

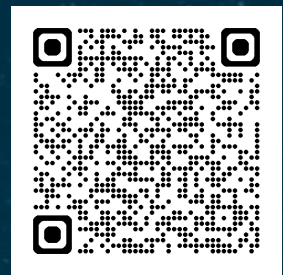


The webinar will be recorded ●



ESA LCA Handbook

Available here:



ESA Clean Space

29/01/2026

ESA UNCLASSIFIED – For ESA Official Use Only



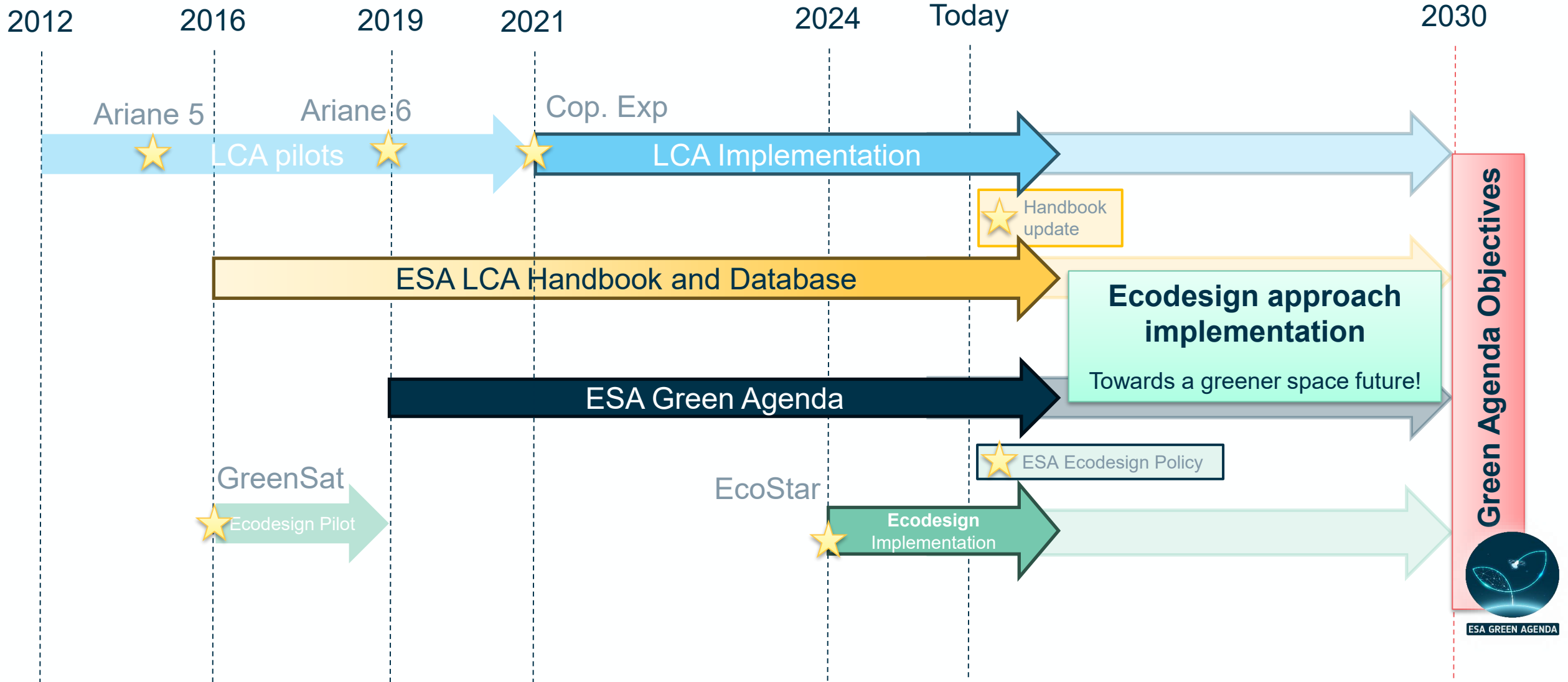
→ THE EUROPEAN SPACE AGENCY

Today's speakers



- ❖ Intro – 10 min
- ❖ Handbook presentation (Part 1) – 35 min
 - ❖ Q/A part 1 – 10 min
 - ❖ Break – 10 min
- ❖ Handbook presentation (Part 2) – 30 min
 - ❖ Q/A part 2 – 20 min
 - ❖ Conclusion – 5 min

The Big Picture: a glance in the past and future



The ESA Green Agenda

Maximise Sustainability Benefits

“Ensure that ESA and European space programmes **contribute to the Paris Agreement and the European Green Deal.**”



Minimise Environmental Impacts

“By 2030, **reduce emissions by 46% for its operational activities and 28% for the activities executed by its suppliers.**”

Five key areas of action →





ESA GREEN AGENDA

APPROACH

Systematic implementation of Life Cycle Thinking and Ecodesign in space programs

- **Understanding** key environmental impacts along programmes life cycle
- **Implementing** – early in design – optimised mitigation solutions to reduce space programmes' environmental impacts

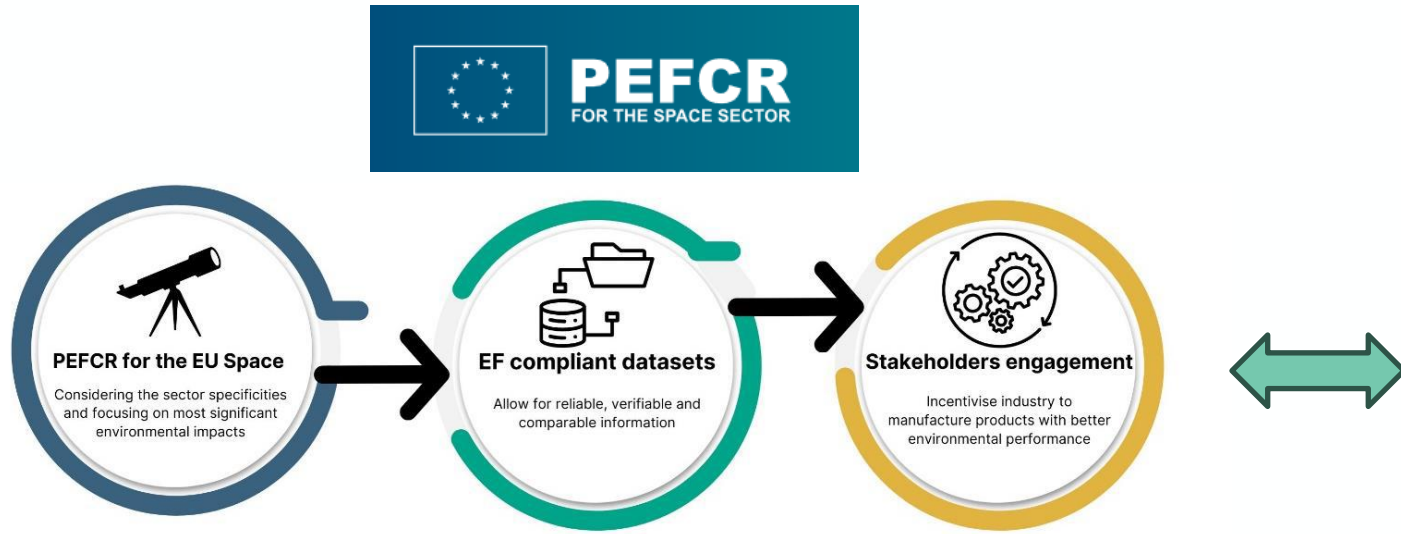
LEARNINGS & COMMITMENTS

- **Industrial activities** accounted for **85%** of the ESA GHG assessment in 2019
- ESA has pledged to **reduce it by 28% by 2030**

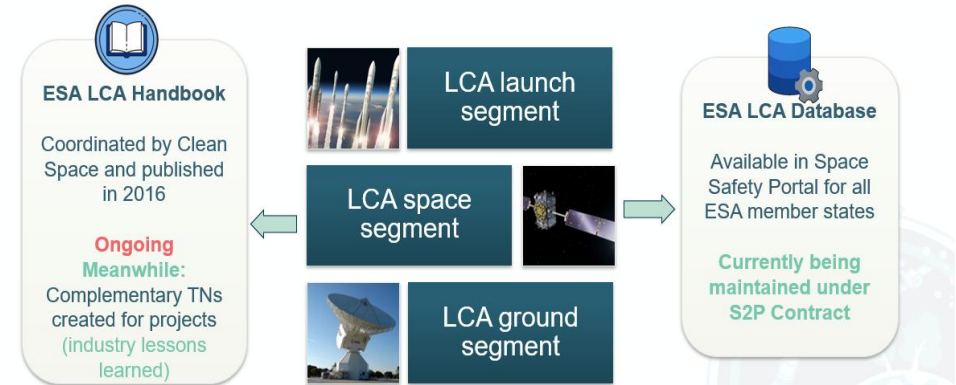
GOAL

Make the European space sector a role model for ecodesign implementation in space projects

ESA-EC Cooperation on PEFCR



ESA LCA FRAMEWORK



ESA and EU active cooperation to harmonise practices and reduce burden on space industry. ESA involvement in all phases of PEFCR for space development.

Example: ESA - EC harmonised data collection questionnaire.

Note: even when ESA, EC requirements are different the questionnaire will be common and tailored for the scope of the different activities

The ESA LCA Handbook 2.0

The LCA HB feedback process

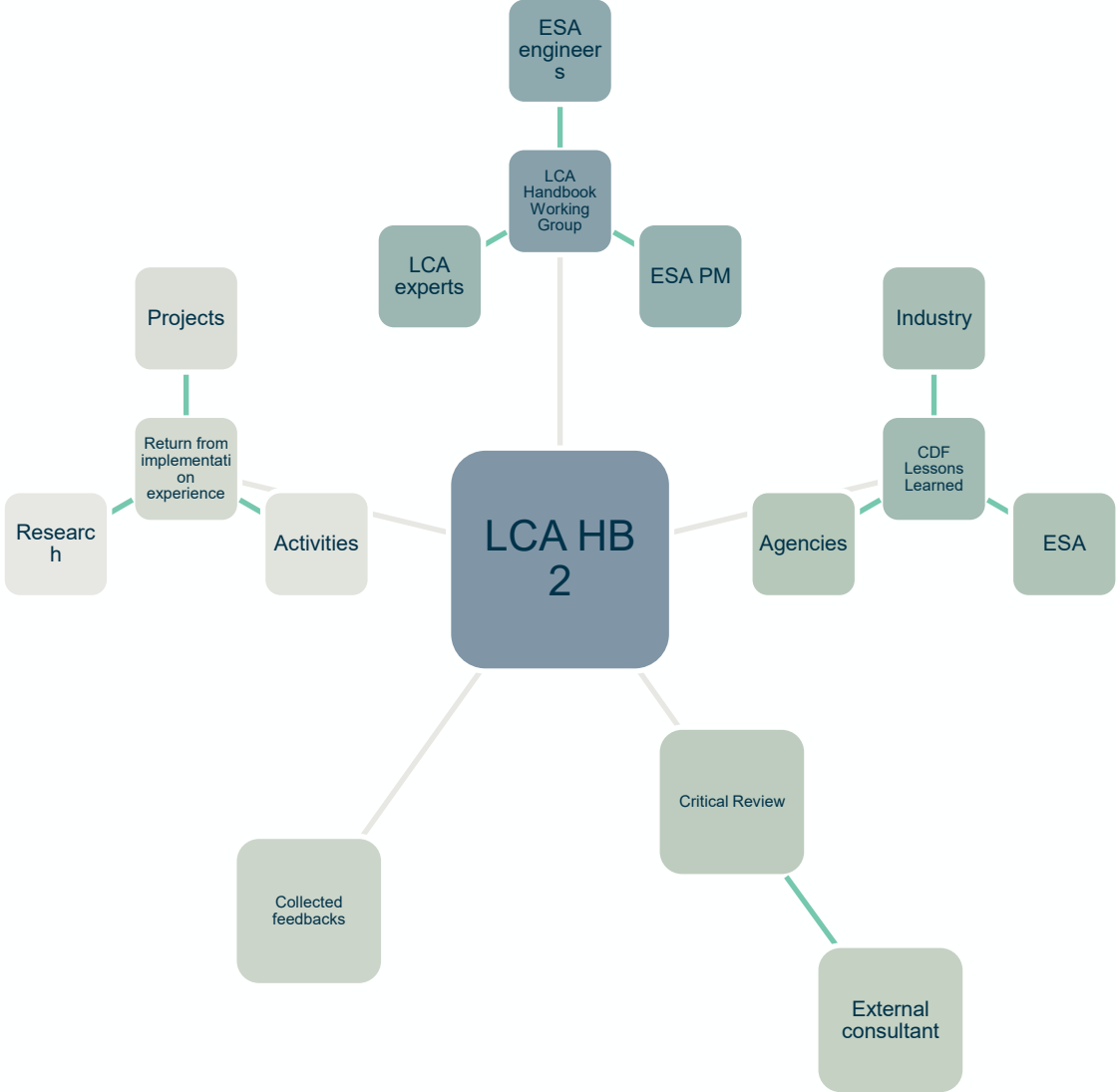
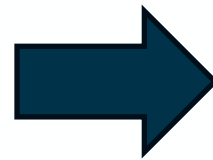


