

# Circular Industrialised Construction

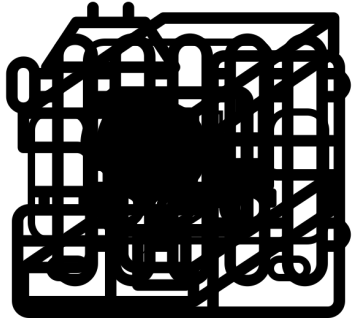
Strategies for the operations  
and end-of-life phases



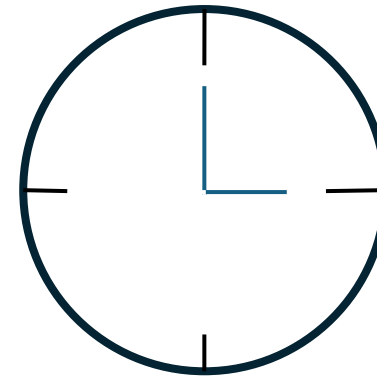
# Contents

- Context
- Methodology
- Initial Results
- Circular Industrialised Construction Framework
- Conclusion

# Traditional Construction



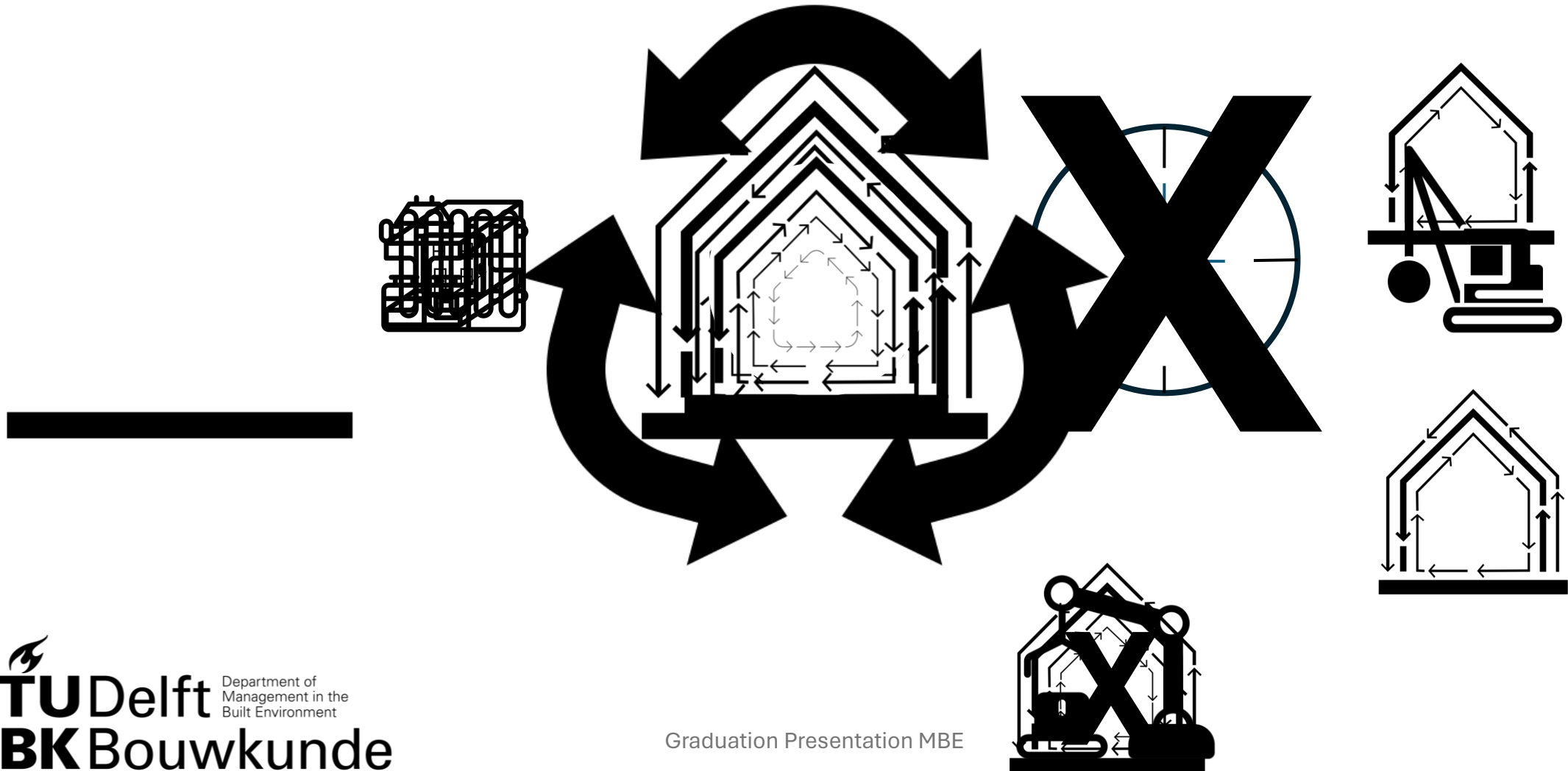
Simple Plan



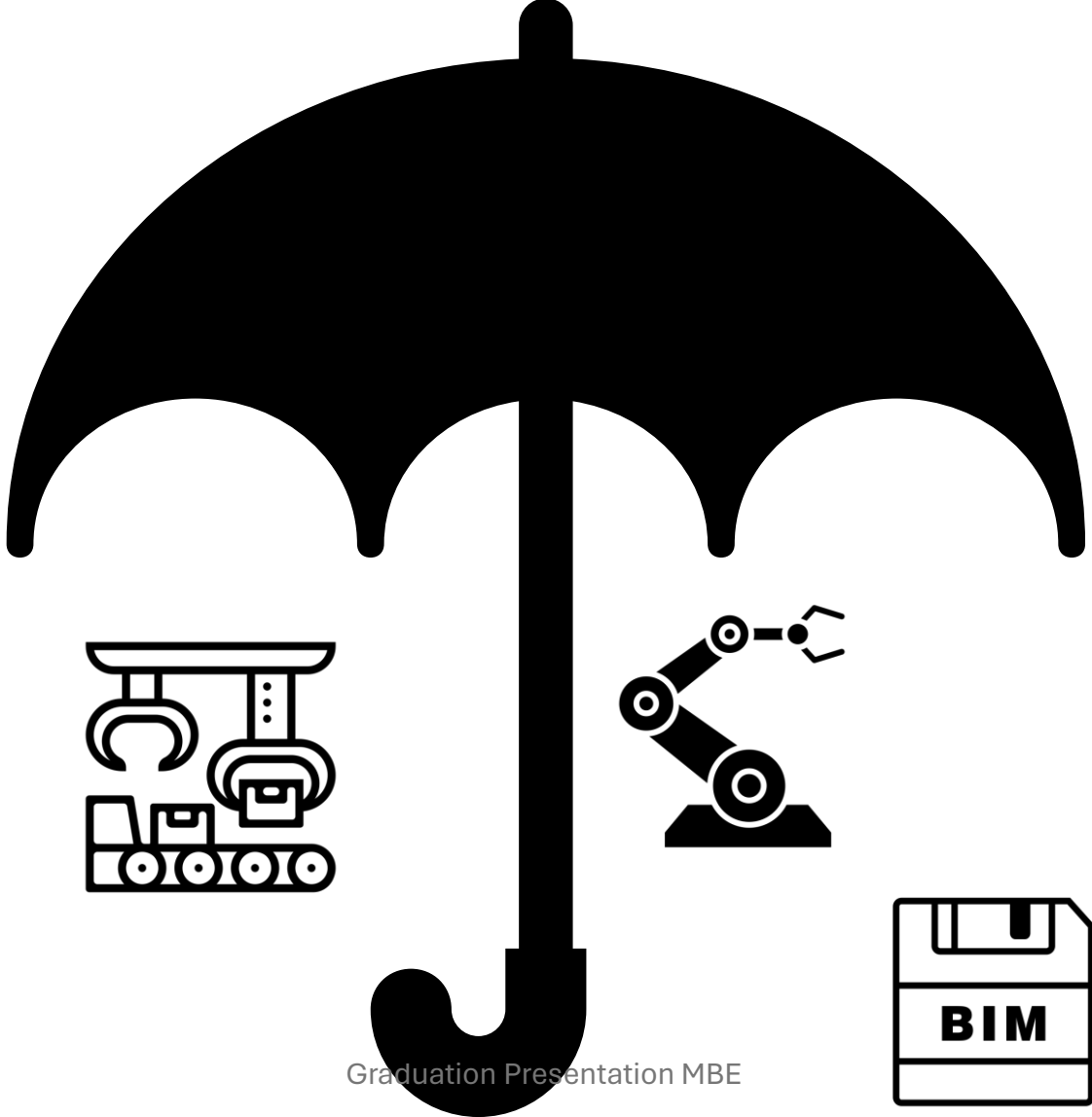
**5% to 25% ends up as landfill!**



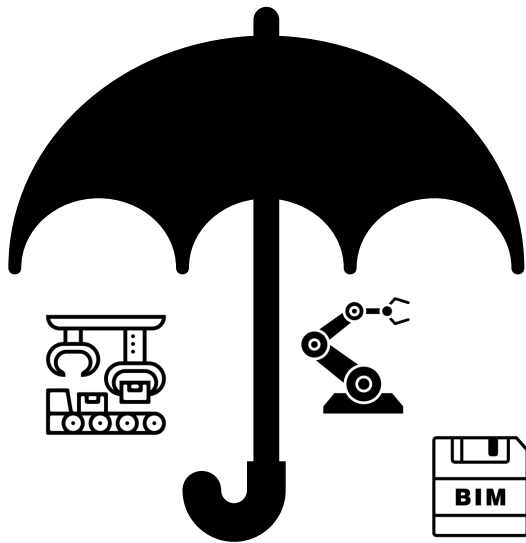
# Circular building



# Industrialised Construction

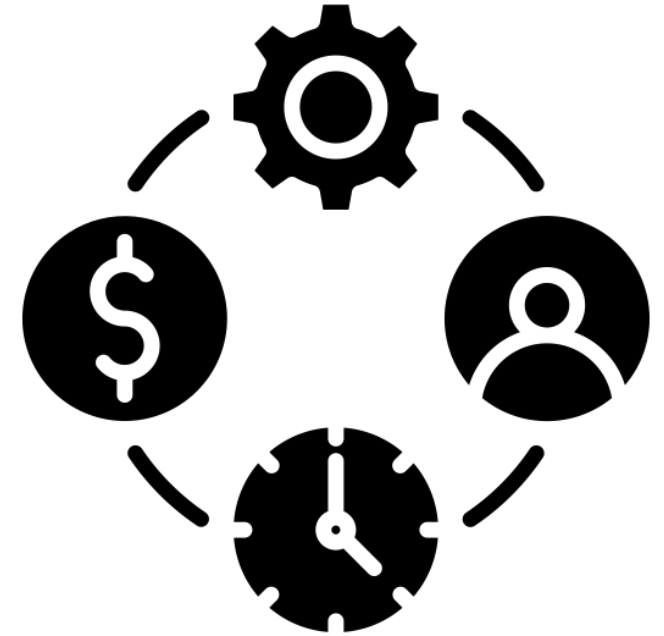


# Industrialised Construction

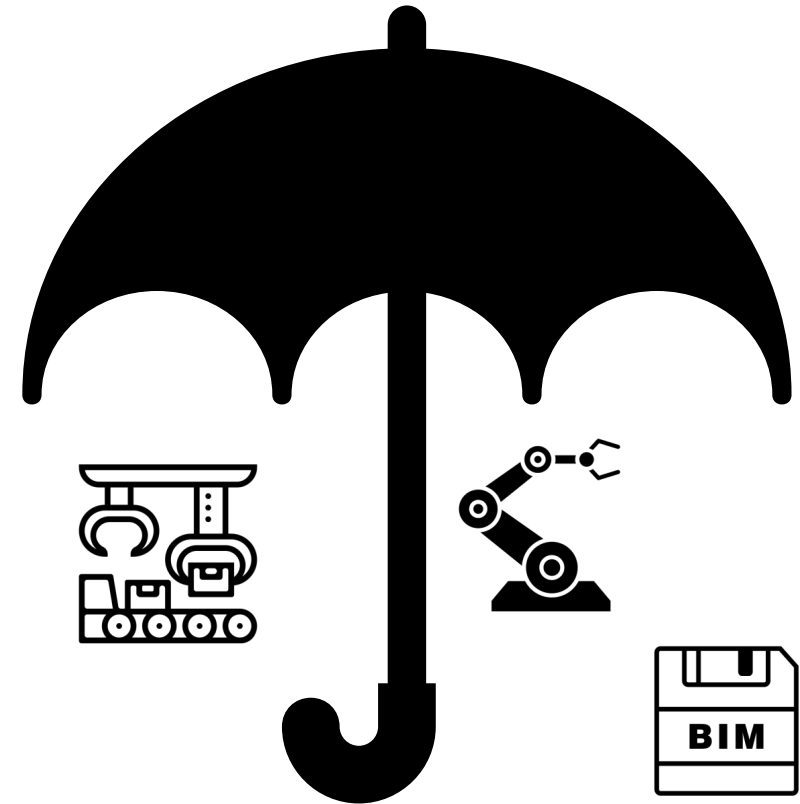
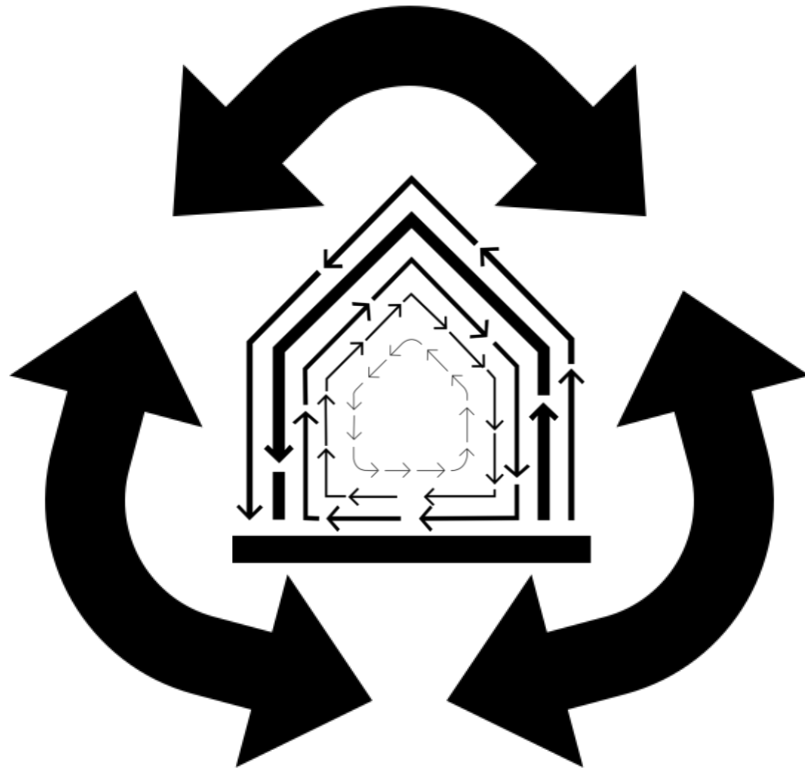


**Improving resource efficiencies**

**Such as Materials, Labour,  
Time, Money, Safety, etc.**



# Circular Industrialised Construction



# Circular Industrialised Construction

What **STRATEGIES** are needed to make sure that **CIRCULAR BUILDINGS** that are manufactured using **INDUSTRIALISED CONSTRUCTION METHODS** are **OPERATED & MAINTAINED** in such a manner to ensure that these buildings remain circular.





# Research Questions

**How can strategies for circular buildings using industrialised construction methods account for the operational and End-of-Life phases?**

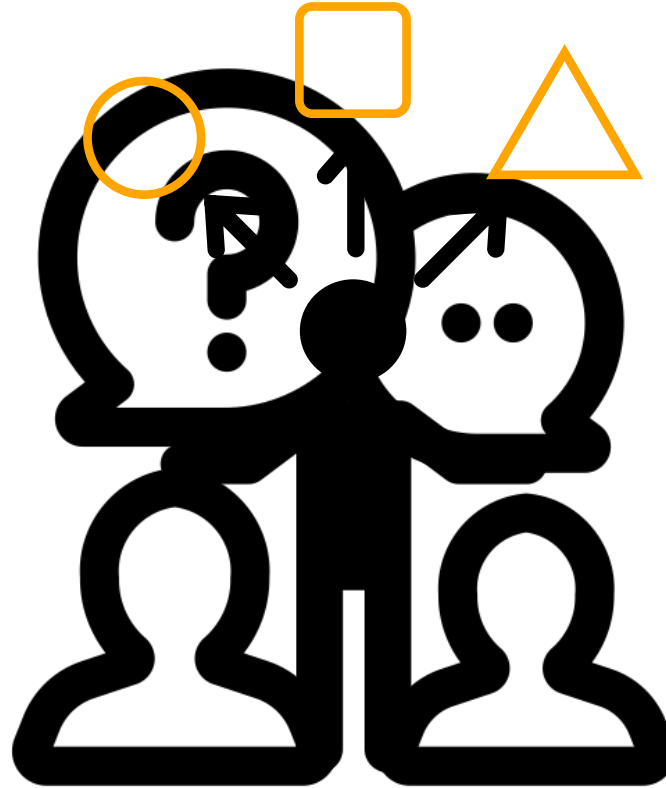
- 1. What strategies for Circular Building using Industrialised Construction methods can be identified?*
- 2. How are the operation and End-of-Life phases taken in consideration during the strategy-making process?*
