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PRAXIS OF URBAN MORFOLOGY

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CONFERENCE PROCEEDINGS - PART II

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PRAXIS OF URBAN MORPHOLOGY

ISUF Belgrade 30th CONFERENCE

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INTRO

ISUF2023 PRAXIS OF URBAN MORPHOLOGY

Coming from 20 architects, geographers, planers and historians, to more than 600 individual and institutional members across the globe, ISUF presents the important international organization of urban form both for researchers and practitioners. Due to its orientation to both of these fields, ISUF 2023 presents a great opportunity to rethink the praxis, perceived as process by which theory/idea is enacted, embodied and realized.

The theme for ISUF 2023 is drawn from the previous experience and ideas, directed toward systematization and synthesis of intellectual knowledge.

Following this line of reasoning, the Conference tracks are envisioned to confront the topics that are represented as being opposed in order to open up a debate how to transfer ideas to operational knowledge.

A. Good in Planning, Landscapes and Townscapes

A1. Urban planning vs. Urban design

A2. *Fringe growth* vs. *Urban belt*

A3. Prescription vs. Description

B. Culture Space, Common Space and Personalities

B.1. East vs. West

B.2. South vs. North

B.3. Networks vs. Individuals

C. History of Ideas and Challenges

C.1. History vs. Future

C.2. Preservation vs. Transformation

C.3. Pre vs. Post

D. Programming and Rethinking Concepts

D.1. Strategies vs. Measures

D.2. Education vs. Practice

D.3. Quantitative vs. Qualitative research

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REFLECTION ON THE CONFERENCE

In its jubilee year of 215 years, the University of Belgrade and the Faculty of Architecture as its constituent member had an opportunity to host the 30th International Seminar on Urban Form Conference (ISUF2023).

This year's conference titled Praxis of Urban Morphology presented a great opportunity to discuss the process by which this discipline is enacted, embodied, and realized. The ISUF 2023 organization committee's endeavor was to build on the previous experience and ideas, and to direct activities toward systematization and synthesis at an international level, aiming to embody these ideas into operational knowledge. The conference was developed in a manner to provide a framework for reflecting on ISUF community intellectual knowledge coming both from the practical and scientific arenas. As a part of side activities, a special issue of the Serbian Architectural Journal - SAJ titled Regional Perspectives of urban morphology was prepared with the goal to demystify advancements of intellectual thought from all continents. Accordingly, the presentation will cover the main issues raised by scholars and practitioners both in SAJ contributions and during conference with the overall goal to contribute to the advancement of knowledge in this field, moreover to reconsider and critically examine advancements and perspectives on urban morphology.

Decision to focus the ISUF2023 conference on the Praxis of urban morphology and SAJ special issue on Regional perspectives on Urban morphology, hopefully, yet unintentionally achieving a harmonious integration of these two. Consequently, the resulting journal double issue serve as valuable testimony of longlisting engagement within the study of urban form in various contexts reflecting a specific moment in time and various perspectives on urban morphology, while conference reveals state of current topics and research fields within the urban morphology. Thus, the first one looks at the history, while the second reflects on the future

The very conference included total of 227 presentations with 580 authors (220 present on site), with representation of participants from 43 countries. The conference was developed in 4 tracks: A. Good in Planning, Landscapes and Townscapes, B. Culture Space, Common Space and Personalities, C. History of Ideas and Challenges and D. Programming and Rethinking Concepts.

Conference proceedings were developed in two parts - One available in print and online format that has texts recomended by session or conference chairs and the second with other submitted full papers.

Editors

PREFACE

The International Seminar on Urban Form (ISUF) gathered for its 30th conference in the Balkans. There was a long way between Lausanne 1994 and Belgrade 2023 – between an exploratory meeting of about 20 urban morphologists, coming from five countries, in Europe and North America, and a robust conference in Serbia gathering more than 200 morphologists coming from five continents. Throughout this way, together, we have increased our knowledge about the basic elements of urban form, how these are combined generating different patterns, and how these are shaped by different processes and agents over time. We also have a better understanding of how these patterns influence the environmental, social, and economic dimensions of human settlements, and how urban morphology can contribute for addressing some of the main challenges of our times, from climate action to the construction of sustainable cities and communities. In a year of celebration, and in addition to the Belgrade conference, some of us have been reflecting on the past, present and future of ISUF (Oliveira, 2024), while others have been debating the role and contribution of our regional networks (Djokić and Samuels, 2023).

The 'Praxis of Urban Morphology' was the last step of a one-decade path starting with the systematic participation of Serbian researchers in ISUF conferences and journal, leading to the creation of the Serbian Network of Urban Morphology, and including the development of research projects with other networks (Kantarek et al., 2022). The 'Praxis of Urban Morphology' organized by Vladan Djokić, Aleksandra Djordjević, Vladimir Lojanica, Ana Nikezić, Milica Milojević, Aleksandra Milovanović and Mladen Pešić was a remarkable event. Each and every part of it was carefully planned, making evident the commitment of its organizers. The event also represented the return to full face-to-face conferences, after two online conferences, in 2020 and 2021, and the hybrid event held in Lodz and Krakow in 2022. The conference was organized in four main themes: i. the good in planning, landscapes and

townscapes; ii. culture space, common space and personalities; iii. the history of ideas and challenges; and iv. programming and rethinking concepts. Each of these themes was then arranged in three pairs of poles to foster morphological debate. The conference had about 230 presentations, authored by almost 600 researchers (more than 1/3 was present in Belgrade) representing more than 40 countries.

Part of the morphological knowledge produced in the Belgrade conference is now gathered in the proceedings edited by Djokić, Djordjević, Pešić, Milojević and Milovanović. The proceedings are a precious record of one week of morphological debate in a notable city, with a rich urban history and built heritage, and a vibrant urban life. They develop new perspectives about our field of knowledge, how urban morphology can support action on the physical form of human settlements (through

planning, urban design, and architecture), and how morphological insights can consolidate knowledge on the main dimensions of urban life, from social equality and good health to decent work, and to responsive consumption of urban energy, to name just a few policy applications. For all this, the International Seminar on Urban Form is grateful to our Serbian colleagues, preparing both conference and proceedings, and to all participants.

