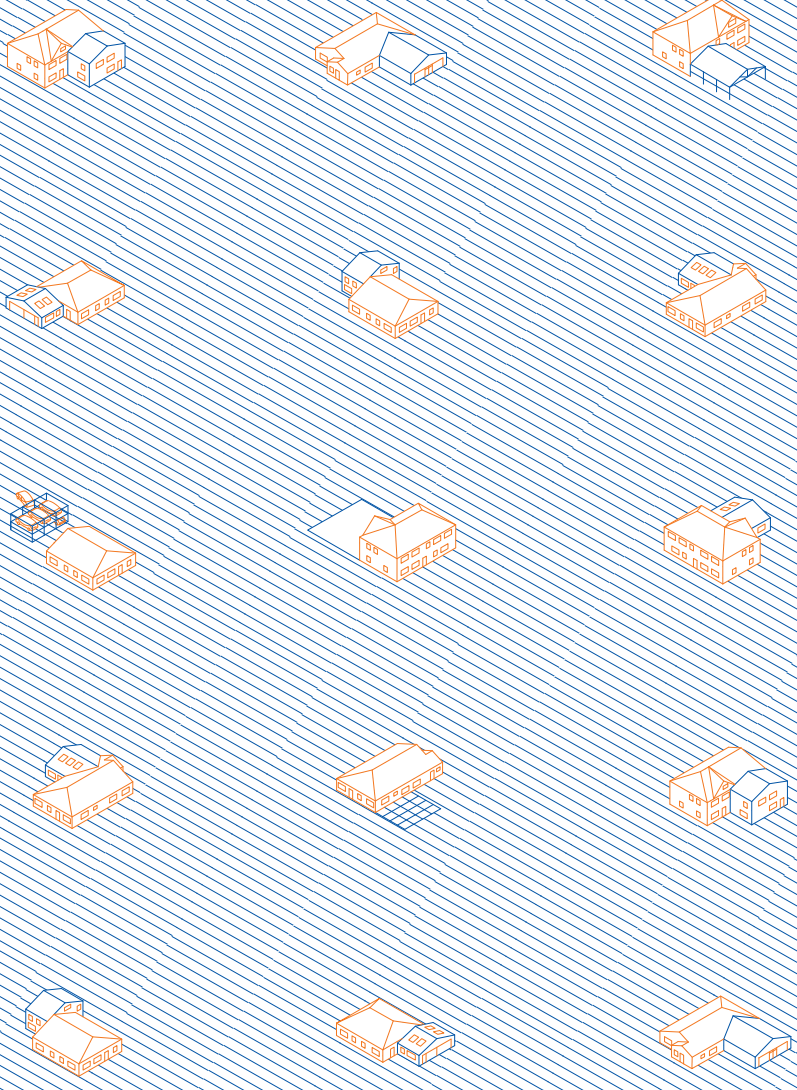
Chapter 6

Urban Theories and Autonomous Vehicles



Chapter 6
Urban Theories and Autonomous Vehicles

The street is not only a contested space in terms of its functionality but also in terms of who claims design autonomy over it. These two contentious issues are interrelated since whoever has design authority over the street decides who gets to use it. The issues become further interrelated by the question of why the space of the street is contested: is it simply because there are many demands on the street and only limited space, or is it because the current process of designing the street and choosing which groups are prioritized is problematic?

In terms of how we choose who designs the street, it is not a straightforward process. We elect groups of people and those people hire staff who carry out the design of the street or, at a minimum, set the priorities for street design to be implemented by consultants. However, in any given city or jurisdiction, certain disciplines carry more sway over the design. This is a discussion which has been had by the notable urban theorist Jan Gehl, who points out that those who have data have a stronger voice because they can quantify the problem and the solution clearly. Gehl advocates for counting pedestrians and cyclists with equal zeal to counting cars. This gives both quantifiable evidence and a voice to underrepresented pedestrians and cyclists, thereby changing design decisions.[1] We can also look to the example of the preliminary design of a large interchange which is landing in an urban area: for example the case of the redesign of the Brunette Avenue/Highway 1 interchange in New Westminster, British Columbia. The preliminary design process involved the traffic engineer articulating what was necessary for free flow conditions at the interchange and determining the interchange configuration based on that modelling. That modelling, done in isolation of all other disciplines, determined the alignment and the road design of the interchange, and also limited the urban design decisions that could be made. In this instance, the traffic engineer had the loudest voice and the interchange was configured overwhelmingly to favour the concerns of the traffic engineering discipline. Should the bridge engineer or the urban design group (including landscape architects in this case) have had the larger voice, the interchange

design would have been significantly different, favouring instead the values put forward as primary concerns by these disciplines.[2] These examples illustrate the critical issue of disciplinary authority over the street.

While disciplinary authority will perhaps soon be an historic way of looking at how we divide knowledge, we will have the legacy of the system for a long time. In the opinion of the author, we are moving towards a 'post-disciplinary' state where people will still have deep and valuable expertise. However, the areas of their expertise may be better thought of as deep spheres of knowledge which are positioned relative to other people's spheres; the artificial linear boundaries drawn between disciplines will fade as many spheres take over.

However, the current situation being what it is, in order to position the inevitable re-designing of the street for autonomous vehicles within a broader design discussion, it is worthwhile considering what contemporary theorists in different disciplines have to say about the design of the street and which design theories may be beneficial in designing the new AV city. Various disciplines claim expertise on design of the street: engineering, transportation planning, planning, urban design, landscape architecture and architecture. These professions have differing approaches to the design of the street, all based on social and cultural concerns. These approaches, or theories, are articulated in their specific professions' writings on the theory of design of the street. Some of the disciplines are more interested in logistics and measurable outcomes, others more in the social and cultural concerns about design and public use. This book focuses more on the social and cultural theories but it is relevant to understand where the interests of different disciplines lie, and what those interests are. The first part of this chapter discusses the positions of the various professions in relation to the design of the street; the second part focuses more on cultural design theories. Further discussion of theories is also to be found in Chapter 9, relating to technology and the city.

Which Professions Govern Design of the Street?

