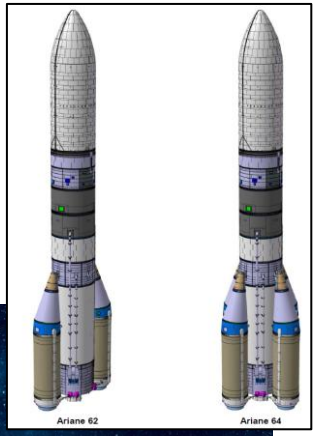

ENVIRONMENTAL IMPACT OF THE EXPLOITATION OF THE ARIANE 6 LAUNCHER SYSTEM

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Cleanspace Industrial Days 2018

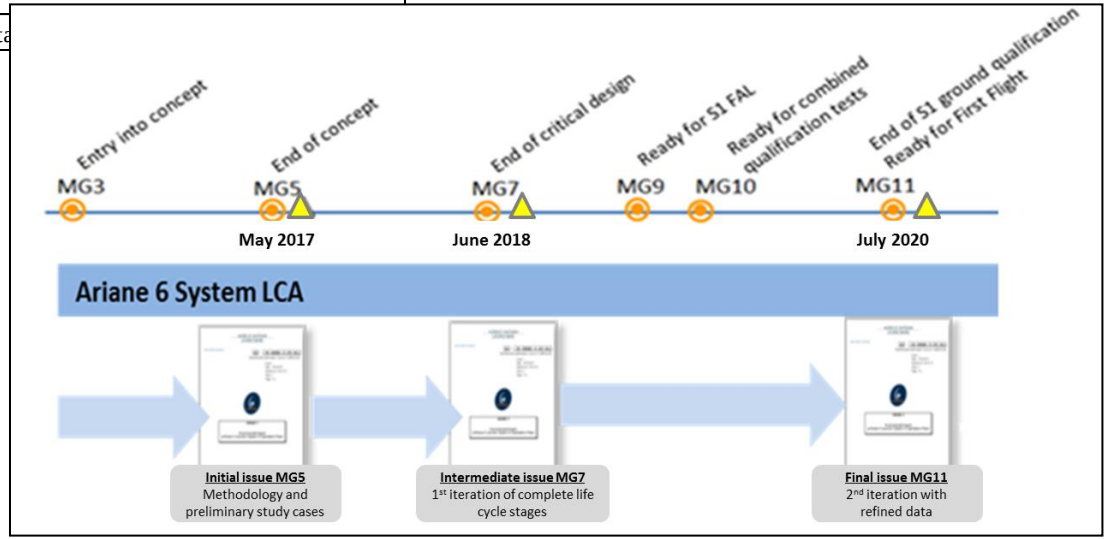
ESTEC

LIFE CYCLE ANALYSIS (LCA) OF A6

ESA requirements and General Roadmap

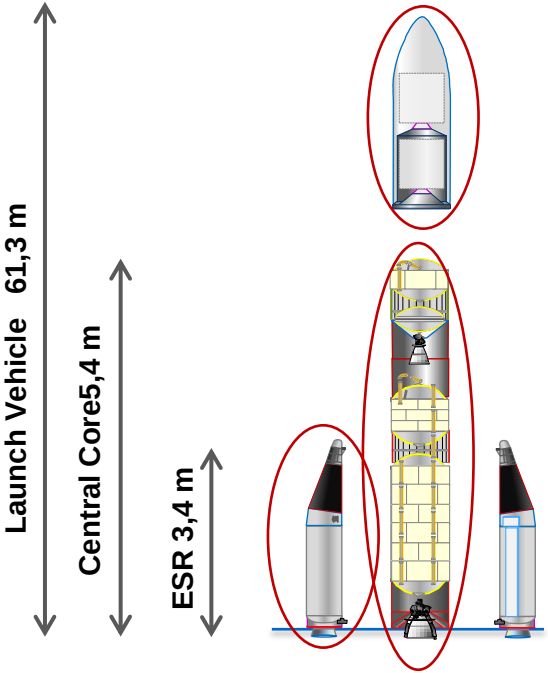
A6-SOW-1-RQ-076	*Title:* Environmental impact
Description: The environmental impact of the exploitation of the Ariane 6 launcher system (Life Cycle Assessment considering production & assembly, launch campaign, and launch event) shall be analysed and compared to that of A5 ECA on the basis of: • One launch • Yearly equivalent P/L mass delivered in orbit.	
Notes:	
Expected answer	Due Item: [DRL-67] Environmental impact of the exploita

