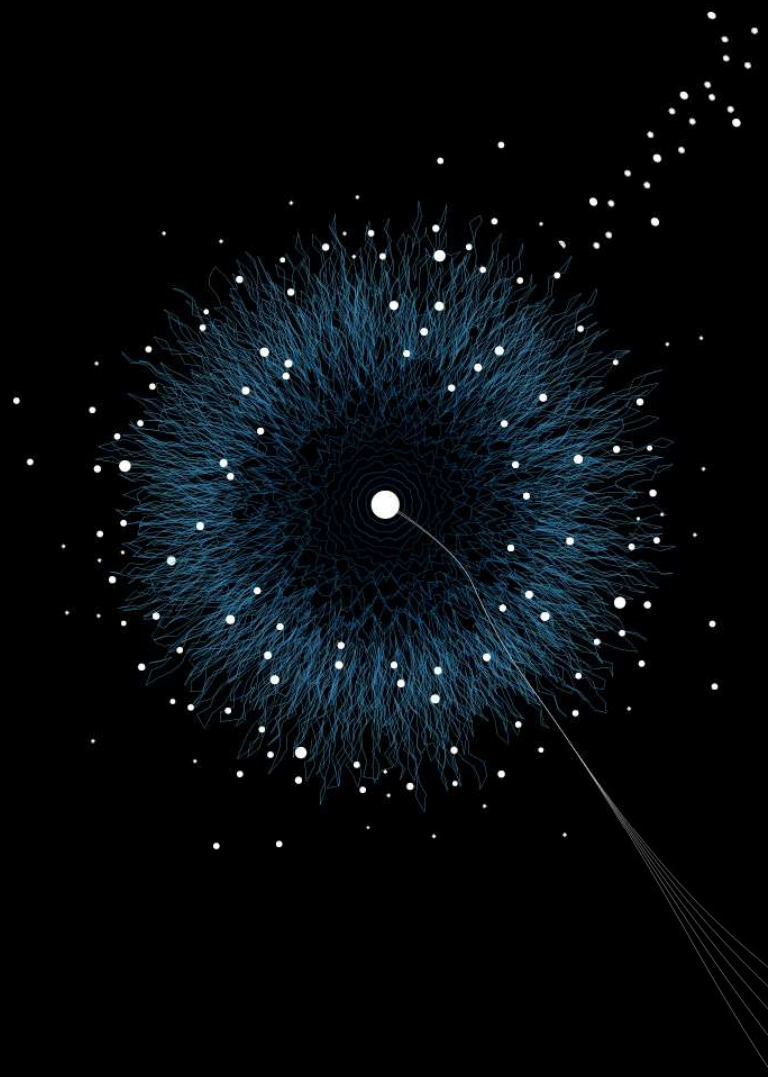
BMS/Industrial Engineering & Business Information Systems

CIRCULARITY INFORMATION PLATFORM

HOW DO BUILDINGS TALK?



PhD Program: Smart Circular Construction Ecosystems
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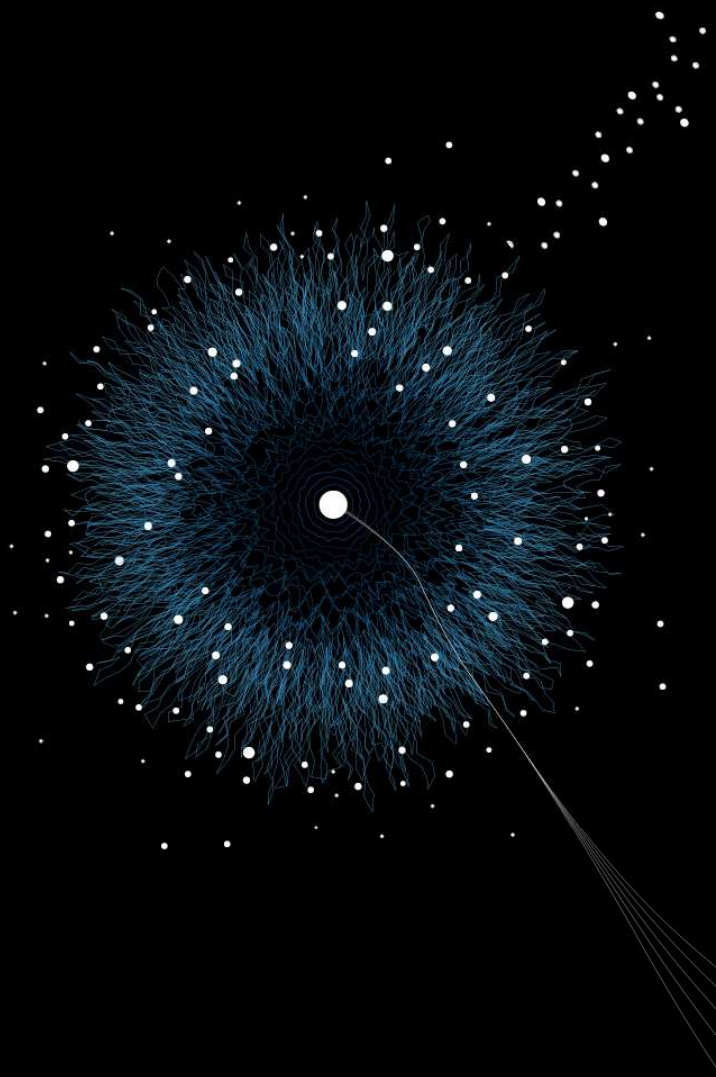
Current position: PhD student (Oct. 2020 – Oct. 2024)

Institution: Department of Industrial Engineering and Business Information Systems (IEBIS), University of Twente

Background: Master's degree in Construction Management and Engineering, University of Twente

Research: Circular Economy in the construction industry



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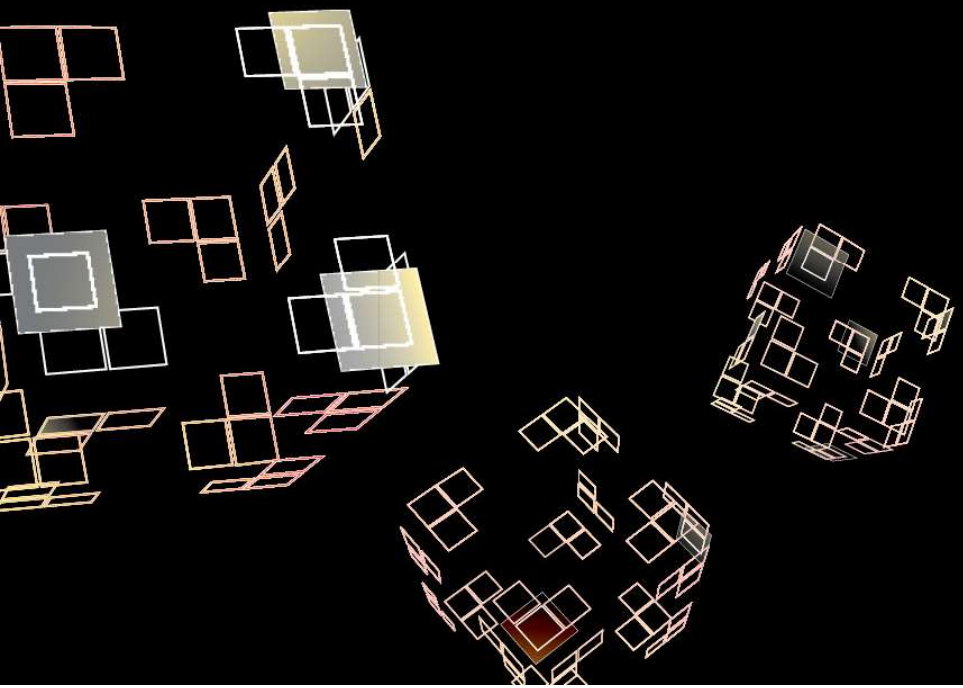

