Lessons learned by applying LCA to the CO2M space mission during phase B2 and C/D

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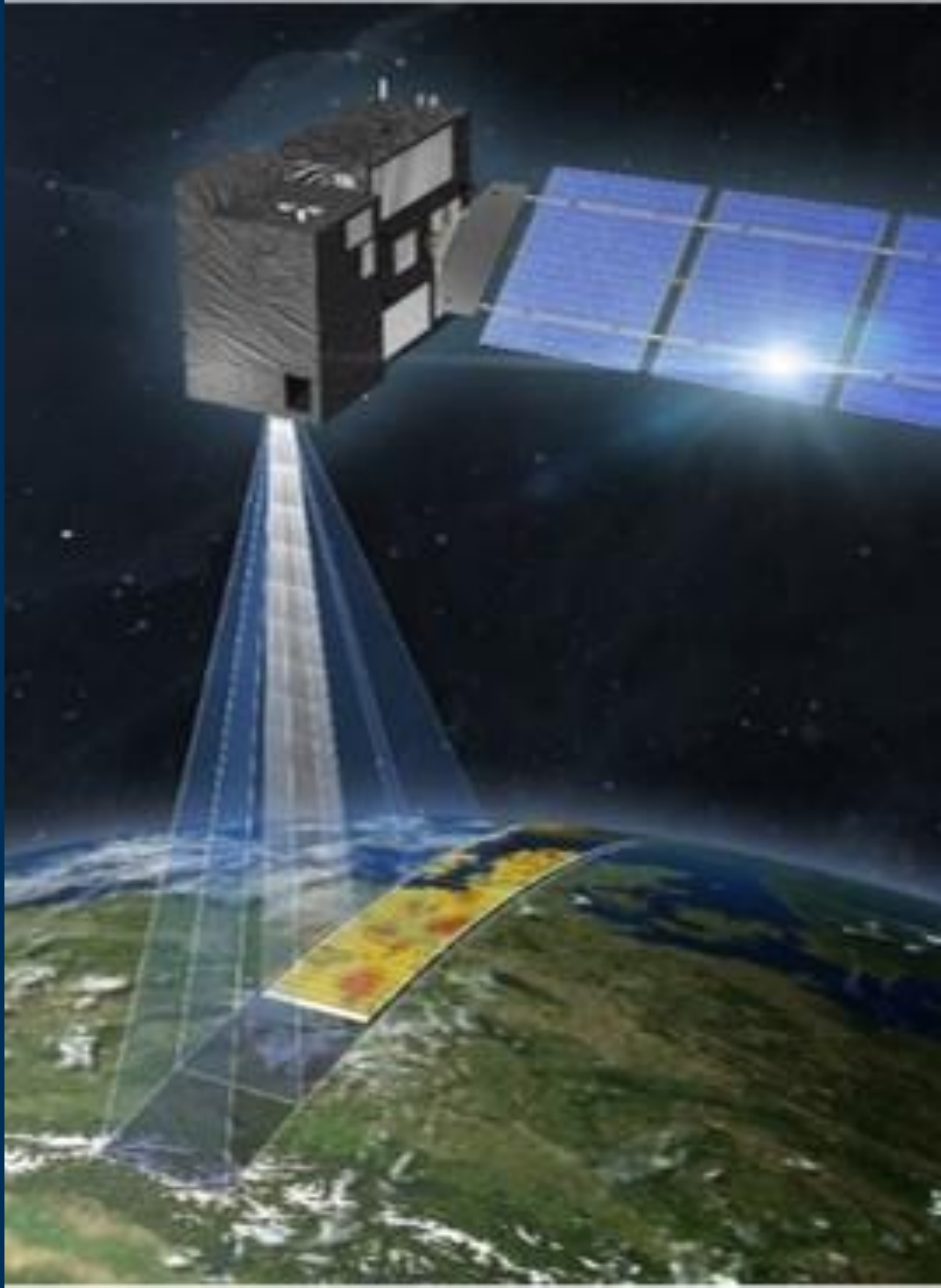
CO2M

OHB



Outline - LCA of CO2M mission

APPROACH

RESULTS OF THE 1ST ITERATION

LESSONS LEARNED

LCA of CO2M mission - approach

How it started:

- Iterative LCA of standard platform for Copernicus missions during phase A/B1
- Identification of environmental hotspots and mitigation actions

What is currently ongoing:

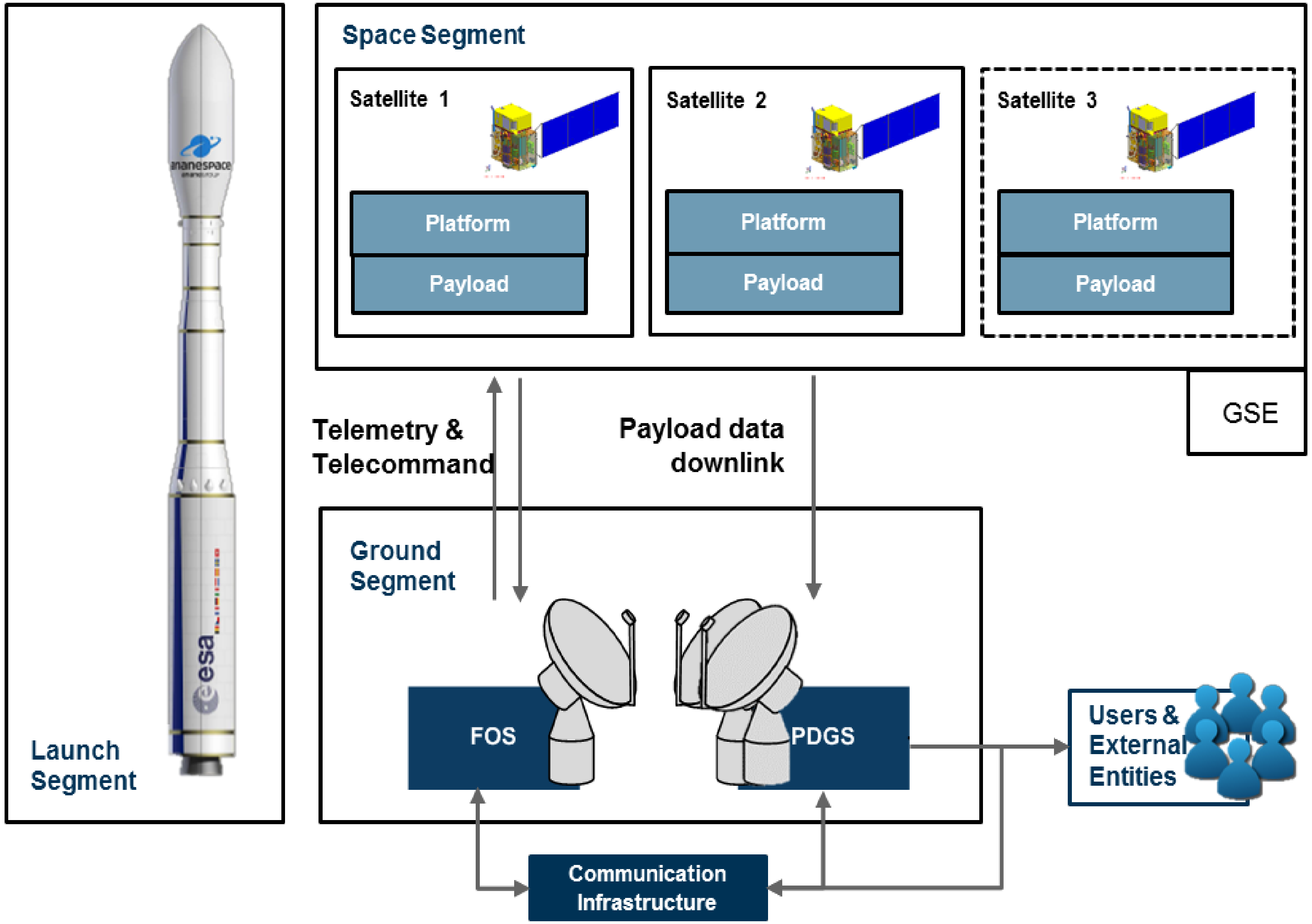
- Iterative LCA of CO2M mission (platform + payload) during phase B2, C, D
- Identification of environmental hotspots and understanding impacts/sources

