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Environmental Expert Evaluation of ESA Space System Life Cycle Assessment Guidelines

Clean Space Industrial Days – October 11, 2022

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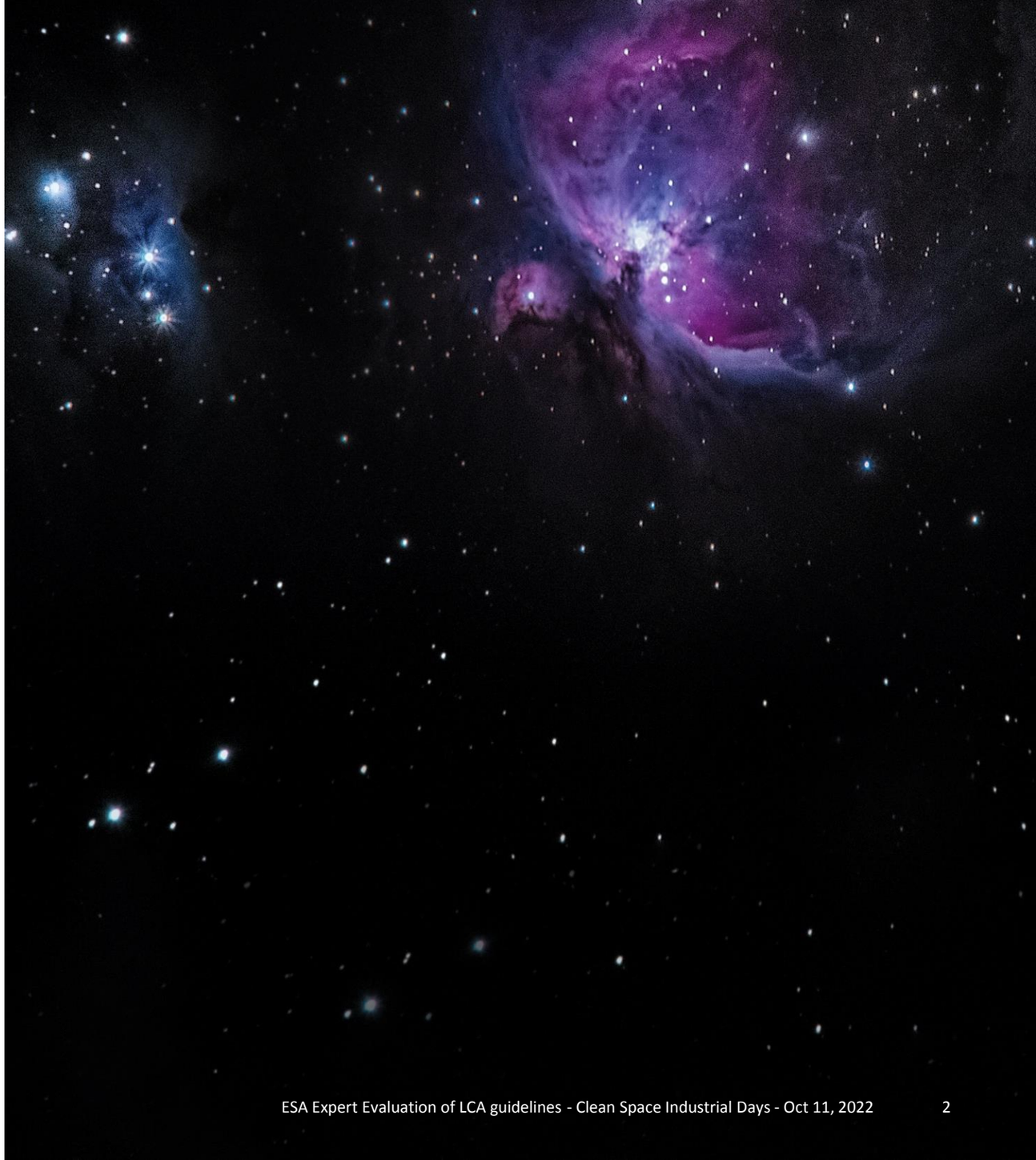
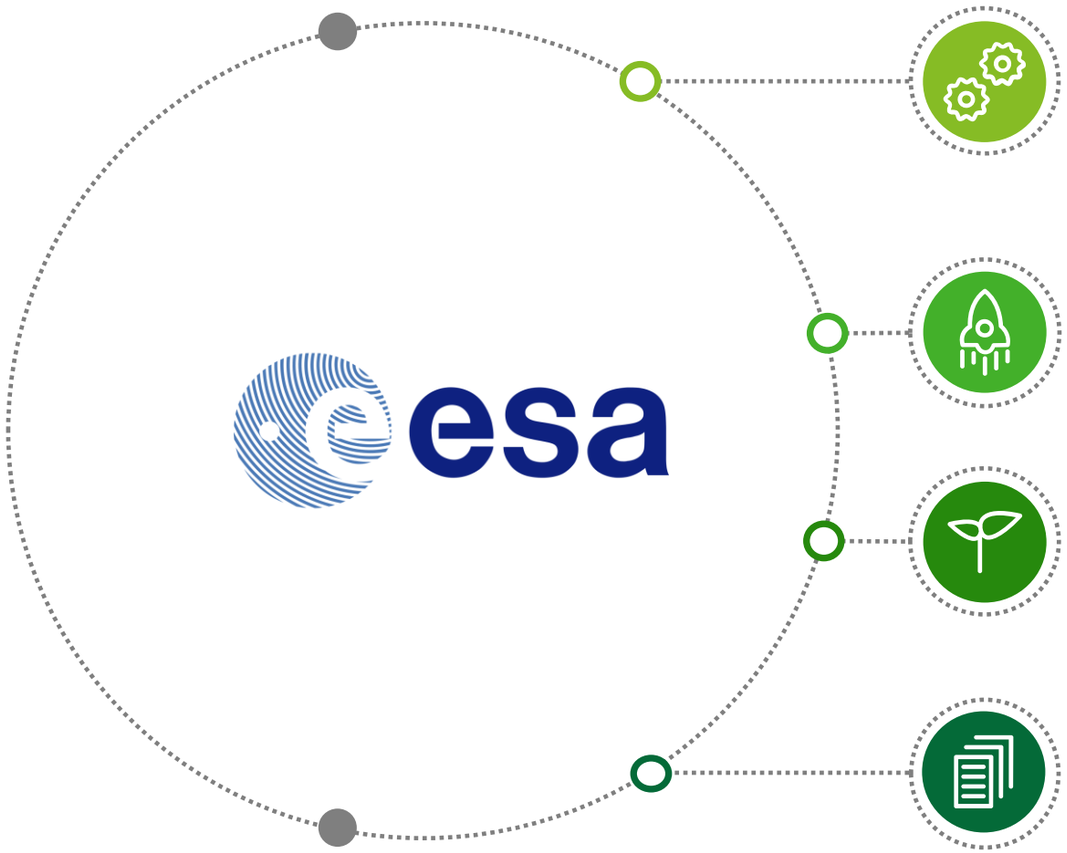
Agenda