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Circular Economy as an Approach to Resilience

The starting point of a building's lifecycle may trace back to a demolition project (Pomponi & Moncaster, 2017)

Photo source: *ArchDaily (2020)*

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Low-Resilience: Unstable Closed-loop Supply Chains

Lack of resilience on closed-loop supply chain development (Benachio et al., 2020)

High resource intensity → Circular Economy in built environment

- Industry: stable secondary material flow
- Government: monitor & coordinate

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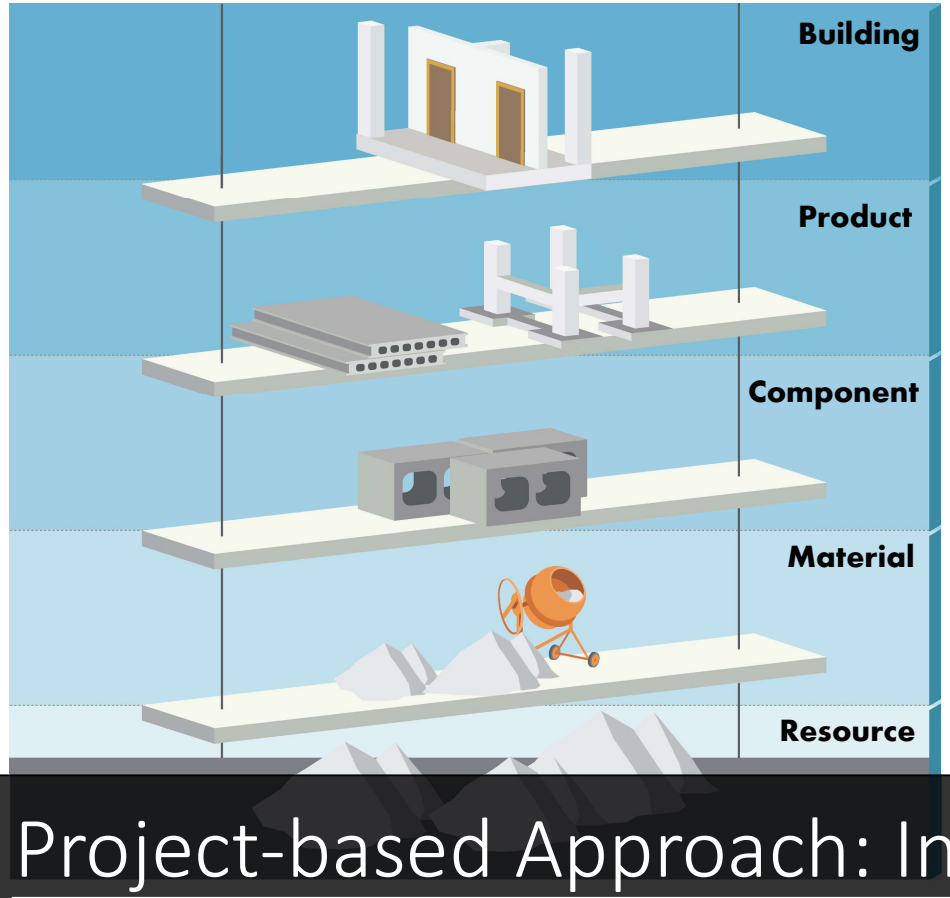
Photo source: *SUEZ (2021)*



Project-based Approach: Information Discontinuity

Fragmented construction supply chain: (1) Multi-stakeholder collaboration; (2) Location-bound design; (3) Outdoor production

Special product characteristics: (1) Unreversible construction methods; (2) Diverse materials; (3) Long lifespan

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Source: *Block et al. (2020)*

Lack of Coherent CE Policy-making

The structural mismatches exist among high-level policies, regulatory frameworks, and industrial practices (Yu et al., 2022b)

Wicked policy-making: (1) Unclear policy target; (2) Lack of practical guidance; (3) Limited feedback-loop analysis

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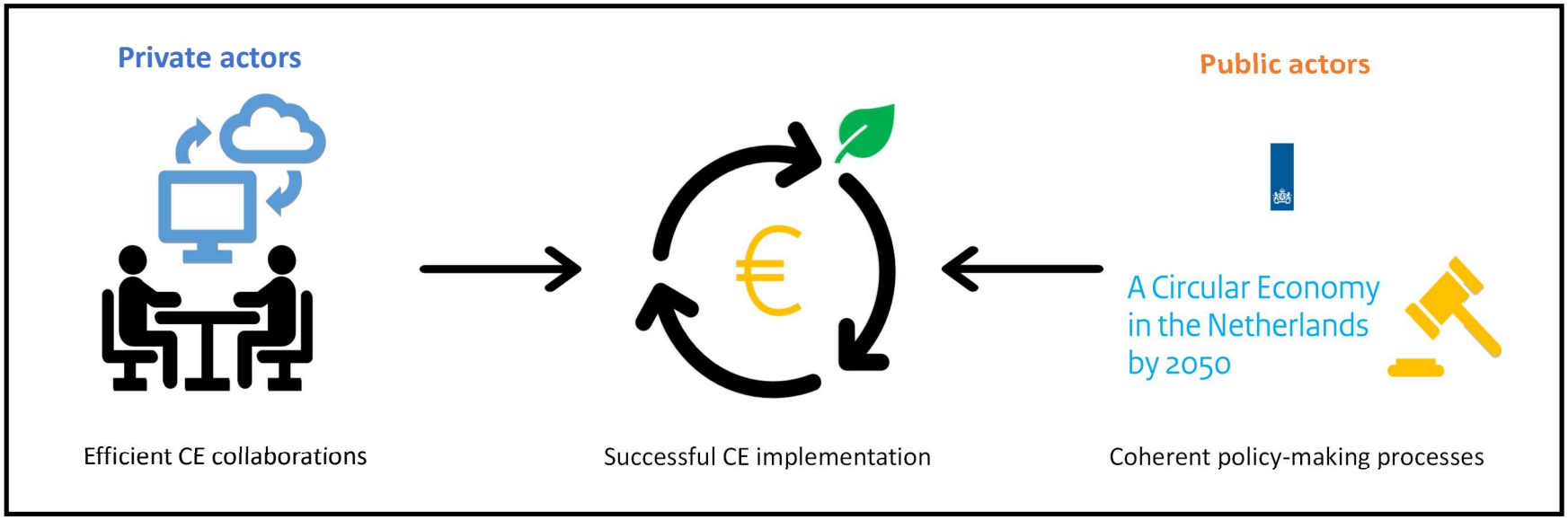
Photo source: *Teller Report (2019)*

