Ecodesign of a launch service based on a semi-reusable minilauncher

Loïs Miraux, environmental and cost engineer

2022 ESA Clean Space Industry Days
12/10/2022

Agenda

1. MaiaSpace vision

2. Preliminary LCA and ecodesign analysis
   - Previous work
   - Mitigation potential
   - Does reusability reduce impacts?

3. Way forward

OUR VISION

Space stands as a major enabler for a better and more sustainable life on Earth

OUR MISSION

Provide competitive, flexible and sustainable space transportation solutions

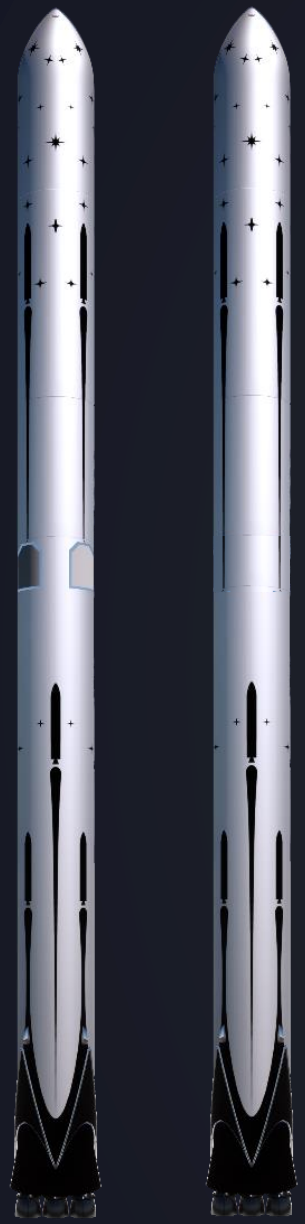
OUR TARGETS

Leader
European minilauncher

Best impact on
Earth environment

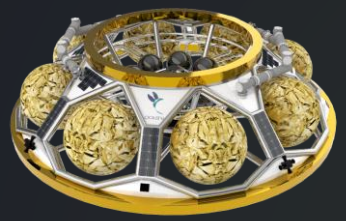
Best impact on
space environment

Access to space sovereignty
& European leadership



RLV ELV

Colibri kick-stage

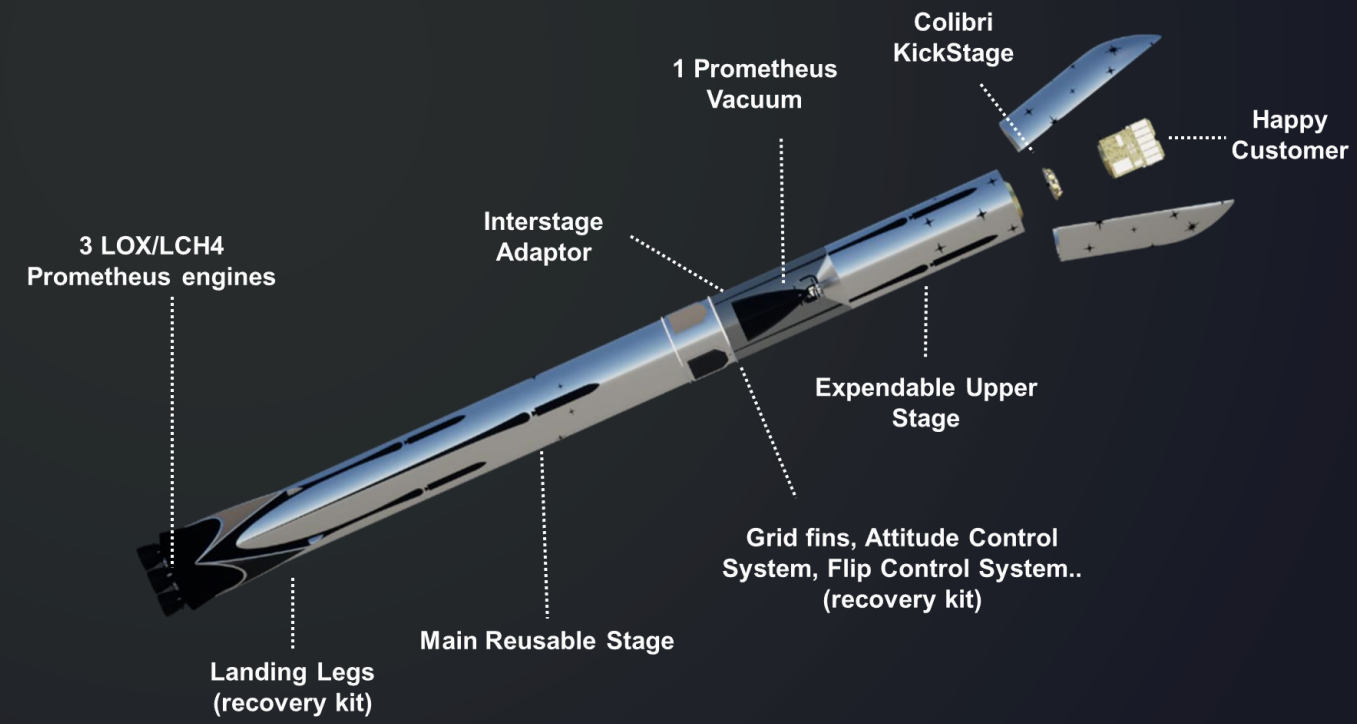


Prometheus engine

1st launch
End 2025

maiaspace

ONE LAUNCHER OFFERING TWO PERFORMANCE OPTIONS AND A COMPELLING SOLUTION FOR CONSTELLATIONS



OUR SOLUTIONS

Reusable, eco-designed and dual-performance launcher

500kg SSO 500km and 1500kg SSO 700km performance

