EPFL

SPACE 4 IMPACT

EZMC

eSpace
EPFL Space Center

SPACE INNOVATION

Sustainability 4 Space

New Space Economy

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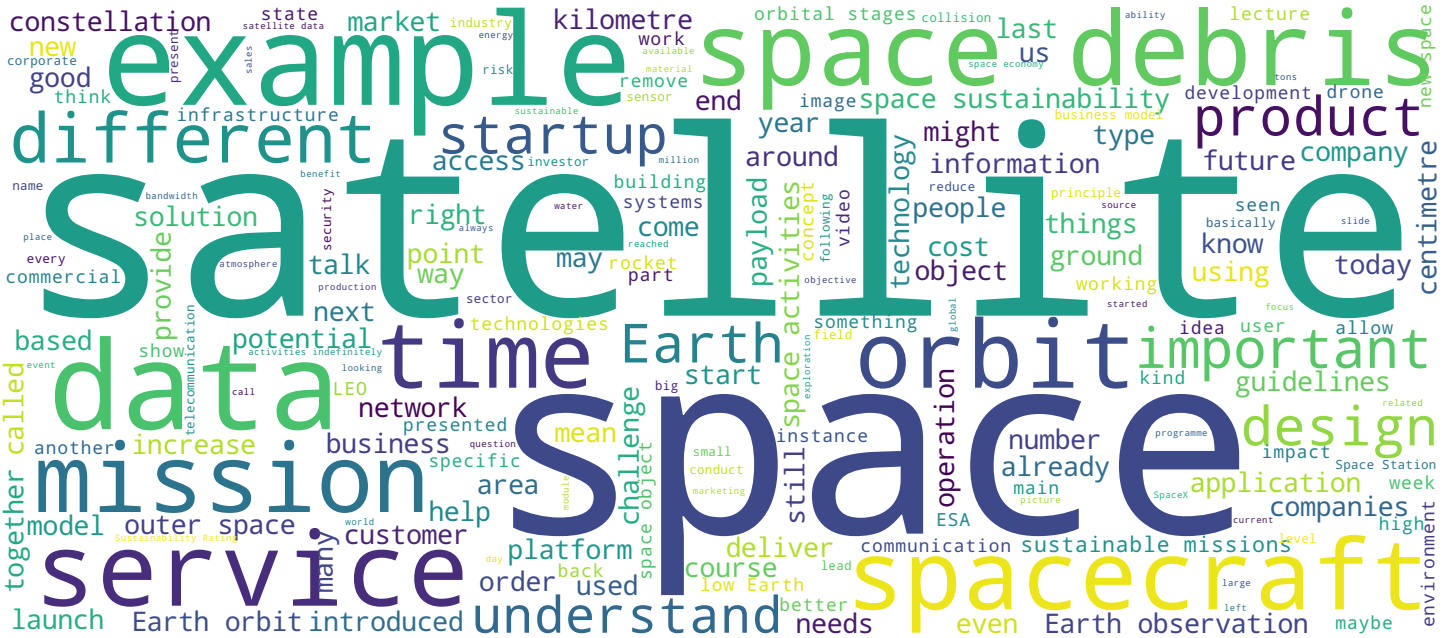


Search MOOC

Video

EPFL

Welcome

- Why do we speak about sustainability in Space?
- What is Space Sustainability?
- How can you design more sustainable missions?

Welcome, everyone, in the session on sustainability in space. You may wonder how the infinite space is also subject to sustainability. But by now, you should be aware that space is not that infinite. And with the increase of space activities, it is important to act wisely. Today, we will answer the following questions: why do we speak about sustainability in space, what is space sustainability, and how can you design more sustainable missions.

