SPACE
SUSTAINABILITY
RATING

Sustainable Space Hub

EPFL

eSpace
EPFL Space Center

https://espace.epfl.ch/
https://www.epfl.ch/labs/lastro/

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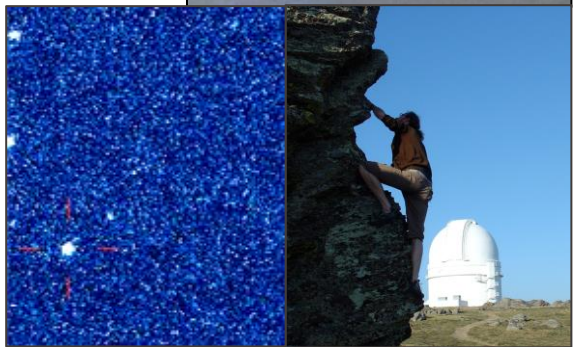
Who are we?

Adrien Saada
Operations Officer
Space Sustainability Rating

SPACE SUSTAINABILITY RATING

Who are we?



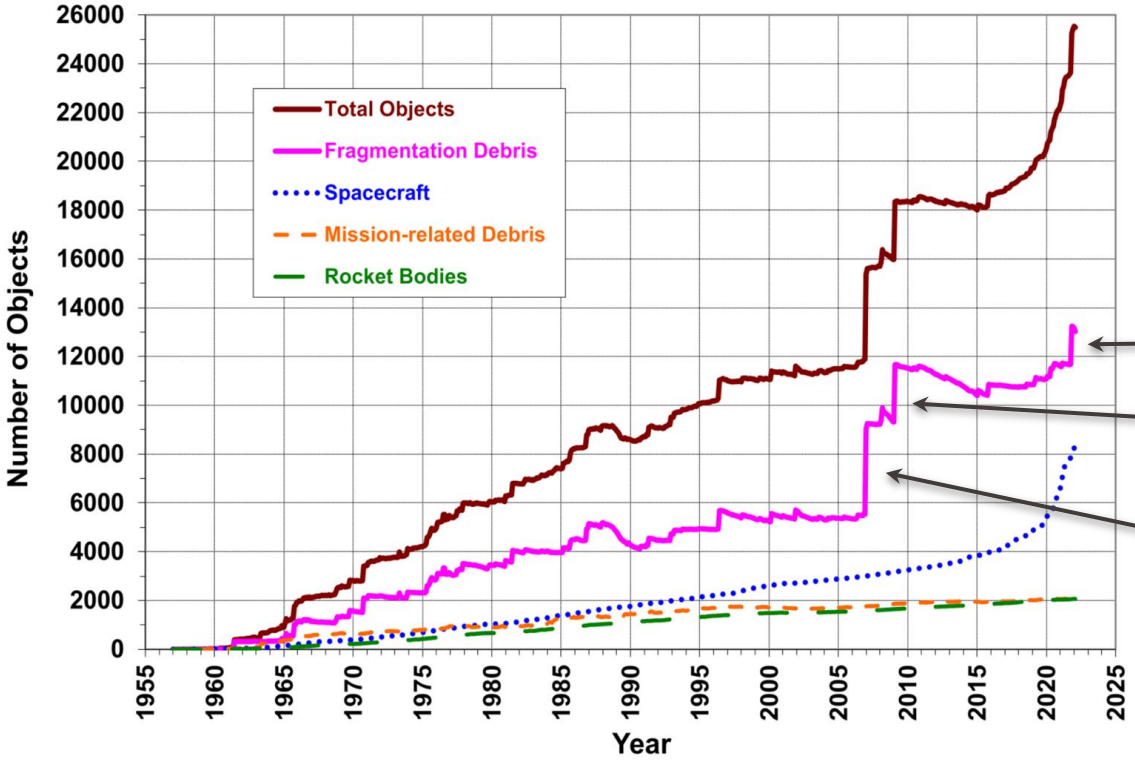
- eSpace
  EPFL Space
  Center

Why do we need space?


opernicus
CLIMATE CHANGE
MARINE MONITORING
ATMOSPHERE MONITORING
LAND MONITORING
SECURITY
EMERGENCY MANAGEMENT

Sustainability in Space?

