EcoDesign – Where does ESA stands ?

EcoDesign Team

21/09/2021

EcoDesign Scope

EcoDesign

Is necessary to understand how much space activities pollute on Earth and to identify alternatives to reduce the environmental impacts

LCA (Life Cycle Assessment)
Assessing the environmental impacts of the whole life cycle of the space missions

Eco-design
Identifying alternative processes or technologies that can be used to reduce these impacts

Environmental regulation
Finding alternatives to abide by legislations and avoid costly disruptions

ecodesign

Context: Space sector at international level

United Nations

General Assembly

Committee on the Peaceful Uses of Outer Space
Scientific and Technical Subcommittee
Fifty-fourth session
Vienna, 30 January-10 February 2017

27.3 States and international intergovernmental organizations should promote the development of technologies that minimize the environmental impact of manufacturing and launching space assets and that maximize the use of renewable resources and the reusability or repurposing of space assets to enhance the long-term sustainability of those activities.

Agenda 2025

ESA Director General's Agenda 2025 published in March 2021 reiterated that **making ESA "a greener organisation"** is a **priority**, to support the implementation of the Paris Agreement and the European Green Deal to the fullest extent

Assessment of the environmental performance

GREEN Tech

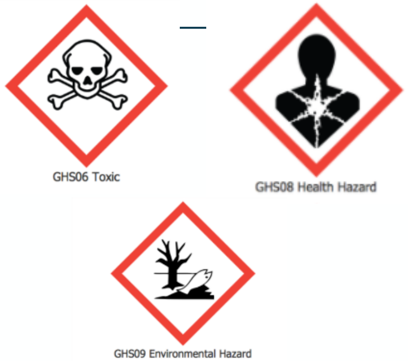
GREEN Design

GREEN Materials

GREEN Initiatives

GREEN Propellants

- Toxicity ? (impact on Human health)
- Eco-toxicity ? (impact on Ecosystems)
- Carbon Footprint ? (impact on Climate Change)
- Bio-based ? (impact on resource depletion)
- Only compliant with the European legislation?



It also works with '**Eco-friendly**'

Reliable, comparable and verifiable information also plays an important part in enabling buyers to make more sustainable decisions and reduces the risk of 'green washing'. Companies making 'green claims' should substantiate these against a standard methodology to assess their impact on the environment. The Commission will step up its regulatory and non-regulatory efforts to tackle false green claims.

