

The Assessment and Comparison Tool (ACT)

Simplified, space-specific, prospective LCA

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Some background



ESA FLPP identified the need for a space-specific ecodesign tool



EPFL Space Center was chosen for its expertise in space sustainability



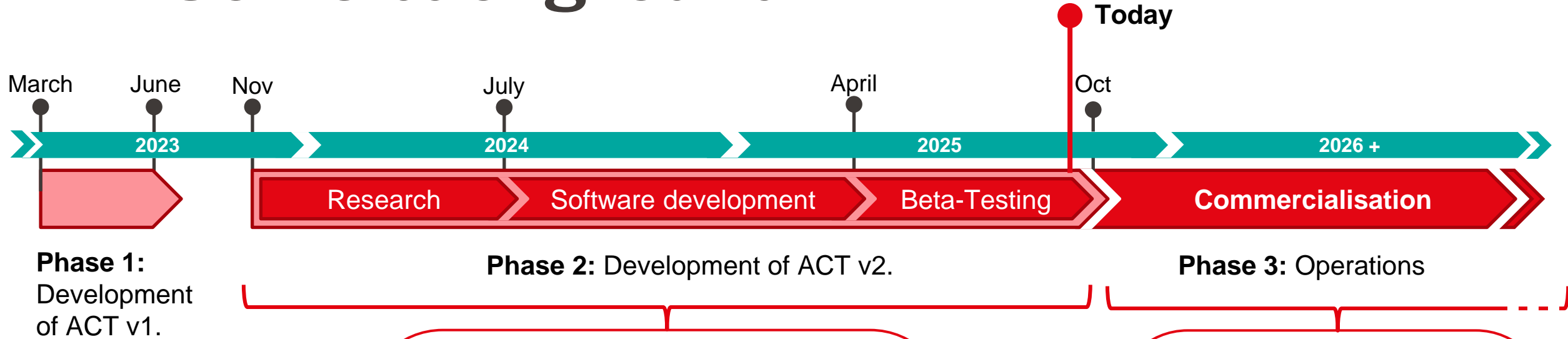
Goal is to make a tool that is used by the industry, after the ESA project

The Assessment and Comparison Tool

- ✓ **Space-specific** scopes, inventories, and methods
- ✓ From **simplified** to full LCAs
- ✓ Data quality rating and impact contribution analysis
- ✓ Iterative assessment thanks to compatibility with Excel and BrightWay
- ✓ Safe by design (no data stored on servers)
- ✓ Easy to use



Some background



Key focus:

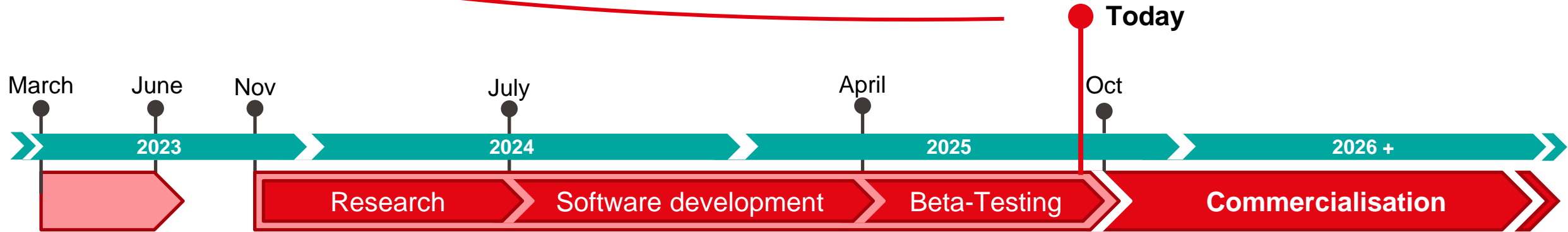
- Align ACT with (future) industry needs
- Integrate ever-evolving LCA methodology changes (PEFCR, ESA guidelines, etc.)
- Improve user experience and simplicity

- End of ESA project
- Start of ACT's implementation with industry
- Continued alignment with industry needs



Some background

- ACT v2 is in its finalisation stage
 - A public demo planned on 19 Nov
 - The team is looking ahead, after ESA project
- } We'll get back to this at the end...



Phase 1:
Development of ACT v1.

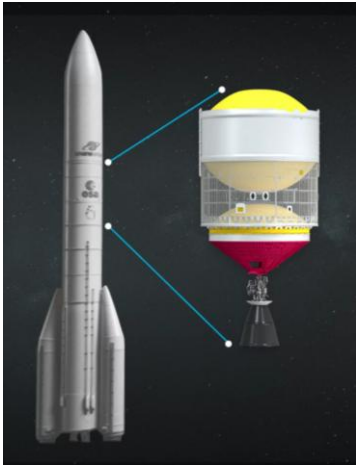
Phase 2: Development of ACT v2.