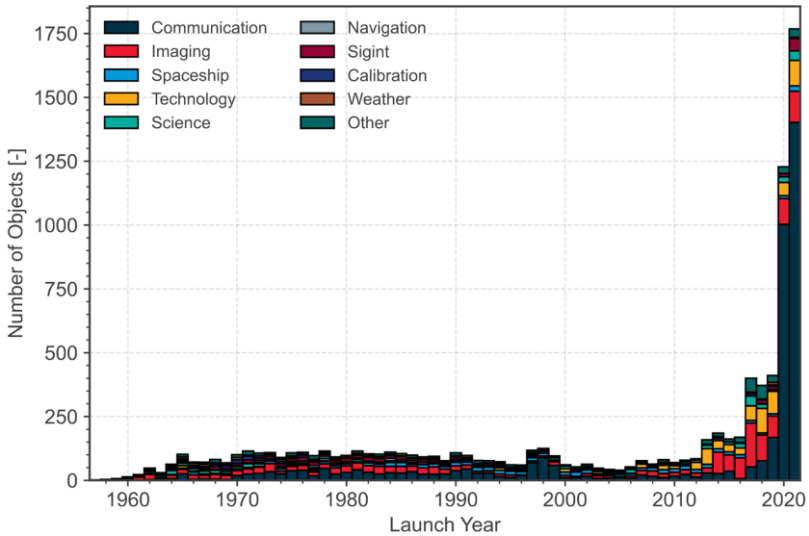
The debris situation



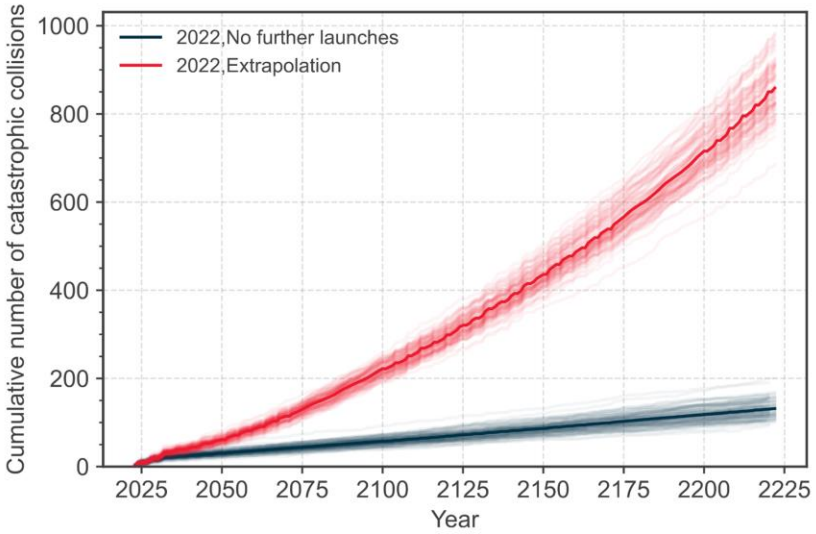
Monthly number of objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network.
NASA: ODPO

- Russian anti-satellite missile test
  November 15, 2021
- Collision of Iridium 33 and Cosmos 2251
  February 10, 2009
- Chinese anti-satellite missile test
  January 11, 2007

The debris situation



Evolution of the launch traffic near LEO per mission type.
ESA: Annual Space Environment Report 2022



Number of cumulative collisions in LEO (simulated)
ESA: Annual Space Environment Report 2022

STARLINK

- 3,200 satellites in orbit
- 9,000 to be launched until 2027
- Approval pending for 30,000 more

OneWeb

- 640+ satellites in orbit
- Generation 2 incoming

amazon | project kuiper

- 3276 satellites to be launched

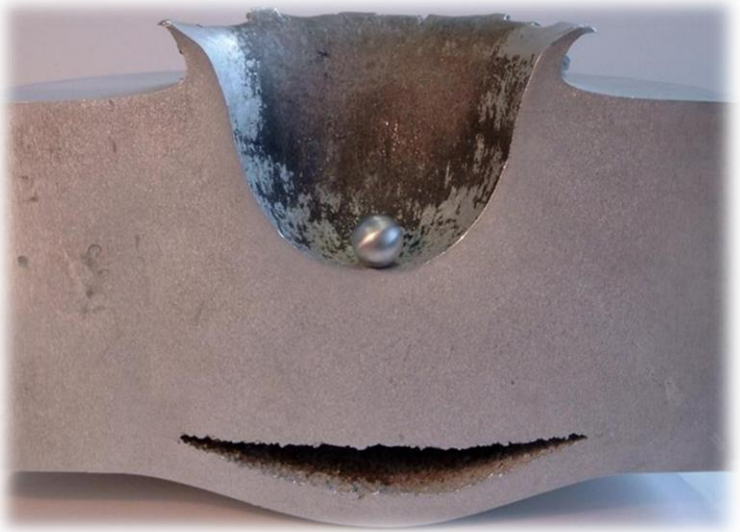
36,500

Debris greater than 10 cm in size in 2022 *(1)*

1,000,000

Debris greater than 1 cm in size in 2022 *(1)*

Source: ESA, Space Environment Statistics



1 cm ≈

Source: ESA, effects of hypervelocity impacts

If we continue business as usual, some orbits around Earth may become **inaccessible** within the next few decades.

Sustainability of Space activities?