Brussels, 11.12.2019
COM(2019) 640 final

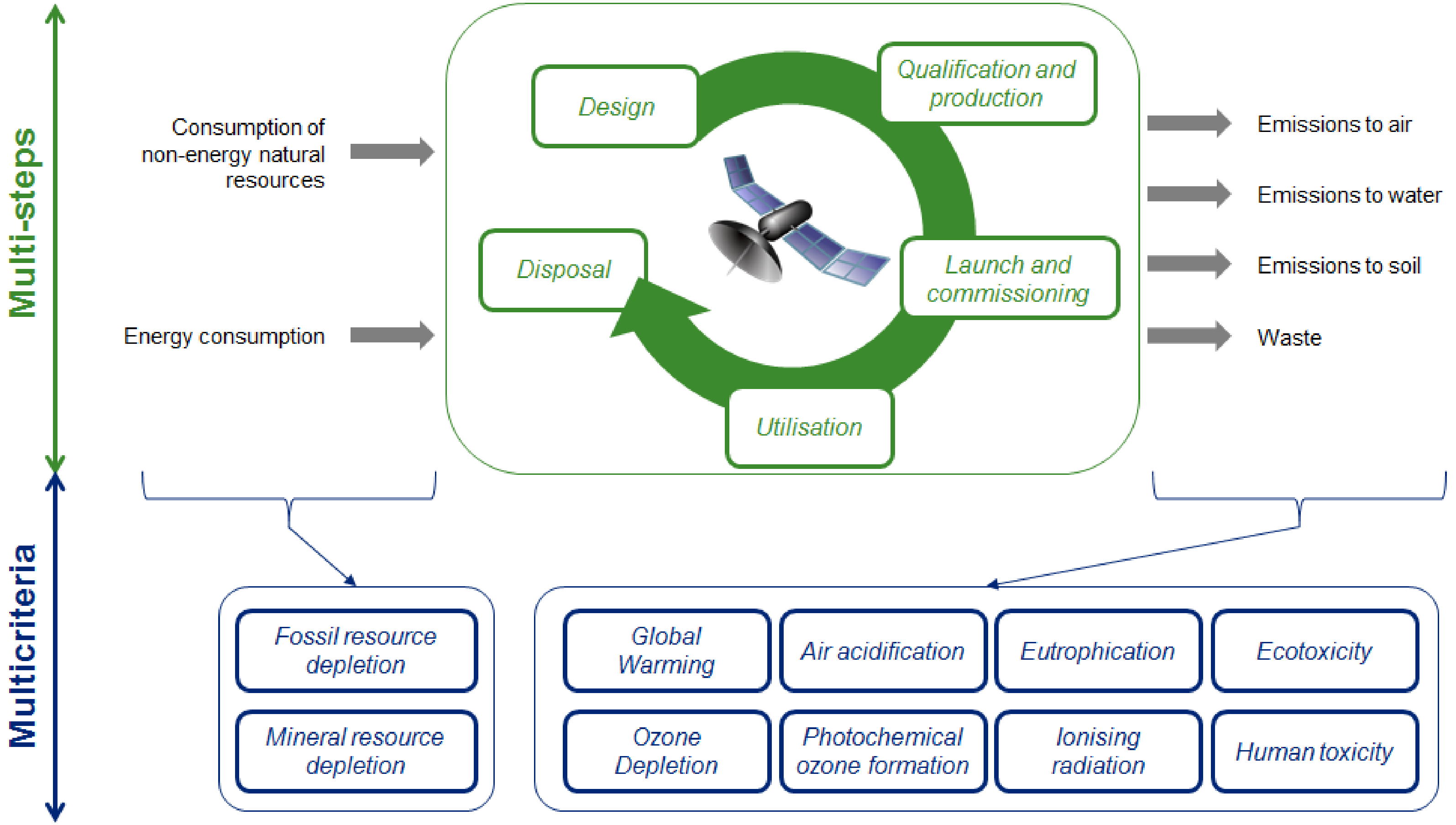
What are the environmental impacts of space activities conducted by ESA?

Life Cycle Assessment – Definition

LCA is an ISO-standardised tool to quantitatively assess the potential environmental impacts of product, process or service

- ✓ **Multi-step analysis**
  The environmental impacts are assessed across all stages of existence.

- ✓ **Multi-criteria analysis**
  The outcomes are expressed with several quantified environmental indicators (impact categories).



Life Cycle Assessment – Rationale

Why LCA ?

Takes in account full life cycle and full set of environmental impacts	• To have a complete picture, not only focussed on one impact category
Identifies environmental hotspots	• To provide a basis for environmental impact mitigation
Performs technology trade-off	• To support eco-design and avoid burden shifting (i.e. reducing impact from impact category but increase it in another)
Delivers visual clear outputs	• To support communication on environmental issues
Better monitoring of the supply chain	• To trace compliance with environmental legislations and avoid potential project disruption