Multi-dimensional CE Challenges

CIP shapes a resilient built environment by enhancing data-driven collaborations among public and private stakeholders (Yu et al., 2022a)

- Lack of **business coordination** – closed-loop supply chain
- Lack of **policy support** – integrated policy-making cycle
- **Poor information management → poor decision support**

We develop a *Circularity Information Platform* ***(CIP)*** to support:



(1) Maintain diversity & redundancy; (2) Manage connectivity

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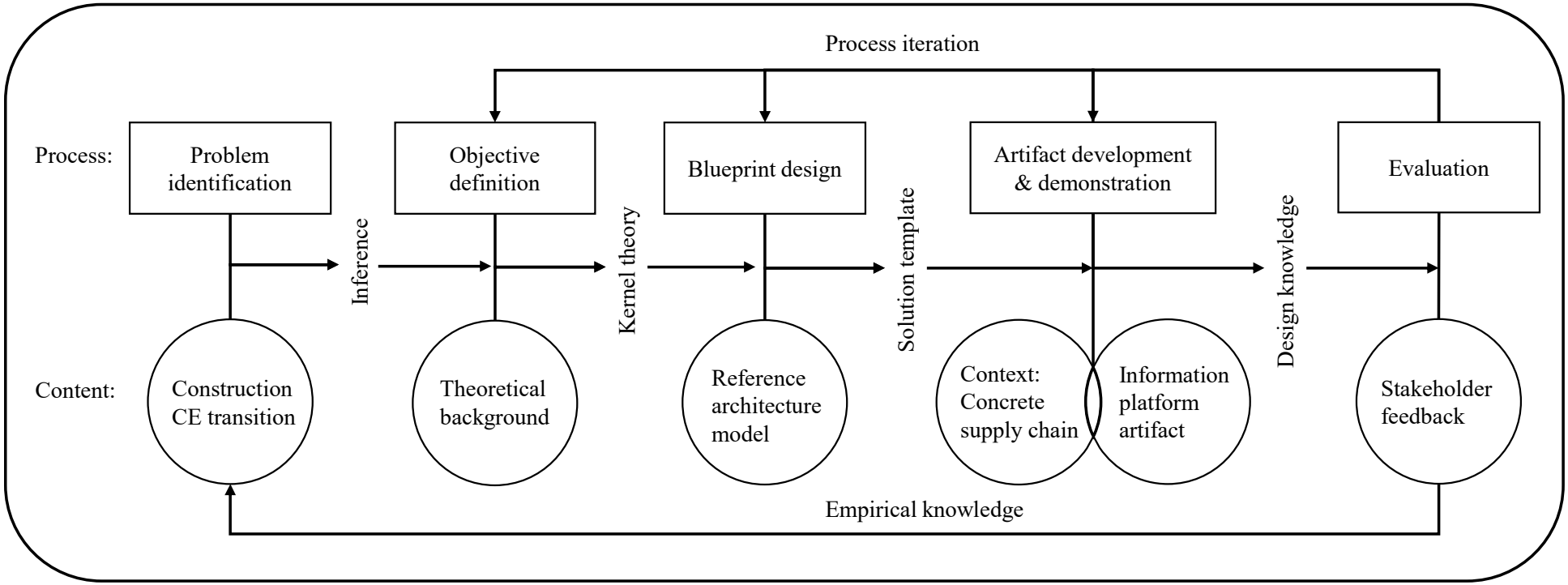
Design Science in Information Systems

The study of the effective design, delivery, and usage of information systems in organisations (Keen, 1980)



Source: *Adapted from Peffers et al. (2007)*

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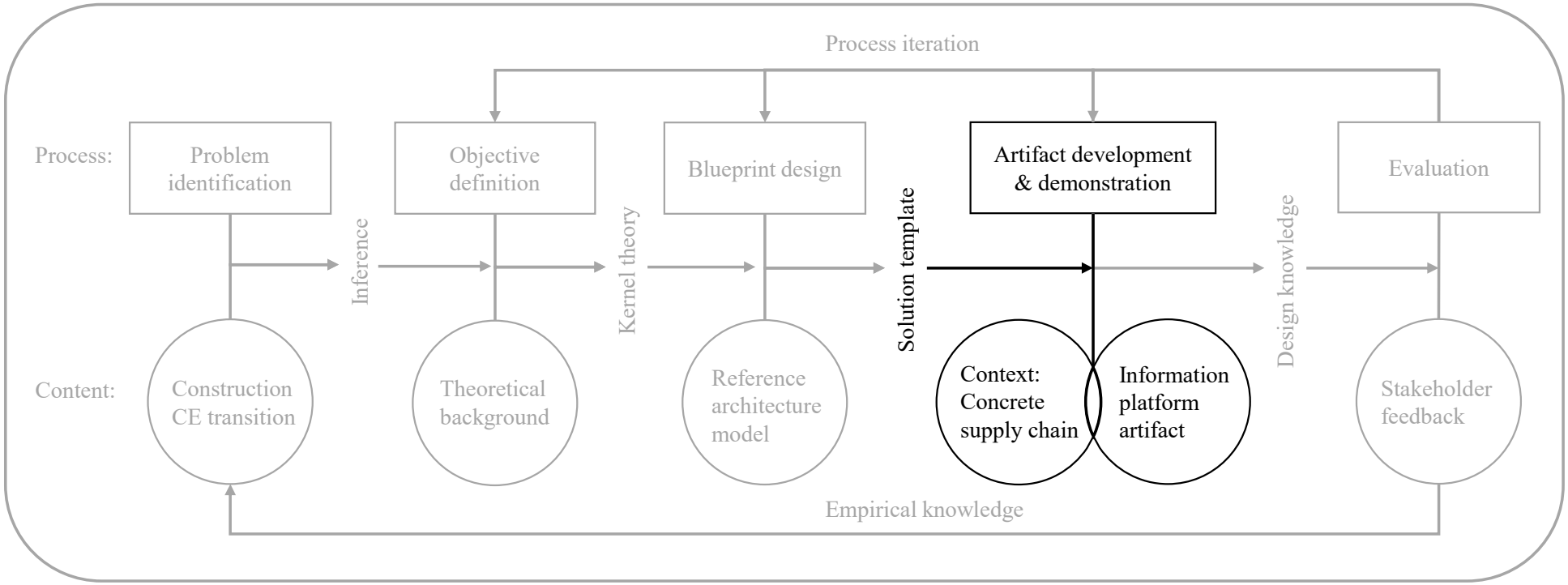