- 3. What are the pitfalls in the strategy-making process for the operation and End-of-Life phase of circular buildings using industrialised construction methods?*

# Methodology

How do you make sure your building is/remains circular after it switches owner?

How do you plan to reuse materials used in your buildings?

How does the application of IC methods impact the stakeholder/actor management once the building is completed?

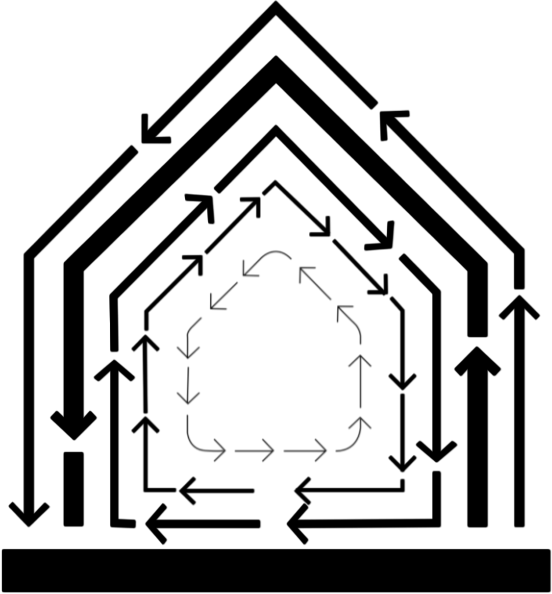
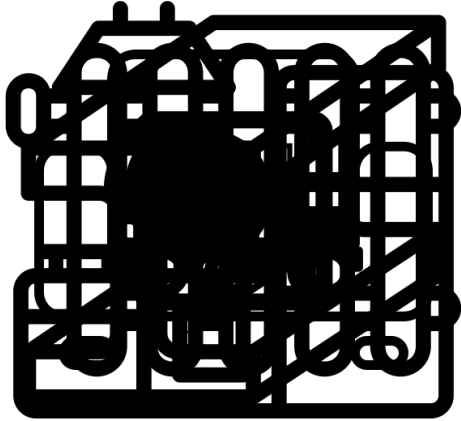


What are your strategies for reducing maintenance and operation costs?

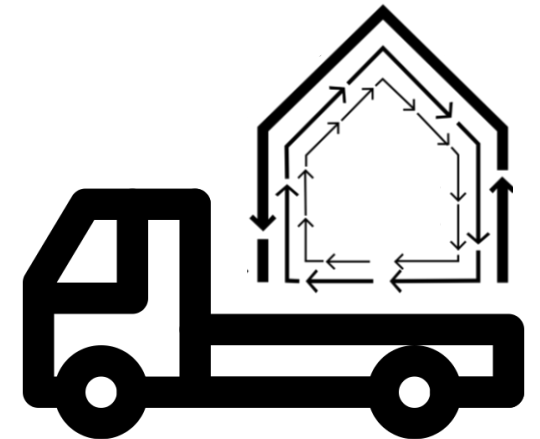
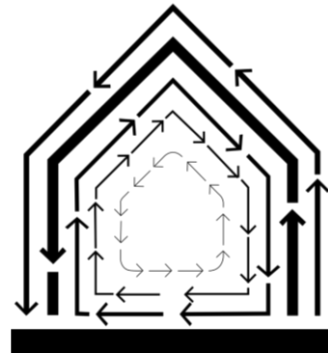
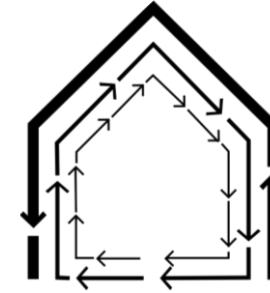
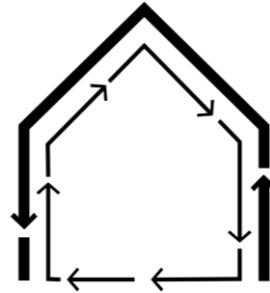
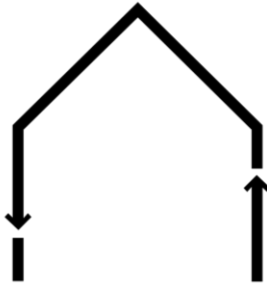
What are important lessons you/X(company) has learned in the application of Industrialised Construction Methods?

What have you done to apply the lessons learned?

# Case Companies



# Case Companies



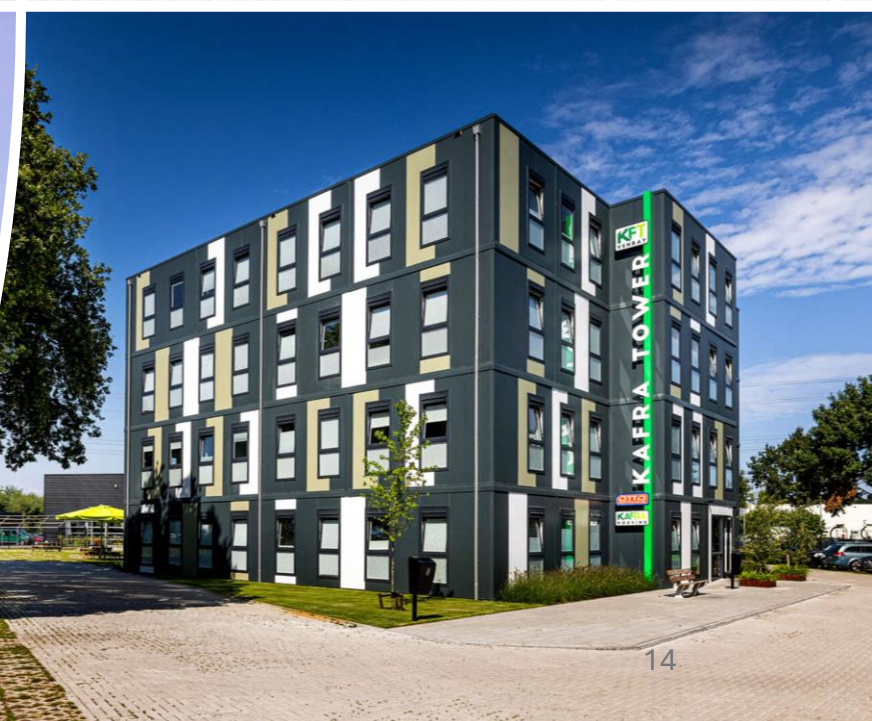
# CitizenM

- CitizenM is a global hotel chain that operates as a fully integrated real estate developer
- Project sizes ranging from 3,500 to 10,000 square meters, accommodating 100 to 350 hotel rooms.
- Off-site production organised through contractors



# Daiwa Modular Europe

- Daiwa House Formerly known as Jan Snel, a container house builder in the Netherlands, and the Daiwa Investor Group from Japan.
- Project sizes ranging from 150 to 300 dwellings.
- Has several factories and can be classified as a general contractor

