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Urban mobility planning and street classification

A space syntax application

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ABSTRACT

Space syntax has been used in various urban mobility and planning contexts from small urban interventions to urban and metropolitan mobility plans (Karimi, 2012; Lerman et al. 2014). In the meantime, new approaches to street classification have sprung up taking into account the street's place function as well as its movement function in order to better address the urban complexity of the urban realm and assist in creating a shared mobility vision for various stakeholders (Jones et al., 2008; Roads Task Force, 2013).

This paper focuses on a recent case study that combines space syntax analysis with a new street classification approach to create a mobility vision based on multi-modality in the context of an extensive urban regeneration scheme. This paper portrays an urban mobility master plan for a medium-sized community in the metropolitan area of Haifa in Israel. Specific detailed description of the following steps is given: (i) a pedestrian movement model derived from an actual pedestrian movement volume survey; (ii) the current street classification based on pedestrian and vehicular movements as well as commercial fronts distribution; (iii) the future vision of the street classification and specific street network changes needed for it to happen; (iv) tying it all together in the context of large-scale urban regeneration, mass transit and future urban development, assisting policy makers in their day-to-day decisions.

KEYWORDS

Spatial Analysis; Urban Mobility; Urban Regeneration; Street Classification; Link and Place

1 INTRODUCTION

Urban and transportation planning projects are increasingly applying space syntax analyses and rely on the insights they provide (Karimi, 2012; Lerman et al., 2014; Acharya et al., 2017; Lerman and Lebendiger, 2019). The relatively lean and quick analyses offered by the space syntax approach provide for coherent visualizations enabling stakeholders and policymakers to address complex planning decisions. This paper presents a planning project for an urban mobility master plan, which combines the application of space syntax with a novel street classification scheme. This mobility master plan was created to promote sustainable urban mobility in a synergetic fashion with large-scale urban regeneration. This paper aims to contribute to the growing literature on the usability of the space syntax for a multitude of urgent urban challenges. The possibility of combining space syntax with an emerging street classification method may assist in reigning in the tendency to plan for single modality transport means (usually vehicular) and help communities realize a holistic and sustainable urban and mobility vision.

The mobility master plan discussed in this paper was prepared for the city of Qiryat Yam, which is an independent municipality within the metropolitan area of Haifa in Israel. The future intentions for this city are to add at least 6,000 housing units through urban regeneration as well as additional housing units in infill projects, growing from 40,000 inhabitants to 60,000 and possibly up to 80,000 people. All this significant urban growth should also be accommodated with higher modal use of non-motorized modes and public transit. In order to accommodate this growth, the regeneration projects themselves need to take place in the most accessible places inside the city and also be accompanied by changes to the public transport scheme for the city which is currently served by a multitude of busses and one BRT (Bus Rapid Transit) line. Furthermore, changes in the land use mix need to occur in order to enable and encourage more walking to take place (as well as improved conditions for walking to transit) and changes to the current street infrastructure is needed to enable more cycling. Finally, the large-scale regeneration projects provide an opportunity to make changes to the street grid itself to create a street network structure which is more conducive to walking and cycling.

Space syntax approach was applied in this planning project with an outlook toward the year 2040. The planning process used multiple space syntax analyses and applied a pedestrian movement model derived from an extensive pedestrian volume movement survey. Finally, the pedestrian movement model and retail distribution map were combined with a novel street classification approach resulting in a robust and long-lasting vision for the future street network, the street network changes and urban land use functionality.

2 THEORY

This chapter presents the two theoretical approaches which are combined in this paper – the space syntax analyses used for pedestrian movement models and the novel street classification scheme (the Link and Place approach) applied in practice to create a coherent vision for the streets as well as the street network.

2.1 Space Syntax Applicability for Pedestrian Movement Models

In order for the regeneration plan to take place, a multi-modal transportation plan was conceived which enables central streets to serve their role as urban places and carry different kinds of traffic with efficiency and minimal friction. Space syntax analyses were used to create a pedestrian movement model as formerly done in other places (Raford and Ragland, 2006; Lerman et al., 2014; Lerman and Lebendiger, 2017). First, a thorough analysis using space syntax is done on the metropolitan scale to understand the various potentials of different street segments. Then a pedestrian movement survey is conducted on a large enough dataset of segments to gather data for analysis. Afterwards, a statistical correlation is done applying both log normalizations for values that are heavy tailed (meaning few large values compared to many small values). The process involves a large amount of space syntax derived variables (mainly various integration and choice measures at different radii and all kinds of combinations among these variables) calculated based on a roads and paths map and may also include other variables representing land use, transit stations distribution and so forth.

2.2 "Link and Place" Street Classification Approach

Under conventional traffic engineering approaches the streets and roads are classified according to their importance to movement and specifically motorized movement. This kind of classification impacts the street sections layout, intersections geometry as well as adjacent land uses and their accessibility. Furthermore, while being focused on motorized movement, this street classification approach also impacts the priority given to pedestrian, cyclists and transit vehicles movement.