Architecture

The role of the design of the city as a whole has always been in flux, and the design of the street with it. As discussed previously, some of the orchestrators of the Garden City and the suburban organization of the streets were architects, as were the designers of visionary city projects such as Le Corbusier and Frank Lloyd Wright. Architects have also contributed to design of the street in special projects—Sir Christopher Wren redesigned the street system of London after the 1666 fire, and both Alberti (c.1470) and Vitruvius (c. 27 BCE)

included comments on design of the street in their treatises. However, in contemporary society the architect is not recognized as the designer of the street. Some say the architect left the field after Modernism when the discipline, made up of baby boomers, became suspicious of architecture as an "inevitable coalescence of power and established regimes of authority"[3] and moved to smaller scale efforts. Others assert that planners claimed jurisdiction over the city much earlier.[4,5,6] One might also argue that the architect's obsession with form has relegated the architect to the confines of the building; the increasing complexity of the building project today has likely reinforced this neglect of the project of the city. In any case, architecture as a discipline has been increasingly marginalized in the design of the city and its streets as other disciplines move in. This is highlighted by Dana Cuff and Roger Sherman in their introduction to *Fast-Forward Urbanism*[7] in which they state:

> architecture has, to a large extent, abandoned the city [... and] the city's principal players—be they developers or policy-makers—have come to see architecture as irrelevant. In the latter case, it is more accurate to say that the city has abandoned architecture.[8]

Cuff and Sherman call on architects to once again engage with the city and help solve some of the very difficult problems that come with issues such as mass movement to cities, natural disasters and human-caused disasters as a result of terrorism or wars.

It should be emphasized, however, that architectural theories on design are potentially highly valuable as the space of the street becomes more contested: architectural theory as the origin of 'design thinking' focuses on solving complex cultural and social problems which also include technological aspects. Architectural design solutions generally question all constraints; solutions are synthetic and propose spatial and object configurations that are multifunctional or provide simultaneous solutions to several problems. On occasion, these approaches are highly celebrated[9]—but rarely are architects asked to design the streets of a city. As mentioned, architecture today is primarily applied to buildings but it has the potential to create solutions to the problems of the highly contested space of the street. This assertion is what led to the development of the field of Urban Design.[10] As such, there is a flux in these two professional areas[11] and it is difficult to draw discrete professional boundaries. However, in any case it is clear that the disciplinary skills of the architect—the ability to imagine the future in multiple forms and the potential of a design approach which incorporates a broad range of cultural and social concerns—are a powerful

tool for designing the future, no matter in which discipline we deposit this 'architectural' design knowledge.

Engineering

I would argue, however, that the history of street design in North America does not show a 'ground-losing' trend by architects but rather the exclusion of architects from the infrastructure design process from the beginning.[12] Granted, the history of infrastructure design in North America dates from around the late 1800s so it is not a particularly long one; but, as previously discussed in Chapter 4, we have inherited the idea of requiring a military to build infrastructure from the French tradition. The military and its engineering offspring have dominated the design of roads since their beginnings.[13,14] Engineers generally focus on the social concerns of safety, functionality and efficiency; through this focussed expertise, they have maintained a firm hold on the field in the name of public safety and efficiency. This was demonstrated when engineers were the ones called in to solve the safety problems caused by the automobile upon its introduction in the street in the early 1900s.[15] While extremely skilled in optimizing roads for transport efficiency and safety, dealing with matters of social and cultural concern outside of safety and efficiency are not in the realm of the engineer's expertise. As such, if any social or cultural issues are brought to the space of the street, other disciplines generally take on these concerns. This collaboration between disciplines takes many forms and hierarchies of decision-making.

Engineers are likely to continue to take a primary lead on design of streets for AVs but will need to work to a much greater extent in collaboration with design disciplines. The ability of the engineer to problem-solve is invaluable when confronted with problematic conditions and, similar to the original role of the engineer as 'arbiter-in-chief' of the street space, the role of solving the problems of the new AV street using technology is still in the firm hands of the engineer. However, engineers are increasingly realizing that the biggest problems to solve are not with the technology itself but with the social aspects—namely the way the human interacts with the technology.[16] Two major aspects relating to AVs are the ways in which people engage with the technology—pedestrian/AV interfaces, for example—as well as how to mediate the contested space of the street and all of the social implications of doing so. It is these challenges in particular that will increasingly require intense collaboration with other disciplines.

Transportation Planning

In order to deal with the challenges of transportation decision-making in the complex public context, there has now developed a specific discipline

called transportation (or transport) planning. The origins of transportation planning came about in the 1940s, when "it was apparent that if certain relationships between land use and travel could be measured, these relationships could be used as a means to project future travel."[17] Analytic models were developed in the 1950s and in 1954 the National Committee on Urban Transportation was created, which for the first time documented comprehensive procedures for transportation planning.[18] This is a multidisciplinary profession that primarily deals with the planning of all forms of transport routes including streets, highways, bike lanes and public transport. It involves multiple stakeholders and looks at analysis and planning of the different modes of transport. The field of transportation planning is primarily concerned with a rational planning model that defines measurable goals and objectives, primarily relating to environmental performance. The field includes planning decisions, as well as engineering modelling of transport modes and routes, and aspects of behavioural psychology as it relates to people's choices regarding modes of transport. This field has been active in modelling and simulating networks of shared autonomous vehicles[19,20] and will continue to play an important role in predicting volume impacts from autonomous transportation decisions on all modes of transport.

Planning

The discipline of planning itself dates back to the National Conference on City Planning in Washington, D.C. in 1909.[21] Its role includes the administration of legislation, data analysis, project management and public consultation.[22] Current conversations in planning are very much centred on data-driven design and include discussions of sustainability and the health impacts of planning decisions. From its inception, the discipline clearly understood the organizing power of new infrastructures of hydroelectricity and automobiles and their ability to spawn communities, as outlined by the Regional Planning Association of America (formed in 1923 and lasting 10 years). In its modern-day form, the discipline of planning focuses to a large extent on the administration, bureaucracy and code-writing for the building forms of the city. Urban design as a specialized focus in planning has now developed into a discipline in its own right. Thus, those in planning who are dealing with design of the street are more likely to be in the professional area of urban design than that of planning.