A64 configuration considered as **baseline** for the LCA anaysis**.**



FOCUS ON LAUNCH VEHICLE CONCEPT A6

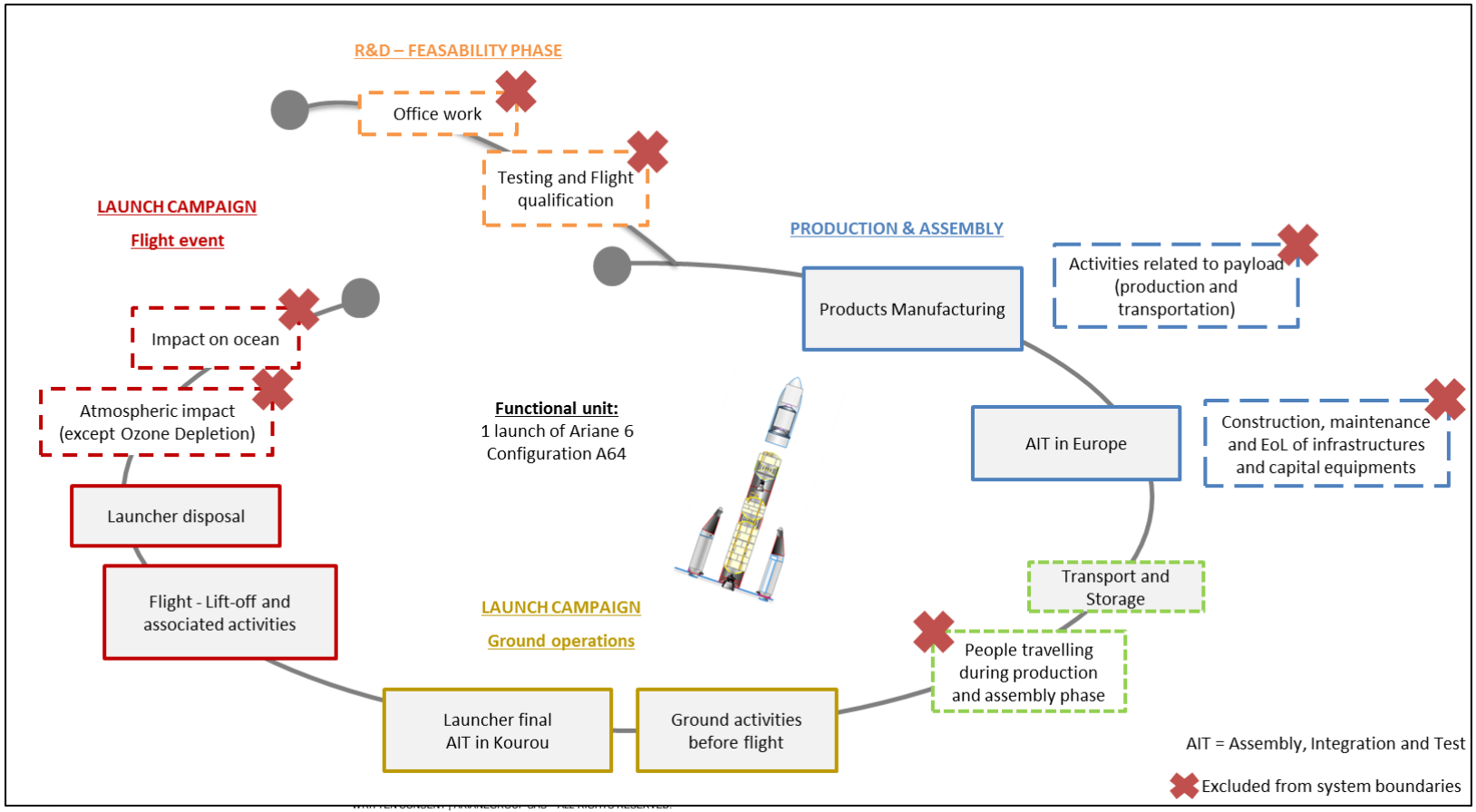
Ariane 6 family is based on Powder-Hydrogen-Hydrogen concept