Phase 3: Operations

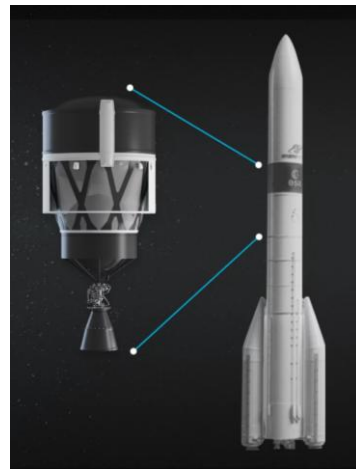


The Assessment and Comparison Tool

ACT is *space-specific* tool for *simplified* and *prospective* (screening) LCA in the space sector to give (visualised) *guidance* on ecodesign and decisions-making



More or less:
Performance ?
Cost ?
Availability ?



Risks ?
Environmental impacts ?



VS



VS




VS



VS



ACT models – building blocks



ACT
Assessment and Comparison ...


- Home
- Design ▼
- Custom datasets
- Building Blocks**
- Configurations
- Missions
- Trajectories

Lower stage Create	Orbital stage Create	Fairing Create	Propulsion engine Create
<p>Default Building Blocks</p> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> Template <p>Ariane5 - EPC View Delete</p> </div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> Template <p>Ariane5 - EAP View Delete</p> </div> <div style="border: 1px solid #ccc; padding: 5px;"> Template <p>Themis lower stage View Delete</p> </div>	<p>Default Building Blocks</p> <div style="border: 1px solid #ccc; padding: 5px;"> Template <p>Ariane5 - ESC View Delete</p> </div>	<p>Default Building Blocks</p> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> Template <p>Ariane5 - Fairings View Delete</p> </div> <div style="border: 1px solid #ccc; padding: 5px;"> Template <p>Themis T3 - Fairings View Delete</p> </div>	<p>Default Building Blocks</p> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> Template <p>Ariane5 - Vulcain2 View Delete</p> </div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> Template <p>Ariane5 - MPS View Delete</p> </div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> Template <p>Ariane5 - HM7B View Delete</p> </div> <div style="border: 1px solid #ccc; padding: 5px;"> Template <p>Prometheus M View Delete</p> </div>

Building blocks specific to space systems

→ More straightforward system modelling

ACT models – building blocks



ACT
Assessment and Comparison ...

Home

Design

Custom datasets

Building Blocks

Configurations

Missions

Trajectories

Create Building Block

Select building block template

Select esa project phase

Building block name

Parameters

LCA activities

Group entries by

Amount: - Amount quality: + ⊖

LCA activity: LCA Activity quality: 4

Search: aluminium

aluminium, AA 2099 billet production Material, raw ESA LCA External 1.3.0b e3.11

aluminium turning, primarily roughing, conventional Processing


ecoinvent: 3.11-cutoff

treatment of aluminium scrap, new, at refiner LCI category to be defined

ecoinvent: 3.11-cutoff

FLPP-defined Life Cycle Steps

ACT models – configurations



ACT
Assessment and Comparison ...

- Home
- Design
- Custom datasets
- Building Blocks
- Configurations**
- Missions
- Trajectories

Select Scenario | Functional Unit Parameters | Parameters | Select STV Blocks | Configure Logistics

Continue | Show Errors (1 error) | Save Configuration

Reusable Launch Vehicle

Defaults from

EMPTY

Start with an empty configuration

Select

Expendable Launch Vehicle

Defaults from

EMPTY

Start with an empty configuration

Select

Space Segment

Defaults from

EMPTY

Start with an empty configuration

Select

Ground Segment

Defaults from

EMPTY

Start with an empty configuration

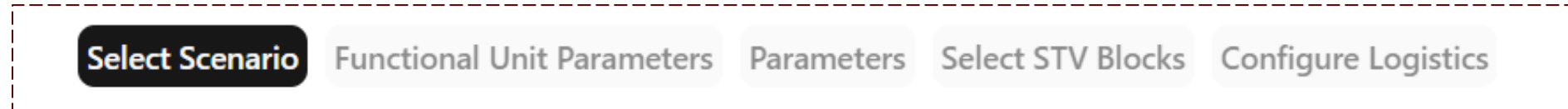
Select

Full space mission configurations
(space, launch, ground segments)

ACT models – configurations


ACT
Assessment and Comparison ...

- Home
- Design
- Custom datasets
- Building Blocks
- Configurations**
- Missions
- Trajectories



Guided LCA steps

ACT models – space missions



ACT
Assessment and Comparison ...

Home

Design

- Custom datasets
- Building Blocks
- Configurations
- Missions
- Trajectories

Create Mission

Mission name

Select configuration	Amount	Allocation percentage (0-100)	
<input type="text" value=""/>	<input type="text" value="1"/>	<input type="text" value="1"/>	+
Configurations			
<input type="text" value="Ariane5 v14"/>	<input type="text" value="1"/>	<input type="text" value="40"/>	-
<input type="text" value="Default ISTV - flight model v14"/>	<input type="text" value="6"/>	<input type="text" value="100"/>	-

To combine and allocate impacts of several configurations



ACT

Assessment and Comparison ...