Basis:

- Methodological rules following Space system Life Cycle Assessment (LCA) guidelines → tailored
- ESA database → data gaps

LCA of CO2M mission – Approach

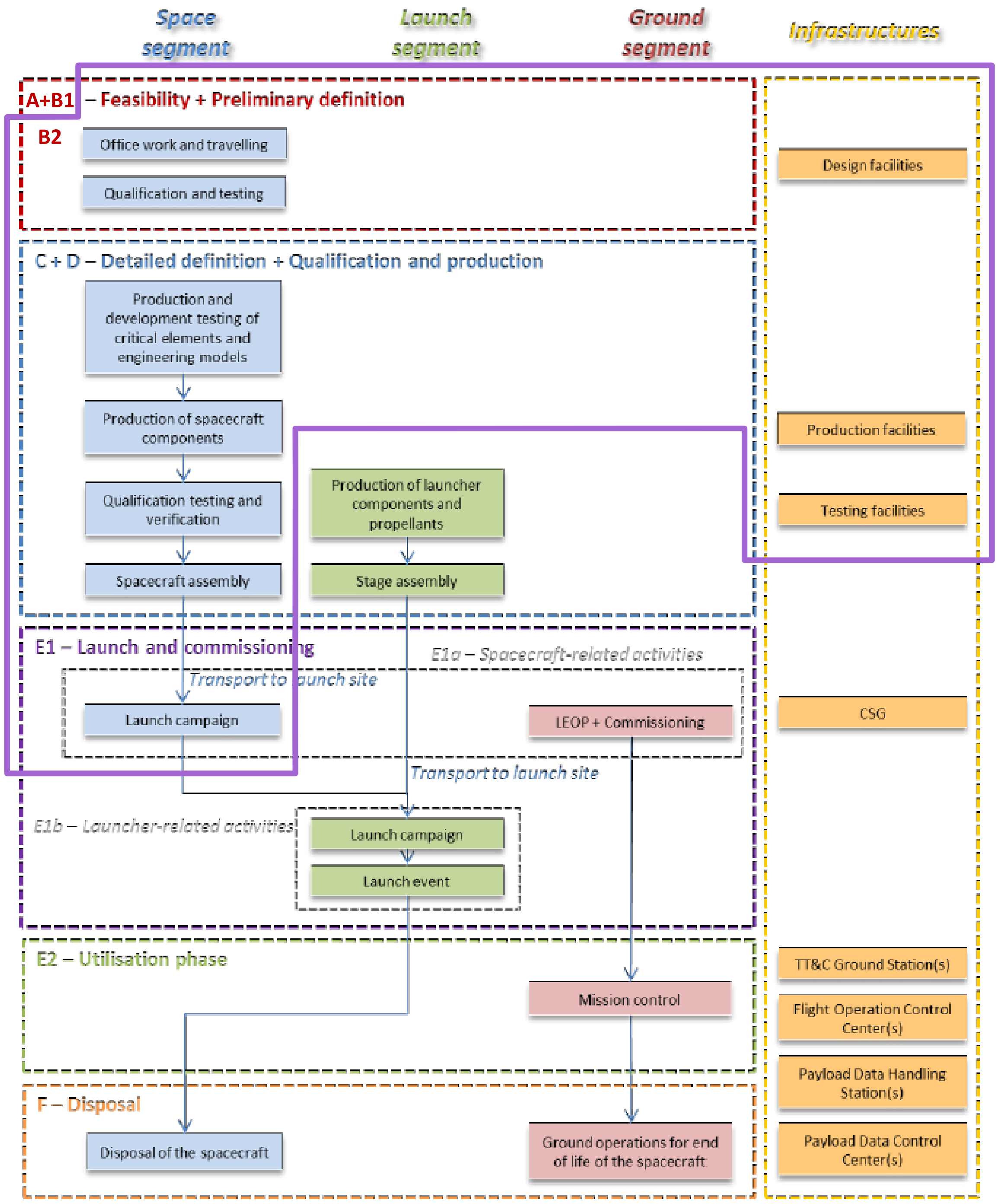
- CO2M Mission objective is to measure and identify hotspots of anthropogenic CO_2-emissions
- **Baseline:**
  - constellation of two satellites with option to include a third one (on-ground storage period of 7 years)
  - 3 spacecrafts are identical
  - launch with the VEGA-C
  - operational mission will last for 7 years, with an extension of up to 5 years



