Fraunhofer IPK

Fraunhofer Institute for Production Systems and Design Technology IPK

Nachhaltig.digital

Digitale Zwillinge für die Nachhaltigkeitsbewertung von Produkten

Theresa Riedelsheimer
Head of Department
Sustainable Product-Ecosystems
Fraunhofer IPK, Berlin, Germany

Find me
on Linked-In

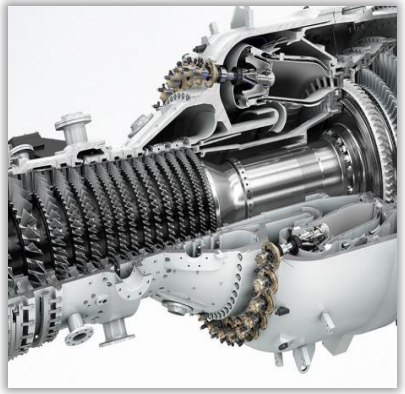
Fraunhofer
IPK

Fraunhofer Institute for Production
Systems and Design Technology IPK

Digital Twin Use Cases in different industries

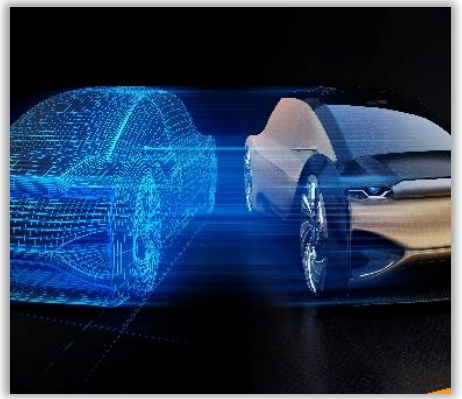
Excerpt of Fraunhofer IPK projects

Digital Twins for performance monitoring and feedback to Design of industrial electrical drives



Digital Twins for Predictive Maintenance of turbine blades

Digital Twins for Feedback to Design and Production optimization in Aerospace sector

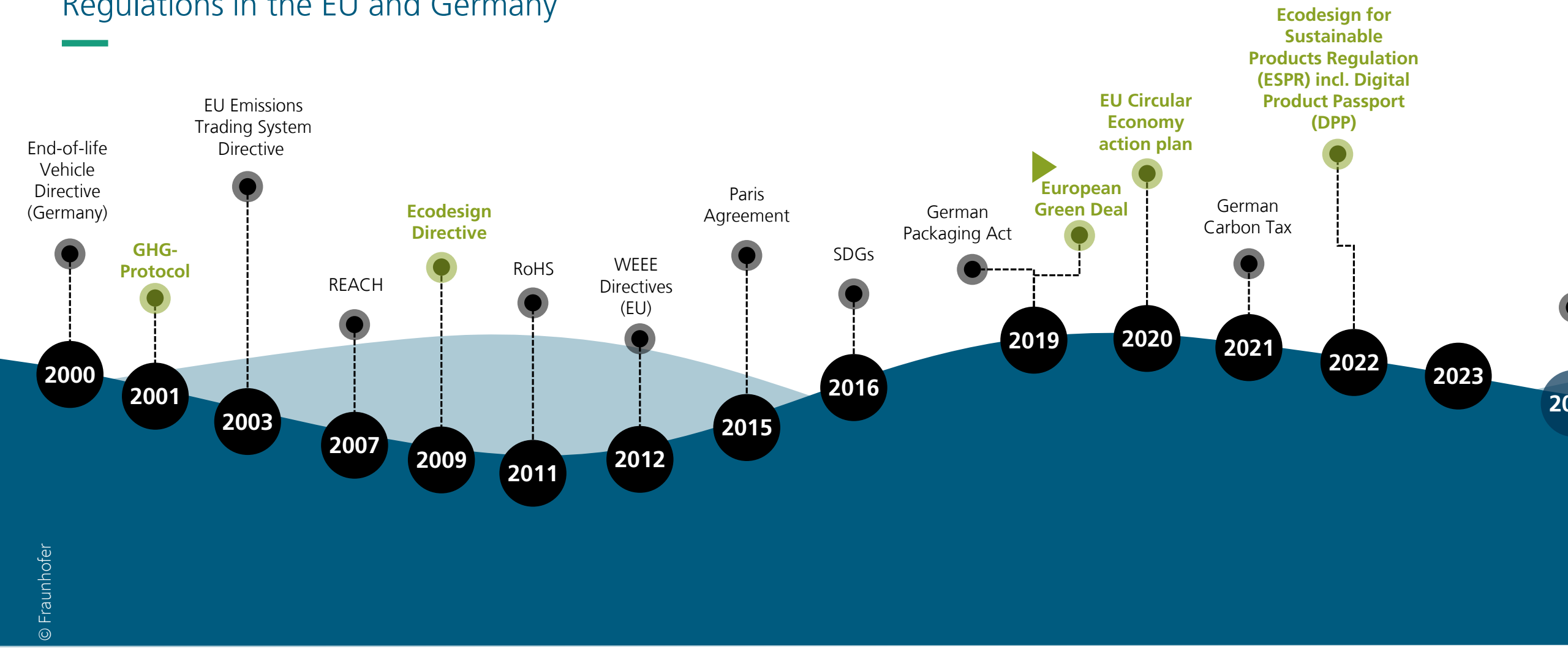


Digital Twins for Circular Economy strategies and EoL decision support of automotive vehicles