Thus, the conventional "traffic-oriented" street classification approach leaves a lot to be desired when it comes to multi-modal transport and the way the streets and roads provide for complex human interactions. Jones et al. (2008) have developed a more holistic street classification approach that classify streets and roads by their multi-modal movement function called "Link" as well as by their importance for human activities and interactions called "Place". This novel approach proposes the use of a matrix of street classification to provide a clearer view of the various streets (and street segments) roles with regard to both the traffic-related considerations with the place-related considerations. Essentially, a street which is important for through movement (meaning a high or medium Link classification) may be also important as a destination by its own right (meaning a high or medium Place classification). Under the conventional (car-first) street classification system, the Place function is mostly ignored in planning discussions, while only the Link function is highlighted and mainly for private vehicles only. This novel approach allows for both functions of the street to be recognized explicitly and has been recently expanded and is gaining momentum through recent projects (and see for example: Jones, 2018). Specifically, this approach has been adopted most notably in London (Roads Task Force, 2013) where a 3 by 3 matrix for link and place has been applied, leading to 9 types of streets and road segments. Figure 1 shows the Link and Place matrix used by Transport for London for street classification. The higher squares on this matrix have higher movement importance, while the rightmost squares have higher place importance. Thus, the square on the bottom left represents local streets which do not have significance for movement and place, and the top right square represents city hubs where high traffic volume (usually of motorized transport, busses and pedestrians) is combined with important focal points for business and culture. This simplistic 3 by 3 matrix has been adopted for the plan presented in this paper also.

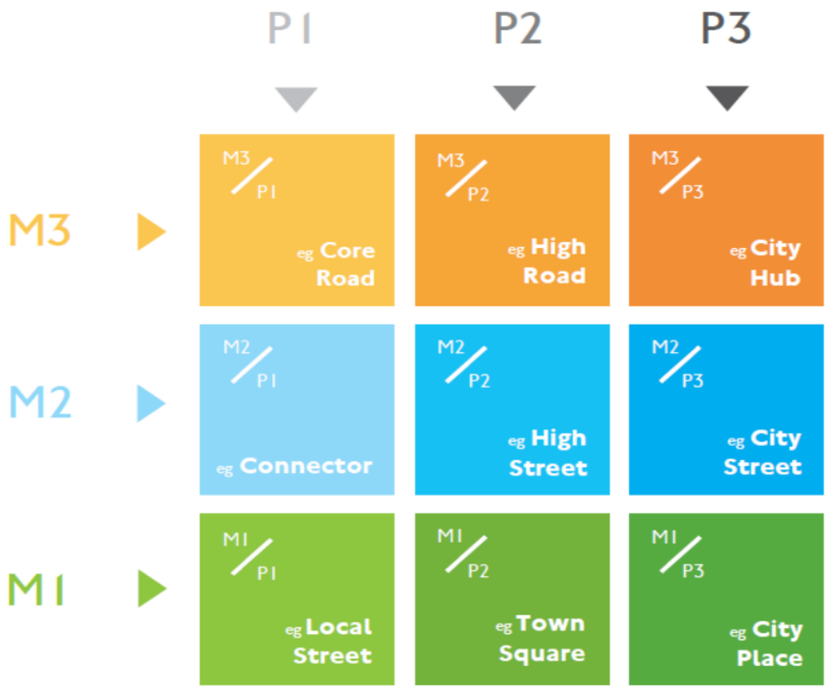

Figure 1: Link and Place street classification matrix adopted in London. (source: Jones, 2018).

3 DATASETS AND METHODS

3.1 Research Area

The research area encompasses the city of Qiryat Yam which comprises a part of the inner suburban ring in the Haifa Metropolitan Area in Israel. This city itself has an area of 4.5 square kilometers with 40,000 inhabitants. The city of Qiryat Yam borders the city of Haifa (which is the biggest city in the northern part of Israel) on the south, the Mediterranean Sea to the west, a closed defence compound to the north and other suburban communities to the east. Currently, one BRT (Bus Rapid Transit) line serves this city while just east of its border lies a suburban rail line with several existing and planned stations.

Major urban regeneration schemes are in the works for most parts of this city, intending to replace a dilapidated building stock (mostly built between 1950 and 1970) with modern mostly high-rise apartments. These development plans are also meant to promote economic growth and a higher quality urban environment and transit accessibility. Figure 2 shows the area of the city with the existing rail transit systems and the streets and paths networks for the current state and the planned state.