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4	How to use this document
5	LCA General Methodology
6	Consideration for space LCA
7	Space sector LCA Methodology
8	Communication of results
9	Example: LCA of a battery
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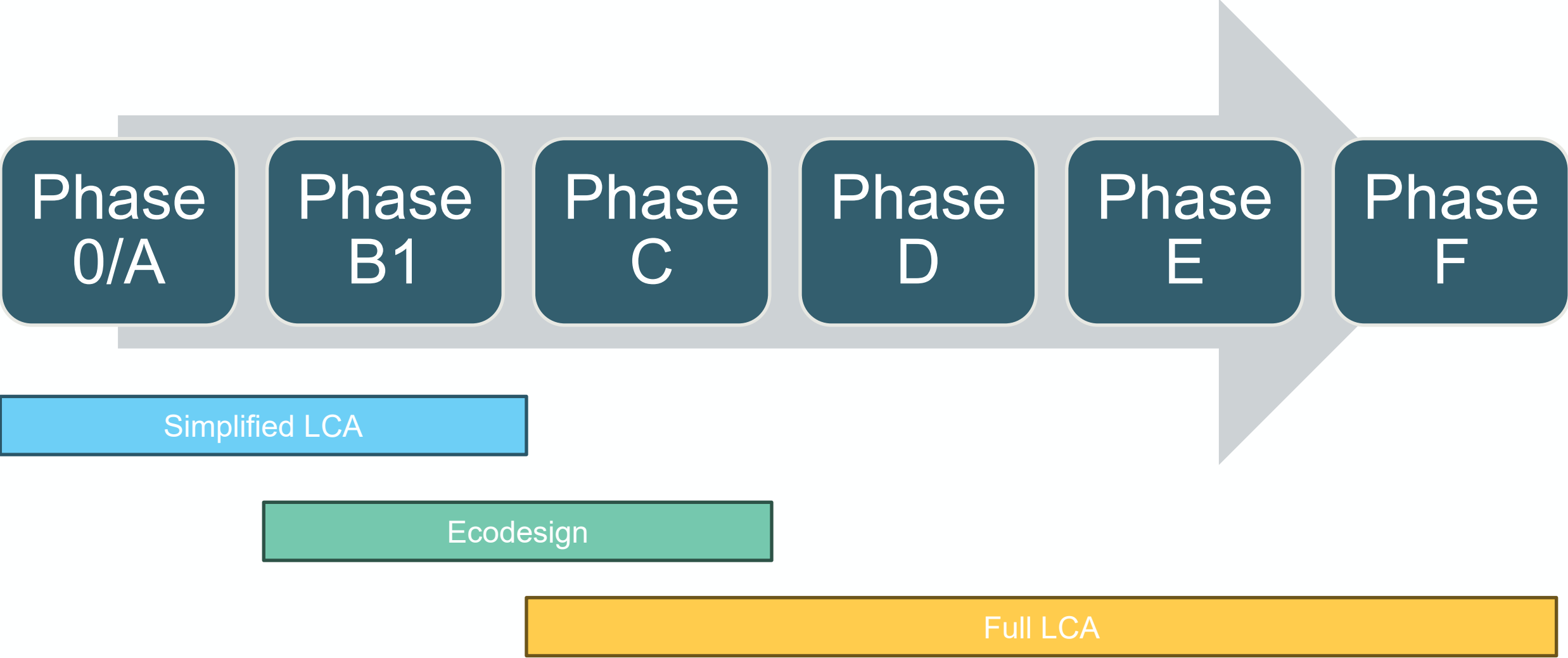


Chapter Titles (2025)	
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E	Atmospheric impact LCA
F	LCA Database and modelling guidelines
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- Removed
- New
- Minor Changes
- Major Changes

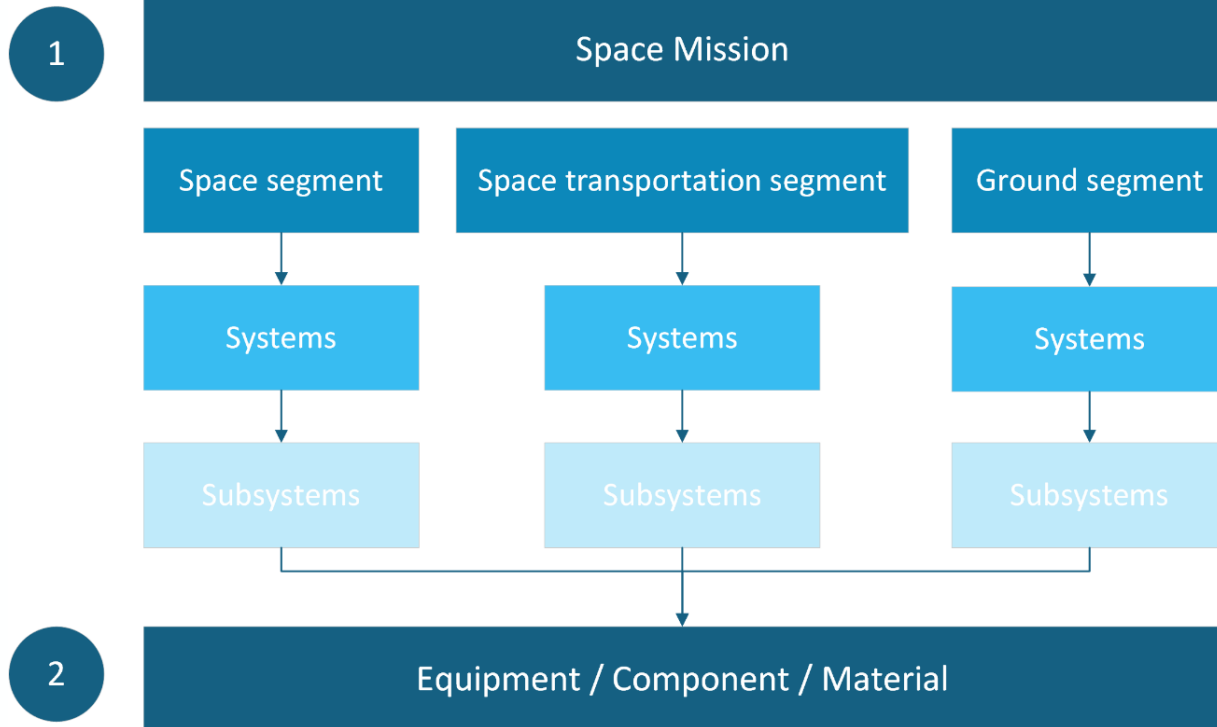
The LCA/Ecodesign View





Specificities of Space LCA





Unique Space Sector Challenges

Space LCA faces challenges like:

- low production volumes with long R&D
- specialized materials
- emissions during launches and re-entry.

Importance of Functional Unit

Functional Unit selection must align with mission goals due to varied space mission purposes and complexities.

Data Accuracy Recommendations

Primary data is preferred, however not always accessible (confidentiality). Secondary and economic data may underestimate or distort environmental impacts.



Testing, R&D, and Cut-off Criteria

Environmental Impact of Testing

Testing in energy-intensive cleanrooms significantly contributes to environmental impacts in the space sector.

Inclusion of R&D Phases

R&D phases should be included in environmental assessments due to their substantial resource consumption in space missions.

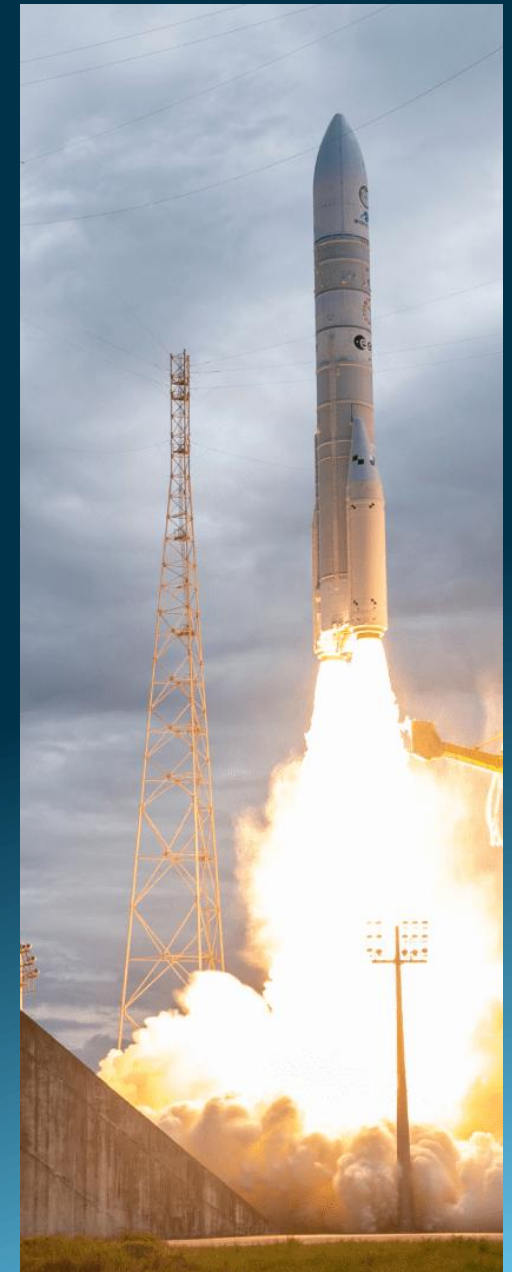
Strict Cut-off Criteria

Cut-off criteria must include critical raw materials and hazardous substances regardless of quantity to ensure accurate impact assessment.

Modeling Infrastructure Impacts

Accurate modeling of infrastructure and cleanroom usage is necessary to avoid underestimating environmental impacts.

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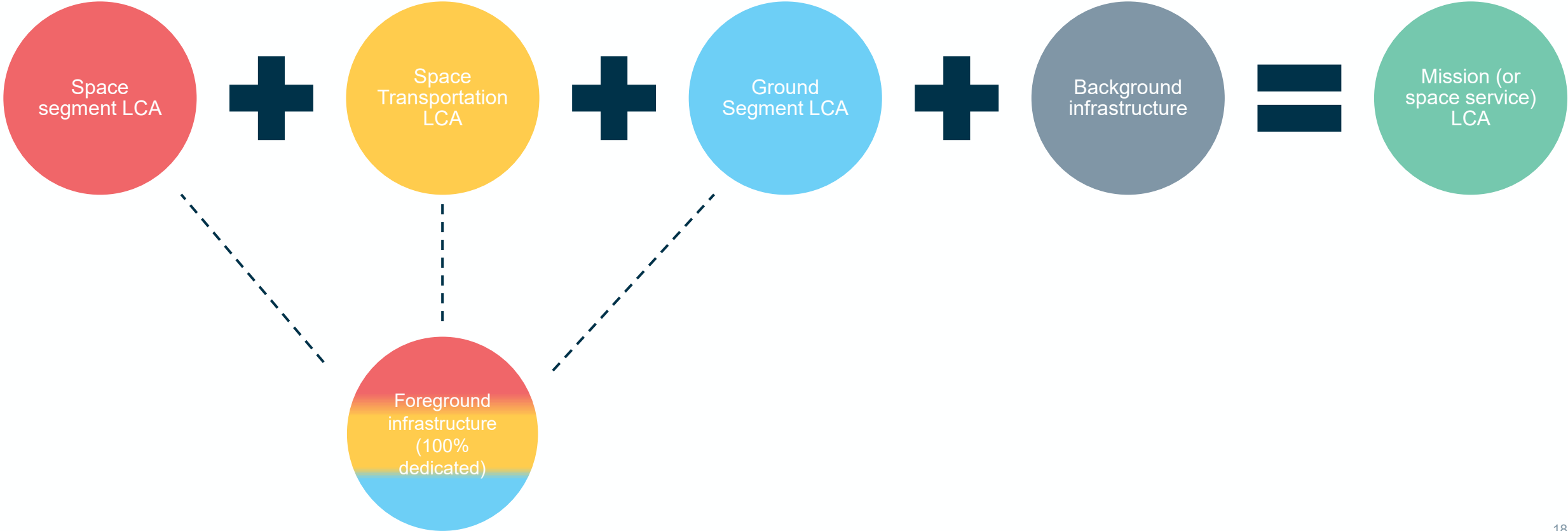
Space Sector