Digital Twins for Life Cycle Assessment (LCA) of automotive components

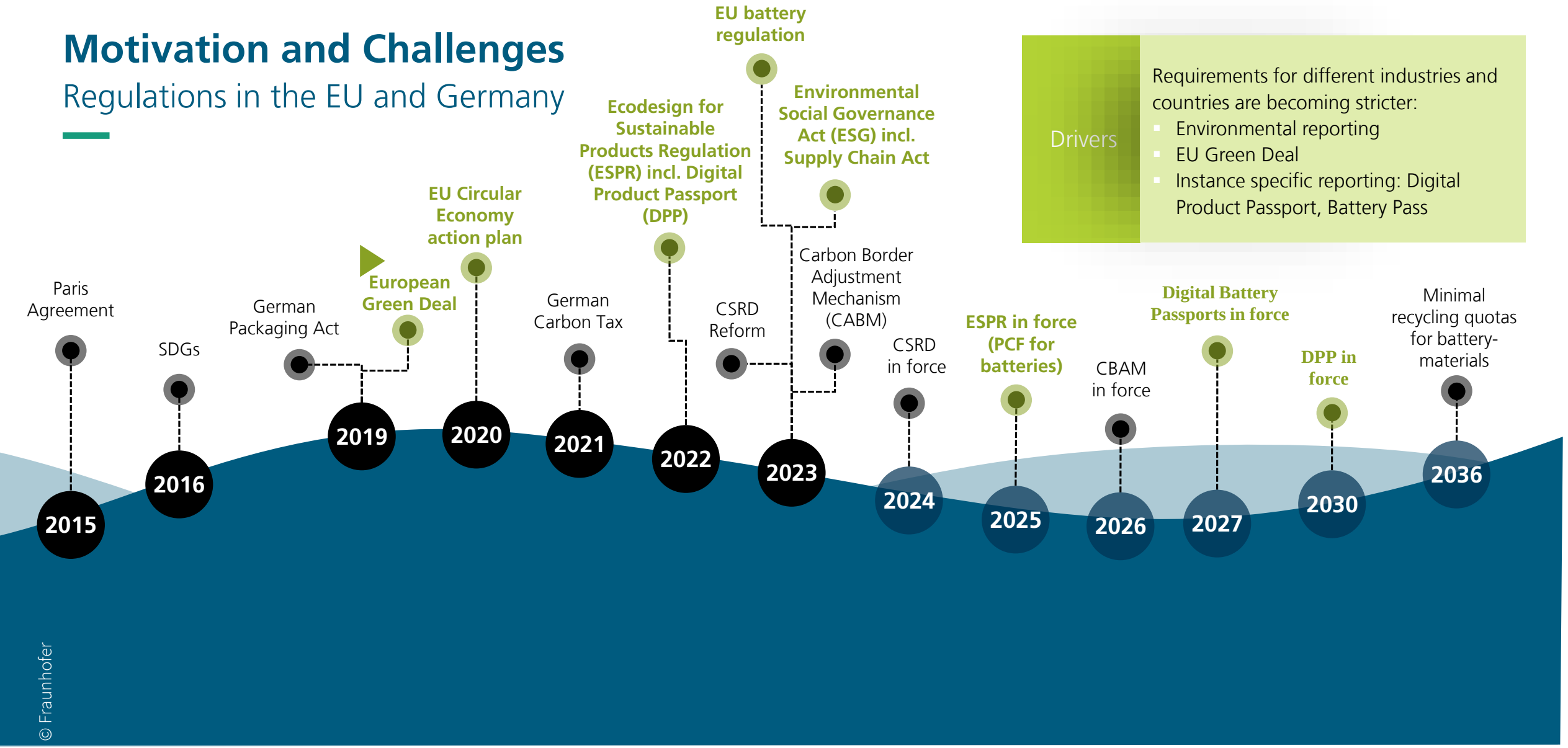
Motivation and Challenges

Regulations in the EU and Germany



Motivation and Challenges

Regulations in the EU and Germany

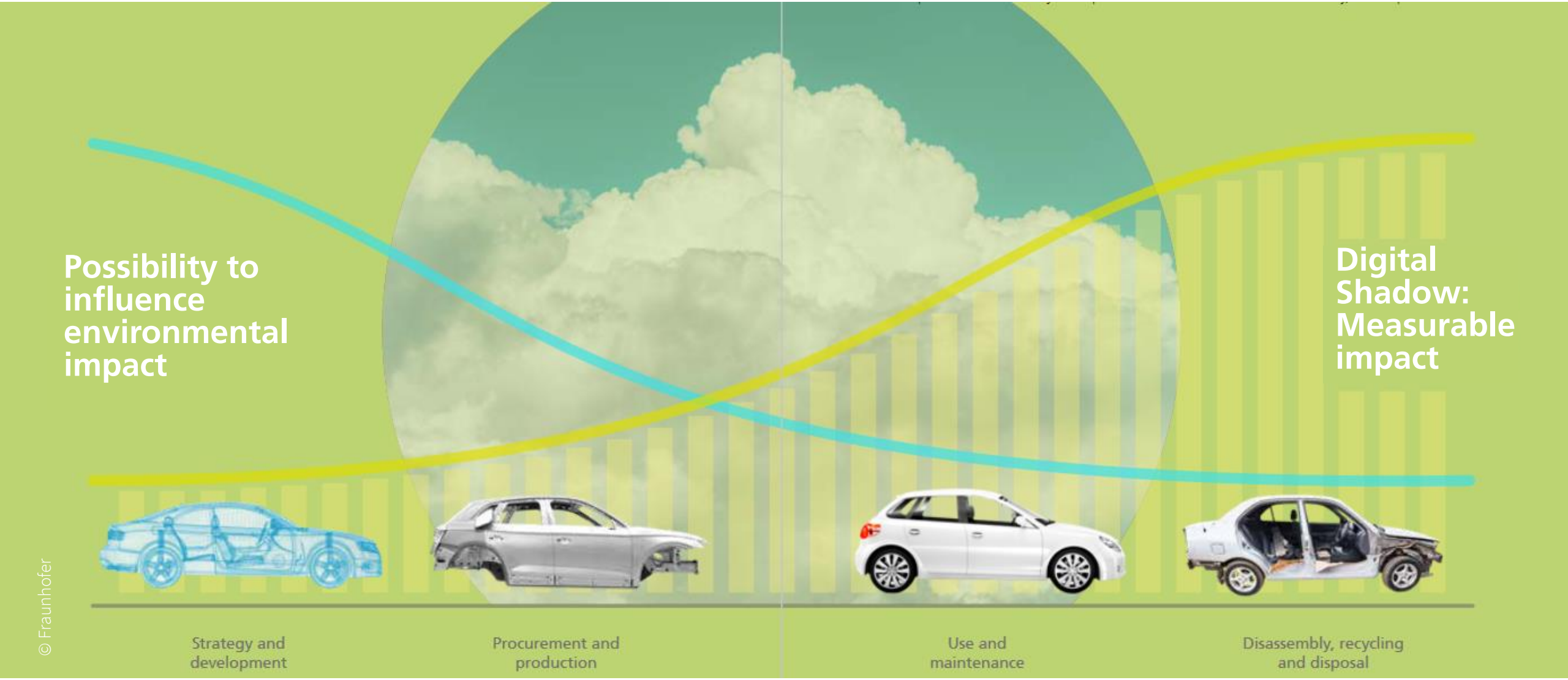


Drivers

Requirements for different industries and countries are becoming stricter:

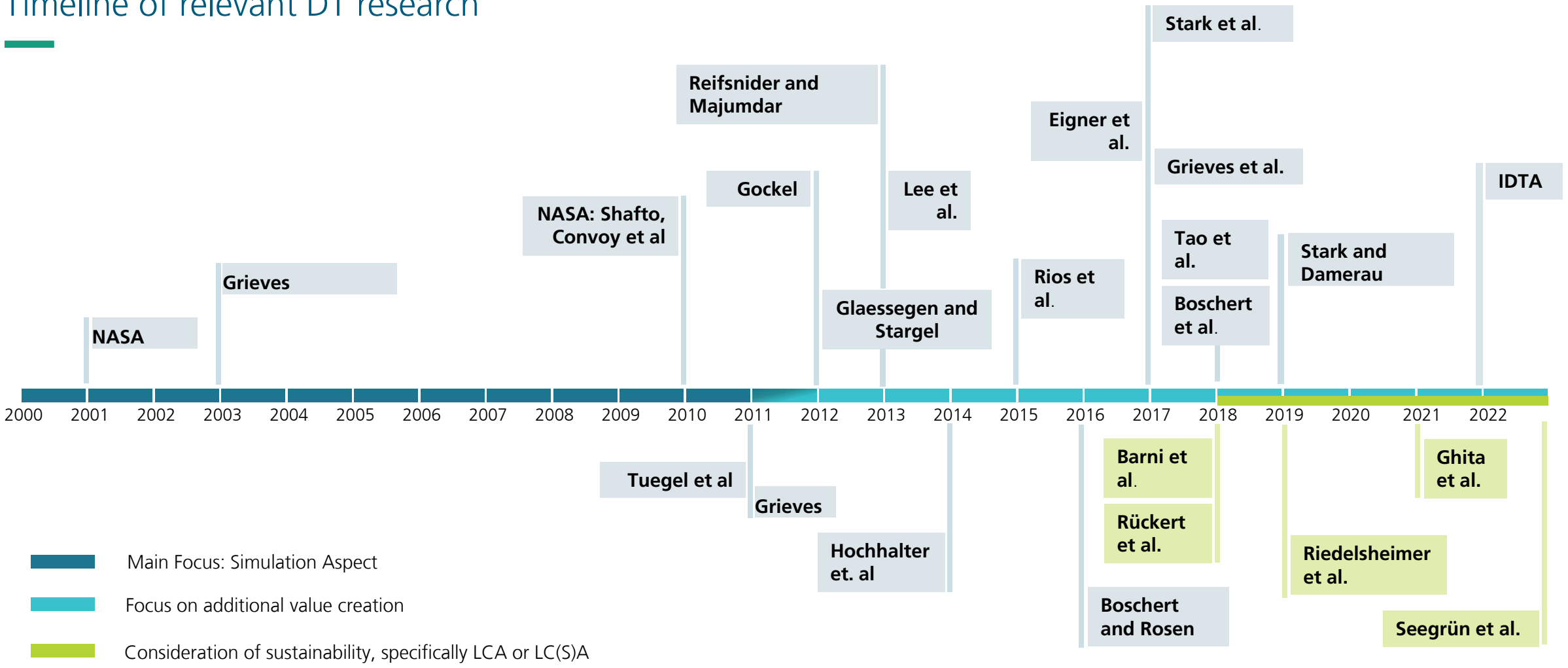
- Environmental reporting
- EU Green Deal
- Instance specific reporting: Digital Product Passport, Battery Pass

