EcoDeltaV

Bringing life cycle insights into your space mission design

Mathieu Udriot, Marnix Verkammen, Jan-Steffen Fischer

30/06/2026 – ESA CleanSpace Days

ECODELTAV

Individual focus, shared ambition

Mathieu Udriot
Co-founder & Lead of Technology Development
(past) LCA & System Engineer at EPFL Space Center

Experienced Project Manager <—

Jan-Steffen Fischer
Co-founder & Lead of Science and Operations
PhD candidate in rocket emissions and LCA

—> Recognised academic expert

Marnix Verkammen
Co-founder & Lead of Business Strategy
(past) LCA Research engineer at EPFL Space Center

Simplified space LCA expert <—

Emmanuelle David
Co-founder & Industry Advisor
(jointly) Executive Director at EPFL Space Center

—> International industry experience

Problem

Today:

The European Space Agency (ESA) and the French Space Agency (CNES) require *environmental impact assessments*

By 2030:

The European Space Act will mandate all companies to perform *life cycle assessments (LCA)*

But

The space industry lacks the expertise and does not have any complete and intuitive tool that simplifies and speeds up the process[1]

Therefore

The industry — particularly SMEs — relies heavily on expensive external services or spend a lot of time in learning basic LCA principles and complicated tools

[1] Validated through market research, interviews and literature

Our Solution

Assessment and Comparison Tool

ACT

The LCA and ecodesign tool built by space engineers, for space engineers

We offer

SaaS

For space companies with some in-house expertise

Sustainability consultancy

For space companies with limited expertise and/or resources

ACT is made for the space sector

	Generic LCA tools	Current space-specific LCA tools	Ad-hoc solutions	Our solution
	SimaPro, sphera, openLCA, Brightway	CNES's OASIS	Excel	ACT
Designed for the space sector	✗	✓	✗	✓
Intuitive for LCA practitioners	—	✓	—	✓
Easy integration in design cycles	✗	✓	—	✓
Complete LCA results	✓	✗	—	✓
Space-specific impacts (e.g. launch exhaust or re-entry)	✗	✗	✗	✓

The development roadmap for the Assessment and Comparison Tool

–

from stakeholders and regulatory analysis to implemented software features

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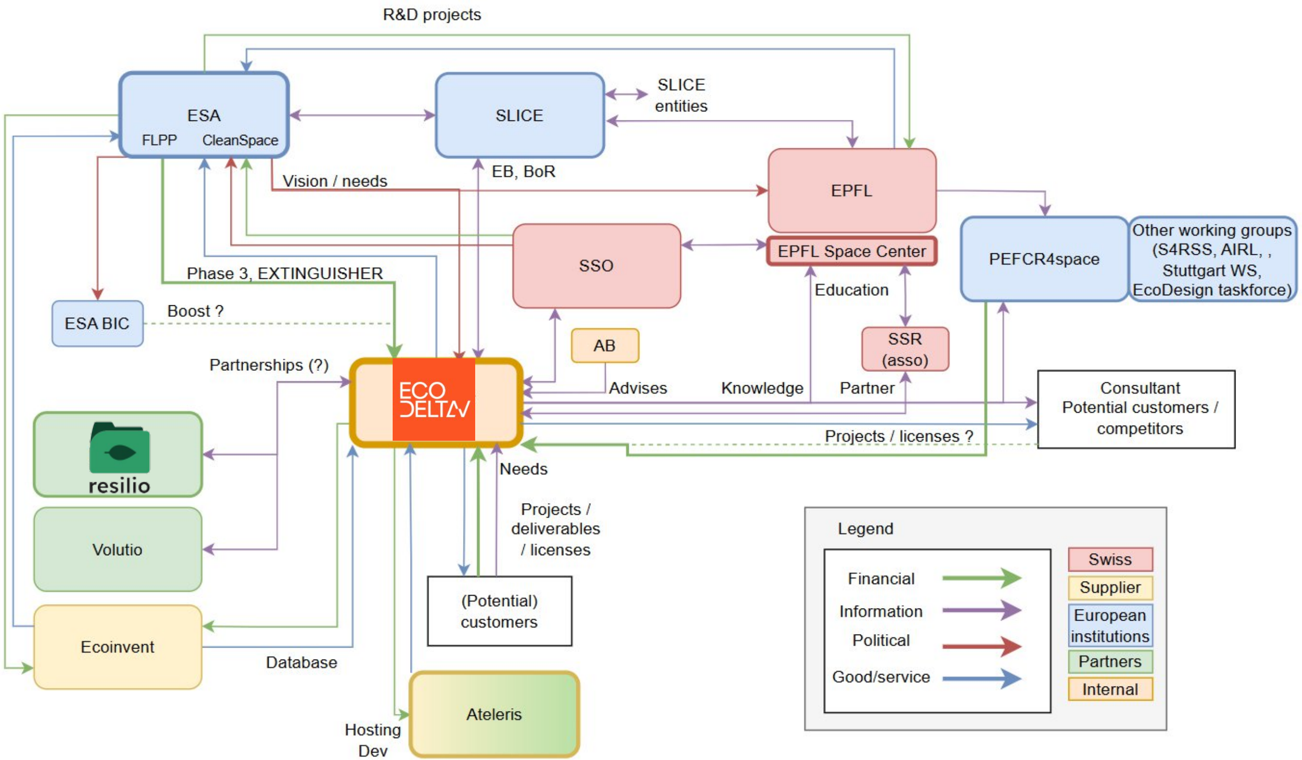
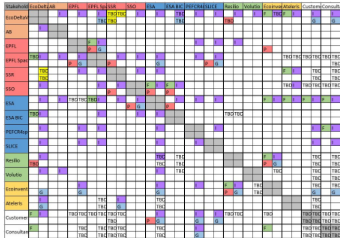
Stakeholders Value Network



