Landscape-oriented transformation of urban streets by considering autonomous vehicles

Yukun Lin and Junhao Li

Independent project • 30 hp
Swedish University of Agricultural Sciences, SLU
Department of Landscape Architecture, Planning and Management
Landscape Architecture Master´s Programme
Alnarp 2024

Landscape-oriented transformation of urban streets by considering autonomous vehicles

Yukun Lin and Junhao Li

Supervisor: Emily Wade, SLU, Department of Landscape Architecture, Planning and Management
Assistant supervisor: Gunilla Lindholm, SLU, Department of Landscape Architecture, Planning and Management
Examiner: Nina Vogel**,** SLU, Department of Landscape Architecture, Planning and Management
Assistant examiner: **Arne Nordius,** SLU, Department of Landscape Architecture, Planning and Management

Credits: 30 hp
Level: A2E
Course title: Independent Project in Landscape Architecture
Course code: EX0852
Programme: Landscape Architecture Master´s Programme
Course coordinating dept: Department of Landscape Architecture, Planning and Management

Place of publication: Alnarp
Year of publication: 2024
Cover picture: Yukun Lin and Junhao Li

Keywords: mobility study; landscape concepts; urban transformation; urban streets; autonomous vehicles; process model; design approaches

Swedish University of Agricultural Sciences
Faculty of Landscape Architecture, Horticulture and Crop Production Science
Department of Landscape Architecture, Planning and Management

Publishing and archiving

Approved students' theses at SLU are published electronically. As a student, you have the copyright to your own work and need to approve the electronic publishing. If you check the box for **YES**, the full text (pdf file) and metadata will be visible and searchable online. If you check the box for **NO**, only the metadata and the abstract will be visible and searchable online. Nevertheless, when the document is uploaded it will still be archived as a digital file.

☒ YES, I/we hereby give permission to publish the present thesis in accordance with the SLU agreement regarding the transfer of the right to publish a work.

☐ NO, I/we do not give permission to publish the present work. The work will still be archived and its metadata and abstract will be visible and searchable.

Abstract

The relevance of streets in the transition towards sustainable mobility cannot be overlooked; however, achieving sustainable urban street transformation remains challenging due to the complexity of existing transport systems and urban development's dependence on the given system. Autonomous vehicles (AVs), as a transformative technological innovation, present a significant opportunity to disrupt the current paradigm. The landscape perspective and its operational methods provide a possibility to formulate revised protocols for the transformation of urban streets. Taking these two views as its entry point, this thesis addresses the question of how to implement sustainable AV street transformation from a landscape perspective. The research employs the concept of three scenarios to systematically categorise and analyse current conceptual designs for AV streets, finding that these designs are insufficient for sustainable transformation. This insufficiency is attributed to their reliance on traditional masterplanning thinking and neglect of public value-based changes, among other factors. Consequently, the study explores the potential of the landscape perspective and its operational methods to address these shortcomings and achieve sustainable AV street transformation. Design approaches for dynamic planning, which can bridge the competing top-down planning and bottom-up design protocols, are interpreted, analysed, and adaptively applied to the context of AV street transformation. The study then outlines design strategies for AV street transformation, focusing on the aspects of who (actors involved), how (organisation of design actions), and when (time-based strategies). An experimental design is conducted in the Lokstallarna area of Malmö, Sweden, guided by the developed design strategies, resulting in a design framework to steer the transformation of AV streets. The findings of this thesis propose a new avenue for the sustainable transformation of AV streets and underscore the significance of design approaches from landscape architecture in shaping future urban streets.

Table of Contents

1. Introduction

1.1 Background

1.1.1 Autonomous vehicles as vehicles for sustainable mobility

Among the objectives aimed at achieving sustainability in the 21st century, sustainable mobility stands out as one of the most formidable challenges. While concerns regarding sustainable mobility have evolved over time, it is universally acknowledged that contemporary discussions encompass a wide range of topics, including but not limited to environmental protection, social concerns, economics, etc. (Banister, 2008; Vogel, 2015; Holden *et al.*, 2019). In the prevailing areas of research in sustainable mobility, autonomous vehicles (hereafter referred to as AVs), which have generated increasing interest among various industries (Taiebat *et al.*, 2018; Holden *et al.*, 2019; Gallo & Marinelli, 2020). AVs refer to vehicles in which essential safety functions are executed without requiring direct intervention from the driver (National Highway Traffic Safety Administration, 2013). The impacts of AVs on sustainability have generally been portrayed as positive, especially when connected to shared mobility and clean energy, including freeing up parking spaces, reducing traffic congestion, benefiting the environment, enhancing safety, and addressing equity and social inclusion issues (Alessandrini *et al.*, 2015; Taiebat *et al.*, 2018; Holden *et al.*, 2019; Narayanan *et al.*, 2020; Litman, 2022).

While there is optimism regarding the potential of AVs to contribute to sustainable mobility, it appears that planning policy has yet to catch up with the pace of technological growth. Rather than focusing on related policies around land use and the environment, current AVs studies focus more on the development of algorithmic systems (Anderson *et al.*, 2016; Riggs *et al.*, 2020). Such a situation challenges the positive effect of AVs on sustainable mobility because the realisation of sustainable mobility not only depends on the technological progress of motorised means of transport but also requires spatial coordination, including the physical shape and conditions of urban structure, a main example being its infrastructure system (Vogel, 2015). Therefore, despite improvements in transport technology, opportunities for designing transportation infrastructure, particularly streets, are still needed.

1.1.2 The worrying critical infrastructure: streets in the era of AVs

The relevance of streets in the transformation towards sustainable mobility cannot be overlooked, since they comprise the most extensive transport cluster infrastructure within the urban built environment. The era of AVs is now knocking on the door. In order to optimise the advantages of AVs and mitigate their drawbacks, it is imperative to undertake research focused on designing streets with AVs in mind (Noyman *et al.*, 2017; Riggs *et al.*, 2020)

When some scenario-based studies have derived projections for urban forms regarding the impacts of AVs (Noyman *et al.*, 2017; Stead & Vaddadi, 2019), some visualised conceptual designs for streets with AVs have emerged (Luo, 2019; National Association of City Transportation Officials, 2019; Lee *et al.*, 2022). The visualised conceptual design approach has the potential to enhance interdisciplinary communication among related fields, connect academic research with the practical construction of future AV streets, and influence both the public and policymakers (Shea, 2012; Lenzholzer *et al.*, 2013). These advantages position such conceptual designs to play a critical role in guiding the transformation of AV streets.

While these visualised conceptual designs are intended to achieve sustainable goals and depict a more sustainable future, it remains necessary to question whether the future they portray can truly encompass sustainability. This is because of these conceptual designs' deep roots in the given system (see more details about scrutinization of visualised conceptual designs in Chapter 2). The given system, established structure, and urban mobility behavioural patterns of contemporary urban development have a tight connection with the "Mobility as Modernity" discourse. This discourse posits that mobility is equivalent to growth. It may lead cities to pursue the efficiency of technological solutions in long-term development rather than the original intention of sustainability (Vogel, 2016), although "green" is usually regarded as part of its goal.

When it comes to spatial planning and design, such efficiency-pursuing logic is performed as a dependence on masterplanning. As the most common protocol guiding urban development since the mid-19th century, masterplanning is ubiquitous and almost invisible in spatial planning (Dahl, 2020). This makes it an integral part of the given system, and almost no urban planning, and certainly no street planning, does not play by its rules. However, even with sustainability as one of the goals, as its opponents claim, "[a] green masterplan is still a master plan" (Jarzombek, 2008:22). The modernist thinking inherent in masterplanning leads to the "greenwash" of urban development. Besides, masterplanning's resistance to openness and incremental changes, inability to recognize existing values and resources, and inadaptation to dynamic social and ecological conditions have also led to overconsumption and unsustainable growth (Dahl, 2020).

Against this background, this study argues that it is necessary to look for an alternative and critical perspective or approach that modifies habits and reframes interests among citizens, stakeholders, and authorities. No matter what the new perspective or approaches will challenge or complement these conceptual designs and the masterplanning thinking behind them, it is aiming to better guide the transformation process of AV streets and ensure that its development can avoid unsustainable path dependence.

The call for a new perspective or approach aims to better guide the transformation process of AV streets and ensure that its development can avoid unsustainable path dependence, whether the result will challenge or critically complement these conceptual designs and the masterplanning thinking behind them.

1.1.3 Transformation towards AV streets from a landscape perspective

In this study, we will investigate street transformation from a landscape perspective and advocate using the theories and models of landscape architecture to deal with AV streets. This is first because the inherent attributes of the landscape architecture discipline determine its advantages in dealing with transformative changes in space and complex systems. Since the discipline's subject matter is biotic—that is, never fixed—these changes occur as a result of constant iterations of becomings or temporalities. (Dahl, 2020). This determines landscape architecture's expertise in fostering non-linear and dynamic processes, which offers distinct advantages for engaging with AV street transformation.

The second reason is the fields that landscape architects focus on in urban development. As American landscape architect Luo (2019), who is committed to the study of AV streets, said, landscape architects should have a voice in the AV street transformation. Because of their concerns about ecology, public space, and the humanities, their participation in the major transformation of AVs will provide unique perspectives that are lacking in the current AVs research.

The third reason is that the operational methods of landscape architecture have the potential to bridge the gap between current AV street conceptual design solutions and ambitious sustainable goals. Design approaches, as the fundamental operational method in landscape architecture, appear to be particularly well suited when tackling complex processes, especially spatial transformation (Diedrich, 2013). These approaches, which draw upon action-oriented site knowledge, are regarded as having the ability to identify the existing resources on site, to resist fixed or limited results, and to work incrementally and across scales (Dahl, 2020), contributing to a more sustainable future. Actually, design approaches have gradually gained attention in the research and practice of street transformation. As scholar William Riggs and his team (2020) have concluded from the "pop-up" design movement in the U.S., street transformation can begin by embracing design actions that take place on site rather than blindly focusing on top-down rewriting of the zoning code and street design manuals.

Taking these three points together, there is reason to believe that considering street transformation through the lens of the landscape may yield fruitful findings that can achieve desirable, sustainable futures.

1.2 Research question

The rapid development of new transportation technologies and the proliferation of on-road trials of AVs are intensifying the fight over the present and future forms of our urban streets, urging a more adequate response. With the premise of taking a landscape perspective on the sustainable transformation of urban streets, the overall question guiding this thesis is:

How to transform urban streets in the meantime between now and AVs' era from the perspective of landscape?

This comprehensive question can be split into four sub-questions explored through literature reviews and the case study in this study. These four questions are:

- **Why** does looking through the lens of landscape offer a new perspective on sustainable AV street development?

  To achieve a deeper understanding of "why", it is necessary to analyse this sub-question from two aspects. One is to explore: what are the features of current AV street-related conceptual designs? What are the direct and deep reasons why they do not adequately support a sustainable transformation or even lead to an unsustainable future? The other is to elaborate on why landscape perspective can provide a critical rethinking and reorientation that transcends the current system and established structure associated with urban street planning, and why the design approaches of landscape architecture can contribute to sustainable AV street transformation.

- **Who** should be involved in the planning process?

  This question aims to identify the actors who can or have the potential to make an impact in the street transformation process. Furthermore, this study explores the roles played by different types of actors in general, their respective interests, their influence on the transformation process, and the connections between them.

- **How** are design approaches of landscape architecture used?

  This sub-question aims to identify practical and strategic design actions that connect masterplanning with on-site design and organise these actions into a structured and transparent workflow. The requirement for both practical and strategic design actions imply the expectation that these actions are not only plausible to apply here and now but also signposting towards a probable future. The concrete workflow aims at increasing transparency and participation levels in the transformation process.

- When to take what actions?

  The objective of this sub-question is to structure the actions and interventions in the transformation process in the time dimension. The study will explore how to determine the appropriate timing and sequence of two competing protocols—a top-down masterplanning and a bottom-up "site-inspired" design—in the transformation process. Furthermore, the question will involve an analysis of how to navigate interventions across different time frames. Additionally, it is also significant to figure out how to make all actors aware of time, or, in other words, capable of positioning the process of transformation in the temporal dimension by understanding how the project is going and what's changing on the site.

1.3 Objective

The genesis of this study stems from a curiosity to investigate the disparity between the current AV street conceptual designs and the sustainable mobility goal. This research also aims to analyse the underlying reasons for this gap.

As the research progressed, the initial curiosity evolved into a more ambitious and challenging endeavour, which constitutes the overarching objective of this study. This objective involves proposing adaptable, generative, and evolutionary design strategies and an operational method from an alternative perspective, namely the landscape perspective, to achieve sustainable AV street transformation. The aim is not to formulate a predetermined vision of how streets should appear in the age of AVs, but to promote greater awareness of how process and performance can serve as guiding principles in achieving open-ended results through design actions involving multiple stakeholders. It is supposed to be both pragmatic and strategic. The pragmatic aspect pertains to the feasibility of implementation in the present, while the strategic aspect signposts towards a possible future.

In addition, this study also aims to conduct an experimental design to facilitate the development of an operational method—a design framework—for AV street transformation. Firstly, the purpose is to continuously test the coherence and operability of the design framework by using an experimental design process, and then reflexively promote the revision of the operational method based on the situation encountered in the process. In such an iteration of testing and revising, the operational method will gradually become stable and purposeful. While another purpose is to make the experimental design a communicative means of the design framework's complexity, further explaining it by showing a visualisation of the design process.

Given these objectives, the intended audience for this thesis comprises landscape architects, AVs-related experts, as well as other professionals or stakeholders involved in the city planning process. Additionally, the thesis targets municipalities, their urban planning services, street and mobility authorities, and developers engaged in concrete street transformation projects, who stand to benefit from the insights and recommendations presented in this study.

1.4 Methodology

1.4.1 Research strategy

This paper utilises two research strategies, namely Interpretation and Projective design, as classified by Simon Swaffield and Elen Deming in their framework (2011).

1.4.1.1 Interpretation

As per Simon Swaffield and Elen Deming's description of interpretative research strategy, investigators acknowledge that the meanings of objects, events, words, actions, and images are not always apparent and necessitate an active engagement to comprehend the phenomena encountered. Hence, the conclusions derived through this strategy cannot be considered completely independent of the researcher since the researcher is considered a social actor, and the comprehension of the research material is established through the interaction between the researcher and the material (ibid).

Regarding the epistemological aspect, the research strategy is positioned between subjectivity and objectivity and is characterised as constructive. With respect to the logical aspect, it resides between inductive and deductive logic, termed reflexive logic, as the researcher oscillates between the observed data and theoretical concepts utilised to comprehend the findings (ibid).

1.4.1.2 Projective design

This strategy aims to conduct research through design activities. As described by Simon Swaffield and Elen Deming "Design only becomes an autonomous research strategy when it produces new generalizable knowledge about the world through its purposes, protocols, and outcomes." (ibid:206)

Design activities are predicated upon the use of individual creativity, imagination, and insight, thereby emphasising the researcher's active role in the generation of new knowledge. Consequently, this approach is characterised by a subjective, rather than objective, orientation. Moreover, it adheres to a reflexive logic in which insights arise inductively from the design context and deductively from the critical evaluation of established concepts (ibid).

1.4.1.3 Summary: knowledge outcomes

The two research strategies chosen in this paper, whether subjective or constructive, consider the influences of the researchers as part of the study and believe that such influences are positive. In this way, rather than believing that knowledge is discovered, this paper advocates for the view that knowledge is actively constructed through human effort, and such knowledge must be understood in the context of its generation.

The use of "reflexive logic" for theory generation and testing entails a researcher moving between theoretical propositions and empirical evidence. Both research strategies employed in this thesis are ingrained in this logic. Unlike research that primarily focuses on "what is or isn't," these strategies explore new potential ways of comprehension and understanding, more akin to investigating "what could be." Consequently, the knowledge produced in this thesis is not deterministic but rather offers a framework for thinking, encourages discussion, and sets the stage for future research.

1.4.2 Research design

This study utilises the interpretive research strategy to guide a literature study and the projective design strategy for a case study.

In the literature study, relevant knowledge fields are reviewed to establish a theoretical foundation. Based on the theoretical foundation, this study interprets existing literature to show that current AV street conceptual designs are inadequate for sustainable mobility. It also constructs a narrative on why and how a landscape perspective can support sustainable urban street transformations. One core of this literature study is to construct a reasonable explanation to support the idea that the viability of a landscape-oriented AV street transformation towards sustainability is worth exploring and affirming. Another core is to extract valuable design strategies for this paper through a literature study.

As for the case study, iterative research work is conducted. Such work is moving back and forth between forming a design framework for AV street transformation and creating an experimental design for a specific site. The oscillation between the framework and experimental design reflexively supports the development and stability of both: for one thing, an operational method with workflow was built to guide the AV street transformation; for another, the possible process of AV street transformation from a landscape perspective is visually demonstrated.

1.4.3 Research methods

1.4.3.1 Literature study

By using snowballing approaches, this thesis studies relevant research fields such as AVs and urban forms, sustainable mobility, contemporary urban planning, landscape theories, and transformation. Compared to the systematic literature review, this approach is more exploratory and efficient.

An inventory analysis was also conducted in this study. Inventory analysis is a systematic process of collecting, organising, and analysing data related to a particular subject or area of interest. It consists of three techniques, namely collecting, sorting, and grouping. Collecting is about collecting data; sorting is about identifying the characters of the selected data based on specific criteria; and grouping is about aggregating similar or related data into larger groups (Deming & Swaffield, 2011). By borrowing these techniques in analysing the current AV street conceptual designs, the analysis process and results could be more systematic and intuitive.

This thesis applies a method called secondary analysis. It is about reusing the pre-existing qualitative data derived from previous research studies to investigate new or additional research questions (Heaton, 2008). This has the advantage of being more efficient and able to obtain high-quality data with limited resources.

1.4.3.2 Case study

Experimental design is about testing new design ideas, materials, techniques, or interventions in a controlled setting to understand their effects on the landscape. It can lead to innovative solutions for future design by exploring new possibilities and pushing the boundaries of traditional design methods (Steenbergen, 2008).

This study employs such a method to develop a landscape-based design approach for guiding the transformation of AV streets. Drawing on Caroline Dahl's research on design approaches for dynamic planning and combining it with the distinctive features of AV street transformation, a preliminary operational design framework is developed during the experimental design process. Subsequently, a design is executed at a specific site, namely the Lokstallarna area in Malmo, Sweden, to test the coherence and operability of the framework. The process of the design either validate or challenge the framework. If the process brings challenges, it prompts iterative revisions of both the framework and design. Consequently, feedback and new insights generated during the experimental design inform the refinement, supplementation, and enhancement of the original framework. Conversely, the stabilisation and progression of the framework lead to a more complete and purposeful design.

1.5 Road map

This study begins with an introduction that contextualises the overall research and outlines the author's original concerns regarding the focus on AV street under the topic of sustainable mobility. The introduction argues that contemporary planning ideas cannot adequately achieve sustainable mobility; a new perspective is needed, leading to the research question of whether the transformation of AV streets could be more sustainable with the help of a landscape perspective. If so, how would one conduct such a transformation from a landscape perspective? Besides, the strategies and approaches that will be adopted to address these questions are also framed in this introductory section.

In part 1 (Literature Study), the study first reviews relevant theoretical ideas to establish a theoretical basis for the literature study. Building on this foundation, the study analyses three AV-street conceptual designs using the “three scenarios” concept. It argues that these designs, rooted in the established system, cannot fully support sustainable mobility and calls for an alternative perspective. The study thereafter explores the possibility of a landscape perspective to transcend the given system and investigates the potential of design approaches for dynamic planning from this perspective to transform AV streets. Thus, transformation projects related to the design approaches of dynamic planning are studied. Their core principles and challenges are summarised. Based on these findings, the design approaches are adapted to form design strategies for AV street transformation.

In part 2 (Case Study), the study presents two designs. The first is a design framework. Based on the design strategies, this design framework is established as an alternative method to guide the AV street transformation. The second is an experimental design of the AV street transformation in the specific Lokstallarna area of Malmö, Sweden. This experimental design serves as an application of the

framework, demonstrating how these design strategies might work and how the dynamics of the site might affect the planning process.

In part 3 and part 4 (Discussion, Conclusion and Future Outlook), the main research question is answered through the discussion of responses to the sub-questions. The study also discusses the sustainability of the design framework, the reflection on the experimental design, as well as the merits and challenges of the research strategies, and ends with concluding remarks and recommendations for further research.

2. Literature study

2.1 Theoretical foundation

The theories considered as relevant to the questions studied in this paper are presented below, which establish a baseline for available knowledge of the subject studied.

2.1.1 Theoretical lenses: mobility study, landscape perspective, process model for change

2.1.1.1 Mobility study

Sustainable mobility and its challenges

The term "sustainable mobility" first appeared on the international agenda in the EU Green Paper (1992) on the Impact of Transport on the Environment. The Green Paper focuses on the complex relationship between the positive effects of traffic and the negative social and environmental impacts it brings, making it generally recognised that the overall negative effects of traffic will begin to outweigh the overall positive effects in a business-as-usual scenario (Holden *et al.*, 2019). As a result of this agenda, a consensus emerged that we must address the increasingly damaging effects of transport and develop it in a sustainable way.

In the 30 years since the publication of the Green Paper, the concept of sustainable mobility has evolved from a focus on environmental issues to a broader perspective that includes economic and social impact, etc. (Gudmundsson & Höjer, 1996; Lautso & Toivanen, 1999; Black, 2010; Castillo & Pitfield, 2010; Berger *et al.*, 2014). Policies and initiatives that promote sustainable mobility are also being implemented by governments, corporations, and organisations in several countries (Hildermeier & Villareal, 2014; Holden *et al.*, 2019). Meanwhile, the related literature also shows a new trend: researchers from different disciplines are applying various perspectives to this concept. There has been extensive academic research on sustainable mobility, focusing on various aspects such as policy and governance (Banister, 2008), infrastructure and technology (Berger *et al.*, 2014; Hickman & Banister, 2014; Lee *et al.*, 2022), behaviour and demand (Julsrud, 2014; Peters & Dütschke, 2014; Puhe & Schippl, 2014), urban planning and public space design (Hildermeier & Villareal, 2014; Næss *et al.*, 2014; Vogel, 2016), and so on.

This study looks at sustainable mobility from an urban planning and design perspective; thus, the understanding of sustainable mobility in this thesis is largely based on the definition that Vogel (2015:35) summarised from several studies and researchers in the field of urban planning:

“•Imposing or encouraging land-use development that demands less transportation and less car use to avoid urban sprawl
• Imposing physical and fiscal restrictions on car traffic
• Improving public transport services
• Improving conditions for walking and bicycling
• Control of road and parking capacities
• Ongoing education of planning and political authorities as well as civil society”

This interpretation emphasises the importance of linking sustainable mobility to integrative transport and land-use planning on a municipal level and to changes in residents' travel patterns.

Despite the growing interest in sustainable mobility and the ongoing relevant theoretical research and practice, the challenges remain formidable. Current urban development is closely linked to the discourse of "mobility as modernity" (ibid). The dilemma we face is that it is difficult to find a balance between transport practices and ambitious sustainable development goals, as current transport models repeat unsustainable consumption with growth as the main objective. Such reality rejects the alternative schemes that might threaten themselves, but why is this the case?

Based on several studies by different researchers in the field of sustainable mobility, the difficulty of fundamentally changing traffic patterns can be attributed to the fact that it faces two challenges, namely the inertia and complexity of the transport system.

The inertia of transportation systems is mainly due to two facts: one is that investment in transportation system technology (vehicles, infrastructure, etc.) is usually long-term. For one thing, the lengthy service life of cars—which requires decades to replace—showcases this long-term character (Holden *et al.*, 2019). For another, the long-term nature is also reflected in the slow change in transport infrastructure. Existing infrastructure is a sunk cost of investment in transportation, so usually it takes a long time for radical changes to occur (Næss & Vogel, 2012).

Secondly, inertia also stems from the fact that non-technical developments are influenced by technical developments. According to Berger *et al.* (2014), The non-technical aspects of transport systems involve the organisational models (e.g., individual car ownership, car and bike sharing, and ticketing schemes), the regulatory framework, the user habits, etc., which usually co-evolve in the long term with the technical aspects (vehicles, infrastructure, etc.). These interconnected dynamics create path dependencies that make it difficult to change the overall direction of development.

In addition to inertia, the complexity of the transport system also presents tough challenges for change. The source of its complexity is that the traffic system is composed of at least three interrelated subsystems, which are respectively the motorised means of transport, the transport infrastructure system, and the energy system (Berger *et al.*, 2014; Holden *et al.*, 2019). This complexity means that linear interventions that push out a single tool for isolated problems are often either ineffective or have negative unintended effects. For example, a municipality's new electric fleet results in an increase in

the number of kilometres driven due to better management of vehicle availability and perceived "cleanliness" (Vogel, 2015); or free bus travel leads to a decrease in bike riding rather than car use (Van Goeverden *et al.*, 2006).

It follows that the fundamental transformation of the transportation system and transportation patterns will require addressing these challenges. Change will be a long-term process and can only be achieved through strong motivation and well-thought-out policies and practices.

Main approaches and three scenarios

We must trigger change, or more precisely, transformation, to address the increasingly damaging influence of transport, which is both very necessary and widely acknowledged. Without major changes in policy and practice, unsustainable transport patterns will persist (Holden *et al.*, 2019). Therefore, it is necessary to review the main approaches to achieving sustainable mobility and to understand how they differ in terms of sustainability.

Berger et al. (2014) distinguish three ways to make transport more sustainable by studying extensive literature on sustainable mobility: travelling more effectively, in diverse ways, and with less frequency. Likewise, Banister (2008) recommends cleaner technologies, a shift to more efficient modes of transport, and a reduction in transport (by reducing travel demand or minimising distance) as three ways to achieve sustainable transport. Peters and Dütschke (2014) , referring to Xenias and Whitmarsh (2013), identified three options: 1) making existing modes of transport more efficient, such as switching to vehicles using alternative fuels; 2) increasing the proportion of more efficient modes of transport, such as public transport; 3) reducing the number of traffic kilometres. In short, they all come up with three key approaches: efficiency, alteration, and reduction.

Vogel (2015) develops three scenarios that are similar to the approaches above but more concrete: technological fix, mobility innovation, and limits to urban growth. These three proposed scenarios are parallel to the three main approaches of the researchers above and draw on the prevalent practices of today, the tendencies that have been seen, and the counterfactual, more radical alternative (ibid:15).

The first scenario's main actors involved are markets and developers (ibid:245). It is characterised by technological advancements and efficiency thinking, which are represented in the continuation of given practices in a business-as-usual condition under the guise of "greenwashing," which is frequently associated with pilot or niche initiatives like sustainable urban districts, alternative fuels, or electric vehicles (ibid:86). In terms of time horizon, it focuses on the short term (ibid:245).

For the second scenario, the main actors involved are individuals and networks. It concentrates on behavioural change, or new lifestyles, and a mobile subject in networked systems, giving mobility management as an option and developing a new smart-management strategy for individuals' own time (ibid:86). It aims to address consumers' mobility patterns, for instance, by limiting parking spaces or using traffic management systems that are backed by ICT (Berger *et al.*, 2014). A Short-Long term focus is the character of this scenario's time horizon (Vogel, 2015:245).

The third scenario involves experts and the public as its main actors, and it includes a thorough rethinking of system structures, normative contexts, and guiding principles in order to reorganise the existing consumption and production patterns and modify the structures we are working inside and upon. This alternative is comprehensive and includes the prior examples of technological advancements and behavioural change, but within a context of demand reduction and sufficiency thinking that recognises and respects the capacity constraints (ibid:108). The more regulated control within this strategy is often through pricing for motorised transport, stringent land use restrictions, or investments in better public transport systems (ibid:86, 94). It is characterised by a long-term focus and aims at ultimately achieving demand reduction and changing values (ibid:245).

All three scenarios provide alternative pathways and are geared towards a sustainable mobility future, but they have different sustainability rationales embedded in them and therefore different societal barriers and potentials for change.

According to Vogel (ibid:95), the prospects in the first scenario, which represents the propensity for technical solution focus and advancements within the given systems, have a short-term effect that is viewed politically and by individuals as advantageous since it initially reduces costs and emissions, for example. However, over time, the efficiency dynamic may lead to increased consumption due to reasons such as "the cars' availability and perceived 'cleanliness'" (Vogel, 2016) and therefore become a hindrance.

The second scenario illustrates a method of mobility management designed for highly adaptive and autonomous mobile individuals. Being an independent, self-sufficient mobility manager seems appealing for modern culture and offers a chance to influence individuals to adjust their behaviours. However, the heavily networked and monitored system that underpins this method has drawbacks as well because it breeds dependence and delegating accountability to the person level while enhancing a mobility ideal that encourages more consumption (Vogel, 2015:95).

The third scenario involves radical alternative views; it supports the formation of new values and seeks to change deeply ingrained societal structures and, accordingly, also alter behavioural patterns. However, such a radical alternative is probably going to encounter political and social rejection since it is likely to involve short-term expenses for long-term rewards, such as posing a danger to individual habits, finances, or artificially generated "needs" (ibid:94, 95).

By systematically analysing the development and comparison of scenarios, Vogel (ibid:10-11) argues that making the mobility system more sustainable necessitates demand reduction, acceptance of capacity limits, and sufficiency thinking because of the inadequacy and potential backlash of technological fixes, as well as the detrimental effects of the unlimited mobility ideal. Put another way, the aspiration of sustainable mobility cannot be achieved by just partial adjustments; otherwise, the primary dynamics would continue. To provide opportunities for new mechanisms that encourage sustainable practices, the system has to be drastically refreshed or reconstructed (ibid:95).

Vogel's argument can also be echoed by Banister's (2008) viewpoints. He claims that the main concerns over fundamental physical issues (urban form and traffic innovation) should be balanced by social elements (demand substitution, distance reduction, and modal shift).

In conclusion, the first two scenarios focus more on improving resource efficiency and less on changing travel modes and behaviours. This still leads to the dominance of cars, perpetuating path dependence and vested interests. Therefore, for the realisation of sustainable mobility, the third scenario is suggested: limits to urban growth. It is a more comprehensive and fundamentally different approach that transcends existing systems, established structures, and behavioural patterns of urban mobility.

Autonomous vehicles

As mentioned earlier, current traffic patterns are difficult to change, and one reason is inertia caused by the sunk costs of technological investment in transport systems. In order to break this inertia, a strong trigger is necessary. Policymakers and industrial players often see technological innovation in transport as a leading solution to sustainable transport (Berger *et al.*, 2014). Due to the strong influence of the public policies formulated by decision-makers on the transformation path, the technological innovation of the means of transport that they attach importance to is seen as an opportunity to reverse the dilemma in this thesis. At present, the technological innovation of sustainable means of transport mainly focuses on three themes: shared mobility, electromobility, and autonomous driving (Holden *et al.*, 2019). Among the three, the curiosity of this study focuses on autonomous driving, but this does not mean that the other two are completely ignored. In fact, the research on AVs shows that the realisation of autonomous driving relies on the data analysis and scheduling capabilities of cloud computing technology (Kumar *et al.*, 2012), which are highly coincident with the technology needed by shared mobility. Therefore, when discussing the positive impact of AVs, they are often tied to shared mobility (Alessandrini *et al.*, 2015; Stead & Vaddadi, 2019) . As for electromobility, electric energy will become the main source of power for AVs in the future (Luo, 2019).

The definition of AVs

Before presenting the definition of AVs, clarification is necessary. Some scholars believe that the terms autonomous vehicles and automated vehicles are worth distinguishing and believe that "autonomous" is a subset of "automated," so the latter concept is more extensive than the former concept (Taiebat *et al.*, 2018). However, for this thesis, these two terms express the same idea and have the same policy implications. Thus, we use them interchangeably.

We chose the term "autonomous vehicles (AVs)" to describe a type of vehicle that is able to determine the right path and manner of driving on the road without drivers by equipping it with special pieces of software (prebuilt maps, global positioning systems, etc.) and many sensors (cameras, radio detection, ranging sensors, etc.) (National Association of City Transportation Officials, 2019). Additionally, AVs have the potential to address issues like traffic accidents, pollution in the environment, traffic congestion, and other problems produced by traditional cars because of their precision, efficiency, and kindness to the environment (Alessandrini *et al.*, 2015; Litman, 2022).

Research on urban forms related to AVs

Even though the impacts of the AVs people envisioned might be promising, the complexity of transformation forced them to think about more systemic change than just product innovation. According to Geels and Schot (2007), the transformation from one type of artificial product to another usually involves the change of its related infrastructure. It is also true for transport and its related infrastructure. Besides, the basic mechanism of how urban structure affects travel has been confirmed in both theoretical and empirical studies (Næss & Vogel, 2012). In the study of sustainable mobility, in addition to the topic of AV technology itself, the changing trend of urban form and transport infrastructure that may be caused by the functional characteristics of AVs has also begun to be discussed.

Urban and regional planning professor Heinrichs (2016) has described three scenarios: "regenerative/intelligent city," "hypermobile city," and "endless city" by considering the form of autonomous driving, urban land use, and driving factors. The "regenerative/intelligent city" scenario includes the formation of intermodal mobility hubs and the reduction of urban parking spaces. The "hypermobile city" scenario involves city centres of high density and the growth of low-density suburbs. The "endless city" scenario includes suburban growth and a general decline in settlement densities.

Urban scientist Noyman, architect Larson, and transformation professor Stibe (2017) presented two extreme conditions: a city only has "privately owned AVs (POAVs)" and a city only has "shared AVs (SAVs)". For the POAVs situation, parking lots will be offered within the city core, highways and road constructions will be increased, the area of sidewalks and bike lanes will shrink, underground constructions and dedicated transit lanes will be decreased, monofunctional land use will become more appealing, and street facades will be less active. For the SAVs situation, the parking lots in the city centre will be removed, road capacity, physical interruptions to street facades, and the need for massive infrastructural projects will be reduced. On the contrary, sidewalks and pedestrian areas will be expanded, while more enjoyable, generous drop-off areas will be required.

In a review based on 13 scenario studies, urban and regional development associate professor Stead and integrated transportation research lab doctoral student Vaddadi (2019) summarised future urban forms into four main types: "Business as Usual (BAU)", "Technology + NonShared (T)", "Technology + Shared (T+)", and "Technology + Shared + Infrastructure/Policy (T++)". In the BAU scenario, urban form featured a similar trend nowadays, such as low-density, fragmented settlement structures. In the T scenario, more transportation infrastructure and parking lots are required because of the introduction of private AVs, resulting in more urban sprawl. In the T+ scenario, parking spaces will decrease dramatically on account of shared use of AVs, there will be more open spaces, and low-density suburban development will grow. In the T++ scenario, street space can be relocated due to the foundation of policy and legislation, the urban environment will be more attractive, and transport infrastructure will be used more efficiently.

From these studies, there is a general consensus that, from a sustainability perspective, AV technology can have a positive or negative impact on how urban structures change: when AVs are linked to shared mobility, it will help urban development closer to the Sustainable Development Goals; on the other hand, when it involves more privatisation, it has unsustainable development characteristics.

When it comes to shared mobility, it is true that the strong data analysis and scheduling capabilities of cloud computing technology can greatly improve the efficiency of shared mobility. However, the underlying principle behind shared mobility is simple: both carpooling/vanpooling and public transit/intermodal mobility are old and established solutions. It suggests that for the transition to a more sustainable society, what is important is to rely on the technological capabilities and driving forces of AVs to further consolidate and significantly increase the market share of environmentally friendly solutions, as well as reduce the market share of polluting and resource-consuming solutions.

Urban streets

Increasing the market share of environmentally friendly solutions at the cost of more severe and resource-intensive ones is a goal that can be integrated into planning policies, strategies, and visions, which can also reflect the Sustainable Development Agenda. But if the goal is not translated into clear, comprehensive, and sensible measures in the context of different situations, it will suffer from a chronic misalignment with practice (Vogel, 2016). To avoid grand goals becoming hollow and vague, it is necessary to connect the story lines of sustainable transport to the practices of everyday life and to develop responses that are context-specific.

In numerous practices, the importance of spatial and infrastructural development at the local level for the transformation of sustainable transport is universally acknowledged. Næss & Vogel (2012) contend that change of urban form, namely spatial practice here, and its inertia and impact on mobility patterns are essential elements for sustainable mobility development, as they can strongly influence the structure and serve as a practice's compass. Berger et al. (2014) echo this statement, arguing that dynamics and interconnections between the transport infrastructure and other transport-related systems create the systematicness and complexity of the transport system, making it challenging to change mobility patterns. Holden et al. (2019) underline the impact of existing transport infrastructure, such as roads, bridges, and airports, on people's travel patterns.

For urban areas of the Organisation for Economic Co-operation and Development (OECD), transport infrastructure consumes 25–40% of the land, and the major element is the street and road system (OECD, 2006:49). Street, as the most extensive transportation infrastructure cluster in the urban built environment, is intimately connected to public life. It will inevitably be included in the theme of urban transformation and sustainable mobility transition, as it is one of the main physical components of structural adjustment and is related to the quality and speed of the transformation process. Therefore, in the grand transformation that might be triggered by AVs, urban streets need a chance.

In fact, history has shown us how city streets change in response to new transport technology, which then reflexively affects traffic patterns. Streets first emerged with the formation of human settlements. People left space between adjacent buildings; within this space, the linear surfaces for people to move and engage with one another became streets in the traditional sense (Moughtin, 1992). Before the 20th century, the urban scale was based on accessibility for pedestrians, as the public took walking as their primary means of movement. At that time, street form grew on the basis of the accumulation of daily activities over generations and was therefore characterised by its human scale (Gehl, 2010), diversity, sense of place and site specificity (Rowe & Koetter, 1984), versatility (traffic, public activities, exchanges, transactions, etc.) (Jacobs, 1993), and harmonious relationship with the environment.

With the increasing maturity of automobile technology after the second industrial revolution, cars were gradually introduced into urban traffic, and urban residents' mode of travel changed from mainly walking to primarily using cars stage by stage (Gehl, 2010). The development of transport technology pushed the starting button for the transformation of urban street form; thereafter, the movement of thought in the fields of architecture and urban planning guided the direction of the transformation. Since the mid-19th century, with the rise of the modernist movement, the traditional model of street formation based on the intergeneration of experience has been gradually replaced by the protocol of master planning. Master planning, in short, is prescriptive change through regulatory planning, communicated in some kind of strategic plan or normative document, and articulated in a long-term vision (Dahl & Diedrich, 2020). Because of its linear process structure, which can determine directional changes from one state to another, masterplanng is favoured by proponents of modern movements intended to make a big difference in urban planning.

In the early 20th century, proponents of modern movements in the fields of architecture and urban planning strongly emphasised the functional need for transport, leading to the phenomenon that the pursuit of speed and efficiency became the main driving force behind the urban street shift (Moughtin, 1992). In order to fully exploit the effectiveness of cars, the proponents believe it is important to design a new form of transport space (Corbusier *et al.*, 1973). Under the direction of this proposition and master planning ideas, car-oriented features such as wide road surfaces and closed fast lanes gradually take over how contemporary street space is distributed, eliminating other characteristics of traditional streets. More and wider car roads, in turn, have become a direct invitation and welcome to promote the purchase and use of cars, resulting in more traffic and demand for more car lanes. Gehl (2010:9) refers to this process of mutual influence between the road and traffic as the "connection between invitation and behaviour", which reflects how urban structures affects travel.

Because of the connection between invitation and behaviour, street chagng is caught in a vicious cycle of "more roads—more traffic". With such change comes a huge increase in energy and material resource consumption, environmental pollution, land occupation, traffic accidents, uneven access to transport services, and other problems that tilt the balance of social and environmental impacts of transport towards the unsustainable side (Berger *et al.*, 2014).

The historical development of urban streets reflects two facts for us: firstly, the new transport technology is the key factor leading to the transformation of street form; secondly, street transformation directions are essentially based on values. There is no “natural” urban process, and people have the power to influence streets’ development, whether in sustainable or unsustainable ways.

Therefore, whether the streets can be truly sustainable depends not only on technological innovation at the product level but also on the way we understand the streets and the way we transform them.

