# Relationship between Spatial Configuration and Ferry, Bus and Railway Patronage in Brisbane CBD

Sima Vaez[1], Matthew Burke[2],Tooran Alizadeh[3]

Email for correspondence: sima.vaezeslami@griffithuni.edu.au

## Abstract

The pattern of an urban network is an important factor influencing traveller's "natural movement" through space. Land uses benefit from areas with rich movement potential. Public transport stations similarly benefit from pedestrian spatial accessibility. What is less clear is how central area spatial characteristics help shape the fortunes of different modes that compete for public transport mode share for travel into central business districts (CBDs). The aim of this paper is to analyse the spatial characteristics of the main public transport stations in Brisbane's CBD and South Bank by using space syntax, a computational approach derived from the work of Bill Hillier (1970), and to compare these spatial characteristics with public transport patronage. The configurational features of the areas surrounding key ferry stops, busway and railway stations are analysed. This is compared with patronage data obtained from Translink *GoCard* smart card ticketing data for the period October 2016. The results show that, as expected, ferry terminals are tightly bounded by the Brisbane River and have reduced spatial accessibility compared to most busway and train stations. Roma Street rail station – a key hub of the busway and rail network – has lesser spatial accessibility than the underground Central station, as well as less patronage. The outputs provide useful inputs for future observational studies of how public transport travellers make sense of unfamiliar environments and find their way from stops and stations to their end destinations.

## 1. Introduction

Bertonlini and Spit (1998) argued that any significant transit station should also be located in a "significant place" in an urban network. In this context "significant place" refers to places with high potential of spatial accessibility. In other words, some areas in an urban network have high movement potential. Transit stations can benefit from this urban spatial characteristic to influence people's natural movement and attract them. Spatial accessibility can be measured by different models and indicators based on GIS analysis. The main aim of this paper is to analyse the spatial characteristics of the main public transport stations in the Brisbane CBD by using the space syntax technique, a computational approach derived from the work of B. Hillier and Hanson (1984) and to compare it with public transport patronage.

Inadequate accessibility of transit stations could have negative impacts on safety and liveability of station areas; and consequently, the public transport usage will decrease. According to Hillier, the degree of integration plays an important role in spatial accessibility of an urban area. So, transit stations located in integrated areas may have more potential to influence people's natural movement and wayfinding decision making.

This paper seeks to analyse the quality of main transit stations areas in the Brisbane CBD; including key ferry terminals, bus stops and railway stations; by measuring the spatial configuration of their walkable catchment areas (r400m). This is compared with patronage data obtained from the *GoCard* smart card ticketing system for everyday of October 2016.

# 2. Space Syntax Methodology: Urban Form and Spatial Behaviour

## 2.1 Spatial Configuration

Configuration is an important notion of space syntax and is defined in Hillier's book space as “a set of interdependent relations in which each is determined by its relation to all the others” (Hiller, 1996, p. 24). Each urban space is composed of a set of urban elements like alleys, roads, streets, boulevards and parks. In the graph representation of the urban network, called the justified graph, the intersection of linear features are considered as nodes and the connections between pairs of nodes are regarded as edges (Miller & Shaw, 2001). An axial map is the basis map for analysing urban network representing the longest distance that a person can ‘see’ while moving through an urban space. The value of integration is the earliest and most important variable for calculation. The quantitative calculations are usually made by space syntax software applications such as DepthMap and Axwoman.

## 2.2 Angular segment based analysis

The most powerful tool for measuring accessibility is angular segment based analysis with metric radius (Hillier, Yang, & Turner, 2012, p. 73). In this context, the radius refers to the metric distance that the syntactic analysis is restricted to.

The main movement indicators measured by angular segment based analysis are *to-movement* and *through-movement*.

Through movement (choice) indicates the potential of a street segment to be chosen by pedestrians or vehicles as the shortest path for urban navigation. To-movement (integration) refers to the possibility of a street segment to be chosen as a desired destination for urban users (W. Hillier et al., 2012).

## 2.3 Theory of natural movement

The theory of natural movement is one of the basic notions developed in the late 1970s. According to this theory the way that people use a public space depends on its spatial configuration (Hillier & Hanson, 1984). The term natural movement describes the potential power of the street network to automatically attract urban users’ movement (Griffiths, 2014; Hiller, 1996). In an urban network people’s natural movement refers to “going-to” and “going-through” (Seamon, 2015, p. 24). According to Hiller (1996), in spatial configuration analysis those urban streets with a high value of integration have powerful potential to be chosen as a destination; and those with higher choice value will have powerful potential to be chosen as a desired route in people’s wayfinding behaviour.