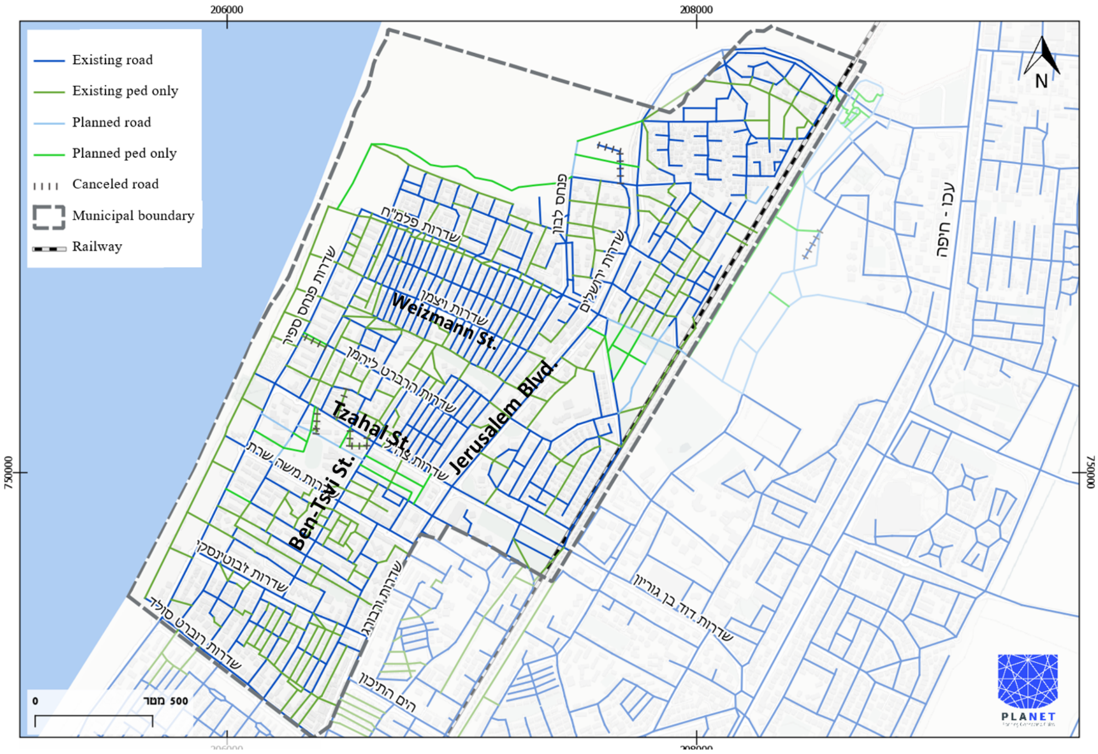

Figure 2: The City of Qiryat Yam Mapping of existing and planned roads and pedestrian paths

3.2 Space Syntax Analyses

In order to enable various space syntax analyses to take place, a segment map of the city of Qiryat Yam and the surrounding area was made, for the city of Qiryat Yam itself and a buffer of 5 km all future plans were also mapped into the future state segment map. Multiple space syntax analyses were done on the metropolitan road segment map (to avoid any boundary issues) to calculate angular segment integration and choice values for all segments for the following radii: 1,250 m, 2,500 m, 5,000 m, 7,500 m, 10,000 m, 15,000 m, 20,000 m, 30,000 m.

These radii were used in order to assess the centrality regimes (Serra and Pinho, 2013) of Qiryat Yam at local scales, urban scales and as part of a larger metropolitan area. The current state of the existing road and path network as well as the future state of the proposed road and path network were analysed incorporating planned developments in and around the city of Qiryat Yam. All local analyses (up to a radius 2,500 m) used a roads and paths segment map, while analyses with a bigger radius were calculated based on roads only segment maps.

3.3 Pedestrian Survey Method

For the pedestrian movement model in this project 72 points were surveyed using the gate count method for eight hours (From 11 AM till 2 PM and from 3 PM till 8 PM) in which for every hour ten minutes were observed and counted at each survey point.

Since the spatial analysis is based on high-resolution analysis at the level of street segment only functional properties which can be applied to a street segment and were found most relevant for pedestrian movement were computed. The following land use variable was added to the space syntax derived variables computed:

Commercial fronts – this variable was calculated based on an actual field survey of all street segments in the project area. Each street segment was given a value of 0, 1 or 2 depending on the amount of commercial fronts in it (retail on two sides, one side or none).

4 RESULTS

4.1 Space Syntax Analyses

In this section several insights derived from space syntax analyses of angular integration and choice are described. Figure 3 shows the analyses results for the different radii and measures described in further detail below.

Essentially, three centrality (integration) scales are revealed by the spatial analysis: (i) a neighborhood scale; (ii) a city scale; (iii) a regional scale. These scales are the radii of 500 m, 2,000 m and 20,000 m. The neighborhood scale shows the centrality of the northern neighborhood (also called Block C) in Qiryat Yam, where a local commercial street (Weizmann Street) runs in the middle of a well-defined neighborhood. The city scale analysis identifies the municipality center itself at the entrance to the city where Jerusalem Boulevard meets Tzahal Street. Lastly, the regional scale shows that road 4 and highway 22 on the eastern side of the metropolitan area are most likely to attract metropolitan scale land uses (a process which indeed takes place in the last decade since highway 22 was opened).

Angular choice analyses provide different insights at three scales of analysis – (i) city scale 2,000 m; (ii) extended city-scale 5,000 m and (iii) regional scale of 20,000 m. At the city scale this analysis identifies the three most important local routes (Weizmann Street, Ben-Tzvi Street and Jerusalem Boulevard). At the extended city scale the significance of Jerusalem Boulevard is clearly shown as well as both major east-west connections to Road 4. At the regional scale Road 4 is clearly the main movement artery.