Notes

Summary

0m 05s

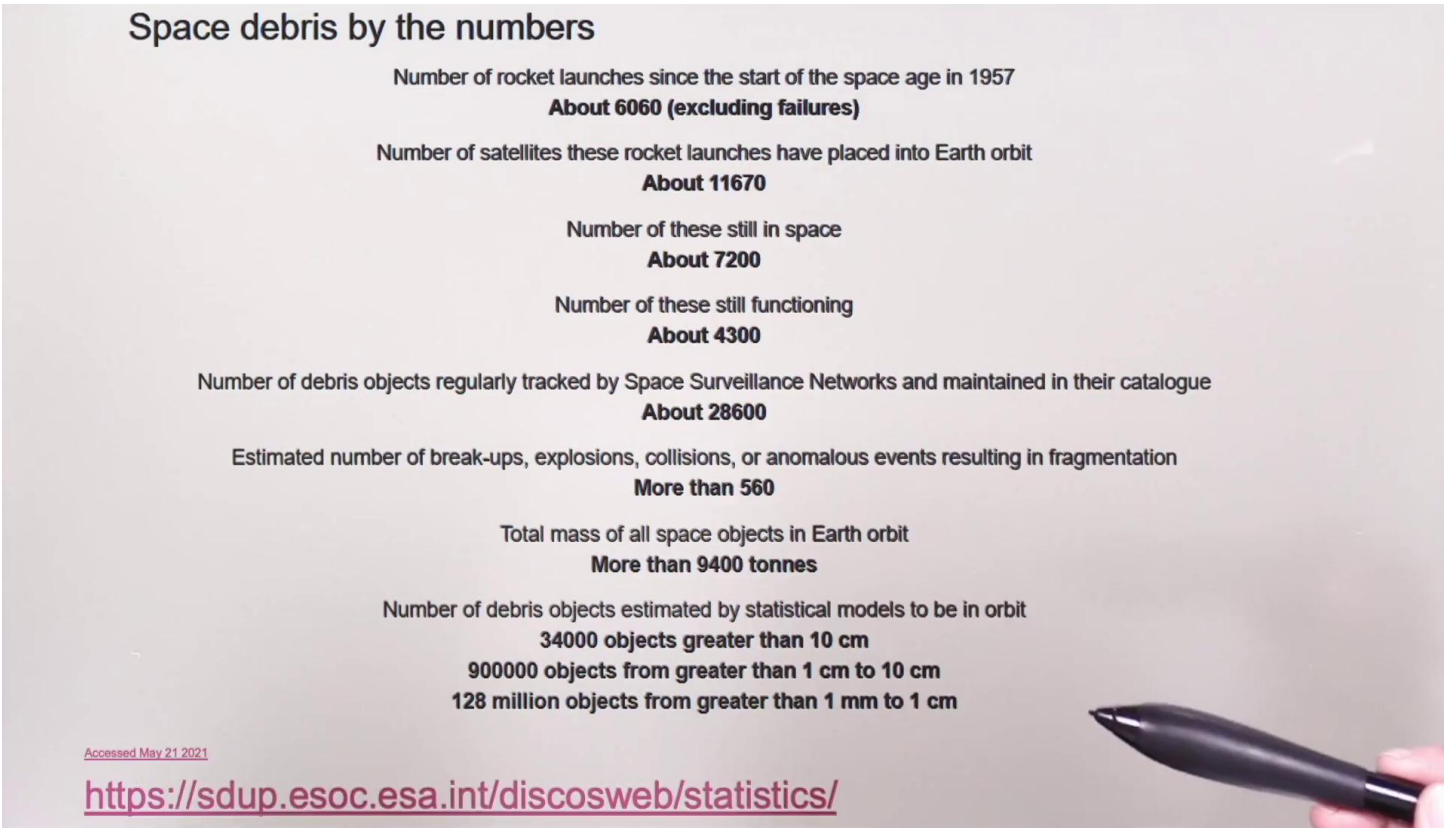
Why do we speak about sustainability in Space?

Let's start the lesson to understand why do we speak about sustainability in space.