The earlier, the better



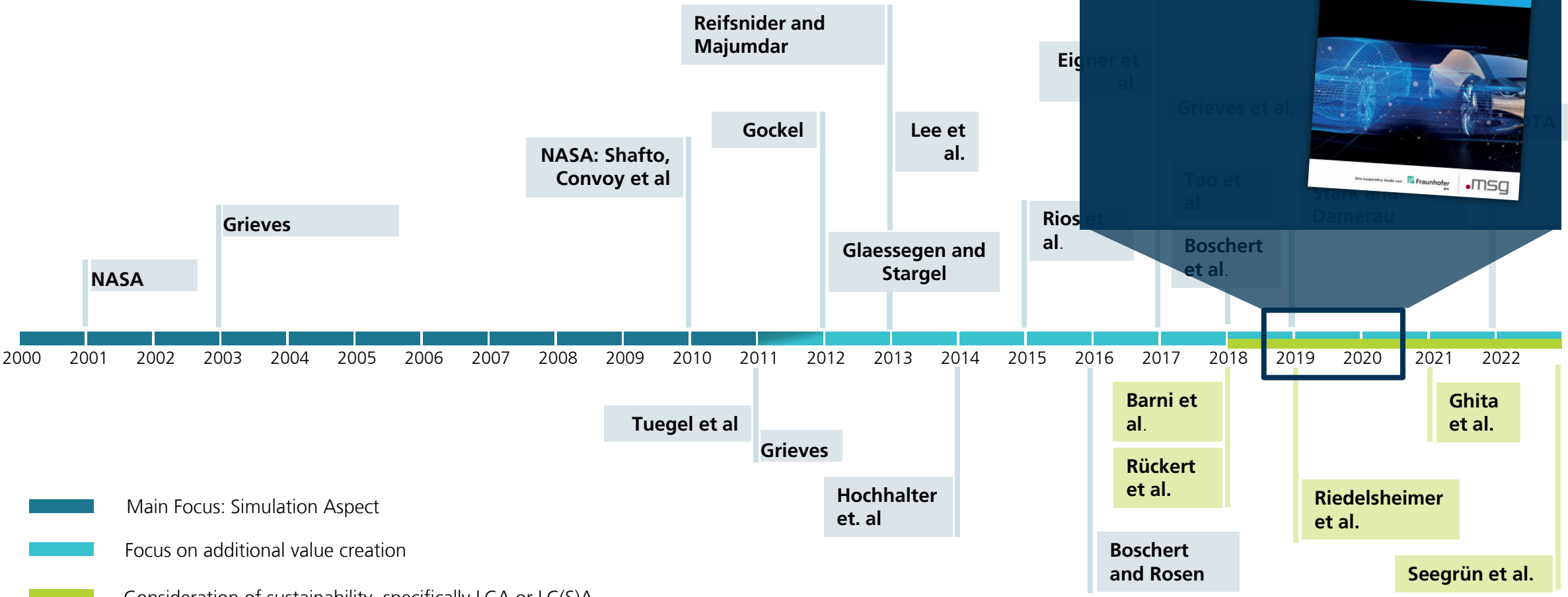
State of the Art

Timeline of relevant DT research



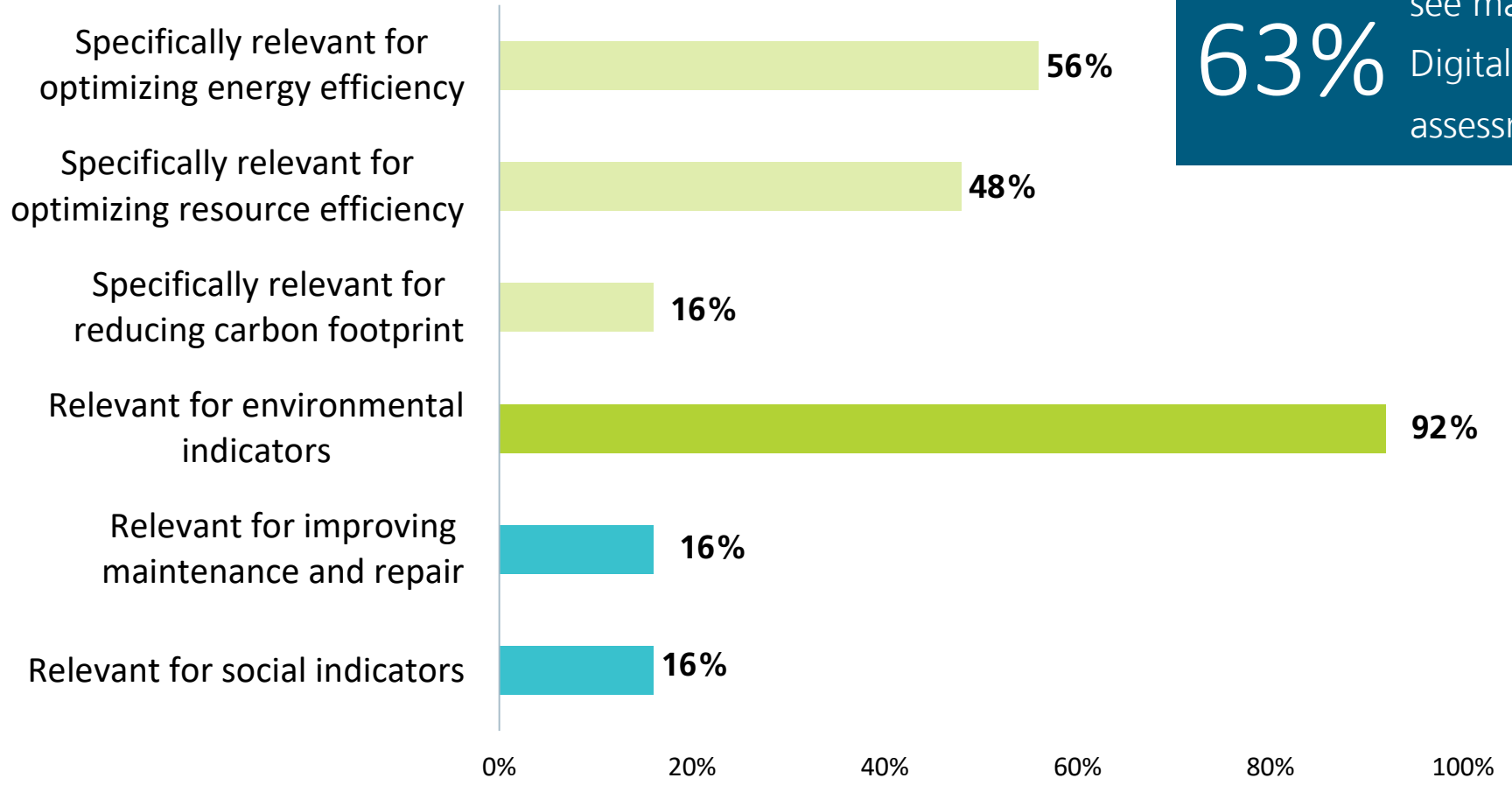
State of the Art

Timeline of relevant DT research

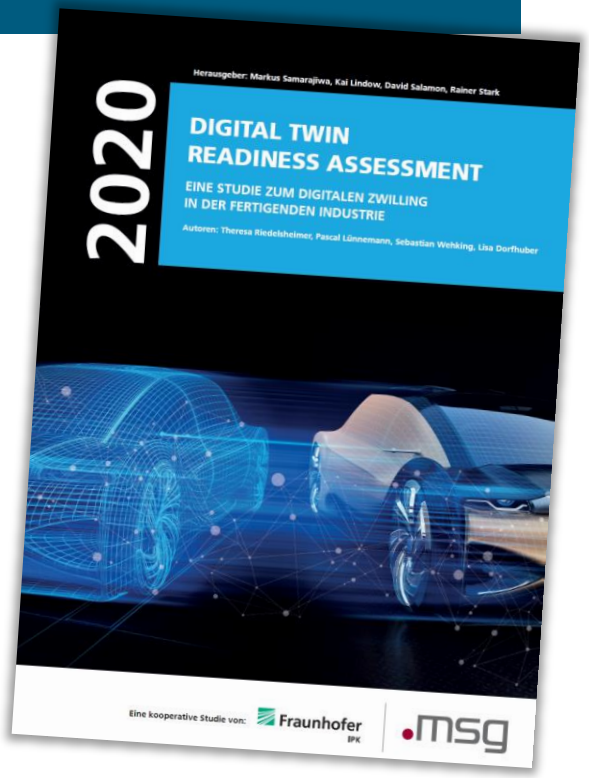


Stakeholder needs: Relevance of Digital Twins for sustainability

N = 26



63% see major potential for a future use of Digital Twins to perform sustainability assessments.