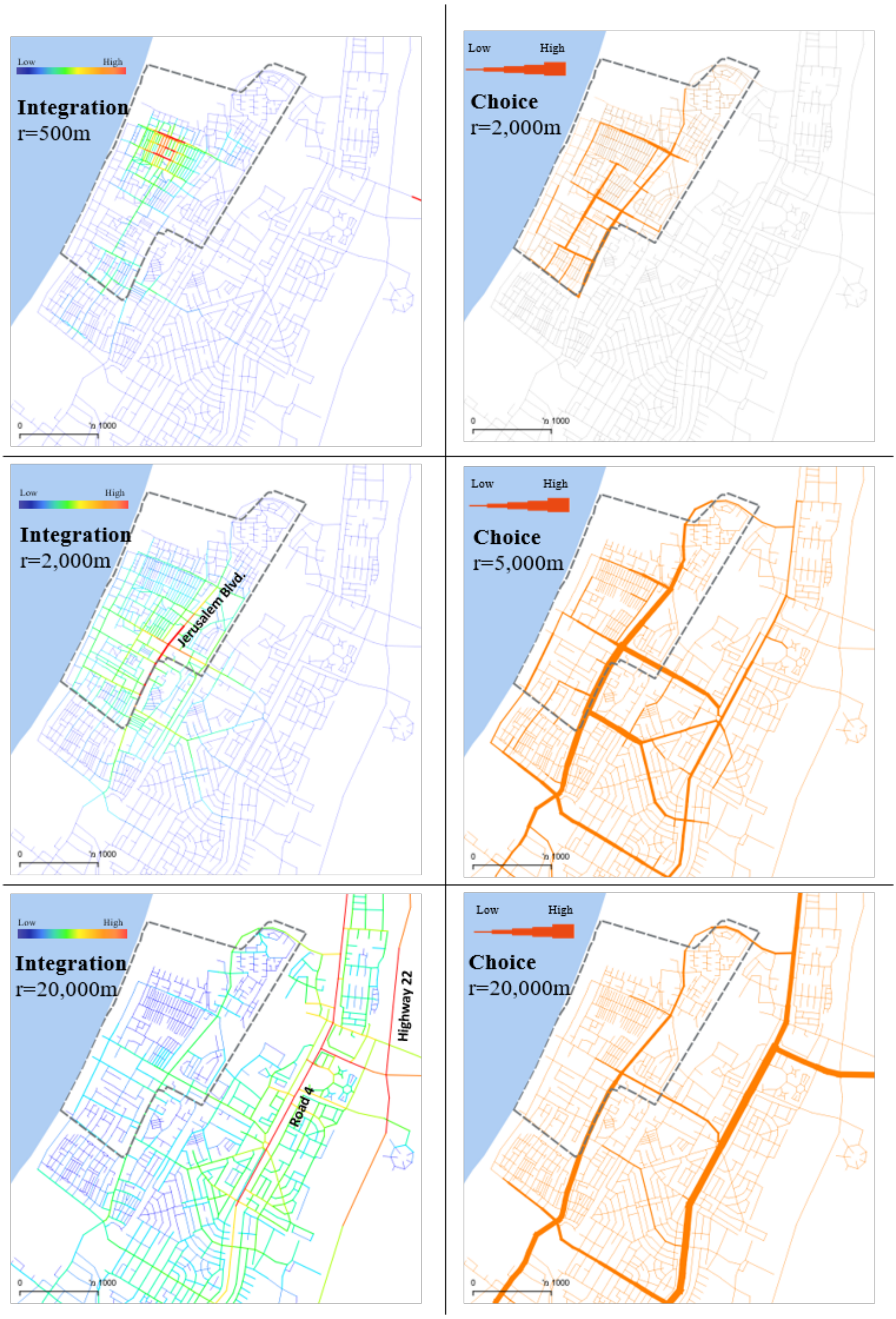

Figure 3: Space syntax analyses of choice and integration at different radii. The dashed line shows the border of the municipality of Qiryat Yam.

4.2 Pedestrian Movement Volume Model

Since pedestrian movement is not distributed evenly and many streets carry low volume of movement compared to the few that carry high volume of movement (Jiang, 2009), the head/tail breaks algorithm (Jiang, 2013) was used to allow for a better visualization of the survey results. This algorithm breaks a heavy-tailed distribution in a deterministic fashion and captures the underlying hierarchy of the data. This is done by partitioning all the data values around the mean into two parts and continuing the process iteratively for the values (above the mean) in the head until the remaining head part values do not exhibit a heavy-tailed distribution. Thus, the 72 survey points were divided into the following three categories:

(1) High pedestrian movement volume (over 126 pedestrians per hour, on average) — 12 points which account for 16.6% of the survey.
(2) Medium pedestrian movement volume (less than 126, but more than 77 pedestrians per hour, on average) — 21 points which account for 29% of the survey.
(3) Low pedestrian movement volume (less than 77 pedestrians per hour, on average) — 39 points which account for 54% of the survey.

Figure 4 shows the pedestrian movement volume distribution divided to the three categories. Out of the empirical survey a pedestrian movement model was built by using statistical correlations as done in other projects (Raford and Ragland, 2006; Lerman et al., 2014). The model regression itself was correlated with an r-square of 0.62 using of two variables. The most important variable in the model, accounting for 72% of the correlation was angular choice at a radius of 2,000 m and the other variable was commercial front existence.

In a similar fashion to the empirical survey the model itself also reflects the nature of urban movement, with a high number of road segments carrying relatively low volume and a low number of road segments who are subject to high movement volume. Therefore, the same head/tail breaks algorithm was applied the to the model results to highlight the most important street segments out of the entire city centre street network.