2.1.1.2 Landscape perspective

Challenges of contemporary street planning and design

Many of the current unsustainable problems on urban streets come down to mindsets rather than technology. While the advent of AV technology will certainly reshape our street systems and provide solutions to some problems, it may also bring new dilemmas and challenges. Rather than seeing high technology as the only cure, it is better to look at the root causes of the unsustainability of the street and find ways to rethink the street space while being prepared to take full advantage of AV technology.

The modernist movement influenced the current pattern of the street, making the pursuit of efficiency and growth the priority. Today, even though there are concerns about the planning protocols inherited from the last century, outdated measures are still being implemented because the masterplanning ideas under the influence of modernism have been rooted in the given system and the established structures and have formed path dependence. It makes the current street design process reflect some challenges. Based on various studies and authors in the field of landscape architecture and urban planning (see e.g. Jacobs, 1961; Karsten, 2005; Mossop, 2006; Tatom, 2006; Gehl, 2010), the challenges can be summarised as follows:

- Regarding design objects, the street is perceived as a vacant "space" instead of a "place" where individuals reside. This perception simplifies the dynamic and relational nature of urban streets to a mere representation that emphasises physical and functional aspects while neglecting the tangible and intangible qualities that already exist. Consequently, this poses a risk of overconsumption and unsustainable growth.
- As for the operational method, the top-down approach of "policy-driven" planning, which is grounded in modernist thinking, can easily lead to a blindness to the intricate interdependencies among the dynamic conditions present on the site. This, in turn, increases the likelihood of a "greenwash" occurring during the street development.
- In terms of the time frame, static and linear plans and models are based on a fixed and limited vision that prioritises comprehensive and holistic actions over openness and incremental change. This understanding of spatial evolution may prove challenging to adapt to the ever-evolving contemporary social, economic, ecological, and political conditions.

Under the influence of these three dimensions of master planning, even if the street changes, such changes are still difficult to transcend the established system structure and will even resist possible alternatives, thus falling into a vicious circle of constant replication along the fixed pattern.

The change in urban streets resulting from the continuation of "business as usual" is not the transformation that this study wants to deal with. Instead, this study believes that what is more essential for sustainability are changes in the way streets are transformed. The way urban streets are transformed should call for a different kind of protocol, changing the nature of masterplanning to "integrated, loose-fit frameworks designed as evolutionary, generative systems, possessing adaptive capacities for intelligent differentiation of place” (Bullivant, 2012:276); it should value the resources that already exist, accommodate complex dynamics, and promote more open change, both in mindsets and tangible forms.

Through the lens of landscape

Dutch scholars and practitioners Tom Bergevoet and Maarten van Tuijl (2016:33) claim that “if we want to make our towns and cities more sustainable, we will have to look for a more flexible set of instruments that can make transformation possible.” This is also suitable for the urban streets, which are a key part of a city and are about to undergo important changes.

In this thesis, we call for thinking about street transformation through the lens of landscape and explore the sustainability of AV street changes with the theory and model of landscape architecture. This claim is based on the inherent attributes of the landscape architecture discipline, the field of concern of the landscape architects, and the unique operational methods of this discipline (see 1.1.3). Based on our argument, the work aims at understanding the street as a landscape.

In general, landscape is a concept that is constantly evolving and being discussed. In this study, we base our inquiry on the understandings that have emerged from contemporary landscape theory and practice.

The European Landscape Convention constitutes a noteworthy advancement in defining the term "landscape" as "an area perceived by people, whose character results from the natural and/or human factors' action and interaction" (Council of Europe, 2000). This definition emphasises the significance of human influence as a constituent element of the landscape, expanding the conventional perception of landscape as a mere scenic or territorial feature. Additionally, the concept stresses the comprehension of landscape as an everyday practice and living environment of which humans are integral parts (Lindholm, 2012). Grounded in this definition, we believe that people's perception of landscape is the decisive factor that makes it go beyond merely being "area" or "space" and gives a recognisable meaning to landscape features.

Scholars have also described landscape as a medium. Charles Waldheim (2006b:39) claims that “landscape is a medium [...] uniquely capable of responding to temporal change, transformation, adaptation, and succession”, through which the contemporary city characterised by horizontal expansivity and rapid change could be apprehended and constructed (Waldheim, 2006a). Similarly,

Gunilla Lindholm (2012) suggests that the use of landscape as a medium makes it possible to retain a variety of flows and stabilities, creatures and their environs, natural and cultural processes, ideas, aspects, potentials, and expectations together as a whole, whether orally or in writing. In summary, the concept of landscape as a medium describes landscape as something that transcends physical space and forms an organic entirety that incorporates interrelated natural and human elements and the dynamic processes that shape and change them. Such a concept can facilitate the handling of complexity by taking into account the connection, interweaving, or conflict of tangible and intangible elements in the spatial dimension, as well as the emergence, progression, and replacement of elements in the temporal dimension.

In the words of James Corner (1999:4), "landscape as noun (as object or scene) is quieted in order to emphasise landscape as verb, as process or activity". James Corner believes that landscape is not only a product of culture but also, and particularly, an agent producing and enriching this culture. He suggests that we focus on the formative consequences of created landscapes through time, how they function, and what they accomplish, rather than the formal aspects of the landscape and its straightforward appearance. Perceiving landscape as design actions instead of sheer scenes, says Lisa Diedrich (2013:31), one can understand the continual transformative process it entails. Thus, the perspective of landscape, from which we approach initiatives involving street transformation, may be perceived as action- and design-oriented.

In conclusion, a landscape perspective on street transformation encourages us to consider streets as environments interacting with people, as medium involving and addressing complex dynamics, and as design actions and transformative processes. The view of the street as a landscape has features that show promise for breaking the conventional mindset of street design under the masterplanning protocol (see Challenges of contemporary street planning and design in 2.1.1.2). Its features are as follows:

- The presence of human beings is an integral part of the street landscape. It is through human cognition that the resources, values, atmosphere, and memory of the current street can be identified. Moreover, human activities play a crucial role in shaping and changing the street environment.
- The dynamics and complexity of contemporary urban streets deserve to be highlighted. A street needs to be seen as an organic whole, and in the process of transforming it, all of its elements—both material and immaterial—should be integrated and coordinated, taking into account their interactions and changes over time.
- In the temporal dimension, it is imperative to focus on the non-linear protocol of space evolution. Street transformation needs to start here and now, tentatively advancing in the direction of a sustainable future through transformative processes with various emergencies taking place.

The next question is: Is it possible for the operational method of the landscape architecture discipline to be leveraged to bridge the gaps between the contemporary street planning practices and sustainability ambitions?

Design approaches, as the fundamental operational method in landscape architecture, appear to be particularly well suited when tackling complex processes, especially spatial transformation (Diedrich, 2013; Braae, 2015). When placed in the context of transformation, the understanding of design is crystallised into an idea that is about transforming something already existing instead of creating something new from scratch. Grounded in this understanding, the design-oriented operational mode provides the capabilities to recognise, assess, and edit the existing values and resources collectively, to intervene in constantly changing dynamics across scales, and to drive transformation by accumulating changes through a series of iterative and incremental design actions in the meantime between now and a more sustainable future, rather than merely static before and after illustrations (Diedrich, 2013; Dahl, 2016; Diedrich & Dahl, 2016; Dahl, 2020).

It needs to be clarified that the word design here in design approaches does not refer to a stage in the linear process limited to 1/ planning, 2/ design, 3/ implementation, 4/ management, but the practice and action throughout the whole process (Dahl & Diedrich, 2020). It necessitates that project participants evaluate dynamics in specific circumstances and locations, as well as engage in a range of behaviours that lead to change. These activities may involve planning, design, implementation, and management, but they take place in a variety of sequences, speeds, and durations, and they may occur concurrently.

Design has the potential to integrate and balance policy-born strategic master planning and site-born incremental actions (Braae, 2015; Diedrich & Dahl, 2016). This offers hope for a sustainable transformation of the streets. As a progressive and site-specific process, design-oriented transformation allows for iterative navigation of complexity and varying timeliness, allowing diverse actors to be brought together to form common strategies, and piecemeal changes on site could be coalesced into a larger process of transformation (Dahl, 2020). According to these capabilities, design approaches have the potential to provide a response to the challenges of masterplanning (Braae, 2015).

2.1.1.3 Process model for change: design approaches for dynamic planning

After a brief overview of the generalizable advantages of landscape-oriented transformation, this section will move on to the process models for change, which will involve specific design approaches.

With the progress of landscape architecture, design approaches are constantly explored and developed. New methods and tools continue to emerge. Here we will introduce the research work of Caroline Dahl and Lisa Dierich, as the design approaches they advocate are considered to have the potential to contribute to the transformation of sustainable AV streets in this study and will be further analysed and discussed later (see 2.3).

The original research topic of Dahl and Dierich (2016) was about the transformative capability of design approaches in the transformation from post-industrial sites to urban sites. In their recent work (2020), they further refined the object of post-industrial site to port area. However, whether they are targeting post-industrial sites or port areas, this paper argues that their results are more adaptable and can inspire a broader transformation of the urban landscape, including the transformation of street space.

Dahl (2020) argues that by enhancing site and time awareness, design approaches can create transformative capabilities that augment, complement, or supplement masterplanning. Dahl and Diedrich's (2020) research work leverages contemporary critiques of masterplan and masterplanning as a springboard to investigate alternative operational modes within the field of landscape architecture, with the ultimate goal of modifying given protocols for the transformation of urban landscapes. These operational modes, or more specifically, design approaches for dynamic planning in the articles, are what our study identifies as having the potential for street transformation. Their work summarised three design approaches, namely iterating, prototyping, and simulating, from three transformation projects of post-industrial ports in Nantes (France), Gothenburg (Sweden), and Providence (USA), respectively. All three approaches attempt to link top-down strategic masterplanning with site-born incremental actions in order to recognise and utilise site-specific resources and navigate the complexities and uncertainties of the site (Dahl, 2016; Diedrich & Dahl, 2016; Dahl, 2020; Dahl & Diedrich, 2020).

2.1.2 Summary: choice and utilisation of the theories and concepts

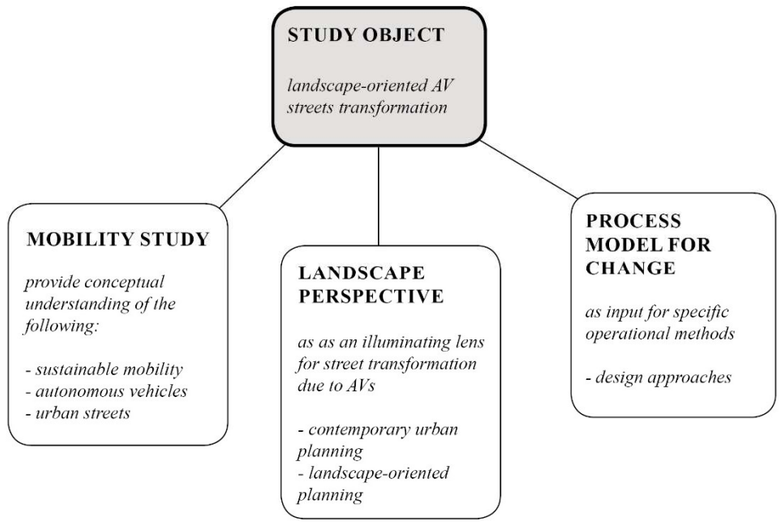


Figure 1: Theoretical junction. (Illustration: Yukun Lin and Junhao Li)

The explanatory theories and concepts from the mobility study serve this study with conceptual understandings of the knowledge related to the main concerns of street transformation due to AVs. Within the main concerns, sustainable mobility is the goal, autonomous vehicles are an important driving force of transformation, and urban streets are the object of transformation. These theories provide the input of concepts of the three scenarios. The concept of three scenarios is utilised as predetermined categories to analyse the sustainability level of existing conceptual AV street design, in addition to serving as a tool for assessing the sustainability of the AV street transformation framework put forward in this study.

The landscape perspective of planning is used as an illuminating lens through which this study examines contemporary urban street planning and design issues. In addition, such perspective and its operation method are introduced as an alternative solution to guide street transformation due to AVs.

Process models for change have served this study as input for specific operational methods. The literature study of design approaches for dynamic planning provides insight into the working mode of linking the masterplanning process with on-site design actions in a spatial transformation. The design approaches are then used as a foundation for adaptation to generate design strategies for street transformation due to AVs, which form the basis of the design framework.

2.2 Studying the sustainable degree of current AV streets conceptual designs

The possible impact of AVs on urban forms has been widely discussed (see 2.1.2.1), and the future of the AV era has gone from illusory to looming. Some institutions and research groups have then begun to explore the urban street forms that would be redesigned due to AVs (National Association of City Transportation Officials, 2019; Riggs *et al.*, 2020). These visual expressions of design thinking and innovation at an early stage are collectively referred to as conceptual design in this study. Such cutting-edge conceptual designs have great potential to influence the opinions of the public, enterprises, and policymakers, as these visual-design-oriented solutions offer narratives that are simple to understand about the potential futures of sustainable mobility systems, therefore owning a natural advantage in interdisciplinary communication and guiding practice (Cross, 2006). This advantage is certainly positive if a conceptual design can contribute to long-term sustainability. But if the conceptual design cannot, its critical function of communication may accelerate speed towards an unfavourable outcome.

This section will conduct a study of current conceptual designs for street transformation due to AVs to determine whether they can effectively support sustainable mobility. With the help of the three scenarios concept and the inventory method, this section will analyse differences in the understanding of sustainability behind these conceptual designs in order to generate insights into the current mainstream situation and opinions in relevant research, as well as their opportunities and obstacles.

The analysis of this section will be theoretically based on the three scenarios created by Nina Vogel (2015), with scenarios presented in ascending order of possibilities for supporting sustainable mobility (see 2.1.1.1). The study will then discuss the current representative conceptual designs in the context of three scenarios. In addition to exploring their adequacy to support sustainable mobility, the concept of three scenarios is also helpful to explore the deep causes of different pathways because the logic of the three scenarios is built on a causal chain (ibid:95).

The exploring procedure in this section borrows from the method inventory (see 1.4.3.1). This method utilises three techniques—collecting, sorting, and grouping—to identify different conceptual designs' mapping to three scenarios. In the process of collecting, three conceptual designs for sustainable AV street transformation were selected after extensive scanning and screening for studies relevant to street form change due to AVs. Secondly, we sort out and analyse the characters of these conceptual designs by answering the questions "who is involved," "how can streets be transformed," and "What is the focus of the time dimension?" The grouping process works with Vogel's three scenarios of paths towards a sustainable mobility future. In this process, each of the conceptual designs is grouped into one of these scenarios according to their characters. Through this collecting, sorting, and grouping procedure, whether these conceptual designs can adequately support sustainable mobility is revealed, and the immanent reasons are also discussed based on the three scenarios.

2.2.1 Collecting: current conceptual designs focusing on AV street transformation

The purpose of collecting is to select qualified cases from things with a certain degree of similar characteristics (in this case, the conceptual design of street transformation due to AVs) for further analysis and regrouping. Here, the screening criteria are: 1) the transformation of AV streets; 2) taking sustainability as a goal or one of its objectives; and 3) taking a visual design proposal as one of the research results. After extensive scanning and several screenings of studies relevant to street form change due to AVs, three conceptual designs were selected.

Of the selected designs, the first is the blueprint for autonomous urbanism created by NACTO (2019). It is proposed based on existing AV-related cases and policy practices in the United States. The blueprint not only discusses sustainable development principles and policy changes but also proposes a systematic strategy for designing cities in the AV era. By comparing the simplified street model of today and the future, this design strategy first discusses the possible changes in street form due to the change in traffic systems (such as shorter travel distances, new ways of getting on and off, etc.) in the AV era. Secondly, the design abstracts the existing American urban streets into a model, classifies them according to functional zoning, and carries out a template design for each type of street, including the changes in the form and proportion of street components (such as sidewalks, bicycle lanes, etc.). The design results are presented in the form of perspectives, before and after transformation elevations. In addition, the plan also discusses the temporary plan for the transition stage and time-based strategies such as using the road edge differently at different times.

The second one is the conceptual design by Sunghee Lee's team (2022). Their design is based on the possible changes of street design elements due to AVs summarised from relevant literature, and the design elements are classified into three categories: road, public space, and new facilities. In response to the change, they proposed a design for AV streets. Specifically, they first conceived an urban design strategy for the coexistence of AV-only areas and conventional areas. Then, based on the conceptual model extracted from Gangnam District in Seoul, they conceptualised a new traffic system for AVs that conforms to the urban design strategy and carried out template design for three different types of design elements in the streets. The result of the design is represented by the before and after transformation perspectives and elevations. In addition, they developed a patchwork urban design concept, an attempt to effectively link AV-only and regular zones and different street types to form a city-wide system. This concept extends the scope of design from the street level to the district level.

The third conceptual design was created by Yadan Luo (2019), a member of the New Mobility and Emerging Technologies Subcommittee. He developed the conceptual design based on the concept of "from transportation infrastructure to green infrastructure" based on his research on driverless experimental reports and policy guidelines. The design presents and visualises two main proposals, including the creation of soft AV lanes and the realisation of the right of way adaptive to real-time demands. The idea behind soft AV lanes is that as autonomous vehicles become more accurate, the fault-tolerant area on the road will decrease, and the debris space that is saved can be converted to green space. Right-of-way adaptive to real-time demand refers to the idea of allocating the right of way in a reasonable manner using a cloud computing system, taking into account the anticipated use of AVs at different times of the day.

Each of these three conceptual designs provides a visual solution for AV street transformation with sustainable mobility as its goal. They share commonalities and differences in sustainability degrees, providing a basis for subsequent analysis. In addition, during the collection process, we also summarised these three visual proposals in a table, which is presented in the appendix 7.1.

2.2.2 Sorting: What is about the conceptual designs?

Sorting aims to analyse the characteristics of the selected items. These characters need to be important enough to be the chief determinants of membership. Based on the previously summarised unsustainable challenges faced by contemporary street design and the inherent characteristics of the three scenarios, the following questions are central to a further understanding and distinction of these conceptual designs of sustainable street transformation:

- Who is involved? Whose perspective are these designs from? Who do they think should be the actors in the process of street transformation? What is their chief motivator?
- How can streets be transformed? What kind of planning and design approach are these based on?
- What is the focus of the time dimension? In what time frame do these studies place the transformation? What kind of change outcomes do they seek? In what way is the temporal dimension expressed?

It is necessary to clarify that the concept of the three scenarios is aimed at a higher level of mobility transformation than street transformation, which is why their properties are not directly used as the criteria for examining the three conceptual designs. As a result, the three questions above act as a link between the three scenarios and conceptual designs: first, they allow for a more in-depth examination

of the features of each conceptual design, and second, they offer a foundation for docking with the attribute characteristics of each scenario in the upcoming grouping procedure.

2.2.2.1 Who is involved?

As for the first question, this study summarises the three conceptual designs in terms of dominant perspective, actors involved in the transformation, and chief motivator (see table 1). Examining the dominant perspective helps to understand the stance and inclination of the design solution and the possible shortcomings, because professionals in different fields will bring knowledge and experience from their field of expertise to discuss the solution. By summarising the actors who have been taken into consideration for the transforming acts, we may get a glimpse of the attitude of "who should have the right to speak in the transformation" in the current AV street conceptual designs. Examining the chief motivators will allow us to talk about the key factors or inner forces that propel the actors to make changes.

According to NACTO (2019), the authors of this conceptual design are experts in transportation and policymaking. Some city departments and government stakeholders are explicitly addressed in this design, and they are asked to actively take responsibility in their respective fields and work together to more efficiently and rationally redistribute street space, as well as build smart networks for AV technology. Private companies related to AV technology are also mentioned, and they have a certain say. However, these companies act more as implementers of plans than as decision-makers. Individuals are also implicitly involved in this design, but it is tacitly accepted that they will take action only at the end of the street planning and design phase on utilising AV streets flexibly with the support of smart networks. Besides, in this design, the chief motivator for the active participation of actors is the innovation of smart networks, but its policy recommendations also slightly reveal the expectation of changing values.

The conceptual design of Sunghee Lee's team (2022) is from the perspective of urban planning and design. Although this proposal does not explicitly mention specific actors, from an implicit perspective, the authors seem to tacitly acknowledge that urban planners are the main actors. It can also be inferred from the article that the individual is considered one of the actors but does not have a voice in the planning stage, only as a street user with options and decisions in the intelligent management strategy for the individual. In this proposal, smart networks are the dominant motivator.

In the third conceptual design, developed by landscape architect Yadan Luo (2019), the landscape architect is explicitly and strongly called upon to play a role in the grand transformation of the street form. In addition, the proposal also mentions the importance of automation engineers, government agencies, and smart-city-related start-ups for AV street design, suggesting including these three in the process of street transformation. The groups listed above are undoubtedly at the core of reshaping the shape of streets and building smart networks. According to its design content, individuals are also vaguely mentioned, but again, they are not associated with street redesign or smart network construction; instead, they are only seen as users of the street. The smart network is the chief motivator, while the discussion of flexible right-of-way also slightly reflects the expectation of value change.

When these three conceptual designs are compared, it becomes clear from the disparate identities of their authors that each of the three schemes has a distinct dominant perspective. This helps to explain why the actors involved appear to differ from one another. However, it is worth noting that they all have a common feature, namely that the actors with high voices not only play a role in the reshaping of the street form but also have an impact on the construction of the AV smart networks. In addition, another common feature is that even if the design involves street users, they are treated as discrete individuals and are not allowed to participate in the early stages of planning to influence specific street designs. For the chief motivator, all three include smart networks, but the first and third designs show a faint expectation of a shift in values.

	Conceptual design by NACTO (2019)	Conceptual design by Lee *et al.* (2022)	Conceptual design by Luo (2019)
Dominant perspective	Mainly transport experts, policy making experts	Urban planner, urban designer	Landscape architects
Actors involved in the transformation	Mayor, city manager, and city council; transportation & public works departments; Transit Authority; Parking Authority; City Planning departments; Sustainability offices; Fleet Service departments; Revenue & Budget Services departments; Private companies; individuals*	City planners & City, designers*, individuals*	Landscape architects, Automation engineers, Government agencies, Smart-city-related start-ups*, individuals
Chief motivator	Smart networks & value-based renewal	Smart networks	Smart networks & value-based renewal

Table 1: Who is involved in the three conceptual designs: * refers to actors who are implicitly mentioned in the proposals as being involved in the design process but who can be inferred from the content.

2.2.2.2 How can streets be transformed?

The answer to the second question is based on the summary of two aspects: one is the planning or design approach, and the other is the highlight of each design proposal (see table 2). The former aims to find out whether the way of doing street transformation has changed, while the latter outlines the design proposals' highlights for further analysis of the deep characteristics of these conceptual designs.

The conceptual design proposed by NACTO (2019) is founded on the policy changes of the AV era, which reflect its policy-driven characteristics. Moreover, the street changes in this proposal are realised by city departments and government stakeholders through top-down regulatory planning. Obviously, the planning and design approach of this scheme belong to master planning. As for the design highlights aspect, it is twofold: the first is developing AV street design guidelines for abstract street models with different functions and at various levels (multiway boulevard, major transit street, downtown street, neighbourhood main street, residential street, minor intersection); the second is envisioning smart management of road curbs, which is called "coding the curb". It hopes that emerging technologies (such as radar and cloud computing systems) will collect data on the use of road curbs and change their usage in real time automatically according to demand, making curbs a flexible area with various functions and for distinct users at different times.

The conceptual design from Sunghee Lee's team (2022) also relies on the thinking of master planning, which is reflected in its strategic planning that pursues fixed results and a top-down "concept-driven" planning process. The proposals for this design mainly focus on two aspects. The first is the creation of a design toolbox for street-level elements. This toolbox illustrates the characteristics of different street elements (road spaces, public spaces, and new facilities) and their corresponding design approaches when considering AVs. The second is the patchwork urban plan. This concept puts the design of AV streets on a larger scale—as a city-wide system integrated into the existing urban environment.

Luo's (2019) proposal also has obvious characteristics of master planning. One is that it also fails to avoid a top-down approach for conventional planning, which is concept-driven and ignores bottom-up site-inspired design. The other is that its future is illustrated in terms of a relatively fixed and linear long-term vision. The highlights of this design are the soft AV lanes and the right-of-way adaptive to real-time demands. The former is at the product level. Based on the accurate driving characteristics of AVs, it transforms all the road spaces except the critical parts used by the wheels into different levels of green spaces, forming a giant green infrastructure network citywide. The latter is at the network level. It involves anticipating and monitoring vehicle flow using cloud computing systems and dynamically assigning the right of way—that is, giving motor vehicles priority during peak hours while releasing the lane for public use for leisure during off-peak hours.

When responding to the question of how AV streets can be transformed, we can see that the approach of masterplanning lingers in the backgrounds of all three conceptual designs. This suggests the fact that while AV street is currently designed to change through innovation, the transformation approach has not fundamentally changed, meaning that the change is still limited to the given system. This view seems to be reinforced by the deep common features of their design highlights. According to the highlights listed above, it is evident that while the three conceptual designs differ, the primary objects of change are related to two categories: the form of infrastructure and the travel mode of individuals that is affected by smart networks. While the former is at the product level and the latter is at the network level, it is apparent that neither reaches a more complete system level.

	Conceptual design by NACTO (2019)	Conceptual design by Lee *et al.* (2022)	Conceptual design by Luo (2019)
Planning or design approach	Masterplanning	Masterplanning	Masterplanning
Highlights of design proposals	Design guide for AV streets with different functions; Coding the curb	Design toolbox for street-level urban design elements; Patchwork urban plan	Soft AVs lanes; Right-of-way adaptive to real-time demands

Table 2: How streets can be transformed in the three conceptual designs.

2.2.2.3 What is the focus of the time dimension?

Through aspects of the time horizon of spatial change, the consequences of change, and the mode of presentation (see figure 3), the third inquiry seeks to explore the three conceptual designs in the temporal dimension. In order to determine the focus and tendencies of the three AV street transformation designs over the course of the time frames, this study will first address the time horizon of the spatial change of streets. Secondly, the changes brought about by these conceptual designs are also discussed to understand the different visions of future sustainable streets. Thirdly, this study also examines the modes of presentation, aiming to explore the openness and flexibility of the time plan through analysing the visual presentations used by the designers.

In terms of the time horizon of spatial change, the conceptual design of NACTO (2019) is considered in this paper with a short-long-term focus. It is because it not only takes into account changes in technology (vehicles, infrastructure, etc.), which is understood as a short-term solution to the immediate challenges of the street, but also achieves smart mobility management through reforming the way traffic is organised (e.g., car sharing, parking strategy, coding the curb, etc.), which can effectively promote sustainable development over a relatively long period of time. But because it fails to move beyond the given system of growth and efficiency and is not able to really change public values, it can't be considered to have a long-term impact. As for the consequences of change, this proposal aims to make the streets safe, efficient, and flexible through smart traffic management. The results of this design are mainly presented through future visions of various types of streets. Besides, visualisations of the street transformation process are also included in the form of conceptual diagrams of today, the interim, and the future, but they are too simplistic.

The conceptual design by Sunghee Lee's team (2022) can also be seen as having a short-long term focus because it not only creates the plan for street-level transportation but also establishes the street organisation model at the urban level when AV lanes coexist with ordinary lanes. This model is crucial for the transition period between now and the AVs era. Moreover, this design engaged with mobility management, which is a key factor in showing relatively deep sustainability concerns and

considerations. The reason it is not considered to have a long-term focus is also because it cannot change the status quo of the city's pursuit of growth at the system level. Thus, the consequences of change are efficient and sustainable street transformation through mobility management, which is visually supported by as-is-to-be models (including perspectives and elevations), as well as future vision plans.

The third conceptual design, by Yadan Luo (2019), includes the smart traffic management network supported by cloud computing technology and attention to the ecological environment, but also does not consider value-based renewal, so it is also judged to have a short-long term focus. The desired result of the changes involved in this design is green and smart streets through mobility management. Before and after elevations, plans, and perspectives, as well as perspectives of future visions, provide visual support for this proposal.

Summarising the three aspects of these conceptual designs under this question, it is easy to find that they appear to have similarities. First of all, all three designs share a short-long focus on the temporal horizon of spatial change. To some extent, the focus demonstrates the depth of their grasp of sustainability; that is, they go beyond the pursuit of achieving significant results in a short period of time, but in the long term, they are unable to challenge the given system and its guiding values. Secondly, regarding the consequences of change, while their ideal streets range slightly, they all view mobility management as a way to achieve these ideals, which illustrates their reliance on smart networks built on technological innovations. Finally, their modes of presentation all include future vision and a group of images similar to the before and after comparison. The former is a fixed and static expectation of the future, while the latter is a linear understanding of time planning. Both suggest the narrow focus of current urban planning on a single future—the pursuit of a "normative" utopian future on the urban model—rather than the overall rethinking of urban planning, which includes consideration of the concept and method of urban transformation.

	Conceptual design by NACTO (2019)	Conceptual design by Lee *et al.* (2022)	Conceptual design by Luo (2019)
Time horizon of spatial change	Short-long term focus	Short-long term focus	Short-long term focus
Consequences of change	Safe, efficient, and flexible streets through mobility management	Efficient and sustainable streets through mobility management	Green and smart streets through mobility management
Way of presentation	future visions，today、Interim、future conceptual diagrams	As-is & to-be models, plans	Future visions

Table 3: What the focus of the time dimension is of the three conceptual designs.

2.2.3 Grouping: Mapping conceptual designs to three scenarios

The purpose of grouping is to put items into predetermined groups based on their characteristics. As mentioned earlier, the three scenarios will be used as such groups. In this case, grouping is about figuring out which of the three scenarios these three conceptual designs belong to. Nina Vogel (2015) analysed and demonstrated the respective attributes of the three scenarios. Here, we sorted the attributes into a checklist with a gradient relationship and gave it a progressive colour to represent the degree of sustainability between them (see Table 4). This table will serve as the criteria for grouping these three conceptual designs. Based on the results of the previous sorting step, we checked the degree of matching between these conceptual designs' features and the attributes in Table 4 and showed them in colour to further discuss the classification of these conceptual designs (see Table 5).

	Technological Fix （T）		Mobility Innovation (M)		Limits to Urban Growth (L)
Main actor involvement	Markets and developers	Between T and M	Individuals and networks	Between M and L	Experts and public
Main driver	Market-based technologies	Between T and M	Smart-networks & innovations	Between M and L	Regulation/value-based renewal
Change approach	Incremental change within given system	Between T and M	Change through innovation (within given system)	Between M and L	Radical change needed through system transgressing measures
Solution approach	Improvement through efficiency	Between T and M	Improvement through flexibility	Between M and L	Improvement through system renewal/change and value change
Main object of change	Technology	Between T and M	Behaviour	Between M and L	System
Scale	At product level	Between T and M	At network level	Between M and L	From systemic to individual level
Time horizon	Short term focus	Between T and M	Short-Long term focus	Between M and L	Long term focus

Consequences for transport	Expansion of infrastructure & electrifying	Between T and M	Smart networks & mobility management	Between M and L	Demand reduction & accessibility through proximity

Table 4: Sustainability attribute checklist adapted from “manoeuver space for scenarios” by Nina Vogel (2015:244).

	Conceptual design by NACTO (2019)	Conceptual design by Lee *et al.* (2022)	Conceptual design by Luo (2019)
Main actor involvement	Network builders and individual network users are dominated; market and developers also have a higher say due to the pursuit of traffic efficiency	Network builders and individual network users are dominated; market and developers also have a higher say due to the pursuit of traffic efficiency	Network builders and individual network users are dominated
Main driver	Smart-network & innovation, slightly involve the value-based change	Smart-network & innovation	Smart - network & innovation, slightly involve the value-based change
Change approach	While considering technological innovation such as mobility smart networks, it does not get rid of the mindset of masterplanning	While considering technological innovation such as mobility smart networks, it does not get rid of the mindset of masterplanning	While considering technological innovation such as mobility smart networks, it does not get rid of the mindset of masterplanning
Solution approach	Proposal “coding the curb” shows its desire to enhance the sustainability of the street through flexibility	“Patchwork urban plan” aims to form an efficient street system; as for “design toolbox for street-level urban design elements”, some parts help with efficiency, some also allow for flexibility.	Proposal “right of way adaptive to real-time demands” shows desires to enhance the sustainability of the street through flexibility, while “soft AV lane” aims at transforming some, space into greeneries, which implies a tendency towards demand reduction

Main object of change	Individual behaviour under the influence of smart network	Individual behaviour under the influence of smart network	Individual behaviour under the influence of smart network
Scale	At the network level: it exceeds the product level that only changes the street form and reaches a highly interconnected network level, but it does not reach a more comprehensive system level	At the network level: it exceeds the product level that only changes the street form and reaches a highly interconnected network level, but it does not reach a more comprehensive system level	At the network level: it exceeds the product level that only changes the street form and reaches a highly interconnected network level, but it does not reach a more comprehensive system level
Time horizon	Short-long term focus	Short-long term focus	Short-long term focus
Consequences for transport	Smart networks & mobility management	Smart networks & mobility management	Smart networks & mobility management

Table 5: Grouping: Mapping conceptual designs to three scenarios.

According to Table 4 and Table 5, it is obvious that although the conceptual design of Lee's team is slightly biassed towards a Technological Fix (T) scenario and the conceptual design of Yadan Luo is slightly biassed towards the Limits to Urban Growth (L) scenario, all three conceptual designs can be roughly mapped to the second scenario, namely Mobility Innovation (M). The similarity in membership of these three representative conceptual designs suggested a trend, that is, in the current assumptions on street transformation by considering AVs, a mindset that regards smart networks based on technological innovation as a solution to achieve sustainable transportation has been promoted.

As described in the three scenarios (see 2.1.1), the scenario of mobility innovation has the potential to bring positive and sustainable change over a period of time but cannot adequately support sustainability in the long run. Admittedly, rather than merely relying on new and more efficient technologies, highly interconnected intelligent networks integrating advanced technologies and capabilities would contribute more to sustainable AV streets. It is because such networks can combine technological innovation (e.g., vehicles, infrastructure) and organisational innovation (e.g., shared mobility, integrated ticketing schemes, intermodal transport) and also provide the necessary support for individuals to use AV streets more flexibly, efficiently, and economically. Smartphone applications, for instance, assist with transport services, reduce transaction costs for users, and offer information and advice to prospective clients on how to schedule their trip and select their mode of transportation (Berger *et al.*, 2014).

However, this scenario has its drawbacks, as it not only breeds reliance on a highly networked and monitored system but also transfers responsibility to the individual level (Vogel, 2015). Firstly, this reliance will become a factor in calling for a mobility ideal that encourages more consumption in the long run, as the mainstream solutions of this approach, including zero-emission vehicles, mobility management, and carpooling, still reflect a general acceptance of car-led mobility decisions rather than a desire to reduce demand (ibid). Besides, in this scenario, the responsibility is shifted to individuals. On the one hand, people with high influence—experts, city departments, and government stakeholders—contribute to sustainable mobility primarily by building intelligent networks. Such a building process, according to what we have learned in the conceptual designs, excludes the individual. On the other hand, the largest users of a smart network are individuals. The smart network provides individuals with information and guidance, letting them have the chance to adjust their travel behaviour, which is key to shaping the direction of sustainable mobility development (Berger *et al.*, 2014). For most people, sustainable transport requires a radical change in the way travel decisions are made. However, years of travel habits naturally make them nervous about the great shifts between modes, so people are not inclined to change their behaviour and then lead to an unsustainable pathway (Banister, 2008). This reflects the shift in responsibility—a more powerful group is hiding behind the scenes but putting the button that decides the future directly into the hands of people who are clearly not ready for it.

In general, the nature of these shortcomings, whether it is the breeding of reliance or the transfer of responsibility, can be summarised as the lack of guidance for the transformation of individual values. In fact, this is also the essential difference between the Mobility Innovation scenario and the Limit to Urban Growth scenario. The renewal of public values represents a more fundamental improvement in the big picture, which serves as the foundation for more radical updates or developments of systems, opening doors for new mechanisms to promote sustainable practices. In the long term, the insufficiency of mobility innovation—the failure to agree at the macro level that 'the demand reduction is most crucial'—will make it easy for transport systems to go to an unlimited mobility ideal in the pursuit of efficiency, which is the opposite way towards sustainability (Vogel, 2015:36).

In conclusion, the three conceptual designs fall under the Mobility Innovation scenario. This means that all three conceptual designs cannot fully support the development of sustainable mobility because they lack the key factor of providing individuals with the means of guidance and supervision to promote value-based change. So how can this essential factor be brought to the topic of street transformation?

According to Banister (2008), the key to achieving a shift in mindset is to create attractive and affordable spaces and places in cities and to engage people in the planning process. In doing so, people can understand the rationale behind policy changes, and thus the attendant behaviour can change. However, in terms of the planning and design process of streetscapes, masterplanning thinking underlies all three conceptual designs, according to the analysis above. It is a stumbling block on the way to creating structural frameworks that provide guidance and regulation to individuals because it excludes people from the process of discussion, decision-making, and implementation. Therefore, in order for the street transformation to truly contribute to the successful implementation of radical change, we need to look beyond masterplanning, which is deeply rooted in the given system, to find a new perspective and approach.

2.3 From the landscape perspective: design strategies for street transformation by considering AVs

Based on the discussion of existing conceptual designs and the deep reasons why they are insufficient for sustainability, we realised that a more sustainable alternative for transformation to AV streets must have a more radical goal, namely, updating the operational modes of mainstream planning.

This goal requires improving the working methods of masterplanning, either by overturning it or critically adjusting it. It aims to form a more flexible and adaptable operational mode that reshapes the roles of citizens, stakeholders, and authorities in the planning arena and the dynamics between them, thereby influencing their mindsets and behaviours.

This study considers landscape architecture to have a transformative ability beyond traditional planning methods because of its inherent attributes, fields of concern, and unique operational methods (see 1.1.3). General advantages for studying street transformation from a landscape perspective and promising design approaches are also briefly presented previously (see 2.1.1.2 and 2.1.1.3). On this basis, we will use existing qualitative research data to further explore the issues concerned by this study—can landscape architecture's operational approach go beyond masterplanning thinking to support the sustainable AV street transformation, and if so, how? The inquiry procedure will follow the method of qualitative secondary analysis (Heaton, 2008). The original data will be the results from Dahl and Diedrich's studies on design approaches for dynamic planning, as well as a few of their references (see e.g. Thurlow Small & Muchi, 2008; Dahl, 2016; Diedrich & Dahl, 2016; Dahl, 2020; Dahl & Diedrich, 2020). We will re-analyse the transformation projects from the original studies and provide an overview of the core principles and challenges of their respective design approaches. Next, it is examined if these design approaches can be used for the sustainable transformation of AV streets and what adjustments need to be made correspondingly. Based on the foregoing findings, the design strategies for the street transformation are finally proposed.

2.3.1 Data with potential: design approaches for dynamic planning

Caroline Dahl and Lisa Diedrich (2020) argued that design approaches—which they refer to as “design approaches for dynamic planning”—have the ability to coordinate the competing protocols of policy-born strategic masterplanning and site-born design actions. In their work, three specific design approaches are identified: iterating, prototyping, and simulating, which are summarised from the urban transformation practices of three post-industrial port areas (ibid). This study believes that the design approaches for dynamic planning are not only beneficial for the transformation of ports or post-

industrial areas but also have the potential to support broader urban transformation practices, including the focus of this study—the sustainable transformation of urban streets by considering AVs.

To better understand design approaches for dynamic planning, it is necessary to interpret and discuss the three post-industrial port transformation practices. This section will interpret these transformation projects from three aspects: who (actors involved), how (organisation of design actions), and when (time-based strategies), while summarising their core principles and challenges.

2.3.1.1 Iterating: Ile de Nantes, Nantes, France

Ile de Nantes is an island located in the city of Nantes, south of France. The western part of the island was abandoned in the early 1990s. Since the beginning of the 2000s, there has been a major urban renovation project transforming it into urban fabric. The team of Alexandre Chemetoff won an architectural competition organised by the developer SAMOA, a local public company. Thus, they have been able to implement a transformation method named *plan-guide*, which they proposed in their winning proposal, on site until 2010. The original research summarised the design actions and activities guided by this method into a design approach called iterating and used field studies as well as literature studies to obtain data about this transformation project (Dahl, 2020).