Impacts of space activities on Earth

- Health risks due to toxic, carcinogenic propellant [1]
- Ground casualty risks (eg. Titanium tank)
- Unknown impacts on atmosphere and oceans

https://www.express.co.uk

https://www.smithsonianmag.com

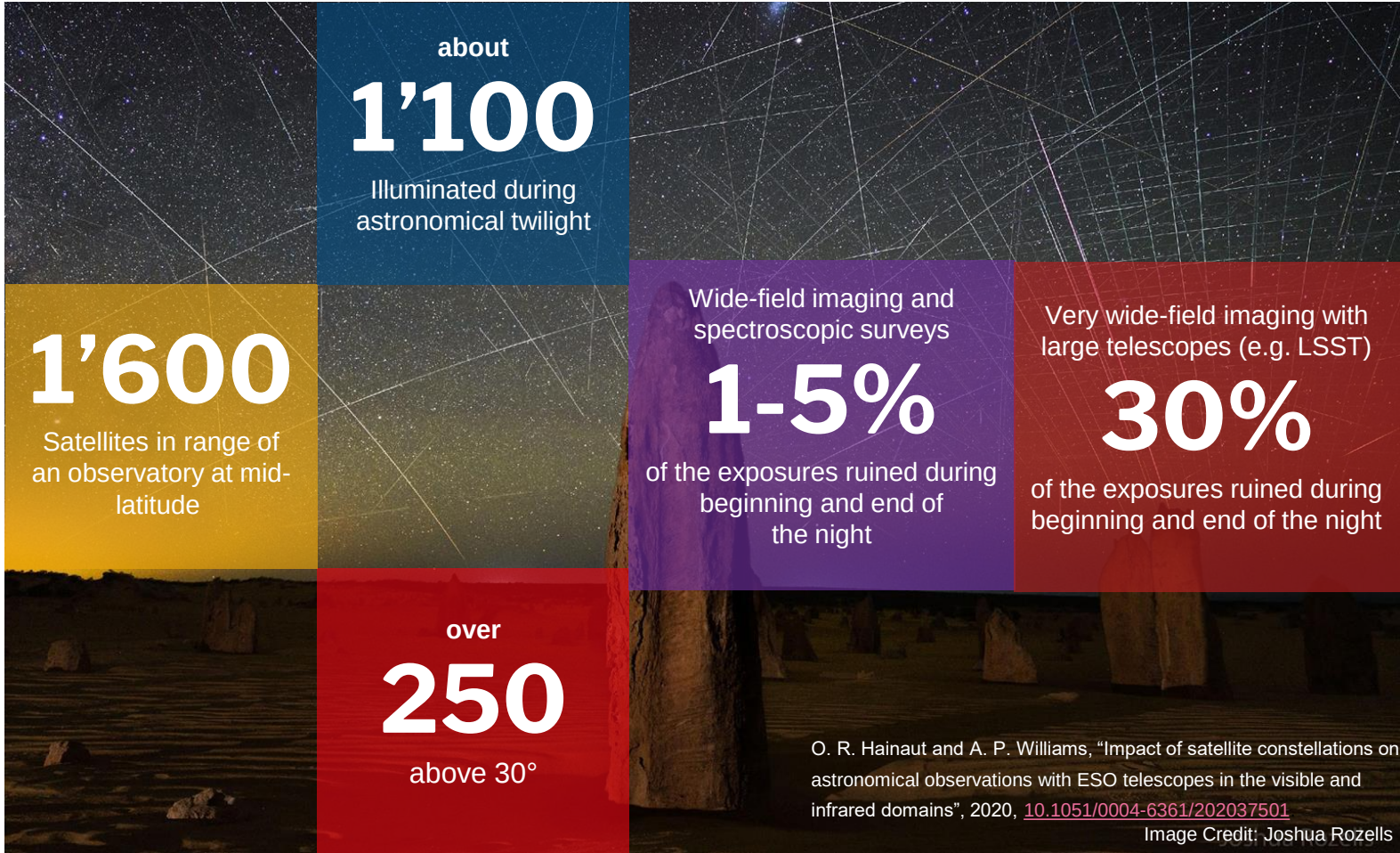
https://www.esa.int/

https://forum.nasaspaceflight.com

https://www.esa.int/Multimedia/Images/2008/11/Recovery_of_an_Ariane_5_booster_at_sea

1) https://www.bbc.com/news/world-europe-19127713

Impact on astronomy



O. R. Hainaut and A. P. Williams, “Impact of satellite constellations on astronomical observations with ESO telescopes in the visible and infrared domains”, 2020, 10.1051/0004-6361/202037501

Image Credit: Joshua Rozells

How can we foster space activities while sustaining the use of outer space in the long term?

Sustainable Space Hub

EPFL's competence group for new technologies and services to secre the long-term usability of space

Goal

Increase awareness of the debris situation in near-Earth space, study environmental impacts and develop tools to identify technology gaps and support sustainable mission design.

Research

Technology Development

Education

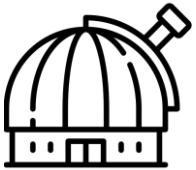
eSpace EPFL Space Center

Sustainable Space Hub

Three Pillar strategy

Sustainable Space Hub

1. **Measure**



Filling the knowledge gaps about space objects

2. **Understand**

Analyse and quantify environmental risks and impacts of missions

3. **Act**

Include assessments in space mission design since the early phase

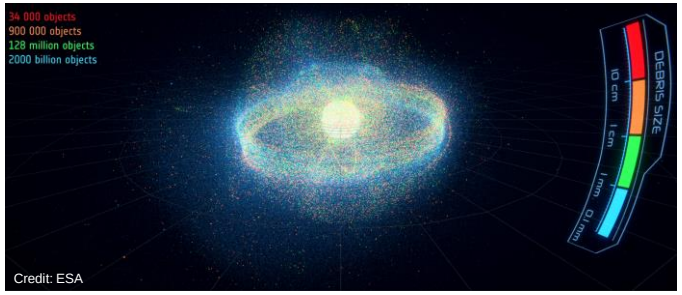
What do we need to measure?

