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Infrastructure as Practice

To design infrastructure is to design a built form that can be generative and directive: it has the potential to create place and suggest future growth. Yet transportation infrastructure in North America is routinely designed as isolated, mono-functioning works of engineering. In urban areas, this singular approach often leaves areas of adjacent land as vacant and unviable public space discouraging to other patterns and modes of movement. Conversely, new infrastructure in dense urban areas could be developed that promotes public space and includes cultural and social agendas as primary generators of built urban form. This new approach would weave novel, responsive elements into an existing fabric, generating a multiplicity of connections, program, and places.

Infrastructure can generally be defined as an underlying foundation or basic framework of a system. More specifically, it is defined as the system of public works of a country, state, or region, or the resources required for an activity: essentially that which supports and facilitates human activity.[1] In the highly-structured environment of the developed world, infrastructure is ubiquitous: it includes everything from satellites to wastewater treatment, prisons, ports, trash removal, ATMs, the Internet, and disaster response systems, to name a few examples. As is evident from such a list, there is an extensive variety of infrastructure that affects our daily lives. For this reason, there is a growing interest in the design profession to play a greater role in the formations and transformations of the infrastructure that surrounds us. Sanford Kwinter for example, comments that:

> What is interesting today and what matters, is infrastructure . . . . Infrastructure simply has an aura different from that of building: it possesses a critical resonance, a direct reach or extensivity into the adjacent material environment that no architecture alone can approximate.[2]

Kwinter's observation, which is borne out in transportation infrastructure, is of particular relevance to architects not only because infrastructure is a support structure to human activity and serves public purpose, but also because of the extended impact it has on our built environment due to its scale and impermeability. It is also of critical relevance because of its ability to provide a reference point in the urban fabric, to be memorable and to gather activity. The proclivity to place-making can be demonstrated by the manner in which a transit station, for example, that has been brought into existence by an infrastructure system, makes a new place present by providing a reason to be in that space. This place-making results in a multi-layered program which relates to commercial businesses, restaurants, and public service programs and also to connections with other transit and streets. This initial function, to provide a transit route and space for transportation, then results in interaction with the transit space and others within it, producing activity and memories. One can consider the Tokyo subway stations, the London Underground, or the Zürich Main Train Station when reflecting upon the experiences provided by such architectural infrastructure. There are numerous bridges and cycle paths which also demonstrate this place-making ability in that they provide a place for transportation but also for an experience of the city that is more spectacular and recreational, even while commuting; all of us have our own local examples that have affected our lives.

I would argue that the quality and specific types of spaces of an infrastructure will result in consequential interactions. If the design of infrastructure is such that it acknowledges and supports human activity and interaction, then a lively public space is more likely to occur than in infrastructure designed with its only objective being functionality and efficiency of transport. In order for transportation infrastructure to result in a space that generates a lively public place, it must be deliberately designed as such.

1. First train to cross Mission Branch Bridge (C.P.R.), spanning Fraser River, Mission, B.C., Canada. (Courtesy of City of Vancouver Archives.)

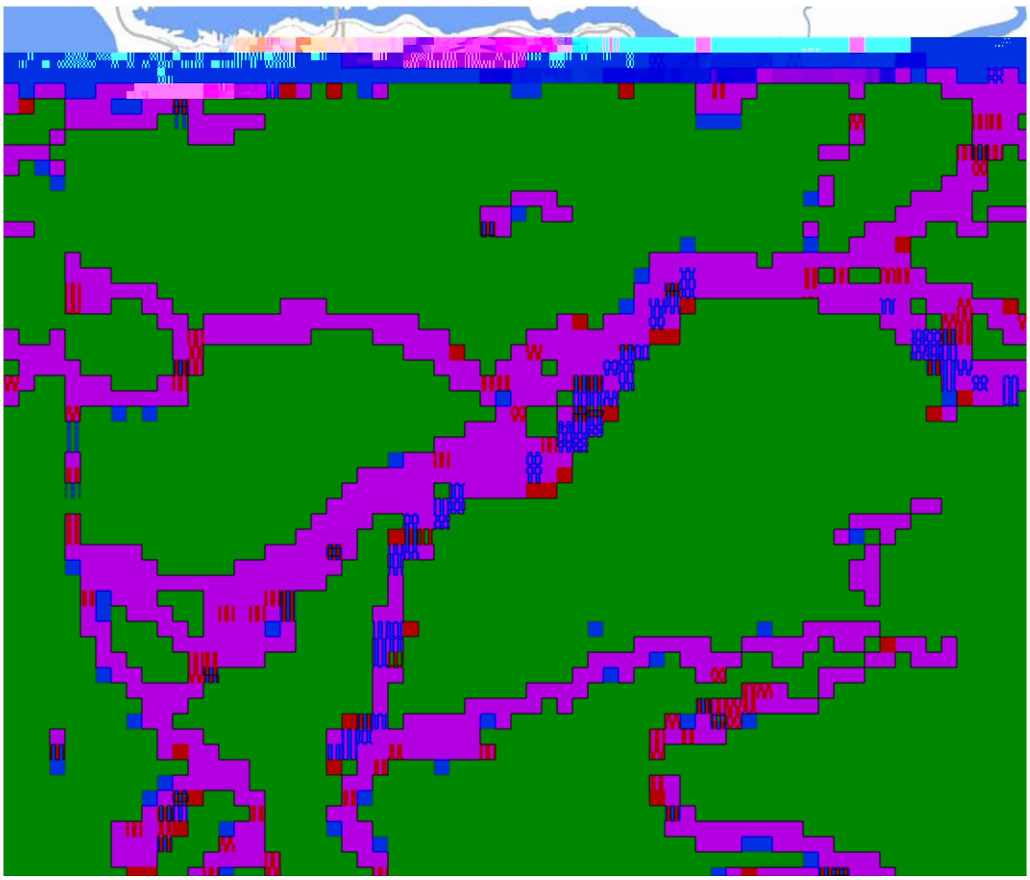
The Current Paradigm

The North American landscape is dominated by the presence of infrastructure for transportation. Historically, infrastructure—the building of railways and roads on vast tracts of land—has been held up as a heroic act of construction.[3] Dedicated, clever and determined men forged passages through formidable terrain in the service of creating the essential connections of a new land, and we can recall the photos that commemorate the completion of these great projects: proud men with their moustaches standing beside their completed projects—feats of engineering (Figure 1).