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Vítor Oliveira

President of the International Seminar on Urban Form

CONTENTS

The Morphogenesis of the Dutch Landscape: The Narrative of Dutch Cities' Medieval Core

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ABSTRACT

Although the initial inception, or genesis, of a city's urban grid, is an important marker of its evolution over time, the process of urban transformation, or morphogenesis, can substantially alter its original townscape. This study sheds light on the morphogenetic impacts of the pre-industrialisation period on shaping the spatial configuration of the historical cores of three Dutch cities, Amsterdam, the Hague, and Delft. While some cities have undergone processes of expansion as physical growth of different grid types, others followed the historical patterns of genesis. This study aims to analyse the spatial mechanisms and morphological logic that lay out the medieval core of Dutch cities to create an adaptive approach for evolving in tandem with waterways. The study: i) reviews the literature and ongoing research initiatives on the Dutch urban planning paradigms and strategies through various time periods; ii) proposes a new spatio-temporal description of the medieval core of cities and their infrastructure, including streets and water networks; and iii) analyses the patterns of their historical core using a space syntax-based approach. Space syntax method and tools are applied to critically understand urban morphologies, as it provides quantitative analysis on multiple scales. The study shows how the relationship with water can constitute a path dependency for urban growth, highlighting the role of water in shaping movement patterns. Those different types of grid structures, such as organic, compact, accumulative, discontinuous, cellular etc., produce different spatial growth mechanisms as a powerful instrument in controlling and defining the functions of cities dominated by water.

Keywords: space syntax, spatio-configurational analysis, Dutch city, urban morphology

INTRODUCTION

Dutch cities have been subject to considerable environmental impacts, shaping diverse facets of their evolution. The initial inhabitants encountered formidable obstacles as they engaged in activities such as fishing, herding, and agriculture to support themselves in an unwelcoming terrain. The prevalent natural surroundings consisted chiefly of marshes, necessitating the adoption of basic techniques like the creation of an interlocking system of trenches to aid in water removal. While these endeavours facilitate some agricultural endeavours by lowering water levels, they unintentionally give rise to detrimental effects. Specifically, the region's peat underwent shrinkage and settling as a direct

consequence of the implemented drainage and urban development strategies. The spatial history of urban environments is viewed as architectural compositions reflecting various layers of historical growth, defined by distinct architectural designs and time periods as background research. Other viewpoints examine the spatial arrangement of cities as an outcome of historical patterns of utilisation and shaping the layout of urban areas from different perspectives, which are defined as urban growth processes, syntactical morphological histories and spatial-locational histories by Griffiths (2012). In the context of this study, the objective is to investigate the morphogenesis of particular aspects of the spatial arrangement within the medieval core of the selected Dutch cities. Analysing the spatial organisation of Dutch cities entails recognising the significant influence exerted by canal systems throughout history. In this context, this study aims to develop an analytical approach to understanding the historical cores of Dutch cities, which provides a systematic review of historical and spatial characteristics of cities (i.e., those shaped in delta environments alongside rivers or seas and have different sizes and urban grid types) to gain a better understanding of their contribution to urbanisation patterns in the following periods.

The evolution and contemporary appearance of Dutch cities is characterised by the arrangement of their components, the demarcation of boundaries and the overall coherence. This appearance was profoundly impacted by the principles of water engineering and the pragmatic considerations related to the conversion of the landscape into a constructible terrain (Read, 1999). Therefore, this study attempts to trace the emergence of some aspects of the particular functional logic of the spatial network of the core of Amsterdam, the Hague and Delft prior to the recognition of inherent internal contradictions in the context of contemporary periods. The medieval core of the cities has been defined as the strongest effects of their spatial legacy on the present-day functioning of the cities' centre. (Rutte, 2016) . As also explained by Read (2000) with a case study of Amsterdam's centre, the spatial mechanism that shaped the medieval core of the city, whose pattern is fundamentally essential to water engineering, predominantly serves as a governing force that modifies all it interacts with, shaping and conforming all conventional standards, planning models, and spatial designs to its specific scale and geometric structures.

Theoretical Background

In the delta geography, some of the earliest enduring human settlements were constructed on elevated artificial mounds, known as terpen, which occasionally rose merely a few centimetres above adjacent marshlands. Subsequent to that era, the territory was reclaimed from the marshes and safeguarded against inundation through an approach involving drainage, pumping, embankment, and elevation of grounded surfaces (Read, 1999). This complex process translated into substantial preparation expenses for making land suitable for construction, necessitating meticulous planning, groundwork, and financial investment prior to augurating new urban zones. Such prerequisites have led to a historical pattern of urban expansion that has largely deviated from what might be referred to as "organic" growth, such as the gradual annexation of areas at town peripheries along linear movement paths, such as London (Hillier and Vaughan, 2007). Contrarily, typical procedures have included the surveying, draining, and readying of entire land segments, which are then rapidly partitioned and developed in accordance with pre-planned projects or sequential initiatives targeting specific population densities (Read, 1999, 2009, 2013; Berghauser Pont and Haupt, 2021). Read (1999) particularly mentions that a pertinent illustration of this process can be observed in the 17th century expansion of Amsterdam, executed on two or three precisely defined land tracts. Consequently, Dutch urban areas often manifest distinct demarcations between different sectors, along with sharp and well-defined boundaries encircling the city in its entirety.

Read (1999) analyses the five Dutch cities ranging in size from the largest in the Netherlands to small provincial centres, which are Amsterdam, the Hague, Haarlem, Alkmaar and Zaanstad by applying space syntax axial analysis. Space syntax represents both a theoretical framework focused on spatial understanding and an ensemble of analytical tools that are quantitative and descriptive, designed for the examination of spatial arrangements within buildings and urban landscapes. By learning to control spatial variables within intricate patterns that constitute the city, it is possible to attain insights into both social antecedents and outcomes related to spatial form in the physical city or in buildings ranging from residential homes to complex structures (Hillier and Hanson, 1984). The result of the research shows the degree of correlation between occupancy rates and integration of streets across three distinct radii when the entire city is utilised as the reference area in the Dutch landscape. Additionally, the results highlight the most correlations when optimised against other areas of reference. Read research clearly shows that, in the Netherlands, urban extensions often involve creating new living environments from scratch on previously agricultural or unused industrial land (Read, 1999). This often means designing a new spatial pattern rather than filling in an existing one. While most of these extensions are well-designed and considered at every level, issues such as the “urban desert syndrome” and risks related to empty and poorly supervised public spaces can be observed.

