Vancouver, the transit-oriented city? The correspondence (or not) of public tran accessibility and urban intensification through the lens of accessibility tools

Jan Scheurer[1], Craig Townsend[2], Carey Curtis[3]

[1] RMIT University, Melbourne/Barcelona, jan.scheurer@rmit.edu.au; [2] Concordia University, Montreal, craig.townsend@concordia.ca; [3] Curtin University, Perth, c.curtis@curtin.edu.au

Abstract

Vancouver, Canada s third largest city, has often been held up as a best-pra transport and land use planning in a New World context. Accordingly, in the a Network Analysis for Multimodal Urban Transport Systems (SNAMUTS) tool to Australasia and North America, Vancouver scored top results on the majority of a public transit. But how does a successful big-picture outcome translate int relate to historic factors that predate Vancouver s focus on sustainability-o during the past quarter century? This paper will contrast the SNAMUTS result wi measuring public transit accessibility based on a time line spanning three dec history and the assessment of recent spatial priorities in land use and transp that despite high recent growth and intensification rates, much of Vancouver oriented urban form can be traced back to the city s light rail and streetcar 20th century, and that the spatial correlation of public transit service intensification over the past 30 years has been anything but consistent. We assessing the contributions of both methodologies towards a comprehensive repres accessibility in Vancouver, and will evaluate the magnitude of the shortfalls policy and practice across other cities in the SNAMUTS sample across the New Wor

Key words: public transit, accessibility measures, land use-transport integratio planning.

1. Introduction

In the 1960s citizens of Vancouver protested against government plans for freewa downtown. They opposed the destructive impacts that freeway construction would city neighbourhoods, the modernist plans for post-freeway urban renewal, a congestion and pollution of more cars in the metropolitan core (Lash, 1976; P organised opposition, together with a lack of government funding and mounting e associated with automobile dependence, led to cancellation of the plans. A government authority then recommended an extensive rail rapid transit system t strong core and transit-oriented land development concentrated in regional t 1976). In 1986 metropolitan Vancouver s first SkyTrain line began operations, a land surrounding stations and an overall restructuring of urban form were well SkyTrain line was followed by an inter-city regional commuter rail line in 1995, in 2002, and a light metro line in 2009. The policy transition saw a new tra focussed on accommodating growth in urban movement on the existing road system alternatives to the automobile (Price, 2012). Despite some to-and-fro over both such policies between municipal and provincial governments, this compact pr resilient over a forty-year period (Filion and Kramer, 2012; Stone, 2013).

Today a wide range of scholars describe Vancouver as an exemplar of effective strong sustainability overtones (Punter, 2003; Berelowitz, 2005; Schiller, Bruun Legacy, 2012). These achievements relate to successes in metropolitan growth ma on urban intensification, the integration of expanding public transport infras fabric, people-friendly and environmentally adapted urban design outcomes, and inclusive culture of decision making. The development of the public transport consolidation in recent years, accompanied by an annual population growth rate Vancouver region, has seen public transport become a more prominent element of 356 million passenger journeys in 2011, a rate of 154 per capita (Translink considerably lower than in many European cities, but appears to have entered Vancouver s larger Canadian counterparts Montreal and Toronto. It outperform Australasian and US cities with the likely sole exception of New York City (2013). The rate of increase of public transport usage has also outpaced populat from 118 trips per capita in 1996 (Kenworthy and Laube, 2001) to 134 in 2006 (Sc

The remarkable transformation of transportation and land use in Vancouver recognized both locally and globally, but there has been little quantification paper is concerned with measuring two elements of the transformation. First, c distribution and intensity of metropolitan Vancouver s overall transit suppl during which rail rapid transit was expanded. We query whether changes to corresponded with expected spatial effects of rail rapid transit: in particular service immediately surrounding railway stations, coupled with declines in are lines. Further, we examine to what extent the actual locations of transit serv areas identified as regional town centres in metropolitan land use plans. Seco urban form and transport network and its influence on the evolution of spatial transport in the Vancouver region. Our interest is whether the city-region s u transport integration can be regarded as a dominant factor in attracting ride something exceptional about the configuration and service levels on the public whether and to what extent both influences work in unison. To assist this exa Vancouver to a sample of other New World cities experiencing urbanisation and t decisions during the same era, consisting of the six largest Australasian Vancouver s Pacific neighbours, Seattle and Portland.

2. Background: Vancouver s Transport Planning Legacy

In a comparison of Vancouver with his native Melbourne, Mees (2007) highlig Vancouver bucked a nationwide trend of increasing urban travel times during the 2005. It was the only metropolitan area to record a three-minute drop in t workplace commute against an average nine-minute increase across Canada. Fro longest average commuting times among Canada s six largest metropolitan areas fell into third place behind Toronto and Montreal by 2005 (Statistics Canada, this position in the 2011 National Household Survey (NHS, Statistics Canada, 2 was accompanied by a growing public transport mode share (19.7% of all journey (ibid)). It was achieved in the absence of major infrastructure projects to ex these two reasons Mees (2007), and later Stone (2013), likened it to the hol successful, simultaneous pursuit of greater self-containment and reduced car dep

Among the factors that, in Mees (2007) view, contributed to this great Vancouver are the coordination of metropolitan-wide land use and transport pl culture informed by genuine participatory elements and analytical rigour, the zoning system to facilitate residential intensification in desired locations, a and regional governments in the planning and operation of public transport.

planning and transport administration was consolidated at a metro-regional sc
planning agency Greater Vancouver Regional District (GVRD) established in 1967.
strong focus to inward growth, partially enforced by the city s constraine
mountain ranges and coastlines, partially by controls on outer suburban growth
and planning approval regimes to facilitate urban intensification. The focus
integration saw a rapid transit system (SkyTrain) reintroduced to Vancouver in
1980s. It was conceptualised to rely on feeder bus services and land use intens
in order to build its patronage, rather than on patronage drawn from park-and-r
comparable New World cities). The SkyTrain system is integrated with buses and
form a grid-shaped network across the core city of Vancouver, and to some exten
al, 2010).