Notes

Summary

0m 46s

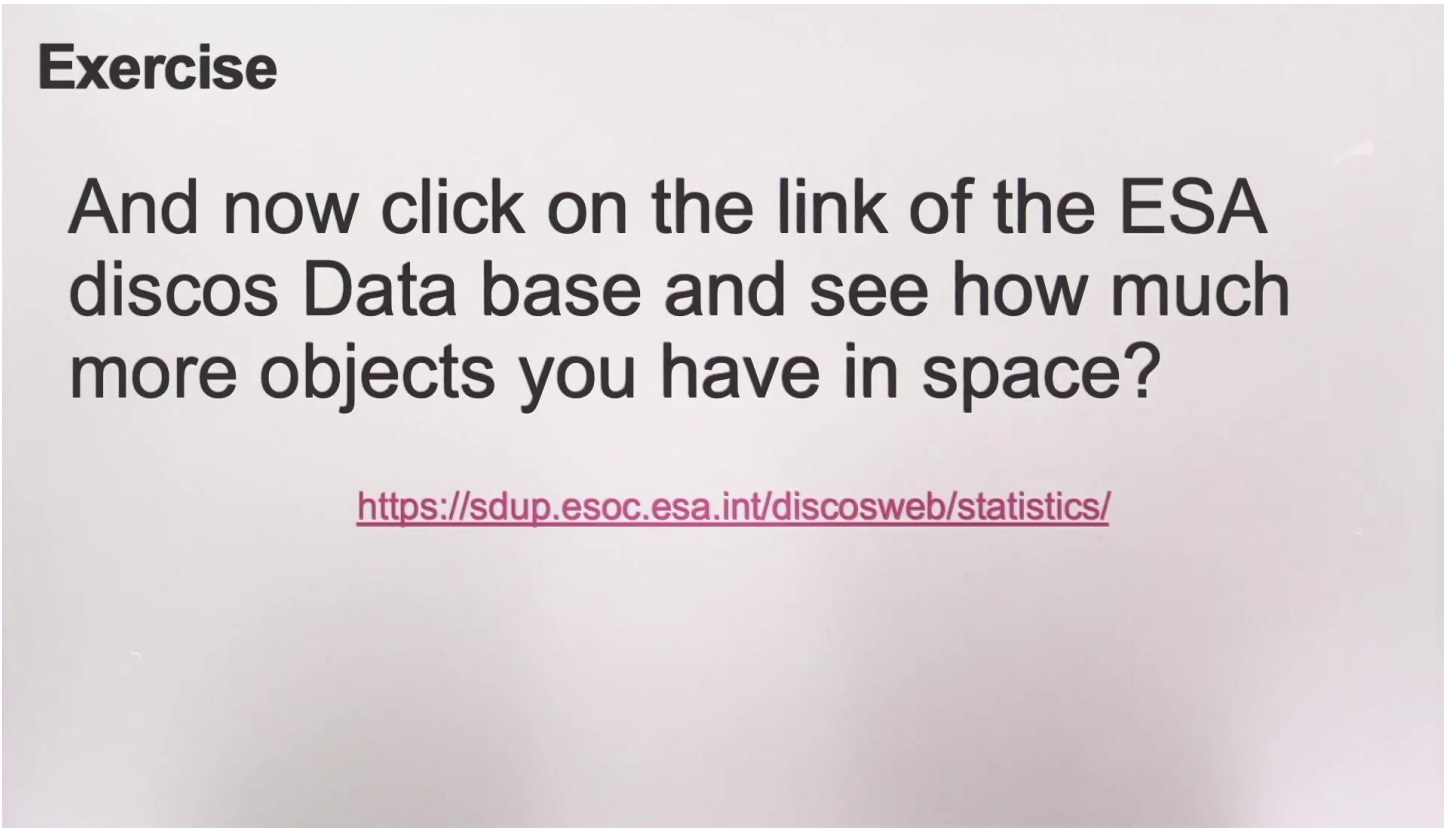


Let's have a look at the space object population. This data is from the European Space Agency Space Debris Office. It was accessed in May 2021, and it presents the main figures on space debris populations. Number of rocket launches since the start of space age in 1957: more than 6,000 launches. Number of satellites these rocket launches have placed into orbit: about 11,670. Number of these that are still in space: about 7,200. And number of these still functioning: 4,300. So now, when we talk about those large constellations that will launch more than thousands of satellites, you understand that space population will increase exponentially. Number of debris objects regularly tracked by the Space Surveillance Network and maintained in their catalogue: about 28,000. Estimated number of break-ups, explosions, collisions, or anomalous events resulting in fragmentation: more than 560. Total mass of space objects in Earth orbit: more than 9,400 tons. At last, number of debris objects estimated by the statistical model to be in orbit. You see that objects greater than 10 centimetre: 34,000. Objects from greater than one centimetre to 10 centimetre: 900,000. And 128 million from greater than one milli to one centimetre. These objects are estimated by statistical model because they cannot be tracked by our current systems.

Notes

Summary

0m 57s



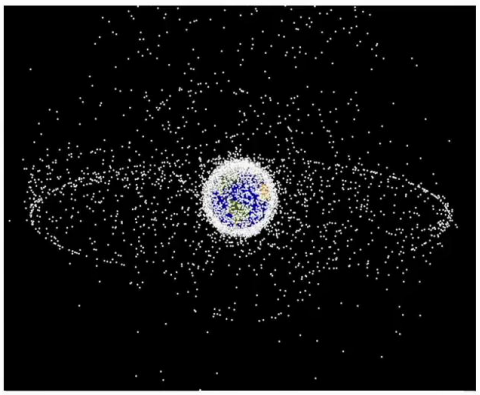
And now, click on the link of the ESA discos database and see how much more objects you have in space at the date you are watching this video.

Notes

Summary

3m 15s

The Kessler Effect (or Snow ball effect)



Par NASA image — NASA Orbital Debris Program Office, photo gallery, Domaine public, https://commons.wikimedia.org/w/index.php?curid=52126

Past a certain critical mass, the total amount of space debris will keep on increasing: collisions give rise to more debris and lead to more collisions, in a chain reaction.

Now that you've seen how big is the space objects populations, I'd like to introduce you to the Kessler Effect or Snowball Effect. As a space debris expert, Don Kessler observed that past a certain critical mass, the total amount of space debris will keep on increasing. Collision gives more debris and lead to more collisions. This is a chain reaction. This observation was performed first in the '80s, so space debris issue is not that new.

Notes

Summary

3m 29s

What is Space Sustainability?

Now that you've gotten introduced to the space debris population and the criticality of the subject, we can now start exploring the definition of space sustainability. What is space sustainability?

Notes

Summary

4m 05s

Space sustainability

The long-term sustainability of outer space activities is defined as the ability to **maintain the conduct of space activities indefinitely into the future** in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the **needs of the present generations while preserving the outer space environment for future generations**.