Yet unlike buildings that can be singularly and completely erased, infrastructure is more difficult to excise; it tends to remain in the landscape in modified and expanded forms—some improved, some deteriorated. North America has evolved into a landscape populated with dense urban centers and sprawling suburbs connected by a new generation of infrastructure. The construction of this newer infrastructure is no longer a heroic adventure; its presence is ubiquitous and in most places mundane and utilitarian; its manifestation is dominated by economics and efficiency. Since the passing of the heroic period of infrastructure, the method of building transportation infrastructure in North America has remained consistent from the recent past through the current period: its design considers travel demand, property acquisition requirements, cut and fill balance, economy of time and materials and, more recently, some ecological issues. This methodology is evidenced by the South Fraser Perimeter Road in British Columbia (Figure 2), a project currently under design by the Province of British Columbia with engineers Delcan and CH2M Hill.[4] With political will established, the engineering begins: a horizontal alignment is laid out based on travel demand and property acquisition requirements. Once the horizontal alignment is roughly established, vertical alignment is determined based on balancing the cut and fill of earth. Bridges are located where crossings of rail or water are required and most efficient. This stage is then followed by design, detail, and construction, as well as property acquisition. The South Fraser Perimeter Road represents a design paradigm based on economy and efficiency.

The methodology of this paradigm is carried into more dense urban areas, but the fit is ill-suited. The clearing of urban areas for construction of massive infrastructure is difficult because more people and politics are concerned, and the result often divides the city into parts. Even if the goal of the infrastructure is ''green,'' the physical manifestation often has a significant impact on the surrounding landscape with an attendant increase in noise and a reduction in the quality of public space both visually and experientially (the Gardiner Expressway in Toronto and the Georgia Street Viaduct in Vancouver are examples). Furthermore, the physical nature of the infrastructure may prove to be an impediment to interaction across its boundaries. Infrastructure, in spite of its overall necessity to society, can become a bad word to those who must live near it.

When cities were young and growing in North America, highways could be widened in response to the demand for transportation capacity, which was then a fairly straightforward undertaking. This type of expansion for road transportation is currently unfeasible in many urban areas owing to lack of space and the multiple, frequently conflicting, agendas of groups such as property owners, public interest groups, environmental groups, and politicians.[5] These parties are well justified in their concern about the construction of large-scale infrastructure; even though as a community we espouse public transportation, personally powered transportation, and walkable cities, the magnitude of infrastructure required for this new paradigm of transportation is monumental. At the same time, society requires more access to ports than



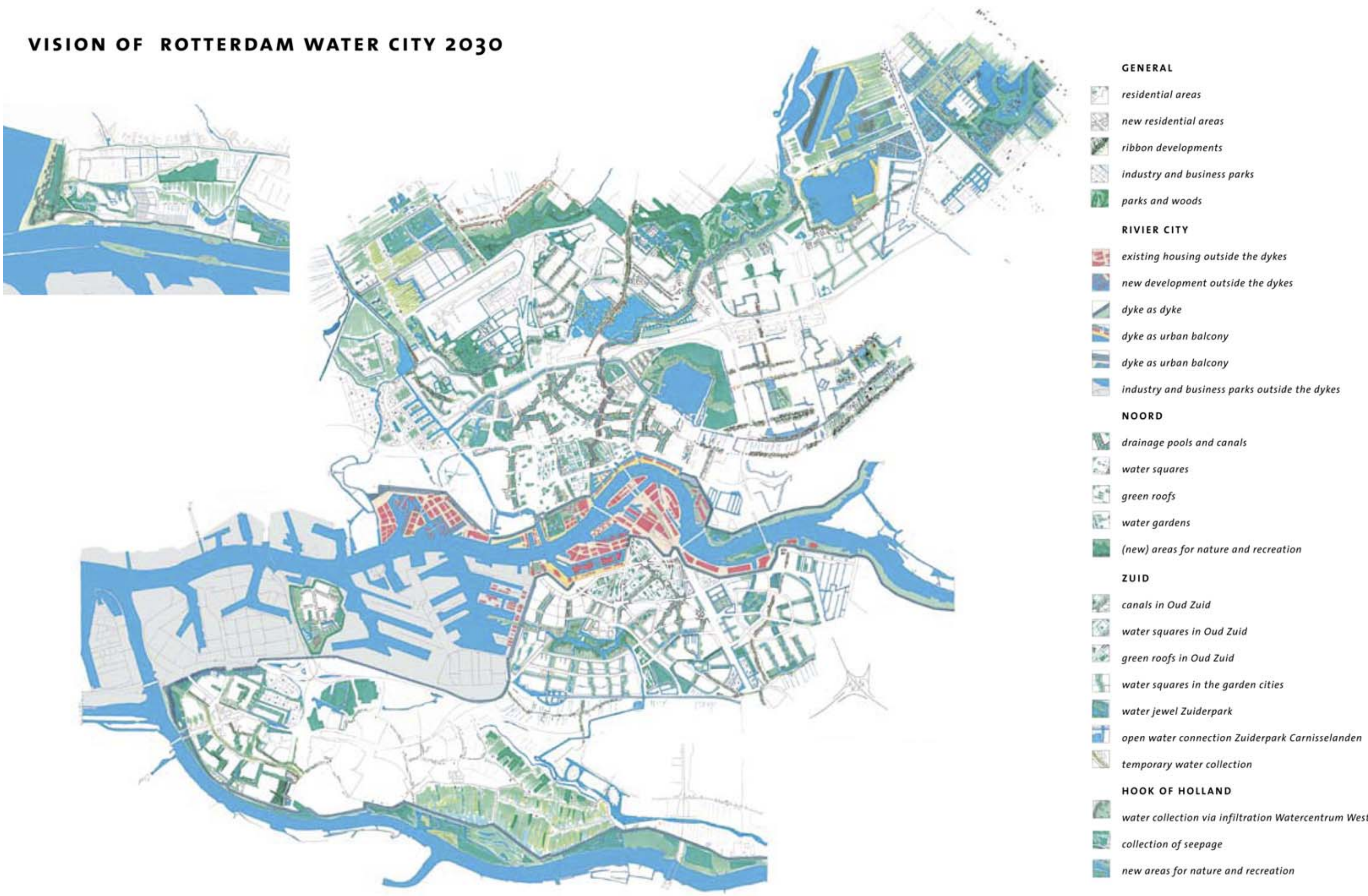
2. South Fraser Perimeter Road horizontal alignment. A new roadway planned as part of a transportation expansion project near Vancouver, Canada. (From Gateway Website, courtesy of the Province of British Columbia.)