- Total number and orbital distribution
  - Evaluation of the current situation
  - Risk assessment
  - Define mitigation measures

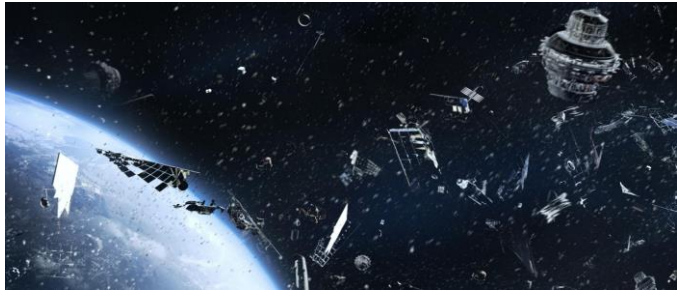
- Rotation states and physical properties
  - Support active space debris removal
  - Detect imminent fragmentation events
  - Study long-term effects of the space environment

- Effects of launches on the atmosphere

- Evaluation of impacts on society

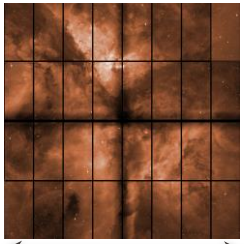


Credit: ESA

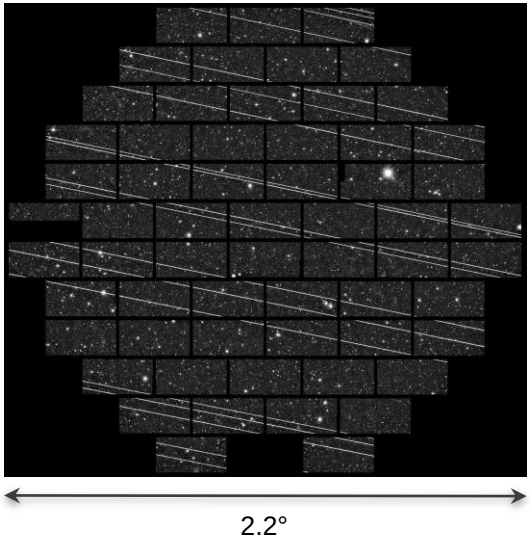



Credit: Christina Koch / NASA

Number, distribution and physical characteristics



- OmegaCAM @ ESO VLT Survey Telescope
  - 2.6 m Telescope on Cerro Paranal
  - 380k images



- DECam @ Blanco Telescope
  - 4 m Telescope on Cerro Tololo
  - 540k images

Physical characterization

Streak detection

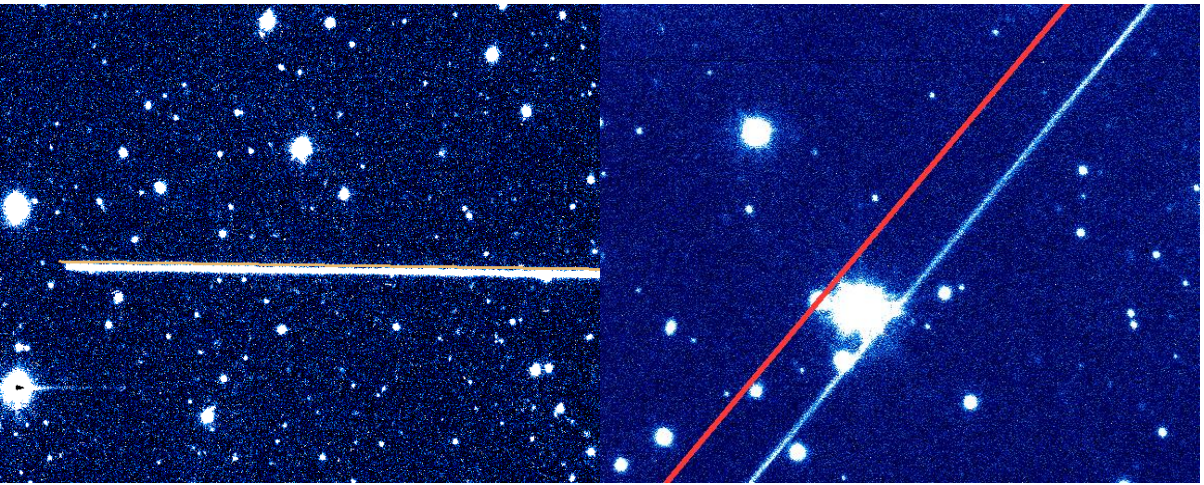
- Develop methods to efficiently extract satellite observations