Urban Design

In *Urban Design* (2009), Alex Krieger suggests that urban designers should take on infrastructure:

> Apart from the occasional efforts to "architecturalize" infrastructure, as in the various mega-

> structure proposals of the 1960s (a source of fascination today), neither planners nor designers have played a significant role in transportation or other urban infrastructure planning. Thus, it has become another sphere for an urban designer to attempt to address at both the pragmatic level of calibrating demands for mobility with other social needs and in advancing new (or reviving 125-year-old) ways in which city form and transportation systems may be integrated.[23]

By implication this suggests that, as of 2009 when the book was published, urban designers had not taken on transportation or other infrastructural planning. Urban design has its own professional internal debate on what the field entails, a debate which has been ongoing since the birth of the profession in 1956 at a conference on the topic at Harvard University.[24,25] In the founding conference on Urban Design in 1956, José Luis Sert, the organizer of the conference and Dean of the Harvard Graduate School of Design, asserted that the field "is that part of city planning which deals with the physical form of the city" and that it is "the most creative phase of city planning, in which imagination and artistic capacities play the important part." Secondly he stated that the purpose of the conference was "to find the common basis for the joint work of the Architect, the Landscape Architect, and the City Planner… Urban Design [being] wider than the scope of these three professions."[26] In general then, the field sits between the design disciplines (of architecture and landscape architecture) and planning and takes up design at the scale of the city. As such, it is surprising that this is not the field which would have the mandate of the design of the street.

In the last number of years, the profession has been criticized by Charles Waldheim (Harvard Graduate School of Design) and others for being too focused on the cultural nostalgia of "New Urbanism."[27] New Urbanism, while having nothing explicitly problematic about its list of goals, focuses on walkable cities with a range of housing types and business. The critique of New Urbanism is that it looks to a traditional and privileged model of what a city should be rather than addressing the messy, sprawling, and often underprivileged metropolises of the world today. As such, it is hard to imagine how the theorists of New Urbanism will discuss the AV as it is hardly relevant in the New Urbanist model of the walkable community: why would one need an autonomous vehicle if one can walk? Contemporary theorists in urban design have proposed new disciplinary models which address issues of the complexity of the city as a plurality with many divided parcels, owners and opinions.[28] Other current theorists, such as Mark Shepard, Dana Cuff, Roger Sherman and Scott Lloyd, deal more with technology and infrastructure and the city (looked

at in more depth in Chapter 9). It is likely that the city of the AV will be influenced by these types of ideas—but only if the discipline engages not just at the theoretical level, but also operationally with the scale of the street and the interactions of technology, public space and the street.

Landscape Architecture

Landscape architects have a history of designing streets and, more importantly, designing landscapes with streets that support the larger intent of a project. As mentioned in Chapter 4, Frederick Law Olmstead designed Parkways as well as street configurations for new subdivisions which are still relevant today. Landscape architects are also asked to design road cross-sections, probably more than any other profession. However, it is landscape architecture's more current theories and thinking which make it the most likely disciplinary framework to engage with designing the new AV landscape.

Current theories in this discipline are highly engaged with the issues regarding the incorporation of ecologies (natural and artificial) and infrastructure, whereas most discussions of the street outside the discipline do not consider environmental concerns or ecological thinking even though they are increasingly a concern in city design. As Pierre Bélanger points out so succinctly:

> Fordist modes of production and Taylorist principles of efficiency have oversimplified the ecology of urban economies and underplayed the social role of urban infrastructures, by way of marginalizing and suppressing the living, biophysical systems. At the center of this ecological divide are the historic practices of engineering and planning that operated well into the twentieth century, under the tenets of efficiency and control through centralization.[29,30]

Landscape architects have suggested in a series of recent manifestos[31] that their discipline should be the one to oversee urbanism, due to its ability to incorporate environmental concerns and ecological thinking. Ian McHarg originally presented this idea in 1956 at a conference on Urban Design but the idea was not carried forward and planning essentially took over the stewardship of urban design for another 50 years.[32] However, there is substantial merit to this argument, which will be elaborated on in the next section, even though to date limited application has been demonstrated.[33] This may change with the increasing need for designers to participate in the design of the increasingly contested space of the urban environment, much of which is the space of the street.

It seems critical that ecological concerns be brought to the issue of the street at multiple scales. In particular, there is great potential to address the

new AV-networked city within the current thinking that considers the environment of the city as a landscape which incorporates natural and artificial systems. In this case what is being referred to is a more literal discussion of ecology, but it is the metaphorical discussion introduced by this discipline which is also critical.

Cultural Theories for Design of the AV City

An innovation in landscape architecture theory evolved in the 2000s, moving landscape architecture from a more pastoral documentation of culture and role as historic protector of the environment to a more active design strategy, shaping large infrastructural systems and integrated urban environments. The call for this innovation can, amongst others, be found in the publication of Strang's "Infrastructure as Landscape"[34] (1996), events such as the Landscape Urbanism conference of 1997 (Graham Foundation, Chicago) as well as in James Corner's *Recovering Landscape* (1999) where he laments the "sentimentality and conservatism" of the current profession and calls for the discipline to engage with the opportunities of using landscape to evolve the built environment.[35]

The supporters of the Landscape Urbanism approach posited that architecture and urban design were not adequately taking on the condition of the contemporary urban city. Their position stated that architecture in the Modernist period, in its zeal for machine-like buildings and universal housing, proposed over-scaled environments incompatible with human occupation and devoid of community and human interaction.[36] Architecture's subsequent swing to the post-Modern relegated it to the production of images that spoke to multiple audiences but which, in fact, served mobile international capital and relegated architecture to producing form within the bounds of the property line. Planning was likewise heavily criticized for having abandoned design in favour of policy, procedure and public consultation.[37] Urban Design, as previously mentioned, was more interested in promoting small-scale walkable communities and was reluctant to engage with the design of the larger city. Landscape Urbanism stepped in with the mandate to address large-scale sites and larger-scale issues with a detailed knowledge of ecological systems.

The resulting movement developed over the course of a decade and its manifesto was documented in *The Landscape Urbanism Reader* (2006).[38] The basis of Landscape Urbanism is the idea that landscape architecture has a "capacity to theorize sites, territories, ecosystems, networks, and infrastructures" and in particular that its "thematics of organization, dynamic interaction, ecology and

technique point to a looser, emergent urbanism, more akin to the real complexity of cities and offering an alternative to the rigid mechanisms of centralist planning."[39] It is easy to see from this concise description how the application of this type of thinking may be relevant to the design of the new AV city. A shared autonomous vehicle (SAV) network, for example, is not an isolated system; in order to generate understanding of the network dynamics, the behaviour of the network will be heavily influenced by urban characteristics such as accumulations of business or housing in certain areas which affect demand locations and wait times at peak hours.[40] Cities which are more segregated will have longer wait times at morning peak hours, for example, due to the time necessary for cars who have already made a trip to return to the residential area. While network design theory can discuss different parameters that may influence an increase or decrease in travel and wait times, in this case it is the urban form itself that is causing the wait times. A more holistic design methodology will document these characteristics and their interrelationships, apply them to the metaphorical ecosystem of the SAV and its relationship to urban form, and thereby generate insights of where an intervention in urban policy may be applicable.