Source: *Adapted from Peffers et al. (2007)*

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BASIC SETUPS

FIND YOUR ROLES AND TASKS

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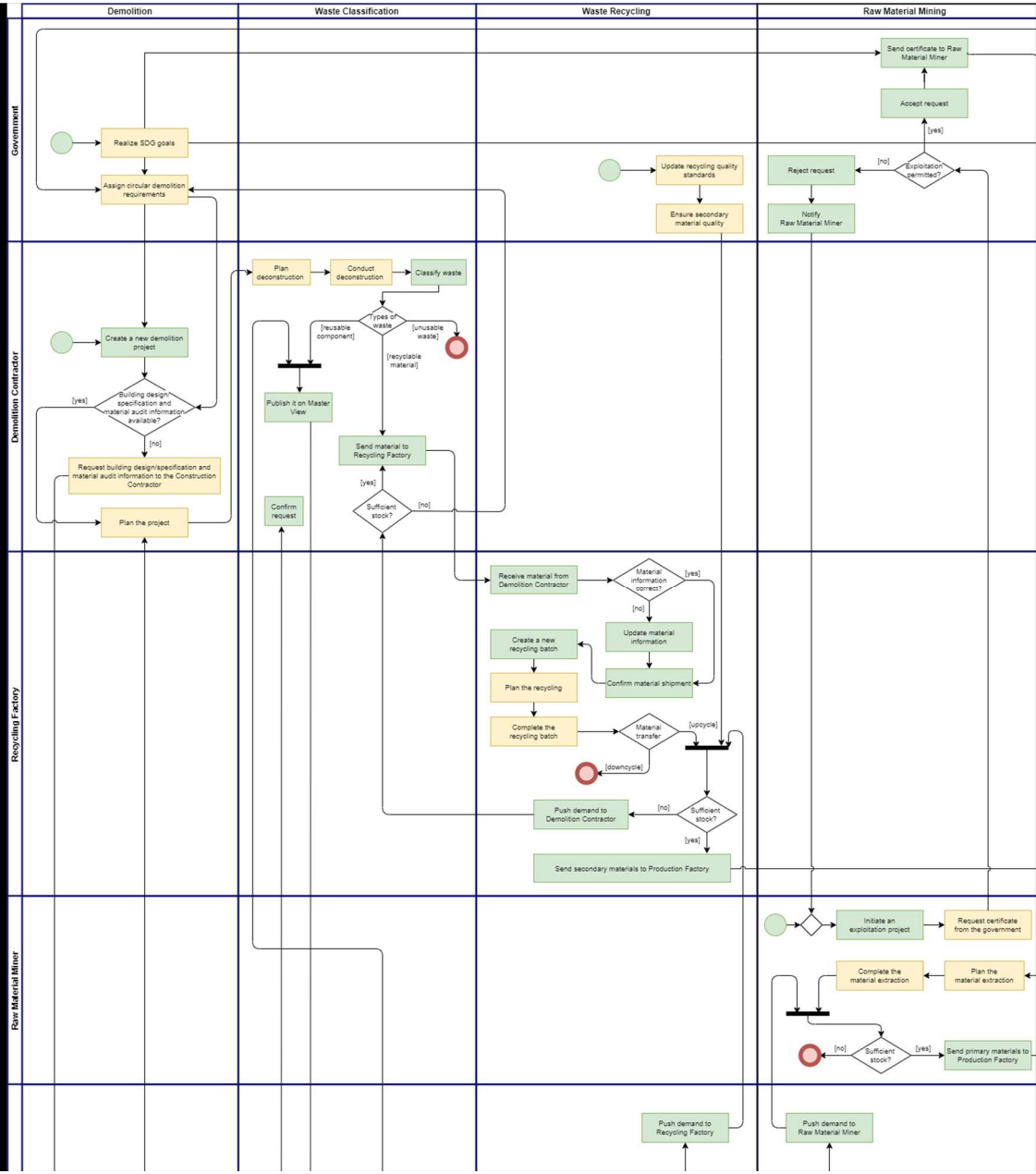
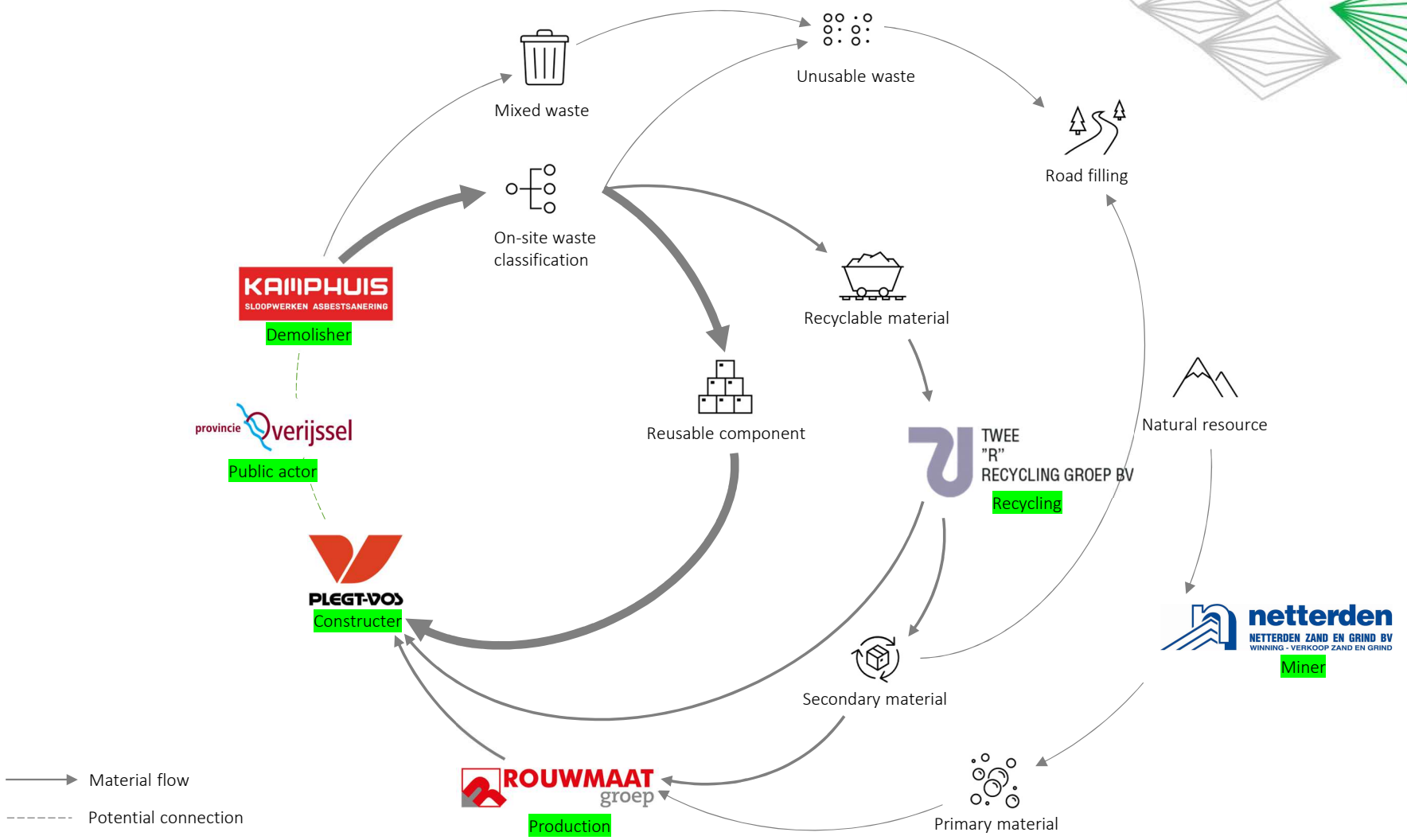