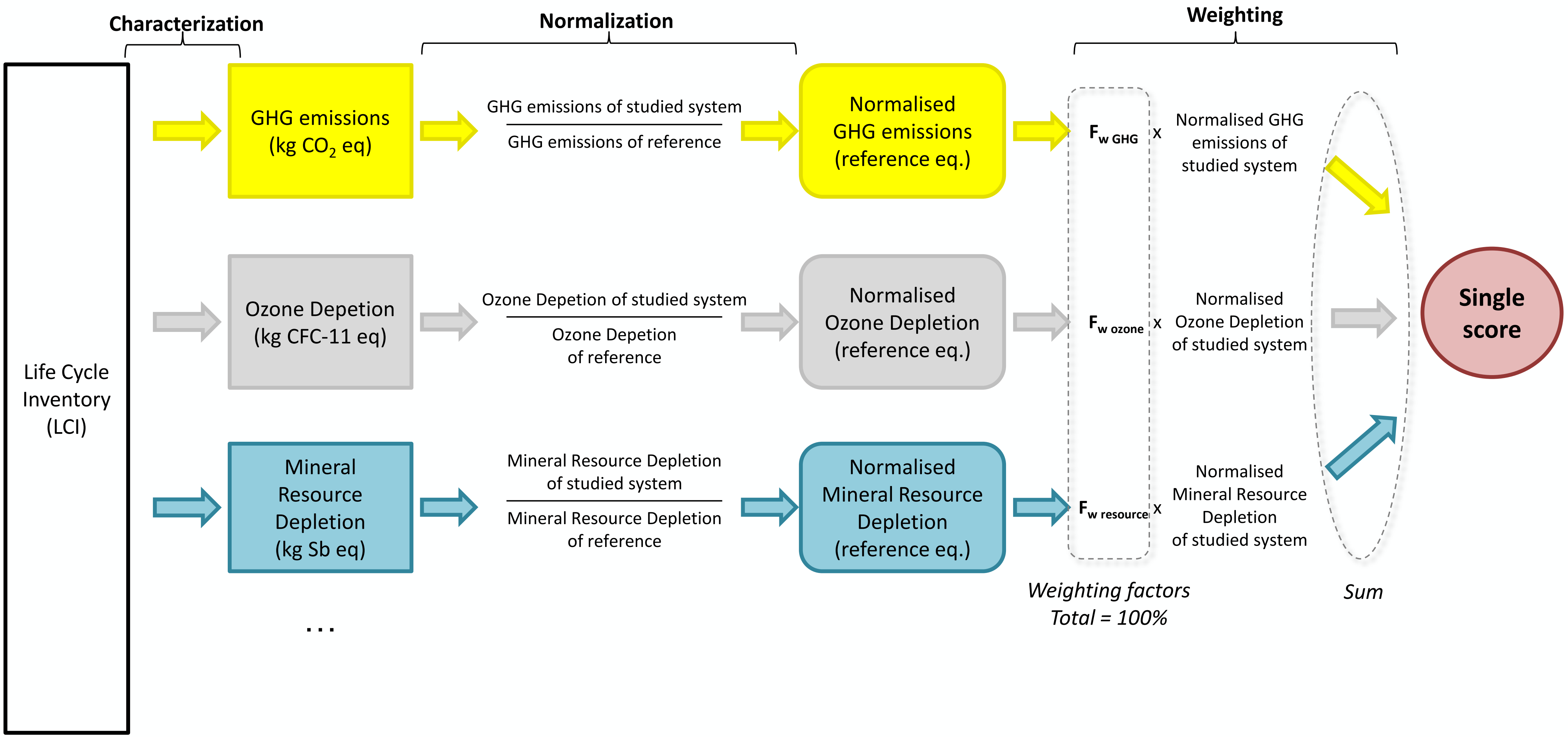
Life Cycle Assessment – Application to Space

The Space sector presents some specificities:

- the low production rates,
- the use of specific materials and components not included in standard databases,
- the fact of having direct emissions into all layers of the atmosphere,
- the required specific and power demanding tests,
- the long time needed for research and developments
- Relative short use phase

➡ **Adaptation of the LCA had to be performed and tools were developed**

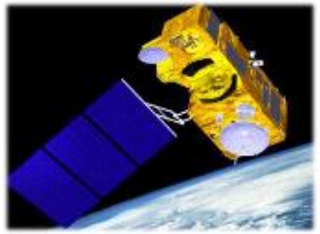
Life Cycle Assessment - Single Score Figure



Life Cycle Assessment - Framework

LCA Launch Segment

LCA Space Segment



LCA Ground Segment

Available under request

ESA LCA Handbook

ESA LCA Database

Available under ESA contract*

Dedicated presentation Wednesday 22th at 2pm

Dedicated presentation Tuesday 21th at 4pm

What are the lesson learned from applying LCA to the Space Sector ?

Methodological Challenges

Defining the Functional Unit

- **Definition**: A FU is a quantified description of the function of a product that serves as the reference basis for all impact calculations, interpretation and use of the results.
- For hand dryers, the FU can be: *Dry 1 pair of hands in less than 15 seconds.*

➔ Defining a common functional unit is especially complex in the space sector as most missions have different purposes or functions (Earth Observation, Navigation, Telecommunications, Science).

Data Management challenge

- Long development time vs tools & methodologies evolving fast
- Comparing the different models using outdated data and initial software version

OR

- Doing the constant update, but then can impacts really be compared between iterations ?