In-Orbit services

Last miles delivery, Debris Removal…

SUSTAINABILITY IS OF THE ESSENCE

ECO-RESPONSIBILITY IS EMBEDDED IN MAIA SPACE STRATEGY, CULTURE, PROCESSES, SERVICES AND PRODUCTS.

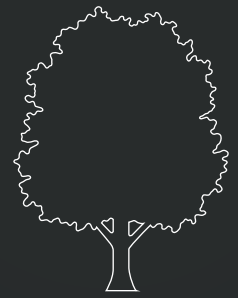
Ambitious environmental impact reduction

Eco-design from the start

Advanced methodology
paving the way for space activities Full Life Cycle Analysis

Frugality to optimise our resources (material, energy, time)

Low emissions and shared shipment from mainland France to French Guiana



Launcher first stage reusability

Bio-methane fuel
Very low soot emission
Low carbon production
Local production & resilient supply

High efficiency cryogenic propellant storage and operations

Systematic debris deorbitation, in addition to satellite injection mission
For a clean space

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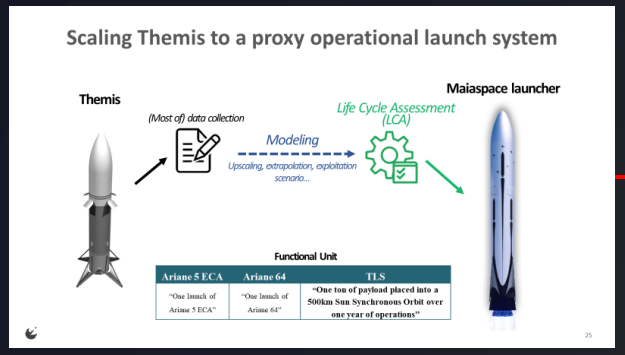
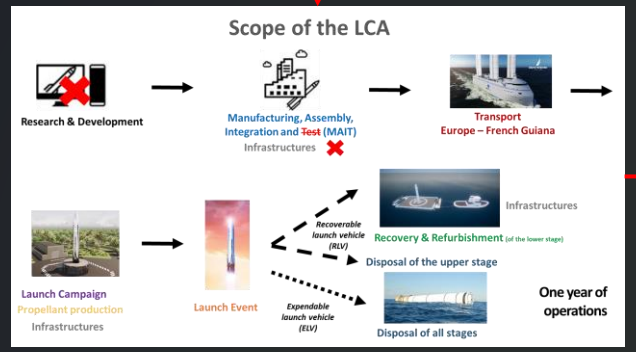
PARAMETRIC LIFE CYCLE ASSESSMENT

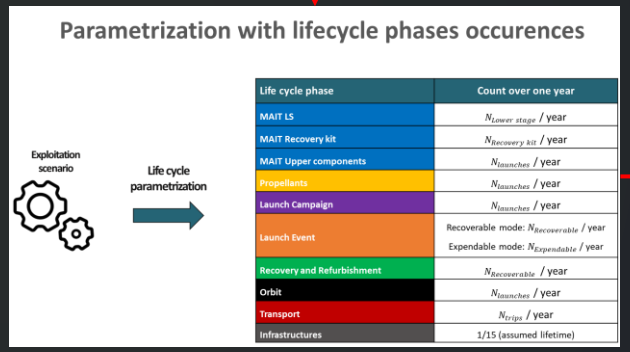
Presented at the 2021 Clean Space Industry Days