Context and objectives of the project (3 mins)
LCA (10 mins) *Methodological approach* *Key findings of the gap analysis of the Handbook* *Examples of high-level suggestions for the ESA LCA Handbook update*
Ecodesign (7 mins) *Methodological approach* *Key findings of the ecodesign analyses* *Potential avenues for developing ESA ecodesign directives*
Questions (10 mins)



Context and objectives of the project



In 2016, ESA published the first worldwide guidelines on how to perform LCA of space systems

This first publication of the guidelines was based on previous ESA LCA studies and on the European guidelines at the time.

ESA and different European stakeholders have used the Handbook

In the past years, more ESA projects included LCA requirements (e.g. Ariane 6, Copernicus, Earth Explorers, Galileo, etc.).

Increased public environmental concern and more stringent European environmental regulations

This environmental and LCA requirement is expected to be included in more ESA projects in the coming years

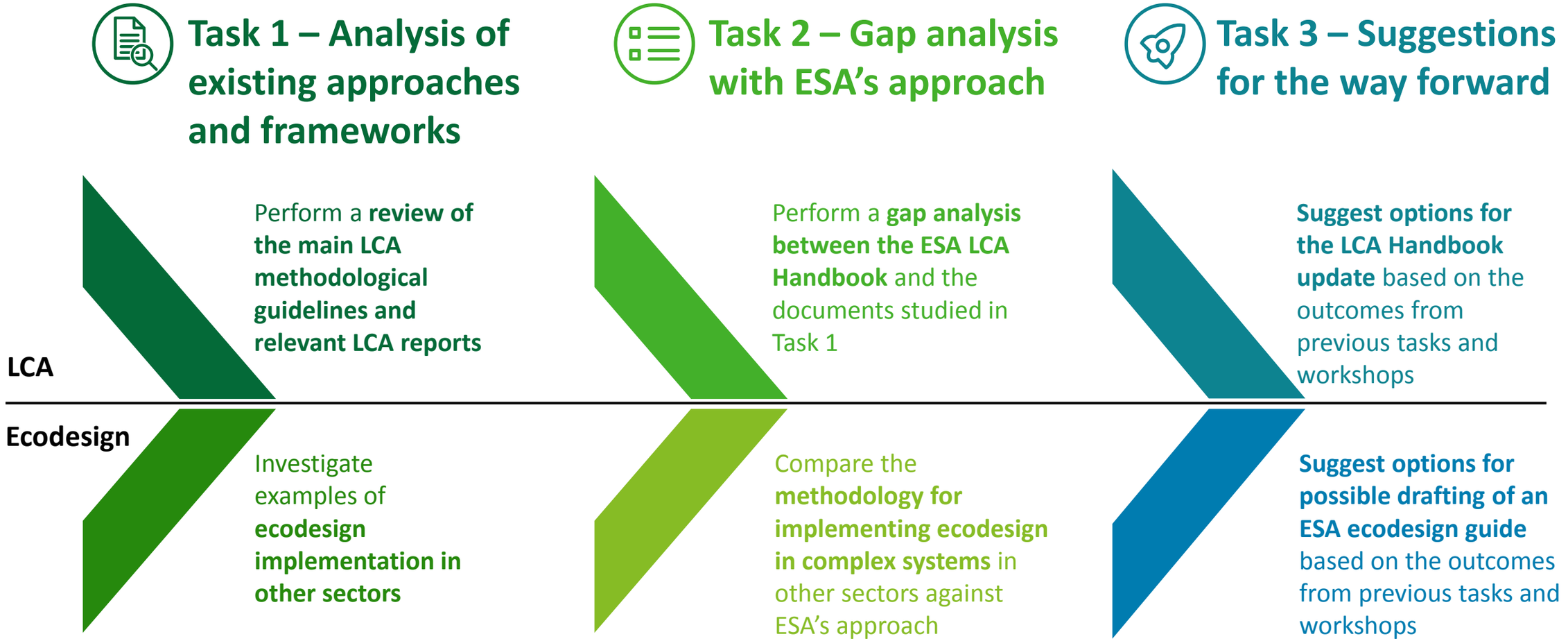
It is essential to keep the Handbook up-to-date

This is in order to keep ESA's leading position in the field of environmental impacts assessment for space systems.

Project objectives > suggest options for the LCA Handbook update:

1. to align the LCA methodology with other existing LCA frameworks where it is relevant and benefit from the return on experience of recent space LCA studies and
2. for the inclusion of guidelines for the use of LCA in the context of space system ecodesign.