Defining the Scope Challenges

Impact of Testing

- From low TRL up to launch, multiple testing is required
- Low production rate and high reliability required
- Important environmental impact, important power consumption and resources needed

➔ Difficult data collection & characterization

➔ Detailed analysis is required

Impact of Infrastructure

- Space mission facilities are used to different ends and for multiple missions → hard impact allocation and high uncertainties

➔ Separate assessment is recommended

➔ No further action is foreseen

Impact of R&D

- Long lasting
- Challenging because : heritage, data collection uncertainties and usage, difficult allocation

➔ Only R&D dedicated to a mission is recommended to be included

Impact of Office Work

- Dependent on the location, multiple location, multiple contract for early phases
- Heritage how much is allocated to an isolated process

➔ Difficult allocation and high uncertainties

➔ No further action is foreseen

Quantification on Environment Challenges

Spacecraft demise impact on atmosphere

- Show relatively low impact
- But High uncertainties

→ Need for in-situ data

Dedicated presentation Tuesday 21st at 3pm

Launch events impact on atmosphere

- Still insufficient knowledge about the characteristics of particles exhausted
- Not enough data to assess impacts at different altitudes

→ Need for in-situ data

Sustainability rating Wed 22st at 2pm

Impact on Deep Sea

- Impact of launchers in deep sea is difficult to evaluate as it is location specific (ecosystem)
- Size of the object vs size of the ocean

→ Case by case studies would be needed with high uncertainties of results

Space Debris

- LCA quantifies environmental impacts on the Earth Eco Sphere
- Space Debris Mitigation Guidelines regulates the Space environment

→ No single tool can include the two

Summary of the Challenges

Defining the Functional Unit

Data Management challenge

Impact of Testing

Impact of Infrastructure

Impact of R&D

Impact of Office Work

Spacecraft demise impact on atmosphere

Launch events impact on atmosphere

Impact on Deep Sea

Space Debris

Q&A

What do we know so far ?

Launchers

LCA Launch Segment

Background

- Environmental impact of the European family of launchers, namely Ariane 5, Vega, and Soyuz launched from CSG assessed in 2011/2012 by BIO by Deloitte.
- A5 and Vega updated in 2014 and 2020 with additional inputs.