Committee on the PeacefulUses of Outer Space, Vienna, 20–29 June 2019

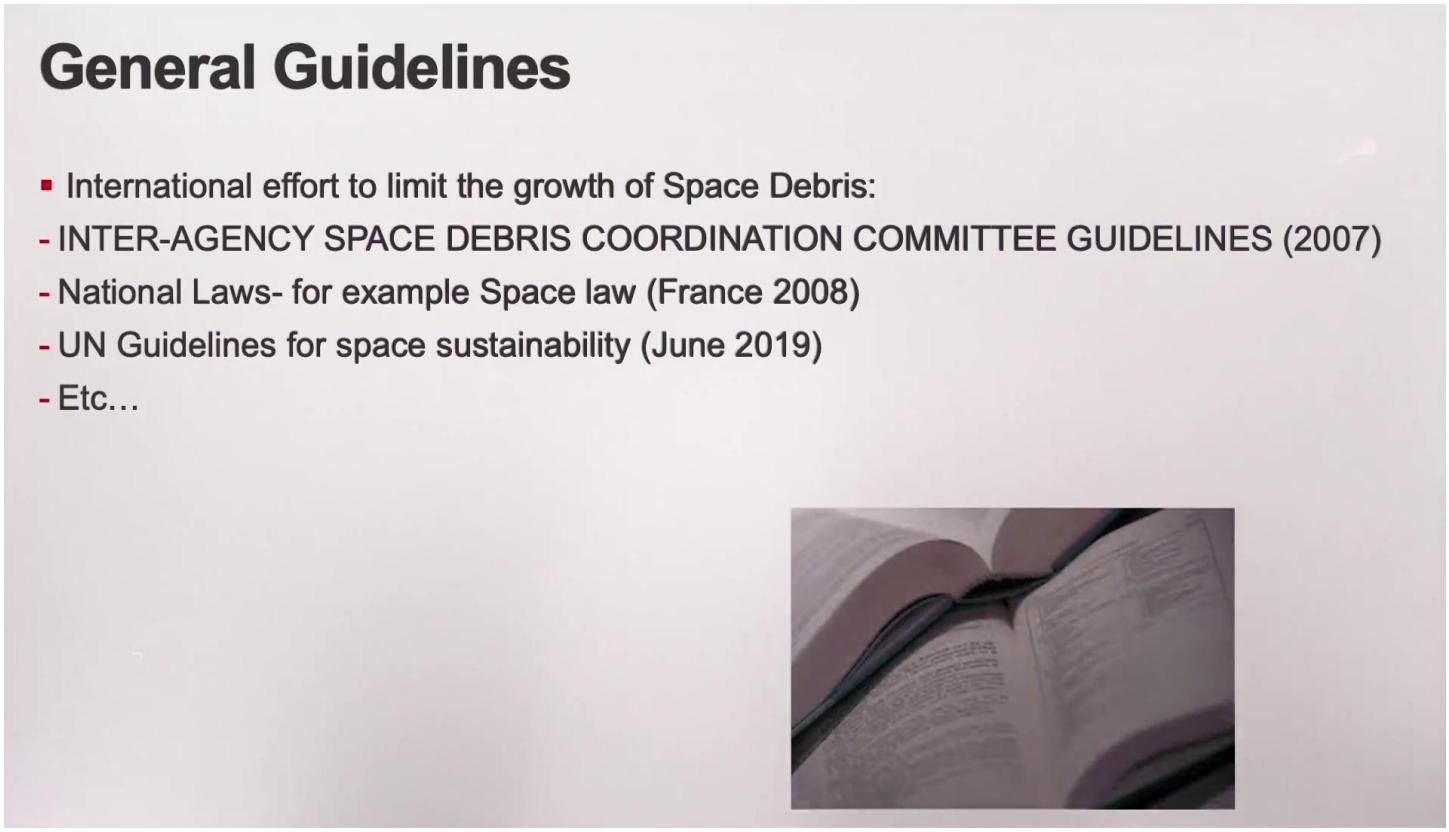
Sustainable Space Logistics

According to the Committee on the Peaceful Uses of Outer Space, the following definition has been presented in 2019. The long-term sustainability of outer space activities Is defined as the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefit of the exploration and use of outer space for people's full purposes, in order to meet the needs of the present generations while preserving the outer space environment for the future's generations. I would like to make you more attentive on the following part: "Maintain the conduct of space activities indefinitely into the future." Kessler Syndrome, Snowball Effect, is not an option. "Meet the needs of the present generations," meaning continued space activities. As well as "preserving the outer space environment for the future generation." We don't want to redo in space the same mistakes we've performed on Earth. How do we do that?

Notes

Summary

4m 19s



There is an international effort to limit the growth of space debris. There are some guidelines and very few binding laws. Here, I've listed a few of these, such as the Inter-agency Space Debris Coordination Committee guidelines from 2007, and last date in 2021. France, for example, has a space law, [foreign language 00:06:21]. And the UN has also emitted guidelines for space sustainability. You can check in your respective country what are the applicable laws and guidelines.