Home



Design



Custom datasets

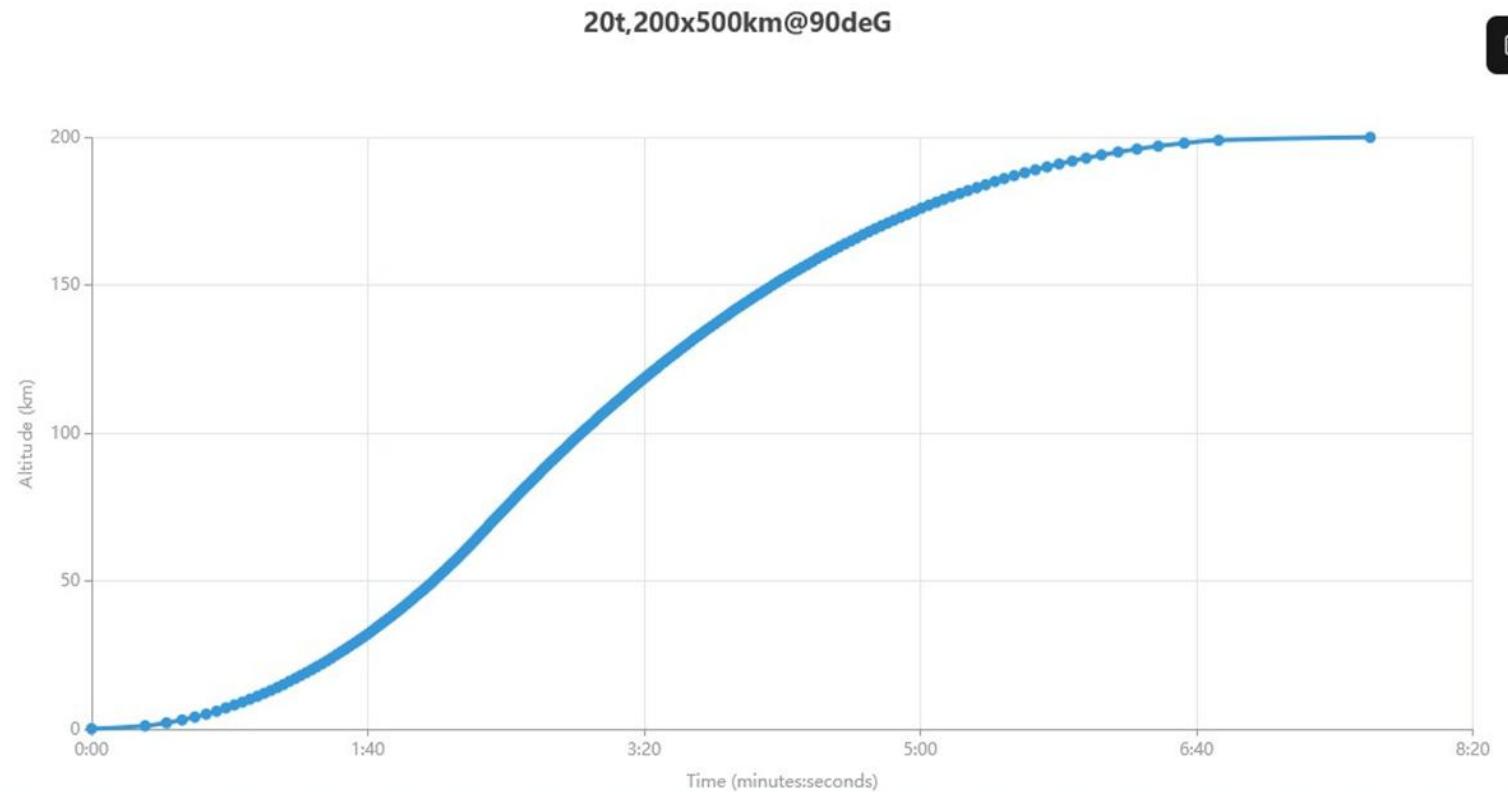
Building Blocks

Configurations


Missions

Trajectories

Trajectory Chart - 20t,200x500km@90deG



ACT outputs – LCIA bar charts



ACT
Assessment and Comparison ...

- Trajectories
- Analysis
- Report
- Comparison
- Settings
- API Keys
- Admin



Note: these are example results and should not be considered as real LCA conclusions for the Ariane 5

ACT outputs – table

ACT
Assessment and Comparison ...

