



2022 MELISSA CONFERENCE
8-9-10 NOVEMBER 2022

CREATING
A CIRCULAR
FUTURE

Circularity indicators and digitalisation for monitoring circular space and terrestrial systems

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CentraleSupélec





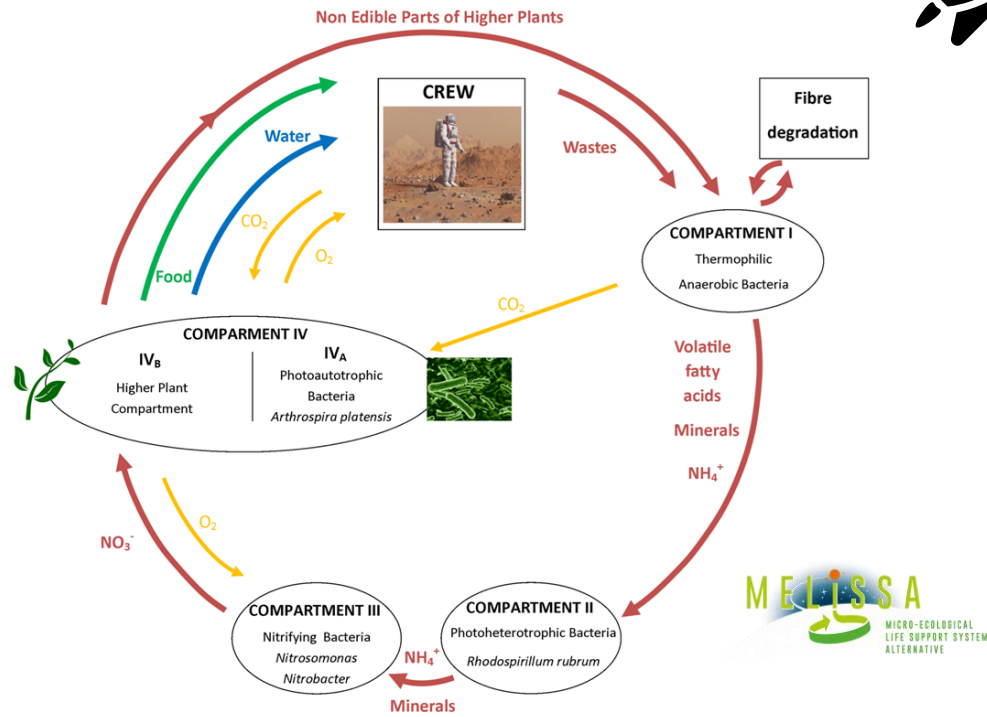
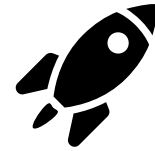
Agenda

1. Terrestrial vs. space systems in a Circular Economy perspective
2. Designing and monitoring more circular systems
 - Circularity indicators
 - Digitalisation
3. Towards a simulation platform for circularity performances
4. Perspectives to bridge the gap between Systems Engineering and Circular Economy



