Investigating Responsibility arrangements for Project Delivery Methods to retain optimal Re-use value

Jalal Chahine   **29th October 2021**   **Master Thesis**

Investigating responsibility arrangements for Project Delivery Methods to retain optimal Re-use value

Master Thesis Report

Graduation thesis

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The research marks the end of my academic journey at Delft University of Technology. It all started almost 6 years ago at the American University of Beirut, having the ambition to integrate sustainability in construction projects. I recall when I applied to my master's degree having in mind several topics that the recruiter requested to research. Fast forward to the last chapter of my master's degree, I happened to investigate the aspect of Data management for the topic of the Division of responsibilities in project delivery methods for material passports to retain their re-use value. This research could not have been accomplished without several people that I would like to take the opportunity and thank individually for their support and contribution.

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Chahine Jalal,
October 2021, Delft.

Executive Summary

The European Union's incentives to make its economy circular by 2050 have pushed researchers to come up with new methods and techniques for the transition to happen from a linear to a circular economy. A material passport is a tool through which circularity could be implemented in the construction sector to promote the re-use of material. The digital tool stores data regarding General Information, the composition of the object, its properties, etc. The data is stored under different levels of detail, hence different levels of access are granted. Moreover, there are different stages for which a passport is active, the so-called active stages are coupled with check-up phases that contain tasks and responsibilities to safeguard the data reported on a passport. However, several stakeholders and actors are involved throughout the lifecycle of the passport. So far, research suggests that issues arise from the uncoordinated tracking of data due to the lack of division of responsibilities in the process which hinders the functionality and applicability of material passports in the Dutch construction sector. The research aims to propose a new set of arrangements for the responsibilities under forms of interventions that are in line with governmental and contractual requirements. The main research question is presented as follows:

> *How can responsibilities of stakeholders for data management and data governance be arranged during the project phases and life cycle of built assets, to ensure the quality of a material passport?*

The following methodology was implemented: Initially, a thorough literature study was conducted to define the most relevant concepts and give a better understanding of the topic. Subsequently, the goal was to understand how the current approach for data collection and data management is being applied using semi-structured explorative interview sessions with people working in the field of material passports. Accordingly, the Conceptual framework for the division of responsibilities was sketched for different project delivery methods, along with the Compass ecosystem that shows a clear graphical view of this division. The parameters of the framework followed several design steps: (1) Identifying the project phases, (2) Recognizing the tasks in Data Management, (3) Classifying Stakeholders, (4) Ranking responsibilities based on a RACI approach, and (5) Drawing the RACI Matrix. Furthermore, the framework was shared amongst users that are implementing material passports on a practical level on projects in the Netherlands. The research has tackled the approach by which organizations and companies involved with material passports are currently dealing with data collection/ management. This was achieved using semi-structured practical interviews with the concerned people. Subsequently, a newly proposed method has emerged, the Supplier approach (decentralized approach to store the data). Finally, the framework has been modified for the alternative approach along with the changes in the compass ecosystem to show the new division of responsibilities. Both centralized and decentralized frameworks have been shared with experts for validation and future recommendations for their applicability in the Netherlands.

The *Centralized* approach refers to the concept of gathering, storing, and analyzing the data centrally within an organization, private company, or a team. It entails that every party will adapt and change its requirements for keeping the data based on their goals and objectives. Hence, every single project accommodates a series of material passports that are constantly being monitored and updated according to guidelines set by a central platform. This approach promotes which data is deemed as valuable for the party given, they are the best to handle their fleet of assets. According to interview sessions conducted, this method of working goes by the way of working and methodology for stakeholders in the Infrastructure sector.

On the other hand, the *Supplier* approach, or the decentralized approach to store the data, entails that data is kept at the source. Accordingly, instead of storing the data on a project level, information is being collected on a national level. For instance, for a single batch of concrete, almost 100 projects can be monitored at the source: with the supplier. Moreover, each supplier can determine which criteria and information are and will be needed in the future, hence allocating additional responsibilities to the supplier. According to the interviews sessions, this approach is best applicable in the Real Estate sector.

Both methods present advantages and disadvantages for their applicability and legitimacy to safeguard the data collected. However, five main limitations were noted along most of the interviews conducted presented below:

- A*bsence of a centralized platform* of BIM application to store the data. This limitation presents issues for safeguarding the data on a long-term basis.
- *Missing a standardized passport format* to store the data. The absence of a common format, or a universal language, does not promote having a common plain field for utilizing the data.
- *Voluntary process of data collection* as it is still not being incentivized earlier in the process. Making a shift towards the circular economy is about designing for re-use.
- Having a *long supply chain* and the duration of a lifetime for some projects may cause data loss in the long term.
- The current aim of material passports is *only to learn* from the data collected, as data currently is not being safeguarded but only being collected for analysis and further development.

The limitations present a general sample of the barriers to the applicability of material passports in the Netherlands. However, the end responsibility must lie with the party that is mostly affected by the missing data. Material passports may provide an added value for the potential re-use of construction products given they are maintained properly, and the party that is missing out on its added benefits should be the one with the end responsibility. The end-user responsible is different from one sector to another:

- For the *Infrastructure sector*, the most profitable party that wants to maintain its asset in the long term is the Lease owner/ asset holder. They have the best interest in keeping the information centrally by their way of working based on the Centralized approach.
- For the *Real Estate Sector*, the cost of maintaining the asset over its entire lifecycle will exceed its capital costs. Hence, having a complete dataset for efficient and effective asset management is essential to maintain the Collateral (Onderpand). This is highly seen in the best interest of Financial parties such as banks and insurance companies, alongside the Municipality once we reach the end of the lifecycle of the asset. Once an asset needs to be decomposed, its residual value will only be relevant if it is known to be present in the passport.

To conclude, having a decentralized approach only to manage the data presents prospects for the successful application of material passports in the Netherlands. One way to safeguard the data collected is by using blockchain technology. It provides a distributed ledger composed of a system of blocks where datasets interact with each other by sharing the change that was made. Change cannot be made unless other blocks confirm it and once a transaction is made, there is no way back. Blockchain technology only provides a basic premise upon which there is a distributed ledger of information over different locations to promote the safeguarding of the data. Finally, material passports have different aims for some parties, and accordingly, the limitations that were found for its applicability are more relevant to some parties than others

for different stages of the project. Eventually, the limitations found will become problems for the parties that have been marked in red in the framework developed, or the most responsible parties in the compass ecosystem.

Recommendations for the application of the framework developed through contractual agreements have shown that material passports are still under development and cannot be forced into the market at the moment. Special contractual agreements can pave the way for the initial setting of the division of responsibilities within contracts between different stakeholders. In the long term, changes can still occur to the procurement law or the civil code, which would eventually promote the transition towards a circular economy. An implementation guideline was developed to apply the framework within a company, organization, or a party concerned presented in Figure 1.
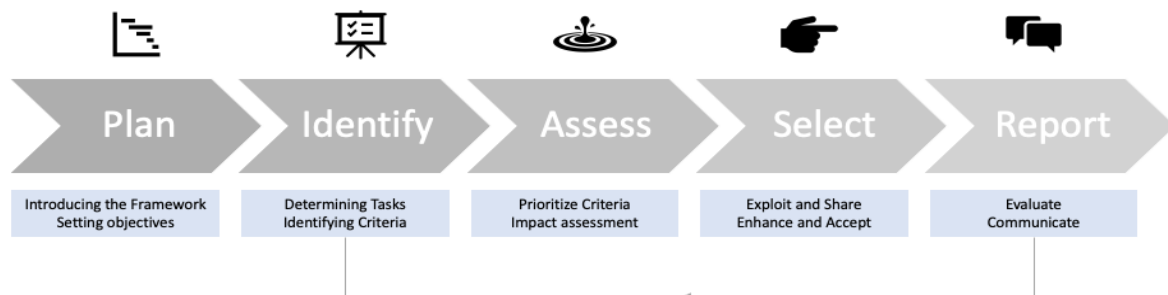

Figure 1. Implementation guideline of the framework

The recommendations that are made throughout this research are the following:

I – Recommendations for practice

- o Maintain proper separation between the two sectors and provide rough guidelines.
- o In the Infrastructure sector, every organization is responsible for determining what type of information is necessary to maintain their goals and overcome the limitations.
- o In the Real Estate sector, suppliers will be the best parties to handle the product data based on certificates and standards in most cases. However, a distinction must be made between the private and public real estate sector. Information data regarding the location can still be managed by a central platform.
- o Finally, having a central platform or a shared database for all users that makes a clear separation for confidential information.

II- Recommendations for future research

- o The framework covered most of the parties present in the market, however, projects are unique, and the framework cannot represent the full spectrum of the market, it provides a rough guideline upon which future studies are made possible.
- o Further limitations will start emerging based on the two approaches presented, this can be exploited through interviews conducted with concerned parties.
- o Additional tasks and responsibilities can be outlined to have a complete division of the responsibilities clear amongst parties.
- o Different organizations may have different aims for the material passports; accordingly, the criteria will be different in some cases. Hence, focusing on each organization can give a better understanding of its goals and the criteria to be assessed.
- o This research doesn't make a separation between new and existing assets, as further research enriches this view by combining expectations from the demolition and recycling companies for existing assets.

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1. Introduction

1.1.   Background Information

Projects have been moving into a sustainable environment while being in line with the European Green deal and the EU's commitment to making its economy sustainable by 2050. A linear construction economy typically procures, implements, and produces waste material from construction projects. The integration of circular economy concepts into the construction sector promotes an enclosed circulation of material used with an extension of their service life. Public authorities have increased their incentives to procure in a circular economy to contribute to a supply chain loop of materials. The European Commission regards that a circular economy would eventually boost competitiveness while creating innovative opportunities and business prospects (European Commission, 2015).

The application of a circular economy needs to conform with the government's vision of a sustainable 2050. The traditional construction approach has a clear distinction between different phases throughout the project. Unlike this linear method, circular construction is a cycle that requires multiple interactions between the phases with no beginning and end to it. Almost all decisions that will be made at one point in time will have an impact on the process in the future. Initiatives to promote a circular economy aim to achieve a minimal inflow of non-renewable materials while keeping a minimal outflow of waste material (Platform CB'23, 2019a), thus working circularly. With time and knowledge, additional innovations become available and hence becoming self-evident.

Circularity can only be endorsed through cooperation, practices, and rules. One of the platforms that have been developed, CB'23, has the ambition to expand on a national level to meet circularity goals. The team working on developing the platform consisted of 85 different organizations, ranging from governments, market parties, and knowledge institutions. Moreover, clear documentation of materials, for instance, material passports provides an additional degree to apply circular procurement in the construction sector. According to CB'23 (Platform CB'23, 2019a), there are mainly 7 different levels of scale in the application of passports: Area, Complex, Building, Element, Construction product, Material, Raw Material.

Material passports are the digital representation of an object used in the construction sector. It documents qualitatively and quantitatively how the material was realized, where it is located and the ownership of its sub-parts (Bokkinga, 2018). The increase of parties getting involved in material passports ensures that there is a diversity in materials being re-used that meets the diversity in needs (Platform CB'23, 2019a). However, a raised concern for the development of material passports is based on the personal preferences of each passport developer from their point of view (Madaster, 2019b). Hence, setting up the proper framework to monitor and keep track of the data for data collection and management and quality throughout the lifecycle of the asset is essential for better integration of data in future projects.

"Delivery" refers to the method for assigning responsibility to an organization or a party for carrying design and construction activities. A project delivery method can make use of different contract formats to fulfill project delivery and can be broken down into the traditional and integrated types of contracts. Each of the various available contract forms has its own set of advantages and disadvantages that are based on the type and characteristics of the project. Different project delivery methods will have various consequences on data management that are mostly affected by the changing nature of stakeholders throughout the project lifecycle. Hence, choosing a delivery method is a complex process that requires sufficient qualitative information, and weighting what each model has to offer in respect to priorities (Naoum & Egbu, 2015).

1.2.   Problem Definition

Promoting circularity in construction projects early on in the process creates momentum to apply circular business models. One of the strategies drawn up from The Circular Construction Economy Transition Agenda is that the government will eventually require 100% circular execution by 2023 for all contracts (Circular Construction Economy transition team, 2018). A **Traditional** project delivery method dictates that the design and construction activities are handled by two different parties. The Client and the Architect/Consultant invite contractors to the bidding phase for the construction tasks (Hobma & Jong, n.d.). Moreover, an **Integrated** project delivery method is a collaborative approach in which the design and construction tasks are delegated to a single party. Under certain conditions, the Contractor will eventually be responsible for maintaining and operating the asset and its building components. The usage of integrated contracts has increased recently in the Dutch Construction sector (Hobma & Jong, n.d.).

In practice, the owner of an asset is legally responsible for maintaining the asset, however, keeping track of the data to update material passports may come in handy for the lease owner in the future once material re-use is incentivized. In the Netherlands, the Municipality and public clients have a strong interest in the long-term perspective of the assets as a large-scale landowner and thus are mostly interested in the application of material passports. Nonetheless, issues arise from data collection and transfer for an asset owned by private parties of the re-used material throughout the lifecycle of the projects. The issue arises mainly from the uncoordinated tracking of data due to the lack of division of responsibilities amongst stakeholders throughout different project delivery methods. Multiple parties have picked up the challenge to find a solution for the long term, as new forms of contracts in which circularity is embedded are under development (Madaster, 2020).

1.3.   Research Question and Sub-Questions

Based on the problem definition and the objective, the main research question is as follows:

How can responsibilities of stakeholders for data management and data governance be arranged during the project phases and life cycle of built assets, to ensure the quality of a material passport?

To answer the research question proposed, the topic is further decomposed into three main sub-questions accordingly:

(A) What are the main elements included in a material passport and the different life-cycle stages in which a material passport is active?

The sub-question aims to gain additional knowledge from the literature available on material passports and the corresponding life-cycle stages. Furthermore, examination on publications and agreements regarding the usage of material passports are exploited to analyze who are the main stakeholders in direct relation and interest with material passports.

(B) What are the commonly used Project Delivery Methods in the Dutch construction market and how the roles of actors for performance monitoring and data governance are divided based on different delivery methods?

The aim of this research question is to understand how the literature available on Project delivery methods, that are mostly used in the Dutch construction sector, brings in added value to this research. Different delivery methods will offer various possibilities for the division of roles and responsibilities of actors throughout the project phase and its life cycle. Contractual elements and the extent to which information is shared with users will help formulate a

conceptual framework for the division of responsibilities (Roles and responsibilities vs Actors involved) to best optimize the re-value that proper data governance may provide.

(C) How can responsibilities for data management be arranged in active stages of the material passport and what are limitations for the transfer of ownership of data between the actors that will have an impact on the re-use value of the asset?

The aim of this sub-question is to gain knowledge from the literature available on agreements regarding the usage of material passports and check the applicability of the conceptual framework. This would eventually help to look into enablers, barriers, and limitations of the process and check whether certain impossibilities would hinder the plan of data collection, management, and transfer from one party to another. Recommendations help assess who would best benefit from this data and will have full ownership of the data collected, hence, by checking the applicability of the framework developed.

1.4.   Research Relevance

This research provides an opportunity to expand the view on the importance of using material passports in the construction industry. This would incentivize a shift towards a circular economy, by initially, promoting the advantages of this implementation and improving the process of standardization for material passports. The research eventually emphasizes the disadvantages and barriers that impose a threat along the process.

Additionally, from a practical point of view, a widely implemented system of material passports will eventually promote a better plan for data collection and management. Hence, providing an opportunity for application in future and existing projects on a larger scale. A change in the view of how parties in the market perceive material passports in the present is a downside due to the lack of standardization and commonly used platforms.

1.5.   Research Objective

Promoting the usage of material passports in the future is linked to the successful application of tender agreements and distribution of responsibilities amongst various stakeholders in all stages of the life cycle. However, the lack of available common standards and agreements will ultimately hinder and create barriers to the application of material passports. Thus, the main objective of this research is to research the position of public and private parties regarding the concept of material passports. Hence, exploiting different opportunities that could be offered, and propose a set of arrangements for users to maximize the re-use value generated by effectively implementing the concept of material passports through a proper data collection plan and transfer, which is referred to in the Framework developed.

2. Research Design

This chapter elaborates on the research approach that is taken while initially defining the research scope and then the methodology used to answer the research questions.

2.1 Research Scope

Defining the boundaries of the research is essential to orientate the scope of the project. The research was conducted mainly for Infrastructure and Real Estate organizations in the Netherlands. Case studies that were taken into consideration tackle the approach by which organizations involved with material passports in the Dutch Construction Sector are tackling projects with the traditional and integrated type of contracts as project delivery methods. The goal of this research is to provide a set of arrangements to divide responsibilities amongst stakeholders throughout different project delivery methods for asset and building components that are associated with a material passport. Through this research, a framework for data collection and management was developed for different project delivery methods in the Netherlands.

2.2 Methodology

The following section elaborates on the approach that was followed to accomplish the research objectives. The research framework is divided into three sections as the following:

A- Shaping a conceptual framework by defining the responsibilities of the actors that are in direct relationship with material passports. Additionally, identifying opportunities for change in the field of data management to ensure a proper distinction of the division of responsibilities throughout different milestones of a project lifecycle.

B- Conduct empirical research to understand the relationship between the different actors based on the delivery method proposed and their degree of involvement with the building element itself. The limitations and barriers will have a role in analyzing this framework and thus, adjusting the framework to have a clear overview of data collection and distribution based on the case studies presented.

C- Examine the effectiveness of the proposed framework in a reflection stage based on a set of criteria that will be collected using thorough interview sessions. The interviews will be scheduled with policymakers that are representatives of both the practical and the theoretical field to come up with further recommendations for future projects.

2.2.1 Design Process Model

The chosen strategy to design the process model is the Double Diamond method. It was initially adopted by the British Design Council in 2005 (Design Council, 2007). The double diamond method is composed mainly of four main phases as shown in Figure 2.
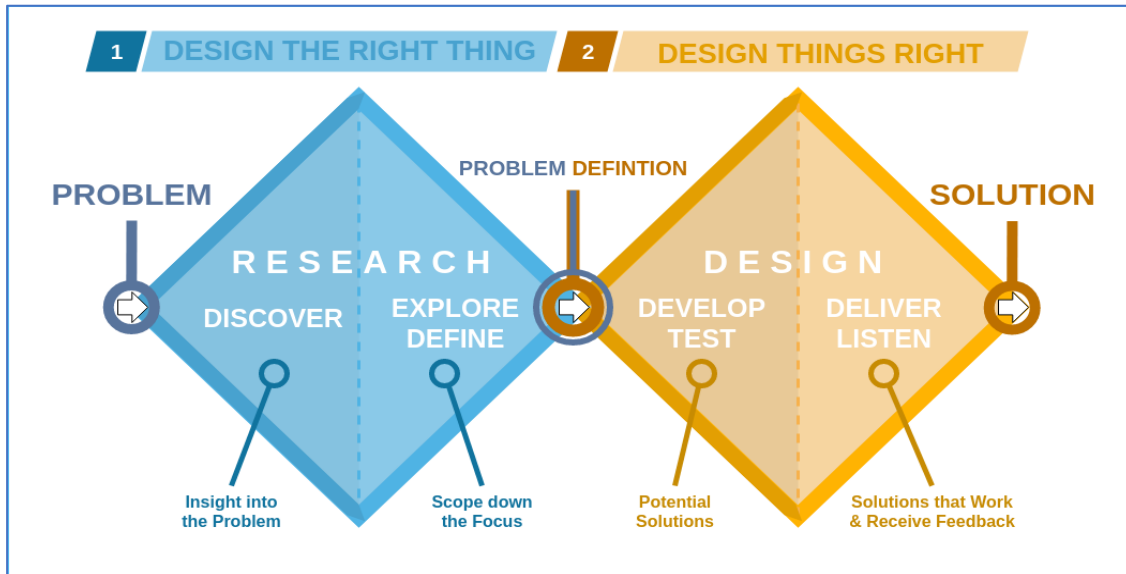
Figure 2. The Double Diamond Design Process

This graphical way of describing the design process is composed of the four main phases: **Discover**, **Define**, **Develop** and **Deliver**. An advantage of using this method is that it is composed of an iterative process of multiple divergent and convergent stages. According to the Design Council (2007), there is no best practice in a design process (Best, 2006). However, unlike other relevant models, it places a large emphasis on the Discover phase as the most critical the designer's knowledge and skills at an early stage (Design Council, 2007).

Table 1. Double Diamond method for data gathering

Stage	Phase	Question(s)	Data Gathering method	Mode of thinking
1	**Discover**	• What is the problem? • What background information is needed? (Sub-question 1)	• Desk Research	Divergent mode to explore the problem definition, gain additional insights and existing knowledge.
	Define	• What is aimed for from this research? • What are common roles and responsibilities? (Sub-question 2)	• Exploratory semi-structured Interviews	Convergent mode to present data and define the aimed results.
2	**Develop**	• How can this model support the circular transition? (Sub-question 3)	• Practical Semi-Structured Interviews • Reference Projects	Divergent mode to study different options and present findings in the model.
	Deliver	• Will it have an impact on policymakers and deciding parties? • How can it be of use and to whom?	• Reflection interviews	Convergent mode to iterate, visualize and rate the model based on barriers and opportunities.

2.2.2   Conceptual Framework

In this section, the goal is to understand the relationships between various stakeholders that are in direct involvement with material passports. Eventually, a theoretical framework is developed based on details from tender documents regarding different project delivery methods. Sub-questions 1 and 2 will be answered through the Literature study and semi-structured interviews' parts.

The **literature study (Discover Phase)** initially defines all the terms and concepts that are essential through market and user research by managing information. Further links and relationships are emphasized to fully understand how several stakeholders are involved. Additionally, key drivers and barriers that affect the usage of material passports in project phases from different stakeholders (Technical, Organizational, Cultural, Market, Technological, Educational, and Legal points of view) are further explored. Finally, a better understanding of the responsibilities for data governance is further elaborated on. Data that is required for this part was referenced from existing literature from TU Delft Repository and Google scholars, mainly from journal publications, research articles, books, and previous thesis documents.

Based on the conflicts and barriers perceived in the literature study and publications, further guidance has helped investigate an effective procedure to construct the framework for different areas where opportunity is available based on the **explorative semi-structured interviews (Define Phase – Appendix D)**. This stage represents the defining stage that is essential for project development and management. Given the interviewee's expertise and knowledge, new approaches are integrated to further divide and have a clear overview of the responsibilities amongst stakeholders.

Table 2. Summary of the Explorative Interviews

Date	Interviewee	Organization	Role
11th June 2021	**Pablo van den Bosch**	Madaster	Director and Co-founder
16th June 2021	**Marijn Emanuel**	Stichting Adviseurs Madaster	Senior Advisor Co-Founder
16th June 2021	**Olaf Blaauw**	CB'23	Advisor and C-creator
1st July 2021	**Jaap Bakker**	Rijkwaterstaat NEN	Advisor Asset Management and Data Integration

2.2.3   Empirical Research

Once a clear framework was defined to divide the responsibilities and tasks based on different project delivery methods, the empirical research has helped investigate links between theoretical findings and data that will be collected from different projects in the Netherlands **(Develop Phase – Visual Management and Development methods)**. The end goal was to come up with a framework that links responsibilities to actors involved in different stages of the project lifecycle.

Initially, **case studies** were conducted on the two main project delivery methods: Traditional and Integrated types of contracts from the Dutch Construction Sector. The case studies helped

investigate causal relations between the stakeholders and determine how the responsibilities may be further divided throughout different construction phases.

An assessment of the end-deliverable and applicability of the framework was developed. Furthermore, **interviews** have assisted in deducing a set of criteria that provides a review and an assessment of the framework developed. Finally, the framework has defined a data governance approach that can best optimize the re-use value based on the links found between actors in the literature part.

2.2.4 Results

This part helps examining the effectiveness of the framework proposed and its applicability to projects in the Dutch construction sector through a Reflection stage by checking its feasibility through experts. To test the proposed framework, the study will be assessed through the set of criteria collected from the previous stages that will help provide future recommendations based on the given data available while conducting interviews with policy-makers from the practical and theoretical fields.

The results deliver a new set of arrangements for the responsibilities under forms of interventions that are in line with governmental and contractual requirements. A better understanding of the escalation of conflicts between the stakeholders that are in direct involvement with material passports was further elaborated on. Furthermore, enablers and barriers that have an impact on the framework and the division of responsibilities have brought in modifications for the proposed framework. Finally, examining the effectiveness of the framework and its applicability to projects in the Dutch construction sector was essential through a Reflection stage. This would help gain a better understanding of the conflicts by leveraging the data present to meet and exceed ambitions across the full lifecycle of procured entities. The usage of material passports will limit the continuous reliability of linear practices through laws and regulations in public policies; an essential transition to meet EU's sustainability targets by 2050.

2.2.5 Limitations of research methods

The conducted research is subjected to various limitations in the pre-research phase that have an impact on the conclusions, as listed below:

- Optimization of responsibilities is a new and recent type of study that may be affected by the **limited number of publications** in this field, as most of the studies conducted so far are from Madaster and CB'23. This limitation is an opportunity to understand literature gaps in this field of research and is necessary for future research possibilities.
- The **choice of the case studies** that have been conducted in the empirical research part needs to stay within the scope of the research. Few projects/organizations were selected to research with the time frame and the connections at hand as this would give rise to uncertainties in the conclusion events.
- The **criteria and experts that have helped evaluate the framework** were not decided on beforehand for reflection. Once a clearer overview of the framework is proposed the project may be chosen.
- Finally, relationships and interviews that are analyzed throughout the research are mainly conducted in the Netherlands, and a limitation is its applicability in the rest of the world.

2.3   Research Outline

Figure 3 summarizes the process that will be followed throughout the research period based on the scope and methods used and Figure 4 shows an overview of the topics that will be covered throughout the main chapters of the Literature section.
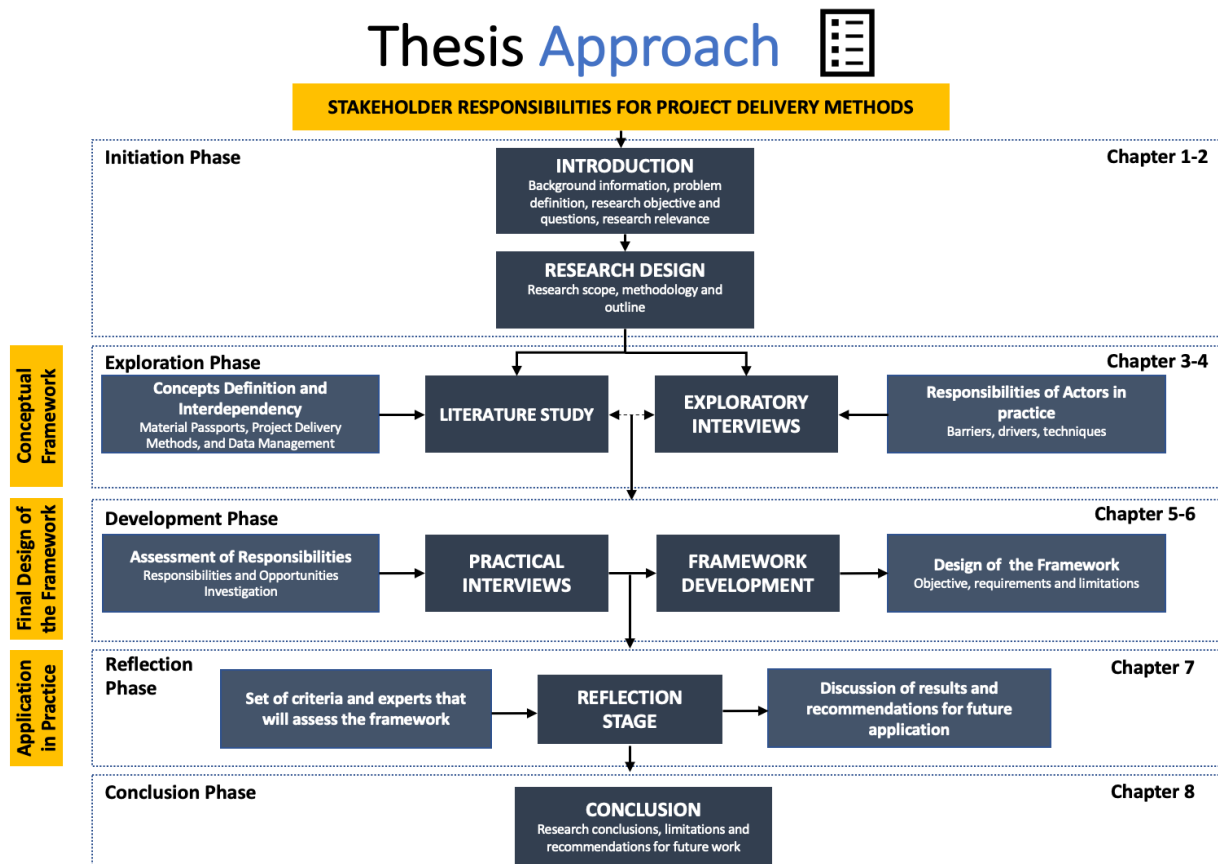
Figure 3. Research Outline
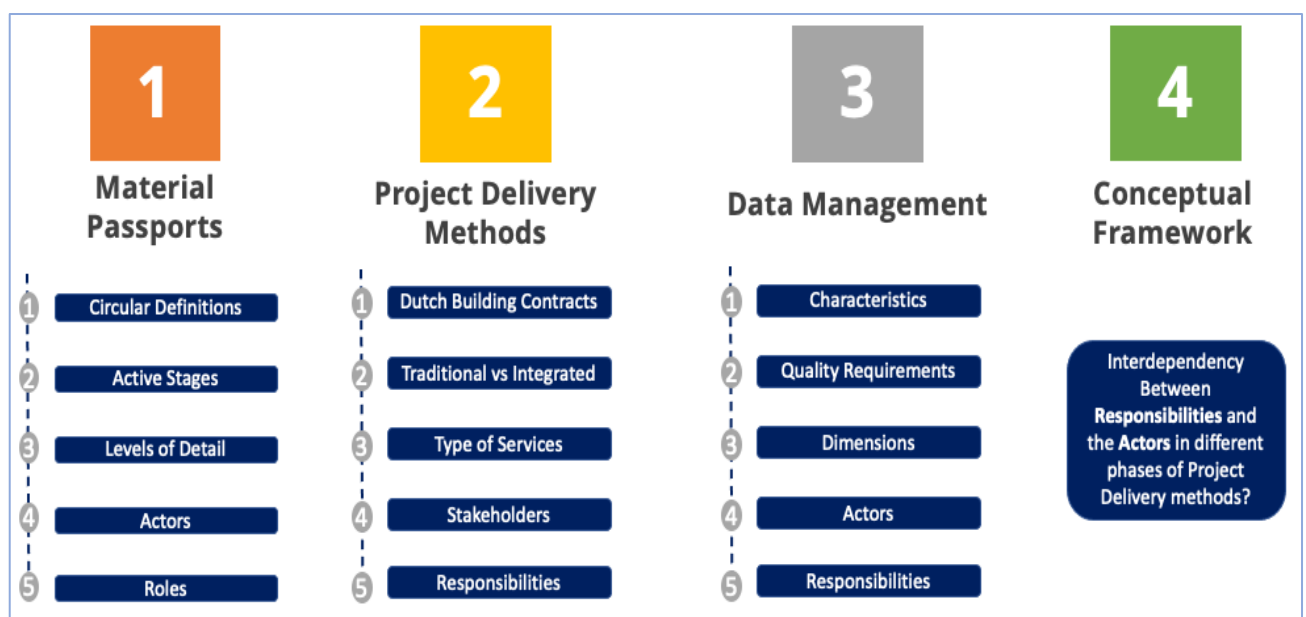
Figure 4. Main sections of the Literature study

3. Literature Study

The chapter discusses literature studies explored based on the research sub-questions proposed to provide an understanding of the main concepts. The theory that was necessary to explore throughout the graduation research of circular economy and re-use value is elaborated on. Several definitions were considered in some cases as subjective and could be interpreted differently by various readers. Appendix A elaborates on those definitions to set a common ground for understanding and using those definitions. The aim of this literature study is therefore to provide a common understanding and setting the ground for this research.

3.1 Circular Transition

Projects have been moving into a sustainable environment while being in line with the European Green deal and the EU's commitment to making its economy sustainable by 2050. A linear construction economy typically procures, implements, and produces waste material from construction projects. The integration of circular economy concepts into the construction sector promotes an enclosed circulation of material used with an extension of their service life. Public authorities have increased their incentives to procure in a circular economy to contribute to a supply chain loop of materials. The European Commission regards that a circular economy would eventually boost competitiveness while creating innovative opportunities and business prospects (European Commission, 2015). Currently, problems arise from the scarcity of natural resources mainly due to the pressure from population growth. It is estimated that it will reach almost 9 billion people by the end of 2050 (Antink et al., 2014), hence, the inevitable transition towards a circular economy. The following sections elaborate on the differences between linear and circular models. A deeper understanding and definitions have outlined the boundaries of the Circular Economy while providing what are the strategies and levels that could be integrated in a such case.

3.1.1 Linear and Circular Economy

To the present day, the linear model is also known as "Take – Make – Dispose" is the most widely used model worldwide (Prins & Mohammadi, 2015). Its economy revolves around reserves of raw materials that end up becoming unusable waste. This model has shown that throughout the years it has fulfilled a successful generation of material wealth up to the 20th century. According to Ellen MacArthur Foundation (2013), it has been demonstrated that there is a diminishing trend to implement a linear model for future projects.
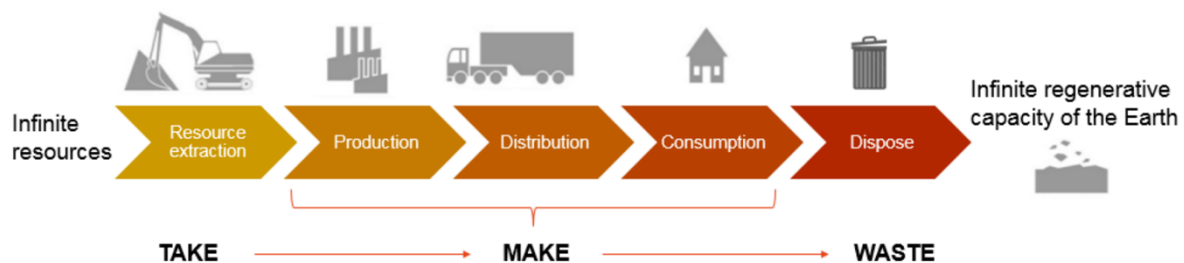
Figure 5. The linear Economy: Take - Make - Waste (Wautelet, 2018)

There is rising recognition of the problem at hand regarding social, economic, and especially the environmental impact of the linear economy among the public and the private sector (Wautelet, 2018). Governments are aware that the linear economic model is becoming more unsustainable and will present risks and threats to the worldwide resource allocation and supply chains as shown in Figure 6 below (BBC, 2012). The need for an alternative to the traditional model has led to the introduction of the concept of the circular economy.
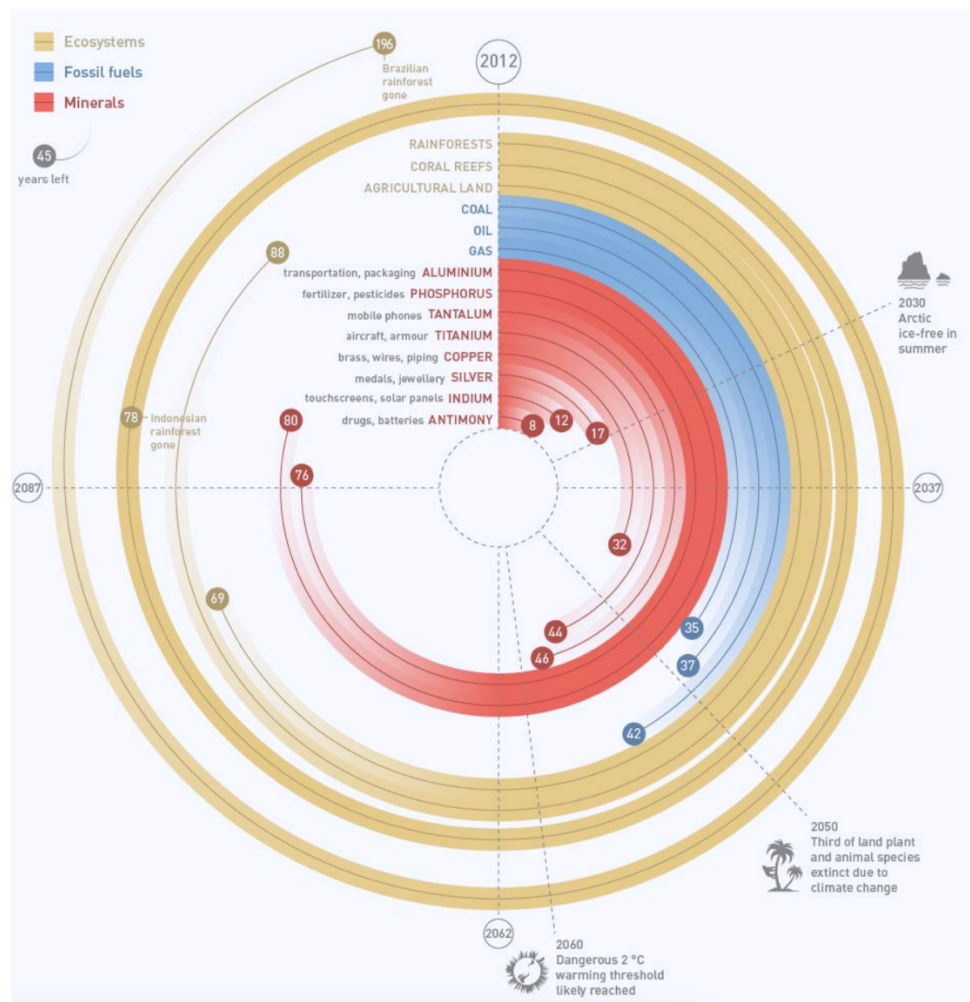
Figure 6. Global Stock Check (BBC, 2012)

To make this transition a possibility; solutions are ought to be present in face of the challenges that are rising. Therefore, the effective usage of our natural resources will require a paradigm change in the way we produce and use goods through the application of the Circular Economy model. The phrase of Circular Economy had deeper roots in the 1960s by many scientists and researchers (Sariatli, 2017). According to CB'23, the Circular Economy is pre-defined as an economic system that aims to optimize the use and the value of the resources while avoiding environmental and societal impact (Platform CB'23, 2019b). (Ellen MacArthur Foundation, 2015) mentioned that the Circular Economy should not be treated as a new concept, rather as a framework, a generic notion by which the notion of circular revolves around a set of principles. It was referred to as a restorative economy model to eradicate waste through proper design strategies as shown in Figure 7.
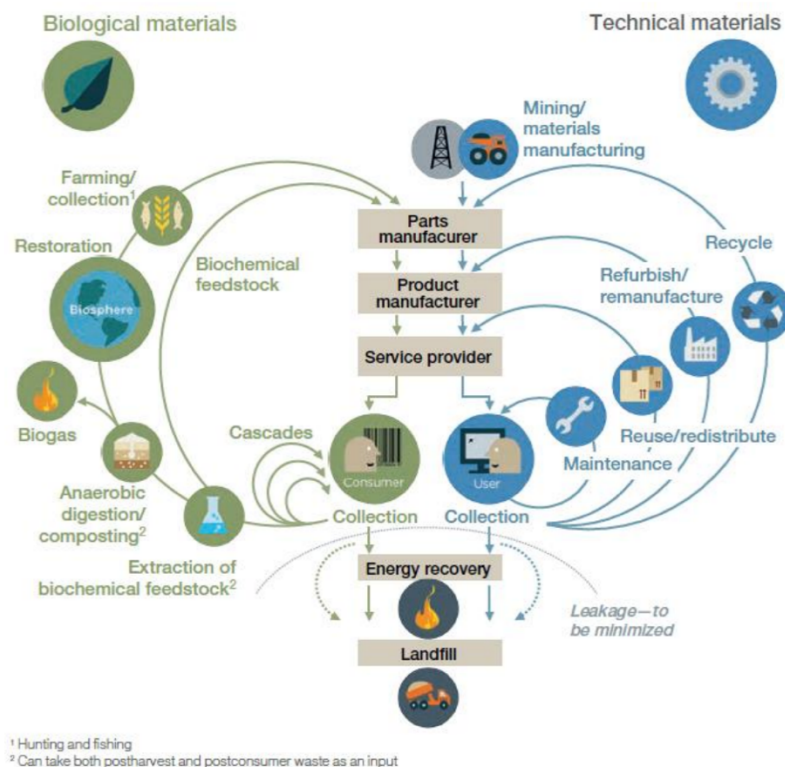
Figure 7. Design Strategies of the Circular Economy (Ellen MacArthur Foundation, 2012)

The butterfly model (Ellen MacArthur Foundation, 2012), reflects the concept of circular design strategies for two cycles: Biological and Technical Materials. The Biological cycles show that all the waste generated from this sector will have a flow of renewable materials, from which the renewable substances are restored and renewed. While the second strategy regards materials that are repaired and further re-introduced in the technical cycle. This distinction has been made between the two cycles since an inter-exchange of materials is not possible based on the main characteristics of the Circular Economy (a green economy that provides a diversity of materials while minimizing the amount of waste generated).