- Trajectories
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Configuration / mission
Ariane5 v14 Download Report

LCA Single Score LCA Emissions REACH DQR

Select impact category
Select options

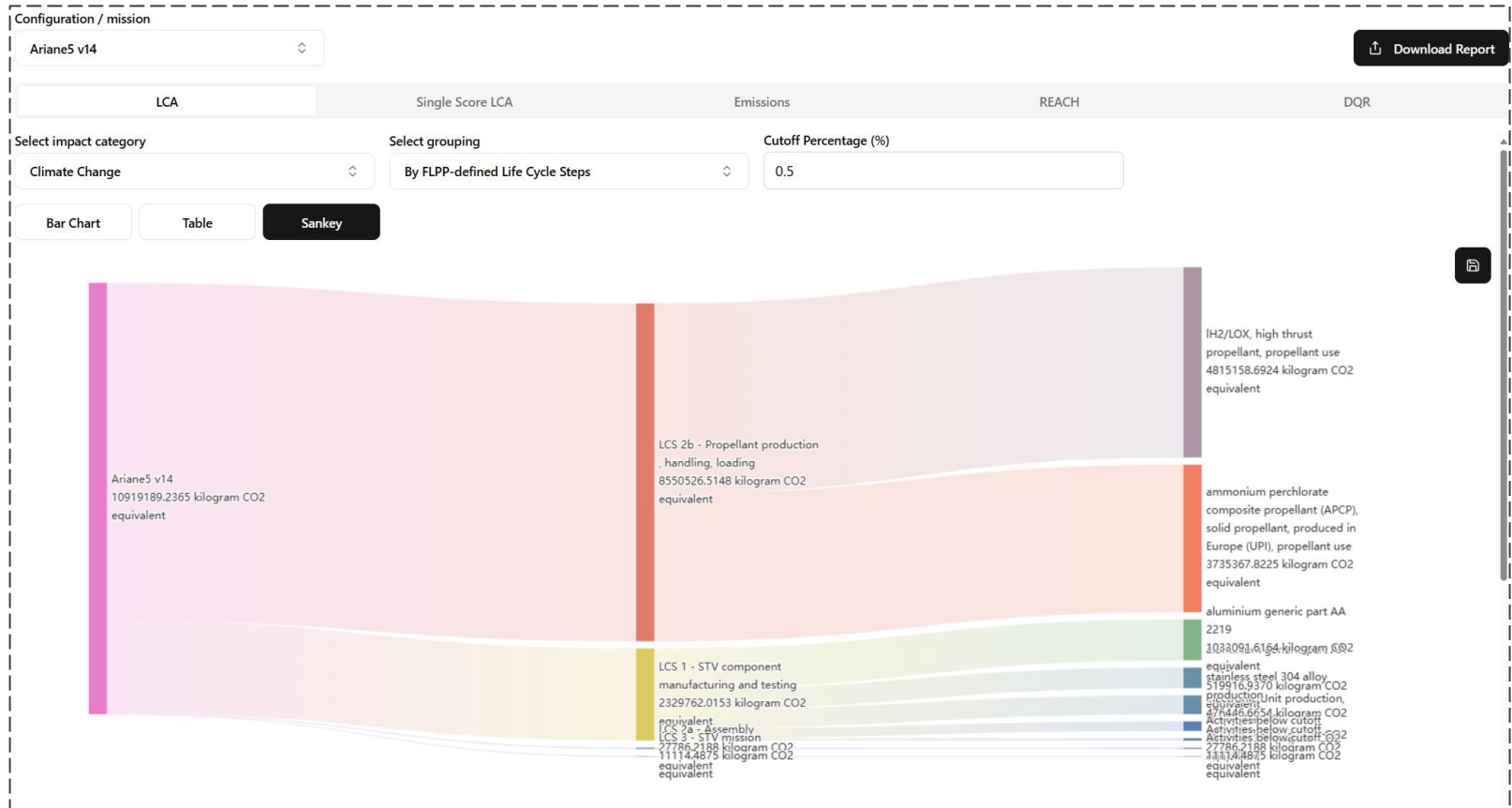
Bar Chart **Table** Sankey

LCA Activity Name ↑↓	Amount ↑↓	ESA project phase ↑↓	ESA input type ↑↓	FLPP-defined Life Cycl... ↑↓	Path ↑↓	Climate Change (kilog... ↑↓
Filter ...	Filter ...	All	All	All	Filter ...	Filter ...
IH2/LOX, high thrust propellan...	170000	E1	Others	LCS 2b - Propellant production...	Ariane5 v14,Ariane5 - EPC,IH2/...	4427133.4651
aluminium generic part AA 7075	6250	C	Raw Materials and lower level i...	LCS 1 - STV component manuf...	Ariane5 v14,Ariane5 - EPC,alu...	317022.5226
aluminium generic part AA 2219	7150	C	Raw Materials and lower level i...	LCS 1 - STV component manuf...	Ariane5 v14,Ariane5 - EPC,alu...	397342.9294
harnessing production	0	D	Raw Materials and lower level i...	LCS 1 - STV component manuf...	Ariane5 v14,Ariane5 - EPC,harn...	0.0000
stainless steel 440b (X 90 CrM...	100	C	Raw Materials and lower level i...	LCS 1 - STV component manuf...	Ariane5 v14,Ariane5 - EPC,stai...	910.2383
aluminium generic part AA 2219	100	E1	Raw Materials and lower level i...	LCS 2a - Assembly	Ariane5 v14,Ariane5 - EPC,alu...	5557.2438
electronic Unit production, Hig...	200	C	Raw Materials and lower level i...	LCS 1 - STV component manuf...	Ariane5 v14,Ariane5 - EAP,elec...	120884.2913
stainless steel 304 alloy produ...	22000	D	Raw Materials and lower level i...	LCS 1 - STV component manuf...	Ariane5 v14,Ariane5 - EAP,stai...	238223.3327
aluminium generic part AA 2219	100	D	Raw Materials and lower level i...	LCS 2a - Assembly	Ariane5 v14,Ariane5 - EAP,alu...	5557.2438
aluminium generic part AA 7075	2000	C	Raw Materials and lower level i...	LCS 1 - STV component manuf...	Ariane5 v14,Ariane5 - EAP,alu...	101447.2072
ammonium perchlorate comp...	240000	E1	Others	LCS 2b - Propellant production...	Ariane5 v14,Ariane5 - EAP,am...	1867683.9112

