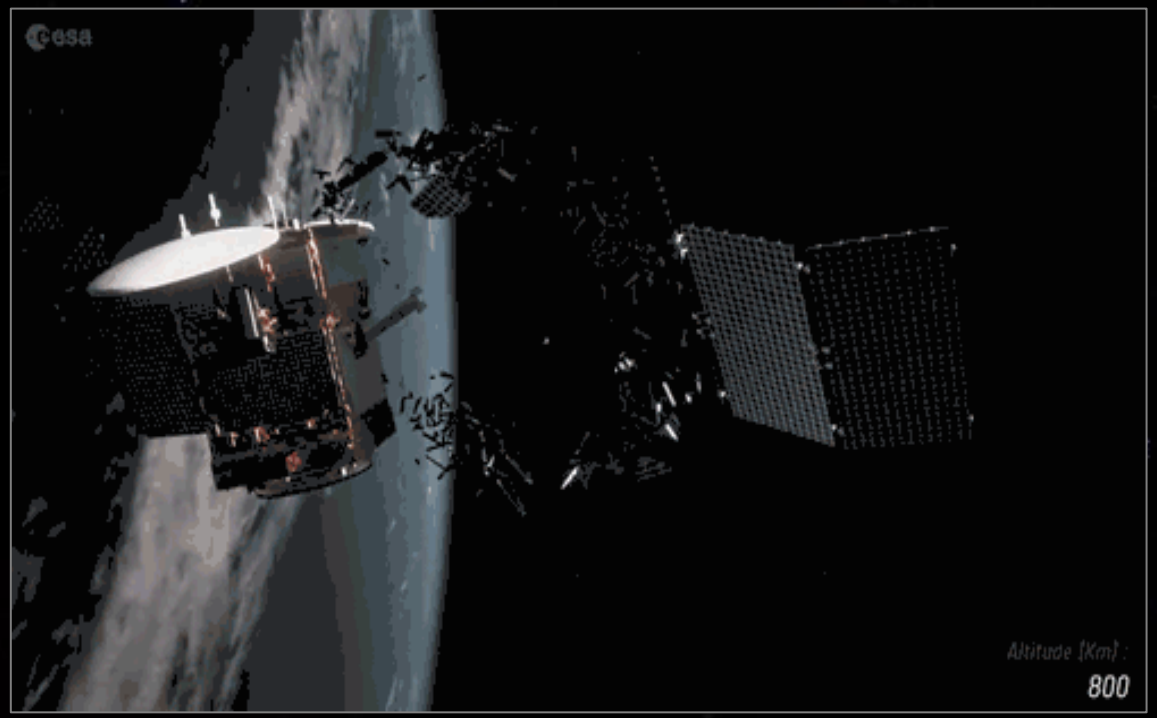
# proliferation

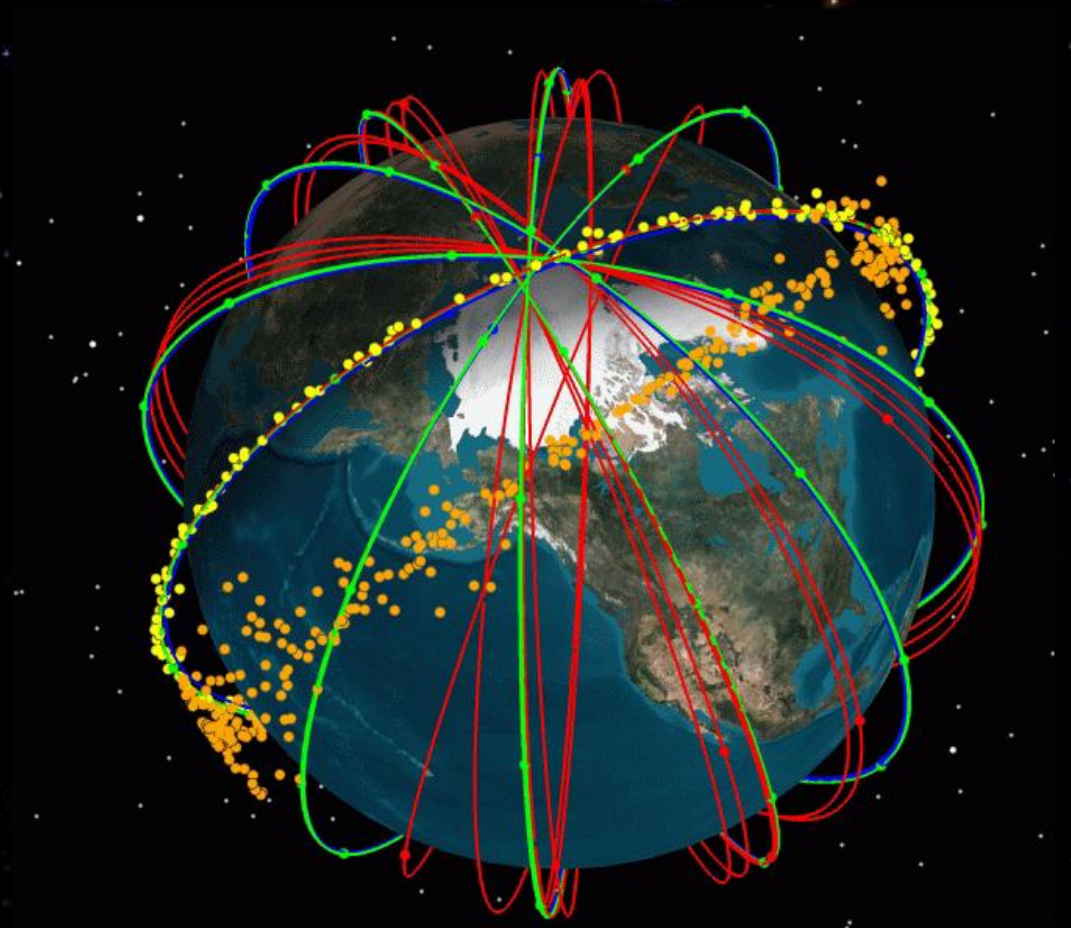


# breakup

estimated number of break-ups, explosions, collisions, or anomalous events resulting in fragmentation

**> 640**



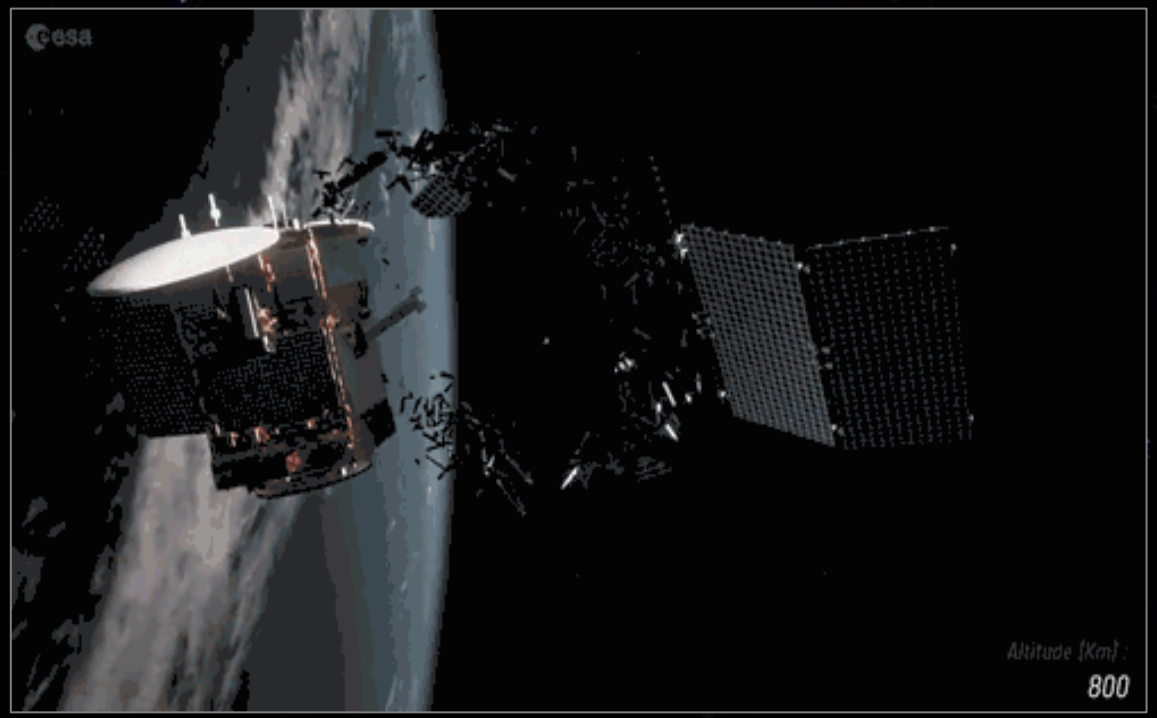
About 65% of the catalogued objects originate from break-ups in orbit (more than 240 explosions)

10 known collisions: **It is expected that in the future collisions will become the dominant source of space debris**

# breakup

estimated number of break-ups, explosions, collisions, or anomalous events resulting in fragmentation