It should be noted, though, that this type of application of the theory is not a conventional use. Landscape Urbanism has mainly been applied to large-scale sites in suburban and peripheral urban areas as a theory to inform the design of the landscape.[41] What is being suggested here is that the ideas behind the theory are applied to the infrastructure of the AV city across the city as a whole and not just on one land parcel: for example, planning the infrastructure and routing for a network of automated transit shuttles or a series of parking facilities for AVs outside the city centres. These are usually planned by transportation planners or engineers but there are invariably many other transportation networks and societal factors involved which may also be interrelated, drawn and understood, with design action resulting from the understanding of the larger urban system—in short, an approach more akin to Landscape Urbanism.

Infrastructural Systems

The media through which Landscape Urbanism was proposed to operate can be defined as infrastructural systems and the public landscapes. It was this adoption of the infrastructural systems that incorporated the manmade into the natural and blurred the distinction between the two. Whereas landscape architecture had always been about creating infrastructural systems through the manipulation of the land, it had never been explicitly put forward as such. The idea of moving 'landscape' as a concept from its role as a visual

representation of nature and a generator of the pastoral to an active manipulator of forces and a large-scale working machine is a process that is still ongoing. Strang outlined the basis of this infrastructural idea at the time of its introduction, stating "Designers have most often been charged with hiding, screening and cosmetically mitigating infrastructure, in order to maintain the image of the untouched natural surroundings of an earlier era. They are rarely asked to consider infrastructure as an opportunity, as a fundamental component of urban and regional form."[42] He goes on to identify the potential for infrastructure to be used for multiple purposes in contrast to the tendency to engineer for a single use and he remarks upon how different that approach is from a design approach which engages biological materials (plants, soil, etc.).

Strang also points out that infrastructural systems are very complex and in many ways similar to biological systems—except that human systems are not resilient. This may be even truer and increasingly problematic when we shift to an AV network whose collapse could paralyze a city entirely. Strang also stresses that human systems should incorporate biological systems rather than neutralize them—an idea which is now accepted as a clearly desirable design approach—and rejects the separation between nature and man-made. He further speculates, "It is not only imaginable but probable that the current shift to a predominantly technological environment has provoked a (similarly) profound spiritual crisis—one that can be relieved by reconsidering the relationship between urban settings and natural processes."[43] This is likely to be exacerbated by the introduction of even more technology into our lives through the significant contribution of the AV.

Strang considers infrastructure to be the result of bringing technology together with nature; he is convinced that linking "technological developments with the organic principles of nature" provides an opportunity for designers.[44] He believes nature and infrastructure together should be a major determinant of urban form and he calls for architects, landscape architects, engineers and biologists to carry this out. Strang is a proponent of multidisciplinary design projects and runs a multidisciplinary firm. However, his examples and discussion are still very general in form, expressing an idea and a desire but not a clear path to get there or any particular projects to support the case. He is, however, one of the first to begin discussing designing the landscape and infrastructure together as one operational component and is quite clear that he envisions these two concepts should be brought together—just not so clear on how to do this.

System Non-Boundaries

Another factor which supports the idea of thinking of infrastructural systems as landscape is the ability to approach the design issue from a position of the system boundaries and not the geographic boundaries the systems cross. As Landscape Urbanism evolved, the view of the city was changing—it was seen as a dynamic system, in flux and responsive. It was also evident that the traditional notion of the city with a downtown and suburbs was no longer relevant; instead we can see cities becoming multiple centres which are connected by a circulation system which comprises various networks—transportation, communication, production, consumption and waste management. The political boundaries are irrelevant to some of the networks but provide boundaries and gradients to others, depending on what those networks are and how they are tied to these organizational structures. As Charles Waldheim says in his 'manifesto' for landscape urbanism, "contemporary landscape urbanism practices recommend the use of infrastructural systems and the public landscapes they engender as the very ordering mechanism of the urban field itself, shaping and shifting the organization of urban settlement and its inevitably indeterminate economic, political and social futures."[45]

The theory of infrastructure as an organizational tool is very strongly positioned to take on the design of the new AV city. The issue that arises is that the organizational framework for the new AV city will likely exist mainly in software. When we look at the concepts illustrated in this book such as 'Unblock the Block,' 'Road Network Hierarchies' and 'Intelligent Directions,' what we see is that spatial organization of traffic flows does not need to be the 'hardware' of the road but can now be embedded in the software providing directions to the AV. Whether this software is explicitly provided as infrastructural wireless directions to AVs or coded within the proprietary mapping systems of the AV is yet to be determined. It would be highly advantageous to a city to be able to adjust its instructions to AVs live so that they could block off affected streets when there are events such as races or parades, or even emergency incidents. If this were to be done, cities would have to take on another software control system which brings its own caveats and costs. It is possible that less affluent cities will simply produce maps which give information to programmers on restrictions on parking, speed limits at various times and no entry areas, for example. Street signs will in either case be unnecessary, and since they are costly to a municipality will likely end up as sentimental wall decorations.

Part of the impetus for this transformation of landscape architecture, and the basis of some of the largest

projects completed within these theoretical bounds, was the recognition that landscape architects are called in to remediate sites.[46] The remediation strategies are often landscape strategies with a biological basis. In these cases, the design work is truly intended as an infrastructural intervention. As Reyner Banham puts it, "A new generation of architects and landscape architects were suddenly asked to operate on a landscape that was neither wholly natural nor machinic."[47] It is perhaps these projects that are some of the strongest demonstrations of the principle.

Other projects, such as the Trinitat Cloverleaf Park by Enric Batlle and Joan Roig, involve the integration of transportation infrastructure and public space.[48] Here, the design task was to stitch a highway into an urban fabric, while allowing both to function simultaneously. In this case there are two major requirements: transportation efficiency and the maintenance of a public space that contributes societally to support recreational functions. In most projects, these two needs are in direct conflict: transportation efficiency requires efficient flow-through at a minimum and, preferably, at speed; a good public space requires the ability to walk as desired and an environment free from excessive noise and air pollution. As Alex Wall and James Corner point out:

> [T]he design of transportation infrastructure is central to the functioning of the urban surface. The importance of mobility and access in the contemporary metropolis brings to infrastructure the character of collective space. Transportation infrastructure is less a self-sufficient service element than an extremely visible and effective instrument in creating new networks and relationships.[49]

It is these types of complex design problems, with conflicting requirements, that call out for an architectural design approach at the scale of the landscape. Landscape architecture in its new manifestation offers this as well as two other benefits: the use of time in design and the knowledge of ecological systems.