CONCRETE SUPPLY CHAIN IN TWENTE REGION



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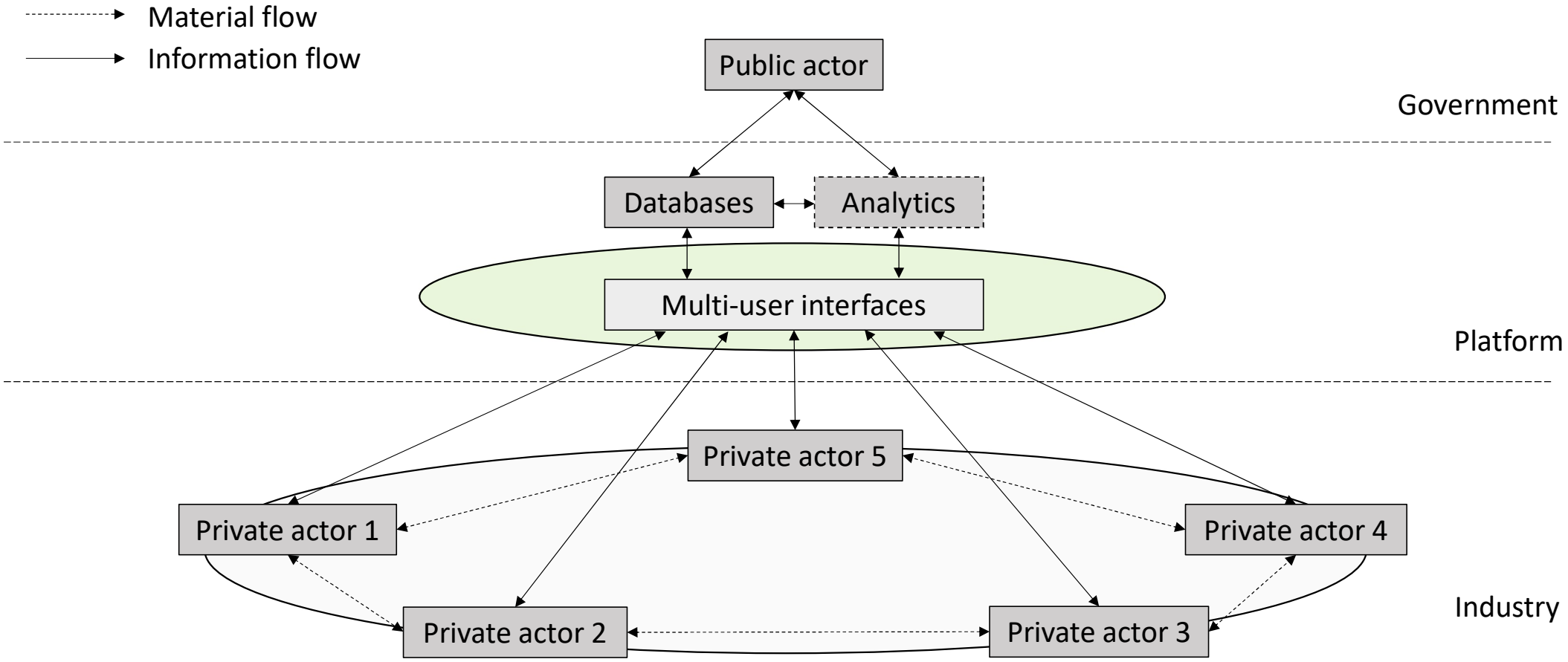
Digital Infrastructure: Policy-Business Ecosystem



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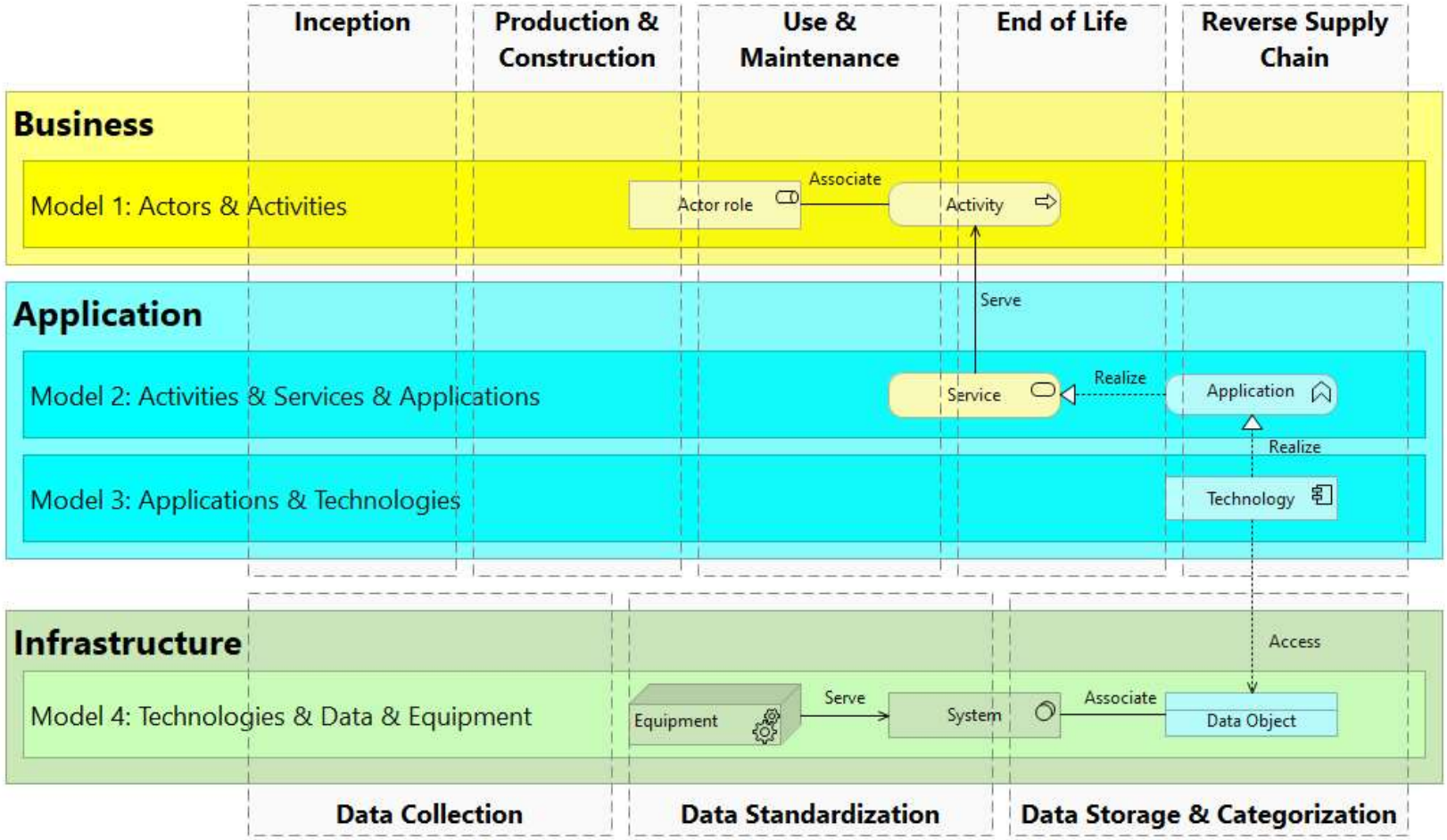
Reference Architecture Framework