**> 640**

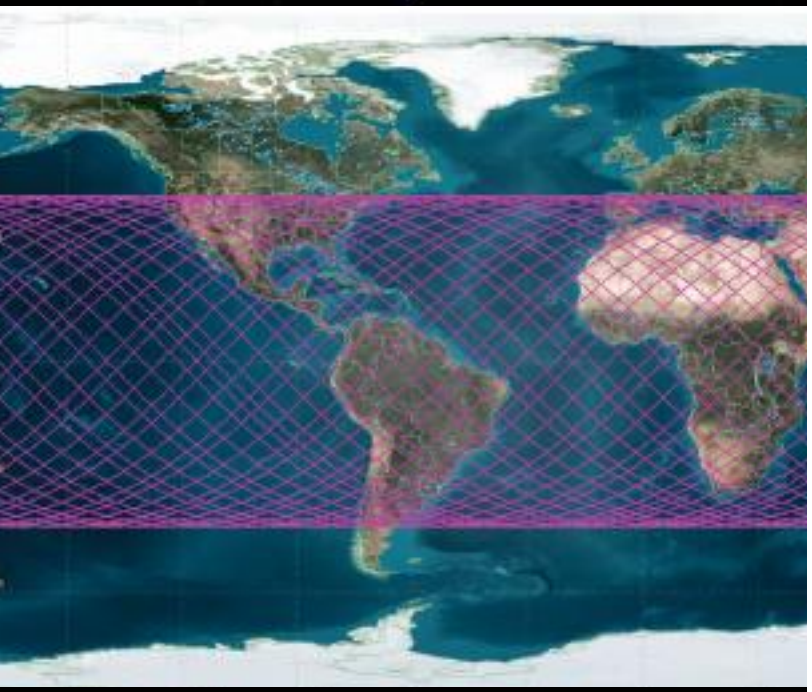


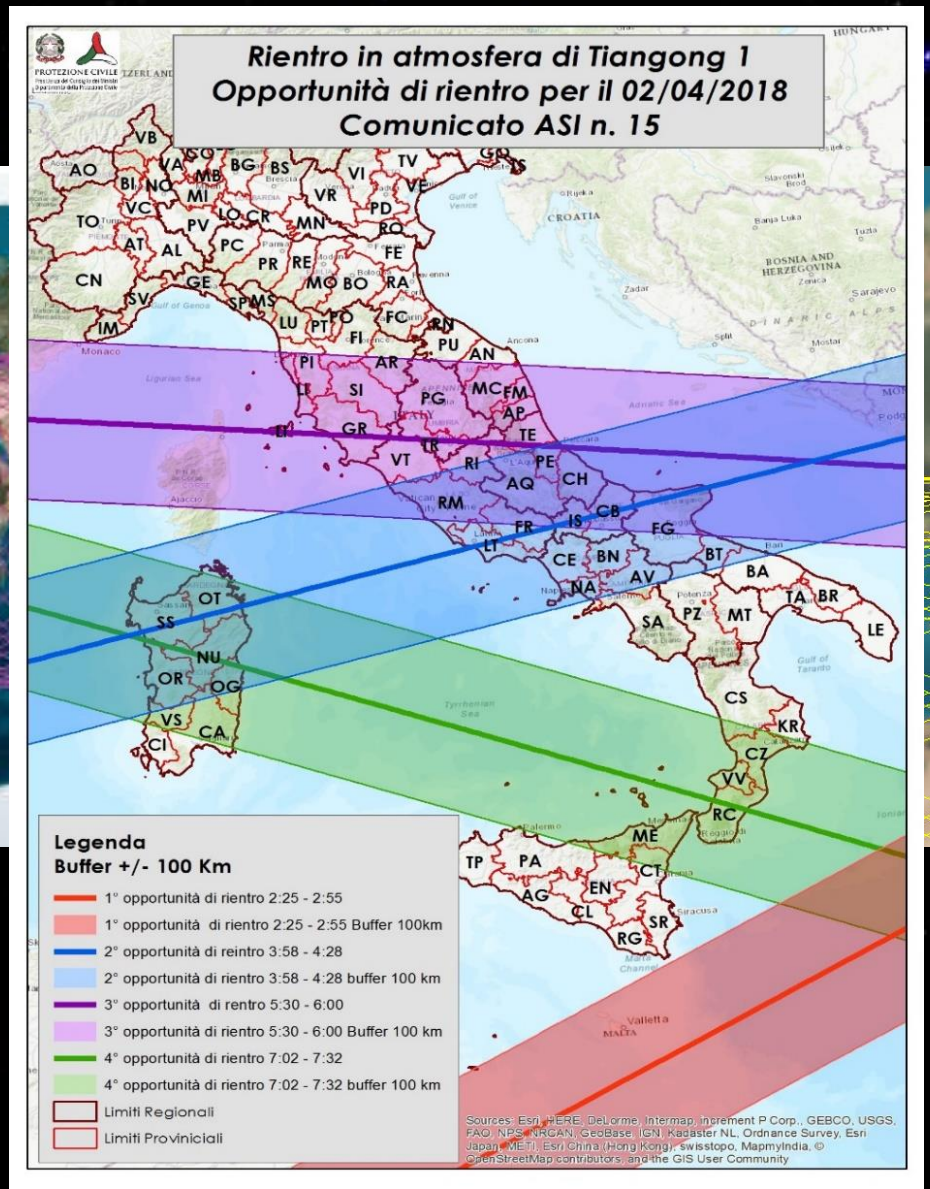


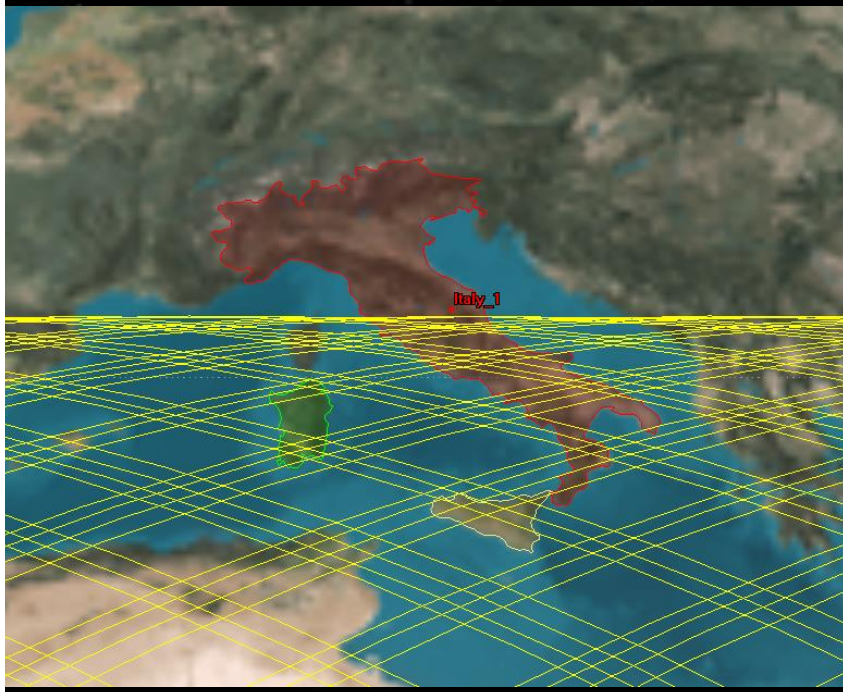
**Lethality treshold: 2 cm**

# reentry

controlled / uncontrolled atmospheruc re-entry of large objects



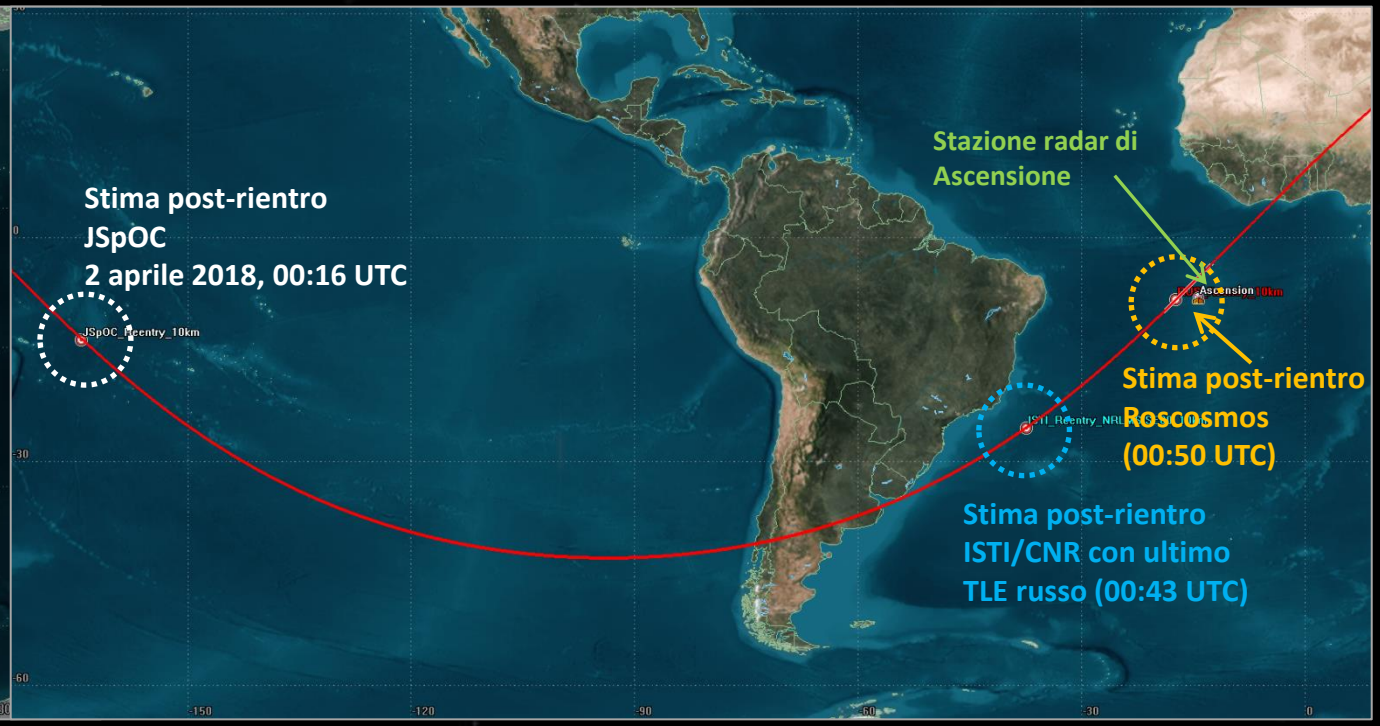



# reentry

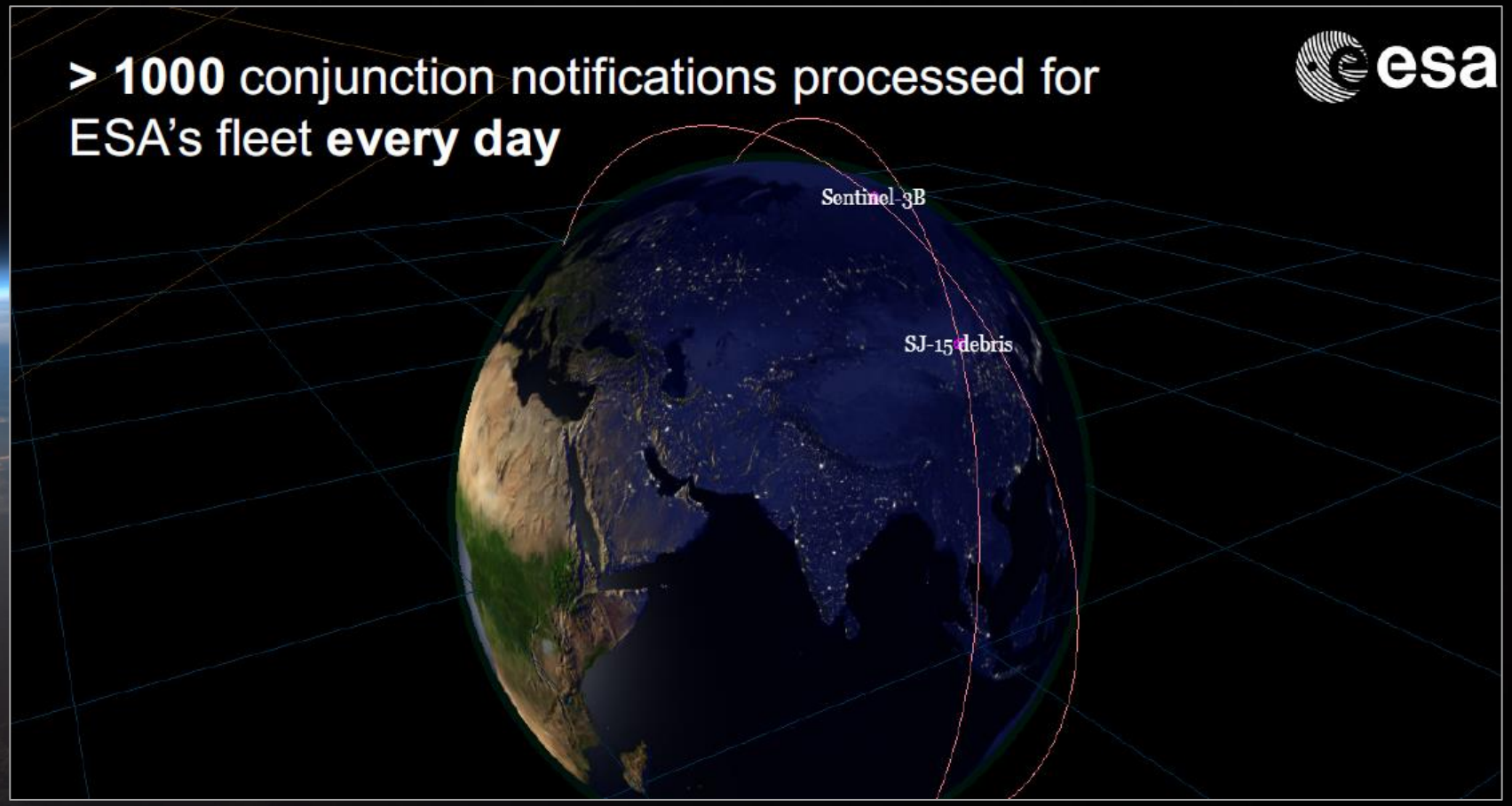
## controlled / uncontrolled atmospheric re-entry of large objects