Space-Time Frameworks

The use of time in design is an aspect that is specific to landscape architecture. Waldheim, Corner, Allen and others propose that landscape is a medium that "is uniquely capable of responding to temporal change, transformation, adaptation and succession."[50] They conceive of landscape "as an analog to contemporary processes of urbanization and as a medium uniquely suited to the open-endedness, indeterminacy, and change demanded by contemporary urban conditions."[51] Thinking about the city and its infrastructures demands an open-ended, staged approach since city building is a time-consuming and expensive undertaking. Both infrastructure and

city building benefit from a design process that explicitly speculates on changes and possibilities over time. Drawing these potential futures is important in order to interrogate and understand them fully. Like a natural ecosystem, the city grows and develops in complex and seemingly unpredictable ways, driven by forces which may not be immediately obvious but are more likely to become so when the future is drawn.

Biological Complexity

The biological complexity of an infrastructural system can be thought of in many forms, from pipes and networks under the street to networks themselves to worldwide digital networks. The forthcoming AV ecosystem and its interconnection to worldwide digital networks, as well as to the urban form of the street, is perhaps the largest example of an interconnected ecosystem with immense complexity. Even within the system of the AV itself, there is already extensive research which uses neural network technology for AV navigation.[52] The complexity of the network and interrelationships between vehicles themselves will very quickly simulate a biological complexity.

These types of networks and interrelationships between the factors are well served by the theoretical approach which has underlaid projects by the firm Field Operations. Stan Allen, one of the principals of the firm, introduces his book by quoting from Michel Serres:

> Stations and paths together form a system. Points and lines, being and relations. What is interesting might be the construction of the system, the number and disposition of stations and paths. Or it might be the flow of messages passing through the lines. In other words, a complex system can be formally described.[53]

Allen is interested in thinking about the city as a complex dispersed field: he considers the city as a field—and sometimes, when referring to Tokyo, as a three-dimensional field. He looks to complex, more bottom-up organizing structures such as flocking and crowd behaviour as a way of understanding organizing forces and structures within the city. Allen is not looking at form but instead looking to organizing structures and forces to inform design. It is easy to see how this type of theorizing can be applied to the AV city when looking at the 'last mile' issue in public transportation, for example. One of the significant challenges with public transportation is how people move from their home to the closest transit station. This is a particularly significant issue in less populated areas, where bus routes are often infrequent and badly served, and it is often necessary to walk some distance. An autonomous on-demand shuttle or SAV service could easily remedy this problem. If

this type of system was to serve transit users well, then the benefit of the public transit to the directly adjacent property changes and likewise does the benefit to further properties. This flattens out the density of the development around the transit. It may also make transit more attractive in the process, but that would require a larger analysis of value to the traveller.[54] Mapping these types of influences and visually representing the interrelationship of forces is key to understanding what they are and how to design for them.

Interfaces

The key space for designers, however, may not be the 'neural network' of the AV system or how it relates to its sensors, but instead the interface between the infrastructural systems and the people who navigate them. This is clearly an example of a complex problem that needs to be addressed, not by solving a technological issue, but instead by looking to understand the social and cultural relationships of people both to the space of the street and to its other users. Several of the examples in the following chapter are pertinent to this discussion, such as the considerations of how to design intersections for the AV landscape: how can an approaching AV predict the movements of pedestrians? Google has algorithms to predict bicycle, pedestrian and other vehicle movements[55] but predicting a bicycle movement is not as complex as predicting those of pedestrians: the wheel movement of bicycles ensures that rapid changes in direction are not possible, but a pedestrian can move suddenly and quickly in any direction. So, will pedestrians always have to "apply to cross the street"[56] (as Jan Gehl puts it) by pressing a button to indicate their desired direction—or is there a better way?

Another example of the potential challenges posed by the new relationship between AVs and pedestrians is that pedestrians will have the ability to cross the street at any point because they know the AVs will stop. This will result in traffic coming to a standstill. While this may be a positive turn of events in the realm of the walkable city, it will result in gridlock if allowed to proliferate. At some point, when everyone accepts that the hierarchy of the street has been overturned, there will be a desire to improve through-flow. This will clearly not be a technological problem but rather a social/technological interface problem. Several design approaches are possible which include (from most physical to least physical): designating a hierarchy of streets so that there are more streets where pedestrians are given priority ('pedestrian mainly') and others which are deemed 'AV mainly' streets where cars are given priority; road design to allocate AV-only zones and limit crossings to specific locations; clearly marking pavements to facilitate group

crossing; media campaigns to support vehicle courtesy zones; and/or fines which are enforced by in-AV-cameras. These are examples of design problems where collaboration between multiple disciplines is necessary and where design approaches become critical.

Ecological Urbanism: The Evolution of Landscape Urbanism

Since the Landscape Urbanism manifesto, there have been many critiques and discussions of the theory and its aspects. One of the most significant of these is outlined in the eponymous *Ecological Urbanism*,[57] which suggests that design is the key to balancing the conflicts between ecology (natural ecosystems) and the overt consumption of urbanism. It is not a completely separate theory from Landscape Urbanism but rather a theory that emphasizes and elucidates an aspect of particular interest within its parent theory. Waldheim, in "On Landscape, Ecology and Other Modifiers to Urbanism,"[58] refers to Ecological Urbanism as "critique and a continuation by other terms of the discourse around landscape urbanism."[59]

Ecological Urbanism brings several things to the fore that Landscape Urbanism did not significantly address: it more thoroughly discusses the interrelationship of systems and includes people as a driver and a force to be accounted for within its theoretical framework. Where Landscape Urbanism is mainly talking of systems (infrastructural, landscape, ecological) and the idea of the landscape as an interconnecting system between buildings, Ecological Urbanism looks at multiple systems and infrastructures, some of which interrelate, as well as people and real-world scenarios of dense urban living which are not always situated in affluent 'first world' settings.

Ecological Urbanism outlines the manifesto of this theoretical framework and does a good job of pointing out what the problem is and how we should think about it; however, it does not point to any examples of how to implement this in a project. It does sum up what the issues are and it proposes that designers are the ones to address these issues. But, as with Landscape Urbanism, the field is very young and the book is a manifesto of sorts. It is worth noting that projects which land under these theories are not yet common and this is likely due to the need for interdisciplinary collaboration on large infrastructural projects, which take many years to come to fruition. The theories are currently still ahead of the implementation.