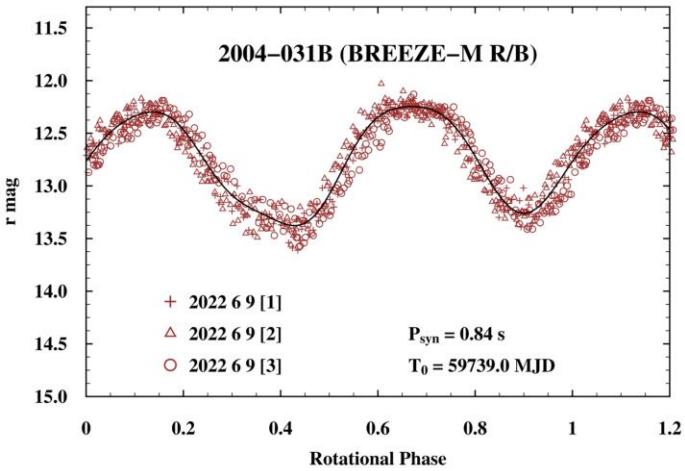
Identification, orbit determination

- Apply advanced orbit determination/fitting methods

Photometry

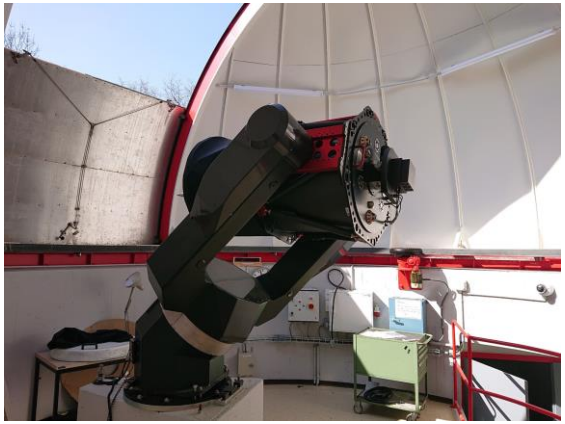
- Extract light curves from streaks to determine tumbling states



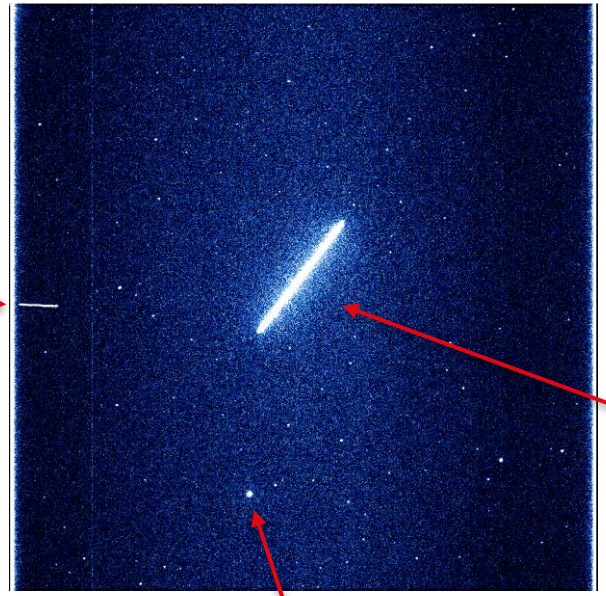


Observations

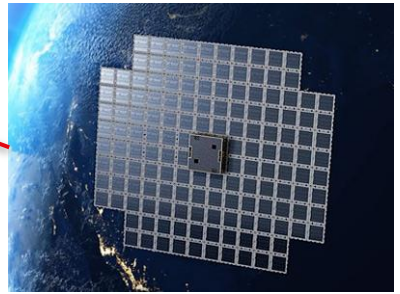
- 0.6 m optical telescope (TELESTO) @ Observatory of Geneva, Sauverny



Globalstar M039 (~350 kg)



magnitude 5 Star
(visible by naked eye)



Bluewalker 3 (~1.5 t, 64m^2)

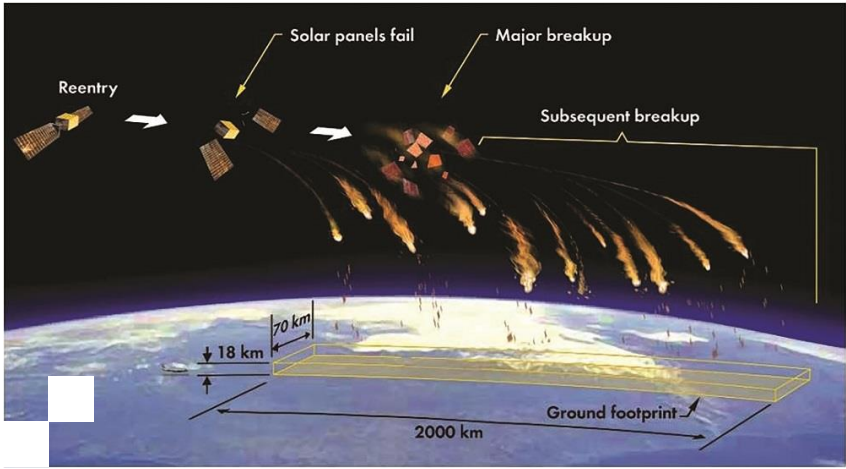
Images: https://space.skyrocket.de

Pose estimation for active space debris removal

- 6D Pose estimation for previously unseen objects
- Domain generalization for pose estimation
- Learning compact networks for pose estimation