Area di possibile dispersione dei frammenti di Tiangong-1 se la stima post-rientro comunicata da JSpOC fosse corretta

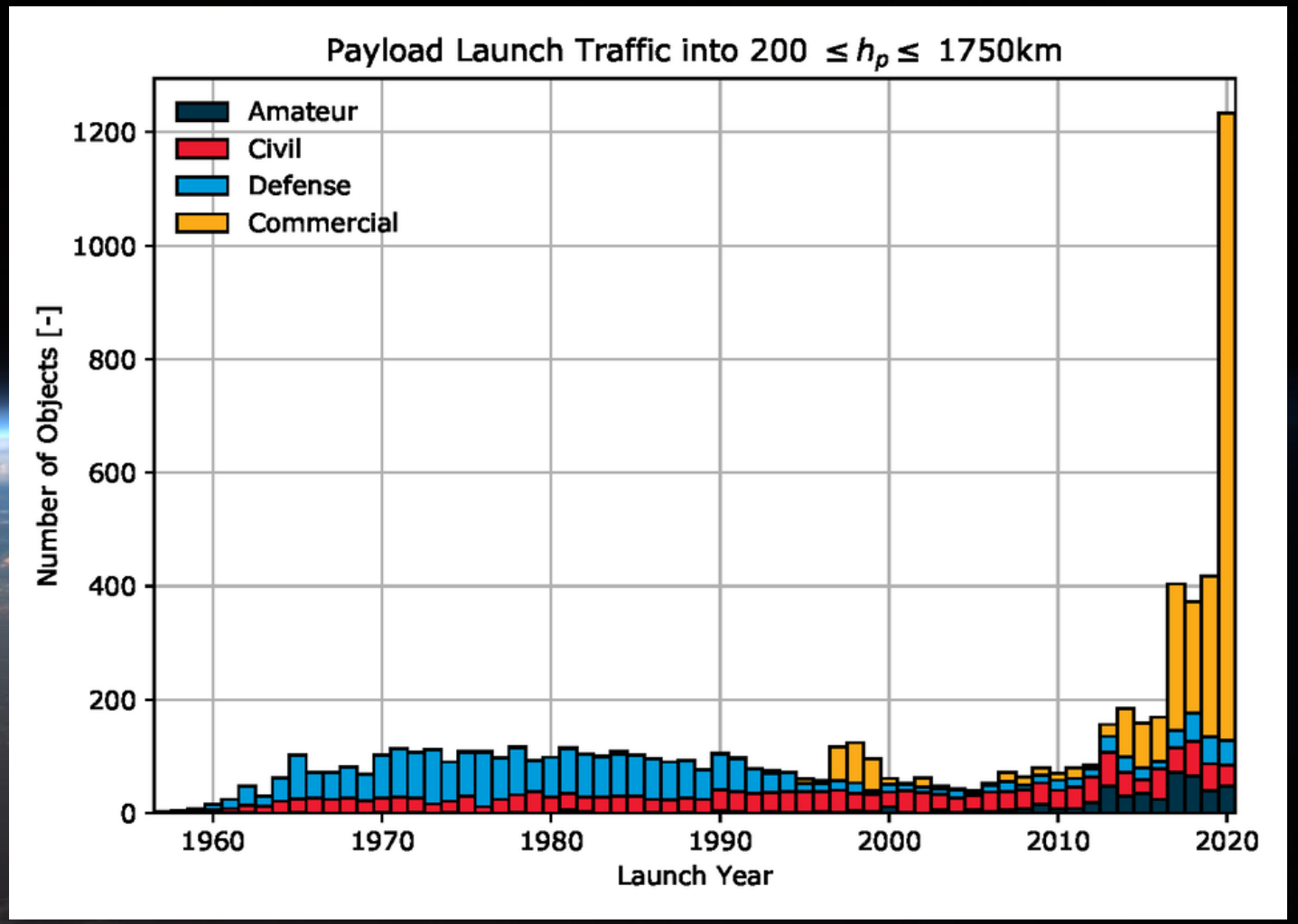



Stime post-rientro di Roscosmos e ISTI/CNR, a 10 km di altezza, basate sull'ultimo TLE russo, confrontate con quella di JSpOC

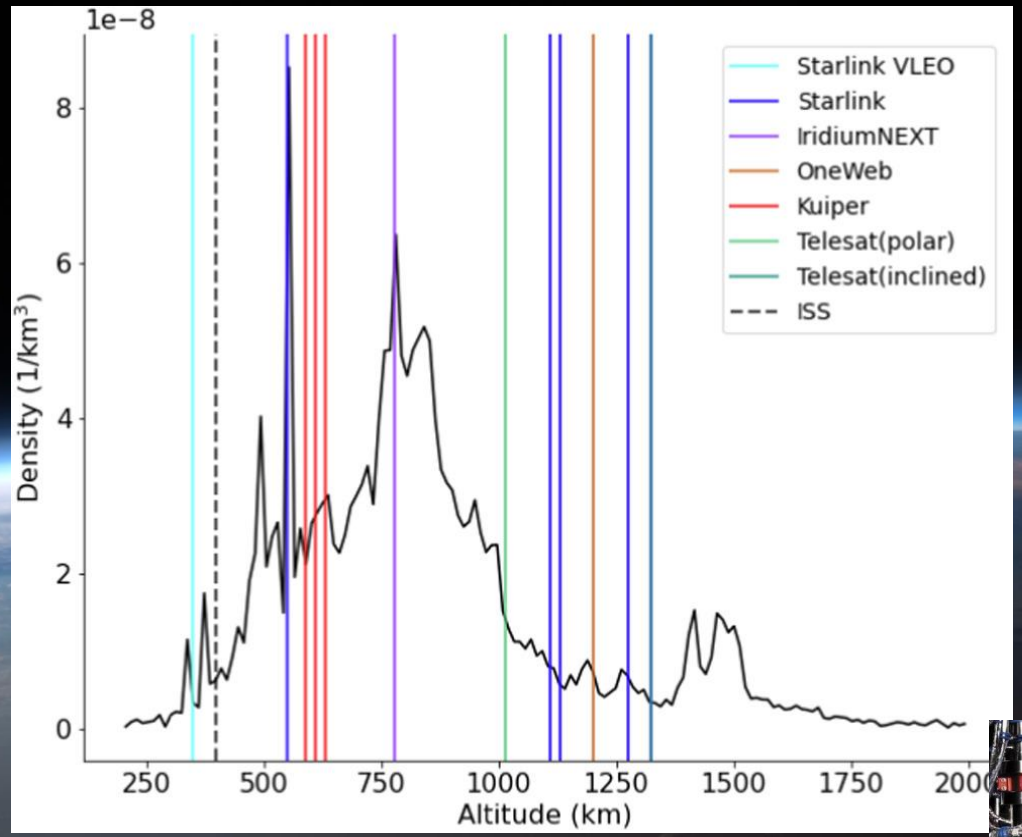
# collision avoidance

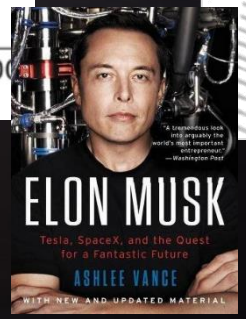


# satellite launch rate



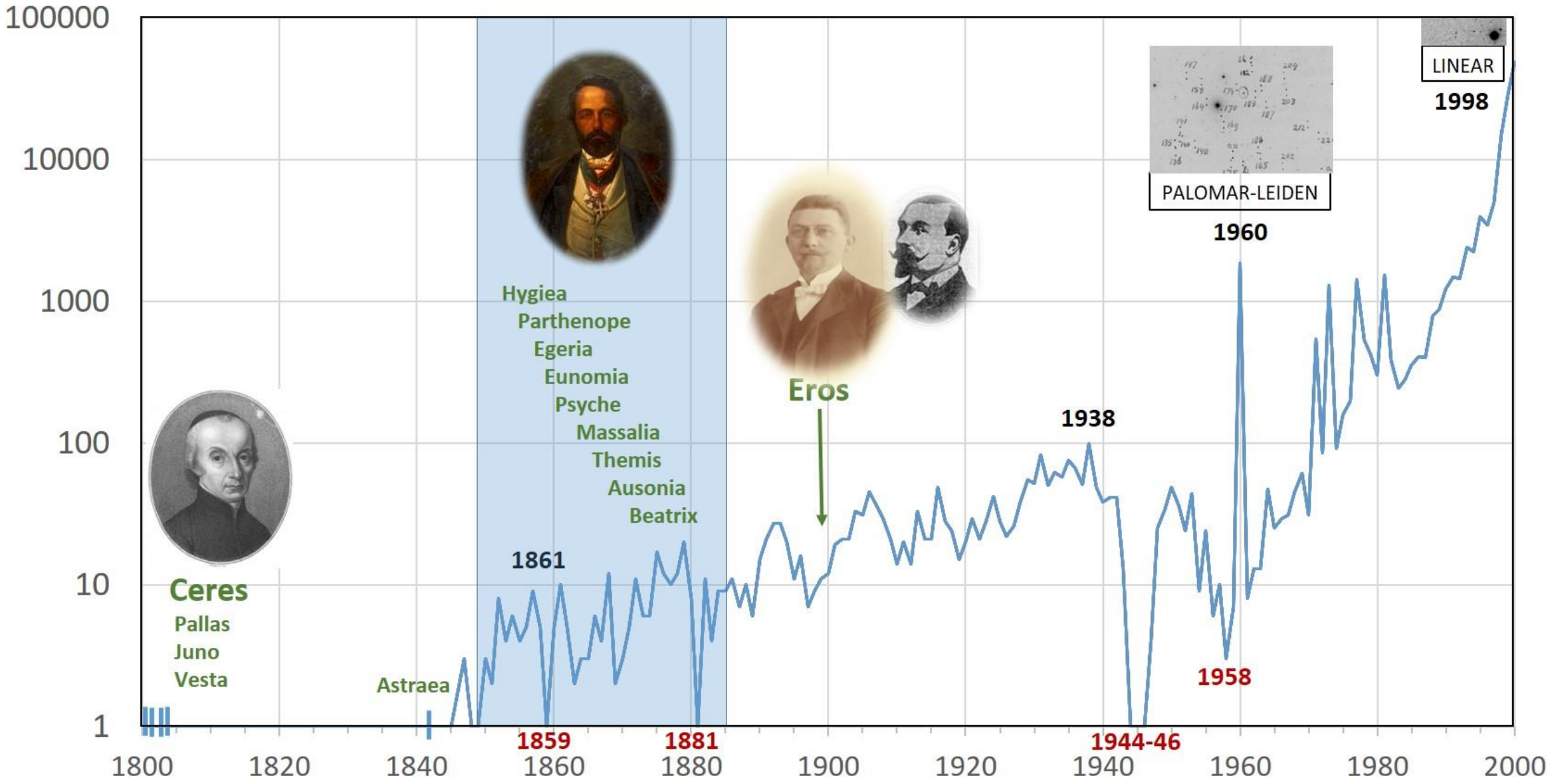
# megaconstellations



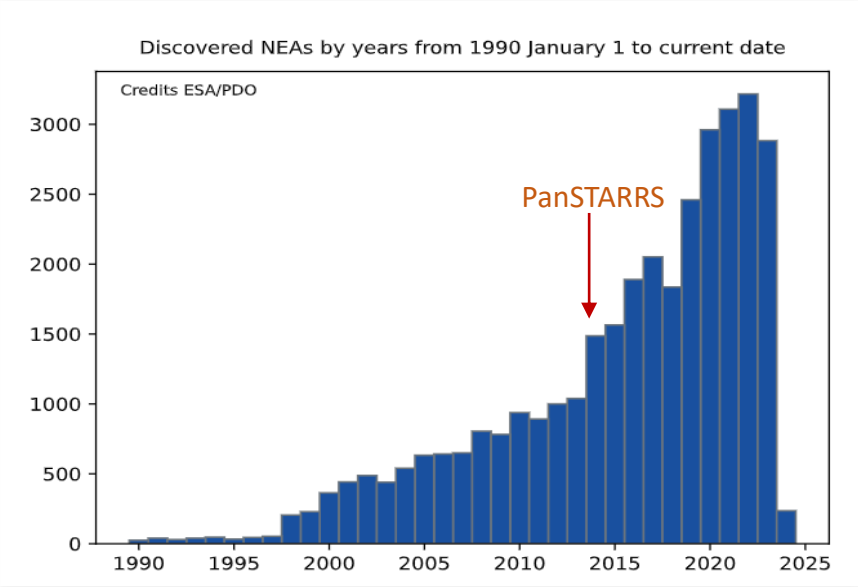

L’apparition de ce corps énorme le surprenait et l’inquiétait. Une rencontre était possible, qui aurait eu des résultats déplorables, soit que le projectile fût dévié de sa route, soit qu’un choc, brisant son élan, le précipitât vers la Terre, soit enfin qu’il se vît irrésistiblement entraîné par la puissance attractive de cet astéroïde.

