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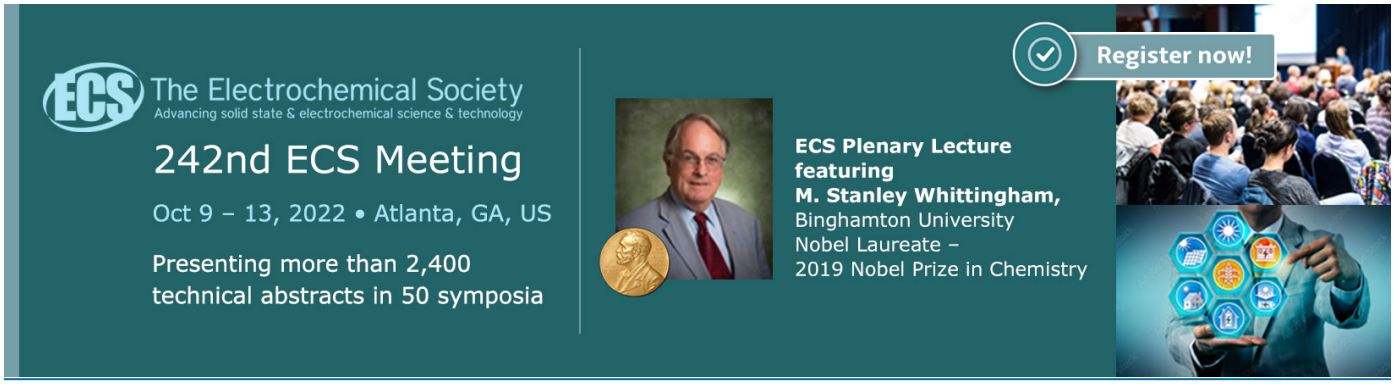

Aligning actors in a road renovation project by a co-design process: the road to circularity?

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Abstract. In a circular economy, the aim is to close material loops that retain the highest utility, quality, and value of products, components, and materials. The environmental impact of the material used in constructing, maintaining, and renovating roads is severe. Within the European H2020 project CityLoops, the municipality of Apeldoorn prepares a circular road renovation project, yet wonders: how to align the actors in public infrastructural projects to come to a circular and, at the same time, executable project? A literature study and experiment were conducted. The experiment consisted of a co-design process aiming for the renovation of a residential road constructed in the late seventies. When conducting road renovation, multiple departments within the municipal organization and different external organizations need to collaborate. To them, circular material usage was introduced as a new specific sustainable objective, while traditional constraints, like time and costs, remained. It was visualized in a process journey, showing who is expected to meet which collaborative milestones and when. The insights from this experiment might help other municipalities, principals, and contractors to come to circular design processes in the road construction industry.

Keywords: road renovation, co-design process, circularity, experiment, actors

1. Introduction

The environmental impact of the construction sector, as well as the transport sector, is large. Serving both sectors the environmental impact of constructing, maintaining, and renovating roads can be reduced, when the materials used are carefully considered [1]. Although currently much waste from the construction industry finds its way into road construction, the basic principle of a circular economy is to close material loops retaining the highest utility, quality, and value of products, components, and materials as possible, as well as slowing material cycles down by means of improving durability.

In the Netherlands, a national policy aims for a 50% circular economy in 2030 and a 100% circular economy in 2050 [2]. Therefore, in many organizations, people have ambitions to start working circularly and to stimulate the development of circular products and services. Services and products are being developed that help to reduce the need for virgin materials, to rely on renewable substitutes, and to close material loops. Ntsonde and Aggeri [3] explain a circular public procurement process at the Danish municipality of Aalborg to select a supplier for school furniture for three years. However, little

information or insights seem to be available on how to shape processes toward a circular economy within a municipal organization exactly. The co-design process initiated at Aalborg took seven meetings with the suppliers before it was possible to come to a call with specifications and criteria [3].

Municipalities fulfil important roles as principal, designer, or advisor when it comes to services, landscaping, and buildings. In other words, they shape our built environment. To achieve these public works, multiple internal departments and external companies need to collaborate. In the European Horizon 2020 project CityLoops, municipalities develop and test tools that help in enhancing a circular economy regarding organic and construction & demolition waste (CDW) [4]. The participating municipalities plan to execute different sorts of organic and CDW projects as circularly as possible.