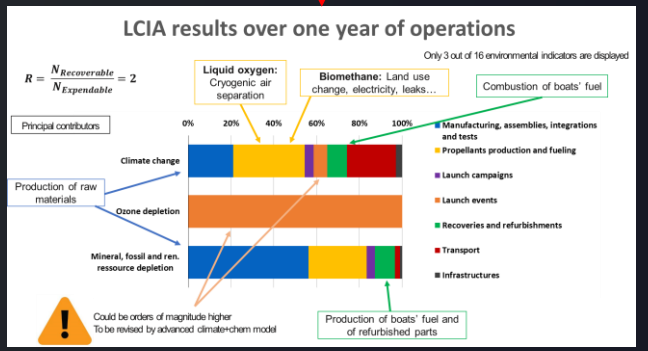
1 Scaling from Themis Functional Unit*



2 Scope



3 Lifecycle parametrization (market, system, operations)



4 LCIA results (one year)

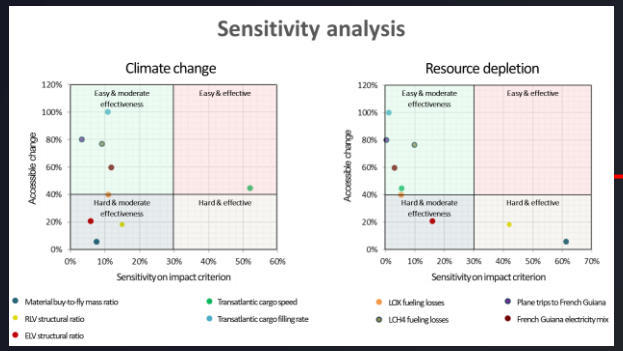
*FU: "One ton of payload placed into a 500km Sun Synchronous Orbit over one year of operations"

Production of components: 21% CC ; 58% RD
Production of propellants: 33% CC ; 28% RD
Transatlantic transport: 23% CC
Launch event: 6% CC ; 100% OD
Recovery and refurbishment: 10% CC and RD

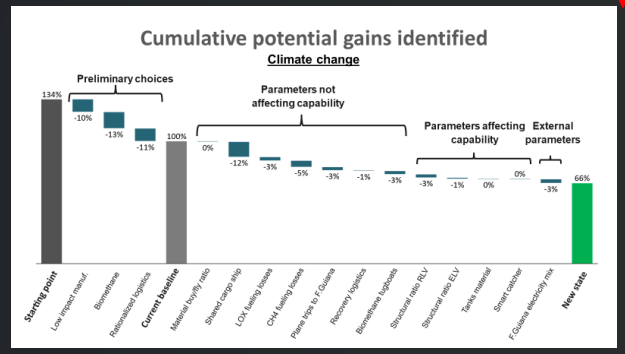
All slides available in appendix

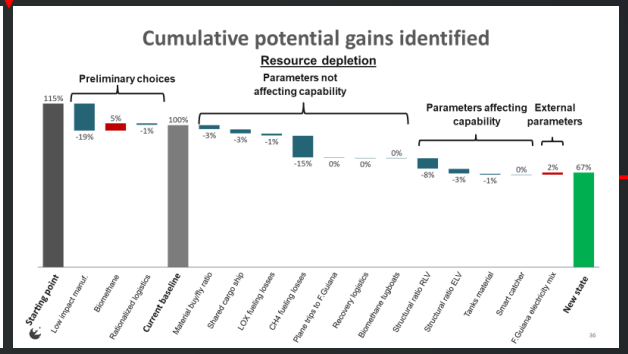
ECODESIGN AND IMPACT MITIGATION POTENTIAL