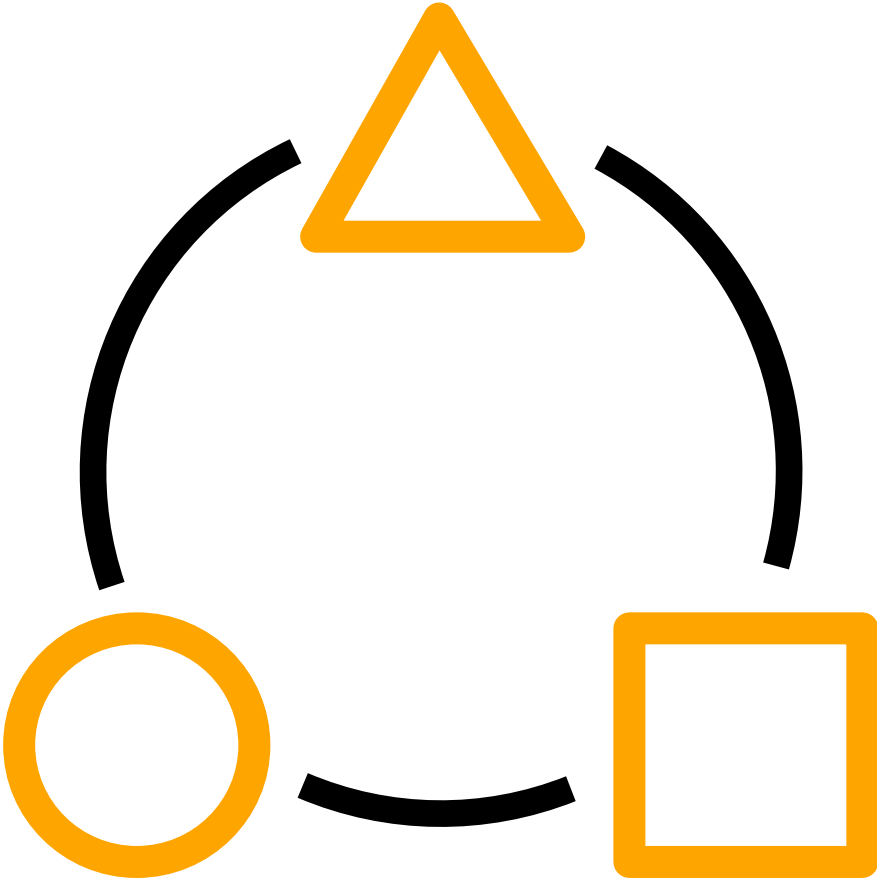


# Home.Earth

- Home.Earth is a sustainable and inclusive urban community developer
- Project sizes ranging from 35 to 200 dwellings
- Off-site production organised through contractors

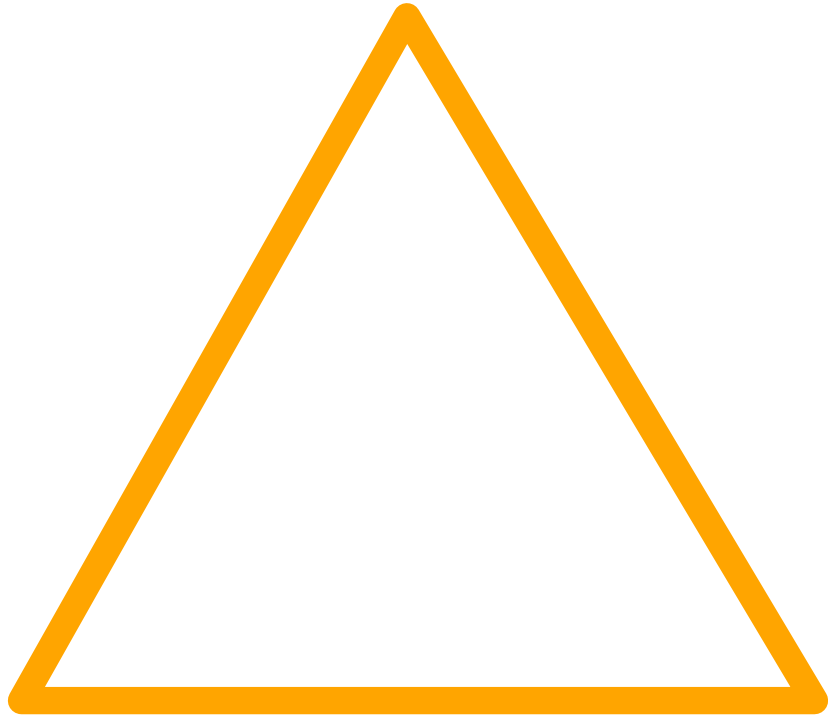


# Case Companies





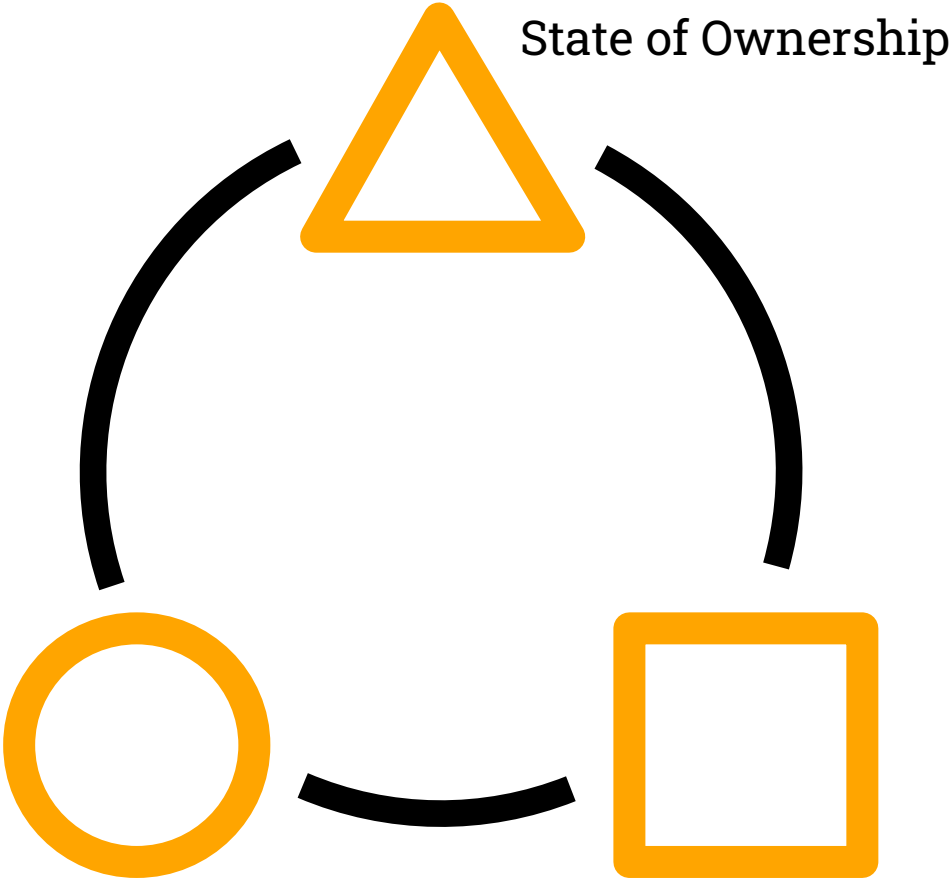
# Case Companies



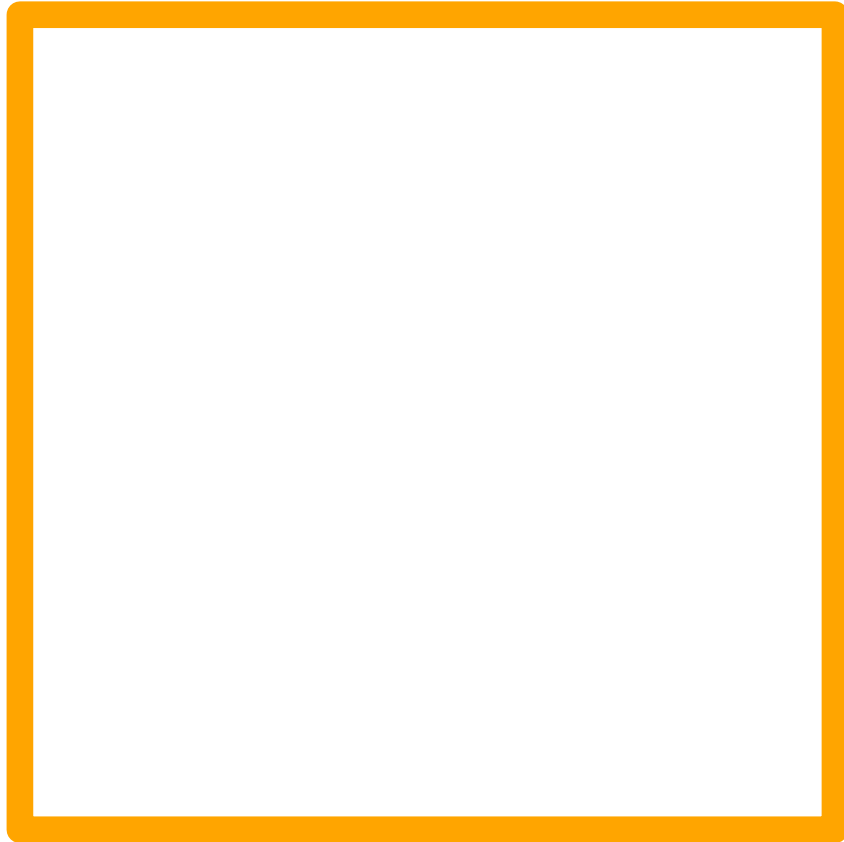
State of ownership during the lifetime of the building

- CitizenM & Home.Earth  
Outsource Manufacturing.  
But are designer and operator after completion
- Daiwa Designs and  
Manufactures based on the needs of clients

# Case Companies



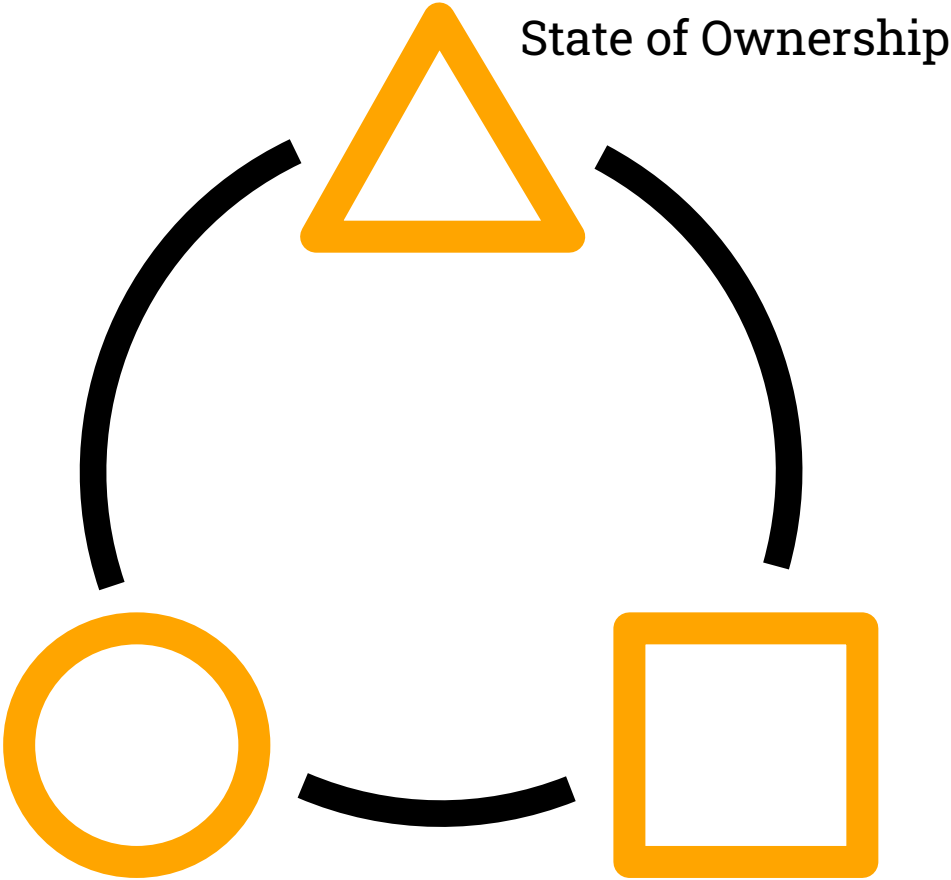
# Case Companies



## Functionality

- Home.Earth and Daiwa construct housing solutions
- CitizenM develops hospitality buildings
- Results in different use of developed real-estate

