USER EXPERIENCE OF THE ESA LCA HANDBOOK AND DATABASE

Clean Space Industry days – 23-25 October 2018

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AGENDA

- Introduction on the ESA LCA Handbook, Database and GreenSat project
- Application of the ESA Handbook and Database in the GreenSat project
- Recommendations for future updates
- Conclusions

INTRODUCTION

Space system Life Cycle Assessment (LCA) guidelines (ESA LCA Handbook)

- Developed by ESA with the goal of establishing **methodological rules** for performing **space-specific LCAs**.
- Why needed?
  - General rules for LCA are set in the ISO 14040 and 14044 standards. However, these **standards are not sector specific** and leave many options open for the LCA practitioner to decide. To obtain comparable results, further guidance is thus needed.
  - The **space sector is unique**: low production rates, long development cycles, specialised materials and processes and has impacts on environments generally not considered in LCA (direct emissions into the high atmosphere).
- LCA for the space sector is a **new area of development**. ESA thus finds it important to establish guidelines as early as possible, to allow the whole sector to carry out LCAs and communicate in a consistent way.

INTRODUCTION

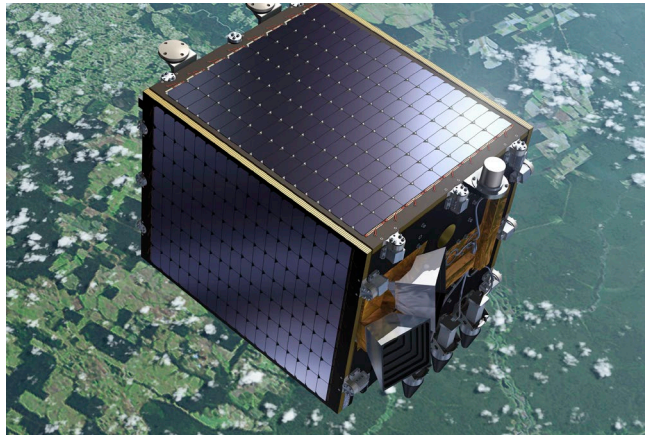
ESA LCI (life cycle inventory) Database

- Contains **space specific materials, components and manufacturing processes**.
- Why needed?
  - Components for space applications **differ from standard applications**:
    - Need to operate in an extreme environment, and thus require a lot of R&D and testing
    - Produced in very small quantities
    - Need to comply with ECSS standards
  - **Lack of publicly available data** for space specific materials and processes
- Some examples of what is included:
  - Materials: tungsten, different alloys of aluminium and titanium, thermoplastics (e.g. polyetherimide, polyether ether ketone), propellants (e.g. hydrazine, nitrogen tetroxide)
  - Manufacturing processes: electroforming, polishing and sanding, non-destructive inspections for propellant tanks
  - Components: solar panels, propellant tanks, wires, honeycomb structural elements