Infrastructural Ecologies

Some of the synergetic aspects of the ecological urbanism theory are well represented by Hillary Brown in *Next Generation Infrastructure*.[60]

Brown looks in a more practical way at issues of infrastructure and ecologies and thinks infrastructure systems should be "multipurpose, interconnected and synergistic."[61] She calls these "infrastructure ecologies," which she defines as co-located services that cost-effectively share flows of energy and resources in a closed-loop system.[62] As a simple example, Brown looks at the renewable energy park of the township of Hempstead, Long Island. The energy park is located at the Town of Hempstead's Conservation and Waterways headquarters. It is a prototype municipal facility featuring wind and solar power, ground-source heating and cooling, electric-vehicle charging, a fuel cell, a net-zero energy office and aquaculture facility. When networked, all of these components constitute an "infrastructural ecology." Brown points out many valuable aspects to the synergetic design of infrastructure and her approach demonstrates an aspect of Ecological Urbanism; it does not, however, go as far in the involvement of society, the city and natural systems as the theory of Ecological Urbanism.

Society | Nature

Ecological Urbanism insists that the social factor of the human be taken into account in a sustainable society. Sanford Kwinter is an architectural theorist who writes about philosophical issues related to design, architecture, and urbanism. Kwinter points out that ecological efficiency does not equal sustainability and warns against narrow or indoctrinated thinking on both ecological and sustainability issues.[63] Kwinter starts his discussion by pointing out that the dichotomy between city and nature is a social construction, largely fabricated by the Industrial Revolution. He argues that the transformation of territory is rooted in this "archaic and false opposition" and that today's economic and biospheric crises are a result of this false opposition. In other words, if we thought of city and nature as an interrelated continuum then we would not be having a climate crisis.[64] He clarifies,

> There can be no "ecological thinking" that does not place human social destiny at the heart of our posture towards our environmental context. We may well learn over the next years that cities, even megacities, actually represent dramatically efficient ecological solutions, but this fact alone does not make them sustainable, especially if the forces of social invention remain trapped in tyrannies that only ecological thinking on an ecumenical scale can free us from. For ecological thinking too has its counterfeit and debased forms, and many 'sustainability' discourses remain more oppressive than liberatory, more stifling than inventive.[65]

Kwinter postulates that the origin of both our understanding of nature today and current thinking on ecology

is based on a movement from the 1970s called 'Deep Ecology.' Deep Ecology included humans within its idea of the larger ecosphere and did not dissociate humans from nature. Once humans are placed within the framework of the larger ecosphere, then the system is continuous and humans are one part of it—influencing it, but also relying on it. This conceptual framework does therefore not allow 'nature' or the 'environment' to be seen as external aspects which can be exploited.

Another theory of the time, the Gaia hypothesis formulated by James Lovelock, was more radical and presented the natural biosphere almost as an autonomous entity—a super organism.[66] This theory looks at the earth as an open but bounded system in which the environment and the life within it are in a coupled state where a change in one results in a change in the other—living organisms affects the environment and the environment affects the organisms.[67] Both the Gaia and Deep Ecology theories try to bring the human into the ecological discussion, a discussion which can be seen as having a clearly different viewpoint from the human—almost a self-interested personality. It may be beneficial to think of AV networks as self-interested systems interrelating to the larger 'biosphere' containing people and 'nature.' In fact, the algorithms which will likely control such systems will have optimization goals which may be independent of both societal interests and nature; their purpose will be to maximize their efficiency on an agent-based level, and to serve the interests of those who control them at the system-wide level.

Urban Form Approaches

Kwinter has a few other points which help clarify the theory of Ecological Urbanism and its theoretical underpinnings. He brings to our attention a reminder that rationalizing and/or modernizing urban areas is a highly problematic undertaking, and design of a city must take this into account.[68] He notes that the fabric of the city—i.e. the circulation corridors of the city—in some places is an outcome of social activity; if one thinks of the definition of infrastructure as that which supports human activity,[69] then the design of the circulation corridors has to support the social fabric. Looking more to city form, Kwinter states:

> Current ameliorative development in cities targets the archaic physical structures and the archaic social life forms that adhere to them. Two examples among hundreds are the destruction of Beijing's Hutongs and the proposed redevelopment of the Dharavi slum quarters in Mumbai. It is an unexamined and possibly dangerous proposition that the solution to the new demographic and economic pressures is to fully rationalize and modernize our existing urban habitats; indeed, the opposite

> may be the case. Take for example the proposed Dharavi redevelopment (as a model for very rapid capital-intensive development taking place in India, China, Brazil and other giant economic territories). Among the great singularities of India is the intensity of its local commerce, the vastness and ubiquity of its social markets, which are virtually coextensive with its metropolitan fabrics.[70]

Kwinter's viewpoint on Ecological Urbanism insists on the integration of the social and creative as part of the ecology. He warns against entrenched, dogmatic and uncreative thinking about the problems of ecology and sustainability, and calls on the design community to serve as an "organizing centre for the variety of disciplines and systems of knowledge whose integration is a precondition for connecting them to clear political and imaginative and, most important, formal ends."[71]

Ecosophy

Underlying the theories of Ecological Urbanism, and providing an important theoretical framework for consideration of the AV city, is the concept of 'existential ecologies.' This idea was put forward by Félix Guattari and includes "everything that is required for the creative and dynamic inhabitation and utilization of the contemporary environment"[72]—or to paraphrase, the social and cultural aspects of our environment as rooted in the natural. Guattari was something of a polymath who wrote *The Three Ecologies* in 1989. He was, amongst other things, an ecological philosopher and even ran for political office on an environmental ticket. Guattari's viewpoint was that a traditionalist environmental perspective does not adequately represent the complex relationship between humans and the natural environment. The two ideas of human systems (culture) and natural systems (nature) are too binary and oppositional and therefore counterproductive to the urgent issue of environmental stewardship. Guattari proposed 'ecosophy' as a better approach, which treats ecology as a study of complex systems including human thought and culture, social relations, and the natural environment all on an interrelated continuum. This idea is also linked back to the 'deep ecology movement' from where the term ecosophy originated.