Planning strategies developed a strong focus on land use-transport integrati
GVRD coordinated the release of a metropolitan strategy (Livable Region Strat
1999) and a transport strategy (Transport 2021, GVRD, 1993) designed to rei
Infrastructure priorities and transport management principles in the transport
the objectives of urban containment. Transit orientation was spelled out in the
the extent that the GVRD expressly rejected road projects proposed by the prov
incompatible with the strategies goals. Both strategies are based on the resu
There is detail on the roles and responsibilities of various stakeholders in t
plans proposals. There is an absence of attempts to avoid accountability by
planning objectives (which can be misinterpreted) or by obfuscating the asso

An influx of one million additional residents during the three decades from 199
Housing these people was to be primarily through residential intensification. A
this was a discretionary zoning system in which local governments have the fin
and character of high-density development. The role of dispute resolution throu
minimised. Consequently municipalities successfully use this lever to dir
commercial intensification into transit-accessible precincts while enforcing
outcomes, and prevent their leakage into locations with inadequate infrastru

Public transport in Greater Vancouver is the responsibility of a regional agenc
has responsibility for road infrastructure. Unlike the experience of Australia
2012) this is an exceptional and well-resourced multi-modal integration of tran
service planning that has made a critical contribution to enabling the public t
up with population growth as well as the transit-oriented objectives of the reg

3. Methods

3.1 Transit coverage over time

This study of Vancouver s public transit service coverage, measured in freque
unit, was undertaken in three main stages. The first stage involved the acquis
bus routes and timetables obtained in paper format for the years 1981, 19
downloaded from the transit operator s website for the year 2011. The challeng
allows for the comparison of change over time. If relatively large spatial unit
over time were used to quantify service change, expected small scale changes s
routes in favour of a larger and faster train, would be missed. While Vancouve
ferry stations, route and timetable information are all now available in elect
and schedules existed only on paper, in the timetables or the paper archives o
time line was commenced in 1981 because there was a full set of timetables, it

a few years before the first rail rapid transit line began operations. In additi
compiled, so that there were 10 year intervals.

Representations of the catchment areas of identified service levels were drawn
km) grid covering the metropolitan area. A grid cell was allocated with a part
whenever it came into contact with the 300-metre linear buffer of the associat
radius of the associated semi-rapid bus stop or 700-metre radius of the associa
ferry terminal. Buffers and station/stop radii are based on Euclidean distanc
average frequency values were calculated for the three steps between the years 1
and 2001-2011 using ArcView. These three figures were then added to produce a c
change over the 1981-2011 period.

3.2 Spatial accessibility

An accessibility instrument, Spatial Network Analysis for Multimodal Urban T
(SNAMUTS), was utilised to assess the interplay of land use patterns and publi
from a variety of angles. This instrument is used to measure a number of differ

- the operational input provided for public transport services relative to po
- the ease of movement these generate between centres of activity,
- the reliance of the network on transfers,
- the percentage of residents and jobs with walking-distance to public tra standard,
- the ability of users to access metropolitan activities within a fixed trave
- the potential spatial flow of travel opportunities across the components of
- the potential resilience of the network and its elements to absorb further
- the flexibility of users to navigate themselves through the city on publi friction losses from excessive waits or poor legibility.

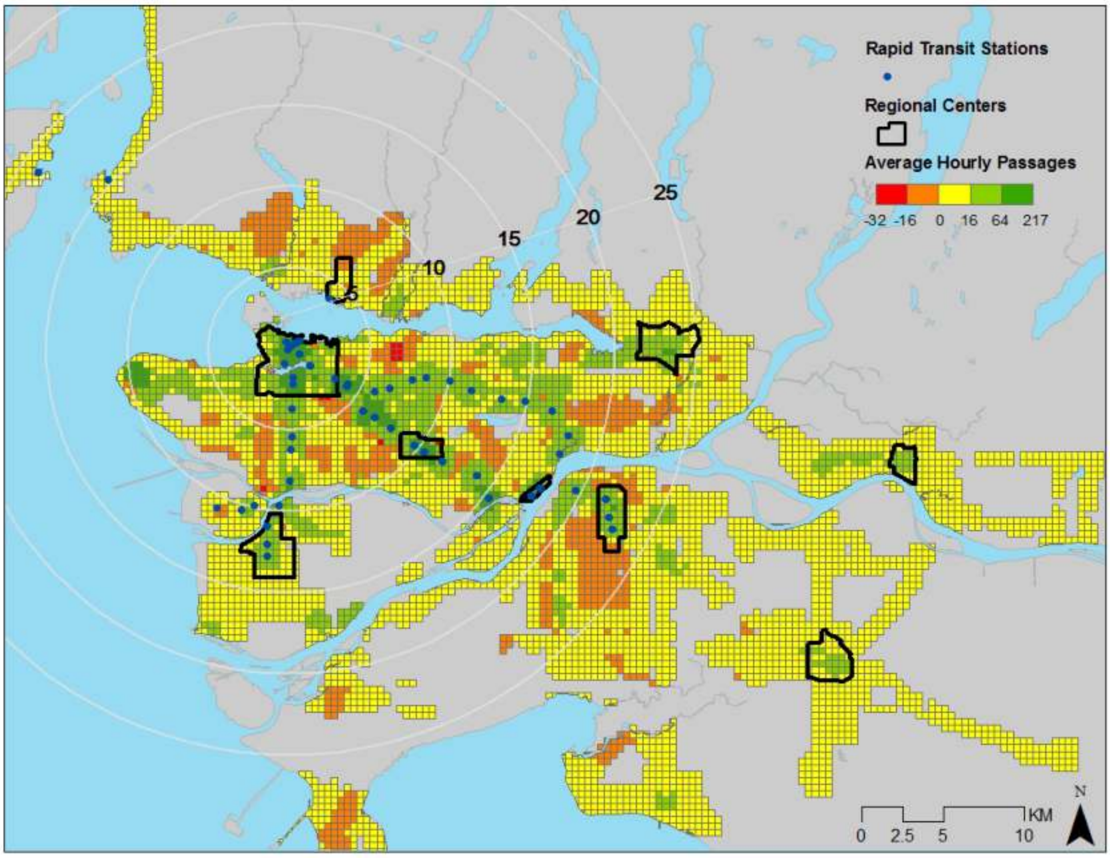
These factors are cast into a set of eight accessibility indicators. Space
preclude a full description of each index including the formulas used for their
find this in Curtis and Scheurer (2010), Curtis and Scheurer (forthcoming) and www.snamuts.com
The analysis is applied to the public transport network as a whole and to a coh
centres across Greater Vancouver. The network and centres were developed by dra
public transport timetables and a field visit to confirm activity centres. The
to those gained from nine other New World cities in Quebec, the US, Australia ar