DSM relationships



Scarcity min 12.8 %

Scarcity max 22.0 %

Roadmap inputs

- Current ACT version
- Existing LCA software tools (inspiration)

- ECSS -E-ST-40C Software
- ECSS -Q-ST-80C Software Assurance
- ISO 27001

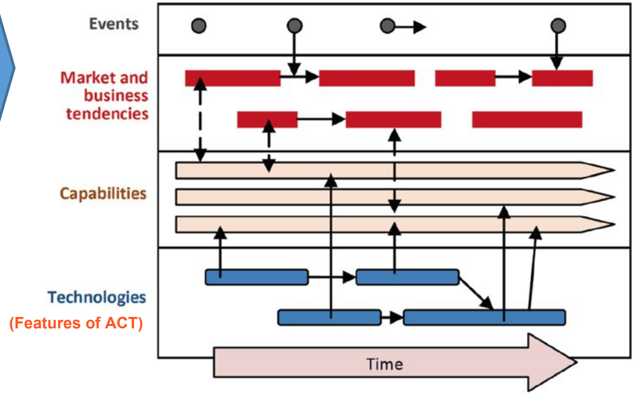
- Beta test / early adopters feedback (**industry**)

- LCA progress in the space sector (other tools, newest ESA handbook, etc.)

- Research evolutions, parallel activities

- ESA's needs and roadmap : **FLPP and others**

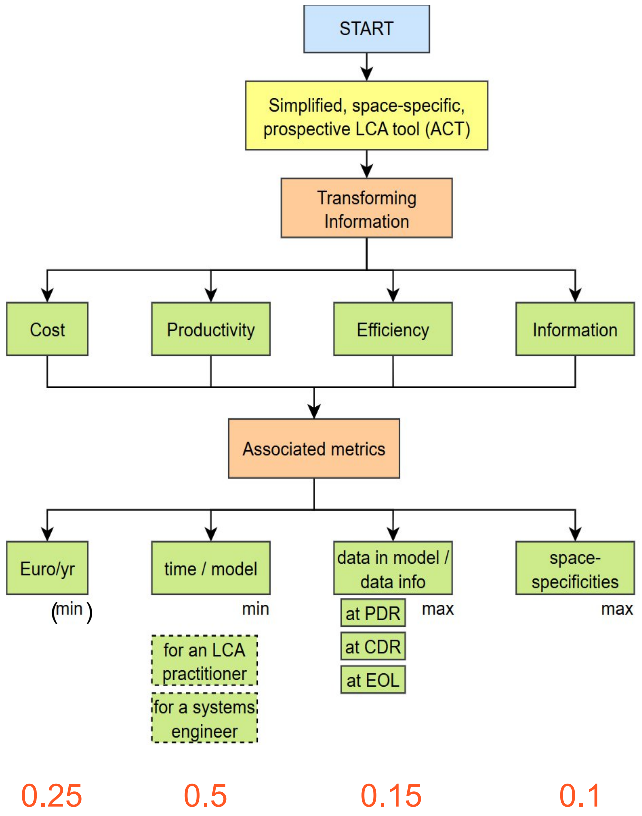
ESA Ecodesign Days 2025 "The Ecodesign Roadmap"
+ 2026 updates ? + Open source needs ?