Various stakeholder groups led by design team

During the 10-year transformation period, the stakeholders involved in the site were diverse, including public developers, private investors, entrepreneurs on site, nonprofits, the public (residents and occasional visitors), and, of course, the design team led by Chemetoff, who acted as a coordinator for all other stakeholders in the site transformation process (Diedrich & Dahl, 2016). This diversity has its roots in the *plan-guide* method, which can identify urban practices and cultures on the site and then encourage the people involved in these practices to become actors and participate in transformation projects. For example, the artist collective Les Machines de l'île was discovered by designers through a site survey. Eventually, the developer SAMOA collaborated with the workshop to introduce what would later become well known as the giant mechanical elephant "walking sculpture" to the site (ibid).

Site survey

In Ile de Nantes projects, transforming actions were initiated within the framework of *plan-guide*. Essentially, this framework is an iterative survey-project tool (Diedrich & Dahl, 2016). It aims to use meticulous quarterly site surveys to identify site quality. Based on these site surveys, different design actions could be initiated, implemented, and then evaluated (Dahl, 2020). The mode of allowing experimentation and evaluation was considered to augment masterplanning, as drafting a master plan based on tested and carried-out change actions enables the plan to be operated in a more resilient and site-specific way (Dahl, 2020; Dahl & Diedrich, 2020).

The specific activities of this method mainly include the identification of site qualities, the implementation of experimentation, evaluation, and decision-making. First of all, the identification of site qualities is achieved by the designer's quarterly survey of the entire territory of the island. The site

qualities identified are various, which are not only limited to the physical materials and structures on the site but also include intangible urban practices and culture (Diedrich & Dahl, 2016; Dahl, 2020). Secondly, the implementation of experimentation is about translating the site qualities into design actions through stakeholder collaboration (Diedrich & Dahl, 2016; Dahl & Diedrich, 2020). Different design actions have different scales, actor constellations, durations, and degrees of refinement, but what they have in common is the emphasis on the reuse of existing resources. For example, on the site, industrial remnants on the ground were retained as a kind of ground material of patchwork pavement (Diedrich & Dahl, 2016). Third, the purpose of evaluation and decision-making is to examine the design action that has been implemented and decide whether it should be abandoned or further developed (Dahl, 2020).

Although activities were known, how the iteration is organised in the whole transformation process has still been a puzzle, as the design team did not communicate a fixed working mode of the *plan-guide* to developers or other stakeholders in the transition process (Dahl & Diedrich, 2020). Because of the lack of transparency, the *plan-guid* gave authorities the impression that there was no overall strategy and it was difficult to predict formal outcomes, which eventually led to the replacement of the *plan-guide* method by the traditional planning method—masterplanning—after the 10-year contract expires.

Iterative process and incremental changes

The *plan-guide* method proposes the thinking mode of a circular time, which is actually the essence of design approach iterating. Recurring site surveys enable an iterative process of design interventions in which new projects will be initiated and initiated projects will be evaluated. If the evaluation result of a project is a consensus on development, the project will then be scaled up and prepared for the next round of evaluation. In the iterative site surveys, the insights gained from each round facilitate the incremental execution of actions and projects on the site (Dahl, 2020).

In terms of time-based strategies, the increments of *plan-guide* fundamentally differ from the phasing of traditional planning methods (ibid). Usually, in projects with a phasing method, after the completion of one separated area's transformation, the transformation of another could be started. However, in the Ile de Nantes project, the transformative design actions were based on site qualities, which could be understood as the selection of a small part considered valuable from the whole of the island and then integrating it back into the whole in the incremental changes. Because of their coexistence in the iterative process, these design actions were eventually aggregated into a collection, so that the entire island was affected by the transformation process (ibid). In such a mode, the design actions in the Ile de Nantes project could "happen with different and overlapping speeds, durations, and permanence" (Dahl & Diedrich, 2020:6). Planning, design, implementation, management, and so on all take place simultaneously in various design actions; therefore, it is inapposite to follow any kind of predetermined, ordered development that specifies exactly what has to be done when and by whom, as is commonly applied to traditional phasing projects.

In summary, the core principles of the Ile de Nantes project can be outlined as follows:

- Diverse participation and collaboration: The process should engage various stakeholders and encourage them to participate in urban transformation processes to provide more creative and sustainable solutions.
- Site quality identification: The site quality identification of the *plan-guide* method makes the design action more targeted. Based on its results, actors can make full use of existing resources and promote the incremental change of the site.
- Iteration and circular time: Adopting a design approach of iteration and circular time helps to flexibly respond to change, allowing the project to transcend the masterplannig, adjust, and improve according to the actual situation.

But the challenges of the Ile de Nantes project should not be overlooked:

- Transparency and communication: The lack of clear communication about how the *plan-guide* approach works led to difficulties in coordination and integration for site stakeholders, affecting the overall effectiveness of this project. Besides, for authorities, opaqueness brought about a sense of uncertainty and uncontrollability, resulting in the eventual replacement of the *plan-guide* approach by traditional planning methods.

2.3.1.2 Prototyping: Frihamnen & Jubileumsparken 0.5 Gothenburg, Sweden

In November 2009, the RiverCity Gothenburg Project, initiated by the City Executive Board, will develop several areas along the Göta River. The Frihamnen area, which is developed by the public developer Älvstranden Utvecklings AB, is one of them. The place-making project Jubileumsparken 0.5, started in 2013 and carried out in the meantime while preparing a top-down development plan, was the first step to developing this area. The aim is to open up the site to the public and test many small projects called prototypes that may be put into the planned park in the future. Due to the independent and parallel development of placemaking and the top-down planning process, the divergence between the two has become increasingly large, which finally led to the stagnation of this project in mid-2016. The original study used the term prototyping to describe the design approach used in this project. In the original research, field studies, a collaboration project, and literature studies were used to obtain relevant project data (Dahl, 2020).

Active stakeholders on both sides

In the project where two protocols were parallel, the stakeholders were active in the two processes separately. For the top-down process driven by masterplanning, a future vision of RiverCity was formulated by the public developer Älvstranden Utvecklings AB and the City Planning Authorities in Gothenburg (Dahl, 2016). For the bottom-up place-making initiative that grew from the site, the change actions were brought in by a group of people consisting of designated mediators within city administration (Dahl, 2020), inhabitants, NGOs, and experts (landscape architects, architects, etc.) (Dahl & Diedrich, 2020).

Building together through prototyping

When the development plan to achieve the RiverCity Vision was still being drafted, an unconventional placemaking project—Jubileumsparken 0.5—started to take root in the Frihamnen area. In this placemaking project, prototyping was employed as an approach to encourage stakeholders interested in the quality of the site, to engage in the building process, and to instigate change actions. Prototypes of the prototyping approach can be understood as small interventions inserted into the site with the intention of acting as test beds for larger projects down the road (Dahl, 2016). Based on prototypes and events, the site and its unique qualities could be investigated and tested before plans are finalised.

Throughout Jubileumsparken 0.5, the mode of operation demonstrates openness to participation. Public workshops, guided site visits, communication through social media, and more were carried out as outreach activities and also to identify site qualities; city inhabitants were invited to take over the place as they wished and engage in collective and in-person construction of prototypes by reusing existing structures and materials from the site (Dahl, 2016). Fostering a deep connection to the site through do-it-yourself initiatives has the potential to unleash planning processes, enable plans to incorporate site-specific details, and then complement masterplans and masterplanning (Dahl, 2020).

Admittedly, the do-it-yourself-driven process of building together had the virtue of inspiring, but in practice, when the top-down planning was running alongside the bottom-up actions, the growing gap between them eventually became a problem. Since the two processes operate independently and somewhat unconnectedly, a twofold "site blindness" was formed. The "site blindness" of facilitators and participants in a placemaking project comes from the neglect of decisions made during the planning process; the "site blindness" of planners who did not work on site roots in the inability to extract site-specific insights from placemaking projects (Dahl, 2016). The "site blindness" eventually results in change actions evolving from site qualities being overlooked and not understood to have value over time, thus discarded in the long-term plan (Dahl, 2020).

Time frames for navigating diverse temporalities

The prototyping approach not only brings to the site physical and institutional changes but also guides design actions across different time frames. In Jubileumsparken 0.5, three distinctive time frames could be distinguished: prototypes were intended to endure 0–5 years, temporary projects were designed to last 5–15 years, and permanent projects, as the name implies, could last in the long term (ibid).

The practice taking place on the site, however, indicates that not all design interventions were confined to a predetermined time frame. In fact, several of the temporary structures were removed from the 'temporary' label and became permanent because they gained national and international recognition and were deemed to be extremely valuable (ibid). This fact reflects the possibility that a design intervention can be transformed in different time frames; these interventions with shorter time frames have the opportunity to be recognised as a site asset and incorporated into the long-term plan by establishing identity over time. However, in order to better operationalize the transition of temporalities for on-site interventions, it is necessary to develop a clear methodology; otherwise, the transition will be slowed down or derailed from its intended trajectory (ibid).

In short, the core principles of the Frihamnen & Jubileumsparken 0.5 project can be summarised as follows:

- Public engagement and social connection: Through an open way of participation, the project successfully engaged the public, prompting them to establish a deep connection with the site through actual participation and the construction of prototypes.
- Prototypes: Actors can assess the viability of larger projects through the implementation of incremental on-site interventions, which also inspire physical and institutional changes.
- Flexibility in time frames: By flexibly planning for different time frames of design actions, including 0–5 years for prototypes and 5–15 years for temporary structures and permanent buildings, the project can be adapted to the actual situation and remain flexible in the transition process.

This project also encountered challenges:

- The coordination problem of dual processes: Because the top-down and bottom-up processes operate independently, a dual "site blindness" is formed. This requires better coordination mechanisms to bridge the gap between the two.
- Complexity of time frames: Relationships and dependencies between different time frames (0–5 years, 5–15 years, and permanent) can be very complex. Without a clear way to structure and operate on these time frames, the direction of the project can become blurred, ultimately slowing the pace of transformation.

2.3.1.3 Simulating: BayCity Providence, Rhode Island, USA

The BayCity Project is located in Providence, Rhode Island, USA, and was designed by two design firms (Thurlow Small Architects and Muchi East). They resisted following masterplanning thinking; instead, they applied a strategy called “planlessness” in order to change the focus of this project from designing a static vision to designing a dynamic transformation process by means of computer simulation(Thurlow Small & Muchi, 2008). However, due to the economic downturn of 2007–08, this plan didn’t become a reality. The original study obtained this project's data through literature studies and interviews (Dahl, 2020).

Three main interest groups and a design team

Three main on-site interest groups were identified: a neighbourhood organisation dedicated to increasing public space for public and recreational use; maritime and public infrastructure industries striving to protect industrial zones that have access to the 40-foot waterway; and the municipality, which is keen to boost the amount of high-density housing in order to raise revenue (Thurlow Small & Muchi, 2008). The design team believes these three forces have the power to shape the future of the Providence waterfront. In addition, the design team itself was an important part of the project.

Parametric computational simulations

The essence of the BayCity project is a speculative design based on computer simulation and parametric design. Benefiting from breakthroughs in computer-aided design, the BayCity project allowed for continually mapping and conveying the conflicting interests of stakeholders on the site by computationally simulating (Dahl, 2020). Rather than having a set vision or plan, it sought to create a process that, when followed, would transform the project's status from concession to opportunity. This was accomplished by expanding public participation, developing a completely new identity, and deepening communication among all stakeholders. (Thurlow Small & Muchi, 2008).

The process entailed activities such as collecting data, modelling, and communicating. As for the first activity, the data refers to the information about actors, events, and products generated on site and their relationships to the site, which was collected by doing fieldwork, holding public hearings, conducting in-depth analyses of different facets, and so forth in conjunction with the City of Providence (Dahl & Diedrich, 2020). The second activity, modelling, can be understood as another form of testing, but it depends on parametric computation-based simulation rather than the actual practices in the field of the first two projects. The use of parametric computation enables the Bay City project to translate the data on relationships collected from the site into a computerised model. In the model, the geometry of the space evolved as a result of intersections with specified ideal situations, and then future scenarios were simulated (Dahl, 2020). As the data on relationships was constantly updated and enriched in the process of collection, proposals generated by computer-aided design processing also evolved dynamically, resulting in a large number of spatial hybrids. In terms of the third activity, communication builds on various proposals generated by modelling as well as a computer-generated visual process framework. The former provides visual support for stakeholders to understand and discuss the simulated future scenario, while the latter communicates the project's organisational approach and overall strategy. These two worked together as a means for negotiating spatial and programmatic proposals (Dahl & Diedrich, 2020). However, the implementation phase is lacking because the project has stalled.

Speculative future

Although the project was not implemented, its planning process based on computer simulation demonstrates the time-based strategies of the project on a theoretical level. The process of parametric computation is seemingly linear because the computation command does not revisit or compute earlier designs, and the "ideal" conditions that form the basis of the set conjecture are never rewritten (Dahl, 2020). But in fact, it is more accurate to understand its time as being circular. The parametric model continues to absorb the data identified at the site. Every time the behaviour that identifies and digitises the on-site relationship happens, it has changed the data in the digital model greatly or slightly from the original basis. Based on the updated data, new design proposals are constantly generated (ibid). In the process of repetition, the simulated solution increases in complexity and detail, becoming increasingly site-specific and adapted to a "real" situation.

Furthermore, due to the deliberate absence of a predetermined final scenario, this project has no static or fixed results. Thus, theoretically, there are a wide range of solutions with respect to both spatial form and temporalities to this project, since the computational procedure has the ability to “freeze” a

particular formal scheme at any given point in time (ibid). This potentially provides an opportunity for urban design to operate in an iterative and open way.

Briefly, the core principles of this project can be summarised as follows:

- Deepening dialogue and consultation: Through ongoing dialogue and consultation, the project attempts to fully understand the potential to meet the needs of stakeholders while engaging a wider range of the public, thereby increasing the project's acceptability and sustainability.
- Computational simulation and parametric design: The project adopts a breakthrough in computer-aided design to continuously convey the conflicting interests among stakeholders through computational simulation and converts data into design schemes with the thinking of parametric design. This approach allows the design to evolve dynamically and gradually adapt to the actual conditions of the site.
- Data-based modelling and communication: The project uses computer-aided design techniques to visualise the process and results of data collection and modelling. This is to support stakeholders in understanding and discussing simulated future scenarios and to communicate the organisation method and overall strategy of the project.

The challenges of this project are vague. Due to the stranding of this project, all the issues that might be exposed in the implementation phase—for example, whether the gap between the simulation and the actual site will affect the suitability of the design—are unknown. Or we could put it this way: simulating the process without field verification is the challenge of the project.

2.3.2 Application to new context: From post-industrial areas to AV street

The design approaches for dynamic planning involved in the original studies provide us with valuable insights and understandings, but they raise new questions about how to effectively apply these insights and understandings to the sustainable transformation of streets. To answer the questions, the similarities and differences between the original research and the target context must be considered, as well as factors that may need to be adjusted. This section explores these key issues before moving on to a summary of the adaptation strategies for street transformation due to AVs.

2.3.2.1 Can design approaches originated in post-industrial projects be used in AV street transformation?

In order to better support the applicability of design approaches for dynamic planning in street transformation projects, it is necessary to clarify the common points and differences between the transformation of post-industrial areas and the transformation of the street. The similarities between the two contexts are mainly reflected in the following three aspects:

Complex stakeholder constellations

As sites located in an existing urban setting, both post-industrial areas and streets naturally relate to a variety of stakeholders and their complex dynamics of interdependence. In the process of sustainable transformation, effective stakeholder engagement is essential. The design approaches in the original research involve techniques such as multi-actor participation planning, the establishment of open communication channels, the organisation of cooperation activities, etc., which can provide references for street transformation.

Site-specific resources

Both transformation efforts target the built environment within cities, and since natural and man-made processes have long interacted, these sites already possess resources specific to their sites. In this context, resources encompass not only physical materials but also the events and practices that are taking place on the site. Prioritising the effective use of already-existing resources is crucial to the spatial transformation process in order to reduce waste and support sustainability. The strategy of recognising, evaluating, and reusing on-site resources involved in the design approaches for dynamic planning is valuable for the street transformation project.

Process over time

To achieve spatial transformation, it is inevitable for both industrial areas and streets to undergo a process of change over a period of time. Establishing a clear time-based strategy for change action can ensure sustainable progress in a changing environment. The design approaches in the original studies, involving the construction of a clear process framework and strategies for navigating different temporalities, can be adapted to the street transformation.

Although there are inspiring similarities between post-industrial port areas and streets in sustainable transformation, in order to drive the successful application of design approaches for dynamic planning from the former to the latter, we also need to learn more about the differences between them.

Differences in morphology

The post-industrial sites typically take the shape of patches with distinct boundaries and separate locations, while the streets stretch out in a linear form and come together to create a coherent network structure in the cities. Due to this morphological variation, the original research's design approaches have to be adjusted to take into account the street's unique morphology in order to ensure the transformed streets are harmonious with other urban structures as well as the overall traffic network.

Differences in function

Due to the development of cities and changes in social needs, the functions of post-industrial sites, which are no longer used for traditional industrial production, have become blurred, and in some cases, they have even been excluded from the functions required by cities. Streets, by contrast, carry a very clear function of accommodating and directing the flow of traffic. This difference conveys a challenge for the migration of the design approaches because, in contrast to post-industrial sites, where planning

can be more flexible with respect to multiple functions, the transformation of the street must balance the needs of other functions with the traffic function.

The intersection of post-industrial and urban streets as starting point

It is important to note that although we discuss the post-industrial site and the urban street as two separate concepts, they are not two urban spaces with no intersections. In fact, there are streets on the post-industrial site, while the urban street network covers the post-industrial site. In view of this fact, it is of value to consider the following inquiry: For citywide street transformation, especially in the case of AVs, what about using streets in post-industrial areas as a starting point?

First, design approaches for dynamic planning, which this study considers promising, originated in post-industrial transformation projects. Although we attempt to adapt these approaches to better apply to all types of street transformations, the transformation may be smoother if it starts at post-industrial sites. In doing so, projects would make better use of the experience accumulated in the post-industrial site of the design approaches as a reference to themselves. Moreover, the post-industrial street projects can serve as a transition to normal urban street transformation, laying the foundation for subsequent methodological adjustments and improvements.

Second, the special position of the post-industrial sites in the city gives it unique potential. Usually, post-industrial sites are located within cities but are excluded from daily use (Sola-Morales, 1995) and only visited on special occasions. This situation presents an opportunity for the development of AV street systems. If post-industrial streets are used as a starting point for the transformation, in the early stages of development, they could provide space for the on-road testing of AVs due to the relatively small amount of human and vehicle traffic on normal days. During the event days, the addition of people and vehicles can simulate a more realistic street environment, allowing AVs to interact with more complex traffic conditions. Later, with the initial construction of an AV street system in the post-industrial area, the project can naturally expand to the surrounding normal streets. From unfrequented areas to communities and then to the city centre, the construction of the AV street system at the city level could be completed gradually.

Using the streets in post-industrial areas as the starting point for street transformation not only helps to advance the project and improve the design method, but also maximises its potential advantages and positively contributes to the sustainable transformation of the city.

In general, this study believes that design approaches for dynamic planning are capable of dealing with other urban structures that are different from post-industrial sites. However, it cannot be denied that the transformation of streets poses challenges to these approaches and calls for adjustments to make them valuable for this study. Therefore, we will turn to a discussion about adjustments to the approaches.

2.3.2.2 What adjustments need to be made?

This study will explore how to adjust design approaches for dynamic planning in two steps. The first is to explore what the street transformation can learn from the post-industrial site transformation based on

their commonalities—more specifically, how to integrate the advantages of the original design approaches and how to deal with their challenges. Secondly, based on the differences between the two contexts, we attempt to discuss how to modify the original design approaches to fit the new context in light of the urban street's features.

For the first step, since the two contexts' similarities—complex stakeholder constellations, site-specific resources, process over time—correspond to the three aspects of the interpretation of the design approaches—who (actors involved), how (organisation of design actions), and when (time-based strategies), it is beneficial to use these three aspects to further analyse and discuss the three original projects. In doing so, we can identify what is worth learning and what needs to be modified, and provide more targeted suggestions and guidance for the adaptive application of the approaches to the transformation of AV streets.

Who: open participation and diverse participants

The three post-industrial transformation projects show a similar feature of the actors involved, namely, the openness of project participation and the diversity of participants. Even with the involvement of city authorities, these projects remained open to engaging with a variety of stakeholders in various ways, including site owners, expert teams, industry interest groups, and ordinary citizens, etc.

Various participants represented different interests and perspectives, but all of them played an important role in the planning, design, and implementation process of the project. They spoke and negotiated for their standpoints, respectively, and collaborated and worked together to promote the project towards the common goal of sustainable transformation. This way of participating is a meaningful reference for AV street transformation, which also involves a variety of stakeholders.

How: integrated approaches to initiating changes

Exploring the characteristics of the three projects in terms of design actions raises a related question about how they can complement each other to form a more comprehensive and effective framework for practice. All three projects shared a common idea of initiating changes: identify site qualities and then take design actions based on those qualities. Although the ideas are similar, the specific measures chosen by the three projects are not identical. In the BayCity project, computer simulations are used for a speculative design (Dahl, 2020; Dahl & Diedrich, 2020). Ile de Nantes operates through recurring experimentation and assessment after quarterly site surveys. The prototyping method based on small-scale intervention was adopted by the project Frihamnen & Jubileumsparken 0.5 Gothenburg. Each of the three projects has its own strengths and weaknesses in design actions, but through cross-learning, each of their weaknesses can be compensated by the strengths of one of the other two solutions.

Speculative design and practical testing: The BayCity project, as a speculative design based on the simulation, demonstrates the advantages of clear process structure as well as continuously generated visual solutions in illustrating the complex planning and decision-making process. However, the simulation results lack on-site testing and verification. This deficiency can be addressed by the practical testing measures adopted in both the Ile de Nantes and Frihanmen projects. Practical testing attempts

to constantly examine and verify the design scheme in practice to ensure the actual feasibility and effectiveness of the scheme.

Recurring testing and a clear process framework: The Ile de Nantes project benefits from iterative site surveys, experiments, and assessments as they enable stakeholders to continuously negotiate their diverse interests and dynamically envisage the future of the site. Nevertheless, as the project has progressed, the lack of transparency has made it challenging for public institutions and clients to comprehend and accept the planning and design process. The BayCity project's coherent process framework appears to provide a decent example of how to get around this weakness. It charted the interaction between various actors and related change actions over time to create a visual process framework for the project's organisation. The framework clarifies which participants are operable in which design action. Its highly structured and transparent process presentation has the potential to improve the comprehensibility and participation of the site survey process.

Small interventions and long-term planning: It is worthy to borrow the prototyping method from the Frihamnen & Jubileumsparken 0.5 project. By introducing small interventions into the Frihamnen, the prototyping method tested the feasibility and various possibilities of the larger projects in a convenient, fast, and frugal way. However, this process ran independently from the long-term top-down masterplanning process, causing "site blindness." As a result, most of the on-site prototypes and their influence were not incorporated into the long-term plan and were ultimately abandoned. The "change as a whole" idea of the Ile de Nantes project might be helpful in reacting to this circumstance. The Ile de Nantes project also had testing interventions on the site, but they were part of an integrated planning process rather than a system operating independently. This implies that each test result could feed into the master plan and have the potential to influence it. The ability to integrate design interventions into the masterplan may help overcome site blindness, ensuring the linkage between actions on the site and the long-term plan and allowing the plan to operate in a more concrete and resilient manner.

The merits of these three projects may be combined to produce an integrated approach that inherits the ability to connect top-down and bottom-up processes while also having flexibility, adaptability, and a clear and coherent process framework. Such an approach may overcome the shortcomings of individual projects, enable a more comprehensive and effective spatial transformation, and better contribute to the sustainable transformation of AV streets.

When: More open and flexible time-based strategies

The questions about time-based strategies invited people to explore how the various design actions of the three projects are organised in the temporal dimension. This further raises the question of how to effectively integrate the time-based strategies from the three projects and make them valuable for the practice of broader spatial transformation.

All three projects rejected the fixed time-based strategy of the masterplanning method, but they operated differently. Ile de Nantes adopted an iterative approach to incrementally improve and adjust the development direction and implementation plan of the project through continuous testing and evaluation

of the design interventions. In the project Frihamnen & Jubileumsparken 0.5, the multiple time frames of the prototyping method provided flexibility for the development of the project, allowing design interventions to be converted across different time frames based on the project's real situation and changing demands. The BayCity project's visual solutions, which evolved with constantly updated site data, provided clearer direction and goals for the project time plan and help actors effectively manage and communicate the progress of the project.

In order to make the approaches from these projects better support the target context, this study believes that it is promising to combine the advantages of the three projects, i.e., to create a time-based strategy that can include flexible time frames in the iterative process and constantly update the visual scheme as the project progresses.

Besides being inspired by the similarities, the differences between the two contexts will also provide clues about how to adapt the design approach from the original study to the urban street transformation.

About form: flexible phased planning due to continuity and integrity of streets

Urban streets cross each other in a linear form to form a network, which determines that there is a high degree of continuity and integrity between a single street and the larger network. It is very different from the patch-like post-industrial site.

Such a difference makes it inappropriate to directly borrow the “change as a whole” (Dahl, 2020) idea in the *plan-guide* method from the original research. Change actions for the whole through increments emphasises that any site survey during the iterative process is for the whole site, based on which various design interventions are proposed, implemented, and evaluated. This way of changing is applicable to post-industrial sites, which are often scattered like islands in the city and have clear boundaries with the surrounding areas. On the contrary, the highly interconnected form of the street makes it difficult to determine what is a "whole"—is it a single street or an intra-district street network?

If a single street is taken as a whole, then its coordination with other streets after the transformation to AV streets may not be as good as before. However, if we consider the street network in an area to be the whole, then it is difficult to implement large-scale construction in the latter stage of development when all small interventions are ready to be transformed into permanent interventions, as a construction for a whole area will inevitably paralyse the traffic in the area. Therefore, in the street transformation, it is difficult to achieve complete change actions for the whole; instead, it is necessary to consider incorporating the features of the phased implementation.

However, different from phasing method, which follows the sequence of planning, design, implementation, and management in traditional masterplaning, what this study wants to explore is a more flexible phased implementation. It can not only introduce small interventions in the overall street network of the area for testing and evaluation but also determine a finalised design scheme and implement it when a certain stretch of the street (which is the whole of itself but also a part of the street network) achieves the desired effect. In such a way, the street network could be transformed, stretch by

stretch. This way preserves the ability to test a design action before confirming it and to navigate different temporalities, while adapting to the characteristics of the street in a stretch-by-stretch implementation manner.

About function：Making the AV route as a special prototype

Unlike post-industrial sites, whose functions are ambiguous and can be considered flexibly, the traffic function undertaken by urban streets requires that streets incorporate the car lanes as a specific element into the design consideration. However, as an important part of public space, streets also have the responsibility to involve other functions besides transportation, such as public activities, exchanges and transactions, and ecological functions. Therefore, adapting the design approaches from the original studies requires considering how to balance the multiple needs of the street, ensuring that other needs are met without compromising its traffic function.

This study believes that integrating the traffic-carrying AV route into the prototyping method as a special prototype and making the AV route serve as the testing bed for future AV lanes has potential. According to the development trend of AVs, the current on-road AVs trial is already in a state that is testing the different routes, which is well suited to the flexible development, evaluation, and modification of the prototyping method. By using the prototyping method, the traffic function of the street can be regarded as a test target for a small intervention. By creating observable, evaluable, and adjustable AV routes, the layout and form of future car lanes can be considered according to the actual operation of the AVs. For another thing, the balance of the vehicle routes and the prototypes with other functions can be tested. In addition, an iterative site survey could be used, so the design scheme can be constantly adjusted and optimised to adapt to the real situation and functional requirements of AV streets according to the results of recurrent implementation and evaluation.

2.3.3 Design strategies for street transformation due to AVs

We have explored in detail the possibility of applying the insights and understanding gained from the original research to the sustainable transformation of streets. The factors that need to be adjusted according to the similarities and differences are also discussed. Now, by using the three aspects of who (actors involved), how (organisation of design actions), and when (time-based strategies) as a framework, this study will propose specific design strategies summarised from the previous discussions.

Who: actors involved

- **Promote diversity of participants:** This means engaging and involving a variety of stakeholders, including local residents, government agencies, companies, and NGOs. Leverage abundant perspectives and resources provided by participants from various backgrounds to promote the comprehensiveness and sustainability of AV street transformation projects.
- **Encourage wide engagement of participants:** Actors should be allowed to participate in various actions of the transformation process, whether it is site investigation or proposing, implementing, and evaluating the design interventions that are introduced to the site, so that they can exert their influence in distinct actions.

How: organisation of design actions

- **Combine speculative design and practical testing:** Construct speculation about future scenarios of site-specific AV streets through speculative design, and then validate the feasibility of the design solution through small intervention-based testing on real sites.
- **Conduct recurring testing within a process framework:** Practical testing should be recurring, including iterative site surveys, workshops to propose new and evaluate previous design interventions, and the implementation of design interventions. In addition, work patterns should be visualised as a clear process framework to map which groups of actors exert influence over which actions.
- **Integrate prototyping into long-term planning:** The prototyping method should be adopted as a specific means of practical testing and integrated into the process of long-term masterplanning. An interactive feedback mechanism should be created between the prototyping process and the planning process: the development of various small interventions during prototyping leads to the adjustment of the masterplan, while the development and temporalities of different prototypes are determined during the planning process. In addition, AV test routes are included in the prototyping process as a special prototype.
- **Adopt flexible phased planning:** This planning approach will make both the testing of the site as a whole and the phased implementation of street sections coexist. It allows small interventions to be tested and evaluated in the street network as a whole, and it also enables the finalised design of a street stretch to be determined and then constructed once it has achieved satisfactory results. In this way, the street network will be transformed, stretch by stretch, in an iterative process.

When: time-based strategies

- **Use an iterative process as the basic framework of the time-based strategy:** Under this strategy, the design actions, i.e., site survey, multi-actor discussion and evaluation, and project implementation, are organised into one round. The result of each round serves as the starting point for the next round. In a series of successive rounds, the project continues to iterate and eventually reach a relatively satisfactory state.

- **Incorporate multiple and flexible time frames:** The iterative process is accompanied by changes, and the flexible time frames could guide changes in the duration and scale of on-site interventions, allowing prototypes to be transformed into temporary projects, permanent projects, or removed.

- **Update the visualisation solution periodically:** As the project evolves, visualisations are periodically updated and improved to help participants better understand the goals and progress of the project, facilitate communication and collaboration, and drive the project moving forward.

3. Case study

3.1 Framework

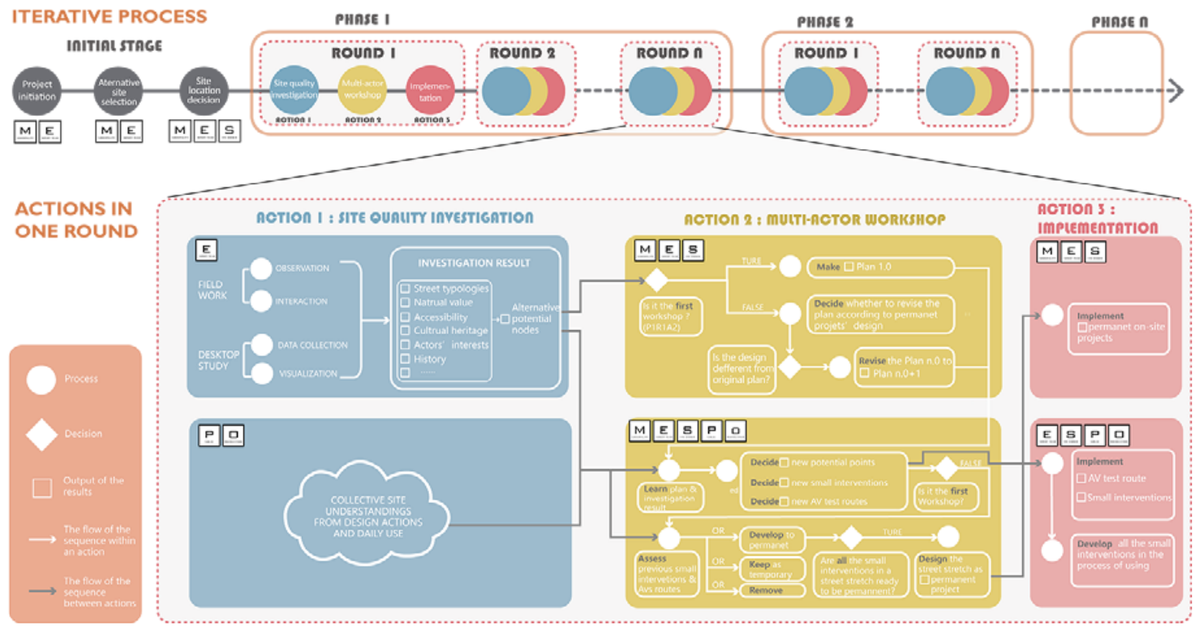
A visual framework of working methods for illustrating how to transform current urban streets into AV streets by applying the design strategies from Chapter 2.3.3. It consists of three parts: who, how, and when.

WHO

Actors who play a key role in the arena of planning

HOW

A workflow chart for the organisation of design actions



WHEN

Conversion process of three time frames

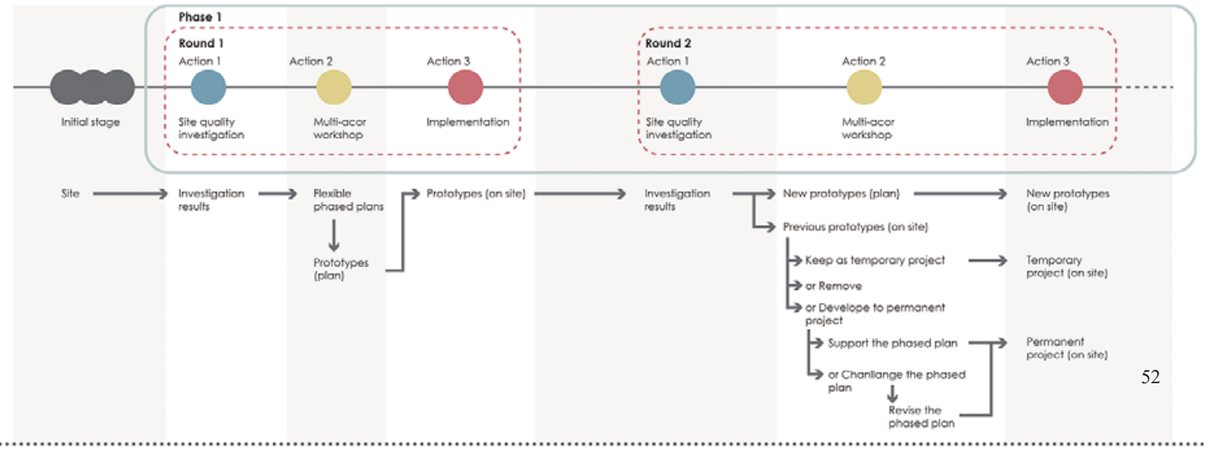


Figure 2: Overview of the design framework. (Illustration: Yukun Lin and Junhao Li)

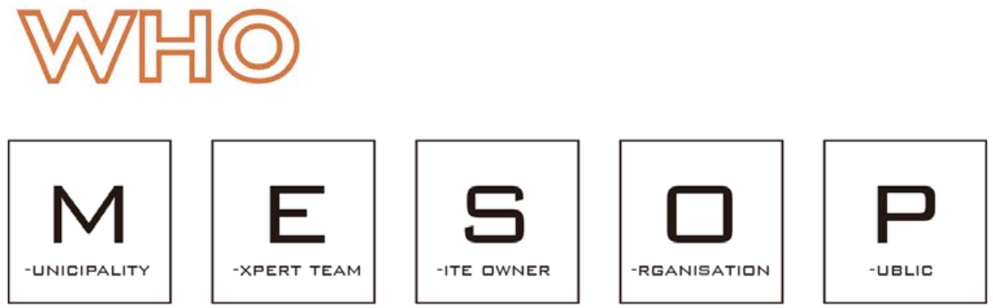


Figure 3: Who: actors play a key role in the arena of planning. (Illustration: Yukun Lin and Junhao Li)

3.1.1 Section I Who

This section presents the actors who should ideally be involved in the AV street transformation project on the site.

In this framework, actors are divided into municipalities, site owners, expert teams, organisations, and the public. It is important to note that this framework does not compile a set of typologies that can be applied to any project because it is almost impossible to do so. The framework is therefore designed to encourage flexible changes in the composition of the typologies of actors in accordance with the actual situation of the project. For instance, when the site is owned by the municipality, the municipality and the site owner can be one typology. In other cases, there may be actors outside of these 5 typologies in the project, and then it is possible to add a new type.

Municipality:

This refers to the urban planning office, the transportation department, or other government departments concerned with the development of city streets in the municipality. It is usually the initiator of city-level AV projects and has a high voice in deciding the start and end of city-level and district-level projects. Their interests are usually based on the perspective of the overall development of the city, focusing on infrastructure, city transportation connections, housing, etc.

Expert team:

A team composed of experts from city planners, landscape architects, architects, traffic planners, engineers, ecologists, etc. They serve as think tanks, executors, and promoters of city- and district-level AV projects. They have a moderate influence on the start and end of city-level and district-level AV projects but have a significant say in the development direction. Their interests include many aspects of city and district development, ranging from overall urban development to urban transportation, ecology, public space, cultural heritage, and so on.

Site owner:

This refers to the owner of the site being developed. It is typically the initiator or facilitator of AV projects at the district level and has a high influence on the start and end of district-level projects. Its interests are based on district or site development, and its main concern is the economic growth of the area or site.

Organisations:

In this instance, it alludes to an organisation that is not affiliated with the government. It can be either a commercial organisation for profit (such as a firm, a studio, or a cafe) or a non-profit organisation for the public good (such as an NGO). They are often promoters of AV projects at the district level, as well as the target population of the site. They have only minor influence over the development direction of the district-level project but considerable discretion over how the site is used. Their interests are based on site growth and the development of their own organisations, mainly focusing on attracting more target groups for their organisations, carrying out on-site activities, establishing organisational culture and site culture, etc.

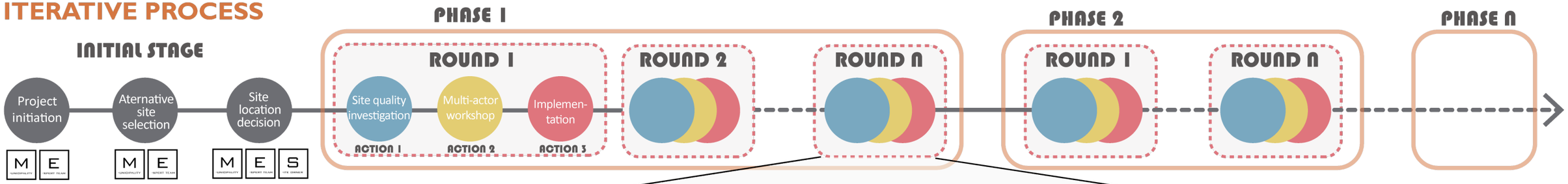
The public:

This refers to any ordinary person who is involved in the site's planning but is not a member of the municipality or any organization. They are the promoters and target population for district-level projects. Their influence is moderate over both the direction of district-level projects and the use of the site (they have a harder time starting large-scale activities than organisations.), therefore becoming the voices most likely to be ignored in planning. Their interests are mainly based on their own on-site experiences, including the need for a more livable environment, greater accessibility, and a variety of activities.

All actors will take action at some point in the development of the site to maximise the inclusion of the voices of each group in the planning and design of the AV streets.