4. Results: Changes in Transit Supply over Time

At a regional scale, transit service frequency increased substantially between
distinct nodes of extremely high increases in transit frequency increase stand
metropolitan core is prominent in the regional plans as well as the transit fre
the eight designated regional town centres (Metrotown and New Westminster) appe
are an additional five nodes (UBC, Broadway-Commercial Drive station, Joyce S
Station, 22nd Street Station) that appear as significant nodes of transit frequenc
designated regional town centres do not appear. If the threshold for service
lowered, two additional regional town centres (Coquitlam and Surrey) appear a
lower level municipal town centres identified in regional plan also appear
they have barely an increase over that found along some transit-rich corridor
increases associated with rapid transit have not corresponded exactly with plans
nodes or centres/sub-centres, corridors are an important spatial descriptor.

Measured in terms of service intensity, there were areas with gains and areas w
year period. However, the magnitude of gains in intensity of service in a range
per hour (increases of between 1.9 and 3.6 passages per minute) were not matched
decrease in any part of the metropolitan area. In other words, some places rea
service that was higher than any corresponding decline.

Map 1: Cumulative change in transit frequency, 1981-2011



The distribution of losses was distributed proportionately equally throughout th
brackets based on CBD radii in multiples of 5 kilometres. The greatest gains we
core (defined as an area within a 5 km radius of a central point in the CBD).
decline were found adjacent to rail rapid transit in this metropolitan core:
transit service was restructured following the introduction of rail rapid transi

Transit service decreases occurred in some areas adjacent to areas of increase,
rail rapid transit leads to consolidation. The higher level of public transit i
transit, or in one case semi-rapid buses and in another case semi-rapid bus
However, this is not true for all station locations. What made the differenc
presence of connecting bus routes and urban density (residences and/or jobs) i
change. Interestingly, in such a scenario the pattern of sub-centre formatio
different from that planned. It suggests a positive correlation of service incre
CBD and with location relative to prior railway technology (trolleys and li
Vancouver s growth during the first half of the 20th century). In those places, game-changing ga

transit service levels were made, while in outlying areas which were develo relatively marginal increases are typical.

5. Results: Transit Accessibility in the Vancouver Region

5.1 Service intensity

The accessibility tool (SNAMUTS) sets a minimum standard for inclusion of public It uses the weekday inter-peak public transport network and stipulates a m frequency on surface routes and a minimum 30-minute frequency on segregated rai The rationale for this is that this comes closest to serving the daily acti traveller who compares a public transport journey with one by car. The service 1) captures the number of public transport vehicles or train sets in simultaneou minimum standard. The figures shown are in relation to metropolitan population.

Table 1: Public transport service intensity in Vancouver and nine other New World ci number of vehicles/train sets in simultaneous revenue service during the weekday inter- minimum service standard, and relative to metropolitan population.

2011 12	Number services	Services 100,000
Vanc	448	19.3
Adelaide	223	18.1
Sydney	654	14.9
Melbourne	536	13.4
Perth	218	12.6
Brisbane	233	11.6
Montreal	399	10.4
Portland	168	10.2
Seattle	271	10.2
Auckland	135	9.2

The index is influenced by the propensity of public agencies to put resources operation and offers a proxy for the priority with which public transport is t funding with other public tasks. These figures also reflect an efficiency chara a large number of small and/or slow-moving vehicles as part of the public tran buses running in traffic in congested conditions), service intensity figures significant number of services are offered through large and fast vehicles (suc alignments) service intensity figures are reduced.

In Vancouver, there is a more pronounced role for buses and trolley buses in th example, in Montreal (which has only a handful of bus services entering the CBD of the difference in service intensity results between the two Canadian Vancouver s bus network expansion and average service frequencies are also su every other city in the comparison, including Adelaide which is only marginally the overall result, but suffers from a far greater degree of bus congestion in t

5.2 Ease of movement (closeness centrality) and transfer reliance (degree cen

The closeness centrality index (Table 2) comes closest to a traditional measu since it only depicts the accessibility of the transport network; it does not t (or land use). The index measures travel impediment as experienced by users mov transport network. In addition to measuring travel time, it includes service important to public transport travellers. Cumulative impediment scores per jou impediment value on each route segment traversed. The node-based figures in M average, non-weighted travel impediment (closeness centrality) between the ref other nodes in the network, selecting the route with the lowest cumulative imp case. Lower values indicate greater ease of movement.