Reentry and hypervelocity impacts

- Number of reentries will increase
- Still a lot of uncertainties in models [1,2,3,4]
- Research on material demise (LPAC)
- Modelling hypervelocity impacts (LSMS)



(2)

[1] ESA CleanSpace blog, 2022
[2] SpaceNews article on environmental impacts of reentry, 2022
[3] Robert G. Ryan et alli, “Impact of Rocket Launch and Space Debris Air Pollutant Emissions on Stratospheric Ozone and Global Climate”, (2022), in: Earth's Future, 10, e2021EF002612. https://doi.org/10.1029/2021EF002612.
[4] Jamie D. Shutler et alli, “Atmospheric impacts of the space industry require oversight”, (August 2022), in: Nature Geoscience, volume 15, p. 598–600, www.nature.com/naturegeoscience.

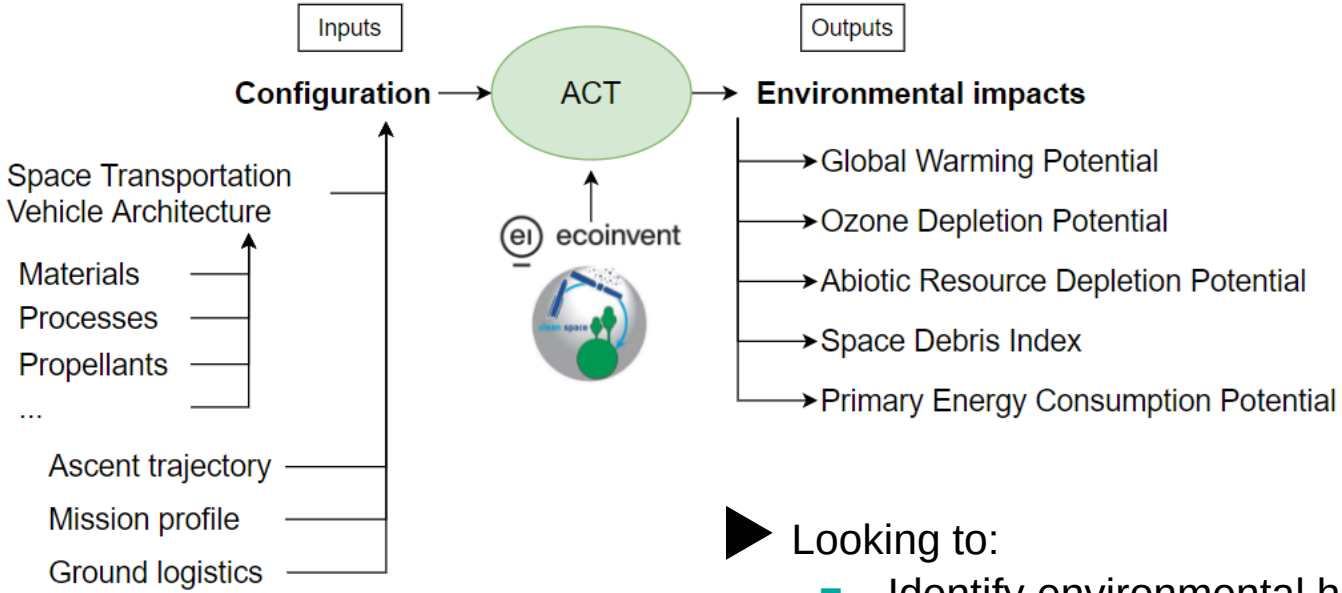
Sustainable Space Hub

Act

Sustainable Space Logistics

https://www.esa.int/Enabling_Support/Space_Transportation/ESA_sets_sights_on_space_transportation_ecosystem

Environmental Impacts assessment



- Looking to:
  - Identify environmental hotspots (LCA)
  - Help design trade-offs and decision-making
  - Identify knowledge gaps

https://act.dev.gsl.ateleris.com/

Pushing the frontier of space policy debate

‘Space sustainability: Policy options and interrelations with Earth system governance’

- Consider impact of missions on Earth System and socioeconomic benefits for developing countries
- Co-construct future scenarios with practitioners to discuss policy options
- Evidence-based policy making through engagement with OECD Space Forum, ITU, etc.