Source: Riedelsheimer et al. „Digital Twin Readiness Assessment: A Study on the Use of Digital Twins in the Manufacturing Industry, 2021, https://www.ipk.fraunhofer.de/de/medien/markt-trendstudien/digital-twin-readiness-assessment/download-studie-digital-twin-readiness-assessment.html.

1. Stakeholder needs: Persona and User Story development

BEGIN OF LIFE	BEGIN OF LIFE	MID OF LIFE	2+ND LIFE	EOL
PRODUCT DEVELOPMENT & PRODUCTION PLANNING	PRODUCTION	USAGE	REUSE (+Rs)	Rs

(I) As a **sustainability manager**, I would like to be able to calculate the environmental impact of different product and process variants in order to be able to identify the best alternative taking into account sustainability aspects over the entire life cycle.

Responsible for assessing and monitoring the environmental performance of a company's products or services throughout their life cycle

(II) As a **product developer**, I would like to be able to break down environmental impacts to the product model in order to identify product components with a high impact.

(III) As a **product developer**, I would like to receive a warning if my planned sustainability limits are exceeded, so that I can initiate appropriate adjustments to the design.

Responsible for evaluating different materials, manufacturing processes, and design options to minimize product's environmental footprint and identify areas for improvement

(IV) As a **production planner**, I would like to be able to calculate the product- and process-specific environmental impact in order to be able to optimize my production.

Responsible for optimizing manufacturing processes and minimizing environmental impacts associated with production

(V) As a **sustainability manager**, I would like to obtain a target/ actual comparison of my implemented LCA requirements by evaluating operating and condition data of the production in order to be able to check their implementation status.

(VI) As a **product developer**, I would like the digital product twin to process sustainability-relevant data during use in order to be able to feed back corresponding findings into earlier product lifecycle phases (e.g. feedback-to-design).

(VII) As a **sustainability manager**, I would like to obtain a target/actual comparison of my implemented LCA requirements by evaluating operating and usage data of products in order to be able to check their implementation status.

1. Stakeholder needs: Persona and User Story development

Exemplary persona and user story

BEGIN OF LIFE

PRODUCTION

(V) As a **sustainability manager**, I would like to obtain a target/ actual comparison of my implemented LCA requirements by evaluating operating and condition data of the production in order to be able to check their implementation status.

Responsible for assessing and monitoring the environmental performance of a company's products or services throughout their life cycle.

BEGIN OF LIFE

PRODUCTION

(V) As a **sustainability manager**, I would like to obtain a target/ actual comparison of my implemented LCA requirements by evaluating operating and condition data of the production in order to be able to check their implementation status.

MID OF LIFE

USAGE

(VI) As a **product developer**, I would like the digital product twin to process sustainability-relevant data during use in order to be able to feed back corresponding findings into earlier product lifecycle phases (e.g. feedback-to-design).