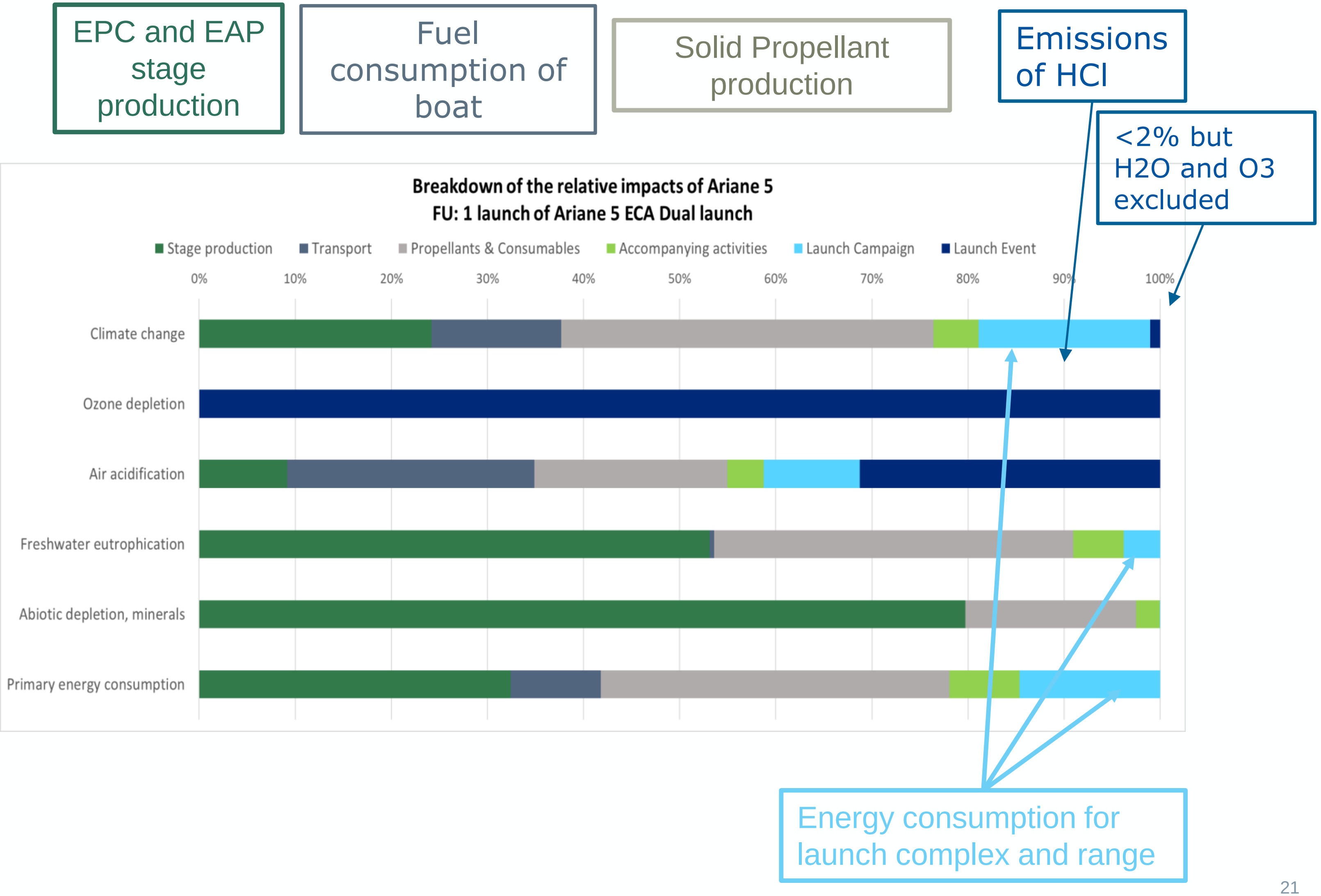
Scope of LCAs

- **A5** and **Vega** (Soyuz discarded due to too many uncertainties).
- Only **exploitation phase** of launchers following LCA Handbook guidelines

Launchers

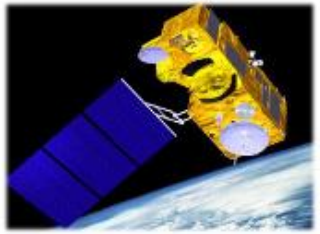
Common Hotspots

- **Stage production** (dry mass production) and **Propellants & Consumables** production are the most impacting steps for all environmental impacts of Ariane 5 and Vega except for
  - Ozone depletion caused at 100% by **Launch event**
  - **Fuel consumption of the boat** for transportation



Satellite

LCA Space Segment



Background

- **Need to understand environmental impacts of satellites**
- Studies performed from 2013 with BIO (by Deloitte), VITO and D'Appolonia
- Sentinel 3 updated in 2017