The degree centrality index (Table 2) measures the reliance of the network on tr transport services on different routes to make journeys on the network. The fi refer to the average, non-weighted minimum number of transfers required between and all other nodes on the network. Lower values indicate lower transfer relianc

Table 2: Average, lowest (best) and highest (poorest) SNAMUTS closeness centrality and centrality results in Vancouver and nine other New World cities.

2011 12	Closeness cent (average)	Closeness cent (lowest valu	Closeness cent (highest val	Degree centr (average)
Vancouver	42.1	25.0	162.1	1.13
Montreal	47.1	28.1	130.1	1.38
Portland	57.4	34.6	171.5	0.79
Auckland	59.0	33.5	133.2	0.95
Perth	59.3	35.2	130.9	1.03
Adelaide	61.1	33.8	147.3	1.09
Melbourne	62.3	36.0	165.2	0.91
Brisbane	64.1	35.1	187.6	0.91
Seattle	64.3	36.4	149.6	1.07
Sydney	81.5	46.4	281.5	1.04

On the ease-of-movement index, Vancouver (alongside Montreal) significantly ou World peers. This measure is influenced by the spacing of the activity centre urban compactness as well as average speeds and service frequencies of the that link these centres. Missing links and a convoluted urban geography e away from desire lines, in contrast, will negatively impact closeness results.

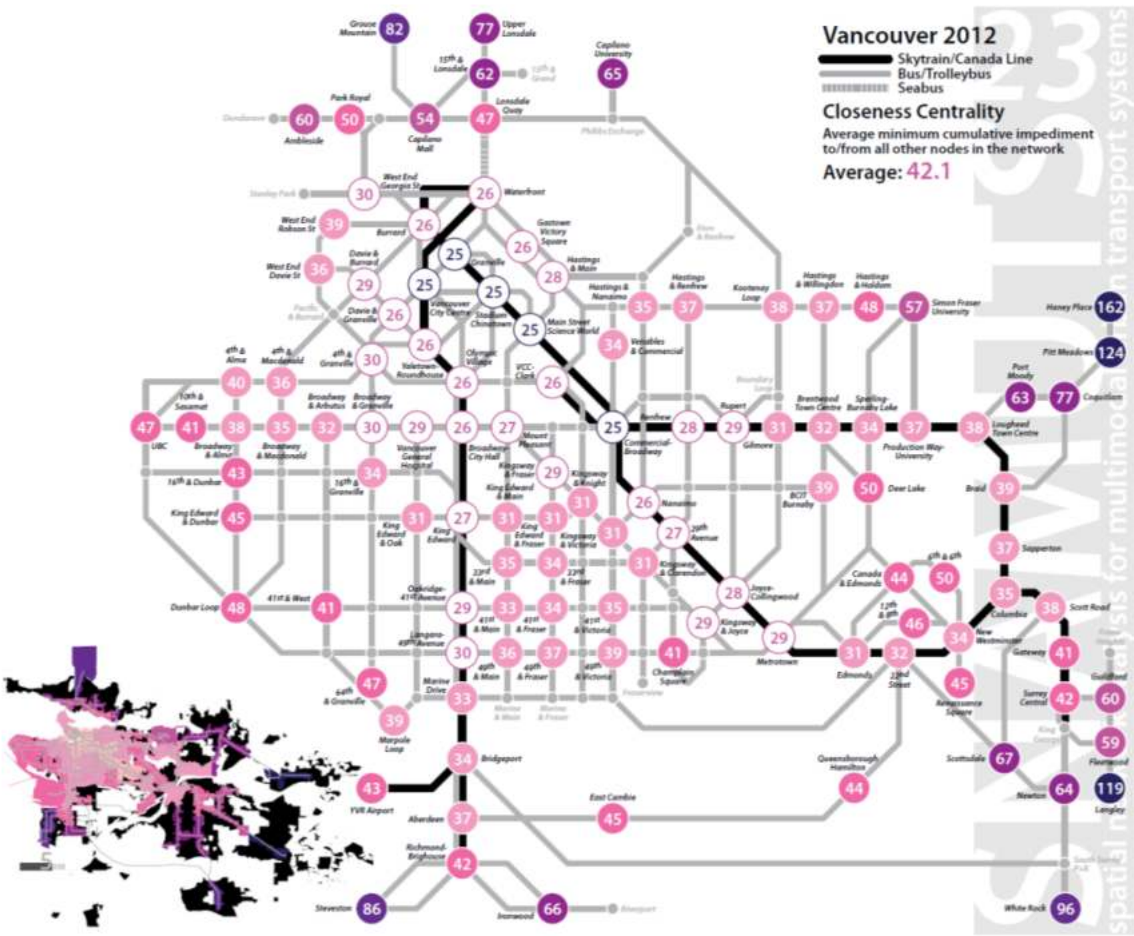
Vancouver s exceptional performance on this index can be associated with the c the SkyTrain system as the network s backbone: its high commercial speeds separation) and high frequencies, generally of five minutes or better (facilit operation, which reduces the marginal cost of additional services), minimise tr its routes. Map 2 shows how the best closeness values in Vancouver follow th Montreal s metro system, though not driverless, shares similar characteristics In contrast, the heavy rail systems of the Australasian cities and Portland s l have daytime service frequencies of fifteen minutes at best.