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ACT outputs – Sankey

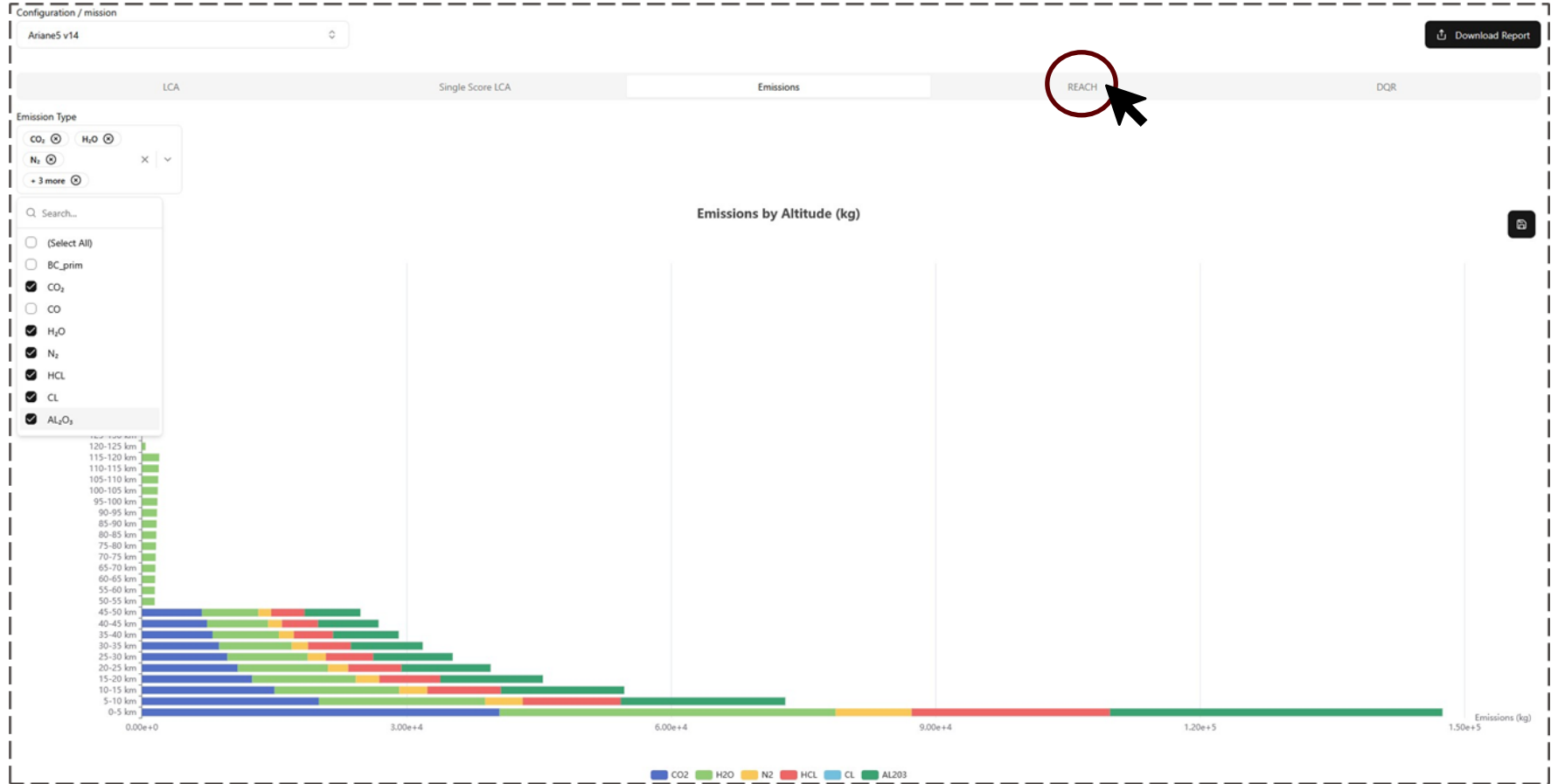
- ACT Assessment and Comparison ...
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Note: these are example results and should not be considered as real LCA conclusions for the Ariane 5

ACT outputs – launch emissions

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Note: these are example results and should not be considered as real LCA conclusions for the Ariane 5

ACT outputs – REACH risks

ACT
Assessment and Comparison ...