Notes

Summary

5m 51s

What are the main principles of the guidelines?

(1) Preventing explosive and collisional on-orbit break-ups

(2) Removing spacecraft and orbital stages that have reached the end of their mission operations from the useful densely populated orbit regions

(3) Limiting the objects released during normal operations.

What are the main principle in these guidelines? The main principles are the following: there should be a need of preventing explosive and collisional on-orbit breakups; you shall remove spacecraft and orbital stages that have reached the end of their mission's operation from the useful, densely-populated orbit region; and you shall limit the objects released during normal operations. In the next few minutes, I will focus on the point one and the point two.

Notes

Summary

6m 35s

The protected regions

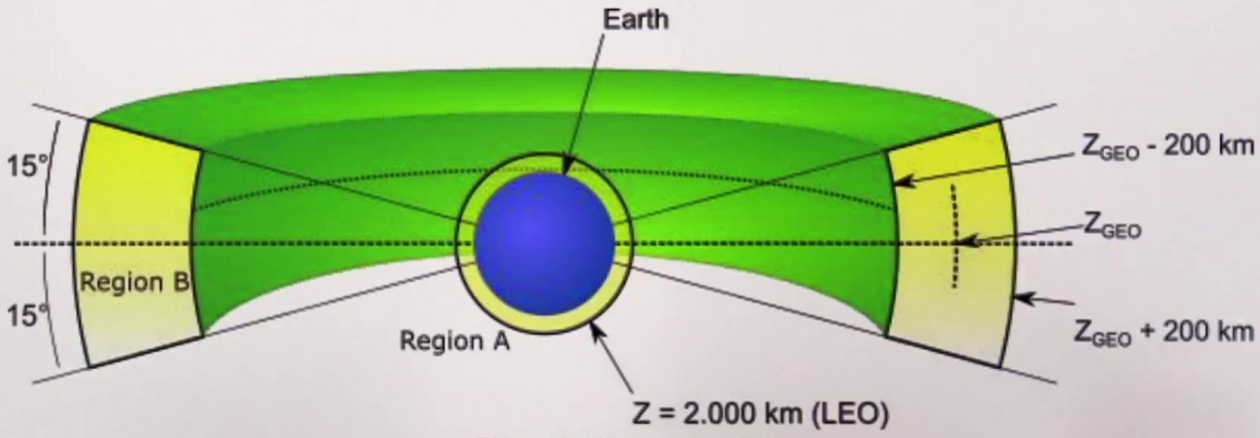


Figure 1 - Protected regions

https://www.iadc-home.org/documents_public/view/id/172#u

In these guidelines, the concept of protected region is also introduced, in particular, GEO and in LEO. You may recall from the Space Transportation lecture the different regions' definitions. The region A, Low Earth orbit, is up to 2000 kilometres. In the region B, GEO, geostationary orbits, are at an altitude up to 36,000 kilometres and are protected around in a radius of plus/minus 200 kilometres and in a radius of plus/minus 50 degrees.

Notes

Summary

7m 20s

How can you design more sustainable missions?

What are the impact of these guidelines on your mission's design? How can you design more sustainable missions?

Notes

Summary

8m 04s

How can you design more sustainable missions?