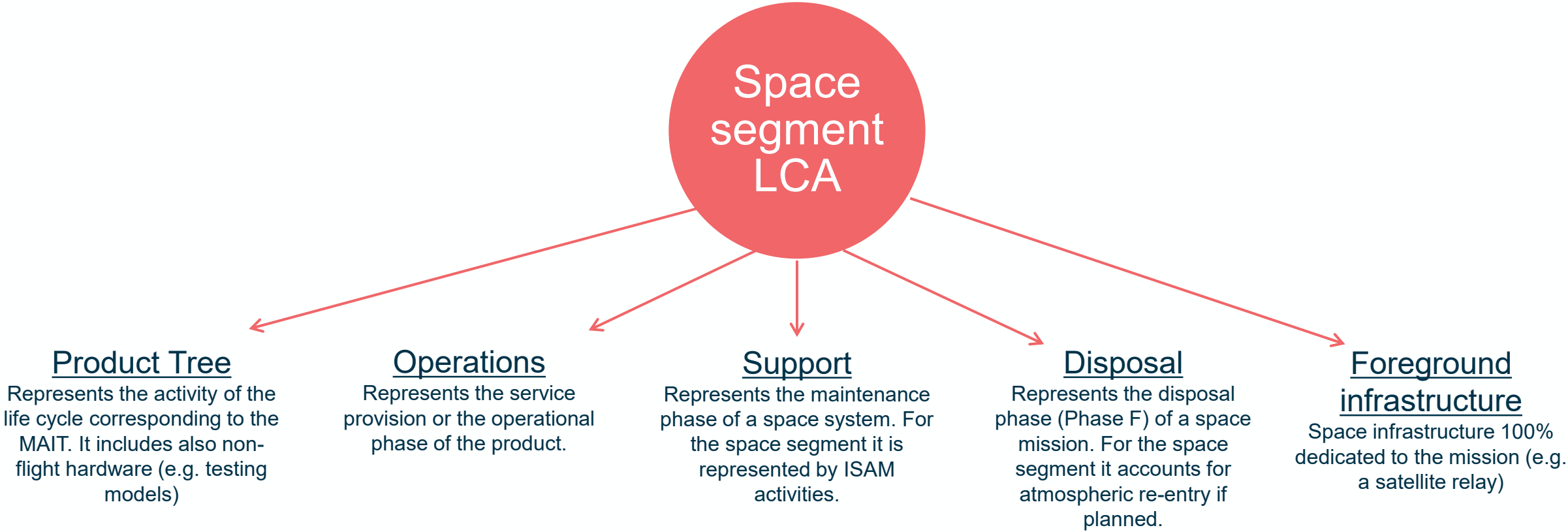
LCA

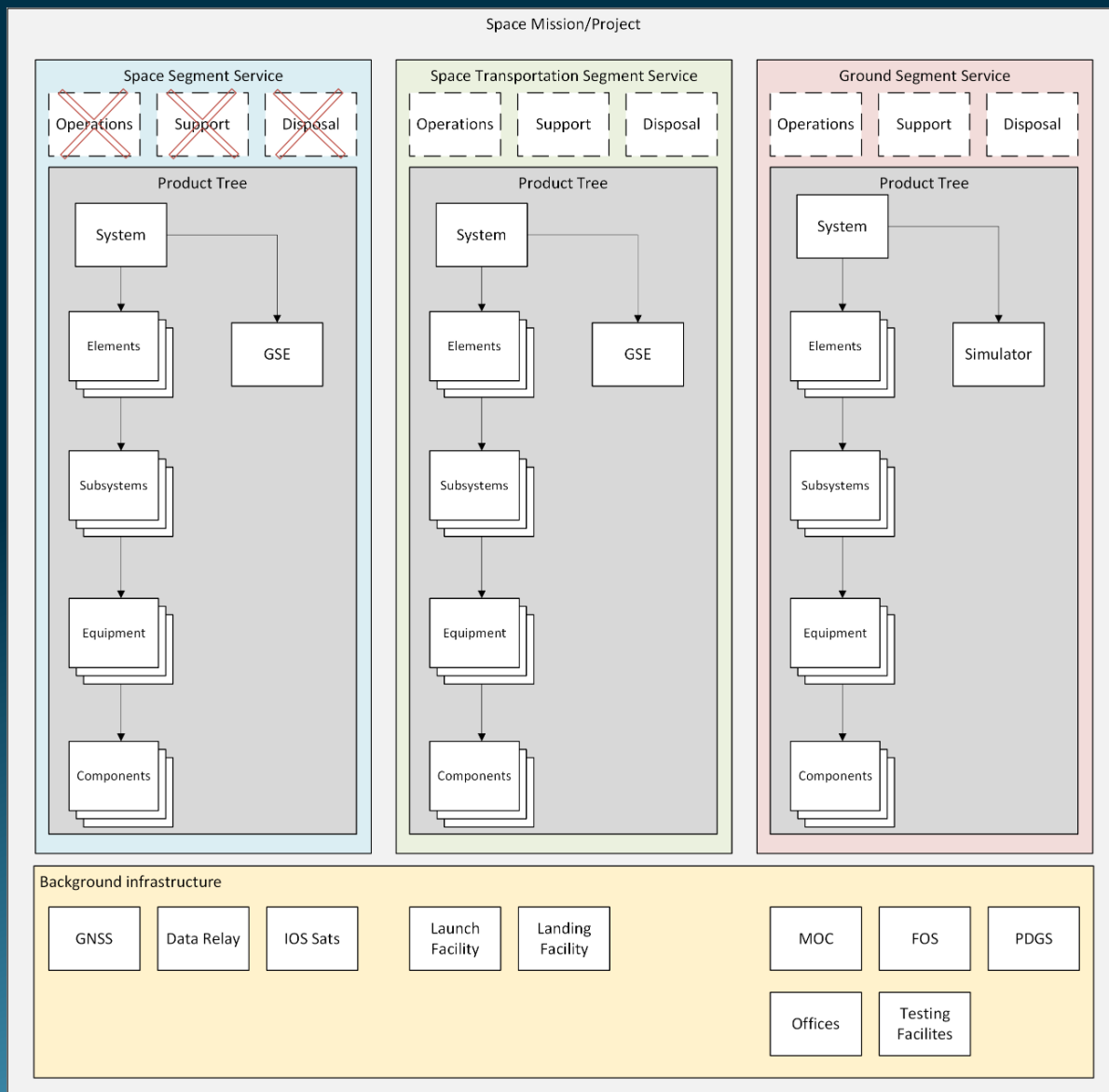
Methodology



Overview of Methodology







Goal and Scope Definition

Defining Goal in LCA

The goal in space mission LCA quantifies environmental impacts to identify hotspots and aid ecodesign decisions.

Establishing System Boundaries

System boundaries include manufacturing to end-of-life but exclude operations outside Earth's biosphere and space debris impacts.

Selecting Functional Units

Functional units reflect mission objectives, such as completing one mission or providing service over time.

Functional Unit and System Boundaries

Type of mission	Service FU Definition
Earth Observation	To observe the XXX area (or entire globe) with XX instrumentation with a revisit period of YY hours over a period of ZZ years.
Navigation	To provide the entire globe with PNT capabilities with XX accuracy over a period of ZZ years.
Science and Space observation	To observe the XXX area (or target) with XX instrumentation over a period of ZZ years.
Space Transportation	See Section 6.4
Human Exploration and Robotics	To perform space human exploration with XX astronauts on YY planet (or space station) over a period of ZZ years. To perform robotic exploration with XX instruments on YY planet (or space station) over a period of ZZ years.
Telecommunication	To provide 1MB of data transfer in XXX area (or entire globe) with XX latency over a period of ZZ years.
Technology development IODs	To demonstrate the use of XX technologies (or instruments) over a period of ZZ years.

Functional Unit Variability

Functional units differ by mission type, such as area observation for Earth missions or data capacity for telecom missions.

Functional comparative approach

Missions providing a similar service could be compared for ecodesign purposes.

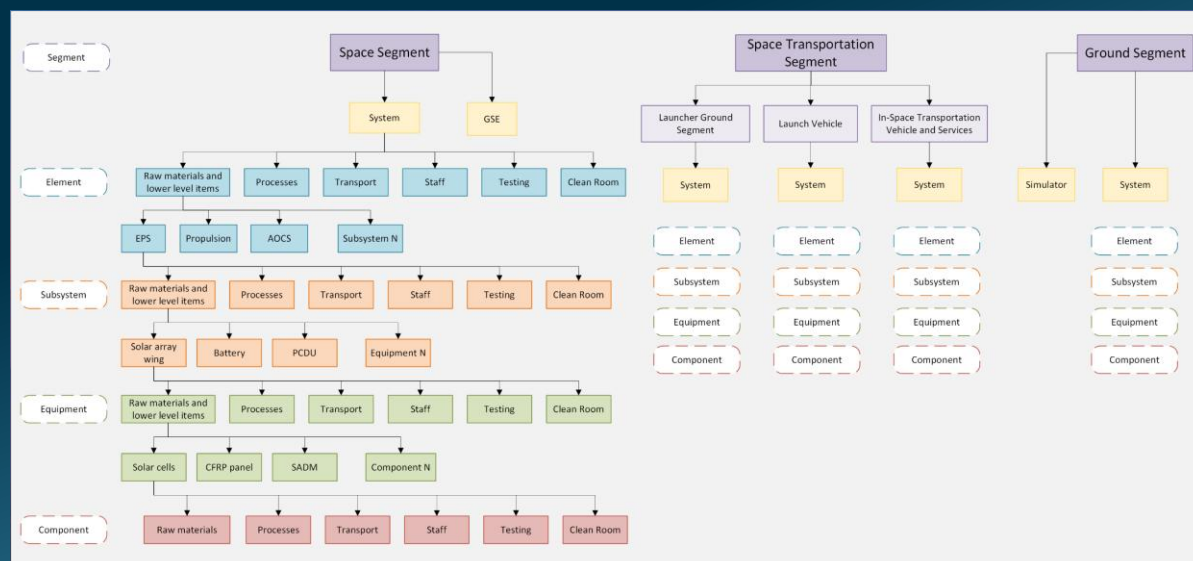
System Boundaries Components

System boundaries include space, transportation, and ground segments, essential to define the mission scope clearly.

Foreground and Background Infrastructures

Foreground infrastructures include testing and cleanrooms, while background infrastructures use average models for material production.

Life Cycle Inventory



Iterative Inventory Approach

ESA recommends starting with a preliminary inventory and refining through multiple iterations for accuracy.

Comprehensive Data Collection

Data includes energy, water, materials, waste, staff hours, cleanroom occupancy, and transportation distances. Now aligned with PEFCR.

Testing and Energy Demand

Testing activities like vibration and thermal vacuum tests are included due to high energy consumption.

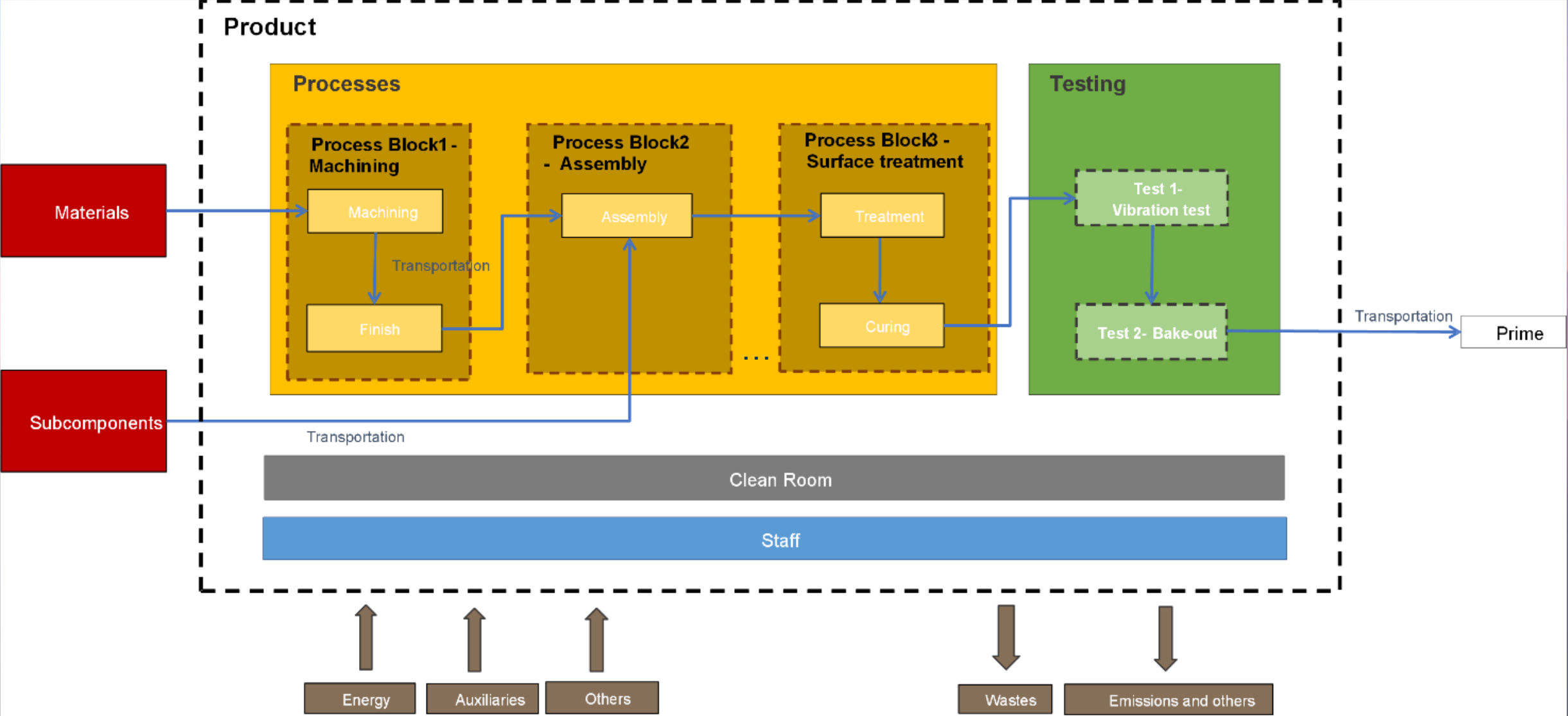
Allocation of Shared Resources

Allocation rules distribute impacts fairly using time-based or surface-area-based methods for shared resources.