3.1.2 Strengths, Weaknesses, Opportunities, and Threats of the Transition

From a conceptual point of view, several benefits are relevant for the transition to happen from a Linear to a Circular Economy. The circular economy is intended to provide a social and economic benefit following its environmental effect (Sariatli, 2017). The benefits of this transition are not only limited to the restriction of waste generated or minimizing production activities but to provide a closed-loop economy for exchanging materials. The economy will therefore make a shift towards an innovative and efficient process that may be associated with its potential growth. Several benefits that could be stated from the transition are a reduction in the volatility of prices, material cost savings, and the creation of employment opportunities (de Wolf et al., 2018).

A comparative analysis between the Linear and the Circular economy was conducted (Sariatli, 2017) using a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats). It is essential to point out that each model has its strengths and weaknesses. Though, there is a constant need to coop with a series of hardships for this transition to happen. It implies that more waste and organization will be expected.

Moreover, awareness of this transition by governments is at a minimal level (Sariatli, 2017) and there is a need to set certain values that may assist in scaling present and future needs based on the SWOT analysis summarized in Figure 8.

STRENGTHS	WEAKNESSES
- Proficiency of material flow cycle is a potential for a **competitive edge** - Reduction in **resource dependence** through the elimination of waste - Less exposure to **price fluctuations** of materials due to the closed-loop process - **Efficiency** in using materials from a value and volume perspective	- Lack of **internationally recognized standards** institution to monitor the sector (Circular Academy, 2017) - **Low investments** regarding the transition from both public and private sector - Lack of **social marketing campaign** that promotes the applicability of Social Economy
OPPORTUNITIES	THREATS
- Designing for a higher quality of material - Provide access for better and cheaper materials - Economy savings through a reduction of material consumption needed - Provides business opportunities for enablers to cross-sectoral challenges	- Difficulties in managing whole life cycle of a material over a long period of time - Transition will require a strong collaborative effort from all market users - Sequential financial disruptions may cause high complexity and interdependency of the sector (Van Ewijik, 2014)

Figure 8. Summary of the SWOT Analysis (Sariatli, 2017)

3.1.3 Existing Circular Strategies

An enclosed circulation of products and construction materials forms the basis of the Circular Economy. PBL (The Dutch Environmental Assessment Agency, 2018) proposes10 different strategies that were integrated into the Circular Economy as the Figure 9 depicts, also called the 10 Rs. The following approaches have been integrated to increase circularity while aiming for less resource dependency and material consumption in the consumption and supply chain (PBL, 2018). The figure describes that low R# strategies (Such as R0 and R1) will ease decreasing the consumption of natural resources, by that increasing circularity degree, even if no material was reused or recycled for another lifetime.
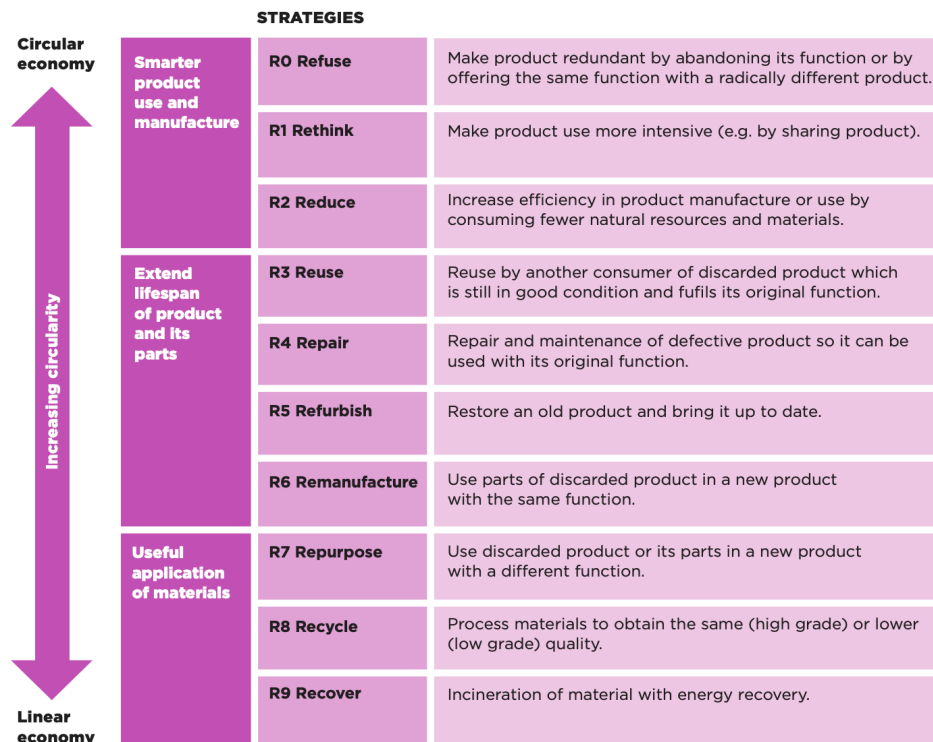
Figure 9. The 10 strategies to promote circularity (PBL, 2018)

The Re-use option (R3) for construction products and elements is a treatment method that is applicable to ensure the closed-loop circulation of materials. Examples that could be stated in the construction sector could be products such as doors, that can be re-used as a door for another project. In Figure 10 of an integrated strategy (PBL, 2018), the essential actors and connected strategies that play a major role in the production chain are shown.

For instance, the re-use strategy was defined as an operation by which products that are not wasted can still be used for the same purpose they were produced for in the first place (Platform CB'23, 2019b). Other strategies are relevant to use to diversify the options available for the Owner.
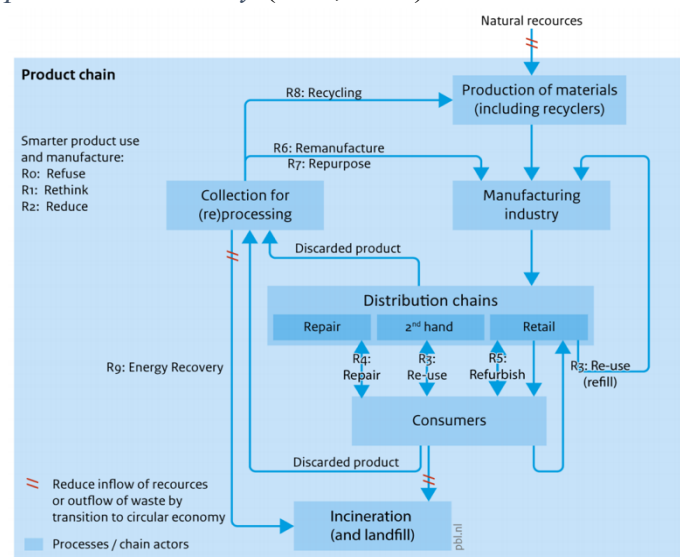
Figure 10. Integrated Strategies within the Production Chain (PBL, 2018)

3.1.4 Circular Levels and Business Model Strategies

The levels of circularity from a construction perspective of an asset is the composition of systems that support the main functions of the asset, in other words, components that are necessary for the system functions such as insulation or finishing. Hence, a building asset is further decomposed into (I) Systems, (II) Components, and (III) Elements (Durmisevic & Brouwer, 2002). From a hierarchical point of view, multiple elements that come from can make up a component, a variety of components represent a system, and the collection of systems represent the building itself (Quinn, 2010).

As mentioned previously, the Circular Economy is composed of one major supply chain market, in which, several actors within the construction process are designated as suppliers.

Accordingly, the transfer of goods from one actor to another that aims at promoting a closed-loop market shows that most users are called suppliers. A clear representation of the relations and this organization was further developed (Prins & Mohammadi, 2015) as shown in Figure 11. It presents three different **categories of goods** that can be distinguished for supply purposes as the following: (I) Products, (II) Components, and (III) Complex Components. The supply categories are managed by **three main actors**: Extractors, Assemblers, and Consumers.
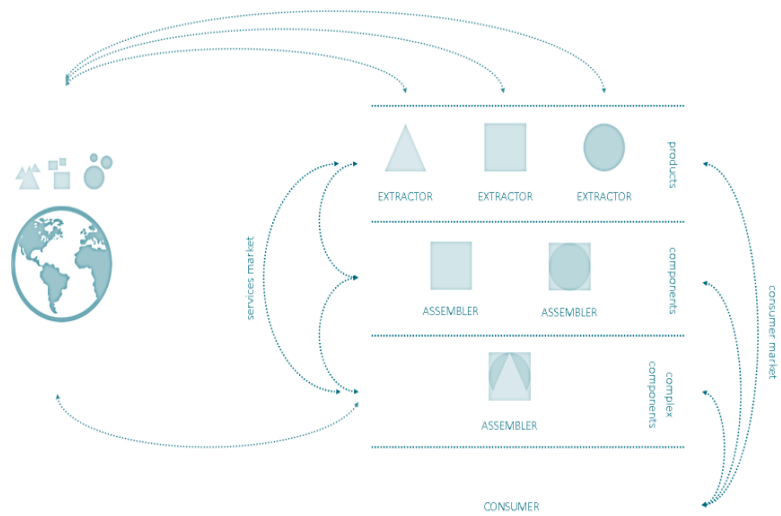
Figure 11. Market Composition for the Circular Economy

(Prins & Mohammadi, 2015)

3.1.5 Conclusions

Despite its growing popularity in both public and private sectors, the concept of Circular Economy is still criticized and faces multiple challenges to this day. Two main challenges are its **achievability** and its **social dimension**. Achieving a full closed-loop for material exchange means that the economy will require a 100% circularity degree. Accordingly, this would require zero losses from material production, zero raw material inputs, and an endless number of loops to make sure that products can fulfill their purpose for multiple lifecycles. Hence, those conditions appear to be radical and limitations to the first challenge presented (Mentink, 2014). Furthermore, another challenge facing the applicability of a Circular Economy is its social dimension. The concept of Circular Economy was criticized by the Ellen MacArthur Foundation in a way that ignores social issues such as equality, fairness, and health distribution while seeking environmental and economic benefits. Thus, it does not question the idea of economic growth since it is trying to limit material consumption.

Contempt of the challenges and limitations present in regard to the Circular Economy, the implementation of a closed-loop of material circulation will promote effective use of the natural resources and provide more room for opportunities. In the meantime, it **is more** about promoting the importance of a Circular Economy if all actors embrace circular thinking. The Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2012) has identified **four fundamental blocks** that will ease the transition towards a circular economy. The blocks are defined to combine the strategies that were presented earlier in the Butterfly model of Figure 7, which includes both Biological and Technical Materials as shown in the following Figure 12.
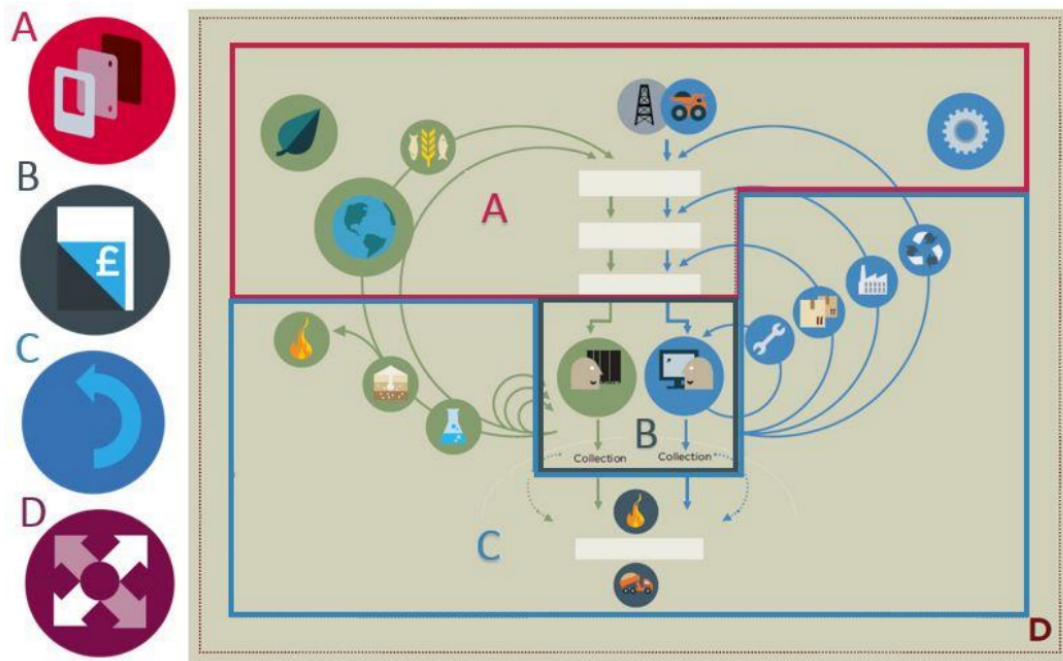
Figure 12. Four main building blocks of a Circular Economy (Ellen MacArthur Foundation, 2012)

(A) **Circular Product Design and Production** could be improved to reduce the costs of material selection, treatment, and production without compromising the material integrity and function. This could be best optimized through standardization, better quality of design, easily dissembled type of material, and an efficient production process to reduce waste.

(B) **New Business Models** aim at providing more attractive value propositions to promote competitiveness against linear products while taking into consideration the needs of the value chain's participants.

(C) **Reverse cycles and cascades** discuss a better quality of treatment systems that are user-friendly and will provide an effective collection plan.

(D) **Enablers and favorable system conditions** through effective cross-sector collaboration and R &D activities that may assist in promoting it through public awareness campaigns. Additionally, responsibility is laid for policymakers to come up with a suitable set of international rules.

To conclude this section, the Circular Economy presents new approaches to the construction industry. It is in line with the growing demands for natural resources while being compatible with the public and private interest once competitive and strategic frameworks are best optimized. However, the transition from a Linear Economy to a Circular Economy is beyond the concepts of supply efficiency and minimization of waste. It will eventually require a "paradigm shift in the way things are made" (Preston, 2012), or an eventual change in the mindset. Ultimately, this transition is not essential, fundamental and does not impose an unrealistic change of the supply chain and the different actors accordingly. The solution to this problem is proposed by the implementation of Material passports in the Construction industry. The material passport is a method that documents the construction element: "Material without an identity is waste" (Pablo van den Bosch, Appendix D: *Interview*). The next section of the chapter discusses how Circular Economy transition could be achieved using Material Passports.

3.2   Material Passports

One of the strategies that facilitate the transition towards a Circular Economy is the application of Material Passports. According to CB'23 (Platform CB'23, 2019b), a material passport, or a "passport for the construction sector", is defined as a digital tool that documents a construction element. It states the ownership of the material and its sub-parts while presenting the purpose of the material from both qualitative and quantitative aspects. Additionally, material passports aim at measuring circularity for building components to facilitate minimal use and re-use of raw material throughout the lifecycle of the construction project (Potting et al., 2017). The following sections elaborate on Material Passports and the stages at which passports are mostly active in a construction project. A deeper understanding outlines the main actors that benefit from the use of material passports with their corresponding roles.

3.2.1 Material Passports

The versatility in measurement methods for circularity has led to higher investment costs for development while providing an imprecise criterion of how the degree of circularity is being measured from one project to another (Ellen MacArthur Foundation, 2013). Therefore, a harmonized measurement method of circularity that is broadly supported will provide a consistent approach for measurement and comparison. For this to be accomplished, data of built assets should be collected and perfectly managed.

The standardization of material passports will provide a good foundation to achieve an organized way for data collection. The primary goals of the material passports are **upcycling materials**, **reduction in raw materials** consumption, and the **reduction in waste** generation as described by CB'23 (Platform CB'23, 2019b). Moreover, the planned timeline of passport usage is following the EU's commitment to shift towards a 100% circular economy by 2050, the timeline proposed was drawn up by CB'23 as shown in Figure 13.
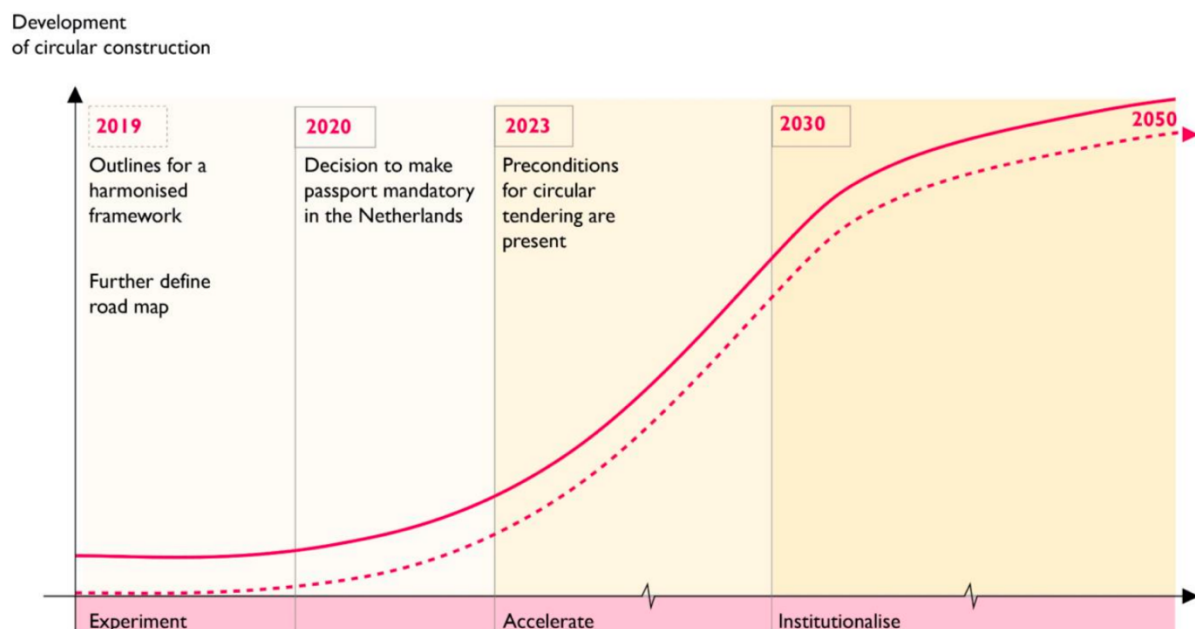
Figure 13. Timeline of Material Passports in the Netherlands (Platform CB'23, 2019b)

According to CB'23 (Platform CB'23, 2019c), the datasets of built assets are divided into several levels to scale and different passport versions that are briefly summarized.

- Passport for the Structure or an Object
- Passport for an Element, Construction Part, or Component
- Passport for Part or Construction Product
- Passport for Material
- Passport for Raw Material

Hence, the list goes from a low to a high level of detail, with the passport for the Structure representing a combination of passports that are established at lower levels (Platform CB'23, 2019b). This "pyramid" representation of material passports is structured to be under the NEN 2660 (Information system for the building field) and the NTA 8035 (Semantic modeling of information in the Built environment). These national standards will dictate a clear structure of the material passports for an effective application of passports (Platform CB'23, 2020b) in the construction industry and are further discussed in the next sections. Additionally, the passport's lifecycle follows four main phases, also known as the active stages of the passport (the **Production** phase, **Construction** phase, **Use** phase, **Demolition and processing** phase) that are further elaborated on in section 3.2.4 of this Chapter.

Different stakeholders have various needs of use for a material passport. For instance, building owners require the information regarding ownership rights, while consultants and contractors use material passports to get better estimates in maintenance planning tools. The transferability of data amongst stakeholders is essential for the following functions (European Parliament & Council of the European Union, 2008).

- Enables high-quality material re-use while elaborating on its conditions and lifecycle.
- Delivers insights on how the object can be disassembled.
- Insights on what changes/repairs the material has undergone during its lifespan.
- Provides object-related maintenance instructions to ensure functionality.
- Delivers basic information on a multi-year maintenance plan and cost of ownership.

3.2.2 Storage and Exchange of Data

Information for material passports is drawn up throughout its whole lifecycle, hence, service-life planning is used to keep the passport updated. The 7 different constituents of material passports have been identified, ensuring value creation while avoiding repetitive information. Nevertheless, complexities lie in interpreting small levels of details by the passport holder in bills of quantities of large-scale construction projects. A variety of data will provide further information detail on the materials, however, the indication of subdivisions is considered as complexity in itself. On the other hand, the lifecycle formed a basis to generate a Passport Matrix that elaborates on the different object scale levels based on the phases of the lifecycle. Passports are constructed in a "pyramid" form in which information at a higher level is made up of objects of underlying scale levels. It consists of static elements such as snapshots, performance recordings, planning applications, handover, mortgages, and insurance. The overall constituents of a material passport according to CB'23 are (A) **General** information, (B) **Composition** of the object, (C) **Properties** of Construction products, (D) **Connections**, (E) **Certification** and marking, (F) **Verification and Validation** Documents, (G) **Other** elements.

Data storage and exchange through the usage of material passports provide a further understanding of agreements and points of attention for future development. Figure 14 shows the cycle involving the material passport throughout different construction phases. It depicts

that there is a missing data system at the end of the project lifecycle that promotes material re-use. Hence, this stage provides an opportunity for data management by dividing the responsibilities for data management and governance.
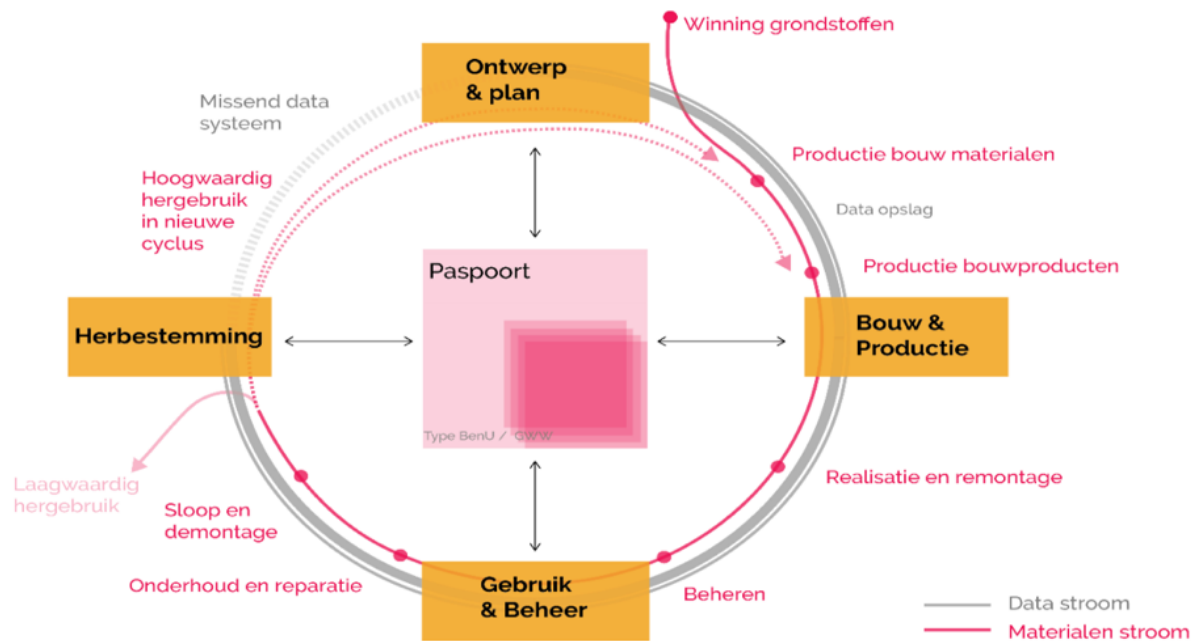
Figure 14. Material passport's data storage through construction phases (Platform CB'23, 2020b)

3.2.3 Levels of Detail and Data Management Opportunities

According to CB'23 (Platform CB'23, 2020b), there are four main levels of detail, ranging from B1 to B4. Information is classified as private and cannot be shared with all passport users in some cases. These roles include **Guests** that have access to general information; **Users** have further access to scale levels; **Administrators** can create new roles and lastly, the **System Administrators** will act as security officers. Values computed for different levels of details that are suitable for the measurement methods range as the following:

B1: Clarity about the material used (e.g., wood).
B2: Generic clarity on the product of the material (e.g., beam).
B3: Specific clarity on the product (e.g., dimensions, safety standards, and recycling information).
B4: Specific data with the supplier and producer information.

Stored information of material passports is needed to keep the closed-loop circulation of materials. Hence, the data needs to be accessible for the parties that need this information. However, some material information is stored for the sake of secrecy which would eventually present a barrier for exchanging material information. In some cases, material information in the form of compositional information is considered competitive knowledge (Heinrich & Lang, 2019). Nevertheless, these cases may be partially transparent by not mentioning the full details of the material's composition as the end-users are solely interested in crucial information regarding a beneficiary or harmful substances in the material. Recent development has shown (Heinrich & Lang, 2019) that an alternative is possible by using a third-party trustee such as Madaster. The party will have access to the information and is only capable of concluding based on their previous knowledge in the field of material passports. This raises concerns about

the stakeholders involved in the process and their opinion on transparency in the application of material passports in the process of the circular economy.

For the transition towards a circular economy to work effectively, most of the stakeholders and parties involved in the process will have to be involved. As previously mentioned, the digitization of material information through the application of material passports will provide a central space for the BIM model for data exchange. However, the data generated for an entity is only transferred over before the commissioning period and rarely after handing over of the building. Hence, for this process to work effectively, information needs to be handed over and updated over all the lifecycle of the building whenever changes occur to the building asset.

New functions in construction projects have emerged recently that will help identify different roles to divide the roles amongst actors (Ellen MacArthur Foundation, 2015). For instance, in the operational phase of a building, changes need to be constantly fed in the model that will help to have an integrated approach while potentially reducing future costs. On the other hand, whenever big changes will undergo a building, the model needs to be updated by the responsible engineering firm and planners who will keep on updating the model. It is important to notice that having a constant information flow is crucial for having accurate information from material passports. This detailed documentation from using material passports provides prospects to exchange, lease or sell the material in question through national trading platforms. The main aim of using a centralized BIM model is to avoid having multiple data entries for the same unit. This way actors may have access to the model to a certain extent. With the shift towards sustainable development, roles will start emerging based on the market demand that will make sure all the information of the material passports are up to date and constantly being monitored throughout the material lifespan (Madaster, 2019a). Additionally, other relevant actors that might be of importance for this process are banks, project developers, material traders, administration, insurance companies, and others. Ensuring that the quality of the material is correct will provide an opportunity for private condition assessments companies and consultants to enter the market.

3.2.4 Active Stages and Lifecycle of Material Passports

As previously discussed in section 3.2.1, the four main active phases for the material passport are:

- The **Production** phase consists of activities such as extraction of raw material, manufacturing, and assembly.
- The **Construction** phase refers to the designing, planning, and implementation phase.
- The **Use** phase refers to the maintenance, repair, replacement, or renovation activities.
- The **Demolition and processing** phase constitutes dismantling, disassembly, processing, and landfill activities.

In accordance, once the building asset has fulfilled its purpose, the **new cycle** begins to sketch a new material passport. This last phase or the end phase is not taken into consideration as a part of the active stages. The end phase will be considered as one of the 10'Rs activities that were previously discussed in Figure 9. Moreover, there are three main levels of scale for material passports: physical space, objects, and raw materials. Raw materials constitute materials and raw materials; the physical object represents an element, building part, or a component. While a physical space represents a road segment or a full network.

The most fundamental principle for the successful application of material passports is the continuous monitoring activities of the material passport throughout its lifecycle. It is of high importance to keep the data up to date to settle a reliable space for data exchange. The

Level of scale		Production Extraction etc.	Implementation Initiation etc.	Passport up to date	Use Maintenance etc.	Passport up to date	Demolition Dismantling etc.
Physical space	Level 1	o	o	X	X	X	o
	Level 2	o	o	X	X	X	o
		o	o	X	X	X	o
	Level n	o	o	X	X	X	o
Physical object	Level 1	o	o	X	X	X	o
	Level 2	o	o	X	o	X	o
		o	o	X	o	X	o
	Level n	o	o	X	X	X	X
	Material	X	X	X	X	X	X
	Raw material	X	X	X	X	X	X

Figure 15. Passport active stages and requirements (Platform CB'23, 2020a)

In the table presented by CB'23 (Platform CB'23, 2020a), the crosses (x) represent moments for which data needs to be recorded to fulfill the requirements, and the circles (o) present situations that are less relevant for data monitoring. The table compares moments that represent the four active phases that were previously mentioned with two check-up stages that come across different levels of detail that were emphasized in previous sections. Accordingly, material passports need to be updated at those stages based on different levels of scale. The levels of scale are further mentioned on the left side of the table ranging from Physical space, physical object, and materials that can be represented as the Systems, Components, and Elements presented by (Durmisevic & Brouwer, 2002) from section 3.1.4

3.2.5 Conclusions

To conclude, perspectives and opinions regarding material passports differ to a great extent. There is a need to integrate sustainability for materials in more than one lifecycle through the 10'R strategies. The fundamental idea is that continuous monitoring through a proper division of responsibilities for users will provide benefits to form a proper data governance plan. Moreover, the market presents different approaches to deal with material passports.

In this chapter, passport constituents, levels of detail, timeline, and actors were discussed. It was noticeable that for competitive reasons, data should only be shared to a certain extent for some actors based on the four levels discussed previously. This separation will eventually create a barrier for users to update the data in a centralized shared BIM model. The main concern is the roles in updating and managing the data. Data monitoring for material passports is active in four main stages: Production, Construction, Use, Demolition and processing phase. Those stages are the moments for which data monitoring and updating are a necessity to provide an accurate result of the measured data for circularity.

However, parties change and vary along the full-time span of the project itself. Once a material cannot be re-used, it will be decomposed and can be used in future potential projects. This versatility in actors and stakeholders is due to the various methods of conducting construction projects, also known as different project delivery methods. The next chapter discusses what are the widely used Project Delivery Methods in the Netherlands and how actors differ from one method to another.

3.3 Project Delivery Methods and Dutch Building contracts

The definition of a contract based on the Dutch Civil Code (Article 6:213), is an agreement between two or more parties that enter a legal obligation towards each other (Chao-Duivis et al., n.d.). In which obligations arise from agreements amongst parties based on the values of reasonableness and fairness in a way that no party may attain a unilateral juridical act on the other party. Typically, there are two types of contracts used under different project delivery methods: The Traditional and the Integrated contracts. The following chapter elaborates on those types of contracts and provides a deeper understanding of different market models that are widely applicable in the Netherlands.

3.3.1 Traditional and Integrated Contracts

The traditional approach of the project delivery method is a two-phase contract. The two main contractual relationships are Client - Consultant (governed by the New Rules DNR 2011) and Client - Contractor (governed by the UAC 2012). Thus, there is an informal relationship between the Contractor and the Consultant/Designer that is not governed legally in any aspect as shown in Figure 16.
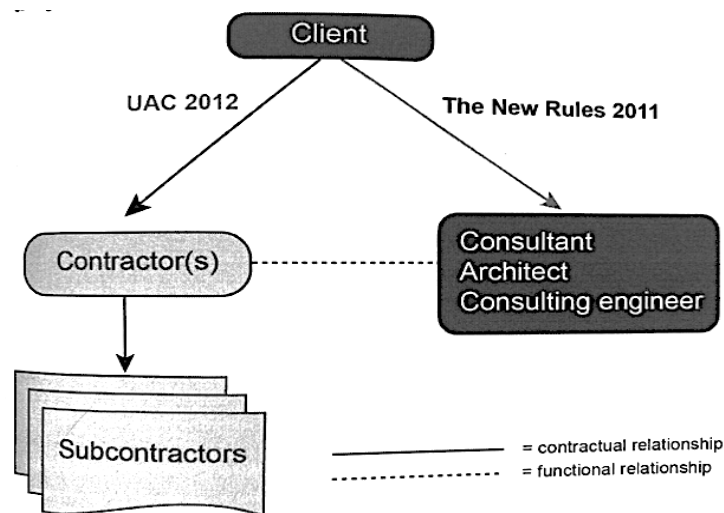
Figure 16. Representation of the traditional building process (Chao-Duivis et al., n.d.)

In this case, the Client has to cooperate to the best of his ability with the Consultant and the Contractor. The Client is responsible for providing information and data to the Consultant on time while having the duty to provide the Contractor with the design of works, orders, changes, and permits for execution. Meanwhile, the Contractor is liable for building materials, labor, plans, and sub-contractors used throughout the project.

On the other hand, the usage of **Integrated contracts** has increased recently in Dutch the Construction sector (Hobma & Jong, n.d.). Contracts entail that the design and the execution of the project are in the hands of a single entity that is in a contractual relationship with a client subject to the UAC-IC 2005 rules. These contracts may be referred to as Design and Build or Turnkey contracts widely used in the construction sector.
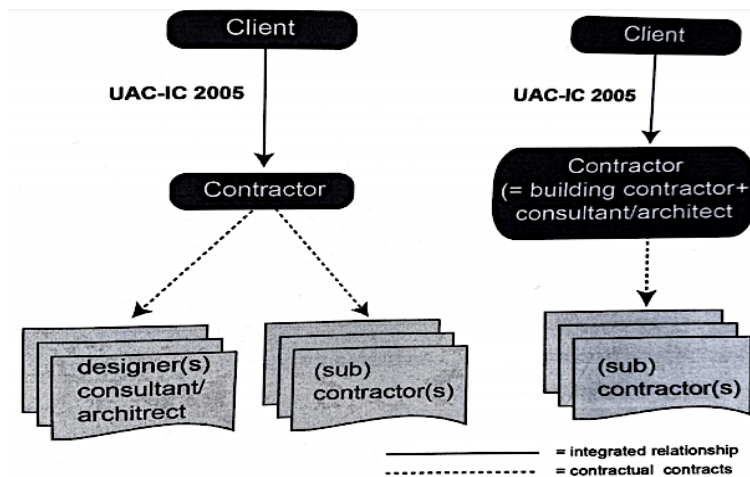
Figure 17. Representation of integrated types of contracts (Chao-Duivis et al., n.d.)

The standard basic contract that must be included in the annexes are an overview of permits, design work verification plan, acceptance plan, and the material released/handled (in this case related to material passports). Based on the contract law (Chao-Duivis et al., n.d.), the client has to provide the correct data for the contractor, cooperate to retrieve permits, and is directly involved with prescribed goods/ nominate suppliers. Typically, in an integrated form of contracts, the Client is not involved in the Design phase and ought not to be included in the selection of the suppliers and goods used for the project. Nevertheless, if the Client wishes to integrate material passports in a project, variations may still apply to the contract as this is laid down by the UAC-IC 2005 contract law. Hence, the Client may nominate a supplier or the usage of product with material passports in his project by either naming the supplier or stating a type of good that could be found through solely one supplier. However, the UAC-IC 2005 entails that the client is responsible if the goods are functionally unfit for the purpose as intended in the contract based on the Client's requirements. Data governance for material passports will eventually follow the EU Construction Products Regulation for quality assurance of the material from a legal perspective. In principle, the Client is directly responsible for the functional fitness of the prescribed goods.

3.3.2 Common Project Delivery Methods and Business Models

The two approaches for project delivery methods can be further broken down into several methods listed below:

- The **Traditional (Design – Bid – Build)** approach ensures a strict separation between the phases. The Client guarantees supervision, the Consultant is responsible for the Design and the Contractor is responsible for the construction. This method is highly sequential with a lower level of collaboration (Chao-Duivis et al., n.d.). A downside to this approach is not using the Contractor's expertise early in the project, or the design phase.
- **Design & Build** ensures that the Contractor is responsible for both, design, and the construction activities. This method promotes a cohesive and well-coordinated project execution. The Contractor will need to have a high technical ability to perform both tasks in-house as few companies can perform both. The Client will eventually have little control over the project as most of the risks will be shifted to the Contractor (Pakkala & Finland. Tieliikelaitos., 2002).
- The **DBFM** approach is like the Design & Build delivery method. However, a private party will also have to bear the finance and maintenance phases based on the contract period while presenting a thorough description of the goods and elements that are included in the project (Lenferink et al., 2013). DBFM contracts are distinguished from a traditional

contract by merging several project phases into a single contract with F representing the payment mechanism (Rezelman & van den Bosch, 2018).

- The **DBFMO** is a market-driven innovative approach that ensures long-term cooperation (Pakkala & Finland. Tieliikelaitos., 2002). The Client will eventually assign the Design, Construction, Financing, Maintenance, and Operations to other parties (all lifecycles except demolishing phase). This method guarantees that the quality of the material used is kept up to the standards since the maintenance phase is in the hands of the Contractor. In this form of collaboration, the contract becomes service-oriented (Castelein, 2018), while contractual responsibilities shift from the client towards the contractor (Chao-Duivis et al., n.d.).
- The **Alliance Model** promotes equality and transparency in the process of project development. All the parties are highly involved throughout the process of the building lifecycle as the risks are shared equally amongst the alliance. The client especially will be more involved in the design and execution phases compared to other models (Chao-Duivis et al., n.d.).

The definitions of project delivery methods show some characteristics to principles related to aspects of the circular economy. One of the principles indicates that producers of a construction product preserve its ownership, for which the client pays for its usage and not the possession (MVO Nederland, 2018). Thus, Alderman & Ivory suggested the need for a transition from the traditional design towards a service-orientated approach (Alderman & Ivory, 2010). Accordingly, Tukker & Tischner (Tukker & Tischner, 2006) divided the product-service system into three main categories:

- **Product-oriented services**: A business model aimed to sell products with the inclusion of additional services, more applicable in a linear economy. Examples of such a service would be the application of take-back guarantees, maintenance, and financing contracts.
- **Use-oriented services**: A business model that promotes the changing of ownership of products that remains with the provider. In other terms, the product is made available for use by several users (for instance, using lease agreements).
- **Result-oriented services**: A business model that focuses on performance by setting up agreements between the client and service providers. A shifting perspective from a product towards value content.

Consequently, Table 3 of different project delivery methods presents the following characteristics related to the application of the Circular Economy concepts.

Table 3. Characteristics of Project Delivery Methods (Hoezen et al., 2010)

	Traditional	Design and Build	DBFM
Specifications	Design-oriented typically	Product-oriented typically Use-oriented partially	Result-oriented typically Use-oriented partially
Scope	Construction	Design and Construction	Design, Construction, Finance, and Maintain
Selection Criterion	Price	Price, Design Creativity, and Constructability	Overall price and quality
Responsibilities of Contractor	None: must follow design specifications	Shared: have little influence over the design	High: flexible in the decision-making process if within the scope
Monitoring Roles	Ongoing, Client	Ongoing, Engineer/Architect	Ongoing, Contractor mostly, financers, and client.

3.3.3 Lifecycle and Project Timelines

Throughout the project lifecycle, delivery methods have different spans and constant changing actors at each phase of the project. Therefore, to properly maintain data for material passports, it is essential to understand for each delivery method the actor responsible for maintaining the data and how can the transfer of ownership of data be accomplished to retain re-use value.

According to Huizing (Huizing, 2019), several phases provide room for potential implementation gaps in contracts based on the project delivery method. The implementation gaps overlap with the active stages of material passports previously discussed in Figure 15 that will promote its successful application. This provides an opportunity to allocate different responsibilities for data management based on the users involved in the four main phases: Design, Construction, Maintenance, and Operation. Additionally, two check-up stages will be included in the process for the evaluation of data monitoring responsibilities that were mentioned previously. The corresponding Figure 18 illustrates the stages below.