Within CityLoops, the municipality of Apeldoorn prepares a circular road renovation project. An important question in this respect is: how to align the actors in public infrastructural projects to come to a circular and, at the same time, executable project? The insights from this experiment might help other municipalities, principals, and contractors to adopt a co-design process and to come to more circular projects. These projects do not need to be limited to road renovation or the road construction industry.

2. **Research setup**

After a literature study on service design, circularity and circular principles, this paper sets out the phases that can be distinguished in construction processes, starting from the initial planning and current situation up to the redesign, tender, and execution phase. From literature also insights will be derived regarding the role or roles of actors and stakeholders.

After the literature study, the municipal organization and the specific case will be explained in more detail. Our case represents a situation that is very recognizable for many municipalities in the world on an annual, monthly, or even weekly basis, namely the renovation of a paved residential road. Constructed in the late seventies and located in the neighbourhood De Maten, the particular street to be circularly renovated goes by the name of Griffiersveld. A street paved with concrete bricks and small 30 cm by 30 cm concrete slabs. When planning, designing, and executing a road renovation project, multiple departments within the municipal organization, as well as different external organizations, need to collaborate.

To the stakeholders involved in this project, circular material usage was introduced as a new specific sustainable objective. However, traditional constraints like time and costs still exist to come to a new renovated residential road. Therefore, circular objectives were introduced and discussed through a set of interventions. Starting with interviews that were conducted with stakeholders from the departments and organizations involved. This taught us more about their needs and roles in the circular process. Based on that, it could be visualized in a so-called process journey, showing who is expected to meet which collaborative milestones and when. When the actors had agreed upon this first version of the visualised process journey, the ways to meet these new milestones and compromise the risks involved were also identified in the circular process journey.

The process to come to this process journey, including the organisation of multiple interactive co-design sessions, was executed by an external organization. Commissioned by the municipality of Apeldoorn, this external organization is Koos Service Design [5] because of their expertise in methods of service design and guiding a team of stakeholders through the co-design process. As one of the participants in H2020 Cityloops, the research group Sustainable Areas and Soil Transitions (SAST) of Saxion University of Applied Sciences was invited to do the reporting and evaluation of the trajectory.

3. **Theoretical framework**

This section provides a concise overview of our literature study.

3.1. Service design and co-design

To introduce the concept of circularity in public space redevelopment at the municipal organisation of Apeldoorn, we adopted in this case the approach of service design thinking. *This approach refers to the process of designing, rather than to its outcome*. The outcome of a service design process can have

various forms ranging from organisational structures to operational processes and from service experiences to concrete physical objects [6, p. 7]. Although service design thinking is a relatively young approach, multiple tools are available that support the cooperation of multiple disciplines towards the goal of success. The visualised process in which multiple stakeholders with different backgrounds co-operate, hence the expression co-design, is referred to by the meaningful name process journey. Although a journey can pass along a bumpy road, a path of divergent and convergent thinking can be followed to come from a problem to a problem definition and in the end a solution. This trajectory can be represented by a so-called double diamond model consisting of five stages [7]:

1. Empathize; a divergent stage in which all internal and (external) stakeholders need to be heard, for example by interviews, to learn about their context, situation, needs, and motivations;
2. Define: a convergent stage in which a visual overview will be created on basis of the input from the first stage. In other words, the process journey with its stakeholders, material streams and date flows will now be visualised;
3. Problem definition: the process journey is checked and evaluated for its accuracy;
4. Ideate: a second divergent stage in which the challenges are identified by all stakeholders and experts in facilitated brainstorm sessions. Opportunities with a high chance for success and a low-risk profile might emerge;
5. Test: a second and final convergent stage in which action plans are created for these identified opportunities. This could be in the form of design sprints in which prototyping and testing with its target audience are done within a week.

In sections to come, we will come back to this double diamond model and its stages. In the left upper corner of Figure 3, the double diamond model can be found.