Terrestrial vs. space systems in a Circular Economy perspective

Example of space system to circularize



Example of Earth system to circularize

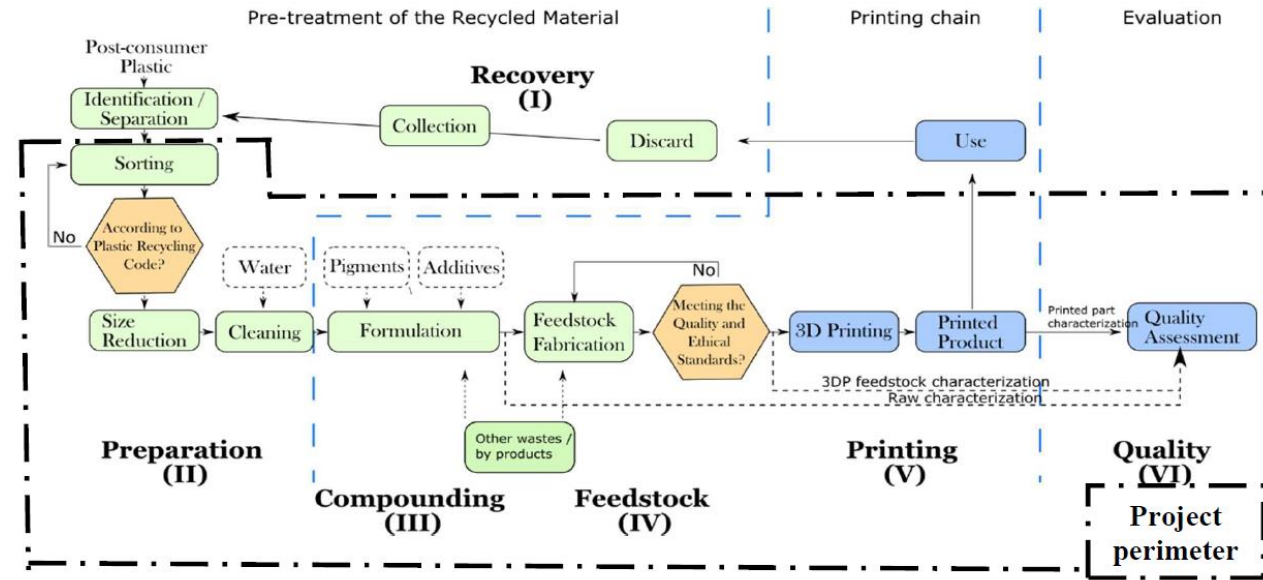


Figure 1: Recycled thermoplastics chain proposed [21].



Terrestrial vs. space systems in a Circular Economy perspective

Circular space system



- Maximizing the efficiency of M- and E-loops to:
 - allow long term space travels
 - keep the crew alive and in good health
- Impacts (like pollution) on the 'external world' (space, the Moon or Mars surface!) are 'not' an issue
- Economic issues are predominant during the design of space systems but are not a criterion to consider during the missions themselves.



Circular Earth system

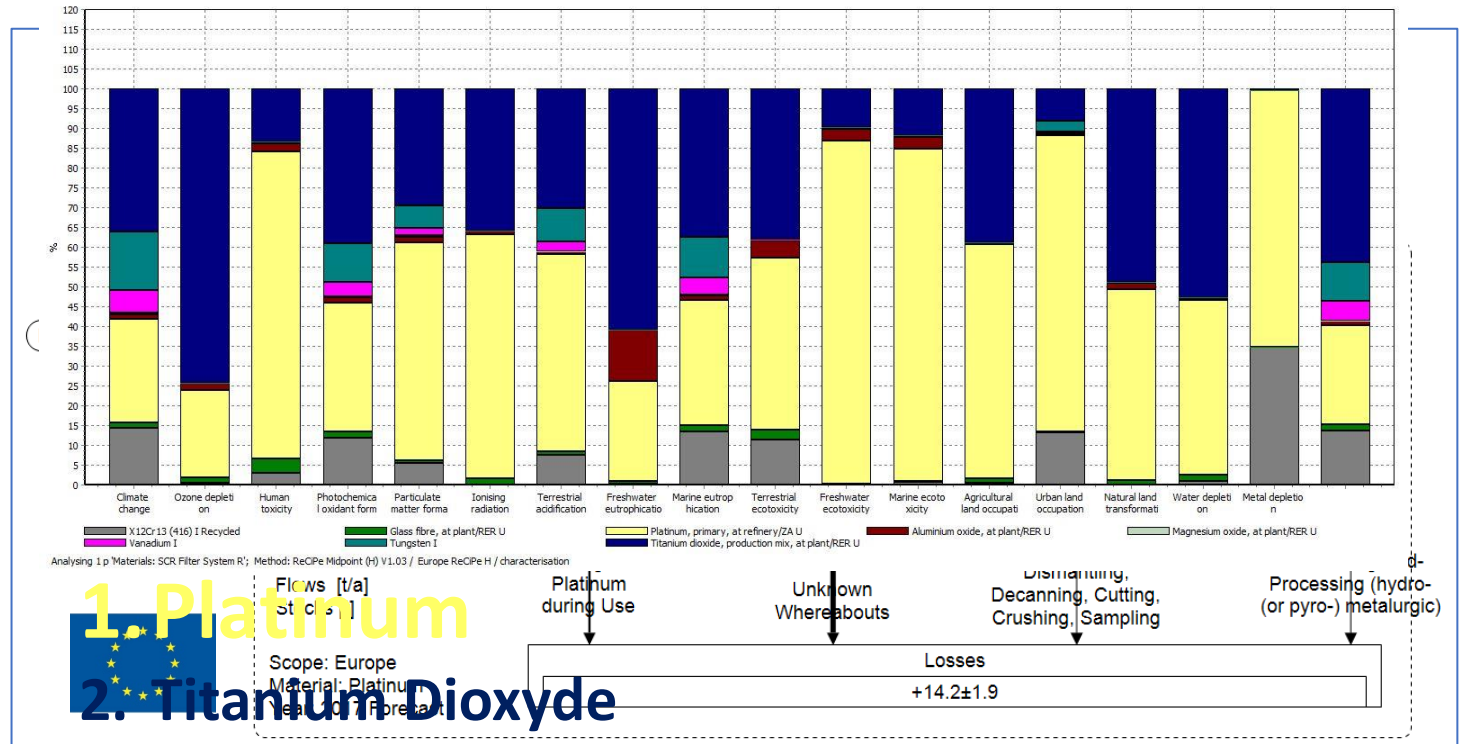
- Maximizing the efficiency of M- and E-loops to:
 - minimize the use of resources and the environmental impact
 - while maximizing the economic performance on the entire life cycle.
- Environmental impact = as much important as the economic performance... depending also on sustainability paradigm – weak or strong – chosen
- + social dimension!