Another notable study focused on how the waterways have affected and been affected by the development and transformation of cities is Psarra’s Venice study on the island communities of the city, their pedestrian and integrated network (combining street and canal networks) using space syntax angular segment analysis measures (Psarra, 2014, 2018). The principal finding of the research underscores that for island communities, navigation through canals is more feasible on a larger scale than through streets. A detailed analysis comparing the angular segment analysis results (Integration and Choice) of street networks with the integrated network of Venice demonstrates that the canal structure exhibits greater robustness in relation to a more foreground network as opposed to the background network. In space syntax theory, the foreground network is characterized by extended, almost linear paths, whereas the background network consists of shorter routes with numerous near-right angle junctures, demonstrating a more localised character devoid of linear continuity (Hillier, 2007). Functionally, the foreground network manifests a rather global pattern of interconnected hubs across various dimensions, optimised to enhance movement driven by micro-economic activities. Conversely, the background network, chiefly residential in nature, is crafted to regulate and structure movement in a way that mirrors particular cultural attributes, thus often reflecting distinct cultural peculiarities (Hillier, 2007). Previously published studies related to urban form and space syntax research area in the context of Dutch cities, as summarised, mainly use descriptive methods and contemporary street network analysis. A discernible gap in our current understanding of the Dutch landscape lies in the need for an analytical integrated model that holistically incorporates waterways alongside streets and building forms, moving beyond the descriptive analyses to a more structural and comprehensive exploration of historical urban areas that utilises historical data. Hence, this study aims to develop a model by joining street and waterway networks by using the space syntax approach. The historical street and waterway networks of the medieval core of the cities are produced by cartographic drawings using the maps of the relevant period. The analyses are executed by Space Syntax Toolkit in QGIS, and a geographic information system is used to investigate further, interpret and visualise data.

METHODOLOGY

Space syntax is the primary approach of the study to analyse the spatial structures (streets and waterways) that shaped the medieval Delft, The Hague and Amsterdam. This research tests the integrated urban model by joining two major networks, a street network (as a road-centre line) and a water-based network (as a waterway segment) via waterway interfaces (mooring/boarding nodes or the places that are suitable for boarding) to process spatial network analysis (see Figure 1). In this research, an integrated urban model is constructed to create a multi-layered network model while incorporating different datasets for spatial accessibility analysis. This integrated urban model synthesizes theoretical constructs and methodologies exacted from prior research on multi-layered networks (Bertolini and Dijst, 2003; Law, Chiaradia and Schwander, 2012; Gil, 2015; Chen and Karimi, 2022) and advanced space syntax modelling (Karimi, Parham and Acharya, 2015). Serving as a geospatial representation of multi-layered urban networks, the integrated urban model possesses the capability to perform network analyses and to interface with urban datasets. Therefore, contrary to axial and segment models, the multi-layered network model allows for measuring the network accessibility, which considers not just metric or geometric costs but also accounts for time-cost, capacity-cost, money-cost etc.

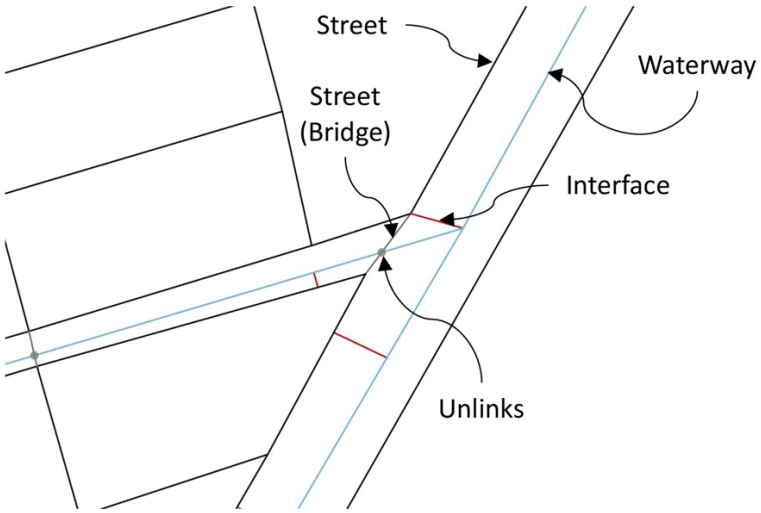

Figure 1. *Multi-layered Network Model.*

Cartographic drawing is used to create historical network data on the base of the maps of Delft, The Hague and Amsterdam. The analyses are executed in DepthmapX Toolkit in QGIS. QGIS, a geographic information system, is also used to analyse further, interpret and visualise data. Historical maps have been utilised as sources for each respective city and period, as it was purported to be around the 17th century (refer to Figure 2 and Figure 3**Figure**).

Angular Segment Analysis (Turner, 2001) is used as a main method of space syntax in this research, which has two fundamental measures defined as Integration and Choice from global to local via intra-city scales. Integration (closeness centrality) is the metric measure that determines how close one segment is to all others based on the definition of metric distance, which is the distance between the mid-points of two adjacent segments along lines. Angular segment integration is described as an indicator of accessibility or closeness and allows the measurement of to-movement potentials (Hillier and Iida, 2005). Choice (betweenness centrality) is the metric measure, which is determined by

counting how many times each segment appears on the shortest path between all pairs of segment analysis within a given metric distance. Angular segment choice is a graph measure that is calculated as the total number of least angular paths that pass through a segment when every segment in the system is an origin and a destination (Hillier and Iida, 2005). Hillier, Yang and Turner (2012) propose a normalisation procedure for the angular weighted graph distance, taking into account the balance between the urban systems' tendency to optimise travel distance between all origins and destinations and the potential cost of segregation due to system size. This normalisation procedure facilitates comparisons across different scales within a city or between cities. Therefore, normalised angular integration (NAIN) and normalised angular choice (NACH) are used as measures in this study.

In addition, integration core and star model has been used as techniques in the study to explore what variables mean in terms of their spatial structure. Integration core refers to a pattern consisting of the 10%, 25% or 50% most integrating spaces of the given number of spaces in large and complex urban systems (Hillier and Hanson, 1984). The spatial values of the urban networks can be represented in a star model, a methodological approach to comprehending cities in terms of normalised angular choice (NACH) and normalised angular integration (NAIN). Within this technique, the mean NACH and NAIN at a local scale and the max NACH and NAIN at a global scale are represented in a star model. Mean and max NAIN elucidate the level of accessibility in both foreground (max) and background (mean) networks, while mean and max NACH index the degree of structure in the system. The mean NACH assesses the extent to which the background network forms a cohesive grid without segmentation into discrete areas, while the max NACH determines how the foreground grid structures the system by deformations and interruptions of the grid (Hillier, Yang and Turner, 2012).