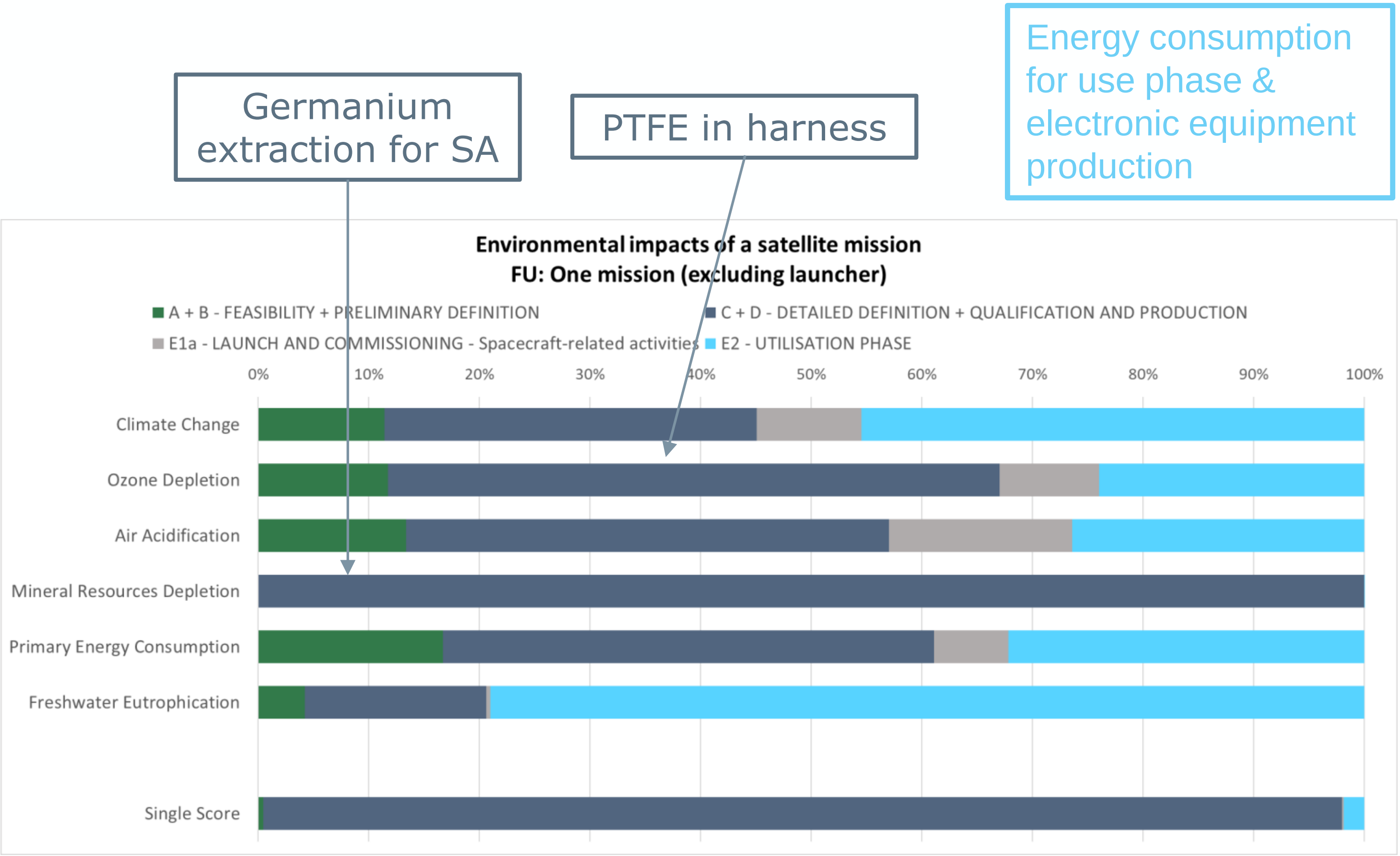
Scope of LCAs

- **Proba 2**, **Proba V**, **MetOp A, Sentinel 3** and **Astra1N**
- Mission type: Science, Earth Observation, Communication
- Including and Excluding launch