Earth-Space Sustainability

- Integrating space and Earth-bound sustainability challenges through frontier social science research
- Embedded in the Earth System Governance global research alliance

Dr. Xiao-Shan Yap, Senior Researcher @ eSpace

SPACE SUSTAINABILITY RATING

TOWARDS A MORE SUSTAINABLE USE OF SPACE

A METRIC FOR SPACE SUSTAINABILITY

Encouraging space actors to **design & implement sustainable & responsible space missions** for the long-term **sustainability of the space environment**

SPACE SUSTAINABILITY RATING

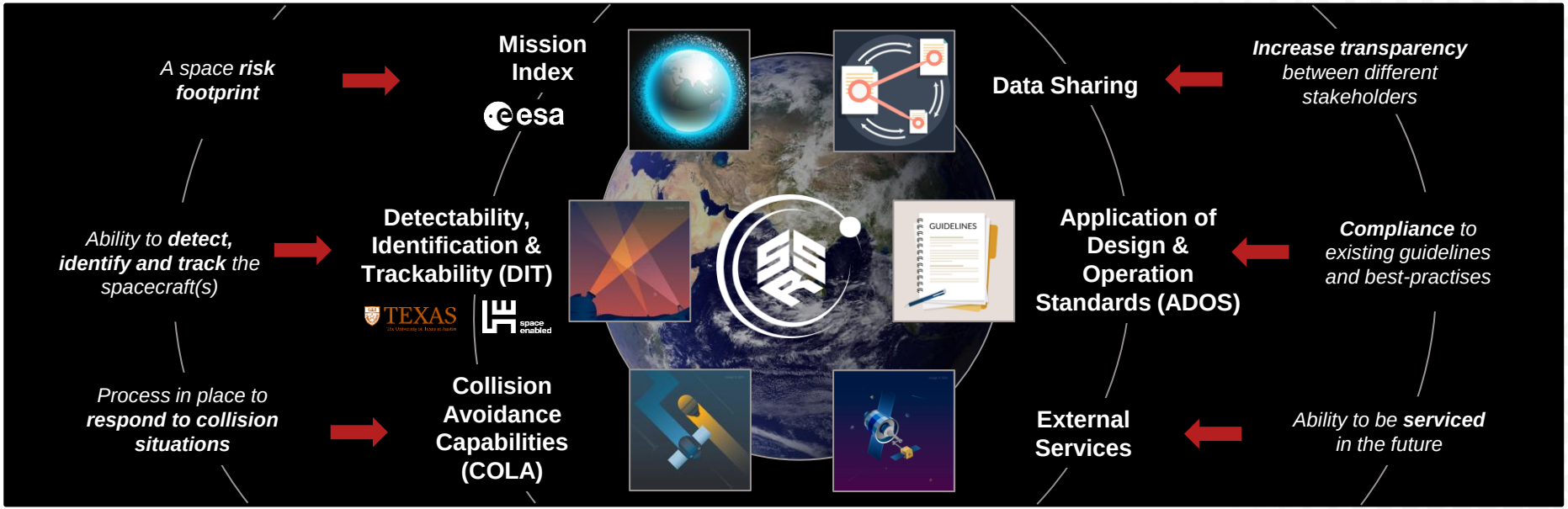
BRONZE

SILVER

GOLD

PLATINUM

A MODULAR RATING



REWARDING RESPONSIBLE BEHAVIOR IN SPACE

A **rating system** informed by **transparent, data-based assessments** of the level of sustainability of space missions

Practical guidance on how to **improve** sustainability performance & practices

A **platform for action-focused collaboration** centered on the rating system to support research and leverage best practices

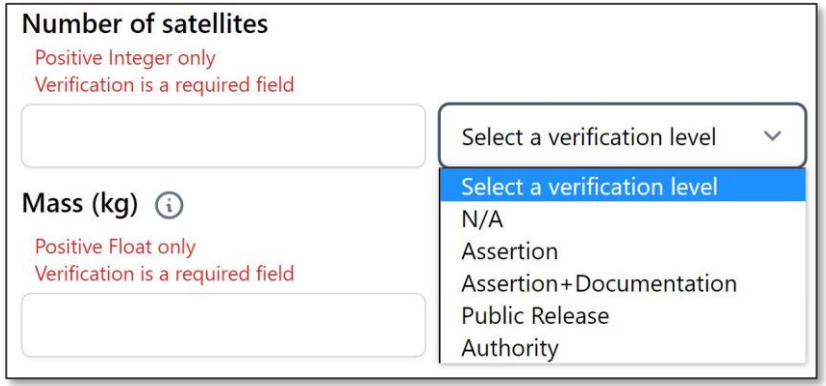
HOW IS A MISSION RATED?