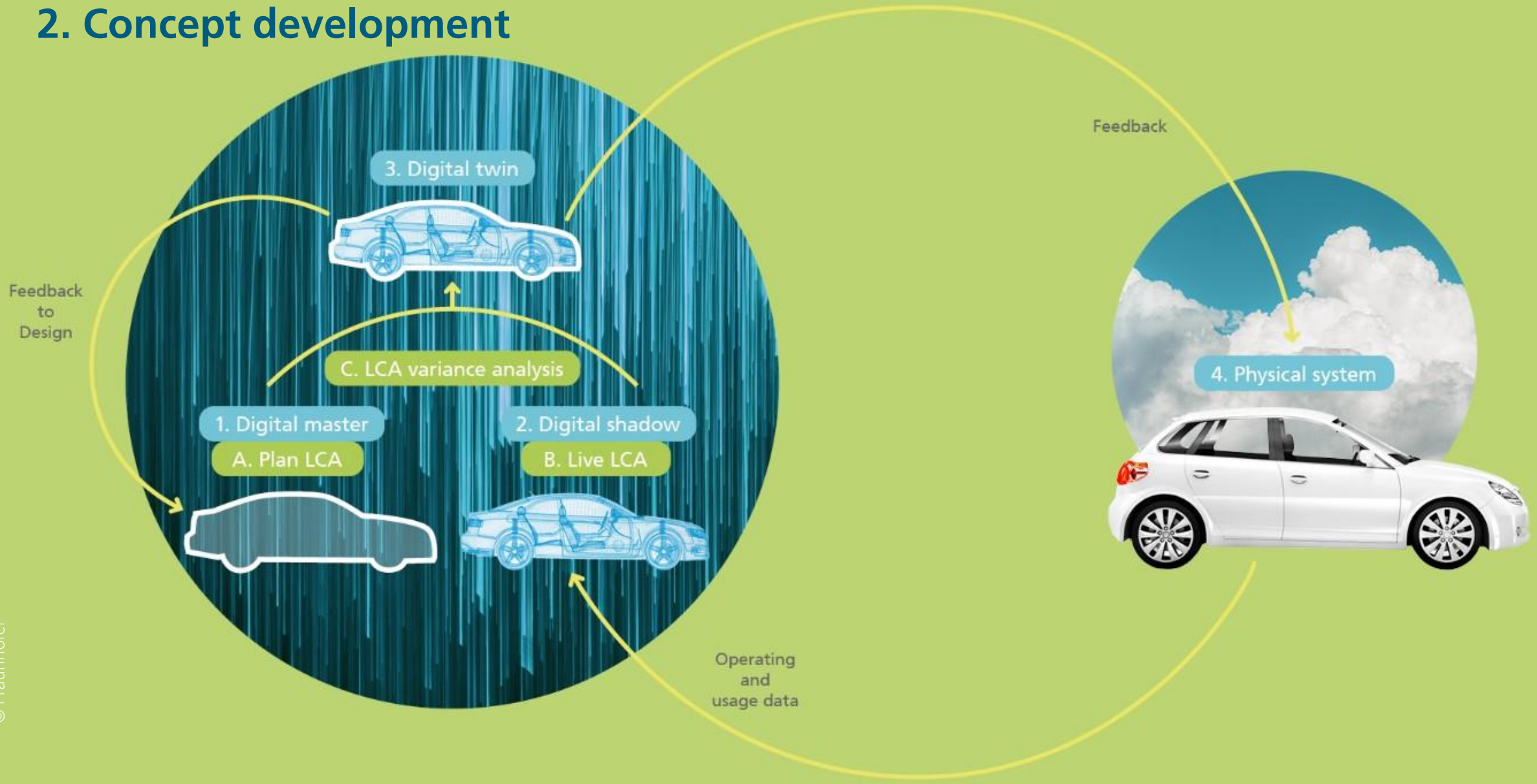
2+ND LIFE

REUSE (+Rs)

EOL

(VII) As a **sustainability manager**, I would like to obtain a target/actual comparison of my implemented LCA requirements by evaluating operating and usage data of products in order to be able to check their implementation status.

2. Concept development



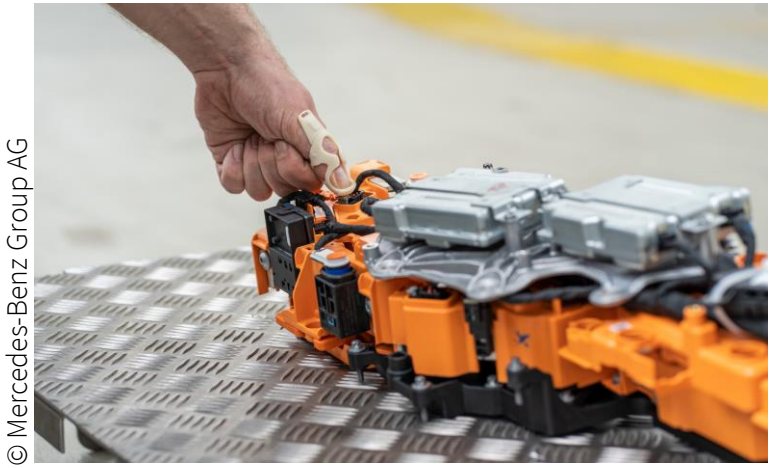
Validation: 3 Use Cases

BioFusion 4.0

© Mercedes-Benz Group AG

Use Case 1:
Line production of engine parts for automotive vehicles

- Industrial environment (Mercedes Benz Berlin)
- Proprietary software for DT Core & PLM
- OpenLCA © and the EcoInvent © database



© Mercedes-Benz Group AG

Use Case 2:
Line assembly of e-car components

- Industrial environment (Mercedes Benz Berlin)
- Proprietary software for DT Core & PLM
- OpenLCA © and the EcoInvent © database

© Fraunhofer

Use Case 3:
3D printing of an orthosis as assembly support

- Laboratory environment
- Open Source software for DT Core
- OpenLCA © and the EcoInvent © database

Fraunhofer Mercedes-Benz budatec KleRo ARBURG COLLIN CONTACT Software GreenDeLTa ModuleWorks BRAL Werner-von-Siemens Centre for Industry and Science

Validation: main findings

BioFusion 4.0

General

- Concept is considered relevant
- Regulatory requirements encourage its implementation within industry
- Challenges:
  - global supply chains to cover Scope 3 emissions
  - compliance with continually changing regulatory requirements
  - digital shadow data definition: realtime requirement and updating the LCA resp. the DT data based on dynamic data

Development approach

- Cross-domain collaboration as data consumer vs. data provider in-balance
- Need for an early proof of concept for industrial application (agile approach recommended)

Added value and lifecycle perspective

- Quantification of added value differs with lifecycle phase
- Monitoring as main objective (regulation)
- Optimization in the hand of individual company strategies and market prices for energy and raw material
- Executed LCA as part of the DT: material choice and supply chain as main lever
- Use phase difficult to consider for private product ownership / control
- EoL-phase only considered in use case 3
- For automotive use case: EoL not integrated yet (e.g. vehicle EoL after ~avg. 20 years)