- Trajectories
- Analysis ▼
- Report
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- API Keys
- Admin ▼

Configuration / mission: Ariane5 v14 Download Report


LCA		Single Score LCA		Emissions		REACH			DQR
ID	Name	CAS Numbers	Thermomete...	Space M...	Can...	Aut...	Space Restrict...	LCA Activities	
543	4,4'-isopropylidenediphenol	80-05-7	<div style="width: 50%;"><div style="background-color: orange; height: 10px;"></div></div> 5/7	19	Candidate		Space Restriction	5 IH2/LOX, hig... View	
542	peracetic acid . . . %	79-21-0	<div style="width: 10%;"><div style="background-color: green; height: 10px;"></div></div> 1/7	0				5 IH2/LOX, hig... View	
541	1,1,2-trichloroethane	79-00-5	<div style="width: 80%;"><div style="background-color: red; height: 10px;"></div></div> 6/7	0			Space Restriction	5 IH2/LOX, hig... View	
540	3,5,5-trimethylcyclohex-2-enone	78-59-1	<div style="width: 10%;"><div style="background-color: green; height: 10px;"></div></div> 1/7	0				5 IH2/LOX, hig... View	
539	thionyl dichloride	7719-09-7	<div style="width: 10%;"><div style="background-color: green; height: 10px;"></div></div> 1/7	0				5 IH2/LOX, hig... View	

Page 1 of 27 - 522 items ← 20 →



Note: these are example results and should not be considered as real LCA conclusions for the Ariane 5

ACT outputs – data quality rating

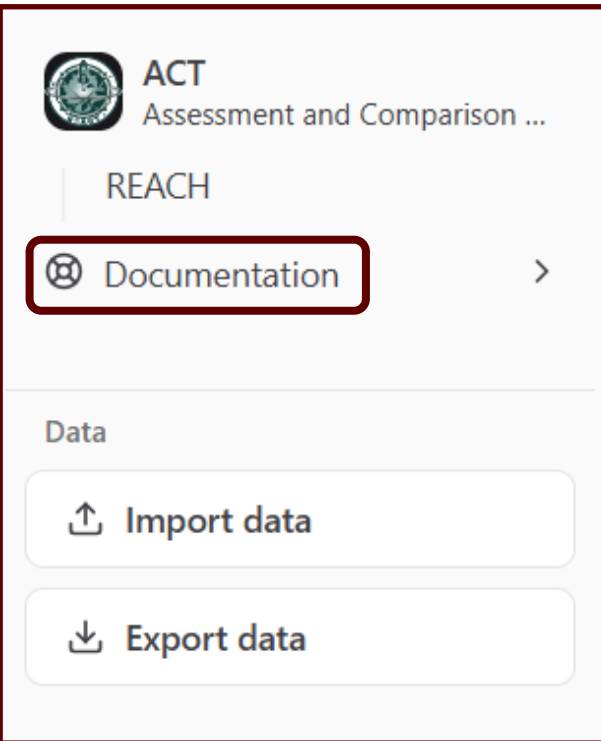


ACT
Assessment and Comparison ...

- Trajectories
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Note: these are example results and should not be considered as real LCA conclusions for the Ariane 5



Welcome to the Assessment and Comparison Tool documentation

Welcome to the ACT documentation!

[Download Documentation as PDF](#)

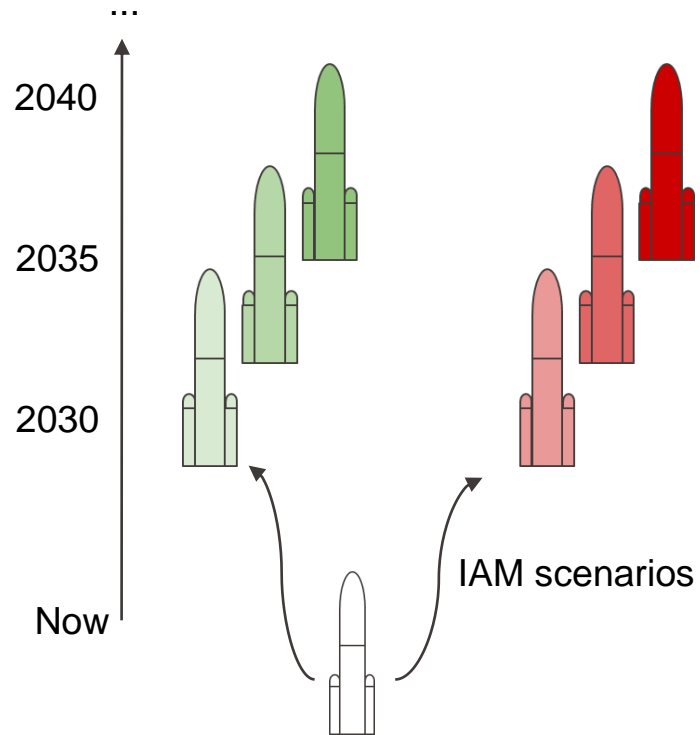
The writing of the documentation was done in parallel with the development of the Assessment and Comparison Tool (ACT). It organises knowledge accumulated during the ESA FLPP-funded ReACT project (2023-2025) and its deliverables (Technical Notes TN 1, TN 2, TN 3). It was also used to produce the User Manual - UM deliverable (ACT User manual ESA Class 2 document).