previously for the movement of goods and services.[6] There is a greater population in urban centers than ever before, which requires greater access of all types to bring commodities in and out of these centers. In a rapidly increasing number of locations, these requirements can no longer be solved by a matter of simply widening or adding capacity to an existing system: it is no longer possible to construct infrastructure as in the past.[7] Given these conditions, North America requires a different type of infrastructure and a different approach to building it.

An Alternative Paradigm

While exploring alternative paradigms for transportation infrastructure design, it is useful to look to an architectural approach: it is my understanding that architects routinely take ''negative'' design criteria and work them into positive attributes of the built form. As a comparative example of this approach at a similar scale and in proximity to dense population, I will look to water control infrastructure in the Netherlands. By the 1700s, the Netherlands had developed sophisticated water control infrastructure at a scale large enough to hold back the sea.[8] These huge constructions used dykes and power supplied by the wind to claim land from the sea and keep it dry, even though the land was (and still is) several meters below sea level. The picturesque windmills, each dewatering their slice of land, are large-scale engineering works which were technologically ingenious even at the time they were first deployed. These infrastructure projects created a landscape of a specific cross-section and configuration; however, the density of the population demanded that the landscape perform multiple tasks. As a result, the water engineering infrastructure that resulted from the windmills has become embedded in the landscape and over time has been appropriated for other uses. Currently the infrastructure is designed into the public space—or perhaps vice versa—with bicycle paths in the Netherlands most commonly situated on top of the dykes. Looking at the city of Rotterdam, the dyke along the harbor is used not only as a bicycle path but also as a noise barrier, a vertical sectional ''tool'' that provides seating, and a delineator of the bounds of a sports facility (Figures 3 and 4). In designing this infrastructure with a multi-functioning agenda, incorporating both public space and engineering functions, the land benefits society on multiple levels, encouraging

3. The dyke as urban balcony, Rotterdam, Netherlands. An example of large scale water control infrastructure designed into a landscape. (Photo by the author.)



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4. Plan of Rotterdam showing dykes as design features of the landscape. (Courtesy of the City of Rotterdam.)

social interaction and physical activity, as well as providing a greenway and a water and noise control system.

The success of the Rotterdam infrastructure illustrates the benefits that can arise from incorporating infrastructure into a completely designed landscape. And although a water-controlled landscape may seem specific to the Netherlands, similar examples can be found in other landscapes. For example, it is possible to see water control infrastructure interacting with built form as a response to floodplains along rivers in urban areas. Along the Bow River near downtown Calgary, the housing and commercial businesses are raised 1.5 meters above road level. These roads serve as transport corridors but serve an additional little-known function in the landscape: to act as canals in the event of flooding. These potential canals provide a multiplicity of function to the streets of Calgary, although silent and unremarkable in the landscape. The lesson to take from

5. West 8's branding for Playa de Palma, Mallorca. The master plan includes everything from infrastructure design to graphic branding. (Courtesy of West 8.)