# Case Companies



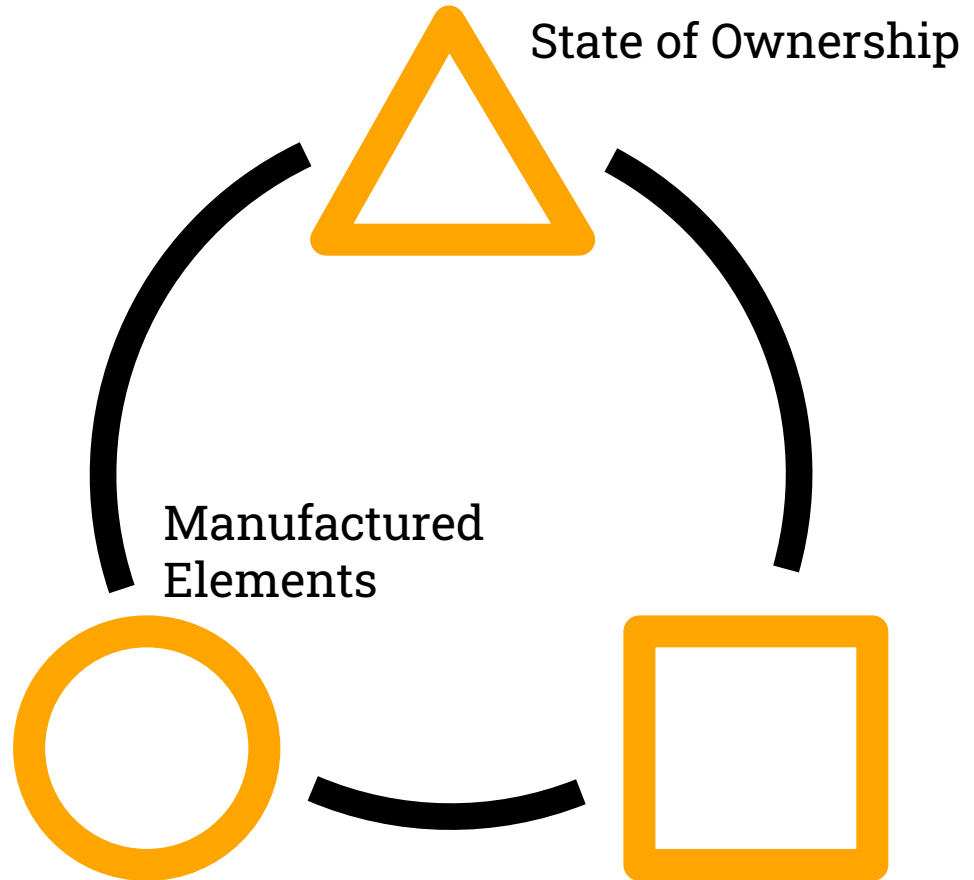
# Case Companies

## Manufactured Elements

- CitizenM and Daiwa Manufacture Prefinished Prefabricated Volumetric Components (PPVC).
- Home.Earth manufactures a combination of PPVC and Planar elements that are configured based on site specifics.

# Case Companies

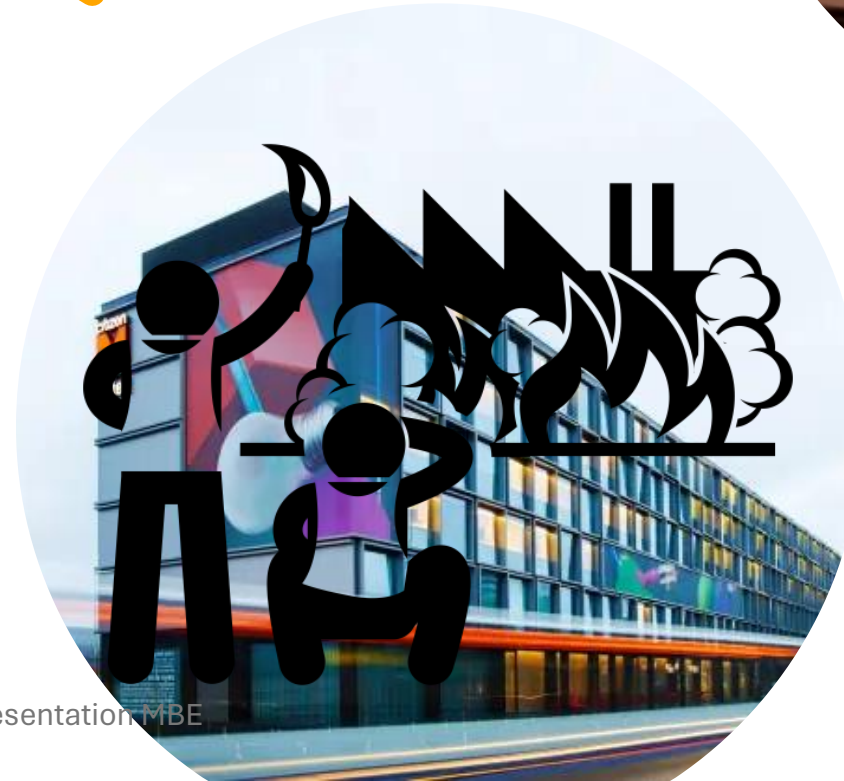
# Initial Results



- Within Case Highlights
- Cross-Case Analysis

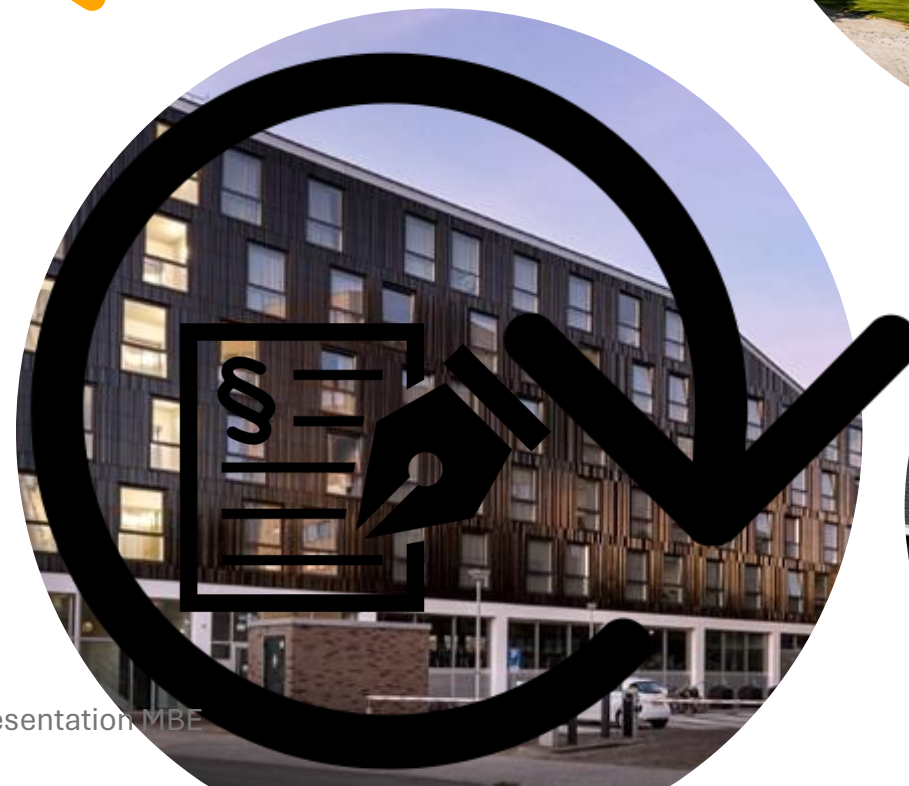
# CitizenM

- "We've recently introduced shower-pods made of PET-G plastic, once they need to be replaced, they can be easily circulated into the supply chain"
- "If suppliers offer the option of re-usage, refurbishments and replacement of elements and components than we enforce this through our contracts with them"
- "If a decision I made makes the job of the person across my desk difficult than they are going to tell me I made a mistake"
- "We were initially surprised by the ability of our guests to completely vandalise a hotel room, [...] we would have to replace a floor on the entire storey, now we just click out a panel and replace it with a new panel. The old panel can be sent back to the supplier and they re-purpose it" (CitizenM)



# Daiwa Modular Europe

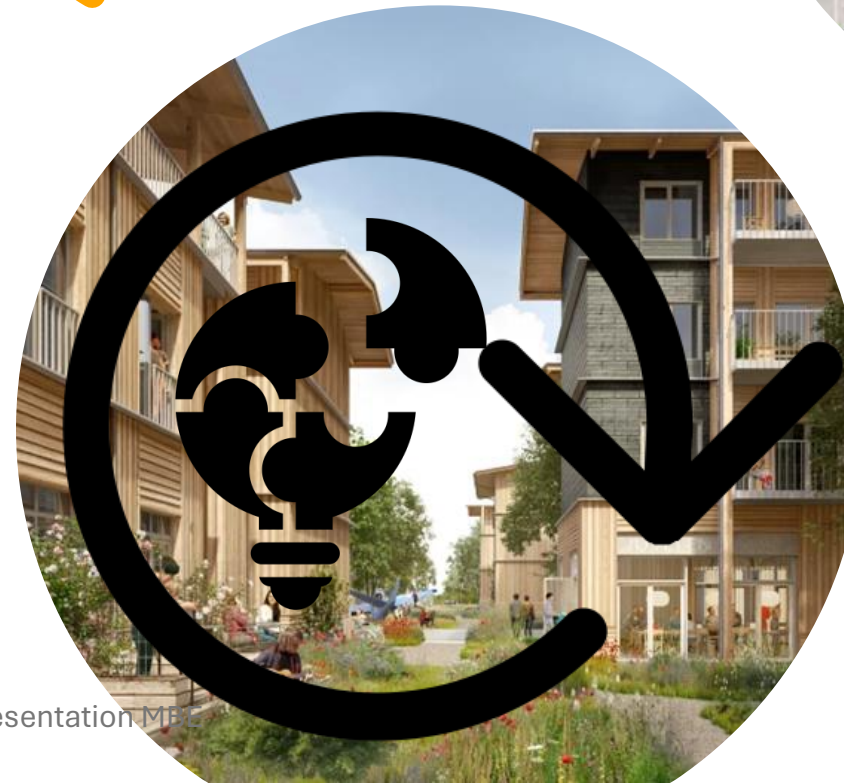
- "The modules have such a degree of *losmaakbaarheid* (*releasability*) (level of reversibility) that nothing has to be demolished [...] the steel, wooden frames and windows can all be disassembled"
- "We got a call to check out a certain building if it was built by us [...] it wasn't. But another party [...] bought this building because it could easily be adjusted due to the level of reversibility"
- "If we know before hand if a building needs to be (re)moved in 15 to 20 years we usually include a deposit arrangement in the contract"
- "it is really frustrating that every Dutch municipality has to evaluate our designs again. Sometimes we have just completed a unit [...] we must wait several months before we again have approval from another municipality, that is frustrating when you try to solve the housing crisis"





# Home.Earth

- “[...] we place more emphasis on quality and durability in our construction investments. The operational phase plays a crucial role. We have an impact system that [...] informs and shapes our designs”
- “We have realised that it is valuable to be able to execute repairs to installations when tenants are not home. Some of our industry partners have made us aware of this”
- “We have selected manufacturers and developed partnerships with them, in order to improve our products”
- “What we need to think of is how are we going to reuse those elements that we designed in version 1 that can be implemented again in version 5”



# Cross-Case Analysis

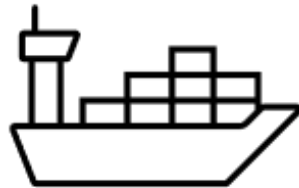
**Design**



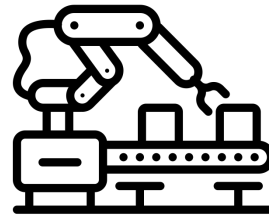
**Manufacture**



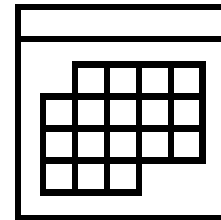
**Transport**



**Assembly**



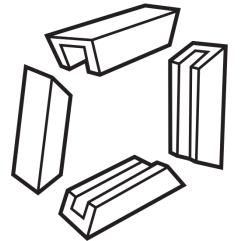
**Operation**



**Maintenance**

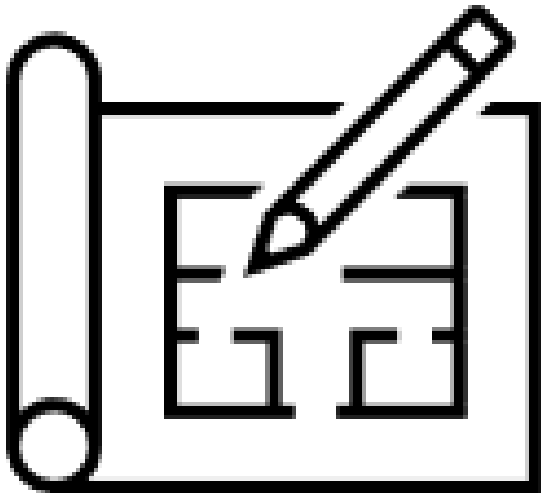


**End-of-Life**



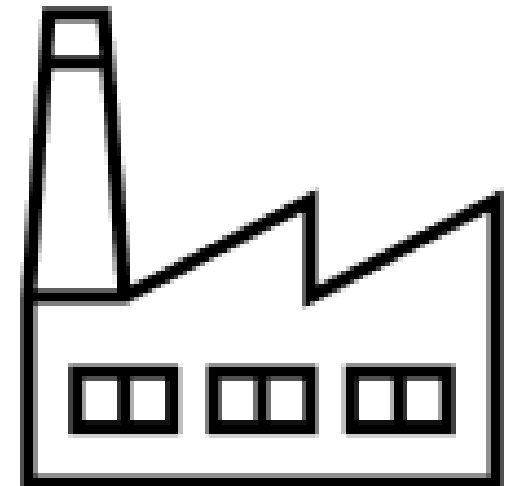
# Cross-Case Analysis

## Design



- **EXTENSIVE COLLABORATION** regardless of inhouse manufacturing or external manufacturing
- The **SPEED** of modular construction important **DECIDING FACTOR**