3.2. Circularity in public space redevelopment

The concept of a circular economy has gained momentum, as Kirchherr et al. [8] aptly put it when analysing 114 definitions to create transparency in understanding this concept. They concluded that a circular economy within their iteratively developed coding framework can be defined as *"an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes"* [8, p. 229]. The butterfly-shaped model for a circular economy of the Ellen MacArthur Foundation is world-famous [9]. The model provides us with two circular loops, namely for biological and technical materials. When it comes to the construction industry, the national Netherlands Transition Agenda Circular Building offers the following translated definition [2]: *circular building means to develop, use and reuse buildings, areas, and infrastructure without unnecessary depleting natural sources, without wasting the environment and without affecting ecosystems. It is a way of building that can be justified economically and that contributes to human and animal welfare. Here and there, at present and for the future.* In exploring how to manage public space Duivenvoorden et al. [10] explain the importance of public spaces in the functioning and quality of life of cities and regions. These spaces need to be the embodiment of sustainable development goals and need to become an integral part of the circular economy. *"…windows of opportunity arise since many public infrastructures are at the end of their lifecycle and about to be replaced."* [10, p. 1]. Hence, materials needed by and available in public space do need our urgent attention, when redeveloping our urban areas.

3.3. Construction processes

Cooper et al. [11] describe four main phases of a traditional construction process. The client's need for a construction project solution is defined in the pre-project phase. In the same phase, the outline for a financial authority is secured to proceed to the pre-construction phase. In this pre-construction phase client's needs are translated into an appropriate design solution, and when the aim of full financial authority is achieved the design can be fully executed during the following construction phase. After

completing the construction phase, the constructed system will be monitored and maintained during the post-construction phase [11]. When the execution of a project has started, changes in the design can result in significantly higher costs, than when these changes had been taken in an early stage of the design process. This last principle seems to be relevant to traditional, as well as circular construction processes; as Gerding et al. [12] put it "*early decision making appears to be a key determining factor in the success of a circular building project*". In their research on how circularity was implemented in three Dutch construction processes, they especially paid attention to which actors should be involved in the design-making process to ensure the circular use of materials and products, which brings us to the next section.

3.4. Stakeholders and actors

Stakeholders are involved in one or more phases of a building project. Typical stakeholders in a construction process are clients, users, investors, sponsors, financiers, client's employees, customers, tenants, client's suppliers, designers, consulting engineers, contractors, material suppliers, citizens, landowners, interest groups, archaeologists, businesses, utility companies, emergency services, government, maintenance staff, demolition companies, salespeople, and experts [13;14]. Stakeholders cannot always exert influence on the outcome of a project by means of its design or execution. In line with the description of Entrop [15], actors are the internal stakeholders that can directly exert influence on the decision-making, or even take decisions, regarding the adoption and implementation of circular measures.

In a circular project, it is, according to [12], greatly beneficial to have involved conventional actors who have acquired knowledge of circularity, and expert actors in the roles of advisor, consultant and assessor. Based on their case study and their knowledge of the construction industry, Gerding et al. [12] think it could also benefit the circular ambitions of a project to have actors on board, such as circularity experts, dismantlers, investors, and reclamation experts. The centrally positioned actors in the network of a construction project can accelerate the implementation of circularity by exploiting their position to acquire support from others and mobilize the entire network of stakeholders linked to a building project [12].

Having studied demolition practices, Van den Berg et al. [16] also mention multiple actors, when they present three relevant conditions in promoting element recovery by demolition contractors. They distinguish actors in the supply chain, namely: manufacturers, designers/architects, builders, building owners, and demolition contractors. These actors can help to improve the likeliness that a demolition contractor can identify economic demands, distinguish disassembly routines, and can control future performance [16].

Enabling us to come to the highest levels of circularity, our literature study shows that it is utterly important to align the actors involved in public space redevelopment in the earliest stages of the design process. At these stages, quantities and qualities of materials already need to be communicated to make sure material loops can be closed with the help of stakeholders involved in other projects that offer or need materials. Since a co-creation process by service design focuses on the process of designing, rather than on its outcome, this could be a valuable approach in reaching the alignment of the actors. In the coming sections, we dive into the situation of a particular road renovation project in the municipality of Apeldoorn.

4. **Entering the field of practice**

Slightly to the east of the centre of the Netherlands, the municipality of Apeldoorn is located. Its population is estimated to be over 165,000 souls. Considering this number of residents and with a surface of approximately 341 km^2, it is by Dutch standards a relatively large municipality. A board of one mayor and four aldermen executes the policy guidelines set by the local council, which holds 39 seats.