Quick documentation navigation

1. [Getting Started](#)
2. [ACT glossary](#)
3. [Step by step user manual](#)
4. [Simplified LCA in more details](#)
5. [External Tools](#)
6. [LCA results interpretation](#)
7. [Examples of the methodology applied to space systems](#)
8. [User manual for administrators](#)

ACT advanced features

- Prospective databases (years and scenarios) – future proof



Prospective Report / Template - Estimated Ariane 5 to GTO

Using prospective data

Configuration

Template - Estimated Ar... ▼

Year

2040 ▼

Scenario

SSP2-2C ▼

Info



ACT advanced features

- Model Context Protocol (Open protocol for LLMs) = "USB-C port for AI apps"
- An interface between ACT **functions** and user **data** (context)
- Predefined **prompts** to create configurations and compute LCIA
- You can choose the (local) model you trust, so your data stays **safe**



CHAT

this will automatically calculate LCA for ALL configurations in the mission (do not ask which configuration, it processes everything automatically)
6. Present the LCA results and analysis

IMPORTANT FOR ENGINE BUILDING BLOCKS (TYPE: PROPULSION):
When creating or updating engine/propulsion building blocks, you MUST provide ALL of the following required properties in a SINGLE operation to avoid validation errors:

- expansionRatioAreaExitAndAreaThroat: Required for emission calculations
- chamberPressureInBar: Required for emission calculations
- exitDiameterNozzleInMeter: Required for emission calculations
- thrustVacuumInKilonewton: Required for emission calculations
- thrustSeaLevelInKilonewton: Required for emission calculations

NEVER create or update an engine building block with only some of these properties - always provide all 5 properties together to prevent iterative validation errors during LCA calculation.

Start immediately, use the ACT tools and go through all steps right now. Do not ask for user confirmation - proceed automatically through all steps including the LCA calculation. IMPORTANT: The LCA calculation tool processes the entire mission automatically - never ask which configuration to calculate.

2023_10_TN_3_ACT_user_manual.pdf

> Used 1 reference

✓ Ran `create_mission` - ACT-dev (MCP Server)

Input

```
{
  "name": "ACT Example Mission"
}
```

Output

Mission created successfully

✓ Ran `create_configuration` - ACT-dev (MCP Server)

Input

```
{
  "name": "Example Launcher",
  "operationalDurationInDays": 1,
  "orbitType": "LEO",
  "payloadMassInKilogram": 1000,
  "performanceInKilogram": 1000,
  "totalMassInKilogram": 500000,
  "type": "EXPENDABLE_LAUNCH_VEHICLE"
}
```