Annex G

EC-ESA Template for LCI (issue 1)

The Elementary Building block – Generic Example



Testing

ESTEC Facilities data available as a proxy

Type of test		Average Power consumption	Typical number of runs	Duration of the test per run	Other relevant consumables/Comments
Mechanical/vibration	Sine	158 kW	12 (4* per axis)	30 min	NOTE 1: 10 days in clean room for all the tests to be added on top. NOTE 2: Only sine or only random test is done (normally sine), but not both.
	Random	158 kW	12 (4* per axis)	30 min	NOTE 3: It is important to consider preparation of the shaker in addition to the duration of the test (120 secs per run) plus margin (30 sec per run). 30 min per run can be assumed to account for everything.
	Shock	Single excitation, negligible	NA	NA	
Thermal	Thermal Vacuum Testing (LSS Sun-OFF)	175 kW	1	28 days	NOTE 1: Liquid Nitrogen (LN ₂): 2500 l/h NOTE 2: Size of the TVAC chamber LSS: 10 m x 10 m x 18 m
	Thermal Vacuum Testing (LSS Sun-ON)	650 kW	1	2 days out of 28 days for Sun-ON simulations	NOTE 1: Liquid Nitrogen (LN ₂): 2500 l/h NOTE 2: Size of the TVAC chamber LSS: 10 m x 10 m x 18 m NOTE 3: 19 Xenon lamps on inside the LSS represent the Sun
	Thermal Vacuum Testing (PHENIX infrared chamber)	52 kW	1	10 days	NOTE 1: LN ₂ : 200 l/h NOTE 2: Size of the PHENIX chamber: 8 m x 4.5 m x 4.5 m
Acoustic	Acoustic LEAF	5 kW	4*	120 sec (+30 sec margin)	NOTE 1: LN ₂ : 36000 l per test. NOTE 2: Duration of the test to be considered is 10 minutes approximately. NOTE 3: Three days in clean room for the testing to be added on top. NOTE 4: Dimensions of LEAF 11 x 9 x 16,4 m
Mass properties		Negligible			
EMC		Negligible			
Other AIT activities in ISO8 Clean Room	Other AIT activities	120 kW	1	3 to 9 months in total including all the tests (also the ones already in Table 6-4) and storage	NOTE 1: Natural gas: 400 m ³ /day to heat the room. NOTE 2: This is for the hosting of one single satellite. NOTE 3: Size of the clean room is 250 m ² x 12 m height.

* 4 runs correspond to the following sequence: initial low level, intermediate, qualification/acceptance and final low level

Source: Data was collected in 2022 from ETS (ESA/ESTEC) and provided by ESA HIF Directorate

Data Quality and Cut-off Criteria

Table 6-2: Cut-off criteria per macro activity

Macro Activity	Cut-off Criteria	Percentage or below threshold	
Raw Materials and Lower-level Items	Mass (1) or Cost (4)	< 5% of mass	< 5000 €
Processes	Mass (1) or Energy (2)	< 5% of mass	< 5% of energy
Staff - Office Work	Energy (2) or Volume (5)	< 5% of energy	< 5% of volume
Staff - Travels	Environmental significance (3)	< 5% of impact	
Transport	Environmental significance (3)	< 5% of impact	
Testing	Energy (2)	< 5% of energy	
Clean Room	Energy (2)	< 5% of energy	

Data Quality Rating Importance

DQR is crucial for ensuring the reliability and accuracy of life cycle inventory data evaluation.

Annex B Guidelines

Guidelines evaluate technological, geographical, temporal representativeness, and data completeness.

Cut-off Criteria Role

Cut-off criteria exclude negligible flows to manage complexity, ensuring focus on significant data. Either one of the two options presented could be arbitrarily chosen.

Mandatory Inclusions

Critical raw materials, REACH substances, and toxic chemicals must be included despite mass or cost.

Allocation Rules and Uncertainty Analysis



Multi-functionality and Reuse

Allocation rules distribute environmental impacts across multiple uses to prevent overburdening initial missions.

End-of-Life Process Allocation

A cut-off at recycling approach excludes recycling benefits from the system under study's impact allocation.

Uncertainty Analysis Method

Monte Carlo simulations with 5000 iterations quantify confidence intervals for robust impact decision-making.

Table 6-3: Uncertainty of input parameters (95 % confidence interval) per data type for a generic pre-phase A space mission

Type of data	Source of data (mean value)	Statistical law	Uncertainty to achieve a 95 % confidence interval
Bill of materials			
Dry mass - Platform equipment (1)	Documentation from S/C's Prime contractor and/or ESA	Uniform	22 %
Dry mass - Platform equipment (2)	Documentation from S/C's Prime contractor and/or ESA + Literature data	Log-normal	50 %
Dry mass - Payload equipment	Documentation from S/C's Prime contractor and/or ESA + Prime contractor assumption	Log-normal	30 %
Manufacturing processes			
Process emissions (also used for launcher related emissions)	Documentation from ESA	Log-normal	50 %
Process emissions (manufacturing processes)	Literature data	Log-normal	100 %
Energy and material consumptions	Literature data	log-normal	100 %
Surface or length of component treated (e.g. surface treatment or welding)	Geometrical calculation	log-normal	50 %
Loss rates	Literature data	log-normal	100 %
Transport distances			
Known departure and arrival place, transport by truck	http://www.viamichelin.fr/	log-normal	100 %
Known departure and arrival place, transport by boat	http://ports.com/	log-normal	100 %
Transport of S/C by plane to spaceport	Prime contractor	log-normal	10 %
Unknown departure or arrival place, transport by truck: 500 km	Assumption	log-normal	100 %
Workload and travels			



1. Goal and Scope Definition:

- (a) Reasons for carrying out the study.
- (b) Purpose of the study (intended application).
- (c) Commissioner of the study.
- (d) Target audience.
- (e) Year of the study, version of the LCA tool used, version of databases used.
- (f) Functional unit.
- (g) System boundaries and exclusion justifications.
- (h) Assumptions and limitations.
- (i) Allocation procedures.
- (j) Treatment of multi-functionality (if applicable).

2. Life Cycle Inventory Analysis (LCI):

- Sources of published literature.
- Data collection and procedures.
- Data quality requirements.
- Calculation procedures.
- Allocation of inputs and outputs.
- Sensitivity analysis
- Additional useful information.

3. Life Cycle Impact Assessment (LCIA):

- Selection of impact categories.
- Classification and characterization (results).
- Normalization, grouping, and weighting in single score.
- Key sensitivity analyses and associated parameters.

4. Interpretation:

Reporting Requirements

Comprehensive Report Structure

LCA reports consist of a standalone summary, detailed main report, annexes, and optional confidential sections for proprietary information.

Essential Report Elements

Reports must cover goal and scope, system boundaries, inventory and impact results, data quality, uncertainty, and recommendations.

Use of Visual Aids

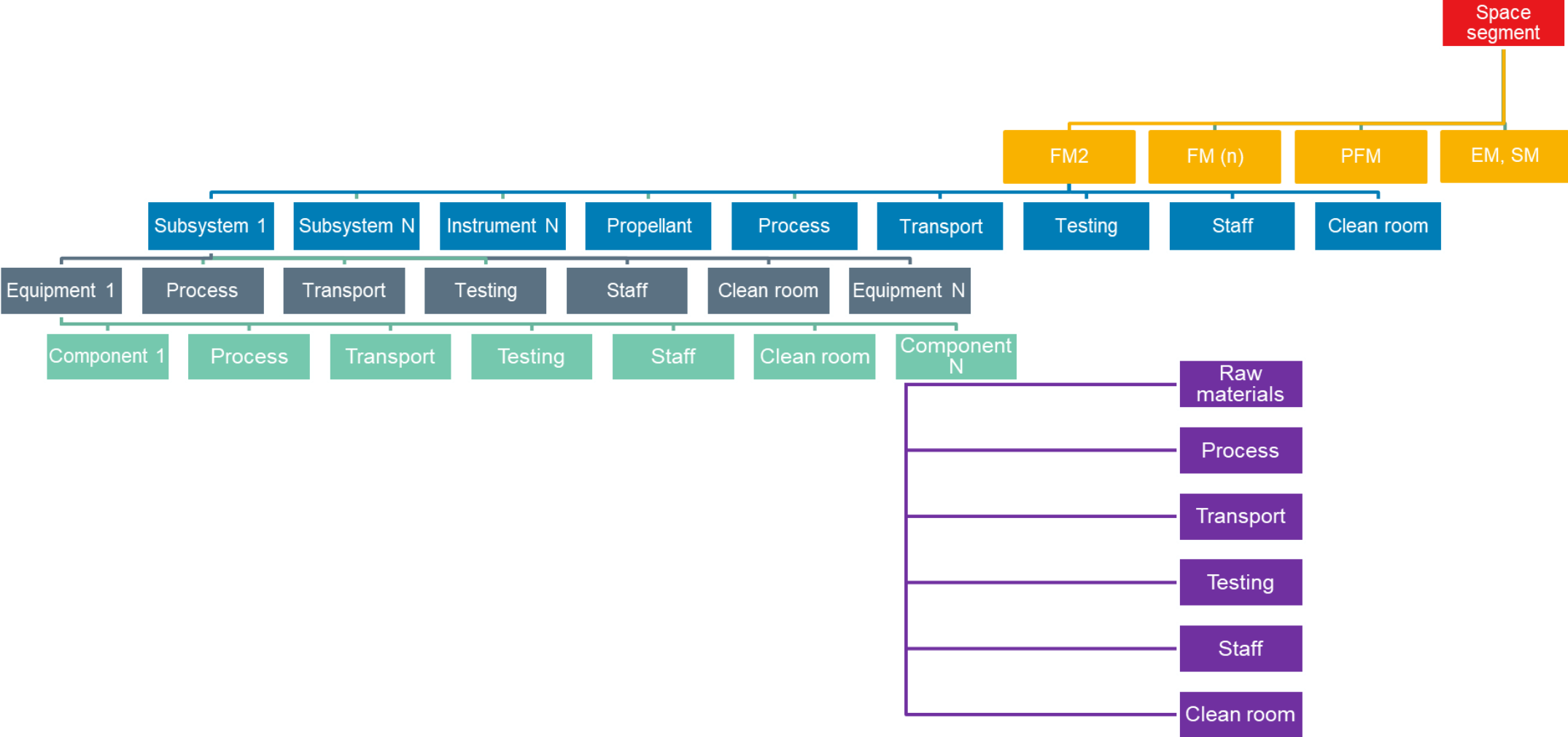
Charts and breakdown diagrams are used to enhance clarity and help stakeholders understand complex data effectively.