Within the municipal organization a board of directors, consisting of one municipal secretary and four theme managers, manages around 1,300 civil servants. The four themes to categorize the municipal departments are "concern" (by means of organization), "spatial and economy", "social development",

and “services and operations”. Every department relates to one of these themes. One of the twenty departments, the department focusing on entrepreneurship, is associated with two themes, namely “spatial and economy” and “social development”. When it comes to urban development −that can be considered more or less as a fifth theme, yet not mentioned as such by the municipality herself− five departments are closely working together. These departments are “environmental policy”, “real estate and land”, “spatial planning and realization”, “vital entrepreneurial Apeldoorn” and “projects, programs, and interim-management”. Surprisingly, the “asset management and maintenance” department is not part of this urban development collaboration.

In this particular case, the objective for the process journey to work on was to renovate as circular as possible a paved road named Griffiersveld, as well as the public space directly surrounding this road. Constructed in 1976, it is located in a residential area called De Maten. The budget for the future contractor to team up in the last phase of the design process was set at € 50,000 and for executing the renovation € 500,000 was set aside. Before the renovation, the winding road Griffiersveld (see Figure 1) consisted of concrete pavers and concrete paving slabs covering a surface of approximately 4,785 m^2 (see Figure 2 for an impression).

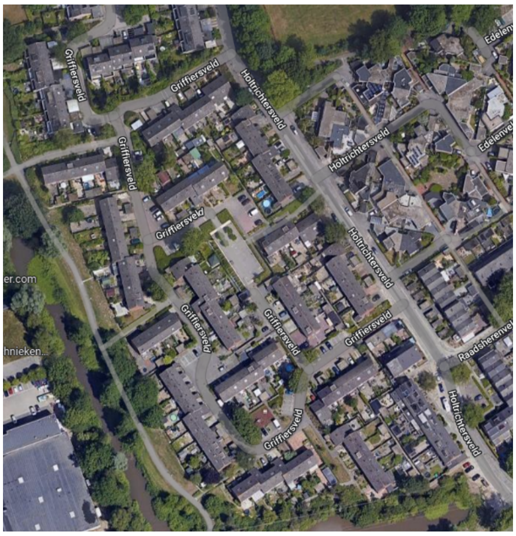

Figure 1. The particular residential area with its winding road Griffiersveld [17].


Figure 2. Impression of the local situation at Griffiersveld in the municipality of Apeldoorn.

Within Apeldoorn’s municipal organization the department “asset management and maintenance” is the main actor responsible for long-term planning. Within this department one generally decides upon what has to happen regarding pavement, green, sewerage, traffic, etc. This department is also responsible for communicating with different stakeholders within the project. For more information on how this particular municipality can be characterized regarding its institutional capacity base in the context of sustainability at an urban level, we like to refer to Ramírez Rincón et al. [18].

5. Results in executing a co-design process

In Table 1 an overview can be found from all departments within the municipal organization of Apeldoorn and external organizations involved in this service design trajectory. These are the main actors who from the kick-off meeting on the 1st of October 2020 were actively involved in setting out their ideas on how to come to a circular road renovation project. For the obvious reason that Koos Service Design and Saxion UAS were not directly exerting influence on the renovation project or its circularity, they are not mentioned in Table 1.

In a final presentation on the 12th of April 2021, all foreseen actions and interactions were laid down in a circular process journey. Other results presented were an inventory of material features for a material

database, a new process scheme for designers of the public space and a circular toolkit for other municipalities to work with. Figure 3 shows the complete service design trajectory, in which these actors were able to express their opinions in multiple settings. These opinions were about foreseen opportunities, but also about challenges and risks. In April and June 2021, the roads were scanned by two different road scanning companies resulting in a proper up-to-date inventory of the materials in place. In the second half of 2022, the road renovation project will be executed by a contractor.

Table 1. Organizations and departments in the process journey for the renovation of Griffiersveld.