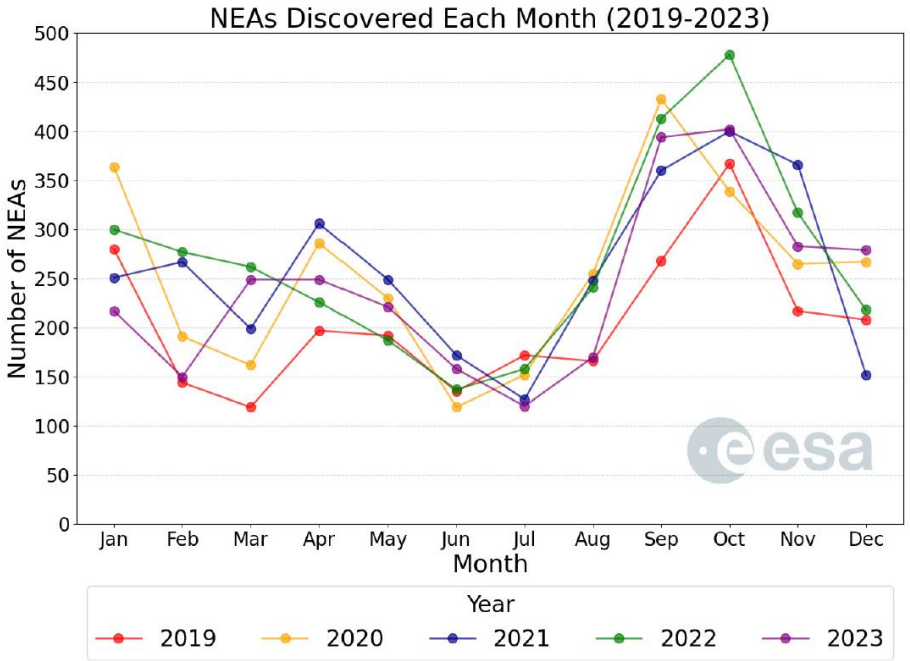
# Asteroid discovery rate 1801-2000



# → NEWSLETTER JANUARY 2024

## ESA's NEO Coordination Centre




## Current NEO statistics

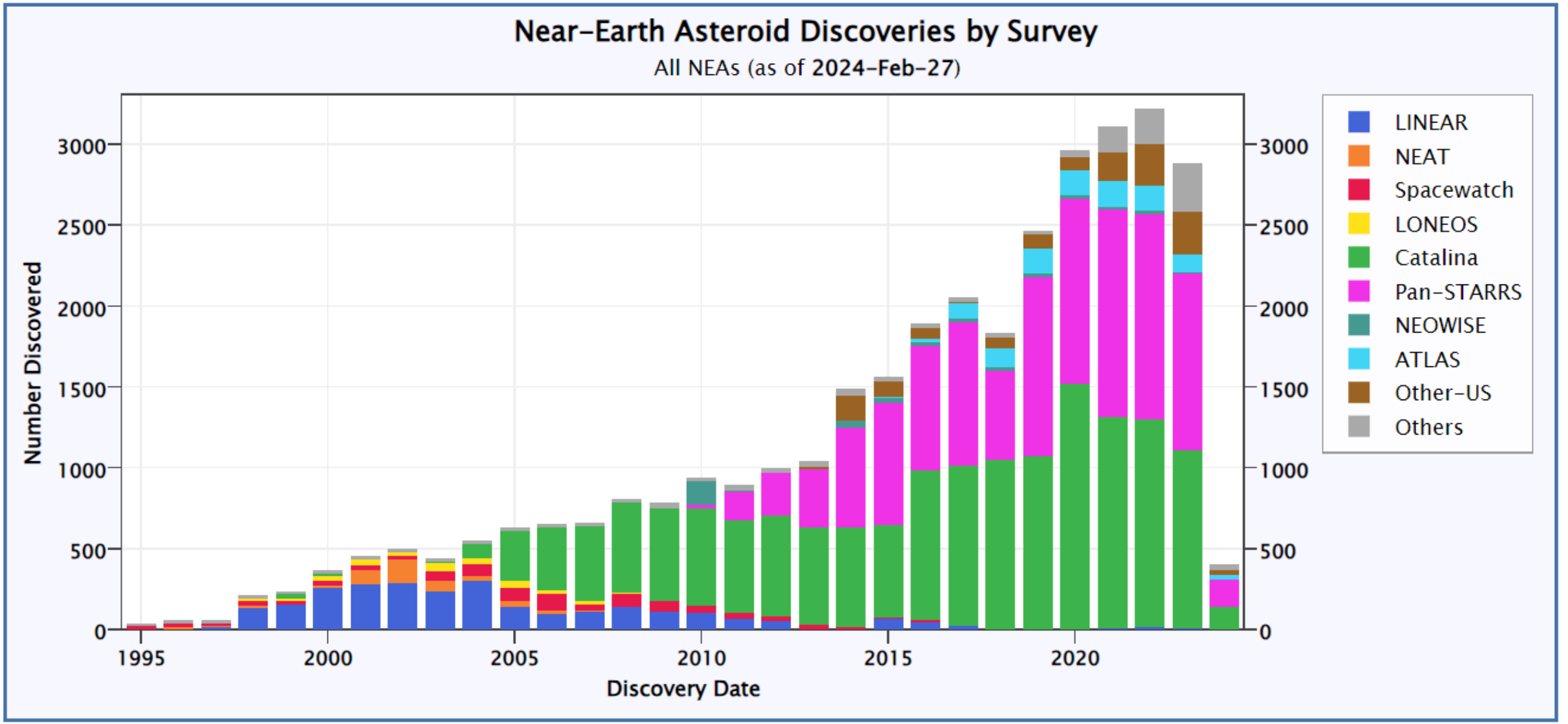
Despite a December rich of discoveries, 2023 closed with less than 2900 new NEOs, the lowest of the last 4 years. This relative reduction of discovery rates is likely due to a few unforeseen shutdowns of major US surveys during the year.

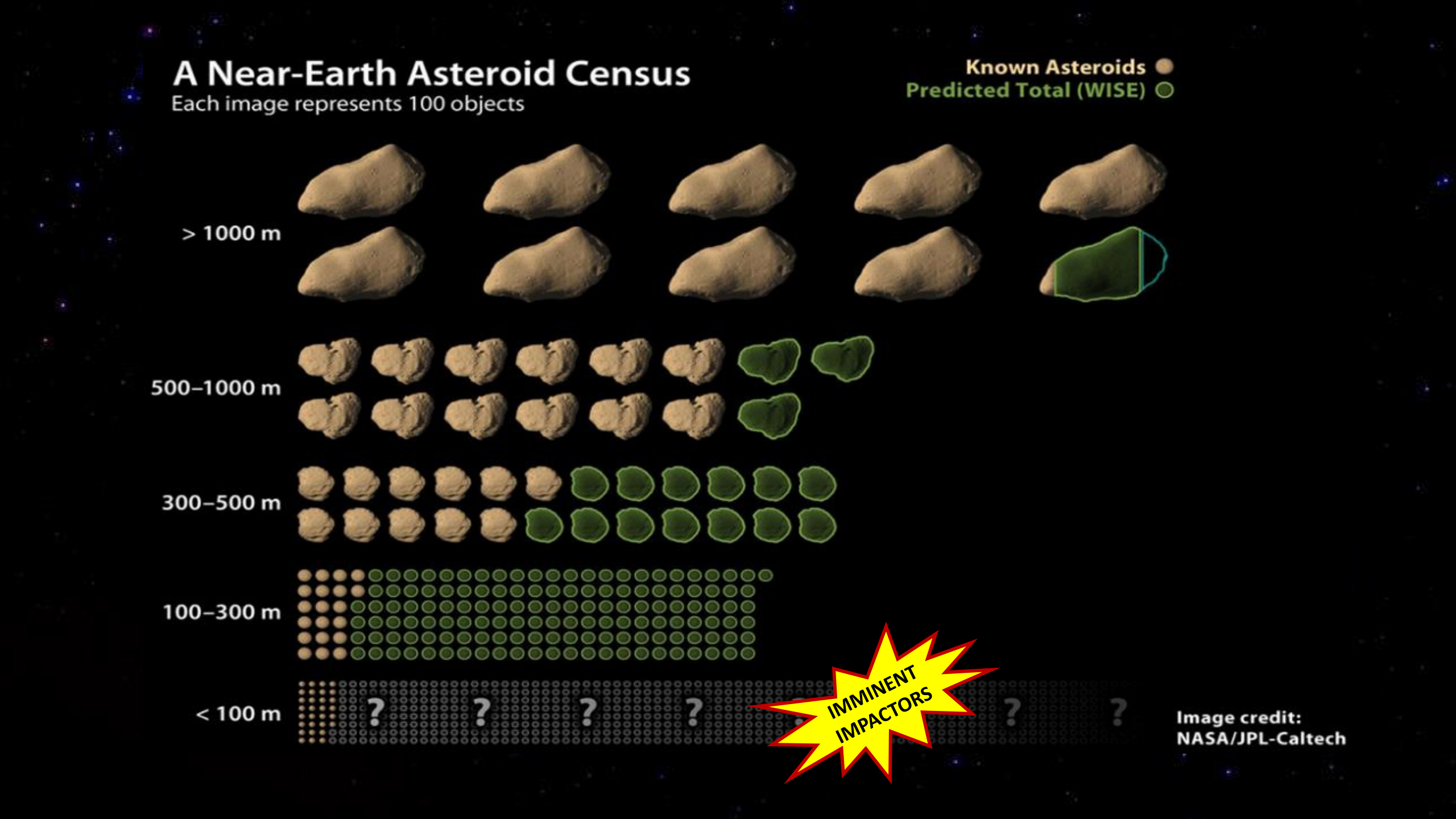
- Known NEOs: 33 948 asteroids and 122 comets
- NEOs in risk list*: 1574
- NEOs designated during last month: 293
- NEOs discovered since 1 January 2023: 2878

The plot presents the monthly NEO discovery rate for the last 5 years.

It shows that year 2023 was nicely in line with most of the recent years, except for some drops in February and August, which resulted in an overall lower total for the year.

It also shows the well-known periodicity of discovery rates, with a minimum during summer months and a maximum in the fall.