Methodological approach



Methodological approach for LCA

Task 1 – Analysis of existing approaches and frameworks

Perform a **review of the main LCA methodological guidelines and relevant LCA reports**

- Review of **16 LCA guideline documents**:
  - The PEF 2013 guide and 2019 update, PEFCR guidelines, 4 PEFCRs
  - International EPD system GPI and 5 PCRs
- Review of **ESA previous LCA project reports**:
  - Ground segment LCA final report
  - Ground station LCA final report
  - GreenSat final reports

Task 2 – Gap analysis with ESA's approach

Perform a **gap analysis between the ESA LCA Handbook** and the documents studied in Task 1

- **Gap analysis** with:
  - LCA methodologies and documents reviewed in Task 1
  - User inputs

Task 3 – Suggestions for the way forward

Suggest options for the LCA Handbook update based on the outcomes from previous tasks and workshops

- Organisation of **three workshops** with the Clean Space Office, LCA academic experts and the space industry
- High-level suggestions for the Handbook update

LCA

Key findings of the gap analysis of the Handbook…

…with other LCA methodologies

System boundary

Model robustness assessment

Results interpretation

Data and data quality requirements

Example of gap

There are outdated characterisation methods for impact indicators in the ESA Handbook, as well as a doubling up on the mineral resource depletion indicator.

Environmental impact categories and characterisation methods

Normalisation, weighting and single score

Example of gap

There is **no guidance on how to perform data quality assessment** in the ESA Handbook, especially compared to the PEF, which includes a clear procedure.

Review

Miscellaneous

…with other ESA reference documents

Ground segment

Compared to the ESA Handbook, the Ground Segment LCA methodological framework and report, and the Ground Station LCA report **provide significantly more detail on how to account for the ground segment in space systems LCA**.

Examples of high-level suggestions from the findings of the gap analyses

Focus areas	*High-level suggestions*
System boundary definition	*Focus on next slide*
Environmental impact categories & characterisation methods	To use the EF method environmental impact categories and characterisation methods, with some additions or adjustments for space specificities
Data and data quality requirements	• To include an approach inspired by the “Data Needs Matrix” to help practitioners identify for which processes specific data is required • To refine the list of processes for which specific data is required • To include the PEF data quality assessment procedure
Normalisation, weighting and single score	To use the EF method normalisation and weighting factors
Model robustness assessment	To outline the different methods of model robustness assessment
Results interpretation	To suggest the use of the PEF procedure for hotspot analysis