In this presentation

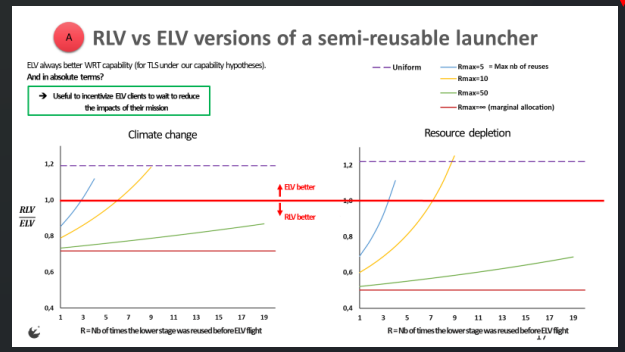


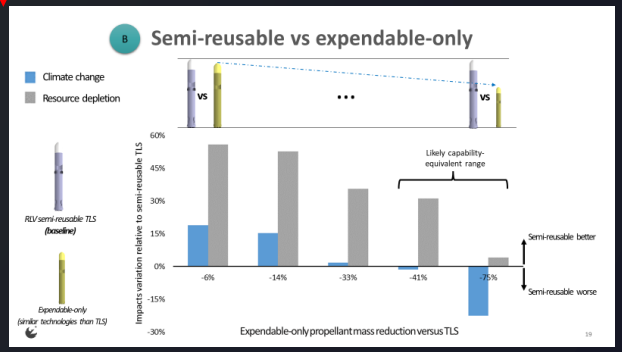
5 Identification of main drivers (sensitivity analysis)