Output

Created configuration successfully with ID: 9c5fcf5d-f82e-4b00-9497-f9dc592aa2e1

> Ran `create_configuration` - ACT-dev (MCP Server) ✓

> Ran `add_building_block_to_configuration` - ACT-dev (MCP Server) ✓

> Ran `add_building_block_to_configuration` - ACT-dev (MCP Server) ✓

Next steps



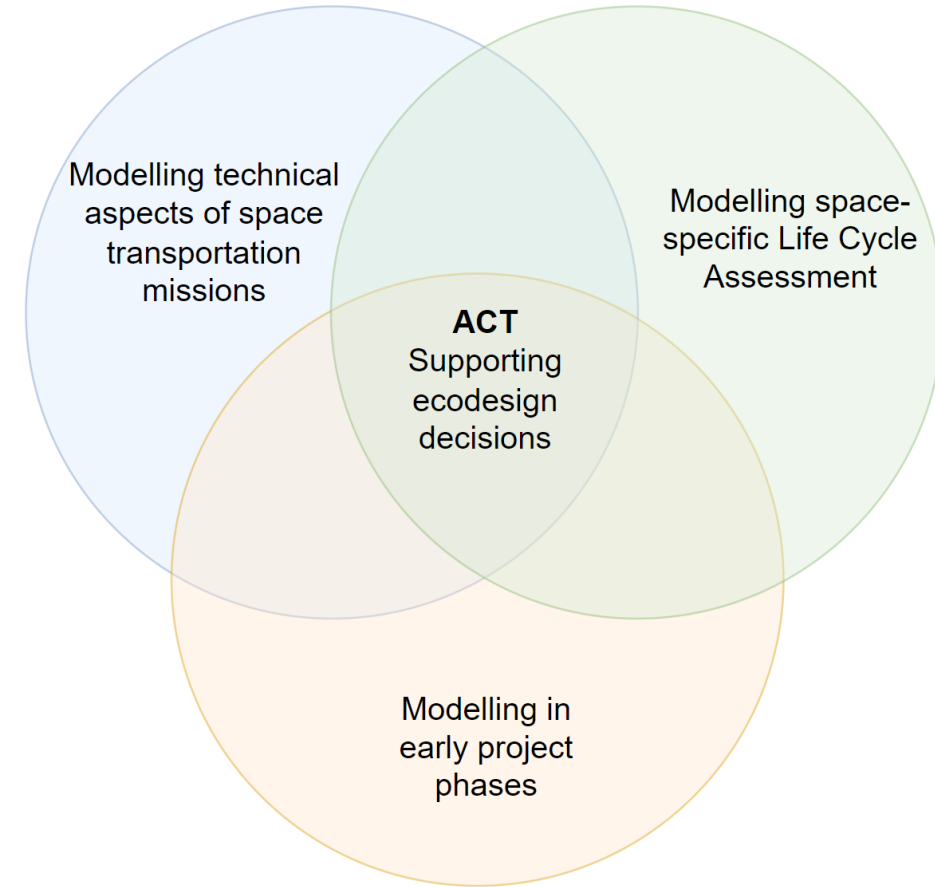
Extensive testing ongoing



Finishing the FLPP project in November

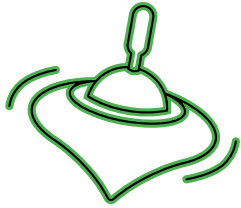


Public Final Presentation on November 19th

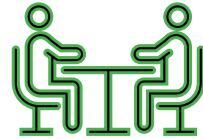


**And, what about after
the ESA Project?**

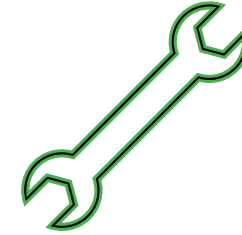
Future plans – EcoΔV



Spin out from
EPFL and Stuttgart
University



Provide tool-based
consultancy
services



Refine ACT further,
matching industry
needs



More info & get in touch:
www.ecodeltav.com

EcoΔV – the team



Jan-Steffen Fischer

The avid climber and launcher impacts expert



Mathieu Udriot

The dutiful firefighter and systems engineer



Marnix Verkammen

The enthusiastic paraglider and ecodesign consultant



Emmanuelle David

The motivated trail runner and advisor



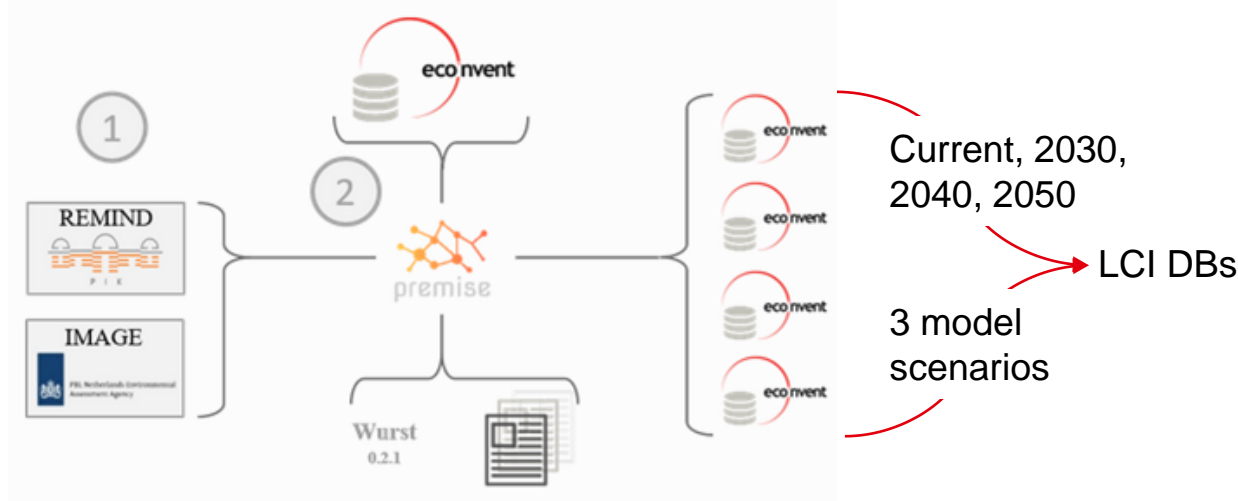
ACT Demo: 19th Nov

**Thank you
for your
attention**



Consistent prospective background LCI

The open software python package «Premise» couples the IAM with ecoinvent and the ESA database (**background**).



Sacchi, R., et al. (2022). PRospective EnvironMental Impact asSEment (premise): A streamlined approach to producing databases for prospective life cycle assessment using integrated assessment models. *Renewable and Sustainable Energy Reviews*, 160 (April 2021), 112311. <https://doi.org/10.1016/j.rser.2022.112311>

- IAMs present a potential future world situation depending on policies to limit global warming (used in the IPCC reports)
- Historically focusing on sectors influencing climate change (energy, steel, etc.), but now starting to concentrate on raw materials use, ozone depletion etc.