The city of Qiryat Yam comprises of 1,303 segments out of which 63 were dimmed to have very high importance in the head/tail breaks (4.8%), another 121 were dimmed as having high importance for pedestrian movement (9.2%), and the rest (1,119 segments, 86%) were dimmed as the low category. Figure 5 shows the pedestrian movement core volume model visualization under the head/tail breaks for the existing road and path network of the city.

It can be clearly seen that at the current state the city of Qiryat Yam has three distinct centers with relatively weak connections among them. The first is the local center of the northern neighborhood (Weizmann Street), the second is where the main entrance to the city is and the third if on the southern section of Jerusalem Boulevard.

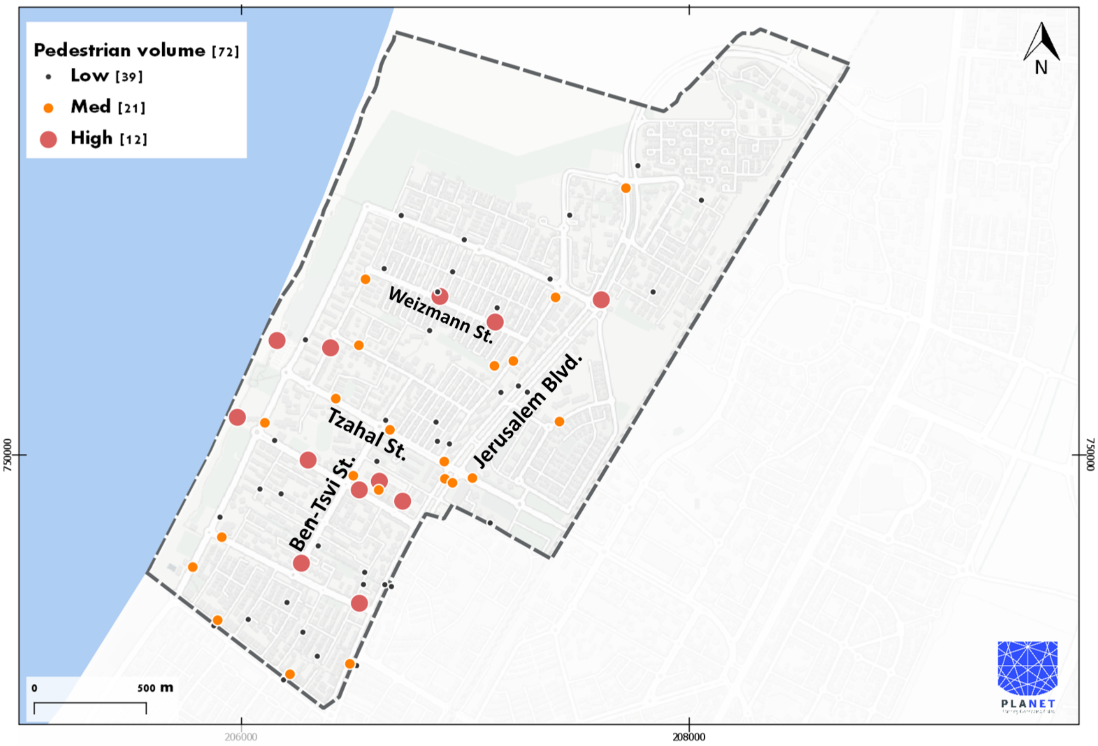

Figure 4: Pedestrian movement volume survey points distibution

Figure 5: Current state pedestrian movement core

The model formula was then applied to the city street network including the (already) approved plans, showing a relative strengthening of the central area in the city in terms of potential volume of pedestrian movement. However, no other major changes were observed, while the three distinct local centers have stayed somewhat separated from each other.

The map combining the current state and approved plans is shows in Figure 6. This map consists of 1,340 segments out of which 76 segment (5.6%) were classified in the top category (very high importance) and 78 segments (5.8%) were classified in the second category (high importance).