Designing and monitoring more circular systems

Historical engineering tools

- **Material Flow Analysis (MFA)** is a systematic assessment of the flows and stocks of materials within a system defined in space and time [MFA Handbook 2004]
- **Life Cycle Assessment (LCA)** is a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle [ISO 14040:2006]



3. Recycled (90 %) Stainless Steel

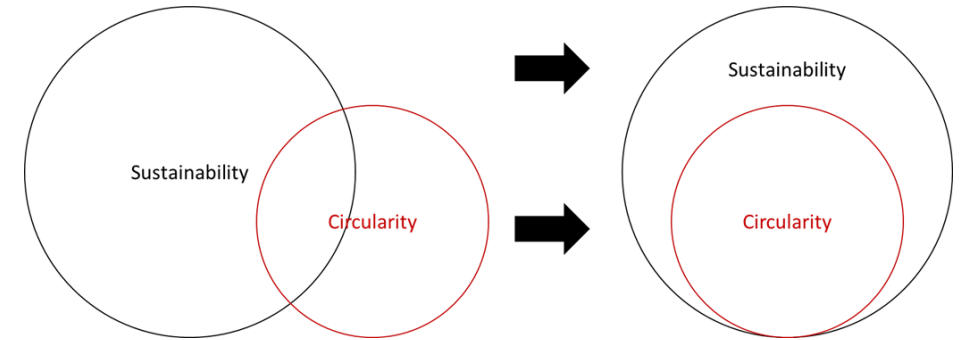
4. {Tungsten, Vanadium}



Designing and monitoring more circular systems

Circularity Indicators (C-Indicators)

- Increasing development since 2010s
- C-performance = resource use, resource loss, renewability, etc.
- “However, due to the intrinsic focus of CE on value and material preservation, **most of the proposed methods focus on measuring material consumption, with recycling being the most dominant CE strategy considered. Additionally, the challenge lies in measuring the social dimension, which remains largely uncovered by the proposed indicators and methodologies.**” [Kravchenko et al. 2020]



CIRCULARITY INDICATORS
AN APPROACH TO MEASURING CIRCULARITY

MCI = 0,46

ELLEN MACARTHUR FOUNDATION

GRANTA MATERIAL INTELLIGENCE

Computation of the MCI:

V	0.67
W _p	0.50
W _r	0.02
W _e	0.03
W	0.52
X	1.00
f(D)	0.90
LFI	0.60
MCI	0.46

Material Circularity Indicator
Dynamic Modelling Tool

Drag the sliders to change input values and see how the MCI changes!