INTRODUCTION

GreenSat: Ecodesign of PROBA-V mission

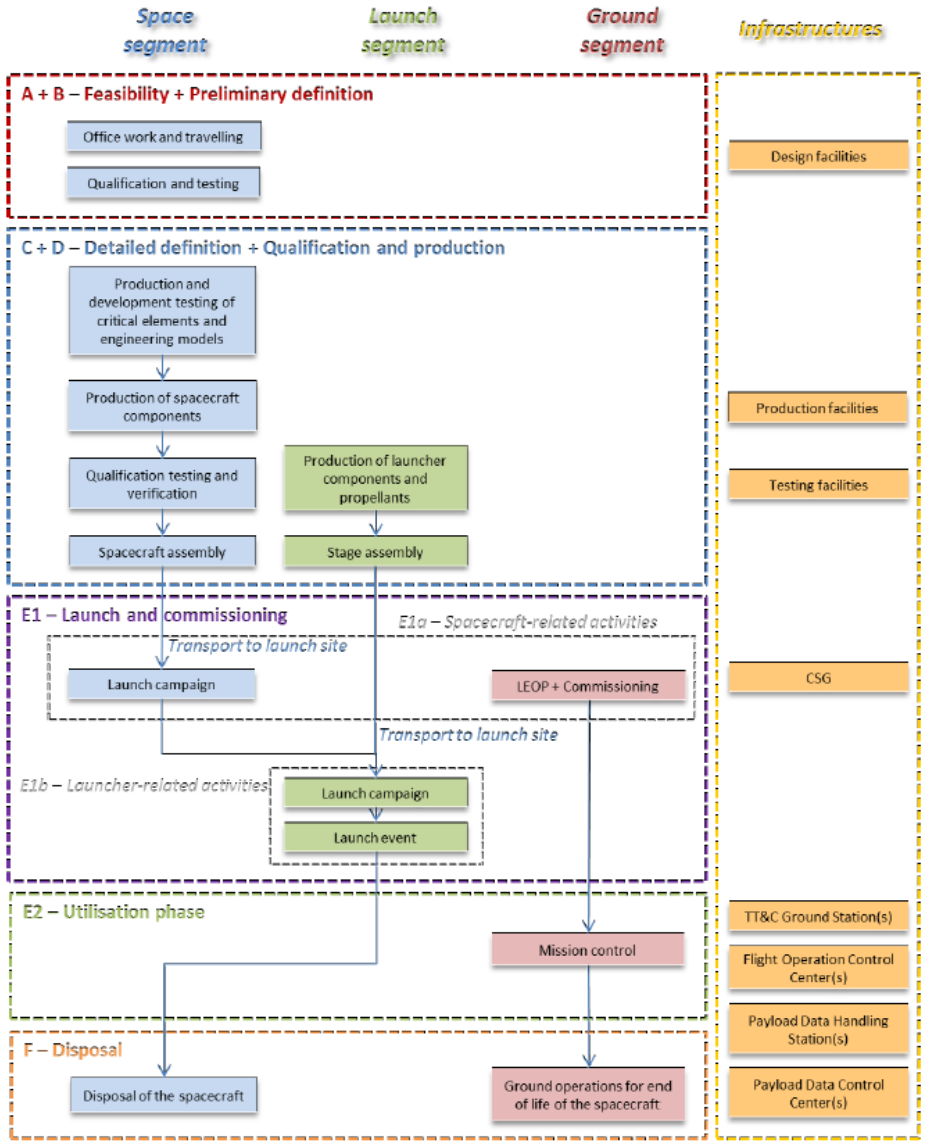
- Cooperation VITO – QinetiQ Space
- Objectives:
  - Redesign a space mission based on ecodesign principles
  - Identify relevant design improvement options, leading to at least a 50% environmental impact reduction on at least three impacts
  - **Use and test Space system LCA-guidelines and ESA LCI/LCA database**
  - Identify potential benefits and difficulties of performing and implementing ecodesign in European space sector