LCA of CO2M mission – Approach

- **Functional unit:** "Definition, production, testing and spacecraft-related launch activities of the space segment of the CO2M mission"

- *Deviation from the ESA Space system LCA guidelines:*
  - *scope is limited to phases B2, C, D and part of E1, excluding the launch and ground segment*



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LCA of CO2M mission – Approach

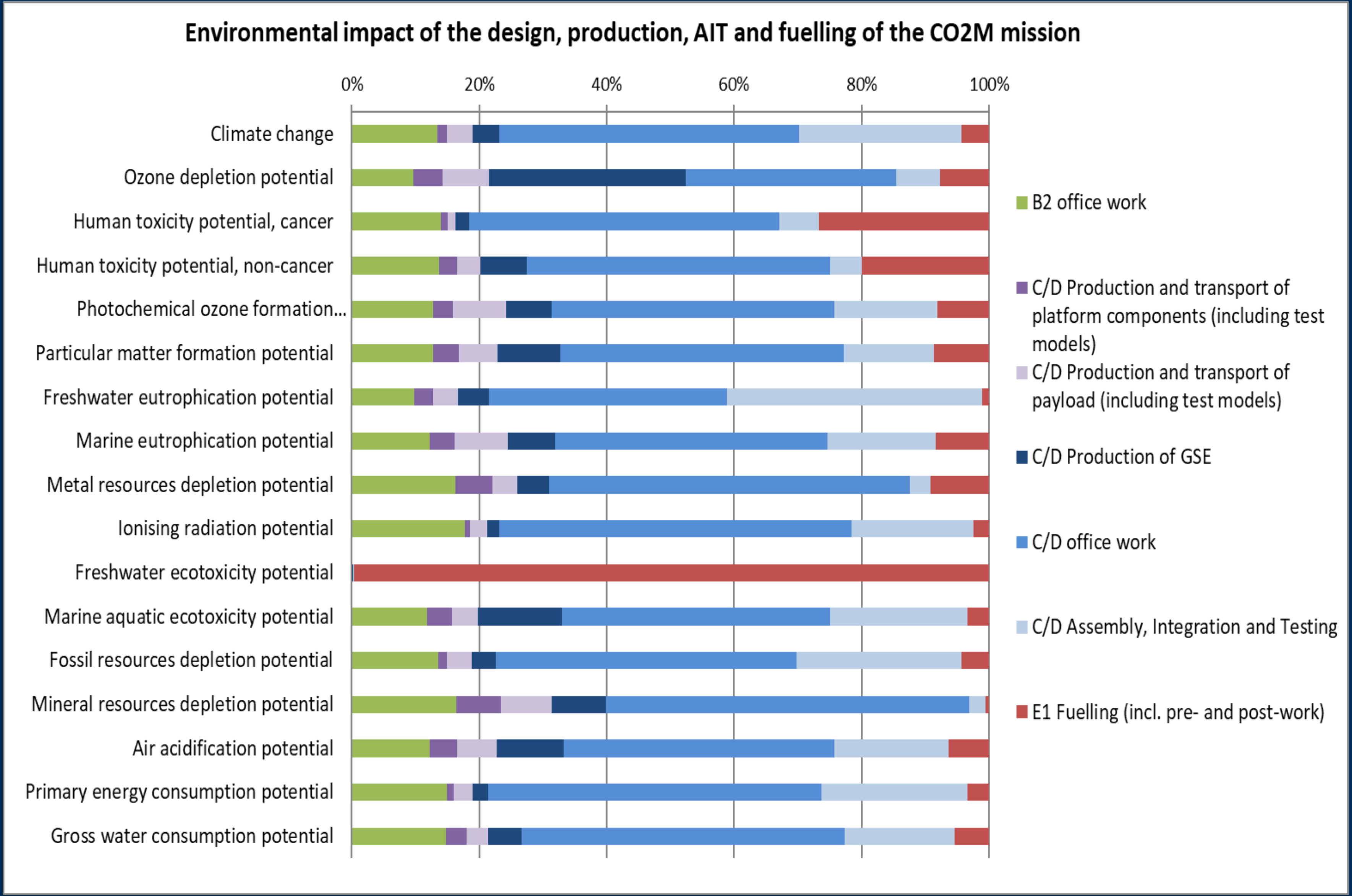
- Foreground processes:
  - specific data as much as possible
    - provided by OHB (platform) and TAS (payload)
    - from DML, DPL, expert judgements
  - generic data only where no specific data are available