Guattari's three ecologies are the 'social, mental and environmental' and all three combine in his ecosophy. He argues that the techno-sciences are crucial to the survival of the planet but that in order to re-orient the techno-sciences to this purpose, capitalist structures and the concept of subjectivity have to be reconsidered. In effect, the requirement that we denounce the dominance of the economic regime of capitalism means that we have to change the way we, as a society, think about things. He calls upon architects,

educators, artists, designers, media people—anyone, in fact, who can influence people's psyches—to produce 'wedges' (defined as "producing an interruption or making openings that can be inhabited by human projects leading to other ways of feeling, perceiving or conceiving"[73]) in order to provoke people to think differently. Guattari discusses subjectivity in this way and recognizes that our philosophies should change and constantly renew, rather than remain stuck in one repetitive theory.

We can see the influence of his thinking on the Ecological Urbanism movement and, in fact, we could say his theories are the basis of the movement. Guattari also proposes that the movement should constantly be questioning itself and evolving and, so far, we can see that as well. In the case of the focus of this book, and as the technological complexity and interrelationship of the natural and unnatural accelerate, the ideas of ecosophy and the re-alignment of the techno-sciences are ever more critical.

Future Ecologies and Urbanisms

Chris Reed and Nina-Marie Lister comment that in the field of science, ecology has, in the last few decades, reinvented itself. Formerly a field which mainly held to classical determinism and reductionist Newtonian concerns about order, certainty and stability, it has evolved to offer a more contemporary understanding of dynamic systems and related phenomena of adaptability, flexibility and resilience.[74] They point out that many other disciplines are adopting complex adaptive systems theories: business with management theory and network organization, engineering with systems design and, of course, computer engineering with AI and machine learning. We have also pointed out in this chapter the adaptive network analysis for transportation engineering. As Reed and Lister write, "Increasingly these concepts of ecological thought are found useful as heuristics for decision-making generally, models or metaphors for cultural production broadly, and for the design arts in particular."[75] They argue that landscape architecture is placed between ecology and design of the built environment and is therefore uniquely placed to use ecological models.

But ecology is now used by many theoreticians and researchers as a metaphor or a broader idea for the behaviour of a system with political, economic and/or social implications; sometimes they have even redefined the term to include these realms. Reed and Lister also refer to Guattari and credit him with the basis of the idea, supporting this with a quotation from *The Three Ecologies*:

> Ecology must stop being associated with the image of a small nature-loving minority or with

> qualified specialists. Ecology in my sense questions the whole of subjectivity and capitalistic power formations.[76]

Reyner Banham had a similar idea in *Los Angeles: The Architecture of the Four Ecologies*,[77] his urban and architectural design history of Los Angeles. Banham writes of a combination of "geography, climate, economics, demography, mechanics, and culture" which is only made evident via movement on the city's characteristic roads and freeways; these constitute four organizational 'ecologies' for metropolitan Los Angeles: Surfurbia, the Foothills, the Plains of Id and Autopia.[78] His book was mainly a re-imagining of LA as a significant city for urban considerations; it became in many ways a model for the future as it reinvented the history of LA in people's minds.

Reed and Lister titled their book *Projective Ecologies* because, unlike ecologists who can only observe their models of ecosystems, designers can create and speculate on systems. Their work is influenced by landscape ecology, human ecology, urban ecology, applied ecology, evolutionary ecology, restorative ecology, deep ecology, the ecology of place and the unified theory of ecology. They think that this theory will encompass interdependencies and complexities that exist in our environments.

Conclusion

Disciplinary theories are frameworks to understand and elucidate how we approach problems in our domains. They bring cultural and social values and knowledge to inform decision making in the field. When examining the theories of the disciplines surrounding the AV and the city, it is clear we need an approach which acknowledges the health of the environment, societal goals, systems that spread beyond boundaries, changes over time and complex networks. Such a framework can be found in landscape architecture and the evolution of its Landscape Urbanism/Ecological Urbanism theories. These theories, however, will need to adapt further to incorporate more fully the digital networks as an integrated force on the transportation network and, therefore, the urban form. Economic, political and policy forces, while acknowledged, are not explicitly dealt with and these are again invisible forces with a wide-reaching influence. While Kwinter does warn us against normalizing development which negates social relationships, there is a lack of theoretical discourse on integrating policy with social patterns beyond the narrow and normalizing concept of 'the neighbourhood.' Future theoretical frameworks could take this on more strongly in the context of the new AV city and its increasingly intense international competition for brain power and capital investment.

Notes

1 Jan Gehl, *Cities for People* (Washington, DC: Island Press, 2013).

2 This interchange design is currently in public consultation phase.

3 Michael Sorkin, "The End(s) of Urban Design," in *Urban Design* (Minneapolis: University of Minnesota Press, 2009), 171.

4 Alex Krieger and William S. Saunders, eds., *Urban Design* (Minneapolis: University of Minnesota Press, 2009), ix.

5 American Planning Association, "American Planning Association History," accessed December 9, 2017, https://www.planning.org/history/.

6 Richard Marshall, "The Elusiveness of Urban Design," in *Urban Design* (Minneapolis: University of Minnesota Press, 2009), 44–47.

7 Dana Cuff and Roger Sherman, *Fast-Forward Urbanism: Rethinking Architecture's Engagement with the City* (New York: Princeton Architectural Press, 2011).

8 Ibid, 15.

9 "Audi Urban Futures Awards." Audi Urban Future Initiative, audi-urban-future-initiative.com/facts/big-bjarke-ingels-group. Accessed September 24, 2017.

10 Alex Krieger, "Where and How Does Urban Design Happen?," in *Urban Design* (Minneapolis: University of Minnesota Press, 2009), 114.

11 Marshall, "The Elusiveness of Urban Design," 49.

12 Pierre Bélanger, *Landscape as Infrastructure* (New York: Routledge, 2017), 50–63.

13 The Army Corps of Engineers, "The U.S. Army Corps of Engineers: A Brief History," US Army Corps of Engineers, accessed January 5, 2018, http://www.usace.army.mil/About/History/Brief-History-of-the-Corps/Improving-Transportation/.

14 Peter D. Norton, *Fighting Traffic* (Cambridge, Massachusetts: MIT Press, 2008), 202–4.

15 Ibid, 103–48.

16 Chris Urmson, Director Google Self Driving Car Project, "The Future of Autonomous Driving," keynote lecture delivered at TRB Conference, January 13, 2016. Also available online at https://www.youtube.com/watch?v=A2IIbgKuf6Y. Urmson points out that the solution of the technical problem of the Level 4 self-driving car is a much easier problem to solve than the people problem of bringing people's attention back to the road in case of emergency. As such, they are skipping Level 3 autonomy and not releasing the technology until Level 4 is reached.

17 Edward Weiner, "Roots of Urban Transportation Planning," in *Urban Transportation Planning in the United States: History, Policy, and Practice* (New York, NY: Springer New York, 2013), 19–30.