6 Cumulative potential gains



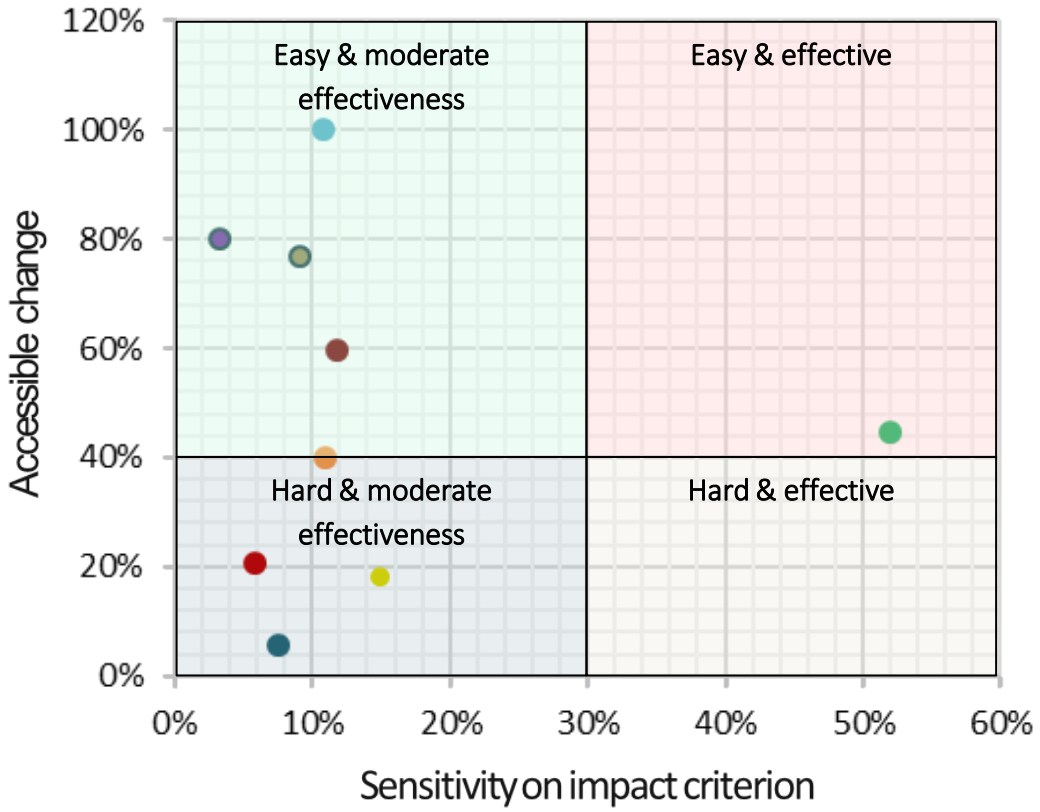


7 Does reusability reduce impacts?

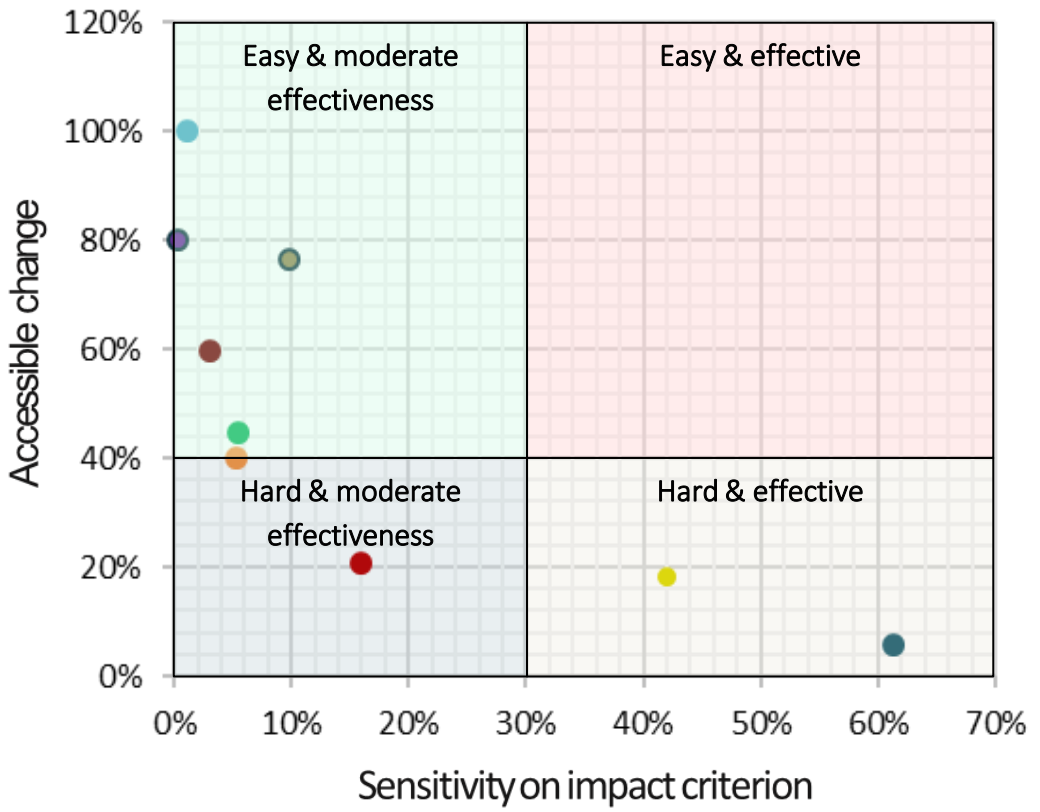
All slides available in appendix

SENSITIVITY ANALYSIS

Climate change

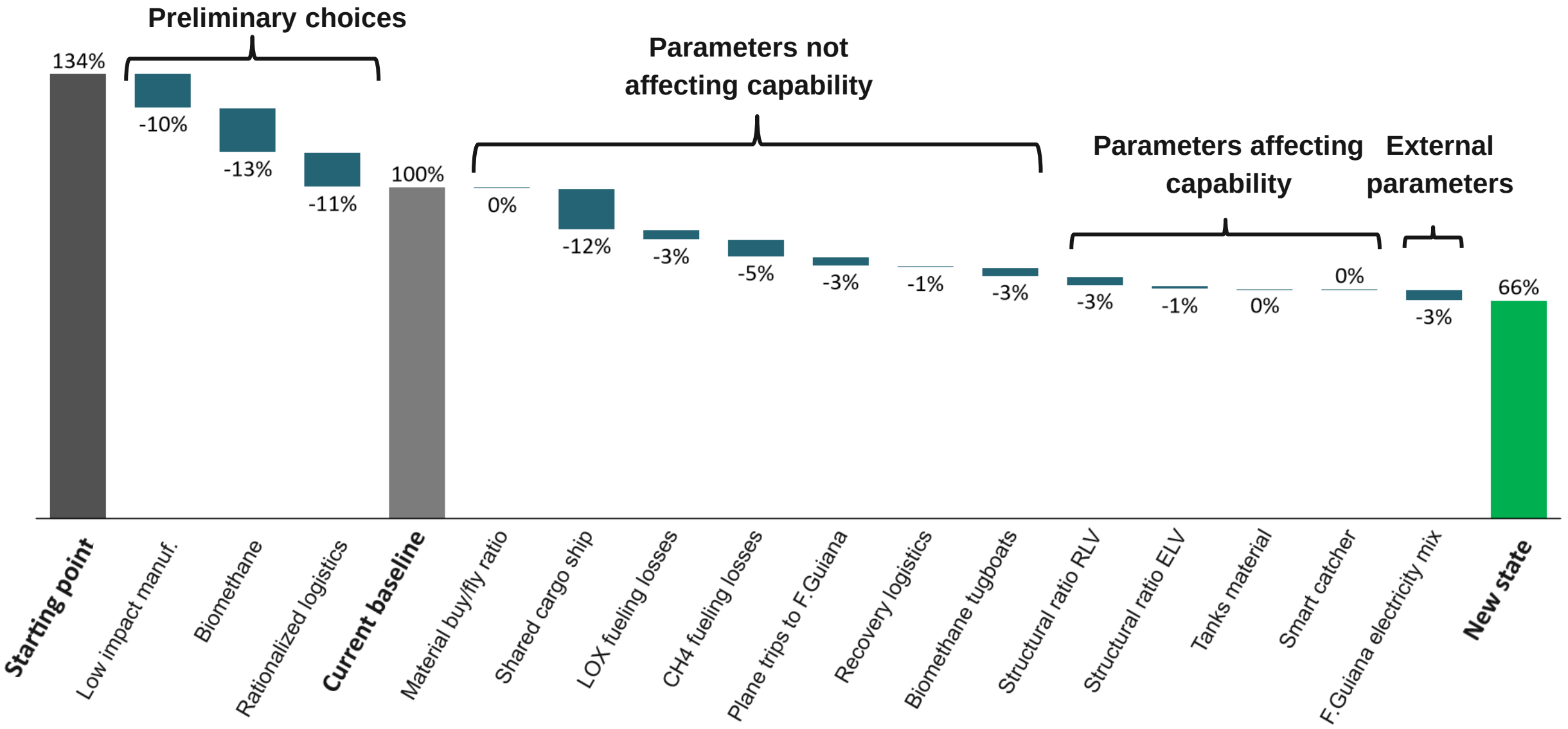


Resource depletion

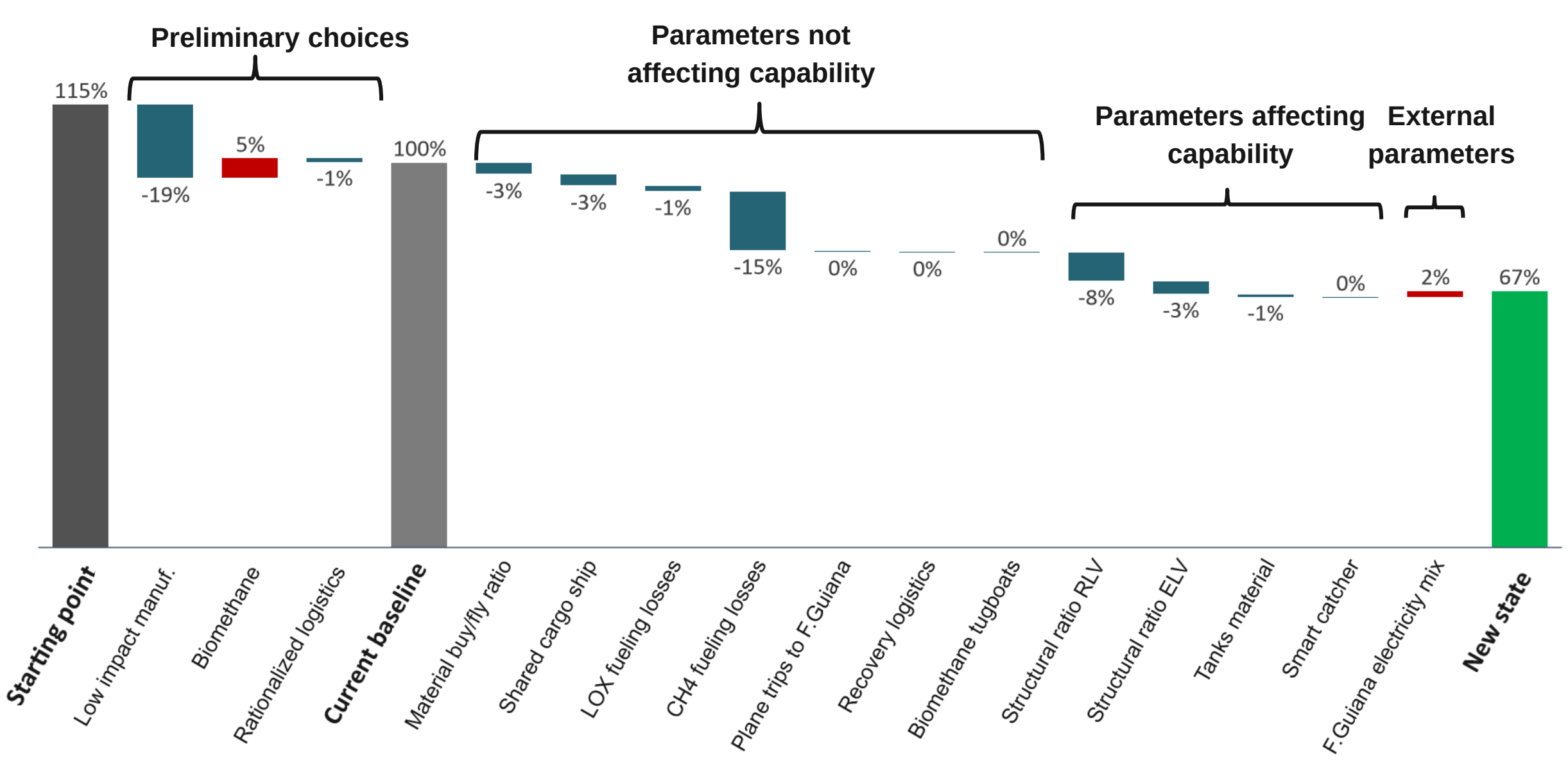


- Material buy-to-fly mass ratio
- RLV structural ratio
- ELV structural ratio
- Transatlantic cargo speed
- Transatlantic cargo filling rate
- LOX fueling losses
- LCH4 fueling losses
- Plane trips to French Guiana
- French Guiana electricity mix

CUMULATIVE POTENTIAL GAINS (CLIMATE CHANGE)



CUMULATIVE POTENTIAL GAINS (RESOURCE DEPLETION)