Figure 18. Major activities in project delivery methods (Huizing, 2019)

1. **Initiation Phase**: Idea, Preliminary Design, Tender specification, and Contractor Selection
2. **Preparation Phase**: Design and Materials Acquisition
3. **Execution Phase**: Site preparation, and Construction
4. **Use Phase**: Operation, Maintenance, and Reconstruction
5. **End-Of-Life Phase**: Demolition, Dismantling, and Recovery of raw materials

Based on the active stages of material passports presented by platform CB'23 (Platform CB'23, 2020a), two check-up phases will be added to the process for data collection and monitoring.
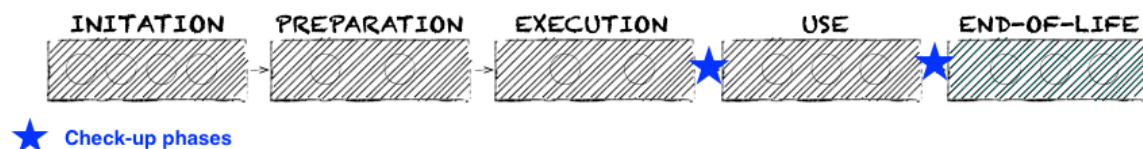
Figure 19. Check-up Phases for an integrated approach

The check-up phases target mainly construction components/elements, thus for a single asset, there could be multiple check-up phases for each project. Material passports focus on the lifespan of the asset. During this lifespan, elements are being replaced once they reach their economic, functional, or technical service life. Check-up phases will only be active for each construction element differently since each has a different lifespan. Hence, the multiple check-up phases will present throughout one project delivery method. However, the idea remains that once a component is installed in a building portfolio the check-up phase will be active for this component. Moreover, after the use phase of this component, another check-up phase is implemented.

By linking the timeline in project delivery methods developed by Huizing (Huizing, 2019) and the check-up activities that need to be covered based on a circular construction point of view, the plan proposed in Figure 20 represents an integrated project delivery method.
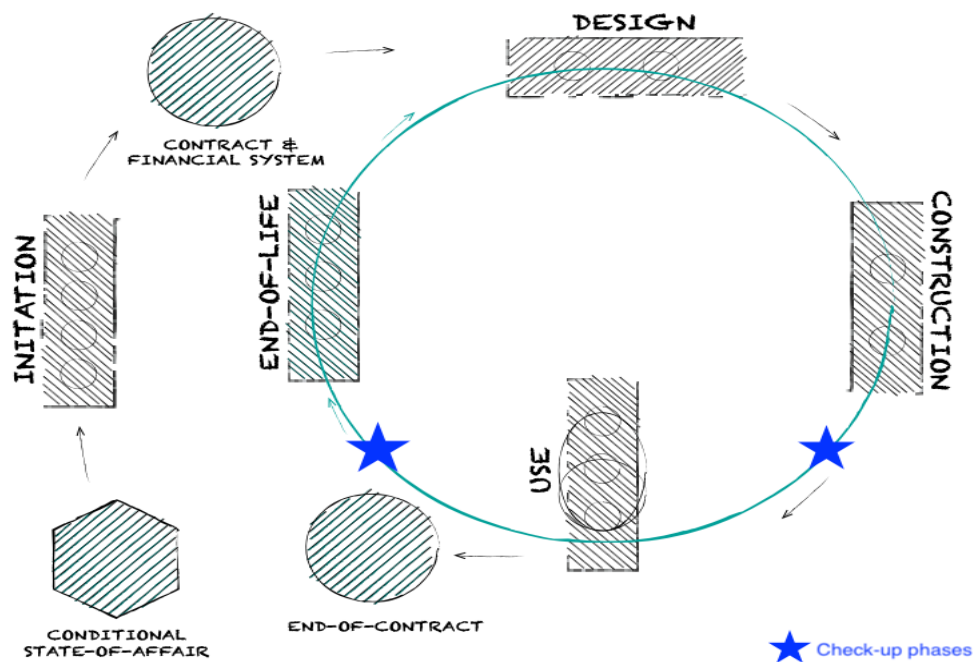
Figure 20. Circular Project delivery method timeline (Huizing, 2019)

3.3.4 Conclusions

Project delivery methods present an opportunity to divide responsibilities for data management and governance based on the execution method used. Stakeholders will vary across different methods for different timelines; however, an integrated approach was developed by (Huizing, 2019)) that marked the main elements that need to be covered through every phase. The phases presented in Figure 20 are four in total that are following CB'23's plans to update and monitor data in material passports.

Additionally, two check-up stages were included after construction and use stages of the material to present further opportunities for condition assessments and for reporting purposes to keep the data about material passports up to date. The next chapter discusses what are the main responsibilities that need to be covered in a data management plan throughout those project phases, to later explore who will be responsible for each task in the final chapter.

3.4 Data Management

Data Management is about making data available at the right time. However, common questions range from the definition of data, frameworks used to collect those data and what are common quality requirements for data collection. CB'23 Platform and Madaster have agreed on using one common approach for data monitoring (Platform CB'23, 2020a), the GEMMA Data Management Plan for material passports. In accordance, a list of data management tasks was recorded and included in the conclusion section based on different project timelines.

3.4.1 Characterization of Data

Data management refers to the set of activities that aim at providing the right data of the right quality in the organization at the right time (VNG, 2019). There are different categories of data, for instance, text input, images, statistical data, audio, administrative or geographic data. Consequently, a categorization was made between Structured, Unstructured, and Metadata (VNG, 2019).

Structured data vary from national key registers to data that are purely interesting to potential customers in a predefined format. Often, it is combined with data from other multiple sources. Accordingly, structured data is decomposed into *Basic registration data* (compulsory through governmental and institutional legislations), *Core registration data* (Designated as an efficient multiple-use collection method for businesses, employees, products, and services), *Sectoral data* (Domain-specific), and *Task-specific data* (Essential for the completion of the task and not relevant to customers). Moreover, **Unstructured** data presents information that does not have a pre-defined model and is neither organized in a pre-defined manner. Different types range from *Rich media* (surveillance, audio, and weather data), *Document collections* (invoices, records, and emails), and *Analytics* (Machine learning and Artificial intelligence). Another aspect in data management covering all categories of the Structured data format is the Geo-data, which are often treated separately based on location using coordinates by GEO-GEMMA. Finally, **Metadata** refers to data that delivers information regarding other data. Often referred to as "data about data" (Kwaliteitsinstituut Nederlandse Gemeenten (KING), 2012), it ranges from descriptive, structural, administrative, reference, statistical, and legal metadata.

The process of generating Material passports involves several parties that have access to information and will be based on the extent to which they are responsible for this information. Hence, Material passports can contain different sets of information from various sources. One aspect of the data secrecy used in material passports is to provide only the necessary data for the right party (Luscuere, 2016). For instance, a sub-contractor that will be responsible for maintaining the HVAC system requires different information from the user or the installer. Consequently, not all stakeholders will require this information at the same time, Luscuere (2016) argued that an architect may need this information in the early design phases, while a user will need is at the operational phase of the project.

3.4.2 Principles of Data Management

When it comes to exchanging data, achieving maximum interchangeability through communication and interaction is essential by the standardization of protocols and procedures for data exchange (reference). According to VNG (VNG, 2019), basic principles refer that (1) data is a business asset, (2) it is shared, (3) is processed by laws and regulations. The following are the main principles for proper data management:

- Following **regulations** to promote the principle of multiple uses of data
- Promote data **sharing**
- Enable a high degree of **flexibility and availability**

- Increase the **quality** of data
- Guarantee data **confidentiality**
- Facilitate **feedback** on the information
- Create **awareness**

3.4.3 Data Governance

Monitoring the correctness of data offer future possibilities for improvement in the circular economy. In this case, the CB'23 action team has proposed using the Dutch national government's Data Governance wheel for data structuring shown in Figure 21. Passport's specifications will be in accordance with the following organizations and official libraries:

- **CB-NL**: The Dutch Library of Concepts
- **IMBOR**: Public space information modeling
- **IDS**: Information delivery specifications
- **Key Register of addresses and buildings**
- **NORA**: Government Reference architecture
- **GEMMA**: Municipal Model architecture
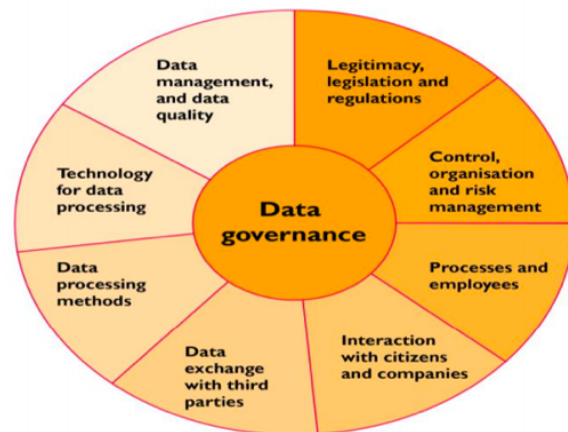
Figure 21. Rijkwaterstaat's Data governance wheel

Eventually, different links may be created between domain-specific libraries based on national standards that will allow a web of correlated datasets (Platform CB'23, 2020b). However, accurate data provide further value to the product in question. Currently, the sector is known to have a lack of data and its quality which would impact the transition towards a circular economy. Recommendations from the CB'23 platform have shown that to maintain good quality and completeness of data, sketching a Bill of Materials (BOM) for both existing and new developments is essential. This way, keeping track of material and its quality is done based on a comparable instrument and must be updated for every maintenance, renovation, and future works in the building.

By organizing the data, material passports will have to comply with the standards that are proposed by CB'23. So far, the Netherlands is lacking the standards and rules that dictate the composition of material passports: there are different alternatives for which a passport can be sketched. The challenge is to organize an efficient process to monitor and collect data for material passports. Data must be made available in a flexible, secure, and transparent process according to pre-agreed quality requirements. The GEMMA is a national framework for data management used in the Netherlands that divides the responsibilities of actors and their roles in the process of Data management (Kwaliteitsinstituut Nederlandse Gemeenten (KING), 2012). This framework can be altered to divide the responsibilities based on the tasks available in using a material passport. Additionally, GEMMA focuses on the whole of activities that are necessary to get the quality at the right time and is following the regulations and libraries used in the Netherlands.

3.4.4 Roles in Data Management

To set up a proper data management plan, agreements regarding functions, tasks, roles, and responsibilities need to be established. Roles within data management differ based on pre-existing functions and the time at which data is collected (VNG, 2019). The proper division of roles makes agreements explicit and connects different tasks. Some roles are pre-defined by law such as a Data Protection Officer (DPO) that is responsible for keeping the integrity of data collected and works for the municipality. The main **pre-defined roles** are shown in Figure 22 and show how data management is handled for the main actors.

- The **Client** also referred to as the manager of the facility, is responsible for the basic registration of data and information collected in a project.
- The **Source Holder** (Bronhouder) is responsible for gathering and keeping data to safeguard its quality regardless of the correctness of information collected based on the feedback received, they have control over which data is supplied to whom.
- The **Supervisor** is the party responsible for checking whether data collection goes according to the agreements and legislation. This supervision may be completed with periodic audits by external parties on behalf of clients, providers, and source holders (His role is referred to in Appendix E as a combination of a Security Officer, Regulations Coordinator, and Data Protection Officer).
- The **Customer** (User) refers to a private party or a governmental organization that purchases the data for its use. Parties such as municipalities, provinces, water-boards are required to collect and use relevant authentic data.
- The **Provider** is the party that manages and operates the national facility for providing data. It is responsible for facilitating the use (provide knowledge to support customers) of the data and for providing the data.
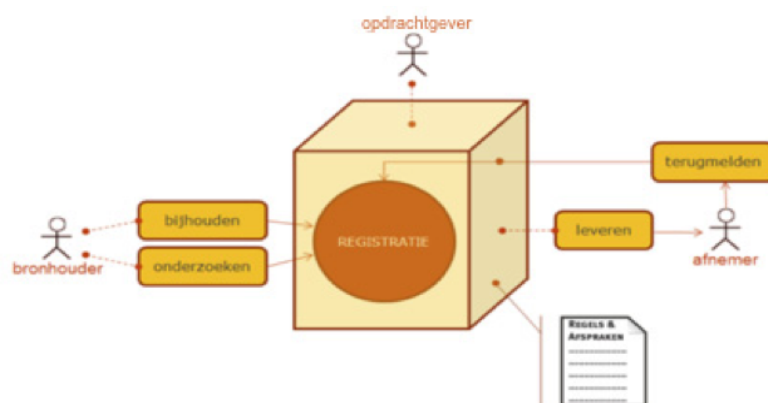
Figure 22. Pre-defined roles in Data Management (Kwaliteitsinstituut Nederlandse Gemeenten (KING), 2012)

According to CB'23 (Platform CB'23, 2020b), "Product-related data" can be solely managed and updated by the supplier and the source through warranty provisions. Hence, the supplier will be always the main responsible for the required product-related data. However, for the "non-product related data", the responsibility of management and maintenance goes to the building owner/manager.

An approach to divide responsibilities will be based on the extent to which an actor has control over the data. Accordingly, Figure 23 presents an example of a RACI Matrix in the field of data management based on the four degrees of responsibility presented earlier.

Figure 23. GEMMA Tactical Data Management RACI Matrix

Producten waarbij Gegevensmanagement rollen een verantwoordelijkheid hebben	Registratiehouder	Bronhouder	Gegevensmanagement functionaris	Architect	Auditor	Afnemer	Gegevensmakelaar	Beheerder Generieke Voorzieningen	Concerncontroller	Functionaris Gegevensbescherming (FG)	Privacy officer (PO)	Security Officer (CISO)	Coordinator ENSIA	Portefeuillehouder ENSIA	RE-Auditor	Lijnmanager	HR manager	Facilities management	Hoofd I&A	CIO	Directie / Gemeente Secretaris	Gemeenteraad	College van B&W
Gegevensmanagement																							
Gegevenslandschap		I	A	R	I		C	C		C													
Gegevenscatalogus	I	C	A	R			C	C		C													
Gegevenswoordenboek		C	A	R	C	I	C	C		C													
Object-entiteitenmodel		A	I	R	I		C	C		C													
Kwaliteitseisen	A	R		C	C	I	R	I		I			I										
Meting en rapportage	A	R	C		C			R															
Auditrapport		C		R					A	I			C										I
Kwaliteitverbetervoorstel	A	R	C	C	C		R			C			I										
Gegevensleveringsovereenkomst (GLO)		A	I	C		C	R	I		I													
Richtlijnen		C	A	R		I	C	I	R	C													
Terugmeldverplichting					C	A			R														
Roadmap		C	A							C		C											
Onderzoeksplicht	A/R			C	I																		
Gegevensregie/beleid		R	C							C		C									A		
Informatiebeveiliging																							
Beveiligingsbeleid		C	I	I																			
Organisatie van informatiebeveiliging (ISMS)		C																					
Beheer van communicatie en bedienprocessen			C																				
Logische toegangsbeveiliging		R	C	C			R																
Verwerving, onderhoud en ontwikkeling		C	C	C																			
Beheer van incidenten		C	C				C																
Bedrijfscontinuiteitsbeheer		C	C																				
Naleving		C	C				C																
Privacy																							
PIA			C																				
Register van verwerkingen			C	C																			
Registratie van privacyincidenten		C																					
Verwerkersovereenkomsten		R	C																				
ENSIA																							
Plan van aanpak werkzaamheden			C																				
Vragenlijst werkzaamheden		C	I				C																
Uitvoering ENSIA werkzaamheden		C	C																				
Opdracht RE-auditor					I																		
Collegeverklaring		C	I																				
Uitvoeren audit en rapporteren			I			R																	
Agenderen en vaststellen Jaarverslag			I																				

Therefore, roles for data management will be divided based on the GEMMA Tactical Data Management in a RACI matrix (R: **Responsible**, A: **Accountable**, C: **Consulted**, I: **Informed**). On one side of the matrix, the actors that were previously presented in project delivery methods and use of material passports. For instance, municipalities are currently assigning architects as 'Keeper of data' for their Personal records database (Platform CB'23, 2020b).

On the other side, the roles and responsibilities will be coupled with different project phases and active stages of the material passports. However, defining the RACI matrix requires further research based on two levels: Initially creating a matrix that will help define who is responsible, and then showing the role of data experts who work in the field of data management.

3.4.5 Quality Requirements

A major element that is of great importance for business processes is the quality of data. Incorrect input of data may eventually lead to levies and waivers, bad debts, and damage to the trust integrated throughout the circular exchange process. If data is one of the most influential aspects of our daily decision-making process, hence inaccurate data may impact our decisions.

The RACI Matrix proposed earlier helps to map the responsibilities and roles when it comes to data management. It provides an insight of whom reports to whom as the data quality is trusted with the Source Holder that monitors the process through audits. Moreover, every customer is obliged to present feedbacks on the data that will be investigated by the Source Holder. The GEMMA Tactical Data management plan proposed several dimensions (Informatie beveiligings dienst (KING), 2013) for check-ups that helps organize the quality of the data presented in Table 4. Dimensions of quality requirements (KING, 2013)

Table 4. Dimensions of quality requirements (KING, 2013)

Accuracy	Completeness	Consistency
Credibility	Correctness	Compliance
Precision	Traceability	Understandability

3.4.6 Conclusions

The RACI Matrix provides a basis to organize the Data Management Plan and check its applicability when it comes to using Material Passports in the Netherlands. This chapter explored the need for data management and the importance to keep track of data quality to promote a trusty environment. The GEMMA Tactical Data Management offers an opportunity to investigate the actors that are involved in the collection process throughout different project delivery methods. Categories of data, functions and different timelines for projects will help assess who is responsible for monitoring the data at a certain stage. Once data is collected, it will be classified based on privacy regulations and potentially sold to other public organizations in the Netherlands. This shared approach will promote multiple uses of the data for an efficient method to update material passports while promoting collaboration between consumers and suppliers.

Moreover, several responsibilities for data management in Material Passports that are involved throughout the Project Delivery methods are summarized in Table 5. The table shows that throughout different active stages of the material passports, several roles and responsibilities can be named based on the. For instance, a condition assessment check is related to the Data Quality, Availability, and Legitimacy dimension that is in relation with one of the dimensions of quality requirements proposed by GEMMA in Table 4. Dimensions of quality requirements (KING, 2013)

Table 5. Tasks and responsibilities in Data Management

Dimensions	Tasks and Responsibilities			
Initiation	Construct Product format	Generate material passport	Design activities	Acquisition agreement
Development	Integration through BIM Model	Construction assignment	Maintenance and renovation work	Use and management works
End of use	End of use plan	Recovery of leased products	Recovery of raw materials	Transfer of ownership
Data Quality, Availability, and Legitimacy	Availability checks	Condition assessment	Progress check	General Information
	Legislation, and regulations	Control, organization, and risk management	Processes and employees	Interaction with citizens and companies
	Data Exchange with third parties	Data processing methods	Technology for data processing	Data Legitimacy and quality

The research elaborated so far on the different stages to monitor material passports based on the active stages. Additionally, the roles and responsibilities for data management were essential to understanding how data will be processed once it is collected and with whom it will be shared. The coming chapter further investigates the different actors and stakeholders that are in direct relation with material passports from the Construction point of view and how can barriers and limitations impact the results of this study.

3.4 Division of responsibilities to further optimize re-use value

Typically, at the end of the lifespan of a building, demolisher companies are mainly responsible for assessing the value of the building to be demolished (Yeheyis et al., 2013). Hence, contracts that are sketched in this type of work include a certain value for the contractor that is leading the demolishing works. In other words, the contractor is pushed to resell or recycle the material for his interest. Furthermore, the traditional way states that revenues of this process are accounted for in this demolishing price stated in the contract. Nevertheless, the integration of material passports in buildings has led to a more transparent process (Luscuere, 2016), leading to new market opportunities to re-use a building component. The usage of sustainable and reusable materials and buy-back guarantees have proven to increase the value of a circular building as depreciating an asset to the zero price is not possible anymore. The following chapter discusses the roles of users that are in a direct relationship with Material Passports. Further literature is provided on data management and governance that will help determine what are barriers and challenges to the division of responsibilities. Finally, a new collection method developed by CB'23 for non-product-related elements was explored; it offers an opportunity for change based on the project delivery method.

3.5.1 Roles and Relationships of Stakeholders

Certain agreements and measures may be taken by the government to ensure the circular design of a building. For instance, in the Netherlands, the combination of landfill tax and a landfill ban has decreased the amount of material that is being wasted in the demolishing phase (Andreas, 2001). However, it was necessary to make a closed loop of materials to ensure the circularity of building products. Once a material passport is developed through BIM, project developers may decide on the circular material that will be implemented in the design phase of the building (Deloitte, 2020). CB'23 has developed pre-conditions to sketch material passports, and one of the main topics of interest is Data Governance. Harmonization and integration of data in the platform are essential to promote an accurate estimation of the material quality. The roles of actors in data management were proposed by CB'23 as Figure 24 shows.
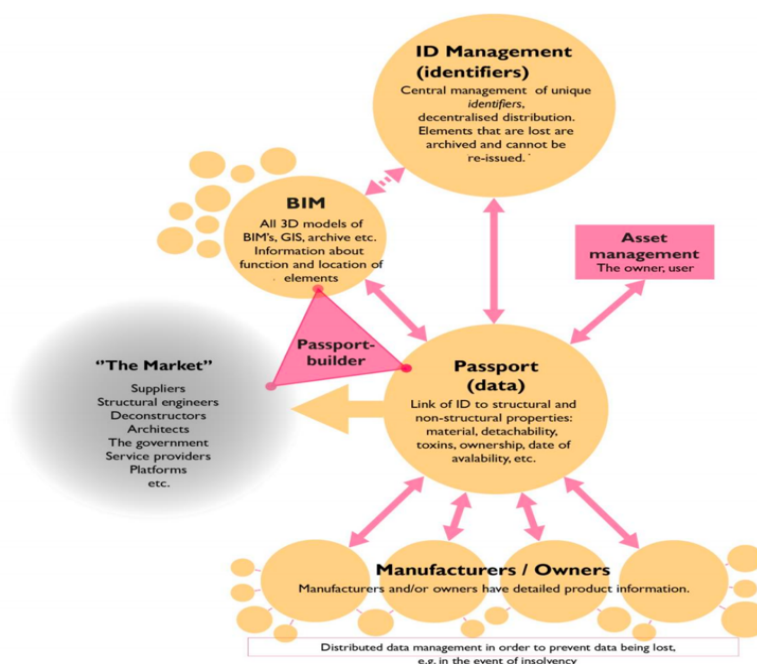
Figure 24. Roles of stakeholders in recording data (Platform CB'23, 2020a)

According to CB'23, further parties will enter the market as new groups will emerge in the role of Management, Financial, Storage, and Consultancy services. Hence the roles for data requirements were divided in Figure 25. Roles and relationships between stakeholders.
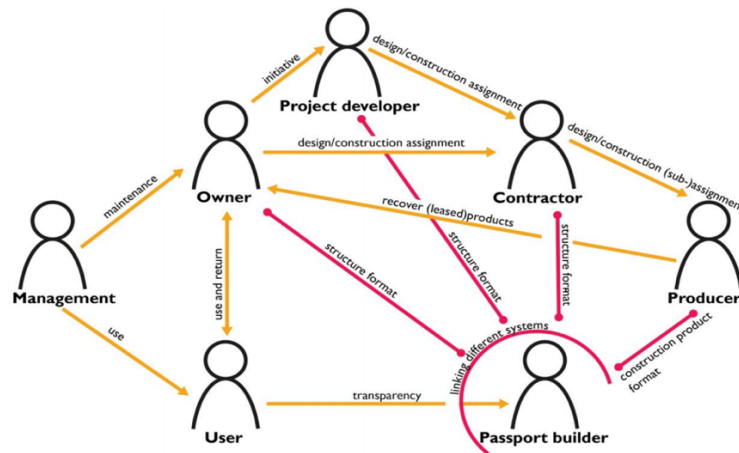
Figure 25. Roles and relationships between stakeholders (Platform CB'23, 2020a)

Therefore, every user drives data based on his point of view. However, the information will always be following the user's requirements. The platform has distinguished 5 main actors that have responsibilities accordingly:

- **Owner/ Client**: First to take the initiative and manages the property during the service life
- **Contractor**: Takes temporary ownership during construction
- **Producer/Manufacturer/Supplier**: Specialist that traces his production
- **User**: Entitled for a transparent process and can change in the structure
- **Passport Builder**: Sets up and manages the data format and is "responsible for the availability and legibility" of this data (Platform CB'23, 2020a)
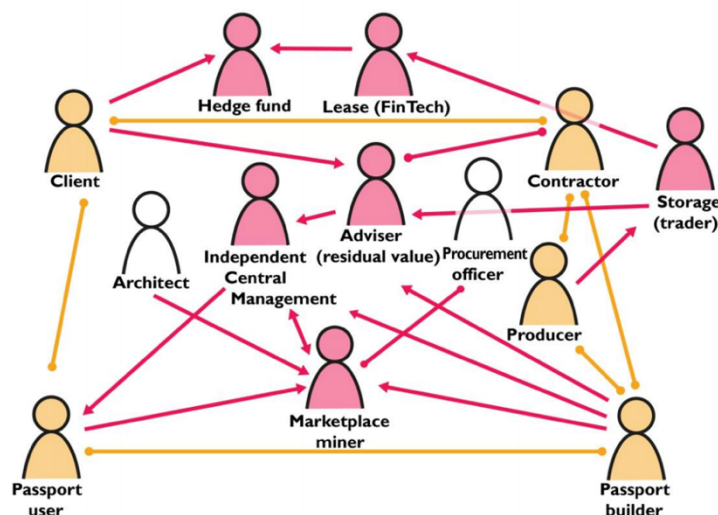
Passport builders present the opportunity for new parties to enter the market as discussed previously and shown accordingly:

- **Management**
- **Financial services**
- **Storage services**
- **Consultancy services**

Eventually, the organization that manages the passports must keep records of the passports if they own them.

Figure 26. New roles and relationships (Platform CB'23, 2020a)

3.5.2 Stakeholders and Responsibilities

According to Wientjes et al. (Wientjes et al., 2016), the complicating factor in the Netherlands is the relationship between clients and contractors and other relevant parties in the construction chain. However, the changing nature of project delivery methods dictates a diverse distribution of stakeholders. One of the aspects presented by Huizing (Huizing, 2019), discussed the importance of stakeholders partnering as a necessity. It was seen that due to the long-term contractual relationship, the Client and the Contractor need to have a close collaborative environment. Further in the analysis, Huizing (Huizing, 2019) introduced the Circular pattern for partnering of Stakeholders as shown in Figure 27 below.
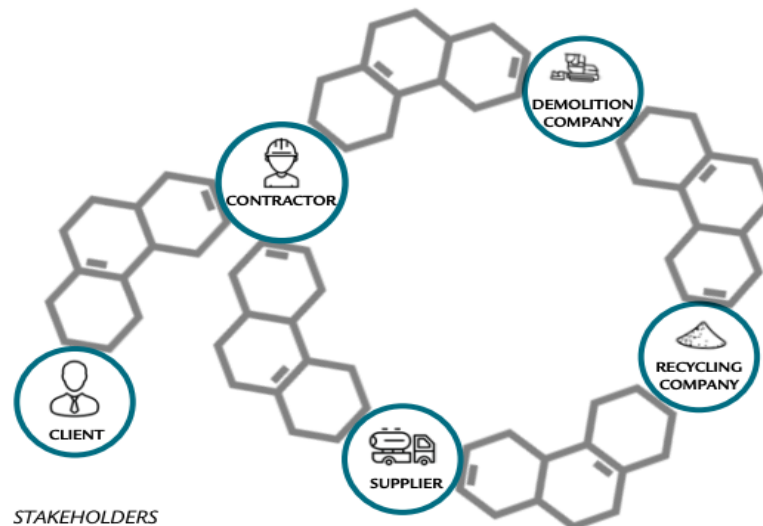
Figure 27. Circular pattern for partnering of Stakeholders (Huizing, 2019)

Actors and stakeholders are divided into **Primary** and **Secondary** Stakeholders based on their degree of involvement throughout the project phases mentioned earlier. **Primary** actors represent the stakeholders that are in direct involvement with material passports and have an active responsibility towards updating information. For instance, the Supplier will be responsible for sharing the data needed to the Contractor that will be working closely with the Designer in updating the information in the BIM centralized model. Primary actors consist of the Client, Designer, Contractor, Supplier, Demolition/Recycling companies, a passport builder (an external party) or a Supervisor that is highly involved in roles for Data Management.

Secondary actors are classified as less involved parties based on the timeline of the project. For instance, in a Design & Build delivery method, the Contractor is considered a secondary actor during the maintenance phase, which is why it will not be included in the following Table 6. Other external services parties will be responsible for the maintenance works and need to keep information updated to maintain a cohesive approach towards a proper data management plan. Table 17 presents a summary of the main actors that will be involved in the framework.

Accordingly, Table 6 shows the distribution of responsibilities for stakeholders based on their degree of involvement at each stage for data management. Note that the secondary actors were not included in the table, since it is less likely for secondary to have an active involvement directly in the project. Based on the project delivery method and the responsibilities in contracts from chapter 3.3, some actors will be responsible for the data based on the project's timeline. For instance, during check-up stages, a third-party trustee such as Madaster will have additional involvement for data management in comparison to other parties that are not relevant at this stage of the project.

Table 6. Responsibilities based on Timeline and Project Delivery Methods (PDM)

PDM Timeline	Traditional	Design & Build	DBFM	DBFMO	Alliance Model
Design Phase	Producer Owner Designer/ Consultant	Producer Contractor	Producer Contractor	Producer Contractor	Producer Owner Designer/ Consultant Contractor
Construction Phase	Passport Builder Supplier Contractor	Passport Builder Supplier Contractor	Passport Builder Supplier Contractor	Passport Builder Supplier Contractor	Passport Builder Supplier Owner & Contractor
Check-up Phase	Contractor Third party trustee	Contractor Third party trustee	Contractor Third party trustee	Contractor Third party trustee	Owner Contractor Third party trustee
Use Phase	Owner Management Party	Owner Management Party	Owner Management Party	Contractor	Owner Contractor Management Party
Check-up Phase	Owner Demolition Company Third party trustee	Owner Demolition Company Third party trustee	Owner Contractor Demolition Company Third party trustee	Contractor Demolition Company Third party trustee	Owner Contractor Demolition Company Third party trustee
End-of-life Phase	Owner Recycling company	Owner Recycling company	Owner Recycling company	Owner Contractor Recycling company	Owner Contractor Recycling company

3.5.3 Barriers and Challenges

The lack of standardization for the national use of material passports has led to the rise of conflicts among actors. Van der Sande (van der Sande, 2019) listed the factors that present a challenge for the application of the Circular economy in Dutch infrastructure projects.

- **General Acknowledgement**: The implementation of circular concepts in tender agreements is labeled as "circular". However, the idea of circular economy is not seen as a generalized concept to be implemented in most construction projects in the Netherlands (van der Sande, 2019).

- **Economic:** Awarding a tender based on the lowest bid is not incentivized based on the project delivery method. In some cases, additional responsibilities are allocated to the Contractor in specific requirements that are impossible for the contractor to implement circular solutions (Diaz Lopez et al., 2018).

- **Data Sharing:** Stored information of materials is often not recorded properly or shared with the right actors (van der Sande, 2019). The lack of a central platform to exchange information regarding materials presents a challenge for the re-use of the data collected.

- **Legal:** Once a lease agreement is set between two legal parties, the asset can be transferred to the user for the application. One could argue that this material is under a lease condition, thus, the ownership is still managed by the previous user. Nevertheless, once the material is transferred over, the element will be incorporated into a building, hence is considered part of the building with full ownership to the building owner. This paradigm was further developed to secure that the ownership remains with the supplier based on the Dutch construction law (Ploeger et al., 2019). The study concluded that the application of buy-back and take-back models seem to be the most suitable in this case with a possibility to cover re-use and recycling options in the future. However, uncertainties remain as there are no precise business models that may be developed for every element of the building. This legal (im)possibility seems to create a barrier to the proper division of responsibilities among stakeholders. Thus, the full ownership of the material that has been implemented in the building will play a major role in defining the responsibilities to properly hold the quality of the material over time and hence retain its re-use value.

- **Governmental and Regulatory:** The lack of regulations on the common application of material passports presents different formats and guidelines to classify construction products. Transparency and standardization were seen as important conditions for the successful application of the Circular Economy in the Dutch Construction sector (de Jesus & Mendonça, 2018).

- **Organizational/Managerial:** Van der Sande (van der Sande, 2019) elaborated on the importance of promoting a Cohesive working Environment between actors. This is mainly due to the high dependency of the stakeholders to have a close loop exchange of materials (Huizing, 2019). As interviews conducted have suggested that the word "trust" was mentioned several times during interview sessions. It was specified that stakeholders do not have an adequate understanding of other stakeholders' working methods.

3.5.4 Conclusions

This chapter discussed the importance of dividing the responsibilities of stakeholders in managing Data for material passports. Furthermore, the roles were divided amongst the different actors that have an active responsibility based on the task at hand in the project delivery method. Actors were divided into Primary and Secondary actors. Primary actors have a bigger responsibility in keeping track of the data than secondary actors based on the extent to which data is shared with them.

Opportunities are presented for new parties to enter the market for functions such as Passport Builders, Management, Financial, Storage, and Consultancy services that will have both Primary and Secondary roles based on the timing of the project. This method allows a closed circulation of material and optimizes the re-use option for materials. Additionally, the different barriers pose a challenge for the applicability of the Circular Economy in the Construction sector.

3.6 Literature Study Conclusion

There is a need for developing standardized solutions to properly divide responsibilities in monitoring and assessing asset conditions. This way, data management, and collection could be easily achieved for new and existing buildings throughout the asset lifecycle. Due to the large versatility of stakeholders present throughout the construction sector, this presents an opportunity for arranging responsibilities for updating and maintaining material passports. One challenge is the documentation of buildings that have different project delivery methods, hence, different actors throughout the stages, as proper coordination and division of responsibilities are the answer to this challenge. Digital solutions will assist in collecting, storing, and exchanging material information in a centralized model. Additionally, this process helps satisfying future market demands early and raises the chances for re-using or recycling based on the condition of the material.

The first chapter discussed the importance of the transition from a Linear to Circular Economy. This transition was further elaborated on using one common method: Material Passports. "Material without an identity is waste" (Platform CB'23, 2020b). Therefore, material passports provide the incentive to document and monitor the source and quality of materials throughout their lifecycle. The lifecycle of a construction product may span over different projects under multiple material passports.

Moreover, every project has its own Project Delivery Method (PDM) that is divided between the Traditional and the Integrated type of contracts. Those contracts emphasize that different stakeholders have various roles based on each delivery method for a certain time. Hence, comes in the different division of responsibilities in data monitoring based on the PDM. For each delivery method, the main timelines and milestones were identified and coupled with the ones from the material passports. In total, Design, Construction, Use, and End-of-life were the main four active stages to collect and update data in material passports. Additionally, two more check-up stages were inserted after Construction and Use phases. In those stages, external parties such as a Municipality representative or architect can have a role in keeping the data for future use.

Further roles and responsibilities were divided in the fourth chapter. It presented the data management plan that is widely adopted in the Netherlands (the GEMMA Data Management Plan) and the degree of its importance. Once data is collected in public or private projects, the Municipality seems to have the greatest interest in storing the information collected from material passports for future use plans. The roles within the Municipality for data management have helped sketch the roles and responsibilities in keeping data for material passports in Construction projects.

The final chapter of the literature divided actors that are in direct relationship with material passports into Primary and Secondary based on their degree of involvement. Room for external parties such as consultants, service, and financial companies are expected to emerge from the transition towards a Circular Economy.

Adopting reversible design strategies is essential for promoting a circular information flow. This lays the path in the future for potential material functionalities, which would eventually force engineering companies to design for a circular economy through the application of material passports. Finally, the absence of regulations and agreements related to the circular economy in the construction field presents a downside as design and deconstruction processes need to be adopted (Durmisevic, 2018). Ultimately, a circular supply chain is only strong based on its weakest link, which requires the involvement of all the stakeholders in the process throughout the material lifecycle.

4. Conceptual Framework

This chapter presents findings from the exploratory semi-structured interviews that were conducted with people that are working in the field of material passports. Moreover, the findings are coupled with results presented in the literature to come up with parameters and principles that helped define the framework.

4.1　Objectives and Requirements

The research follows the double diamond method (see Figure 2). In the first part of the study, the Discovery phase was covered in the Literature review section along with semi-structured exploratory interviews with people working with material passports. Research concerning the first diamond will deliver an approach for the problem statement using a conceptual framework that will be developed based on the Discovery phase. The objective of the framework is to come up with a clear division of responsibilities for data collection/management in the field of Material passports.

To get insights into the practical problem, the literature section is combined with the practitioners' points of view. The theoretical framework will identify the main characteristics that need to be monitored throughout the material lifecycle. Moreover, the developed solution will be tested, evaluated, and redesigned based on the case studies and finally validated again at later stages. The next step in the process is to design the first conceptual model that shows the connections and the research findings.

4.2　Exploratory Semi-structured Interviews

At this stage of the research, it was decided to conduct semi-structured explorative interview sessions. Interviews have helped assess how respondents differ in their views throughout the different topics. Additionally, they confirmed whether there is a common understanding of the key terms such as material passports and project delivery methods. The topics that were covered have been included in Appendix C: Interview Protocol, and the full recording are followed in Appendix D: Interview Recordings. A thematic overview of the interviews that were covered per topic is summarized in Table 7. The is no fixed formulation of questions and answers to be covered. To secure a reliable and informative set of data and answers, the interviews lasted between 45 and 80 minutes that were recorded and transcribed. A summary of the conversation was sent to the participants to confirm the content of the transcription.

The interviews were conducted with people working with material passports in the Netherlands. Multiple parties that were mentioned in the report such as CB'23 Platform and Madaster have had a great influence on the applicability of material passports in the Netherlands. The interviews' main goal was to elaborate on topics that were covered in the literature section: Material passports, Project delivery methods and Contracts, and Data Management. Exploratory interviews (See Table 2) were conducted with the Director of Madaster (Register that stores data in material passports format), a Senior Consultant working with CB'23(National platform for the circular transition), and a Senior Consultant working with both Madaster and CB'23 Platform.

Table 7. Exploratory Interview Findings

Topics	Interview A *Madaster*	Interview B *Stichting Adviseurs/Madaster*	Interview C *Platform CB'23*	Notes
Material Passports	- Named the **Public parties** that are involved in the Infrastructure and Real Estate sectors.	- **Check-up phases** are good to distinguish the As-built from the As-is information.	- Integration in circular design strategies. - Present benefits of its application.	**One common understanding** of material passports was seen across the interviews.
Project Delivery Methods and Contracts	- Liabilities in data collection are not clearly stated. - A **cooperative environment** present in integrated contracts offers more opportunities for material passports.	- End **responsibility** goes to the owner of the physical object. - Ideally, the physical object and its **ID in the BIM model must stay together.**	- Named **Private parties** and project phases. - **"He who changes stuff will be responsible for updating the dataset."**	Everyone wants to **avoid financial consequences** for legal unclarities and the victim of that is proper documentation that can be fixed in a collaborative environment.
Data Management	- **Facility management and Maintenance services** are responsible for the Check-ups. - **BIM modeler** is responsible in Madaster. - **Assessment companies** check the integrity of the data.	- Facility and Asset management are third parties that will enter the market for data management and take over after the construction team. - Independent third parties will check the correctness of the data.	- An **infinite amount of data** needs to be stored which will eventually slow down the process - Data is nothing without correlation, or selective filters to retrieve it. - The producer's **responsibility** is maintained throughout the use phase but to a lower extent.	- Data collection is **voluntary** and is not incentivized **early** in the process. - **Long supply chain** and the **duration of a lifetime**, data voluntarily assembled was lost from one phase to another.
Framework Approach	"The owner of the data is responsible for it and a RACI Matrix will enrich the view and it is a nice way to look at responsibilities."	"You cannot be responsible for something that you do not know. If the owner is responsible for what he owns, he should be able to "force" the producers to give him the information and take the responsibility."	"We haven't solved it yet, a nested set of information that is centrally managed is good." Some information should be kept confidential: commercial and private models are both viable options.	**Approve** of the approach that responsibility for data collection/management is divided based on the extent to which a party has access to this data.
Limitations	Absence of a centralized model for data storage.	A standardized format for material passports is missing and will impact the data collection/management process.	Risk of data loss if a company dies if it's not centrally stored.	**Missing of standardized** approaches to store the data.

Moreover, findings from the Interview in the field of Data Management are presented in Table 8 (the full transcript can be found in Appendix D: *Interview Recordings*).