Overview	Configuration Item Number	Material	Transportation	Manufacturing process	Source & Data Quality		
						Models	
					Source	Materials	Manufacturing processes
PLATFORM	111.00.00.00						
Electrical and Power Subsystem	111.01.00.00						
Battery Unit	111.01.01.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
Power Conditioning and Distribution Unit	111.01.02.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
Solar Array	111.01.03.00	Available	Available	Available	DML&DPL from Another Project	Masses estimated	none
Solar Array Drive Assembly	111.01.04.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	none
Payload Power Distribution Unit	111.01.06.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
Data Handling Subsystem	111.02.00.00						
On-Board Computer	111.02.01.00	Available	Available, including for each material	Available	Direct Info from Supplier	Exact masses	readily available manufacturing processes
Remote Terminal Unit 1	111.02.03.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	none
Remote Terminal Unit 2	111.02.04.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	none
Remote Terminal Unit 3	111.02.05.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	none
Payload Data Handling Unit	111.02.06.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
Telemetry, Tracking and Command Subsystem	111.03.00.00						
S-band Antenna (Hemi)	111.03.01.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	none
S-band Transponder	111.03.02.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
S-band TT&C RFDN	111.03.03.00						
S-Band 3 dB Hybrid Coupler	111.03.03.01	Available	Available	Available	CO2M DML&DPL	Masses ranges	none
S-Band Coax Cables	111.03.03.02	Not Available	Available	Not Available	Modelled using Proxy	Masses estimated	none
Attitude and Orbit Control Subsystem	111.04.00.00						
Star Tracker Sensor	111.04.01.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	none
GNSS Receiver (including antenna)	111.04.03.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
Coarse Sun Sensor	111.04.04.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
Magnetometer	111.04.05.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
Reaction Wheel and ext. Electronics	111.04.06.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
Magnet Torquer	111.04.07.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
Reaction Control Subsystem	111.06.00.00						
Propellant Tank	111.06.01.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
20N Thruster	111.06.02.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	none
Ball Latch Valve	111.06.03.00	Available	Available	Available	CO2M DML&DPL	Masses ranges	readily available manufacturing processes
Pressure Transducer	111.06.04.00	Not Available	Available	Not Available	Modelled using Proxy	Masses estimated	none
Fill and Drain Valve	111.06.05.00	Not Available	Available	Not Available	Modelled using Proxy	Masses estimated	none

- Background processes:
  - generic data or proxies
  - ESA LCA database (preferred) or Ecoinvent (default)

- *Deviations from the ESA Space system LCA guidelines:*
  - *No detailed data quality ranking method is described in the guidelines*
  - *ESA currently requires data quality to be determined according to the method used in the Environmental Footprint (EF) initiative → only performed in final iteration*
  - *Alternative quality ranking approach: color coding applied on availability matrix*