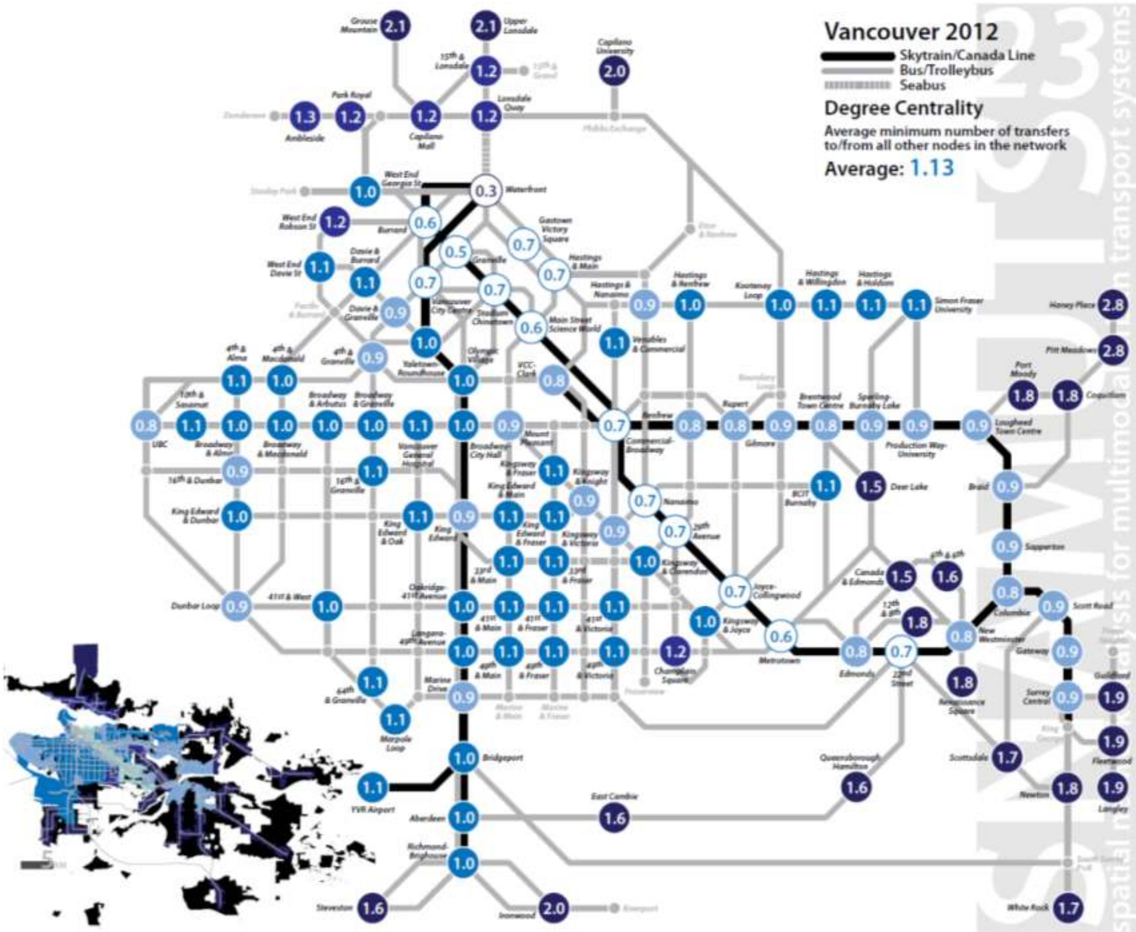
Another contributing factor for Vancouver s relative ease of movement on public
grid-shaped surface network, made up of buses and trolley buses also operated
than in most comparison cities. This can be seen in the relatively smooth deca
across most of the Burrard peninsula where the density of the surface network is

Vancouver s constrained geography appears to assist, rather than obstruct,
effectively containing a significant part of the urbanised area on a relatively
in contrast to Sydney, Seattle and Auckland, where water bodies act as segregat
of the metropolis which public transport, as well as the road system, struggle t

Vancouver and Montreal have the highest reliance on transfers in the New World
both, there is a hierarchical network design which designates the (limited) ra
backbone corridors and the (more widespread) bus networks as feeders and distr
however, retains a greater role for surface modes in the city centre and thus
number of transfer-free connections between CBD and suburban nodes than its Qu
(see Map 3). The most transfer-dependent nodes in the Vancouver region ar
municipalities to the north, east and south where bus routes act more as class
than as connectors along corridors that extend across several local government a

Map 2: Closeness centrality in Vancouver s public transport network in 2012
Map 3: Degree centrality in Vancouver s public transport network in 2012