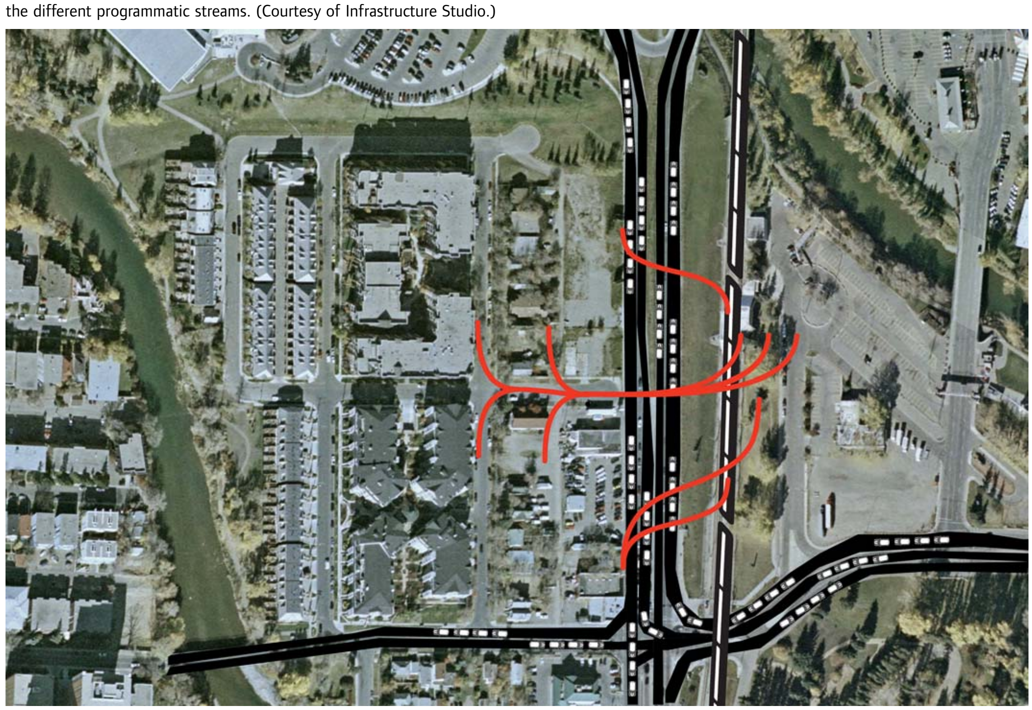
these infrastructural landscapes is that in order to benefit public space, the infrastructure must be fully integrated into the design of the built form: the design must place a similar value on both the infrastructure and the public space it serves. The designer must understand the multiple conditions of the environment and its ecology in order to create such integrated work, and the political entities involved must be ready to adopt insights and interests which go beyond economics and efficiencies.

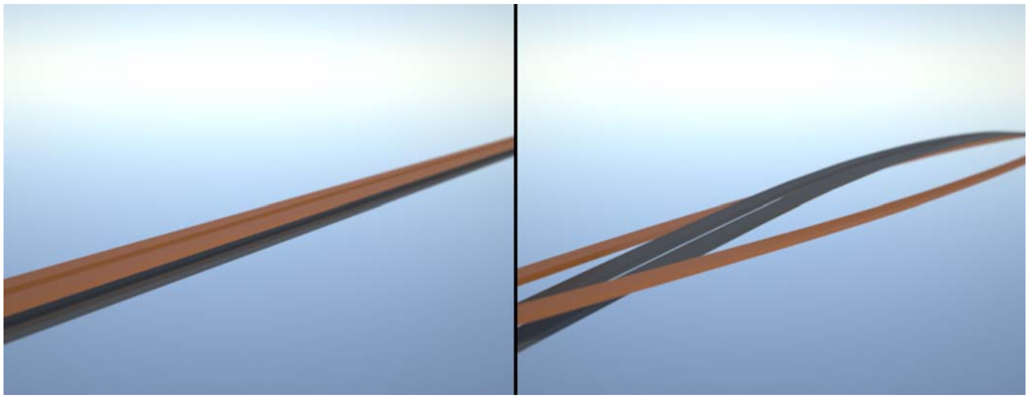
Landscape architecture is the most closely connected with infrastructure, having been involved in the booming business of mitigating infrastructure for the last half century.[9] Its practitioners have remediated and stitched together abused and broken landscapes—*dancing around the elephant*. But very slowly the issues of public space and ecology are being considered in infrastructure design as the public's awareness of environmental and land use issues in stressed urban areas is pressuring governmental bodies into action.[10] Architects (landscape or otherwise) are well positioned to step in and orchestrate such work. Projects in densely populated areas with valuable land and contested opinions from groups with differing stakes in such projects lead to more comprehensive approaches which bring issues of public space, ecology, public amenities, and experiential aspects to the fore. Projects by firms such as West 8, Field Operations, and Foreign Office Architects (FOA) represent examples of this integrative approach and the developing paradigm of alternative practice, by taking the infrastructure requirements as a part of an overall design package. West 8 in their Playa de Palma master planning for Mallorca even went so far as to provide branding for the project (Figure 5) which included a light rail transit system (LRT) and bicycle infrastructure.[11] Although these overall planning projects include transportation infrastructure as a component of the project, their focus is not solely on infrastructure. An integrated approach, such as that demonstrated by West 8, will ideally apply to the whole built environment. I believe that in cases where there are limited resources for design, a concentration on infrastructure moves us further towards a livable, vital environment, and sets the stage for future projects.

Scales and Approach

Foreign Office Architects states, "There is no difference between making a city and making

6. A program diagram from a preliminary study of a new pedestrian, roadway, and Light Rapid Transit configuration showing transportation desire lines of the different programmatic streams. (Courtesy of Infrastructure Studio.)





7. Comparison of configuration of two transportation streams: subway and roadway alignments. (Courtesy of Infrastructure Studio.)

a building or a detail.''[12] I would include infrastructure in this statement and its approach to building and argue that the design of large-scale infrastructure should be approached with methods that consider programming, history of the site, and physical interaction of infrastructure with the body, in addition to viewscapes, experiential aspects, and the environment as a space both for recreation and a resource to be preserved. Renderings can be made so the new built environment can be visualized. It is possible for green agendas to be fulfilled as personally powered transportation is enhanced and the area used for more than one program agenda at a time. For infrastructure construction, it may be a revolution in action and yet it is ''just architecture'' applied at a different scale and with a different programmatic content.