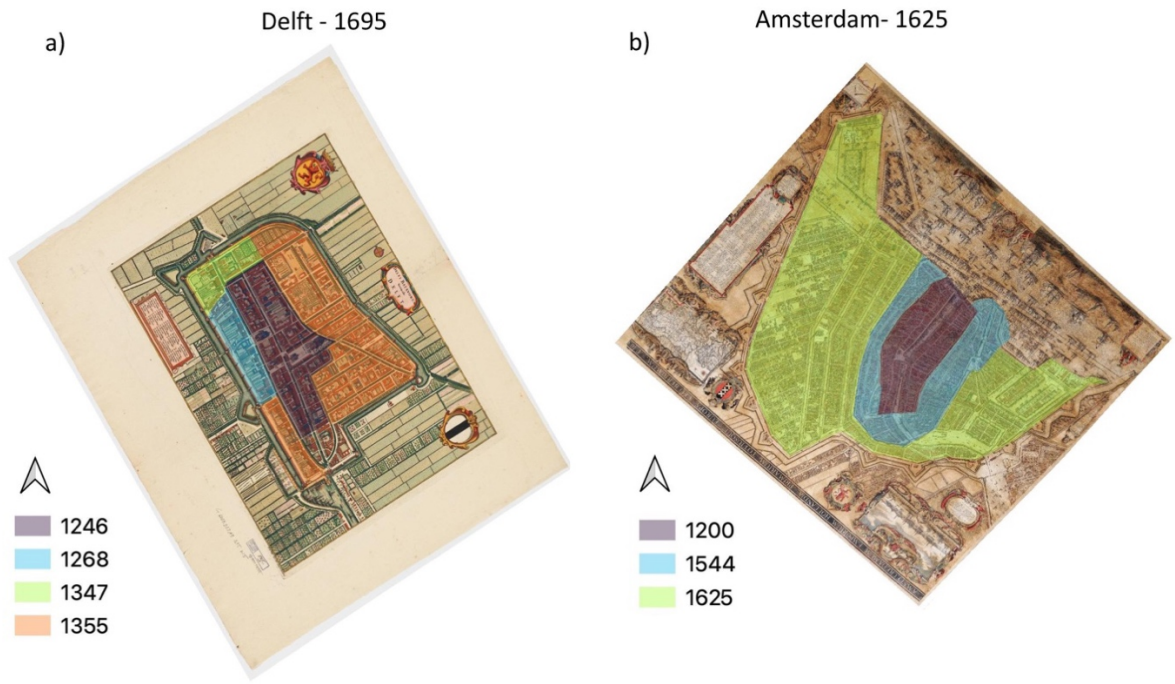

***Figure 2**. a) The development periods of Delft until the late 17th century. b) The development periods of Amsterdam until the late 17th century (Maps' Source: Oldmapsonline.com).*

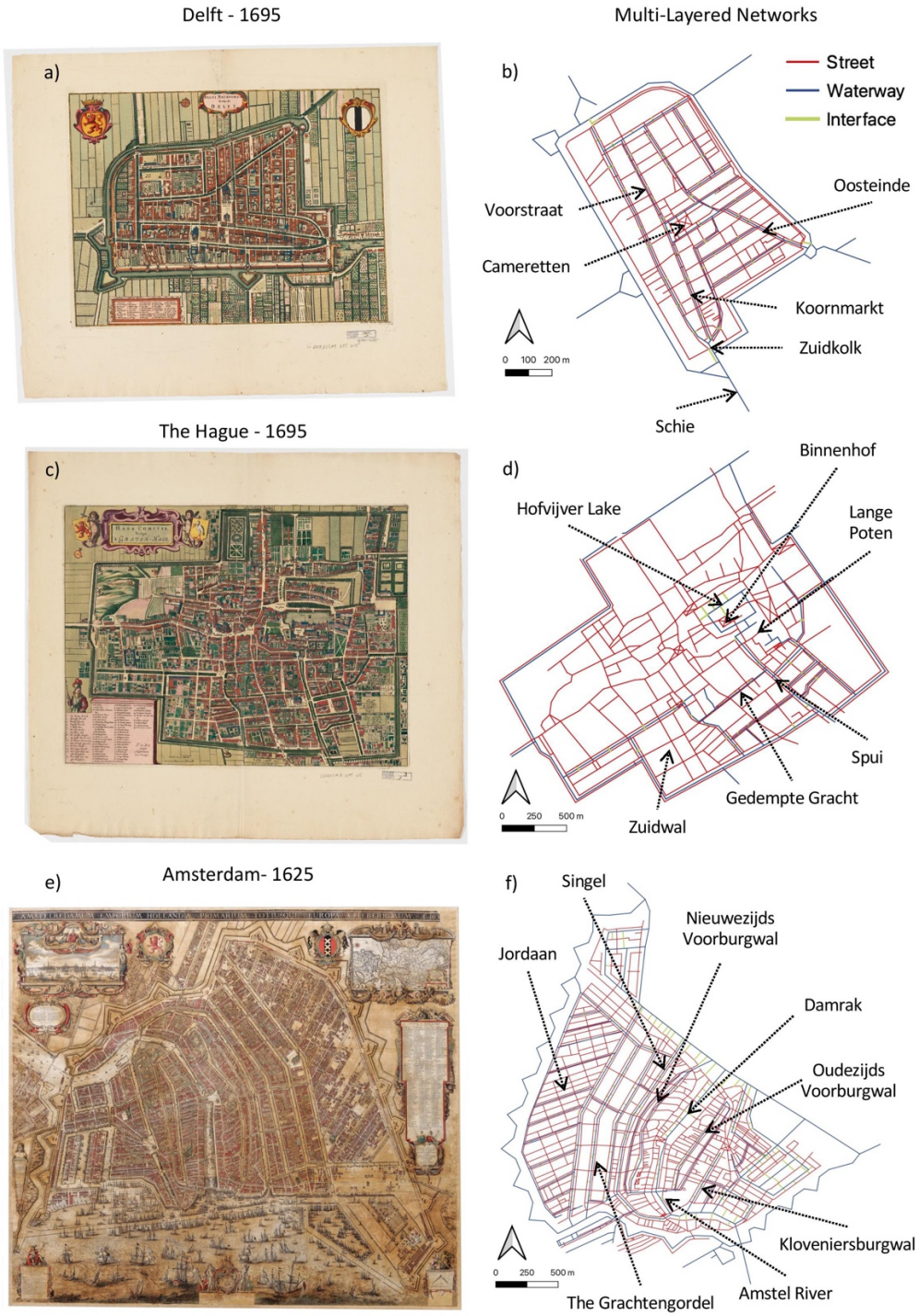

***Figure 3**. a) The map of Delft, created by Frederik de Wit in 1695 (SOURCE). b) Multi-layered network of Delft in 1695. c) The map of the Hague, created by Frederik de Wit in 1695. d) Multi-layered network of the Hague in 1695. e) The map of Amsterdam, drawn by van Berkenrode in 1625. F) Multi-layered network of Amsterdam in 1625 (Maps' Source: Oldmapsonline.com).*

RESULTS AND DISCUSSIONS

Analysis Results

The street, waterway and multi-layered model of cities are intended to analytically examine the generative laws of the medieval historical core of cities, which has grown in marshlands as an unwelcoming terrain. This section aims to explore the embedded logic underlying Delft's, The Hague's and Amsterdam's historic city cores. By the late 1600s, three cities had become a collection of islands encircling a compact city surrounded by fortifications. Three of them can be classified as compact urban fabric perforated by canals. Figure 3 shows different street and waterway patterns of Delft, The Hague and Amsterdam during the Dutch Golden Age in the 17th century. A Dutch town's success greatly depended on its accessibility by water, its position in the trade network and, associated with that, its function as a regional or international market. In most city cases, their formation was closely linked to landscape transformations such as reclamation and interventions related to water management. In this section, the space syntax analysis of the street, waterway and multi-layered networks of the medieval Delft, the Hague and Amsterdam has been presented and discussed.