# 3. Space syntax analysis of the study area

## 3.1 Evaluation of Spatial Configuration of the Main Station Areas in the Brisbane CBD

In order to examine the spatial configuration of Brisbane CBD’s station areas, the axial line map of the catchment area of each station was produced. According to a study done by Burke and Brown (2007), the appropriate distance for people to walk to the transit stops is 400 metres, albeit they will walk longer distances to a larger railway or busway station. Therefore, this paper has considered a catchment area of 400 metre for each station. To reduce the edge effect due to cutting, 400 meters is added to the initial radius (800 metre). The axial model of each station area is then recalculated by Depthmap to determine the global values of Integration and Choice As explained in section 2, space syntax technique is a graph based analysis; therefore, each catchment area has its own distinct spatial configuration characteristics.

Tables 1, 2 and 3 show the syntactic measures of each station/stop are compared to the frequency of passengers who used them as an origin.

**Table1: Summary of syntactic values and frequency of passengers for each busway station in the CBD and South Bank**

| **Bus Stations** | **To-movement** | **Through-movement** | **No. of passengers*** |
|---|---|---|---|
| King George Sq. | 1.12 | 0.66 | 195384 |
| Roma Street | 0.79 | 0.54 | 135510 |
| Queen St. | 1.08 | 0.9 | 226605 |
| Cultural Centre | 1.11 | 0.94 | 353137 |
| South Bank | 0.86 | 0.85 | 130693 |
| **Average** | 0.99 | 0.77 | 208265 |

*Number of passengers who used these stations as an origin

**Table 2: Summary of syntactic values and frequency of passengers for each railway station in the CBD and South Bank**

| **Train stations** | **To-movement** | **Through-movement** | **No. of passengers*** |
|---|---|---|---|
| Central | 1.03 | 0.63 | 755661 |
| Roma Street | 0.79 | 0.54 | 230196 |
| South Brisbane | 1.17 | 0.92 | 86285 |
| South Bank | 0.86 | 0.85 | 99625 |
| **Average** | 0.96 | 0.73 | 292941 |

*Number of passengers who used these stations as an origin

**Table 3: Summary of syntactic values and frequency of passengers for each ferry stop in the CBD and South Bank**

| **Ferry stops** | **To-movement** | **Through-movement** | **No. of passengers** |
|---|---|---|---|
| North Quay | 1.01 | 0.89 | 14465 |
| QUT | 0.64 | 0.85 | 12241 |
| Eagle street pier | 0.99 | 0.9 | 6989 |
| Riverside | 0.81 | 0.86 | 36049 |
| South Bank 1&2 | 0.91 | 0.84 | 17188 |
| **Average** | 0.87 | 0.67 | 17386 |

We also ran correlations of syntactic values of the catchment area of each station and its corresponding frequency of passengers who used that station as an origin.

The correlation between syntactical properties and transport ridership for busway stations is very strong. Therefore, the influence of space on transport ridership is as expected. However, the correlations regarding the railway stations and ferry stops is very weak or even negative (Table 4).

**Table 4: Correlations of syntactic values (to/through movement) of the street segment that each station is located on and its correspondence frequency of passengers who used that station as an origin.**

| Syntactic properties-Transport patronage correlation (R) | | |
|---|---|---|
| | **To-Movement** | **Through-movement** |
| **Busway stops** | 0.74 | 0.62 |
| **Railway stops** | 0.11 | -0.57 |
| **Ferry stops** | -0.02 | -0.03 |

# 4. Discussion

The applied contributions are significant also. The busway stations are in a single corridor serving only a part of the CBD and South Bank, where the density of activity particularly around the three central city stations is uniformly high, where the syntactical properties play a role and there is the opportunity for people to cross that system effectively. Urban planners can benefit from these results to locate transport stations on the most accessible street segments to encourage people to walk to the stations and use public transport. That major bus stations sit directly under the Queen Street Mall is helpful. However, the Central and Roma Street stations are a little away from the highest potential streets in the CBD. Roma Street station is especially isolated and out of the way, with a major park on its former rail yards disconnecting it from the north-west. Central station is lot further east and serves the majority of the CBD by itself until the arrival of the much awaiting Cross River Rail project. Syntactic properties may play a lesser role on the rail network's patronage because of this monopoly function Central station enjoys. Something similar may be apparent in the ferry services. Riverside is just dominant, because it is the only stop along the eastern side of the CBD for CityCat services. Eagle Street Pier by contrast only offers the lesser used CityHopper and Cross River Ferries at lower frequencies. QUT ferry stop services a reduced catchment and a different market dominated by students. These understandings may be helpful to policy makers as they consider the future of Brisbane's central public transport networks, particularly as employment shifts west and north beyond the CBD's limited peninsular.