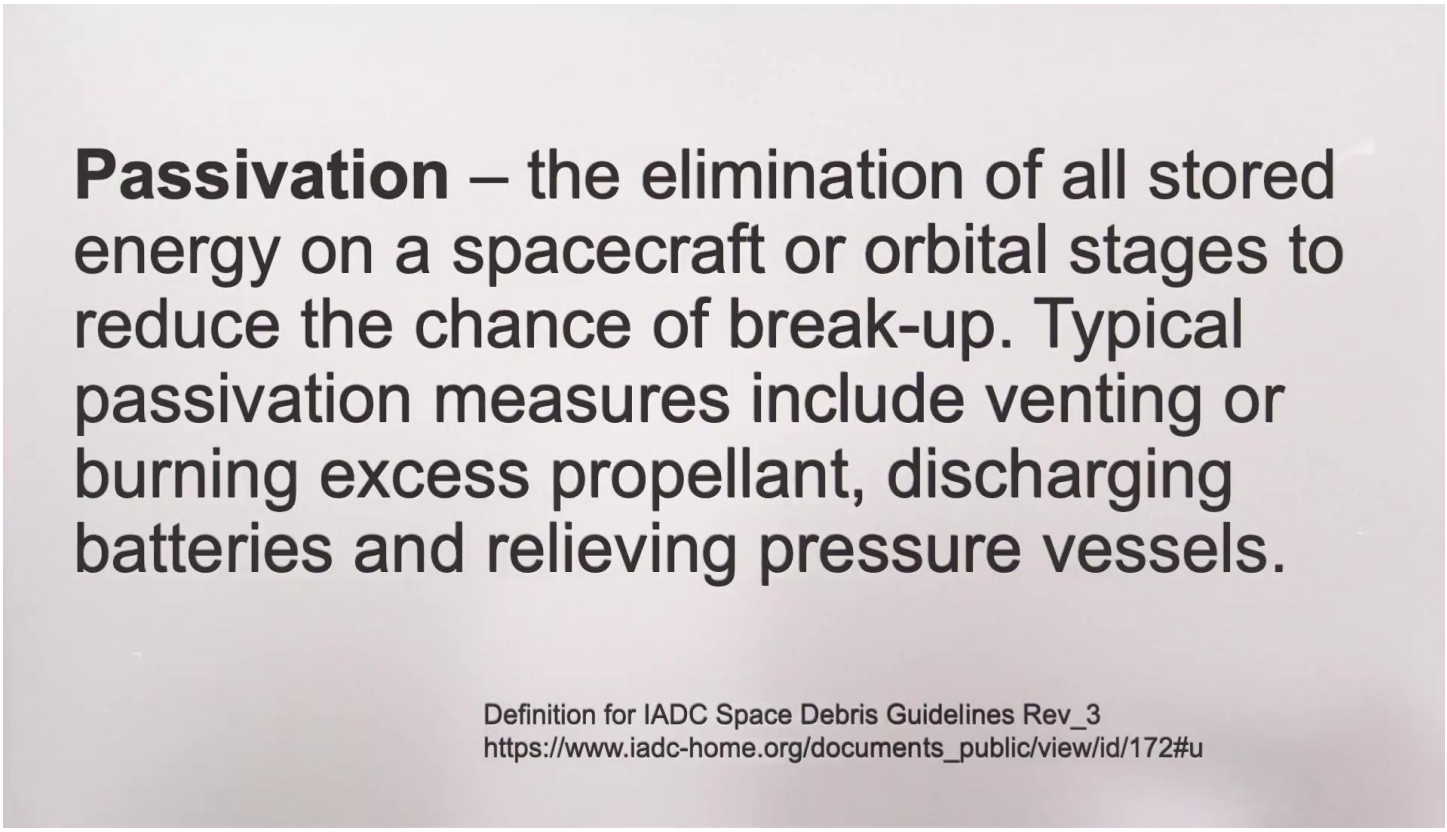
(1) Preventing explosive and collisional on-orbit break-ups

Let's first explore the prevention of explosive and collisional on-obit break-ups.

Notes

Summary

8m 13s



According to the definition of the IADC Space Debris guidelines, a break-up is any event that generates fragments which are released into Earth orbit. This include an explosion caused by the chemical or the thermal energy from propellants, pyrotechnics, or so on. This could be caused by the propellant that is left in your spacecraft at the end of the mission. A rupture caused by an increase in internal pressure. Also explosion of tanks, for example. A break-up caused by energy from collisions in other objects, if you have a space debris that hits your spacecraft. In order to avoid those kind of explosion, we talked about passivation, passivating the spacecraft. Passivation is the elimination of all stored energy on a spacecraft or orbital stages to reduce the chance of a break-up. Typical passivation measures include venting or burning excess of propellant, discharging batteries, and relieving pressure vessels. You are removing all the energy in your spacecraft.

Notes

Summary

8m 21s

How can you design more sustainable missions?

(2) Removing spacecraft and orbital stages that have reached the end of their mission operations from the useful densely populated orbit regions

We will now explore the second principle on removing spacecraft and orbital stages that have reached the end of their mission operations from the useful, densely-populated orbit, meaning the protected regions, regions A and B, LEO and GEO.

Notes

Summary

9m 40s

Reduce Orbital Lifetime

- Add a complementary system such as a drag sail
- De-orbit your spacecraft at the end of the mission