Table 8. Exploratory Interview D Findings

Topics	Interview D *Rijkwaterstaat / NEN*	Notes
Data Collection	- Hard to define what type of information you need early on. - Instead of documenting millions of datasets, **data is kept with the supplier** and is updated according to changes.	- Data collection is **voluntary** and is not incentivized **early** in the process.
Data Management	- **Suppliers** need to follow guidelines and should become certified to store data. - **Supplier** is responsible for coming up with their material passports based on findings in **pilot studies**. - **Auditors** check the integrity of the data. - **Each producer decides what type of information is relevant, rather than creating millions of material passports, so data is not centrally managed.**	- Data storage is not done on a **project level** but on a **national level**. - There should be **two different approaches** for existing and new buildings. - The aim is not to store data for 80 years because everything is going to change, **the aim now is to learn**. Maybe in the future, we can **focus more on production.**
Framework Approach	"Great, that's really useful research I think and it's good to look at the problem from a hand-over point of view".	**Approve** of the approach that responsibility for data collection/management is divided based on the extent to which a party has access to this data.
Limitations	Suppliers and producers may not last for over 80 years and data can end up missing if not locally stored in a data warehouse.	**Missing of standardized** approaches to store the data.

4.3   Parameters of the Framework

As identified earlier, the development of the framework will support stakeholders to integrate all project activities into a process of collaboration. From the data gathered it turns out there are some conditional changes that will be applicable at different stages that are mentioned below. To develop the conceptual framework, the following design steps are taken:

1- Identifying the project phases

According to section 3.2.4, data monitoring for material passports is active at six main stages: Production/Design, Construction, Check-up Phase 1, Use, Check-up phase 2, Demolition and processing phase.

2- Recognizing the tasks needed for Data Management

Based on the findings presented from Table 5. Tasks and responsibilities in Data Management), the tasks were divided based on the **Initiation** phase (refers to Production/Design), **Development** phase (refers to Construction and Use), the **End of Use** (refers to Demolition and Processing phase), and finally the **Data Quality, Availability, and Legitimacy** (refers to both Check-up phase 1 & 2).

3- Classifying Stakeholders and Dividing/changing Ownership of the product

Stakeholders of the project delivery methods and the Actors that are in direct involvement with material passports are coupled throughout the different phases identified earlier. The initial are numbered in Section 3.3 (Project Delivery Methods and Dutch Building contracts) and the latter are named in Section 3.4 (Data Management). The findings are fully summarized in Table 6. Responsibilities based on Timeline and Project Delivery Methods (PDM). Moreover, insights from the interviews have introduced additional actors that are involved in the process.

Ownership requires fundamental changes in the organization of projects. It influences specifications and the proper distribution of responsibilities from the production phase until the end of the life of the construction product. Through the interview sessions that were conducted, it became clearer that ownership should be considered for the entire lifecycle of the material itself. Accordingly, responsibilities are present from the production phase with the Producer. For instance, once the product is transferred over from producer to supplier, data about the product will have to follow this change of ownership. In other words, the Supplier has the bigger extent of responsibility for data management: The product and its ID for data filter must have a joint connection. This method will be applicable throughout all the phases of the project.

4- Ranking Responsibilities of relevant Stakeholders

"He who owns it is responsible for the data". An approach to better integrate an accurate quality of the data collected is using a RACI (Responsible, Accountable, Consulted, Informed) matrix. The matrix will help identify at each stage of the project, what parties are involved in the process and to which extent they are held responsible. A **Responsible** party has an active responsibility in maintaining the data for partially sharing its ownership based on the task. An **Accountable** party has a responsibility in updating the data based on its degree of involvement in completing tasks and deliverables. A **Consulted** party provides an opinion regarding a subject, typically a two-way communication from an expert-oriented party. An **Informed** party is kept up-to-date on the progress, with whom it's one-way communication.

5- Drawing the RACI Matrix

The last step is the development of the conceptual framework for different project delivery methods found in Section 0 (

Preliminary Design of the Framework).

4.4 Preliminary Design of the Framework

In this section, the preliminary draft of the framework is developed for the Traditional project delivery method as shown in Figure 28. The framework proposed describes different roles and responsibilities in the field of Data Management based on the delivery methods. The results presented in the RACI Matrix represent the different roles that were interpreted in the report based on the different project timelines that are associated with the active stages of the material passports. The RACI Matrix is a representation that further divides the responsibilities into four main categories accordingly: (R) Responsible, (A) Accountable, (C) Consulted, and (I) Informed.

Data Collection and Management Information	Responsibilities and Tasks	Extractor	Producer	Supplier	Project Developer	Designer Consultant / Architect	Contractor	Sub-Contractors	Management Services	Financial Services	Storage Services	Assessment/Consultancy Services	Demolition Company	Recycling Company	Owner	User	Passport Builder	Auditor	Customer	Data Broker	Security Officer	Regulations Coordinator	Data Protection Officer
Initiation/Design Phase	Construct Product Format	R		A	I								I	I	R			C				C	
	Generate Material Passport		R	A	I								I	I	A		R				I	A	
	Design Activities			A	R	I							I	I	A								
	Acquisition Agreement			R	A	I									I			A	C	I			
Construction Phase	Integration through BIM Model		C	C	R	A									A					I			
	Construction Assignment		I	C	A	R	R/A								C						I		
	As-Built Updates		I	C	A	A	R	I		I					I								I
Check-up Phase 1	Availability Checks			I					R						A					I			I
	Condition Assessment			I					I		R				A								I
	Auditing and reporting			I					I	R					I			R					I
	Legislation, and Regulations								I		A				I							R	I
	Control, organisation and risk management								A	R					A					C			I
	Data Legitimacy and quality								A		I							R					I
	Data Exchange with third parties			I					C	A	I				C			C		R	C		I
Use-Phase	Maintenance and Renovation Works			I	A	C	I		R	A	I				A	C		I		I			
	Use and Management Works			I	A	C	I		A	R	I				A	C		I		I			
	As-Is Updates			I	A	C	I		C		R				C	I		I		I			
Check-up Phase 2	Availability Checks			I					R						A					I			I
	Condition Assessment			I					I		R				A								I
	Auditing and reporting			I					I	R					I			R					I
	Legislation, and Regulations								I		A				I							R	I
	Control, organisation and risk management								A	R					A					C			I
	Data Legitimacy and quality								A		I							R					I
	Data Exchange with third parties			I					C	A	I				C			C		R	C		I
End-of-Life Phase	End of Use Plan				I	A	C	I	I		I	R	C		A					I			
	Recovery of Leased Products					A	C	I	I				C	R	I		C			I			
	Recovery of Raw Materials					A	C	I	I				C	R	I		C			I			
	Transfer of Ownership				I	A	C	I	I		I		A	R	A					C			
Additional Tasks	General Information			I					I						R					I			C
	Processes and employees														C						R		I
	Interaction with potential Customers														C					R	A		
	Communication and processing methods														C					C	R		
	Re-auditing														C			R				A	
	Data Management																						
	Data Landscape			I						C					C		R			I			
	Quality Requirements			I											C					I	R		
	Data Catalog and Reference Book			I						C					C		R			I		A	
	Quality Improvement			I											C			C		I	C		
	Return Obligation			A											R	A							I
	Duty to investigate														R			A					I
	Roadmap														A								R
	Information Security																						
	Security Policy			I					I						C					R			A
	Organization of Information Security			I					I						C					A		I	R
	Acquisition, maintenance and development			I			C			I	A				C					I			R

*Figure 28. RACI Matrix Division of Responsibilities for the **Traditional** Approach*

Moreover, the main aim of the framework is to divide responsibilities based on the tasks assigned per project phase. For instance, during the initiation phase of the project, the Architect is held Responsible for the Design Activities task. However, responsibilities are still available for other parties but to a lower extent such as the Project Developer acting as the Owner of the Data, those parties are held accountable at this stage. Additionally, at this stage, the Contractors and Demolition/Recycling companies are kept informed of the progress for the Traditional Project delivery method (*Chapter 7* gives a detailed overview for its applicabilityTable of Contents).

To present results visually, the compass ecosystem for the circular process was developed for the project delivery methods. The tool graphically presents the results of the Matrix throughout the phases of the project and responsibilities are explained accordingly in Figure 29.

*Figure 29. The Compass Ecosystem for the **Traditional** Circular Process*

The drawn design depicts which parties are Responsible, Accountable, Consulted, and Informed at certain stages of a project based on the chosen project delivery method. In this case, the Traditional contract depicts that the Designer is responsible for the Design Phase. However, the compass shows that responsibilities are distributed based on different tasks in the Design Phase as the RACI matrix showed in Figure 28. Once a party such as the Designer is responsible for a Task in the Design phase, other parties shown in red become accountable until the task is changed. Further actors are integrated into the compass ecosystem based on the RACI Matrix developed. However, the compass ecosystem presents only a summary of the Matrix and does not elaborate on the full tasks that are covered in the Matrix. Appendix F: *Centralized Framework* provides a full overview of the Framework proposed for each project delivery method.

5. Empirical Research

Previous findings have been presented from the Literature section and the Explorative semi-structured interviews. The case studies covered the Infrastructure and the Real Estate sectors to understand the full spectrum of construction projects in the Netherlands. The consideration of different points of view of organizations is essential to update the model based on the data acquired from the case studies. The main purpose is to gain an understanding of the current practical situation and what changes will need to take place to ensure a proper data management application based on each organization. Information is gathered through meetings and interviews with representatives of the relevant organizations. Finally, the barriers and opportunities were identified for the applicability of the framework.

The main aim of this section is to understand how data collection and management is being tackled from a practical point of view for the Infrastructure and the Real estate sectors. This chapter starts by elaborating on the findings from the infrastructure sector in Section 5.1. Then Section 5.2 presents the results found from the interviews conducted with people working in the real estate sector. Moreover, an analysis of what to change in the framework is presented in Section 5.3. Finally, the limitations and conclusions are drawn in Section 5.4. The corresponding Table 9 shows a summary of the Interviewees selected.

Table 9. Summary of Practical Interviewees

Date	Interviewee	Organization	Role	Sector
16th July 2021	**Tamar Niemeijer**	Delfland	Program Manager Circularity	Infrastructure
1st July 2021	**Jaap Bakker**	Rijkwaterstaat	Advisor Asset Management and Data Integration	Infrastructure
25th Aug 2021	**Marten Hoeksema**	Waterschap Vallei-Veluwe	Manager Advisory Team Dike Design	Infrastructure
19th July 2021	**Martijn van Dijk**	DeltaWonen	Project Manager Circularity Specialist	Real Estate
27th Aug 2021	**Rob Rutgers**	SWZ	Asset management Coordinator	Real Estate
31st Aug 2021	**Erik Kooij**	Constructif	Senior Advisor	Real Estate

5.1 Findings for the Infrastructure Sector

The practical interviews were conducted with people involved with material passports in the Dutch Infrastructure sector. The case studies do not cover singular projects, rather it was chosen to interview organizations' representatives to understand their approach by which data management is being practiced in Infrastructure projects in the Netherlands.

Table 10. Summary of Practical Interviews in the Infrastructure Sector

Topics	Rijkwaterstaat (Proposed Strategy)	Delfland	Waterschap Vallei-Veluwe
Goals	Becoming 100% circular by 2050.	The aim is to reduce usage of raw materials by 25% in 2025.	Promoting circular designs by 2024.
Material Passports	Material passports are currently being used on Pilot studies in close coordination with Ministry of Internal Affairs.	Usage of material passports is **mandatory** and developed in-house in all projects of Delfland (less detailed than the construction passport).	Developed a circular assessment tool with indicators: One of the indicators is material passports that are **mandatorily** collected.
Data Collection	- Hard to define what type of information you need early on. - Instead of documenting millions of datasets, **data is kept with the supplier** and is updated accordingly.	- **The Contractor** is responsible for delivering the passport. - Everyone has a responsibility in **filling sections** of the passport.	- **Contacting CB'23** for the format and work on a prototype. - **The Contractor** is asked to finalize and fill the passports, to be transferred over to the asset manager.
Data Management	- **Suppliers** need to follow guidelines and should become certified to store data. - **Supplier** is responsible for sketching their material passports based on **pilot studies**. - **Producer decides what type of information is relevant,** rather than creating millions of material passports, **so data is not centrally managed.**	- Data collected from projects will **help assess** which materials can be reused in the future. - Once delivered, the contractor will **no longer have access to it.** - **Data can still be shared** with other public organizations. Once enough data is collected, materials will be divided based on **categories**.	- Passports are kept under the format of the **Object Breakdown Structure (OBS)** - **Upper** layers of the OBS are kept **centrally**, while small **details** (like pumps) will remain with the **producer**. - No **plan** for quality checks - Missing a **certain format** to be followed. There is **little knowledge** of what you will have and how to make the best use of it.
Limitations	Suppliers may not last for over 80 years and data can end up missing if not locally stored in a data warehouse.	**Absence of a data warehouse** and quality checks.	**Over collection** of some information that is only needed every 5 to 12 years for asset managers.

Based on the interviews conducted, one common goal is maintained with shared views on the problem. The usage of material passports is being promoted throughout different national projects in the Netherlands, and data collection is mandatory in pilot and real projects. Moreover, the passport is set to be tailor-made based on the criteria set by the organization. However, storing this passport has seen different approaches: Rijkwaterstaat wants to store the data with the supplier, while Delfland prefers storing it centrally in-house. Both strategies have their advantages and disadvantages that are further discussed at a later stage to find the optimal solution for the Infrastructure sector in the Netherlands.

5.2 Findings for the Real Estate Sector

The practical interviews were conducted with people working with material passports in the Dutch Real Estate sector. The case studies do not cover singular projects, rather it was chosen to interview organizations' representatives to understand their approach by which data management is being practiced in the Dutch Real Estate projects.

Table 11. Summary of Practical Interviews in the Real Estate Sector

Topics	DeltaWonen	SWZ	Constructif
Goals	Develop a cultural and economic spot to educate the neighborhood on circular processes.	Integrate sustainability in the construction sector.	Promoting passports as a marketing and educational tool within the firm.
Material Passports	- **No usage of material passports** due to **financial preferences**. - Most of the project managers are **not familiar with technological advancements** in the field.	**No usage of material passports, but open for its application in the future.**	**If you want to understand something try to teach it, but if you want to learn something, try to use it.**
Data Collection	- Material passports are perceived as excel sheets for data. Its application **may come in handy in the long run.** - Data is locally stored in excel sheets due to **financial incapability**.	- Currently storing data in **excel sheets** or through **BIM** application. - Services such as Madaster are **not expensive** given the investment and return you are making from material passports in the long-term.	- **Not a big fan of** storage companies such as **Madaster**, they are only commercial: **they do not have the highest interest**. - **All the parties are obligated** to deliver the right data to the principal. - **The supplier approach** means more work to the supplier, **thus more money.**
Data Management	- **Third-party storage services** such as Madaster make an analysis of the data for a price. - There are **no confidentiality issues** in the Real Estate sector: Everyone has access to this data. - **Demolishing companies** can distinguish up to 95% of building constituents, the added value of material passports is still small.	- There are **no confidentiality issues** in the Real Estate sector: Everyone has access to this data. - **Data can be shared** with any user that has a task in updating this data.	- **The Client should hold the most responsibility**; once he knows how to use this data, its value becomes attractive. - **Banks and insurance** companies will have a big role in its applicability in this sector. - **Suppliers are not familiar with how circular they already work.**
Limitations	**"If you do not know what you are doing then you cannot have an impact.** We cannot bear the costs of using passports at the moment." One limitation is how to keep up to date with small changes occurring in the houses from self-employed people: **People can be a limitation.**	**Different sets of data might be needed for different construction products for various partners.** They don't see other barriers regarding the applicability of material passports.	In general, **people are lazy** and do not care about the quality, those who commit will be better off in the future. On the other hand, how can you set a **price tag for existing** structures? Or how can we **decompose buildings** and best re-use decomposed materials?

The findings from interviews conducted in the Real Estate sector show that there is a common goal applicable regarding circularity. Housing associations perceive material passports as an expensive solution to this issue in the long term. Data is stored locally on excel sheets under a multi-year maintenance plan that states the conditions of some building components that need

regular maintenance. Nevertheless, two limitations were adopted throughout: the initial is the uncertainty of the information we are looking for, and the second limitation is self-employed people that can make changes freely in the Real estate sector. One way to keep up with those changes is by keeping the data with the Supplier and avoiding a centralized model for millions of passports. One interesting point to reflect upon: "**Suppliers are not familiar with how they already work**".

5.3   Agenda for Change

Based on the findings presented in the previous sections, the framework that was developed earlier will be susceptible for change grounded on selected criteria for assessment. The findings from the theoretical field are compared to what is being done in practice as Figure 30 suggests.
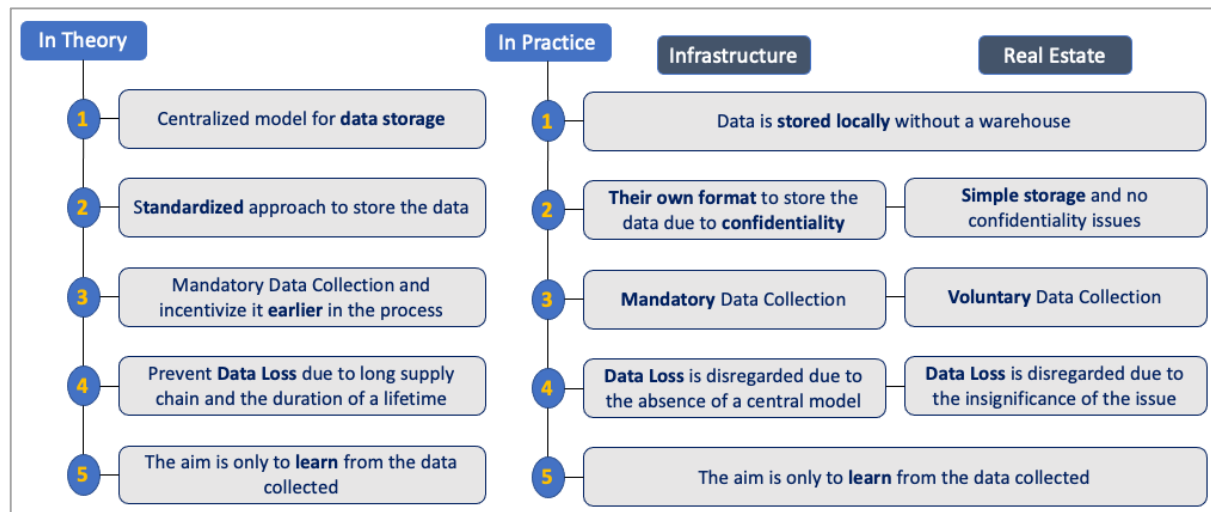
Figure 30. Comparison In Theory vs In Practice

The criteria that were selected are found to be of crucial importance for the sectors to be compared. In the *Infrastructure* sector:

- *Data Loss* was seen as an important issue to tackle; data were centrally stored within the organization to avoid future problems regarding this matter.
- There is a preferred use of *Standardized passport format* that is tailor-made based on ongoing projects of the organization. Passports show information that is relevant for the future and differ from the typical construction passports in some cases.
- *Monetary* issues are not seen as a problem for the moment being since infrastructure projects are built to last while trying to reach the 100% circular goals by 2050.
- Finally, *Confidentiality* is an important criterion to keep into consideration. Some information about material passports cannot be revealed to the public in some cases.

On the other hand, for the *Real Estate Sector*:

- Data is stored locally, however, *Data Loss* is not seen as an important issue to tackle. Once an asset is handed over to Demolition companies, they claim to know almost most but not all its building components.
- Having a *Standardized passport format* is not perceived as a good approach since material passports are not incentivized to be used in the Real Estate sector due to their high costs.
- *Monetary issues* present eventually a limitation for the applicability of material passports in the sector. Having to maintain a material passport for a long period is seen as time and budget-consuming.
- Moreover, *Confidentiality* is not perceived as an important issue in the Real Estate sector unless there are some sensitive materials in few cases.

Lastly, three additional criteria are found to be commonly essential for both sectors:
- Having a ***Mandatory collection of data*** promotes the collection of some information in passports as it becomes more valuable and provides an accurate value for the construction component.
- The ***Early Involvement*** of most parties in the initial phases of the projects promotes the concept of a circular economy by integrating values of circular design earlier in the process.
- Ultimately, ***Learning experiences*** provide a way to understand what type of information passport holders are looking for in different passport formats. This will offer an opportunity to collect and store data in an efficient way for future endeavors.

A summary of the presented criteria selected for each sector is shown in Table 12.

Table 12. Criterion selected based on Practical Interviews

Criteria	Infrastructure Sector	Real Estate Sector
Data Loss	✓	✗
Standard Format	✗	✗
Monetary	✗	✓
Confidentiality	✓	✗
Mandatory Collection	✓	✓
Early Involvment	✓	✓
Learning Experiences	✓	✓

5.4 Method Limitations and Conclusions

To adjust the framework presented earlier based on the criteria selected for both sectors, the limitations offer prospects of change accordingly:
- "People can be a limitation" (Interview F, Interview D), the statement in itself suggests that for the Real Estate sector, certain changes in building components cannot be kept updated at all times due to self-employed people. They have the ability to make changes internally without reporting it, this will have an impact on the accuracy of the data presented in a passport. **The approach of storing the data with the Supplier** can overcome this struggle. This way, the producer will be responsible for sketching the passport format for each type of product and the supplier is responsible for updating the passport according to changes. Instead of generating millions of passport formats for each construction product, each supplier will be able to determine what type of information is necessary to maintain the circular process in the Real Estate sector.
- The infrastructure sector offers room for change in the way data is being stored. However, since confidentiality is seen as an important aspect of the research, some information must be kept private and will eventually need to be stored centrally within the organization. Each public organization can choose to store the data in-house or with a third services company such as Madaster. Eventually, **the approach of storing the data centrally with the organization** will promote having a tailor-made passport based on the organizations' needs and will fit the goals of the infrastructure sector.

"The process is about providing rough guidelines and not making tailor-made approaches for both sectors." (Interview C, Appendix D). Thus, there is a clear separation between the Infrastructure and the Real Estate sectors. The chosen approaches presented earlier will help updating the model accordingly.

6. Final Framework Design

This chapter presents the changes that were made to the framework shown in previous stages based on the practical interviews that were conducted with people that are working in the field of material passports. The aim is to provide an approach that will help to assigning responsibilities based on the timeline, the tasks, and the criteria that were selected from previous sections. Section 6.1 presents the objectives and requirements of the new approach. Next, Section 6.2 elaborates on the changes made for the new approach, moreover, the differences between the two approaches are discussed in Section 6.3. Finally, limitations and conclusions are presented in the final section.

6.1   Goals and Objectives

The first part of the study has helped sketch the main parameters of the framework. Its objective is to come up with a clear division of responsibilities for data collection/management in the field of Material passports. However, based on results presented in the practical interviews, the approach for data collection is different from one organization to another. Therefore, the framework was divided into two main approaches: The first approach is a centralized model in which data is stored in-house that was previously elaborated on in Chapter 4, and the second is a supplier approach in which the data is stored with the suppliers.

The main differences between the two approaches will assign further responsibilities to the Supplier and the Producer at different stages of the passport. Information, in this case, will not be updated on a project level but on a national level. This approach seems to be an effective tool for storing the data, however, both have advantages and disadvantages that are tackled in the coming sections.

6.2   The Alternative Supplier Approach

In this section, the final draft of the framework is developed for the Traditional project delivery method from a Supplier Approach. The framework proposed describes different roles and responsibilities in the field of Data Management based on the delivery methods. The two approaches present room for a change in responsibilities; however, the main highlights are assigned to the Supplier. In this case, the Storage services companies are not involved in the field of Data Management as data is safeguarded with the supplier. Eventually, the Supplier will inherit all the responsibilities from the Storage services companies. Additionally, some roles such as Security Officer and Data Protection officer in the Framework are shared roles and will be present as long as data collection and management are foreseen as significant.

The **Supplier approach** entails that the Supplier will be responsible for keeping the data. Hence, the role of storage services companies will not be needed for this approach. "The idea is that from one product code, you can access information that is being stored with the producer. This is a smart way to look at the data from a supply chain which builds our structures." (Interview D, Appendix D). For instance, a producer of cement could store information for 100,000 bags of cement that will be procured by 10,000 projects. Instead of storing information for almost 10,000 projects at the same time, this approach entails that the producer/supplier of cement can store this information from a single batch.

Based on previous findings, the approach of storing the data with the source overcomes the limitation of self-employed people that can make changes without reporting it. Thus, the data will be updated beforehand which improves the information on the passport. Eventually, "every producer will be able to decide what type of information will be needed for the application of the circular economy", they will dictate what data is needed for the passport itself. Once

changes have occurred to the material, updates have to be followed accordingly to keep the data reachable and structured. For this to work, the "producer/supplier needs to become certified in his field of work" (Interview C, Appendix D). Once most of the parties become certified for the circular economy, the application of material passports would be easily implemented throughout the Dutch economy. The changes were highlighted in red as shown in Figure 31. Accordingly, the compass ecosystem of this framework will change as presented for the traditional and the additional tasks shown in Figure 32 and Figure 33.

Data Collection and Management Information	Responsibilities and Tasks	Extractor	Producer	Supplier	Project Developer	Designer Consultant / Architect	Contractor	Sub-Contractors	Management Services	Financial Services	Assessment/Consultancy Services	Demolition Company	Recycling Company	Owner	User	Passport Builder	Auditor	Customer	Data Broker	Security Officer	Regulations Coordinator	Data Protection Officer
Initiation/Design Phase	Construct Product Format	R	A	I					I	I				R		C					C	
	Generate Material Passport		R	A	I				I	I				A		R				I	A	
	Design Activities				A	R	I		I	I				A								
	Acquisition Agreement				R	A	I							I		A	C	I				
Construction Phase	Integration through BIM Model		C	C	R	A								A					I			
	Construction Assignment			I	C	A	R	R/A						C							I	
	As-Built Updates			I	C	A	A	R	I					I								I
Check-up Phase 1	Availability Checks			I					R					A					I			I
	Condition Assessment			I					I		R			A								I
	Auditing and reporting			R					I					I			R					I
	Legislation, and Regulations								I		A			I							R	I
	Control, organisation and risk management								A	R				A				C				I
	Data Legitimacy and quality								A	I							R					I
	Data Exchange with third parties			A					C	I				C			C		R	C		I
Use-Phase	Maintenance and Renovation Works			A	A	C	I		R		I			A	C		I			I		
	Use and Management Works			R	A	C	I		A		I			A	C		I			I		
	As-Is Updates			I	A	C	I		C		R			C	I		I			I		
Check-up Phase 2	Availability Checks			I					R					A					I			I
	Condition Assessment			I					I		R			A								I
	Auditing and reporting			R					I					I			R					I
	Legislation, and Regulations								I		A			I							R	I
	Control, organisation and risk management								A	R				A				C				I
	Data Legitimacy and quality								A	I							R					I
	Data Exchange with third parties			A					C	I				C			C		R	C		I
End-of Life Phase	End of Use Plan			I	A	C	I		I			R	C	A						I		
	Recovery of Leased Products				A	C	I		I			C	R	I		C				I		
	Recovery of Raw Materials				A	C	I		I			C	R	I		C				I		
	Transfer of Ownership			I	A	C	I		I			A	R	A				C				
Additional Tasks	General Information			I										R					I			C
	Processes and employees													C					R			I
	Interaction with potential Customers													C					R	A		
	Communication and processing methods													C					C	R		
	Re-auditing													C			R				A	
	Data Management																					
	Data Landscape			C										C	R					I		
	Quality Requirements			I										C						I	R	
	Data Catalog and Reference Book			C										C	R					I	A	
	Quality Improvement			I										C			C			I	C	
	Return Obligation			A										R	A							I
	Duty to investigate													R			A					I
	Roadmap													A								R
	Information Security																					
	Security Policy			I										C						R		A
	Organization of Information Security			I										C						A	I	R
	Acquisition, maintenance and development			I				C		A				C							I	R
	Incident management			I				C		I				C							I	I

*Figure 31. RACI Matrix Division of Responsibilities for the **Traditional Supplier** Approach*
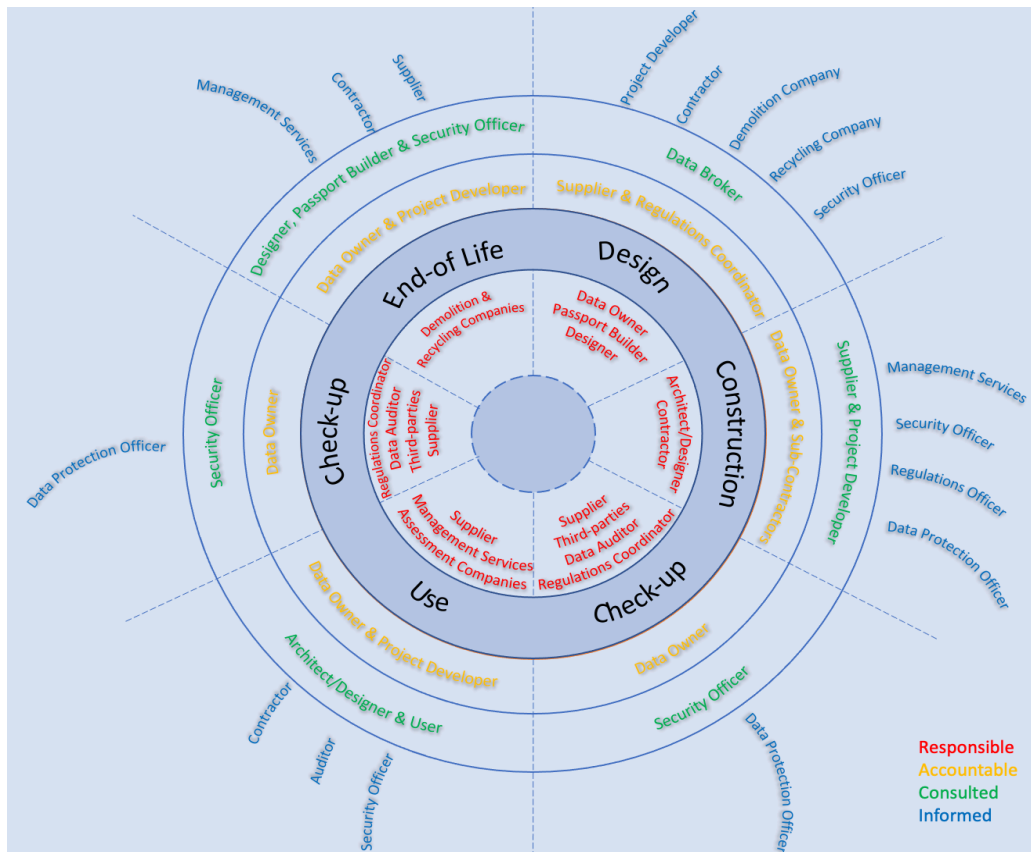
*Figure 32. The Compass Ecosystem for the **Traditional Supplier** Circular Process*
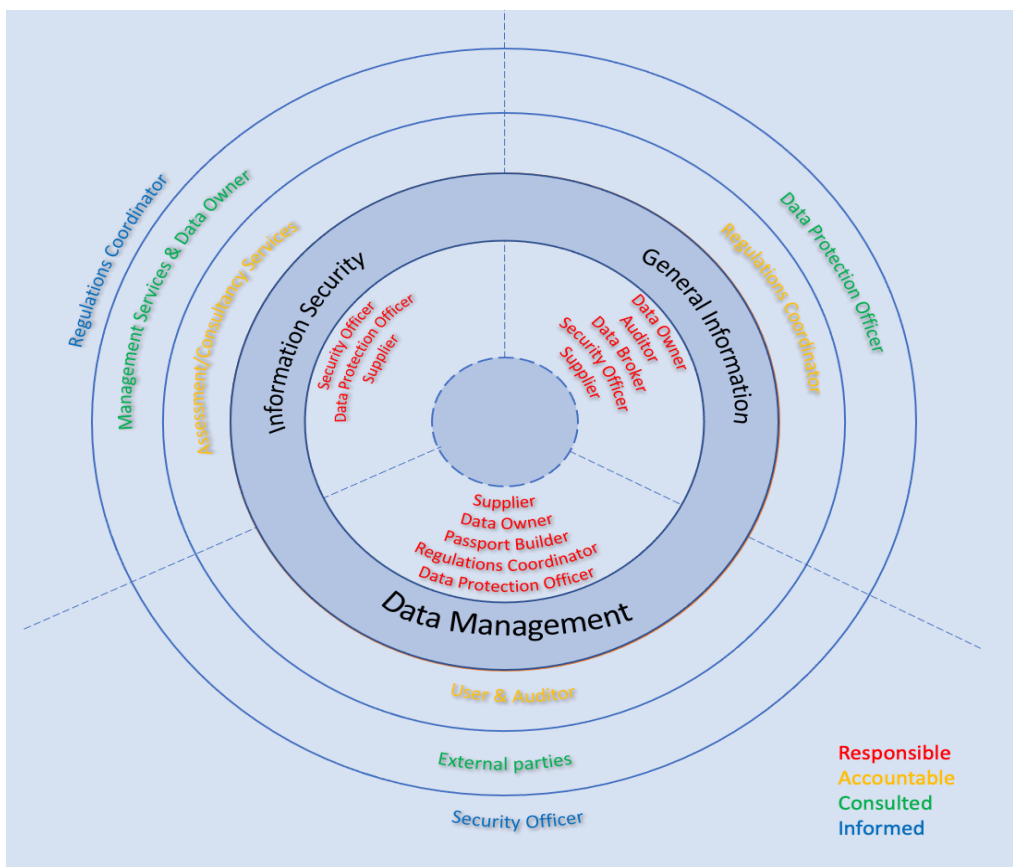
*Figure 33. The Supplier Compass Ecosystem for the **Additional tasks** Circular Process*

6.3   Discussion and Analysis

The centralization of data is more of a concept rather than a product, it is the idea of gathering, storing, and analyzing the data centrally within the organization. The **Centralized approach** to store data has been discovered through the literature study, it entails that every organization/party will adapt and change its requirements for keeping the data based on its own goals and objectives. Moreover, each project represents a series of passports that will have to be recorded and updated constantly under guidelines from a central platform. The main aim is to keep data easily accessible, and tailor-made based on its demands. This approach can be applied within organizations, teams, or asset owners. It promotes the value for which data is perceived as important for the organization/asset owner and is considered as one of the most important assets of the organization. Thus, the more accurate the data, the higher its value, accordingly this concept is applicable for material passports.
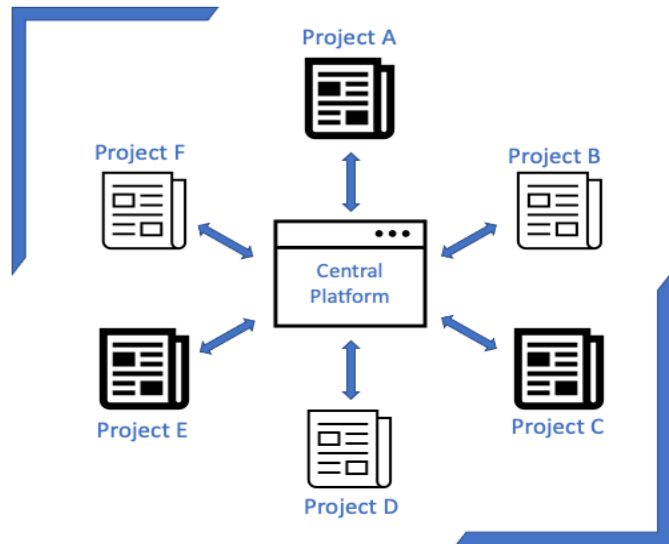
*Figure 34. The **Centralized** approach for Data Management*

As previously discussed, the **Supplier approach** dictates that data will be collected based on a national level rather than looking at each project. Each construction product will have a product code that refers back to the product itself and accordingly, updates will have to follow based on the changes that are made to this product. For instance, Supplier A could be a representative of Concrete suppliers and will have data regarding passports in multiple projects. Accordingly, each supplier will be able to determine which type of information is essential to best make use of the material passports: "Once we know what we are looking for, material passports become instantly more attractive" (Interview C, Interview Recordings D). In other words, suppliers will have a higher responsibility in keeping the data stored. This poses several challenges regarding their legitimacy to safeguard the data collected throughout a lifetime.
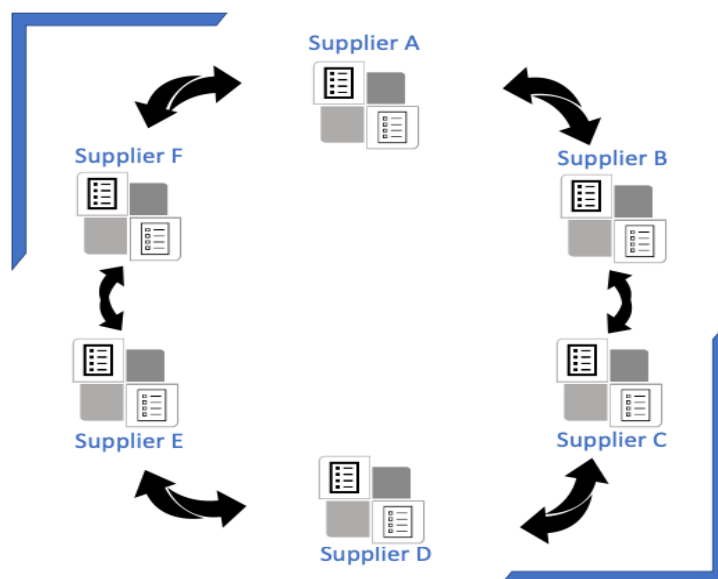
*Figure 35. The **Supplier** approach for Data Management*

The choice of the approach for collecting, storing, and using this data would rather have various outcomes in terms of responsibilities within diverse parties at different phases of a project. The two approaches for data management and data collection have been thoroughly discussed earlier. Table 13 presents the advantages and disadvantages of using each approach based on the criteria that were selected from the practical interview sessions.

Table 13. Comparison between the two approaches

Evaluation Criteria	Type of Approach	
	Centralized	*Supplier*
Data Loss	This approach promotes storing information centrally within the organization that can be shared through a central platform.	The supplier is responsible for storing the information. This approach puts the data stored at the risk of loss due to possibility of bankruptcy or changes in the market.
Standardized Format	An advantage of using a standardized format will help conformity and thus promotes re-use of this data in the future according to the guidelines.	Suppliers can understand what information is needed to be recorded. An advantage of tailor-made passports is not over-recording the data.
Monetary	Material passports are seen as an expensive approach in the real estate sector to maintain an asset over 50-60 years.	Keeping the data with the supplier is a good approach to update information about a single construction product for different projects or assets.
Confidentiality	Confidential information is highly regarded in the infrastructure sector and is some information need to be kept internally and centrally.	The supplier approach does not promote keeping information confidential; however, this is not seen as an issue for the real estate sector.
Mandatory Collection	Changes cannot occur in the infrastructure sector without updating the passport. This promotes the application of a centralized model.	Internal changes may occur weekly from self-employed people in the real estate sector. Keeping the data with the supplier promotes an accurate representation and updates of the passport.
Early Involvement	Parties that have a responsibility in keeping the data will be involved earlier in the process: both approaches can promote the design for circular. Parties that are involved at a much earlier stage of the project, in some cases, this cannot be applied to infrastructure projects.	
Learning Experiences	Asset owners or Suppliers will be able to understand what information is necessary from a passport to promote circularity through time. Both approaches promote effective use of the data collected as long as the party responsible fully understands that their active involvement is necessary to promote circularity.	
Data Storage	Using this approach for the infrastructure sector goes with the aim of material passports and how they are perceived by public parties and organizations based on the interviews.	Using this approach for the real estate sector is following the aim of material passports for public and private parties working in the real estate sector.

The aim of using material passports throughout different sectors in the Dutch construction sector is different from one party to another. The limitations that were presented in Figure 30 were incited from the literature and explorative interview sessions conducted with people working in the field of material passports. The limitations that were found presented a common ground to choose the criteria for the analysis. However, those limitations are more important for one party than another: based on the Compass ecosystem (for instance Figure 32) developed to divide responsibilities, parties that are marked in Red color at some stages have the highest degree of responsibility for other parties. Accordingly, the limitations and concerned parties are cited below:

- The absence of a BIM application for a centralized model of data storage presents a barrier to keep the data stored for material passports on a long-term basis. Based on the parties that have a responsibility in updating material passports, only parties that are present in the long term such as the Owner and Project Developer should be concerned with this limitation.

- The missing a standardized passport format to store the data should be the concern of parties working at the beginning phases of the project such as Producer/Supplier, Design team, and in some cases the Contractor. Not having a format to follow would eventually make the party responsible for information that has not been recorded, or information that should not have been registered in the passport.

- Since data collection is still a voluntary process and is not being incentivized earlier in the process. This presents a limitation on the degree of circularity that is being promoted in a project and will affect decisions taken by consultancy and design firms that are not getting involved earlier in the process.

- The long supply chain and the duration of a lifetime for some projects will have an impact on data storage and may cause data loss in the long term, this presents a problem in the real estate sector, where data end up being lost due to bankruptcy or changes occurring in the market for private parties such as Management, consultancy and storage services companies.