DOES REUSABILITY REDUCE IMPACTS?

A RLV vs ELV versions of the same semi-reusable launcher

Micro/minisats market

RLV

VS

ELV

Mini/smallsats market

ANSWER*:

Allocation rules required

Impacts/ton : ELV better (Maia hypotheses)

Absolute impacts :

- depends on market (when ELV occurs)
- RLV better up to a critical nb of launches
- Ncritical depends on scenario
- No obvious answer !

Flexibility brought by RLV not valued

Useful to incentivize ELV clients to reduce impacts

B RLV version of a semi-reusable launcher vs expendable-only with same payload capacity

RLV semi-reusable

Identical market

VS

Expendable-only

ANSWER*:

Reusability likely **reduces resource depletion,** but may **increase climate change** impacts **in a worst case scenario and if no RLV ecodesign levers are activated**

Systemic changes in space economy ➔ **backfire rebound effect**

*Climate change and resource depletion indicators

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ECODESIGN ENGINEERING: IMPLEMENTATION

Business, R&D, industralisation teams

Targets
Market scenario
Design data
Cost data
Suppliers
Manufacturing data
CONOPS
Mission analysis
…

Estimation, monitoring

E-LCA model

€

RC and NRC model

Risk analyses

Feedback
Trade-off support
Mitigation

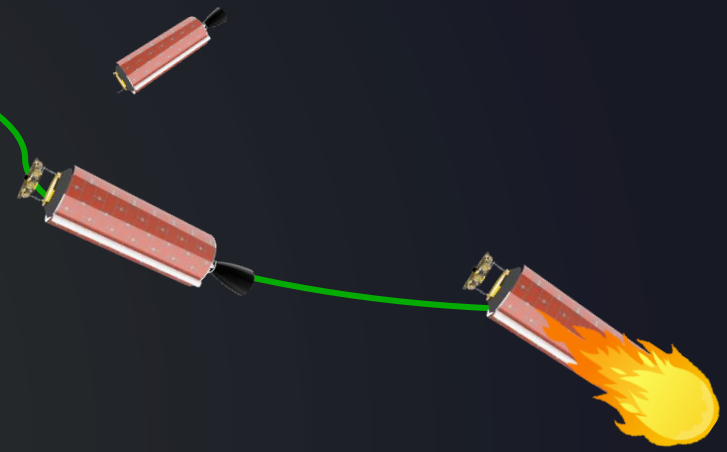
<u>Performance parameters</u>
Thermal
Structural
Fluidic
Power
…