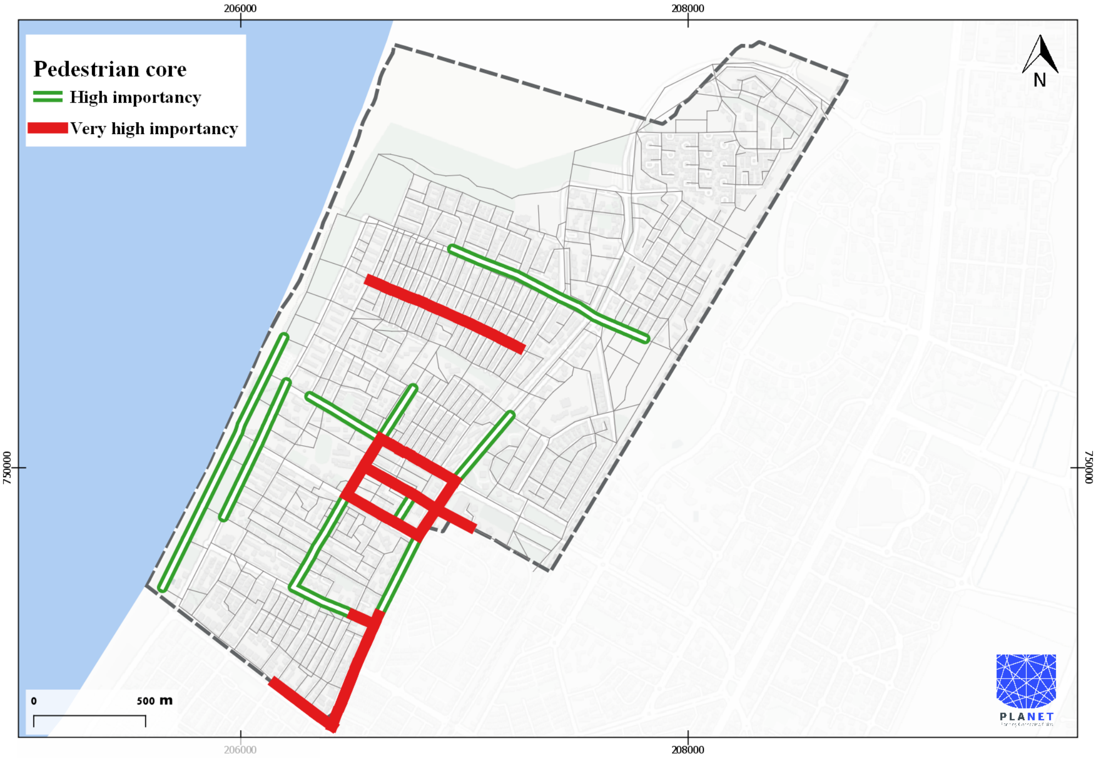

Figure 6: Current state and approved plans pedestrian core

Finally, a strategic plan consisting proposed street network changes was applied with the model formula to create a proposed pedestrian core network and emphasize the most important aspects of future street network changes that need to take place when planning urban regeneration projects throughout the city. The proposed map is derived from the current and planned state movement models and incorporates a vision for the future of Qiryat Yam. The pedestrian core of the future proposed street network is shown in Figure 7. To further differentiate among the street segments significance for pedestrian movement a medium importance category was added to the pedestrian core map. In this map there are 1,357 segments out of which 109 segment (8%) have very high importance for pedestrian movement, 38 segment (3%) have high importance and 122 segment (9%) have medium importance.

This vision enables the creation of multiple medium and high importance streets in Qiryat Yam through the generation of continuous urban grid, which would also further promote local retail locations making the urban environment more conducive to walking, cycling and transit use. Specifically, the most important changes to the street network, deemed as must happen are:

(i) The extension of Ben-Tzvi street east to Weizmann Street.

(ii) The extension of Weizmann Street north-west towards the waterfront and south-east to connect to Jerusalem Boulevard.

(iii) The creation of a legible street grid connected to its surroundings at the mega-block currently used for multiple public building just north of the city center.

(iv) Defining a continuous medium importance grid to tie most of the city neighbourhoods together with a legible pedestrian core network.

This exercise in visioning the future pedestrian movement core for the city of Qiryat Yam provided the planning team with the needed Place index and justified a set of future (rather complex) projects aimed at changing the internal street network structure of the city at the most important and valuable places to have the greatest and most beneficial impact.