O. L. de Weck, "Technology Roadmapping and Development", https://doi.org/10.1007/978-3-030-88346-1_8

Figures of Merit (FoMs)

- Based on de Weck et al. (2022), four types of figures of merit (FOMs) —>
- Our "technology" == ACT
- *Transforming information*
- FOMs to benchmark and prioritise
- Weights first assigned internally



Adapted from M. Lemaire, R. Svoboda (2024)

The benchmark

- Where we are
- Where others are

Initial weights

								Competition				
Weights	FOM class	FOM	unit	X_min	X_max	Objective	ACT (now)	Brightway	OASIS	SimaPro	Excel	Open LCA
0.250	Productivity	time to create a model for an LCA **practitioner**	time [h]/model	0	40	min	0.75	0.85	0.98	0.85	0.50	0.85
0.500	Information	space-specific information (discrete, qualitative)	-	0	9	max	0.72	0.17	0.28	0.11	0.00	0.11
0.150	Efficiency	fraction of LCA data that can be used in the model at **PDR**	data / data	0	1	max	0.90	0.90	0.50	0.90	0.80	0.90
0.100	Cost	use licence cost	euro/yr	0	10000	min	0.45	1.00	1.00	0.40	0.95	1.00
						Global FOM	ACT (now)	Brightway	OASIS	SimaPro	Excel	Open LCA
							0.729	0.531	0.558	0.443	0.340	0.503

Updated weights
(0.35, 0.33, 0.14, 0.18)

Global FOM	ACT (now)	Brightway	OASIS	SimaPro	Excel	Open LCA
	0.708	0.659	0.683	0.532	0.458	0.640

The benchmark

- Where we are
- Where others are
- Where we go

To improve our global FOM score (top-down)

1) increase information (and keep SOTA)

2) reduce time per model

3) make sure one can use as much data as possible across different phases

4) (adapt license cost)

Initial weights

								Competition					ACT's FOMs evolutions			
Weights	FOM class	FOM	unit	X_min	X_max	Objective	ACT (now)	Brightway	OASIS	SimaPro	Excel	Open LCA	All (ideal)	Information	Productivity	Efficiency
0.250	Productivity	time to create a model for an LCA **practitioner**	time [h]/model	0	40	min	0.75	0.85	0.98	0.85	0.50	0.85	0.88	0.75	0.88	0.75
0.500	Information	space-specific information (discrete, qualitative)	-	0	9	max	0.72	0.17	0.28	0.11	0.00	0.11	1.00	1.00	0.72	0.72
0.150	Efficiency	fraction of LCA data that can be used in the model at **PDR**	data / data	0	1	max	0.90	0.90	0.50	0.90	0.80	0.90	1.00	1.00	1.00	1.00
0.100	Cost	use licence cost	euro/yr	0	10000	min	0.45	1.00	1.00	0.40	0.95	1.00	0.45	0.45	0.45	0.45
						Global FOM	ACT (now)	Brightway	OASIS	SimaPro	Excel	Open LCA	All (ideal)	Information	Productivity	Efficiency
							0.729	**0.531**	**0.558**	**0.443**	**0.340**	**0.503**	**0.914**	**0.883**	**0.775**	**0.744**