Delft

By the late 17th century, the urban form of Delft could be characterised as a compact grid structure, with the canal system predominantly shaped in alignment parallel and perpendicular to the street form. This structure had evolved incrementally across different periods, commencing as early as the 13th century (refer to Figure 2). Figure 4**Figure** shows normalised angular integration analysis results of street and multi-layered networks of Delft on global radii of rN, and its integration core, which is a pattern of the 10% most integrating spaces of the given number of spaces. The angular segment integration analysis of the street network reveals that the core of the city's spatial integration principally consists of three intersecting streets. The first extends from the southwest gate and port, known as Zuidkolk, opening the Schie canal, which connects medieval Delft with Rotterdam and is presently referred to as Koornmark and Voorstraat. The second establishes a connection between the city centre and the southeast gate, currently named Oosteinde. The third, located at the core of the city centre, serves to interconnect the other two, linking key urban elements such as the square, churches, and governmental buildings. The angular segment integration analysis applied to the multi-layered network of Delft reveals that the integration core of the city centre exhibits an expansion. Furthermore, the analysis elucidates that the northern and north-western parts of the medieval city demonstrate higher integration values at the global scale relative to those obtained through the street network analysis. While the streets and the square (Cameretten, refer to Figure 3) that interconnect the church and governmental buildings and social institutions appear relatively segregated from the overall urban structure in the street network analysis, they illustrate higher integration within the results of the multi-layered network analysis (refer to Figure 4). This implies that these particular urban elements display better ease of accessibility in the foreground network when the canals are added to the existing street configuration.

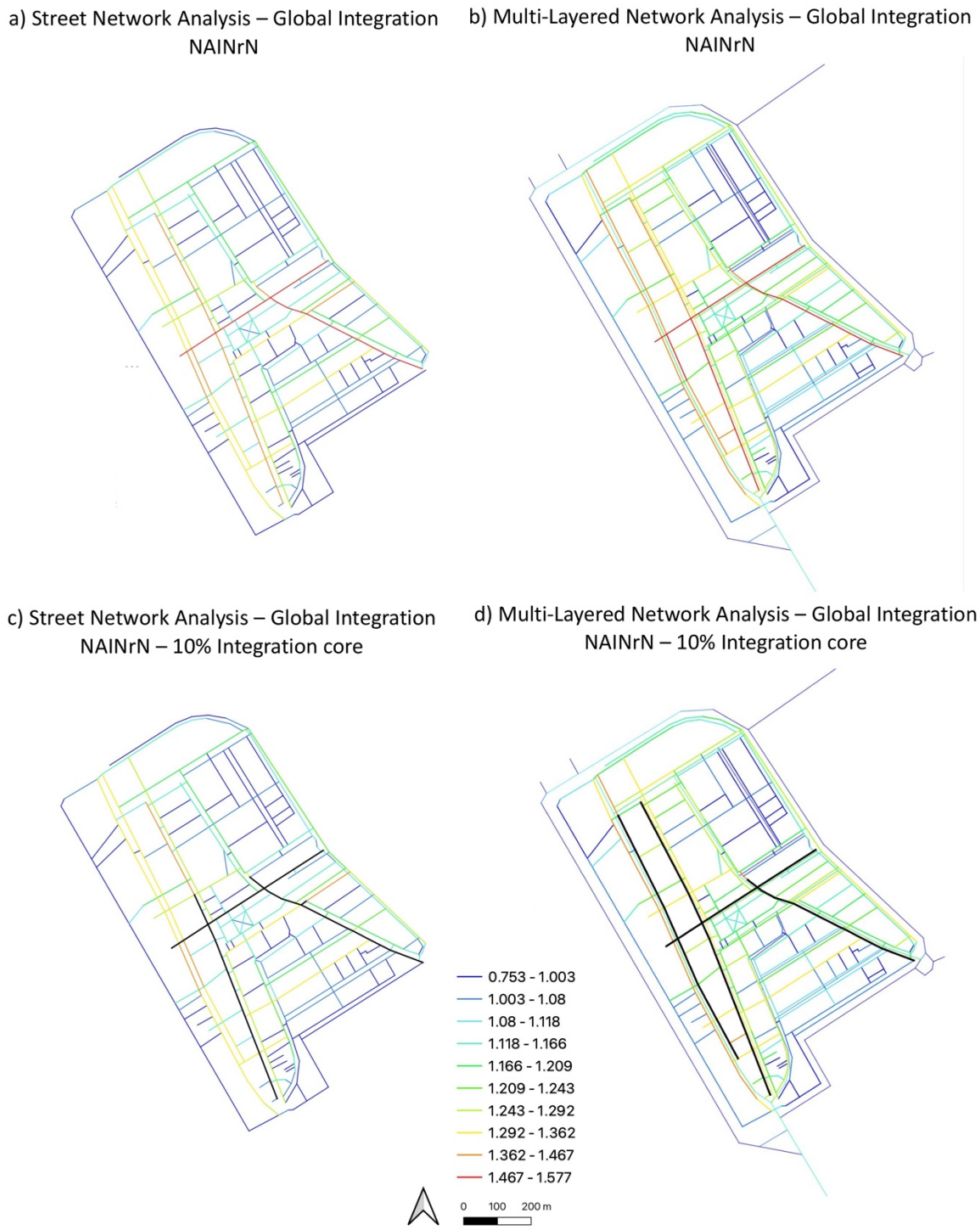

***Figure 4**. a) Angular segment analysis of the street network of Delft - NAINrN. b) Angular segment analysis of the multi-layered network of Delft - NAINrN. c) Global integration core of the street network of Delft – 10% Integration Core. d) Global integration core of the multi-layered network of Delft.*