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OVERVIEW OF USER ROLES & TASKS IN THE PLATFORM

REMEMBER YOUR ROLE AND ACCOUNT DETAILS

Demolition Contractor

Construction Contractor

Raw Material Miner

Production Factory

Recycling Factory

Government

Master View

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STORYLINE A

ONE-TO-ONE DIRECT REUSE SCENARIO

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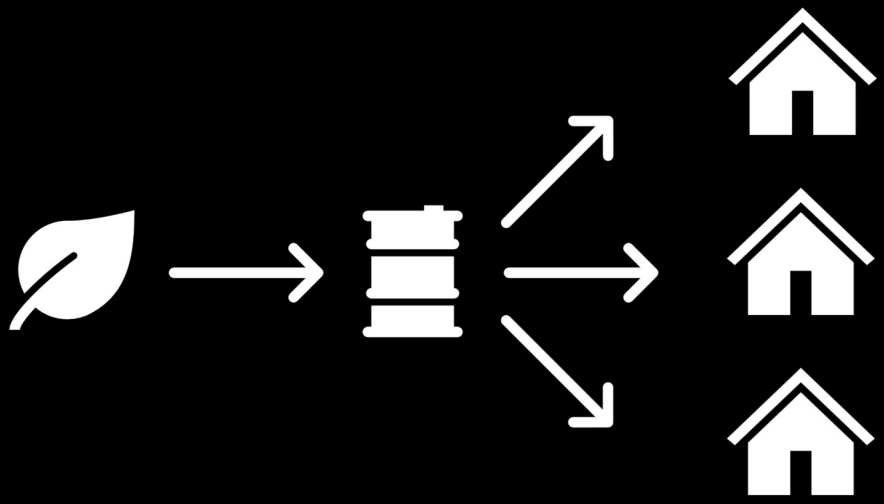
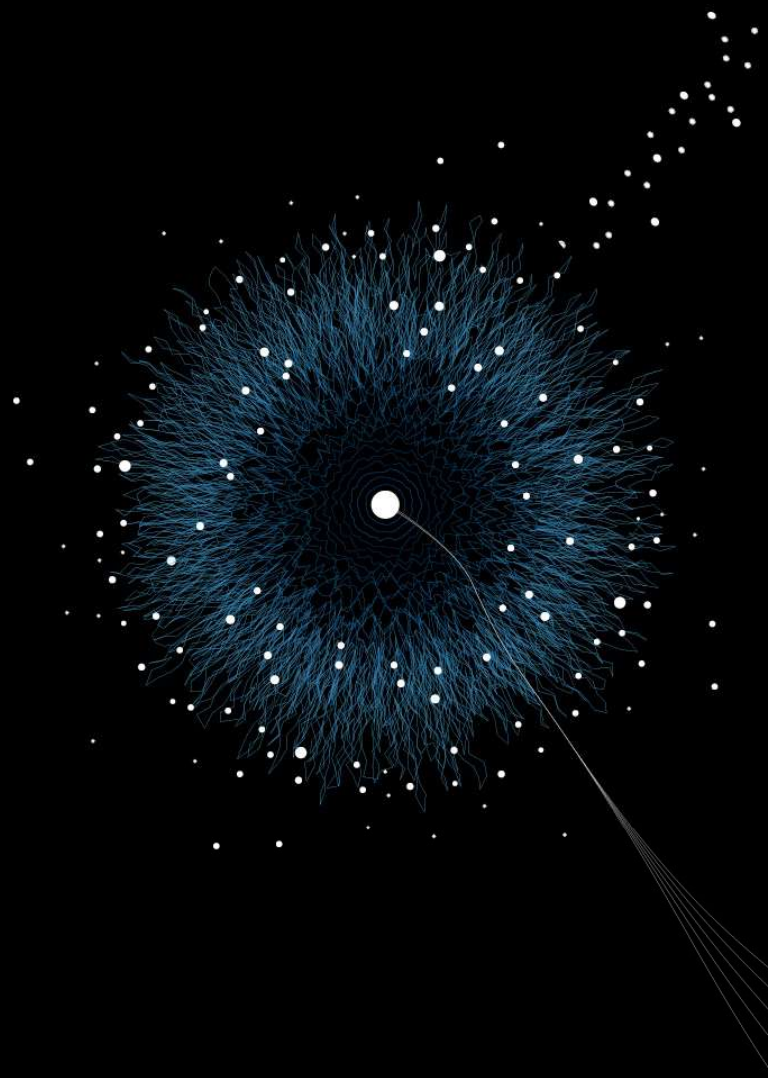
STORYLINE B

