STUDY IN THE FIELD OF ULTRA-GREEN LAUNCH & SPACE TRANSPORTATION SYSTEMS

- STUDY PERFORMED FOR ESA STS FLPP -

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1. INTRODUCTION

Context – Horizon 2030 - 2050

How to define greener Launch & Space Transportation Systems

2. HOW TO FRAME AN ULTRA-GREEN L&ST SYSTEMS?

Approach overview

First step: define Earth environmental issues and targets

Second step: identify a set of trade-offs to be explored

Third step: define the methodology to be applied among the trade-offs

Environmental impact evaluation methodology

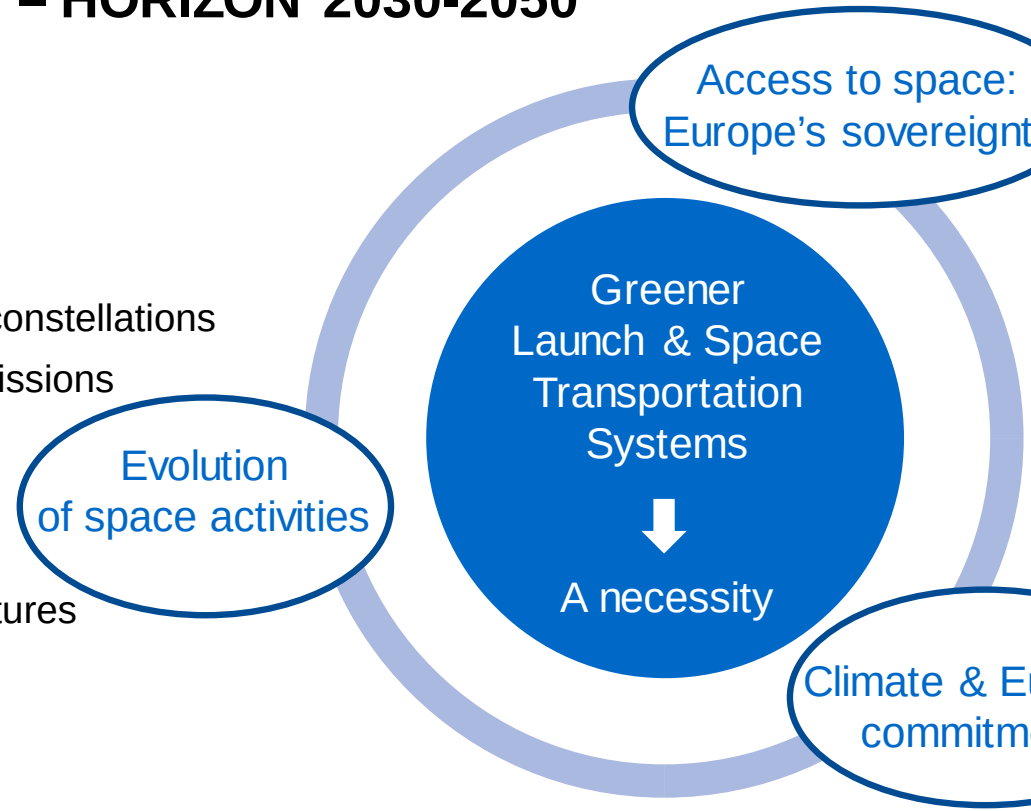
3. TOWARDS AN ULTRA-GREEN L&ST SYSTEM

Life cycle approach

Synthesis

01
INTRODUCTION

CONTEXT – HORIZON 2030-2050



Strenghten European autonomous access to space

Position Europe as a key player of space transportation

Mega constellations

Exploration missions