Near-Earth Asteroid Discoveries by Survey
All NEAs (as of 2024-Feb-27)
Number Discovered
Discovery Date
0
500
1000
1500
2000
2500
3000
1995
2000
2005
2010
2015
2020
LINEAR
NEAT
Spacewatch
LONEOS
Catalina
Pan-STARRS
NEOWISE
ATLAS
Other-US
Others

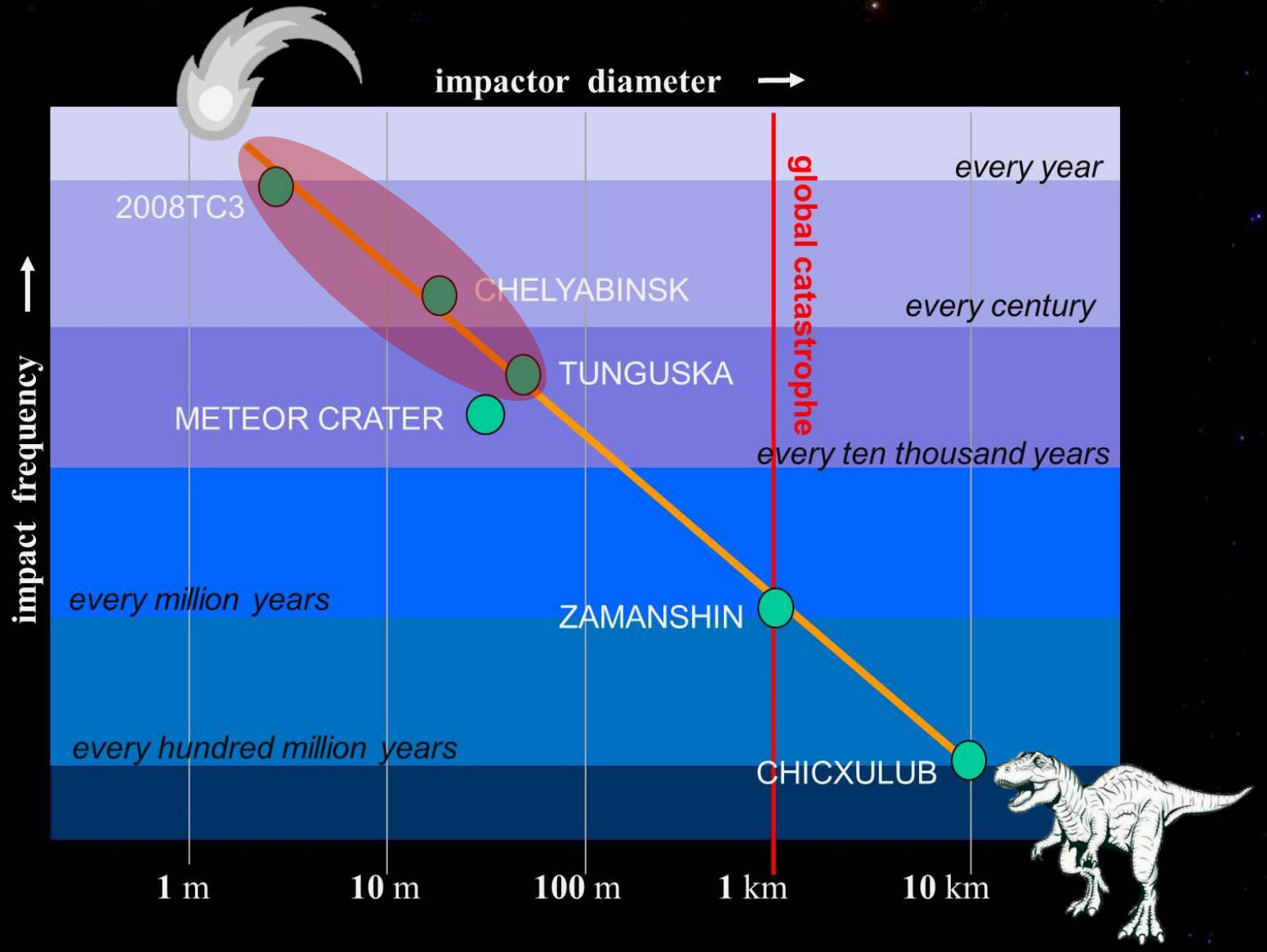

A Near-Earth Asteroid Census
Each image represents 100 objects
Known Asteroids
Predicted Total (WISE)
> 1000 m
500–1000 m
300–500 m
100–300 m
< 100 m
? ? ? ? ? ?
IMMINENT IMPACTORS
Image credit:
NASA/JPL-Caltech

# the imminent impactors threat

2008 TC3

CHELYABINSK

TUNGUSKA



The Meteoritical Society

*Meteoritics & Planetary Science* 55, Nr 4, 886–894 (2020)
doi: 10.1111/maps.13469

# Earliest evidence of a death and injury by a meteorite

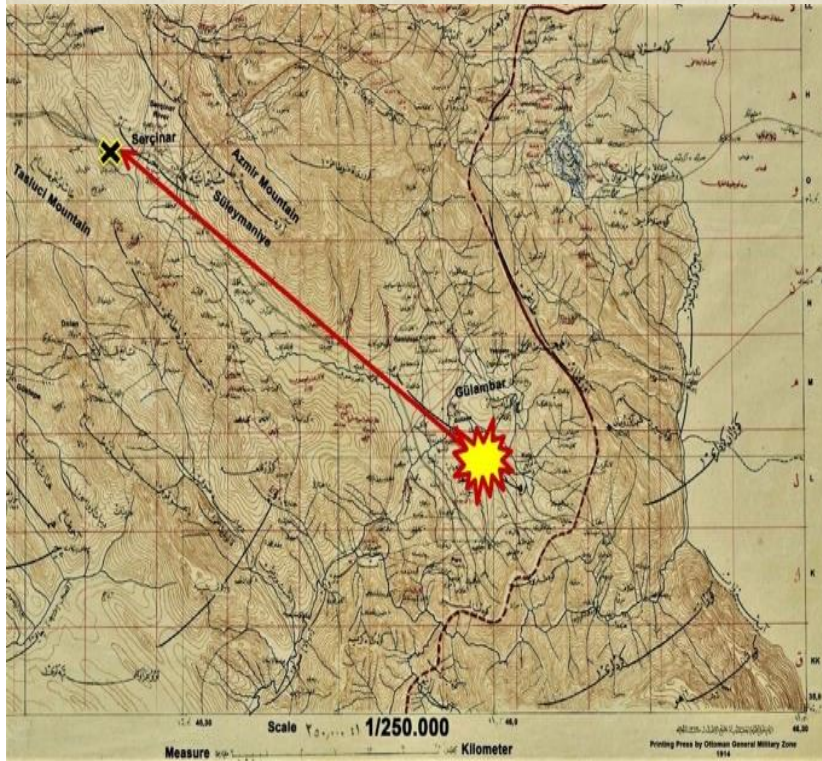
O. UNSALAN [1]*, A. BAYATLI [2], and P. JENNISKENS [3]

[1]Department of Physics, Faculty of Science, Ege University, 35100 Borne
[2]History Department, Faculty of Letters, Trakya Universit
[3]SETI Institute, 189 Bernardo Ave, Mountain
*Corresponding author. E

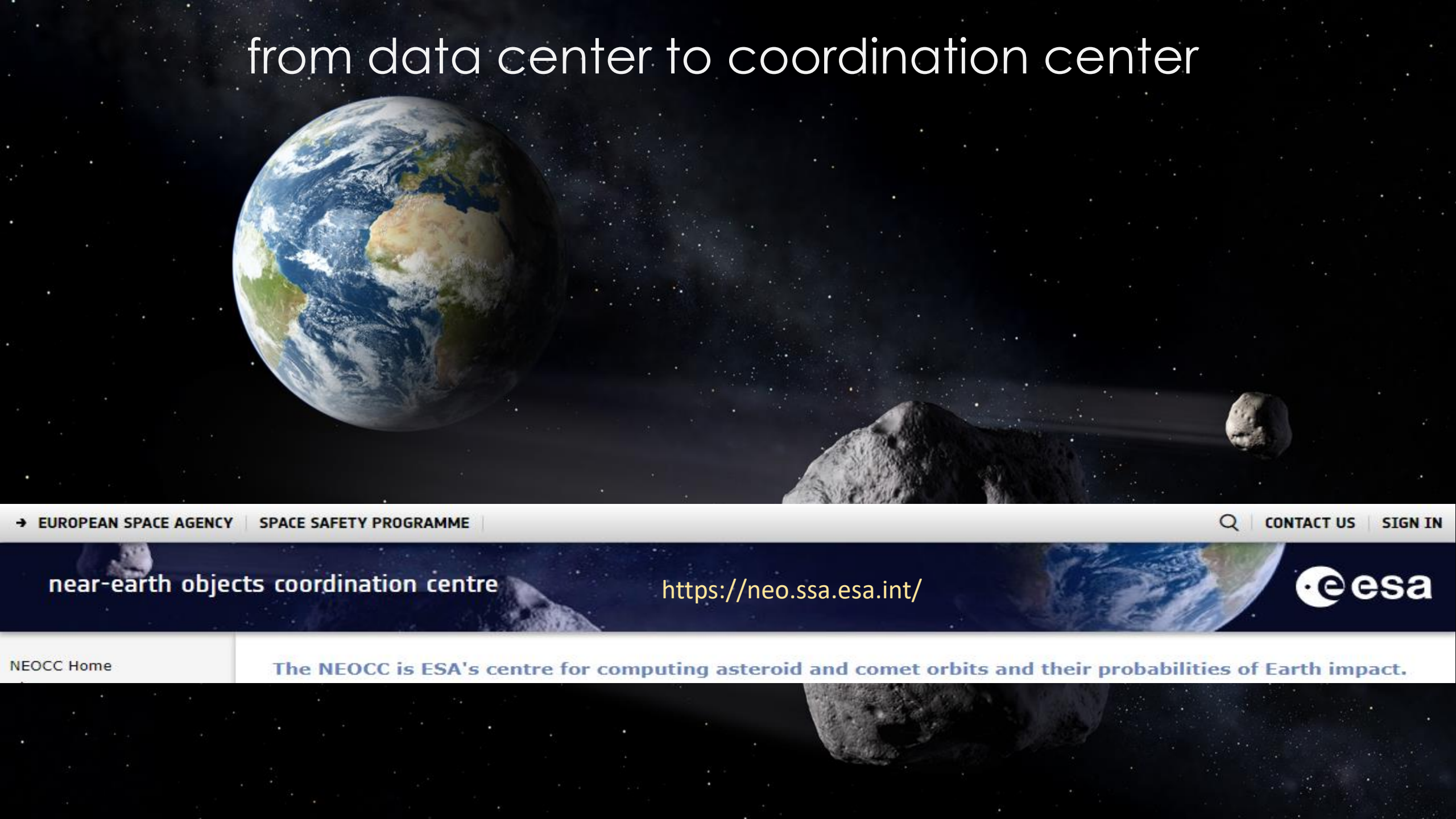
(Received 02 ... February 2020)

**Abstract**–Our pla... of meteorites with different airburst and ground impact risk. Some ... meteors can survive after the atmospheric passage and fall into the ground. Although there are claims that people were hit and killed by meteorites in history, the historical records do not prove this fact so far. This issue might be due to the fact that either the manuscript was written in a language other than English or there is not enough interest in historical records. To the best of our knowledge, we show the first proof of an event ever that a meteorite hit and killed a man and left paralyzed another on August 22, 1888 in Sulaymaniyah, Iraq, based on three manuscripts written in Ottoman Turkish that were extracted from the General Directorate of State Archives of the Presidency of the Republic of Turkey. This event was also reported to Abdul Hamid II (34th sultan of the Ottoman Empire) by the governor of Sulaymaniyah, which was under Ottoman reign in those days. These findings suggest other historical records may still exist that describe other events that caused death and injuries by meteorites.