Results of the 1st LCA iteration



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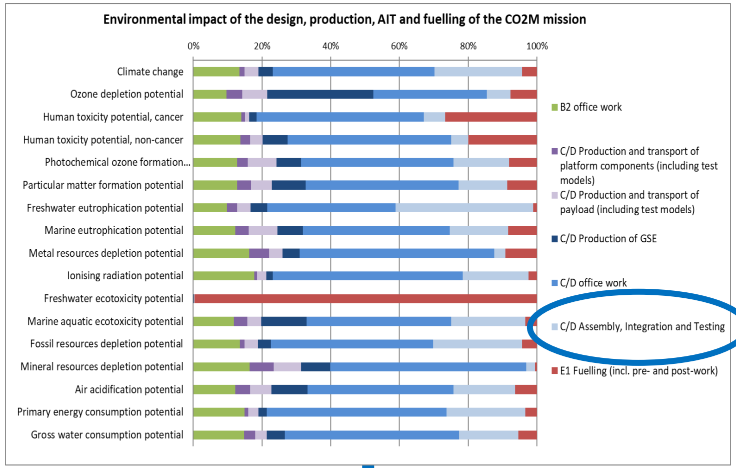
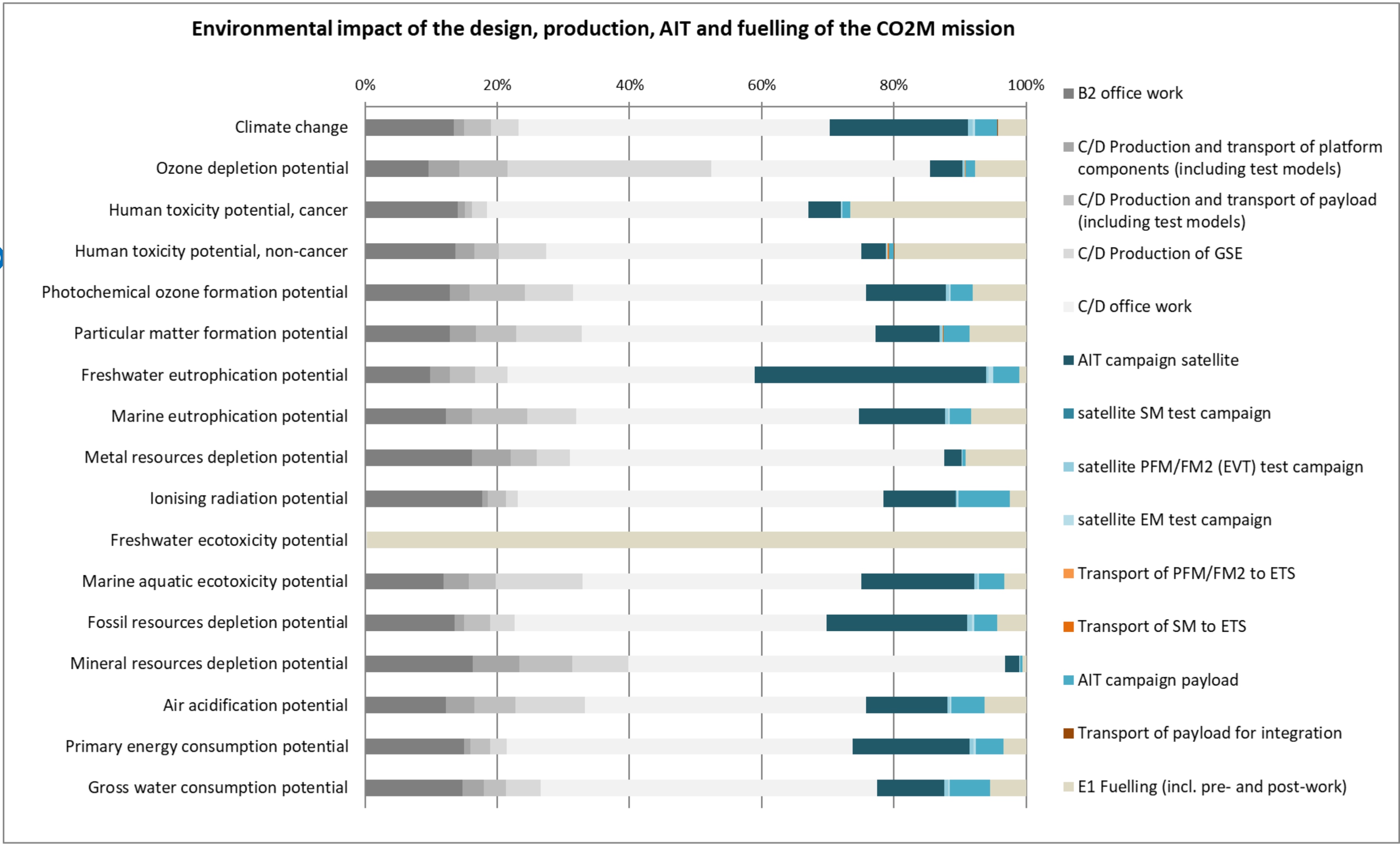
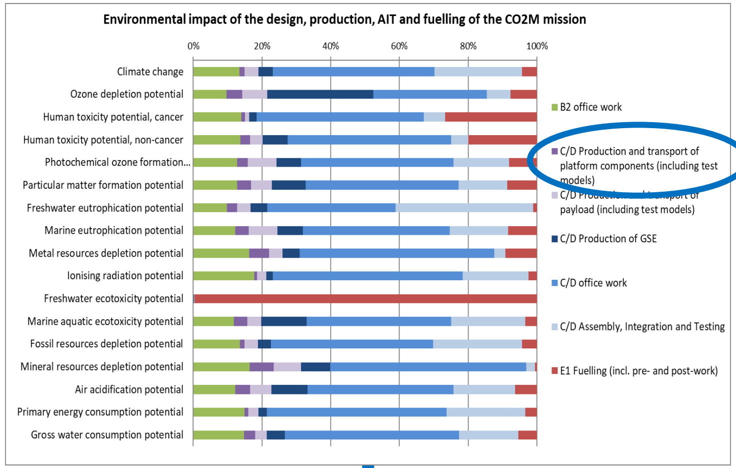
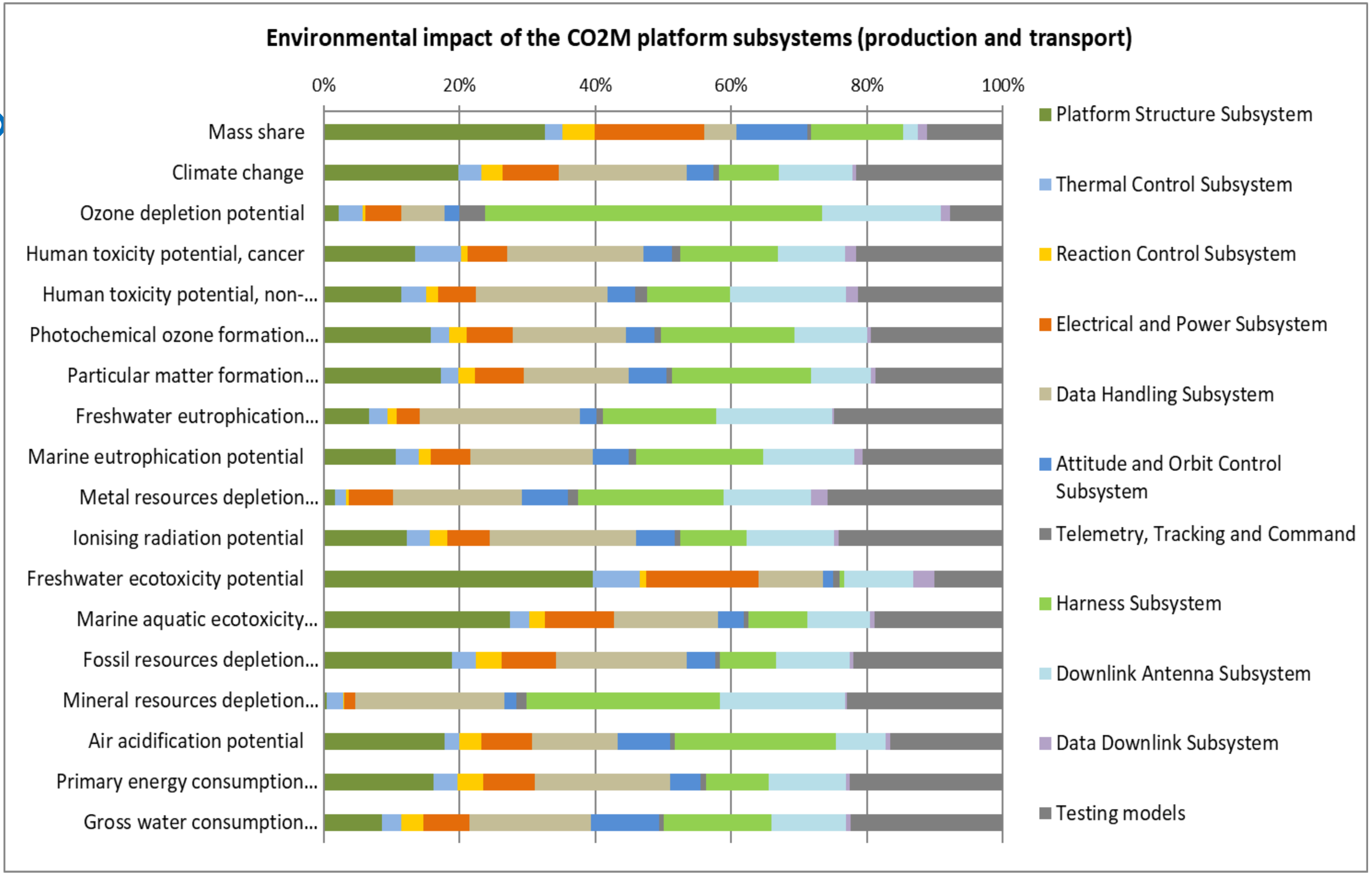