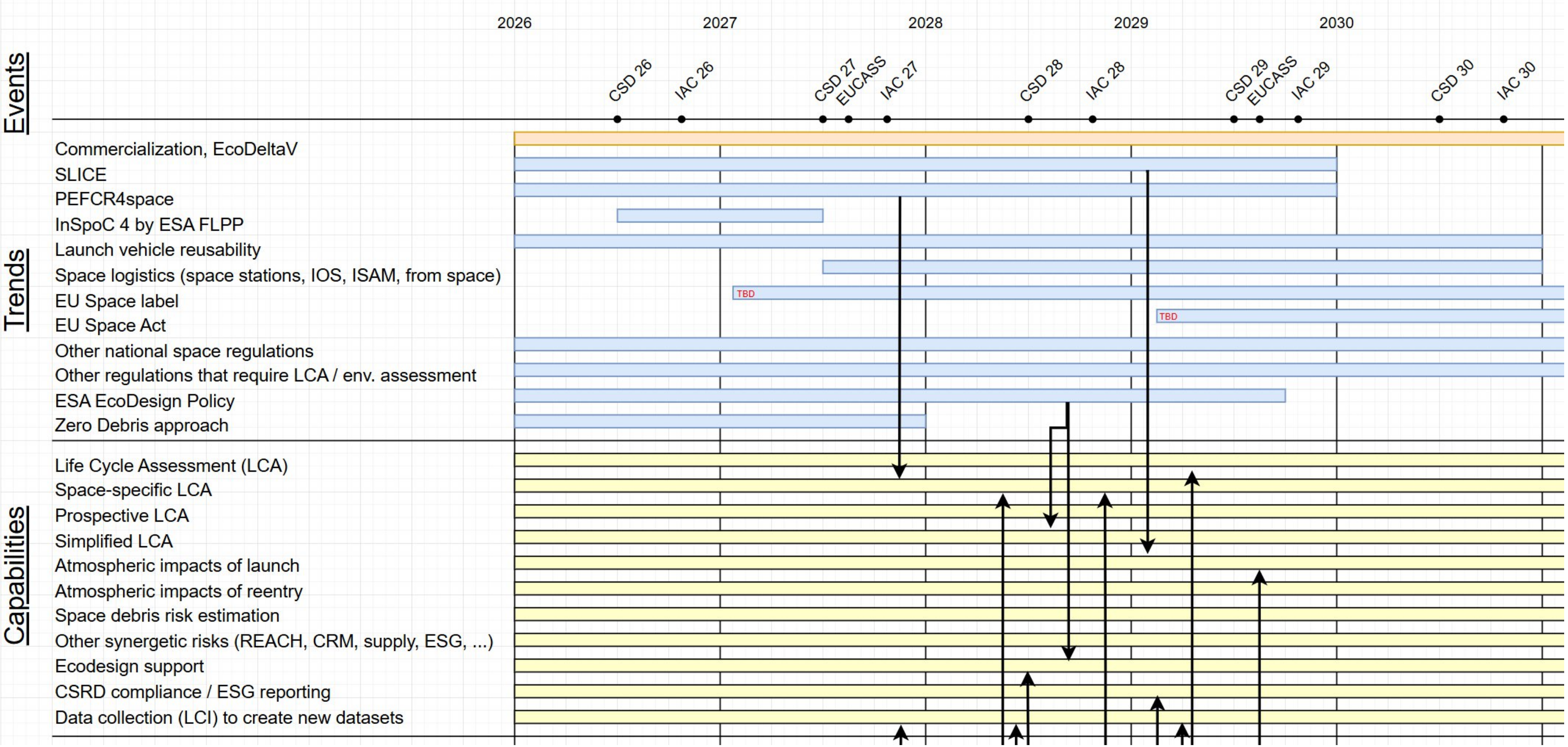
Updated weights

(0.35, 0.33, 0.14, 0.18)

Global FOM	ACT (now)	Brightway	OASIS	SimaPro	Excel	Open LCA	All (ideal)	Information	Productivity	Efficiency
	0.708	**0.659**	**0.683**	**0.532**	**0.458**	**0.640**	**0.857**	**0.814**	**0.766**	**0.722**

—> Similar trends

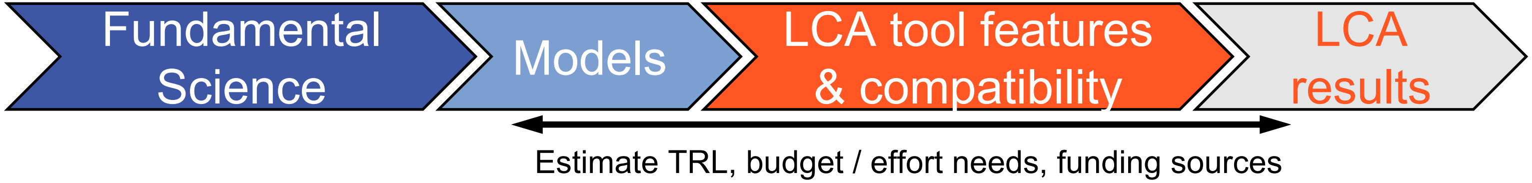
The roadmap



R&D projects, features, technologies **feed into** the capabilities

Projects, features, technologies into the roadmap

- Each contributes to improving 1 or more FOM
- Some are more or less directly linked to ACT



Examples of activities

- Compatibility with MBSE software
- Improved atmospheric impacts' understanding
- Space-specific parametric LCI databases
- PEFCR4space adaptations to the tool
- ...