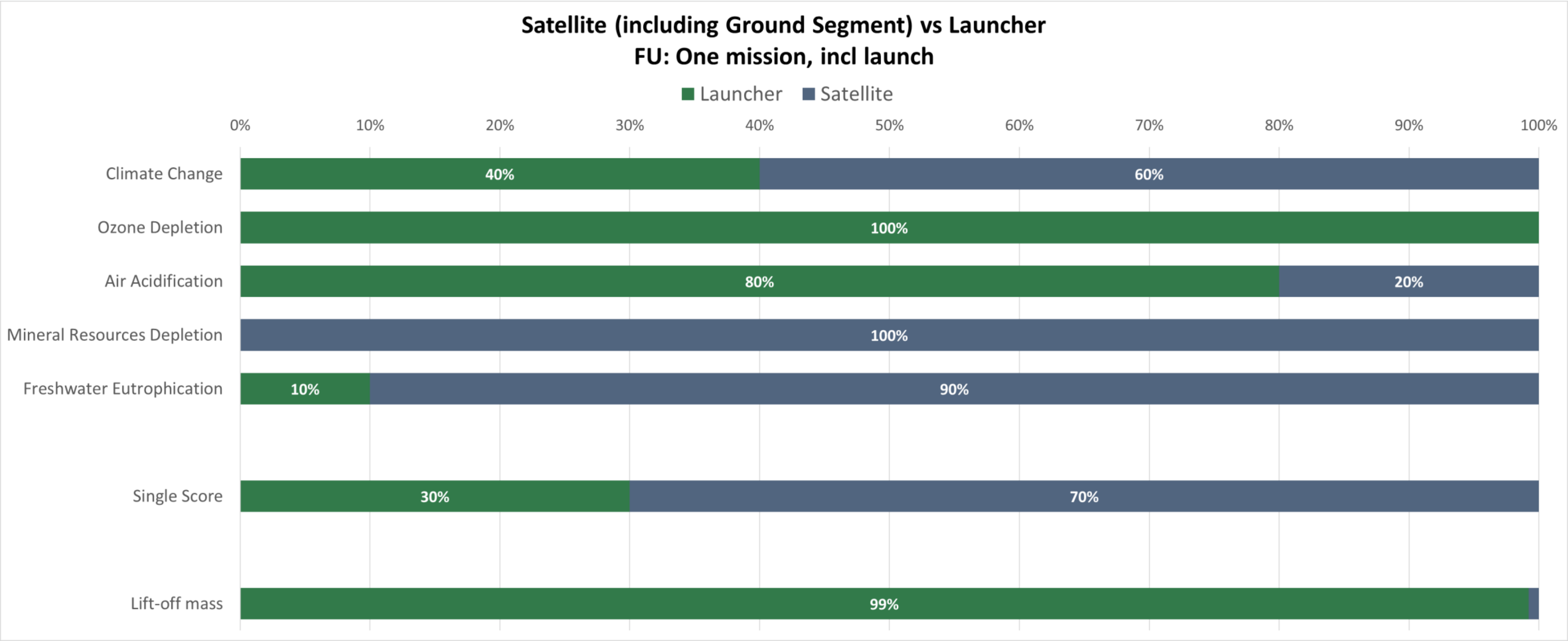
Satellite

Common Hotspots (Excluding launch)

- **Development phase** and **Utilisation phase** have the most impact
  - Phase C+D: energy consumption, **mineral resource depletion** (around 90% from **extraction of Germanium** and data processing) and **ozone depletion** (**PTFE** (Teflon) production for cable coating)
  - Phase E2: **energy consumption** and **production of electronics**
- **Energy related** for the majority of impact categories → Electricity consumption from non-renewable energy sources in all phases



Satellite vs Launcher



- When analysing satellite and launcher together, LCA results show that **100% of ozone depletion is due to the launcher**.
- Contrariwise, **100% of mineral resource depletion is due to the satellite**.

➔ This is not a final result and still work in progress.

Ground Segment

Background

- Evaluate the impacts of the different facilities of the Ground Segment (MOC, SOC, GSTta)
- Evaluation of the **Mission and Operation phase**
- Evaluation of the impact of **development of the facilities**

LCA Ground Segment

First Results

- Looking at a single mission use of the Ground Segment
  - Utilisation phase has the most impact with **energy consumption**
  - Regarding the mission types some might need some **specificities** that can impact more (larger data storage, development of new antennas,…)
- Higher impact for the development of **Ground Station** mainly due to **the structure holding the antenna**

2 Dedicated presentations
Tuesday 21th at 2pm

Second study

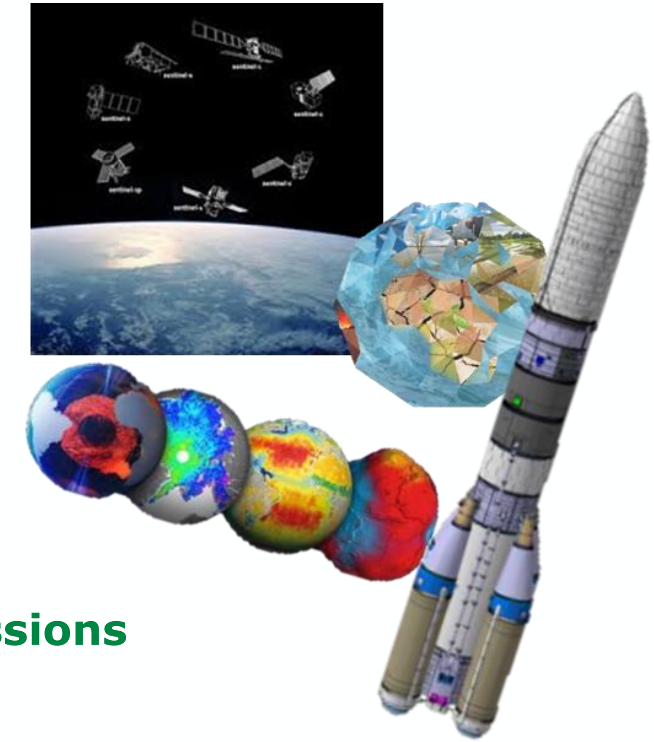
- Evaluate the impacts of the most impactful of the facilities: **the Ground Station**
- **Kiruna** and **Cebreros** Ground Stations

Second results

- Structure of the antenna impacts most indicators
- Electronics impact (lead-acid batteries, cables) in resource depletion

Application of LCA in space

Green Technologies ⟷ ESA Projects



- Ariane 6
- Earth Explorer 9 & 10
- Copernicus Expansion missions
- Galileo 2^{nd} Generation
- …

Q&A

What has been done to mitigate those impacts ?