- According to several sources, the current aim of material passports is only to learn from the data collected. This presents a problem for the public authorities that want to promote the application of material passports, if seen not necessary, current data for material passports are not being safeguarded and are only temporarily collected for analysis.

The end responsibility lies with the party that is mostly affected or missing out on the added benefits of passports. Material passports are a tool that allows data storage to promote potential re-use and retains the value of construction products; however, several limitations that have been identified earlier have pointed out that different stakeholders have a bigger responsibility throughout different phases of the project. In the end, the most profitable party that will want to maintain its asset is the Lease owner/ Asset Holder for the **Infrastructure** sector.

While for the **Real Estate** sector, a distinction must be made between public and private parties. For the **private sector** (such as commercial places), the financial parties and the Municipality can mostly see the true value of collecting the data for potential re-use of materials. They care about the land retaining its value the most throughout its use phase. "Over the course of the lifecycle, the operational expense will exceed capital expenses to build the asset in the first place. So, it will be of highest interest for those who manage the facility to have information at their disposal once it is completed." (Interview L, Interview Recordings). Financial parties such as banks and insurance companies will have the highest interest to have a complete dataset for efficient and effective asset management to maintain the Onderpand (Collateral). "Once you want to decompose your asset, its residual value will be there only if you know it will be there, at the end of the day the financial parties such as banks and insurance companies will pay for it in the Real Estate sector". (Interview L, Interview Recordings). At the end of the lifecycle of

the asset, if a company goes bankrupt, the Municipality should be able to hold a certain degree of responsibility too. Accordingly, for the **public sector**, such as residential and housing associations, it is in the best interest of the Municipality and the financial parties to hold the end responsibility. However, an exception should be made for public parties such as governmental agencies, that represent the "infrastructure" side of real estate assets, it is in their best interest as asset owners amongst the Municipality to implement material passports since they follow the typical way of working of the centralized approach.

6.4   Limitations and Conclusions

The alternative approach for data collection and data management presents prospects of improvements for the successful application of material passports. Several advancements in the market point out the benefits of applying both approaches to different sectors as elaborated earlier. However, one way that can safeguard the alternative approach to collecting, storing, and trading the data is through the usage of blockchain technology. The technology provides a distributed ledger technology that is a system of blocks where datasets interact with each other by sharing the change that was made. Change cannot be made unless other blocks confirm for it and once a transaction is made, there is no way back. Blockchain technology only provides a basic premise upon which you can have a distributed ledger of information over different locations to promote the safeguarding of the data. Currently, this is out of the scope of this research, but the idea is to have a decentralized approach to store the data.

Throughout the research, the literature study was coupled with explorative semi-structured interview sessions with people working in the field of material passports. This has laid a foundation for a centralized approach to store the information needed. However, the division of responsibilities differ from one project to another and so far, further interviews were conducted with people working in material passports from a practical point of view in both the Infrastructure and the Real Estate sector. Results have shown that an alternative approach to storing the data centrally in-house or with one party has its advantages and disadvantages that will be explored in the next chapter. The alternative approach entails that data will be stored and safeguarded with its source; in this case, the notion refers back to the producer/supplier of the construction product.

Correspondingly, the framework has been developed for both **Centralized** and **Supplier** approaches and presented in _Appendix F: Centralized Framework_, and _Appendix G: Alternative Approach of the Framework_. An important note is that the framework developed is not the state of the art for every project but presents an approach by which the division of responsibilities is made clear for the projects in question. Due to the diversity and versatility of parties in various projects, there is a large number of interchanging parties that could not be represented in every single project. A clear distinction was made between the two presented approaches based on the practical interviews, seven main criteria have helped assess which approach is better for the application of material passports in the Infrastructure and the Real Estate sector. Each method presented advantages and disadvantages along with its limitations.

Finally, material passports have different aims for some parties, and accordingly, the limitations that were found for the applicability of material passports are more relevant to some parties than others for different stages of the project. One research gap is that the limitations will be problems for the parties that have been marked in red, the responsible parties in the compass ecosystem developed for each project delivery method. For instance, the Owner of the construction product or the Project developer in some cases should be highly concerned with the application of a BIM model to store the data since this limitation presents a barrier to keep the data on a long-term basis, and hence contradicting the concept of promoting the re-use value of the construction product.

7. Framework Applicability

This chapter discusses the applicability of the Framework developed from both approaches: Centralized and Supplier. The appendices have presented a thoroughly detailed division of responsibilities amongst the relevant stakeholders for different project delivery methods. The aim of this chapter is to elaborate on the most appropriate way to use the framework by embedding it through contractual agreements. Section 7.1 presents the goals and the objectives that the framework has helped promoting through contractual agreements. Moreover, section 7.2 elaborates on the four different methods for using the framework in contractual agreements. Once a method is chosen, Section 7.3 shows a detailed roadmap for its applicability based on the main two approaches: Centralized and Supplier. Finally, conclusions and limitations are presented in Section 7.4 on the applicability of the framework developed in the Dutch Construction Sector.

7.1   Goals and Objectives

The goal of the framework developed is to provide an overview of the division of responsibilities amongst major stakeholders throughout a project. The framework divides the project into different timelines, and accordingly, several tasks in data management related to material passports have been identified and explored.

Further responsibilities have been assigned to cover the full spectrum of tasks related to data management as explored earlier. The main objective of the framework was to show a clear division of those responsibilities. However, every team/organization has different ways of working, and implementing this framework through contractual forms can be limiting in some cases. The following section explores the possibilities through which the framework can best work without hindering the relationships amongst parties and the objectives of the project.

7.2   Applicability through Contractual Agreements

Throughout the framework, responsibilities have been assigned to multiple parties. Accordingly, there are several degrees to which a party is held responsible as elaborated upon previously. "He who owns it is responsible for the data". The approach that was followed is using a RACI (Responsible, Accountable, Consulted, Informed) matrix. The matrix has helped to identify at each stage of the project, what parties are involved in the process and to which extent they are held responsible for a specific task. A summary of the degrees of responsibilities is presented as the following:

- A **Responsible** party has an active responsibility in maintaining the data for partially sharing its ownership based on the task.
- An **Accountable** party has a responsibility in updating the data based on its degree of involvement in completing tasks and deliverables.
- A **Consulted** party provides an opinion regarding a subject, typically a two-way communication from an expert-oriented party.
- An **Informed** party is kept up to date on the progress, with whom it's a one-way communication.

Moreover, parties that are held responsible can best handle certain issues and tasks regarding material passports. From a legal point of view, the framework needs to be integrated within contractual agreements for its proper application. **<u>One way</u>** to hold a party responsible for a responsibility that they have is by integrating the framework in General Terms and Conditions of contracts such as the UAC 2012 or the UAC-IC 2005. The Uniform Administrative Conditions are based on the "traditional" way that dictates the relationships between different

parties. According to Chao-Duivis, the UAC 2012 is a revised version of the 1989 set with "hardly any sweeping changes". The UAC lays down conditions and terms for which the parties have agreed upon regarding administrative and legal provisions and does not elaborate on technical specifications. The latter are included and described in detail in the Specification section. Nevertheless, discrepancies could occur between the UAC and the specification section, hence the UAC is the governing rule given it is generally known unless it is explicitly stated otherwise in the specification. An alternative contract form to the UAC 2012 is the UAC-IC 2005 for integrated contracts that is also commonly used and sets out General Terms and Conditions between the parties. In addition to the Basic contract, the relationship is also based on the Client's Requirements, Annexes, UAC-IC 2005, Tender, and additional documents with the given order of precedence. The client's requirements are of great importance and compromise the schedule of requirements, provisional or the final design demanded.

According to Chao-Duivis, the **General Terms and Conditions** (GTC) are sets of conditions that lay down arrangements recurring in almost every contract form. Even though these conditions save a great amount of time for parties, they present in some cases unilateral advantages for some parties regarding others. Holding a party responsible is possible through stipulations such as the price, the place of agreement, goods to be supplied (etc.). Due to the importance of speed in legal operation, the GTC presents an attractive method to apply the framework in the Dutch construction sector. However, since multiple parties are involved in setting up those conditions, it is more problematic to apply changes for the General Terms and Conditions and would eventually be more time-demanding.

(II) Another way to introduce the framework is through **Special agreements**. Even though the statutory rules on those types of agreements are mostly permissive and can be waived. They usually occur more frequently in practice and help to assist the contracting parties in practice in *Purchase agreements*, *Contracts for works,* and *Commission Contracts*.

- *Purchase agreements* provide insurance for consumers purchasing both movable and immovable property (if the latter case applies it must be done in writing).
- *Contracts for works* are less common in practice due to the application of major sets of the GTC that can apply most of the time.
- *Commission contracts* refer to agreements by which a party does the work for someone else and not under a contract of employment.

Moreover, a third way to integrate the framework is through changes that may occur to the **Procurement Law**: the purchasing of goods and services from an outside body. Procurement is divided into three main categories: Supplies, Services, and Works.

- The *Supply* category covers the acquisition of products.
- The *Work* category covers construction and engineering activities.
- The *Services* category covers non-construction services such as auditing and legal advice.

Even though procurement laws are mostly embedded in the process leading up to the contract phase under the form of international conventions or European Directives. The European directives contain more concrete rules and sets out the **EU Legal Framework for procurement**, this set of rules dictates mandatory rules that have to be implemented. However, one downside is that procurement law does not apply to all works and contracts, buy for public work contracts, especially the Infrastructure sector.

Finally, a **fourth way** to divide the responsibilities according to the framework is to include it in the **civil code**, indicating who has which responsibilities under an adaptation of the axe itself. For instance, by setting minimum standards for environmental performances of buildings.

In summary, four approaches have been chosen to integrate the framework through contractual agreements: **(I)** Changes to the GTC of a contract such as the UAC; **(II)** Special Agreements that makes the other party responsible for certain tasks not part of the GTC but part of the contract itself; **(III)** Changes to Procurement Law; and **(IV)** Changes to Civil Code.

Moreover, the advantages and disadvantages of each method have been presented earlier. To choose between the alternatives, an understanding of how policymakers perceive material passports is essential. Interviews have been conducted with a representative from the Ministry of Infrastructure and a Consultant from the Municipality of Amsterdam. Both viewpoints cover the sectors that are researched in this study and are further summarized in Table 14.

Table 14. Summary of Policymakers Interviews

Topics	Ministry of Infrastructure	Municipality of Amsterdam
Goals	The ambition is not to "become" but to "**work**" circular.	Developed a program with the aim of making the municipality more sustainable.
Material Passports	- Developed a **strategy** that integrates different tools and criteria to assess, it researches material passports. - **"We still need to know more about it, what do we need with it, and how we can best use it to our advantage".**	- We are working with **three types** of passports: Madaster, Insert, and Excess and have different ways of working. - Key players come together and try to sketch guidelines for passports such as CB'23. **To what extent should we follow those guidelines?**
Involvement and Progress	- Material passports are being researched by organizations/companies: "**we support** by giving money to finance the research". For instance, **Rijkwaterstaat** is working on pilot projects. - **Material passports are still in the development phase and cannot be implemented on all our assets. It is not something we have to use in every project yet, but it is important that find out more about it.**	- **"We still have a lot of questions, but we should not undermine the will of doing things".** - Working on Pilot projects involving different approaches for passports. - **Regulations** are making it hard for us to re-use materials. For instance, you are able to re-use in the same building, even if the current regulations would forbid it.
Chosen Approach	- It would be expensive to use it for every project and we do not know how much it would cost for one project. - You can make the market do it for you, but then "you are not the boss". As asset managers, we don't want to get into the borrowing business. => **Centralized approach** preferred.	- **We do not know what type of information we are looking for.** - You need to change the way you work, and regulations do not allow to do so. The regulations affect to what extent we are able to re-use materials: the best thing to do is to **balance out two aspects**: the security of policymakers and the environmental groups. => **Both approaches** will work.
Limitations	To implement a new tool, **quantitative** measurement tools are easier to use. For material passports and circularity, it's all **qualitative**. **It's still too early to tell if the supplier will be able to do it by himself, will it be economically feasible? How can we best use it?**	**One limitation** is that the process is still in the beginning, and we do not know what to do with those passports. The issue remains the willingness of the parties. **Another limitation** is that the need of users changes over time, a structure may be used differently in the future.

Material passports are still in the Development phase, policymakers cannot make their applicability mandatory. However, according to the representative of the Municipality of Amsterdam, there are some laws and regulations that are making the re-use of materials difficult. For instance, building rules prohibit you to re-use construction materials on a new site unless it is implemented on the building itself. According to Olaf, "it's not about making exceptions for the rules, but one thing you can live by, if rules and regulations withhold you from doing the right thing then you are responsible of changing the rules." (Interview L, Interview Recordings), which is why changes can only occur on the long-term especially under the civil code and procurement laws.

According to an employee working at the Ministry of Infrastructure, "We still need to know more about it, what do we need with it and how we can best use it in our advantage" (Interview Recordings, Appendix D). Moreover, insights from the Municipality of Amsterdam's representative stated that "We do not know what type of information we are looking for" (Interview Recordings, Appendix D). Hence making the usage of material passports mandatory is not possible at the time being given that it does not still hold an attractive value for the asset owner. Accordingly, major changes cannot be implemented unless proven beneficial for most parties, thus only one option is suitable given the problem at hand.

The most fitting approach is by using special agreements for certain tasks regarding material passports in the contract itself rather than making changes to universally known sets of terms and conditions.

On another note, a problem may occur once two parties enter into negotiations with the intention of entering into a contract but each attempts to conclude the contract based on their terms and conditions. Even though changes could be applicable, they must be accepted by both: the user and the contracting party. One issue of this is if Party A offers that his GTC should apply, and Party B replies that he accepts the agreement and wants his GTC to apply, in other words, they both could assign the same task to the other party. The issue is known as the "Battle of forms", it refers to a general principle that states if the offer and the acceptance refer to different GTC, the first reference applies. In principle, the provision states the following: "The second reference has no effect unless the conditions in the first reference are explicitly rejected"(Chao-Duivis, A Practical Guide to Dutch Building Contracts). Moreover, it is essential to state that the rejection of the first reference's GTC does not mean the second reference's GTC applies, the new conditions proposed must in turn be accepted.

One obvious way to tackle this issue is through proper integration of both sets of conditions within the same contract under negotiations between the user and the contracting authority. In this case, the contract promotes a cooperative environment and supports parties repeatedly doing business together in the future. Negotiations ensure that both parties have enough consent and agree over the terms and conditions set.

7.3 Roadmap for Applicability

An implementation guideline for the Framework proposed is composed of 3 main steps: **Identification** of the project/organizational criteria, **Assessment** of the criteria according to aims and goals, and **Selection** of the Approach that will be followed. The following section presents a step-by-step guide for the application of the framework in the practical field.

Preparation

Every team, on a project or organizational level, should be able to assess the criteria needed that will contribute to the application of material passports. The preparation phase consists of introducing the framework developed to the team following the tabs provided in the Excel template (double click on the Icon for more information).

Conceptual
Framework - RACI

Step 1: **Identification of the project/organizational criteria**

At this stage, the team needs to become familiar with the tasks and responsibilities that are selected for the project. Tasks and responsibilities can be updated according to the objectives, and the focus would be to exploit the criteria that will have an impact on the applicability of the objectives selected. Hence, the team can make a list of the essential tasks and criteria.

Objectives (O)	Tasks (T)	Criteria (C)
O1: Reduction of costs	T1	C1
O2: Confidentiality	T2	C2
…	…	…

Step 2: **Assessment of the criteria according to aims and goals**

Based on the criteria selected, an assessment of each criterion should be identified to select a degree of importance that will help to rank those criteria according to the project's scope and the goals of all stakeholders. The ranking system will provide an added value of (+1) if it has a contribution towards the Centralized approach, and a (-1) if it has a contribution towards the Supplier approach.

Objectives (O)	Tasks (T)	Criteria (C)	Impact
O1: Reduction of costs	T1	C1	+1
O2: Confidentiality	T2	C2	-1
…	…	…	…

Step 3: **Selection of the Approach to be followed**

The positive and negative values do not dictate that one approach is preferred over the other, it only provides a brief representation of each team's preferences. Once all the criteria and their impacts have been accounted for, an overall score is calculated which will give the final overview of which is better to follow.

Monitoring and Reporting

The final stage regards evaluating and reporting the results based on the application of the model on a practical level. This stage ensures constant communication between team members and will help continuously updating the framework according to the changes to promote knowledge transfer from one project to another. The previous steps that have been stated are summarized in the following order in Figure 36.

Plan — Introducing the Framework / Setting objectives

Identify — Determining Tasks / Identifying Criteria

Assess — Prioritize Criteria / Impact assessment

Select — Exploit and Share / Enhance and Accept

Report — Evaluate / Communicate

Continuous transfer of knowledge
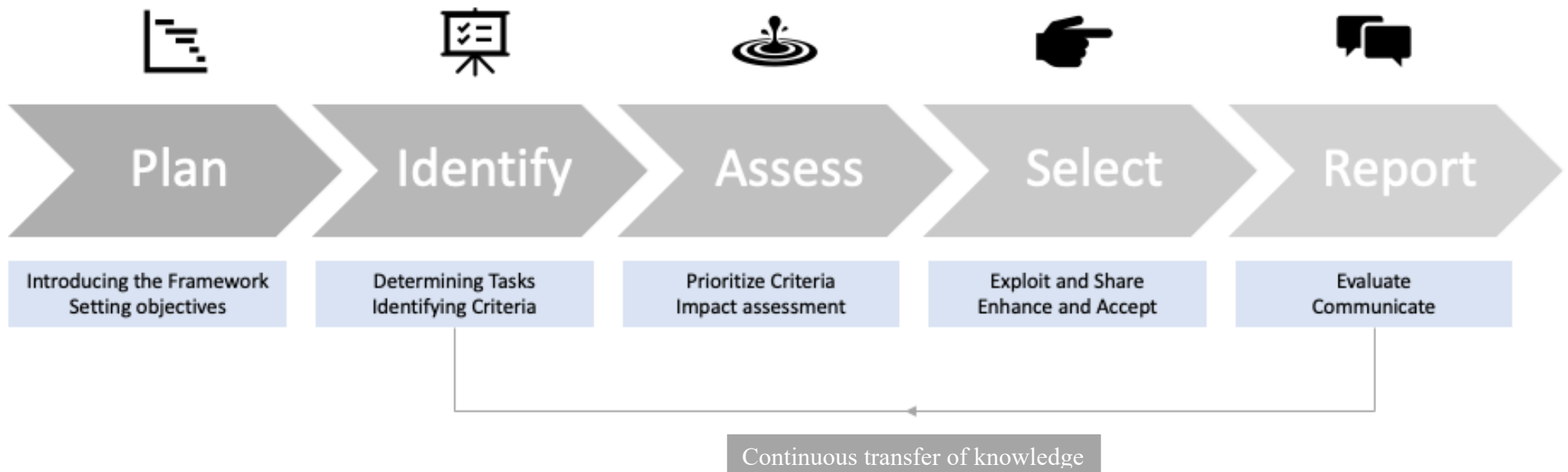
Figure 36. Implementing the Framework for an Approach selection

7.4   Validation, Limitations, and Conclusions

The framework presents prospects for its application through contractual agreements. Even though the framework has been developed for different project delivery methods, embedding it within the General Terms and Conditions of generally known and used contracts such as the UAC 2012 or the UAC-IC 2005 can be time-consuming and would require acknowledgment from multiple parties. One of the limitations of material passports that were presented in previous chapters is that parties are not familiar with what type of information they need and will eventually need in the future. Those results were taken from interview findings from a representative from both the Ministry of Infrastructure and the Municipality of Amsterdam. In addition, given that material passports are still incentivized in the construction sector and not mandatory, making changes to general contracts and procurement laws may seem improbable.

The proper way to implement it is by introducing it under special conditions within the contract itself. An issue may occur once two parties enter into an agreement, and both choose to have their GTC to be used. The notion refers to the battle of forms, for which each party may have assigned a certain task(needed to sketch/update the passport) to the other party. In general, the so-called "winner" is the last party to put forward its terms and conditions that are not explicitly rejected by the recipient before the contract was concluded. To conclude, the framework has been shared and assessed by two experts from the field as summarized in Table 15.

Table 15. Validation Sessions for the Framework

Topics	CB'23 Platform Validation Session	
	Validation Expert #1 (Interview L)	Validation Expert #2 (Interview M)
Structure	"I think it looks good and that it shows the things that I see as well when I look at the market".	"The people that you interviewed have participated with CB'23, I agree on several things with your findings".
Constituents	"When I look at the division of responsibilities, it obviously makes sense, because you have done it in a logical manner. You take the different phases; they promote the safeguarding of data".	"All those limitations have been presented recently in a paper that we published but in a much broader scope. What I really **like** is that along the entire value chain you thought of who is responsible of the data in a RACI way".
Applicability in Sectors	- "I think this can easily be applied in the **Real Estate** sector, given you provide the correct umbrella for data management". - "I think for the infrastructure sector, it's understandable that some organizations want to maintain the data for themselves, and the framework is applicable".	I also recognise that there is a distinction between the Infrastructure and the Real Estate sectors. At the end, it depends on the organization you are dealing with if they have the incentives to store the data themselves centrally. For **policymakers** I think it's reasonable if it's their way of working.
Contractual Applicability	I guess, special agreements are the initial way to go. Then on the long-term changing the procurement law may happen later on, however, general terms and conditions can never occur and will not change anything.	I think that what you did by making **crystal** clear of who is responsible of doing what in the value chain will help us solve the limitation of collaboration amongst stakeholders.
Overall Comments	"It's the little things that you point out through the symbols in green or red that I recognize immediately, to me it's important because I'm not the only person to see this".	"Would you let me send your findings to the people we are working with along with your report; I believe it's a nice way to think of how we can distribute the responsibilities like you did".

8. Conclusions, Recommendations and, Limitations

In the final chapter, the conclusions of this study are elaborated on in Section 8.1. Moreover, the research recommendations are provided for application in future projects in the Dutch construction sector alongside recommendations for further research in Section 8.2. To close, limitations post-research are summarized in Section 8.3.

8.1 Research Conclusions

This research has focused on understanding how responsibilities in the field of Data Collection and Data Management for material passports are divided amongst concerned parties for the Infrastructure and the Real Estate sectors. To achieve the research objective, the main research question was formulated as the following:

How can responsibilities of stakeholders for data management and data governance be arranged during the project phases and life cycle of built assets, to ensure the quality of a material passport?

The main research question is further decomposed into 3 sub-questions and accordingly the study was divided into **three main parts**. **Initially**, drawing a conceptual framework that introduces the responsibilities of the actors that are in direct relationship with material passports. This would help identify opportunities for change in the field of data management to ensure a proper distinction of the division of responsibilities throughout different milestones of a project lifecycle based on semi-structured interviews with theoretical people that are involved with material passports. **Moreover**, conducting empirical research to understand the relationship between the different actors based on the delivery method proposed and their degree of involvement with the construction element itself, based on semi-structured practical interview sessions. Limitations and barriers found have a role in analyzing this framework and thus, modifying it to have a clear overview of data collection and distribution based on the case studies presented. **Finally**, examining the effectiveness of the proposed theoretical framework in an evaluation stage based on a set of criteria that will be collected through an expert assessment session and finally provide further recommendations for future projects.

As a result, a framework that aims at dividing those responsibilities was developed for two main approaches: a centralized and a supplier approach, and properly integrated with a section to check its applicability. To conclude this research, the 3 sub-questions and the main research question are fulfilled:

> ***SQ 1:*** *What are the main elements included in a material passport and the different life-cycle stages in which a material passport is active?*

A material passport, or a "passport for the construction sector", is defined as a digital tool that documents a construction element. It states the ownership of the material and its sub-parts while presenting the purpose of the product from both qualitative and quantitative aspects (Platform Cb'23, 2019b). The overall constituents of a material passport according to CB'23 are (A) **General** information, (B) **Composition** of the object, (C) **Properties** of Construction products, (D) **Connections**, (E) **Certification** and marking, (F) **Verification and Validation** Documents, (G) **Other** elements.

Perspectives and opinions regarding material passports differ to a great extent. There is a need to integrate sustainability for materials in more than one lifecycle through the 10'R strategies (Figure 9). The fundamental idea is that continuous monitoring through a proper division of responsibilities for users will provide benefits to form a proper data governance plan. Moreover, the market presents different approaches to dealing with material passports. It was

noticeable that for competitive reasons, data should only be shared to a certain extent for some actors based on four levels of detail: B1 (Clarity about the material used), B2 (Generic Clarity on the product of the material), B3 (Specific clarity on the product) and B4(Specific data with the supplier and producer information). This separation will eventually create a barrier for users to update the data in a centralized shared BIM model.

The main concern remains the roles in updating and managing the data. Data monitoring for material passports is active in four main stages: **Production**, **Construction**, **Use**, **Demolition and processing** phases. In addition, two check-up phases were chosen to be inserted with the active stages of the material passports to help ease data collection and management through a continuous process: One check-up phase is between Construction and Use phase that will help checking the As-is condition, and another check-up phase is between the Use and Demolition phase that will provide more accurate information of the product after operational phase.

Those stages are the moments for which data monitoring and updating are a necessity to provide an accurate estimation of the quality of the material. However, parties change and vary along the full-time span of the project itself. Once a material cannot be re-used, it will be decomposed and can be used in future potential projects. This versatility in actors and stakeholders is due to the various methods of conducting construction projects, also known as project delivery methods.

> **SQ 2:** *What are the commonly used Project Delivery Methods in the Dutch construction market and how the roles of actors for performance monitoring and data governance are divided based on different delivery methods?*

Project delivery methods present an opportunity to divide responsibilities for data management and governance based on the execution method used. Stakeholders will vary across different methods for different timelines; however, an integrated approach was developed by (Huizing, 2019) that marked the main elements that need to be covered through every phase. Moreover, several tasks and responsibilities in the field of Data management were stated in Table 5 that will help divide the responsibilities for data management once data is collected and processed.

The roles were divided amongst the different actors that have an active responsibility based on the task at hand in the project delivery method. Actors were divided into Primary and Secondary actors. **Primary** actors have a bigger responsibility in keeping track of the data than secondary actors based on the extent to which data is shared with them. While **Secondary** actors will be classified as less involved parties based on the timeline of the project. Some relevant actors to mention are the Owner/Client, the Contractor, The Producer/Manufacturer/Supplier, User, and Passport Builder. Additionally, opportunities gave rise for new parties to enter the market for functions such as Management, Financial, Storage, and Consultancy services that will have both Primary and Secondary roles based on the timing of the project as presented in Appendix E.

Finally, The RACI Matrix provides a basis to design the conceptual framework for Data Collection and Management based on qualities and requirements that are needed to keep a convenient data management plan. The GEMMA Tactical Data Management offered an opportunity to investigate the actors that are involved in the collection process and were coupled with the actors from different project delivery methods. This shared approach will promote multiple uses of the data for an efficient method to update material passports while promoting collaboration between consumers and suppliers.

> **SQ 3:** *How can responsibilities for data management be arranged in active stages of the material passport and what are limitations for the transfer of ownership of data between the actors that will have an impact on the re-use value of the asset?*

The framework developed was based on the literature study and semi-structured explorative interviews that were conducted with people working in the field of material passports. Different point of views has allowed to further divide some tasks and responsibilities into the roles and parties involved in different project delivery methods. Topics from the Interviews covered mainly Material passports, Project delivery methods, and Contracts, and Data Management. Accordingly, the parameters of the framework are listed as the following: (1) Identifying the project phases, (2) Recognising the tasks needed for Data Management, (3) Classifying stakeholders and dividing/changing ownership of the product, (4) Ranking the responsibilities of relevant stakeholders, and finally (5) Drawing the RACI Matrix.

The conceptual framework was developed to involve 22 parties in total that are divided into 4 main categories: Parties directly related to the project, third-services companies, Demolition and Recycling companies, and finally parties that are highly involved in the field of Data Management. Moreover, the responsibilities were divided into **4 main types**: (R) Responsible, (A) Accountable, (C) Consulted, and (I) Informed that are further explained in *Appendix F: Centralized Framework*. In addition, based on the framework developed for each project delivery method, a graphical representation called the Compass Ecosystem was sketched to be able to visualize the parties and their degree of responsibility based on the project phase for each project delivery method.

The model has allowed a closed circulation of data and optimizes the re-use option for materials based on the different barriers that pose a challenge for its applicability to the Circular Economy in the Construction sector. Nevertheless, the model was developed based on findings from the Literature section and explorative interviews. In comparison to the practical field, several **limitations** were selected that resulted in modifications to the model as follows:

(1) Missing of a centralized BIM model for data storage
(2) Non-conformant standard approach to store the data under one passport format
(3) Data Collection is not mandatory and not incentivized earlier in the process
(4) Data Loss due to the long supply chain and the duration of a lifetime
(5) Current aim is only to learn from the data collected

Therefore, through results presented from the sub-questions, the main question can be fulfilled:

> *How can responsibilities of stakeholders for data management and data governance be arranged during the project phases and life cycle of built assets, to ensure the quality of a material passport?*

Initially, interviews have been conducted with parties from the infrastructure sector and one common goal is maintained with shared views on the problem. The usage of material passports is being promoted throughout different national projects in the Netherlands, and data collection is becoming mandatory in pilot and real projects. However, storing this data has seen different approaches: some want to store the data with the supplier, while other parties prefer storing it centrally in-house. Both strategies have their advantages and disadvantages that will be discussed at a later stage to find the optimal solution for the infrastructure sector in the Netherlands.

Moreover, findings from interviews conducted in the real estate sector have shown that there is a common goal applicable regarding circularity, however there should be a distinction between public and private real estate sectors. Housing associations perceive material passports as an expensive solution to this issue in the long term. Data is stored locally on excel sheets under a multi-year maintenance plan that states the conditions of some building components that need regular maintenance. Nevertheless, two limitations were adopted throughout: the

initial is the uncertainty of the information we are looking for, and the second limitation is self-employed people (or DIY: Do it yourself) that can make changes freely in the real estate sector.

The model that has been developed from previous stages emphasized the fact that data will be stored centrally within the organization. However, with the emergence of the alternative approach from the interviews conducted: the supplier approach, a better understanding of the two situations is provided as follows.

The Centralised approach refers to storing data centrally within each organization, every organization will be able to determine what information is necessary to have the "complete" passport to promote material re-use. On the other hand, the Supplier approach dictates that data is collected and stored with the supplier. Instead of generating millions of formats of material passports, every supplier will be able to determine what type of data is needed and thus will be responsible for keeping the data on a national level.

According to the findings, several criteria were selected according to the limitations and the interviews conducted with both sectors. The criteria that will help in providing a judgment are **Data Loss**, *Standardized passport format*, *Monetary*, *Confidentiality*, *Mandatory collection of data*, *Early Involvement*, *Learning experiences,* and finally an additional criterion of **Data Storage**. A clear distinction has been made between the goals of the Infrastructure and the Real Estate sector, based on the advantages and disadvantages presented in Table 13, using a Centralised approach to store the data is best optimized for the infrastructure sector: confidential data is safeguarded on the long-term while tailor-made passports can be designed based on the organization's demands. While for the real estate sector, the supplier approach is best applicable to residential and commercial uses, due to limitations such as self-employed people (DIY) that can make changes to a construction element without updating the model.

A solution to this is the central management of data in a decentralized approach where the position information (location of the product) is there centrally managed, but the product data remains with the supplier/producer. Hence, keeping the product data with the source can benefit in recording one batch on a national level, instead of keeping track of thousands of projects, thus avoiding monetary issues while promoting the mandatory collection of data through the supplier.

To close, the limitations that were collected present barriers for certain parties more than others at certain stages of a project. The division of responsibilities that are shown in the compass ecosystem gives a better understanding of how those barriers can be perceived as problems for some users that have a higher responsibility at certain stages. Similar to how material passports may have different aims for some users, the problems emerging from the barriers that were retrieved will be different from one party to another. Hence, as long as every organization is able to adapt this framework based on its own needs and goals, both the centralized and the supplier approaches can be applicable: "The process is about providing rough guidelines and not making tailor-made approaches for both sectors." (Interview C, Appendix D).

8.2   Recommendations for future work

Alongside this research, multiple recommendations are divided into two main parts. Recommendations are presented on a practical level in Section 8.2.1 and recommendations for future research are presented in Section 8.2.2.

8.2.1 Recommendations for practice

- Usage and application of the framework on construction projects in the Netherlands from both: Infrastructure and Real Estate sectors. This application will help promote a continuous feedback process upon which the framework can be updated.
- In addition, the local government must ensure proper separation between the two sectors. Rough guidelines should be provided to check the applicability of this framework for the sectors and accordingly will help choosing an approach for the problem at hand.
- In the **Infrastructure sector**, every user will be responsible for determining what type of information is necessary to have the "complete" version of a passport on an organizational level. Different organizations will have different goals and aims they want to reach. Hence on an internal level, it is necessary to acknowledge what every organization needs from the passport and accordingly overcome the limitations that they face along the way.
- In the **Real Estate sector**, recommendations have shown that Suppliers will be the best handlers of data over a centralized model due to the limitations present. Which allocates additional responsibilities for the Supplier throughout the lifecycle of the construction product. The central government should set minimum requirements by which the supplier is able to apply a circular model while promoting re-use of the construction product, this can be typically achieved through standards and certifications. However, there should be a distinction between the Real Estate sector itself, public and private sectors will have different end responsibilities with a high involvement of the Municipality, asset owners and financial parties.
- Finally, it is important to have a shared database upon which organizations and private users are able to share this data. A clear separation must be made between confidential information, especially for the infrastructure sector, and non-confidential data. This database can provide further opportunities for new upcoming projects.

8.2.2 Recommendations for further research

- The scope of this research is limited to optimize the responsibilities for data collection and data management for parties that represent a great portion of the market. However, parties change based on the organization and the project under discussion, the framework cannot represent the full market and can only provide rough guidelines upon which future studies can search for changes on a supplier/organizational level.
- The introduced approaches to store the data Centrally or with the Supplier may present additional limitations that were not accounted for in this research. Induced limitations should be exploited through interviews to maintain the goal set. The study can be extended with literature on barriers for organizational changes and understand how those barriers can be overcome.
- Moreover, this research followed the Gemma Tactical Data Management plan to determine some data management tasks and activities. Further research may help get a better estimation of the tasks that can be included in the framework developed.
- Several criteria have been identified throughout the research that has helped understand what topics are crucial for the successful application of this framework. Future research may help determine how those criteria can be different from one organization to another, as the research could be extended on how these can be determined in regard to the project at hand.
- A limitation of this research is that there was no separation between new and existing projects in the Netherlands. The research was not conducted with a

company/organization which can be a limitation in itself in finding the data needed for existing buildings. Once data is lost, existing buildings may pose several challenges for the applicability of the framework on those types of projects. Future research may look into combining expectations from Demolition & Recycling companies and Suppliers to get an estimation of the constituents of the asset, hence enriching the results of the framework.

8.3 Research Limitations

The methodology used throughout this study has provided multiple insights into the responsibilities for data collection and data management for the Infrastructure and the Real Estate sectors. However, certain limitations of this research need to be stated as the following:

- Participants in the semi-structured interviews gave multiple insights into the problem as interviews were following a protocol to cover the topics of Circularity, Material passports, Project Delivery Methods, Data Collection, Data Management, Limitations, and Recommendations. However, not all participants had the ability to cover most of the topics that were mentioned previously. Additionally, the research was not conducted with the help of a company, and accordingly, the number of interviews may be considered enough to cover the research questions. However, conducting additional interviews could help formulate a better understanding of additional points of view and provides an accurate model for the division of responsibilities.

- Some interviews were conducted with people working with the Platform CB'23, that for instance, has a board that changes every year, and conducting further interviews with newcomers may result in different points of view and accordingly different findings based on the shared perspectives. Similar to how material passports have different aims for some users, some limitations are found to be more important for some parties rather than others in the construction market. This presents a limitation in how different parties perceive the problems of the applicability of material passports. Therefore, conducting additional interviews continuously will help further formulate the problem and can help updating the model accordingly.

- The results for the final design of the framework were based on interviews conducted with organizations and people working with material passports: in practice. The key element to mention is that the case studies that were chosen to base the results on were how organizations are approaching the problem of Data management rather than focusing on individual projects. In other words, the research covered only their approaches to managing the Data. This forms a limitation since every project might present different conclusions that can have an impact on the framework developed. To overcome this limitation, every organization can reflect on its projects and assign different degrees of importance to update the model based on its own goals and needs.

- The developed framework was not tested in practice to check its applicability and its effectiveness. Since results were based on theoretical and practical interviews, the validation of the model was conducted with an expert that has some insights into the practical field and is not highly involved in the theoretical and research field. Hence, the application of the framework for different organizations may not be typically identical and does not provide an accurate representation of the market.

Reflection

Looking over the past months, I have been eager, full of ambition, and motivation on the research topic regarding material passports. Being an optimistic person has pushed me with the drive to look for the positive aspects of things. Whatever challenge lies ahead, I tend to capture the opportunity amidst all chaos. The limitations and barriers that stand in the way of the applicability of material passports have pushed me further to find solutions to the problems at hand. I was curious enough to research the Data management aspect of material passports and how can we turn those limitations into our advantages. Most importantly, my main motivation was the constant interest that I received from the people that have contributed to this research.

My conclusion is the following: I see material passports as a tool upon which circularity could be implemented. With or without, we have goals to reach and barriers to break that will help ensure the transition towards a circular economy by 2050. Change does not happen overnight, and one of the best ways to cope with it is using material passports. Multiple studies regard the technical aspect of how we create material passports and how to standardize them. The **Why** is well known, the **What** only partly because it's an idealized version of a utopia for everything down the line. What needs to be emphasized is **How** is it going to present an economic benefit so that a well-designed circular program will always out-compete with a linear counterpart. "The real engine of change lies with the people, and they are only willing to act if they see its economic benefits, people are only willing to plant trees if they can make money from tree plantations" (Olaf Blaauw, Interview Recordings). Accordingly, the way we exploit our data to ensure circularity throughout different lifecycles of an asset can only be brought to the economy if it shows that its profitability is ensured better than its alternatives would have done.

I learned multiple lessons throughout this journey, and to quote the significant ones:

- o Information is only valuable if it is correct and how to correctly use it to our advantage. It's necessary to have the data centrally managed while emphasizing the importance of maintaining a standardized passport format to maintain the same level of plain field (same language) upon which the supply chain can be facilitated.
- o There are always different viewpoints on the problem. Once you reach the consensus that all parties must come together at some point and take the decision to tackle the issue at hand, only then can progress be made. Eventually, the problems will be the fitting pieces of an overall puzzle.
- o Introducing new ways of working for some can be difficult. Additional responsibilities will be further assigned in a way that it contradicts with our habits and ways of working. Nonetheless, change is inevitable and can only be achieved with time once we realize that its benefits work in the long term.

Reflecting on the outcomes of the research, I can proudly claim that I am satisfied with the results obtained and the framework established. If I had more time, I would have piloted the framework developed on projects and teams that are working in both the Infrastructure and the Real Estate sectors. Each organization or team can now fine-tune the framework based on their own needs and goals. To close, Olaf elaborated further, "If there is no desire to treat the information as dynamic, it will remain as a static document to meet the demands, which hinders its functionality tremendously. Anything can be applicable anywhere, the main question remains, are they going to do it?".

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Appendix A: Terms and Definitions

During the research, Table 16 presents definitions and abbreviations that were used in the application of Circular Economy.

Table 16. Overview of Terms and Definitions

Term	Definition	Source
Bill of Materials (BOM)	*List of the components and materials used in a project*	BS 8001, (2017)
Building/Material Passport	*Digital document that records the object's constituents qualitatively and quantitatively, its ownership and location*	CB'23, 2020a
Circular Construction	*Carrying out construction activities by re-using building components without depletion of natural resources*	CB'23, 2020a
Circular Economy	*System that optimizes the use and value of resources flow*	14 in CB
Construction Product	*Produce from incorporation of materials and raw materials and used throughout Construction works*	NEN 2660
End-of life	*Stage for which a material has reached the end of its functional life and is processed as waste for treatment*	NEN-EN 45555
Project Delivery Method (PDM)	*Legal system used to organize design, construction, operations, and several services for a construction project*	Chao-Duivis, et al., 2018
R principle	*Circular Strategies such as Reuse, Recycle, Repair (etc.)*	PBL, 2017
RACI Matrix	*The Responsible, Accountable, Consulted, and Informed matrix delingates the degree of responsibilities with Responsible being the highest*	CB'23, 2020a
Raw material	*Material produced by earth's natural resources used by humans to produce materials and construction products*	CB'23, 2020a
Reuse	*Provide a second opportunity to use construction products and components in the same function after treatment*	Stichting Bouwkwaliteit, 2019
Waste	*Substance that holds no value in the eye of the holder and intended to be disregarded*	EU parliament 2008

Appendix B: Thesis Planning

To fulfill the research objectives a schedule was sketched given the different milestones and parts presented previously. The research project will start on the 19th of May 2021 once it is approved by the graduation committee. The goal is to deliver the final report and defend my thesis project by the 19th of October 2021 the latest. There are foreseen risks that will have to be overcome from which:

- Late and fewer responses on the survey that will be conducted might result in inaccurate results and thus will have an impact on the results and recommendations. Mitigation measures are limited, however, keeping the surveys short and to the point will keep the attraction of the reader for an efficient process.
- Communication is becoming more challenging with the uncertainty that lies with the COVID-19. Data that is required will have to be scheduled and planned of the week to prevent future delays.