- A **Central Core** proving thrust thanks to a **Lower Liquid Propulsion Module (LLPM)** equipped with a **Vulcain 2.1 engine** and an **Upper Liquid Propulsion Module (ULPM)** equipped with a **Vinci engine**,
- **Equipped Solid Rocket Motors (ESR)** that provide the main thrust during the first propulsive phase. Depending on the configuration, A6 is equipped with 2 (A62) or 4 (A64) common ESRs.
- An **Upper Part** carrying and encapsulating the Payload(s), composed of: a Fairing, a Launch Vehicle Adapter (LVA), Payload Adaptor Fitting(s) and any system allowing to perform dual launch or multiple launch (e.g. DLS).

SCOPE OF THE A6 LCA STUDY

Functional unit and System boundaries



LIFE CYCLE INVENTORY & MODELIZATION

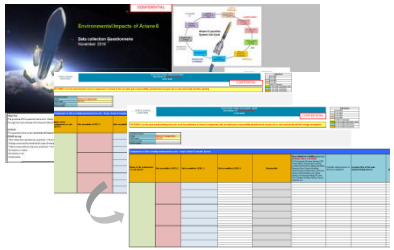
Iterative data collection through specific questionnaire

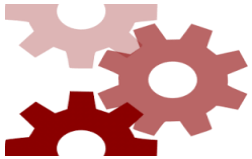
- Comprehension of the system is based on **general documentation delivered at maturity gate level** (MG5, MG6.1, MG6.2). Thus, **data based on preliminary design status and available information from internal and external partners (will be reevaluated for MG11).**

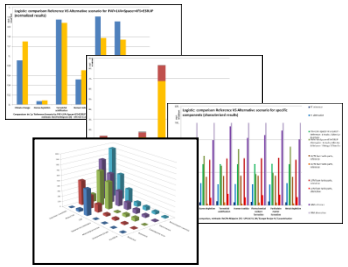
- **Functional arborescence based on Product Breakdown Structure (PBS) and sub-assembly focal point at industrialisation level.**

≈ 18 focal point Industrial Partners for products (MTA, ASE, AVIO, APCO, etc.) – AGS

≈ 10 Internal Focal Points for integration in Europe and final Kourou activities







Software : **Simapro 8.4**
Databases: **ecoinvent V 3.0 & ESA Space LCI Database (2017)**
Environnemental indicators:
ESA LCA Guidelines and comparable with LCA of A5-ECA (Deloitte, 2012)

LIFE CYCLE INVENTORY

Included / Excluded data for 1st iteration

Production & Assembly

- Data on material and mass (product + thermalprotection, etc.), manufacturing processes, consumables and waste treatment.
- Data on testing for exploitation (not qualification).
- Data on fluidic consumption of integration buildings in Europe.

Data to be refined: pyro-elements and avionics (no data). Very few data on cryo and non-cryo lines.

Transports – End-to-End logistic scenario

- Data from supplier to integration line in Europe.
- Transport from integration to launch pad in Kourou.

Data to be refined: detailed transport inside suppliers production, packaging (no data).