HOW

ITERATIVE PROCESS



ACTIONS IN ONE ROUND

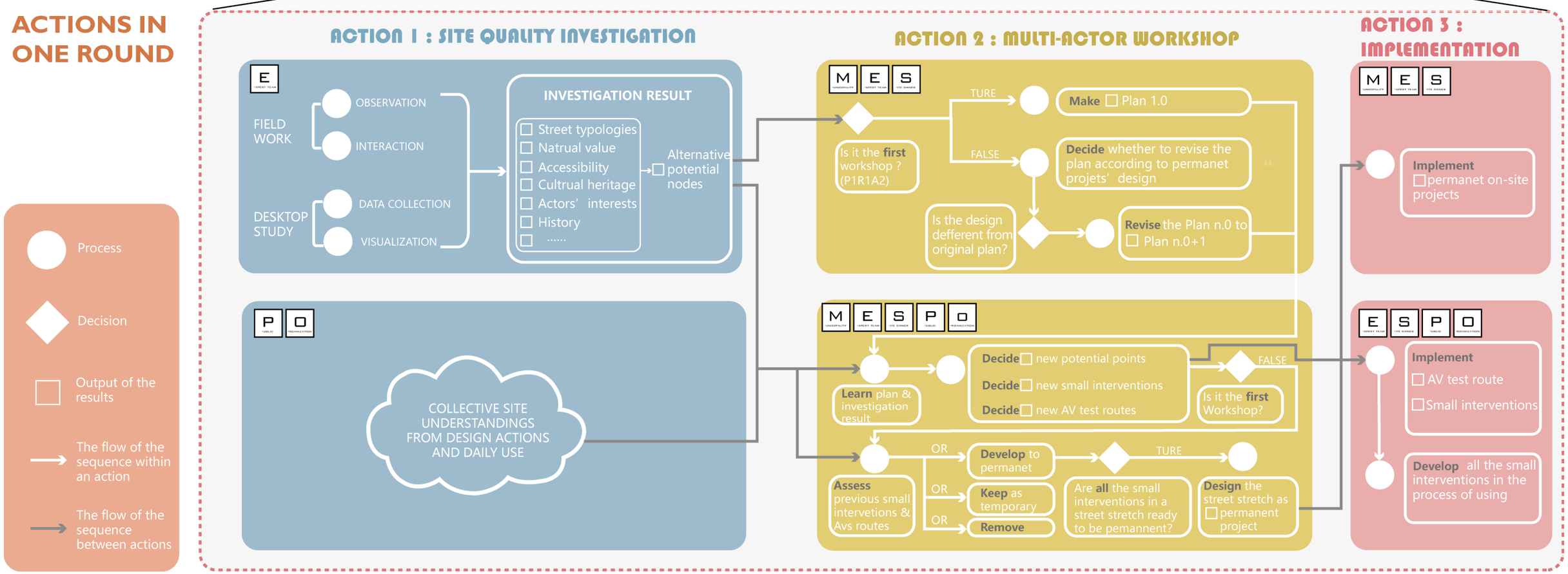


Figure 4: A visual workflow chart of organisation of design actions. (Illustration: Yukun Lin and Junhao Li)

3.1.2 Section II How

This section illustrates how various types of actors take actions in the planning and design process to contribute to the AV street transformation.

Like the composition of actors' typologies, the visual process attempts to offer a template. Instead of duplicating the template verbatim, projects are more encouraged to adapt this template to their specific sites to make the most of the method's potential.

The units of process at different levels:

Action:

Figure 5: Action. (Illustration: Yukun Lin and Junhao Li)

This is the most basic process unit in planning. Although the process of doing something in each action can be further subdivided, ones with the same goal are grouped together and defined as one action. Except for the actions in the project's initial stage (the grey ones), all other ones in the planning process are divided into: action 1: site quality investigation (blue); action 2: multi-actor workshop (yellow); and action 3: implementation (red).

Round:

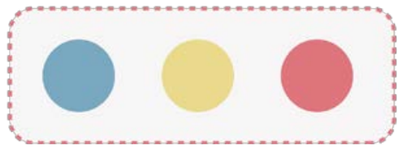


Figure 6: Round. (Illustration: Yukun Lin and Junhao Li)

Apart from the particular actions in the initial stage, every three fixed actions (action 1, action 2, and action 3 in sequence) form a round. The purpose of each round is to move the project forward by taking actions in order to bring the project to the next phase.

Phase:

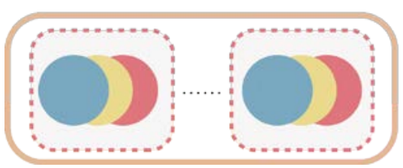


Figure 7: Phase. (Illustration: Yukun Lin and Junhao Li)

After the initial stage and at the beginning of the district-level project, some actors jointly made an original flexible phased plan starting from selected sites. This plan will be divided into several distinct phases to be realised round by round. Additionally, the number of rounds in each phase is not fixed and is determined by the decision of the permanent projects.

Iterative planning process:

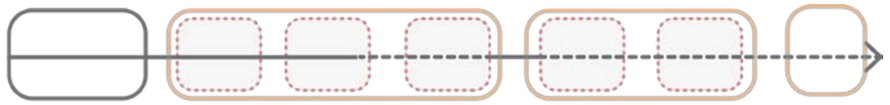


Figure 8: Overview of the planning process made up of phases. (Illustration: Yukun Lin and Junhao Li)

In terms of phases, the process is made up of an initial stage and several phases. The initial stage is the period when the planning is still at the city level, which is similar to the formulation process of comprehensive planning, while the phases refer to the period after entering district-level planning.

Figure 9: Overview of the planning process made up of actions. (Illustration: Yukun Lin and Junhao Li)

In terms of actions, the process is made up of many actions taken by various types of actors. Descriptions of different actions are presented in the following:

In initial stage:

Project initiation:

A city-level project is initiated in this action. It is enforced by the municipality through the preparation of an institutional structure (such as the AVs city initiative declaration or AVs promotion ordinance) and setting up an expert team that would help improve related laws and institutions in the initial stage and also take part in the spatial improvement in the following phases. Since a declaration or ordinance cannot be put into effect until it has been adopted by city council, the institutional document signifies that the proposal has the support of the public of the city. It signifies that the project is not a policy that the mayor arbitrarily pushed through on his own power or something that a public official in charge proposed out of the blue.

Alternative site selection:

It refers to the action of selecting one or several alternative sites as a kickstart for district-level projects. The executive roles of the actions are the municipality and the expert team. The criteria for the alternative site selection are based on the site's location, the quality of the site, and so on.

Site location decision:

It is the action of choosing which site to develop from the alternative sites. The actors involved are the municipality, the expert team, and the site owners. In conversation with site owners, the municipality and the expert team choose one or more sites among the ones whose owners agree to carry out the AV street project.

In a round of a phase:

It is significant to note that in the detailed visualisation of these actions, the more influential actors engage in activities in the top half of the chart, which is closer to a top-down process, and the less influential actors conduct the bottom half, which is a bottom-up process. One purpose of visualising in this way is to show how the top-down and bottom-up processes interplay.

Action 1: Site quality investigation

The first action in a round. This action is aimed at investigating the site qualities that deserve attention.

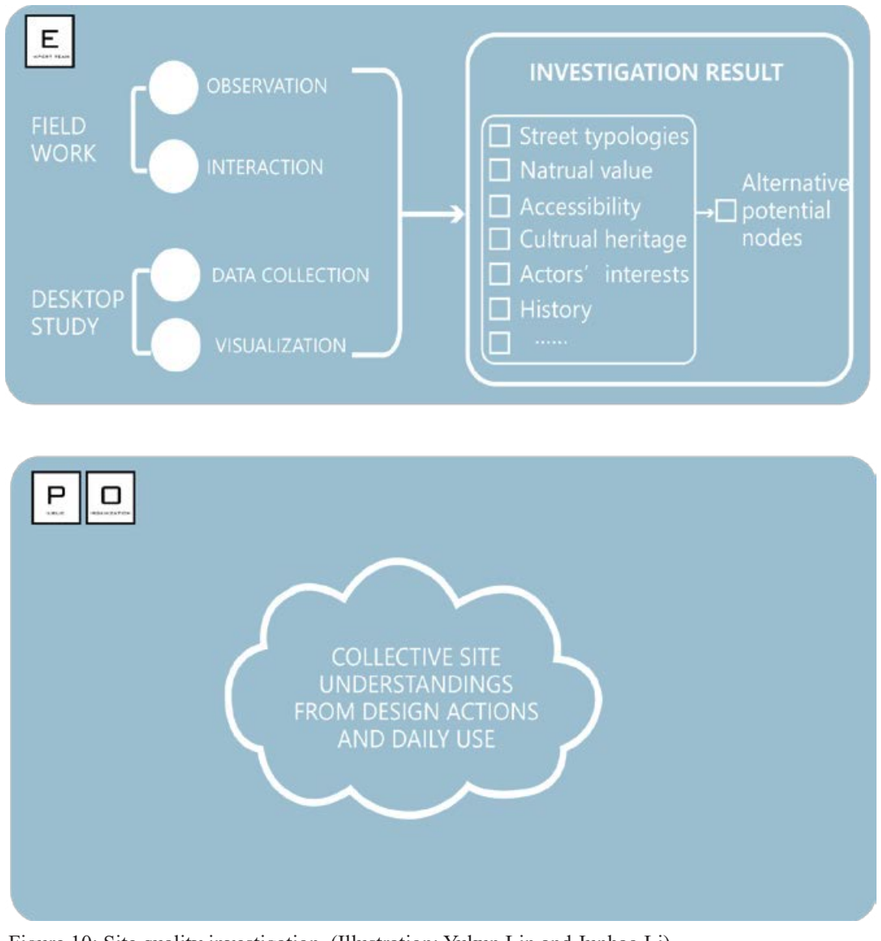


Figure 10: Site quality investigation. (Illustration: Yukun Lin and Junhao Li)

The top part is executed by the expert team by consciously investigating the site qualities through both fieldwork and desktop study. The process of field work involves non-interventionally observing the site's objective facts, such as natural values, cultural heritage, street typologies*, etc., as well as getting actors' subjective views in an interventional way, such as through interviews or questionnaires to understand their interests and needs. The desktop study includes collecting information about the site's history, comprehensive plans, etc., as well as organising and visualising all the investigation results and selecting some alternative potential nodes of the site as a reference for Action 2.

The bottom part is carried out by the public and organisations unconsciously when they are on site. By taking part in design actions, using, and experiencing the site in daily life, a collective memory and knowledge of the site are accumulated in the minds of the site users.

**street typologies*

Although there are many ways to compile street typologies, many institutions choose their criteria based on the amount of traffic streets can carry or the functional areas they are located in (National Association of City Transportation Officials, 2019; Transport of London, 2019). This study believes that such typologies cannot accurately describe AV streets with variable functions in time and space, so it is suggested to introduce a street classification model named Livsrumsmodellen. The classification criterion of this model is the way street users interact with street space. This model might be helpful in the early stages of design to clarify the role and claims of the street space. According to the model, street space can be sorted into Frirum, Integrerat Frirum, Mjuktrafikrum, Integrerat Transportrum, and Transportrum (Johansson & Linderholm, 2016). See the appendix 7.2 for details.

Action 2: Multi-actor workshop

Multi-actor workshop

The second action in a round. The aim of this action is to foster dialogue between the various types of actors in the planning process to ensure that as many interests and needs as possible are met.

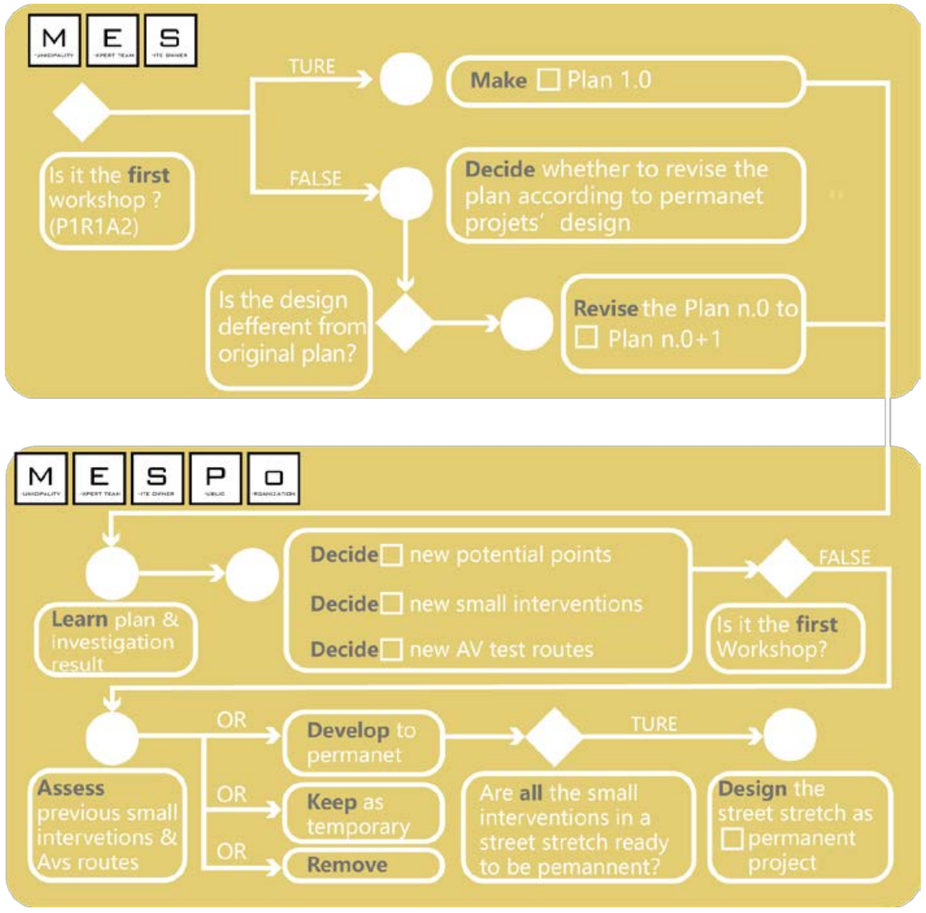


Figure 11: Multi-actor workshop. (Illustration: Yukun Lin and Junhao Li)

For the upper part, it is a pre-workshop before the formal one. The pre-workshop is mostly carried out by the municipality, the expert team, and the site owner. But depending on which round this action is in, there are two situations: if it is in the first round of the whole process, these three types of actors should make an initial draft of a plan, called Plan 1.0, based on investigation results and alternative potential nodes; if it is not the first round, the results of the workshop from the last round need to be used to determine whether the plan from the last round has to be revised. When the result (usually a permanent on-site project design) is different from the current plan, the plan should be revised; otherwise, it maintains the status quo. It is important to note that the main purpose of the plan's visualisation is to serve as a basis for the formal multi-actor workshop.

The bottom part can be called the formal multi-actor workshop, which is attended by all types of actors. In this workshop, no matter which round, all actors should first learn the latest version of the plan, as well as the site investigation results and alternative potential nodes from Action 1. Secondly, based on the learned information and their own site understandings, all the actors jointly decide: 1) the potential nodes that will be developed in Action 3; 2) the small intervention form that will be put into the potential nodes; and 3) the newly added AV routes and their supporting facilities.

Furthermore, in the bottom part, there is another process depending on the order of this action's round: if it is any workshop after the first round, then all small interventions at potential nodes and AV routes should be assessed to see whether to remove or keep as temporary projects to have further observation or develop into a permanent on-site project. When the assessment result is to develop an intervention into a permanent project, all actors are supposed to make a design together or agree on a design made by part of the actors. The design scheme will be implemented in the next action and can be input into the next round's pre-workshop to see if the plan should be revised.

Action 3: Implementation

Implementa-tion

It is the third action in a round whose aim is to implement the workshop results from action 2.

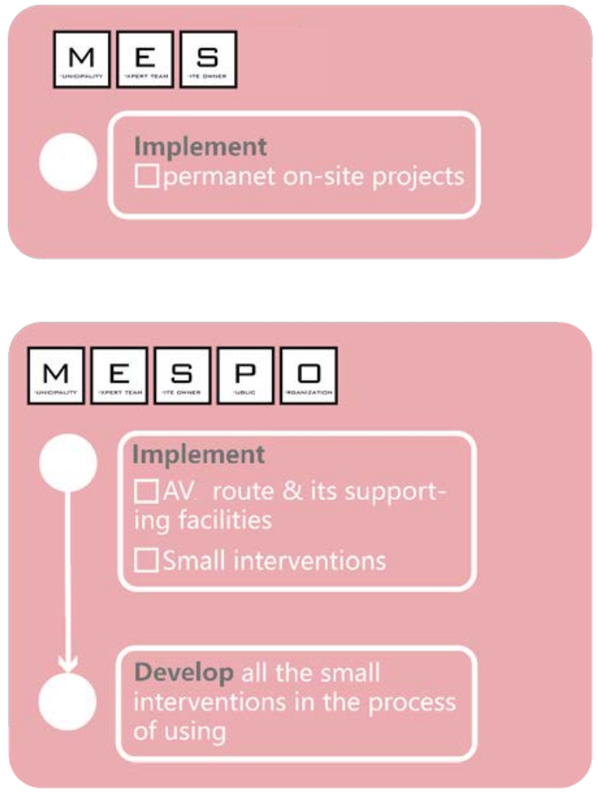


Figure 12: Implementation. (Illustration: Yukun Lin and Junhao Li)

The upper part is the implementation of permanent on-site projects conducted by expert teams and overseen by the municipality, the site owner.

The bottom part: First, the small interventions, including AV routes and other prototypes, are input into the site by the site owner and expert team; second, the small interventions are built jointly by various actors and evolve as the public and on-site organisations use and modify them.

3.1.3 Section III When

This section presents an explanation of the organisation of various actions in the transformation process from a time-based perspective. A timeline of the first two rounds of Phase 1 is provided in the figure below, where “site-inspired” designs, including small interventions and AV routes, are referred to as prototypes. The figure demonstrates the optimal timing for the application of top-down masterplanning and bottom-up “site-inspired” design. For instance, in Phase 1 Round 1 (P1R1), top-down phased plans guide bottom-up prototypes. In Phase 1 Round 2 (P1R2), top-down plans are revised when the permanent projects challenge the plans to guide new bottom-up prototypes.

The figure also illustrates how different moves in one action can be performed within the same workflow and how different moves can be executed simultaneously. For example, in P1R2, new prototypes are designed concurrently with the assessment of previous prototypes.

The figure on the right indicates how to navigate interventions across different time frames. The interventions will first be in the prototype phase for 0–5 years, followed by evaluation to determine whether they should be developed into permanent projects, removed, or observed further to become temporary projects lasting 5–10 years. If the intervention becomes a temporary project, it will be evaluated again to determine whether it should be developed into a permanent project or removed.

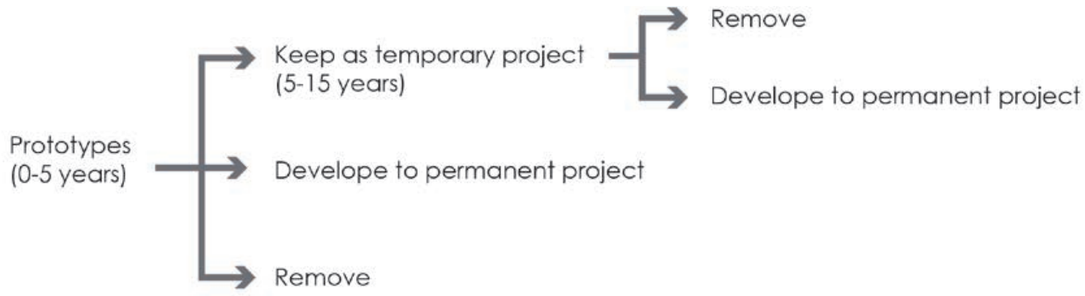
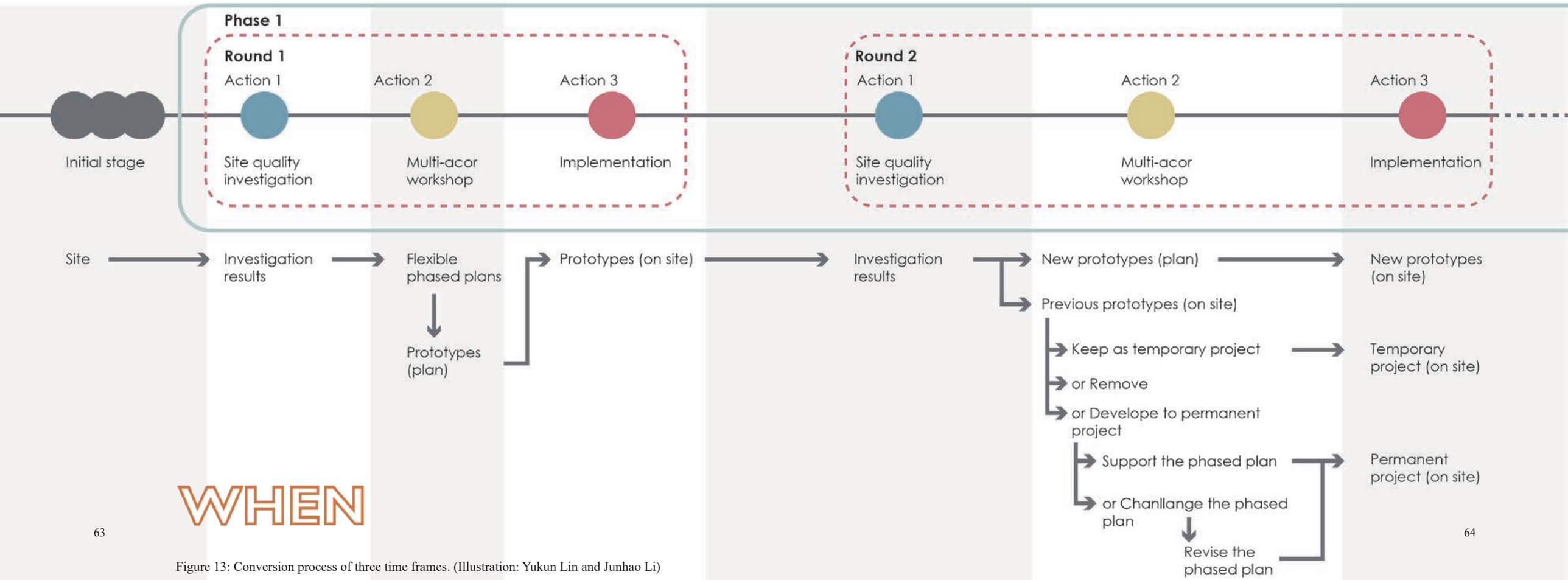


Figure 14: Flexible timeframe. (Illustration: Yukun Lin and Junhao Li)



WHEN

Figure 13: Conversion process of three time frames. (Illustration: Yukun Lin and Junhao Li)

3.2 Experimental design

Application of design strategies. It can serve as a complementary interpretation of the design strategies and framework.

I am a landscape architect on the expert team. The expert team consists of urban planners, traffic planners, engineers, etc. In addition, the co-creators of the project include the other four groups on the right side.

Let's time travel to 2050 for a presentation of the street reshaping taking place in Lokstallarna, Malmö.

Hello and welcome to the presentation. Our project reshaped streets by considering AVs in Lokstallarna, Malmö, between 2025 and 2050.

EXPERT TEAM

We are officers from Malmö stad

MUNICIPALITY

We are from Jernhusen

SITE OWNER

We are organisations on the site.

Including both profit corporations and NGOs.

ORGANISATION

We are people from different ages and backgrounds.

PUBLIC

In the following pages, I will introduce the development of our project in chronological order.

Figure 15: The preface of experimental design. (Illustration: Yukun Lin and Junhao Li)

3.2.1 Initial stage

3.2.1.1 Project initiation

The current AV projects in Sweden and Denmark

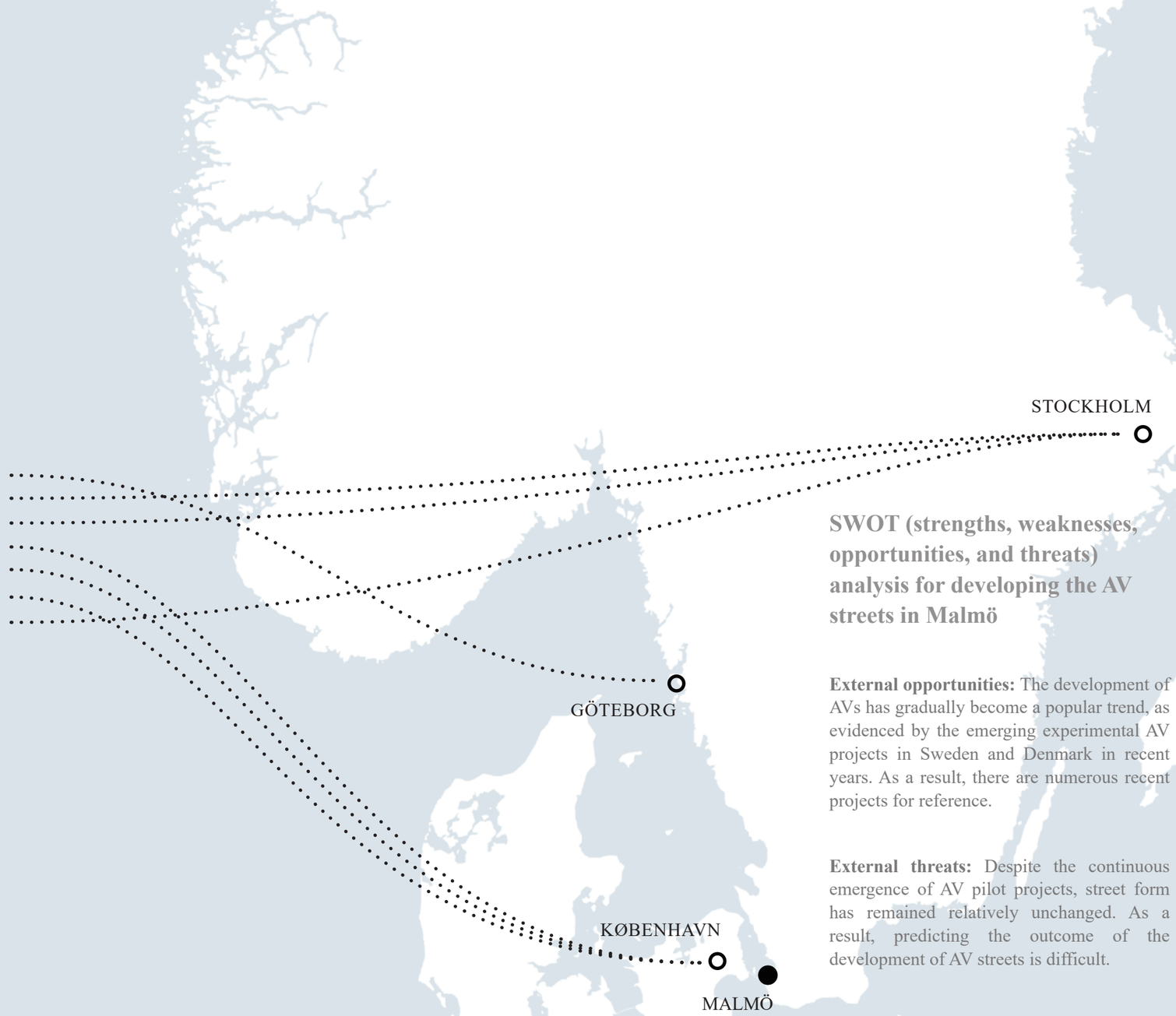
In order to prepare cities for the emerging AV technology, Av projects have sprung up in cities around Sweden and Denmark in recent years:

2017-2020 Shared Shuttle Services (S3)
2017-2020 The Auto Pilot in Barkarby
2017-2020 Autopiloten in Kista
2018-2021 The LINC project
2018-2022 AVENUE project
2018 University Hospital of Zealand Autonomous Bus
2021-2023 5G Ride – Control Tower

City of Malmö

Malmö is located in the area of the Øresund. It connects Denmark and even the entire European continent to Skåne and even the entire Swedish peninsula. The city's excellent geographical position preserves the city on a relatively human-friendly scale while also allowing the city to explore new ideas like a metropolis. This indicates that developing landscape-oriented AV streets has a lot of potential and benefits in Malmö. However, Malmö currently lacks AV-related projects, so it is meaningful to do AV practice here.

Figure 16: Location analysis. (Illustration: Yukun Lin and Junhao Li)



SWOT (strengths, weaknesses, opportunities, and threats) analysis for developing the AV streets in Malmö

External opportunities: The development of AVs has gradually become a popular trend, as evidenced by the emerging experimental AV projects in Sweden and Denmark in recent years. As a result, there are numerous recent projects for reference.

External threats: Despite the continuous emergence of AV pilot projects, street form has remained relatively unchanged. As a result, predicting the outcome of the development of AV streets is difficult.

Internal strength: The City of Malmö has the ambition to develop more human-friendly, climate-friendly, and sustainable urban streets.

Internal weakness: The City of Malmö lacks concern about AV technology.

Streets of Malmö

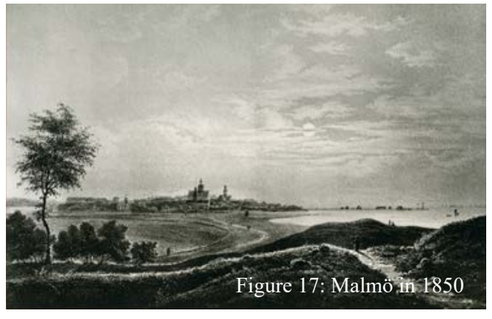


Figure 17: Malmö in 1850

Figure 19: Malmö in 1938

Figure 21: Malmö in 1967

Figure 23: Malmö in 2017

Figure 18: Malmö in 1925

Figure 20: Malmö in 1957

Figure 22: Malmö in 1970

Figure 24: Malmö in 2019

In the 1920s, when cars just appeared in the city, the urban street space was still designed based on pedestrians, bicycles, carriages, and trams, and there was almost no space designed for cars in the city, such as parking lots (Larsson and Urde, 2013).

In the early 1930s, some streets in the city were planned with the concerns of cars, such as parking spaces in downtown neighborhoods. In the 1930s and 1940s, because cars gradually dominated the streets in Malmö, urban planning was gradually made from cars' perspective, making many urban streets and Esplanades important traffic lanes, many parks parking lots, and brick roads asphalt roads. Although Malmö's streets were not congested in the late 1940s, there were still many traffic accidents, particularly at intersections. Urban planners suggested that this was due to the city's unreasonable street design, so starting in the 1950s, Malmo's street planning seriously separated traffic, such as by preventing intersections of cars, bicycles, and pedestrians (ibid).

In the 1960s, due to the increasing number of cars in the city, the streets in the centre of Malmö became congested. In order to ease traffic pressure and keep the city centre unchanged at the same time, the design idea of Malmö suburban streets started to focus on cars. As a result, there are several larger roadways for heavy traffic in the suburbs, and some already-existing roads have widened. In the 1970s, Malmö's street design became even more focused on separating different types of traffic; as a result, footbridges and sunken roads emerged (ibid).

In 2017, in order to create a more pleasant city environment, Malmö launched the summer streets experiment in Friisgatan. This means that from April to October of every year, selected streets will be devoid of cars and furnished with plants and other temporary structures. It was a big success, and the city has since seen the emergence of more and more summer streets. The emergence and success of summer streets show that the scale of urban street design is beginning to shift from one oriented towards vehicles to one based on people (Malmö stad, 2022).

According to the "Comprehensive Plan" (Översiktsplan) for Malmö (2018), the development of transportation space will focus more on sustainable ways of travelling and will be more friendly to people. There are also ambitions to transform traffic routes into city streets.

Neptunigatan was reconstructed in 2019 as a new main street with room for public transportation, vehicle traffic, pedestrian traffic, and bicycle traffic. There were also 28 biofilter elements for stormwater management, demonstrating that Malmö's urban street design started to prioritise sustainable traffic space and climate adaptation space (NCC, 2022).

District-level AV street development strategy

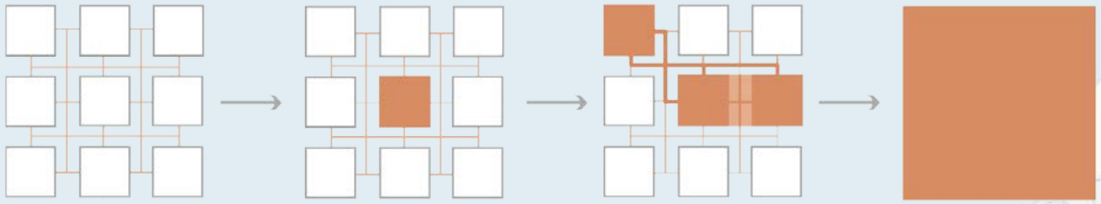


Figure 25: District-level AV street development strategy.
(Illustration: Yukun Lin and Junhao Li based on Lee et al., 2022)

3.2.1.2 Site selection

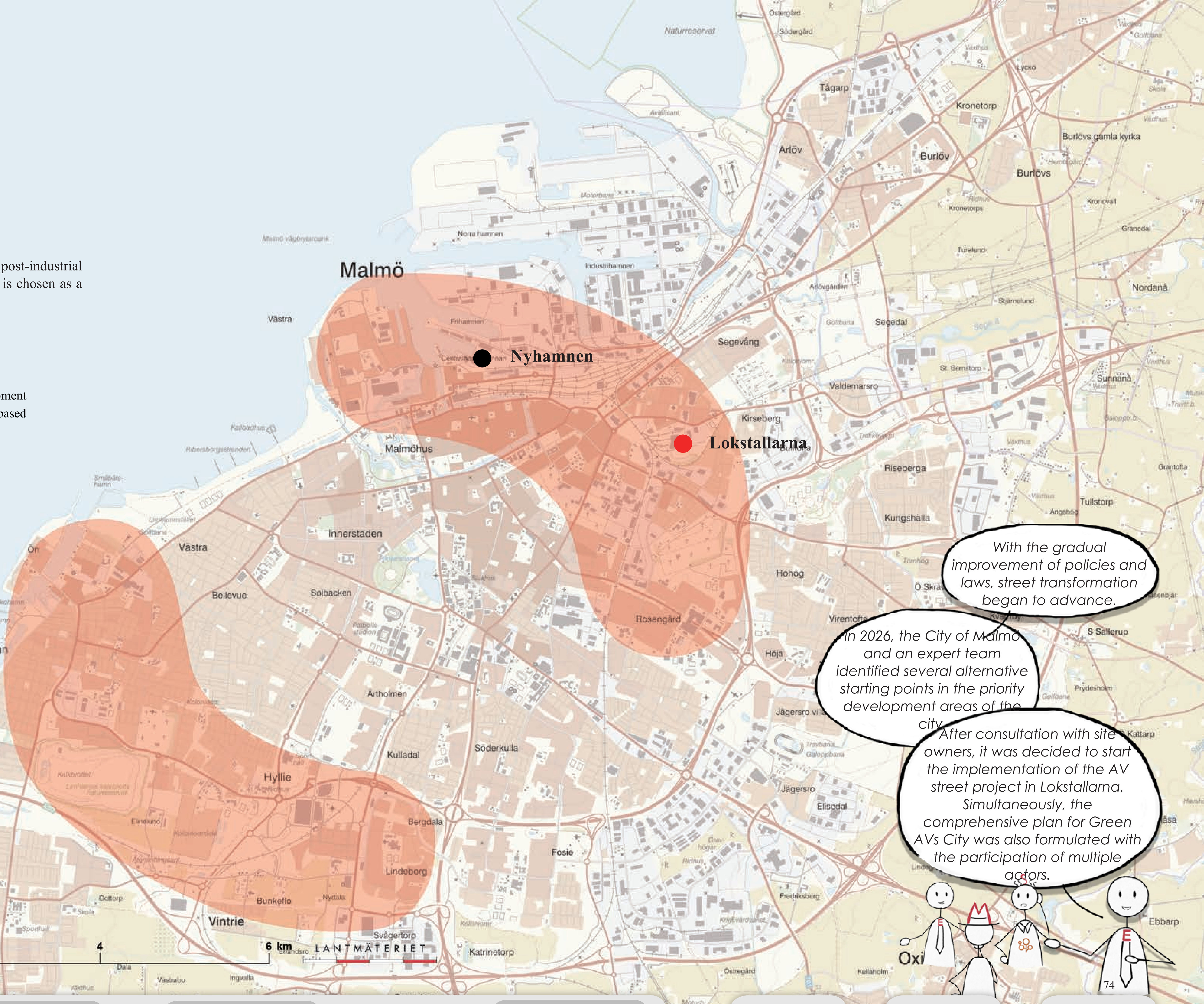
Future development of Malmö

To transform Malmö into the Green Avs city, post-industrial areas are chosen as catalysts, and Lokstallarna is chosen as a kickstart (see 2.3.2.1 for more details).

Figure 26: Site selection based on the future development of Malmö. (Illustration: Yukun Lin and Junhao Li based on Malmö stad, 2018)

Prioritized development areas

The chosen site



3.2.2 Phase 1

3.2.2.1 Round one

Action one: Site quality investigation

Next, let's zoom in on the process of district-level street reshaping, starting from Lokstarnalla

The first round of Phase 1 will be presented first. In Round 1:
1.The most comprehensive site quality investigation was conducted;
2.Multi-actor workshop was held, including making the Plan (1.0) ;
3.Implementation of decisions made in workshop was achieved.

Imformation collecting

Overview:

In the following, the application is concentrated on the post-industrial site called Lokstallarna, where the project area starts. This area formerly belonged to the State Railways (SJ), being used as a railway workshop for storing and repairing trains, boxcars, and other related industrial uses. Today, it is an area facing extensive structural changes. In the comprehensive plan for Södra Kirseberg and Östervärn from 2020, the vision set out is to transform the site into a generic mix-used urban district with residential, business, and office uses (Malmö stad, 2020). But before this masterplan-based vision can be realised, the site has begun to be an urban arena undergoing transformation with a wide variety of programmes and actors: event spaces, offices, hotels, community gardens, and so on. All these industrial traces of the past, ongoing programmes of the present, and uncertain picture of the future together influence the attractiveness and identity, and by extension, the cultural and economic value of the area.

History:

On once arable and pasture territory, constructions on SJ's railway workshop in Lokstallarna started in the year 1914 (Wahlgren, 2014:5). In 1918, SJ decided to consolidate their primary railway workshops in six places across the country, and Lokstallarna, Malmö, was one of those locations. With investment in new facilities, the workshops became the second largest workplace in Malmö,with a maximum workforce of 1,100 (ibid).

From 1914 to 1919, the railway workshops were constructed in two phases, starting with the construction of the office, the main storage room, and the gatekeeper's residence (ibid). With the expansion of business scope, in 1917-1919, the big locomotive and wagon workshops, the wheel workshop, the forge, the steam centre, and other structures were built (ibid:7-9). In the workshops, steam locomotives, passenger vehicles and freight wagons were maintained (ibid:9). This persisted until the 1950s, when fewer steam locomotives were operating, which resulted in the closure of a significant amount of business. When steam locomotive operation was phased out, the gatekeeper's residence and the locomotive workshop were both demolished in the early 1980s to make room for the bus workshop and garage (ibid:10). When the railway workshops' operations declined

Figure 27: Lokstallarna area in 1924

Figure 28: Vision for Kirseberg. (Malmö stad, 2020)

and the empty spaces started to be rented out, new activities started to migrate into the area starting in 1993 (ibid:14).

Now and future:

Although the majority of the structures remain, the workshops have long been devoid of wagons and locomotives. Instead, the site has recently been occupied by a group of creative small entrepreneurs who were able to move into the old workshops due to reduced rent from the property owners: state-owned Jernhusen. As small entrepreneurs build and use the site, the area becomes lively and creative. Consequently, locals begin to return to this site. Amid the rusty rail lines and spontaneous vegetation, they experience the interweave of history and present, the collision of conservatism and innovation.

In ÖP (Malmö stad, 2020) it is presented that there are ambitious plans for the area's development, including new streets and connections, green spaces, housing, new jobs, new primary schools and preschools. Construction is anticipated to begin in 2025.

The action one: site quality investigation was carried out by the expert team in early 2027.

For the desktop study, our team collected and organised information about the site's history and future planning vision.

Transect line

It is critical to identify the site on a larger scale than the site itself. The map shows the route of passing through places where man has had an influence. The transect connects Malmö's Augustenborg, Sorgenfri, Lokstallarna, and the east section of Kirsberg. The goal is to investigate various types of human-made boundaries and how they might be viewed as an opportunity from a different perspective.

Travelling through many areas, it is clear to see what is happening in Lokstallarna's surrounding urban environment, such as the implementation of the stormwater management community, the bottom-up construction of the children's playground, the transformation of the post-industrial area into a community, and so on. Simultaneously, the quality of the site is also explored, which includes a desirable position, spontaneous vegetation, free spaces, cultural heritage, and a distinctive atmosphere.