WE NEED AN IMMINENT IMPACTORS OPERATIONAL DEFINITION FOR CIVIL PROTECTION
Meteorites - Chelyabinsk - Tunguska



# from data center to coordination center



Sapete che gli strumenti d’ottica hanno acquistato una grande perfezione: con certi telescopi si è giunti ad ottenere degl’ingrandimenti di seimila volte e ad avvicinare la Luna a quaranta miglia circa. Ora, a questa distanza gli oggetti che hanno sessanta piedi di fianco sono perfettamente visibili. Se non si è spinta piu in là la potenza di penetrazione dei telescopi, gli è che tal potenza non si esercita che a detrimento della chiarezza, e la Luna, la quale è solo uno specchio che riflette, non manda luce così intensa da permettere si possano portare gli ingrandimenti al di là di questo limite.

# LEO

- *LEO: fast moving objects /short exposures*
- *Catalogue build-up: survey telescopes*
- *Catalogue maintenance: survey telescopes*
- *Short-term dynamics: catalogue obsolescence*
- *Observation assets dispersed in longitude*
- *Detection & correlation functions*
- *Follow-up only for specific cases*
- *Positions errors too large -> too many warnings*
- *Breakup parent body*
- *Classified data*

# NEO

- *Slow moving objects / long exposures*
- *Discovery: survey telescopes*
- *Catalogue entries: follow-up network*
- *Catalogue improvement: follow-up*
- *Observation assets dispersed in latitude*
- *Chaotic dynamics: impact monitoring*
- *Discovery & identification*
- *Moving object detection SW: avoiding fakes*
- *Physical characterization*
- *Public data*

**MEO GEO LTO**

**ArtSats**

# THE FLYEYE TELESCOPE

*Survey telescope using innovative optics: extremey large FOV (45 sqdeg) for NEO and Space Debris*

## NEO

- *Flyeye Mark I (16-camera)*
- *Realized by OHB-I for ESA*
- *Nominal Limiting magnitude: 21.5*
- *Mount Mufara site (Sicily) under connstruction*
- *Commissioning and science verification @ ASI CGS (Matera)*
- *Flyeye Mark II (8-camera)*
- *Nominal Limiting magnitude: 21 (desirable)*
- *Best for Imminent Impactors*

## SST

- *Flyeye Mark I (16-camera)*
- *4-telescopes ordered to OHB by ASI*
- *Sites: Italy, Mexico, Argentina, Australia*
- *Italian site: ASI CGS (Matera)*
- *Best for High LEO, MEO catalogue*

# THE MUFARA SITE

Agenzia Spaziale Italiana

Monte Mufara Sicilia

Agenzia Spaziale Italiana

# THE MUFARA SITE

Monte Mufara Sicilia


HOMEPAGE ▸ BANDI ▸ BANDI ASI ▸ OPEN CALLS, CALL FOR IDEAS E ALTRE OPPORTUNITÀ SCIENTIFICHE E TECNOLOGICHE ▸

# CALL FOR PROPOSALS – DEVELOPMENT OF INNOVATIVE OPTICAL COMMERCIAL SENSORS

https://www.asi.it/bandi_e_concorsi/call-for-proposals-development-of-innovative-optical-commercial-sensors/

https://app.albofornitori.it/alboeproc/albo_asi?customEntryView=elencoBandiAlboPublicEntryView&idProcedura=217

Agenzia Spaziale Italiana

# THE MUFARA SITE

Monte Mufara Sicilia

Quoique tres genee, l’Italie trouva deux cent mille lires dans les poches de ses enfants, mais en les retournant bien.

Jules Verne, 1867

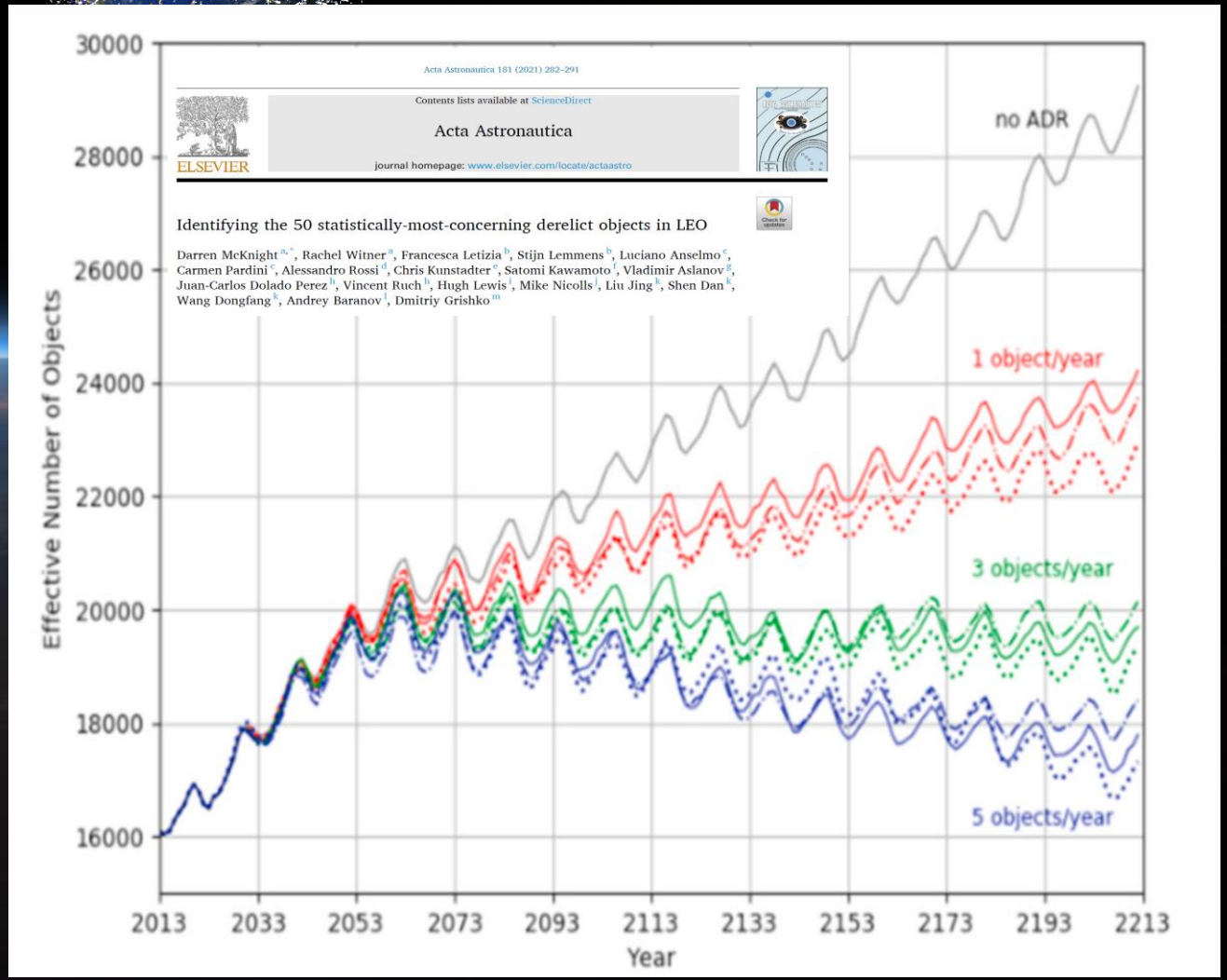
# SPACE TRAFFIC MANAGEMENT

## SATELLITE BOX SCORE

(as of 05 January 2021, cataloged by the U.S. SPACE SURVEILLANCE NETWORK)

| Country / Organization | Spacecraft* | Spent Rocket Bodies & Other Cataloged Debris | Total |
|---|---|---|---|
| CHINA | 441 | 3810 | 4251 |
| CIS | 1551 | 5696 | 7247 |
| ESA | 93 | 56 | 149 |
| FRANCE | 72 | 510 | 582 |
| INDIA | 101 | 119 | 220 |
| JAPAN | 189 | 145 | 334 |
| USA | 2866 | 4998 | 7864 |
| OTHER | 1131 | 123 | 1254 |
| TOTAL | 6444 | 15457 | 21901 |

* *active and defunct*



# SPACE TRAFFIC MANAGEMENT

The US Space Policy Directive-3 (SPD-3), released in June 2018 provides general guidelines and direction for space traffic management, and contains key references and guidelines specific to orbital debris

It address the threat from orbital debris, improve fundamental knowledge of the space environment, promote orbital debris mitigation and best practices with the global community, *etc.*

# SPACE TRAFFIC MANAGEMENT

**REMEDIATION**

- design for demise
- in-orbit servicing
- environmental index

**MITIGATION**

25y rule for uncontrolled re-entry
controlled re-entry –
de-orbiting / re-orbiting into graveyard orbits –
minimizing release of mission-related debris –

Inter-Agency Space Debris Coordination Committee

from

## SPACE SITUATIONAL AWARENESS

to

# Space Safety



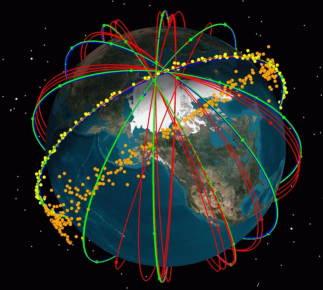

**SWE**
SPACE WEATHER

**SST**
SPACE DEBRIS

**NEO**
PLANETARY DEFENCE

re-entry

collision avoidance



fragmentation

EUSST

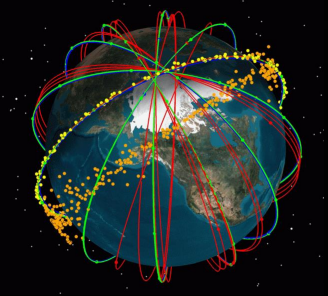
# consortium

**DECISION No. 541/2014/EU of the European Parliament and of the Council of 16 April 2014 establishing a Framework for Space Surveillance and Tracking Support.**

asi agenzia spaziale italiana · CDTI · cnes CENTRE NATIONAL D'ÉTUDES SPATIALES · DLR · ~~UK SPACE AGENCY~~ + GPSST · POLSKA AGENCJA KOSMICZNA · rosa agenția spațială română romanian space agency