Actor	Role(s) of the organization	Role(s) in the project
1. Department "Asset Management & Maintenance"	Responsible for keeping the public space clean, intact, and safe, including outdoor space, car/bicycle parking, forests, estates, and cemeteries.	It oversees the long-term planning and operates as a principal and communicator for civil engineering works (e.g. pavements, green, sewerage, traffic, etc.).
2. Department "Engineering Agency"	Apeldoorn's engineering firm works out the plans provided by the department "asset management and maintenance".	This department works out the specifications, drawings, and plans and finds a contractor for realizing the renovation project.
3. Consulting company	This actor is an international engineering and environmental consulting firm in the fields of environment, infrastructure, urban planning, and water.	This actor provides the asset management software Gemeentelijk Beheer Informatiesysteem (GBI). Apeldoorn uses GBI to store GIS-based data regarding maintenance on and the quality of her roads.
4. Trading platform	This actor offers a digital matching platform for materials to accelerate the transition to a circular economy by showing the financial and ecological value of materials.	In Griffiersveld the actor offers insights into the environmental impact of the materials in place and helps in finding a next (valuable) purpose for them; an advanced online marketplace
5. Data collector A	This road scanning company scans sites, and civil and road constructions by a gamma spectrometer and ground radar to facilitate planning, executing, maintaining, and managing projects.	Data collected in Griffiersveld by this actor assists in assessing the current quality status of Griffiersveld and shows if stored data in GBI complies with the real-life situation.
6. Data collector B	This second road scanning company can scan sites, and civil and road constructions with a high-resolution camera, laser, and ground radar to facilitate planning, executing, maintaining, and managing projects.	Data collected in Griffiersveld by this actor assists in assessing the current quality status of Griffiersveld and shows if stored data in GBI complies with the real-life situation.

5.1. Developing the process journey

The process journey started with a kick-off meeting for the actors to become familiar with each other and to set out the trajectory (step 1: empathize). Within two weeks interviews had taken place with all individuals involved, which resulted in an extensive inventory of what everyone had in mind when it comes to the process journey of renovating Griffiersveld circularly. Questions were asked about the opportunities the process journey can offer, the potential pitfalls one might foresee, and who needs to collaborate. In the answers to these questions the relevance of a ledger for materials, road data, guidelines for procurement & tendering, future maintenance, and proper, yet adaptable or flexible planning was mentioned. Offering the possibility to store data on quantities and qualities of materials and offering insights into maintenance history, a specific instrument was mentioned by the majority of the actors, namely the asset management software already adopted by the municipality of Apeldoorn: Gemeentelijk Beheer Informatiesysteem (GBI). The results of the interviews were used to design the first process journey (step 2: define). This process journey is discussed in an interactive collaborative session in which also the template of the process journey was updated (step 3: problem definition).

5.2. Identifying chances and opportunities

In November 2020 the actors entered the second stage (step 4: ideate) in the service design trajectory. A stage in which chances and opportunities were listed, identified and assessed in a co-creation session. In this session, these chances and opportunities were made specific by positioning actions in the complex

network of actors. During the different stages of the renovation process, this network changes by means of actors, that come and go. The assessment took place using post-its with different colours. Each colour represented a specific thought on how easily the chance or opportunity could be adopted: was it a clear no-brainer or were some high risks foreseen.