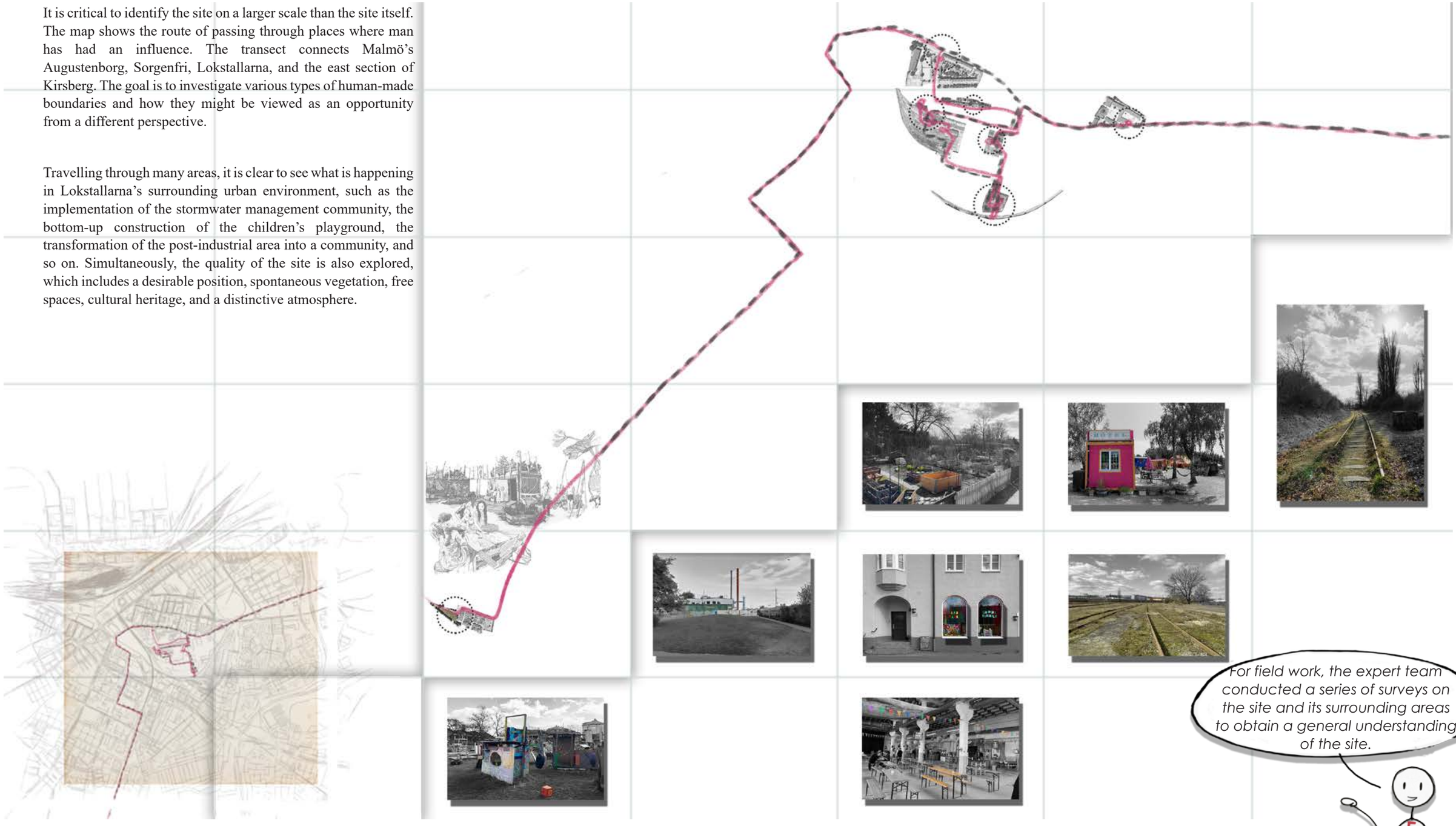


Figure 29: Travelling transect line. (Illustration: Yukun Lin and Junhao Li)

Figure 30: Lokstallarna area. (Photo: Yukun Lin and Junhao Li)

Stakeholders on site

STAKEHOLDER ANALYSIS		
Stakeholder	Influence (Power of groups)	Interest
SITE OWNER	High	To obtain profit from developing this area
MUNICIPALITY	High	To develop housing and suatainable transport infrastructure
EXPERT TEAM	Medium	To develop differernt aspects—e.g., AVs, Cultural heritage, Ecosystem, etc.
ORGANIZATION	Medium	To develop activities, to create demand, etc.
PUBLIC	Low	To create livable environment , to improve the user experience, etc.

Figure 31: Stakeholders on site (Illustration: Yukun Lin and Junhao Li)

Organizations

1. Creative Dialogues
Creative Education

2. Edge
Shapes the cities, infrastructure and landscapes of the future

3. Eve n 'Ivy
Management and marketing for artists

4. GADE18
Production company film

5. Grand Circus Hotel
Hotel and camping

6. in-discourse
Audio, Visual and art direction - sound and media studio

7. Lilla Kafferosteriet
Coffee roastery

8. Maries Bihantverk
Professional beekeeping, lectures and tastings

9. Mats Källblad
Cartoonist

10. The food workshop
Restaurant

11. Nomadic studio
Co-working space

12. Pappas Gata
Silversmithing / Jewelry Art

13. Pink Ivy Management
Music management

14. Restore
Consultant in Construction and Cultural Conservation

15.Sagofen Isadora
Theater + screenwriter

16. SaltaSoloMedia
Photo & graphic studio

17. Sara Rosengren
Artist / painting

18. Sonic
Music Mastering & Film Sound Post Studio

19. Studio Sickan
Recording studio

20. Nobina

Vincent's Spices Import & Export
Spice wholesaler

Woodstock DDC
Motorcycle club

Trafikverket

Landowner
Jernhusen

Municipality
Malmö stad

Public

Expert team

Layered analysis

Accessibility

- Entrancce
- Entrancce (abandoned)
- Railways
- Railways (abandoned)
- Road

Livsrumsmodellen

- Integrerat transportrum (IT)
- Mjuktrafikrum (M)
- Integrerat frirum (IF)

Natural value

- High natural value
- Significant natural value
- Certain natural value

Cultural heritage

- historical buildings

Secondly, investigations also covered the current connection, the types of street spaces, and the natural and cultural values of Lokstarllarna.

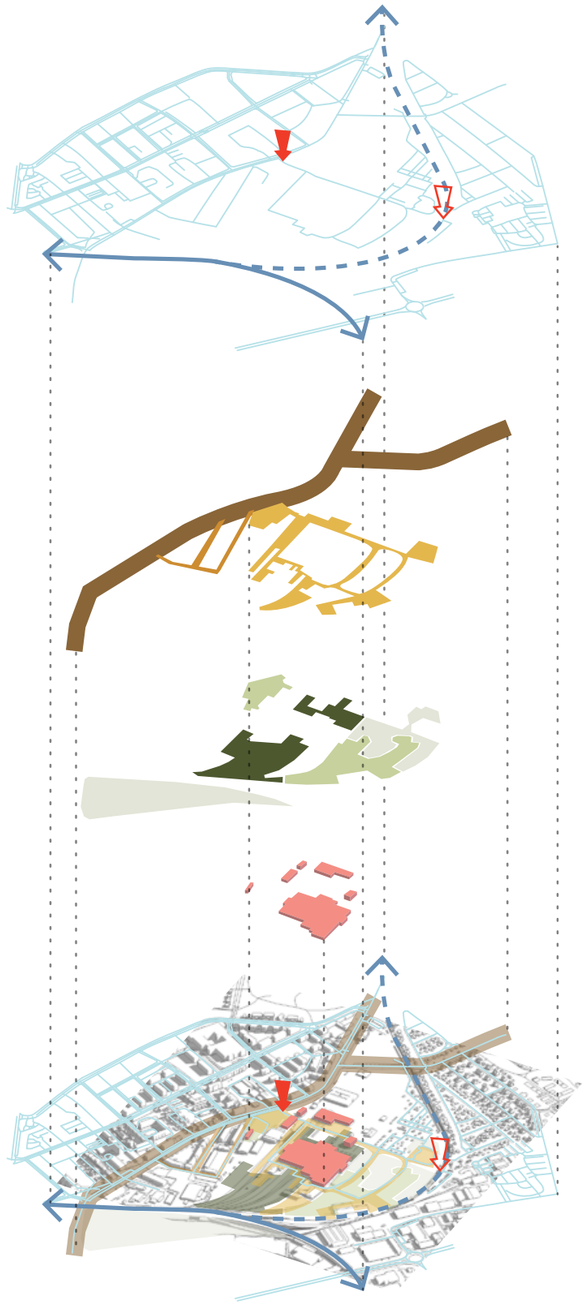


Figure 32: Layered analysis. (Illustration: Yukun Lin and Junhao Li)

Points of interest

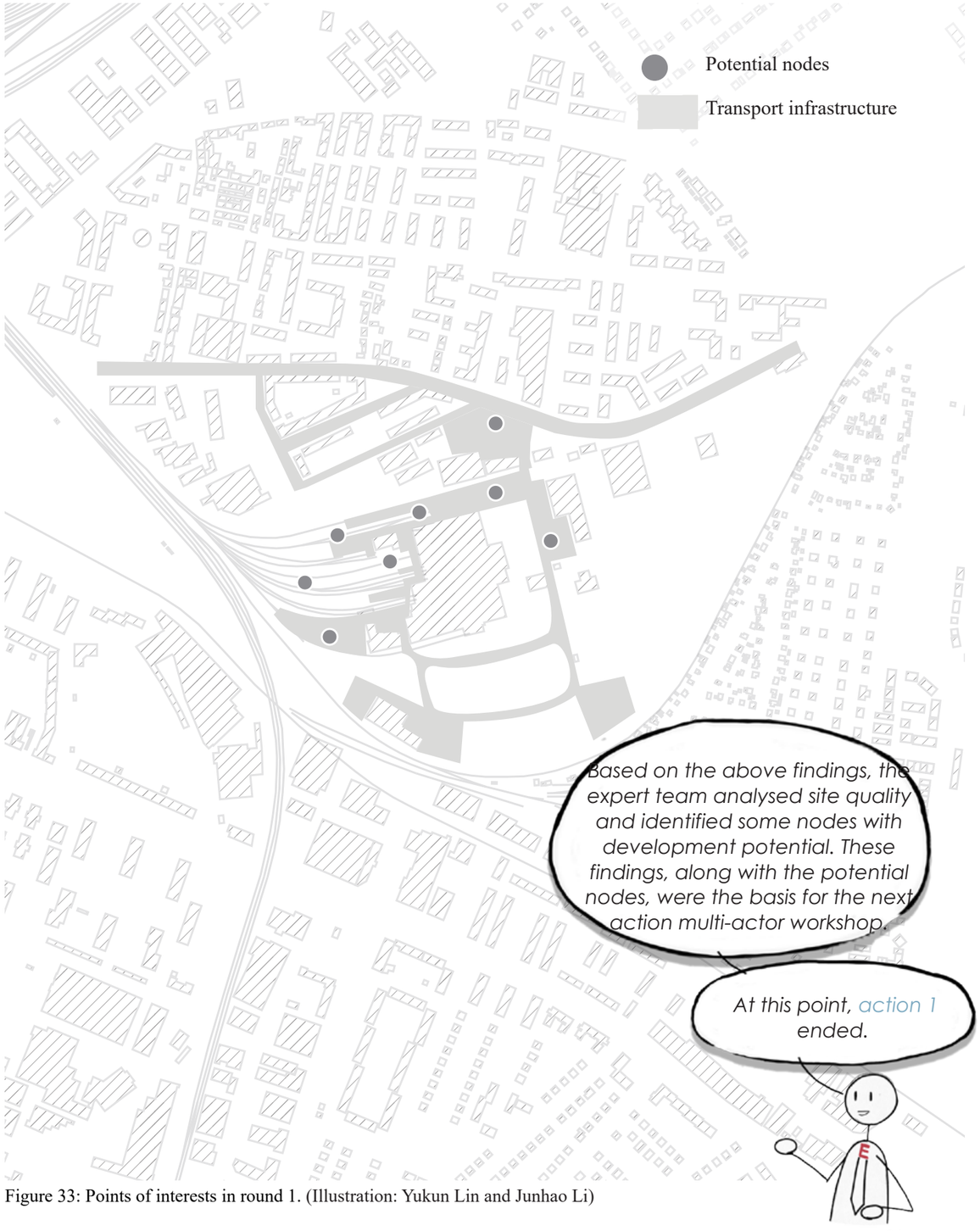


Figure 33: Points of interests in round 1. (Illustration: Yukun Lin and Junhao Li)

Plan 1.0

The first and second phases of this plan assume that there are just a few AV-only zones in the city, while the third assumes that there are AV/HV-streets linking these AV-only areas. The fourth phase envisions more portions of the city becoming AV-only zones.

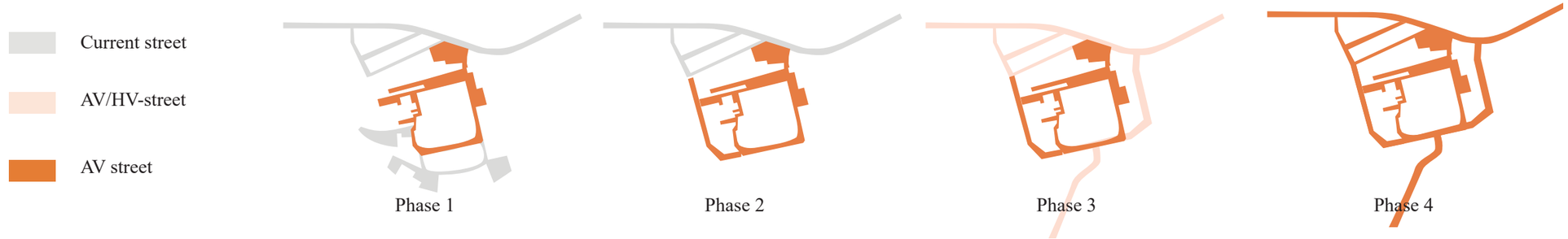


Figure 34: Flexible phased plan for AV street (1.0). (Illustration: Yukun Lin and Junhao Li based on Malmö stad, 2020)

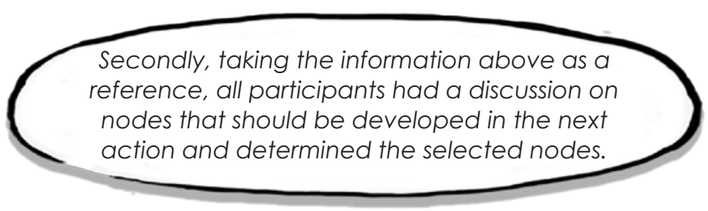
Figure 35: Green infrastructure plan. (Illustration: Yukun Lin and Junhao Li based on Malmö stad, 2020)

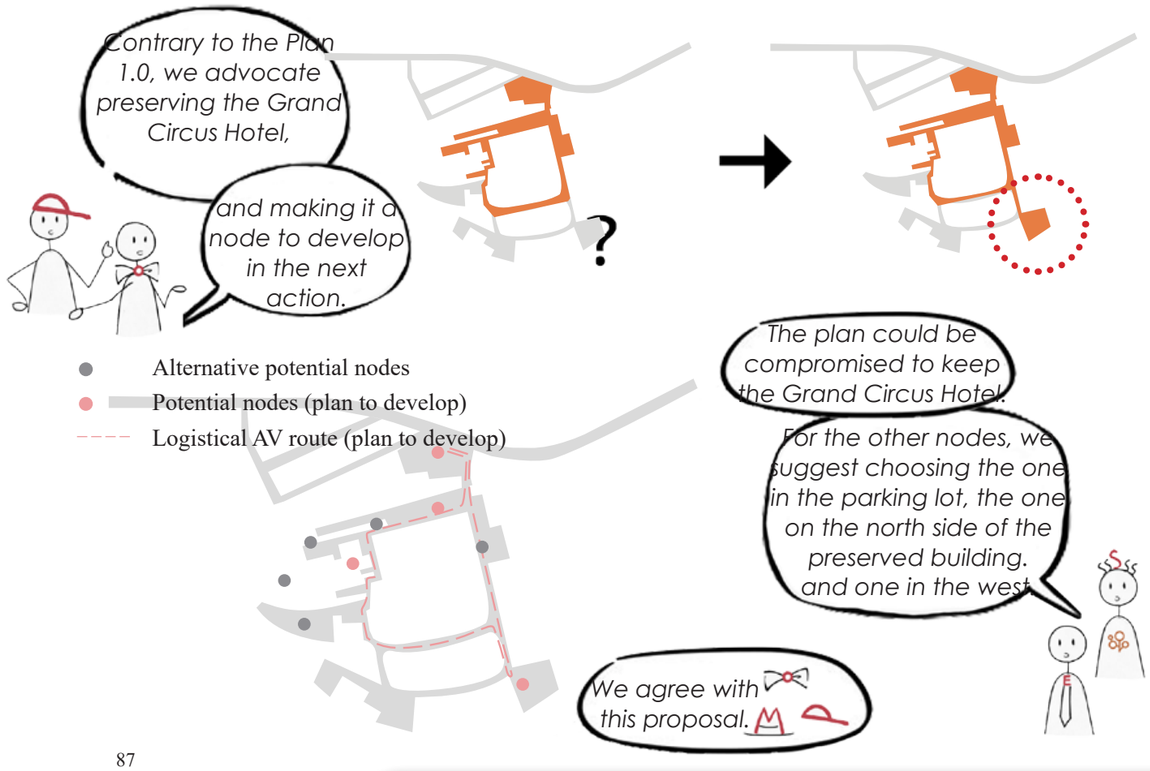
Figure 36: Street typologies. (Illustration: Yukun Lin and Junhao Li based on Malmö stad, 2020)

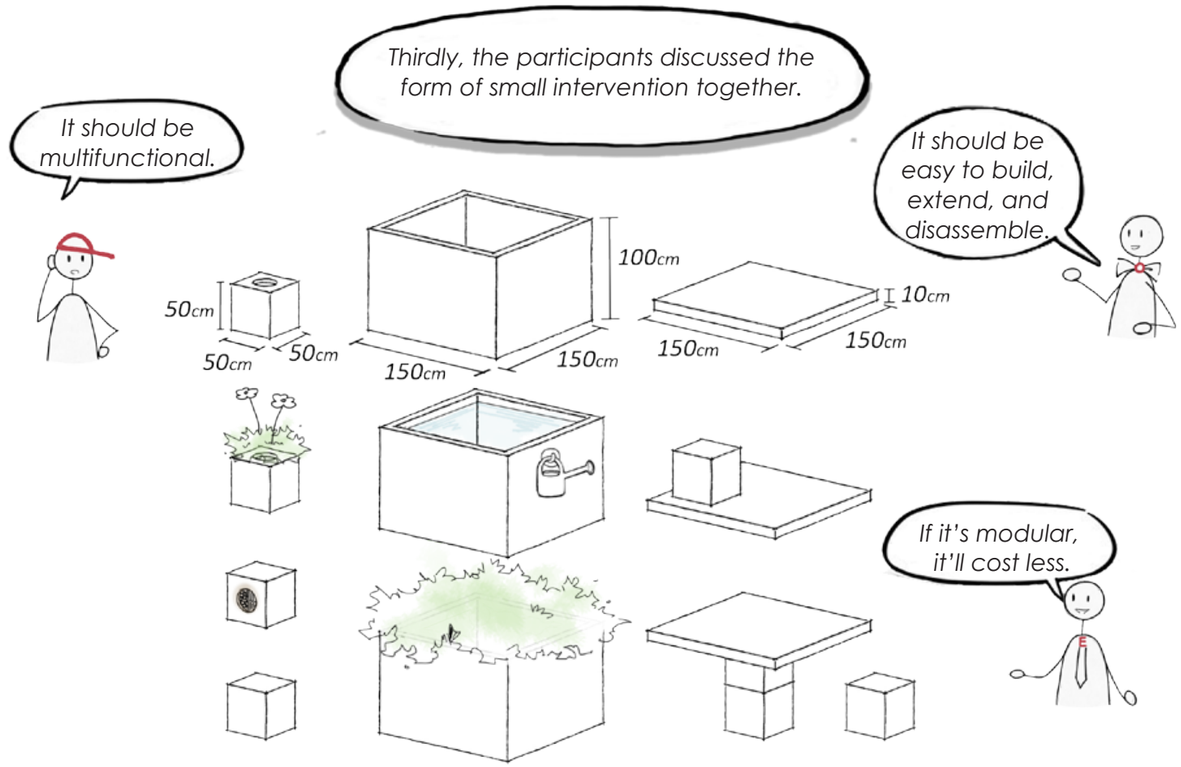
Firstly, since this was the first workshop of the project, the Plan 1.0 was made by the expert team, the city of Malmö, and Jernhusen according to site investigation results. It was the basis for further discussion during the formal workshop.

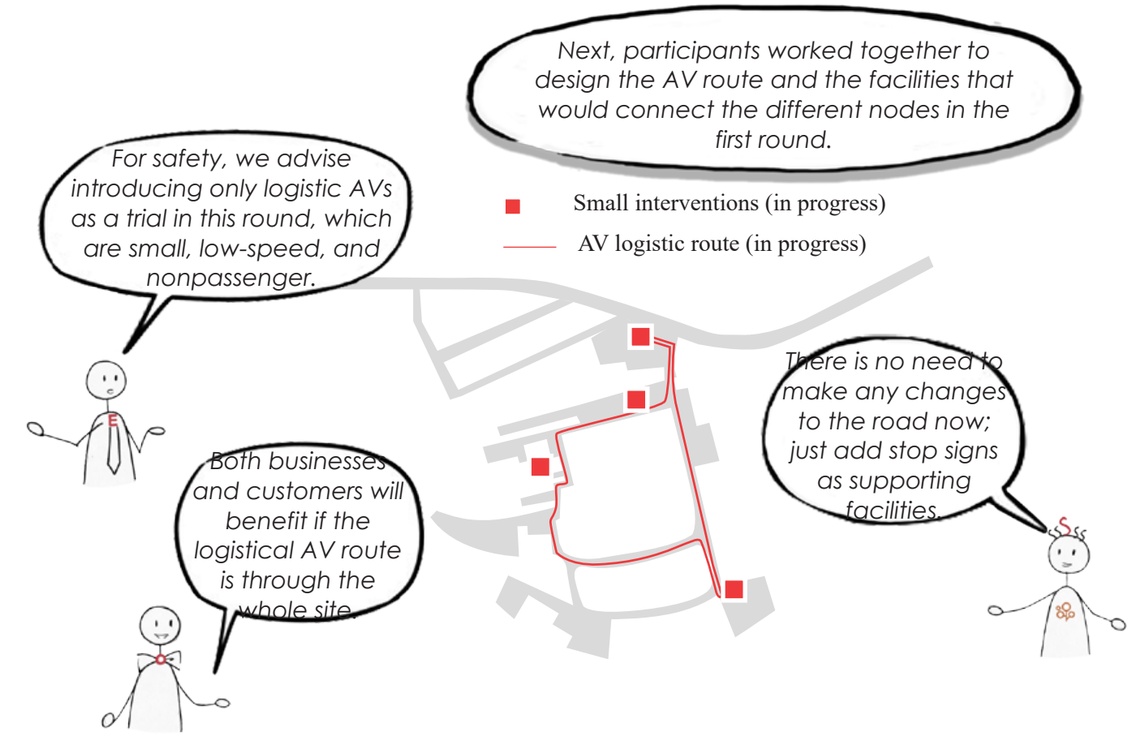
In mid-2027, the 1st round of Phase 1 moved to the 2nd action: multi-actor workshop

Figure 37: Workshop discussion in round 1.
(Illustration: Yukun Lin and Junhao Li)









Action three: Implementation

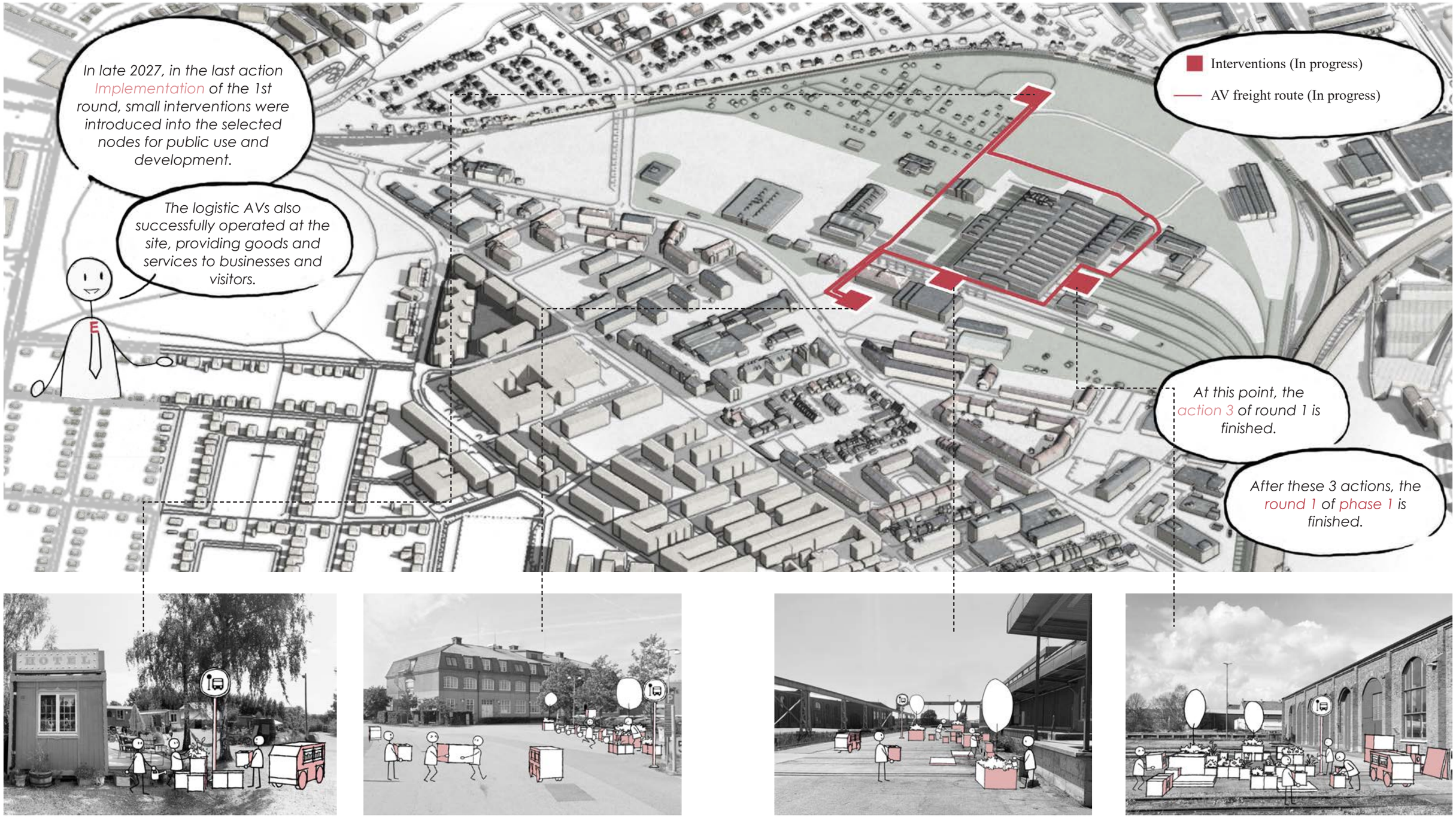


Figure 38: Implementation in round 1. (Illustration: Yukun Lin and Junhao Li)

3.2.2.2 Round two

The period from 2028 to 2030 was Round 2 of Phase 1. What have been done in this round were:
1. A site quality investigation was conducted from both top-down and bottom-up about all the changes caused by the last round's actions.
2. A multi-actor workshop including selecting the new nodes for small intervention as well as the new AV routes; discussing and deciding whether the last round's nodes and AV routes should be removed, maintained, or further developed into a permanent project; and deciding whether to revise the Plan 1.0 due to the above discussion results.
3. An implementation to realise the results of the workshop.

Action one: Site quality investigation

From the beginning to the end of 2028, the site quality investigation happened.

During the whole year, our team visited the site regularly to collect information and initially identify new alternative potential nodes.

We have subconsciously accumulated site understandings due to frequent visits to the site, the use and development of small interventions, and interactions with the AVs.

These can be called our bottom-up investigations.

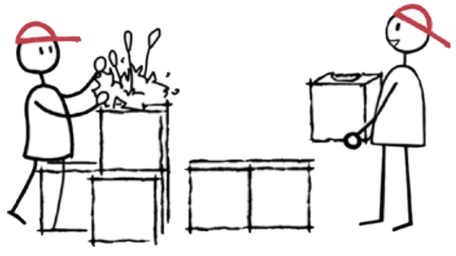
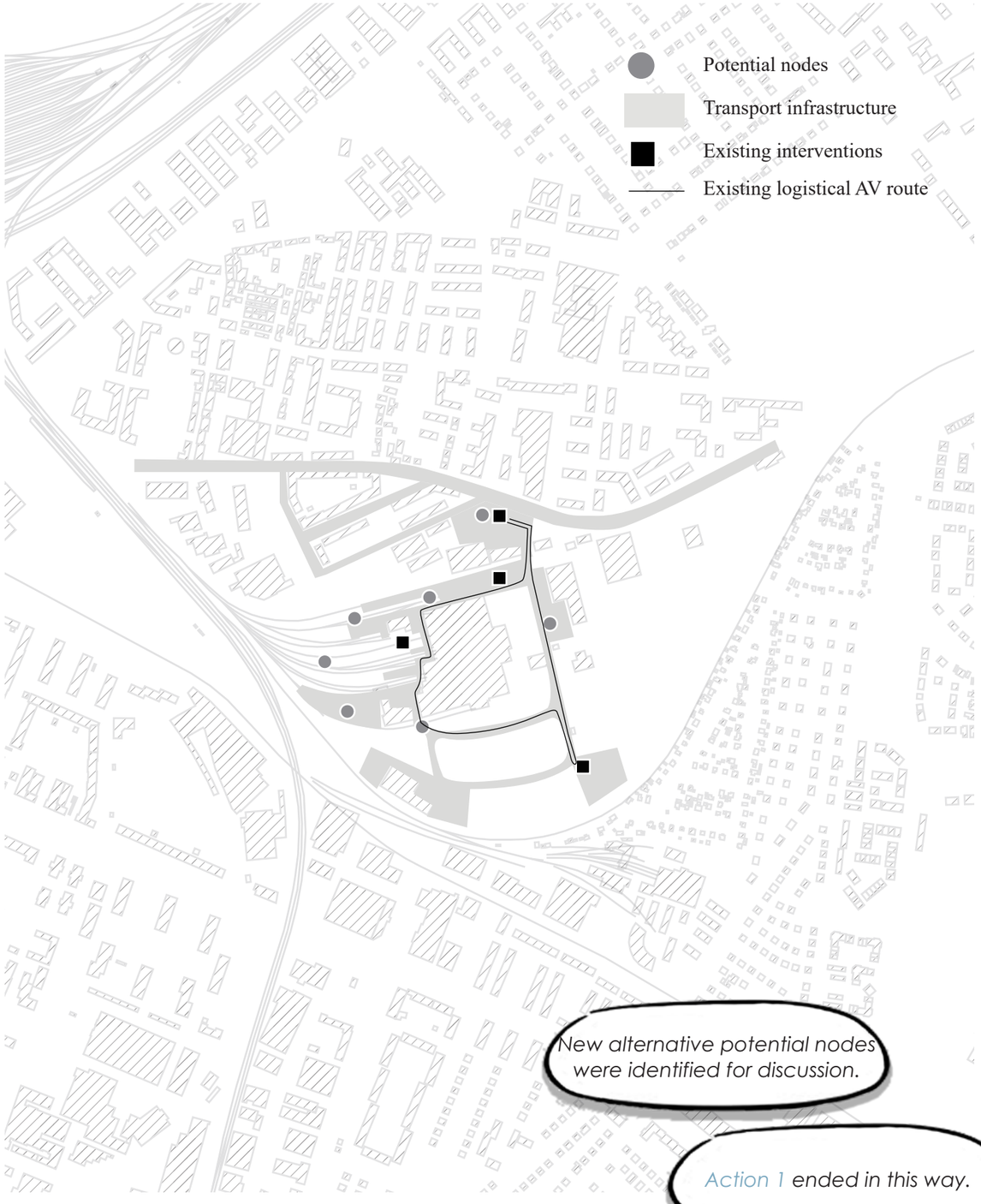


Figure 39: Site quality investigation in round 2. (Illustration: Yukun Lin and Junhao Li)

Points of interest



New alternative potential nodes were identified for discussion.

Action 1 ended in this way.

Figure 40: Points of interest in round 2. (Illustration: Yukun Lin and Junhao Li)

Action two: Multi-actor workshop

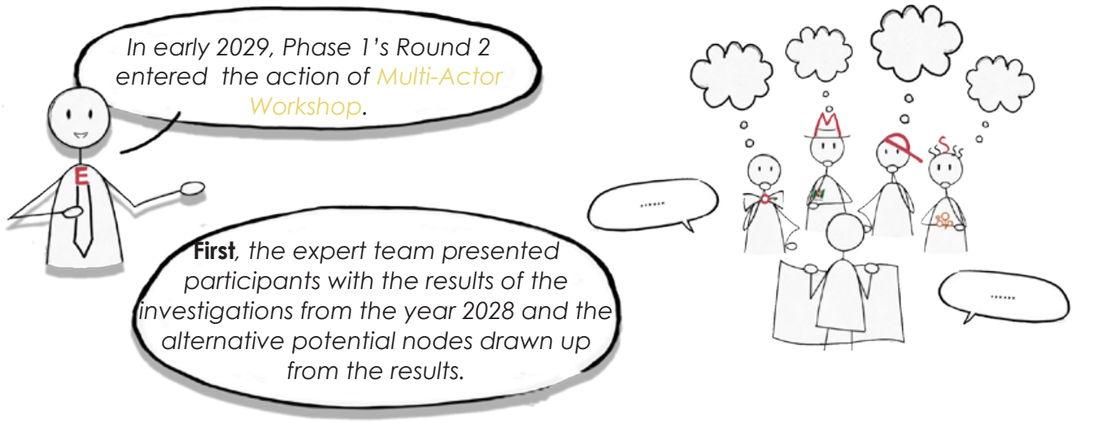
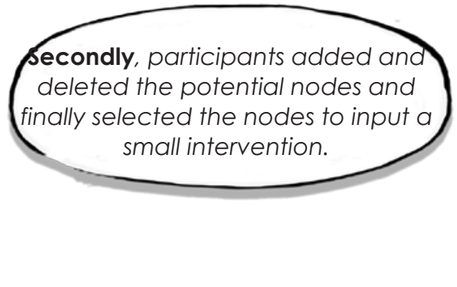
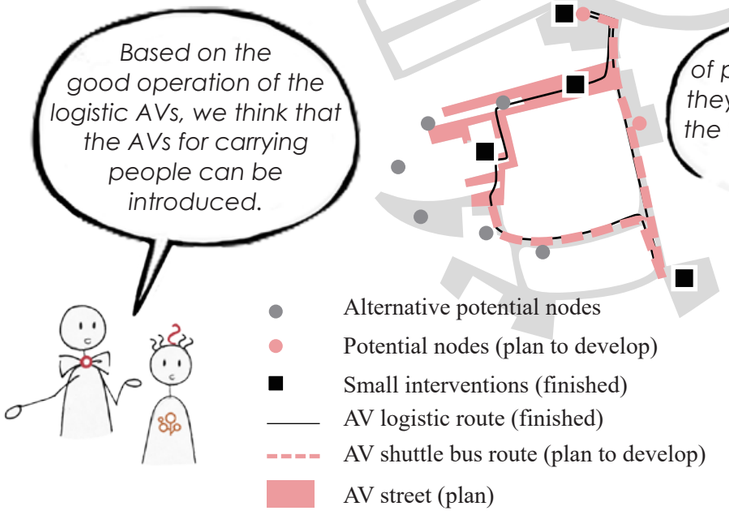
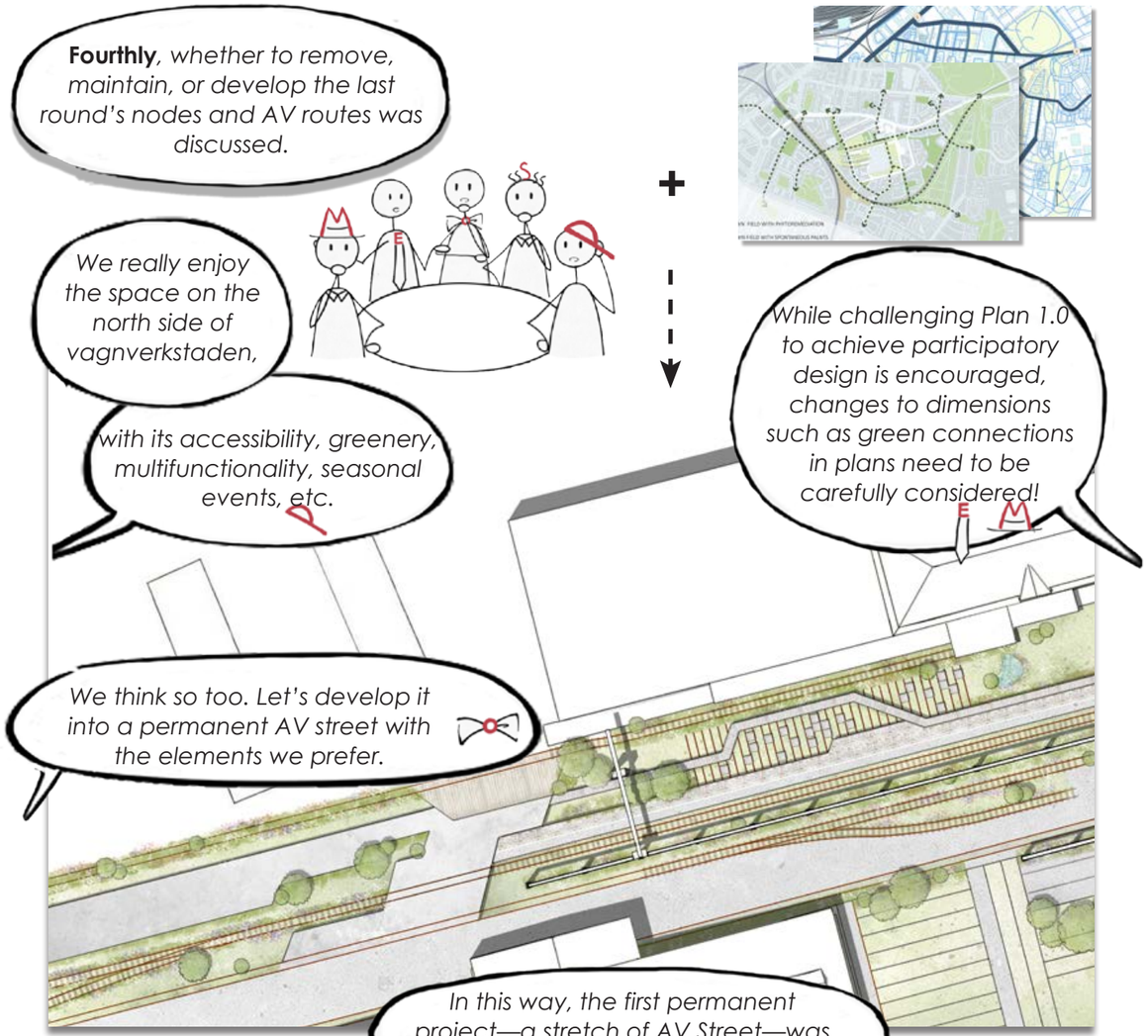
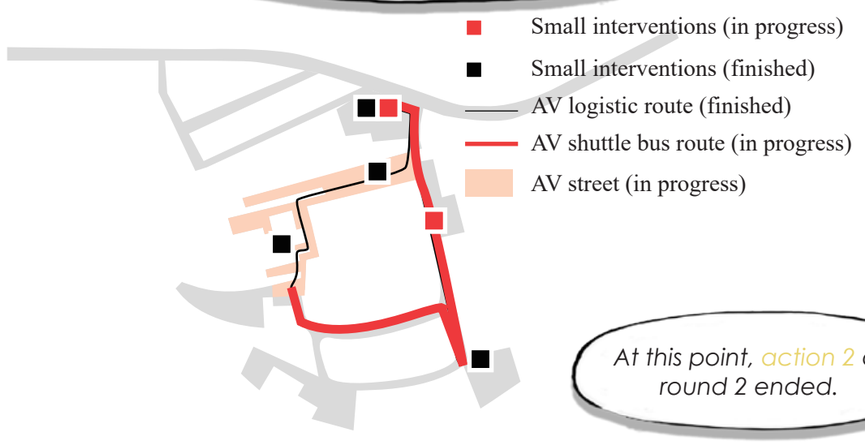