re-entry

collision avoidance



fragmentation

mitigation

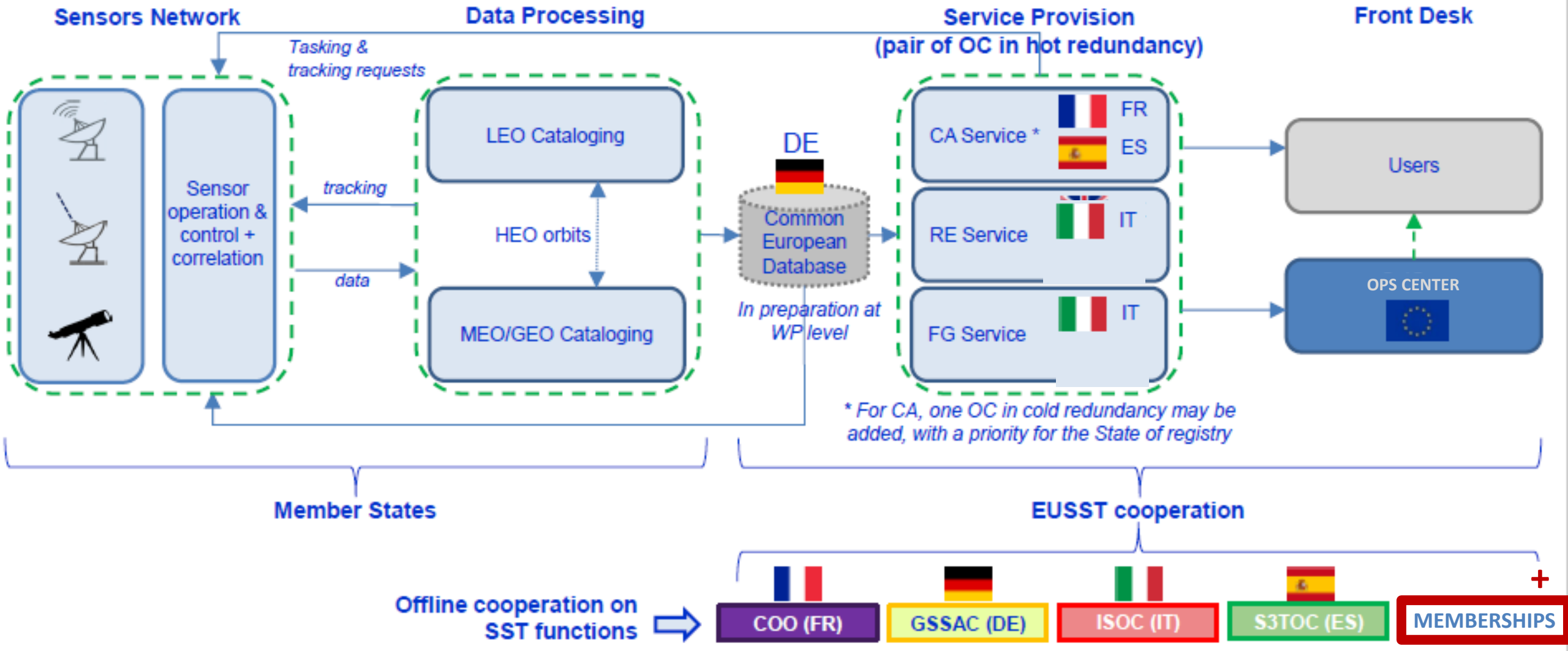
remediation

EUSST

partnership

AUSTRIA CZECH REPUBLIC DENMARK FINLAND FRANCE GERMANY
GREECE ITALY LATVIA THE NETHERLANDS POLAND PORTUGAL
ROMANIA SPAIN SWEDEN

# service provision model



# Italian sensors

*laser*
- MLRO

*optical*
- SPADE
- CAS
- PdM-MiTe
- PRISMA

*radar*
- BIRALES
- MFDR
- BIRALET









# EU BUDGET FOR THE FUTURE
## THE EU SPACE PROGRAMME

#EUBudget #EUSpace

## WHAT IS THE BUDGET AND HOW WILL IT BE SPENT?

The EU Space Programme has a budget of **€ 16 billion over 2021-2027** and consolidates all Union space-related activities into a coherent, simplified and flexible programme:

| | Galileo and EGNOS | Copernicus | GOVSATCOM & SSA |
|---|---|---|---|
| **Role** | global navigation and regional satellite navigation systems | free and open Earth observation data of land, atmosphere, sea, climate change and for emergency management and security | access to secure satellite communications for national authorities and monitoring of space hazards |
| **Budget** | € 9,7 billion | € 5,8 billion | € 0,5 billion |

# EU BUDGET FOR THE FUTURE


22 June 2021

European Commission

EUSPA

For the next EU budget 2021-2027, the Commission wants to increase **investment, adapt to new needs and technologies and reinforce Europe's autonomous access to space.**

# EU BUDGET FOR THE FUTURE


22 June 2021

European Commission

EUSPA

esa

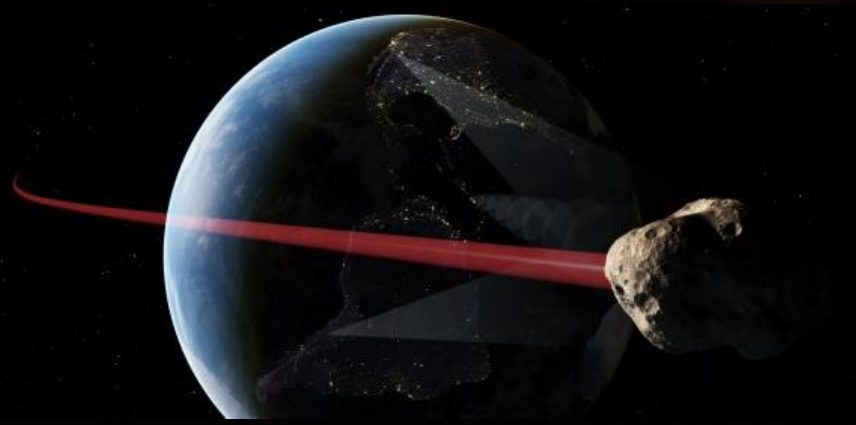
For the next EU budget 2021-2027, the Commission wants to increase **investment, adapt to new needs and technologies and reinforce Europe's autonomous access to space.**

# SSA NEO COMPONENT

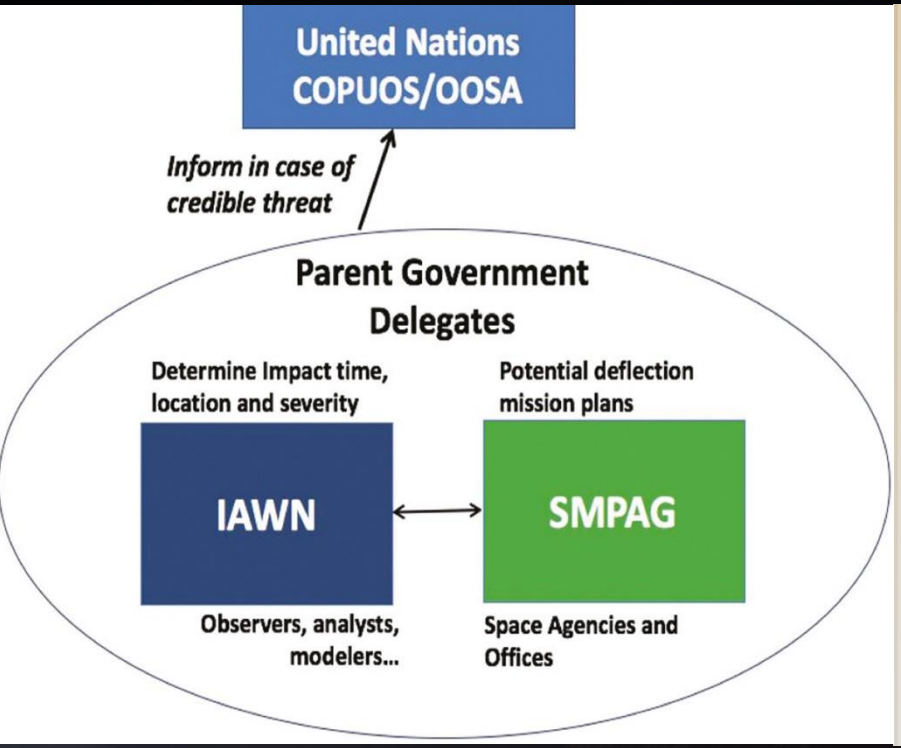
## FFPA ENTRUSTED TASKS TO ESA

- Promotion of networking of MS facilities and research centres
- Establishing and maintaining a European NEO catalogue - physical properties database
- Development of provision of a (space based) rapid expert response service
- Study of precursor services: European hot-redundant Minor Planet Centre backup

UNOOSA



# International Asteroid Warning Network




## Steering Committee

- Sergio Camacho (former Chair of UNCOPUOS Action Team on NEOs)
- Lindley Johnson (NASA Hq)
- Boris Shustov (INASAN)
- Giovanni Valsecchi (INAF-IAPS/NEODyS)
- Patrick Michel (Observatoire de la Côte d'Azur)
- Alan Harris (DLR)
- Detlef Koschny (ESA/ESTEC)
- Paul Chodas (JPL)
- Gonzalo Tancredi (Universidad de la República, Uruguay)

## IAWN Signatories

**7** Space Agencies (**1**)

**18** Research Institutions (**0**)

**28** Amateur Observatories (**9**)

# The NEO ROCKS Rapid Response Experiment

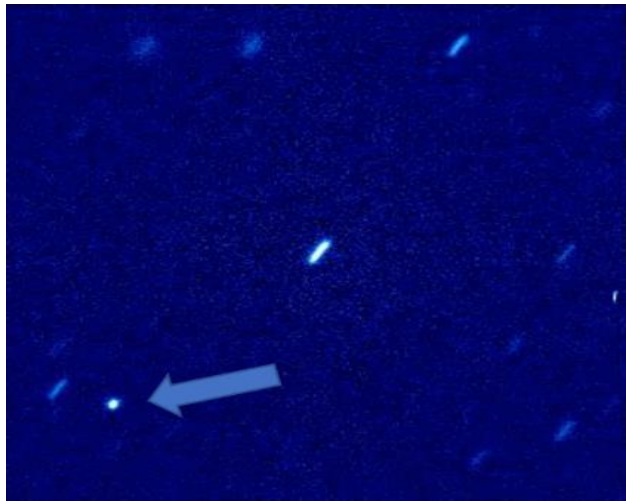
Near Earth Object Rapid Observation, Characterization and Key Simulations

- **The 2022 GC1 NEOROCKS CAMPAIGN**

*A 100m object which would make a distant close approach to Earth on 17 April 2022*

- 2 April 2022: NEO Confirmation Page entered
- 2 April 2022: NEOROCKS astrometric observations submitted
- 2 April 2022: MPEC discovery confirmed
- 5 April 2022: NEOROCKS physical properties observations carried out@TNG

*In the night between 5 $^{th}$ and 6$^{th}$ of April, despite a high proper velocity (about 200 arcsec/h), standard BVRI photometry was successfully obtained, thus closing the loop within 3 days from discovery.*

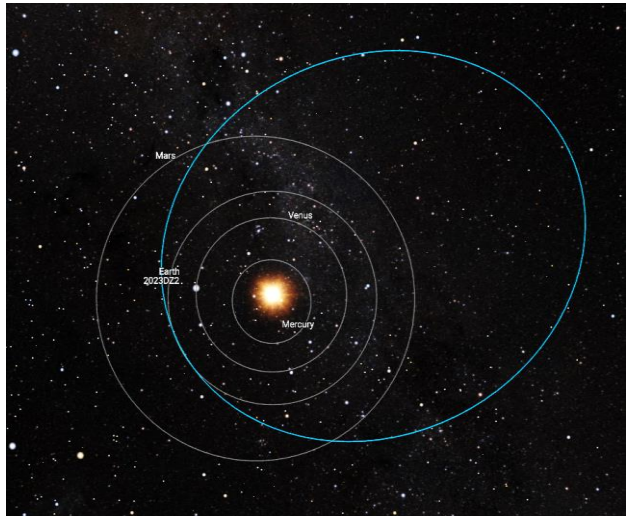


- **The 2023 DZ2 IAWN CAMPAIGN**

*Size (50-100m) consistent with Tunguska-class imminent impactors, Earth close approach within half the lunar distance on March 25, 2023*

- 27 February 2023: NEO Confirmation Page entered
- 16 March 2023: MPEC Discovery Confirmed
- 20-27 March 2023: IAWN physical properties campaign

*7850 observations, 22 different telescopes, 12 different countries: about 50% professional observers – including NEOROCKS partners – 50% amateur/educational observatories.*