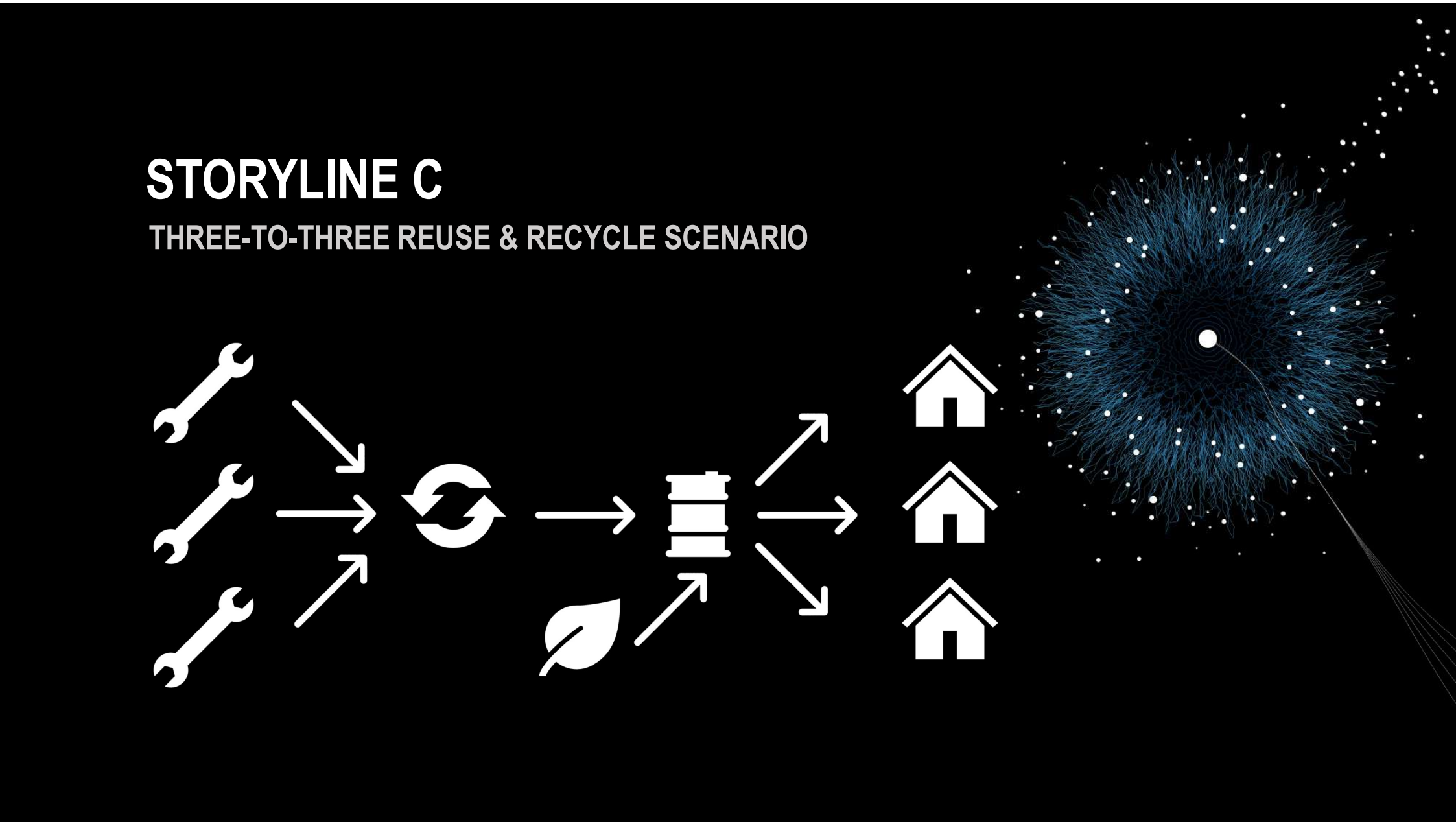
ONE-TO-THREE LINEAR ECONOMY SCENARIO





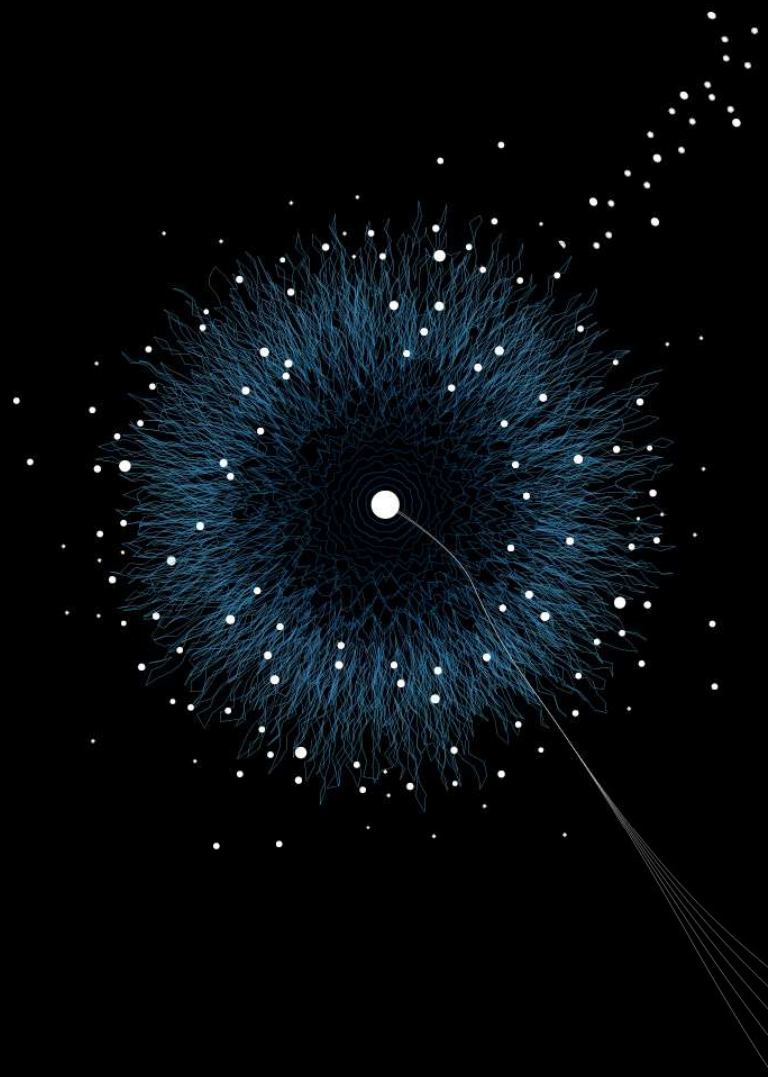
STORYLINE C

THREE-TO-THREE REUSE & RECYCLE SCENARIO



DEMONSTRATION

MENDIX CLOUD



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3. Evaluation Form

		Score: Strongly disagree ← Disagree ← Neutral → Agree→ Strongly agree				
No.	**Statements**	**1**	**2**	**3**	**4**	**5**
1	It is clear to me what the artifact is developed for.					
2	It is clear to me what the structure of the platform is.					
3	I think the artifact is useful to show the design of the platform.					
4	**Function A:** Support on-site waste information collection	/	/	/	/	/
4.1	I think "Function A" can be helpful to CE.					
4.2	I understand how "Function A" fits in the platform.					
5	**Function B:** Support dynamic waste matchmaking	/	/	/	/	/
5.1	I think "Function B" can be helpful to CE.					
5.2	I understand how "Function B" fits in the platform.					
6	**Function C:** Ensure traceable & reliable information-sharing	/	/	/	/	/
6.1	I think "Function C" can be helpful to CE.					
6.2	I understand how "Function C" fits in the platform.					
7	**Function D:** Communicate construction design across the life cycle	/	/	/	/	/
7.1	I think "Function D" can be helpful to CE.					
7.2	I understand how "Function D" fits in the platform.					
8	**Function E:** Create feedback channels for policy evaluation	/	/	/	/	/
8.1	I think "Function E" can be helpful to CE.					
8.2	I understand how "Function E" fits in the platform.					
9	**Function F:** Enable national resource monitoring & planning	/	/	/	/	/
9.1	I think "Function F" can be helpful to CE.					
9.2	I understand how "Function F" fits in the platform.					
10	After using this artifact, I understand better the role that my organization plays in the circular concrete supply chain.					
11	After using this artifact, I understand better the roles that other actors play in the circular concrete supply chain.					
12	The artifact introduces an efficient approach to CE transition in the construction industry.					
13	The artifact provides a meaningful roadmap for future development.					
14	Overall, I am satisfied with the artifact.					