Lunar missions

Large infrastructures in space

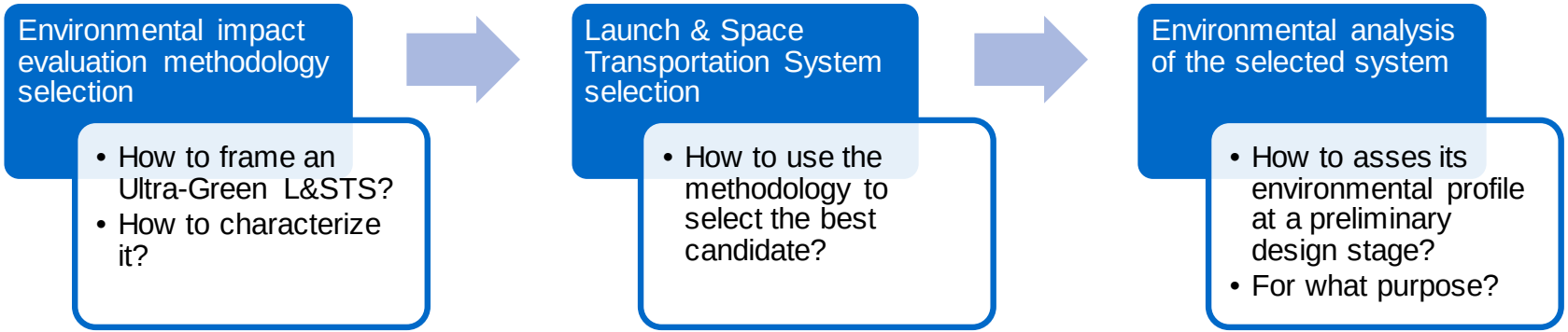
European Green Deal

Global warming mitigation

HOW TO DEFINE GREENER LAUNCH & SPACE TRANSPORTATION SYSTEMS

The study in the field of Ultra-Green Launch & Space Transportation Systems to investigate the potentiality to reach a greener system

The following steps of the study are detailed in this presentation



Focusing on the environmental impact evaluation methodology

- As a new approach to integrate envionmental aspects from the very beginning of a concept selection
- As a way to characterize what a greener Launch & Space Transportation System could be
- As a way to orientate design choices, assessing a very preliminary envionmental profile

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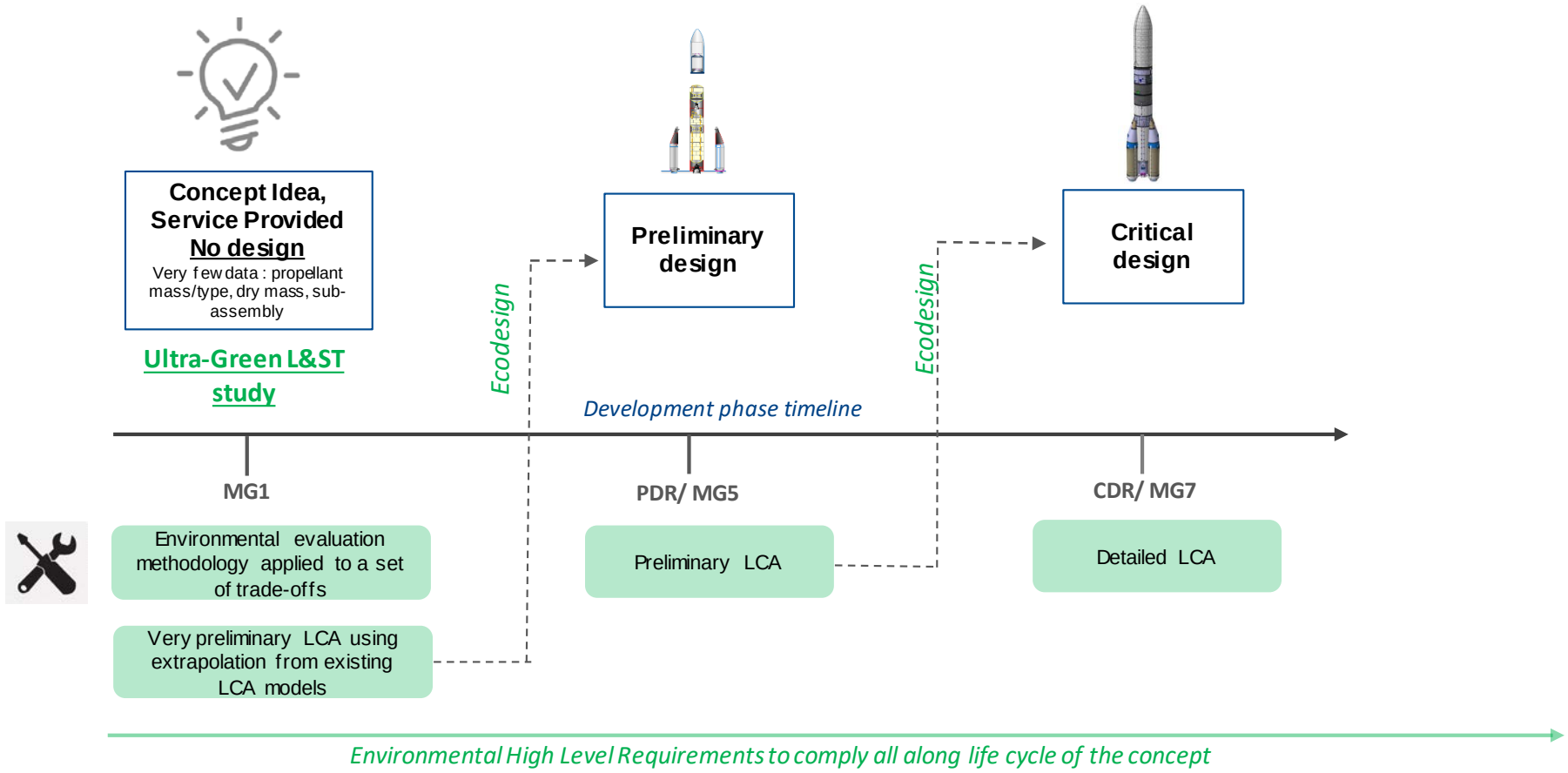
HOW TO FRAME AN ULTRA-GREEN L&ST SYSTEM?