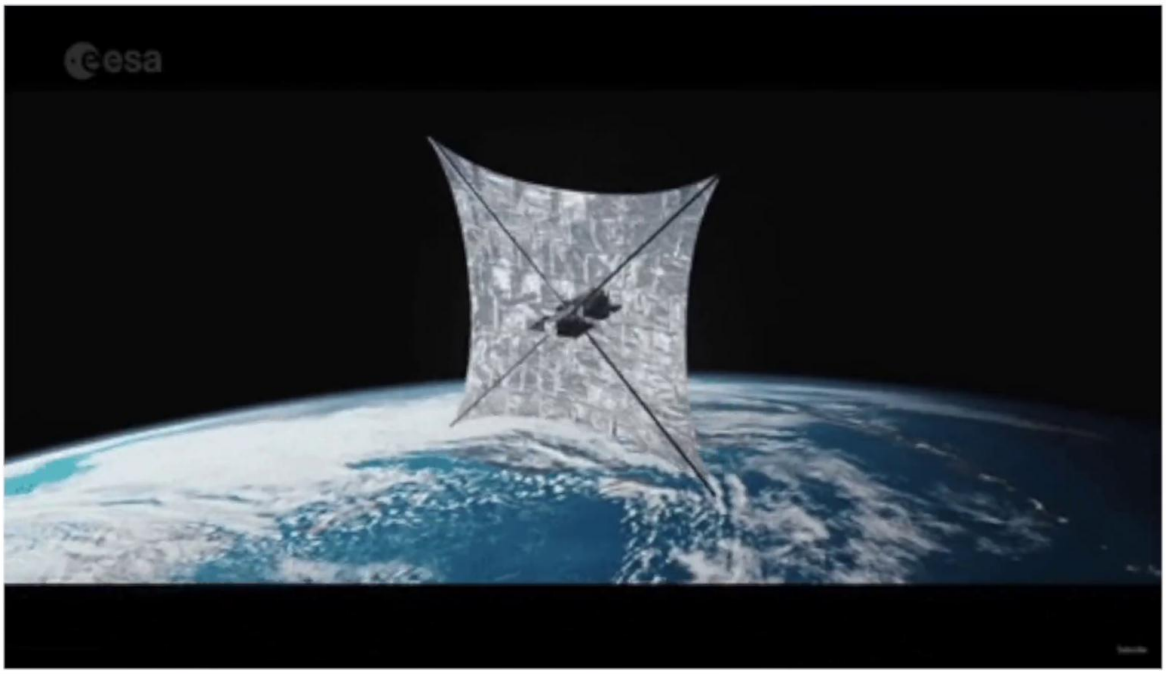
In order to remove the spacecraft and the orbital stages from the orbit, either you can use the current engine on your spacecraft and use the remaining fuel for this last operation, or you can add a complementary system such as a drag sail. The next video will show you an example of development performed through ESA.

Notes

Summary

10m 01s

Reduce Orbital Lifetime



https://www.esa.int/ESA_Multimedia/Images/2021/04/Deploying_a_drag_sail#.YNQ2qQXBpYk.link

We can see here the drag sail opening itself in order to reduce the lifetime of the spacecraft.

Notes

Summary

10m 28s

Space debris Removal – Clearspace

- Space debris Removal (Video Clearspace, you can put me in front of the video and make it start when I stop talking)

If your spacecraft has no capacity to remove itself from its orbit, you will then be soon able to procure such service. ClearSpace, a spin-off from EPFL Space Centre, will remove the first debris by 2025. You can see on the following video how the chaser come with the robotic arm and grasp the space debris.

Notes

Summary

10m 40s

Design for Demise

© ESA/D.Ducros - 2007

This is the last step you want to consider in the lifecycle of your mission: the re-entry. It is important to design a spacecraft that when re-entering in the atmosphere, will completely demise, meaning that no piece of debris shall reach the ground and therefore potentially harm people.

Notes

Summary

11m 17s

Re-entry of Object

- https://www.esa.int/ESA_Multimedia/Videos/2018/03/ESA_reentry_expertise#.YNQ5uAYoRkY.link

We see about 100 tons of space hardware re-entering in an uncontrolled way, distributed over 50 individual events. So roughly, you can say there's one major event in a week.