Space Segment



Space Segment - Modelling Example

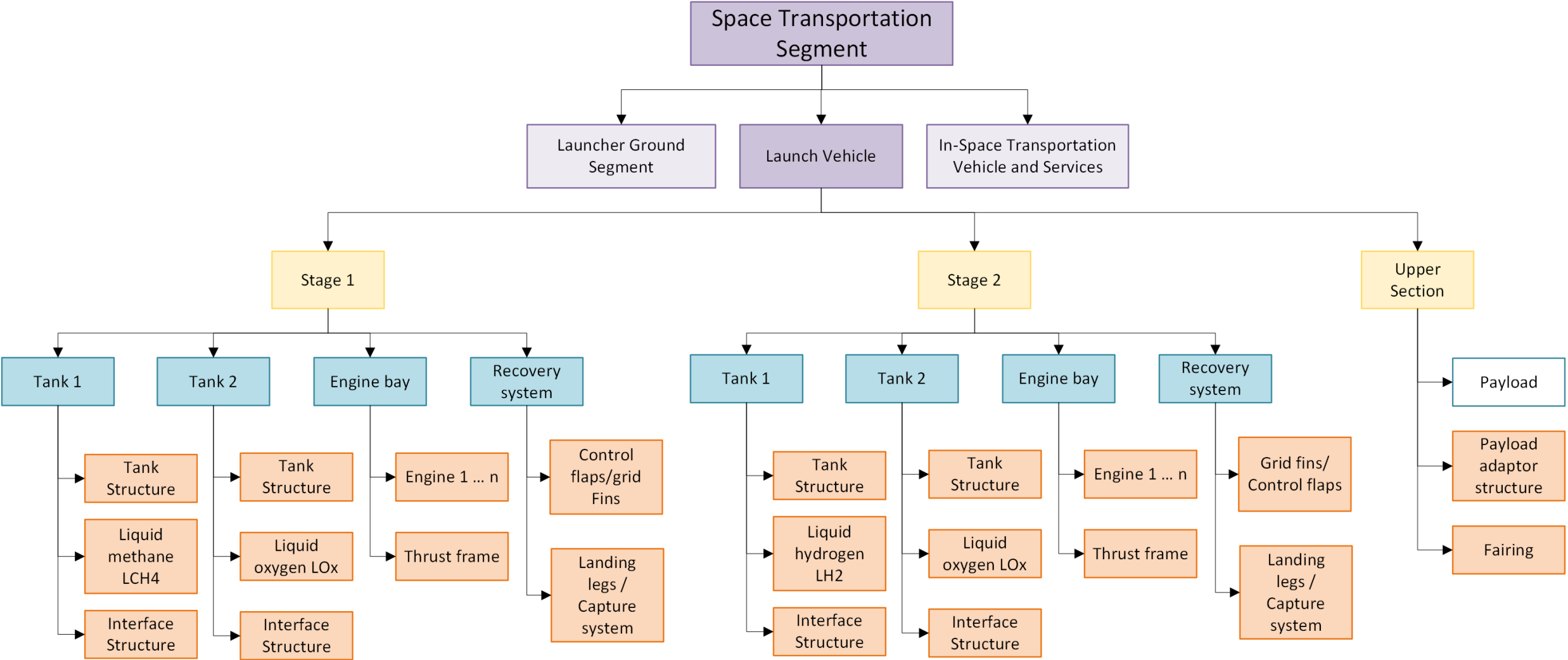




Space Transportation Segment



Space Transportation - Modelling Example

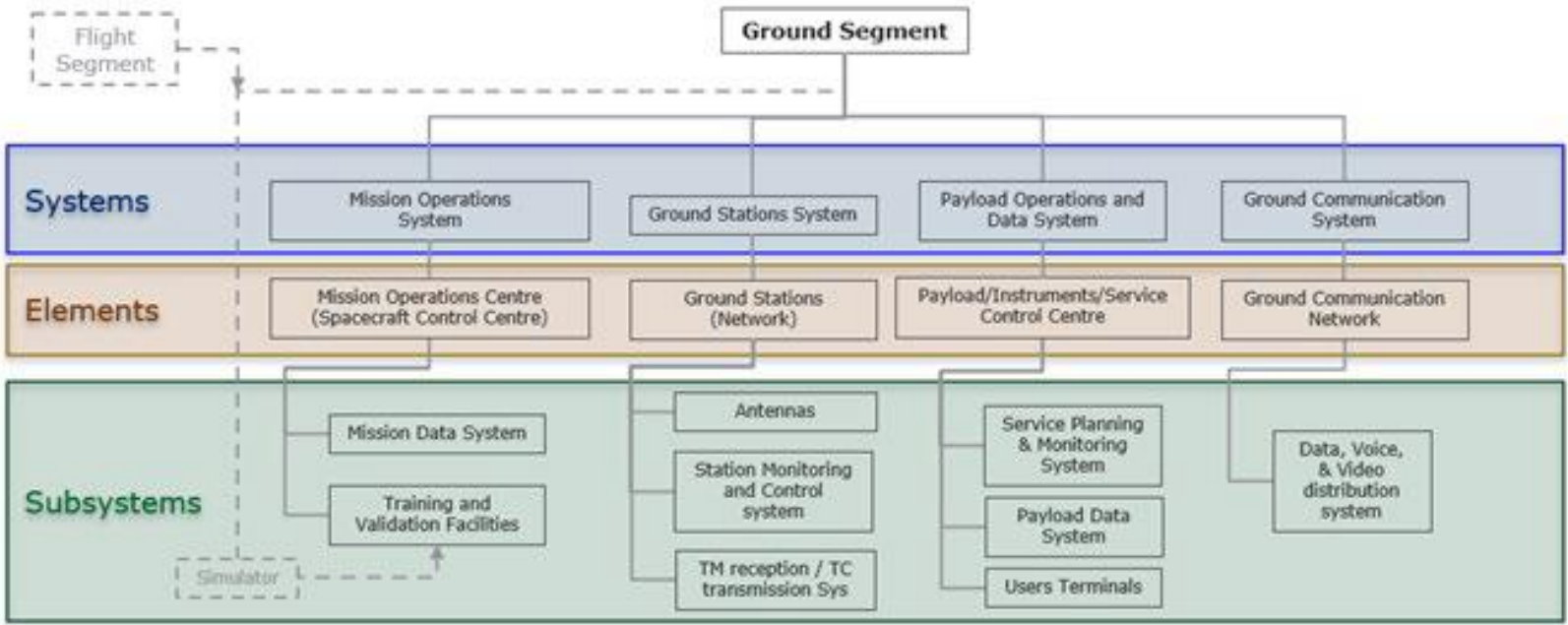




Ground Segment



Ground Segment- Modelling Example





Example: LCA of a Battery Module



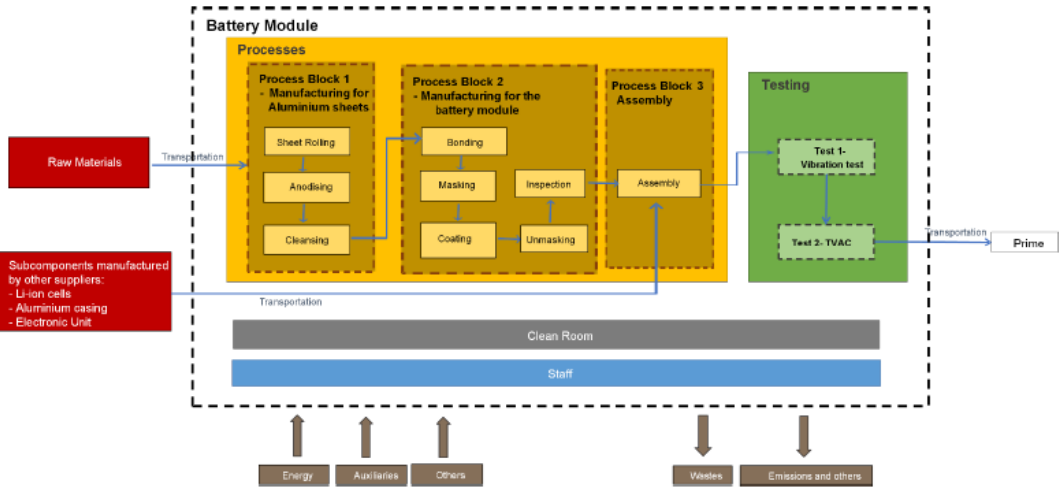
Goal and Scope

Assessment Focus

The LCA examines the cradle-to-gate environmental impact of "1 kg of battery module".

System Boundaries

Includes material procurement, manufacturing, assembly, and testing; excludes use and disposal phases.



Life Cycle Inventory Analysis (LCIA)

Material Breakdown

Inventory data details materials like Li-ion cells, aluminum casings, and electronic units essential to product composition.

Energy Consumption & Transport

Energy (electricity and gas) use and transport distances are tracked to assess environmental impact during production and distribution.

Testing Process Hotspots

Battery cell production and energy-intensive tests like thermal vacuum and cleanroom usage represent key environmental hotspots.

Nature	Breakdown	Quantity	Units	Life cycle inventory examples
Material inputs				
Cells, Li-ion (mass) <i>Amount of Li-ion cells procured by the manufacturer per kg of battery module</i>	70 %	0,700	kg / FU	Battery cell, Li-ion, NCA {GLO} market for battery cell, Li-ion, NCA Cut-off, U
Aluminium casing (mass) <i>Amount of aluminium sheets procured by the manufacturer per kg of battery module</i>	23 %	0,230	kg / FU	Aluminium, AA 6061 {RER} billet production Cut-off, U
Aluminium casing (surface) <i>Surface of the aluminium sheets</i>		0,0309	m ² / FU	
Electronic Unit, low IC (mass) <i>Amount of electronic units procured by the manufacturer</i>	4 %	0,040	kg / FU	Low IC - 1kg
PBA_PWB	1%	0,010	kg / FU	rPBA_PWB, {DE} production Cut-off, U
PBA_EEE			m ² / FU	rPBA_EEE, {DE} production Cut-off, U
Wires	1.5%	0,015	kg / FU	Single wire [mass], AWG 20 {GLO} production Cut-off, U
Epoxy Resin	0.5%	0,005	kg / FU	Epoxy resin, liquid {RER} market for epoxy resin, liquid Cut-off, U
Processes - Energy consumption and consumables				
Electricity consumption at manufacturer <i>Primary data, electricity consumption at the manufacturer during the manufacturing processes and assembly of the battery module</i>		0,534	kWh / FU	Electricity, medium voltage {DE} market for Cut-off, U
Gas consumption at manufacturer <i>Primary data, heat consumption at the manufacturer during the manufacturing processes and assembly of the battery module</i>		0,00034	m ³ / FU	Heat, central or small-scale, natural gas {RER} market group for Cut-off, U

Life Cycle Impact Assessment and reporting



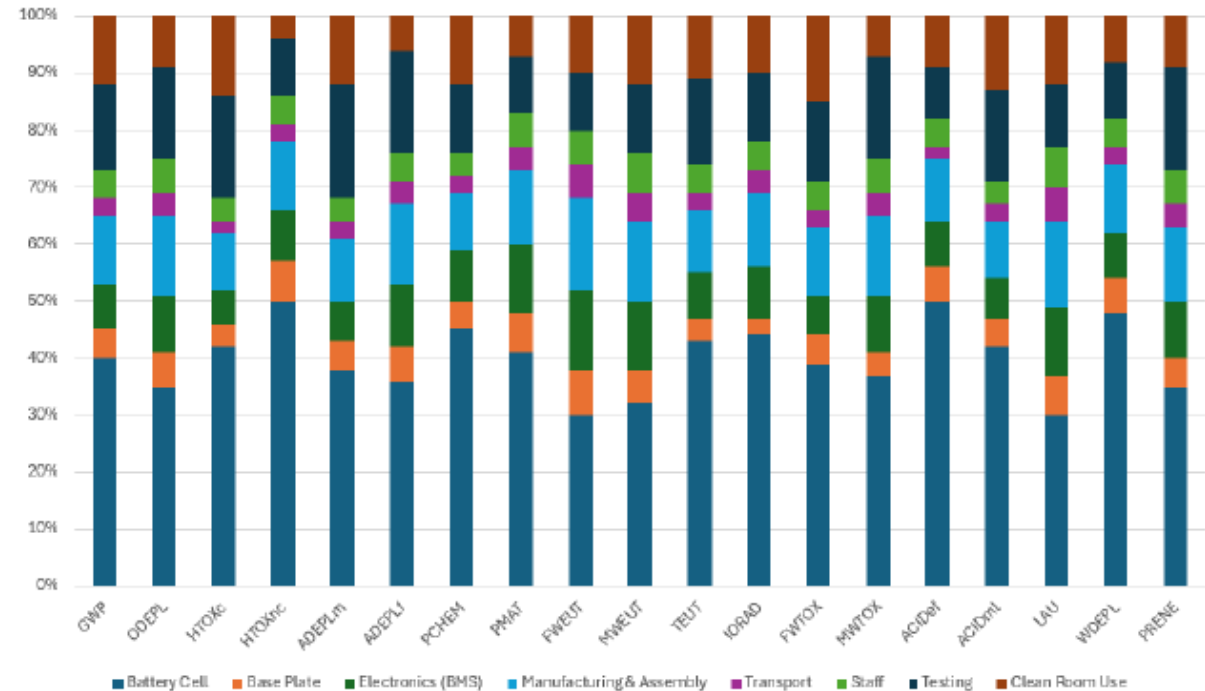
Environmental impact results

Graph showing the environmental indicators and the breakdown of the impacts across the categories.

Reporting and Ecodesign Opportunities

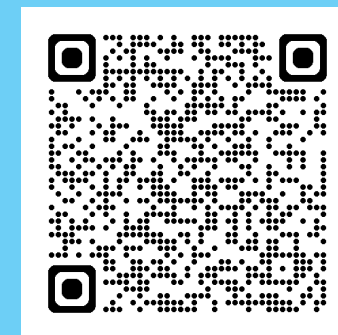
Results interpretation identifies areas where ecodesign improvements can reduce environmental impacts effectively.