SPACE DEBRIS MITIGATION

COLIBRI Flexible Kickstage

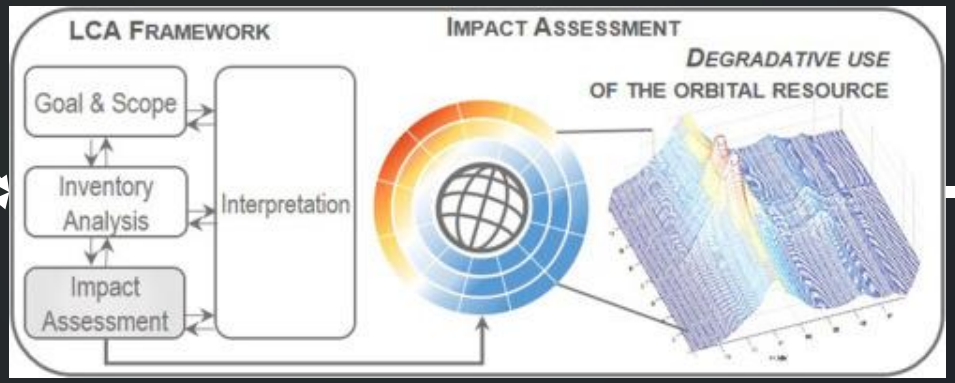
FLY

CLEAN



Baseline orbital propagation

Direct deorbitation



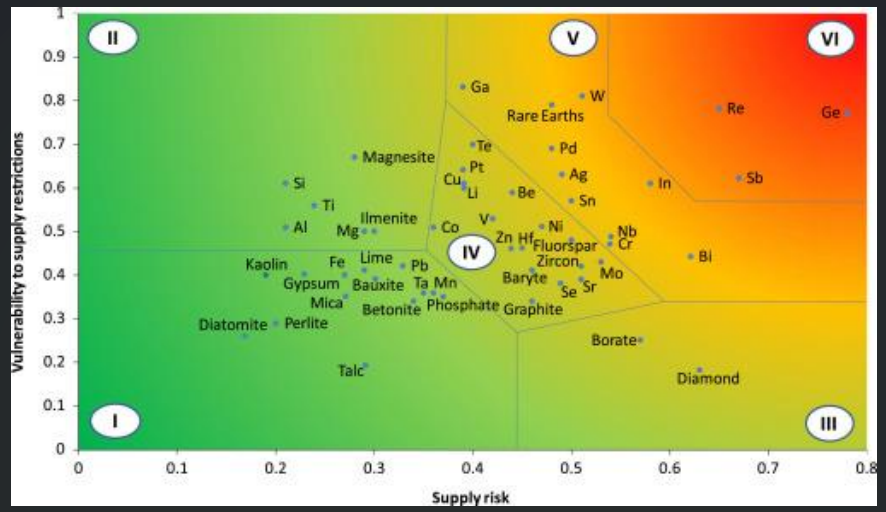
Maury et al., 2019

Score on space debris LCIA category

+ different re-entry trajectories? → different re-entry effects

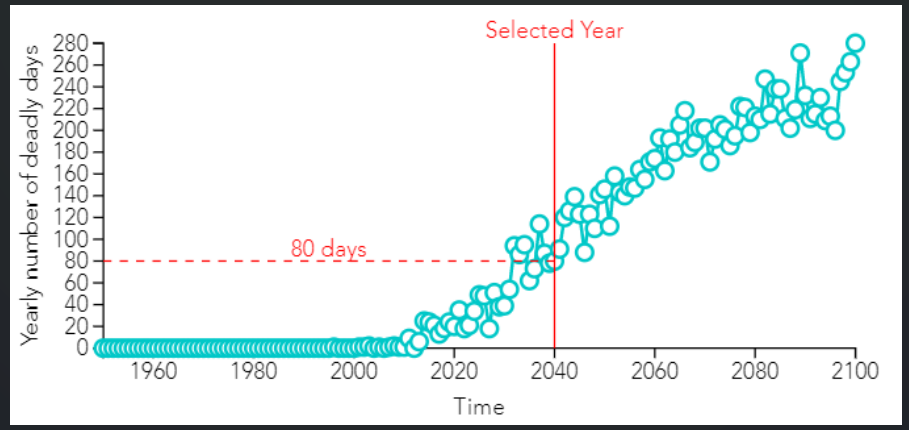
RISK ANALYSIS

Critical raw materials



Design trade-off
Supplier choice

Vulnerabilities and resilience to global change



French Guiana, RCP4.5

Launch site
CONOPS
Infrastructures

KEY TAKEAWAYS

LCA of a launch service based on a semi-reusable launcher ➔ Presented at the 2021 Clean Space Industry Days

Ecodesign strategy

- In early design stages to maximize leverage
- Driving parameters identified (system-level and market-level)
- Potential mitigation of -34% on climate change and -33% on resource depletion identified (baseline already including biomethane and optimal industrial organization)
- Evaluation of the environmental benefits of reusability

Way forward

- Complete scope
- Investigate high-altitude effects
- Refine mitigation potential
- Implement ecodesign by managing various performance indicators
- Include space debris indicator
- Perform risk analysis

Proactive approach

- Contribution to building a common framework for environmental studies
- Open to data sharing

To go further

Parametric Life Cycle Assessment of a Space Launch Service Based on a LOx/Biomethane Semi-reusable Launcher, 73rd International Astronautical Congress (IAC), Paris, France.

Contact info:

Loïs Miraux

lois.miraux@mines-paristech.fr