APPROACH OVERVIEW



FIRST STEP: DEFINE EARTH ENVIRONMENTAL ISSUES AND TARGETS

Environmental issues and associated targets which are:

- Critical for the space sector
- Aligned with European environmental regulation (including the European Green Deal ambition)
- Relevant considering the available data at this stage

Climate change

- Reduction of greenhouse gases

Energy Demand

- Reduction of energy consumption
- Use of renewable energy

Resource depletion & criticality

- Reduction of resource consumption
- Reduction of supply risk linked to Critical Raw Material (CRM*)

Ozone depletion

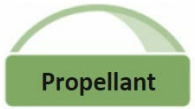
- Reduction of emissions impacting ozone layer

Human toxicity & Ecotoxicity

- Reduction of toxic substances use
- Reduction of marine pollution

SECOND STEP: IDENTIFY A SET OF TRADE-OFF TO BE EXPLORED

On what to focus the efforts to reach a greener L&ST ?



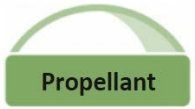
Main contributors to all impacts (total share of 72%)

Propellant: share of impact is 88% for solid propellant

Focus an Launcher: ***Environmental profile of A64- Global trends***

SECOND STEP: IDENTIFY A SET OF TRADE-OFF TO BE EXPLORED

On what to focus the efforts to reach a greener L&ST ?



- **T/O on Reusability** — ✓ **assessed** throught the methodology
- T/O on Technology manufacturing and raw material — ✗ Not feasible at this step
- **T/O on Propellant Launcher and Space Transportation vehicle** — ✓ **assessed** throught the methodology

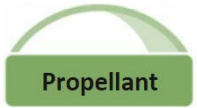
Focus an Launcher: ***Environmental profile of A64- Global trends***

THIRD STEP: DEFINE THE METHODOLOGY TO BE APPLIED AMONG THE TRADE-OFF

« Internal » inventory data available at this stage : service provided → dry mass, mass of the propellant, sub-assembly architecture and mass

« External » inventory data available : existing LCA models (Ariane 6, Themis study), ESA Space LCI database.

Extrapolation of existing LCA models:
generic data creation adapted to the level of reusability studied
→ quantify emissions factors on GWP, Energy demand and Abiotic Resource depletion