5.3 Network coverage and contour catchments

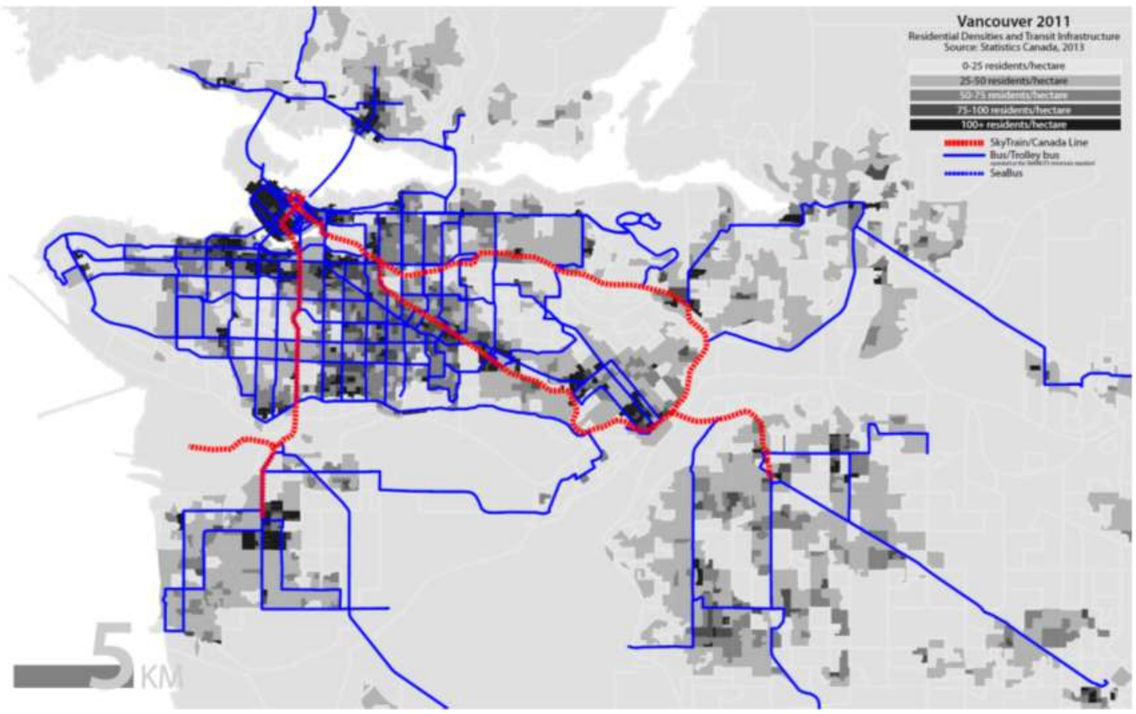
These two measures introduce a land use component to the transport assessmen
Network coverage (Table 3) measures the percentage of metropolitan residents
walking distance (roughly 800 metres around rail stations and ferry terminals,
bus and tram corridors) of public transport routes that meet the minimum ser
measure provides an answer to the question who gets access? It is an indicat
city as a whole is by public transport. The ideal result would be 100%. Conto
measures the percentage of metropolitan residents and jobs that can be reache
node by way of a 30-minute public transport journey with a maximum of one tran
indicate larger contours. This measure is more usefully considered for each cen
used diagnostically to explore how well served are activity centres that dr
population (such as a university or main hospital).

Table 3: Network coverage and average 30-minute contour catchments in Vancouver and nine
World cities.

2011 12	Network coverage (percentage of met residents and j	Average 30 min contour (percentage of metrop residents and jobs
Vancouver	61.4%	19.5%
Sydney	54.6%	8.3%
Montreal	49.3%	15.0%
Adelaide	48.8%	10.7%
Melbourne	46.8%	9.3%
Portland	41.7%	10.5%
Perth	41.4%	10.6%
Brisbane	37.5%	10.6%
Seattle	35.2%	8.4%
Auckland	32.8%	10.2%

Network coverage can be read as a proxy indicator for the willingness of public bring a good level of service to as large a share of the population as possible in competition with the deployment of operational resources on those corrido potential for ridership growth (Walker, 2012). Hence, good results on this in compact urban form which makes it easier to allocate limited resources to a residential and employment areas.

Map 4: Relationship between residential density and movement lines of public transport i