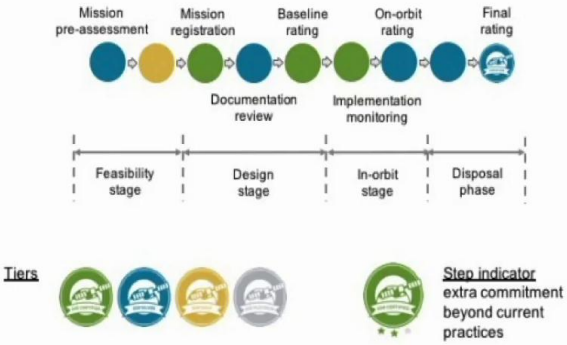
Notes

Summary

12m 26s

Space Sustainability Rating

22

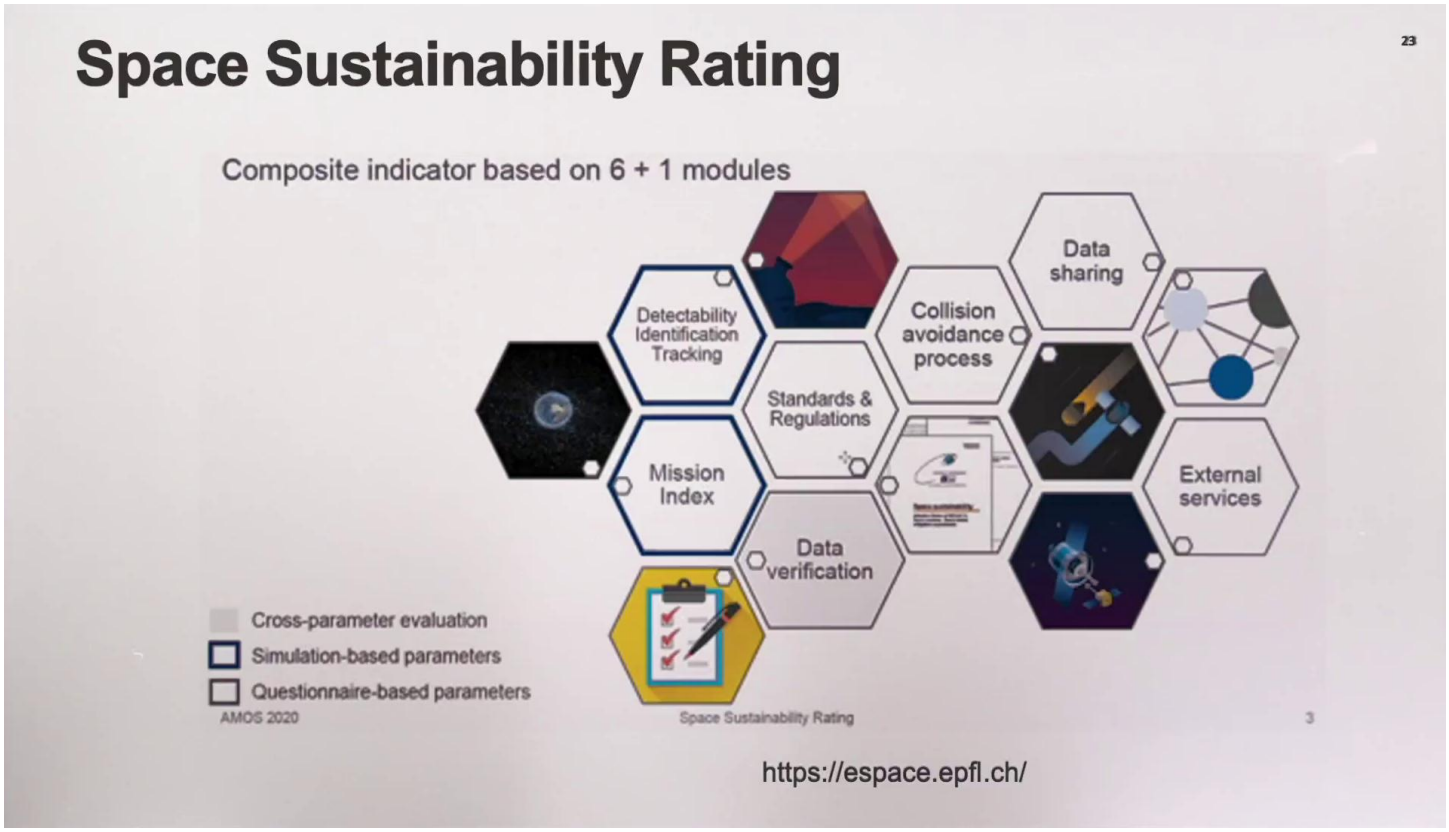


I've now presented you different solutions to design your spacecraft. To conclude on these lessons, I would like to present to you the Space Sustainability Rating. This rating allows you to assess, based on predefined criteria, the sustainability of your mission. Along your development, you can perform this assessment from the feasibility stage up to the disposal stage.

Notes

Summary

14m 11s



The Space Sustainability Rating is composed of seven modules, from two are computational, meaning based on simulation-based parameter such as the orbit, the probability of facing a collision, for example for the mission index, but as well as the detectability, identification, and tracking of your objects. The other modules are based on a questionnaire and are related to the compliance of your mission to space debris mitigation guidelines, the data verification, if you have a collision avoidance process, how you are sharing data on your spacecraft, and the compatibility to external services. This rating shall allow to have a more transparency on how missions are conducted and help you design more sustainable missions.

Notes

Summary

14m 42s

Conclusion

- **Why do we speak about sustainability in Space?**
  - Space is not an infinite ressource
  - Orbits are crowded
  - Risk of collisions and loss of spacecraft
- **What is Space Sustainability?**
  - Definition of the UN
- **How can you design more sustainable missions?**
  - Guidelines and their principle
  - Design for demise
  - Space Sustainabilty Rating

With this, I hope I've introduced you to some of the first notions around sustainability in space and how you can contribute to the more sustainable use of outer space. Space is not an infinite resource, and orbits are crowded. We went through the UN definition of space sustainability, explaining that we shall maintain the conduct of space activities indefinitely into the future. Then, we have explored how you can design more sustainable missions by learning about the space debris mitigation guidelines and the principles. We've introduced a few technical aspects to consider while developing and planning a space mission. I've also presented the concept of design for demise, and I've introduced to you Space Sustainability Rating. Sustainability is nowadays the concern of everyone, and you should take this into consideration while operating in space. I thank you for your attention.

Notes

Summary

15m 45s