1. **Data collection and verification**

THE SSR DATA VERIFICATION ASSESSMENT

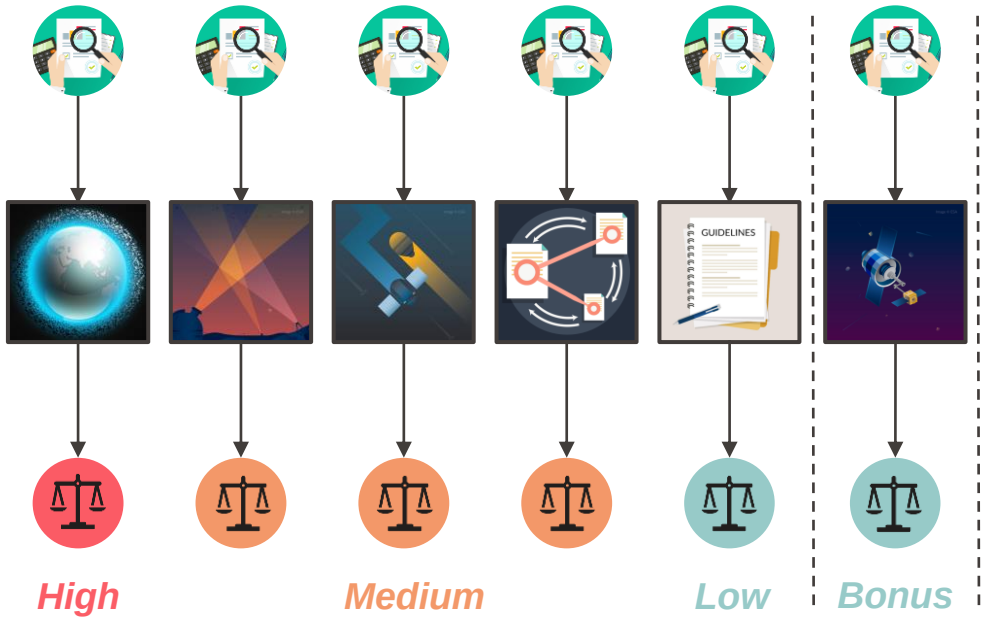
Level of verification	Factor
Assertion Affirmative statement by the applicant is provided, without supporting documentation	**0.5**
Technical documentation supporting the assertion Supporting technical documentation on the mission design is disclosed to the SSR entity	**0.6**
Public release of the technical documentation Supporting technical documentation is submitted to a government or non-profit available for public review	**0.8**
Authority – independent technical review An independent technical review or confirmation of compliance by a third-party technical expert is provided	**1**

Each information provided shall be associated with a confidence level



HOW IS A MISSION RATED?

1. **Data collection and verification**
2. **Module evaluation**
3. **Weighting**



81 – 100 %

71 – 80 %

56 – 70 %

40 – 55 %

SPACE
SUSTAINABILITY
RATING

[Operator's logo]

SPACE SUSTAINABILITY RATING

CERTIFICATE

[Company and Mission Name],
completed a rating and achieved a **Gold Rating** with **Two Bonus Stars**.

Scope of certificate: [Mission Phase]

GOLD

Date of issue

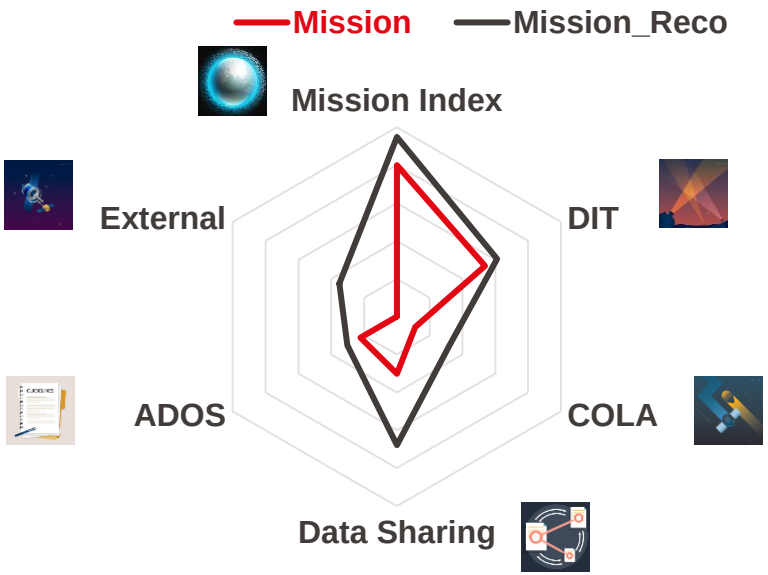
[Date]

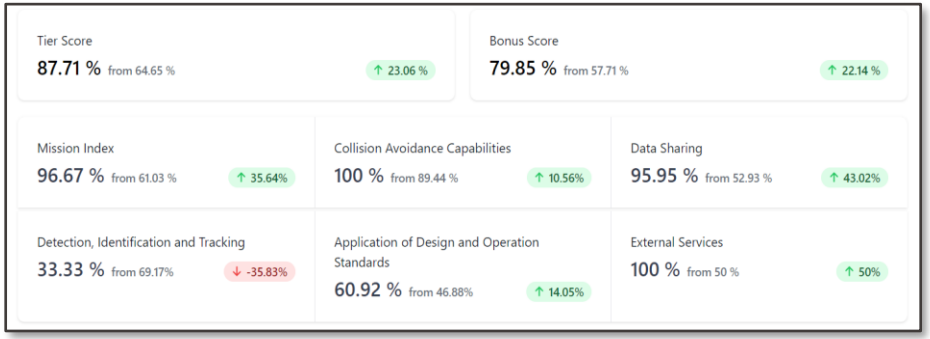
[Signature]

Prof. Jean-Paul Kneib
Academic Director
eSpace - EPFL Space Center

This document is not an official certification and is valid during the [Mission Phase] of the assessed mission.
This rating can be re-evaluated upon request of the applicant, or if it is deemed necessary by the issuer. This certificate is the property of Space Sustainability Rating.

The SSR as an incentive tool



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Thank you
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spacesustainabilityrating.org
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