Environmental impact results of a battery module



Q & A

Download the ESA LCA Handbook here:





Download the ESA LCA Handbook here:



Break (10 min)

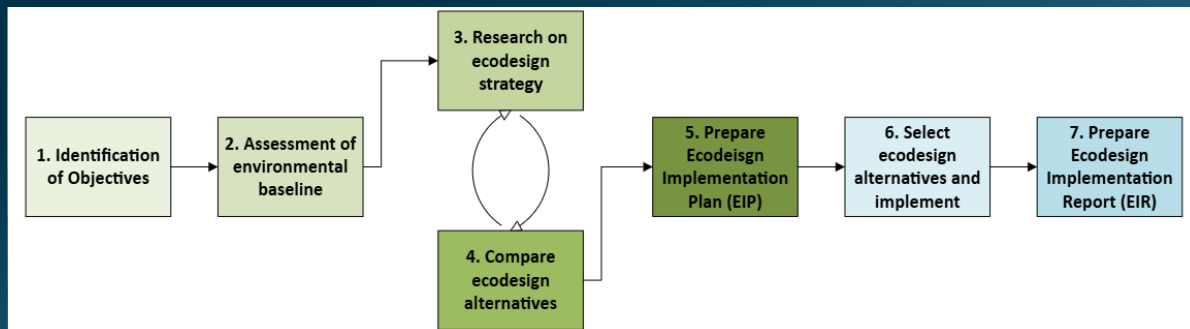




Ecodesign for Space Systems



Definition and Principles



Ecodesign Approach

Ecodesign integrates environmental considerations throughout all product development stages to prevent negative impacts.

Key Principles

Principles include multi-criteria analysis, life cycle thinking, system-level perspective, and iterative improvement.

Objective of Ecodesign and LCA

Aim to reduce environmental impact without sacrificing performance, quality, or cost-effectiveness.

Role of LCA

Life Cycle Assessment quantifies environmental impacts and helps compare design alternatives effectively.

Implementation and Reporting

Seven Steps of Ecodesign

The ecodesign process includes defining goals, assessing impacts, identifying hotspots, researching mitigation, comparing LCAs, and implementing solutions.

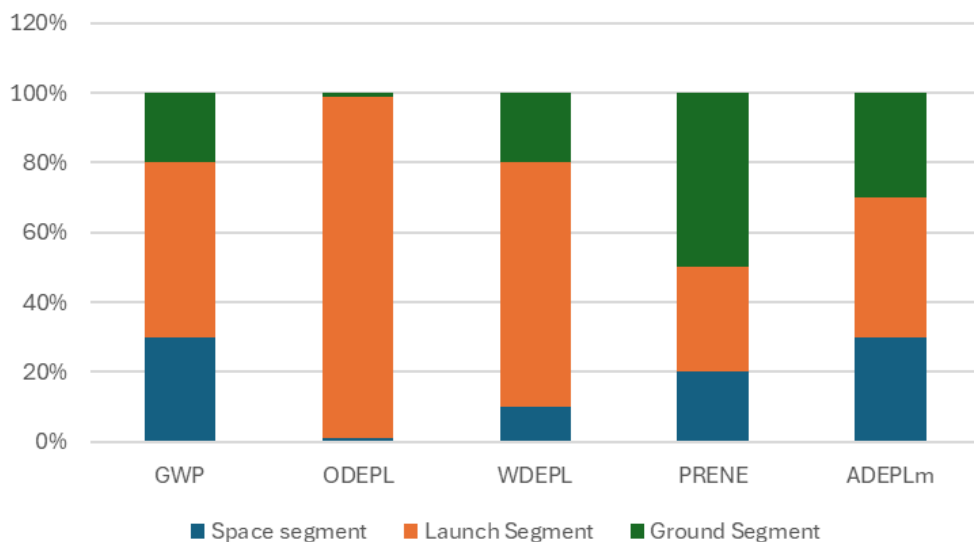
Reporting Documents

Reporting entails creating an **Ecodesign Implementation Plan** and an **Ecodesign Implementation Report** documenting objectives, trade-offs, timelines, resources, and risks.

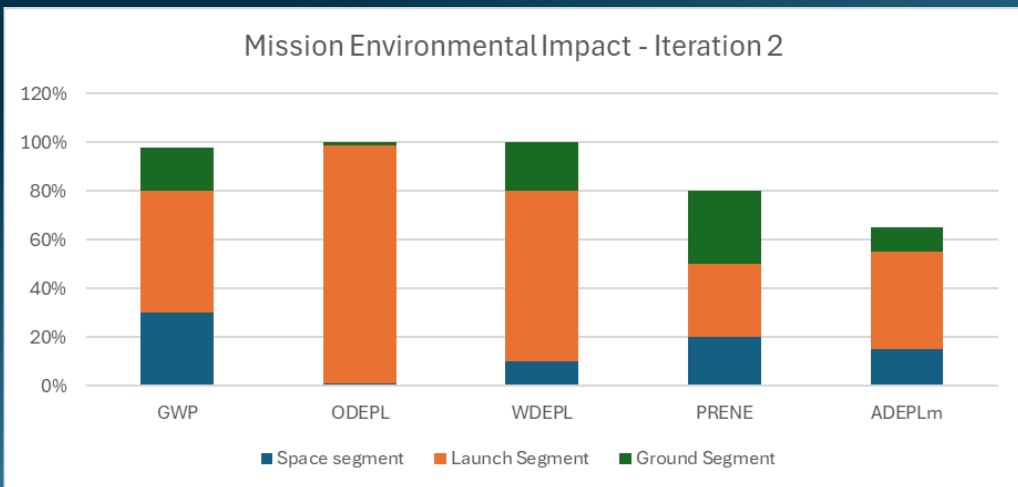
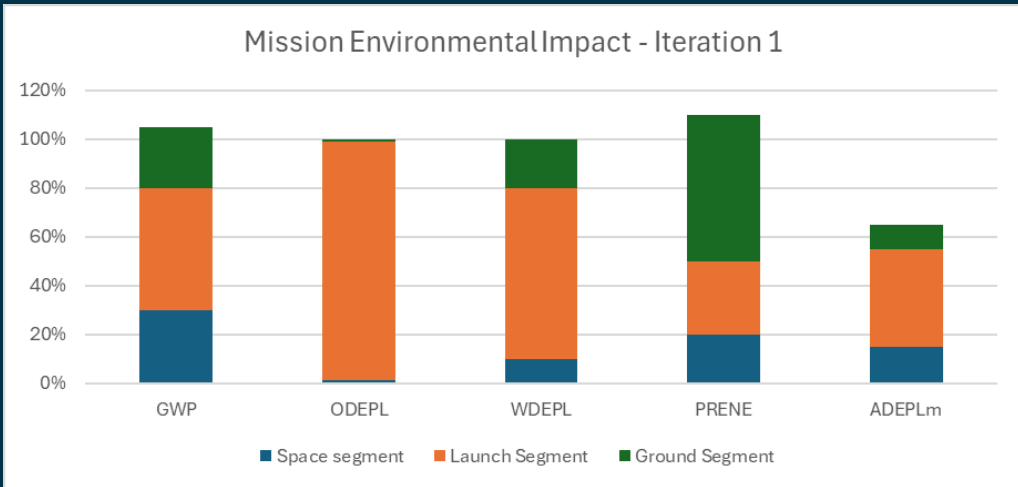
Example of Evaluation

Identification of objectives and assessment of environmental baseline.

Mission Environmental Impact (baseline)



Implementation and Reporting



Example of Evaluation – iteration 1

Research on ecodesign strategy to reach the environmental reduction target. Compare options with LCA.

Example of Evaluation – iteration 2

Research on ecodesign strategy to reach the environmental reduction target. Compare options with LCA.

Examples of Evaluation

Prepare the Ecodesign Implementation plan with trade-offs. Select the Ecodesign alternative and implement. Prepare Ecodesign Implementation Report.



Communication of Results



Standards and Best Practices

ISO 14044 Compliance

LCA results communication must adhere to ISO 14044 standards to maintain transparency and credibility.

Independent Critical Review

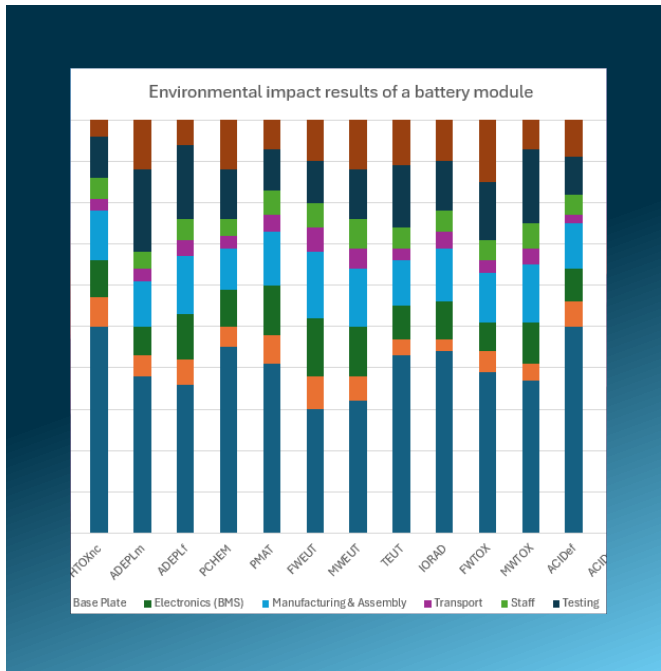
Public comparative assertions require review by an independent expert panel for credibility and validation.

Audience Tailoring

LCA results should be customized to suit internal stakeholders, external partners, or the public appropriately.

Avoid Simplified Results Externally

Simplified LCA results carry high uncertainty and should not be used for external communication until a full LCA is performed to confirm findings.



DO	DON'T
Define the goal of the study by answering to "why are we analysing this"?	Description of the goal of the study is missing or biased.
Example: To assess in a quantitative and objective manner the environmental impact relative to the life cycle of a commercial battery module used for telecommunication GEO satellites, and to define the main environmental hotspots for sustainable decision-making.	Example: To show that our commercial battery module is green.
Define the scope of the study by answering to "what are we analysing and how we can analyse it"?	The scope is not defined or the results of the LCA are extrapolated for other technologies, use profiles, geographical context, years that are out of the scope of the study.
Example: A commercial battery module used for telecommunication GEO satellites up to its manufacturing ("cradle-to-gate" approach).	Example: Manufacturing of a commercial battery module.
Present the environmental indicators of the study as well as their unit and the associated Life Cycle Impact Assessment method (see Annex A).	Few or irrelevant or new or subjective environmental indicators for the space sector are used. No mention of the Life Cycle Impact Assessment method used.
Example: The environmental indicators used in this study are: <ul style="list-style-type: none"> • Global Warming Potential at 100 years (kg CO₂ eq. baseline model of 100 years of the IPCC), • Human toxicity potential (CTUh, USEtox2.1 model), • Abiotic resource depletion potential (kg Sb eq., CML 2002), • Photochemical ozone formation potential (kg NMVOC eq., LOTOS EUROS model), • Freshwater eutrophication potential (kg P eq., EUTREND model), • Ozone Depletion Potential (kg CFC-11 eq., Steady State ODPs), • Air Acidification potential (kg SO₂ eq., CML 2022), • Primary Energy Consumption (MJ, Cumulative energy demand model) 	Example: Only one environmental indicator is used: Climate change. The abiotic resource depletion potential is studied (without mentioning the reference Life Cycle Impact Assessment method).
The output values of the study are presented in a clear and precise manner. Relative values are used, and absolute values can be added in complement.	Only absolute values without comparison are presented.

Dos and Don'ts

Clear Communication Methodology

Clearly describe methodology, goals, scope, functional unit, system boundaries and indicators with units to ensure accurate understanding.

Use of Relative and Absolute Values

Combine relative values with absolute figures for better clarity and comprehensive data interpretation.

Avoid Vague Claims

Do not use unsubstantiated terms like 'green' or 'sustainable' without clear evidence or data support.

Transparency to Prevent Greenwashing

Disclose limitations, exclusions, data quality, hotspots, and uncertainties to maintain transparency and credibility.



Annexes A–G



Table A-1: Environmental midpoint impact indicators

Impact Category	Impact Indicator	Abbreviation	Unit	Methods to be used
Climate Change	Radiative forcing as Global Warming Potential (GWP100)	GWP	kg CO2 eq.	Baseline model of 100 years of the IPCC (based on IPCC 2013) RD [33]
Ozone Depletion	Ozone Depletion Potential (ODP)	ODEPL	kg CFC-11 eq.	Steady state ODPs as in (WMO 2014 + integrations) RD [37]
Human toxicity, cancer	Comparative Toxic Unit for human (CTUh)	HTOXc	CTUh	USEtox2.1 model (Fantke et al. 2017), adapted as in Saouter et al., 2018 RD [30]
Human toxicity, non-cancer	Comparative Toxic Unit for human (CTUh)	HTOXnc	CTUh	USEtox2.1 model (Fantke et al. 2017), adapted as in Saouter et al., 2018 RD [30]
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserve)	ADEPLmu	kg Sb eq.	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002 ultimate reserve RD [32]
Resource use, minerals and metals	Abiotic resource depletion (ADP reserve base)	ADEPLmr	kg Sb eq.	CML 2002 model, (van Oers et al., 2002) - reserve based RD [32]
Resource use, energy carriers	Abiotic resource depletion fossil fuels (ADP-fossil)	ADEPLf	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002 RD [32]
Photochemical ozone formation	Photochemical ozone creation potential (POCP)	PCHEM	kg NMVOC eq.	LOTOS EUROS model (Van Zelm et al., 2008) as implemented in ReCiPe 2008 RD [36]
Particulate matter	Disease incidence due to kg of PM2.5 emitted	PMAT	Disease incidence	PM method recommended by UNEP (UNEP 2016)
Eutrophication, freshwater	Phosphorous equivalents	FWEUT	kg P eq.	EUTREND model (Struijs et al. 2009) as implemented in ReCiPe RD [35]

Annex A- Impact Categories and Methods

Environmental Impact Indicators and flow indicators

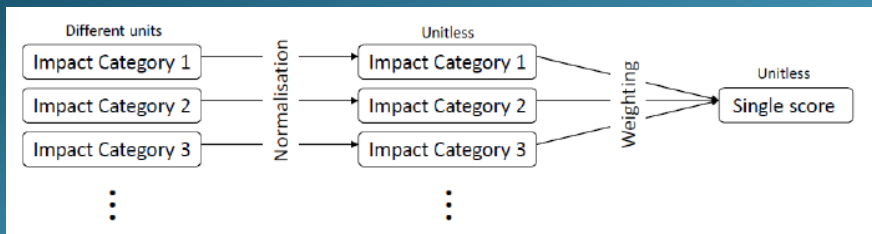
Key indicators include Global Warming Potential, Ozone Depletion, human toxicity, resource depletion, and water usage.