Figure 41: Multi-actor workshop in round 2.
(Illustration: Yukun Lin and Junhao Li)

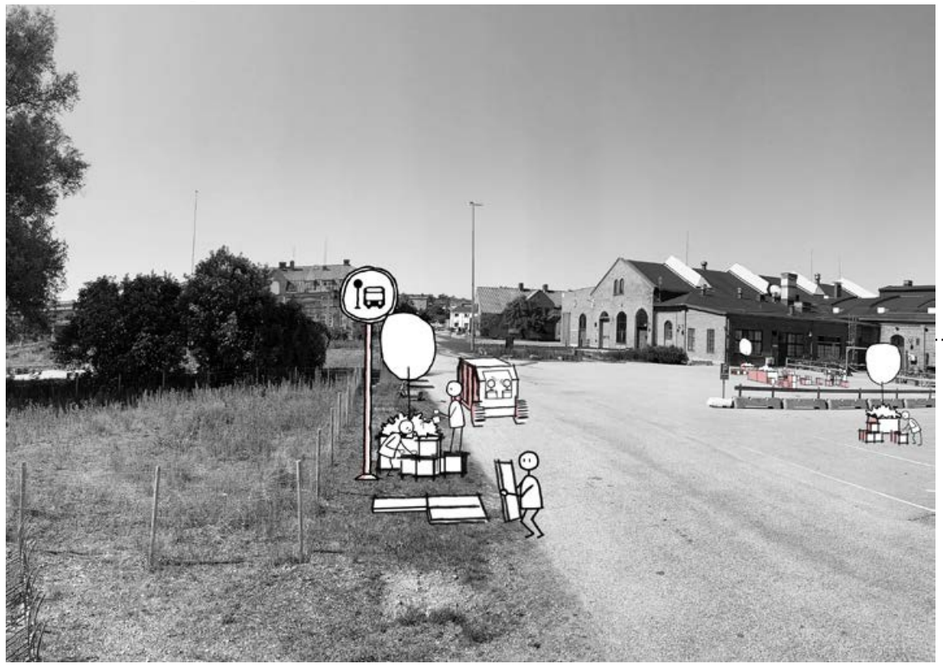








Action three: Implementation



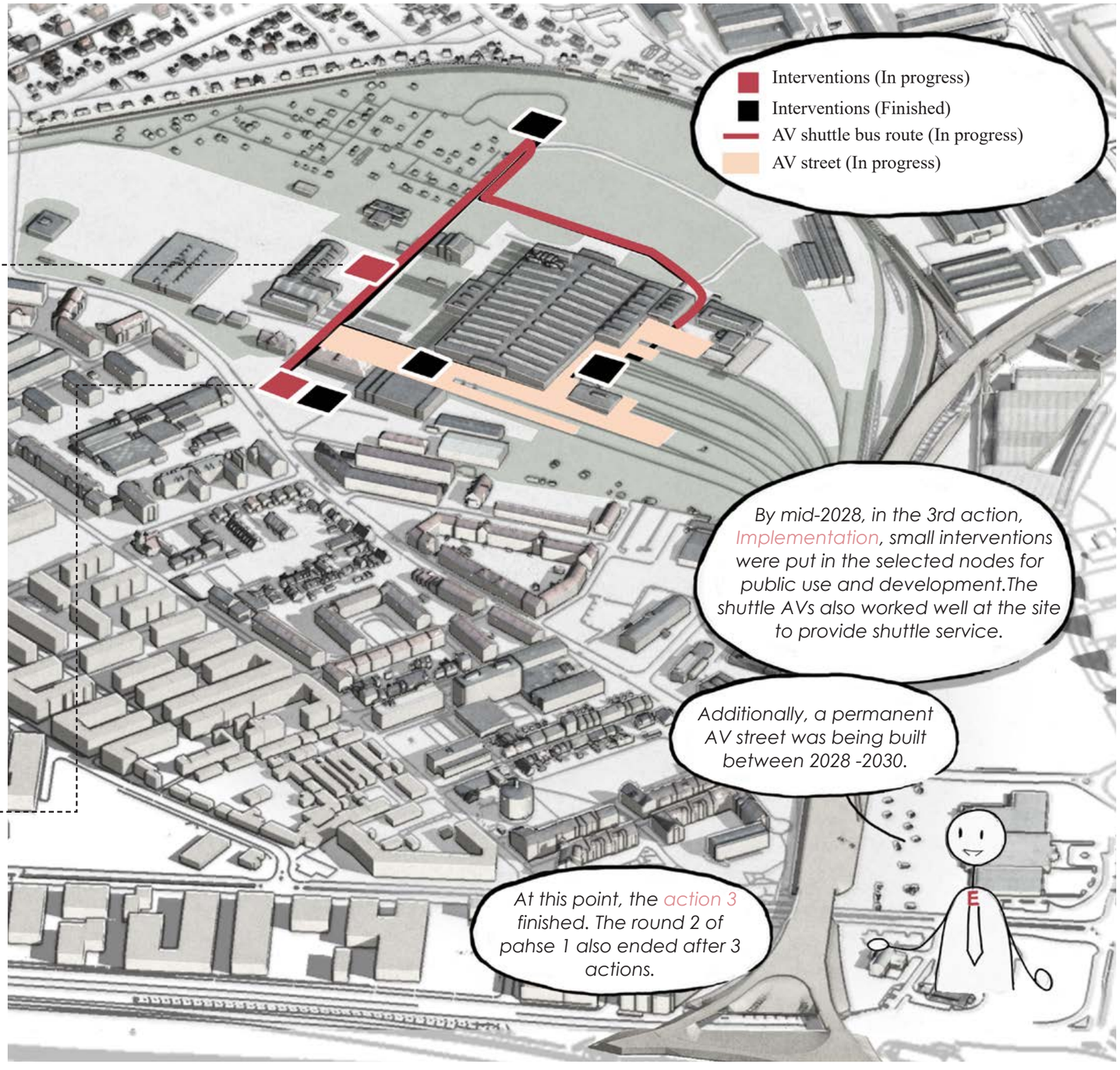


Figure 42: Implementation in round 2. (Illustration: Yukun Lin and Junhao Li)

3.2.2.3 Round three

Round 3 of Phase 1 took place from 2030 to 2032. In this round, the following were accomplished:
1. A top-down and bottom-up site quality investigation of all the changes brought about by the previous round's efforts.
2. A multi-actor workshop that includes selecting new nodes for small intervention as well as new AV routes; discussing and choosing whether the nodes and AV routes from the previous round should be removed, kept, or further developed into a permanent project; and deciding whether to revise Plan 1,0 based on the above discussion results.
3. An implementation for putting the workshop's outcomes into action.

Action one: Site quality investigation

The site quality investigation occurred from mid-2030 to mid-2031, partially coinciding in time with the implementation action in round 2.

Like investigations in round 2, our team visited the site on a frequent basis throughout the year to gather information and find additional alternative potential nodes.

As for our bottom-up investigation,

Due to regular visits to the site, the usage and reorganisation of small interventions, and interactions with the AVs, we have subconsciously gathered information and understandings about the site.

Figure 43: Site quality investigation in round 3. (Illustration: Yukun Lin and Junhao Li)

Points of interest

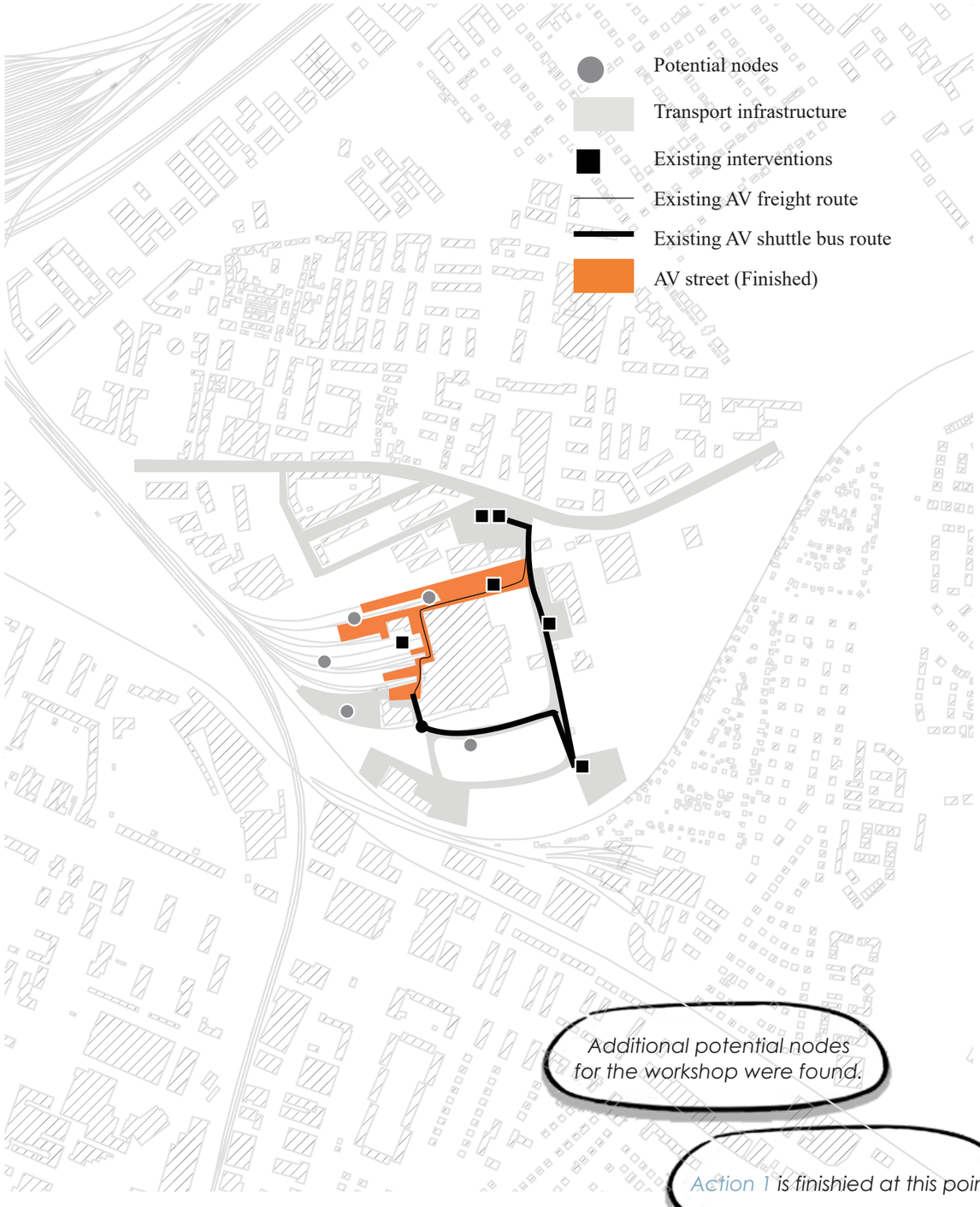


Figure 44: Site quality investigation in round 3. (Illustration: Yukun Lin and Junhao Li)

Action two: Multi-actor workshop

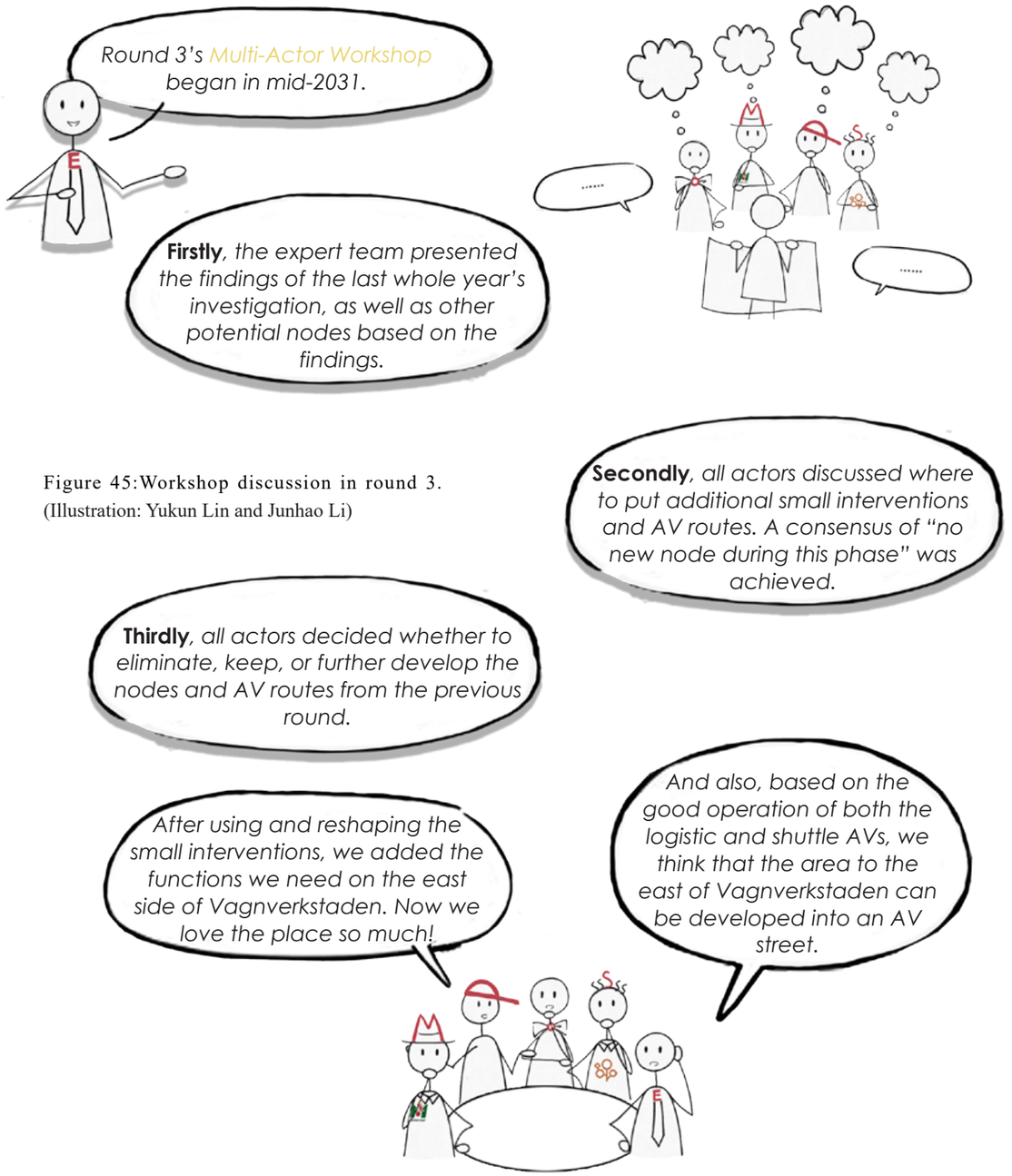


Figure 45:Workshop discussion in round 3. (Illustration: Yukun Lin and Junhao Li)

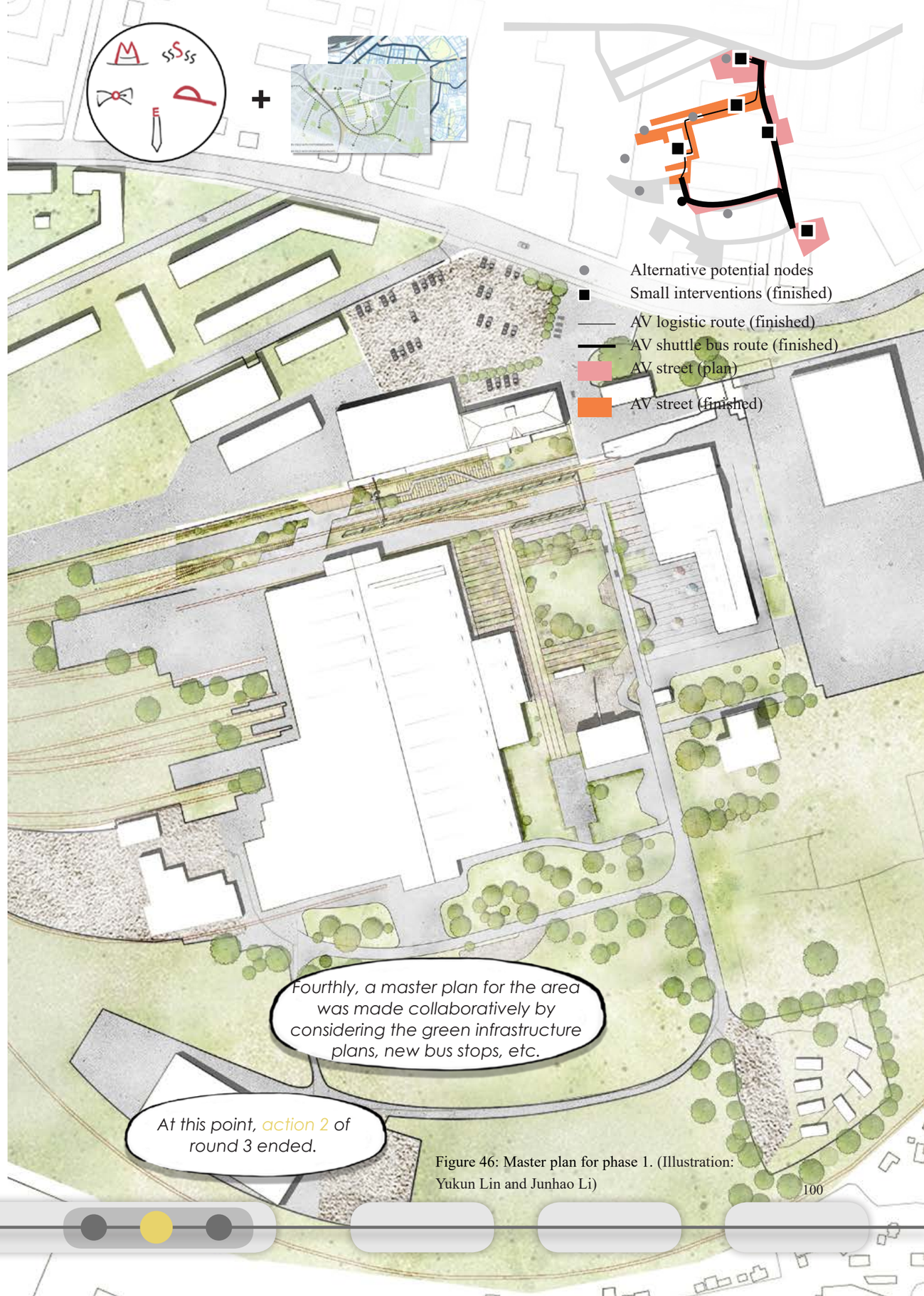


Figure 46: Master plan for phase 1. (Illustration: Yukun Lin and Junhao Li)

Fifthly, determine whether to revise Plan 1.0 based on site development.

After several rounds of inspection and development, the Grand Circus hotel, which was proposed to be kept by the public and organisations in round 1's workshop, operates well and is highly compatible with AVs.

As the most common users of the site, we also love this hotel, which is full of personality and vitality!

Therefore, we propose to revise Plan 1.0 to permanently retain this area.

Plan 1.0

Plan 2.0

Figure 47: The revision of Plan 1.0. (Illustration: Yukun Lin and Junhao Li)

At this point, action 2 of round 3 is finished.

Action three: Implementation

Round 3's implementation began in late 2031, and finished in 2032.

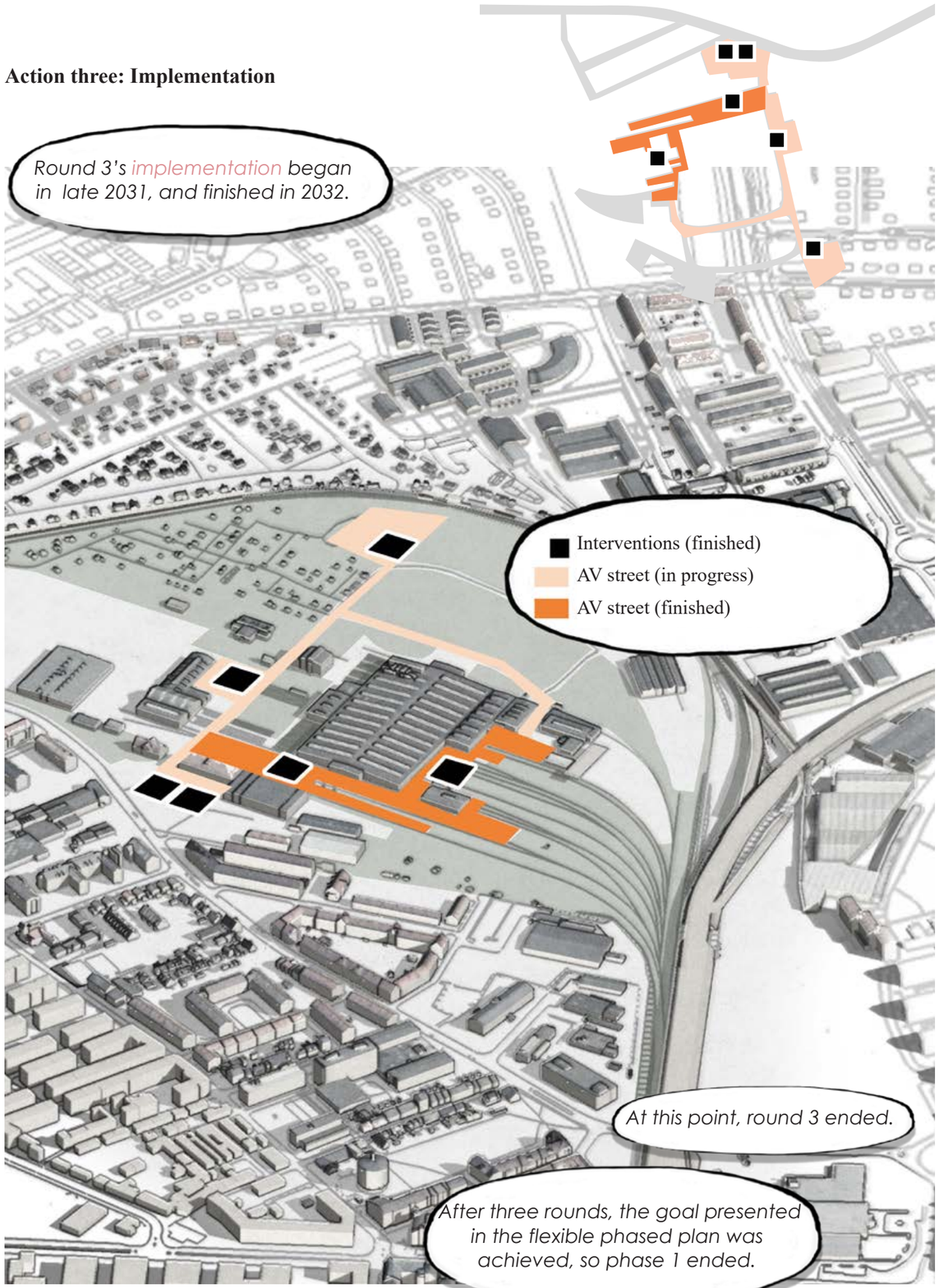
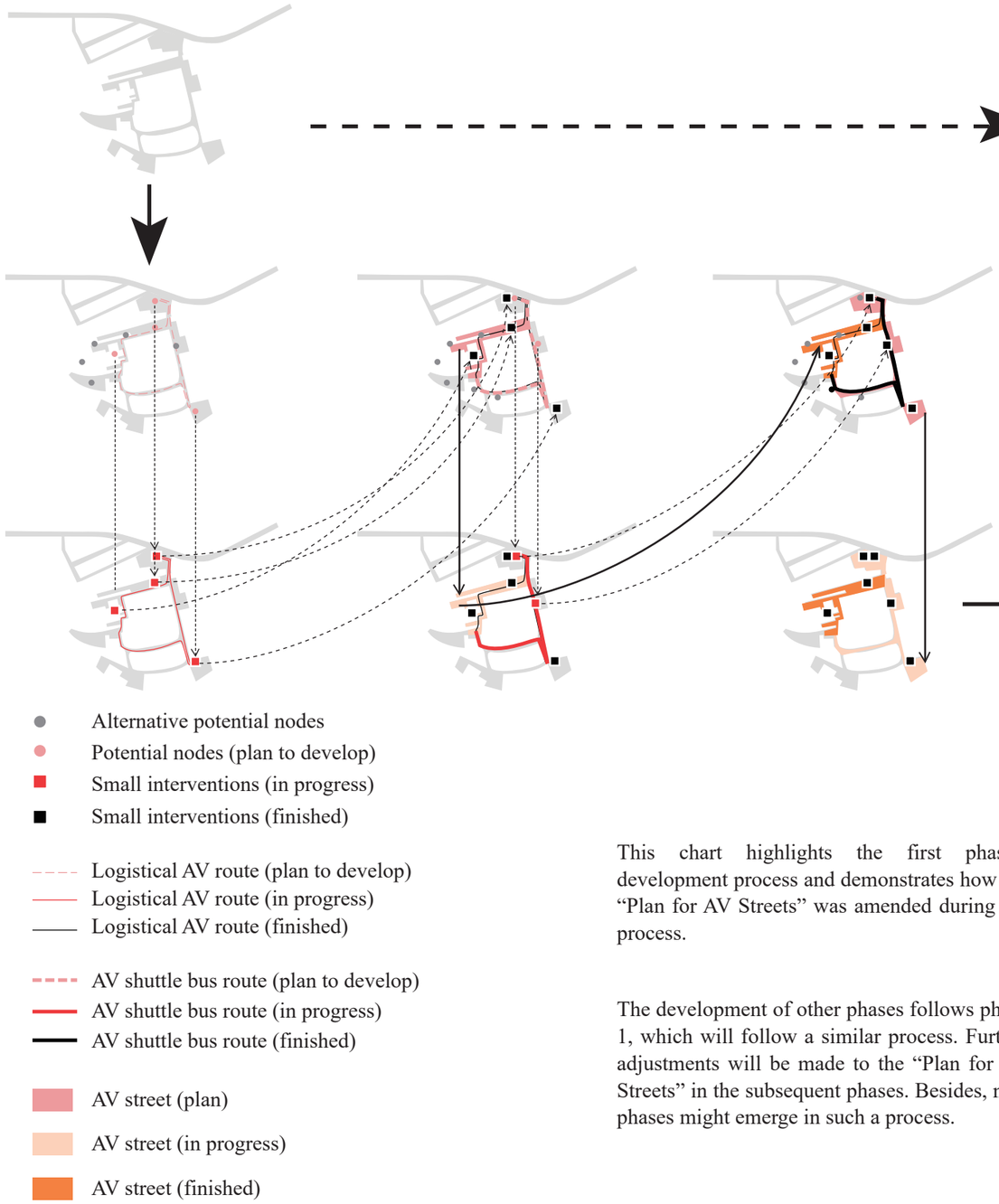


Figure 48: Implementation in round 3 (Illustration: Yukun Lin and Junhao Li)

3.2.3 Phase 1 and onwards

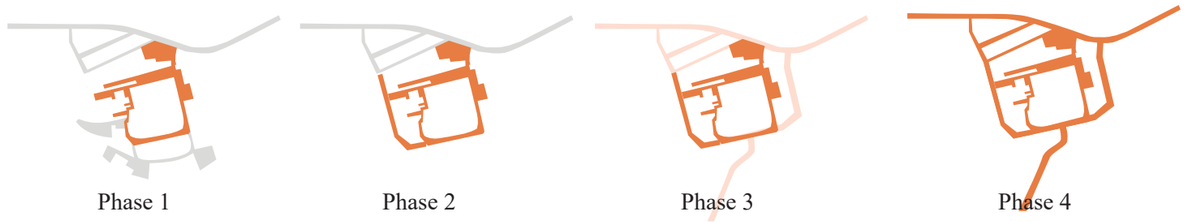


This chart highlights the first phase's development process and demonstrates how the "Plan for AV Streets" was amended during the process.

The development of other phases follows phase 1, which will follow a similar process. Further adjustments will be made to the "Plan for AV Streets" in the subsequent phases. Besides, new phases might emerge in such a process.

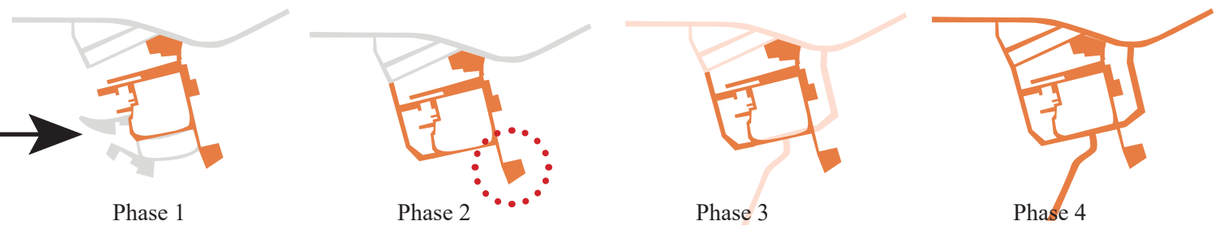
Plan 1.0

"1.0" refers to the original version of the flexible AV street plan. This plan is made before the development starts.



Plan 2.0

"2.0" means this is the first revision of the flexible AV street plan. This plan is based on the development process of phase 1.



Plan n.0

The "n.0" indicates that this plan has had many revisions following the development of phase 1. Below is an example of possible adjustments that may be made.

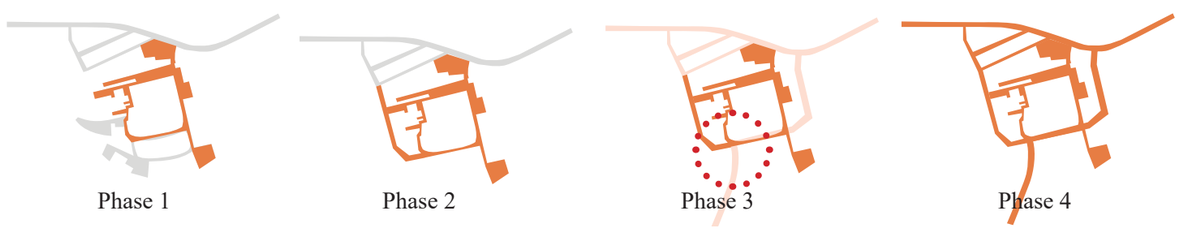
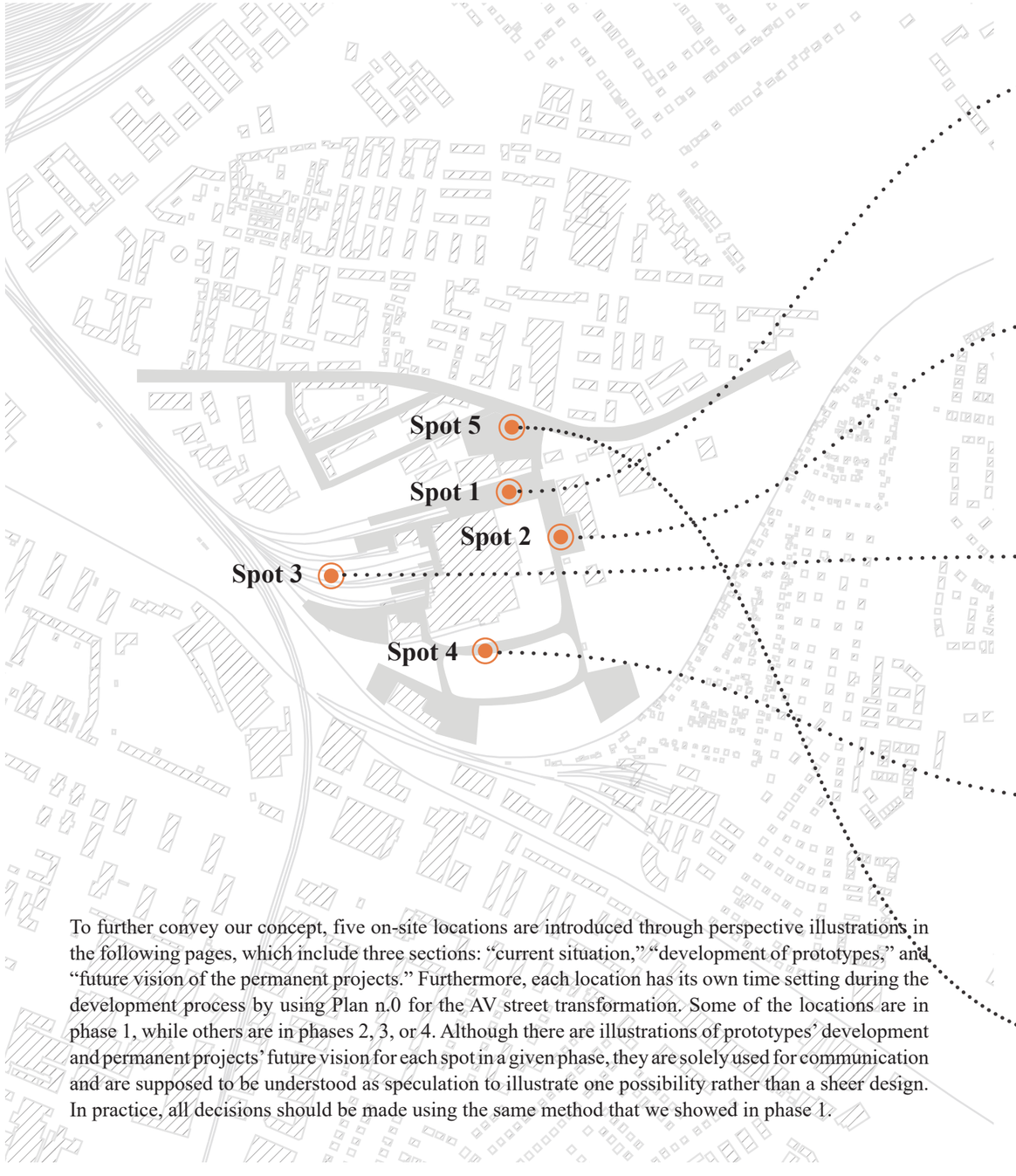


Figure 49: The iterating development of the plans (Illustration: Yukun Lin and Junhao Li based on Diedrich & Dahl, 2020)

3.2.4 Spots



To further convey our concept, five on-site locations are introduced through perspective illustrations in the following pages, which include three sections: “current situation,” “development of prototypes,” and “future vision of the permanent projects.” Furthermore, each location has its own time setting during the development process by using Plan n.0 for the AV street transformation. Some of the locations are in phase 1, while others are in phases 2, 3, or 4. Although there are illustrations of prototypes’ development and permanent projects’ future vision for each spot in a given phase, they are solely used for communication and are supposed to be understood as speculation to illustrate one possibility rather than a sheer design. In practice, all decisions should be made using the same method that we showed in phase 1.

Spot 1

Spot 2

Spot 3

Spot 4

Spot 5

Figure 50: Locations of the spots (Illustration: Yukun Lin and Junhao Li)

3.2.4.1 Spot 1

Current situation

Figure 51: The current situation in spot 1. (Photo: Yukun and Junhao)

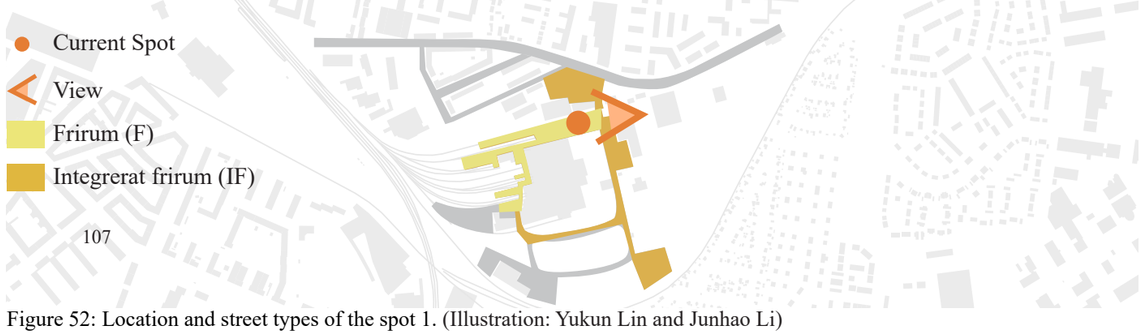


Figure 52: Location and street types of the spot 1. (Illustration: Yukun Lin and Junhao Li)

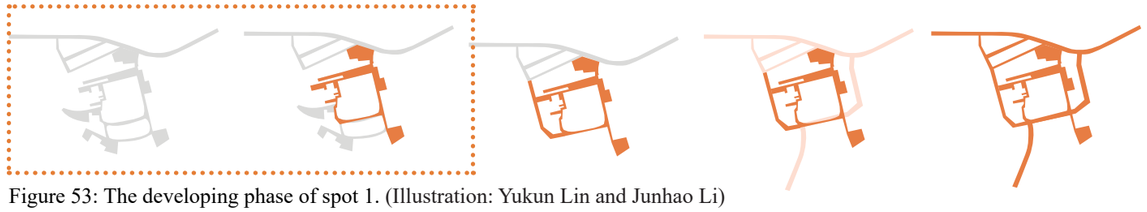


Figure 53: The developing phase of spot 1. (Illustration: Yukun Lin and Junhao Li)

For spot 1, the major changes happen in phase 1. According to the former introduction of phase 1, the existing transport infrastructure in this spot will serve as logistic AVs' infrastructure. The street type here after development will be considered the "Frirum (F).

Development of prototypes

Figure 54: The development of prototypes in spot 1. (Illustration: Yukun Lin and Junhao Li)

Future vision of the permanent projects

Figure 55: Future vision of the permanent project in spot 1. (Illustration: Yukun Lin and Junhao Li)

3.2.4.2 Spot 2

Current situation

Figure 56: The current situation in spot 2. (Photo: Yukun Lin and Junhao Li)

Figure 57: Location and street types of the spot 2. (Illustration: Yukun Lin and Junhao Li)

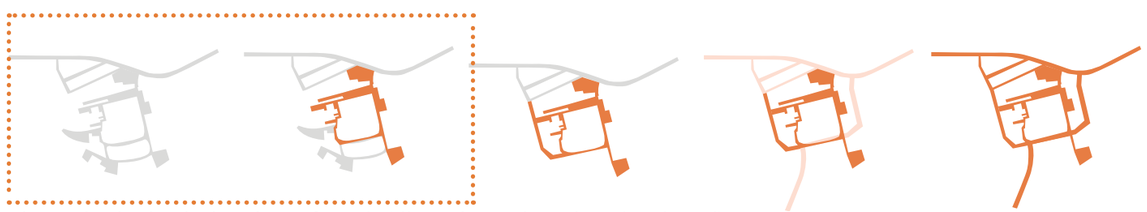


Figure 58: The developing phase of spot 2. (Illustration: Yukun Lin and Junhao Li)

For spot 2, the evolution in phase 1 will be depicted because significant changes occur in this period. However, it is different from spot 1, as mentioned in the previous introduction of phase 1. Spot 2 is located in the area for both logistic AVs and shuttle AVs. The street type here after development will be considered the “Integrated Frirum.”