The Hague

By the late 17th century, The Hague had two different street patterns: The first is the organic urban form at the centre, which today contains Gevangenpoort, Binnenhof and Hofvijver Lake, and secondly, the regular grid form on the south and south-west periphery area, which is today called Zuidwal (refer to Figure 3**Figure**). Compared to Delft and Amsterdam, the analysis results of the street network of the Hague show a fragmented integration core consisting of the intersection of three streets, called today Gedempte Gracht, Spui and Lange Poten, and the streets and squares around Hofvijver Lake, accompanying Binnenhof, which means Inner Court. It was originally built as a ballroom, the Gothic Ridderzaal (the great hall), which today forms the centre of the Binnenhof. It was the residence of the Counts of Holland for a short period in the late 13th century. From the 13th century onward, the counts of Holland used The Hague as their administrative centre and thus became the seat of many government institutions. Both the street and the multi-layered analysis results of the medieval Hague illustrate that the global integration core of the medieval city extends further to the south-eastern area (refer to Figure 5). At the local scale, east- edge and south-edge are also found to be particularly integrated, being accessible to local residents within 400 metres radius, which leads from the centre own towards the south and east. Locally integrated streets also occur in other parts of the city, including a street leading down to the Plein, which is a town square located adjacent to the Binnenhof. It was constructed in 1632 as a garden and was inspired by the Place des Vosges in Paris (Tucker, 2013).

Amsterdam

By the late 17th century, the grid structure of Amsterdam had two distinct types: The organic urban structure, which dates back to the 13th century and is today known as De Wallen, Burgwallen Nieuwe and Nieuwmarkt; the regular grid structure of planning decisions, which are Grachtengordel and Jordaan (refer to Figure 3). The map presented in Figure 2 depicts the urban growth of Amsterdam until the 17th century. At the beginning of the 17th century, Amsterdam initiated expansion plans in response to rising population density and to facilitate economic growth. These plans encompassed the Grachtengordel and the Jordaan district (Berghauser Pont and Haupt, 2021). The newer expansions represent a distinct shift contrasted with earlier growth patterns. The Grachtengordel, in particular, was characterised by a regular and symmetrical design, with rectangular blocks and divisions made up of streets and canals, all aligned and set at right angles to the Amstel River. Conversely, the Jordaan area is marked by its atypical orientation relative to the rest of the city. Having originally developed informally outside the city walls, the revitalisation strategy for the Jordaan entailed widening roads and demolishing certain structures to adjust the alignment of the streets. Although the Grachtengordel plan introduced a criteria related to plot conditions and architectural elements alongside the canals, these regulations were not extended to the Jordaan region. An angular segment analysis of the street and multi-layered network models from the 17th century Amsterdam illustrates that the Grachtengordel region displays a higher degree of integration relative to the Jordaan area, reflecting the proximity of each segment to others based on the sum of angular changes made along each route. Moreover, an analysis involving the 10% most integrating streets, considering both the street network and the multi-layered network analysis, suggests that the core of integration extends towards the northern part of the Grachtengordel and the eastern bank, encompassing areas like the Waag and Nieuwmarkt square (refer to Figure 6).

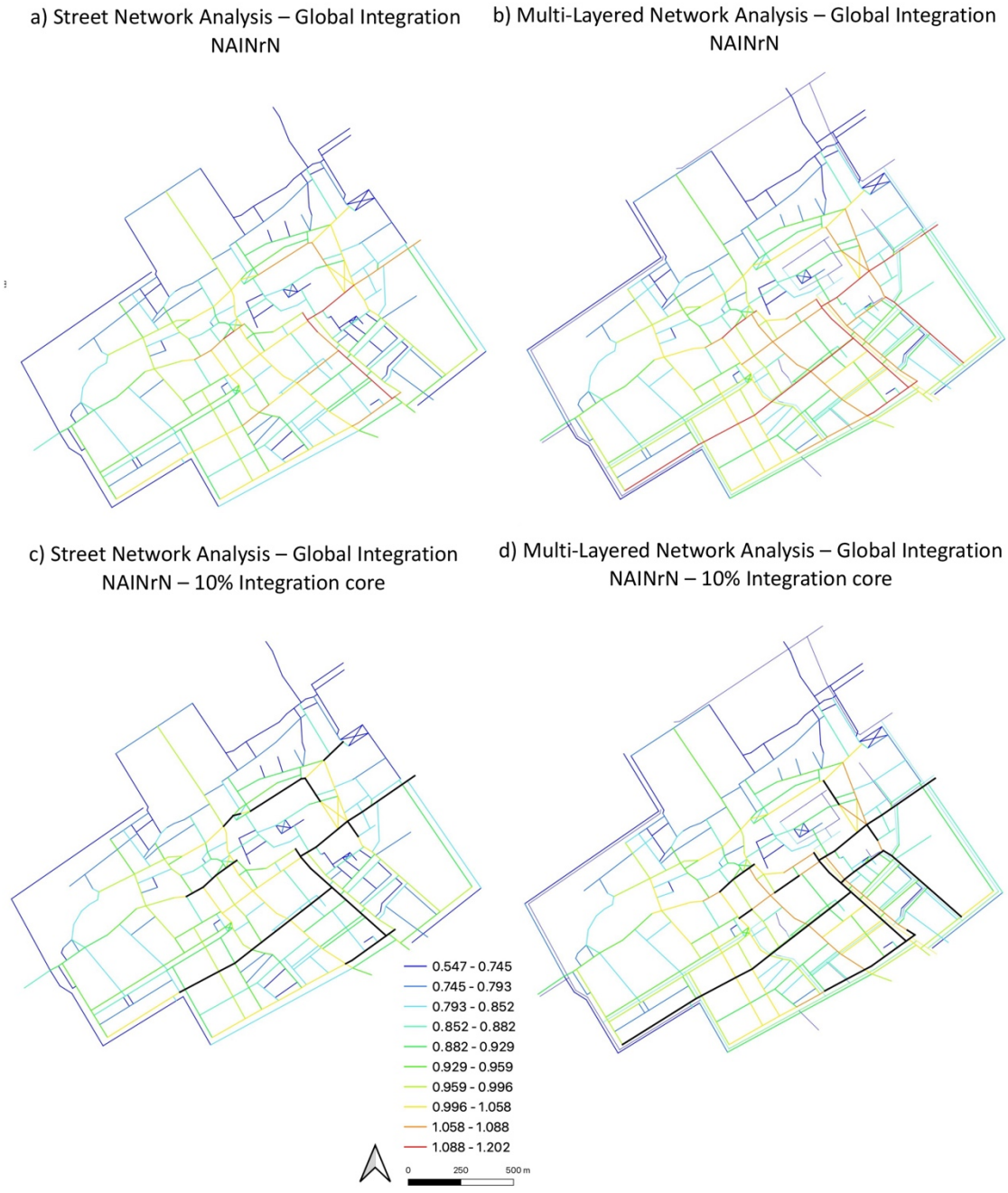

Figure 5. *a) Angular segment analysis of the street network of the Hague - NAINrN. b) Angular segment analysis of the multi-layered network of the Hague - NAINrN. c) Global integration core of the street network of the Hague – 10% Integration Core. d) Global integration of the multi-layered network of the Hague – 10% Integration Core.*