18 Ibid.

19 Daniel Fagnant, Kara Kockelman, and Prateek Bansal, "Operations of Shared Autonomous Vehicle Fleet for Austin, Texas, Market," *Transportation Research Record: Journal of the Transportation Research Board* 2536 (January 1, 2015): 98–106.

20 Gereon Meyer and Susan Shaheen, *Disrupting Mobility: Impacts of Sharing Economy and Innovative Transportation on Cities* (New York: Springer, 2017).

21 American Planning Association, "American Planning Association History."

22 American Planning Association, "Choosing the Planning Profession," accessed September 24, 2017, https://www.planning.org/choosingplanning/.

23 Krieger, "Where and How Does Urban Design Happen?," 124.

24 Ibid, 114–30.

25 Marshall, "The Elusiveness of Urban Design," 44–45.

26 Krieger, "Where and How Does Urban Design Happen?," 114 quoting Sert.

27 Charles Waldheim, "On Landscape, Ecology and Other Modifiers to Urbanism," *Topos* 71. June (2010): 22.

28 See for example: Brent D. Ryan, *The Largest Art: A Measured Manifesto for a Plural*

Urbanism. (Cambridge, Massachusetts: MIT Press, 2017).

29 Pierre Bélanger, *Landscape Infrastructure: Urbanism beyond Engineering* (Wageningen University, 2013), 276.

30 Bélanger, *Landscape as Infrastructure*.

31 Charles Waldheim, *The Landscape Urbanism Reader* (New York: Princeton Architectural Press, 2006); Pierre Bélanger (New York: Routledge, 2017), *Landscape as Infrastructure*; Mohsen Mostafavi and Gareth Doherty, *Ecological Urbanism* (Baden: Lars Müller Publishers, 2010).

32 Krieger, "Where and How Does Urban Design Happen?," 125.

33 Krieger and Saunders, *Urban Design*, 126.

34 Gary L. Strang, "Infrastructure as Landscape [infrastructure as landscape, landscape as infrastructure]," *Places* 10, no. 3 (1996): 9–15.

35 James Corner, *Recovering Landscape: Essays in Contemporary Landscape Architecture* (New York: Princeton Architectural Press, 1999), 1–26.

36 Reyner Banham, *Theory and Design in the First Machine Age* (Cambridge, Massachusetts: MIT Press, 1960), 9–12.

37 Charles Waldheim, "Landscape as Urbanism," in *The Landscape Urbanism Reader* (New York: Princeton Architectural Press, 2006).

38 Charles Waldheim, *The Landscape Urbanism Reader* (New York: Princeton Architectural Press, 2006).

39 James Corner, "Terra Fluxus" in *The Landscape Urbanism Reader* (New York: Princeton Architectural Press, 2006), 23.

40 Fagnant, Kockelman, and Bansal, "Operations of Shared Autonomous Vehicle Fleet for Austin, Texas, Market."

41 Brent D Ryan, "Hard Urbanism," *Journal of Urban Design* 20, no. 3 (2015): 321.

42 Strang, "Infrastructure as Landscape," 11.

43 Ibid, 15.

44 Ibid.

45 Waldheim, "Landscape as Urbanism," 39.

46 Projects by West8, Hargreaves Associates, Corner/Field Operations and DIRT Studio.

47 Reyner Banham, *Theory and Design in the First Machine Age* (Cambridge: The MIT Press, 1980).

48 Waldheim, "Landscape as Urbanism," 45.

49 Alex Wall and James Corner, "Programming the Urban Surface," in *Recovering Landscape* (New York: Princeton Architectural Press, 1999), 233–49.

50 Waldheim, *The Landscape Urbanism Reader*, 39.

51 Ibid.

52 Dean A. Pomerleau, "Efficient Training of Artificial Neural Networks for Autonomous Navigation," *Neural Computation* 3, no. 1 (1991): 88–97.

53 Stan Allen, *Points and Lines: Diagrams and Projects for the City* (New York: Princeton Architectural Press, 1999).

54 See an analysis of current technologies on agent based modelling on transportation and land use: Miller, Eric J. "Modeling the demand for new transportation services and technologies," *Transportation Research Record: Journal of the Transportation Research Board* 2658 (2017): 1–7.

55 Zhu, Jiajun, Michael Steven Montemerlo, Christopher Paul Urmson, and Andrew Chatham. "Object detection and classification for autonomous vehicles." U.S. Patent 8,195,394, issued June 5, 2012.

56 Jan Gehl, "Cities for People" (Vancouver, BC, January 24, 2011).

57 Mostafavi and Doherty, *Ecological Urbanism*.

58 Charles Waldheim, "On Landscape, Ecology and Other Modifiers to Urbanism," *Topos* 71, no. June (2010): 21–24.

59 Ibid, 24.

60 Hillary Brown, *Next Generation Infrastructure* (Washington, DC: Island Press, 2014).

61 Ibid, 17.

62 Ibid, 18.

63 Sanford Kwinter, "Notes on the Third Ecology," in *Ecological Urbanism* (Lars Müller Publishers, Baden, 2010), 103.

64 Ibid, 94–105.

65 Ibid, 103.

66 James E. Lovelock, "Hands Up for the Gaia Hypothesis," *Nature; London* 344, no. 6262 (March 8, 1990): 100.

67 Ibid.

68 Kwinter, "Notes on the Third Ecology," 99.

69 Merriam-Webster dictionary defines infrastructure as 1. 'the underlying foundation or basic framework (as of a system or organization)' and in 3. as the system of public works of a country, state, or region; also : the resources (such as personnel, buildings, or equipment) required for an activity. "Definition of INFRASTRUCTURE," Merriam-Webster, accessed January 3, 2018, https://www.merriam-webster.com/dictionary/infrastructure.

70 Kwinter, "Notes on the Third Ecology," 99.

71 Ibid, 105.

72 Ibid, 104.

73 Verena Andermatt Conley, "Urban Ecological Practices: Félix Guattari's Three Ecologies," in *Ecological Urbanism* (Lars Müller Publishers, Baden, 2010), 139.

74 Chris Reed and Nina-Marie E Lister, *Projective Ecologies* (Harvard University Graduate School of Design Cambridge, MA/New York, 2014): 15.

75 Ibid.

76 Ibid, 13.

77 Reyner Banham, *Los Angeles: The Architecture of Four Ecologies* (Harmondsworth, Eng.: Penguin Books, 1973).

78 Ibid.