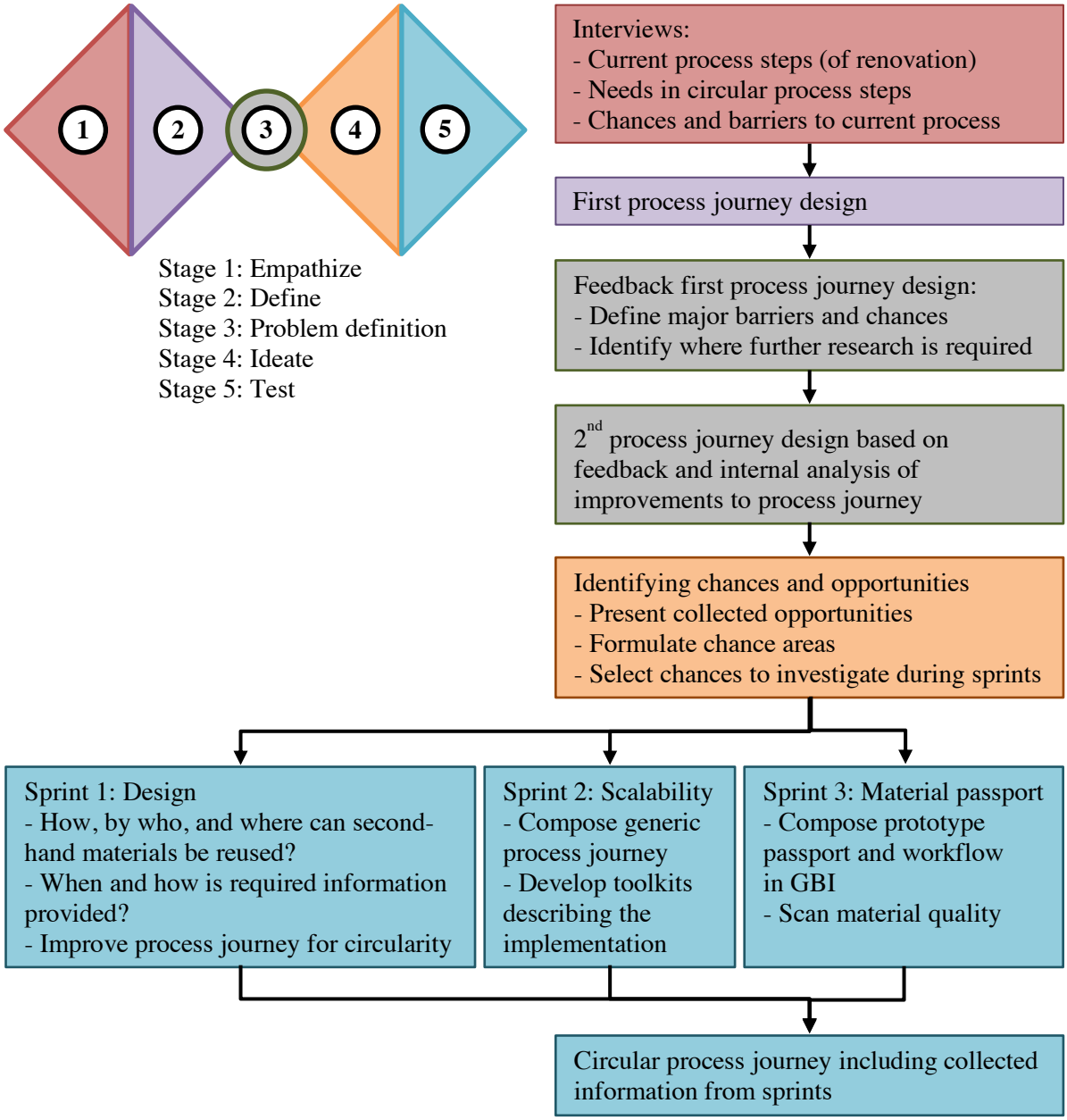

Figure 3. Overview of the complete service design trajectory resulting in a circular process journey.

A specific plan was to scan the roads of Griffiersveld so that qualitative and quantitative data on the used pavement would come available. This data could be used to check and to further complete the data in the asset management software GBI of the Asset Management & Maintenance department. To better prepare for the execution of the renovation project, this data was also made available to the Engineering Agency. Furthermore, the participants in the session already gave thoughts about what data is needed for an online marketplace. This marketplace can offer products coming out of Griffiersveld. However,

potential buyers are more likely to show their interest, when clear information about the volumes and quality of these products is available.

5.3. Sprinting to tooling

In January and February 2021 three so-called 'sprints' took place with each a specific limited number of actors (step 5: test). In these sprints 1) the gains and pains of the design trajectory were a focal point, 2) intervention cards were developed to stimulate the municipal organization to speed up the circular transition process and 3) a set of rules was developed for a material database.

Relative to the first sprint, the civil servants of the municipality of Apeldoorn and a collaborating fellow municipality and the facilitator of the co-design process came to the following insights:

- The design process needs to open up and be constrained less because current requirements oppose restrictions on coming to circularity;
- Little expertise seems to be available within the municipal organization when it comes to sustainability or circularity;
- Little responsibility is felt within the municipal organization when it comes to achieving sustainable or circular objectives in projects;
- It is not easy to find a proper supply of already used products.