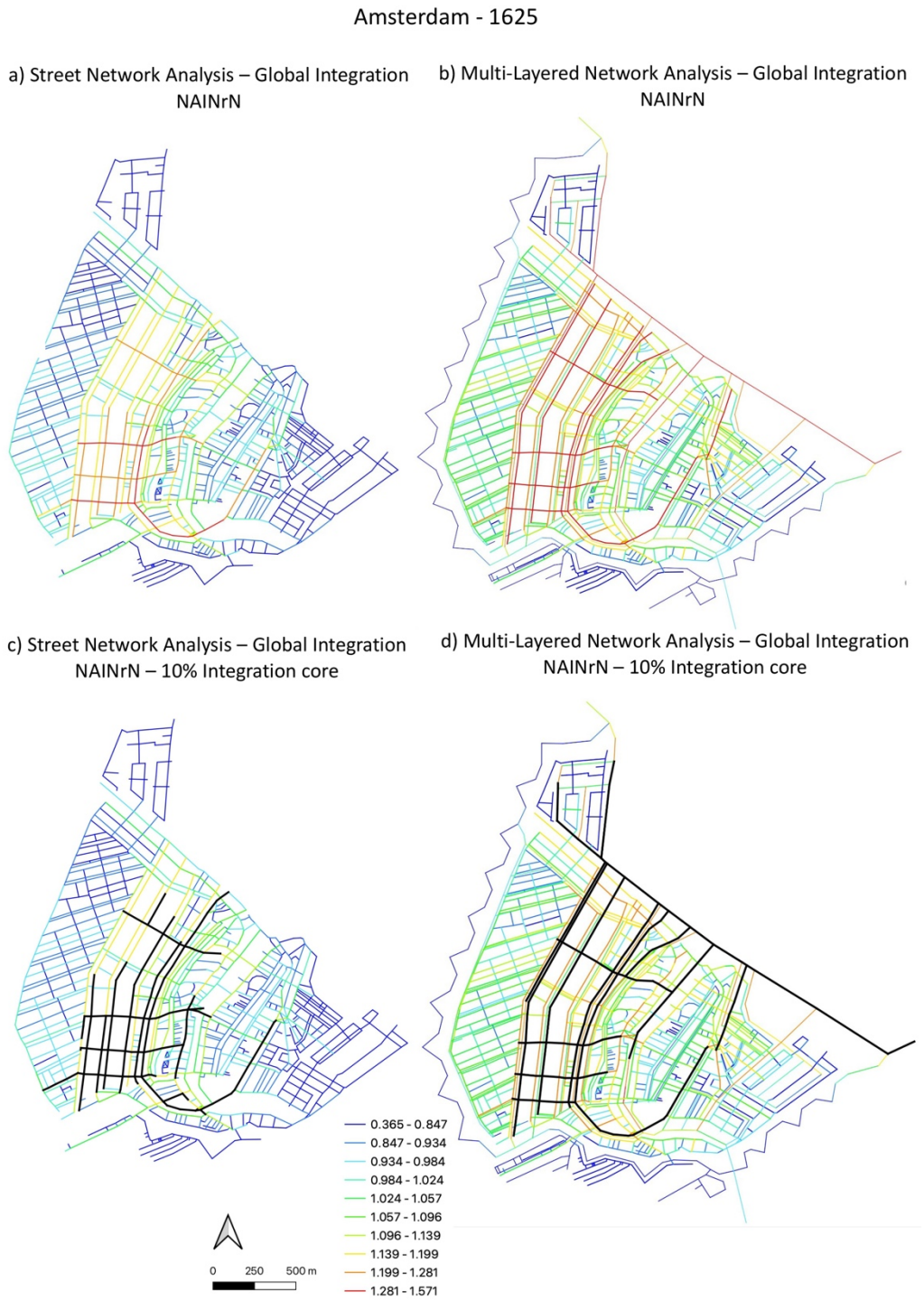

Figure 6. *a) Angular segment analysis of the street network of Amsterdam - NAINrN. b) Angular segment analysis of the multi-layered network of Amsterdam- NAINrN. c) Global integration core of the street network of Amsterdam – 10% Integration Core. d) Global integration core of the multi-layered network of Amsterdam – 10% Integration Core.*

Discussion

The concept of a generic city in space syntax approach posits a theoretical urban model, encompassing many spatial and functional elements across diverse cultures. As articulated in this theory, which is grounded in a comprehensive examination of numerous cities and settlements, both ancient and modern, cities consist of a small number of long lines and a large number of short lines. These collectively form a dual system: the foreground network, which is characterised by longer lines and nearly straight connections, and the background network, which is made up of shorter lines with more localised and less linear continuity. The foreground network links various functions and centres at different scales, optimised to encourage movement and propelled by minor economic activities. Conversely, the background network primarily serves residential purposes, and its design limits and movement in a way that reflects a particular culture (Hillier, 2007). This theory often manifests in unique geometrical expressions, rendering the overall spatial appearance of the city. A multi-layered network analysis of the historic urban structures within three Dutch cities reveals how the foreground and background network patterns change when the canals added to the spatial model and the way results relate to the location of social and political institutions. Until the late 17th century, constructs like buildings, open spaces, and infrastructure components functioned as manifest instruments reflecting the socio-economic and political dynamics of city development. Throughout the Medieval period, a multifaced interplay occurred among economic, political, familial, social and religious aspects on various scales. This interplay was structured around a distributed system of authority that included squares, churches, institutions, and a range of social strata throughout the residential spatial context. Within these complex and intertwined frameworks and identities, social institutions served to unify diverse segments of society and distribute them geographically across squares, churches and palaces. The analytical findings from the three Dutch cities under this study demonstrate that these processes were strategically executed in particular locations, with a strong connection to the combined network of both water and land, especially the foreground network. In the case of Delft and Amsterdam, the pervasive centrality of squares and the global centrality of churches, squares and social institutions show that islands shared the formation of both foreground and background networks. While churches and social organisations reveal a key role in shaping the city, these functions are collectively constructed through the interrelations of water and land. On the contrary, those functions have been found isolated in the Hague in both street and multi-layered network analyses.