Figure 59: The development of prototypes in spot 2. (Illustration: Yukun Lin and Junhao Li)

Future vision of the permanent projects

Figure 60: Future vision of the permanent project in spot 2. (Illustration: Yukun Lin and Junhao Li)

3.2.4.3 Spot 3

Current situation

Figure 61: The current situation in spot 3. (Photo: Yukun Lin and Junhao Li)

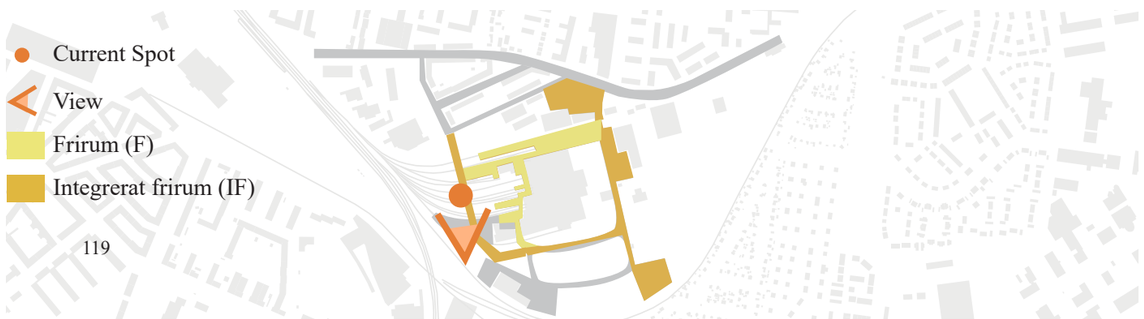


Figure 62: Location and street types of the spot 3. (Illustration: Yukun Lin and Junhao Li)

Figure 63: The developing phase of spot 3. (Illustration: Yukun Lin and Junhao Li)

For spot 3, the development is concentrated from the start to phase 2. The transportation infrastructure for AVs from phase 1 will be expanded in phase 2, and a new AV street will be added. This spot is in the vicinity of the new AV street. The street type here after development will be considered the “Integrated Frirum.”

Development of prototypes

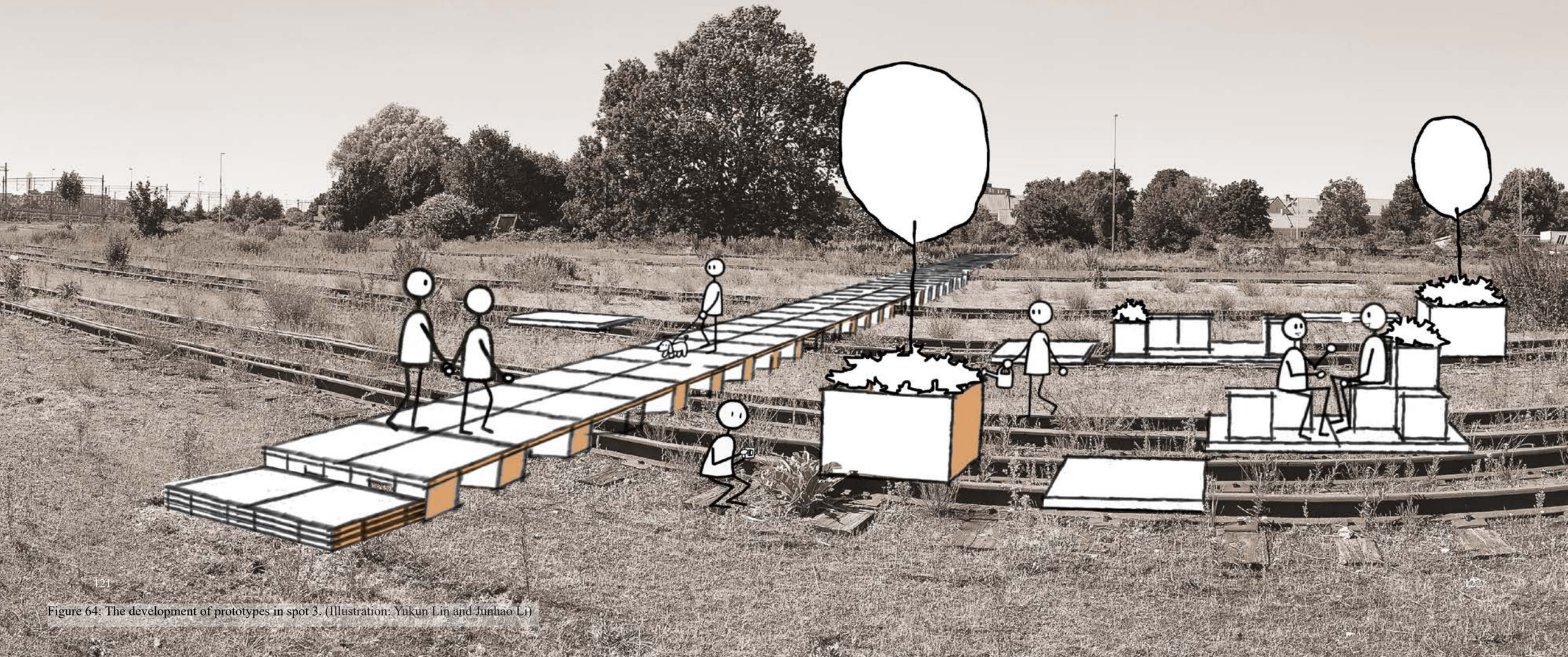


Figure 64: The development of prototypes in spot 3. (Illustration: Yukun Lin and Junhao Li)

Future vision of the permanent projects

Figure 65: Future vision of the permanent project in spot 3. (Illustration: Yukun Lin and Junhao Li)

3.2.4.4 Spot 4

Current situation

Figure 66: The current situation in spot 4. (Photo: Yukun Lin and Junhao Li)

Figure 67: Location and street types of the spot 4. (Illustration: Yukun Lin and Junhao Li)

Figure 68: The developing phase of spot 4. (Illustration: Yukun Lin and Junhao Li)

The major development of spot 4 happens up to phase 3. A new type of transportation infrastructure for both HVs and AVs will be added in phase 3. The location map shows that spot 4 is in the area for this new type of transportation infrastructure. The street type here after development will be considered the “Integrerat transportrum (IT).”

Figure 69: The development of prototypes in spot 4. (Illustration: Yukun Lin and Junhao Li)

Future vision of the permanent projects

Figure 70: Future vision of the permanent project in spot 4. (Illustration: Yukun Lin and Junhao Li)

3.2.4.5 Spot 5

Current situation

Figure 71: The current situation in spot 5. (Photo: Yukun Lin and Junhao Li)

Figure 72: Location and street types of the spot 5. (Illustration: Yukun Lin and Junhao Li)

Figure 73: The developing phase of spot 5. (Illustration: Yukun Lin and Junhao Li)

For spot 5, the major development is considered up to phase 4. The majority of the city's roadways will be AV-only during this phase, and the whole urban area will be an AV-only zone. The street type here after development will be considered the "Mjuktrafikrum (M)."

Development of prototypes

Figure 74: The development of prototypes in spot 5. (Illustration: Yukun Lin and Junhao Li)

Future vision of the permanent projects

Figure 75: Future vision of the permanent project in spot 5. (Illustration: Yukun Lin and Junhao Li)

4. Discussion

The main question this thesis sets out to explore is: How to transform urban streets in the meantime between now and the AVs' era from the perspective of landscape? The research outcome was determined by the responses to four sub-questions. The responses to these four sub-questions will be covered in the discussion chapter. The design framework, which aims to direct the transformation of streets towards a more sustainable future using an operational method of landscape architecture, is another outcome of this study. This chapter will also address the framework's sustainability and reflect on experimental design. Finally, this chapter will end with a discussion and reflection on the merits and challenges of the research strategies.

4.1 The individual research questions

This study demonstrates that considering the street transformation due to AVs from a landscape perspective can have a positive impact on sustainable mobility. It provides a new possible alternative solution, namely, building on design approaches to create a method that guides the sustainable transformation of the AV streets. The results of this study will be presented and reflected on in a discussion formatted in accordance with the research sub-questions in the following section.

4.1.1 Why does looking through the lens of landscape offer a new perspective on sustainable AV street development?

The landscape perspective is compelling because, for achieving more sustainable AV streets, it provides new insights and operational modes that have the possibility to address the problems of contemporary urban street design and respond to the challenges of conceptual designs in current research focusing on AV street transformation.

The general problems of contemporary urban street design, summarised in 2.1.2.2, showcase the reasons why the use of masterplanning protocols is not able to adequately support street transformation in a sustainable way. First of all, streets are simplified as functional spaces; their importance as places for people's social lives is inescapably overlooked, which may lead to the neglect of resources and characteristics and the risk of overconsumption. Second, adopting a top-down approach to "policy-driven" planning tends to lead to blindness to the complex interrelationships between dynamic conditions on the site and the possible "greenwash" phenomenon. Finally, the static and linear planning models are not able to cope with the dynamic social, economic, ecological, and political conditions, which limits the flexibility and adaptability of the planning and design processes.

Considering the street transformation from the perspective of landscape, it is expected to prevent the streets from repeating unsustainable changes under the contemporary model. First of all, regarding the street as a landscape, it breaks the inherent limitations of current street design. It encourages us to consider streets as environments interacting with people, as medium involving and addressing complex dynamic relations, and to think of street design actions as transformative processes. Secondly, design approaches—the fundamental operational method of the landscape architecture discipline—provide streets with the capacity to collectively identify, evaluate, and edit the values and resources that are currently on the site; to intervene across scales in the dynamic relations that are constantly changing; and to propel transformation by accumulating changes through a sequence of incremental and iterative design actions in the meantime between the present and a more sustainable future. Therefore, exploring landscape perspectives and operational methods is valuable to bridge the gaps between problematic urban street design practices and ambitious sustainability goals (see 2.1.2.2).

When the question was further focused on the potential sustainability issues that street transformation due to AVs may encounter, a closer look at the conceptual designs in the relevant research was prompted. Through the inventory analysis based on three scenario concepts (see 2.2), the key challenge of the current conceptual designs was revealed, namely, that they followed traditional masterplanning thinking. They all took a top-down view, focusing on the street transformation at the technological (physical structures adapted to AVs form and function) and network (intelligent mobility management) levels without providing the means to guide and regulate the value-based change of individuals. These operational modes result in difficulties for the public in comprehending the rationale behind sustainable transformation, making them less inclined to change their behaviour to achieve demand reduction. In such a situation, even though the transport system may usher in positive changes in the short term, it will still move towards the opposite of sustainability in the long run due to the pursuit of efficiency and growth. Therefore, an alternative approach was called for to achieve a more radical goal, that is, to update the operational mode of the planning, making it involve more stakeholders in the discussion, decision-making, and implementation. The involvement would allow more people to understand and establish a sense of sustainability in their participation.

Such requests may find a response in design approaches that centre on the urban landscape transformation emerging from landscape architecture. Based on critically improving the working methods of masterplaning, these design approaches underline the full use of site-born incremental design actions through different means, forming a more flexible and adaptable mode of operation to reshape the roles and dynamics of citizens, stakeholders, and authorities in the planning arena. The benefits of these approaches are twofold: first, a greater range of actors can actively negotiate disparate interests to achieve more comprehensive sustainability; and second, their personal involvement in the street design process can impact their mindset and behavioural patterns, thereby promoting the shift in values from the pursuit of efficiency to the reduction of demand.

Although street transformation extends beyond the current landscape types that these design approaches focus on, it is possible to adapt these design approaches to make them valuable to our research (see 2.3).

4.1.2 Who should be involved in the transformation?

Public acceptability drives political acceptability (Banister, 2008); only when there are enough voices to support the transformation can actions take place and changes be sustained. Therefore, for the long-term sustainability of AV streets to become a reality, it requires the active support of all major stakeholders in addition to those in power. The support from the stakeholders depends on values, and the key to changing values is to include more diverse participants in the discussion, decision-making, and implementation of the street transformation process, because participation is the core to promoting understanding of the rationale and mindset change. This study answered the question of who should be involved in the transformation process in two parts: one is the design strategies in 2.3.3, and the other is the "who" part in the design framework in 3.1.1.

By studying the design approaches of three reference transformation projects, the design strategies established the overall tone of the response: that the process of street transformation due to AVs requires 1) a diversity of participants and 2) encourages a wide range of engagement. These two principles entail actively engaging and incorporating a variety of stakeholders, such as government agencies, residents, companies, and NGOs, and making the most of their diverse capabilities to include them in more phases of the transformation process, such as site surveys, planning, design, and implementation (see 2.2.3).

Building on the diversity of participants that the design strategies emphasise, the design framework of this study further compiled a set of typologies that present different types of actors who are considered to be involved in the process of street transformation: municipality, site owner, expert team, organisations, and the public. In most cases, municipalities and site owners are the initiators of the project and have a high voice in the transformation process because they have the right to decide the start and end of a project. The expert team, a think tank composed of traffic planners, landscape architects, engineers, and so on, is usually the promoter and implementer of the project and has a significant say in the development direction of the project. Organisations are profit-making corporations or NGOs that are not affiliated with the government and act as facilitators of a project. They have a slight influence on the direction of the development of the project but have a great deal of discretion on how to use the public space on the street. The public is the promoter of the project and also the most extensive users of the street, but under normal circumstances, their influence on the project is very limited, and it is the most easily ignored voice in the transformation.

It needs to be clarified that the classification of actors is not intended to establish a hierarchy to limit the voice of a certain category in the transformation process, but rather to identify the capacities, interests, and influence of the distinctive actors on the transformation in order to develop a working method that involves and inspires all stakeholders in an effort to achieve synergies. Besides, this study does not encourage such a set of typologies to be fixed, as it cannot be applicable in all cases. This set of typologies aims to provide a reference basis for specific projects. Flexibility to change the composition of the actor types according to the actual situation of the project should be encouraged.

In summary, this study argues that stakeholders at all levels should be given the opportunity to take action during the transformation process. It is also important to actively utilise their distinctive capabilities rather than reducing their voices by focusing on their limitations. As for how to mobilise these actors to influence the transformation in appropriate ways, this study will elaborate on it in the discussion of the next sub-question.

4.1.3 How are design approaches of landscape architecture used?

The third question of how design approaches of landscape architecture are used invites explorations of how design approaches can bridge the gap between masterplanning and on-site design actions to drive changes and how these design approaches can be organised into an exercisable and structured workflow to promote transparency and communication. In response, we proposed the "how" part of design strategies. This part guides what design actions should be taken to link two seemingly competing protocols (see 2.3.3); then, this study further illustrated the visualised process framework to show the organisation of design actions (see 3.1.2).

The strategies for design actions are based on the study of design approaches for dynamic planning, which aim to link the two competing protocols, making the design actions involved plausible to take here and now while signposting towards a probable future (Dahl, 2020; Dahl & Diedrich, 2020). This research suggests that these design approaches have the potential to guide broader urban transformation practices. In order to enable these approaches to generate value for street transformation due to AVs, we have made adaptations to them, combining the advantages of different design approaches to make up for their shortcomings. Thus, design strategies were generated: 1) bridge the overall planning and on-site design actions by combining speculative design with practical testing; 2) practical testing should occur in a recurring and iterative manner and be carried out under a clear process framework; 3) use prototyping as a specific means of practical testing (in which the AV testing route is a special prototype) and integrate it into long-term planning; 4) adopt flexible phased planning, including both testing of the whole site and phased implementation of different site parts (2.3.3).

Drawing upon the design strategies, this study visualised how these design actions are organised in the design framework's "How" section, which is also a detailed workflow chart for design and planning. This chart shows the specific process of iterative testing and flexible phased planning in the form of a timeline. Moreover, by visualising one round in the timeline, the chart elaborates the sequence in which three different actions (site quality investigation, multi-actor workshop, implementation) take place and the patterns in which top-down and bottom-up processes operate and interconnect in each action. In addition, in order to show how distinctive actors exert their different abilities, the design framework also associates and represents the types of actors with their corresponding actions in the chart.

In order to make the design strategies and framework of this study applicable to different situations, better clarification is essential. The clarification includes four points, which will be elaborated on in detail below.

Adaptability of the design framework

Although this study invites people to consider strategies of design actions when embarking on a transformation project and seeks to demonstrate a clearly structured process framework to guide the operational details, we don't think projects should duplicate the template verbatim. Instead, the framework allows for adaptation according to project specificity in order to make the most of its potential.

Master plan as a tool to confirm changes

Both the four strategies of design actions and the framework based on these strategies suggest that, in landscape-oriented street transformation projects, the masterplan, while still in place in name, changes its role from initiating change to confirming it. Specifically, the expert team will make a draft master plan based on development goals and site qualities at the beginning of the project, which can be called Plan 1.0. However, the purpose of Plan 1.0 is not to provide a solution with a fixed vision to initiate changes but to present a possible future scenario of the site as a medium of communication through which other stakeholders can preliminarily understand the concept of the authority and, on this basis, express their views and negotiate interests. The task of initiating change shifts to bottom-up on-site design actions, in which on-site actors build, use, and develop prototypes based on stakeholders' interests and the site qualities they perceive. These actions will not only instigate change on the site but also test the change before confirming it. The initiated changes are then evaluated in the multi-actor workshop. Once the changes are accepted, they will be decided to evolve to the next stage (either removal or upgrade), and these decisions will then be fed back to the masterplan. Plan 1.0 will be adjusted based on the approved decisions and then turned into Plan 2.0. The Plan 2.0 will also serve as a communication medium to start a new cycle of "initiating changes—confirming changes."

Flexible phased planning as a way to implement projects flexibly

The clear function of the streets makes them indispensable to people's daily lives. It connects the various parts of the city and is the place where people travel, whether by car, biking, walking, or otherwise. In view of this fact, in the late stage of the transformation project development, when most of the small interventions in the whole area face the moment of being constructed as permanent projects, it is unrealistic to implement a change for the whole area (see 2.3.2.2 for more details). Therefore, the design framework proposes a compromise solution, which is called flexible phased planning in this study. In site surveys, when it is found that AV routes and other small interventions in a stretch of street achieve balance and dynamic stability, actors will discuss the stretch’s further development in workshops. Once actors agree that this stretch of the street and all its existing interventions can be developed into a permanent project, these interventions will be packaged into a unit along with the stretch itself. Actors will then finalise a plan for this unit according to the situation of the site and then carry out construction. After the completion of some such units, the construction of units in other stretches started, so there are always passable streets in the street network to meet the needs of daily use. The range of a unit can be a section between two intersections; the street network will be transformed in the development of one unit after another.

Such an operation smacks of masterplaning's phasing method. However, it is more flexible than the phasing method in that it still supports the prototyping method for whole-site testing. For a small intervention, the prototyping process will continue until it is packaged into a unit. While some units are under construction, the prototyping processes of other interventions on the site will not be affected and will continue.

Opportunities for distinct actors to influence transformation

The framework maps the correspondence between actors and different design actions in the chat of "how" (see 3.1.1). The aim is to demonstrate an organisational mode through which the change in the values of people will be supported and guided. As discussed in the second sub-question, certain types of actors have certain resources, perspectives, and capabilities. They should influence transformation in different and appropriate ways. This difference leads to the treatment of the two competing protocols in this study, which conceptually separates a top-down strategic planning process from a bottom-up "site-inspired" design process and recognises that both have their own characteristics and abilities. However, in the process of street transformation, it is advocated to make the two processes coexist and link them through design approaches. The coexistence of the two processes implies that actions of different characteristics will occur, which opens up the possibility of assigning appropriate opportunities for action to distinctive actors.

Specific types of actors, such as municipalities, site owners, and expert teams, usually have more power, more resources, or more expertise and skills, which enables them to have greater influence in the transformation process. Therefore, they need to assume more responsibilities in the policy-driven top-down process, such as formulating the overall goal of transformation and development, conducting site surveys, analysing and presenting from a professional perspective, and so on. Of course, this does not mean that less influential actors, such as the public and organisations, will be given less opportunity to influence the transformation because of their limitations; on the contrary, they will play an important role in the bottom-up design actions on the site. As the most extensive future users of the site, they were empowered in the formal multi-actor workshop to express their site understanding gained from design actions and daily use from a "first-person perspective."

The views expressed by actors participating in bottom-up activities will subsequently influence the type and location of newly introduced interventions; equally important, their perceptions of interventions that already exist on the site also impact the durations or time frames of those interventions. Besides, the influence of the public and organisations is reflected in the implementation and use of small interventions. Prototypes built jointly by people as testing beds can also be developed through people's daily use. In such a process, not only are transformational projects advanced, but also the knowledge, arguments, and values of all actors with an interest in the quality of their streets are communicated. People are encouraged and guided by each other in the implementation of design actions to form a common position in pursuit of street sustainability.

4.1.4 When to take what action

The French art critic Nicholas Bourriaud (2009:113) once said, “Time is one of the coordinates of space.” For street transformation, which generates and accumulates spatial changes in the process of development, time is a key dimension of design and planning. In this study, there are three main concerns about the time-based part of street transformation: First, of the two competing protocols for the transformation process, which one should be taken at what point in time? Secondly, how to manage the different time frames for interventions. The third is how to help the actors position themselves in timelines so that they understand the stage of the project and the changes that have taken place on the site. The three concerns work together to answer the question of when to take what action.

The adoption sequence of two competing protocols in the transformation process

The proposition that two competing protocols can coexist during street transformation is both suggested in the design strategies (see 2.3.3) and discussed in the previous sub-question. The flowchart of design actions in the design framework (see 3.1.2 figure 4) demonstrates the process in more detail, involving the sequence of different actions, which responds to the concern of when to adapt which protocol.

Although a top-down masterplanning process and a bottom-up “site-inspired” design process coexist in the process of transformation, they do not always occur continuously and simultaneously; there are sequences between them. On the basis of two basic premises: “site quality investigation predates multi-actor workshop, which is based on investigation results" and “implementation postdates multi-actor workshop, which determined the development direction of one spot”, this design framework could deal with the iterative process in figure 4 (see 3.1.2). Such an iterative process takes the action sequence of "site quality investigation—multi-actor workshop—implementation" as one round and promotes development round by round. Thus, this framework reveals the link pattern between top-down masterplanning and bottom-up “site-inspired” design actions.

From the illustrations (figure 4) in 3.1.2, we can intuitively see that this cycle is divided horizontally into three actions: site quality investigation, multi-actor workshop, and implementation. Internally, these three actions are divided into two parts vertically: top-down activities and bottom-up activities.

In the "site quality investigation," which is the first action in a round, top-down and bottom-up activities can occur simultaneously. The top-down activities presented in the top half of the image (figure 10) are carried out by the expert team, including the field work of investigating the site from a professional perspective; desktop study to research and review the existing information about the site through resources such as maps and paper records; sorting through the above data and selecting candidate potential nodes of the sites; and so on. The bottom-up activities in the bottom half of the image (figure 10) are an unintentional and spontaneous site investigation. Specifically, it means that when the public and organisations carry out on-site design activities (such as building together) or use the site for daily activities, they unconsciously form a cognition of the materials, atmosphere, and practices of the site. Although unprogrammed, this bottom-up process is also recognised as an investigation of the site qualities, and the results are allowed to be communicated in subsequent workshops. There might be

some overlap in the timing of these two processes, which is beneficial in certain ways. For example, expert teams are able to investigate the site when the public or organisations are using it; this aids in the "site quality investigation," because how people use the site may reflect some of its characteristics.

As for the "multi-actor workshop" action (figure 11), the top-down activities will take place initially, followed by the bottom-up activities. In this action, the top-down activity is a pre-workshop involving the municipality, site owner, and expert team, aiming at preparing materials for the following formal multi-actor workshop. The specific content of the top-down activity involves discussing and making a Plan 1.0 (if it is the first round) or updating the plan according to the on-site changes confirmed, for example, updating the Plan 1.0 into 2.0 (if it is the second round). The pre-workshop results are then used to inform a formal workshop. This workshop is open to all sorts of actors. The main content includes discussing which potential nodes should introduce interventions based on site qualities, evaluating new or enhanced interventions, developing plans for permanent projects, etc. In short, the order of the two activities in this action is fixed because one is the preparation of the other.

Regarding the third action, "implementation,"(figure 12) the order in which the two activities occur is uncertain. Here, bottom-up activities refer to jointly building prototypes by multiple actors according to decisions made in the workshop and developing the prototypes during usage. Top-down activities refer to the construction of permanent on-site projects, which are usually carried out by an expert team and supervised by the site owner and municipality. The construction decision for permanent on-site projects was finalised in the workshop. The premise of decision-making is that the value of some prototypes was recognised, and it was unanimously decided that they should be scaled up and their duration should be extended for a long time. Therefore, for a single project, it can be said that the bottom-up activities of implementation take place before the top-down activities, and the time difference between them is more than one round. However, for different projects in the same round, there is no fixed order for these two types of activities of implementation. In such a case, the order will be determined by stakeholders based on the readiness of each project.

In short, the flowchart of design actions in the framework highlighted the sequence and link between the top-down masterplanning process and the bottom-up "site-inspired" design process.

Different time frames and their conversion

A distinctive feature of the street transformation guided by the landscape design approach is that the site will be transformed incrementally, intervention by intervention. However, any design intervention for the street transformation is to some extent piecemeal, even fragmented, as these interventions are built at different times and locations on the site and have distinct durations. It is the periodical survey and assessment of the entire site that connects all of the interventions to the larger whole.

The perspective of the landscape requires the simultaneous existence of various temporalities, which counteract the linear and successive processes (Dahl, 2020). But different and sometimes shifting temporalities and durations produced complex relationships and connections in the process of street transformation. If they are left unorganised, the direction of the transformation will become increasingly

ambiguous and eventually slow down. Thus, there is a demand for a clear method to structure the temporalities of the interventions and make them functional.

In response to this demand, the design strategies of this study specify that interventions are supposed to be coded and regulated in three distinct time frames: prototypes, temporary projects, and permanent projects (see 3.1.3 figure 14). The method using three time frames to organise design interventions draws upon the design approach of prototyping, which was conducted in the Jubileumsparken 0.5 project and summarised in the research work of Caroline Dahl and Lisa Diedrich (2020) . When applying it in this study, different time frames not only mean that interventions have different durations on the site: prototypes for 0–5 years, temporary projects for 5–15 years, permanent projects for more than 15 years, and until the next transformation, but they also hint at the stage the interventions are in: an intervention with a shorter duration has the possibility to evolve into a longer-lasting one; otherwise, it will be removed from the site after its planned duration.

Figure13 in the part When of the design framework (see 3.1.3) further showcases the way to navigate interventions in various time frames in detail. One point that needs to be clarified is that the adoption of various and flexible time frames relies on an iterative process. When an intervention is decided in the "multi-actor workshop" to be introduced to the site, it is first built on potential nodes in the form of a prototype in the "implementation" action in the same round. After that, the prototype will undergo continuous changes due to exposure to wind and sun, people's use, and so on. The following round's investigative activity will look into these changes. Based on the investigation results, the prototype will be evaluated in the "multi-actor workshop" of the next round. The assessment in the workshop will then expose this intervention to one of three fates: being removed, kept as a temporary project, or developed into a permanent project.

To be removed, as the name implies, is to be taken down from a site because a prototype is deemed not to match the site. The retention as a temporary project means that the value of the prototype is recognised to a certain extent, and it is expected to remain on the site for people to use for a longer period of time under the condition that the scale and form are unchanged or slightly changed. The development of a permanent project represents a deeper recognition, so it is hoped that this prototype can expand its scale while retaining its original function and providing relatively fixed services on the site in a stable and long-term form. Compared with the other two, an intervention that is retained as a temporary project has more room for manoeuvre. It will remain largely intact until it is faced with these three options again in a subsequent round of evaluation.

In summary, various and adaptable time frames enable actors to better comprehend layers of change and their own pace of operation, thus facilitating design interventions with distinct and changing temporalities to co-exist in an organised way on the site and develop in an orderly manner in the time dimension.

Synchronising the two timelines by periodically updated plans

The street transformation towards a sustainable future will take time. In order for the time cost of transformation to be understood and accepted, it is necessary for actors to have the ability to locate the progress of transformation in the temporal dimension; in other words, be aware of the current state of a constantly changing site and its distance from sustainable street goals. Achieving this state requires stakeholders to be involved in the transformation process of the street and, more importantly, to share multiple information and perspectives in the process to synchronise different timelines.

The dual-track planning and design process allowed the transformation project to have two timelines: the progressive phases of the master plan represent the planned timeline, while the ongoing occurrence and evolution of design activities scattered across the site represent the real timeline. The urban planning practice tells us that under the two time systems, double blindness is easy to occur (Dahl, 2016).

It is difficult for the actors engaged in top-down activities to be aware of the specific trends happening on the site in real time. Meanwhile, it is challenging for those working on the site to perceive changes in the planned timeline (such as changes in the bigger picture and changes to the master plan). Without a measure to periodically synchronise the two timelines, the differences in the two timelines will become so large that they will lose relevance altogether. Stakeholders on both sides will also lose track of each other's timeline, and thus the transformation project will be trapped in a dilemma.

Periodically updating the visualisation scheme, this study argues, is the key to synchronising the two timelines, as this process requires that those working and participating on the site constantly become familiar with the ongoing planning process and that those not working on the site continuously recognise the changing site dynamics. The process of periodically updating is illustrated in figure 11 of the design framework and will be further elaborated in the following.

The initial drafting of the visualisation scheme, Plan 1.0, is done through top-down activities. It includes the cognition and imagination of the expert team, municipality, and site owner for the whole site, so it follows the planned timeline. In the following formal workshop, two groups that play a major role in the bottom-up activities—the public and organisations—will get a glimpse of the planned timeline through the presentation of Plan 1.0. With Plan 1.0 as the object of discussion, the two groups will express different views and opinions on the proposed potential nods and forms of prototypes in the plan. After a multi-actor discussion, an agreed-upon master plan is created to guide subsequent implementation. During the bottom-up activities of implementation, prototypes will then be built together by various actors on the site and may partly deviate from the masterplan in practice and in use. This represents the actual timeline on the site, and the deviation from the planned timeline is almost unavoidable (Dahl & Diedrich, 2020). Thereafter, the changes to the site in the real timeline will be confirmed in the site investigation action in the next round and also fed back to the expert team, municipality, and site owner in the pre-workshop. Through this feedback process, the three groups engaged in top-down activities were connected to the real timeline of the site. Moreover, according to the confirmed changes, the masterplan will undergo modifications, evolving from Plan 1.0 to Plan 2.0, which means that the planned timeline is synchronised with real time for the first time. Since then, the

visualisation scheme will be iterated periodically in the same way, continuously serving as a medium for communication between different actor groups and a tool for synchronising the two timelines.

By participating in the process of iteratively updating the visualisation scheme, different types of stakeholders are more fully aware of the timeline of the site, whether planned or real. For one thing, this process helps stakeholders understand the complexity of the street transformation to a sustainable future, which in turn encourages them to accept and support the time costs of that transformation. For another, this process enhances dialogue, promotes transparency, and helps to increase confidence in the entire transformation process.

4.2 The sustainability degree of the design framework for street transformation due to AVs

By mapping existing conceptual designs of AV streets into three scenarios (see 2.2), this study reveals the common sustainability challenge of these designs, namely their inability to achieve a long-term transformation by influencing people's values. The design framework was proposed to address precisely this challenge, aiming to provide a possible solution for the transformation of AV streets. However, how sustainable this design framework is needs to be further discussed. In order to better illustrate the sustainability of the design framework, it is necessary to subject it to the same test as the conceptual design, that is, to map the design framework to three scenarios using the gradient table in 2.3.3 as the criteria.

The framework proposed is intended to provide guidance for a street transformation that is considered in this study to contribute to the realisation of the scenario Limits to Urban Growth (L). The discussion of the determinants of membership will be unfolded as follows:

According to the 'who' section of the design framework, a variety of stakeholders will act as participants in the project. From policymakers, site owners, and the expert team, who have a larger say, to on-site organisations and public individuals, who are typically difficult to impact on the project, they are all included in the project process. Complex and diverse perspectives allow different interests, needs, knowledge, and values to be communicated, and the possibility of value shifts increases as people understand the rationale behind sustainability in organised communication. The inclusion of more diverse participants in the transformation process shows that what drives the transformation is not only the pursuit of efficient and smart networks but also the renewal of values.

The part of How in the design framework suggests that what this framework aims at is not only the shift of street form or smart network of AVs but also a radical change of the operational mode to guide the transformation process. This goal resulted in a critical adjustment to contemporary top-down planning. Although the masterplan still nominally remains, its function varies. AV street transformation projects are no longer built in one move on a site after top-down planning. Instead, it integrates bottom-up, site-inspired design actions into the planning process through a transparent, coherent, and systematic

working method, enabling actors to repeatedly build, test, and evaluate prototypes on the site to influence the master plan. Permanent projects are also implemented in a flexible manner in stages, incrementally completing the transformation of the entire street network. This approach means that, beyond traditional planning thinking, the development plan is no longer fixed but needs to be constantly modified according to the on-site design actions during the transformation process. Broad participation in street planning will create a belief among actors that even individual contributions are important for sustainable development. This perception is essential and is the basis for a change in public mindset and behaviour.

In the part When of the design framework, we can see that the iterative process enables the transformation project to have a plan open to change rather than a static vision. The use of various prototypes with three distinct time frames reflects that the expected result of change is a reduction in demand. It is because, rather than only focusing on traffic functions, prototyping aims to insert various functions in streets and let them become permanent projects over time, which will result in more space for the public and less for transport in streets. In this case, the demand for traffic would decrease based on the connection between invitations and behaviour (see 2.1.1.4 for more details). Moreover, benefiting from the time awareness cultivated in the participation process, people's values change and will accept the time cost of a long-term interest.

By summarising the contents discussed in accordance with the checklist of three scenarios, we created table 6. The Limits to Urban Growth envisions a scenario in which established systems are transcended through radical change and guidelines and norms are formed to guide individuals to reduce the demand for transport in order to achieve long-term sustainability. According to the discussion and Table 6, the design framework proposed in this study responds to these characteristics to some extent. Thus, this design framework can be considered intended to guide a street transformation that contributes to the realisation of the Limits to Urban Growth scenario. The results reflect an improvement in supporting more complete and long-term sustainability than existing conceptual designs.

Main actor involvement	Municipality, site owner, expert team, organisations, and the public	Main object of change	Not only include the street form and the smart network, but also the system of generating them.
Main driver	Value based renewal	Scale	From systemic to individual level
Change approach	Critical change of masterplanning by integrating on-site design actions; Masterplan still remains but is with a different function	Time horizon	Long term focus: with the change of values, people accept the time cost of a long-term interest

Solution approach	Improvement through system renewal/change and value change	Consequences for transport	Demand reduction & accessibility through proximity: through the design result guided by the design framework

Table 6: Mapping design framework for AV street transformation to three scenarios.

4.3 Experimental design: AV street transformation in Lokstallarna, Malmö

In the case study chapter, this thesis presents an experimental design. Here are some explanations and reflections on it.

The difference between the thesis structure and research process and its reason

In contrast to the research process, the thesis structure places the experimental design and design framework sections in a different sequence.

The research process unfolded as follows: using the experimental design method, design strategies compiled from a literature review were applied to a site. Subsequently, through the process of experimental design, a more detailed and instrumentalized approach than the initial design strategies emerged. This was summarised and charted as the design framework. In terms of timeline, experimental design preceded the formulation of the design framework. However, in the specific process, the two influenced each other through iterative and reflexive practices, with their durations almost overlapping.

However, in terms of thesis structure, this thesis presents the design framework section before the experimental design section. The primary reason for adjusting the order is to enhance readability and communicability. The presentation of the experimental design process and results can serve as a complementary interpretation of the design strategies and framework. The structure of the content is designed to guide the reader seamlessly through the research outcomes. By presenting the design framework first and the experimental design subsequently, its concepts become more accessible.

The presentation of phases and spots

The presentation of the experimental design in this thesis is divided into two parts: phases (see 3.2.1-3.2.3) and spots (see 3.2.4). The former provides a conjecture on the process of AV street planning and design, with the purpose of clarifying which actions by various actors in the street transformation process are operable and how they are implemented. The latter offers visions of specific spots on the site at different project stages, aiming to help the reader understand how certain streets on the site are transformed into a permanent project using the prototyping method.

Why choose Lokstallarna as the site?

In theory, street transformation may commence on streets in any part of the city. Why, then, did this study choose Lokstallarna—a post-industrial site—as the target for experimental design? Several general reasons are addressed in discussions to determine the applicability of design approaches to street transformation (see 2.3.2.1). A more detailed explanation specific to Malmö follows:

Firstly, the streets of Lokstallarna can serve as a transitional site before applying the operational method for AV street transformation to regular streets. Design approaches originated from transformation projects on post-industrial sites, making such a site an ideal starting point. This allows for better utilisation of the experience accumulated from these design approaches. Furthermore, initiating the project on a post-industrial site provides flexibility to adjust and improve the operational method as needed. Secondly, Lokstallarna holds a unique position in Malmö. On one hand, it is within the city, surrounded by residential areas, and not far from the city centre. The main street passing through it even connects with Nobelvägen, the busiest street in Malmö. On the other hand, it is somewhat excluded from the city's daily use.

Given these points, Lokstallarna is an ideal starting point for a city-level AV street transformation in Malmö. In the early stages of the project, testing AV routes and other prototypes can proceed more smoothly. In later stages, the AV street transformation can naturally extend to the more vibrant surrounding areas and streets. Furthermore, since Lokstallarna is located in prioritised development areas, using it as a starting point aligns with Malmö's overall development plan.

4.4 About research strategies

Through a thorough qualitative analysis of the selected materials, we attempt to theoretically explore the reasons why the landscape perspective is promising for a sustainable AV street transformation in the first part of this study, the literature study. We also seek to explore potential avenues for achieving sustainable AV street transformation from a landscape perspective. Therefore, we decided to use the interpretation strategy to guide this section, which has the following advantages, even though it will make the research findings more subjective and have poor universality:

Firstly, because the AV technology is not yet mature, there is a lack of research and practice related to the sustainable transformation of AV streets. For such a relatively new topic, it is necessary to understand and introduce existing knowledge from other fields. Due to the tolerance of the subjective understandings of authors, the interpretation strategy could provide rich, detailed insights into the meanings and perspectives of the research materials, helping to uncover underlying motivations, values, and reasons. This helps us to better analyse the selected research materials and relate them to our research topic. Just like the interpretation and application of concepts and theories in this study, such as sustainable mobility, three scenarios, process models, etc. Secondly, its exploratory nature helps us to propose the hypothesis that landscape perspective has the potential to guide sustainable AV street transformation and further explore the adaptive adjustments of landscape design methods under this topic.

The projective design strategy is used to guide the second part of the study, the case study. This research strategy is selected to project the design strategies of AV street transformation proposed in the first part of this study into a specific experimental design scheme, expecting to convert the abstract and theoretical design strategies to a more design-directed and instrumentalized transformation method in such an experimental design process.

Due to the subjective and individual nature of design actions, the contribution of the research results guided by this strategy to universal problems is controversial (Deming & Swaffield, 2011). Furthermore, due to the attempt to theorise the design results, the design process becomes complicated, making the research results in this study neither as rigorous as the pure theory construction nor as comprehensible as the empirical design knowledge. However, this strategy well bridges the gap between abstract theoretical guidance and concrete design experience. Because design as a kind of research allows theoretical knowledge to be projected in design, and design results in turn contribute to theoretical knowledge.

In conclusion, the benefits of these two strategies outweigh the challenges because our study is more about exploring a new possibility than producing a rigorous, generalised finding. Specifically, we are aiming at exploring the possibility of achieving sustainable AV street transformation from a landscape perspective and seeking the possible design methods from the landscape architecture discipline to realise such a possibility. Besides, to make the research process and results easier to understand, we visualised both the experimental design process and the resulting AV street transformation framework.

5. Conclusion and future outlook

5.1 Conclusion

The primary focus of this thesis has been to explore how to transform urban streets in the meantime between now and the AVs' era from the perspective of landscape. This question attempts to look for specific strategies and an operational method to guide a transformation process and is therefore broken down into four more specific questions: Why does looking through the lens of landscape offer a new perspective on sustainable street development? Who should be involved in the transformation? How are the design approaches of landscape architecture used? When to take what action?

In the process of exploring these four sub-questions, design strategies for AV street transformation have been summarised in literature studies. To put it simply, these strategies are as follows: 1) Involving various participants in the transformation process; 2) adopting design approaches of landscape architecture to instigate changes; 3) building the ability to navigate temporalities.