APPLICATION IN THE GREENSAT PROJECT

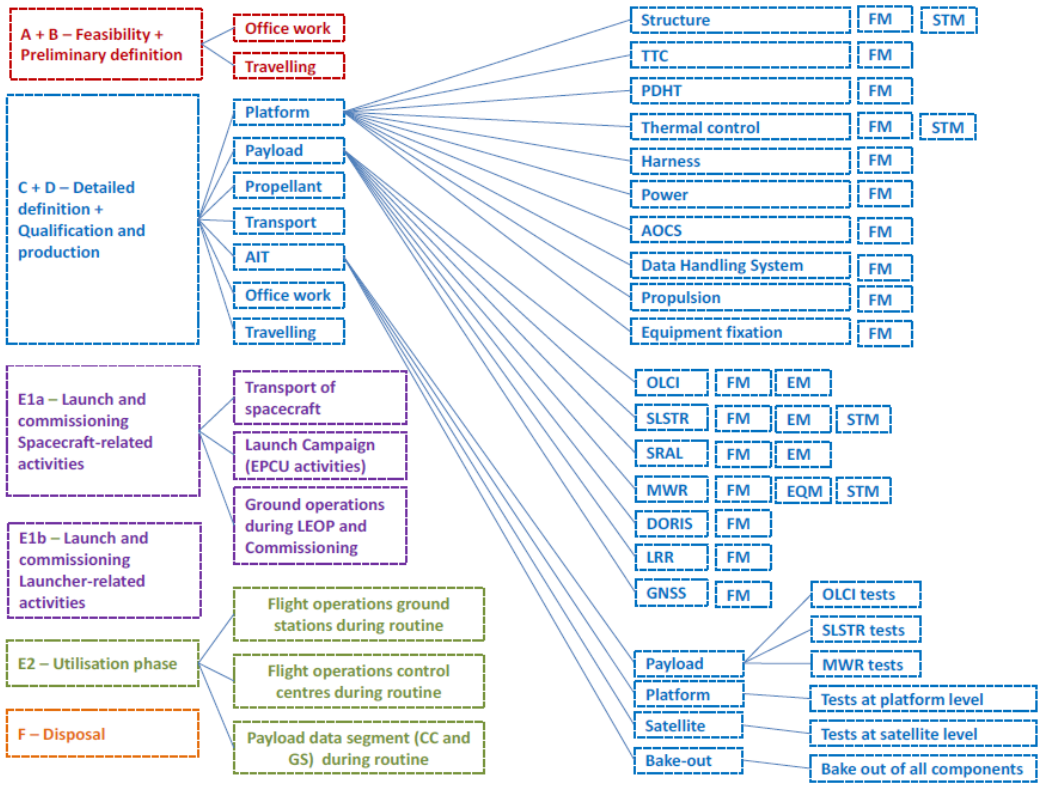
ESA LCA Handbook

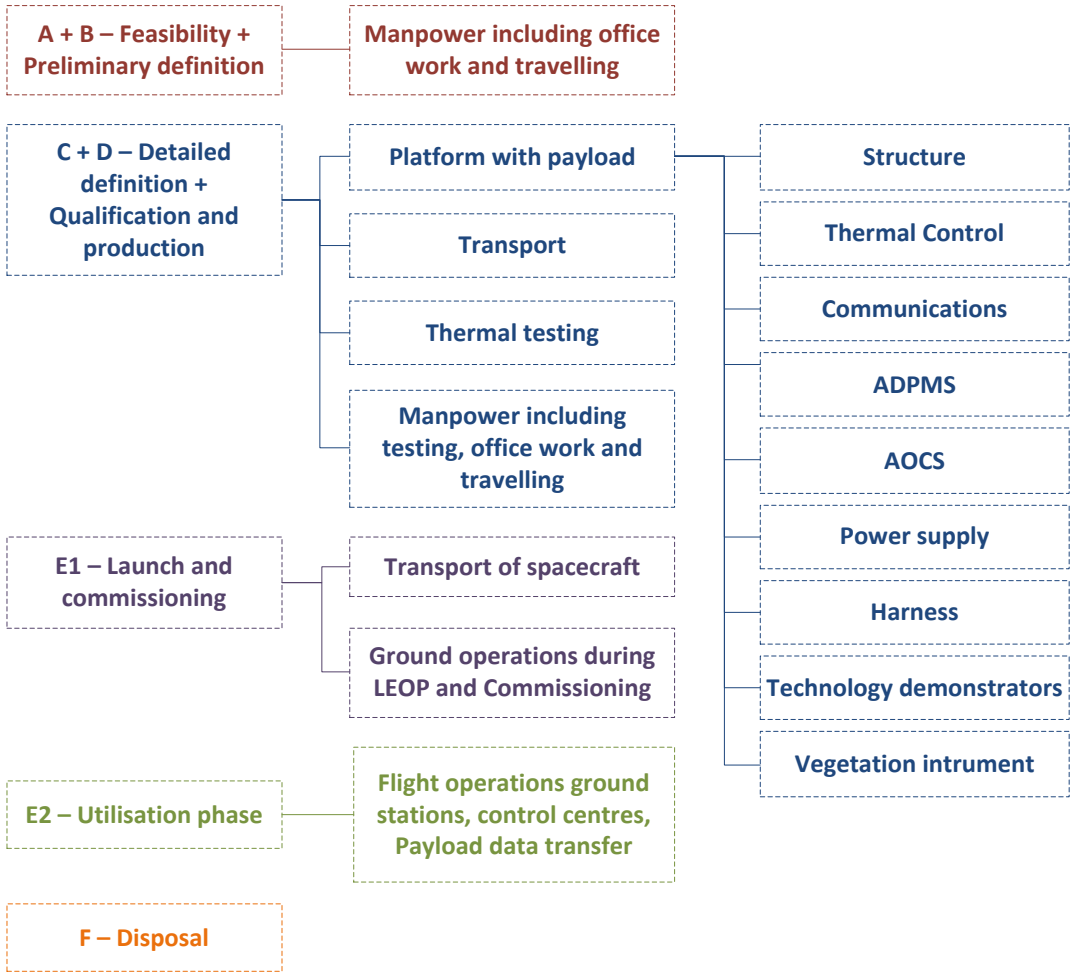
- **Functional unit**: “one space mission in fulfilment of the mission's requirements”
- Space mission **system boundaries**: distinction between space-, launch- and ground-segment activities
- Overview and description of the **different phases** of a space mission