## Manufacture



# Cross-Case Analysis

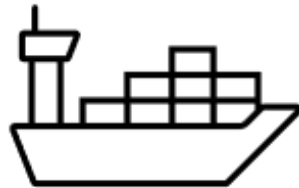
**Design**



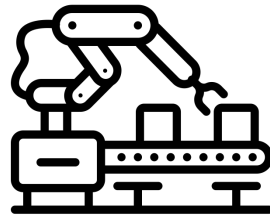
**Manufacture**



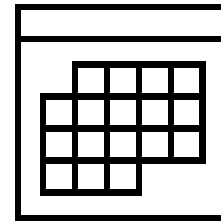
**Transport**



**Assembly**



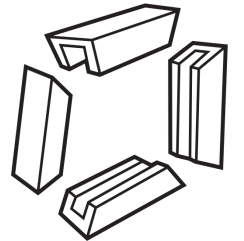
**Operation**



**Maintenance**

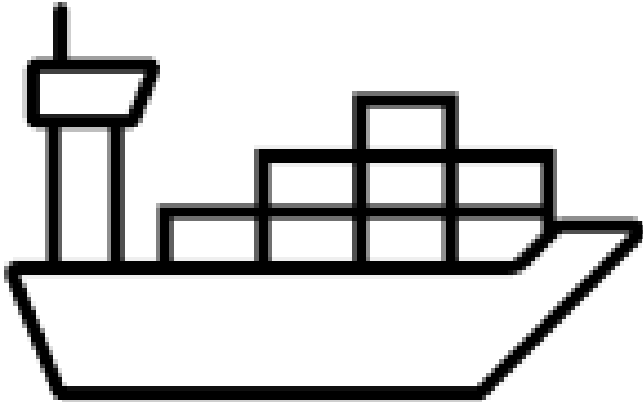


**End-of-Life**



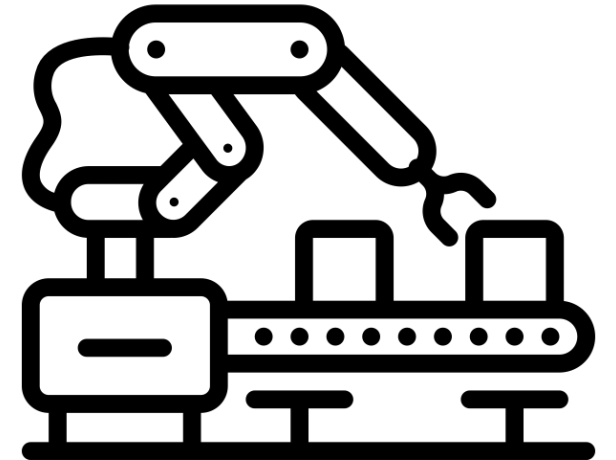
# Cross-Case Analysis

## Transport



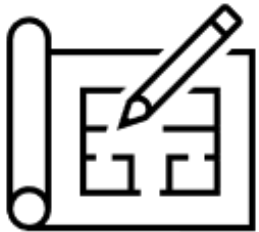
- The **SELECTION** of knowledgeable partners transport partners to prevent **STRUCTURAL DEFORMATION**

## Assembly



# Cross-Case Analysis

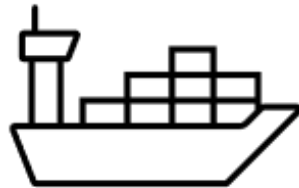
**Design**



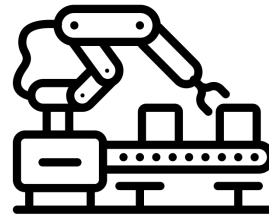
**Manufacture**



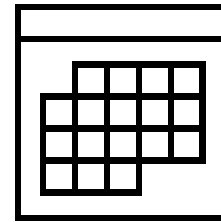
**Transport**



**Assembly**



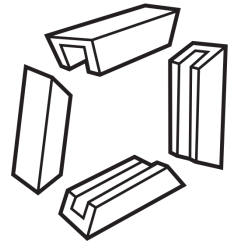
**Operation**



**Maintenance**

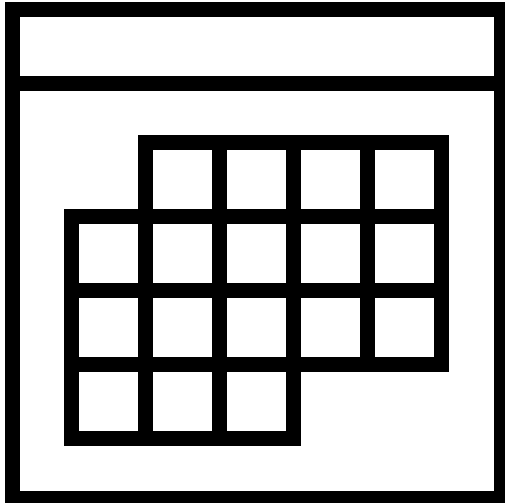


**End-of-Life**



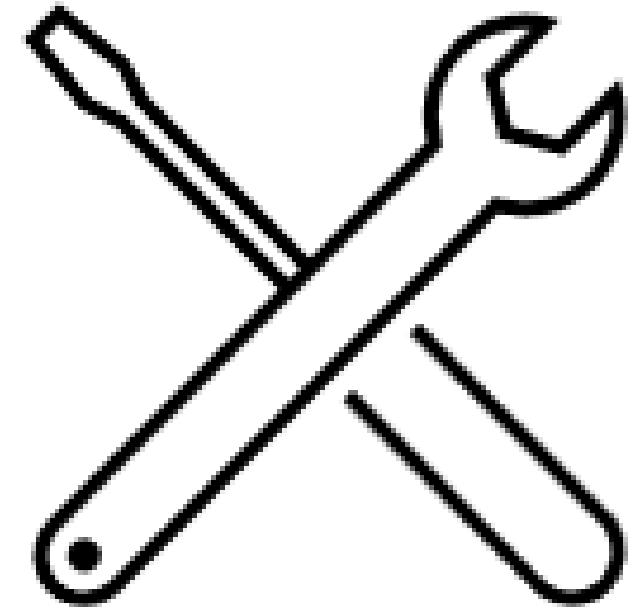
# Cross-Case Analysis

## Operation



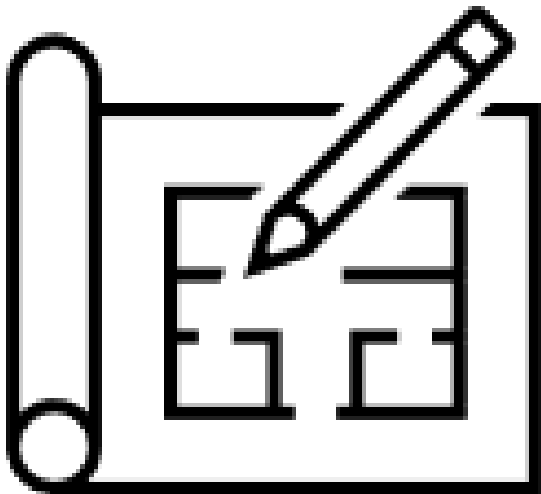
- The **TOTAL COSTS OF OWNERSHIP** become significant
- Easy **ACCESS** for **MAINTENANCE** works
- **REWARD SYSTEM** for users if the costs remain within budget

## Maintenance



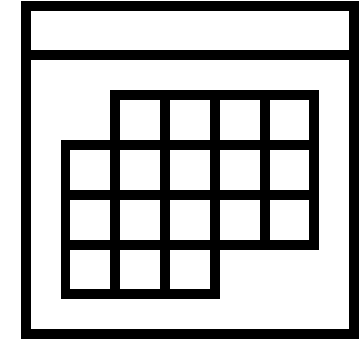
# Cross-Case Analysis

Design

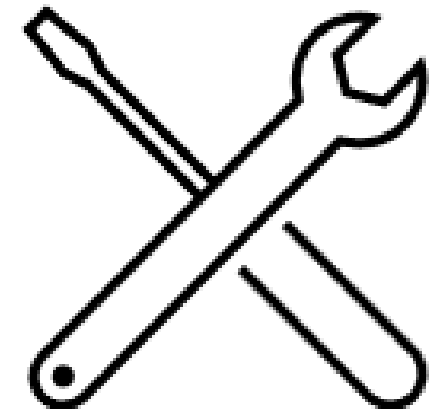


- **FEEDBACK LOOPS** between the operation & Maintenance and the Design departments
- **DELAYED** loops between departments
- **INTERACTION BOOST CONSIDERATION**

Operation



Maintenance





# Cross-Case Analysis

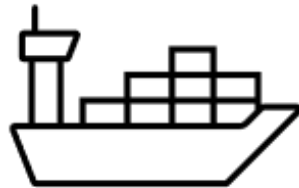
**Design**



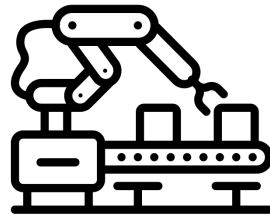
**Manufacture**



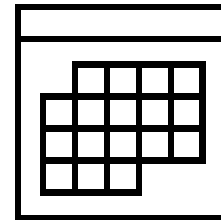
**Transport**



**Assembly**



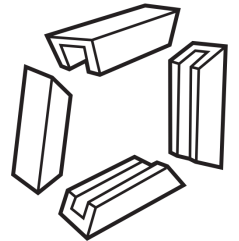
**Operation**



**Maintenance**

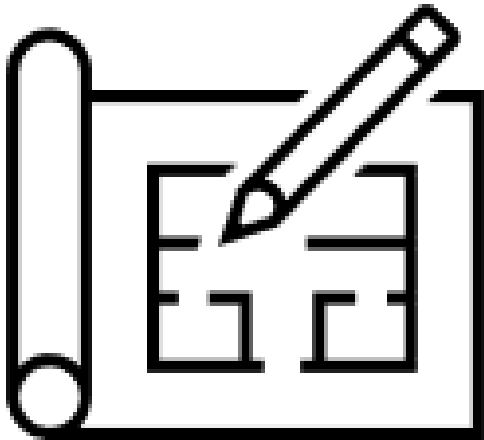


**End-of-Life**



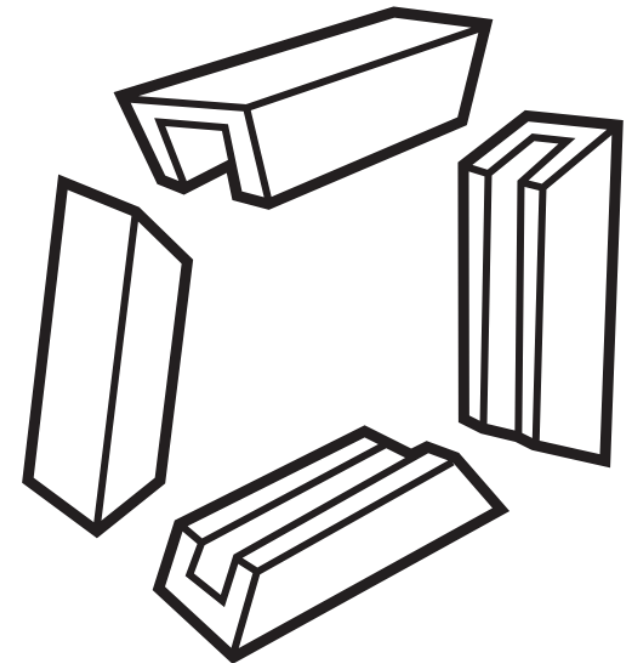
# Cross-Case Analysis

## Design



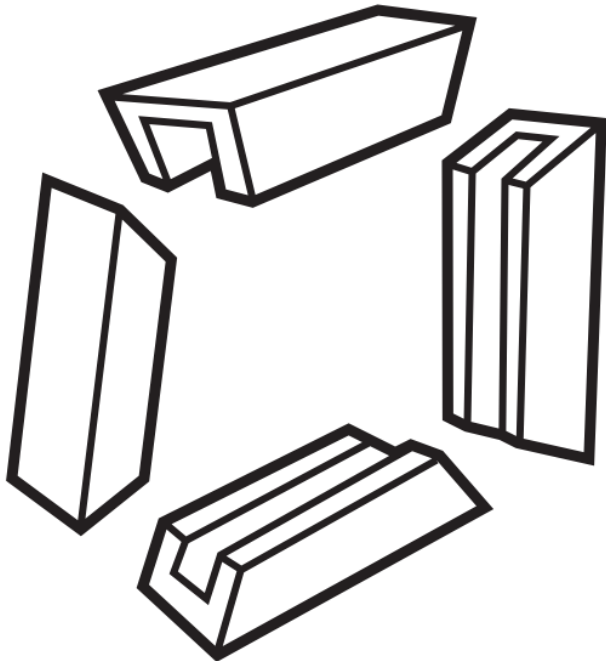
- **DESIGN FOR ... CIRCULARITY**
- **PROCUREMENT** of suppliers that enable a circular environment
- **PRODUCTS** as a **SERVICE**
- **DEPOSIT ARRANGEMENTS**