Furthermore, based on these design strategies, a design framework for AV street transformation has been created, which is a specific operation method proposed in this study. It visually shows how various design actions can be organised into a workflow and how different types of actors can work together to initiate design actions. The results of this article also include an experimental design, which can be regarded as a supplementary explanation and application demonstration of the design framework, showing a possible process of AV street transformation from a landscape perspective. In fact, the experimental design and the design framework were formed by interacting in a reflexive process.

In summary, this study contributed to the argument over the importance of landscape perspective and the operational method of landscape architecture in street transformation by considering AVs. It also provides a possible solution for supporting more sustainable street transformation due to AVs.

5.2 Future outlook

This paper discusses the transformation of AV streets from a landscape perspective, focusing more on the spatial transformation. The impacts of AV technology on street space are borrowed from existing AV-related conceptual designs and research. They are not enough to foresee the exact AV street forms. Thus, future studies can also add the perspective of transport technology to further explore the changes in the relationship between people and vehicles, between vehicles and roads, and between people and roads in the AVs era, so as to provide more references for spatial transformation. Besides, from the perspective of landscape, in addition to the process model selected in this study, some models and methods in landscape urbanism also have the potential to contribute to our topic. It is a valuable future research direction to extensively relate and analyse them in the AV street transformation context.

The experimental design part of the case study is only based on the author's work combined with the interview with the city planning office, which cannot reflect a truly complex urban planning context. Adding more diverse stakeholders to a more realistic simulation of AV street transformation and even moving beyond the simulation and applying this design approach to real projects is an interesting follow-up study. In addition, we chose to conduct such a design simulation at a post-industrial site due to its unique advantages as a starting point for a street transformation project (see more details in 2.3.2.1). The particularity of the post-industrial site makes such simulation results inevitably have some distinctiveness. Therefore, it will also be a valuable study in the future to conduct such a design simulation in a more ordinary urban area.

6. References

Alessandrini, A., Campagna, A., Site, P.D., Filippi, F. & Persia, L. (2015). Automated Vehicles and the Rethinking of Mobility and Cities. *Transportation Research Procedia,* 5, 145-160. https://doi.org/https://doi.org/10.1016/j.trpro.2015.01.002

Anderson, J.M., Kalra, N., Stanley, K.D., Sorensen, P., Samaras, C. & Oluwatola, T.A. (2016). *Autonomous Vehicle Technology: A Guide for Policymakers*. Santa Monica, CA: RAND Corporation. https://doi.org/10.7249/RR443-2

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy,* 15(2), 73-80. https://doi.org/https://doi.org/10.1016/j.tranpol.2007.10.005

Berger, G., Feindt, P.H., Holden, E. & Rubik, F. (2014). Sustainable mobility—challenges for a complex transition. *Journal of Environmental Policy & Planning,* 16(3), 303-320.

Bergevoet, T. & van Tuijl, M. (2016). *The Flexible City: Sustainable Solutions for a Europe in Transition*. Nai010 Publishers.

Black, W.R. (2010). *Sustainable Transportation: Problems and Solutions*. New York, NY, USA: Guilford Publications.

Bourriaud, N. (2009). *The Radicant.* New York: Sternberg Press

Braae, E. (2015). *Beauty Redeemed: Recycling Post-Industrial Landscapes*. Basel: Birkhäuser.

Bullivant, L. (2012). *Masterplanning Futures*. London: Routledge. https://doi.org/10.4324/9780203720684

Castillo, H. & Pitfield, D.E. (2010). ELASTIC–A methodological framework for identifying and selecting sustainable transport indicators. *Transportation Research Part D: Transport and Environment,* 15(4), 179-188.

Corbusier, L., Eardley, A. & Giraudoux, J. (1973). *The Athens Charter*. New York: Grossman Publishers.

Corner, J. (1999). Recovering landscape as a critical cultural practice. In: *Recovering Landscape: Essays in Contemporary Landscape Theory*. Princeton Architectural Press.

Council of Europe (2000). *European Landscape Convention (ETS No. 176)*. Florence. http://conventions.coe.int/Treaty/en/Reports/Html/176.htm. [Accessed 15th February 2022].

Cross, N. (2006). Designerly Ways of Knowing. In: *Designerly Ways of Knowing*. London: Springer London. 1-13. https://doi.org/10.1007/1-84628-301-9_1

Dahl, C. (2016). Gothenborg's Jublieumsparken 0.5 and Frihamnen: explorations into the aesthetic of DIY. *Spool,* 3(2). https://doi.org/10.7480/spool.2016.2.1115.g1500

Dahl, C. (2020). *Building transformative capacities: Links between site and plan in post-industrial urban landscapes.* Diss. Alnarp: Swedish University of Agricultural Sciences. https://res.slu.se/id/publ/105445

Dahl, C. & Diedrich, L. (2020). Building transformative capacities: integrating design research into port-city transformation. *PORTUSplus,* 9, 1-21.

Deming, M.E. & Swaffield, S. (2011). *Landscape architecture research : inquiry, strategy, design*.

Diedrich, L. (2013). *Translating Harbourscapes. Site-Specific Design Approaches in Contemporary Harbour Transformation.* . Diss. Frederiksberg: University of Copenhagen. https://soeg.kb.dk/permalink/45KBDK_KGL/fbp0ps/alma99122756178305763

Diedrich, L. & Dahl, C. (2016). Ile de Nantes 2000–2010: a method for the meantime? *Journal of Landscape Architecture,* 11(2), 72-83. https://doi.org/10.1080/18626033.2016.1188576

European Commission (1992). *Green Paper on the Impact of Transport on the Environment. A Community Strategy for*
'Sustainable Mobility', COM (92) 46 Final. Brussels, Belgium: Commission of the European Communities. https://op.europa.eu/en/publication-detail/-/publication/98dc7e2c-6a66-483a-875e-87648c1d75c8 [Accessed 15th November 2022].

Gallo, M. & Marinelli, M. (2020). Sustainable Mobility: A Review of Possible Actions and Policies. *Sustainability,* 12(18). https://www.mdpi.com/2071-1050/12/18/7499

Geels, F.W. & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research policy,* 36(3), 399-417.

Gehl, J. (2010). *Cities for people*. Washington, DC: Island press.

Gudmundsson, H. & Höjer, M. (1996). Sustainable development principles and their implications for transport. *Ecological economics,* 19(3), 269-282.

Heaton, J. (2008). Secondary analysis of qualitative data: an overview. *Historical Social Research,* 33(3), 33-45. https://doi.org/https://doi.org/10.12759/hsr.33.2008.3.33-45

Heinrichs, D. (2016). Autonomous Driving and Urban Land Use. In: Maurer, M., Gerdes, J.C., Lenz, B. & Winner, H. (eds) *Autonomous driving: Technical, legal and social aspects*. Berlin, Heidelberg: Springer Berlin Heidelberg. 213-231. https://doi.org/10.1007/978-3-662-48847-8_11

Hickman, R. & Banister, D. (2014). *Transport, climate change and the city*. Routledge.

Hildermeier, J. & Villareal, A. (2014). Two ways of defining sustainable mobility: Autolib'and BeMobility. *Journal of Environmental Policy & Planning,* 16(3), 321-336.

Holden, E., Gilpin, G. & Banister, D. (2019). Sustainable Mobility at Thirty. *Sustainability,* 11(7). https://www.mdpi.com/2071-1050/11/7/1965

Jacobs, A.B. (1993). *Great Streets*. Cambridge, Mass: MIT Press.

Jacobs, J. (1961). *The Death and Life of Great American Cities*. New York: Random House.

Jarzombek, M. (2008). A green masterplan is still a masterplan. In: Ruby, I. & Ruby, A. (eds) *Urban Transformation*. Berlin: Ruby Press. 22-29.

Johansson, R. & Linderholm, L. (2016). *VGU-guide : Vägars och gators utformning - Utformningsprocess*. Borlänge: Trafikverket. [Accessed 12th April 2022]

Julsrud, T.E. (2014). Activity-based patterns of everyday mobility: The potential for long-term behaviour change across five groups of travellers. *Journal of Environmental Policy & Planning,* 16(3), 401-417.

Karsten, L. (2005). It all used to be better? Different generations on continuity and change in urban children's daily use of space. *Children's Geographies,* 3(3), 275-290. https://doi.org/10.1080/14733280500352912

Kumar, S., Shi, L., Ahmed, N., Gil, S., Katabi, D. & Rus, D. (2012). CarSpeak: a content-centric network for autonomous driving. *SIGCOMM Comput. Commun. Rev.,* 42(4), 259–270. https://doi.org/10.1145/2377677.2377724

Larsson, S.L. & Urde, I. (2013). *Healing the city through city street – A study of the potential of Nobelvägen as a city street.* Department of Landscape Architecture, Planning and Management. Swedish University of Agricultural Sciences. https://stud.epsilon.slu.se/6304/

Lautso, K. & Toivanen, S. (1999). SPARTACUS system for analyzing urban sustainability. *Transportation Research Record,* 1670(1), 35-46.

Lee, S., Jang, K.M., Kang, N., Kim, J., Oh, M. & Kim, Y. (2022). Redesigning urban elements and structures considering autonomous vehicles: Preparing design strategies for wide implementation in cities. *Cities,* 123, 103595. https://doi.org/https://doi.org/10.1016/j.cities.2022.103595

Lenzholzer, S., Duchhart, I. & Koh, J. (2013). 'Research through designing' in landscape architecture. *Landscape and Urban Planning,* 113, 120-127. https://doi.org/https://doi.org/10.1016/j.landurbplan.2013.02.003

Lindholm, G. (2012). 'Visible gestures': On urban landscape perspectives in planning. *Planning Theory,* 11(1), 5-19. https://doi.org/10.1177/1473095211400151

Litman, T. (2022). *Autonomous vehicle implementation predictions: Implications for transport planning*. [Accessed 11th March 2022]

Luo, Y. (2019). FROM TRANSPORTATION INFRASTRUCTURE TO GREEN INFRASTRUCTURE — ADAPTABLE FUTURE ROADS IN AUTONOMOUS URBANISM. *Landsc. Archit. Front.,* 7(2), 92-99. https://doi.org/10.15302/j-laf-20190209

Malmö stad (2018). *ÖVERSIKTSPLAN FÖR MALMÖ.* [Accessed 10th April 2022]

Malmö stad (2020). *ÖVERSIKTSPLAN FÖR SÖDRA KIRSEBERG OCH ÖSTERVÄRN* [Accessed 6th April 2022]

Malmö stad (2022). *Sommargator-och torg*. https://malmo.se/Stadsut-veckling/Tema/Bebyggelse-och-ute-miljoer/Sommargator--och-torg.html [Accessed 6th April 2022]]

Mossop, E. (2006). Landscapes of infrastructure. In: *The landscape urbanism reader*. Princeton Architectural Press. 163-177.

Moughtin, C. (1992). *Urban Design: Street and Square*. Butterworth Architecture.

Næss, P., Andersen, J., Nicolaisen, M.S. & Strand, A. (2014). Transport Modelling in the Context of the 'Predict and Provide' Paradigm. *European Journal of Transport and Infrastructure Research,* 14(2), 102-121.

Næss, P. & Vogel, N. (2012). Sustainable urban development and the multi-level transition perspective. *Environmental Innovation and Societal Transitions,* 4, 36-50. https://doi.org/https://doi.org/10.1016/j.eist.2012.07.001

Narayanan, S., Chaniotakis, E. & Antoniou, C. (2020). Shared autonomous vehicle services: A comprehensive review. *Transportation Research Part C: Emerging Technologies,* 111, 255-293. https://doi.org/https://doi.org/10.1016/j.trc.2019.12.008

National Association of City Transportation Officials (2019). *Blueprint for autonomous urbanism*. New York, NY: National Association of City Transportation Officials.

National Highway Traffic Safety Administration (2013). *Preliminary statement of policy concerning automated vehicles*. (1). Washington, DC: National Highway Traffic Safety Administration.

NCC (2022). *Ombyggnad Neptunigatan, Malmö* https://www.ncc.se/vara-projekt/neptunigatan-malmo/ [Accessed 10th April 2022]

Noyman, A., Stibe, A. & Larson, K. (2017). Roadmap for autonomous cities: Sustainable transformation of urban spaces. In: *Proceedings of the Twenty-third Americas Conference on Information Systems (AMCIS)*, Boston, MA, USA. [Accessed 11th March 2022]

OECD (2006). *Decoupling the Environmental Impacts of Transport from Economic Growth*. Paris: OECD. https://doi.org/10.1787/9789264027138-en

Peters, A. & Dütschke, E. (2014). How do consumers perceive electric vehicles? A comparison of German consumer groups. *Journal of Environmental Policy & Planning,* 16(3), 359-377.

Puhe, M. & Schippl, J. (2014). User perceptions and attitudes on sustainable urban transport among young adults: Findings from Copenhagen, Budapest and Karlsruhe. *Journal of Environmental Policy & Planning,* 16(3), 337-357.

Riggs, W., Appleyard, B. & Johnson, M. (2020). A design framework for livable streets in the era of autonomous vehicles. *Urban, Planning and Transport Research,* 8(1), 125-137. https://doi.org/10.1080/21650020.2020.1749123

Rowe, C. & Koetter, F. (1984). *Collage City*. MIT Press.

Shea, A. (2012). *Designing for social change: Strategies for community-based graphic design*. Princeton Architectural Press New York.

Sola-Morales, I.D. (1995). Terrain vague. In: Davidson, C. (ed.) *Anyplace*. Cambridge, Massachusetts: MIT Press. 119-123.

Stead, D. & Vaddadi, B. (2019). Automated vehicles and how they may affect urban form: A review of recent scenario studies. *Cities,* 92, 125-133. https://doi.org/https://doi.org/10.1016/j.cities.2019.03.020

Steenbergen, C. (2008). Composing Landscapes: Analysis. *Typology and Experiments for Design, Basel*.

Taiebat, M., Brown, A.L., Safford, H.R., Qu, S. & Xu, M. (2018). A Review on Energy, Environmental, and Sustainability Implications of Connected and Automated Vehicles. *Environmental Science & Technology,* 52(20), 11449-11465. https://doi.org/10.1021/acs.est.8b00127

Tatom, J. (2006). Urban highways and the reluctant public realm. In: *The landscape urbanism reader*. Princeton Architectural Press. 179-195.

Thurlow Small, A. & Muchi, E. (2008). plan-less-ness The Bay City Project. *PRAXIS: Journal of Writing + Building*(10), 74-80. http://www.jstor.org/stable/24329243 [2024/06/10/]

Transport of London (2019). *Streetscape Guidance*. London: Mayor of London. [Accessed 12th March 2022]

Van Goeverden, C., Rietveld, P., Koelemeijer, J. & Peeters, P. (2006). Subsidies in public transport. *European. Transport,* 32, 5-25.

Vogel, N. (2015). *Transition in the making. A critical dispute on urban transition processes toward sustainable mobility.* Diss. Aalborg: Aalborg University.

Vogel, N. (2016). Municipalities' ambitions and practices: At risk of hypocritical sustainability transitions? *Journal of Environmental Policy & Planning,* 18(3), 361-378. https://doi.org/10.1080/1523908X.2015.1099425

Wahlgren, B. (2014). *Wahlgren, B. 2014. Antikvarisk förundersökning, Järnvägsverkstäderna, Järnvägen 1:5 i Malmö. Del A (av A och B)*. https://malmo.se/download/18.6f4cd7c416cadbf90b233609/1579098130337/Antikvarisk%20förundersökning%20-%20Järnvägsverkstäderna.pdf. [Accessed 25th April 2022]

Waldheim, C. (2006a). Landscape as urbanism. In: *The landscape urbanism reader*. Princeton Architectural Press. 035-053.

Waldheim, C. (2006b). A reference manifesto. In: *The landscape urbanism reader*. Princeton Architectural Press. 013-019.

Xenias, D. & Whitmarsh, L. (2013). Dimensions and determinants of expert and public attitudes to sustainable transport policies and technologies. *Transportation Research Part A: Policy and Practice,* 48, 75-85.

Alessandrini, A., Campagna, A., Site, P.D., Filippi, F. & Persia, L. (2015). Automated Vehicles and the Rethinking of Mobility and Cities. *Transportation Research Procedia,* 5, 145-160. https://doi.org/https://doi.org/10.1016/j.trpro.2015.01.002

Anderson, J.M., Kalra, N., Stanley, K.D., Sorensen, P., Samaras, C. & Oluwatola, T.A. (2016). *Autonomous Vehicle Technology: A Guide for Policymakers*. Santa Monica, CA: RAND Corporation. https://doi.org/10.7249/RR443-2

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy,* 15(2), 73-80. https://doi.org/https://doi.org/10.1016/j.tranpol.2007.10.005

Berger, G., Feindt, P.H., Holden, E. & Rubik, F. (2014). Sustainable mobility—challenges for a complex transition. *Journal of Environmental Policy & Planning,* 16(3), 303-320.

Bergevoet, T. & van Tuijl, M. (2016). *The Flexible City: Sustainable Solutions for a Europe in Transition*. Nai010 Publishers.

Black, W.R. (2010). *Sustainable Transportation: Problems and Solutions*. New York, NY, USA: Guilford Publications.

Bourriaud, N. (2009). *The Radicant.* New York: Sternberg Press

Braae, E. (2015). *Beauty Redeemed: Recycling Post-Industrial Landscapes*. Basel: Birkhäuser.

Bullivant, L. (2012). *Masterplanning Futures*. London: Routledge. https://doi.org/10.4324/9780203720684

Castillo, H. & Pitfield, D.E. (2010). ELASTIC–A methodological framework for identifying and selecting sustainable transport indicators. *Transportation Research Part D: Transport and Environment,* 15(4), 179-188.

Corbusier, L., Eardley, A. & Giraudoux, J. (1973). *The Athens Charter*. New York: Grossman Publishers.

Corner, J. (1999). Recovering landscape as a critical cultural practice. In: *Recovering Landscape: Essays in Contemporary Landscape Theory*. Princeton Architectural Press.

Council of Europe (2000). *European Landscape Convention (ETS No. 176)*. Florence. http://conventions.coe.int/Treaty/en/Reports/Html/176.htm. [Accessed 15th February 2022].

Cross, N. (2006). Designerly Ways of Knowing. In: *Designerly Ways of Knowing*. London: Springer London. 1-13. https://doi.org/10.1007/1-84628-301-9_1

Dahl, C. (2016). Gothenborg's Jublieumsparken 0.5 and Frihamnen: explorations into the aesthetic of DIY. *Spool,* 3(2). https://doi.org/10.7480/spool.2016.2.1115.g1500

Dahl, C. (2020). *Building transformative capacities: Links between site and plan in post-industrial urban landscapes.* Diss. Alnarp: Swedish University of Agricultural Sciences. https://res.slu.se/id/publ/105445

Dahl, C. & Diedrich, L. (2020). Building transformative capacities: integrating design research into port-city transformation. *PORTUSplus,* 9, 1-21.

Deming, M.E. & Swaffield, S. (2011). *Landscape architecture research : inquiry, strategy, design*.

Diedrich, L. (2013). *Translating Harbourscapes. Site-Specific Design Approaches in Contemporary Harbour Transformation.* . Diss. Frederiksberg: University of Copenhagen. https://soeg.kb.dk/permalink/45KBDK_KGL/fbp0ps/alma99122756178305763

Diedrich, L. & Dahl, C. (2016). Ile de Nantes 2000–2010: a method for the meantime? *Journal of Landscape Architecture,* 11(2), 72-83. https://doi.org/10.1080/18626033.2016.1188576

European Commission (1992). *Green Paper on the Impact of Transport on the Environment. A Community Strategy for*

'Sustainable Mobility', COM (92) 46 Final. Brussels, Belgium: Commission of the European Communities. https://op.europa.eu/en/publication-detail/-/publication/98dc7e2c-6a66-483a-875e-87648c1d75c8 [Accessed 15th November 2022].

Gallo, M. & Marinelli, M. (2020). Sustainable Mobility: A Review of Possible Actions and Policies. *Sustainability,* 12(18). https://www.mdpi.com/2071-1050/12/18/7499

Geels, F.W. & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research policy,* 36(3), 399-417.

Gehl, J. (2010). *Cities for people*. Washington, DC: Island press.

Göteborgs stad (2019). *2AN The living room model*. https://tekniskhandbok.goteborg.se/2-forutsattningar/2a-funktion-och-behov-i-gaturummet/2an-livsrumsmodellen/ [Accessed 6th June 2022]

Gudmundsson, H. & Höjer, M. (1996). Sustainable development principles and their implications for transport. *Ecological economics,* 19(3), 269-282.

Heaton, J. (2008). Secondary analysis of qualitative data: an overview. *Historical Social Research,* 33(3), 33-45. https://doi.org/https://doi.org/10.12759/hsr.33.2008.3.33-45

Heinrichs, D. (2016). Autonomous Driving and Urban Land Use. In: Maurer, M., Gerdes, J.C., Lenz, B. & Winner, H. (eds) *Autonomous driving: Technical, legal and social aspects*. Berlin, Heidelberg: Springer Berlin Heidelberg. 213-231. https://doi.org/10.1007/978-3-662-48847-8_11

Hickman, R. & Banister, D. (2014). *Transport, climate change and the city*. Routledge.

Hildermeier, J. & Villareal, A. (2014). Two ways of defining sustainable mobility: Autolib'and BeMobility. *Journal of Environmental Policy & Planning,* 16(3), 321-336.

Holden, E., Gilpin, G. & Banister, D. (2019). Sustainable Mobility at Thirty. *Sustainability,* 11(7). https://www.mdpi.com/2071-1050/11/7/1965

Jacobs, A.B. (1993). *Great Streets*. Cambridge, Mass: MIT Press.

Jacobs, J. (1961). *The Death and Life of Great American Cities*. New York: Random House.

Jarzombek, M. (2008). A green masterplan is still a masterplan. In: Ruby, I. & Ruby, A. (eds) *Urban Transformation*. Berlin: Ruby Press. 22-29.

Johansson, R. & Linderholm, L. (2016). *VGU-guide : Vägars och gators utformning - Utformningsprocess*. Borlänge: Trafikverket. [Accessed 12th April 2022]

Julsrud, T.E. (2014). Activity-based patterns of everyday mobility: The potential for long-term behaviour change across five groups of travellers. *Journal of Environmental Policy & Planning,* 16(3), 401-417.

Karsten, L. (2005). It all used to be better? Different generations on continuity and change in urban children's daily use of space. *Children's Geographies,* 3(3), 275-290. https://doi.org/10.1080/14733280500352912

Kumar, S., Shi, L., Ahmed, N., Gil, S., Katabi, D. & Rus, D. (2012). CarSpeak: a content-centric network for autonomous driving. *SIGCOMM Comput. Commun. Rev.,* 42(4), 259–270. https://doi.org/10.1145/2377677.2377724

Larsson, S.L. & Urde, I. (2013). *Healing the city through city street – A study of the potential of Nobelvägen as a city street.* Department of Landscape Architecture, Planning and Management. Swedish University of Agricultural Sciences. https://stud.epsilon.slu.se/6304/

Lautso, K. & Toivanen, S. (1999). SPARTACUS system for analyzing urban sustainability. *Transportation Research Record,* 1670(1), 35-46.

Lee, S., Jang, K.M., Kang, N., Kim, J., Oh, M. & Kim, Y. (2022). Redesigning urban elements and structures considering autonomous vehicles: Preparing design strategies for wide implementation in cities. *Cities,* 123, 103595. https://doi.org/https://doi.org/10.1016/j.cities.2022.103595

Lenzholzer, S., Duchhart, I. & Koh, J. (2013). 'Research through designing' in landscape architecture. *Landscape and Urban Planning,* 113, 120-127. https://doi.org/https://doi.org/10.1016/j.landurbplan.2013.02.003

Lindholm, G. (2012). 'Visible gestures': On urban landscape perspectives in planning. *Planning Theory,* 11(1), 5-19. https://doi.org/10.1177/1473095211400151

Litman, T. (2022). *Autonomous vehicle implementation predictions: Implications for transport planning*. [Accessed 11th March 2022]

Luo, Y. (2019). FROM TRANSPORTATION INFRASTRUCTURE TO GREEN INFRASTRUCTURE — ADAPTABLE FUTURE ROADS IN AUTONOMOUS URBANISM. *Landsc. Archit. Front.,* 7(2), 92-99. https://doi.org/10.15302/j-laf-20190209

Malmö stad (2018). *ÖVERSIKTSPLAN FÖR MALMÖ.* [Accessed 10th April 2022]

Malmö stad (2020). *ÖVERSIKTSPLAN FÖR SÖDRA KIRSEBERG OCH ÖSTERVÄRN* [Accessed 6th April 2022]

Malmö stad (2022). *Sommargator-och torg*. https://malmo.se/Stadsut-veckling/Tema/Bebyggelse-och-ute-miljoer/Sommargator--och-torg.html [Accessed 6th April 2022]]

Mossop, E. (2006). Landscapes of infrastructure. In: *The landscape urbanism reader*. Princeton Architectural Press. 163-177.

Moughtin, C. (1992). *Urban Design: Street and Square*. Butterworth Architecture.

Næss, P., Andersen, J., Nicolaisen, M.S. & Strand, A. (2014). Transport Modelling in the Context of the 'Predict and Provide' Paradigm. *European Journal of Transport and Infrastructure Research,* 14(2), 102-121.

Næss, P. & Vogel, N. (2012). Sustainable urban development and the multi-level transition perspective. *Environmental Innovation and Societal Transitions,* 4, 36-50. https://doi.org/https://doi.org/10.1016/j.eist.2012.07.001

Narayanan, S., Chaniotakis, E. & Antoniou, C. (2020). Shared autonomous vehicle services: A comprehensive review. *Transportation Research Part C: Emerging Technologies,* 111, 255-293. https://doi.org/https://doi.org/10.1016/j.trc.2019.12.008

National Association of City Transportation Officials (2019). *Blueprint for autonomous urbanism*. New York, NY: National Association of City Transportation Officials.

National Highway Traffic Safety Administration (2013). *Preliminary statement of policy concerning automated vehicles*. (1). Washington, DC: National Highway Traffic Safety Administration.

NCC (2022). *Ombyggnad Neptunigatan, Malmö* https://www.ncc.se/vara-projekt/neptunigatan-malmo/ [Accessed 10th April 2022]

Noyman, A., Stibe, A. & Larson, K. (2017). Roadmap for autonomous cities: Sustainable transformation of urban spaces. In: *Proceedings of the Twenty-third Americas Conference on Information Systems (AMCIS)*, Boston, MA, USA. [Accessed 11th March 2022]

OECD (2006). *Decoupling the Environmental Impacts of Transport from Economic Growth*. Paris: OECD. https://doi.org/10.1787/9789264027138-en

Peters, A. & Dütschke, E. (2014). How do consumers perceive electric vehicles? A comparison of German consumer groups. *Journal of Environmental Policy & Planning,* 16(3), 359-377.

Puhe, M. & Schippl, J. (2014). User perceptions and attitudes on sustainable urban transport among young adults: Findings from Copenhagen, Budapest and Karlsruhe. *Journal of Environmental Policy & Planning,* 16(3), 337-357.

Riggs, W., Appleyard, B. & Johnson, M. (2020). A design framework for livable streets in the era of autonomous vehicles. *Urban, Planning and Transport Research,* 8(1), 125-137. https://doi.org/10.1080/21650020.2020.1749123

Rowe, C. & Koetter, F. (1984). *Collage City*. MIT Press.

Shea, A. (2012). *Designing for social change: Strategies for community-based graphic design*. Princeton Architectural Press New York.

Sola-Morales, I.D. (1995). Terrain vague. In: Davidson, C. (ed.) *Anyplace*. Cambridge, Massachusetts: MIT Press. 119-123.

Stead, D. & Vaddadi, B. (2019). Automated vehicles and how they may affect urban form: A review of recent scenario studies. *Cities,* 92, 125-133. https://doi.org/https://doi.org/10.1016/j.cities.2019.03.020

Steenbergen, C. (2008). Composing Landscapes: Analysis. *Typology and Experiments for Design, Basel*.

Taiebat, M., Brown, A.L., Safford, H.R., Qu, S. & Xu, M. (2018). A Review on Energy, Environmental, and Sustainability Implications of Connected and Automated Vehicles. *Environmental Science & Technology,* 52(20), 11449-11465. https://doi.org/10.1021/acs.est.8b00127

Tatom, J. (2006). Urban highways and the reluctant public realm. In: *The landscape urbanism reader*. Princeton Architectural Press. 179-195.

Thurlow Small, A. & Muchi, E. (2008). plan-less-ness The Bay City Project. *PRAXIS: Journal of Writing + Building*(10), 74-80. http://www.jstor.org/stable/24329243 [2024/06/10/]

Transport of London (2019). *Streetscape Guidance*. London: Mayor of London. [Accessed 12th March 2022]

Van Goeverden, C., Rietveld, P., Koelemeijer, J. & Peeters, P. (2006). Subsidies in public transport. *European. Transport,* 32, 5-25.

Vogel, N. (2015). *Transition in the making. A critical dispute on urban transition processes toward sustainable mobility.* Diss. Aalborg: Aalborg University.

Vogel, N. (2016). Municipalities' ambitions and practices: At risk of hypocritical sustainability transitions? *Journal of Environmental Policy & Planning,* 18(3), 361-378. https://doi.org/10.1080/1523908X.2015.1099425

Wahlgren, B. (2014). *Wahlgren, B. 2014. Antikvarisk förundersökning, Järnvägsverkstäderna, Järnvägen 1:5 i Malmö. Del A (av A och B)*. https://malmo.se/download/18.6f4cd7c416cadbf90b233609/1579098130337/Antikvarisk%20förundersökning%20-%20Järnvägsverkstäderna.pdf. [Accessed 25th April 2022]

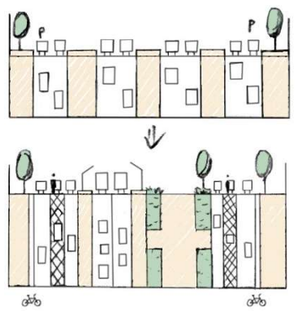
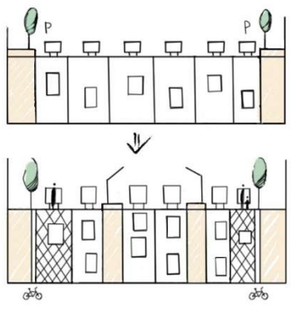
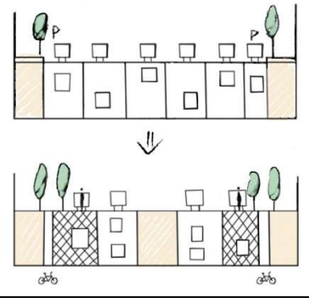
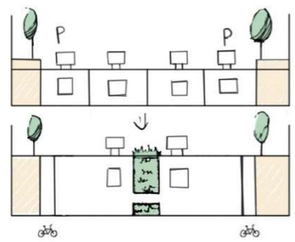
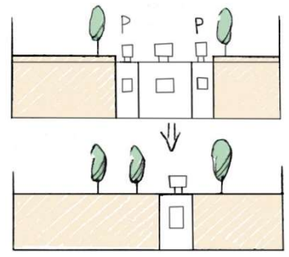
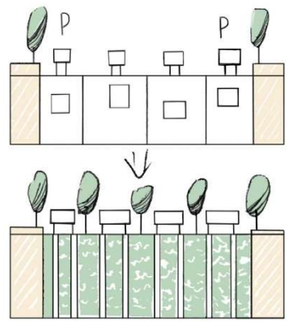
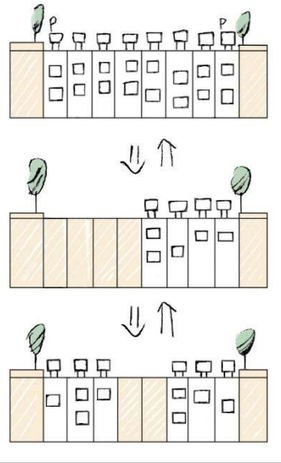
Waldheim, C. (2006a). A reference manifesto. In: *The landscape urbanism reader*. Princeton Architectural Press. 013-019.

Waldheim, C. (2006b). Landscape as urbanism. In: *The landscape urbanism reader*. Princeton Architectural Press. 035-053.

Xenias, D. & Whitmarsh, L. (2013). Dimensions and determinants of expert and public attitudes to sustainable transport policies and technologies. *Transportation Research Part A: Policy and Practice,* 48, 75-85.

7. Appendices

7.1 Appendix A: Conceptual designs for AV street transformation.

	Situation	Street form	Description
Conceptual design by NACTO	Only AVs on the road		For "Multiway Boulevard," there will be a central transit way that affords priority space for traffic. Green infrastructure with public spaces, bike lanes, and flex zones will be added. The flex zone is used for urban freight, public activities, etc. at different times in the day.
			For "Major Transit Street," there will be dedicated transit lanes for public transport. Crossing distances will be shorter because of the new mobility hubs. Flex zones and bike lanes will be added.
			For "Downtown Street," car lanes and parking lots will be reduced. Crossing distances will be shorter because of the new public spaces. Flex zones and protected bike lanes will be added.
Conceptual design by Luo	Only AVs on the road		For "Residential Street", there will be more green infrastructure. Human activities will be prioritised by limiting the speeds of AVs.
			For "Neighborhood Main Street," crossing distances will be shorter because of the new green infrastructure. The car roads will be transformed into separated but flush lanes for both AVs and bicycles.
			This is called "the road softening program," which assumes that AVs only need two tracks (0.5-meter-wide in total). The spaces left can be transformed into green infrastructure. Parking spaces will be reduced.
			This is called "right of way adaptive to real-Time demands", which means the transport infrastructure will no longer be only for vehicles, it will change its right of way according to the real-time traffic demands. Parking spaces will be reduced.

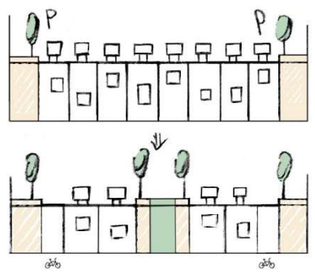
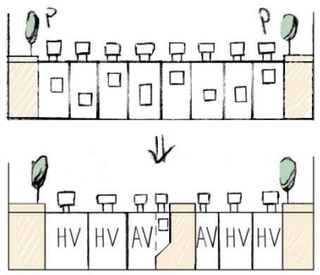
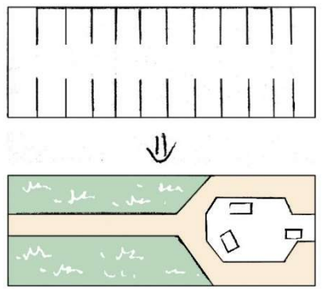
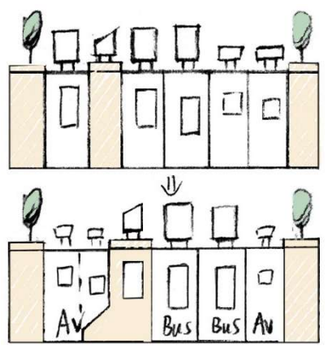
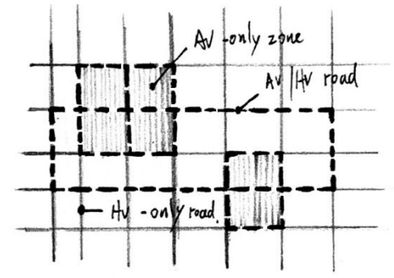
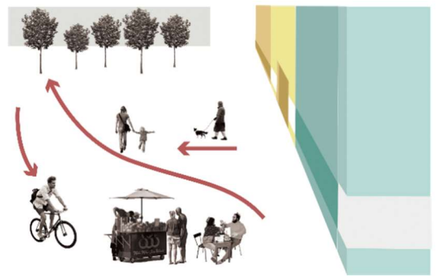
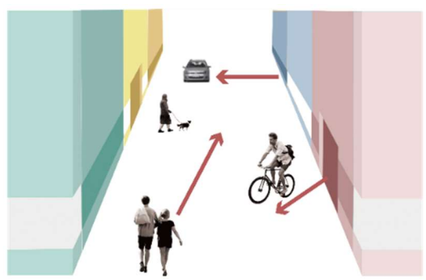
Conceptual design by Lee et al.	Only AVs on the road		Roads will be narrower (less than 3 meters). Car lanes will be reduced. Crossing distances will be shorter because of the new public spaces. Bike lanes will be added. Parking spaces will be reduced.
	Both AVs and HVs are on the road		AV-only lanes will be added to the current transport infrastructure. Crossing distances will be shorter because of the new pick-up and drop-off area for AVs.
	Only AVs on the road		Dedicated parking lots will be transformed into AV-stations. Green spaces and public spaces will be added because some newly released parking spaces
	Both AVs and HVs are on the road		The bus terminals will be expanded and transformed into stations for intermodal transport between AVs and public transportation.
	Both AVs and HVs are on the road		This is the urban design approach for AVs at the district level. The AV/HV roads will be utilised to connect the AV-only zones.

Table 7: Conceptual designs for AV street transformation (Illustration: Yukun & Junhao based on Luo, 2019; National Association of City Transportation Officials, 2019; Lee *et al.*, 2022); = green space, = public space, = flex zone, = vehicles, = vehicles (section).

7.2 Appendix B: Livsrumsmodellen

Illustration	Description
	Frirum (F) A space for cyclists and pedestrians. Trafficking in motor vehicles is prohibited. Design features have the potential for interpersonal interactions because the design is centred on the perspective and speed of pedestrians and cyclists. Squares, roadside parks, playgrounds, and distinct paths for pedestrians and bicycles are a few examples of these car-free zones.
	Integrerat frirum (IF) A section of the road where cyclists and pedestrians get priority. Motor vehicles may only be permitted limited entry, and they must drive with the utmost consideration for any vulnerable street users. It is necessary to drive slowly, and bicycles and pedestrians have priority. The facade of the street is made up of buildings that have entrances into the street. People think it's normal to engage in a variety of activities here.

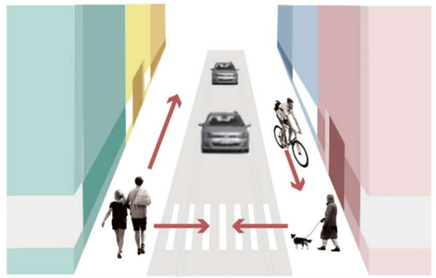
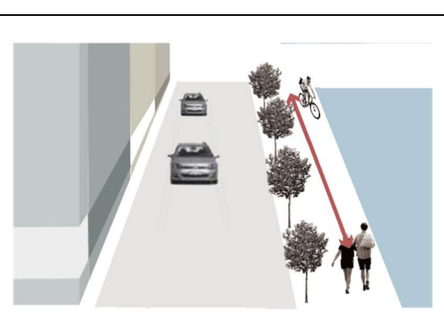
	Mjuktrafikrum (M) A space that meets people's needs for both transverse and longitudinal mobility. Traffic and unprotected street users have to cohabit in this area. Car traffic zones should be minimised regarding how the street is used. The facades on the street express a claim to contact and presence.
	Integrerat transportrum (IT) Unprotected road users could traverse the area but have limited rights to do so. There are small claims for staying in this type of space as well. The street facades face the street but have no claim to it. In this type of street, the distances to entrances are long, and the possibility to cross only appears when a street connects to other streets with crosswalks. The street space often has a dominant transport function.
	Transportrum. (T) Space for motor vehicle traffic only, while cyclists and pedestrians are segregated on a safe sidewalk and have no opportunity to cross the automobile lane. The facades direct their requirements away from the area. The sole purpose of the transportrum is transport.

Table 8: Livsrumsmodellen (based on Göteborgs stad, 2019).

8. Acknowledgements

We would like to express our sincere gratitude to our supervisors, Emily Wade and Gunilla Lindholm, for consistently imparting their knowledge and offering us constructive advice. We also thank our examiners, Nina Vogel and Arne Nordius, for reading our work and offering crucial and constructive advice at important moments in our work process. Our appreciation extends to Lars Böhme at Stadsbyggnadskontoret, Malmö stad, for sharing his experience, knowledge, and materials regarding Lokstallarna. We are deeply grateful to our family and friends for their unwavering support during times of stress and depression. Special thanks to Kittima Ritthichot for sharing her academic writing skills and providing delicious food. Lastly, we thank each other for the mutual support and inspiration. Our knowledge has been greatly enhanced by our discussions, and this thesis could not have been accomplished without each of our contributions.