From Ideology to Practice

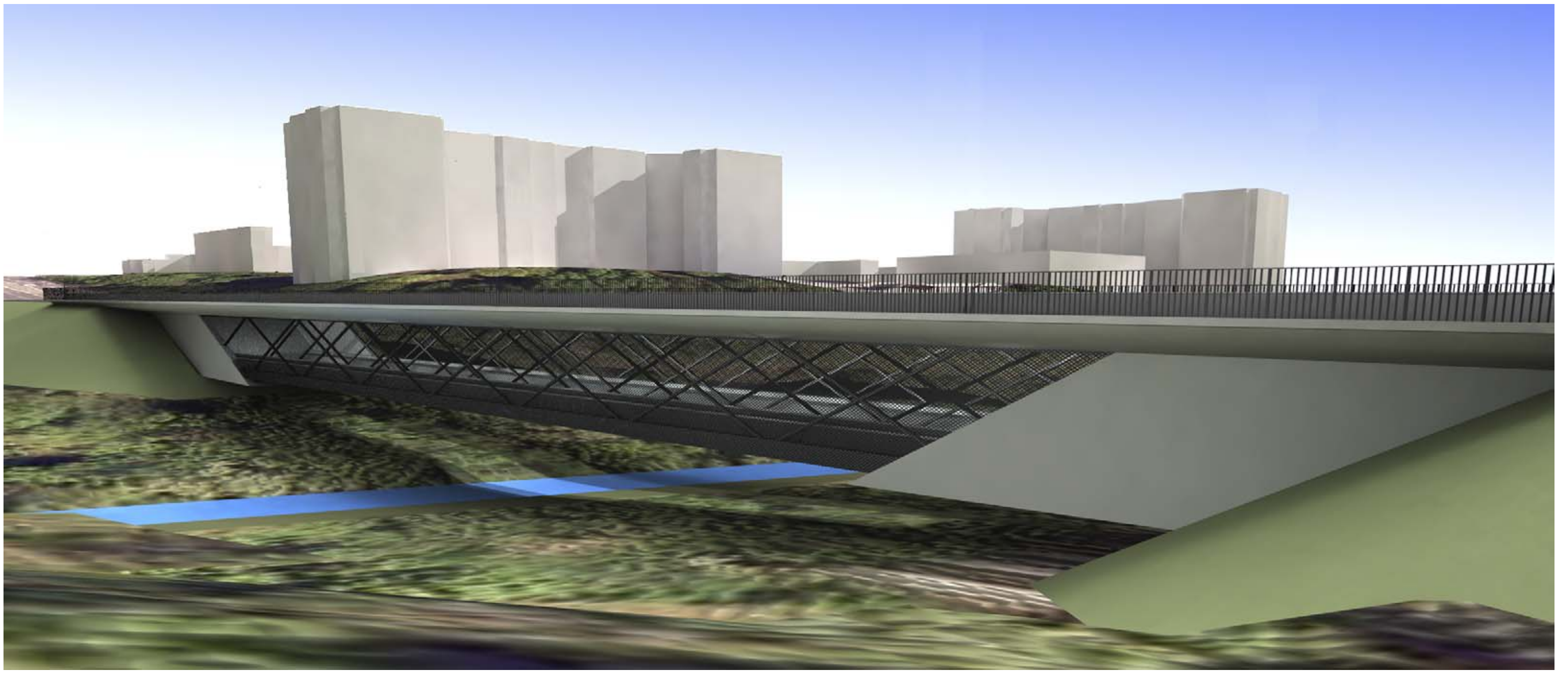
Infrastructure Studio (the author's practice) focuses on the design of transportation infrastructure that allows for the testing of the theories developed in university research. The practice of Infrastructure Studio brings an alternative paradigm to the design of infrastructure for clients who find it increasingly necessary to deal with multiple stakeholders in primarily contested urban areas. The practitioners' background in bridge engineering and architecture allows the integration of both engineering and public space issues to be addressed simultaneously.

Design Approaches

The deterministic nature of interactions sets up algorithms[13] for infrastructure typologies by providing bounding conditions for gradients and contacts in program or space. Some spatial determinations such as clearance envelopes and property lines are fixed; others, such as vertical alignments or interactions between streams, are flexible and pose various considerations: should a sidewalk be at the level of vehicles, above that level by more than six inches, or should it interact with the subway below? Should they have a visual or physical connection to one another? If a roadway and a subway have maximum gradients, how can these be used to determine alignments so that pedestrian interactions are optimized? When approaching this issue with engineering efficiency considerations only, these types of questions are never asked.

The primary difference when considering the design of space for transportation modes as opposed to the design of space for occupation is that the programmatic elements are pathways and not destinations (Figure 6). These pathways contain moving elements for cyclists, cars, and subway trains that can be thought of as streams. Where and how these streams interact is of particular interest

8. West 8's Eastern Scheldt storm surge barrier design works at a scale suitable to highway speed, but composed of smaller scale shells which also function ecologically as camouflage. (Courtesy of West 8.)