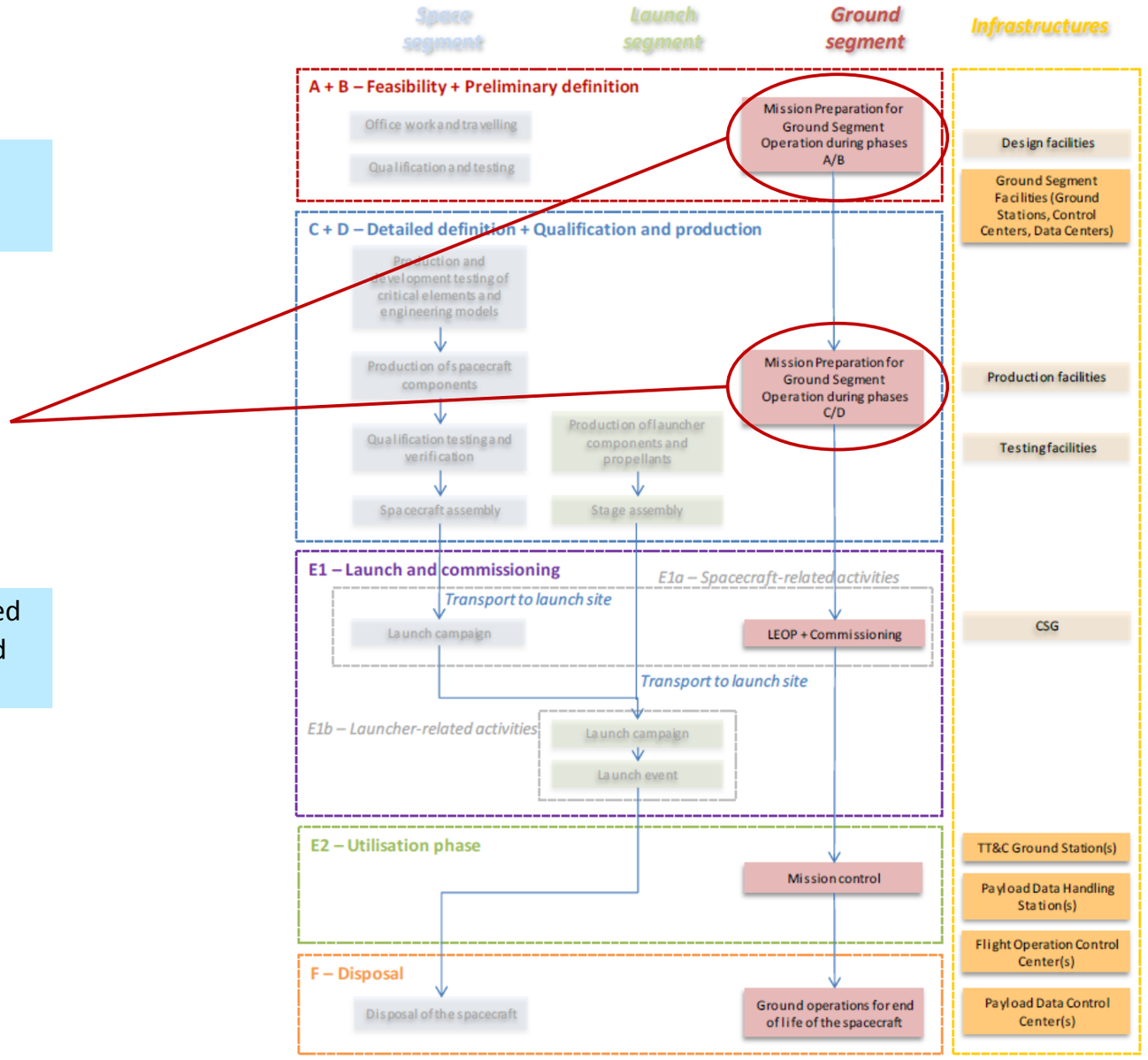
High level suggestions – system boundary
Focus on the ground segment (1/2)

High-level suggestion: to investigate whether or not it would be relevant to include the ground segment preparatory activities in Phases A-D

- The ground segment could be included in space mission Phases A-D: preparation and preliminary use of control centres including training of the operators, before the launch of the spacecraft.
- *Note: in the current Handbook, this preparatory phase could already be included in Phase E1a: "time of operation…during simulations/trainings to prepare these activities."*

High-level suggestion: to add more detail on what should included in terms of buildings, machinery and IT equipment for the ground segment

- In general, **all ground segment equipment** such as IT equipment, antennas, mechanical and electro-mechanical equipment as well as buildings **should be evaluated in the ground segment of a space mission LCA** (production and end of life).
- LCA experts highlighted that in the case of MOC/SOC, then **all IT equipment should be evaluated but not as part of "infrastructures."**



High level suggestions – system boundary
Focus on the ground segment (2/2)

High-level suggestion: to add more detail on how to include those ground segment building blocks

- **Semi-specific models** could be developed to make it easier for practitioners, based on the LCI datasets developed in the frame of Ground Segment LCA and Ground Station LCA studies, with the procedure:

1. Hotspot analysis
2. Identification of key drivers which should be specified for each site (e.g. electricity consumption, antenna size)
3. Inclusion in ESA LCA database of generic “unit” datasets

- As a reminder, the Ground Station LCA offers a simplified Ground Station model, which could be provided by ESA as an LCI dataset for 1 year of operations.

High-level suggestion: to clarify the inclusion of IT equipment

- The inclusion of IT equipment must be consistent with the two other segments.
- As mentioned, other LCA standards do not include IT equipment as infrastructures.