Eco-design definition

"Eco-design considers environmental aspects at all stages of the product development process, striving for products which make the lowest possible environmental impact throughout the product life cycle"

The main objective of eco-design is

- ✓ To **improve the environmental performances** of products and services through the assessment of their environmental impacts
- ✓ Starting from **the design phase** and this,
- ✓ **Without reducing their final quality or performance**.

LCA → **Hotspot identification** → **Eco-design**

GreenSat

Background

- In 2017 two parallel studies to **re-design** existing space missions
- **Using eco-design practices** on real satellites
- With the objective to use eco-design **to reduce by 50% the environmental impact** of at least **3 eco-indicators** without increasing the others
- Launch segment is excluded

Hotspots → **Alternatives**

	Hotspots	Alternatives
PROBA V	• PTFE in system and subsystem harnessing • Data processing during phase E2 • Testing • The use of germanium for solar cells • Level of autonomy of the PROBA systems • Electronic assemblies	• Use PE instead of PTFE • Data processing improvements • Include virtual thermal testing methods • Use recycled Germanium for solar panels • More on-board versus on-ground autonomy • Optimize electronics
S3B	• The use of germanium for solar cells • Centralised Avionics • Propellants	• Use ELO technology for solar cells • Decentralise avionics • Replace N2H2 with a REACH compliant propellant

GreenSat

Conclusions

- Eco-design **can** be applied to space systems.
- Eco-design should **focus** on environmental **hotspots** which either affect multiple indicators or are high contributors in a single impact category.
- 50% reduction in 3 indicators could not be achieved,
- But alternative solutions could be identified and analysed**, showing significant reductions** of the environmental impacts of missions **without transfer of impacts** (burden shifting) and sometimes **improved overall performances**.

➔ Most promising solutions are **under dedicated studies**.

Green Technologies – ESA Overview

Definition of Green Technology from the ESA Handbook

Technologies designed with the aim of decreasing their Earth environmental impact.

This is achieved by performing a life cycle assessment to show an improvement with respect to the existing technology.

The following criteria are taken into account:

- ✓ Reduction in the consumption of resources and energy
- ✓ Engaging pro-actively with environmental legislation
- ✓ Managing the residual waste and polluting substances as a result of activities

At ESA, we are:

- Defining an updated definition of a green technology/process/material
- Working on a methodology to rate technologies and classify them as totally green, intermediate or not green
- Investigating different green technologies/processes/materials

Green Technologies – Studies

Green Technologies derived from LCA hotspots

- Effective use of Germanium
- Green electronics

Other Green Technologies (derived from legislation or other sources)

- Electroless plating
- Green polyurethane
- Electrically conductive black primer
- Citric acid as replacement of nitric acid
- Fingerprinting of materials and processes
- Bio-composite structure
- etc

Environmental Legislation → **Alternatives** → **LCA**

LCA → **Hotspot identification** → **Eco-design**

Dedicated session Thursday 23rd

Green Technologies – Example

Citric Acid as a Green Replacement for Steel Passivation

Environmental Legislation

Potential risk from Nitric Acid: Toxicity

Alternatives

- Alternative identification: Citric Acid
- Identification of materials for testing

LCA

LCA comparison of Nitric Acid VS Citric Acid

CONCLUSION

- **Many LCA studies** have been performed covering missions and technologies.
- The **LCA Database and Handbook** are essential tools but need to be maintained and improved.
- Applying LCA to space systems is not an easy task and there still are many challenges to overcome.
- Some **uncertainties s**till exist **to characterize** the impact of space systems.
- Comparison of space systems is complicated (challenging to compare iterations of the same product and even more difficult to compare one system with another)
- **Recurrent impacts/hotspots** were derived from LCA and **solutions** are under development.
- Eco-design can be applied but further work is required.
- Eco-design is still premature but we are paving the way.
- Creating awareness among university, industry and ESA is paramount.