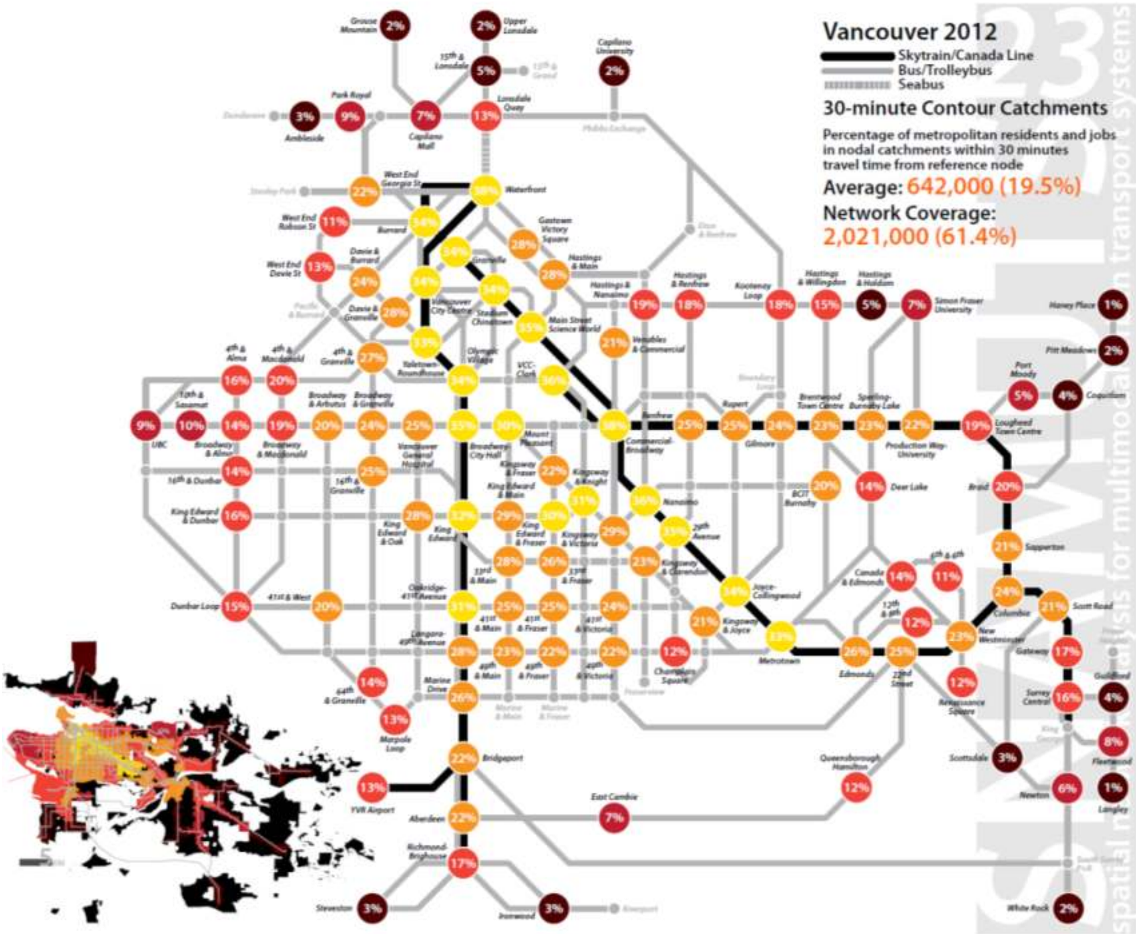


Vancouver s network coverage is greater than that of any other New World city
an achievement associated with the core city s dense surface network that cove
within walking distance at the minimum standard. In suburban areas, public trans
corridor-based though, unlike in Montreal, these corridors serve all significa
metropolitan area. While Greater Vancouver, like every other city in the New
significant share of low-density, dispersed suburban development, the physi
waterfronts, mountain ranges, an area of protected farmland and the Canadian-U
limit the spread of this urban form to the foothills in North and West Vancouv
fringe of the metropolitan area.

Vancouver also leads the cohort of New World cities on the average 30-minute c
result associated with several factors that work in favour of successful land
The speed and frequency of the rail system in conjunction with the relativel
expansion of the bus and trolleybus system continues to exert an influence her
geographical size of contour lines. In addition, it is likely that Vancouve
relatively effective policy to concentrate urban intensification programs into
transit-oriented locations is succeeding by agglomerating urban growth around t
public transport, thus also increasing the density of origins and destinatio
contour line (Filion and Kramer, 2012; see also Map 4). Vancouver beats Montrea
city which benefits from a larger heritage of older and traditionally denser ur
Columbian counterpart, but arguably has a weaker policy to facilitate further
around transit (Filion and Kramer, 2012).

Map 5 illustrates the importance of the SkyTrain corridors as well as the d
connecting them especially in the south-east of the core city (Main Street, Fra
corridors) to maximise the expansion of contour catchments for a broad range of

Map 5: 30-minute contour catchments in Vancouver s public transport network in 2012



5.4 Spatial distribution of travel opportunities (betweenness centrality)

This index visualises how potential preferred travel paths (those that offer t while also considering transfers and service frequencies) between any pair of weighted by catchment size and travel impediment, are distributed across the ne which routes and nodes potentially attract the most through-put from travel oppo the land use-transport system as a whole? Higher values indicate greater network

The concept of betweenness centrality has several sub-measures. Nodal betweene betweenness describe the number of potential travel opportunities attracted t route segment (Map 6). Global betweenness (Table 4) is a measure adding the (number of activities connected divided by the travel impediment that separates nodes on the network, extracts the square root of this sum per node and then e proportion to the total number of metropolitan residents and jobs. It is used t level of presence of public transport movement opportunities for trip mak typical path length measure (Table 4) is a proxy for the percentage of metropol located alongside a public transport journey of average length; it is influence land use activities around public transport nodes on the one hand (with higher the figures), and by the configuration of the network to facilitate travel al journey path (with greater encouragement for passengers to take detours in order higher-frequency services also inflating the figures).

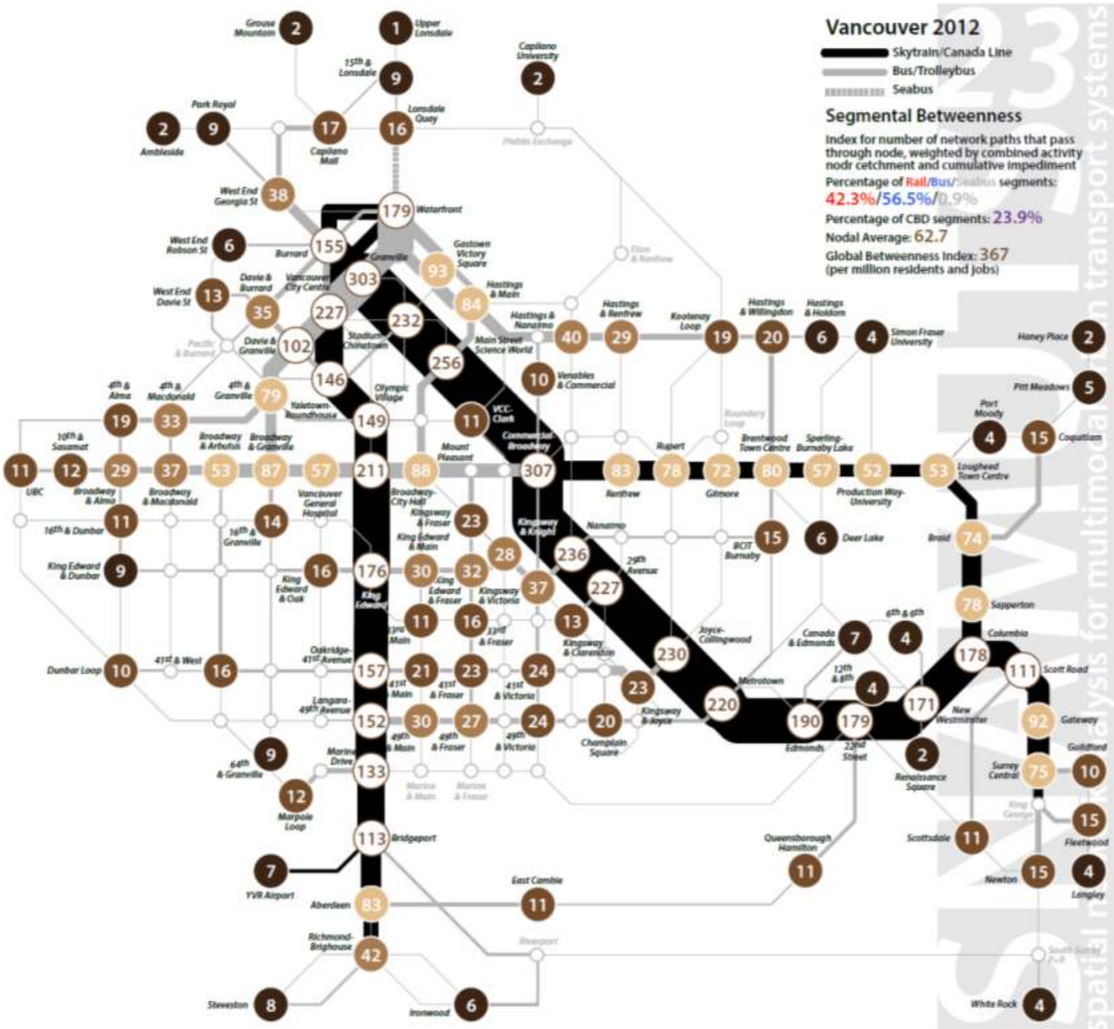
Table 4: Global and nodal betweenness centrality, and catchment of typical path length
nine other New World cities.