Roadmap maintenance and use

- **Track** figures of merit (top-down)
- Assign **priorities** depending on stakeholders' expectations* and available fundings (bottom-up)
- **Update** / refresh the roadmap at least once a year

*See early adopters on next slide

Early Adopter Program = continuous inputs

Early Adopter Program launch in mid-2026

What do Early Adopters get?

- Private access to ACT and all its (space-specific) functionalities
- Access to the ecoinvent database within ACT
- Discounted license price for the duration of the program (25 - 50% off)
- Personalised and rapid support
- Privileged feature request consideration

What can Early Adopters do?

- Perform space-specific LCA: simplified or detailed, prospective or current
- Speed up the LCA process and integrate it efficiently within the mission design process
- Reports of any issues / missing functionality when using ACT
- Exchange of ideas and needs from the industry

Conclusion

- A technical roadmap to guarantee the continued **relevance** of ACT
- Currently, the **information** and **productivity** FOMs have most improvement potential
- Ongoing projects and beta tests shall confirm **users needs** too (bottom-up)

Other presentations by EcoDeltaV members

Wed 2:30pm

“Development of space transportation launch and re-entry emission inventories for 2019-2025 and analysis of the chemical interaction with the atmosphere”
with Jan-Steffen

Thu 10:15am

“A bridge between space sustainability goals and engineering decisions: the EPFL Handbook on Sustainable Practices of Space Mission Design”
by Marnix

And Martin will present a **poster** on “A High-Level LCA Framework for Early Space Systems Engineering”

Let’s bring life cycle insights into space mission designs

Thank you for your attention

ECODELTA∇

Our purpose

To empower capital-intensive sectors with **data-driven** environmental assessments, starting with the space industry to tackle the global climate crisis before expanding to adjacent sectors

Our Objectives:

Equip the booming space industry with essential LCA tools

Champion ecodesign principles in space mission planning

Establish EcoDeltaV as Europe’s leading developer of space LCA and ecodesign tools by 2030

ESA project, completed by experts

esa

EPFL Space Center

University of Stuttgart Institute of Space Systems

PSI

ATELERIS

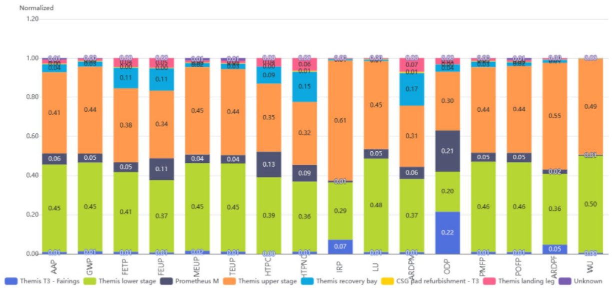
isae Institut Supérieur de l'Aéronautique et de l'Espace SUPAERO

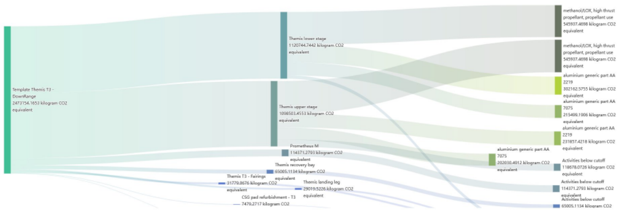
Ways Ehead Towards Sustainable Actions

ACT

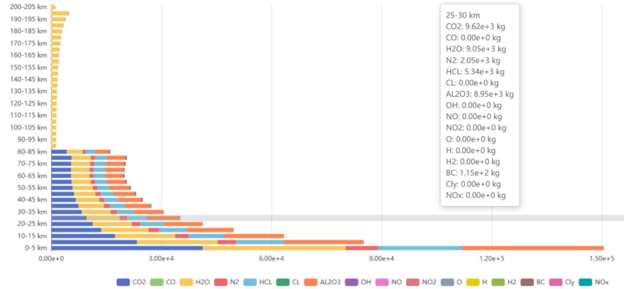
Complete results

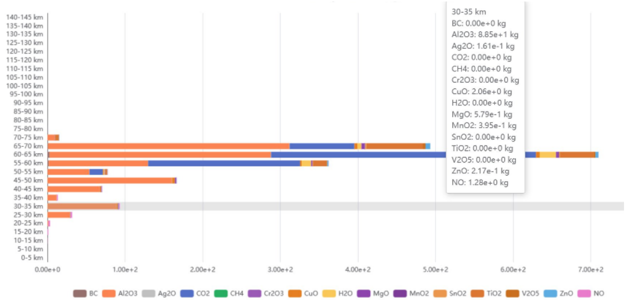
Classic & visual LCA results





Space-specific results





Note: these results serve as examples and should not be considered real LCA results