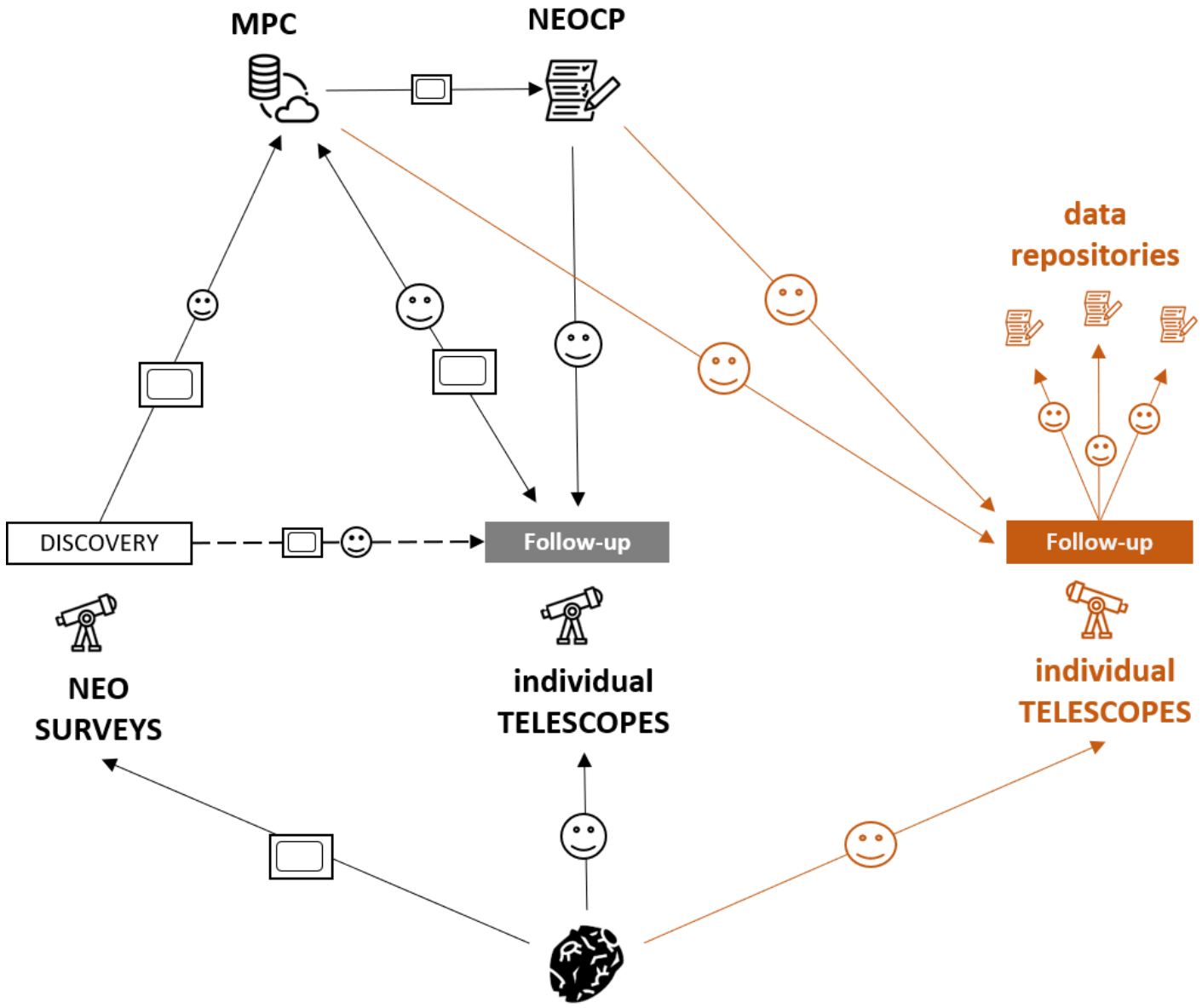

Horizon 2020
G.A. N.870403

NEO ROCKS

# The NEO ROCKS heritage

Near Earth Object Rapid Observation, Characterization and Key Simulations

## PRESENT




tasking
from → to

astrometric

physical

human

software

data base

tool

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**NEOCP** – MPC NEO Confirmation Page
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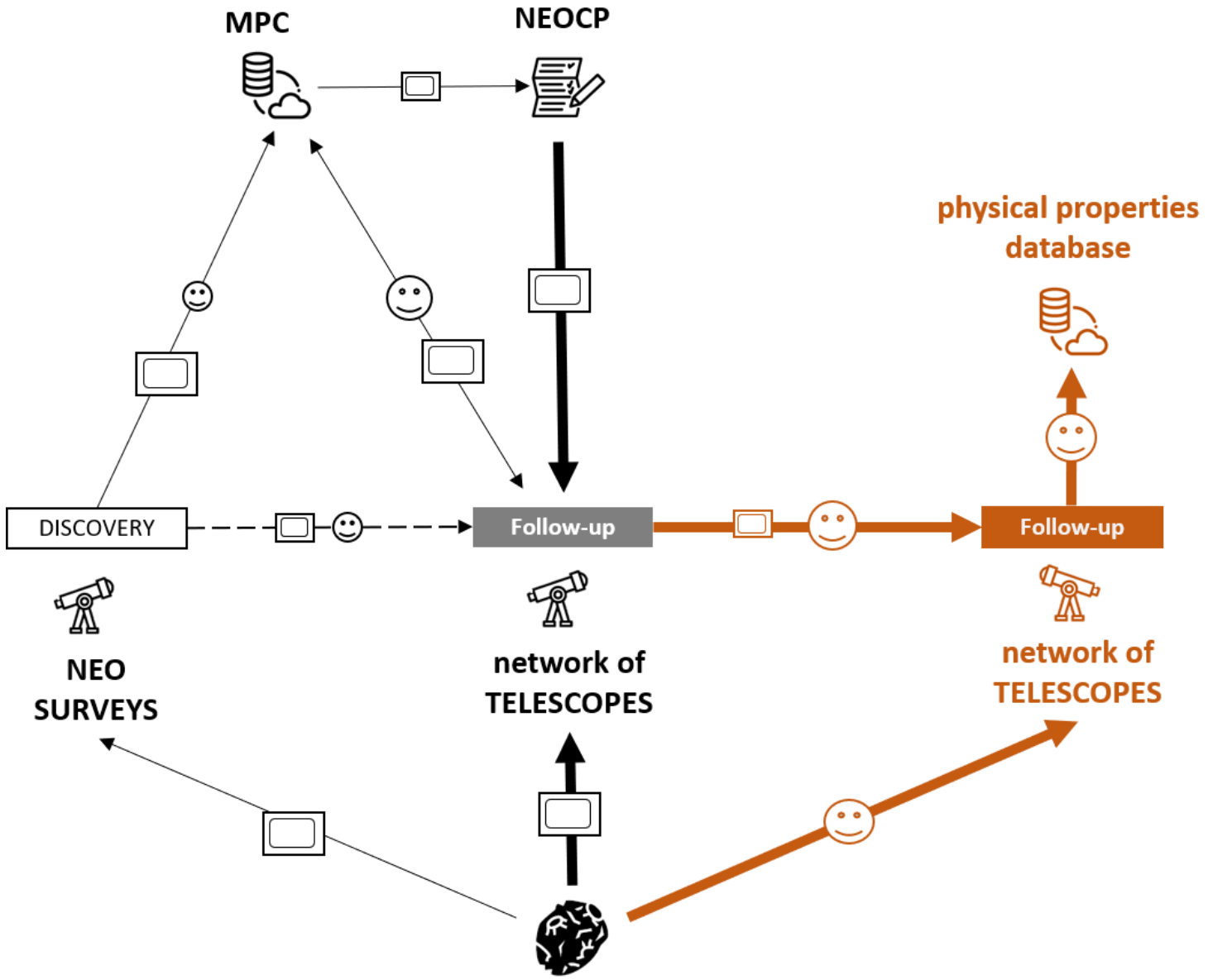


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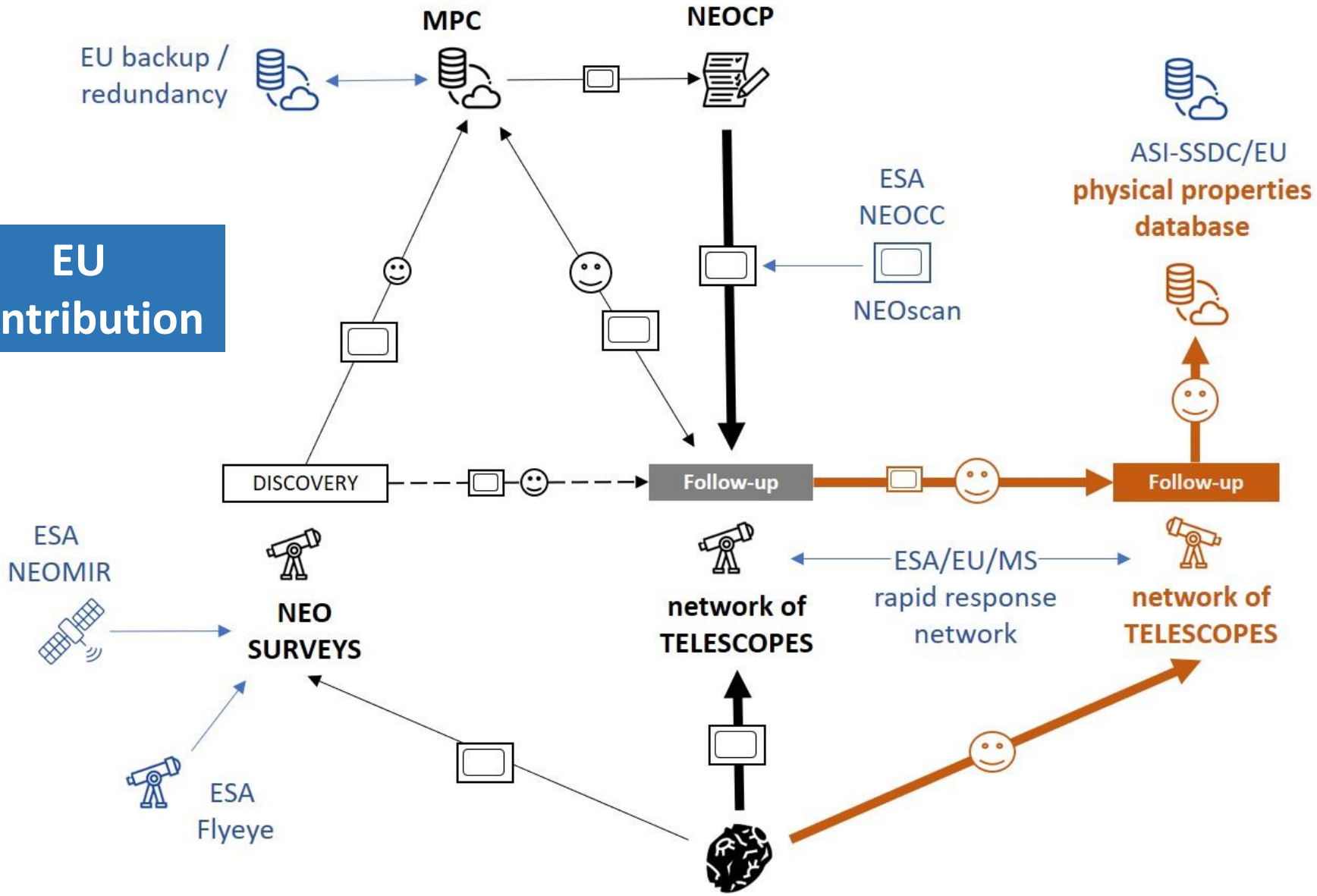
# The NEO ROCKS heritage

Near Earth Object Rapid Observation, Characterization and Key Simulations

**EU contribution**

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NEO ROCKS

bisogna sempre mettere un pochetto d’arte in quel che si fa


DON'T
PANIC!
DOUGLAS ADAMS
The Hitchhiker's Guide to the Galaxy