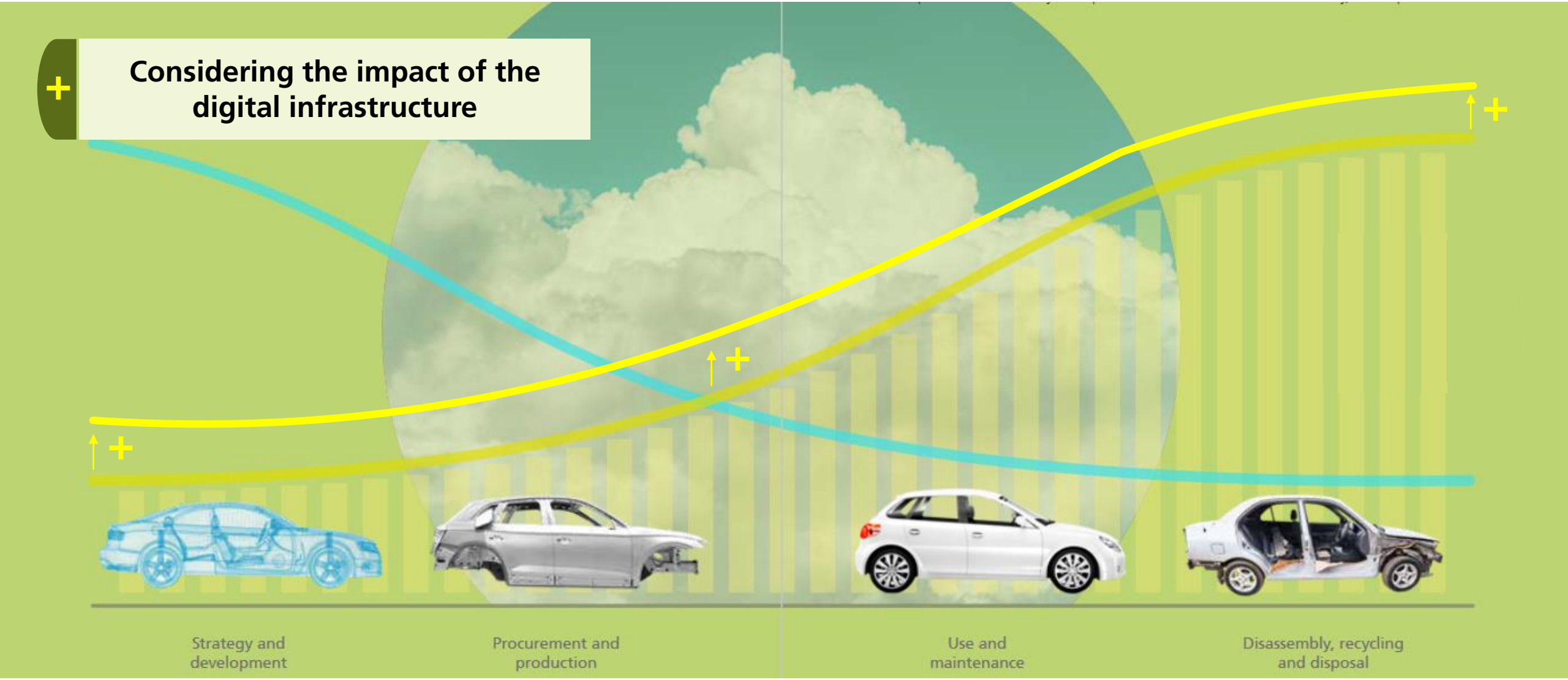
Operation of the DT for LCA

- high effort required for data collection, data management, as well as setup of cross-IT system & cross-company data exchange
- Defining appropriate events for triggering LCA update

Fraunhofer Mercedes-Benz budatec KleRo ARBURG COLLIN CONTACT Software GreenDeLTa ModuleWorks BRAL Werner-von-Siemens Centre for Industry and Science

What is next?

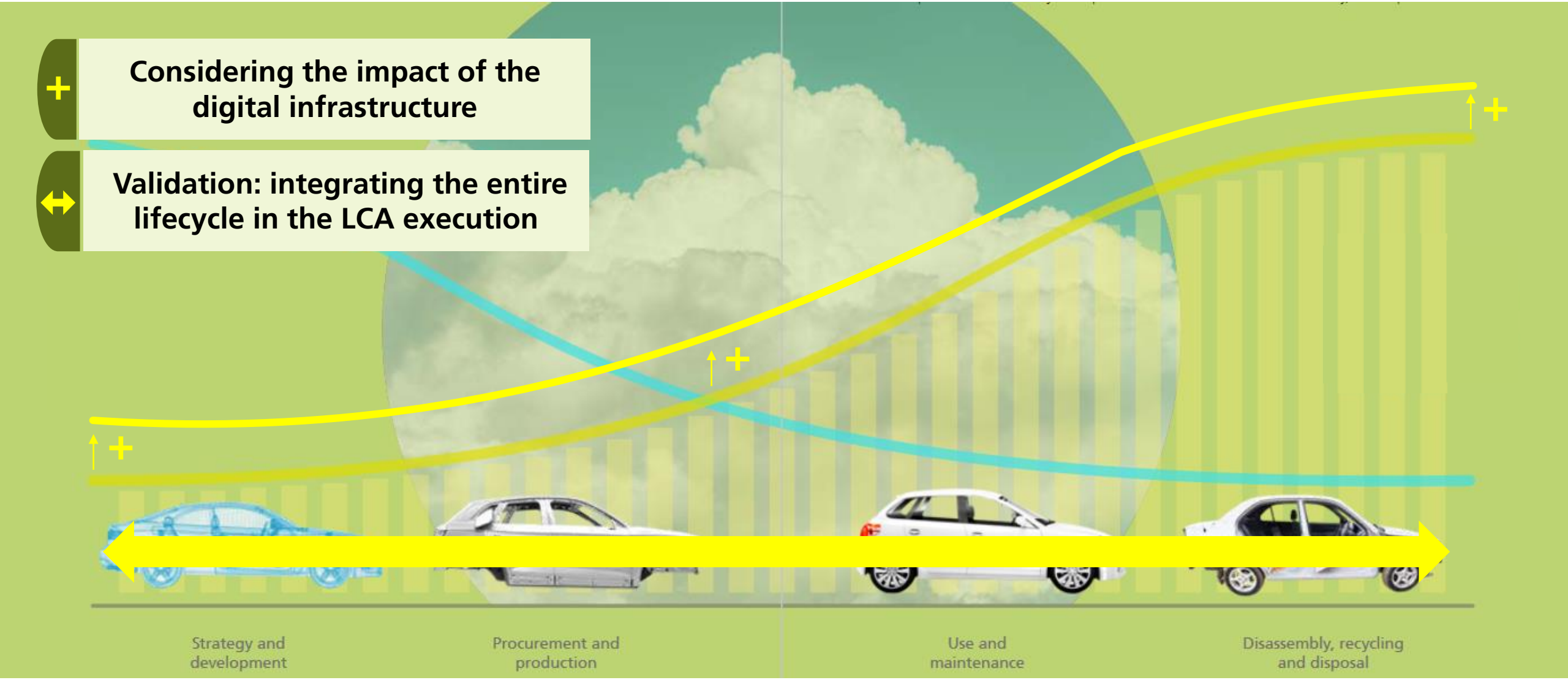
Considering the impact of the digital infrastructure



What is next?