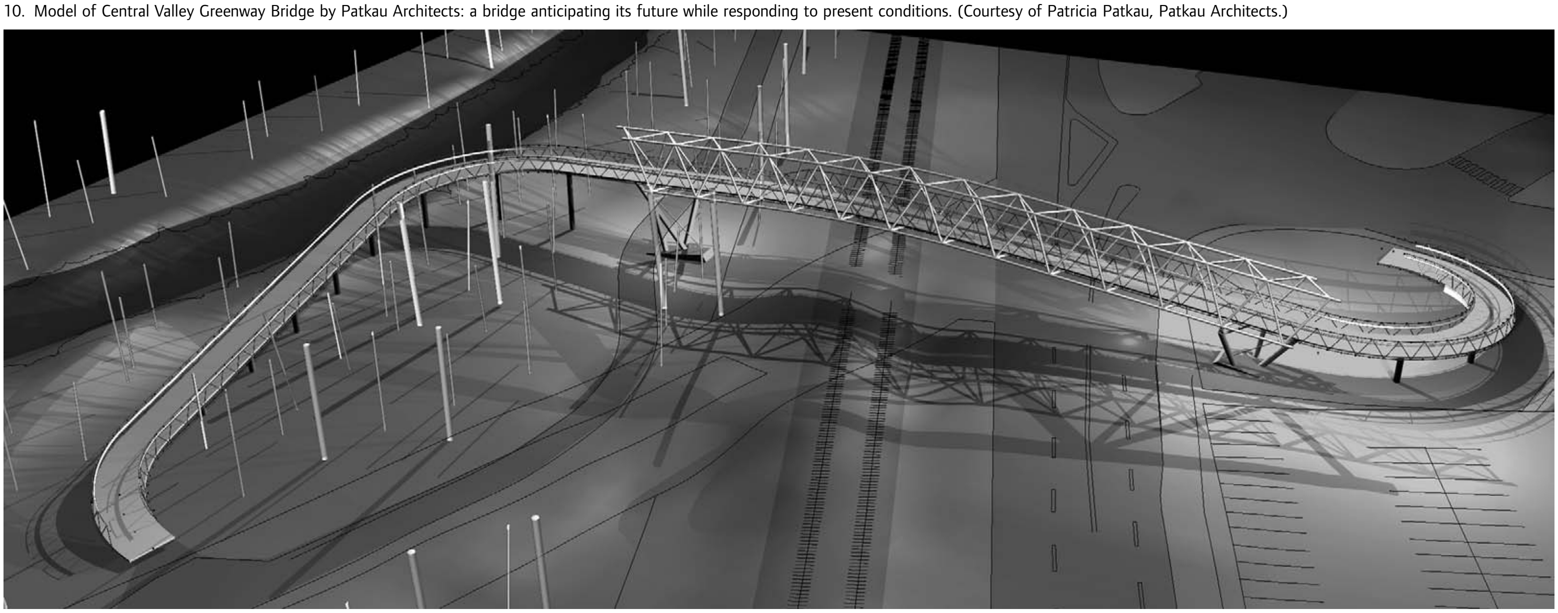


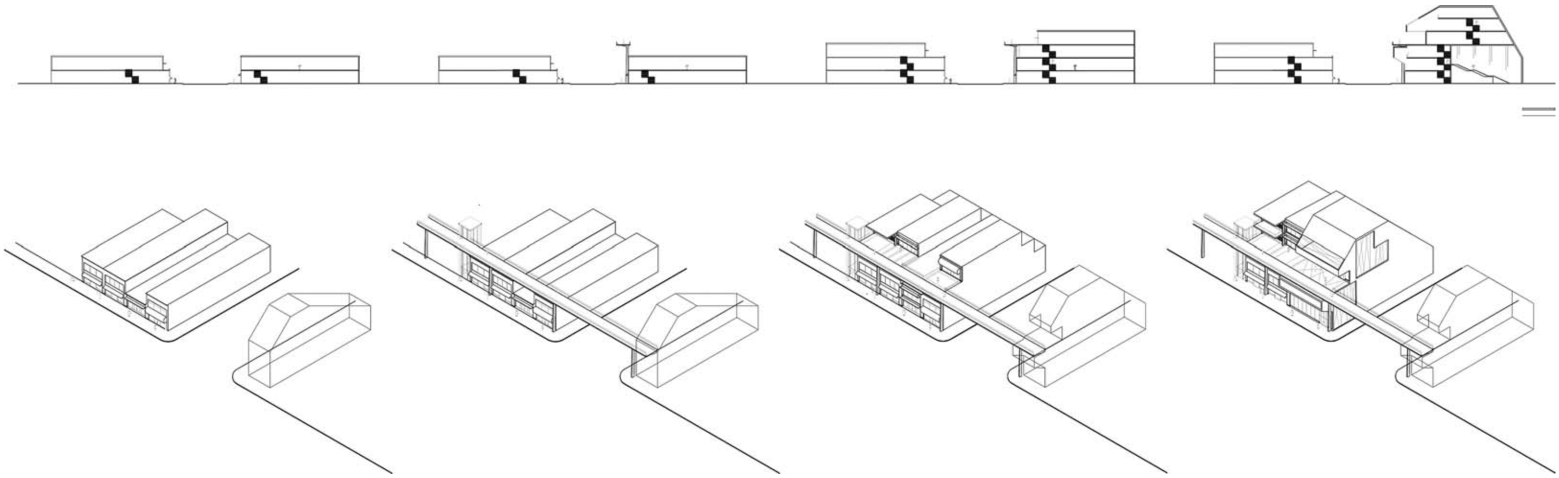
9. East Don Crossing (Infrastructure Studio): an option using the depth of subway structure below deck as a deep truss supporting the upper roadway level. Structure also expresses the speed of movement and emphasizes the temporary surfacing of the underground tunnel. The abutments are tilted to provide the longest viewtime possible from the subway. (Courtesy of Infrastructure Studio.)

in the design process and the interaction is again deterministic enough in its nature to provide the basis for an algorithmic approach: pedestrians move over, under, or to the side of roadway traffic but weave in and out of subways, LRTs, and other public transportation methods. At certain locations, modes might meet, thus requiring pedestrian or rail movement between them. For example, rail, road, and ship traffic meet and interweave at a port in deterministic configurations. The consideration of interaction in transportation design is a critical element of the approach.

A common aspect of working in an urban environment is the need to layer programmatic elements: the lack of available ground space gives rise to considering development above the ground level. Where there are physical constraints at the ground level, the transportation will be stacked vertically relative to, and over, the existing transportation networks. This is evidenced by subways and other light rapid transit which often run above or below major thoroughfares. This need to layer infrastructure requires structural consideration. Infrastructural layering also allows links to be made in directions other than along the horizontal axis of an existing infrastructure. At the East Don Subway Crossing in Toronto, designed by Infrastructure Studio, a new subway/roadway bridge allows for the passage of people and wildlife under the transportation streams. The spatial determination

10. Model of Central Valley Greenway Bridge by Patkau Architects: a bridge anticipating its future while responding to present conditions. (Courtesy of Patricia Patkau, Patkau Architects.)