The following Figure 37 and Figure 38 shows the detailed schedule with linked activities.

Task Name	Duration	Start	Finish	Predecessor
⁴Master Thesis	110 days	Wed 5/19/21	Tue 10/19/21	
Kick-off Meeting	0 days	Wed 5/19/21	Wed 5/19/21	
⁴Theoretical Framework	30 days	Wed 5/19/21	Tue 6/29/21	
Literature Study	10 days	Wed 5/19/21	Tue 6/1/21	2
Structured Interviews	20 days	Wed 6/2/21	Tue 6/29/21	4
Report Writing 1st Section	30 days	Wed 5/19/21	Tue 6/29/21	5FF,4SS
Milestone 1	0 days	Tue 6/29/21	Tue 6/29/21	6
⁴Development of the Framework	35 days	Wed 6/30/21	Tue 8/17/21	
Case Studies	20 days	Wed 6/30/21	Tue 7/27/21	7
Mid-term Meeting	0 days	Tue 7/27/21	Tue 7/27/21	9
Designing of the Framework	15 days	Wed 7/28/21	Tue 8/17/21	10
Report Writing 2nd Section	35 days	Wed 6/30/21	Tue 8/17/21	11FF,9SS
Milestone 2	0 days	Tue 8/17/21	Tue 8/17/21	12
⁴Application in Practice	25 days	Wed 8/18/21	Tue 9/21/21	
Evaluation Phase	25 days	Wed 8/18/21	Tue 9/21/21	13
Report Writing Part 3	25 days	Wed 8/18/21	Tue 9/21/21	15SS
Milestone 3	0 days	Tue 9/21/21	Tue 9/21/21	16
Report check and review	10 days	Wed 9/22/21	Tue 10/5/21	17
Green-light Meeting	0 days	Tue 10/5/21	Tue 10/5/21	18
⁴Finalize Thesis	10 days	Wed 10/6/21	Tue 10/19/21	
Report check and review	5 days	Wed 10/6/21	Tue 10/12/21	19
Deliverable Final Version	0 days	Tue 10/12/21	Tue 10/12/21	21
Presentation Preparation	5 days	Wed 10/13/21	Tue 10/19/21	22
Final Presentation Date	0 days	Tue 10/19/21	Tue 10/19/21	23

Figure 37. Schedule with activities and milestones to be achieved
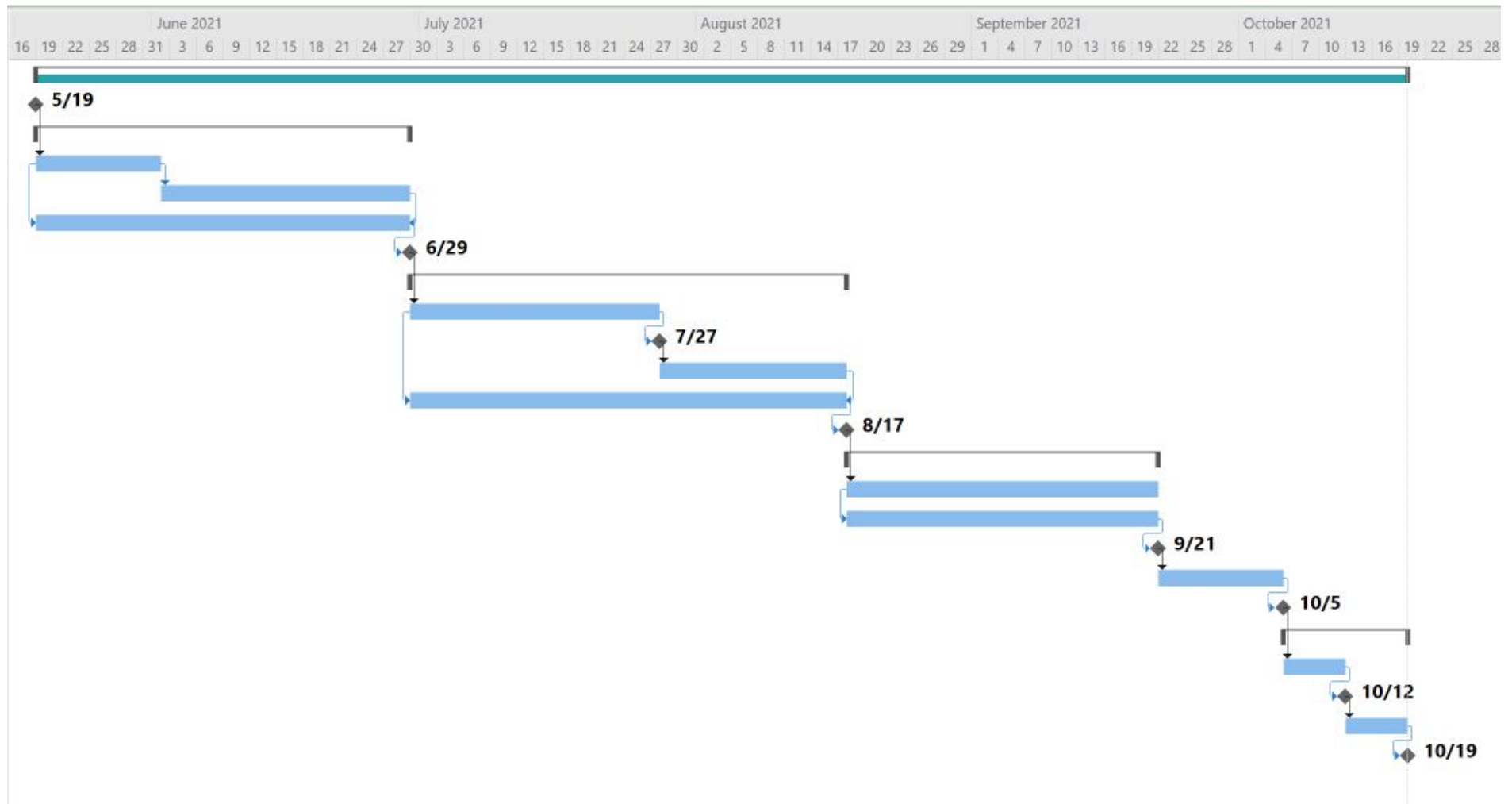
Figure 38. Planned Schedule based on the activities

DATE		
ORGANIZATION		
INTERVIEWER	Jalal Chahine	chahinejalal@gmail.com
INTERVIEWEE		

- Thank you for taking the time to contribute to this research. Before we start with the interview, I would like to ask if it is possible to record this conversation.

Introduction

- Present some personal background information
- Construction Management and Engineering Master Student at TU Delft
- Show my interest in Sustainability in Construction and the focus on Material passports
- What is your current position at the organization? And for how long have you been working there?

Research Objective

The aim of this research is to investigate the responsibilities for data collection and management for material passports based on different project delivery methods. The transition from a Linear to a Circular Economy is lacking standards and frameworks that divides those roles for data monitoring throughout the project lifecycle. Eventually, data ends up being uncollected, or ignored in some cases.

In this research, I aim to investigate how we can divide those responsibilities based on the actors and the tasks that needs to be covered at every stage of a project. Eventually, I gather insights from different perspectives: Client, Contractor, Municipal representatives, CB'23 or Madaster (etc.). It was decided to conduct semi-structure interviews.

Purpose of the Conversation

Gain insights into opportunities and barrier that stakeholders perceive in the application of Data collection and management for the Dutch Construction sector.

Structure of the Interview

The interview entails three main parts. The initial part will focus on the applicability of the Circular Economy and Material passports in the Dutch Construction sector. The second part reviews topics related to Data management. Finally, the last part will be a reflection on the future and potential application of material passports.

Interview

INTRODUCTION

- What is your perceptive on Circular Economy?
- Are you familiar with the concept of Material passports?
- What kind of activities does your organization undertake regarding Material passports?

TOPICS

- **General Acknowledgement**
  - Importance of data gathering
  - Active stages of Material passports
  - Check-up stages
- **Project delivery methods**
  - Traditional vs Integrated contracts
  - Timeline and milestones of projects
  - Concept of circularity in contracts
- **Stakeholders**
  - Main stakeholders for material passports
  - Pre-defined roles
  - Classification of stakeholders
- **Data Management**
  - GEMMA Tactical Data Management Plan
  - Future use of the data
  - Who would benefit from it?
- **Tasks and Responsibilities**
  - Name some responsibilities
  - Criteria to divide tasks (Economic, Legal, Governmental)
  - Extent of the responsibilities
  - RACI Matrix

REFLECTION

- What are your future perspectives to the applicability of material passports?
- What are limitations and barriers for data management?
- What are opportunities for data management?

Thank you for your time and participation. I will transcribe the interview and then send it over to you for review. You will receive a copy of the report upon completion of the research.

Appendix D: Interview Recordings

DATE	11th June, 2021
ORGANIZATION	Madaster Services (Director & Co-founder)
INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)
INTERVIEWEE	*Pablo van den Bosch (**Pablo.vandenbosch@madaster.com**)*

Introduction section

The main aim of my thesis is to come up with a framework that shows the responsibilities of parties in data collection and monitoring. Data sometimes, ends up being uncollected and ignored in some cases. It was mentioned on the website of Rijkwaterstaat, that it is one of the biggest data buyers in the country, however some data ends up being unused. The purpose of our conversation is to gain more insights into opportunities and barriers that stakeholders might perceive in data collection and management.

Rijkwaterstaat is one of the parties because they focus on infrastructure and own a big chunk of infrastructure in the network. They have a big budget to spend on all sorts of activities, but they think they are (subjectively) the only party that can do this but looking at the sector from wider angle you see that there are many players that have a much more dominant role in the data part. Governments are typically not aware of what's going on around them because they think that they are the only ones that run the show and so there is an arrogance in how they work, and they are not being corrected because they are such a big buyer. For instance, contractors are dependent upon the clients so they're not giving the pushback that they should receive. This is a subjective part close beyond that maybe based on what you're doing but I reviewed your topic and I think it's a very interesting one you are investigating.

An interesting question, we were discussing Rijkwaterstaat as a major party in data management. What are other actors that play have a say in the process?

First part is a split between infrastructure and real estate both are about as big as they are both the same in size. When you just look around you understand half of it are buildings and the other half of it are bridges. You cannot speculate with infrastructure, but you can with real estate since the value is different. Looking at the various players, you see that on the infrastructure side it is an oligopoly where you have the country's public organizations on a country level; you have it on a regional level which in the Netherlands are the provinces and finally you have it on a municipality level. Those three parties are on the show with infrastructure, with Rijkwaterstaat being one of the most dominant players especially since they moved together with the rail infrastructure. Additional parties' part of the execution are ProRail, the Ministry of Infrastructure and waterworks on a national level. On a regional level, they are not extremely strong, and on the municipal levels there are only 10 players that are strong enough and the strongest of them are the G5: the five biggest cities (Amsterdam, Utrecht, De Haag, Rotterdam and Eindhoven).

They are the only ones that have the capabilities to do something up to the national level, but apart from these municipalities provinces and national organizations we have a couple of national organizations that have a strong infrastructure role as well: the networking companies for electricity (Tenet etc.), Delfland (waterworks on a regional level) and drinking water companies. This will make up the full sketch of the infrastructure, looking at those independent organization as the electricity, surface water and drinking water; they are strong independent but not fast because they are not a central organization such as Rijkwaterstaat. If you look at the size of all these local regional players, they are bigger than Rijkwaterstaat but not as organized.

This was only half, the other half as mentioned is Real Estate. When you go into a material level and on a project level, there is no difference with respect to treating data. However, there a difference between the two Domains. The infrastructure is local and dominated by national structures, national organizations. You do not see Rijkwaterstaat work together with the ministry in Belgium or in Germany. Different countries, different cultures and there's no entrepreneurship in it to to develop something new because there's always plenty of questions. On the real estate side, you see that there is a full domination on a global scale like pension funds, commercial investors, asset management funds, construction companies or developers as dominating organizations are always international with an interesting landscape.

Would you like to share for the conversation your current position at Madaster and for how long have you been working there?
I am the Cofounder and currently one of the directors of Madaster services which is the central organization taking care of the platform and the organization that provide services through the various operational companies in the different countries (Switzerland, Germany, Norway and very soon in Belgium).

What is the main goal of Madaster and what type of activities does it cover?
Madaster is the register for product and materials in the built environment. We provide the service to register and document data by using methodologies such as link data or connecting to other data providers. So, we can reach data, we valuate the registered object, so either real estate or infrastructure from a from an environmental perspective (circularity indicator) for instance but also from a financial perspective so what's the value of the material applied in a construction object. Of course, next to this we generate the material passports.
The reason why we're doing this is that we have a vision: we see waste as materials without an identity and therefore we have a mission to give materials an identity by giving them material passports and to make sure that the data that is being registered is available for our economy to facilitate a circular economy because without the data you cannot reuse products and materials.

<u>**Section: Material Passport**</u>

Without investigating into definitions of basic terms that are present on the website of Madaster. Material passports have stages at which they are mostly active: Production, Implementation, Use and Demolition phases. Do you agree with this composition?
Yes, so the concept of a material passport is easy to understand. The actual passport itself is not the objective; it's just a means to register the data. That's the most relevant part and you can use this data in different stages and if you want to call it a passport or if you group data into a document that a passport that's fine. But it's not the passport itself, it's the content of the passport which is the data. It's like you have a Belgian passport that but it's not the booklet

itself that is the value it is the whole concept behind that when you receive the passport, it represents a whole set of documentation and legislation of who you are

Regarding data in material passports, is this data being monitored throughout different phases?
It should be. For the past 10-15 years, with the start of BIM throughout the lifetime of construction objects you see that the way how data is used is not consistent. Because the supply chain is very long and the duration of a lifetime can be very long, so data assembled in the initial design phase was lost when it was handed over from design to construction, or from construction to use. This is applicable throughout all project phases from one to the next years until demolition phase. This is mainly because of the big supply chain to make, maintain and demolish construction objects and the complexity of the data was not a central item. Data is not properly managed and still voluntary collected and that is one of the important factors why reuse is not taking place during a long process and technology has made that possible to lower the costs with proper documentation so that's why it's only recently becoming more relevant in the Construction sector.

Are there any check-up phases in between those phases that were mentioned previously?
In buildings you call them facility management and maintenance while in Infrastructure you have monitoring and maintenance services. There are multiple checks in between project phases. For instance, if you compare it to the automotive industry when you buy a car you do frequent maintenance and based on the amount of maintenance you do at the manufacturer you can also see a value back in value of your car. When you are not doing your maintenance, there is this risk if you do not maintain it as a dealer, you have an issue. In this case, its monitorable because we're talking about the life span of 10 years with automotive. With buildings that can be hundreds of years and so the direct connection at the supply chain between designs the maintenance players very long duration is has a limited chance that everything is centrally monitored and observed.

By central monitoring observation, do you see Madaster acting as a centralized BIM model for material and passport exchange?

That's a tricky question. I see Madaster as the central register where you can store data where the register takes care that the data will not be lost. We do not see ourselves as a replacement of a working archive for maintenance activities. We make sure that what you do operationally can be safeguarded into Madaster and we do not want to replace the working libraries so to say of maintenance or construction companies mainly also because we do not have the tools to optimize efficiency of the maintenance. I'm being a bit careful to claim that position also because that position is taken by other parties that are focused on the efficiency of the process, we are focused on maintaining the data: we are just the register.

Based on the "Training the Ark" example of a material passport shared on Madaster's website: it showed a clear and detailed example of a material passport and so to have this detailed information about material passports; who are the actors from the private sector that are involved in this process?
In the world of real estate are multiple partners more than at the infrastructure level. Just to give you an example of the entities that are involved in assembling, gathering and then registering the data we're talking about designers, architects, engineers, procurement managers, contractors, manufacturers and consultants that give advice with respect to sustainability. We also have installation companies that are taking care of the build of the installation works so

you usually get up to 10 different parties that are involved in a basic building only in the construction phase when buildings are bigger modeling is sort of tricky work. Specialized agencies can enter as we have engineers for facades for construction for fitting, the amount your separate project managers, with obviously the client involved. So, 10 players for a basic building and can go up to 20 players when we are talking about bigger customers, and they're all involved in material passports or can be involved. If we focus on data sharing and gathering the data, then they are all involved into putting that into a passport in Madaster. Very often you see either a consultant/engineer designer or BIM modeler that takes care of the role of putting all the information into Madaster.

How detailed can a passport be shared with the user?
It can be shared as detailed as you want to get. An LOD 100 is basic, to 300 is very frequently used. An LOD 400 is more into detail and an LOD 900 documents every single aspect. Madaster can support up to an LOD900. It is up to the owner of the data, or in this case the owner of the physical object, to choose how much information is shared with different parties. If it has not been developed yet, a representative of the future owner will determine who can read, write and delete information.

Section: Project Delivery Methods

From a tender point of view, let's suppose I'm a project developer and want to implement the concept of material passports in my project. Can it be defined inside a contract, or does it have a universal definition?
As Madaster, we have guidelines how to include Madaster in your tender process that are available on our website. Very often, the general statement states that Madaster needs to be implemented. From the documentation part, the requirements of data are present to upload it to Madaster.

Based on the different project delivery methods: Traditional vs Integrated contracts. Is the contractor responsible in updating and collecting data for material passports? Who owns the data at that stage?
This is a good question, and the reason for that is because you can lose yourself in liabilities with respect to documentation. This is also widely seen in the construction sector, where liabilities are a big thing. Before something is being built, they spend thousands of euros and hours of time into the legal aspect of it and there is an incentive to avoid risks and to exclude activities that might lead to a liability. One of these items is obviously, documentation.
I do not see you is liable now because simply I do not know, but I do see that there is a benefit for both, the client and the supplier, to avoid difficulties through proper documentations. To put it in a simple way, if there are two lawyers (Supplier vs Client) sitting opposite to each other, it would be easier to share information if the supplier and the client are present face to face through documentation if we can skip it in the contract. Everyone wants to avoid financial consequences for legal unclarities and the victim of that are proper documentation and reading responsibilities that can be fixed in a more collaborative environment.

Does this mean that an Alliance model will promote the usage of Material passports over the Traditional contract model?
In some way, improving cooperation will help the documentation process. Cooperation is not always the intention if you are the supplier, you want the best deal. The environmental impact is typically not the aim of the supplier in relation with the Client. Market regulations can help change that through governments.

<u>Section: Data Management</u>

It was mentioned on the website that Madaster is not responsible of the correctness of the data provided? What about the responsibility for data management and updating data at each stage?
When you do your personal finance registration and ask how you look at the money you get and what you spend every month, you can write it down. If you change in those numbers, you lie to yourself and if somebody wants to check your monthly income for instance yes, they believe what you're writing down but then they do some checks through an accountant to put his signature. It's like an excel sheet, you can write down whatever you want but it does not mean you are correct, it is just to register the information. To this day, you have assessment companies that will check the integrity of the files registered. Once you register the data in Madaster, it is archived, and you can choose to freeze the data so nobody can change it anymore. We are only responsible of providing you the service and not check the correctness of the data.

Are there any external parties that will be responsible of the integrity of those files? Are there any frameworks being followed now for data management?
Can be engineers, assessment companies, such as SGS they are certified and can take care of that. There are multiple parties working on different guidelines and measures, Rijkswaterstaat's wheel of data governance for instance, CB23 is working on frameworks and guidelines. In my opinion, you cannot rule the world with guidelines. In the Infrastructure sector, it is quite easier for Rijkwaterstaat to implement those guidelines because they have a smaller number of players involved in the process. But when it comes to a local contractor that mentioned that he came up with a new guideline, ok that's good for you.

What are responsibilities to create the ultimate complete material passport?
We tried to facilitate gathering of information that's relevant, but we are talking about so much information that cannot be gathered by a single professional or single party. so, when you want to have the detailed environmental impact information of all products that you apply in a construction object, you're talking about gigabytes of data and there's too much data available, so you need to automate it. what we do is using link data concepts so when you upload your files, we enrich it automatically through data collection and sometimes it's more than 10,000 components. We're talking about training complex systems where the data behind it cannot be managed and that's why platforms like Madaster exist. We as Madaster are the library where everything is documentation, but we are only a platform that connects parties and data repositories together in a less risky way. Sometimes large organizations want to do it all by themselves for instance like ministries and Rijkwaterstaat or a Municipality. Even if they have a large amount of money, it is difficult to get all this data in and its one of the reasons why organizations go down. Madaster is a source that is connected to other sources that makes the data infrastructure resilient. When we go down, we are connected to other parties that will take care of the data, data will still be there no matter what, and this is quite difficult for some organizations to understand that: why should we keep the data?

As I mentioned previously, I'm trying to create a framework to divide responsibilities and my current approach is the divide them based on a RACI matrix. Some parties are responsible, other are accountable and some are informed. Do you see there is a link between the responsibilities of data and the extent to which they have access to this data?

Yes, I like your approach. I think a RACI is a nice way for looking at Data. I like the concept of responsibilities, accountabilities, consultation and being informed. What we do is that we say that the owner of the product is responsible of its data, but I think you can enrich this view using a RACI approach.

We talked earlier about limitations and barriers for data management. What do you see as opportunities in data management?
Most people think that you are a construction engineer while working with things about materials and how to put materials to get us through a product then eventually get into an object. Well actually you are in construction management and you're graduating on the data domain. My point is that the construction and building industry is rapidly transforming into an industry that relies on data especially from an engineering perspective the transition towards data is very slow. I talk to manufacturers of products where they said they used to be a machine and production company, but we are becoming a data company with machinery and production and that's a big transfer. There is the difference between profit or loss, and it is about how do they manage data and it's a big transfer in the whole process of construction and it's something that still organizations see they want and that is not fully integrated to the core process.

Some parties do not see the importance of data collection until they start shifting their agenda towards it. But once data is collected, who will be needing this data?
We are not selling data; however, data is always valuable. Data always has a sense of value. Madaster was not set up to sell the data, it is only valued by the owners of the data. When we generate new data, metadata through algorithms, we can use this data to facilitate the circular economy. Will the data then be free? Of course not, it requires efforts to produce store and protect and manage data and there is a cost involved in that. Would it be valuable? Of course, yes, every data is valuable and multiple organizations want to have insights on value. We know that data is and always will be an asset.

Closing section

DATE	16th June, 2021

ORGANIZATION	Stitching W-E Adviseurs (Senior Advisor)
	Madaster Services (Co-founder)

INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)

INTERVIEWEE	*Marijn Emanuel (**Emanuel@w-e.nl**)*

Introduction section

Could you provide an introduction of yourself and the company you are working at?
My little introduction, I used to work as an Architect for many years in Amsterdam. After that I moved to Madaster Platform for a couple of years. At this moment, I'm working at W-E advisor group. We contribute to CB'23 which is a central platform set organized the NEN.

Section: Material Passport

Starting with our first discussion, according to you, how do you define a material passport?
A material passport is the digital representation of materials and products in a building, it provides all the documentation that is needed for this. To be more comprehensive, the passport is one set of data that is linked to other forms of data and Madaster acts as a register to document the data. Platform CB23 has different goals and aims from Madaster, they aim at providing frameworks and guidelines based on the transition agenda of 2023 for a 50% circular building economy. The platform's main aim is broader than just material passports from circular design, financial rules and regulations, and how to measure circularity.

When we talk about material passports, there are different stages at which a passport is active: Production, Implementation, Use and Demolition phases. Are you familiar with additional check-up phases for the material passports?
CB'23 follows one of the standards to look at the project phases from a lifecycle of the building point of view. There are several phases that can divide the project and at the end of each design and build process there is one point where everything comes together because the building process is finished and then you can have an information model called as built (it should be as is). It represents all the information about materials present in the building itself. As built is a long term for the builder, it is static at one moment of time acting as a starting point. While as-is more dynamic since once you replace the door, you want the data updated.

In the case of As-is example, is there a party responsible of checking and updating the data for the door for instance?
Not now, but there are two important things to mention. Big companies involved in real estate have something called facility/asset management. When you start, your material passport shows data for the as-built aspect, when you take it in the software and as long as you are using

your building and you profit from recording the data. It will become feasible and logical at the end to know what you have/own. The end responsibility will go with the owner for the data of physical objects.

What are public clients working with material passports now?
Everybody is either thinking about it or working with it. Some of the actors are the Governmental real estate agency, Rijkwaterstaat and Municipalities. And it doesn't mean that you cannot compare material passports. They is what CB23 is aiming to achieve, a standardized format of material passport. When you get a passport from both municipalities and a private company, there needs to be a streamline of information present. This has a potential to grow from a broader scale on the EU level. However, it is still not mandatory to generate material passports based on the transition agenda of 2020. Typically, to implement this concept, the government will aim at trying it out through pilot studies and look at the work of CB23 using the Transition team that was allocated by the NEN to advise the minister.

Section: Project Delivery Methods

From a contract, or project delivery methods perspective let's say: Traditional vs Integrated approach. How are responsibilities different from one project to another?

This is a bit future leaning part. With a product there comes a material passport, for instance, when you are demolishing a building or taking it apart you get this whole overview of its products and along with them the passports. When you are implementing these old doors in new buildings you can ask for the project passports of the old building to move them into the new building. There should always be a connection between the physical object and the digital representation of it. When you demolish the door, you can take its unique ID out of the BIM model and use it elsewhere, but ideally the physical object and the passport must stay together.

Does this mean the industry is moving from a product to a service-oriented approach to procure now construction elements?
I don't think it really matters or it differs regarding the information that you want to have since responsibility lies somewhere else and does not influence the kind of data you need.

Section: Data Management

Once you collect data, who would be responsible of the correctness of the data?
Independent third parties, who are the assessors of the data. Today, there are software that gives you an assessment of your building and confirms that your circular calculations are good and certified. Madaster is now collecting the data, however, it is still not certified.

What are limitations for collecting data for material passports?
There are two limitations for new and existing limitations. Regarding new buildings the barrier is the willingness of the parties that are involved to make the information available. While for the existing buildings it is more about the general availability about the building itself. We recently started Madaster, if it had been present for the past 50 years, you wouldn't have the problem that you think that you have. Users were not incentivized to look beyond a certain time and plan. Its like electing representatives for the next 4 years as a horizon, and then beyond that its someone else's responsibility.

There are different levels of detail for a material passport and some actors cannot access all the information in the passport. Do you think you can divide responsibilities based on the extent to which you have access to the data itself?
Yes, of course that's good. You cannot be responsible for something that you do not know. If the owner is responsible of what he owns, he should be able to "force" the producers to give him the information and take the responsibility. For instance, you do not know what poison is in your laptop, yet you are the owner and the responsible of it. This is the idea where ownership can stay with the party that can handle this responsibility.

Can this division of responsibilities for data collection and management be implemented through contracts?
This is one of the goals of CB23, to be able to present a format of a material passport and you can demand it in a contractual form. At the end, when I buy the building, I want to receive this exact format.

Who do you think will benefit most from the data that is being collected?
It's an interesting question, in the end the owner will benefit from it. But from the beginning, everybody and nobody owns the earth. So, materials in it are common assets so we all benefit from the rise in value from an egalitarian view as everybody should benefit from the data.

Closing section

DATE	17th June, 2021

ORGANIZATION	Stitching W-E Adviseurs (Senior Consultant)
	Platform CB23 (C-Creator)

INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)

INTERVIEWEE	*Olaf Blaauw (Olaf@c-creators.org)*

Introduction section

Could you provide us with a background of your career?
I'm originally a Biologist, I moved to the construction field almost 7 or 8 years ago with my ideas about systemic sustainability, where nothing can come from nothing. We have this limited amount of Lego blocks and never understood why circularity was not introduced earlier in our economic system in the first place. The goal is to give every single organism a chance for happiness and fulfilment whilst never exceeding the ecological limits, this simple concept is a mean to make an impact in the built environment. If they can do it for concrete and steel then we can do it easier for all construction products while keeping in mind that it's the least reliant on raw material. The bridge to our conversation is that I was asked to join as a Circular Economist expert, covering not just circularity as a concept but how we can make circularity work in an economic setting. It's okay to design for deconstruction and re-assembling but if nobody knows where the value is that you are trying to cycle, there will be no cycled value.

What is a material passport and what are limitations to its applicability?
The information of what is where and who controls it and when it becomes available is key to control the design strategies for future integration. In the built environment, the passport is the first step we should take to understand where in the world things are spatially through BIM and combine this data with qualitative aspects, so the object becomes available for re-use based on its function. That's where I come into coach companies to start implementing passports, not as a static representation of as-built elements, but a dynamic tool for asset management and have the benefits of circular design visible for people.
For instance, if you ask people to invest time and money in building passports and BIM only to find out that it will be re-usable in 50,60 or 70 years later: nobody will do it. What im trying to do is present the benefits of circular design from a financial point of view from Day 1 and it continues to go from an ownership to a service oriented. You should know to what specifications your products adhere to cover it in a service approach, all the qualitative and quantitative information that you would put in the passport are necessary for you to manage your product as a service.

I completely agree with you, parties that are not incentivized to use material passports from Day 1 will not see the benefits of investing 50 or 70 years in advance.
That's why I'm pushing for an actual quantification of those benefits. I can tell that it is true, there are benefits but it does not mean that there are any. For example, if you want to buy an

elevator based on the specifications you have an option A for 80,000 euros or an Option B for 120,000 euros. If you are a construction company, you will typically care to profit and eventually use option A based on the competition that you have in the market.

A lot of people look at what's the cheapest to build and not what is cheapest to own or the cheapest to run. What I really need to think about is how much value I create with this amount of money; you move from a cost thinking to value thinking. On the long run the elevator will cost 300,000 euros less in the next 20 years between operative and maintenance phases. The main problem is that the construction company is not the same party as the people they sell the building to, a private investor, your decisions will be more likely to be the cheaper options, by that a more competitive and bigger return margin. What's good in a material passport approach is that the producers need to have a material passport at hand that will value their service, it's always good to know where things are, and that's why material passports really represent: it documents the potential value of an asset. If the passport is just a snapshot of something as built, then it loses its significance over time. It's like keeping it in the drawer and coming back in the next 50 years and trying to save what we can salvage from the building, so if it is not treated as a dynamic instrument for the assessment of the value of the asset you are managing then it will not look as feasible.

Functional value is always greater than material value on the long run. In a circular economy you would rather recycle the functional than the material value of an object. Recycling is the last thing we should be thinking about, we should be thinking that we cannot lose anything. We start with the Ellen MacArthur inner loops of the butterfly diagram; it shows how can I keep something in its highest functional value for potential re-use. The essence of a circular economy is not that we re-use stud we have today, but everything we use becomes re-usable on the highest functional value.

Sometimes data ends up being uncollected or ignored in some cases, that relieves responsibilities to some actors that have a role in data collection/management.
I understand your problem very good, the one thing I can tell you is that we haven't solved it yet. The passport is a nested structure with everything you know, most of the detailed information can be found with the product producers. If you simply connect your dataset to the external dataset, it would be an optimum scenario. But if that company goes bankrupt and the data gets lost there is not backup then it would be your responsibility from now onwards. We can still consider a shared information network where you can share your data with multiple elements in the network just like Bitcoin. However, to document all the information it will eventually slow down the processes because you need to keep adding more information with time.

Although the principle is great, but how do you do that with a material passport? Can we do that with a third-party trustee such as Madaster?
That's one issue. If you want to have data about every single building element in the world. Even if we look even at the Netherlands, we cannot have a digitized approach for every single element we have on site. They form trillions and trillions of datapoints that can be stored in categories. From my point of view, there is no such thing as a passport: it is data about special information, so what is where. Some added information are in your custody and other information can be derived from eternal datasets. Data is everything, but data has no purpose unless you have filters to be applied in a selective way to retrieve information. Otherwise, without correlation it's just data. If we want to apply that to the planning phase of my maintenance plan, then I know from a financial point of view how I can start planning for that. It's not only about the building and its composition: it's about the metadata.

Now, the material passport is just an excel sheet of what my building consists off. If there is an exchange platform for which this information can be distributed amongst parties, then it becomes a complex system with the same data and the way you assess data will be different, but this is in the future. This information is typically coupled with the BIM that is as-build and not as is, and it is divided into qualitative and quantitative information. If you want to check the wear and tear for some of your product you can check your maintenance plan and it is according to the market demands.

Are there any standards that are applicable in this case?
Nobody usually looks at that. Obviously, there are certifications for LEED and BEAM and all the beautiful gold shining stamps. It shows the minimum standards that are being claimed by producers and importers they might sometimes pre-off a bit.

According to CB23, there is a new guideline coming out. What would it entail?
Yes, on July 1st a new guideline will be released regarding procurement strategies. For example, you don't decide that you need an elevator, but what you really need is a vertical transportation. The question changes to who can give me the best value for money in a vertical transportation rather than buying a product. The users of the building will have to pay for the upkeep of the building, and this is reflected in the choice of elevator we discussed earlier. Sometimes the more expensive option will result in a cheaper monthly use expense. They don't sell you the elevator but sell you the mobility.

What are private parties working with CB23?
One of the companies that I work with would like to take on repairs and renovations of the objectives they refurbished. It works with existing building, if you have a subscription-based model you are less scared of the volatility of prices. Those companies will assess the amount of money an asset can make. Again, if the quality of the decisions you base on the data will improve as well.

Do they have a responsibility in collecting/updating this data?
If they don't, they will end up losing money. All this information can be found in different places of companies. But if you have a central organization of this data where everything is connected. Usually, responsibilities are divided based on two aspects: procurement of ownership or procurement of right-to-use. Is it a surface you are buying or a product you are taking responsibility for? There is of course extended producer liability and product responsibility which does not allow you to let go of something you produced.

How do you define material passports or circularity in contracts?
One of the things when we discuss circular procurement, you can specify functionally. It's all based on the parameters that you base your decisions to buy or acquire. The nested set of information is part of the things that you would be buying of that supplier is central. It's after all up to the collective design process to create the product that will go along. You should start looking at the functionality and which provider will help me achieve this functionality im looking for and how it positions itself from other functionalities? It's the same way how you derive the structure of the passport. Through the procurement, it's not only with information of the product itself, but information about dismantling and installation of the product. The producer's responsibility is maintained throughout the use phase but obviously to a lower extent and not every producer can do this.

If we are moving towards a service-oriented approach. By leasing the product over to you, who will be responsible of updating the data in the material passport?

If you are the owner of the product that gives a service for what somebody else pays, you as the owner needs to know about his asset, thus liability lies with the producer in this case the owner of the asset. Unless you have a deal with a renovation/maintenance party they will have to monitor those changes with respect to the material which is functioning in the building. Basically, he who changes stuff will be responsible of updating the dataset. In a broad scope, the asset manager himself will have to give the orders to make changes based on his plans of centralized data. It's all about ownership and who actively changes the content of the building that will have an impact on the output of the passport.

What about external parties that act as centralized BIM model such as Madaster. Do they have to keep contact with all the parties that are involved in a project?

Initially, the Bouw(construction) team is responsible of building the initial dataset. The asset management company will take the dataset and add the user-oriented information to it. The BIM itself will have to take care that there is identity attached to each element of the building. If you are interested in an element of the building, Madaster will be able to keep track of the identities in the BIM model itself. Eventually, it will not be the responsibility of those who maintain a unique identity for elements to even monitor the datasets attached to elements on site. They are only a database that acts as a dashboard of information, but they are not responsible of the quality of the data: this falls under the asset manager of the asset in question.

What do you think about the division of responsibilities based on the extent to which one has access to this data as a framework? Limitations to the RACI matrix approach?

Obviously, you can only be held accountable for things that you have access to and cannot assume things. It will all depends on whether we will consider this as an open source or an open access type of database, or we want to grand access to the commercial model such as Madaster is doing. It's much easier to have an open access to all the data that are not sensitive information for some companies. For example, there is an example of a bridge in Amsterdam that contains almost 400 Kgs of gold, and that sort of information should be kept private. This could be applicable to bank and private buildings. You do not want to tell everything about everything and having uncertainties sometimes is okay. Sometimes it's easier to make smaller exemptions rather than having most things as an exemption. Both options private and open space access are viable and can be monitored by a company such as Madaster to keep competitive information private using filters. So having access to the data is the deciding factor whether you are responsible of maintaining the integrity of the dataset, or accountable for the task at hand.

Once we collected the data, can you sell/buy it to the public sectors and what happens to confidentiality?

How deep do you wish the rabbit to go? You can have your firewall at any level of information. I can choose to show you what the element's main functionality is about and not tell you the constituents of its material. When it comes to the complete recycling of the product then a deeper level of detail is of importance. It may remain a black box for the duration of its use, if we know what the costs are to own and have access to it with its parameters. So, you don't need to know what's in there but what it does. It's up to the NEN to promote standardization so we can equally interpret material passports. We as CB23 try to provide rough guidelines and we cannot create a tailor-made approach for both sectors, but we can only try to standardize the information.

Closing section

DATE	1st July, 2021

ORGANIZATION	Rijkwaterstaat (Specialist Advisor) NEN (Condition Assessment committee)

INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)

INTERVIEWEE	*Jaap Bakker (**Jaap.bakker@rws.nl**)*

Introduction section

Could you provide us with a background of your career?
I've been working at Rijkwaterstaat for 25 years, always in the asset management area mainly. Managing of the structures mainly, and for the past 3 years my main occupation is the border between Data and Asset Management. As multiple things in asset management are nowadays data driven like smart structures, but also more complex questions come to us in the use phase of the structure relate to the environment these days. One of those aspects is the Circular economy data. I am involved in the Data Strategy for Rijkwaterstaat on Circular Economy. We think it's important to have a strategy about that because it's quite a challenge to store a lot of data which you might need in the future for a very long time.

What kind of data is Rijkwaterstaat interested in mostly?
Data can be anything, even if there is coating on a steel element. It might contain material that you think to be relevant in the future. From a strategy level, you need to be able to find anything you want from an information point of view. It's usually very hard to define what type of information you need in the future, so the idea is that if you have an iPhone, I know its product code and can tell which metals are used in there, by that we can determine its residual value. The idea is that from one product code, you can access information that is being stored with the producer. This is a smart way to look at the data from a supply chain which builds our structures. Usually the data is there, at the moment of construction of the product. For instance, the producer of cement can store information for 100,000 bags of cement that will be sent out to 10,000 projects at the same time. Your two options are to store information for 10,000 projects or to store the CE information with the Producer himself for one batch of cement. Our data strategy is organised in a way that the data will be stored with the source and can be easily reached when needed.
Producers of cement will be able to decide what type of information we will need for the application of Circular Economy; hence, it will help define what is the information needed for the passport itself. Data will eventually build up with who produces it and who changes in it, it will eventually follow a pattern that once we add aggregates to the cement it will be updated accordingly (Cement, Aggregates, Mortar, Concrete Beam, Finishing). Each product has a code that relates to a passport which contains information based on a standardized format where information can be stored in a CB-NL library. Once change has occurred to the product, I will

assign to it a new product code. This is only a concept of how we look at it that will help us structure the data.

One of the problems is that not the same type of information is being stored, which would hinder data analysis in future phases. So, is Rijkwaterstaat trying to formulate an ecosystem approach for data collection?
You should analyse which data is relevant for CE in order to sketch your passport. We are working on couple of pilot projects, and we have a meeting with the Ministry of Internal Affairs, they coordinate all sorts of national activities, and we want to find out if we can make this approach a national strategy. Later on, we want to join people in the market and inform them how it should be organized and ask them to work on passport formats. At the moment we do not aim at storing information for 80 years because everything is going to change, but the main aim is to learn.
We know that its only possible to build up a good information structure if you first agree on how to structure it, what to store and in what format. Otherwise, you are only collection data and not information.