Considering the impact of the digital infrastructure

Validation: integrating the entire lifecycle in the LCA execution

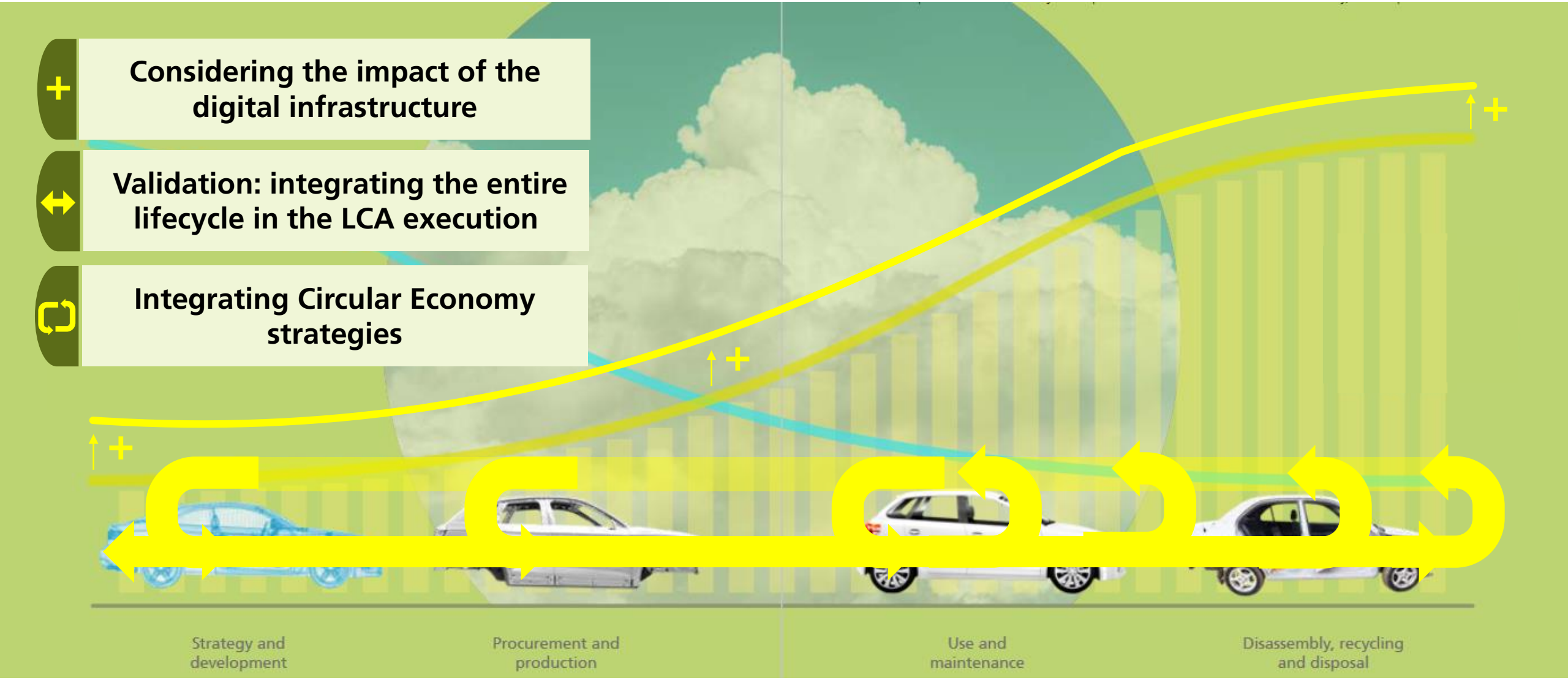


What is next?

Considering the impact of the digital infrastructure

Validation: integrating the entire lifecycle in the LCA execution

Integrating Circular Economy strategies



What is next?

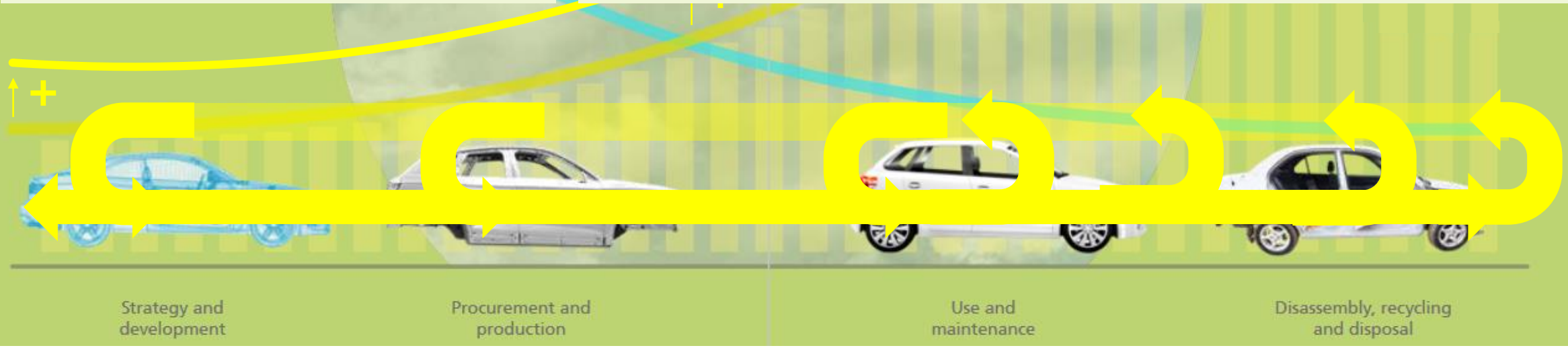
Considering the impact of the digital infrastructure

Validation: integrating the entire lifecycle in the LCA execution

Integrating Circular Economy strategies

To facilitate the establishment across different industries, it is necessary to develop a **standardized approach as well as standardized data models and interfaces, that enable the efficient and sustainable definition** of the frequency and trigger of **LCA updates based on primary data** and ultimately enable **cross-company data exchange.**

BioFusion 4.0 | Catena-X Your Automotive Network | DIGMA-DT | AEROSPACE-X



Theresa Riedelsheimer
Head of Department Sustainable Product-Ecosystems
Fraunhofer IPK, Berlin, Germany

theresa.riedelsheimer@ipk.fraunhofer.de
Find me on Linked-In:

Fraunhofer IPK

Fraunhofer Institute for Production Systems and Design Technology IPK