Input	Value	Target
Feedstock	0%	0%
Reused	0%	0%
Recycled	33%	50%
Recycling efficiency	95%	95%
Lifespan	1.0 x industry average	
Functional units	1.0 x industry average	

Destination after use: 0%, 50%, 95%

No.	Name of component range of the Catalyst Converter	Material Mass x Price of component	MCI of ref. component
1	Canning (Stainless Steel)	20	0.70
2	Substrate (Carbonite)	31	0.33
3	Coating (Platinum)	150	0.46
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Total Material Mass x Price: 176
Combined Material Circularity Indicator: 0.48

Combined Material Circularity Indicator
MCI = 0.48

[Ellen McArthur Foundation 2015]



Designing and monitoring more circular systems

Circularity Indicators (C-Indicators)

Different Levels of CE Measurement:

- Real vs. Potential Circularity
- Consequential vs. Intrinsic Circularity
- Units (kg; \$; J; ...) Issue - Single vs. Multiple Indicators
- Usages (Assessment, Improvement, Managerial, Benchmarking, Communication)
- + Distinction of Circularity Loops, etc.

Levels	Definitions	Examples
Macro	City, province, region, nation, society	19% of the UK economy is circular in 2010
Meso	Inter-entreprise Industrial symbiosis	Indicators used to assess the EIPs performance
Micro	Single company Products Materials	Input-Output Analysis in the manufacturing process



Designing and monitoring more circular systems

Circularity Indicators (C-Indicators)

to monitor and improve the circularity of a product, company, industrial value chain, territory...

Online platform to select C-indicators:

<http://circulareconomyindicators.com/>

Journal of Cleaner Production 207 (2019) 542–559



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Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro



Review

A taxonomy of circular economy indicators

Michael Saidani ^{a,*}, Bernard Yannou ^a, Yann Leroy ^a, François Cluzel ^a, Alissa Kendall ^b

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Circularity Indicators _ The Advisor
Target the Right C-Indicators
Unlock the C-Potential of your Products



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Monitoring the circular economy

All the indicators and tools you need!

The [C-Indicators Advisor](#): the tool to select and implement the right circular economy indicator(s).

The [C-Potential Indicator](#): the tool to unlock and track the circularity performance of your products.

To go further and know more about the challenges related to measuring and advancing the circular economy at different scales (materials, products, companies, systems, regions, countries), check out our latest [publications](#).

You are aware of a new circularity indicator? You are developing a new one? You have tested some of them? You are looking for a particular indicator or tool? Let us [know](#) your progress or needs, and [contribute](#) to the sharing of knowledge fostering the circular economy transition for a more sustainable world.

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Designing and monitoring more circular systems

Digitalisation for Circular Economy

Nexus of circular economy and sustainable business performance in the era of digitalization

Rohit Agrawal, Vishal Ashok Wankhede, Anil Kumar, Arvind Upadhyay, Jose Arturo Garza-Reyes

International Journal of Productivity and Performance Management

ISSN: 1741-0401

Article publication date: 1 April 2021



Issue publication date: 15 February 2022

DOWNLOADS



Procedia CIRP
Volume 64, 2017, Pages 19-24



The Emergent Role of Digital Technologies in the Circular Economy: A Review ☆

Aris Pagoropoulos, Daniela C.A. Pigosso, Tim C. McAlone

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CIRCULAR ECONOMY

How digitalization can help build a circular economy ecosystem

Aug 25, 2022



One Earth

Volume 4, Issue 6, 18 June 2021, Pages 783-785

Commentary

Toward a circular economy: The role of digitalization

Annika Hedberg, Stefan Šipka

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Although not actively recognized, the ongoing digital transformation can serve as an enabler and even as a catalyst for creating a circular economy. It is time to build on this potential and create a digital circular economy that can benefit people, businesses, and the planet.