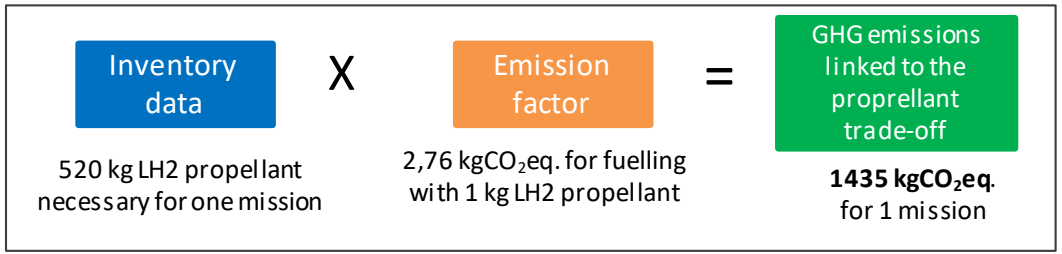


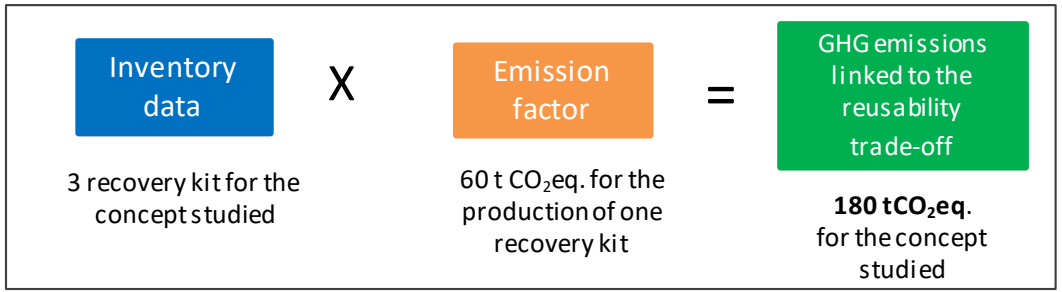
Use of the « propellant modules » available in ESA Space LCI DB
→ quantify emissions factors on GWP, Energy demand and Abiotic ressource depletion

ENVIRONMENTAL IMPACT EVALUATION METHODOLOGY-

EMISSIONS FACTORS PRINCIPLE

- **Examples for Climate Change Issue**





- **For each T/O : scope (life cycle step), applicability of criteria and availability of data were specified**

ENVIRONMENTAL IMPACT EVALUATION METHODOLOGY-

SYNTHESIS

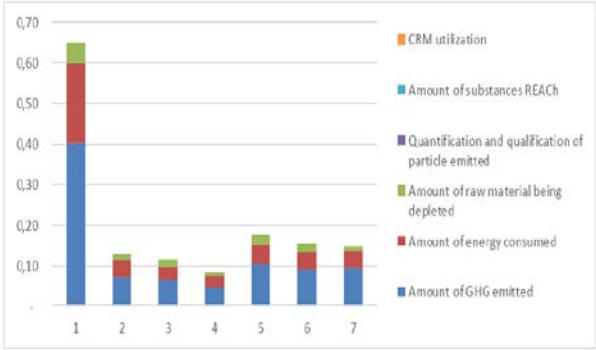
- Climate change
- Energy Demand
- Resource depletion & criticality
- Ozone depletion
- Human toxicity & Ecotoxicity

Emissions factors principles
→ results in:

- x Kg CO2 eq
- y MJ
- z Kg Sb eq

① Normalized

② Weighted



→ Decision making results

Assessment using « primary data » (mass, ..), which availability depending on the design level

Not detailed here

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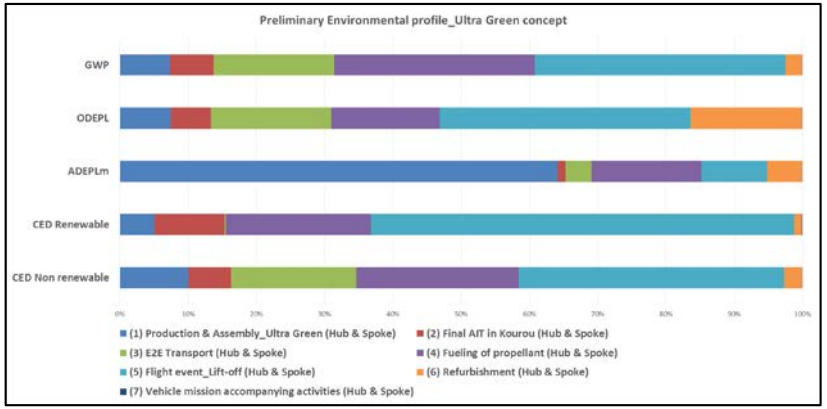
TOWARDS AN ULTRA-GREEN L&ST SYSTEM