APPLICATION IN THE GREENSAT PROJECT

ESA LCA Handbook → applied in GreenSat project





APPLICATION IN THE GREENSAT PROJECT

ESA LCA Handbook

- **Cut-off criteria**: “material/sub-assembly inputs constituting all together less than **5% of the total mass** of the component considered and for which all following justifications can be given, can be excluded from the scope of the assessment” (if no high risk materials)
  → **PROBA-V**: did not exclude any (known) materials, however rough estimates for the mass of smallest elements were used
- If no data are available or representative in **ESA database**, generic LCI datasets are to be used from:
  - LCI data sets of industrial federations
  - Generic databases like Ecoinvent
- Guidance on which **background data** to use, e.g. electricity mix of the considered country
- **Examples** of:
  - how to execute LCA for a battery module
  - data inventories for different components (in annex)

APPLICATION IN THE GREENSAT PROJECT

ESA LCA Handbook

Environmental impact assessment (LCIA) **method** + additional **flow indicators**

Environmental impact category	Unit
Global warming potential	kg CO_2 eq.
Ozone depletion potential	kg CFC-11 eq.
Human toxicity potential (cancer and non-cancer effects)	CTUh
Photochemical ozone formation potential	kg NMVOC
Particulate matter formation potential	kg PM2.5-eq.
Freshwater eutrophication potential	kg P eq.
Marine Eutrophication potential	kg N eq.
Mineral resources depletion potential	kg Fe eq.
Ionising radiation potential (human health)	kBq U^{235} eq.
Freshwater ecotoxicity potential	CTUe
Marine aquatic ecotoxicity potential	kg 1,4-DB
Fossil resources depletion potential	MJ
Mineral resources depletion potential	kg Sb eq.
Acidification potential	kg SO_2 eq.

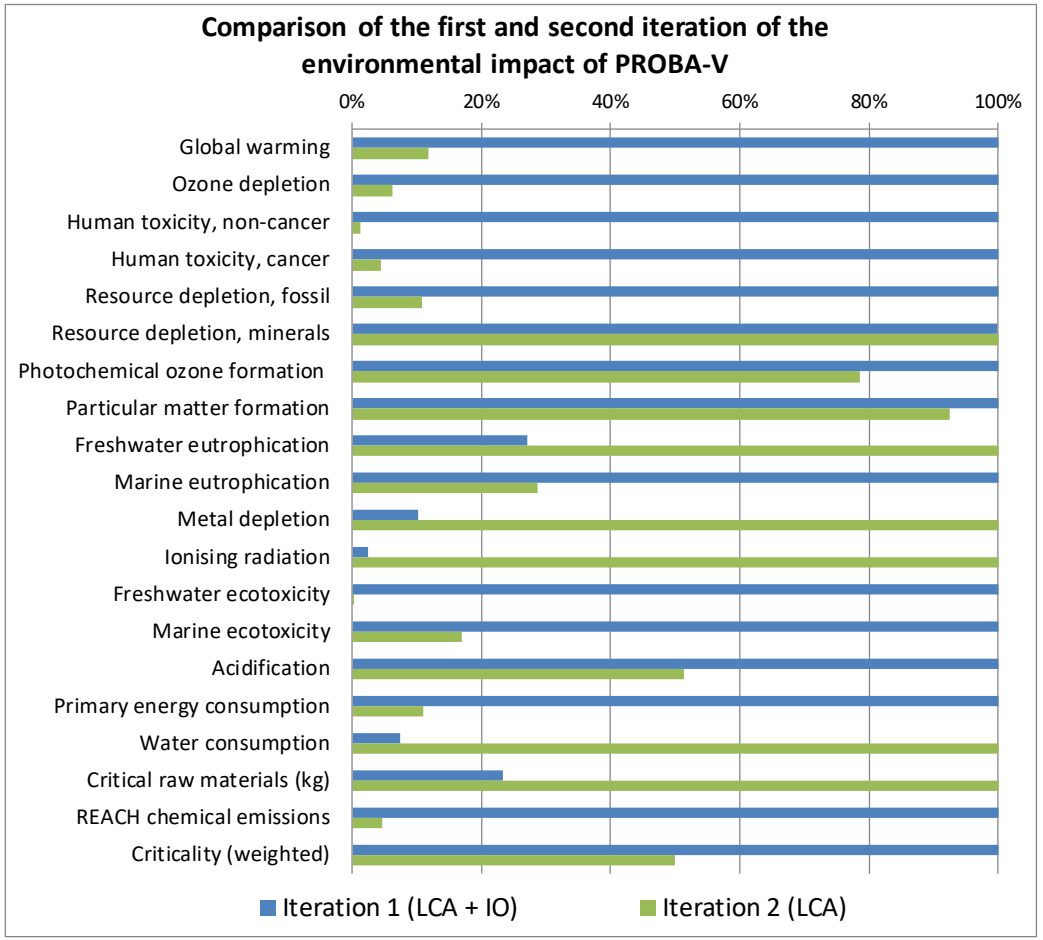
Flow indicator	Unit
Primary energy consumption potential	MJ
Gross water consumption potential	m^3
Critical raw materials	kg
REACH	kg