Characterization Methods

Methods like IPCC, CML, USEtox, and AWARE are used to assess each impact category scientifically. Alignment with PEF.

Normalization and Weighting

PEF Single score normalization and weighting aggregate multiple indicators into a composite environmental impact measure.



Annex B - Data Quality Rating (DQR)

Assessment Criteria

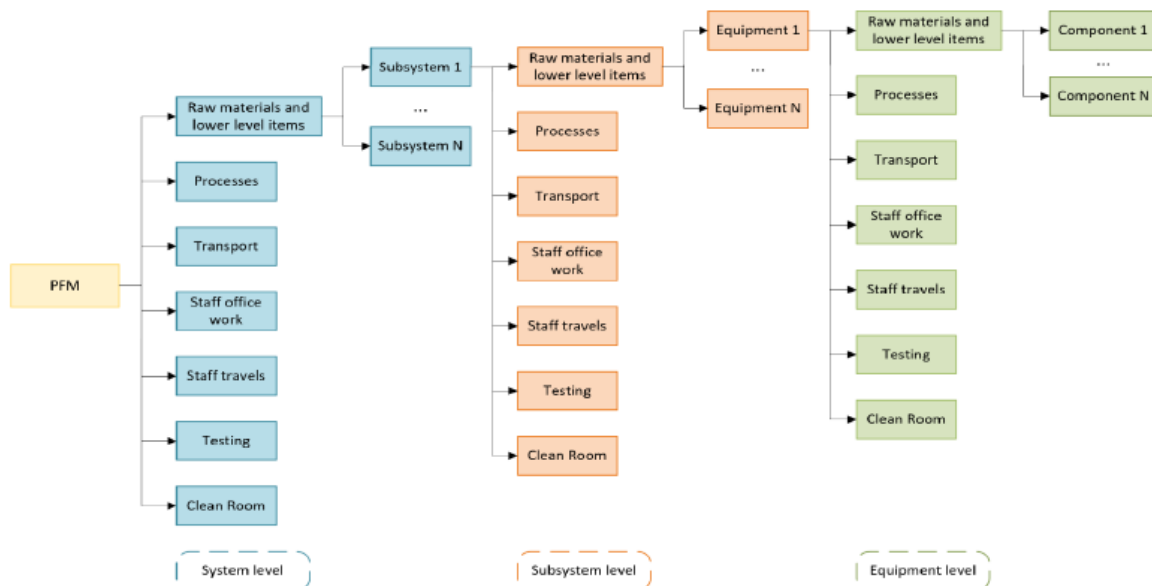
DQR methodology evaluates data based on technological, geographical, and temporal representativeness plus completeness.

Pedigree Matrices and Aggregation

Pedigree matrices and aggregation rules enable calculation of DQR at equipment, subsystem, and system levels. To simplify the method and the process, a **single DQR indicator** has been introduced.

Importance of High-Quality Data

High-quality data ensures credible Life Cycle Assessment results and helps prioritize data collection efforts.



Annex B - Data Quality Rating (DQR)

For every macro activity		
Score 1	≥60 %	PD-D
	≥ 30 %	PD-I
	≤ 10 %	SD-I
	≤ 10 %	SD-AD
	≤ 10 %	SD-NAD
Score 2	≥ 30 %	PD-D
	≥ 30 %	PD-I
	< 40 %	SD-I
	< 40 %	SD-AD
	≤ 10 %	SD-NAD
Score 3	≥ 30 %	(PD-D+PD-I)
	< 70 %	SD-I
	< 70 %	SD-AD
	≤ 10 %	SD-NAD
Score 4	< 30 %	(PD-D+PD-I)
	< 50 %	SD-NAD
Score 5	≥ 50 %	SD-NAD
*Contingency of 10% for SD is included		

Completeness

LCI at each level needs to include all known macro activities (raw materials, processes, office work, travels, transport, testing and clean room) shared by data owner. Document any data gaps agreed with ESA.

Assessment through pedigree matrix

For each macro-activity a single DQR is needed, based on the proportion and quality of the process flows contributing to it.

Aggregation method

The aggregation is using only the most relevant impact categories and it is done for each level of the product tree. It consist in an arithmetic average to consider data gaps.

Data Quality Rating (DQR) Assessment Template



Iteration #2	Raw material & LLI	Processes	Staff - office work	Staff- travels	Transport	Testing	Clean Room
Solar Array							
Completeness							
Total number of flows	19	20	5	5	3	10	4
Number of flows modelled	19	18	5	3	3	10	2
If different, justification		Wastes not modelled		Daily commuting not included			Only clean room ISO is given by the supplier, duration estimated by the LCA practitioner
Data source							
Number of PD-D	15	6	2	0	0	4	0
Number of PD-I	4	8	3	2	0	4	1
Number of SD-I	0	4	0	1	3	2	1
Number of SD-AD	0	0	0	0	0	0	0
Number of SD-NAD	0	0	0	0	0	0	0
Check	Correct	Correct	Correct	Correct	Correct	Correct	Correct
DQR computation	2	3	2	4	4	3	4



Data Quality Rating (DQR) Aggregation Template



Element	DQR total	Relative Impact for impact category GWP	Raw materials & LLI Items	Process	Staff Office work	Staff Travels	Transport	Testing	Clean Room	
Payload 1	4.42	0.12		5	1	3	2	5	5	
Equip 1	4.43		1	5	5	5	5	5	5	
Equip 2	4.57		2	5	5	5	5	5	5	
Equip 3	4.43		1	5	5	5	5	5	5	
Equip 4	4.71		3	5	5	5	5	5	5	
Equip 5	4.67		3	5	5	5	5	5	5	
Equip 6	4.43		1	5	5	5	5	5	5	
Payload 2	2.43	0.03	1	3	1	3	1	3	5	
Structure	2.57	0.06	2	3	1	3	2	2	5	
Thermal Control System	4.10	0.05		5	5	5	5	5	5	
Thermal Passive Hardware	2.43		1	2	3	1	3	2	5	
Thermal Active Hardware	5.00		5	5	5	5	5	5	5	
Propulsion	3.14	0.09	2	3	3	4	3	2	5	
Power	3.59	0.03		5	5	5	5	5	3	
PCDU	3.57		1	3	2	5	4	5	5	
Battery	3.14		2	2	1	5	3	4	5	
Solar Array	3.14		2	3	2	4	4	3	4	
DHS	3.81	0.06		5	5	5	5	5	3	
Onboard Computer	4.00		4	5	2	5	3	4	5	
Remote Interface Unit	3.29		3	2	1	5	3	4	5	
Mass Memory and Formatting Unit	3.43		4	2	3	3	4	3	5	
AOCS	3.63		0.09		5	5	5	5	5	3
Star Tracker	3.71		4	3	1	5	4	4	5	
Magnetometer	3.29		3	2	4	5	2	2	5	
Magnetorquer	3.29		2	3	2	5	3	3	5	
Reaction Wheels	3.43		4	4	2	2	4	3	5	
GNSS Receiver	3.88		4	3	3	5	3	4	5	
Reaction Wheels	3.17		4	3	3	3	2	2	5	
GNSS Antenna	3.43		3	4	1	5	3	3	5	
Coarse Earth Sun Sensor	4.00		4	5	4	5	2	3	5	
TMTC	3.96		0.04		5	5	5	5	5	3
S-Band Transponder	3.88			3	3	3	5	3	5	5
S-Band Patch Antenna	3.88	4		2	4	5	4	3	5	
S-Band Helix Antenna	3.57	3		2	3	5	4	3	5	
PDT	3.75	0.03		5	5	5	5	5	3	
X-Band Downlink Assembly	3.43		3	3	2	5	3	3	5	
X-Band Antenna	3.29		2	4	3	5	2	2	5	
Harness	4.00	0.01	3	5	2	4	4	5	5	
System PFM	DQR_System_GWP		/	5	1	3	2	2	3	
RI for impact category GWP	3.28		0	0.02	0.01	0.09	0.08	0.07	0.12	
Check RI for impact category GWP	1 #needs to be 1									



The proposed content of the Prime inputs to LCA document is:

- Mission description: objective and description of the mission and the segments. Explanation of the scope of the contract. When available a CAD figure can be added.
- Programmatic overview: Teams involved in the project (e.g. Prime for satellite, platform, payload, GSE, Ground Segment, launch procurement and countries, when known suppliers and countries can also be described).
- Model philosophy (EM, PFM, FM2 . including a description of the models, equipment, man hours). When possible, similarity between the different models it is important to highlight.
- Satellite(s) & GSE decomposition (i.e. product tree) and mass budgets (when available).
- Commonalities with previous Prime missions for which LCA was performed or datasets can be reused.
- Logistics (Sequence of activities & transport) (e.g. type of transport mean and distance).
- Satellite test campaign schedule (including type of facility needed and duration):
 - Supplementary information when activities are performed by the Prime (or subcontractor):
 - o energy consumption per year (i.e. [kWh]) and Energy mix used (i.e. depends on country),
 - o persons working in the building,
 - o total number of persons working on the activity under study,
 - o type of cleanroom (if needed),
 - o volume of cleanroom used (area and hight) (if needed),
 - o energy per m2 of cleanroom and year/month (i.e. [kWh/(m2*year or month)]) (if needed).
- Office work and travels:
 - Prime contractors LCA Data:
 - o location
 - o total number of employees on site
 - o working hours per person per day
 - o working days per year
 - o primary consumption (e.g. heating, water, electricity) per year for offices and cleanrooms
 - travels and persons travelling, type of travels (car, plane, train)
 - usage of cleanroom (ISO, duration, areas).

Annex C - Prime Inputs for LCA

Mission-Specific Datasets

Annex C details essential mission datasets including product trees and mass budgets for LCA accuracy.

Logistics and Schedules

Logistics and test campaign schedules are key inputs to model life cycle inventories effectively.

Resource Consumption Data

Resource consumption data supports integration into ESA's LCA framework for comprehensive analysis.

Annex D - Simplified LCA

Streamlined LCA Approach

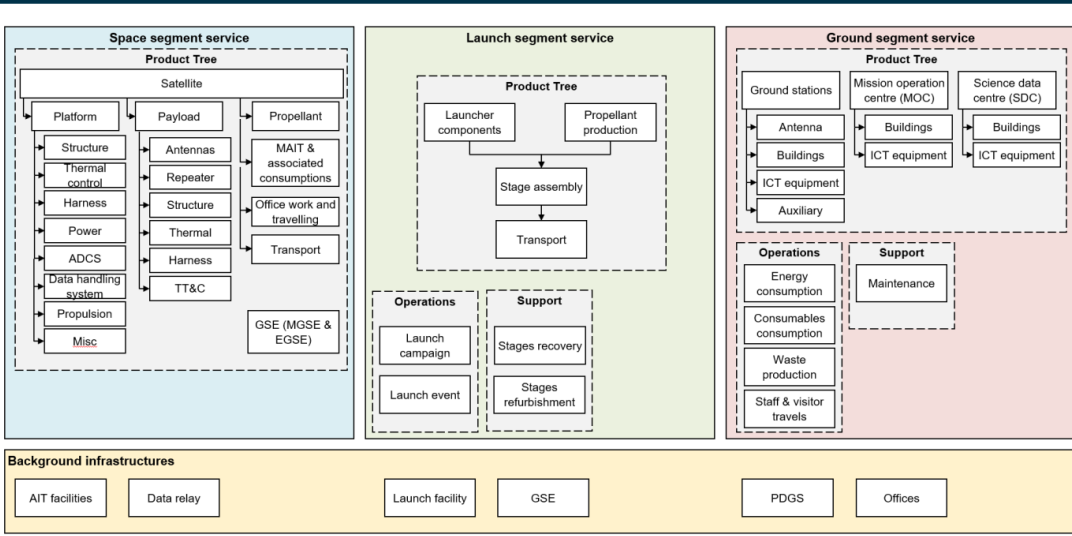
Simplified LCA method emphasizing key indicators and minimal data for early design phases, valuable for **decision making** without compromising credibility of outcomes.