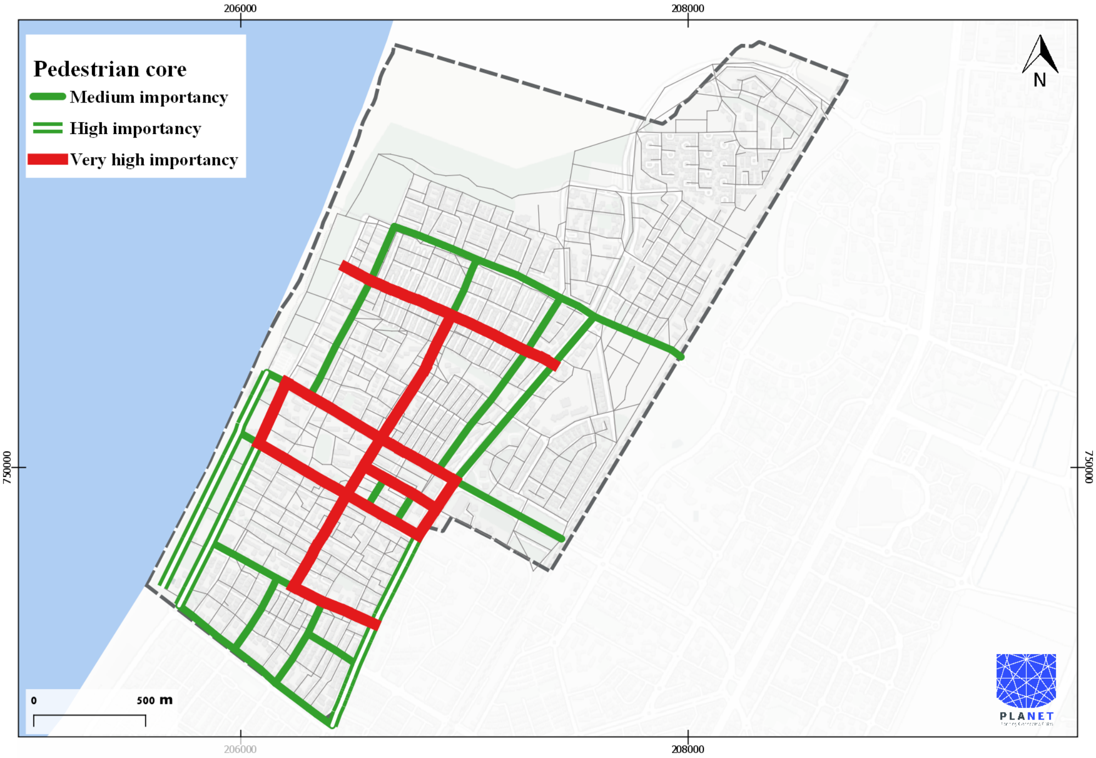

Figure 7: Future (proposed) pedestrian core map of Qiryat Yam

4.3 Streets Classification

Following the creation of the pedestrian movement model and its associated pedestrian core maps, the task of street classification according to the “Link and Place” approach could take place. To conduct this classification, the pedestrian core map for the current state was combined with the retail distribution map and the motorized classification network map (not shown here). The process also involved several discussions with the city officials to come up with a coherent map reflecting the current state and vision the city had for itself, based on the different movement models (pedestrian and motorized), retail distribution and waterfront development aspirations.

Figure 8 shows the current street classification (on a map that consists of the current street network combined with the approved plans), while Figure 9 shows the proposed street classification map with the hypothetical changes to the street network in the city.

This classification provides a clear map that distinguishes among street segments according to both their movement and place importance at the same time and reveals clear points in the city where changes in street functions need to take place. For example, it is clear to see the exact point of change between the northern part of Jerusalem Boulevard, which has a strong movement function and a medium place function, and the southern part of this boulevard which has both a strong movement function and a strong place function. The same goes for the difference between the eastern part of Tzahal Street and its western part where the western part has a strong place function combined with a medium movement function, while the eastern part has a weak place function combined with a strong movement function.

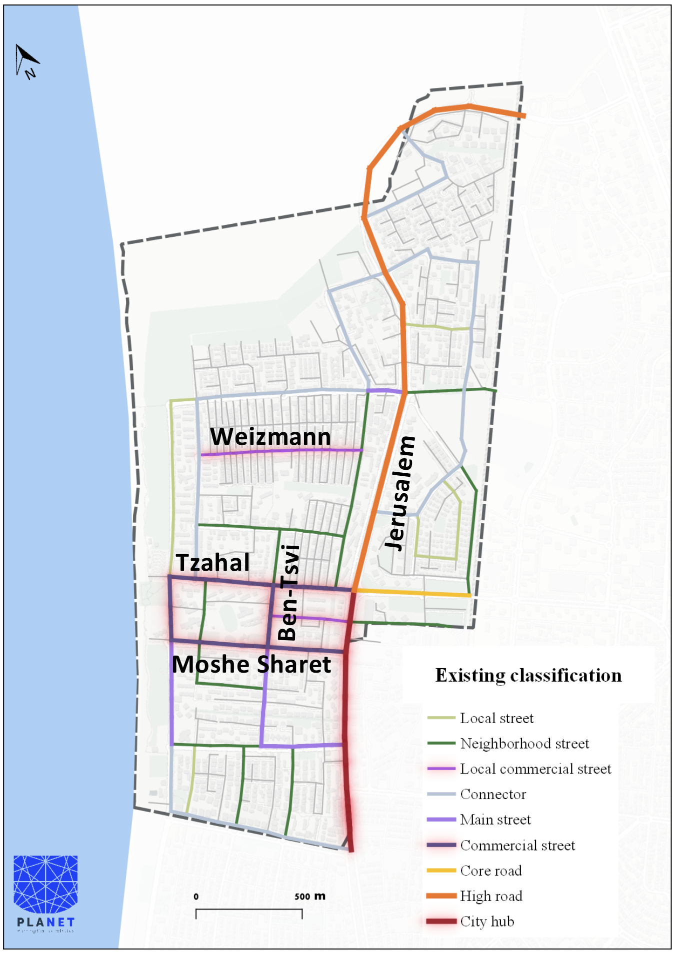

Figure 8: Current state (with approved plans) street classification according to the Link and Place approach