## End-of-Life



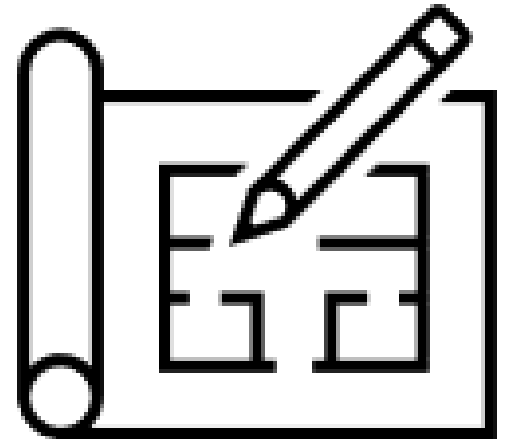
# Cross-Case Analysis

## End-of-Life



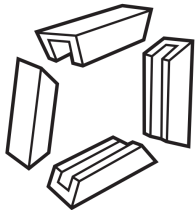
- **COMPATABILITY** with future designs
- Design **FROM** Disassembly

## Design



# Cross-Case Analysis

**End-of-Life**



**Design**



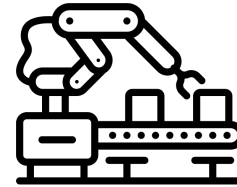
**Manufacture**



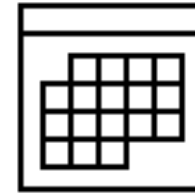
**Transport**



**Assembly**



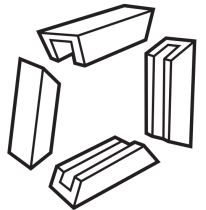
**Operation**



**Maintenance**

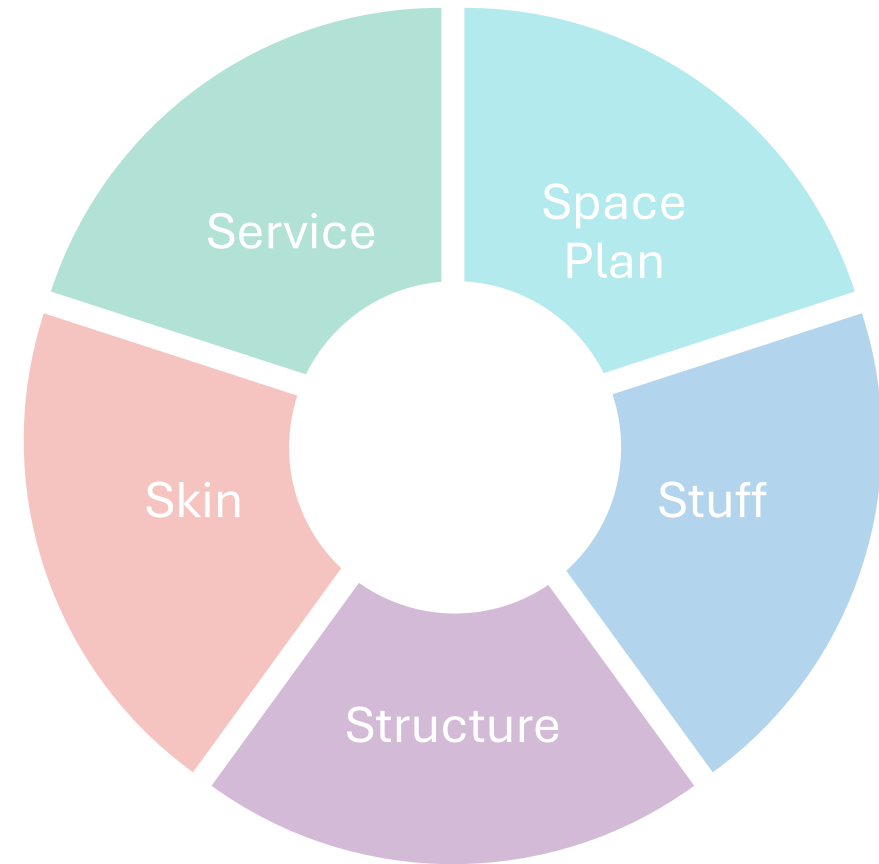


**End-of-Life**



# CIC-Framework

Based on the **LAYER** and **PHASE** in the **CIRCULAR BUSINESS PROCESS** several strategies can be applied

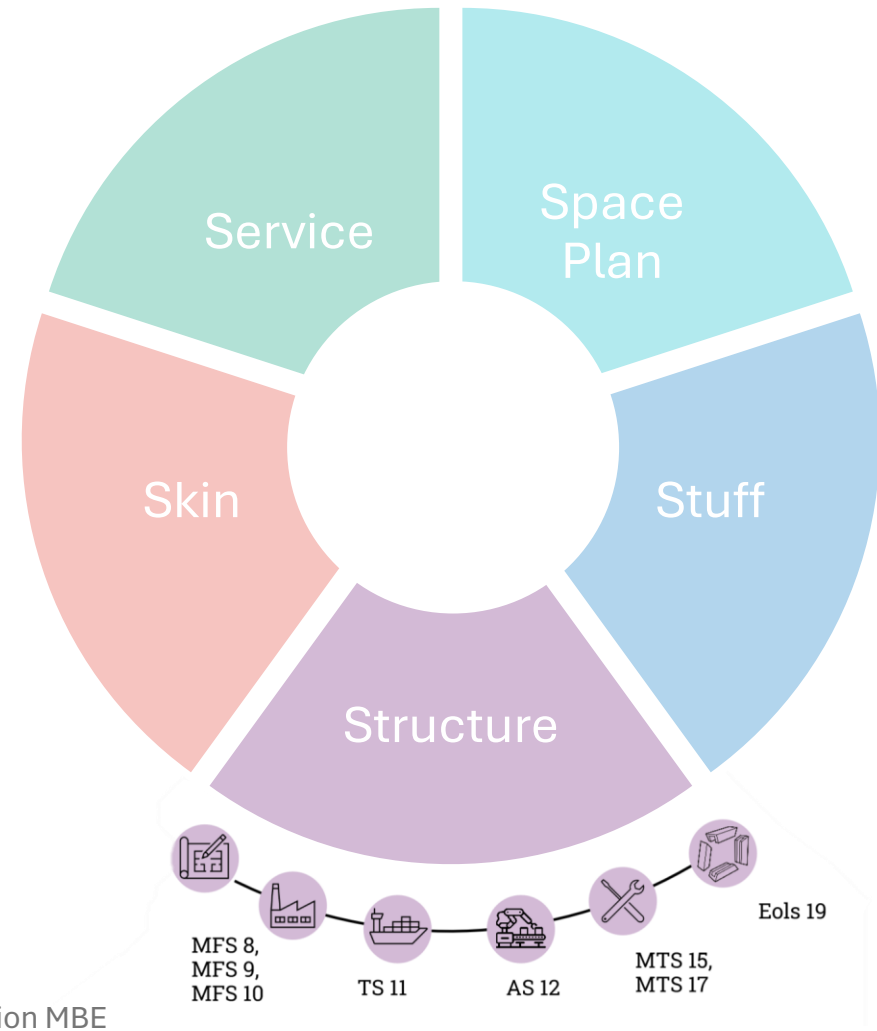


# CIC-Framework

- The **structure** layer is often the **normative** dimension. Therefore **manufacturing**, **transportation** and **assembly** become **normative phases** for this layer

Phase	Structure	
Design	1	Prepare for replacement
	2	Procurement of Circular Suppliers
	3	<b>Modularise for Iterations</b>
	4	Stand firm with your concept
	5	<b>Design for manufacturing</b>
	6	<b>Configure to site specifics</b>
	7	<b>Integrating feedback</b>
Manufacture	8	<b>Collect feedback</b>
	9	<b>Build collaborative partnerships</b>
	10	<b>Selection of a production method</b>
Transportation	11	<b>Prevent structural deformation</b>
Assembly	12	<b>Selecting knowledgeable partners</b>
Operation	13	Build sustainable relationships with clients
	14	Reward proper use of space
Maintenance	15	<b>Prolong the lifetime of materials</b>
	16	Refurbish damaged or soiled materials
	17	<b>Effortless maintenance works</b>
End-of-Life	18	Return materials to suppliers
	19	<b>Reimbursement arrangements</b>

# CIC-Framework



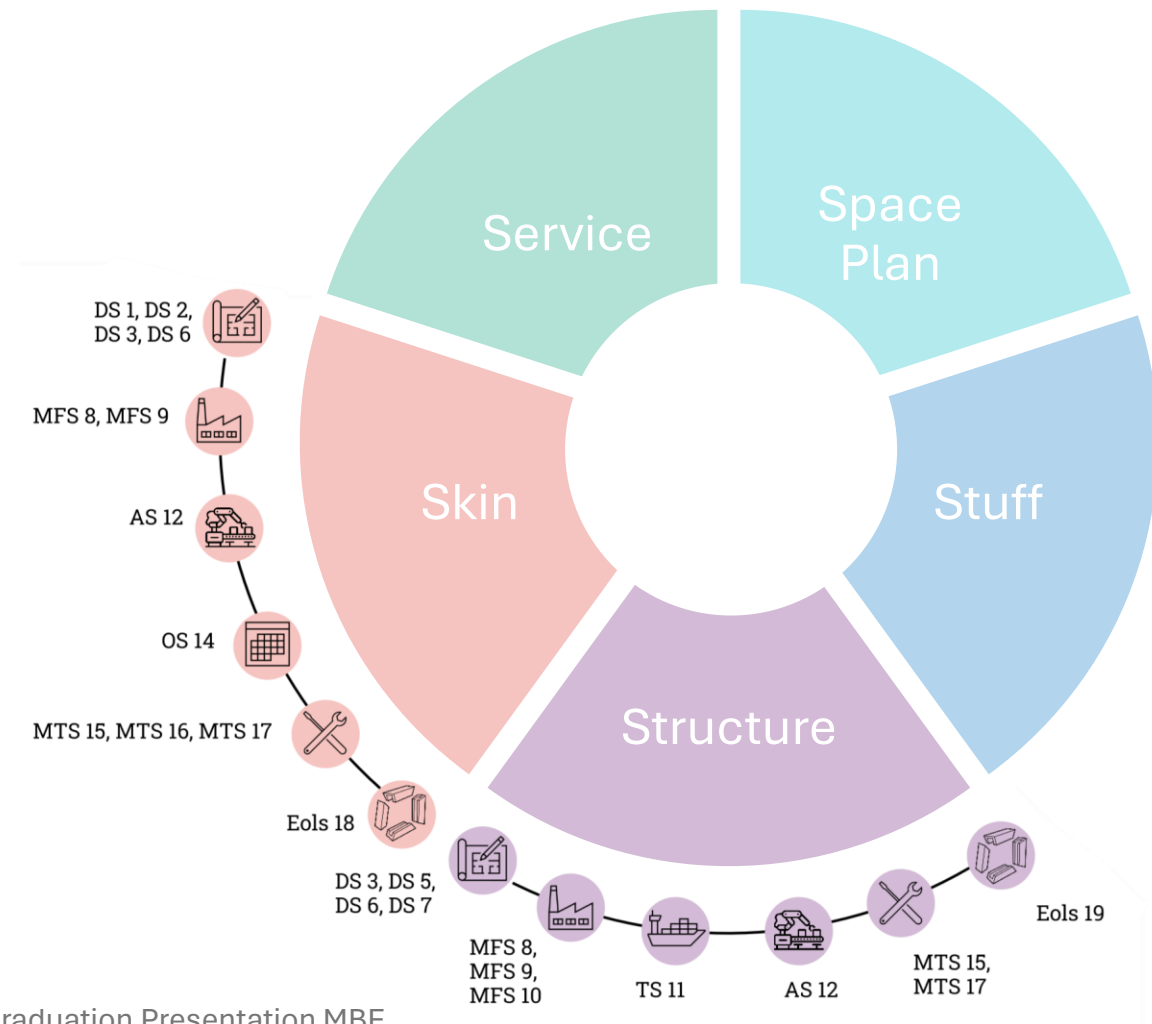
# CIC-Framework

- For the **Skin** layer the aspect of **maintenance** is a **normative** aspect. Due to the **inaccessibility** of **components**.