The second sprint did result in a few intervention cards. Intervention cards describe a plan for a product or service with a set of specific actions in time resulting in an (as identified by the involved actors in the process journey) achievable opportunity. However, three intervention cards focusing on design for disassembly, an internal marketplace tool, and a marketplace tool for residents stayed far from implementation. A fourth intervention card addresses the possibility to start a material depot. However, within the municipality of Apeldoorn, positively to circularity, actions were already taken to offer this service; one depot for soil and sand was already available, one depot to store building materials came available in January 2021, and plans for a new extra depot already existed.

The third sprint requested a workshop with all actors, as mentioned in Table 1, and a collaborating partner municipality. A set of interventions were discussed to make circularity more tangible. The following interventions were considered:

- To apply automated scanning to collect up-to-date information about the current status of roads;
- To make use of material or project passports, linked to the GBI software already in use, to provide insights into quantities and qualities of materials;
- To make sure the municipality retains ownership of all pavement materials during all phases of road renovation projects;
- To develop an internal marketplace for used products using a physical material depot within the municipality;
- To develop an external marketplace through an online platform open to multiple industries or conventional second-hand material traders.

With the input of these actors, the first draft of a project passport for Griffiersveld came available after this workshop.

6. **Analysis**

As explained in the former section, an intensive co-design trajectory was followed, that took slightly over half a year. It covered a significant part of what can be referred to as the pre-project and pre-construction phases. This trajectory was a pilot project to better close material loops when it comes to road renovation within the municipality of Apeldoorn. Traditionally, a road renovation project is initiated, designed, and executed by different municipal departments with specific interactive moments

to hand information over from one department to another. In Figure 4, the traditional and circular process journeys are presented including the actors involved in each phase.

The circular process journey shows extra interactive elements, which are not included in the traditional process. In line with the experiences of Gerding et al. [12] in their case study research, the pre-construction phase of the sustainable process journey focuses on the reuse and redistribution of materials, bringing the GBI platform in position within the municipality as a project passport, and by mapping and evaluating the current situation within the project itself.

Different from the renovation project of Gerding et al. [12] is the exclusion of the contractor during the pre-construction phase in the circular process journey. In addition, the prevention and reduction of material use, recycling, and energy recovery do not seem to have been included in the process journey. Although, energy recovery for road pavement may not be possible, preventing material use is the most important step in a circular design. The usage of biological renewable materials and recycling, in line with the Ellen MacArthur Foundation [9], are also often applied nowadays, when it comes to renovating roads and their direct surroundings. However, this is also not referred to in the circular process journey.

In the post-construction phase of the renovation project, decisions about repair and maintenance are taken [12], which is also done in both process journeys (traditional and circular). The circular process journey is distinctive here by updating the digital asset management software GBI. Having the data updated can be considered to have an effect on the reuse potential of materials and on defining maintenance plans.

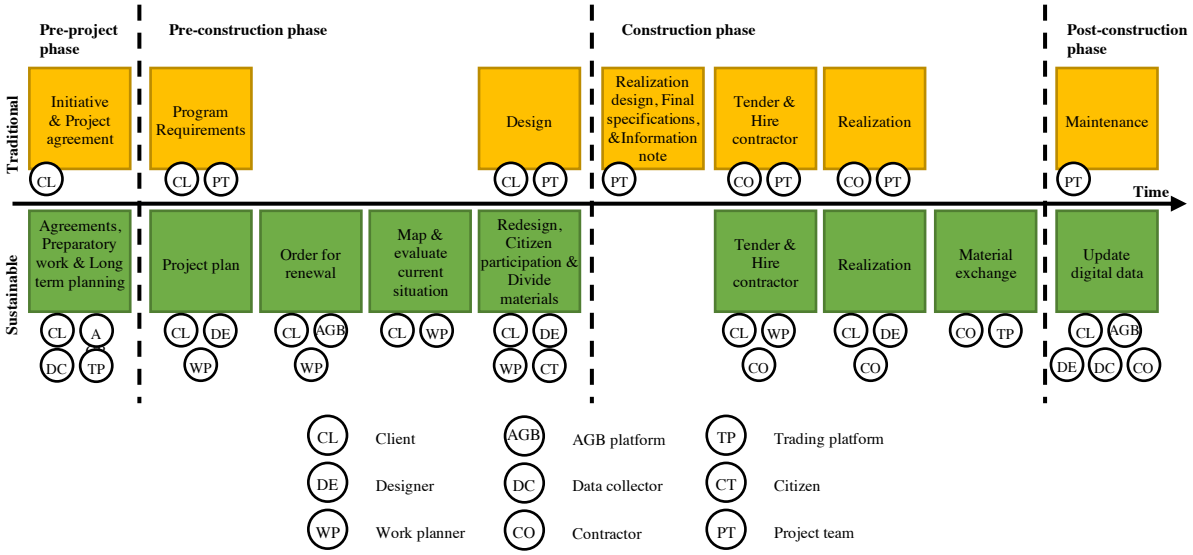

Figure 4. Overview of phases and actors in a traditional and circular process journey at Apeldoorn.