Who has a responsibility in collecting the data, is it following a centralized approach?
The idea would be that you don't need a central storage for each project. When we demolish things it's not likely to be able to re-use material in the same project. The Contractor cannot predict what will be re-used and thus cannot cause delays in the project timeline and would prefer to use new materials. We expect that there will be a separate market for new products. CE will not be on a project level, but on a national level. We can have millions of product codes but then you cannot re-use the beam since it can come from another Province that does not organize the data in the same way. As the owner of the house, you will not take the initiative to collect the data and create a passport but if we store the information with the Producer it's possible to re-use your material. We are not going to build a whole complete dataset for each project in the world. It's more likely to store the data at the source and each product has a code and with it you will be able to find all type of information for a material passport.

What is needed to be done to complete this step?
We need to talk to the sector suppliers and inform them how they can store this information for a long time. One the challenges that we must face at the moment is that what happens if we store information with a company that will not exist in the coming 80 years, by organizing something in the future if we apply this strategy.

Once data is stored, who checks the integrity and the quality of this data?
I would imagine that for instance Suppliers along with guidelines for justification of the quality of your data management and that could be certified of course. There should be a quality system that the supplier should qualify for and with the Auditor being involved to check it based on standards and guidelines.

I know that you are working with the condition assessment committee at the NEN 2660. Are there any guidelines you are using for data collection/management?
I'm active at the NEN 2660 and that a standard we made on how to exchange data in the sector. You have to be able to publish everything is a link data format. You store it somewhere on the web address, and there are all sorts of users that can search for this data with LinkData.

What do you perceive as opportunities for data collection for material passports?
In the short term, we need to focus on what data needs to be stored and under what format and organizing initially. The focus should be on learning and standardizing while for the long-term we can focus more on producing. Data should not be stored at Rijkwaterstaat but somewhere else with the supplier and of course while delivering a uniform approach.
You should be able to make a distinction between the data that you already have and what you don't know about: data about existing building and new data. For an already existing bridge, we should have all sorts of data analysis with techniques that will help know what data we need for CE using data analysis and then will tell what data we need using algorithms.

Are you familiar with CB-23 and Madaster?
There is a difference in approach with Madaster, they state that we should store data based on the project, on a project level. Imagine you are storing information for each Iphone device you have sold. In the beginning its good to start this way and count on initiatives like Madaster, but it is not the best way for the future. Maybe, when a Supplier goes bankrupt there should be a storage services as a backup for the data stored for security, where data is stored in this data warehouse.

What about confidential and competitive information?
That's still an issue when there is always risk of vandalism. Having different levels of access to this data can be helpful. You cannot store military building plans along with residential projects information where anyone can have access to it. Confidential information should be kept on both: existing and new structures. There may be confidentiality issues for some users like the material in a bank.

At this stage, I explained my approach to my thesis and the framework I developed.
Great, that's really useful research I think. That's good from a hand-over point of view, it's a good division of responsibilities with the phases. I would like you to share with me your findings. I would like to state that the strategy of Rijkwaterstaat is only a proposal so far and nothing is official, we cannot state how organisations run things because we want to do it. In the coming weeks will have a meeting with other organizations and partners to discuss it.

Closing section

DATE	16th July, 2021

ORGANIZATION	Delfland (Program Manager - Circularity)

INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)

INTERVIEWEE	*Tamar Niemeijer (tniemeijer@hhdelfland.nl)*

Introduction section

Could you provide us with a background of your career and your role at Delfland?
I am a manager of the program in Delfland, I am not aware of every process, but I hope I can help you. The program is divided into four different sections: climate/energy, raw materials, fresh water, and the living environment. All those are important aspects in our program, the main thing Delfland is looking for is how can we hold freshwater in our system, but most importantly how can we re-use it in our systems. The target of our program in raw materials is to reach 50% circular by 2050 and 100% circular by 2050, and within that we use material passports to reach that goal.

How are you using material passports at your organization?
First you want to know what do I use? What do I have before I need to reuse them and to know the state in which we are right now? The material passport we are using is not the same one used in the construction field, we have material passports made for our own for the water board. We made the passports a little less detailed because we still have to investigate more about the information we need from our materials. When you start, overdoing something is sometimes unnecessary and time wasting, that's why we develop our own passport format.

What are parties involved in the process of material passports?
There are multiple parties involved, but the ones we have connections to are contractors. Contractors that are hired are asked to provide us with material passports to show us which materials are being used in our project. At the moment, we are just collecting material passports and once the contractor delivers the passport he will no longer have access to it. We are still in the beginning stage; our next step is to find how are we going to share this data. At Delfland we are very forward with it, but we are still developing which materials we are going to re-use or for other people to re-use this material.

Could other organizations make use of those materials at some point?
Yes, of course we can share the data with other organizations such as Rijkwaterstaat if they want to have it. But if you are making a material passport for a certain object in certain project I am not sure other organizations can make use of this object. But maybe in the future when we eventually collect a lot of passports we can divide them into different categories where it will be shared.

How is data for material passports stored at the moment in Delfland?
Data is stored only at Delfland, it is still very simple, and we do not have a data warehouse yet, but that's what we are planning to do. It takes a lot of time, but that's what a lot of organizations have to do at the moment.

Within an organization, is there anyone responsible of maintaining the data. Who checks the quality of the data?
The plan is that everyone have some responsibility in filling in sections of the passport and we do not check for the quality of the data. As far as I know, no one is responsible of maintaining it at Delfland and we only need to store it at the moment.

Regarding Data collected, what is your approach as an organization to prevent data loss?
We store it in a digital format with a colleague that makes it more professional information, but we do not have a built system for it. Someone of course is managing the data, but we are not at the time where materials are being used that's why we can only collect it to investigate what is useful for us and how is Delfland going to re-use materials. We have a lot of projects and its mandatory for all contractors to provide us with the passports. They have to do it.

Even though we are at the beginning state of using material passports, but it has a purpose to collect information and materials. The purpose is very simple, you want to re-use the materials as a next step, and we are early in the process. Within the water authorities, we are the far most of the organizations and the first ones who worked on it, but we still have a lot to learn in order to eventually maintain your goals in the future.

Closing section

Interview F

DATE	19th July, 2021
ORGANIZATION	Delta Wonen (Project Manager - Circularity)
INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)
INTERVIEWEE	*Martijn van Dijk (m.v.dijk@deltawonen.nl)*

Introduction section

Could you provide us with a background of your career?
Almost three and a half years ago, I was studying business management with a specialization in sustainability. At the end of my studies, I ended up with the circular economy and was really interested in real estate. That's how I started working at DeltaWonen: We are a housing corporation for people who cannot afford to buy a home. But the nice thing about the housing association is that you have the whole lifespan of the asset and know what's in it and when to maintain it or renovate it. Sometimes when we do it in a circular way, we hold certain values that will save you or earn you money since building prices are crazy at the moment and material prices are higher by the day. Not to mention the CO2 taxes waiving in the air, we always try new materials and new construction methods. Sometimes we want to implement something outside of the box, we test it out at the old location of the Hotel of Wijnberg in Zwolle.

Is DeltaWonen involved in material passports?
We have a different look regarding material passports. To be understood, we don't use material passports, and the reason for that is that it costs some money. Since you can only spend your money once we don't think having a material passport can make your real estate circular. Most of my colleagues barely know anything about a BIM model. They are familiar with it, but they don't use it. They are very good project managers but not very up-to date about this field. Material passports gives you insights but that does not make it circular, it tells you what we know about our homes. In theory we are doing a lot of things, but also its always important to check it in practice. At this moment, we already have a lot of data stored and every couple of years you need to update this passport and we do not think we can compensate for it. In the future, maybe yes once you build up a good set of information in your passport.

Demolishing companies for instance already have a lot of data on the building based on their construction date. If we have to demolish a building for instance built in 1965, we are already certain what type of materials we are going to find in it. So, we are still discussing what's the added value of material passports at this moment.

What is the alternative way to store this data or information?
We already have the data from a building project in a database for the project itself. From that we can tell what type of activities we need to cover in the future. The information is stored in excel sheets, but it could be that its imported from another database but I'm not sure. Even though it does not go too much into detail such as Madaster.

How detailed do you think we should record information?
I'm not sure about the level of detail. Third-party services such as Madaster can store a lot of information, but for Madaster is acting just like an excel sheet. What makes a bigger difference is that you need to make an interpretation of the data and that's the reason why Madaster can help you for a certain price. One common limitation is that data collection is still a voluntary process.

How is data then safeguarded at DeltaWonen? Risk of data loss
I don't think that's very difficult to keep the data. We have almost around 14 thousand houses and if you lose an overview it's not a problem. When we have all the data, we always go on site to check what's the condition of a certain material. That's something that you do if you have a digital twin. I don't see at this moment a need for it since it would cost you more money to store it. It's all theoretical, painting a house every 10 years is different from 12 years.

Is there any confidential information that you cannot share at this moment? Can everyone access this data from the excel sheets?
At this moment, everyone can access it. It's not that we will share the files with everyone but only with companies you are working with. It could be that are some things that is not good for your health, and we do not want it out on the street. In Madaster maybe you can choose who can get access to certain information.

Based on the research findings, it turns out that some organizations prefer to store data with the suppliers while others prefer to do it in-house or with third parties such as Madaster. Do you have any comments on the framework that I shared?
I think that's a key finding to share it with most users of the material passports, I like the design of it. Only one thing that could be a challenge, when there are small changes done in some projects how can you keep data up-to date. Sometimes you see self-employed can make changes in their own houses such as a plumber, how can you ensure that data is up to up when he is making the changes.

Which approach do you think is better to store the data?
Thinking about the two, third parties such as Madaster can give an added interpretation about the data so you can get different views. I don't think it's a problem of confidentiality when we can keep data with someone else that is giving us insights on the asset and its components.

What do you see as a limitation for the applicability of material passports?
The people in themselves are limitations: the user of the building. The real question is how you can keep the data up-to date in those 50 years the house is standing.

Regarding the old Hotel of Wijnberg, could you elaborate more on the project?
The Hotel is already demolished couple of years ago, now it's only a parking spot. We are trying to find new collaborations to make the project work. We are now thinking about the ground level being more cultural and economic spot for the neighbors to come and learn about new building methods and experience the circular thoughts. Above that we hope to build five levels of apartments while collaborating with a demolishing company and Gemeente Zwolle as they need this type of data. We work also with Architects and some roles are changing, they need to scout for old and new materials together with the demolishing companies involved early in the process. The project already started but due to corona it's difficult tight place to build. In these homes we want to learn how to make it circular and teach the tenants in ways of living in a circular way, with a shared washing machine or using a circular kitchen as a

lifestyle. It's always nice to see ideas of circularity are coming from the architect, small changes can occur such as chosen window frames ahead of time. Demolishing companies know best how to demolish a house, that's why they know the best how we can build it.

What are other parties that might be involved?
We are looking at a selection of construction companies. We have someone acting as a representative of the neighborhood, he monitors what's changing in this neighborhood and how we can give in added value to it. Municipality of Zwolle is always involved and of course the party responsible for permits and approval for architectural area fitting (wellstand).

Do you see a future in applying material passports in this project?
Its expansive to use it for a long-term project. But in this case when you are still testing and for a temporary project it's always good to get added information. I think we will learn a lot from it, and it will help: It's not that material passports are bad but if you do not know what you are doing then you cannot have an impact. This is like the energy labels for your house, you have a scale for it but then what changes? First, I see the need to change then we can act to manage the data. Another problem is that after several years of storing, what happens if Madaster goes bankrupt, this is also a difficulty in taking-back guarantees. But I need to be an optimist and look forward for circularity in the future.

Closing section

DATE	25th August, 2021

ORGANIZATION	Gelderse Vallei and Veluwe Water Board
	(Manager of the Advisory Team for Dike Design)

INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)

INTERVIEWEE	*Marten Hoeksema (**MHoeksema@vallei-veluwe.nl**)*

Introduction section

Could you provide us with a background of your career?
I am working partly for Rijkwaterstaat and for the Water Board of Vallei Veluwe. At the water board, I was technical manager of the Project "De grebbedijk", and about five years ago we started the project with the idea that we should do something about sustainability in the project. Back then, the question is what can we do to make a difference? It costs us couple of years and then we found out that we should do something with circularity, in the end we made a tool that gives a circular assessment of how the project is doing using indicators. One of those indicators is using material passports. We realized that if we really want to make a circular project, we should know what we have. Our project was focusing on what we need and not what we have, that's how we came to use material passports.

Is the project currently still in the Design Phase?
Yes, the project is divided into three phases: Initiation, Design and Realization by 2024. If we want to make a project circular, then this is the moment that we should take the initiatives and put all the right things in our design process. That's why we are trying to make a proper material passport for our dike project.

What are parties that can be involved in such a project?
We are not only making the dike, but the project is much bigger. Some parties that are involved are the Province of Gelderland, Province of Utrecht, Nature parties, different councils, Rijkwaterstaat, the Water Board of Veluwe and Gelderse Vallei and multiple parties.

What are then parties directly involved in material passports?
The Water board is in the lead for the project, but for the material passports we are still in the exploration phases. We are contacting CB'23 that will help us sketch passports based on the prototype that they made using a pilot phase that we participated in, with our coach Olaf Blauw. In our team we have a person from system engineering and someone from PIM Info (a company that provides geographical information); and in the end we maintain connections with our Asset Manager.

Does the Asset Manager act as the owner at some stage of the facility/dike?

Yes, the end-owner. In the end, those material passports will be owned by the asset manager. In the meantime, we are only trying to sketch the passports and fill them with the input of our building phase. When we finish the project we will put everything in his system.

Regarding the PIM Info, is there some kind of data specialist working on it?
He is currently working in geographical information, and we also have to make a connection to the BIM. The BIM side of our organization isn't there yet. The water board is still researching what to do for the system to be up and running.

How detailed do you think a passport will be? Are you certain what type of information you are looking for at the moment?
We discovered that different phases of our projects need different information. In the design phase, it is crucial to know what you have and the condition of what you have. We have for instance, steel walls in our dike, one interesting part is that if we know really well how good its condition is then we can determine its value in the future. In the end of the project, we have to know much more about the potential life value. Once you reach deconstruction phase, you will be needing more information in the future about every single element we have built. So different levels of information needed through different phases.

If you are planning on sketching material passports, how are planning to coordinate activities for data management with the Contractor for instance?
That's an interesting question. We are at the start of a new phase with a new engineering company, a new contractor. We asked him to finalize our material passport and to fill it. They will have the lead of creating the passport until a different phase starts. Once he finishes, the material passports are transferred over to the asset manager. Hopefully by then, the water board will have an idea in which format we want to keep the passport.

If I may ask you a question? Right now, CB'23 made a passport in Excel, which is a flat data. We are discussing in what type of program we should store the data; we want to make it easier for designers to use the program and to visualize this data. Do you have an idea of which tool we can use that can help us?
I think so far, one limitation that I found in my research is that we do not have any tool that can help you sketch a material passport. The reason for that is that different parties have different uses of a material passports and there is a missing generalized approach to store the data. What I know so far, there are third services storage companies such as Madaster that charge you for storing this information. However, everything comes at a price, they usually offer services not only to store the data, but they give you an analysis for it. This approach can be considered expensive in some cases if you want to maintain information for a dike for over 100 or 200 years, especially that some data can be lost from team to another. Maybe developing an in-house central tool could be part of the solution, however, most of the tools are charging for their services to store the data in a user-friendly way.

May I ask what you are actually looking in a tool? How would you actually check for the legitimacy of this data?
We built our dike in an Object Breakdown Structure (OBS), a system engineering method. We realized that the data we need to collect should be in the same structure as the one of lower levels of the OBS. Hopefully, it will make it easier to keep the data up to date. Much of the OBS will be used for the structure of the material passports for synchronization. However, we

are not planning on checking for its quality rather than collecting it for now, but what happens in 10 years? We have no clue so far, maybe through a quality assessment every couple of years.

After explaining the framework and the approaches discovered. Are you planning on keeping material passports centrally with the organization?
It actually depends on the layers: Upper layers of the OBS will have our own coordination, but the moment where we reach the level of a pump, somewhere there is the switch to keeping information with the provider.

Do you see a potential for the future use of the data?
Our asset manager should make good use of it. He actually want to do something with the data, but there is very few knowledge about what you will have and how you can use it. That's a limitation; my colleagues suggested to the skip the word material passport and call it some kind of Asset Management tool, because he is the one that have to collect the data and keep it up to date. The only different is from a terminology since the public can see it as more fashionable.

Regarding the issue of storing the data, are you planning on using a special tool or keep it simply in an excel sheet?
I'm looking forward to our engineering company, since I want to ask them how their designers want to work and how we should provide the information for their designers. Maybe like storing with BIM 360, that's a discussion that are going to have soon. But I think, if we relate to the two approaches you presented we are more towards the Centralized approach mostly since it's much easier to keep it in your own department of your organization.

Do you see there might be a barrier for the application of material passports?
The problem is that we collect way too much information for the asset manager. There are so many components in our Dike, and I think for an asset manager, he only needs the information that is necessary to look at every 5 or 12 years. There is no short-term knowledge of what is needed in the future. Every couple of years a new colleague takes over and we have a very big chance that this information is lost. You need someone that keeps the data up-to-date and is capable of making the connection with the one who should use it: that's the hard part.

Do you think material passports will help re-using dike components in the future?
I see a lot of potential, once we take the climate goals serious, there is no other way to know what we have than to start a different approach of the design phase: it's about designing for re-use rather than creating new things every time.

Closing section

DATE	27th August, 2021
ORGANIZATION	SWZ Housing Association (Asset Management Coordinator)
INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)
INTERVIEWEE	*Rob Rutgers (rrutgers@SWZ.nl)*

NB: The Interviewee preferred to respond in Dutch for most of the answers. To avoid translating inaccurate information, the conversation was translated through an external help and summarized in the following table.

Topics	SWZ
Goals	Integrate sustainability in the construction sector.
Material Passports	**No usage of material passports, but open for its application in the future.**
Data Collection	- Currently storing data in **excel sheets** or through **BIM** application. - Services such as Madaster are **not expensive** given the investment and return you are making from material passports on the long-term.
Data Management	- There is **no confidentiality issues** in the Real Estate sector: Everyone has access to this data. - **Data can be shared** with any user that has a task in updating this data.
Limitations	**Different sets of data might be needed for different construction products for various partners.** They don't see other barriers regarding the applicability of material passports.

Interview I

DATE	31st August, 2021
ORGANIZATION	Constructif (Senior Advisor)
INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)
INTERVIEWEE	*Erik Kooij (ekooij@constructif.nl)*

Introduction section

Could you provide us with a background of your career?
I studied Architecture at TU Delft; I have been working at architectural offices throughout my career. Couple of years ago, I quit my job and sold everything and started my own company to start a new period in my own career. At the moment, I am an advisor for the board of architectural offices. I help them from a business point of view, after all it is a firm, and a lot of architects have to earn money. I advise them on fees and coach new architects in more than 5 offices. I am a judge for arbitrary conflicts, alongside being an advisor for the construction company Constructif. There are some guidelines everywhere, but long story short I try to help translating those guidelines and how they can make use of those guidelines in practice.

How much are Constructif being involved in material passports?
It's very new and still in the beginning stage, in 2030 there is an obligation in the Netherlands, you have to use 60% of circular materials and in 2050, the goal is to reach 100%. The directive of Constructif have asked me to prepare the company for this change and reach our goals within the timeframe. They want to promote it as some kind of a marketing and educational tool within the firm. If you want to understand something try to teach it, but if you want to learn something, try to use it.

What are some guidelines that will followed to sketch those material passports?
I know Madaster is collecting information and they are building a database. In my viewpoint, it's very good what they do, but it is more or less commercial. One of the aims of your study is who is responsible for this information and how useful can it be. I'm not a big fan of them collecting and only storing its data. When you are constructing a big building all the parties are obligated to deliver the right data to the principal.

Would then all parties have different responsibilities at different stages of the project?
Yes, exactly. I think when the job is done and the construction is completed, the passport needs to be delivered to the owner of the new building. From that moment on, he will have to transfer the passports when he sells the building.

Are there any quality checks for the data that is being collected?
It's an interesting question, I think yes. However, you cannot stay in control all the time and check the quality at all times. This is highly possible around the construction period. During the process, the material passport will grow if suppliers are making a complete dataset of the material that will be delivered on site.

Who do you think can best handle the data once its collected?
It's a very good question. Its best to answer it with an example, most of the time after we finish the building we deliver the drawings and all datasets to the Client. Based on my experience in the field, most of the time the Client is not able to open the files and does not use those files properly. If he can open the data, he cannot change it since it's all in pdf formats. Once we transfer it to the client, he should be responsible for it and be able to use it in my opinion. He can use an advisor or a third-party that will help him with this data, this way he use those data and then he can make changes during the whole lifecycle of the asset and its components. Once he works on that, the value of the data and the materials will become attractive: the worth of the building is a combination of the physical site in itself and stored information like a material bank about those materials.

Would a central platform work for material passports?
Yes, interesting point you are making. In my opinion, the owner and the asset manager has to keep the information up to date. We do not need to use commercial firms because they do not have a real interest.

Do you think there are barriers for the applicability of material passports in the Netherlands?
There are multiple barriers, for instance, how can you set a price tag for existing buildings? How to actually decompose buildings? It's important to know how to re-use decomposed materials at the same instance, otherwise you would have to extract its raw materials and re-work on it.

An explanation of the two approaches was presented to ultimately give a choice of the two approaches:
If you want to keep the data with the supplier, there might be a little problem because not all firms will survive as long as buildings exist and not all companies can survive that long. If the supplier cannot survive that long then data is lost. You can choose to store this data somewhere safe to safeguard it, but I think the owner of the data has an obligation to have a proper documentation of the material passport.

Do you think it would be more expensive to store this data on a long-term basis, and we are talking about hundreds of years?
That's a very important point you are mentioning, I think in general people are lazy, they do not care about the quality. On the long-term, yes it will be useful, but then you have to invest in it every year, the more you build up information the better off you will be in the future. It is not an obligation and the asset manager do not do it because they are short sighted. By the time they want to sell the building they have to update the information and they will not be able to do it. Yes, it will be beneficiary to update it yearly but as long as you keep on doing it. If you are an asset manager, you will think that maybe in five years you will get another job. However, if you are the asset owner, then you want to have a complete material passport.

What are key players that will play a role in the applicability of material passports?
I think the banks and insurance companies will have a vital role in imposing the usage of material passports before allocating the resources that will help you in your investment. Sometimes, the law and recommendations can help with that, but this will be a problem for existing buildings in the future.

When you have a reference to sketch a material passport its really becoming easy to have at least a 60% complete material passport. At the moment, Constructif have asked me to make material passports, but the information needs to be sent mostly by the suppliers and right now I'm negotiating with almost 80 suppliers with a questionnaire of 20-30 or 40 questions and that's a totally new work for them.

Do you think additional charges will follow from this additional work that they have to do?
No, since they are getting promoted at the same time in the project they are being involved in from a marketing point of view. I want to touch on a very important point of view, sometimes Suppliers are not familiar with how circular they already work. I am impressed and surprised by how circular the materials already are. For instance, glass is 100% circular, aluminium is 100% circular, steel the same, insulation materials the same, the rooftop water resistance materials, the pebbled on a roof, the concrete also. I can go on forever, and the interesting point is that they are not aware how circular they are. They might also get a guarantee that they will take back the materials in 40 or 50 years to re-manufacture it into new materials.

Do you think having an integrated approach can help with this?
I think the data and the object has to be one, and this responsibility goes to the asset owner when it comes to keep it up-to date. I think the skin of the building (roof and façade) will not change much during the lifecycle of the building. Major changes will occur in interior sections of the building such as painting and lightning. You need to be able to understand what your building is composed of and how to decompose it, once you are able to do so, you can truly understand what its value is.

Closing section

DATE	31st August, 2021

ORGANIZATION	Gemeente Amsterdam (Sustainable Cities Consultant)

INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)

INTERVIEWEE	*Max Beijneveld (**m.beijneveld@amsterdam.nl**)*

Introduction section

Could you provide us with a background of your career and your role at the Municipality of Amsterdam?
I am a Sustainability Advisor at the Municipality of Amsterdam; I work for a program that has an aim of making the municipality more sustainable. We have almost 18,000 people working for the Municipality, and we manage the refurbishment of public Infrastructures and manage major buildings in the Real Estate sector. Therefore, we play a big role in the purchase of material, additionally, we work on maintaining the structure and updating the materials to be able to best re-use it based on the big demands that we get. Moreover, we work on other sources than materials such as food. But in short, my role in this whole story is that I'm trying to advise all the departments pertaining to the municipality which are trying to deliver all kind of services to the Municipality of Amsterdam to make better sustainable choices that they offer to the city of Amsterdam.

When we talk about sustainable choices, some departments have the highest impact when we talk about Infrastructure and renovating buildings, which demand a lot of materials. That's how I work with material passports for several pilot projects that we worked on. Most of the time we use different approaches to these passports. We see several ways in which materials can be made, several companies can also work on them, but also people are getting more and more acquainted with its usage. Key players come together and try to sketch those guidelines and write what those passports should contain, such as CB'23 Platform. As an advisor, you get accustomed to these advancements and understand what those pilot projects communicate to the material passports in order to fulfil the goals of those guidelines. Then as a Municipality we need to check whether or not we should follow those guidelines blindly, or they are too much detailed and we can check if those guidelines will suffice our needs regarding the re-use of materials.

It's always with these kinds of projects, we ask ourselves to what extent do we follow these guidelines. Based on the pilot projects that were conducted, the question remains: What standpoint will the Municipality of Amsterdam take on this? We have still lots of questions, we know the power of talking, but what is really essential is not to undermine the will of doing things.

What is the take of the Municipality of Amsterdam on Material passports?
The initial situation is when we started a Taskforce within the Municipality to answer the main question: What standpoint do we take on material passports? Unfortunately, and that's a

personal opinion, we need to have a certain kind of mandate to answer the question which you already have before you start the meeting. What you are actually in need of is some kind of commitment from the Stakeholders and that sometimes challenges my patience. I am more guided towards innovation and like to do and accomplish things, however, in the municipality how things work is through discussions and talking sessions.

At the moment, we are working with three types of passports: Madaster, Insert and Excess material exchange. Madaster has a separate way of working, they are less in detail to be able to re-use them on the spot and that's something that Madaster is lacking.

Do you think the lessons learned from the pilot studies can be applicable everywhere?
Material passports should be used in the same way everywhere. For instance, there are big differences between the infrastructure vs the Real estate sector. The progress that is being made in the infrastructure sector is far more foreseen in comparison to the Real estate sector.

For the Infrastructure: The reason for that is that key aspects that make the sector more circular are easier to be applicable in this field of work because in Amsterdam there is a limited number of materials that we use in building Infrastructure. When you talk about buildings in the infrastructure sector, the uniformity of the materials used is much lower. What we see at the municipality is that we are trying to pilot the use of a digital marketplace, where a lot of the data that represents both sectors. If we need to rebuild this neighbourhood, the things in hands will eventually help us. The difficulty in the process is that there is a very long process for which a lot of key stakeholders need to be involved. If people are not keen to re-use materials then they become a burden. Eventually, the process of buying new materials is much easier than designing for re-use, which raises the complexity. Exchanging materials internally at the municipality will help retain its value at the highest level.

In the real estate sector, pilots have shown that we are inexperienced in what type of information we are looking for, what people to reach out to? The process is still in the beginning. One limitation is that we do not know what to do with those passports ourselves. I think one of the big issues is willingness. Probably, you need to change the way you work, and regulations do not allow to do so. One of the regulations for example in the real estate sector, is that you are able to re-use materials in the same building even if the current building regulations would forbid the use of these type of materials in constructing of new buildings. It's very complex, for instance, we have a certain type of window that we cannot use in new buildings, however, one loophole is that if we re-use the materials on the same building you are allowed. These types of regulations also affect to what extent we are able to re-use materials.

If you refurbish a building, the need of users will change with time, so does its structure and its constituents, not all materials will be re-used on the same building. When you ask recycling companies, there way of working is just destroying everything they have given their limited time. As a municipality we have very strict deadlines to reduce usage with 50% by 2025. If we only design for re-use I am certain we will not be able to maintain those goals. The pragmatic approach is to build for re-use and at the same time we need to make sure that we take the initiative to re-use as much as possible.

Who do you think will play a bigger role in changing the policies set for material re-use?
One of the easier policies to implement is to tax materials more than labour, which would facilitate the re-use of the materials. We are not certain to what extent the labour intensity of

deconstructing materials will cost more than the normal process. Making the regulations more flexible regarding the re-use of materials will help promoting material re-use. The problem has two aspects, the security of the policy makers and the environmental groups on the other side. They need to be able to balance it out given we have a lot of stakeholders involved in the process.

Could you elaborate more on the central platform that you are working on?
Yes, it's called Insert. It's a platform that mostly close to a Marketplace that was developed by multiple demolishing companies. They were seeing more and more circularity regulations and policies pushing for re-use of materials. As an answer to the increase of demands from policymakers they Initiated a digital marketplace called Insert. Constructors and demolishers are able to publish materials and products to be re-used and its usage is still limited at the moment.

Based on my research, I reached to the conclusion that there two approaches for the problem at hand: the Centralized and the Supplier approach. Do you think shifting from one to another will have an impact on decisions taken by policy makers?
I think the centralized approach is the way to go, because in the end policies should be changed to make the process easier. However, this type of re-usable materials will start flying because people are incentivized to re-use material because it will be cheaper.
Come to think of it, the supplier approach seems to be very interesting as it states that the supplier will be responsible of its re-usage. I think both approaches could work in different situations, and it will not interfere with my experience in practice.

Closing section

DATE	3rd September, 2021
ORGANIZATION	Ministry of Infrastructure (Sustainability Team Member)
INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)
INTERVIEWEE	*Name Undisclosed*

NB: The Interviewee wanted to keep his/her identity confidential, and the connection was made possible through the contact of the Directeur-General of Mobility at the Ministry of Infrastructure: **Kees van der Burg** (kees.vander.burg@minienw.nl).

Introduction section

Could you inform us to what extent you are involved with material passports at the Ministry?
It's definitely not part of my daily routine, let me tell you what I mean about that. We have made a strategy towards Circularity in the Infrastructure sector and the ambition is to work circular based on different criteria such as fuels, CO2 emissions and so forth. For instance, a lot of ships can bring sands to the coast, and this would have a huge impact on our scope, not to mention the infrastructure such as roads and tunnels that we have to maintain. My point is that we have a lot of assets to maintain and the scope at the Ministry is very big at the time being. At this moment, I think you have more information about material passports than I do.

By maintaining, are you trying to re-use materials or at least promoting the design for re-use?
That's all part of the strategy, and the organizations that work on a daily basis on the projects. They know the best how to deal with these kinds of things. I'm from the Ministry and I do not know how we can best re-use the asphalt, but the companies we are signing with for our projects do know and we have to question them in what way. Most of the time, when we approach new things it's much more expensive, and the bigger the scope the more money we will eventually need.
There are lots of new developments and not everything can be monitored every day, one of these things is material passports. We know it's something for the future, but we had a big discussion about the contract with Rijkwaterstaat in the coming two years as there is very little money and things become tighter. We still manage to get money for the ambitions we have and for the research conducted for material passports. Part of this development is combined to my work, and we still need to know more about it, what do we need with it and how we can best use it to our advantage. These kinds of things are done by Rijkwaterstaat, and we support by giving them money to support their research.

In what phase you are still in regarding material passports?
We are not using it yet in our projects, I know for sure Rijkwaterstaat are still doing pilot projects with material passports but to my level of involvement this is what I know of. Material passports are not something we have to use in every project yet, but we see material passports

as something important that we want to find out more about it: It's still in the Development phase. We have an amazing amount of assets, and we cannot implement it right away on all our projects, its only reasonable to research more about it.

So far, the research have suggested that material passports need to be updated and safeguarded on a long-term. Regarding their applicability in the Infrastructure sector, do you think it would be financially feasible to use them for almost a 100 years?
I think it will be expensive because we have an amazing amount of assets. But we are still uncertain about how much it will even cost for one project, and I cannot confirm my answer yet. We are still busy with this transition; I know it's an important development, but this is not my priority. There is so many things that needs to be done, and my main scope is the production phase, and this is the next step.

Do you think as policy makers you will have an impact on the applicability of those passports? I know you want to maintain the circularity goals by 2030 and 2050, will you need to apply new policies to keep up with those goals?
We are not yet very good at making the goals smart. Circular economy is quite a technical aspect, it's not only about the material and how to re-use it but, what will be the future use of our assets. We have quantitative measurement tools for emissions for instance, but circularity is more qualitative. We have ambitions and roadmaps that we follow for the main impact activities and at some point, when we start using the tool, then we can determine how we can actually monitor that. I see material passports as a tool that we are still developing and that will give you insights, and we are not yet there.

Do you think material passports will become mandatory for Infrastructure projects?
I know that we have not decided that yet, but if you take circular economy seriously, we need to know what you have. It's too complicated as the government to do it yourself, but then you can make the market do it for you. We have not decided that yet since we need to make smarter circular goals and then decided what we need to monitor. That's why we do not call it 100% circular materials but circular working. The main goal of this Ministry is to be the Asset Manager and to be the Mobility server for the national networks. We do not make infrastructure because of circular economy.

Elaborated on both Centralized and the Suppliers approaches, and which would they support? If they have to choose one over the other, would it have an impact on them?
We are the asset managers and the government. I personally don't think we would like to get into the borrowing business because it would be very difficult. You can think of it this way: we will not be the boss anymore. I never think this would work in a good way for us and not the right task.
However, since we are not yet certain of the goals, we are not sure if it would be good for us to keep the data central to our organization's reach. I think a good way to put it, we can always ask for material passports since we don't do the projects ourselves, we always ask people to work for us. We can then put it in our database and someone else **must** be using it as smart as possible. Will it be economically interesting to re-use? We are still not sure, and maybe the Supplier approach can help us as a government be laid back and it's still too early to tell and people like you can help solve the mystery question: how can we best use it?

Closing section

DATE	13th September, 2021
ORGANIZATION	Stitching W-E Adviseurs (Senior Consultant)
	Platform CB23 (C-Creator)
INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)
INTERVIEWEE	*Olaf Blaauw (**Olaf@c-creators.org**)*

Introduction section

What do you think of the research findings and the presentation delivered?

I looked at your presentation obviously, first of all I think it looks good and that it shows the things that I see as well when I look at the market. The type of problems you are discussing, the lack of centralization or the lack of proper decentralization, having a distributed type of framework easily coop with the fact that you cannot have a centralized system.

The other thing that I would like you to see, if there is no monetary importance being given to the figures, there is no impotence or no desire to treat the information as dynamic. It becomes a static document to meet the demands for a certain party at a certain point in time, which hinders its functionality tremendously. It's the little things that you point out through the symbols in green or red that I recognize immediately, to me it's important because I'm not the only person to see this, so that helps and thank you for that.

I have summarized in the presentation 5 main limitations that were found in theory and still present in practice. Which one of those 5 limitations will have the highest impact on the applicability of material passports in the future?

Interesting question, well, obviously my statement is always that information is only valuable if its correct. Even though I have a great interest in Limitations 3,4 and 5 (); what safeguards things best is the standardization approach (Nbr. 2: having a standard passport format). To make sure we have a level plain field, when party A mentions a certain factor X it means the exact same thing as party B's. Your data loss becomes less relevant if things can move on along the supply chain with always the same identity. In order of relevance, 2 – 3 – 4. Having a mandatory data collection is long-term and you can capture 3 and 4 at the same time. You allow then working for 5, by utilizing the passports from an economic point of view, not just what is where.

On a side note, I think number 1 is of great importance, because your access to data is defined by how the interface between all those decentralized databases work. There is a split you can make for 1, it's not necessary to have the data in a central place, it's the central management of the de-centrally sorted data that is of importance, which can only be done once standardization is applied under one language: hence number 2 is the most crucial.

If each limitation presents different impact in the future, who do you think will be mostly affected by those limitations?

Well, the landowner just sees the value of his property change and that is good or bad. I personally don't care too much about that, I just think that once you develop a piece of land into Real Estate, it retains its value better than others would be then the price of the land goes up as well. I think those who are responsible for the financial management of the real estate benefit most. It's in the operational phases of the building that most profit comes out of knowing which value is where and how to cycle renovations and optimize your asset. You find that over the course of the lifecycle, operational expense will exceed capital expenses to build the asset in the first place. So, it will be of highest interest for those who manage the facility to have information at their disposal once its completed, which means they should aim to have the complete dataset to allow for a more efficient and effective asset management. In Dutch it's called an Onderpand (collateral/insurance), once you want to decompose a building in for instance 80 years, its residual value will be there only if you know it will be there. At the end of the day, the financial parties will pay for it.

Could you provide me with feedback about the framework developed for both approaches?

When I look at the division of responsibilities, it obviously makes sense, because you have done it in a logical manner. You take the different phases; they promote the safeguarding of data. The only thing that worries me is that for corporations or organizations it's easy to implement it as they can keep track of what comes in and out, but what would you do for individual house owners who want to make changes internally? I don't think they can fit in any framework.

I actually found it to be a limitation in one of the interviews in the Real Estate sector, that people that are able to makes changes without being monitored are the DIY or Do it yourself people. That's where the supplier approach may come in handy: you track the material back from the source, or with the supplier.

Yes, that can work, but then the supplier will have additional responsibilities in keeping up with the location of all the materials that have been outsourced. That's the framework system in which you add a unique identifier to anything that you build such as QR code that makes it detectible in the real physical world. Because if you ask a supplier of screws to keep track of every screw, that will not work especially if the company is small and cannot stress too much on the data management part. When you present services instead of products that's easier to implement, but when ownership gets transferred to the DIY people, this is where the fun starts, or in our case where the trouble starts.

A solution to this would be to have a more sophisticated central management of data so that at least the position data are there centrally but not the product data. For instance, you know where the kitchen is located in a matrix of some sorts, but the information regarding the kitchen itself should be with the supplier: Location information should be centrally handled as long as there is something against data loss through some form of distributed ledger (not like bitcoin in a billion places but 10 places are enough, if 7 of those fail I still have the level of security that I can live with).

One of the limitations is that suppliers might not survive 50 or 60 years, what do you think of the Supplier approach?

Once a supplier/producer is out of business, how do you safeguard against data loss? That is the main question. With this distributed ledger technology this can be safeguarded. We will always incur losses in data, we can never have 100% data retrieval systems obviously, but those will be corrected by the deconstruction phase. But I think this can easily be applied in the Real Estate sector, given you provide the correct umbrella for data management.

Can you elaborate more on the idea of having a distributed ledger technology or the blockchain idea you were mentioning?

Basically, blockchain is a system where datasets interact with each other's by sharing the change that was made on one dataset among a larger dataset. If someone tries to rechange the initial dataset, then the 9 or 100 other datasets will not allow to do so. It tries to safeguard data from being changed for the wrong reason which is why it is the basis for bitcoin. Once a transaction is made it cannot be erased, it's now stored in a chain of blocks. If it's a correct change it cannot be undone. Maybe it's too advanced at the moment, but the basic premise is that you distribute information over a limited of locations that safeguards this information if one of the locations stop functioning. It's the basic underlying principle of blockchain.

Presented the findings from the Ministry of Infrastructure: "they want to be the boss". Which approach do you think will suits better for this sector?

I think for the infrastructure sector, it's understandable that some organizations want to maintain the data for themselves, they want to be in control of the data that describes their assets, they are the central part of the government. There is a different point of view, if you look at the system as whole, what suits them may not suit the rest of the players. They have sufficient scope to be able to do it as they have a central management already in place, so for them it's easier this way.

Do you think policy makers will have an issue changing between one approach to the other?

Like you mentioned, they want to have control. Not for bad reasons, but they can afford to have that in the way of working. They cannot project that to the market, given that its multiple ownership and they are singular ownership: that shouldn't be the same.

Presented the findings from the Municipality of Amsterdam. That there are rules regarding the re-use of materials that allow you to re-use a product only on the same building and not somewhere else. Do you think becoming more lenient around the rules is this issue?

Yes, not just that. Some laws are here to protect some citizens and cannot be changed. Some areas are becoming more lenient as long as you show that this change of rule can have its advantages. But that's making exceptions to the rule, while it should be that if you can provide sufficient evidence that what you are doing is safe, sound and contributing to the greater cause then you can do it. One thing we should always live by, if rules and regulations withhold you from doing the right thing and you are responsible not be doing the wrong thing, you are responsible of changing the rules.

Regarding the applicability of the framework, do you think it can be implemented in organizations or even within teams?