Methodological approach for ecodesign

Review of ecodesign approaches in other complex industrial sectors

- Interviews with ecodesign representatives from 8 companies in 6 sectors
- Summary of key drivers and methodologies employed for ecodesign

Review of ecodesign approaches in past ESA projects

- Review of approaches used in 4 past ESA projects
- Analysis of ecodesign approaches in other industrial sectors and in ESA projects

Workshops and discussions with ESA experts

- Organisation of one ecodesign workshop with ~20 ESA (non-Clean Space) experts
- Discussions with Cost Engineers
- Summary of key learnings from the workshops

Potential avenues for developing ESA ecodesign directives

Key findings from…

…the ecodesign interviews

- **Environmental challenges** and ecodesign approaches are in fact **specific to each company**
- **LCA** is overall **widely used** by other industrial sectors
- Ecodesign can be based on LCA, but not only
- Initially, companies based themselves on existing environmental guidelines (LCA guidelines, ISO 14001), and with increasing experience, **developed their own internal ecodesign guidelines**
- **Multiple environmental indicators** are focused on, most notably: climate change, energy use, and recyclability
- Both a **product-oriented** approach and a **site-level environmental management** approach are commonly used
- **Collaboration between different actors in the supply chain** can facilitate data collection while complying with data confidentiality requirements
- Sponsorship and **support from top management** is necessary to implement ecodesign approaches
- Players in the space sector are generally **following ESA for guidance** on sustainability, LCA and ecodesign topics

…the ecodesign approaches in previous ESA projects

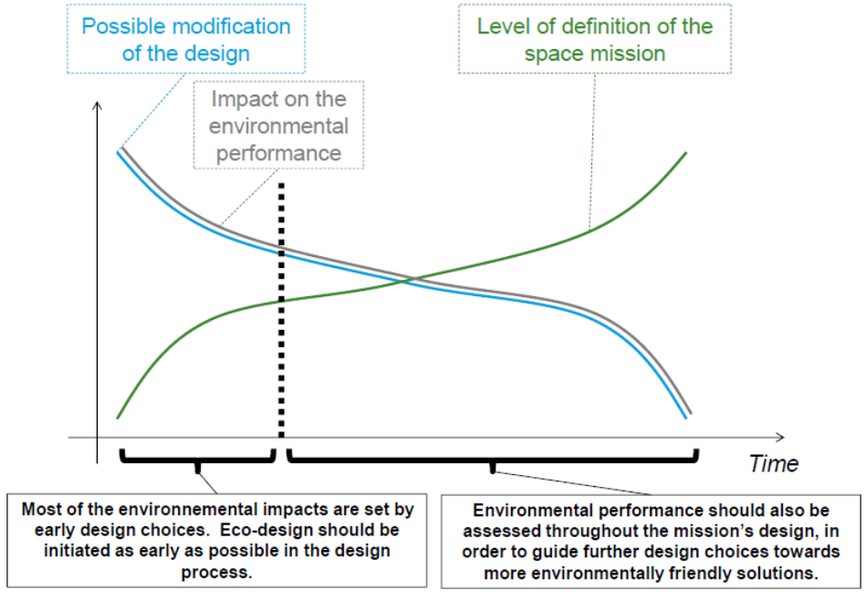
The **same general workflow was used in each project**: hotspot analysis of LCA results, identification of options with experts, and trade-off and selection of options.

Economic and **technical** criteria were used on top of **environmental criteria** for the trade-off and selection of options.

LCA of the ecodesign options tended to be conducted **to confirm the improved environmental performance**.

Potential avenues for developing ESA ecodesign directives

The **key challenge** in ecodesigning space missions is **data availability with respect to the space mission phase**.



It is only at a late stage in the design process that enough data is available for a full environmental quantification

LCA is relevant in ecodesign… But is it feasible to apply LCA at every stage of a space mission's design?

Further investigate on data availability by phase, by segment, and by mission type

First inputs:

- High-level trade-offs regarding the Launch and Ground Segment are taken early in the design.
- Launch and Ground Segment can represent 60% to 80% of the environmental impacts of a space mission.
- Launchers and GS elements are often chosen "off the shelf" which means that it is easier to make their environmental performance available to the design teams.

Develop a generic database for ecodesign (including semi-specific models)

Develop an approach to address uncertainty in the design process

Thank you for your attention!

Any questions?

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