Designing and monitoring more circular systems

Digitalisation for Circular Economy

- Current tendency: digitalisation of territories and value chains
- Examples: in France, Program for the Digital Transformation of Territories in June 2021: « *a smart territory in which services and public policies are monitored by data, thanks to diverse digital tools* »



MINISTÈRE
DE L'ÉCONOMIE,
DES FINANCES
ET DE LA RELANCE

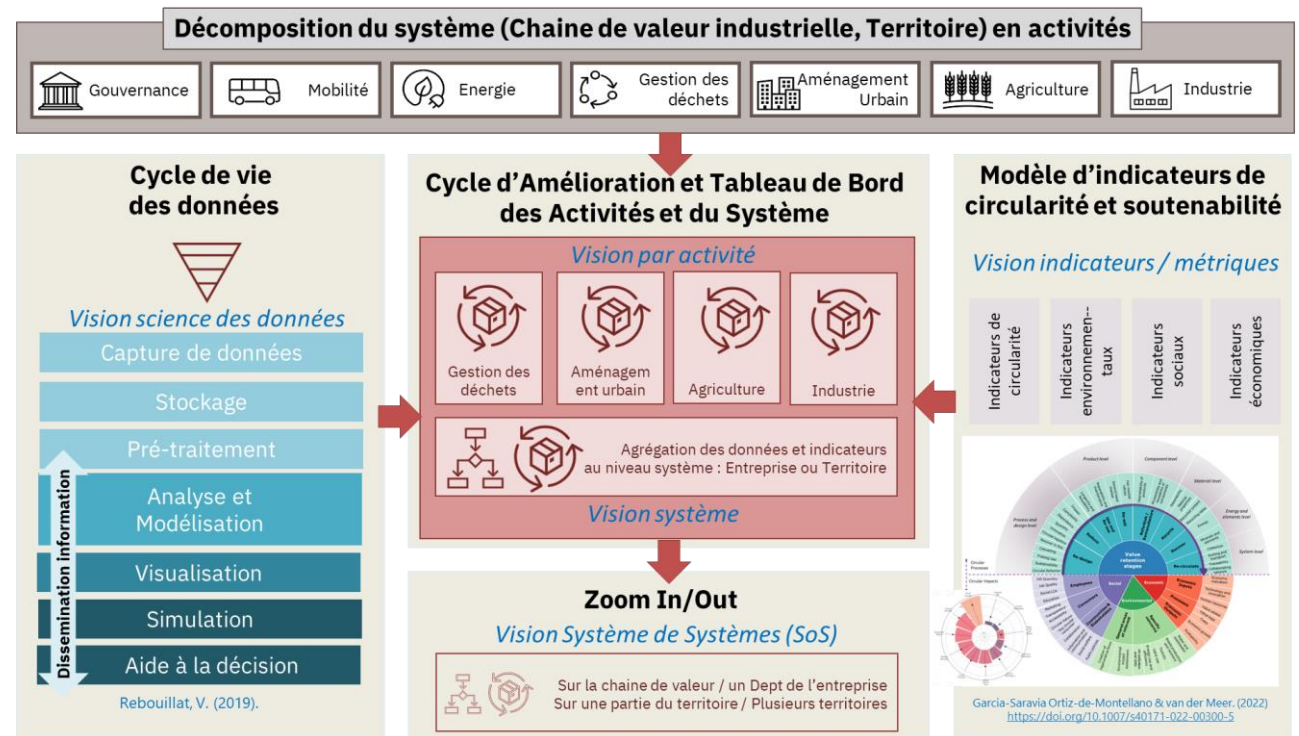


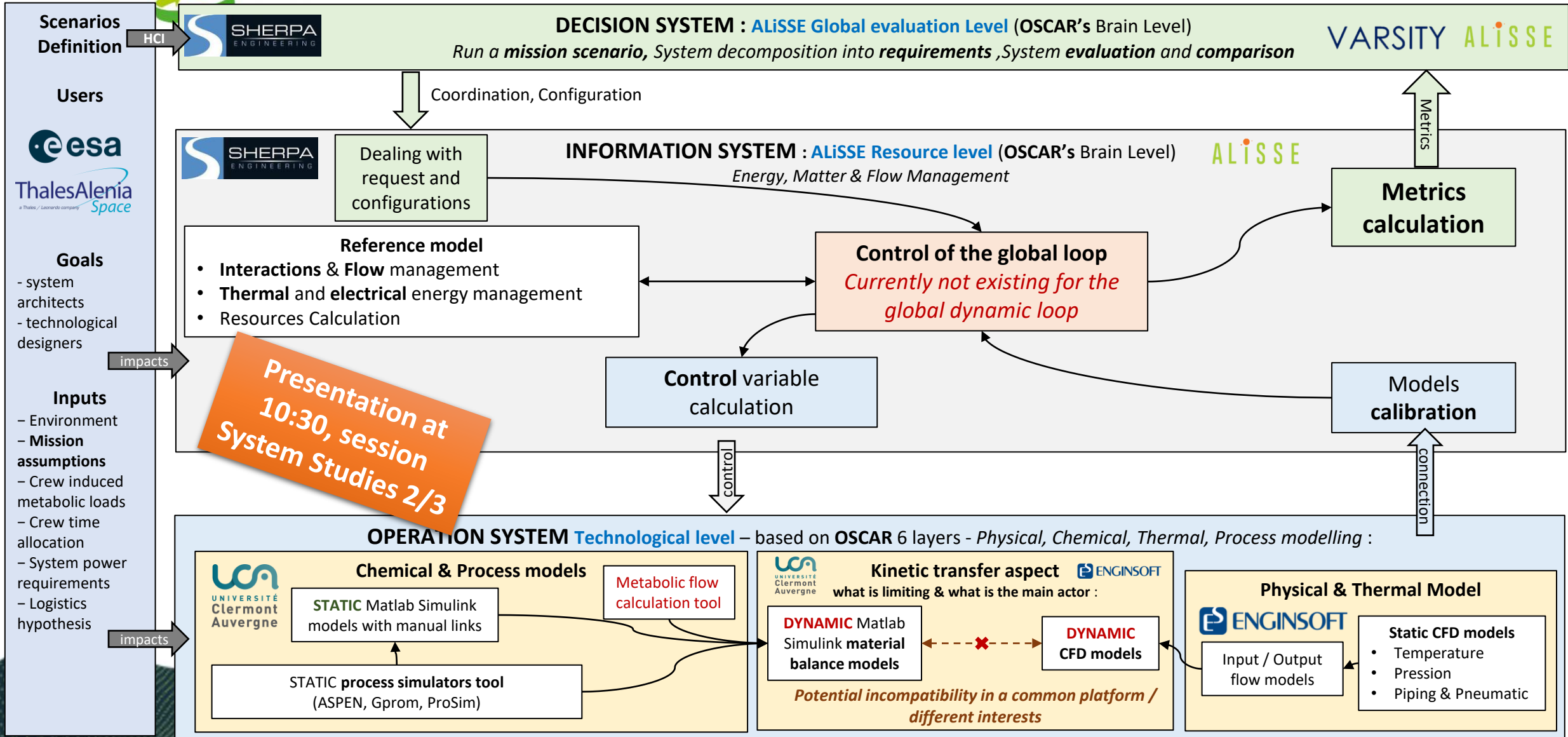


Towards a simulation platform for circularity performances

Launching of the CircularIT Alliance

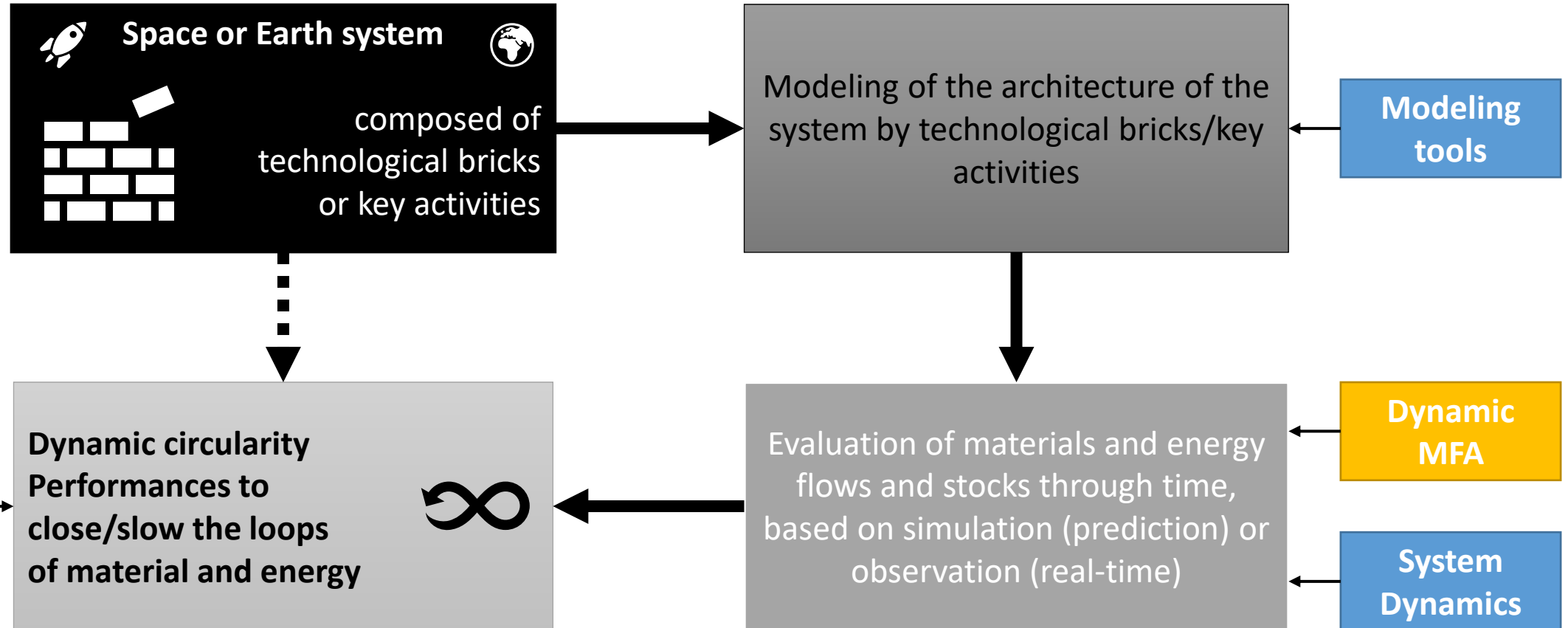
- Quantify, improve and monitor the circularity and sustainability performance of industrial systems and territories
- **Objective:** develop a methodology from the diagnosis of key activities of an industrial company or a territory to the deployment of a digital platform to monitor and improve circularity and sustainability







Towards a simulation platform for circularity performances



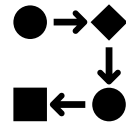
-  Systems Engineering domain
-  Circular Economy domain



Perspectives to bridge the gap between Systems Engineering and Circular Economy

Systems Engineering

- Complex and heavy processes
- Necessary to design complex systems
- Still « reluctant » to successfully integrate environmental aspects
 - Most of the time mono-criteria or on a limited scope



Circular Economy

- Considers more and more complex systems
 - large value chains, territories, multi-stakeholders...
- Lacks of rigorous processes and tools when complexity increases
- Integration of tools like MFA, LCA, C-Indicators...

→ Gather together experts from both disciplines to make complex engineered systems much more circular

→ Simulation platform for circularity performances

→ For space systems: foster collaborations within the MELISSA ecosystem?



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www.melissafoundation.org

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THANK YOU.

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