Comments
What do you like?
Do you have any suggestions for improvement?
Other comments

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4. Evaluation Workshop Program

Location: University of Twente	**Duration:** 2 hours
Purpose: Evaluate the artifact performance when users operate the CIP simultaneously	
People: Invited potential users & research team members	
Preparation: Participants have received the artifact demo and instructions	
Objective: Complete expected Circular Economy tasks by using the artifact under three scenarios	

Timeline	Activities
10:00 – 10:10	**Welcome:** Recap the research background and welcome participants
10:10 – 10:20	**Introduction:** Introduce the basic setup of the CIP artifact
10:20 – 10:30	**Get ready:** Specify the functionalities and the activity requirement of each user
10:30 – 10:40	**Scenario 1:** One-to-one reuse scenario
10:40 – 10:45	**Coffee break**
10:45 – 11:00	**Scenario 2:** One-to-three conventional linear economy scenario
11:00 – 11:15	**Scenario 3:** Three-to-three reuse & recycle scenario
11:15 – 11:45	**Feedback:** Participants provide qualitative feedback based on hands-on experiences
11:45 – 12:00	**Ending:** Summarize the workshop and fill in the evaluation form

Basic functionality tests:

1. Log in to the system with expected user roles;
2. Access and operate the expected user interfaces;
3. Demonstrate the customized work processes of each user role;
4. Delivery information to the master view publicly;
5. Delivery information to the target user privately;
6. Review material/waste shipments and confirm information is sent to target users automatically;
7. Review and confirm the updates of the inventory data view with new shipment information;
8. Demonstrate the opportunities for incorporating the potential functions.

Scenario explanations

1. One demolition project and one construction project exchange reusable components at the same location;
2. The raw material miner delivers primary materials to the production factory as the only input to produce concrete products. Then, the production factory delivers concrete products to different construction sites;
3. Built upon the previous scenario, the production factory receives inputs from the raw material miner and the recycling factory. The secondary materials provided by the recycling factory are based on the demolition waste collected from different demolition projects.

EVALUATION RESULTS

Comprehensive development roadmap for CIP

No.	Statements	User 1	User 2	User 3	User 4	User 5	User 6	Score	Normalized Score
1	It is clear to me what the artifact is developed for.	5	4	5	5	5	4	4.7	1.5
2	It is clear to me what the structure of the platform is.	3	4	4	4	4	4	3.8	-1.1
3	I think the artifact is useful to show the design of the platform.	4	4	4	5	5	4	4.3	0.5
4.1	I think "Function A" can be helpful to CE.	5	5	4	5	3	5	4.5	1.0
4.2	I understand how "Function A" can fit in the platform.	4	4	5	4	3	4	4.0	-0.6
5.1	I think "Function B" can be helpful to CE.	3	4	3	5	5	5	4.2	-0.1
5.2	I understand how "Function B" can fit in the platform.	5	4	5	4	5	5	4.7	1.5
6.1	I think "Function C" can be helpful to CE.	5	5	4	4	5	5	4.7	1.5
6.2	I understand how "Function C" can fit in the platform.	5	4	5	3	5	4	4.3	0.5
7.1	I think "Function D" can be helpful to CE.	5	4	4	5	5	4	4.5	1.0
7.2	I understand how "Function D" can fit in the platform.	5	4	5	5	4	4	4.5	1.0
8.1	I think "Function E" can be helpful to CE.	3	5	5	3	4	4	4.0	-0.6
8.2	I understand how "Function E" can fit in the platform.	4	4	5	4	3	4	4.0	-0.6
9.1	I think "Function F" can be helpful to CE.	4	4	2	5	4	4	3.8	-1.1
9.2	I understand how "Function F" can fit in the platform.	4	3	5	3	4	4	3.8	-1.1
10	The artifact helps me to understand better that my organization play in the circular concrete supply chain.	5	4	2	3	5	3	3.7	-1.5
11	The artifact helps me to understand better the roles that other organizations play in the circular concrete supply chain.	4	4	4	4	4	3	3.8	-1.1
12	The artifact introduces an efficient approach to CE transition in the construction industry.	3	5	2	5	5	4	4.0	-0.6
13	The artifact provides a meaningful roadmap for the future development.	4	5	3	5	5	4	4.3	0.5
14	Overall, I am satisfied with the artifact.	4	4	4	5	4	4	4.2	0.1

Score: Strongly disagree (1) < Disagree (2) < Neutral (3) > Agree (4) > Strongly agree (5) **Average:** 4.2 **Std.Dev.** 0.3

- **Simplicity:** the prototype provides understandable descriptions of CIP's structure and functions;
- **Utility:** the prototype demonstrates useful and relevant functions;
- **Comprehensiveness:** the prototype includes mostly important elements and aspects of CIP.

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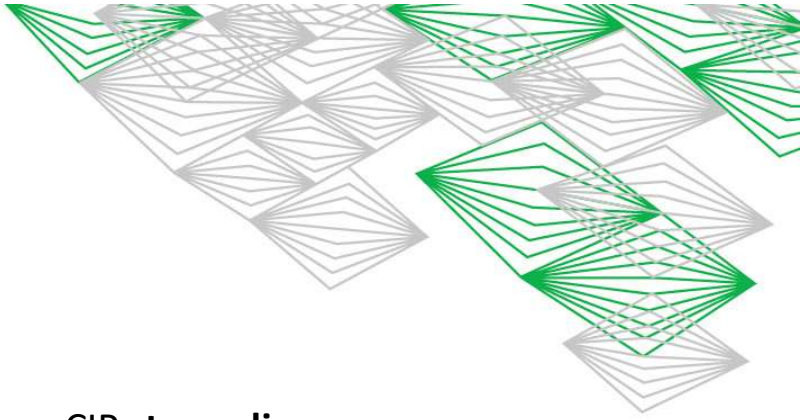
DESIGN THE DESIGN

CIP for a digitalised and circular future



Circularity Information Platform fosters the co-creation of added CE value:

- By linking waste generation and material consumption in a closed-loop structure, CIP **streamlines complex information flows** among various actors;
- CIP introduces a collaborative **socio-technical model** where stakeholders seize timely CE opportunities;
- The platform contributes to resilience by enriching the candidate list of CE collaborations;
- Towards an open-source building information ecosystem;
- The urban resilience is enhanced because of less dependence on external resource supply;
- The results are beyond merely an end-product but rather a **design manual** for practitioners and policymakers shaping the built environment towards a digitalised and circular future.

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THANK YOU

CIRCULARITY INFORMATION PLATFORM

Smart Circular Construction Ecosystems

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