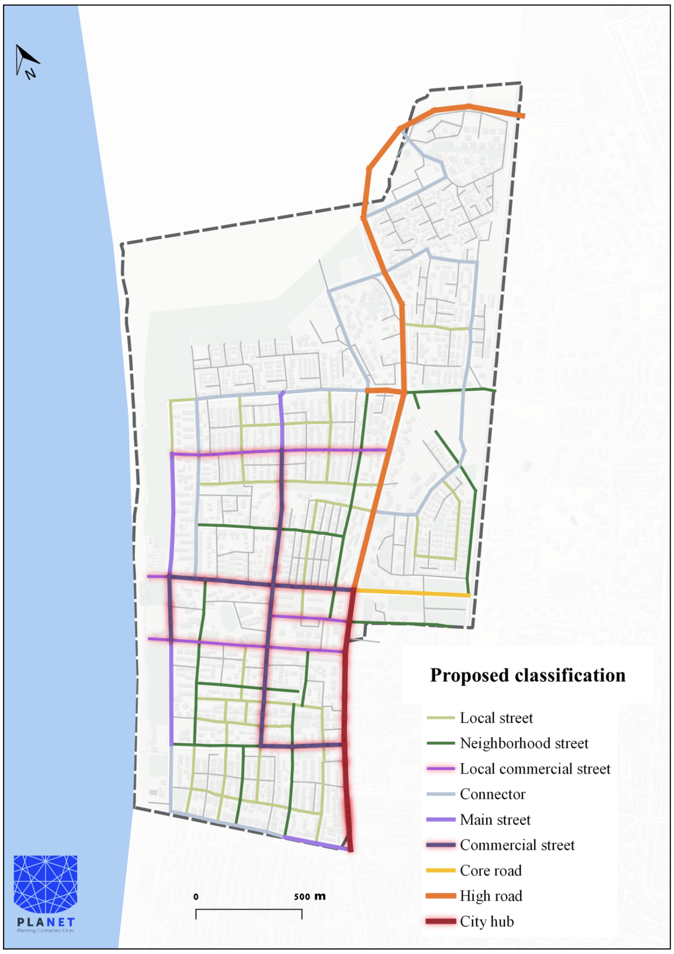

Figure 9: Proposed (visionary) street classification according to the Link and Place approach

Finally, setting the future street classification enables the full array of changes that need to take place to be fully visualized and articulated. For example, in the proposed street classification network significant changes to the street network are shown that are needed in order for this vision to come to fruit. Furthermore, these network changes are combined with changes to the movement and place functions of the relevant existing and proposed street segment. These changes are prominently displayed in Ben-Tsvi Street which is to be extended north toward Weizmann Street, leading to a creation of a new arterial street with a high place function in the city of Qiryat Yam. Other changes are exemplified by streets like Moshe Sharet which has its future movement function reduced in order to serve as a major local retail destination, allowing for pedestrian and cyclist movement with lower friction and conflicts with motorized transport.

4.4 From Vision to Actual Projects

Following the entire project to the final street classification map has enabled the city as well as other governmental organizations (chief among them the Haifa District Planning Committee which oversees the local planning committee and the district transportation officials) to clearly understand the mobility vision for the city of Qiryat Yam. This vision was clearly combined with the efforts taking place to promote urban regeneration in the city and exploit these opportunities to enhance the local street grid.

The discussions with the city on its current and future street classification network allowed the city engineer and his team to delve into the most significant development issues for the future of the city and to clearly understand the importance of certain street network changes to the viability of a sustainable and economic future for the city. Furthermore, the coherent visualizations enabled sharing of the street network visions with higher level governmental entities, whose cooperation is needed to realize the proposed changes.
At last, the proposed street classification was used to clearly define ten specific projects with different degrees of complexity and range of stakeholders to be followed up and executed. These projects together with the proposed street classification map serve as the city's roadmap to the future.

Addressing both the Link function and Place function of each street allowed for holistic solutions to be agreed upon. An example for one of the projects derived from the mobility plan was a thorough change planned for Tzahal Street from a car-oriented road to a commercial boulevard incorporating BRT infrastructure running across the length of this street. Defining this street as a having a medium Link function and a high Place function had a strong influence of the traffic discussion with the district transport officials. Eventually, this classification led to an urban design scheme which incorporates the BRT in the street section, while trying its best to reduce the severance this transportation means creates, reducing car presence in the street and avoiding an excessive number of fences and clutter (a first in Israel). Figure 10 below shows a rendering of the proposed solution for Tzahal Street, which would not have been possible to reach without using the novel street classification approach.

Figure 10: A rendering of the re-imagined Tzahal Street, combining high Place function with medium movement function and BRT infrastructure.

5 CONCLUSIONS

This paper presented a synthesis between space syntax derived analyses (and especially space syntax applicability for pedestrian movement models) and the "Link and Place" street classification approach. This synthesis was demonstrated through an urban mobility masterplan for the city of Qiryat Yam in Israel.

The advantages of combining both approaches are in making robust decisions regarding the Link function and Place function of each street segment which leads to clear visualizations of current and future street classification, thus enabling an open discussion of the mobility visions as a whole and each street specific role in attaining that vision. Creating such a clear and easy to convey mobility vision helps to define specific actions that are needed to enable this vision to take place. Another advantage of this street classification process is the help it provides in getting agreements from various stakeholders for the future steps needed.

The proposed street classification map shows the opportunity that lies in large-scale urban regeneration projects to both improve the local street grid as well as enhance mobility and accessibility providing high public and private value to the city and helping future decision makers to carry out the vision across the years it would take to realize. The street grid changes have been thoroughly evaluated through space syntax analyses of both integration and choice values. Applying the space syntax approach and its analyses have made the street classification process easier and more robust both for the current state and for the proposed state.

While focusing of the space syntax analyses and the street classification method, this paper has not discussed most of the issues related to public transport and rail transport, which were also addressed in the mobility plan due to their relatively weak connection to the space syntax approach (together with their somewhat conventional manner).

Lastly, combing space syntax with the Link and Place approach shows real promise as way to promote space syntax in actual planning project as well as replacing the traditional street classification approach (which mostly resulted in prioritizing motorized transport), with the holistic approach of the Link and Place classification scheme. These two approaches fit each other well and hopefully will be used in conjunction in other places to address the challenge of sustainable urban growth.

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