Results of 1st LCA iteration





Lessons learned

Iterative approach – 1st iteration

- Develop preliminary environmental profiles
- Identify the environmental hotspots of the mission
- Set focus for the data collection in the next iteration

Lessons learned

- Energy consumption is not measured per activity, thus it had to be estimated for the **cleanroom** and for the **tests campaigns**
- For **propellant production, fueling and handling**, we could rely on the data available in the ESA LCA database
- Data for number of **manhours** (office work) are available, but modelling of the impact of manhours relies entirely on data from previous studies
- The first iteration shows that it will be important to focus future efforts on data collection and modelling of office work and test campaigns. The Ground Support Equipment is also expected to become a significant contributor to the impact.

Lessons learned – Focus points for further data collection

Related mission phase	Contribution to environmental impacts (based on Iteration 1)	Identified improvement area (in order of importance)
C/D Production of payload and platform		Enhanced approach and data for the modelling of manufacturing processes
C/D AIT		Data for modelling cleanroom infrastructure
		More specific information about cleanroom (type, size, energy use)
		More specific information about energy use of test equipment, and/or type of test equipment (installed power, duration of test)
C/D Production of payload equipment		Collect specific data for MAP and CLIM instruments, and masses for currently non-modelled payload equipment to avoid currently applied cut-off criteria
		More specific information about the material composition of most payload equipment (when DML/DPL become available)
C/D Production of platform equipment		Platform Structural Model production to be included (production of test models)
		More specific information (materials breakdown) for platform equipment (indicated as not available for the 1st iteration) currently modelled using proxies
B2, C/D manhours		Possible inclusion of travel in the manhours (B2, C/D) impact
C/D Production of GSE		Masses of GSE equipment and more specific information or estimates for materials used

Lessons learned – Guidance & support of ESA

- ESA facilitates and enhances uptake of environmental considerations in space
- Supported by guidance documents, database, … → Need to continuously update

- **ESA space system LCA guidelines (ESA LCA Handbook):**
  - Tailoring **of system boundaries** in specific context is required
  - More recent developments available for **LCIA methodology** → method used in CO2M not fully compliant with method suggested in handbook
  - Clear guidance required for **DQR**:
    - Find balance between detail & effort
    - Different DQR per level
    - Distinguish DQR between prime and tier -1, -2, etc.
  - **Tailor/distinguish** guidelines in ESA Handbook specific for G&S and LCI to
    - Design stages of space mission
    - System level, subsystem level, component level, …
    - Objective of the LCA

Lessons learned – Guidance & support of ESA

- **LCA Data questionnaire harmonization:**
  - Allows data collection per supplier
  - Helpful for prime, but still data and time intensive for suppliers → prioritization is needed
  - Link with DML and DPL?

- **ESA Database:**
  - Supports for some equipment, but not for all
  - Lacks (default) data for testing, manhours, manufacturing processes, infrastructure → this is exactly type of (background) data which is difficult/impossible to collect
  - Should be considered as a proxy that matches DQR if no detailed supplier data are available

- Keep in mind the objective of the LCA-work during space mission development
  - For ecodesign
  - For ‘green claims’
  - For elaborating ESA database
  - …

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