Added in GreenSat project:
weighted criticality indicator (taking into account socio-economic constraints of each material)

APPLICATION IN THE GREENSAT PROJECT

ESA LCA Handbook

- Use of **input-output (IO) data** considered problematic for the space sector by the ESA LCA Handbook.
- However, it also has **benefits**: allows to have a quick estimation of the magnitude of the environmental impact, and to take into account the full supply chain (there are no cut-offs).
- Furthermore, IO data can be used to model parts of the life cycle that are not really specific to the space sector, as is done with the manhours in the first iteration of the PROBA-V LCA.



APPLICATION IN THE GREENSAT PROJECT

ESA LCA Database

- Useful for the modelling of PROBA-V
  - several data records used:
    - especially on **material level** (e.g. aluminium and stainless steel alloys, polyetherimide, Glass Fiber Reinforced Plastic)
    - also on **subcomponent level** (e.g. wires, solar cells)

- **Adapting** the ESA LCA database records was **possible** thanks to the transparent, modular and adaptable structure and information provided.
  - For example, in the PROBA-V LCA this was done to create other alloys and to modify the cathode active material of the battery

RECOMMENDATIONS FOR FUTURE UPDATES

ESA LCA Handbook (1)

- Recommended to use the **terminology** “shall”, “should” and “may”
  - as applied in ISO 14040/44 standards and ILCD handbook

- Some sections would benefit from **additional clarification**, e.g.
  - scaling of environmental impacts of transport with volume or mass
  - calculation and interpretation of uncertainty

- Some sections could be strengthened by **explaining** why a specific **choice** was made, e.g.
  - choice of impact categories

- We suggest **leaving options open** in some cases, e.g.
  - avoiding systematically excluding parts of the life cycle
  - allowing to do a first iteration with economic input-output data

RECOMMENDATIONS FOR FUTURE UPDATES

ESA LCA Handbook [2]

- A more general **guidance on the system boundaries** would help, it is not very clear which approach should be taken, e.g.
  - mandatory to use the cut-off at recycling/recycled content method? → this would be contradictory to what is done in the ESA LCA Database

- Broaden guidelines to become applicable to a **generic platform concept** used for multiple missions: relevant to include **heritage** by
  - allocating the environmental impact of initial design and development over different missions, or
  - considering a specific functional unit for a platform design.

RECOMMENDATIONS FOR FUTURE UPDATES

ESA LCA Database

- It would be good to also **include**:
  - **office work**
  - **ground stations**