Our work has limitations in that we have ignored many other factors that influence patronage and have only looked at a limited number of sites in one Australian city. But as a first series of one-way tests this approach and method offers pathways for further multivariate analysis, and opportunities to use similar methods elsewhere. The figures for the Cultural Centre busway station are also likely inflated by interchanges under the current busway operating model, which will be addressed when the system is converted under the proposed Brisbane Metro project. More advanced analysis is possible and the authors hope to move in that direction in the future.

# References

Al-Sayed, K., Turner, A., Hillier, B., Iida, S., & Penn, A. (2014). Space syntax methodology: Bartlett School of Architecture, UCL.

Bertonlini, L., & Spit, T. (1998). *Cities on Rails: The Development of Railway Stations and Their Surroundings*: E & FN Spon.

Bhat, C. R., & Singh, S. K. (2000). A comprehensive daily activity-travel generation model system for workers. *Transportation Research Part A: Policy and Practice, 34*(1), 1-22.

Burke, M., & Brown, A. (2007). Distances people walk for transport. *Road & Transport Research: A Journal of Australian and New Zealand Research and Practice, 16*(3), 16.

Choi, E. (2012). *Urban diversity and pedestrian behavior: Refining the concept of land-use mix for walkability.* Paper presented at the Eight International Space Syntax Symposium, Santiago de Chile, 3-6 January.

Duncan, M. J., Winkler, E., Sugiyama, T., Cerin, E., Leslie, E., & Owen, N. (2010). Relationships of land use mix with walking for transport: do land uses and geographical scale matter? *Journal of urban health, 87*(5), 782-795.

Dunphy, R., & Fisher, K. (1996). Transportation, congestion, and density: new insights. *Transportation Research Record: Journal of the Transportation Research Board*(1552), 89-96.

Griffiths, S. (2014). 14 space syntax as interdisciplinary urban design pedagogy. *Explorations in Urban Design: An Urban Design Research Primer*, 157.

Hiller, B. (1996). Space is the Machine: A configurational theory of architecture: Cambridge University Press, Cambridge, UK.

Hillier, B., & Hanson, J. (1984). *The social logic of space*: Cambridge university press.

Hillier, B., & Iida, S. (2005). *Network effects and psychological effects.* Paper presented at the 5th International Space Syntax Symposium, Delft.

Hillier, W., Yang, T., & Turner, A. (2012). Normalising least angle choice in Depthmap-and how it opens up new perspectives on the global and local analysis of city space. *Journal of Space syntax, 3*(2), 155-193.

Hillier, B. (2014). *Space syntax as a theory as well as a method.* Paper presented at the Porto, Portugal: 21st International Seminar on Urban Form-ISUF2014.

Jiang, B., & Claramunt, C. (2002). Integration of space syntax into GIS: new perspectives for urban morphology. *Transactions in GIS, 6*(3), 295-309.

Kubat, A. S., Özbil, A., Özer, Ö., & Ekinoğlu, H. (2012). *The effect of built space on way finding in urban environments: A study of the historical peninsula in Istanbul.* Paper presented at the Proceedings: Eighth International Space Syntax Symposium.

Levinson, H. S., & Wynn, F. H. (1963). Effects of density on urban transportation requirements. *Highway Research Record*(2).

Miller, H. J., & Shaw, S.-L. (2001). *Geographic information systems for transportation: principles and applications*: Oxford University Press on Demand.

Ozbil, A., Peponis, J., & Stone, B. (2011). Understanding the link between street connectivity, land use and pedestrian flows. *Urban Design International, 16*(2), 125-141.

Penn, A. (2003). Space syntax and spatial cognition: or why the axial line? *Environment and Behavior, 35*(1), 30-65.

Pushkarev, B., & Zupan, J. M. (1977). *Public transportation and land use policy*: Indiana Univ Pr.

Rashid, M., Boyle, D. K., & Crosser, M. (2014). Network of spaces and interaction-related behaviors in adult intensive care units. *Behavioral Sciences, 4*(4), 487-510.

Seamon, D. (2015). Understanding place holistically: Cities, synergistic relationality, and space syntax. *The Journal of Space Syntax, 6*(1), 19-33.

Xia, X. (2013). A Comparison Study on a Set of Space Syntax based Methods: Applying metric, topological and angular analysis to natural streets, axial lines and axial segments.