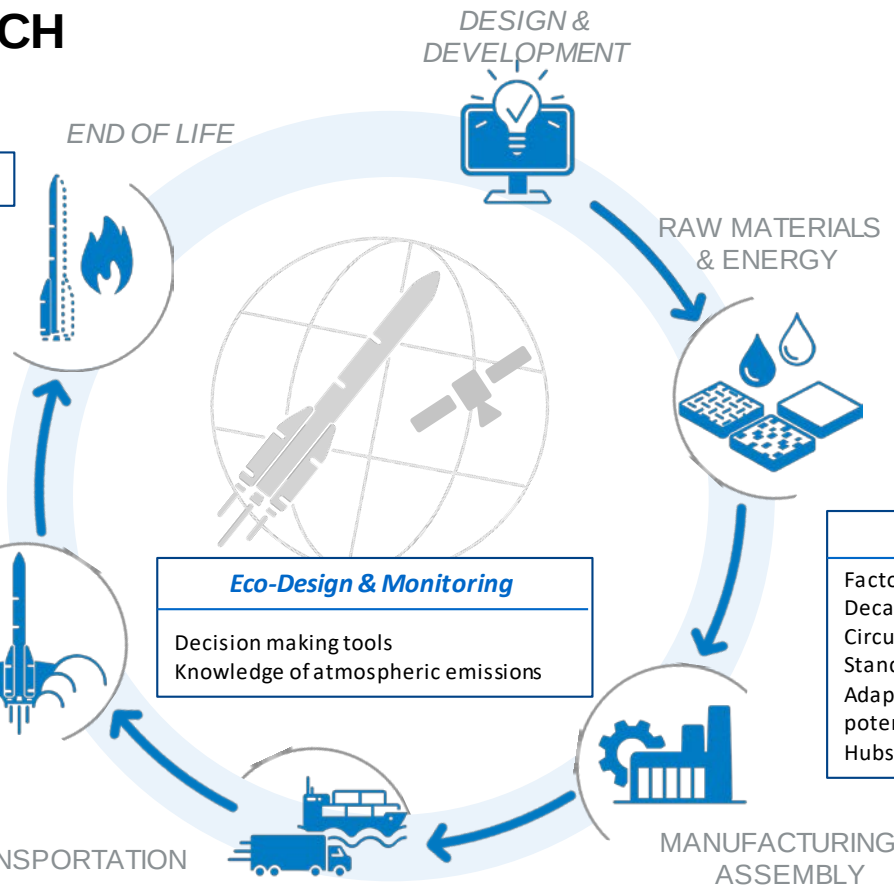
TOWARDS AN ULTRA-GREEN L&ST SYSTEM / LIFE CYCLE APPROACH

Preliminary LCA outcome / Topics to be further explored

- Choice of High temperature raw material
- Prodution route of propellant
- Better application of ALM
- Material and energy efficiency of manufacturing processes and sequences
- Energy consumption of launch activities during lift-off



TOWARDS AN ULTRA-GREEN L&ST SYSTEM / LIFE CYCLE APPROACH



Materials & Processes

Trade-off on material choices
- Composite/Metallic structures
- Qualification of recycled materials
- Bio-sourced materials, etc.
- Lightweight materials
- Less CRM (or O CRM based alloy)

Propellant and Propulsion System supply chain

New technologies:
- Tank manufacturing : ALM, FSW
- Composite tanks

Manufacturing & Assembly

Factory 4.0
Decarbonized production processes
Circular Economy
Standardized products
Adaptation of facilities (reuse, growth potential, less clean room, reduction of tests)
Hubs & MAIT repartition on the map

Eco-Design & Monitoring

Decision making tools
Knowledge of atmospheric emissions

New generation logistic and transportation

Share of transportation
New transportation: boat, ballon, drone...

Launch segment & in-space mission

Optimized ground support activities
Space/Ground communication network

Reusability

Recovery
Refurbishment

Dismantling

TOWARDS AN ULTRA-GREEN L&ST SYSTEM / SYNTHESIS

Eco-design is key to improve the Earth environment impact of Launch & Space Transportation Systems…

- Applying a high level environmental impact methodology
- Comply High level requirements all along the life cycle step
- Identify ways of improvment using ecodesign approach through each development step

… But needs to be supported by ambitious key sector decarbonization targets

- Benefit decarbonization of the operations, from production to refurbishment phases

Towards a Green Deal for Launch and Space Transportation Systems

- How to translate Green Deal ambitions to space sector and have a common Ultra-Green vision?