FOM - information

Discrete, qualitative scale for space-specific information FOM

- None : 0
- Space-specific database can be imported : +1
- Atmospheric impacts of launch : +1
- Atmospheric impacts of reentry : +1
- Space debris risk estimation : +1
- ESA REACH info : +1
- ESA handbook compliant : +1
- PEFCR4space compliant : +1
- Space-specific UI / model structure : +1
- Extra specific database : +1

FOM – inputs assumptions

Class	Figure of merit	unit	X_min	X_max	Obj	ACT (now)	Brightway	OASIS	SimaPro	Excel	Open LCA	ACT (ideal)	ACT (info)	ACT (productivity)	ACT (efficiency)
Productivity	inverted: time to create a model for an **LCA practitioner**, and get results (from GH&S to LCIA, interpretation excluded)	h / model	0	40	min	10	6	1	6	20	6	5	10	5	10
	inverted: time to create a model for a **new systems engineer**, and get results (from GH&S to LCIA, interpretation excluded)		0	40	min	12	16	1	16	20	16	6	12	6	12
Information	space-specific information (discrete, qualitative)	-	0	9	max*	6.5	1.5	2.5	1	0	1	9	9	6.5	6.5
Efficiency	amount of LCA data that can be used in the tool/model at **PDR** divided by amount of available data and info at **PDR**	data / data	0	1	max	1	1	1	1	0.8	1	1	1	1	1
	amount of LCA data that can be used in the tool/model at **CDR** divided by amount of available data and info at CDR		0	1	max	1	1	0.5	1	0.7	1	1	1	1	1
	amount of LCA data that can be used in the tool/model at **EOL** divided by amount of available data and info at EOL (reporting)		0	1	max	0.8	1	0.1	1	0.6	1	1	0.8	0.8	1
Cost	use licence	euro/yr	0	10000	min	5500	0	0	6000	500	0	5500	5500	5500	5500

We had to make assumptions

FOMs’ weights

Total (average)		B			
Figures of merit [unit]		Productivity	Information	Efficiency	Cost
A	Productivity [hour / model]	1.000	1.507	2.280	1.507
	Information [-] (qualitative*)	0.664	1.000	3.240	1.880
	Efficiency [data in model / data available]	0.439	0.309	1.000	0.947
	Cost [euro / year]	0.664	0.532	1.056	1.000

Sum of columns	2.7660	3.3472	7.5763	5.3333
Normalized				
Figures of merit [unit]	Productivi	Informatio	Efficiency	Cost
Productivity [hour / model]	0.3615	0.4501	0.3009	0.2825
Information [-] (qualitative*)	0.2400	0.2988	0.4276	0.3525
Efficiency [data in model / dat	0.1586	0.0922	0.1320	0.1775
Cost [euro / year]	0.2400	0.1589	0.1394	0.1875
Check	1	1	1	1
Weights (average per row of normalized score)				
Figures of merit [unit]	Computed	Rounded		
Productivity [hour / model]	0.349	0.35		
Information [-] (qualitative*)	0.330	0.33		
Efficiency [data in model / dat	0.140	0.14		
Cost [euro / year]	0.181	0.18		
	1.000	1.000		

