The need for a paradigm shift and integrated approaches for a future (proof) built environment

de Boer, J.J.

Publication date
2022

Document Version
Final published version

Published in
Design Actions for Shifting Conditions.

Citation (APA)
de Boer, J. J. (2022). The need for a paradigm shift and integrated approaches for a future (proof) built environment. In F. Berlingieri, R. Cavallo, E. Corradi, & H. de Boer (Eds.), *Design Actions for Shifting Conditions.* (pp. 37-51). TU Delft OPEN Publishing.

Design Actions for Shifting Conditions

Fabrizia Berlingieri
Roberto Cavallo
Emilia Corradi
Hans de Boer
Editors

TU Delft OPEN

Design Actions for Shifting Conditions

Fabrizia Berlingieri
Roberto Cavallo
Emilia Corradi
Hans de Boer
Editors

POLITECNICO MILANO 1863
DIPARTIMENTO DI ARCHITETTURA E STUDI URBANI
DIPARTIMENTO D'ECCELLENZA FRAGILITA' TERRITORIALI 2018–2022
TU Delft
TU Delft Deltas, Infrastructures & Mobility Initiative

DESIGN ACTIONS FOR SHIFTING CONDITIONS

Editors
Fabrizia Berlingieri, Politecnico di Milano
Roberto Cavallo, TU Delft
Emilia Corradi, Politecnico di Milano
Hans de Boer, TU Delft

Keywords
Urban Design, Transition, Climate Change, Architectural design

Published by
TU Delft OPEN Publishing | Delft University of Technology, The Netherlands

ISBN/EAN: 978-94-6366-517-9
DOI: https://doi.org/10.34641/mg.24

Layout design: Kevin Santus
Cover design made by Fabrizia Berlingieri

TU Delft OPEN

Text contributions by: Fabrizia Berlingieri, Marco Bovati, Roberto Cavallo, Emilia Corradi, Cassandra Cozza, Hans de Boer, Elena Fontanella, Aikaterini Gkoltsiou, Jutta Hinterleitner, Artur Jerzy Filip, Agim Kërçuku, Raf Ilsbroekx, Miltiades S. Lazoglou, Thanos Pagonis, Laura Pogliani, Giulia Setti, Krystyna Solarek, Ilaria Valente, Maarten Van Acker, Špela Verovšek.

Project contributions by: Gianandrea Blaconà, Andrea Cappiello, Leonidas Christoulis, Dimitris Loukos, Daniele Marturano, Michele Mazzoleni, Yassin Nooradini, Hooman Riazi Jorshari, Nataliia Saltan, Louis Bernard de Saint Affrique, Kevin Santus, Arianna Scaioli, Stefano Sartorio, William Guild, Sylwia Rebelo, Maciej Polakowski.

The publication has been realized thanks to the contribution of:
DAStU "Territorial Fragilities" Research Project funded by the Italian Ministry of Education, Universities and Research (MIUR), Departments of Excellence Initiative 2018-2022; DIMI Deltas, Infrastructure and Mobility Initiative, TU Delft.

Participating universities:

TU Delft

POLITECNICO MILANO 1863
DIPARTIMENTO DI ARCHITETTURA E STUDI URBANI
DIPARTIMENTO D'ECCELLENZA FRAGILITA' TERRITORIALI 2018-2022

University of Ljubljana

Warsaw University of Technology

National Technical University of Athens

THE NEED FOR A PARADIGM SHIFT AND INTEGRATED APPROACHES FOR A FUTURE (PROOF) BUILT ENVIRONMENT

Hans de Boer

Introduction

This contribution is on the basis of the experience, projects and programs related to the DIMI-theme Future (proof) Built Environment & Urban Infrastructures, initially started in 2009 with a focus on water and transport infrastructures but gradually moving to a broader spatial context of the built environment. Many disciplines are involved, like architecture, urbanism, landscape architecture, transport, governance and policy. DIMI promotes and facilitates integrated and multidisciplinary approaches, the relationship between education and research, and focus strongly on societal issues and collaboration with societal stakeholders. Firstly, a concise overview is given with some broad brush strokes indicating some relevant development phases in the water and transport infrastructures in The Netherlands. The water infrastructures are more specific and related to the geographical conditions of The Netherlands, while transport infrastructures are more generic in the context of the development and growth of Western economies. Secondly, the nexus of emerging issues related to growth and system limits and the challenge by the effects of climate change, ask for reflection and reconsideration of present policies and practice. Are there already patterns of change visible, as evolving paradigms that could gradually replace dominant paradigms, which could lead to new directions and a way out of the present state of affairs to a more future-proof built environment?

Phases of development in the domain of transport and water infrastructures in the Netherlands

Societies and economies highly dependent on all kinds of infrastructures for transport, water, energy, communication and data. Its development contributes to the wellfare of countries and its ability to perform within an international and global context. When looking at the global competitiveness of countries, infrastructure is one of the pillars to rank them, next to institutions, ICT adoption, macroeconomic stability, health, skills, product market, labour market, financial system, market size, business dynamism and innovation capability (Schwab 2019). High ranking countries have all extensive, available, reliable and efficient transport and

←

Madrid Rio Project – (photo: West 8 architects)

utility infrastructures. As merit goods, mainly governmental bodies on several administrative levels are responsible for investments, development, operations, and maintenance to facilitate social and economic functions and activities.
When narrowed down, the type of infrastructures that have an environmental and spatial defining impact and footprint than transport and water infrastructures are foremost and globally recognizable.

Transport and water infrastructures
When focusing on transport infrastructures, they all have physical characteristics and a spatial context depending on their function and location within the particular network and related scale(s) (Figure 1). Large infrastructures like (sea)ports in deltaic areas and international airports are comprehensive systems in themselves with a typical governance structure, industrial and/or commercial functions, extensive supportive facilities and a large spatial footprint. This latter, both in a physical sense, due to its size and an environmental sense, due to its impact on a larger scale concerning safety, noise, emissions and smell. Infrastructures like roads, railways, waterways, tunnels and bridges are vectors for destination points where stations and transfers act as nodes integrating networks of different modalities.
In the Netherlands, flood barriers like dikes, dams and movable barriers have a special meaning due to the geographical location at sea and as the delta of two large rivers with 35% of land below sea-level where several highly urbanized major economic regions are located (Leenaers 2013).

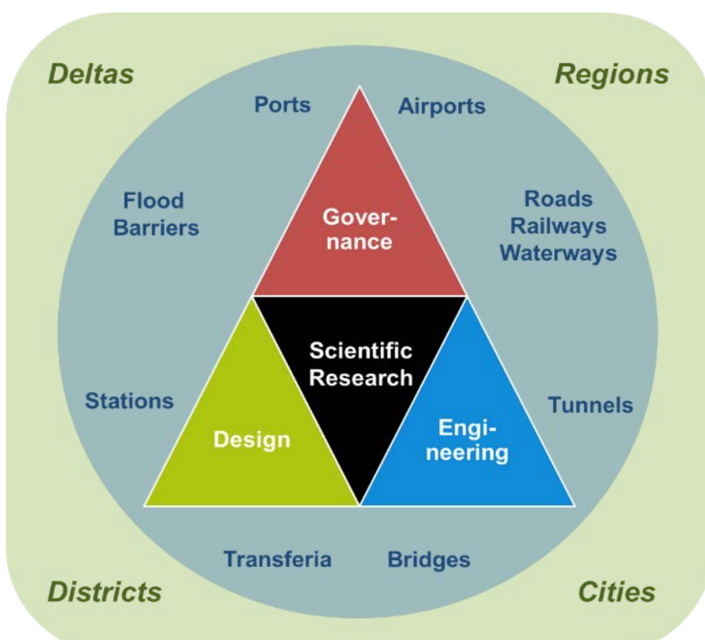

Figure 1 – Transport and water infrastructures, spatial context and knowledge domains.

Due to its nature, context and impact, several knowledge domains are related to the development, operation and maintenance of transport and water infrastructures. As merit goods and public ownership, disciplines like economics, governance (public administration, policy sciences) and law are relevant. As artefacts and structures, a broad range of design and engineering disciplines are relevant like road design, structural design, architecture, urban design, landscape architecture, structural engineering, transport engineering, geo-engineering, etc. As a mean and facility, a range of interdisciplinary disciplines are relevant like spatial planning, transport planning, logistics, operations research, etc.
The formal body of disciplinary knowledge is largely defined by scientific research where international peer reviewed journals are the main medium to publish insights, findings, conclusions and notions on the basis of empirical observations and data. The different meanings and specialized knowledge from these disciplines reflect its complexity for common understanding, addressing issues and collaboration. This complexity gets an extra political dimension when considering the high public investments, complicated and judicial tender procedures and contracts, and inherent risk accountability, which could lead to serious conflicts and disputes between commissioners and constructors, which hampers realization and cause significant budget overshoots (Berg 2020).

Growth and expansion

As economically developed country, the Netherlands is (also) facing the effects of the ongoing (sub)urbanization, individualization, consumerism, mobility growth and inherent environmental pressure. This is strongly related to population growth, economic progress and democratizing since the post-WW2 period characterized by urban sprawl, vast commuting, growing car ownership and transportation of goods.
For The Netherlands, the period 1959-1973 has been characterized by a phenomenon of mass motorization resulting in traffic growth, road construction and car ownership[1]. After the oil crisis of 1973, road construction for the national highway road system had slowed down due to a change of public opinion, social resistance, completeness of the network, and environmental pressure. However, cars' growth rose to 8.531.000 in 2019, while this number was 2.810.000 in 1973 (Autosnelwegen 2021, CBS 2019). Ultimately, leading to a congested highway road system, crowded inner-cities and polluted living environments by emissions and noise. In 2020 the total length of roads was 141 361 km, whereby the national highway system has a length of 5 504 km, which is 3,9 % of the total length. For municipalities and waterboards, the total length is 128 041 km, 91% of the total length (CBS 2020).
Public transport evolved more moderately by adding railway lines for mass transport between cities and regions and metro and tram lines for large and medium-sized cities. Being more efficient than

[1] After this period of growth and expansion the national governance of spatial planning was decentralised to other governance levels like provinces and municipalities from the nineties up until now, while infrastructure development and maintenance for the national transport and water networks are still on national level.

car use, but its exploitation depends on sufficient demand, capacity utilisation and governmental subsidies (Baggen and Van Ham 2019). The total length of railways is 3041 km in 2020 (CBS 2020).
When looking at the use of public transport on a daily basis of at least one trip, only 8,6% of the traffic participants in 2019 use this transport mode (CBS 2020).

In the domain of water, infrastructures, especially rivers and canals, are in use for transport. Sluices and floodgates manage height differences and the draught of ships with different sizes and loads to facilitate barges' navigation from (sea)ports to the hinterland and vice versa. Canals, *boezems* and ditches and pumping stations are mainly for water management of the different water levels preventing inundation of polders, mainly in use for agriculture and farming, and the built environment. Dikes and dams are mainly for flood protection and were already there from the middle ages, which are reflected in city names like Amsterdam and Rotterdam (Meyer and Hoekstra 2020).
To protect the Netherlands, there are in total of 3.700 km of flood defences (Rijkswaterstaat 2021) and 6297 km of waterways to have an indication of its relevance and magnitude (CBS 2019).

Consolidation and reconsideration
For many decades transport infrastructure development had followed and facilitated growth to maintain accessibility and control loss of travelling time and related costs. The national highway network mainly facilitates accessibility to regions and cities with more lanes and signalling systems for maintaining efficient and uninterrupted traffic flows by offering and managing capacity. Accessibility to inner-cities is mainly facilitated by nearby parkings and artery roads connected to the national highway network. Developments mainly demand driven and solving particular bottlenecks in order to keep the transport system ongoing. , with as a downside, the use of more space, new barriers and inherent spatial fragmentation. Due to the high investments, environmental pressure and norms, social resistance, legal procedures and public opinion, the expansion of the highway network or artery roads in cities isn't evidently any more. Also, the maintenance and renewal of existing and vast transport infrastructures like bridges and viaducts, largely from the second half of the last century, takes an ever growing part of the budget. The budget of the so-called Infrastructure Fund for new developments and maintenance of national highways, waterways and railways was 6 billion euro in 2016, 0,9% of the Dutch GDP (Centraal Planbureau 2016). New developments were only limited to solving traffic difficulties and not for further expansion.

Both central government as well municipalities of large and middle-size cities have focused more and more on the stimulation and facilitation of a modal shift from car to public transport. More use of the train by commuters on a (inter)regional scale and use of the train, tram or metro connected to peri-urban areas on a more local scale when coming by car from the region. Mainly to maintain or to improve accessibility but also to reduce environmental pressure caused by the car.
In the first case, stations are pivotal. The 'rediscovering' of the role of stations has led to an upgrade or transformation of stations not only as a point of transfer but also as place to meet and on an urban scale even as generator for urban renewal or development (Bertolini 1999, Boomen 2012, Acker and Triggianese 2021).
In the second case, transferia or Park & Rides (peri-urban) located near highways reduce the flow of cars to the inner-city, reducing environmental pressure, especially in more densified urban areas. Consequently, the downgrade of artery roads and reduction of parking space are now options to reconsider other use of space.
Also related to modal shift is the promotion of cycling and walking in the context of reducing environmental pressure and stimulating exercise to contribute to health. As a consequence, safe cycling paths and pavements are necessary. Also, the vicinity of functions, programmes, and public transport stops are relevant factors due to both modalities limited radius and speed. From a perceptual notion, public space should be safe and attractive with proper dimensions on a human scale.

For water infrastructures, the flood disaster of 1953 in the south-west of The Netherlands, with nearly 1800 casualties and large economic damage, was a national wake-up call. The combination of a north-west storm surge at high tide and the then condition of (sea)dikes has led to this disaster which initiated the Delta-plan for flood protection of the south-west. A vast system of dams, dikes, and movable flood barriers shortens the coastal line by closing several sea arms and maintaining the navigation of ships for the ports of Rotterdam and Antwerp. Paradoxically, the clean-up, rebuilding of houses, recovery of existing dikes, and the building of new works from 1953 had given impetus to the economic growth of the national economy (CBS 2019).
Another event related to flooding was the extremely high water levels of the main rivers Rhine and Meuse in the south-east of the Netherlands in 1993 and 1995. The thread of flooding of large areas behind the river dikes led to people and live-stock in large numbers being evacuated along a large stretch of both rivers. Again a wake-up call that flooding not only could come from sea but also from the rivers that had led to a spatial plan *Space for the River* decided by the national governance in 2007 with 39 measures (Rijkswaterstaat 2021). The traditional approach to reinforce and

to heighten the dikes should deal with many hundreds of kilometers of dikes including demolishing housing and sacrificing landscape and nature. Also, due to environmental awareness and the notion of spatial quality, another perspective was taken over this traditional approach where deepened forelands must give excessive water more space, parallel channels and at particular polder locations instead of canalising the surplus throughout the whole river stretch up until the discharge at sea or the IJssel Lake. Still, particular sections were reinforced or relocated, but the plan's spatial accommodation was key, which is now fully realised in 2019.

The initial expansion of both transport and water infrastructures has gradually set new conditions by its space-defining character and related environmental impact, social and environmental awareness, large maintenance budgets and need for renewal, high investments for extra interventions reducing environmental impact and by the distribution of powers and interest on multiple governance levels and sectorial authorities. A dominant paradigm of growth and expansion isn't appropriate anymore. At the same time, developments seem to consolidate somehow by its risen complexity where a reconsideration of a new paradigm seems needed to create new prospects for action.

Patterns of change: evolving paradigms and climate change are challenge present dominant paradigms for the built environment and constituent elements

As mentioned before, transport and water infrastructures have an environmental and spatial defining impact and footprint within the natural and the built environment. By facilitating mobility for society and economy, they both connect and fragment space as constituent elements of the environmental and spatial context. For the Netherlands, water infrastructures are also of significant importance for flood protection and water management.

The interdependence and interrelationship of the functional and spatial parameters of the built environment are strong and time-bounded due to its permanent character and its occupation of space which isn't infinitely. In this chapter, a more reflective and system perspective is taken in order to position the present phase in particular transport infrastructures within the broader spatial context of the built environment. Which patterns of change and related paradigm shifts could be identified? Could climate change act as a catalyst for developing new paradigms which could give direction and action for a future built environment?

Connected as well locked-in by infrastructure networks

As a consequence of the ongoing urbanisation, economic growth and interrelated infrastructure development, the spatial layout turned out into a tabula scripta of complex and filled in patterns

and layers of occupation by built areas, networks and (leftover) open spaces (Schaick and Klaasen 2011, CRA 2019). The common characteristic of transport and water infrastructures, expressed by its space-defining vectors between nodes at multiple scales of neighbourhoods, districts, cities, metropolitan areas and regions, limit possibilities and options for spatial planning whereby a tabula rasa condition is from the (far) past. Upon the limitation of the existing spatial layout, environmental and safety norms, accessibility issues, and high investment cost for infrastructures co-defining the solution space for new functions and programs.
In order to make use of existing infrastructures, avoid the further sacrifice of the natural landscape, and avoid mobility growth due to further sprawl, the Dutch national governance has refocused the large housing issue and its realisation on the existing built environment. Not on the basis of a grandmaster plan but by establishing a policy framework, offering guiding principles, instruments and legislation for spatial planning, where other administrative levels should develop a vision, agenda and plan related to their spatial responsibility. This should be operational from 2022 whereby urban functions should be combined, existing spatial qualities should be taken as starting point, and all issues should be solved at the particular scale of the particular developments. The urbanisation strategy of a municipality must address the large demand for housing within the existing city-perimeter saving the surrounding landscape and connected to existing transport infrastructures and around transport hubs (NOVI 2020).
Distributed powers and interests on multiple governance levels and sectorial authorities aren't an easy starting point for policy development and decision-making. Infrastructure development defines space and creates an environmental impact on multiple scales. In some manner, the fragmentation of space by networks is also mirrored in the multi-level administration by the fragmentation of responsibility and accountability as a kind of locked-in for developments and action.

Dominant paradigms challenged by evolving paradigms

For many decades the dominant paradigm for the built environment was urban sprawl offering ground-bound homes with a garden as an idealized vision of family life (Figure 2). Sprawl and extension of the transport network are interrelated whereby capacity was the answer to the growth of cars needed for travel to work. Even with the slowdown of new road infrastructure, intelligent traffic systems are optimising the existing capacity better to manage car growth. Sprawl and the transport network have also led to mono-functional business-parks nearby the highway road system and city's out-skirts, mainly accessible by car and well positioned for logistic functions. Public space in cities, apart from parks, seems to be more an appendage of the road infrastructure in the street profile, which is also mainly paved. All these paradigms, as models ubiquitous realized and thereby dominantly defining space, are highly interrelated whereby the mobility and the built environment paradigms have the most interrelations and shared elements. A shift of both could also set a paradigm shift for the subordinate elements of the built environment. However, this needs a paradigm shift for the governance & policy paradigm whereby several governance levels and sectorial bodies maintain the dominant paradigms: a crystallisation of polices, legislation, budgets, tasks, and responsibilities. Best practices and policies for other approaches need to be widespread among public institutions and practice to serve as a paradigm that directs action and realisation. As a prerequisite for change, a paradigm shift by involved governmental levels and sectors is unmistakably needed.

Several emergent issues like environmental pressure, especially in cities and the poor accessibility of regions and cities, have led to all kinds of measures where modal shift from car to public transport or bike is an evolving mobility paradigm found in many cities. With better public transport, the need for a car could be lesser for commuting or mainly used at regional level in case transport nodes like stations or Park & Rides facilitates, provide seamless accessibility to inner-cities. In the Netherlands, at all governmental levels, policies are developed and investments have been made with a thematic focus on the accessibility of regions and cities by (re)design of (new) stations and strategic locations for P&R. This indicates that already a paradigm shift is ongoing which could evolve into a new dominant paradigm if its measures, instruments and organizations are institutionalized. As infrastructures, there is also more awareness of embedding those objects better in the urban fabric. This counts partly also for road infrastructures nearby living areas whereby cover-ups, deepening, tunnels or downgrade of urban roads creates

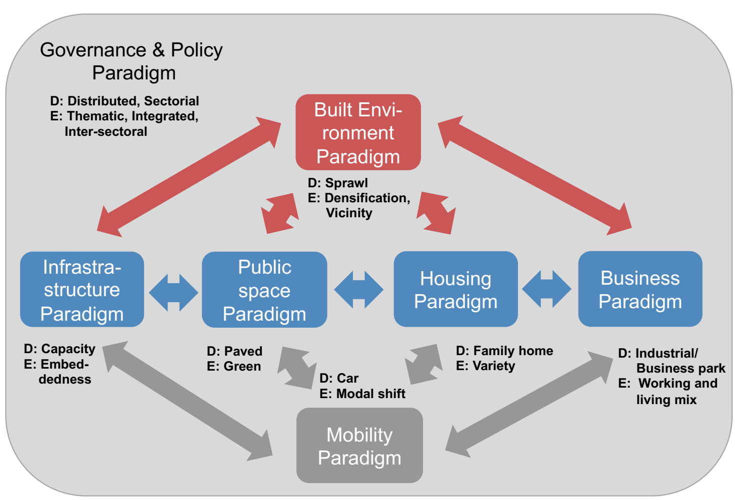

Figure 2 – Dominant and evolving paradigms for the built environment and sub-ordinate elements and mobility.

urban space for other functions or further densification with housing. The latter is a strategy to accommodate the need for housing without expansion of territory. Demographic and economic developments in western countries also show the decline of the size of households and the growth of single households, leading to another need and variety of housing. There is also a tendency to mix start-ups, small maker-business, etc., more and more with housing in urban districts. These several trends also address another approach for public space concerning use and appearance. With more focus on walking and cycling in the spatial context of densification and vicinity, the layout and design of public space will be key for user experience. The effects of climate change like extreme rainfall and heat stress pressure the paved public space where green accommodates several needs.
The interdependency of emerging trends and space requires a more thematic and integrated approach from multiple governmental levels and inter-sectoral collaboration to develop and establish new dominant paradigms that give direction for action and change. In so far, climate change could be a catalyst for the already evolving paradigm shift for mobility, built environment, and subordinate elements will be explored in the next paragraph.

Climate change as catalyst for paradigm shift and system change

Apart from emergent issues and particular measures related to the operation of the (daily) urban system or the flood protection and water management of the built environment, a major driving force is related to climate change and inherent mitigating and adaptive measures addressing cause or impact. The use of fossil energy and related CO_2 emissions has contributed significantly to global warming and inherent climate change. Its impact like sea-level rise, drought, extreme rainfall, and heath-stress endanger nature and mankind (in)directly. Even with the alarming state of affairs, there is a slow and diverted carry-over from the Paris agreement of 2015 aiming at CO_2 neutrality in 2050 to a broad spectrum of policies for the economy, society and environment and its subordinate themes like energy transition, sustainable transport and climate adaptation. However, climate change-related issues and policies could push many systems to another state or reconfigure them regarding their purpose, functionality, activities, services, (infra) structures, conditions, and administrative, policy, and economic framework. Ahead of a widespread system change, interpreted as a transition from the present to another system state, a paradigm shift should firstly set the scene for another way of interpreting, thinking and acting foremost initiated by forerunners and embraced by early adopters. When relating the effects of climate change like extreme rainfall to the built environment, the sewage of the water system and the paved roads and sidewalks of the urban transport system

are directly involved. In case of heat stress, the latter is also involved, but using infiltration opportunities could nourish the water system in providing other functions like water storage and vegetation maintenance for cooling as an ecosystem service. All measures related to the green public space paradigm are connected to some elements of the transport and water system.
When relating the energy transition to the built environment, the energy performance and efficiency of buildings for warming or cooling and the way of transport are directly involved. From the architectural perspective attention, need to be taken to the direction to the sun, the materials and openings of the facade and roof and its overall insulation performance. Eventually, the water system concerning the retention and use of rainwater for the maintenance of vegetation at the roof or façade for cooling could also play a role. It is also related to the green paradigm for the public space.
Alternative ways of transport are related to the modal shift as an evolving mobility paradigm. Walking and cycling are energy neutral, public transport is energy efficient per passenger, and the car park's electrification could benefit from renewable energy. When the latter is also combined with car-sharing due to limited possibilities for charging-infrastructure in neighbourhoods, parking space could be reduced or reorganised within the public space, including infiltration of rain water in the soil. Also, walking and cycling have a strong impact on the urban street profile and as such, on the transport system and its use of public space. Walking and cycling are at another scale level also related to the spatial layout and distances between functions and amenities, referring to the planning and development of the built environment.

All before mentioned measures are related to the adaptation or mitigation paradigm of climate change which could involve the water and/or transport system and its use of (public) space within the built environment. TTo make this all happen in the long term, the paradigm of the built environment itself should be involved whereby densification and vicinity are conditional aspects of the evolving mobility paradigm of modal shift. The last one is mainly initiated from congestion and environmental issues and the economic need for accessibility but could be reinforced and taken to another level driven by climate change. As such, climate change could act as a catalyst for some interrelated paradigms, which could steer system change for particular aspects and scales.
The interdependency and interrelationship between the effects of climate, the involved systems and measures that redefine the use of space and materials require an integrated and inter-sectoral approach whereby different time-scales should be taken into account due to the speed of change of the built environment, its elements and layers.

Change as temporal phenomenon

As defined before a paradigm shift is related to a different interpretation, way of thinking and acting on issues than traditionally which is institutionalized in design, artefacts, policies, legislation, structures, budgets, tasks and responsibilities. So there is (also) a strong cultural aspect related to a paradigm shift which is a precursor for system change even if it addresses particular components instead of the whole system. This could take generations of planners, designers, engineers and policy advisors who act according to the dominant paradigm related to the driving forces for society and economy and to the prevailing vision and conditions as zeitgeist. The built environment has also its characteristics which have a temporality related to its functions and layers.

As described before, climate change is the main driving force for the forthcoming decennia. The combination of mitigation and adaptation measures and evolving paradigms like modal-shift and urban densification impact the transport and water systems and ultimately have a spatial impact that also involves public space.

At (sub)system level, the intersection of the transport and water system with the spatial system is clearly as constituent elements of the built environment (as a static representation of a city) and of the urban system (as a dynamic representation of a city). Especially the networks which connect urban functions, activities and flows have a space defining character (Figure 3).

Change at functional and network level for transport, water management or flood protection could influence the spatial layout due to its causal interrelationship for the need for space. However, the dynamics are mainly related to use and activities and not at a functional or network level which is intrinsically static and layered. The speed of change related to urban functions like living and working and related buildings have a timescale of at least several decades while transport or water infrastructures will have a lasting impact and expressing permanency for many decades and even centuries (Zandbelt 2017, Schaick and Klaasen 2011).

The first steps of change are more trying to optimize the particular system components with soft measures by policies and in a next stage by actual physical interventions, both could set new conditions for further developments. As an example, concerning modal-shift, a municipality could introduce environmental zones and norms for (diesel) cars or introduce high parking tariffs, presuming that commuters of visitors will take other forms of transport to the inner-city whereby (also) high fines should enforce the intended behaviour. Alternatively, the built of parks & rides at strategic locations combined with reduced parking and public transport tariffs also stimulates the intended behaviour but stimulates positive incentives. The benefits related to the necessary investments should come from less busy traffic, less emissions and noise and less space needed for parking. So new opportunities for the public space could emerge from downgrading car infrastructure to build more near former busy city arteries and give way for pedestrians and cyclists which require more attention for spatial quality due to scale, speed and experience (Boomen, Hinterleitner, and de Boer 2017). Measures and interventions are still within the present transport and spatial system boundaries but they gradually change at the component level and shift the dominant car paradigm to that of a self-moving city-dweller. An autonomous driving car will be still part of the car paradigm and more evolutionary than introducing a fully opposite perspective which could develop as a new paradigm. Such a paradigm shift could stimulate new policies and elicit other interventions in the built environment for urban densification, green or intricate pedestrian and/or cyclist networks at a large urban scale and improving the living environment in general. Public space is key and the main parameter for change, and due to its nature a public merit good related to public opinion, political interests and policy making. Both spatial design by architects or urbanists as well related technical design by engineers are part of a broader discourse nourished from many perspectives and interest and are not autonomous actions in itself. Without a clear dominant paradigm and integrated, multidisciplinary and inter-sectorial approach, it will be a challenge to address a multitude of issues that all claim space, especially in already dense urban areas or in a vulnerable natural environment.

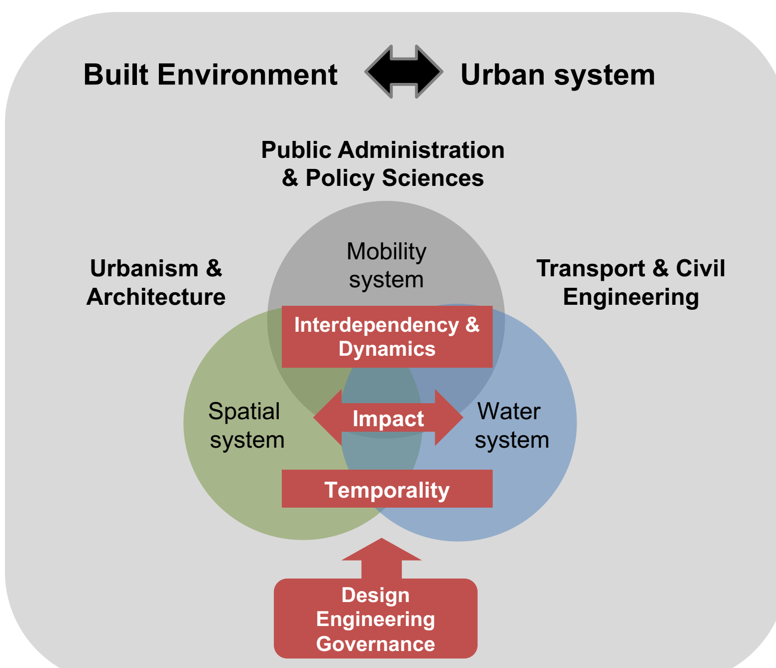

Figure 3 – Intersection of systems within its domain of application

References

Autosnelwegen. 2021. Accessed May 24, 2021. https://www.autosnelwegen.nl/index.php/geschiedenis/7-1959-1973-massamotorisatie.

Acker, Maarten van, and Manuela Triggianese. 2021. "The spatial impact of train stations on small and medium sized European cities and their contemporary urban design challenges". *Journal of Urban Design* 26, no. 1: 38-58.

Baggen, John, and Hans van Ham. 2019. *Het Transportsysteem*. Delft: Delft Academic Press/VSSD.

Berg, Harm van den, and Tjesse Riemersma. 2020. *Megaproject moet weer te beheersen zijn*. Amsterdam: NRC Handelsblad.

Bertolini, Luca. 1999. "Spatial Development Patterns and Public Transport: The Application of an Analytical Model in the Netherlands". *Journal Planning Practice and Research* 14, no. 2 (May).

Boomen, Tijs van den, Hinterleitner, Jutta, and Hans de Boer. 2017. *Snelweg x stad: De toekomst van de stedelijke ringweg / Highway x city: the future of the urban ring road*. Amsterdam: BNA Onderzoek.

Boomen, Tijs van den, and Ton Venhoeven. 2012. *De mobiele stad, over de wisselwerking van stad, spoor en snelweg*. Rotterdam: nai010 publisher.

Centraal Planbureau. 2016. *Nederland is nog niet af. Policy Brief 2016/06*. Den Haag: CPB.

CBS Statline. 2019. "Aantal personenauto's". Accessed May 24, 2021. https://www.cbs.nl/nl-nl/nieuws/2019/51/meer-dan-200-maalzo-veel-personenauto-s-als-in-1927.

CBS Statline. 2019. "Lengte van vaarwegen". Accessed June 7, 2021. https://opendata.cbs.nl/statline/#/CBS/nl/dataset/71531ned/table?ts=1623076505452.

CBS Statline. 2019. "Schade watersnoodramp 1953". Accessed January 20, 2021. https://www.cbs.nl/nl-nl/corporate/2019/47/watersnoodramp-1953-cbs-brengt-schade-in-kaart.

CBS Statline. 2020. "Lengte van spoorwegen". Accessed June 7, 2021. https://opendata.cbs.nl/statline/#/CBS/nl/dataset/71024ned/table?ts=1623080489443.

CBS Statline. 2020. "Lengte van wegen". Accessed June 7, 2021. https://opendata.cbs.nl/statline/#/CBS/nl/dataset/70806ned/table?ts=1623079136996.

CBS Statline. 2020. "Verkeersdeelname en deelname openbaar vervoer. Accessed June 7, 2021. https://opendata.cbs.nl/statline/#/CBS/nl/dataset/84707NED/table?ts=1623080765472.

CRA - College van Rijksadviseurs. 2019. *Guiding Principles Metro Mix, Hoe gemengde hoogstedelijke milieus met meerwaarde voor Nederland te ontwikkelen*. Rapport, Den Haag: College van Rijksadviseurs. Accessed September 24, 2021. https://www.collegevanrijksadviseurs.nl/adviezen-publicaties/

publicatie/2019/04/11/reos-advies

Leenaers, Henk, ed. 2013. *Water Atlas of the Netherlands*. Groningen: Noordhoff Atlasproducties.

Meyer, Han, Hoekstra, MaartenJan, and John Westrik. 2020. *Stedenbouw, Kern en perspectieven*. Amsterdam: Boom uitgevers.

NOVI. 2020. *Nationale Omgevingsvisie, Duurzaam perspectief voor onze leefomgeving*. Den Haag: Ministerie van Binnenlandse Zaken en Koninkrijksrelaties.

Rijkswaterstaat (a). "Waterkeringen". Accessed June 7, 2021. https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/waterkeringen

Rijkswaterstaat (b). "Ruimte voor de rivieren". Accessed May 24, 2021. https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/ruimte-voor-de-rivieren

Schaick, Jeroen van, and Ina Klaasen. 2011. "The Dutch Layers Approach to Spatial Planning and Design: A Fruitful Planning Tool or a Temporary Phenomenon?". *European Planning Studies* 19, no. 10: 1775-179

Schwab, Klaus, ed. 2019. *The Global Competitiveness Report 2019*. Cologny/Geneva: World Economic Forum. Switzerland.

Zandbelt, Daan. 2017. *Transformation frequencies of urban elements*, one of the discussion-topics for DIMI from the State Advisor for the Environment of the Netherlands, July 7, 2017.