Launch Campaign / Ground operations

- Data on fluidic consumption of integration buildings in Kourou.
- Data on propellant production. In Kourou
- Data on transports of elements inside CSG.
- Data on people travelling to/from Kourou.

Data to be refined: data on Launch Pad and CNES buildings (no data).

Launch Campaign / Flight Event

- Data on fluidic consumption during ground operations before flight (energy), chronology (gaz), deluge (water) and revalidation (energy).
- Qualitative data on disposal location. No data on impact due to fall down into to ocean.
- Emissions of launchers in atmosphere during flight (ozone depletion only is adressed).

Data to be refined: data on Ground Stations needed for flight, space debris generated.

PRELIMINARY RESULTS

Environmental profile of A64

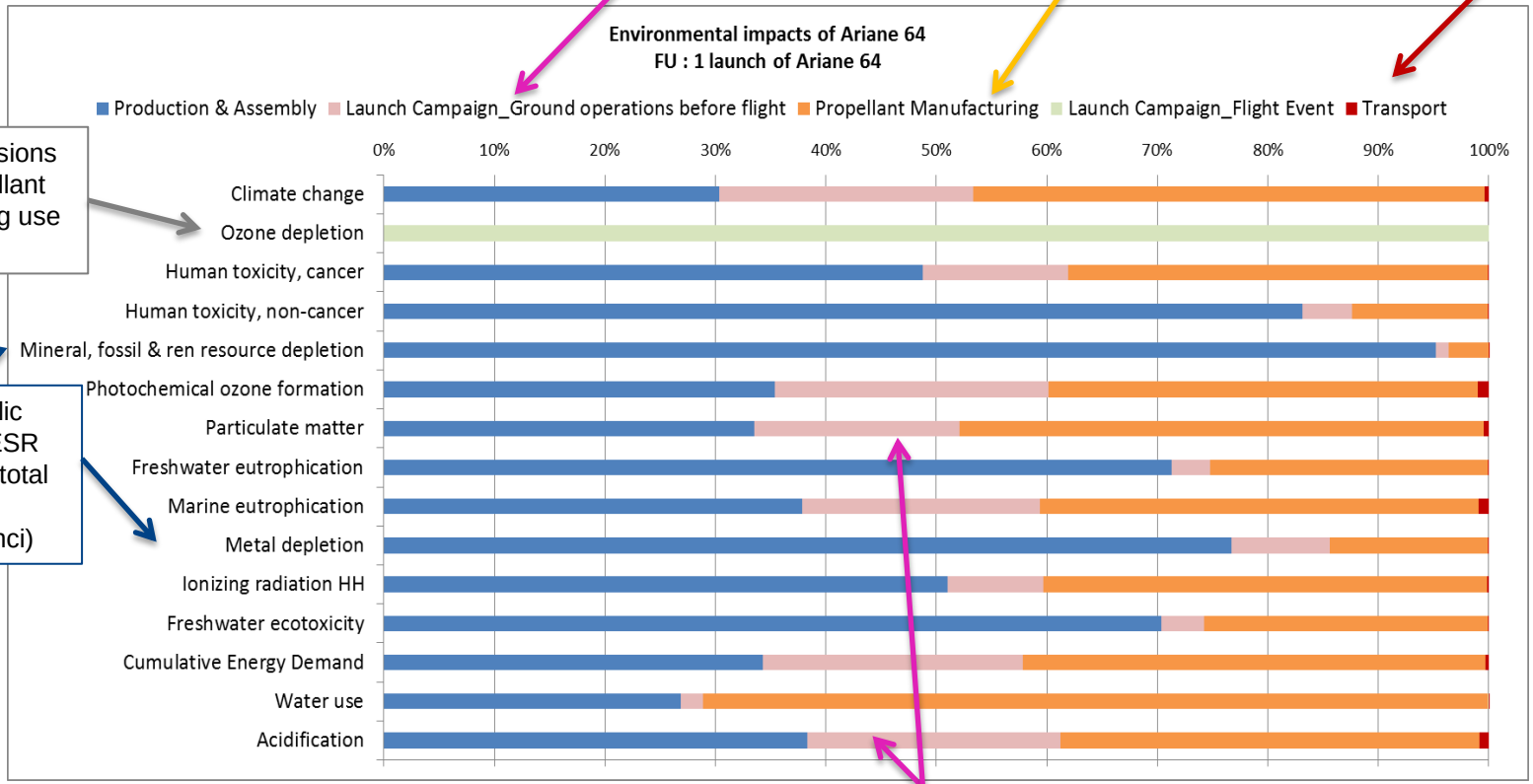
Fluidic consumption for Chronology (LH2, LOx, GN2, Ghe)