I think anything can be applicable anywhere, you can always ask organizations to do something. The question remains, is this the best way to do it? Applicable it is. First you checked what roles the different players and stakeholders have in this game, then you check how each player interacts with the other. If we are not discussing what method is the best, but if any method can be applied, then you have checked most of the stakeholders. You will always have inconsistencies, but looking at your framework, I think as far as I know that is pretty close to what you should be doing. Maybe fine tuning can work, however, in general terms you see that most stuff lie with the owner or the supplier depending on the approach: That's the right way to do it, it cannot be any different, to me it makes sense because this is how I view the world and of course I like it. This is both a good thing to do and as far as I can tell its achievable.

Discussed the three options to apply the framework in contractual agreements and which would he agree upon?

I think making special agreements come closest to your idea, every time you make a unique contract you will end up with the same rules to play by. So, I guess, special agreements are the initial way to go. Then on the long-term changing the procurement law may happen later on, however, general terms and conditions can never occur and will not change anything.

Where do we go from now? And what do you think is future potential research?

A lot of studies now talk about how we create passports or how to standardize and it's all technical. The why is well known, the what only partly because it's an idealized version of a utopia for everything down the line, what we will need is much more emphasis on the economic benefits of have proper data. How do our asset management models change, how can we consider that we don't just store the information but know how to utilize it? What is the use of the information rather than how to collect it in a standardized fashion? The next step is how can I put it into economic use so that a well-designed circular program will always out compete a linear counterpart: in other words, proving that there is no need to build linearly ever because it would cost you more money than a circular design would bring you. This is the real engine of change. This is the only way people would respond to, they will not respond to ideologies such as saving the world or planting trees. People are only willing to do so if they can make money of tree plantations. That's the real problem because it's the true mankind: we are all greedy and only care for our kin. There is a Dutch saying: "**Martelen doet minder pijn aan de jan zee dan aan de Rijn**" (torture hurts less along the river than along the rhine). Thinking people care about the system but that is only a short minority, in some cases that's scientists or people that study the topic that you do, and I do. But it's a very a small percentage and the economy is about the survival of the fittest and in the end it always comes down to money. The way we exploit our data that wish to ensure circularity in design and use in a way that it actually serves the purpose can only be brought into our economy if we show that its profitability is ensured better than its alternatives would have done.

Closing section

DATE	28th September, 2021
ORGANIZATION	Kirkman Company (Senior Consultant) Platform CB23 (C-Creator)
INTERVIEWER	Jalal Chahine (**chahinejalal@gmail.com**)
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Introduction section

Could you introduce yourself for this conversation?

My background comes with my involvement with the digital tool: material passports. I've been involved with it before the beginning of Platform CB'23. I am the chairman of the action group on the side, and you can imagine I work with Kirkman company who focuses on sustainability in a broader perspective. I co-founded C-creators and they focus on the built environment especially in Amsterdam, we are involved in projects, community building and sharing knowledge. Passports have a been a topic we have worked on since the beginning, we have knowledge and experience on this topic that is more and more evolving.

The findings have been presented using a PowerPoint to provide a reflection on the topic.

I agree with the limitations you presented. All those limitations have been presented recently in a paper that we published but in a much broader scope. It would be harder to rank those limitations because they are all kind of related to each other. I think some are struggling a lot how to store the data and the issue is that it is not being incentivized earlier in the process to know how to do it. The paper can be found below:

https://c-creators.foleon.com/publicaties/digitaliseringindebouw/rapport/

Some of the people that you interviewed have participated in sessions for platform CB'23, so I reckon and agree on several things with your findings. I also recognise that there is a distinction between the Infrastructure and the Real Estate sectors. At the end, it depends on the organization you are dealing with if they have the incentives to store the data themselves centrally. For instance, a Municipality would want to store the data themselves, while housing corporations wouldn't mind using the second approach unless we prove that its economically beneficial.

The two approaches have been presented and discussed with opinions of Policymakers.

I think what we did not do and what you were able to do is that if we are going to assign tasks to the entire value chain, who is going to be responsible of doing what. I think between the two approaches, it should not be much of a difference other than the location/place of the data. But in general, the responsibilities could be quite similar.

For policymakers I think it's reasonable if it's their way of working. Once everyone works in a similar manner, and as long as they are able to keep this data to ensure that it's in accordance with their asset management plan then its okay.

Who is mostly affected by not updating material passports?

If I own a house, the last thing that will be on my mind as a house owner is to update the house. For the real estate, I don't think the biggest party is the house owner, however, all stakeholders will be losing from this added value, hence everyone will be affected in a shared way. The issue is that people need to know what is expected from them and we are working on that in order to introduce it in a procurement process by next July.

Where do we go from now regarding material passports?

What we are going to solve as CB23 is what type of data we are going to tackle in the future. We need to improve the business case on collecting the data and incentivize it earlier for storing data for over 40 years to show how we are creating value. I'm quite confident that we are going to solve it, and I think that what you did by making crystal clear of who is responsible of doing what in the value chain will help us solve the limitation of collaboration amongst stakeholders. It's not only one actor that is doing a lot, but a lot of actors that come together to create added value, your research could really be a way to collect this data and create this value.

To reflect on your work, what I really like is that along the entire value chain you thought of who is responsible of the data in a RACI kind of way. Would you let me send your findings to the people we are working with along with your report; I believe it's a nice way to think of how we can distribute the responsibilities like you did. I like that approach and maybe we can polish it based on each organization.

Closing section

Appendix E: Overview of the main Actors

Table 17 presents a summary of the actors that will be used in the Framework based on the findings from the Literature section. The four colors associated with the roles from the Framework bring an aesthetic view of the results. The **green** presents the parties that have a high degree of involvement throughout the project. The **yellow** represent parties that act as third-parties capable of providing external services. Moreover, the **orange** color show the roles of demolishing and recycling companies, and finally, the **blue** color relate to parties highly involved in the field of data management. An overview of the roles is presented accordingly.

Table 17. Summary of the main Actors in the Framework

Actor	Role	Reference
Extractor	*Removal and refinement of raw materials from the ground. Responsible of creating and collecting materials to exchange with the producer.*	pp. 19
Producer	*Acts as an assembler of the materials into products and components, his main role is to produce end goods and services for the supplier.*	pp. 19
Supplier	*Acts as an intermediate between consumers and producers of products. The three preceding roles may act as one entity as producer-extractor and supplier of materials in some cases, all referred to as the role of Owner of the data.*	pp. 19
Project Developer	*On site representative of the project owner. Responsible of overseeing the tasks completed on site and project delivery for the project owner.*	pp. 36
Architect	*Designing and planning the project, while consulting the Project Developer. The architect or consultant has an important role in promoting material passports through an early application of circular designs based on the delivery method.*	pp. 36
Contractor	*Carrying out construction activities based on the project delivery method. The contractor has a big responsibility in delivering material passports to the asset owner once the asset is transferred over.*	pp. 36
Management Services	*Have the responsibility of maintaining and operating the material passport throughout the use phase of the asset.*	pp. 37
Financial Services	*Third parties that offer financial evaluation and estimation of the construction product through time based on the data provided from management services.*	pp. 37
Storage Services	*Third-party that stores the data of material passports, such as Madaster. They have a responsibility in safeguarding its quality once its stored.*	pp. 37
Consultancy Services	*Additional services that may be offered once data is stored to interpret this data and propose a new setting of arrangement for data management.*	pp. 37

Demolition Company	*Contractor responsible of dismantling building components once the asset is transferred over. Demolition companies become responsible of making a disposition decision for dismantling the building.*	pp. 38
Recycling Company	*Provides a re-use plan for the components that were demolished. His early involvement in the design phase promotes decisions to design for re-use.*	pp. 38
Owner	*Owns the physical product and manages its material passport. The ownership of the construction product may change throughout time. For instance, during production phase, the owner is the Producer, accordingly the material passport is transferred over to the Supplier once the material is exchanged. Hence the title of Owner refers to multiple parties at different stages.*	pp. 37
User	*User of the facility/ asset that is familiar with its condition. The user may refer to tenants or owners of the asset itself that have an active responsibility of speaking up for defects and changes that need to occur in the asset.*	pp. 37
Passport Builder	*Sets up and manages the data format for a construction element. The passport builder is mainly a representative of storage service company such as Madaster. However, this role can still be applicable in-house for suppliers.*	pp. 37
Auditor	*Checks the quality and legitimacy of the data recorded, a representative of the organization or the storing services company.*	pp. 44
Customer	*Potential buyer of the data for future learning opportunities. Typically, represents organizations that are interested in big data for interpretation.*	pp. 33
Data Broker	*Licensed collector and seller of data to third parties. This role is associated with the organization/company holding the data.*	pp. 33
Security Officer	*Checks and ensures a good data strategy is being followed. The role is formed within the organization or the storing services company. This role is inherited by the **Supervisor** role in the Gemma Tactical Data Management plan. He acts as a third-party trustee while being highly involved in the Data management tasks.*	pp. 33
Regulations Coordinator	*Oversees the methods and guidelines followed to collect/manage the data. Typically, an architect assigned by the central government to keep track of the guidelines and rules. This role is inherited by the **Supervisor** role in the Gemma Tactical Data Management plan*	pp. 35
Data Protection Officer	*Grants different levels of access for users of the data based on confidentiality. The role is formed within the organization or the storing services company. . This role is inherited by the **Supervisor** role in the Gemma Tactical Data Management plan.*	pp. 33

Appendix F: Centralized Framework

The section presents the results of the framework for the different project delivery methods as discussed in Chapter 3, of the Literature study.

Data Collection and Management Information	Responsibilities and Tasks	Extractor	Producer	Supplier	Project Developer	Client Consultant	Contractor	Sub-Contractors	Management Services	Financial Services	Storage Services	Assessment/Consultancy Services	Demolition Company	Recycling Company	Owner	User	Passport Builder	Auditor	Customer	Data Broker	Security Officer	Regulations Coordinator	Data Protection Officer
Initiation/Design Phase	Construct Product Format	R	A	I									I	I	R			C			C		
	Generate Material Passport		R	A	I								I	I	A		R			I	A		
	Design Activities					C	A	R					I	I	A								
	Acquisition Agreement					R	A	I							I			A	C	I			
Construction Phase	Integration through BIM Model				C	C	A	R							A					I			
	Construction Assignment				I	C	A	R	R/A						C					I			
	As-Built Updates				I	C	A	R	R	I			I		I								I
Check-up Phase 1	Availability Checks			I					R			A								I			I
	Condition Assessment			I					I	R		A								I			I
	Auditing and reporting			I					I	R		I						R					I
	Legislation, and Regulations			I					I		A	I										R	I
	Control, organisation and risk management								A	R		A								C			I
	Data Legitimacy and quality								A		I							R					I
	Data Exchange with third parties			I					C	A	I	C						C		R	C		I
Use-Phase	Maintenance and Renovation Works			I	A	C	I		R	A	I	A	C	I						I			
	Use and Management Works			I	A	C	I		A	R	I	A	C	I						I			
	As-Is Updates			I	A	C	I		C		R	C	I							I			
Check-up Phase 2	Availability Checks			I					R			A								I			I
	Condition Assessment			I					I	R		A								I			I
	Auditing and reporting			I					I	R		I						R					I
	Legislation, and Regulations			I					I		A	I										R	I
	Control, organisation and risk management								A	R		A								C			I
	Data Legitimacy and quality								A		I							R					I
	Data Exchange with third parties			I					C	A	I	C						C		R	C		I
End-of-Life Phase	End of Use Plan			I	A	C	I		I		I	R	C	A						I			
	Recovery of Leased Products				A	C	I		I			C	R	I				C		I			
	Recovery of Raw Materials				A	C	I		I			C	R	I				C		I			
	Transfer of Ownership			I	A	C	I		I		I	A	R	A						C			
Additional Tasks	General Information			I					I			R								I			C
	Processes and employees								C										R				I
	Interaction with potential Customers								C									R	A				
	Communication and processing methods								C										C	R			
	Re-auditing								C									R			A		
	Data Management																						
	Data Landscape									C					C	R				I			
	Quality Requirements			I											C					I	R		
	Data Catalog and Reference Book			I						C					C	R				I		A	
	Quality Improvement			I											C			C		I	C		
	Return Obligation		A												R	A							I
	Duty to investigate														R			A					I
	Roadmap														A								R
	Information Security																						
	Security Policy			I							I				C						R		A
	Organization of Information Security			I							I				C					A	I		R
	Acquisition, maintenance and development			I				C	I	A					C						I		R
	Incident management			I				C	I	I					C						I		R

*Figure 40. RACI Matrix Division of Responsibilities for the **Design & Build** Approach*

*Figure 39. The Compass Ecosystem for the **Design & Build** Circular Process*

Responsible
Accountable
Consulted
Informed

Figure 42. RACI Matrix Division of Responsibilities for the DBM Approach

Data Collection and Management Information	Responsibilities and Tasks	Extractor	Producer	Supplier	Project Developer	Client Consultant	Contractor	Sub-Contractors	Financial Services	Storage Services	Assessment/Consultancy Services	Demolition Company	Recycling Company	Owner	User	Passport Builder	Auditor	Customer	Data Broker	Security Officer	Regulations Coordinator	Data Protection Officer
Initiation/Design Phase	Construct Product Format	R		A	I							I	I	R		C				C		
	Generate Material Passport		R	A	I							I	I	A		R				I	A	
	Design Activities					C	A	R				I	I	A								
	Acquisition Agreement				R	A	I							I			A	C	I			
Construction Phase	Integration through BIM Model				C	C	A	R						A						I		
	Construction Assignment				I	C	A	R	R/A					C							I	
	As-Built Updates				I	C	A	R	R	I				I								I
Check-up Phase 1	Availability Checks		I				R							A						I		I
	Condition Assessment		I				I			R				A								I
	Auditing and reporting		I				I			R				I			R				R	I
	Legislation, and Regulations						I				A			I						R	R	I
	Control, organisation and risk management				A			R						A						C		I
	Data Legitimacy and quality				A						I						R					I
	Data Exchange with third parties		I				C			A	I			C			C		R	C		I
Use-Phase	Maintenance and Renovation Works		I	A	C	R				A	I			A	C	I				I		
	Use and Management Works		I	A	C	A				R	I			A	C	I				I		
	As-Is Updates		I	A	C	C					R			C	I					I		
Check-up Phase 2	Availability Checks		I				R							A						I		I
	Condition Assessment		I				I			R				A								I
	Auditing and reporting		I				I			R				I			R					I
	Legislation, and Regulations						I				A			I						R	R	I
	Control, organisation and risk management				A			R						A						C		I
	Data Legitimacy and quality				A						I						R					I
	Data Exchange with third parties		I				C			A	I			C			C		R	C		I
End-of-Life Phase	End of Use Plan		I	A	C	I					I	R	C	A						I		
	Recovery of Leased Products			A	C	I						C	R	I			C			I		
	Recovery of Raw Materials			A	C	I						C	R	I			C			I		
	Transfer of Ownership		I	A	C	I					I	A	R	A						C		
Additional Tasks	General Information		I							I				R						I		C
	Processes and employees													C					R			I
	Interaction with potential Customers													C					R	A		
	Communication and processing methods													C					C	R		
	Re-auditing													C			R				A	
	Data Management																					
	Data Landscape		I							C						C	R			I		
	Quality Requirements		I													C				I	R	
	Data Catalog and Reference Book		I							C						C	R			I	A	
	Quality Improvement		I													C		C		I	C	
	Return Obligation		A											R	A							I
	Duty to investigate													R			A					I
	Roadmap													A								R
	Information Security																					
	Security Policy		I							I				C					R			A
	Organization of Information Security		I							I				C					A	I	R	
	Acquisition, maintenance and development		I			C				I	A			C						I		R
	Incident management		I			C			I	I				C						I		I

Figure 41. The Compass Ecosystem for the **DBM** Circular Process

Responsible
Accountable
Consulted
Informed

RACI Matrix — Data Collection and Management Information

Data Collection and Management Information	Responsibilities and Tasks	Ext	Prod	Sup	PD	CC	Con	SubC	SS	ACS	DemC	RecC	Own	User	PB	Aud	Cus	DB	SO	RegC	DPO
Initiation/Design Phase	Construct Product Format	R		A	I						I	I	R			C				C	
	Generate Material Passport		R	A	I						I	I	A		R				I	A	
	Design Activities				C	A	R				I	I	A								
	Acquisition Agreement				R	A	I						I			A	C	I			
Construction Phase	Integration through BIM Model			C	C	A	R						A						I		
	Construction Assignment			I	C	A	R	R/A					C							I	
	As-Built Updates			I	C	A	R	R	I				I								I
Check-up Phase 1	Availability Checks			I			R						A			I					I
	Condition Assessment			I		I			R				A								I
	Auditing and reporting			I		I			R				I			R				R	I
	Legislation, and Regulations					I				A			I							R	I
	Control, organisation and risk management					R							A					C			I
	Data Legitimacy and quality					A			I							R					I
	Data Exchange with third parties			I		C		A	I				C			C		R	C		I
Use-Phase	Maintenance and Renovation Works			I	A	C	R		A	I			A	C		I			I		
	Use and Management Works			I	A	C	R		A	I			A	C		I			I		
	As-Is Updates			I	A	C	R			A			C	I		I			I		
Check-up Phase 2	Availability Checks			I			R						A			I					I
	Condition Assessment			I		I			R				A								I
	Auditing and reporting			I		I			R				I			R				R	I
	Legislation, and Regulations					I				A			I							R	I
	Control, organisation and risk management					R							A					C			I
	Data Legitimacy and quality					A			I							R					I
	Data Exchange with third parties			I		C		A	I				C			C		R	C		I
End-of-Life Phase	End of Use Plan			I	A	C	I		I		R	C	A						I		
	Recovery of Leased Products				A	C	I				C	R	I			C			I		
	Recovery of Raw Materials				A	C	I				C	R	I			C			I		
	Transfer of Ownership			I	A	C	I		I		A	R	A						C		
Additional Tasks	General Information			I					I				R						I		C
	Processes and employees												C					R			I
	Interaction with potential Customers												C					R	A		
	Communication and processing methods												C					C	R		
	Re-auditing												C			R				A	
	Data Management																				
	Data Landscape			I					C				C	R					I		
	Quality Requirements			I									C						I	R	
	Data Catalog and Reference Book			I					C				C	R					I	A	
	Quality Improvement			I									C			C			I	C	
	Return Obligation		A										R	A							I
	Duty to investigate												R			A					I
	Roadmap												A								R
	Information Security																				
	Security Policy			I					I				C					R			A
	Organization of Information Security			I					I				C					A	I		R
	Acquisition, maintenance and development			I		C		I	A				C						I		R
	Incident management			I		C		I	I				C						I		I

*Figure 44. RACI Matrix Division of Responsibilities for the **DBFMO** Approach*

Legend:
- Responsible
- Accountable
- Consulted
- Informed

*Figure 43. The Compass Ecosystem for the **DBFMO** Circular Process*

Figure 46. RACI Matrix Division of Responsibilities for the **Alliance** Approach

Data Collection and Management Information	Responsibilities and Tasks	Extractor	Producer	Supplier	Owner (Aps)	Designer (NOPD)	Contractor (NOPC)	Management Services	Financial Services	Storage Services	Assessment/Consultancy Services	Demolition Company	Recycling Company	Owner	User	Passport Builder	Auditor	Customer	Data Broker	Security Officer	Regulations Coordinator	Data Protection Officer
Initiation/Design Phase	Construct Product Format	R		A	I							I	I	R		C					C	
	Generate Material Passport		R	A	I							I	I	A		R				I	A	
	Design Activities			A	R	A						I	I	A								
	Acquisition Agreement				R	A	A							I			A	C	I			
Construction Phase	Integration through BIM Model			C	A	R	A							A						I		
	Construction Assignment			I	A	A	R							C							I	
	As-Built Updates			I	A	R	A	I		I				I								I
Check-up Phase 1	Availability Checks				I		R							A					I		I	
	Condition Assessment				I		I			R				A								I
	Auditing and reporting				I		I		R					I			R					I
	Legislation, and Regulations				I		I				A			I							R	I
	Control, organisation and risk management						A	R						A						C		I
	Data Legitimacy and quality						A			I							R					I
	Data Exchange with third parties				I		C			A	I			C			C		R	C		I
Use-Phase	Maintenance and Renovation Works			I	A	C	I	R		A	I			A	C	I				I		
	Use and Management Works			I	A	C	I	A		R	I			A	C	I				I		
	As-Is Updates			I	A	C	I	C			R			C	I	I				I		
Check-up Phase 2	Availability Checks				I		R							A					I		I	
	Condition Assessment				I		I			R				A								I
	Auditing and reporting				I		I		R					I			R					I
	Legislation, and Regulations				I		I				A			I							R	I
	Control, organisation and risk management						A	R						A						C		I
	Data Legitimacy and quality						A			I							R					I
	Data Exchange with third parties				I		C			A	I			C			C		R	C		I
End-of-Life Phase	End of Use Plan			I	A	C	I	I		I		R	C	A						I		
	Recovery of Leased Products				A	C	I	I				C	R	I			C			I		
	Recovery of Raw Materials				A	C	I	I				C	R	I			C			I		
	Transfer of Ownership			I	A	C	I	I		I		A	R	A						C		
Additional Tasks	General Information			I				I						R					I		I	C
	Processes and employees													C					R	R	A	I
	Interaction with potential Customers													C				R	R	A		
	Communication and processing methods													C				C	R			
	Re-auditing													C			R				A	
	Data Management																					
	Data Landscape			I						C				C		R				I		
	Quality Requirements			I										C						I	R	
	Data Catalog and Reference Book			I						C				C	R					I	A	
	Quality Improvement			I										C			C			I	C	
	Return Obligation			A										R	A							I
	Duty to investigate													R			A					I
	Roadmap													A								R
	Information Security																					
	Security Policy			I				I						C					R		A	
	Organization of Information Security			I				I						C					A		I	R
	Acquisition, maintenance and development			I			C		I		A			C						I		R
	Incident management			I			C		I	I				C						I		I

Figure 45. The Compass Ecosystem for the **Alliance** Circular Process

Legend: **Responsible** (red), **Accountable** (orange), **Consulted** (green), **Informed** (blue)

Figure 47 summarizes the responsibilities for *Additional tasks* in data management that were added to the project delivery method.
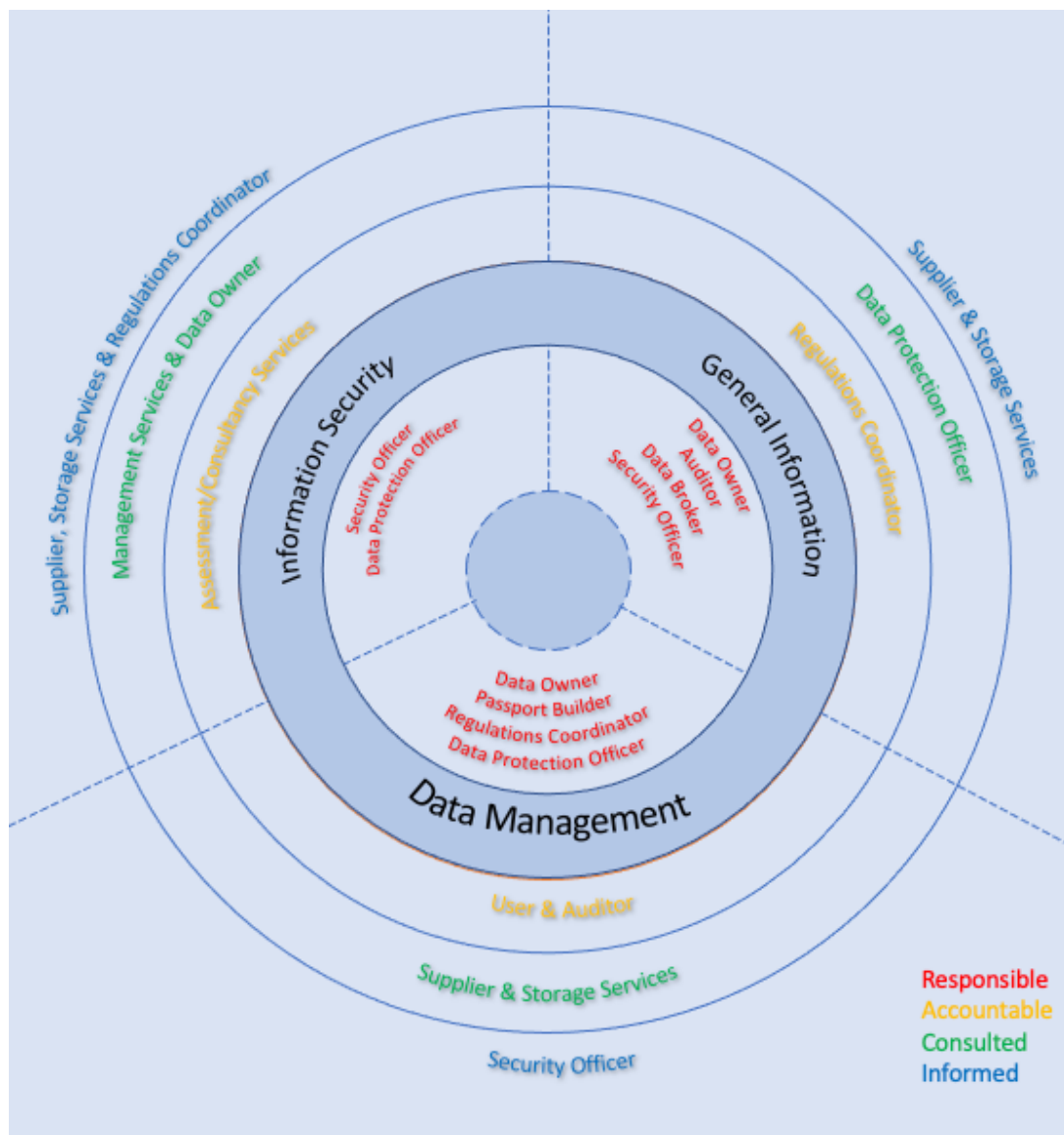
*Figure 47. The Compass Ecosystem for **Additional Tasks** in the Circular Process*

*Figure 48. RACI Matrix Division of Responsibilities for **Additional Tasks** in Data Management*

Appendix G: Alternative Approach of the Framework

The section presents the results of the Supplier approach to the framework for the different project delivery methods as discussed in Chapter 6.

Data Collection and Management Information	Responsibilities and Tasks	Extractor	Producer	Supplier	Project Developer	Client Consultant	Contractor	Sub-Contractors	Management Services	Financial Services	Assessment/Consultancy Services	Demolition Company	Recycling Company	Owner	User	Passport Builder	Auditor	Customer	Data Broker	Security Officer	Regulations Coordinator	Data Protection Officer
Initiation/Design Phase	Construct Product Format	R		A	I				I	I				R			C			C		
	Generate Material Passport		R	A	I				I	I				A		R				I	A	
	Design Activities			C	A	R			I	I				A								
	Acquisition Agreement				R	A	I							I			A	C	I			
Construction Phase	Integration through BIM Model			C	C	A	R							A					I			
	Construction Assignment			I	C	A	R	R/A						C							I	
	As-Built Updates			I	C	A	R	R	I					I								I
Check-up Phase 1	Availability Checks			I					R					A					I		I	I
	Condition Assessment			I					I		R			A								I
	Auditing and reporting			R					I					I			R					I
	Legislation, and Regulations								I		A			I							R	I
	Control, organisation and risk management								A	R				A				C				I
	Data Legitimacy and quality								A	I							R					I
	Data Exchange with third parties			A					C	I				C			C	R	C			I
Use-Phase	Maintenance and Renovation Works			A	A	C	I		R	I				A	C	I				I		
	Use and Management Works			R	A	C	I		A	I				A	C	I				I		
	As-Is Updates			I	A	C	I		C	R				C	I	I				I		
Check-up Phase 2	Availability Checks			I					R					A					I			I
	Condition Assessment			I					I		R			A								I
	Auditing and reporting			R					I					I			R					I
	Legislation, and Regulations								I		A			I							R	I
	Control, organisation and risk management								A	R				A				C				I
	Data Legitimacy and quality								A	I							R					I
	Data Exchange with third parties			A					C	I				C			C	R	C			I
End-of-Life Phase	End of Use Plan			I	A	C	I		I			R	C	A						I		
	Recovery of Leased Products				A	C	I		I			C	R	I				C		I		
	Recovery of Raw Materials				A	C	I		I			C	R	I				C		I		
	Transfer of Ownership			I	A	C	I		I			A	R	A						C		

*Figure 49. RACI Matrix Division of Responsibilities for the **Design & Build Supplier** Approach*
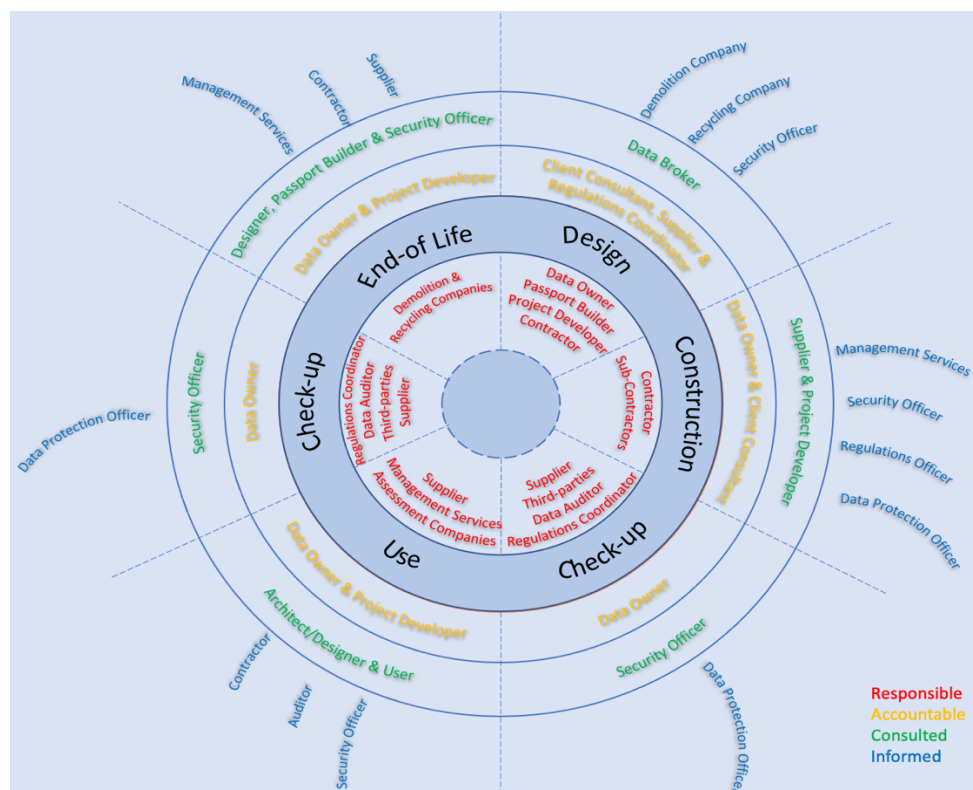
*Figure 50. The Compass Ecosystem for the **Design & Build** Circular Process (Supplier Approach)*

Figure 51. RACI Matrix Division of Responsibilities for the **DBM Supplier** Approach

Data Collection and Management Information	Responsibilities and Tasks	Extractor	Producer	Supplier	Project Developer	Client Consultant	Contractor	Sub-Contractors	Financial Services	Assessment/Consultancy Services	Demolition Company	Recycling Company	Owner	User	Passport Builder	Auditor	Customer	Data Broker	Security Officer	Regulations Coordinator	Data Protection Officer
Initiation/Design Phase	Construct Product Format	R		A	I				I	I			R		C					C	
	Generate Material Passport		R	A	I				I	I			A		R					I	A
	Design Activities			C	A	R			I	I			A								
	Acquisition Agreement				R	A	I						I			A	C	I			
Construction Phase	Integration through BIM Model		C	C	A	R							A					I			
	Construction Assignment		I	C	A	R	R/A						C							I	
	As-Built Updates		I	C	A	R	R						I								I
Check-up Phase 1	Availability Checks			I		R							A						I		I
	Condition Assessment			I		I		R					A								I
	Auditing and reporting			R		I							I			R					I
	Legislation, and Regulations					I				A			I							R	I
	Control, organisation and risk management					A		R					A						C		I
	Data Legitimacy and quality					A				I						R					I
	Data Exchange with third parties			A		C				I			C			C		R	C		I
Use-Phase	Maintenance and Renovation Works			A	A	C	R			I			A	C	I				I		
	Use and Management Works			R	A	C	A			I			A	C	I				I		
	As-Is Updates			I	A	C	C	R					C	I	I				I		
Check-up Phase 2	Availability Checks			I		R							A						I		I
	Condition Assessment			I		I		R					A								I
	Auditing and reporting			R		I							I			R					I
	Legislation, and Regulations					I				A			I							R	I
	Control, organisation and risk management					A		R					A						C		I
	Data Legitimacy and quality					A				I						R					I
	Data Exchange with third parties			A		C				I			C			C		R	C		I
End-of Life Phase	End of Use Plan			I	A	C	I		R	C			A						I		
	Recovery of Leased Products				A	C	I		C	R			I		C				I		
	Recovery of Raw Materials				A	C	I		C	R			I		C				I		
	Transfer of Ownership			I	A	C	I		A	R			A						C		

Figure 52. The Compass Ecosystem for the **DBM** Circular Process (Supplier Approach)

Table with 19 role columns (Figure 53 RACI Matrix):

Data Collection and Management Information	Responsibilities and Tasks	Extractor	Producer	Supplier	Project Developer	Client Consultant	Contractor	Sub-Contractors	Assessment/Consultancy Services	Demolition Company	Recycling Company	Owner	User	Passport Builder	Auditor	Customer	Data Broker	Security Officer	Regulations Coordinator	Data Protection Officer
Initiation/Design Phase	Construct Product Format	R		A	I			I	I			R		C					C	
	Generate Material Passport		R	A	I			I	I			A		R					I	A
	Design Activities				C	A	R		I	I		A								
	Acquisition Agreement				R	A	I					I			A	C	I			
Construction Phase	Integration through BIM Model			C	C	A	R					A						I		
	Construction Assignment			I	C	A	R	R/A				C							I	
	As-Built Updates			I	C	A	R	R				I								I
Check-up Phase 1	Availability Checks			I			R					A						I		I
	Condition Assessment			I			I	R				A								I
	Auditing and reporting			R			I					I			R					I
	Legislation, and Regulations						I	A				I							R	I
	Control, organisation and risk management						R					A						C		I
	Data Legitimacy and quality					A		I							R					I
	Data Exchange with third parties			A			C	I				C			C		R	C		I
Use-Phase	Maintenance and Renovation Works			A	A	C	R	I				A	C		I			I		
	Use and Management Works			A	A	C	R	I				A	C		I			I		
	As-Is Updates			I	A	C	R	A				C	I		I			I		
Check-up Phase 2	Availability Checks			I			R					A						I		I
	Condition Assessment			I			I	R				A								I
	Auditing and reporting			R			I					I			R					I
	Legislation, and Regulations						I	A				I							R	I
	Control, organisation and risk management						R					A						C		I
	Data Legitimacy and quality					A		I							R					I
	Data Exchange with third parties			A			C	I				C			C		R	C		I
End-of Life Phase	End of Use Plan			I	A	C	I			R	C	A							I	
	Recovery of Leased Products				A	C	I			C	R	I		C					I	
	Recovery of Raw Materials				A	C	I			C	R	I		C					I	
	Transfer of Ownership			I	A	C	I			A	R	A						C		

*Figure 53. RACI Matrix Division of Responsibilities for the **DBFMO Supplier** Approach*

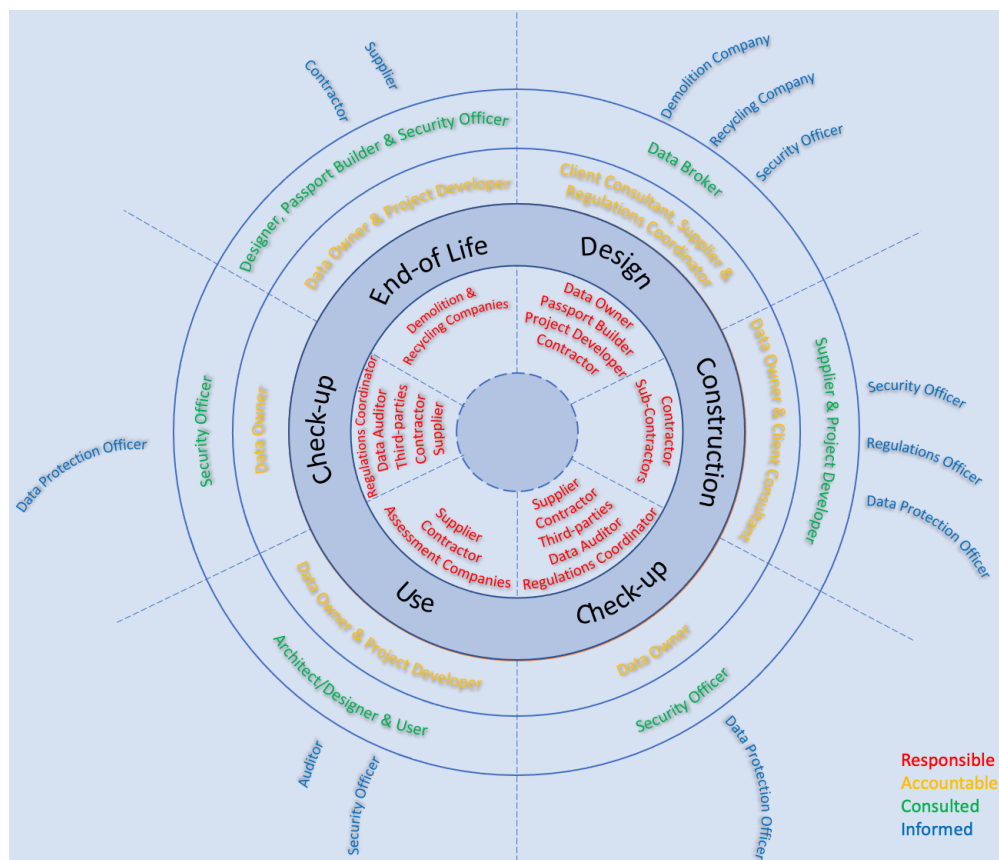*Figure 54. The Compass Ecosystem for the **DBFMO** Circular Process (Supplier Approach)*

Figure 55. RACI Matrix Division of Responsibilities for the Alliance Supplier Approach

Data Collection and Management Information	Responsibilities and Tasks	Extractor	Producer	Supplier	Owner (Aps)	Designer (NOPD)	Contractor (NOPC)	Management Services	Financial Services	Assessment/Consultancy Services	Demolition Company	Recycling Company	Owner	User	Passport Builder	Auditor	Customer	Data Broker	Security Officer	Regulations Coordinator	Data Protection Officer
Initiation/Design Phase	Construct Product Format	R		A	I				I	I			R		C					C	
	Generate Material Passport		R	A	I				I	I			A		R				I	A	
	Design Activities				A	R	A		I	I			A								
	Acquisition Agreement				R	A	A						I			A	C	I			
Construction Phase	Integration through BIM Model			C	A	R	A						A						I		
	Construction Assignment			I	A	A	R						C							I	
	As-Built Updates			I	A	R	A	I					I								I
Check-up Phase 1	Availability Checks			I				R					A						I		I
	Condition Assessment			I				I		R			A								I
	Auditing and reporting			R				I					I			R					I
	Legislation, and Regulations			I				I		A			I							R	I
	Control, organisation and risk management							A	R				A						C		I
	Data Legitimacy and quality							A		I						R					I
	Data Exchange with third parties			A				C		I			C			C		R	C		I
Use-Phase	Maintenance and Renovation Works			A	A	C	I	R		I			A	C	I				I		
	Use and Management Works			R	A	C	I	A		I			A	C	I				I		
	As-Is Updates			I	A	C	I	C		R			C	I	I				I		
Check-up Phase 2	Availability Checks			I				R					A						I		I
	Condition Assessment			I				I		R			A								I
	Auditing and reporting			R				I					I			R					I
	Legislation, and Regulations			I				I		A			I							R	I
	Control, organisation and risk management							A	R				A						C		I
	Data Legitimacy and quality							A		I						R					I
	Data Exchange with third parties			A				C		I			C			C		R	C		I
End-of Life Phase	End of Use Plan			I	A	C	I	I			R	C	A						I		
	Recovery of Leased Products				A	C	I	I			C	R	I		C				I		
	Recovery of Raw Materials				A	C	I	I			C	R	I		C				I		
	Transfer of Ownership			I	A	C	I	I			A	R	A							C	

Figure 56. The Compass Ecosystem for the Alliance Circular Process (Supplier Approach)