Phase	: Skin	
<u>Design</u>	1	<b>Prepare for replacement</b>
	2	<b>Procurement of Circular Suppliers</b>
	3	<b>Modularise for Iterations</b>
	4	Stand firm with your concept
	5	Design for manufacturing
	6	<b>Configure to site specifics</b>
	7	Integrating feedback
<u>Manufacture</u>	8	<b>Collect feedback</b>
	9	<b>Build collaborative partnerships</b>
	10	Selection of a production method
<u>Transportation</u>	11	Prevent structural deformation
<u>Assembly</u>	12	<b>Selecting knowledgeable partners</b>
<u>Operation</u>	13	Build sustainable relationships with clients
	14	<b>Reward proper use of space</b>
<u>Maintenance</u>	15	<b>Prolong the lifetime of materials</b>
	16	<b>Refurbish damaged or soiled materials</b>
	17	<b>Effortless maintenance works</b>
<u>End-of-Life</u>	18	<b>Return materials to suppliers</b>
	19	Reimbursement arrangements



# CIC-Framework

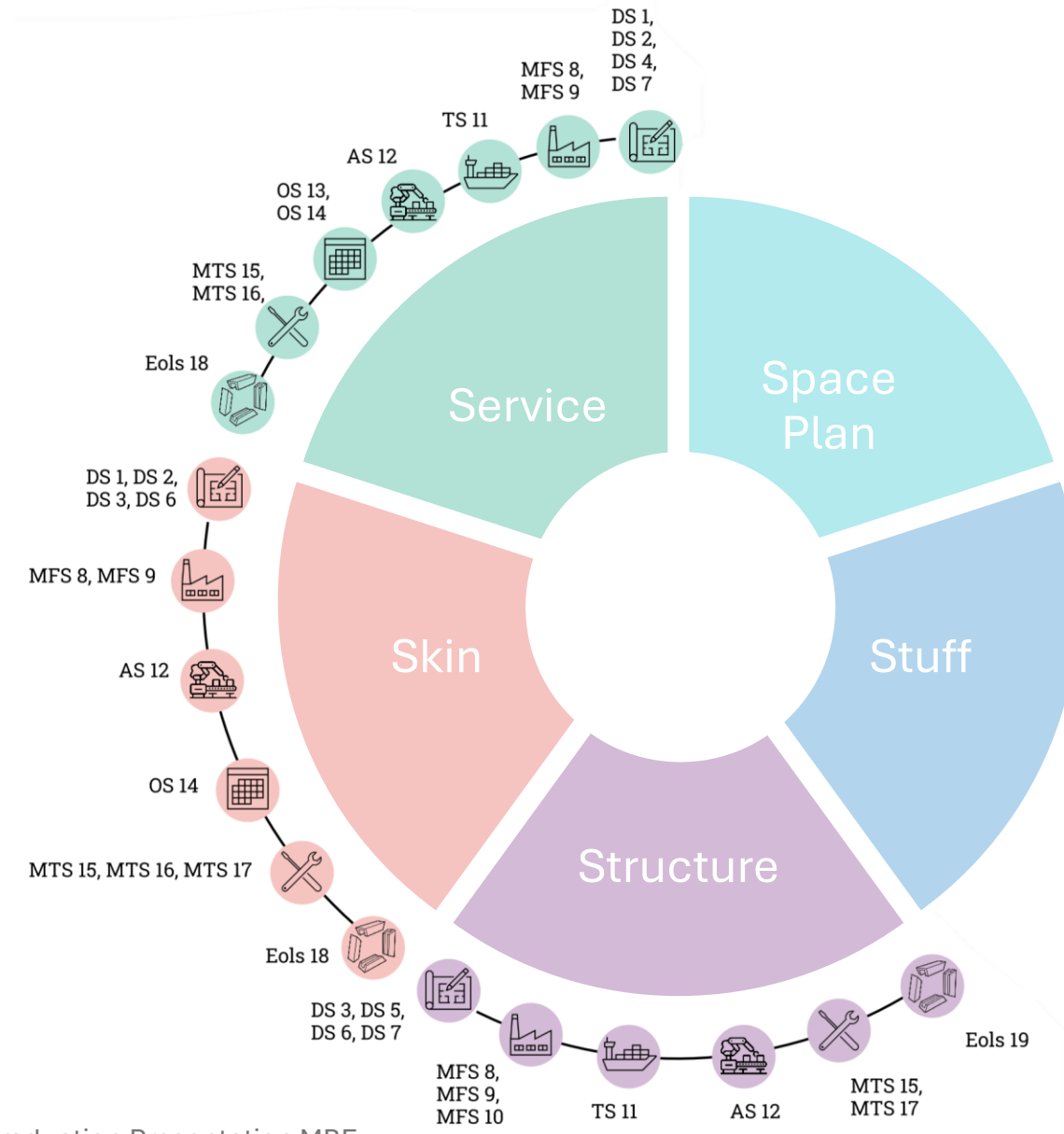


# CIC-Framework

- For the **Service** layer the aspect of **Effortless** maintenance is a **normative** aspect. Due to the **components** that need to be accessible.

Phase	: Service	
<u>Design</u>	1	<b>Prepare for replacement</b>
	2	<b>Procurement of Circular Suppliers</b>
	3	Modularise for Iterations
	4	<b>Stand firm with your concept</b>
	5	Design for manufacturing
	6	Configure to site specifics
	7	<b>Integrating feedback</b>
<u>Manufacture</u>	8	<b>Collect feedback</b>
	9	<b>Build collaborative partnerships</b>
<u>Transportation</u>	10	Selection of a production method
	11	Prevent structural deformation
<u>Assembly</u>	12	<b>Selecting knowledgeable partners</b>
<u>Operation</u>	13	Build sustainable relationships with clients
	14	<b>Reward proper use of space</b>
<u>Maintenance</u>	15	<b>Prolong the lifetime of materials</b>
	16	<b>Refurbish damaged or soiled materials</b>
	17	<b>Effortless maintenance works</b>
<u>End-of-Life</u>	18	<b>Return materials to suppliers</b>
	19	Reimbursement arrangements

# CIC-Framework

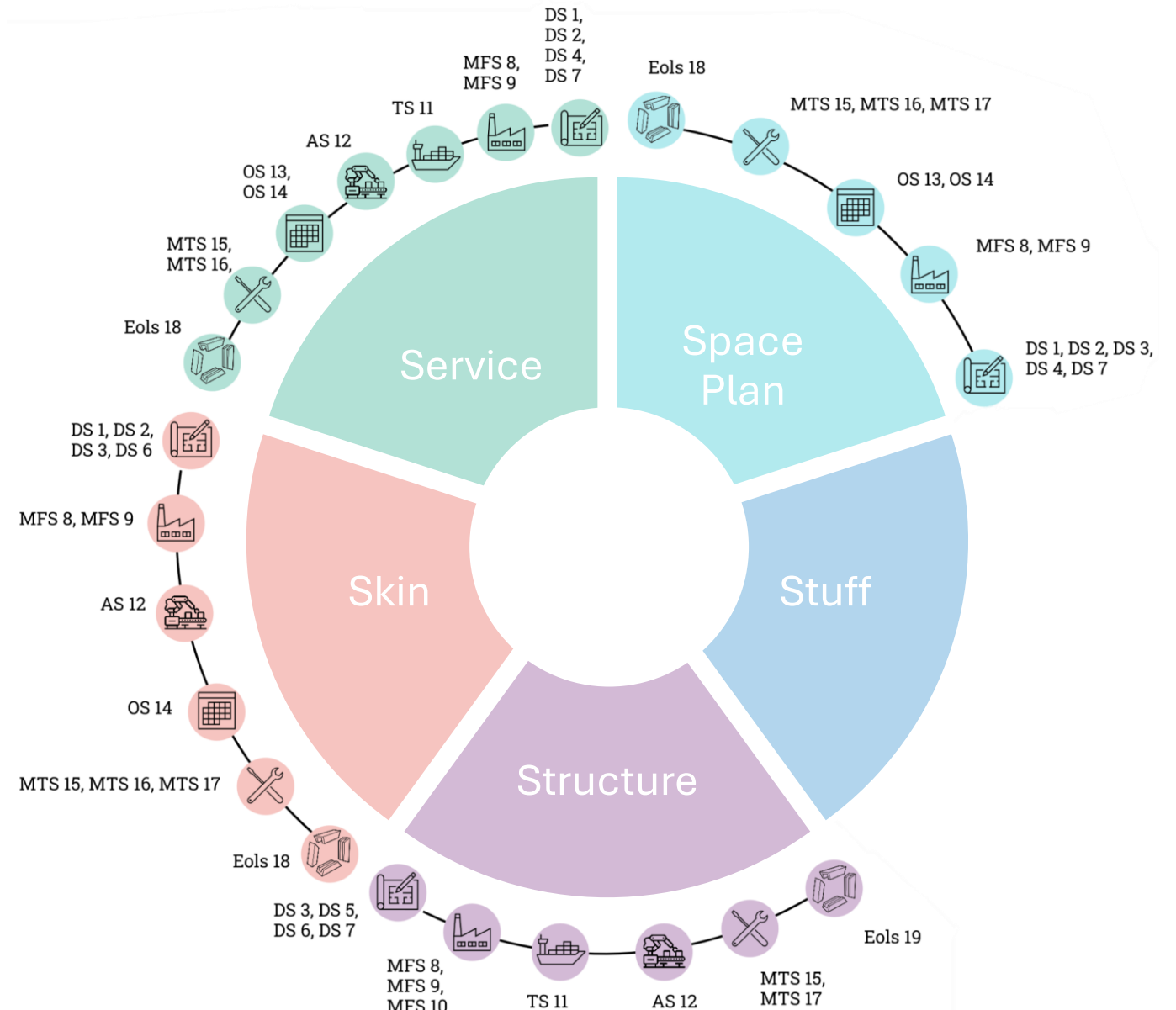


# CIC-Framework

- For the **Space Plan** layer the aspect **proper use** of the **materials** and **areas** is the **normative** aspect.

Phase : Space plan	
<u>Design</u>	1 <b>Prepare for replacement</b>
	2 <b>Procurement of Circular Suppliers</b>
	3 <b>Modularise for Iterations</b>
	4 <b>Stand firm with your concept</b>
	5 Design for manufacturing
	6 Configure to site specifics
	7 <b>Integrating feedback</b>
<u>Manufacture</u>	8 <b>Collect feedback</b>
	9 <b>Build collaborative partnerships</b>
	10 Selection of a production method
<u>Transportation</u>	11 Prevent structural deformation
<u>Assembly</u>	12 Selecting knowledgeable partners
<u>Operation</u>	13 <b>Build sustainable relationships with clients</b>
	14 <b>Reward proper use of space</b>
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<u>Maintenance</u>	16 <b>Refurbish damaged or soiled materials</b>
	17 <b>Effortless maintenance works</b>
	18 <b>Return materials to suppliers</b>
<u>End-of-Life</u>	19 Reimbursement arrangements

# CIC-Framework



# CIC-Framework

- For the **Skin** layer the **circularity aspects** can be more **effectively** be **redistributed** along the **supply chain**.