The client, designer, contractor, and citizens of the circular process journey are supplemented with three circular actors. Data collectors A and B act as specialists that collect data to assess road quality. This data is compared with data in the GBI platform of the third actor, the consulting company, enabling the municipality to check if everything is up to date. If it is found that materials can be reused, actor four acts as a reclamation expert by offering an online platform that enables the municipality and future contractors to exchange materials. Based on the inspection data and the derived knowledge that some concrete pavers are still of good quality, the client, designer, and work planner (so not the trading platform) decided on reusing a part of the concrete pavers currently already available at Griffiersveld in the design for the renovated road. The intensified collaboration in the co-design process helped to stimulate these actors to take more circular decisions with the updated information brought in by new actors.

Lastly, it needs to be stated here that the ambition was to invite citizens or at least representatives of Griffiersveld's residents to participate. However, COVID-19 regulations prohibited an open dialogue with residents, and that trajectory was postponed.

7. Conclusion and recommendations

The main research question this project started with was; how to align the actors in public infrastructural projects to come to a circular and, at the same time, executable project? In the experiment, the actors experienced that a co-creation process by service design can help to identify multiple opportunities to collaborate. By bringing in an external process facilitator, the municipality could set up multiple interactive meetings in which select groups of actors in a road renovation project were able to give their thoughts about how materials loops could be closed. To the external organizations, this opportunity normally does not come standard in residential road renovation projects.

The group of actors was able to develop a project passport mentioning quantities and qualities of materials in Griffiersveld. Through road scanning, data was obtained to further expand the knowledge of the municipality regarding the materials in place. The connection between this new data and the data in the asset management software was made. However, the idea of automatically using this bigger data set to supply an online marketplace was not yet utilized. Currently, it seems that a large part of the old concrete pavers, concrete curb stones, and concrete paving slabs will end up in a crusher, which can be considered a loss in value and is therefore not circular.

Residents were not invited to the meetings due to COVID-19 regulations. When closing material loops is an ambition, the absence of one or more potential contractors might even be of greater concern. It is the contractor namely that will be moving around all materials in a road renovation project. However, strict tender protocols might stand here in our way. Although the prevention and reduction of material use and recycling are not included in the circular process journey, the client, designer, and work planner did decide, based on the positive results of the road inspection, to partially reuse the current concrete pavers to create parking places, approximately 495 m^2 of reused concrete pavers, and crosswalks, approximately 65 m^2 of reused concrete pavers. They also decided to crush some remaining concrete to operate as a stormwater infiltration volume beneath these same parking spaces.

However, this induces a large part of the materials still to be virgin for the new road. In addition, by deciding to make use of a new concrete paver with a specific colour throughout, the environmental impact at that point will not even be reduced. A contract between the municipality and the material supplier states that concrete paving products need to consist of secondary aggregates by at least 15 per cent of their volume. However, the same contract encompasses a disclaimer in case pavers need to be coloured throughout.

A co-design process for public space redevelopment tried to incorporate circularity systematically in the pre-project and pre-construction phases of Griffiersveld. It is recommended that the municipality of Apeldoorn opens up her traditional project process to other actors to make sure opportunities to close material loops receive the attention they deserve. The outline of meetings in the experiment can also be used in other municipal projects. However, obtaining all three sub-trajectories or all five stages of the double diamond model in every public space project might be overkill, now that it already was experienced how the asset management software can be used as a material passport. On the other hand, contractors and maybe even waste managers could be provided with a position within those meetings to improve circularity. Furthermore, not all opportunities seen and mentioned in the experiment were put into practice, so this will probably not be the last pilot project in its sort at this municipality.

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