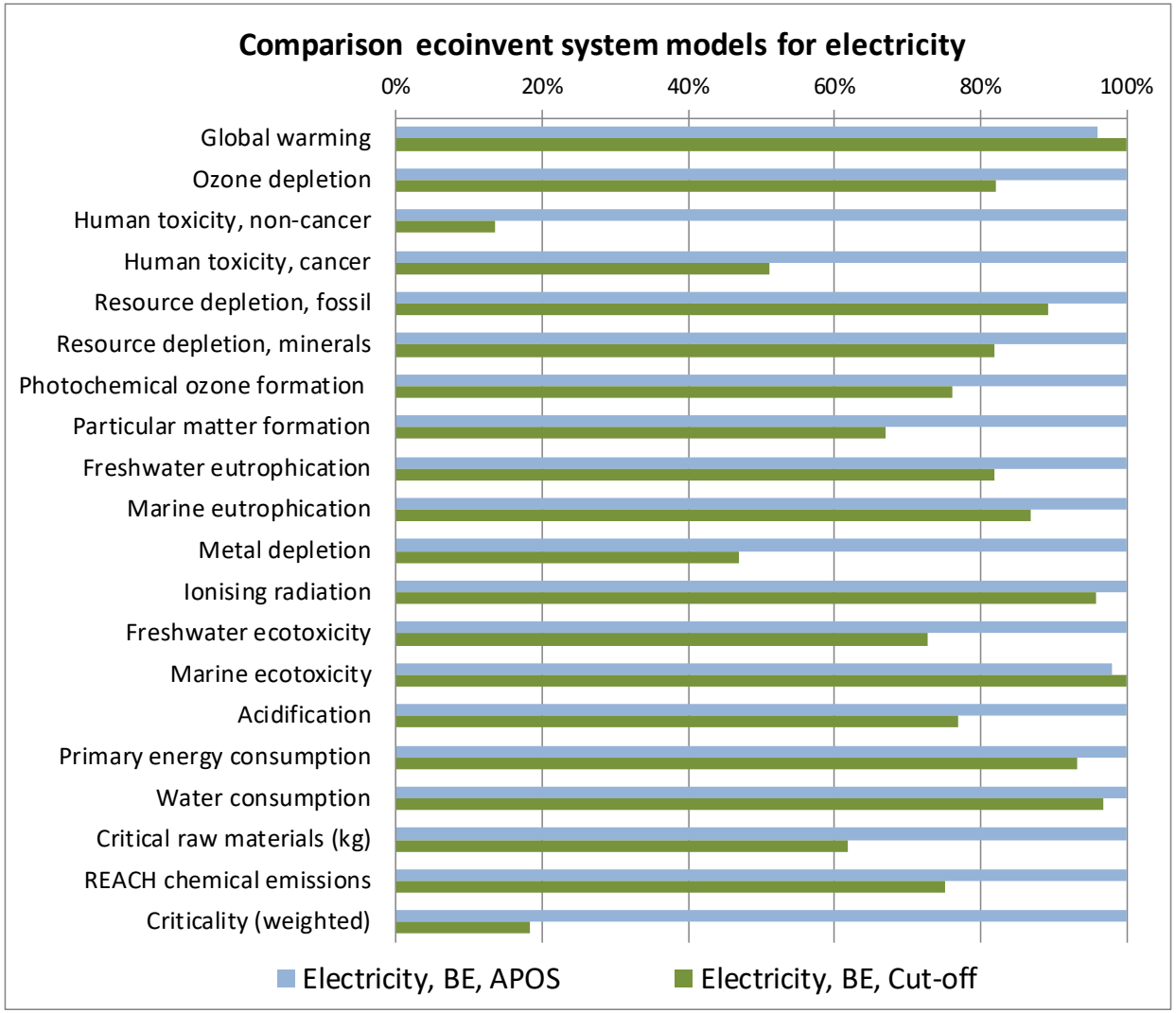
- Some minor errors were found

- **Ecoinvent default model** (Allocation at the point of Substitution or **APOS**) is used:
  - all treatment steps are modelled up to the point where the by-products could substitute a reference flow from another production process
  - economic allocation is applied between reference products and by-products (partitioning of impacts according to their market value) → not in line with the ESA LCA Handbook, which states that economic allocation should be avoided
- APOS system model has some theoretical advantages, but is very **complex** and may lead to results that are difficult to explain
  - more straightforward recycled content (cut-off at recycling) system model is often preferred

Note: Economic allocation is also sometimes used in the Recycled Content system model, for example to allocate the burdens of joint metal extraction over the different metals.

RECOMMENDATIONS FOR FUTURE UPDATES

APOS versus recycled content



CONCLUSIONS

- Both ESA LCA Database and Handbook are helpful when performing space specific LCAs
- It would be good to update them regularly, taking into account user experience and new developments in (space) LCA
- The assessment of ecodesign options could benefit from guidelines for multiple missions platforms

QUESTIONS

Thank you for your attention!

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