99% contribution for solid propellant

Transport contribution small. No data on packaging. Possibly underestimated.

CFC-11 eq. emissions induced by propellant combustion during use phase

Production of metallic structures. Mainly ESR production (70% of total mass) and engines (Vulcain 2.1 and Vinci)



Fluidic consumption for AIT ESR Kourou

STUDY LIMITATION
Ways of improvement

- Manufacturing data are sometimes given as global by suppliers when they produce other references, **assumptions based on m² used were done by industrial partners or internally,**
- In some cases, **data are based on knowledge on A5 when definition steps** are not finalized or production as not yet started (mainly solid and liquid propulsion),
- **Exhaustive logistic schema during the manufacturing and assembly phase** of products could not be reached due to high complexity of industrial partners involved at different steps, more details is needed for next iteration of the study,
- Refrigerant fluid for air conditioning were not taken into account due to lack of data,
- Waste during production and assembly phase are taken roughly and associated with generic end of life treatment when provided by the industrial partners.
- **End-of-Life**: lack of environmental methodology for **parts degrading in the ocean,**
- **Flight event emissions: need of specific impact study,**

COMPARISON WITH A5-ECA

Preliminary results

- **Production & Assembly and Propellant Manufacturing are the major contributors to impact for both A5-ECA and A64 (comparable for** 8 indicators (among 14).

- **Contribution of transport to environmental profile is much higher in A5 ECA than in A64** (but should be refined in 2nd interation)

	A5-ECA	A64
Year of study	2011-2012	2016-2020
Software	Simapro (v?)	Simapro 8.4
Database	ecoinvent 2.2	ecoinvent 3.0
N° of iteration	4	1
Environnemental indicators	Comparable (integration of AWARE method for water use)	
Life Cycle Stages	a) Stage production (b) Transport (c) Propellant & Consumables (d) ARTA Campaign (e) Launch Campaign (f) Launch Event	a) Production & Assembly (b) Propellant manufacturing (c) Transport (d) Launch Campaign_Ground Operations (e) Launch Campaign_Flight Event
End-of-Life phases	Space debris excluded Recommandation on need of mode for atomosheric emissions and toxi impact of falling launcher.	Impact on the ocean excluded (lack of model)
Uncertainty analysis	YES	Planned for MG11

TAKE HOME MESSAGE

- **Pioneering study at industrial level: 1st complete LCA iteration of A64 in exploitation phase** based on preliminary design status, next to come in 2020

- **Recommandation for 2nd iteration**

Evaluate associated gain of application of new technos on A6 tank manufacturing and horizontal integration
Refined data of all system, integrate data from pyro products and avionic
Refined data of CNES activities/buildings at Launch site in Kourou
Sensitivity and uncertainty analysis planned for MG11
Technical exchange will be needed for better comprehension of A6 vs A5-ECA

- **Recommandation for improvement of LCA in space industry**

Continue to improve ESA LCA database with specific raw materials and processes
Better understanding of End-of-Life impact on ocean and Atmospheric emissions with exploitable data
Integrate Space debris generation and impact to orbital resource

THANK YOU FOR YOUR ATTENTION

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