To explore the variables of urban structure and the city as a whole, the spatial values of the urban networks can be represented in a star model, a methodological approach to comprehending cities in terms of normalised angular choice (NACH) and normalised angular integration (NAIN) as explained in the methodology section. Figure 7 represents the plots of values for each of the three networks (street, waterway, street+waterway) of three cities in a single star model. In terms of streets, the Hague has the lowest mean and maximum values for both integration and choice. Also, unlike Delft and Amsterdam, which distinguish between foreground and background, the mean and max values of the Hague are much closer. In the comparison of street, waterway and combined network values, the waterway networks of the three cities illustrate the highest mean NAIN, but the other three values of the waterway network illustrate the lowest values in all cities. This means that the canal system is strong on to-movement in the background network, which refers to the movement to a space as a destination from all others. When canals are added to the street network (multi-layered network), Delft and Amsterdam show the highest maximum NAIN and NACH values. This clearly reveals that canal networks had a great contribution to those cities' main foreground networks in the 17th century, demonstrating the properties of the generic city and the role of the canal network.

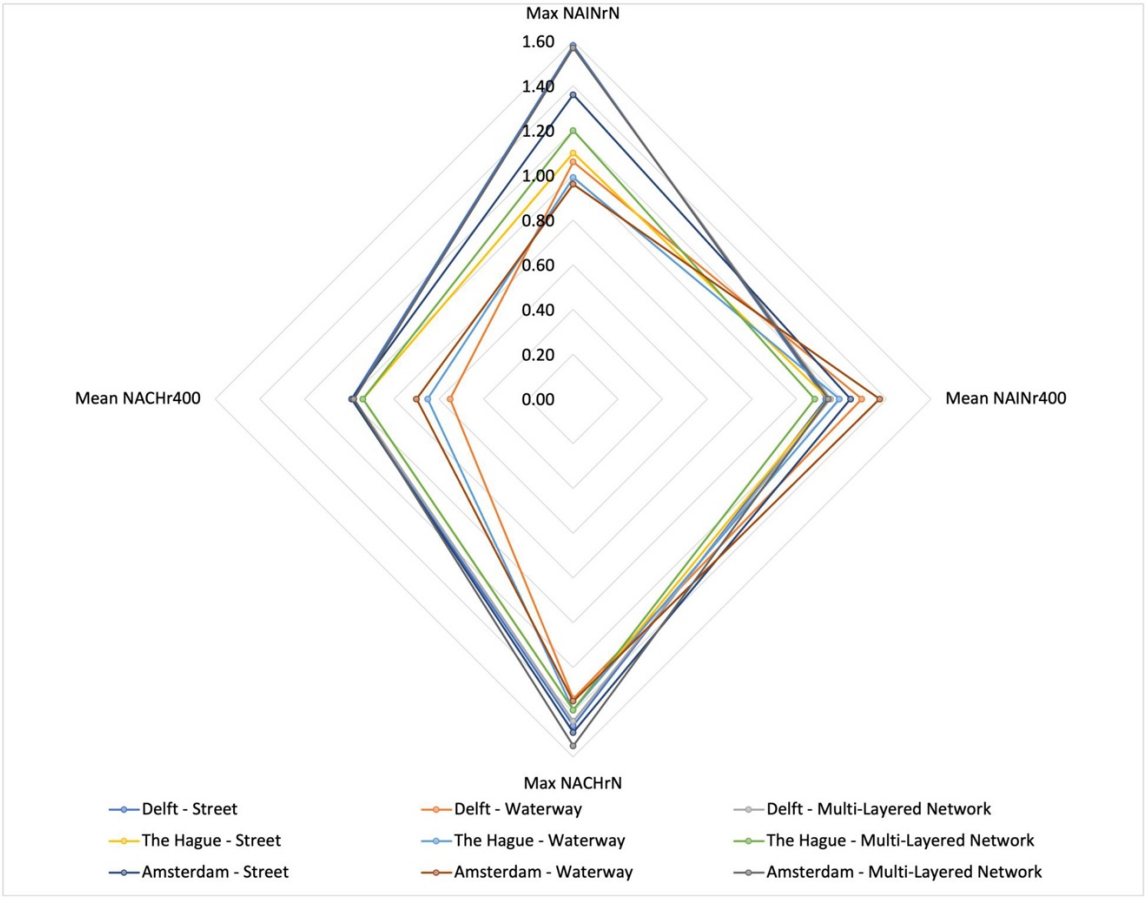

Figure 7. *Star-model of street and multi-layered networks of cities.*

CONCLUSIONS

The main findings of this study are twofold: Firstly, how the street network has worked in tandem with the canal network; equally important, how the canal network has worked in tandem with the street network while shaping the medieval core of the selected case study areas. This study presents the great opportunity that the multi-layered network model offers to produce meaningful descriptions of the roles of different spatial structures in shaping urban fabric. In the context of physical expansion, historic Dutch cities typically maintained regular growth around their fortified boundaries. In general, Dutch cities have undergone a temperate expansion guided by the gradual development of a planned urban grid system. As a result, in many instances, the historical hearth of the cities continues to be the epicentre of community life and the hub for urban functions. Furthermore, it is clear that significant segments of urban heritage have been conserved within the broader framework of the historical core, rendering them economically and socially sustainable spaces for both inhabitants and visitors. The analysed historic maps created by syntactic analysis can provide a set of evidence to reinforce how the spatial structure is shaped in response to the geographical properties and the activities of urban society. The other analysis of medieval Dutch cities is of the relationship between elements of cities (squares, churches, socio-political institutions etc.) and their spatial structure, which mainly consists of streets and canals. The elements of the city are the major spaces or buildings which accommodate the main socio-economic and socio-political activities of the city. Although these elements have a

spatial nature, they are strongly linked with functional, economic, political and cultural aspects of the society in those times; the constitution of urban elements inside the spatial system is able to reveal a better view of the Dutch system through the multi-layered analysis of urban structures. On the other hand, during the medieval era, both in Western and Eastern contexts, a relatively consistent urban design emerged and endured until the Industrial Age. From this period, some cities experienced a distinct mode of development characterised by their unique size, scale and momentum (Karimi, 2000). As this study embarks on the continual exploration of urban morphology, the forthcoming research direction will pivot towards a detailed analysis of the industrial and contemporary periods of these cities to explore how the spatial expansions have influenced the inherent spatial configurations of their historic cores. Such an investigation will not only offer a comprehensive temporal understanding of urban development but also elucidate the interplay between historic legacies and modern spatial interventions. This integrated approach promises to deepen our comprehension of the evolution of spatial structures in response to changing socio-economic and cultural paradigms.

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