11. Exploration showing how a development sequence prompted by new infrastructure at a different datum might occur over time.

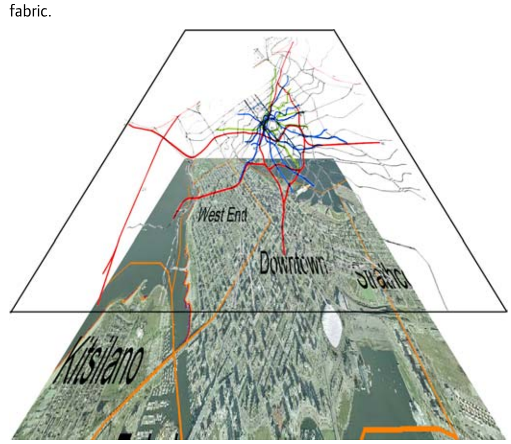
of property lines restricted the weaving of the subway into the vertical plane of the roadway, because that would have required the roadway to move outward. However, the vertical alignment of the roadway and subway was a flexible factor and provided for the diagram of the scheme (Figure 7).

The sectional nature of layered infrastructure spurs an architectural dialogue, which now involves structure and space. And if we look at the purpose of the built form, we can add speed to the mix. Stan Allen notes that, ''The experience of a city today is not so much the orderly progression of scales as an experience in rapid shifts in scale and speed of movement.''[14] How speed affects our interaction with the environment is a critical issue. Different modes of travel create different scales of perception: detail is not perceived when traveling quickly. This consideration is used by West 8 in their approach to infrastructure for their project at Eastern Scheldt Storm Surge Barrier in the Netherlands. Considering the interplay between large and small scale, they designed an experience for the space of the highway.[15] As the motorist passes the infrastructure, he or she will notice a very large-scale black and white patterning by the side of the road, positioned at an angle to the traveled path (Figure 8). This patterning is created by the placement of very large amounts of black and white shells; the shells perform an ecological function as a camouflage for dark and light birds but also provide a visual element in the highway landscape. West 8's strategy for the East Scheldt project employs the finer-grained element of the shell to create a larger-scale pattern. The design approach to the barrier responds to sites that cover large tracts of land as well as to different scales of perception, a general strategy that West 8 employs elsewhere also. The application of this strategy to infrastructure design is particularly appropriate when considering Allen's observations regarding how we experience the fast pace of the city. These strategies can be taken further and tailored to different speeds and experiences as they relate to different streams of transport.

Movement is what defines the experience of transportation. The speed of the system that synchronizes this movement is a critical design component in transportation infrastructure. The designers must ask themselves, where does the speed drop and what occurs there? How can we manipulate the speed of the transport modes and how do these different speeds register architectural input? A given speed should not always be assumed; it, too, can be designed. Strategies for speed control can be taken from studies of traffic calming and other traffic behaviors which demonstrate similar results. For instance, a constantly curving roadway is safer than a straight roadway with sudden curves because it keeps motorists at a constant speed relative to the radii of the curves and spirals of the alignment.[16] Likewise condensing space within a road right of way slows traffic: clearly, configurations of space affect traffic flow. Using such information infrastructure can be spatially configured to allow traffic flow to produce an event as well as a node or a crossing. This strategy is employed by Infrastructure Studio at the entry into the historic village of Thornhill, Canada. The site location is along a busy arterial road that required consideration of both space and velocity. Traffic lane widths were narrowed in order to reduce speed, thus providing a pause in traffic flow and a signification of a scale change suitable to the smaller scale of the historic village. The building of the East Don Crossing on the north side of the historic village area required that the depth of the East Don River structure (necessary for a span of 150 meters) was brought above the roadway deck and employed as a spatial device. This overhead structure assisted in defining the entry and provided a visual constriction to further emphasize the entry to the smaller-scale village. The structure was further reduced in scale to be relevant to personally powered transportation and to the scale of a village.

Forms of infrastructure can greatly benefit from the design approach discussed by Greg Lynn in which he deals with motion, force, and vectors.[17] This design approach is essentially a language closely related to the ''first principles'' of engineering described through calculus: velocity is defined as a change in distance over time. In Infrastructure Studio's design of the East Don crossing, programmatic intent for the subway stream is related to experience: the crossing of East Don is marked in the subway tunnel by providing a view of the golf courses and daylight into the subway cars. This is the only point in the

12. Speculative map of the new layer of infrastructure woven into the city fabric.



13. Rendering of the speculative Superway infrastructure above Granville Street in Vancouver, newly built and anticipating future growth and connection.

extension where a view out is possible and the only time the subway rises above the ground plane, thus providing the features necessary in order to use this design strategy to denote a crossing. Such a strategy also takes velocity into account: if the surfacing time is insufficient, there will not be enough time to experience the view. A calculation of time relative to the anticipated speed of the subway train and the distance of the span of the bridge over the valley determined the view period and played into the configuration of the structure to provide the longest view time possible (Figure 9).

Instigation and anticipation

The designer of infrastructure looks to the future to inform design by envisioning future growth, providing pre-connection, pre-conditions, and anticipatory adaptability to changing conditions. Infrastructure must anticipate stages ahead, responding to the unseen future with a present built form, owing to its inherent nature as a base from which other development grows. The Central Valley Greenway Bridge currently under construction and designed by Patkau Architects with Delcan Engineers in Burnaby, British Columbia, is situated in a landscape of infrastructure—a green corridor for cyclists, a Skytrain station, two roadways, and a railway co-exist (Figure 10). The site divides a protected greenscape and an industrial greyscape, dealing with each both experientially and by form. However, the bridge's position is primarily for the future because the city anticipates it will become the centerpiece of an urban village. The need to consider future conditions gives infrastructure design an affinity with landscape architecture because the future morphology of the site is a major factor in the design, yet out of the control of the designer. Ideally, as Stan Allen comments, ''The designer creates the conditions under which entirely different and perhaps unanticipated spatial characteristics may emerge from the interplay between designed elements and the indeterminate events of the future.''[18]

Speculation

Design explorations that speculate upon future conditions are valuable since infrastructure appears to be a constant, unchanging and stable factor in the landscape. An image of a future configuration can give life and possibility to a new paradigm of infrastructure which challenges the status quo of the existing, frequently super-sized, and often unquestioned monofunctional infrastructural state. The Superway is one such speculation by Infrastructure Studio. The relatively new Vancouver planning model is based on the townhouse and podium typology, now common within the city.[19] This typology results in a new but unconnected landscape at the fourth floor level above the ground plane of Vancouver. The Superway is a speculative greenway that generates a new landscape at another elevation. The greenway provides connection to these landscapes and to the current rooflines of the shopping districts, currently zoned below four floors. The Superway is an idealized form of infrastructure that acts as a conduit and connects bikeways, sidewalks, greenways, parks, places for shopping, places for leisure, playgrounds, terraces, gyms, transit, cultural attractions, the seawall, and of course viewing locations. It generates a new level of interaction and anticipates the growth that will occur at this new level (Figures 11–14).

Speculation on future options challenges the current acceptance of infrastructure by looking at what could be, and opens up the shape of the city to a whole new range of choices that might not otherwise be considered. Without these idealized investigations of what *could* be beneficial in infrastructure, it is not yet possible to solve the dilemmas of infrastructure or recognize the potentially negative ways it can impact the city.

An architectural practice in transportation infrastructure provides solutions to current needs for infrastructure and demonstrates alternative approaches that actively seek to promote successful public space and a positive ecological impact while providing the transportation arteries required for a healthy city. I contend that the powerful design strategies that architects employ are both critically needed and hugely valuable to transportation infrastructure design: architecture at the scale of the city.

14. Rendering of the Superway shopping district, second level of infrastructure, multiplying the existing Robson Street in Vancouver by providing a new level. (Figures 11–14 courtesy of Infrastructure Studio.)

Notes

1. Merriam Webster On-Line Dictionary, ''infrastructure,'' http://www.merriam-webster.com/dictionary/infrastructure.
2. Sanford Kwinter, *Far From Equilibrium*, ed. Cynthia Davidson (New York: Actar, 2008), pp. 29–31.
3. See, e.g., Herbert H. Harwood, *Impossible Challenge: The Baltimore and Ohio Railroad in Maryland* (Baltimore, MD: Barnard, Roberts and Company, 1979), p. 1.
4. Gateway Program, ''South Fraser Perimeter Road Project Description,'' http://www.gatewayprogram.bc.ca/ (accessed March 1, 2009).
5. See http://www.gatewaysucks.org/about for an example of organized public dissent to a large highway development project under way by the Province of British Columbia.
6. Gateway Program.
7. Massachusetts Turnpike Authority, ''Big Dig Project Background,'' http://www.masspike.com/bigdig/background/index.html (accessed March 1, 2009). The description of this large-capacity expansion project in a dense urban area illustrates the public nature of an infrastructure project and the need for a new approach to infrastructure design, both by the nature of the old infrastructure as well as the approach to the new.
8. Hans Ibelings, Adriaan Geuze, and Chidi Onwuka, *West 8: Mosaics* (Basel: Birkhauser Verlang AG, 2007).
9. Charles Waldheim, ''Landscape as Urbanism,'' in Charles Waldheim, ed., *The Landscape Urbanism Reader* (New York: Princeton Architectural Press, 2006), pp. 35–53, quoting Richard Weller.
10. Jacqueline Tatom, ''Urban Highways and the Reluctant Public Realm,'' in Charles Waldheim, ed., *The Landscape Urbanism Reader* (New York: Princeton Architectural Press, 2006), pp. 179–95.
11. Adriaan Geuze, ''Punish the Sea—Living With Water'' (lecture presented at the annual meeting of the International Federation of Landscape Architects for Transforming with Water, Apeldoorn, The Netherlands, July 2008).
12. Farshid Moussavi and Alejandro Zaera Polo, Interview by Fernando Marquez Cecilia and Richard Levene, *El Croquis Complexity and Consistency: Foreign Office Architects*, eds. Fernando Marquez Cecilia and Richard Levene (Madrid: El Croquis, 2003), p. 26.
13. Benjamin Aranda and Chris Lasch, *Tooling* (New York: Princeton Architectural Press, 2006), p. 9.
14. Stan Allen, ''Mat Urbanism: The Thick 2-D,'' in Hashim Sarkis, Pablo Allard, and Timothy Hyde, ed., *Case: Le Corbusier's Venice Hospital and the Mat Building Revival* (New York: Prestel/Harvard Design School, 2001), pp. 118–26.
15. West 8. Eastern Scheldt Storm Surge Barrier, http://www.west8.nl/projects/landscape/eastern_scheldt_storm_surge_barrier/ (accessed March 1, 2009).
16. John C. Collins, ''Applying Context Sensitive Design to the Innovative Development of Major Highway Projects.'' Paper prepared for presentation at the 2004 Annual Conference of the Transportation Association of Canada, Quebec City.
17. Greg Lynn, ''Body Matters,'' *Journal of Philosophy and the Visual Arts* 96 (1993): 60–69.
18. Allen, p.126.
19. See Poto:type Competition Brief, http://www.poto.ca/ for background relating to the townhouse and podium typology in Vancouver.