Updated weights —> scores

								Competition					ACT's FOMs evolutions			
Weights	FOM class	FOM	unit	X_min	X_max	Objective	ACT (now)	Brightway	OASIS	SimaPro	Excel	Open LCA	All (ideal)	Information	Productivity	Efficiency
0.35	Productivity	time to create a model for an LCA **practitioner**	time [h]/model	0	40	min	0.75	0.85	0.98	0.85	0.50	0.85	0.88	0.75	0.88	0.75
0.33	Information	space-specific information (discrete, qualitative)	-	0	9	max	0.72	0.17	0.28	0.11	0.00	0.11	1.00	1.00	0.72	0.72
0.14	Efficiency	fraction of LCA data that can be used in the model at **PDR**	data / data	0	1	max	0.90	0.90	0.50	0.90	0.80	0.90	1.00	1.00	1.00	1.00
0.18	Cost	use licence cost	euro/yr	0	10000	min	0.45	1.00	1.00	0.40	0.95	1.00	0.45	0.45	0.45	0.45
						Global FOM	ACT (now)	Brightway	OASIS	SimaPro	Excel	Open LCA	All (ideal)	Information	Productivity	Efficiency
1.000							**0.708**	**0.659**	**0.683**	**0.532**	**0.458**	**0.640**	**0.857**	**0.814**	**0.766**	**0.722**

TRL for SW

TRL	Definition	Software Description
1	Technology Research - Basic principles observed and reported	Scientific knowledge generated underpinning basic properties of software architecture and mathematical formulation.
2	Technology concept - Concept and/or application formulated Invention begins.	Practical application is identified but is speculative; no experimental proof or detailed analysis is available to support the conjecture. Basic properties of algorithms, representations, and concepts defined. Basic principles coded. Experiments performed with synthetic data.
3	Proof-of-Concept - Analytical and experimental critical function and/or characteristic proof-of- concept	Development of limited functionality to validate critical properties and predictions using non-integrated software components.
4	Technology Demonstration - Generic design demonstrating concept- enabling performance consistent with potential applications - Low-fidelity validation of critical functions using breadboards/brassboards with non-flight-like parts and packaging in a laboratory environment at room temperature or environment required for functional validation	Key, functionality critical software components are integrated and functionally validated to establish interoperability and begin architecture development. Relevant environments defined and performance in the environment predicted.
5	Conceptual Design and Prototype Demonstration - Flight performance requirements, definition of critical environments, preliminary interfaces, and conceptual design complete - Components characterized - Performance, lifetime, and “robustness” in critical environments validated by analysis - Components and subassemblies with new technology or moderate to significant engineering development validated in newly developed areas using stand-alone subassembly- level prototypes of approximate size, mass, and power and built with anticipated “flight-like” parts and materials tested in a laboratory environment at extremes of temperature and radiation (if relevant)	End-to-end software elements implemented and interfaced with existing systems/simulations conforming to target environment. End-to-end software system tested in relevant environment, meeting predicted performance. Operational environment performance predicted. Prototype implementations developed.

TRL for SW

6	Preliminary Design and Prototype Validation - Preliminary assembly, subsystem, and system hardware and software design complete - Multiple assemblies or subassemblies incorporating new technology or moderate to significant engineering development validated in newly developed areas using engineering models (integrated form, fit, function prototypes) of the correct size, mass, and power, built with flight-like parts, materials, and processing and packaging, tested in a flight-like environment over the range of critical flight-like conditions	Prototype implementations of the software demonstrated on full-scale, realistic problems. Partially integrated with existing hardware/software systems. Limited documentation available. Engineering feasibility fully demonstrated.
7	Detailed Design and Assembly Level Build • Final assembly, subsystem, and system hardware and software design, interfaces, performance, and constraints documented • Production capability and/or parts availability, discrepancy paper, drawings, CAD/CAM files, and vendor's current capability validated • Near flight-like assemblies pass stress and life tests that demonstrate significant margins operating at extremes of input and output over a range of driving environments • Flight-like assemblies or subsystems successfully pass function/performance validation tests	Prototype software exists having all key functionality available for demonstration and test. Well integrated with operational hardware/software systems demonstrating operational feasibility. Most software bugs removed. Limited documentation available.
8	Subsystem Build and Test - Flight assemblies fabricated, integrated, and functionally tested - Build and test procedures qualified in subsystem assembly facility - Flight subsystems built and functionally tested - Identical/actual flight subsystem environmentally tested	All software has been thoroughly debugged and fully integrated with all operational hardware and software systems. All user documentation, training documentation, and maintenance documentation completed. All functionality successfully demonstrated in simulated operational scenarios. Verification and validation completed.
9	System Operational - Flight system build and test procedures qualified in flight system integration facility - Flight system integrated and functionally tested against requirements and operating scenarios - Flight system environmentally tested	All software has been thoroughly debugged and fully integrated with all operational hardware and software systems. All documentation has been completed. Sustaining software support is in place. System has been successfully operated in the operational environment.