Life Cycle Inventory

Data availability is limited. Existing databases adapted, generic datasets, proxies. Acknowledge the data gaps and assumptions.

Key Impact Categories

Recommended impact categories include global warming potential, ozone depletion, human toxicity, resource use, water and energy consumption.



Annex D - Simplified LCA

Interpretation and reporting

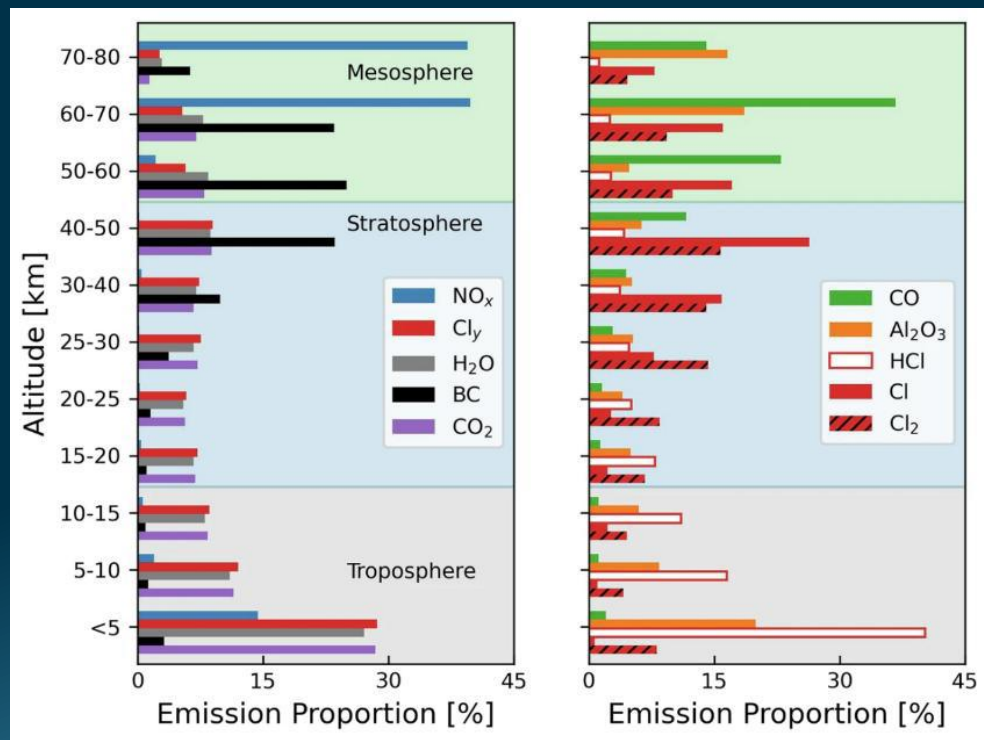
Due to uncertainty, results are not meant to be presented publicly, but a simplified LCA study is a mandatory output. Comparing two simplified LCAs can facilitate the pursue of an ecodesign solution.

Limited data availability

At early stage available documents and data are limited. Several modelling approaches and assumptions are provided for space, launch and ground segments.

At PRR	Raw materials (identification and mass)	Processes (e.g. assemblies, integrations, surface treatments.)	Staff (e.g. development hours, travels, number of people)	Transport (km)	Testing (e.g. type of test, duration and plan availability)	Cleanroom usage (surface, time, class)
Segment	Not applicable	Not applicable	Available (c,h,j)	Not applicable	Not applicable	Not applicable
System (e.g. PFM, FM2)	Not applicable	Not Available	Available (c,h,j)	Available through secondary data (c)	Available through secondary data (c, j)	Available through secondary data (a,c, j)
Subsystem	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available
Equipment	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available
At SRR	Raw materials (identification and mass)	Processes (e.g. assemblies, integrations, surface treatments)	Staff (e.g. development hours, travels, number of people)	Transport (km)	Testing (type of test, duration and plan availability)	Cleanroom usage (surface, time, class)
Segment	Not applicable	Not applicable	Available (C,J)	Not applicable	Not applicable	Not applicable
System (e.g. PFM, FM2)	Not applicable	Available through secondary data (i,ii,vi)	Available (C,J)	Available through secondary data (C)	Available through secondary data (C,J)	Available through secondary data (A,C,J)
Subsystem	Not Available	Not Available	Available through secondary data (C)	Available through secondary data (C)	Available through secondary data (C,J)	Not Available
Equipment	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available

Annex E - Atmospheric Impact



Tracking Key Atmospheric Pollutants

Emissions from launches include CO₂, H₂O, NO_x, soot, and Al₂O₃, significantly affecting atmospheric chemistry.

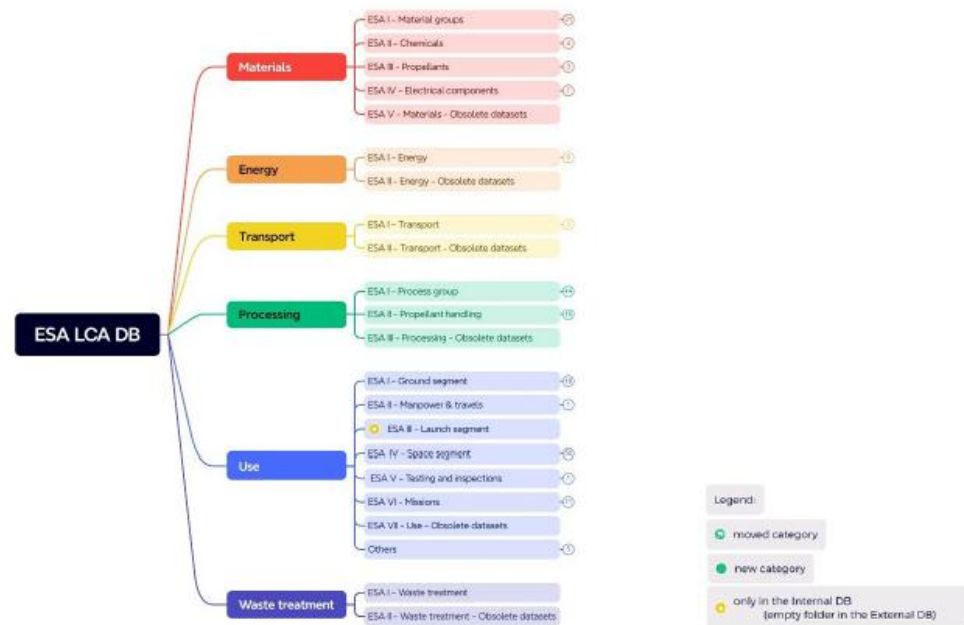
Awareness on Ozone Depletion and Radiative Forcing

Certain emitted species contribute to ozone layer depletion and influence radiative forcing, impacting climate.

LCA Integration Recommendations

Recommendations promote integrating these atmospheric impacts into life cycle assessments with new flows and factors.

Annex F - LCA Database and Modelling Guidelines

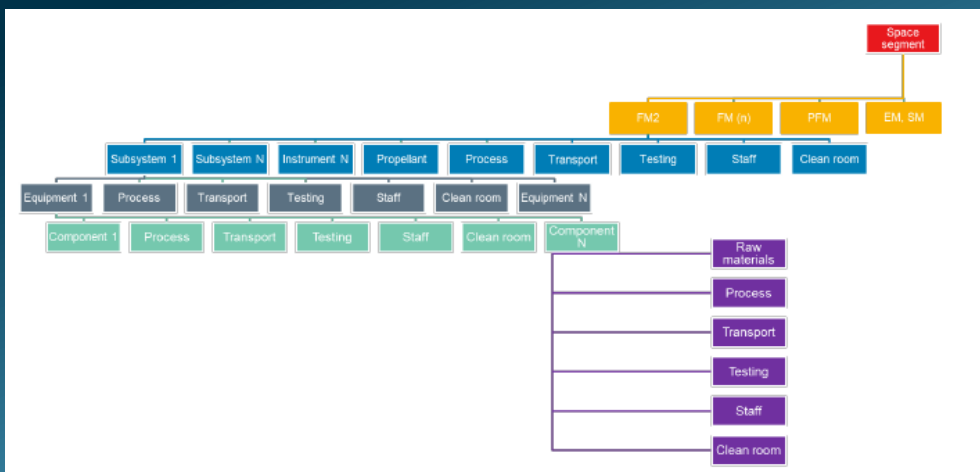


Space-Specific LCA Datasets

The ESA LCA Database includes datasets for materials, energy, transport, processing, use, and waste specific to space applications.

Modelling Guidelines

Guidelines provide product tree templates and assembly structures to standardize lifecycle assessment across projects. Importance is given to macro activities at each level.



Annex G - Templates

Data Collection Questionnaires

Annex G provides standardized questionnaires to ensure comprehensive and consistent data gathering for life cycle assessments.

DQR Aggregation Tables

Templates for DQR aggregation tables help aggregate data quality ratings to maintain inventory accuracy and reliability.

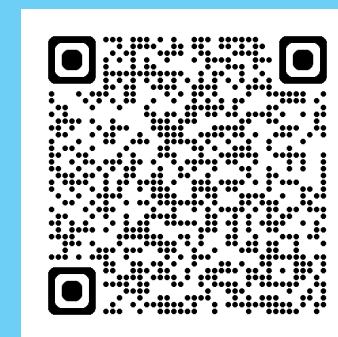
Support for LCA Practitioners

These templates assist LCA practitioners and suppliers in harmonizing reporting and ensuring compliance with ESA guidelines.



Q & A

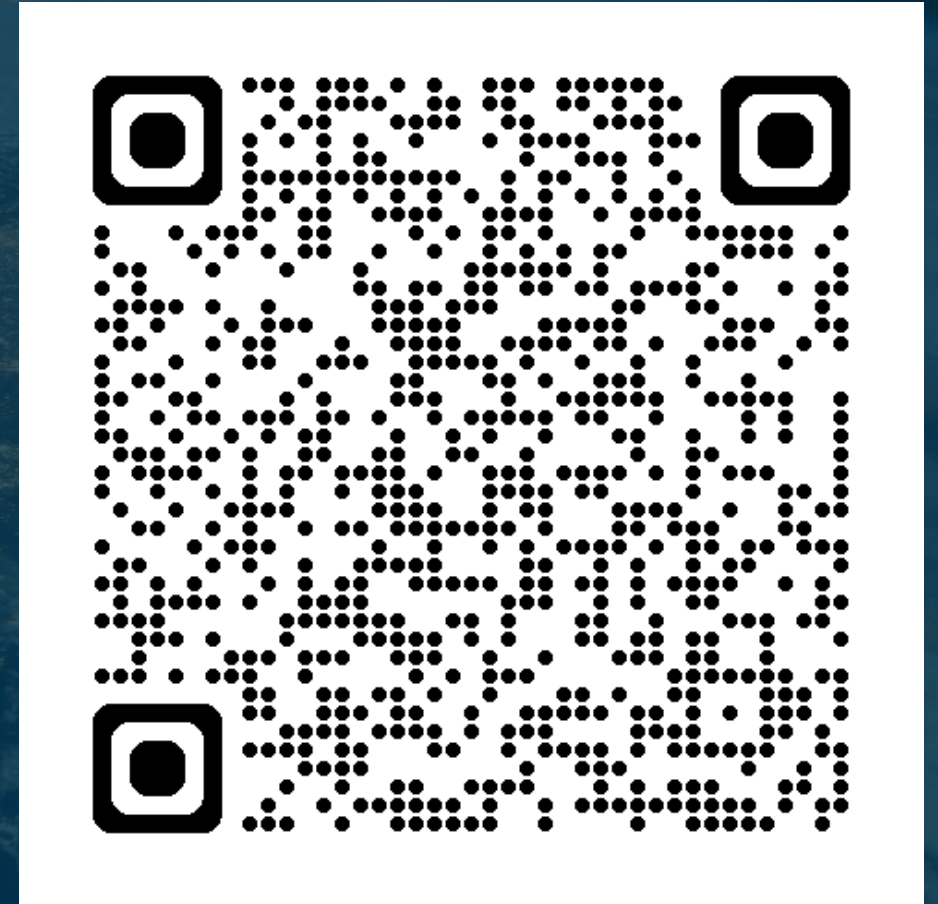
Download the ESA LCA Handbook here:



- The new methodology is flexible to meet the new trend of industry (reusability, ISAM, service provisions)
- To meet green agenda objective of -28% GHG in projects by 2030 we need ecodesign
- Ecodesign will be based on simplified LCA
- Improved communication of results
- New and simplified DQR
- Impact categories are aligned with PEF
- There is a common ESA-EC data collection template

For further questions: cleanspace@esa.int

Download the ESA LCA Handbook here:



Thank you for your attendance

Download the ESA LCA Handbook here:

