Typo-Morphology of Transportation

Looking at Historical Development and Multimodal Futures of Swedish Streets and Roads

by Todor Stojanovski
KTH Royal Institute of Technology

Keywords: typo-morphology, urban design, streets, transportation, multimodality.

Abstract: This paper is a part of a book on historical development and envisioning streets multimodal futures of Swedish streets and roads. It discusses typo-morphological methodology to study streets, roads and streets layouts. It looks in the history of Swedish cities to analyze types of streets and roads and proposes futuristic (scenarios) for the typical Swedish streets and roads considering new trends towards multimodal transportation (a mix of walking, cycling and public transportation) and new transport technologies such as self-propelled cars and carpools. Swedish morphologists have classified streets according to historical periods. There is also international research about historical street development and types. Currently new planning trends and new patterns of mobility are emerging such as energy efficient mobilities (walking and cycling), shared automobiles and bicycles, hybrid and electric cars and self-driving vehicles. These new transportation technologies will change the way in which streets and roads are designed in the future. Urban morphology can help with conceptualizing typologies and design elements in a context of morphologically informed design.

1. Introduction

Sustainable mobility is a new paradigm to understand the complex link between transportation systems and cities, mobility and society (Cervero, 1997; Marshall & Banister, 2000; Marshall, 2001; Banister, 2008; Rode *et al.*, 2017). The focus is on envisioning future sustainable cites, understanding transportation systems as human-scaled spaces and promoting multimodal transportation (sustainable mix of walking, cycling and public transportation). In a same time, technological innovations in automation, new mobility services emerge such as shared automobiles and bicycles, carpooling, hybrid and electric cars and self-driving vehicles. The sustainable mobility paradigm and new transportation technologies will change the way in which streets and roads are designed in the future.

This paper proposes and discusses a typo-morphological methodology to study streets, roads and streets layouts. The purpose is to develop historical typologies and create new visions about future multimodal roads and street design. It indirectly aims to open discussions about how to use the existing streets to facilitate walking and cycling alongside new mobility technologies (new transit systems, carpools and self-driving cars). Sustainable mobility and the process of

DOI 10.36158/978889295357434
www.tabedizioni.it

urban design and envisioning future cites can be informed and guided by typologies as a theory or doctrine of types (Steadman, 2014).

2. Theoretical framework and methodology

2.1. *Typo-morphology and morphological structure of cities*

Typo-morphology is an approach in urban morphology that understands cities and their evolution through types and typological processes. Types are abstractions about urban forms (e.g. modernist apartment block is a type of a building). Typo-morphologists identify and dissect various urban elements (Moudon, 1997), investigate their interrelationships, organize them in a morphological structure and create typologies (Conzen, 1960; Caniggia & Maffei, 2001 [1979]; Kropf, 2011; 2014). Figure 1A shows streets, plots and buildings in the morphological structure of cities (Kropf, 2014), whereas Figure 1B shows the street in the hierarchy of urban elements.

Within the morphological structure (of streets, plots and buildings), the streets can be understood as a street layout underlying neighborhoods, a transportation infrastructure under the plots and buildings (Southworth & Owens, 1993; Southworth & Ben- Joseph, 1995). The street layouts can be classified and organized in typology. The street layouts can be dissected into elements. There is a hierarchy (major and minor main streets and side streets) and relationships (topology) in the street layouts (Figure 2).

Within the new paradigm of sustainable mobility the street is understood as a space (Marshall, 2001; Banister, 2008). Figure 3 shows the typical street spaces representations. The street space can be analyzed on plan as space between buildings (Figure 3A), as a street section (Figure 3B) or as street frontage/city block elevation (e.g. Appleyard, 1977; Talen, 2019). The street as spaces also have elements such as car lanes, sidewalks, bus lanes and so on. It is a place where transportation modes compete for space in the street section (Figure 3B2) The street space includes an interaction between several urban form elements: car lanes, bike lanes, sidewalks, building façades, front yards, fences, landscaping elements as lines of trees or shrubs, and so on. There are also mobile elements such as vehicles, pedestrians, animal life, and so on. The street is also a space that can be public, private or privatized (Figure 3C).

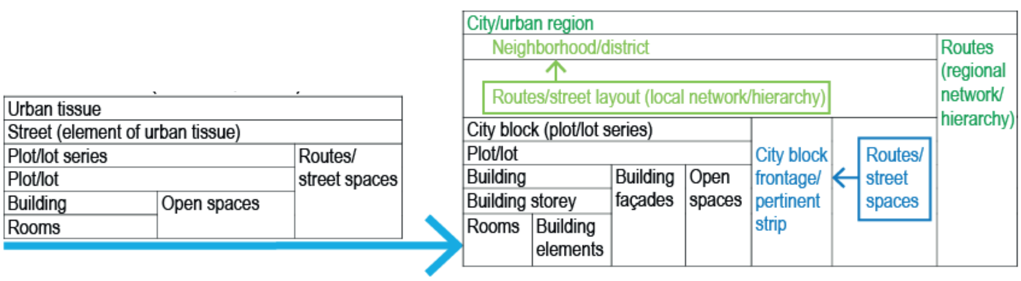

Figure 1. *Generic morphological structure (Kropf, 2014) and the street in the hierarchy of urban elements (a. Generic morphological structer (Kropf, 204) b. Street in the morphological structure).*

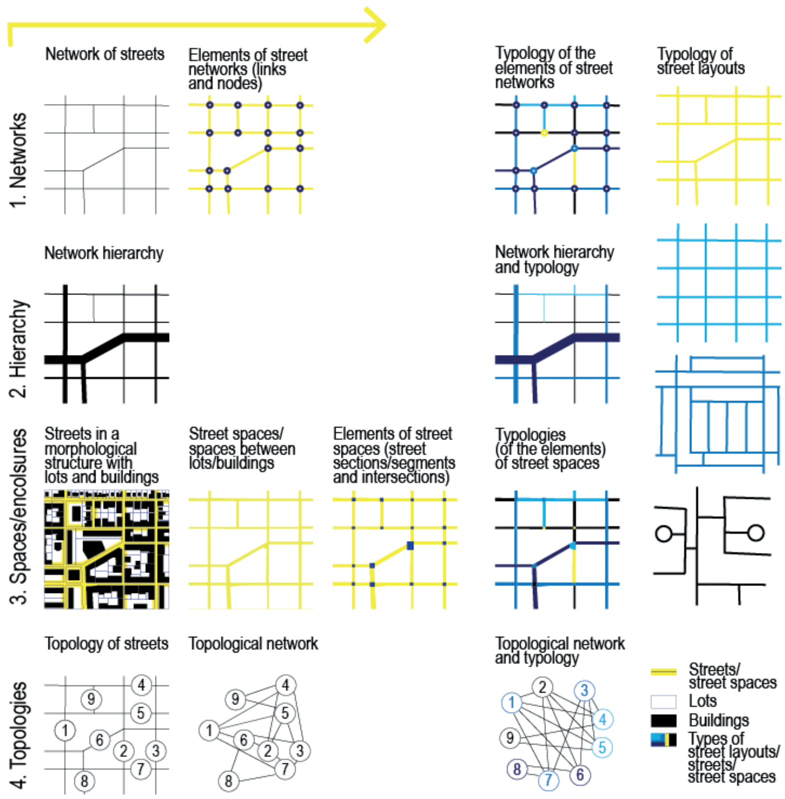

Figure 2. *Streets and typo-morphological representations (a. Representation of streets and creating typologies; b. typologies (typomorphological representation)).*

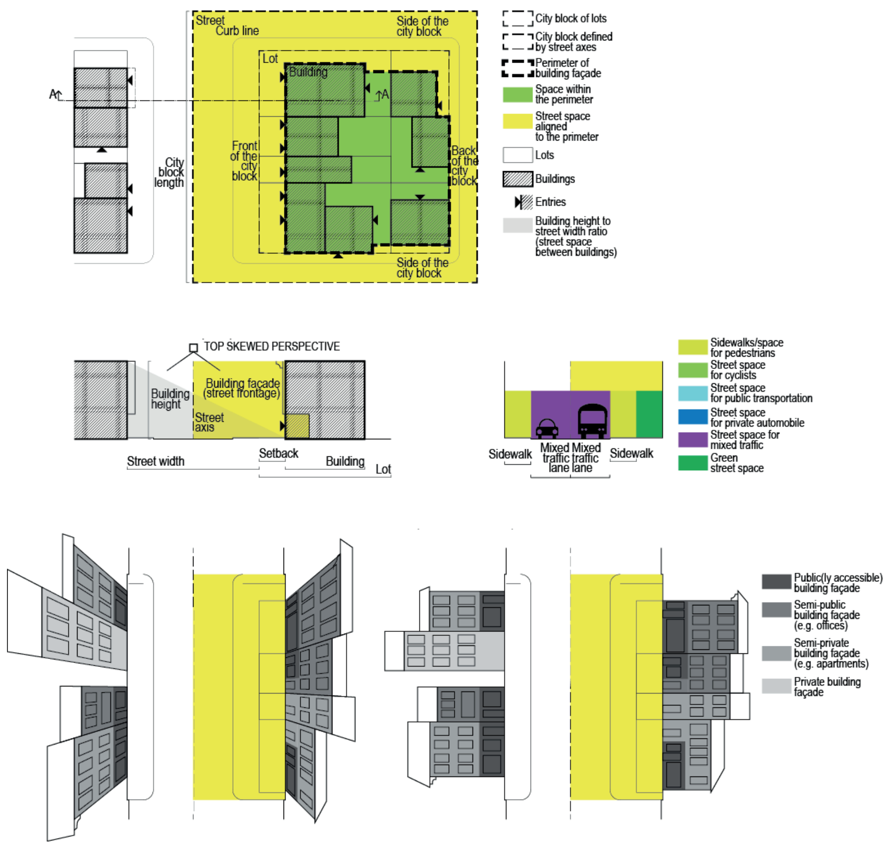

Figure 3. *Street spaces and representations (a. Street space on a plan of a city block; b1. Street space as urban design elements in a street section (A-A); b2. Street section (A-A) as space with transportation elements; c1. Street space within top skewed perspetcive; c2. Street space within building façades (elevations)).*

2.2. *Technological change, development cycles and morphogenesis*

Urban form and mobility are intertwined (Brotchie, 1984; Vance 1990; Brotchie *et al.*, 1995). Transportation revolutions, technological changes and visions of future mobilities (such as sustainable development) continuously shape, problematize and reshape cities (Figure 4A). This process implies continuous urban and transportation morphogenesis. There is urban morphogenetic processes is specific for every transportation technology. The transportation technologies integrate with cities through experiments, social evaluation and acceptance of transportation technologies, visioning and development of ideal urban forms (neighborhoods), construction of transportation infrastructures and establishment of mobility cultures in these communities (Vance, 1990). The garden suburbs in the 19th century could not function without railway stations and public transportation and commuting by public trains produced a unique mobility culture. A house with a garage encourages urban development that favors automobility as a mobility culture (Stojanovski, 2019). The transportation technologies create specific neighborhood types and mobility classes that support them (Figure 4B).

Cyclical changes and historical periods are crucial concepts in typo-morphology. Cities experience random development cycles of urban growth and refurbishment followed by recensions and inactivity (Hoyt, 1933; 1939; Whitehand, 1987; Whitehand & Gu, 2017). Henri Lefebvre (1996 [1968]; 2003 [1970]) further develops the cyclical changes by analyzing the process of industrialization and urbanization. He examines the evolution from the zero point (the non-existent city and the complete predominance of agrarian life) to fully realized urbanization and the absorption of the countryside by the city and the total dominance of industrial production (Lefebvre, 1996 [1968]; see also Soja 1989; Brotchie *et al.*, 1995; Graham & Marvin, 1996). The historical periods as development cycles manifest themselves through typical buildings, streets and street layouts, neighborhoods and so on that can be abstracted into typology.

2.3. *Abstraction and scenario method*

This paper uses abstraction methods to produce typology and a scenario method to create visions of cities with new automated vehicle systems. Typologies can be created by selecting representative examples (Goethe, 1988 [1817]; Steadman, 1979; 2014; Southworth, 2005b, Marshall & Çalişkan, 2011). Swedish typo-morphology has a long tradition (Abarkan, 2009; 2013). Urban typologies have been developed according to: architectural styles (Björk *et al.*, 1983; 2003; 2009); planning paradigm (Rådberg, 1988; Rådberg & Friberg, 1996); and social and economic development epochs (Engström *et al.*, 1988). Many municipalities (such as Stockholm and Malmö) use typologies (building types, urban development, city characteristics or city types) in comprehensive and detailed plans (SSBK, 1997; MSBK, 2001). Swedish city morphologists have also classified streets according to historical periods (Forshed, 1997; see Figure 1). There is also international research about historical street development and types (Southworth & Owens, 1993; Southworth & Ben-Joseph, 1997).

The scenario method are based on future explorations. The scenario is where automated cars will run in mixed traffic is not probable due to legislative constrains (the autopilot and its company will be always blamed for a car accident). The first future scenario assumes that the automated vehicles will be segregated. The second scenario is the convergence of private automobile and public transportation in a hybrid system of smaller on-demand vehicles or smaller vehicles that circulate on major paths and create major nodes (robo-taxis discussed by Cervero, 2017). These will require a nodes or squares/public spaces where they will load and unload pas-

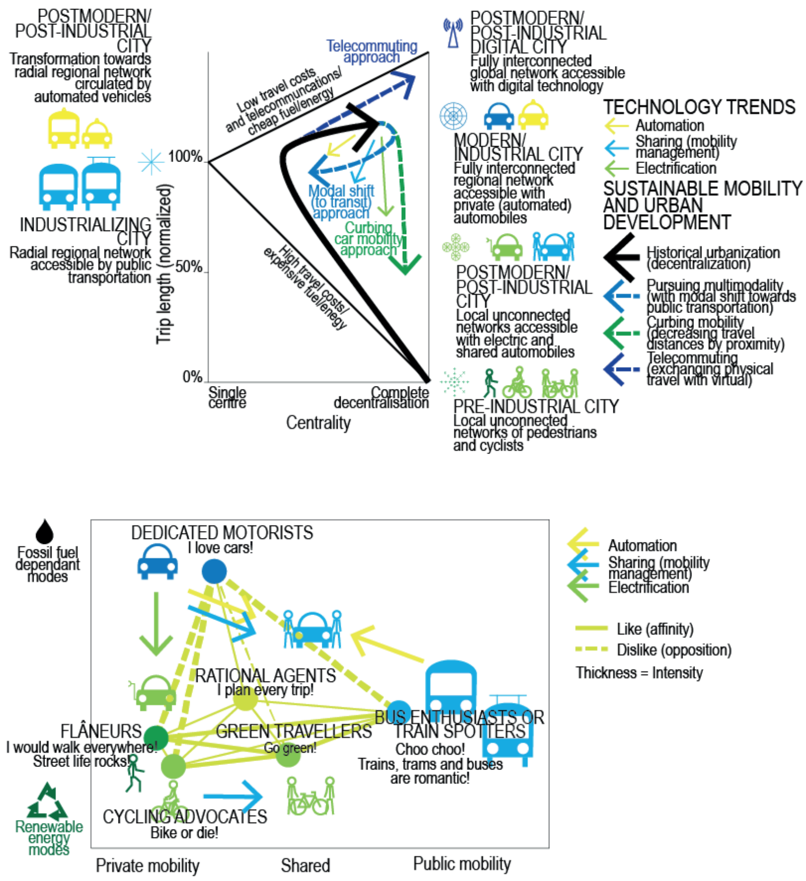

Figure 4. *Technological change, transportation technologies, urban form and mobility classes in the "Brotchie triangle" (see Brotchie, 1984; Brotchie at al., 1995) (a. Technological change and urban form (Brotchie, 1984); b. Technological change and new mobility cultures (Stojanovski 2018, 2019)).*

sengers. The difference will be that they can travel from each node to another node at quickest speed (not system of lines as today's public transportation). The second scenario is not used in this paper, but it will be considered in the book. In terms of spatial requirements the first and second future scenario diffet little.

3. Analysis/Results

The analysis/results section shows a neighborhood typology and abstraction of street layouts and street spaces for one neighborhood type (NT5 in Figure 5). The same method will be used for other neighborhood types in the neighborhood typology presented on Figure 5. The Swedish neighborhood typology builds upon Lefebvre's theory and previous typo-morphological classifications (Engström *et al.* 1988; Rådberg, 1988; Rådberg & Friberg, 1996; SSBK, 1997; 2000).

The Swedish streets and road followed the urbanization pattern of neighborhood types (NT). The typical traditional (preindustrial) Swedish city displays organic or rectangular street grids with wooden or stone houses organized in city blocks. The names trästad (wooden city, Figure 5 NT1) or stenstad (stone city, Figure NT2) denote these neighborhood types. The medieval cities were surrounded by villages with detached houses scattered organically in the landscape (Figure 5 NT3). These villages became urbanized with the rapid motorization in the second half of the 20th century. The industrialization produced a very dense urban core, an expansion of

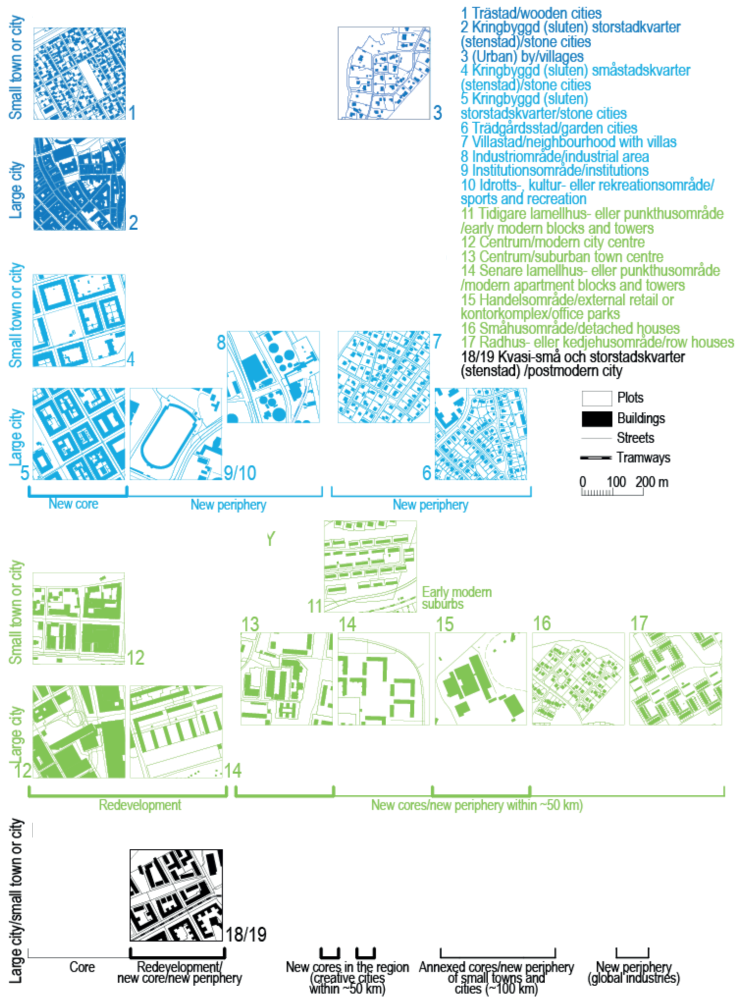

Figure 5. *Swedish neighborhood typology (a. Pre-industrial city (walking and carts); b. Industrialising city (cycling and transit); c. Modern/industrial city (private automobiles); d. Postmodern/post-industrial city (multimodal transportation)).*

the medieval stone city (Figure 5 NT4-5). In a same time, it created an urban fringe of industrial zones, institutional (healthcare, education and so on) and sports complexes (Figure 5 NT9-10). The trägårdstad or garden city (Figure 5 NT6) and its residential suburban villastad or neighborhood with villas (Figure 5 NT7) emerged along the first suburban railways on the end of the 19th century. The modernist movement and the welfare state inspired the biggest building boom in Sweden in the mid-20th century. The experimental early modernist apartment blocks emerged on the edges of the old cores and in the suburbs from the 1930s (Figure 5 NT11). In the 1950s the functionalist city (Figure 5C), so called ABC-city, mainstreamed. In ABC, A stands for arbetsområde or work areas (office parks and industrial zones), B for bostadsområde or residential areas with apartment blocks (Figure 5 NT14) or row houses (Figure NT17) and C for community/town centers (Figure NT13). In this period, parts of the old cores in the small or large cities were modernized (Figure 5 NT12) and transformed into office parks serving an entire region. From the 1970s a new type of residential suburbs with single detached houses (Figure 5 NT16) emerged, followed by external shopping malls (Figure 5R) and new office parks. The trend in the last two decades is to develop new postmodernist neighborhoods (Figure 5 NT 18/19) on the industrial fringes of the old cores. In the same time, the predominantly commercial old cores (Figure 5 NT12) are densified to increase the number of residents (Engström, 2008). Figure 6 shows neighborhood map and the typical street layouts in the neighborhood type NT5 on Figure 5.

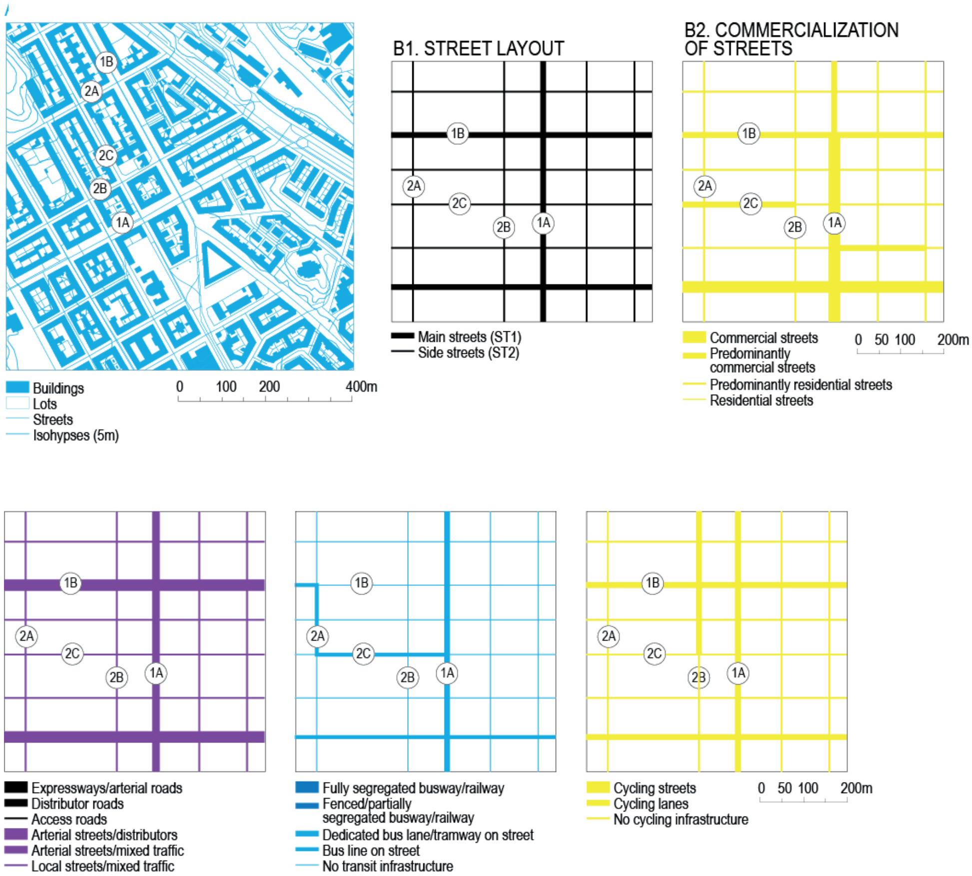

Figure 6. *Typical streets in the typology (a. Map of neighborhood type nt5; b. Street typology and commercialization (b1. Street layout, b2. Commercialization of streets); c. Transportation modes (c1. Private automobile; c2. Public Trasportation; c3 Cycling)).*

Neighborhood type NT5 has rectangular street layout (Figure 6). The size of the city blocks is between 80 and 100 meters. The street layout with two typical streets. The main streets are 30 m whereas the side streets are 15-18 m. Figure 7 shows the variation of the typical streets in NT5.

Figure 8 shows a future scenario where segregated lanes for automated vehicles are introduced in the street layout of NT5 and in street spaces. The lanes can be introduced only on the major car arteries like Birger Jarlsgatan and side streets with mixed traffic. The segregated lanes for automated vehicles will create a parallel superblock structure. The traffic lights would need a new green field for automated vehicles. These lanes can disturb or replace the existing public transportation network. The traffic lights will also disturb the flows on existing cycling and car lanes and create new conflict points at intersections.

4. Discussion/Conclusion

This section discusses typo-morphological method to analyze streets and roads transportation systems. The transportation systems are underlying element of urban form and they cannot be separated by the typical neighborhood. Figure 5 shows a typology of neighborhoods, whereas Figure 6 abstracts underlying street layout for a specific neighborhood type (NT5) where different transportation modes circulate and create hierarchies. Figure 7 shows the typical streets

Figure 7. *Typical streets in NT5 and variations (c1. Section of street type st1 (main street); c2. Section of street type st2 (side street); d1. Variations of street type st1; d2. Variations of street type st2).*

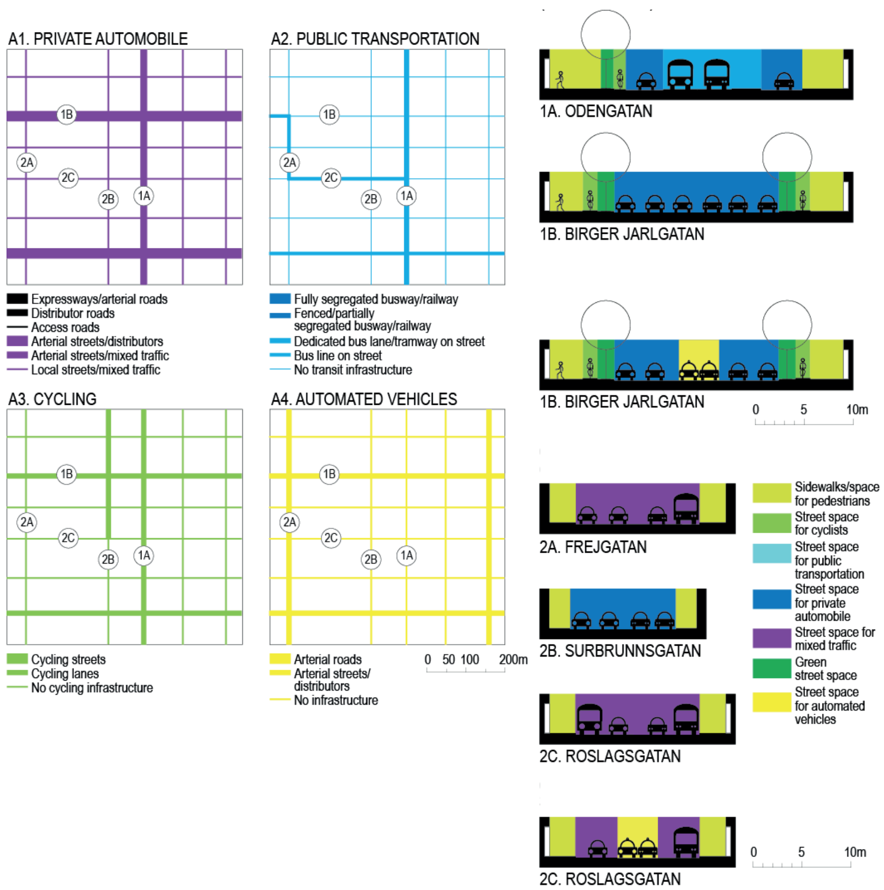

Figure 8. *Future scenario of introducing lanes for automated vehicles in the street layout and street sections (a. Transportation modes in a future street layout of neighborhood type nt5 (a1. private automobile, a2. public transportation, a3. cycling, a4. automated vehicles) b1. section of street type st1 (main street), b2. Future section of street type st1 (main street); c1. Section of street type st2 (side street); c2. Future section of street type st2 (side street)).*

of NT5 and its variation. This method can be applied to create street typologies of all the neighborhood types on Figure 5. This research and abstractions will be conducted in the future.

Figure 8 shows a future scenario where lanes for automated vehicles are inserted in the existing street layout and street sections for the typical streets for neighborhood type NT5. The segregated lanes for automated vehicles will create a parallel superblock structure and create disturbances in the existing public transportation, cycling and car network. This will create new conflict points at intersections that would need to be solved with traffic lights.

This paper does not show the interaction of the street with the surrounding façades (Figure 3C) that will suffer when lanes for automated vehicles are introduced. They will create barrier effects in urban space and change the interaction on the main streets. The pedestrian flows will divert towards the city block. Figure 9 shows the background images for such analysis and the future research will develop a methodology.

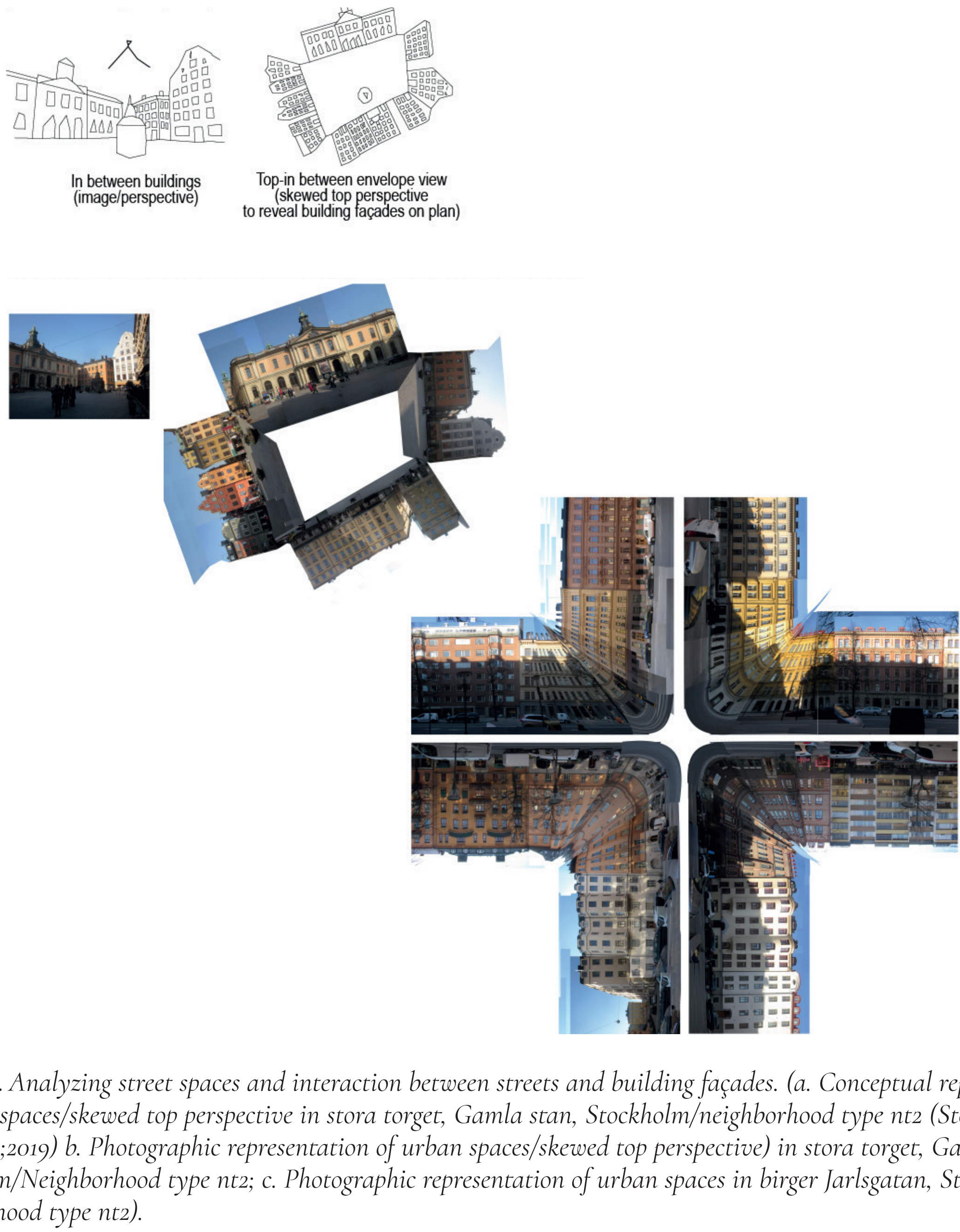

Figure 9. *Analyzing street spaces and interaction between streets and building façades. (a. Conceptual representation of urban spaces/skewed top perspective in stora torget, Gamla stan, Stockholm/neighborhood type nt2 (Stojanovski; 2013;2019) b. Photographic representation of urban spaces/skewed top perspective) in stora torget, Gamla stan, Stockholm/Neighborhood type nt2; c. Photographic representation of urban spaces in birger Jarlsgatan, Stockholm/neighborhood type nt2).*

In the end, the process of urban design can be guided by typologies as a theory or doctrine of types (Steadman, 2014). The neighborhood types serve as points of references for designs (discussed by Schön, 1988). Neighborhood type is a combination of certain type of street, plot division, building type, building façade type and so on. The urban design processes often include various solutions (or patterns as composition of elements) and rules (see urban design experiments in Sanders & Baker, 2016). Furthermore, there are new procedural models for generation of cities. These procedural models or generative algorithms are based on creating compositions of urban elements. By classifying neighborhood typologies that consist of urban elements and characterizing them with urban form parameters (see Sanders & Woodward, 2015 for buildings and elements of buildings) it is possible to create new tools for urban design and modelling. This paper classifies neighborhood typologies with underlying street layouts, but future research would equally focus on the underlying metrics behind street layouts, interaction of urban elements in street spaces.

5. Awknoledgements

This research is supported by a scholarship from Stiftelsen Fredrik Bachmans Minnesfond and a grant from Energimyndigheten, the Swedish Energy Agency (P44455-1 or 2017-003267).

References

Abarkan A. (2009), *The study of urban form in Sweden*, in *Urban Morphology*, 13(2), p. 121.

Abarkan A. (2013), *Typo-morfologi: Metoden och dess tillämpning på bebyggelsesmönster*, in *The Nordic Journal of Architectural Research*, 13 (1-2).

Appleyard D. (1981), *Livable streets*, University of California Press, Berkeley, CA.

Banister D. (2008), *The sustainable mobility paradigm*, in *Transport policy*, 15(2), pp. 73-80.

Björk C., Reppen L., Kallstenius P. (1983), *Så byggdes husen 1880-1980: arkitektur, konstruktion och material i våra flerbostadshus under 100 år*, Statens råd för byggnadsforskning, Stockholm.

Björk C., Kallstenius P., Reppen L. (2003), *Så byggdes husen 1880-2000*, Forskningsrådet Formas, Stockholm.

Björk C., Nordling L., Reppen L. (2009), *Så byggdes villan: svensk villarkitektur från 1890 till 2010*, Forskningsrådet Formas, Stockholm.

Brotchie J.F. (1984), *Technological change and urban form*, in *Environment and Planning A*, 16(5), pp. 583-596.

Brotchie J.F., Batty M., Blakely E., Hall P., Newton P. (1995), *Cities in competition*, Longman, Melbourne.

Brotchie J.F., Anderson M., Gipps P.G., McNamara C. (1996), *Urban Productivity and Sustainability—Impacts of Technological Change*, in Hayashi Y., Roy J. (eds.), *Transport, Land-use and the Environment*, Kluwer Academic Publishers, Dordrecht, pp. 81-99.

Caniggia G., Maffei G.L. (2001) [1979], *Architectural Composition and Building Typology: Interpreting Basic Building*, Alinea, Firenze.

Cervero R. (1997), *Paradigm shift: from automobility to accessibility planning*, in *Urban Futures*, 22, pp. 9-20.

Cervero R. (2017), *Mobility niches: jitneys to robo-taxis*, in *Journal of the American Planning Association*, 83(4), pp. 404-412.

Conzen M.R.G. (1960), *Alnwick, Northumberland: a study in town-plan analysis*, in *Transactions and Articles* (Institute of British Geographers), (27), pp. 111-122.

Engström C.J, Lindqvist A., Lagbo E., Landahl G. (1988), *Svensk tätort*, Svenskakommunförbundet, Stockholm.

Engstrom C.J. (2008), *Kunskapsdriven näringsutveckling och stadsomvandling*, in Cars G., Engström C.J. (eds.), *Stadsregioners utvecklingskraft-trender och nya perspektiv*, Kungliga tekniska högskola, Stockholm.

Forshed K. (1997), *New Design Guidelines for Stockholm*, in Guinchard C.G. (ed.), *Swedish Planning Towards Sustainable Development*, Wesdund & Soner, Gavle.

Goethe J.W.V. (1988), *Scientific studies*, Suhrkamp, New York.

Hoyt H. (1933), *One hundred years of land values in Chicago: the relationship of the growth of Chicago to the rise in its land values, 1830-1933*, University of Chicago Press, Chicago.

Hoyt H. (1939), *The structure and growth of residential neighborhoods in American cities*, Federal Housing Administration, Washington.

Kropf K. (2011), *Morphological investigations: Cutting into the substance of urban form*, in *Built Environment*, 37(4), pp. 393-408.

Kropf K. (2014), *Ambiguity in the definition of built form*, in *Urban Morphology*, 18 (1), pp. 41-57.

Lefebvre H. (1996) [1967], *Right to the city*, in Lefebvre H., *Writings on cities*, Blackwell, Cambridge, Mass., pp. 61-181.

Lefebvre H. (2003) [1970], *The urban revolution*, University of Minnesota Press, Minneapolis, Minn.

Marshall S. (2001), *The challenge of sustainable transport*, in Layard S., Davoudi S. Batty (eds.), *Planning for a Sustainable Future*, London.

Marshall S., Banister D. (2000), *Travel reduction strategies: intentions and outcomes*, in *Transportation Research Part A: Policy and Practice*, 34(5), pp. 321-338.

Marshall S., Çalişkan O. (2011), *A joint framework for urban morphology and design*, in *Built Environment*, 37 (4), pp. 409-426.

MSBK (Malmö Stadsbyggnadskontoret) (2001), *Översiktsplan för Malmö 2000 (Öp 2020)*, MSBK, Malmö.

Moudon A.V. (1992), *A catholic approach to organizing what urban designers should know*, in *Journal of Planning Literature*, 6(4), pp. 331–349.

Moudon (1994), *Getting to Know the Built Landscape: Typomorphology*, in Franck K.A., Franck K.A., Schneekloth L.H. (ed.), *Ordering space: types in architecture and design*, Van Nostrand Reinhold, New York, pp. 289-314.

Moudon A.V. (1997), *Urban morphology as an emerging interdisciplinary field*, in *Urban morphology*, 1,3-10.

Rode P., Floater G., Thomopoulos N., Docherty J., Schwinger P., Mahendra A., Fang W. (2017), *Accessibility in cities: transport and urban form*, in Meyer G., Shaheen S., *Disrupting mobility*, Springer, Cham, pp. 239-273.

Rådberg J. (1988), *Doktrin och täthet i svenskt stadsbyggande 1875-1975* (Doctoral Thesis, Kungliga Tekniska högskolan).

Rådberg J., Friberg A. (1996), *Svenska stadstyper: historik, exempel, klassificering*, Kungliga Tekniska högskolan, Stockholm.

SSBK (Stockholms Stadsbyggnadskontoret) (1997), *Stockholms byggnadsordning*, SSBK, Stockholm.

Sanders P.S., Woodward S.A. (2015), *Morphogenetic analysis of architectural elements within the townscape*, in *Urban Morphology*, 19(1), pp. 5-24.

Sanders P., Baker D. (2016), *Applying urban morphology theory to design practice*, in *Journal of Urban Design*, 21(2), pp. 213-233.

Schön D.A. (1988), *Designing: Rules, types and words*, in *Design studies*, 9(3), pp. 181-190.

Southworth M. (2005), *Designing the walkable city*, in *Journal of urban planning and development*, 131(4), pp. 246-257.

Southworth M., Ben-Joseph E. (1995), *Street standards and the shaping of suburbia*, in *Journal of the American Planning Association*, 61(1), pp. 65-81.

Southworth, M., & Owens, P. M. (1993). The evolving metropolis: studies of community, neighborhood, and street form at the urban edge. *Journal of the American Planning Association*, 59(3), 271-287.

Steadman, P. (1979). *The evolution of designs: biological analogy in architecture and the applied arts*. Cambridge: Cambridge University Press.

Steadman P. (2014), *Building types and built forms*, Matador, Kibworth Beauchamp.

Stojanovski T. (2013), *City information modeling (CIM) and urbanism: Blocks, connections, territories, people and situations*, in *Proceedings of the Symposium on Simulation for Architecture & Urban Design*, pp. 111-118.

Stojanovski T. (2018), *City Information Modelling (CIM) and Urban Design – Morphological Structure, Design Elements and Programming Classes in CIM*, in Kepczynska-Walczak A., Bialkowski S. (eds.), *Computing for a better tomorrow – Proceedings of the 36th eCAADe Conference*, vol. 1, Lodz, Poland, pp. 507-516. http://papers.cumincad.org/cgi-bin/works/paper/ecaade2018_274

Stojanovski T. (2019a), *Urban Form and Mobility Choices: Informing about Sustainable Travel Alternatives, Carbon Emissions and Energy Use from Transportation in Swedish Neighbourhoods*, in *Sustainability*, 11(2), p. 548.

Stojanovski T. (2019b), *Urban Form and Mobility-Analysis and Information to Catalyse Sustainable Development* (Doctoral dissertation, KTH Royal Institute of Technology).

Talen E., Jeong H. (2019), *Does the classic American main street still exist? An exploratory look*, in *Journal of Urban Design*, 24(1), pp. 78-98.

Whitehand J.W.R. (1987), *The changing face of cities: a study of development cycles and urban form*, Basil Blackwell, Oxford.

Whitehand J.W.R., Gu K. (2017), *Urban fringe belts: evidence from China*, in *Environment and Planning B: Urban Analytics and City Science*, 44(1), pp. 80-99.