Phase	Stuff
Design	1 Prepare for replacement
	2 Procurement of Circular Suppliers
	3 Modularise for Iterations
	4 Stand firm with your concept
	5 Design for manufacturing
	6 Configure to site specifics
	7 Integrating feedback
Manufacture	8 Collect feedback
	9 Build collaborative partnerships
	10 Selection of a production method
Transportation	11 Prevent structural deformation
Assembly	12 Selecting knowledgeable partners
Operation	13 Build sustainable relationships with clients
	14 Reward proper use of space
Maintenance	15 Prolong the lifetime of materials
	16 Refurbish damaged or soiled materials
	17 Effortless maintenance works
End-of-Life	18 Return materials to suppliers
	19 Reimbursement arrangements



# Conclusion

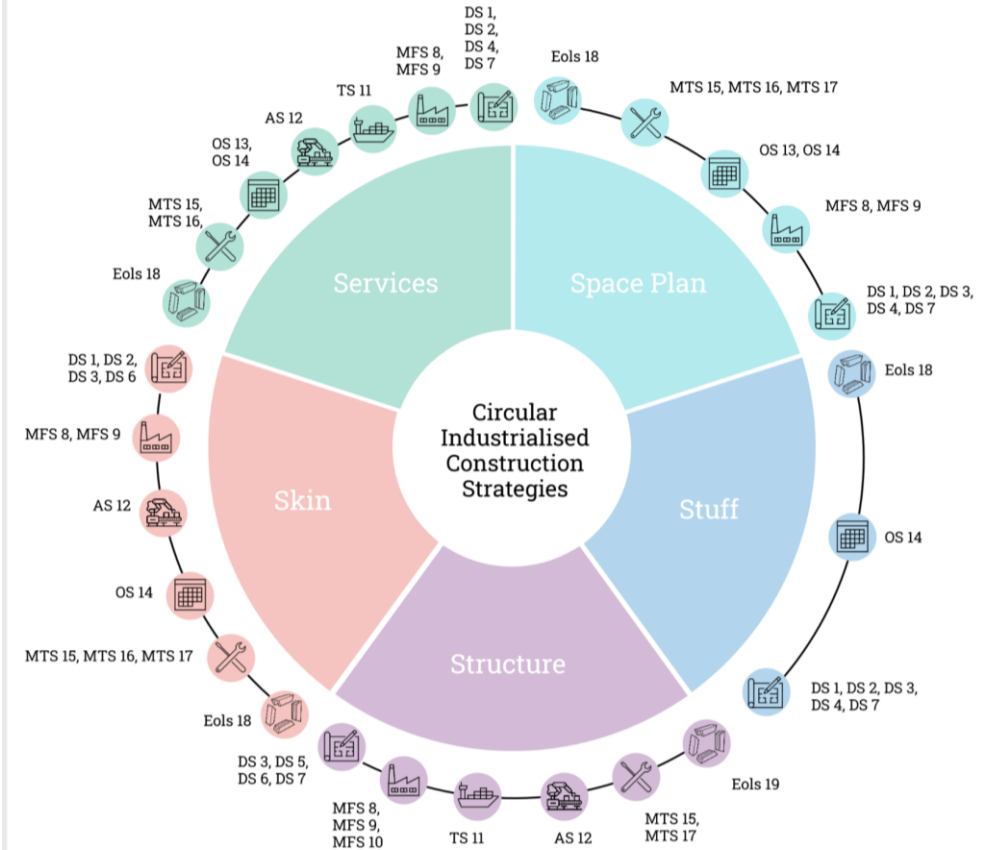
**How can strategies for circular buildings using industrialised construction methods account for the operational and End-of-Life phases?**

- 1. What strategies for Circular Building using Industrialised Construction methods can be identified?*
- 2. How are the operation and End-of-Life phases taken in consideration during the strategy-making process?*
- 3. What are the pitfalls in the strategy-making process for the operation and End-of-Life phase of circular buildings using industrialised construction methods?*



# What strategies for Circular Building using Industrialised Construction methods can be identified?

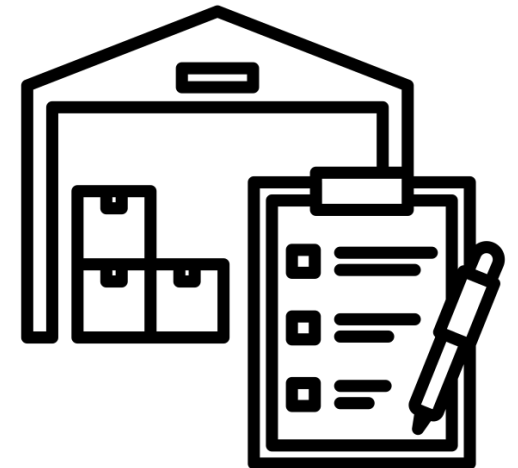
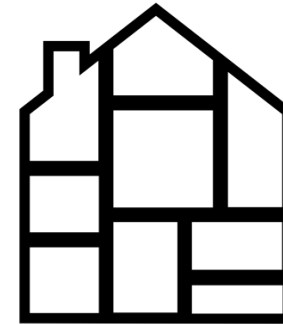
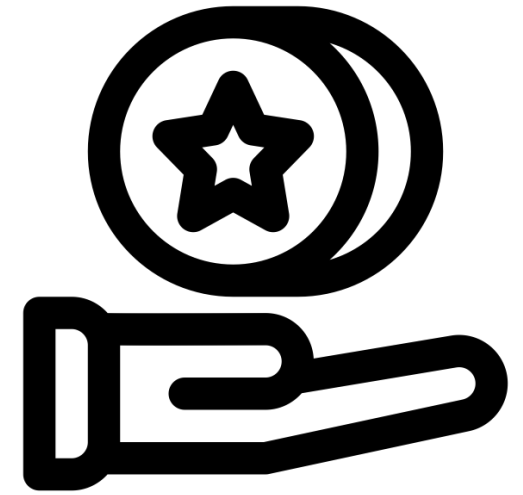
- 19 Strategies have been identified
- Taking charge of the design process
- Developing feedback loops between the design department and other phases



DS 1 : Design Strategy	1 : Prepare for replacement
DS 2 : Design Strategy	2 : Procurement of Circular Suppliers
DS 3 : Design Strategy	3 : Modularise for iterations
DS 4 : Design Strategy	4 : Stand firm with your concept
DS 5 : Design Strategy	5 : Design for Manufacture
DS 6 : Design Strategy	6 : Configure to site specifics
DS 7 : Design Strategy	7 : Integrating feedback
MFS 8 : Manufacture Strategy	8 : Collect feedback
MFS 9 : Manufacture Strategy	9 : Build collaborative partnerships
MFS 10 : Manufacture Strategy	10 : Selection of a production method
TS 11 : Transportation Strategy	11 : Prevent structural deformation
AS 12 : Assembly Strategy	12 : Selecting knowledgeable partners
OS 13 : Operation Strategy	13 : Build sustainable relationships with clients
OS 14 : Operation Strategy	14 : Reward proper use of space
MTS 15 : Maintenance Strategy	15 : Prolong the lifetime of materials
MTS 16 : Maintenance Strategy	16 : Refurbish damaged or soiled materials
MTS 17 : Maintenance Strategy	17 : Effortless maintenance works
EoLS 18 : End-of-Life Strategy	18 : Return materials to suppliers
EoLS 19 : End-of-Life Strategy	19 : Reimbursement arrangements

*How are the operation and End-of-Life phases taken in consideration during the strategy-making process?*

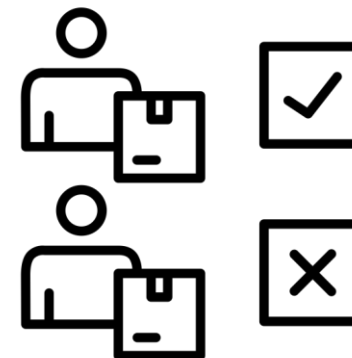
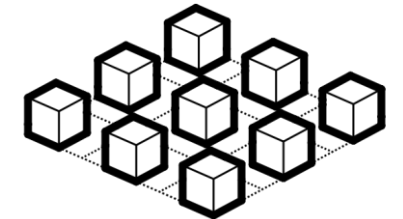
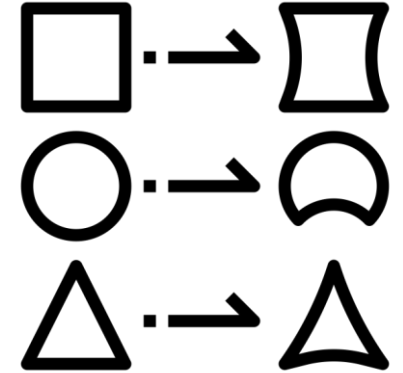
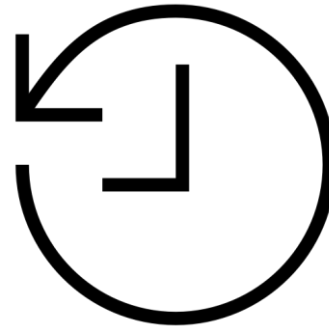
- **Procurement of suppliers that offer a take back guarantee**
- **Design for easy replacement or DfDA**
- **Incentivising proper use of spaces**
- **Deposit arrangements for building components**



*What are the pitfalls  
in the strategy-  
making process for  
the operation and  
End-of-Life phase of  
circular buildings  
using industrialised  
construction  
methods?*

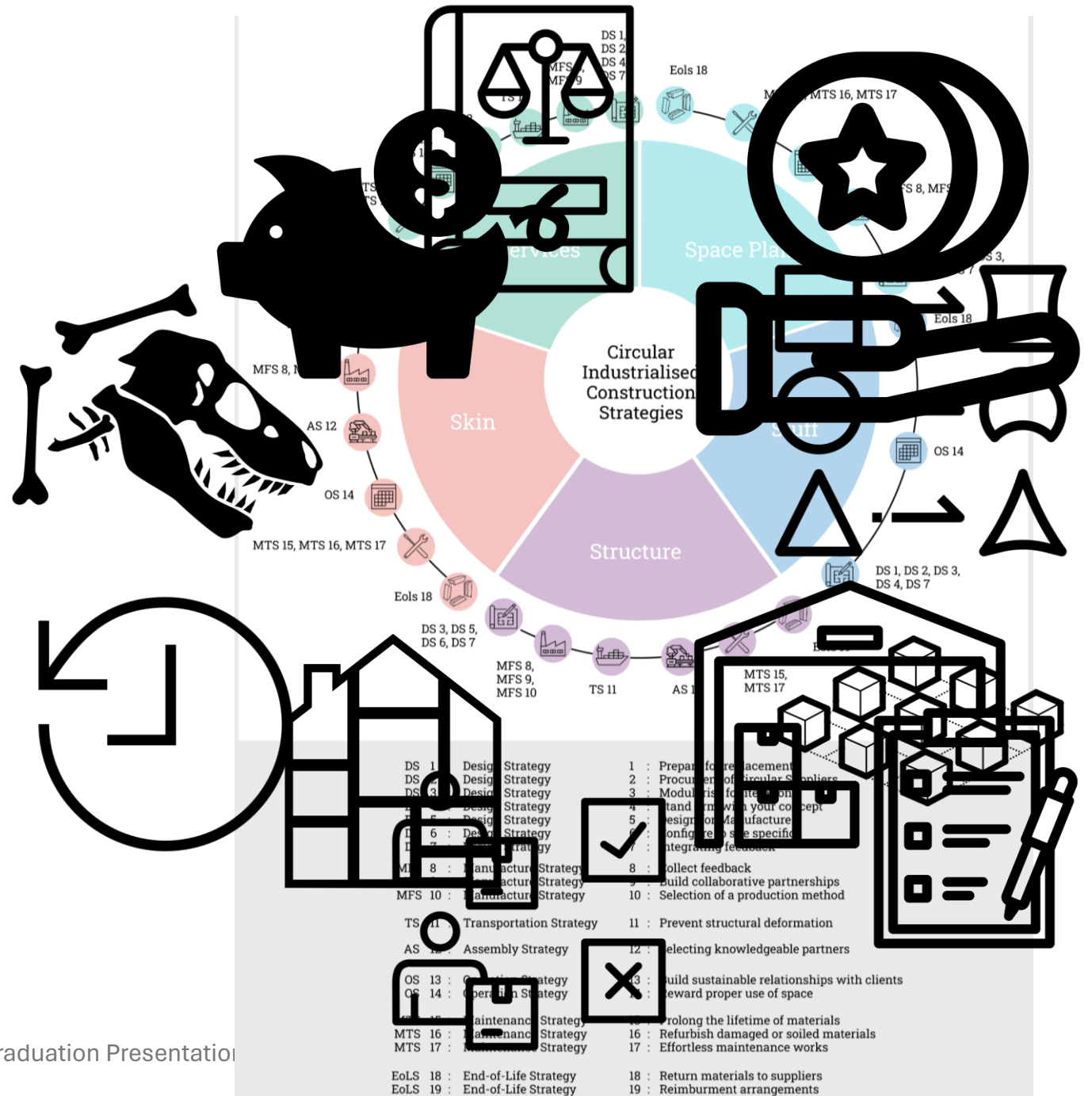
# *The identified pitfalls are:*

- **Legislative issue causing delays**
- **Structural deformation**
- **Continuing the concept**
- **Selecting of partnerships**
- **Circular suppliers**
- **Speed of construction**



# How can strategies for circular buildings using industrialised construction methods account for the operational and End-of-Life phases?

- Applying the identified strategies to the circular business process
- Consider rewarding users for proper use, and design for the entire lifecycle of a building
- Avoid the identified pitfalls



# Final remarks