2011 12	Relative glo betweenness i	Average nodal between	Catchment o typical path
Vancouver	367	62.7	3.22%
Adelaide	289	24.4	2.36%
Montreal	274	77.6	2.51%
Perth	249	30.9	2.06%
Auckland	239	30.5	2.17%
Portland	230	35.3	2.67%
Brisbane	227	33.6	1.93%
Seattle	201	34.0	1.54%
Sydney	198	40.5	1.80%
Melbourne	175	33.1	1.55%

On the relative global betweenness measure, Vancouver significantly outperforms the New World sample, indicating a public transport system richer in travel op ranked nodal betweenness figures, however, which place the British Columbian c so Montreal) much higher compared to the relatively even field of the Australas point to some problems. They can primarily be attributed to the performance g dominant modes operating in both cities heavy rail and buses which is elsewhere due to the SkyTrain s (and Montreal s metro s) high service freq speeds. In combination with the easier legibility of both cities still quite characteristics have the potential effect of attracting passengers to ra geographically direct connections may be available on the bus network. Vancouver for example, includes a big loop enclosing the core city s south eastern subur neighbouring Burnaby. A number of bus routes cut through this area in relativel circuitous SkyTrain trip will get most passengers to their destination faster th travel opportunities are then counted at every rail station along their geogra and together drive up average nodal betweenness results. The same observation f average catchment of typical path length measure, on which Vancouver also lead considerable margin. It responds to common geographical detours making average and traversing a greater number of intermediate centres than strictly necess effects may be of great disbenefit to the user per se, the potential concentra limited number of high-performance corridors away from their desire lines congestion, as well as higher than necessary energy use per passenger. This is to the public transport planner wary of the system s overall efficiency.

Map 6 shows the extraordinary concentration of potential travel opportunities SkyTrain and Canada Line corridors, complemented by only a limited number of st chiefly along Broadway, Granville Street, Main Street and Hastings Street.

Map 6: Betweenness centrality in Vancouver s public transport network in 2012



The segmental betweenness index can also be queried in terms of the percentage travel opportunities attracted to congestion-prone areas such as the CBD, and peak performers in terms of passenger capacity and competitiveness to the speed and amenity. Table 5 shows the rankings of the New World cities – the h greater the share of travel opportunities captured by rail modes or within the C

Table 5: Percentage of metropolitan-wide segmental betweenness values on segrega modes, and in the CBD area, in Vancouver and nine other New World cities.

2011 12	Segmental between (all rapid rai
Sydney	57.9%
Melbourne	52.2%
Montreal	50.1%
Portland	49.9%
Perth	46.5%

2011 12	Segmental between (CBD area)
Vancouver	23.9%
Portland	27.9%
Montreal	30.3%
Brisbane	31.8%
Sydney	32.2%

2011 12	Segmental between (all rapid rai
Vancouver	42.5%
Brisbane	35.7%
Adelaide	21.3%
Auckland	15.2%
Seattle	8.8%

2011 12	Segmental between (CBD area)
Melbourne	32.7%
Auckland	35.4%
Perth	40.0%
Seattle	42.8%
Adelaide	62.0%

Despite the aforementioned potential sponge effect of high-performance rail of travel opportunities over the network, Vancouver s overall rail share on slightly below that of New World cities where heavy or light rail systems were the backbone of public transport in recent decades (Montreal, Portland and Vancouver s SkyTrain network arguably lacks the maturity of Montreal s metro 20 years earlier) or Perth s suburban rail system which, like Sydney s and Me lines that have been continuously operated as commuter rail services for a cer extensions currently under way, such as the Evergreen Line extension to Port M (under construction) and the proposed Broadway corridor along the spine of should lift Vancouver s share of travel opportunities on rail modes, and thus time-competitive public transport for choice travellers, towards (or even beyond

Of all the ten New World SNAMUTS cities, Vancouver has the lowest concentrati travel opportunities in the CBD area, despite the city centre s relatively hi transport routes. This measure, which one would usually expect to drop with gro regarded in the context of the relatively peripheral location of Vancouver geographical heart of the regional settlement area, a circumstance that also Moreover, it is indicative of a network configuration that succeeds in deflect away from the CBD area by offering an array of strong orbital connections, and developed in Vancouver than in any of the other cities in the sample. The advan is the ability of public transport to penetrate into markets other than classic and thus provide viable travel alternatives to a larger share of everyday transp

5.5 Network resilience

This index extracts a ratio between the betweenness index and the actual carryi each component of the network, determined by the service frequency and the me size). It is designed to assist in differentiating network elements by their increases in patronage derived from further urban growth or improvements in pu share. The index follows a scale from a positive value of 30 to open-ended negat figures indicating greater potential stress or lower resilience. Individual r invite closer scrutiny whether they constitute a cause for concern.

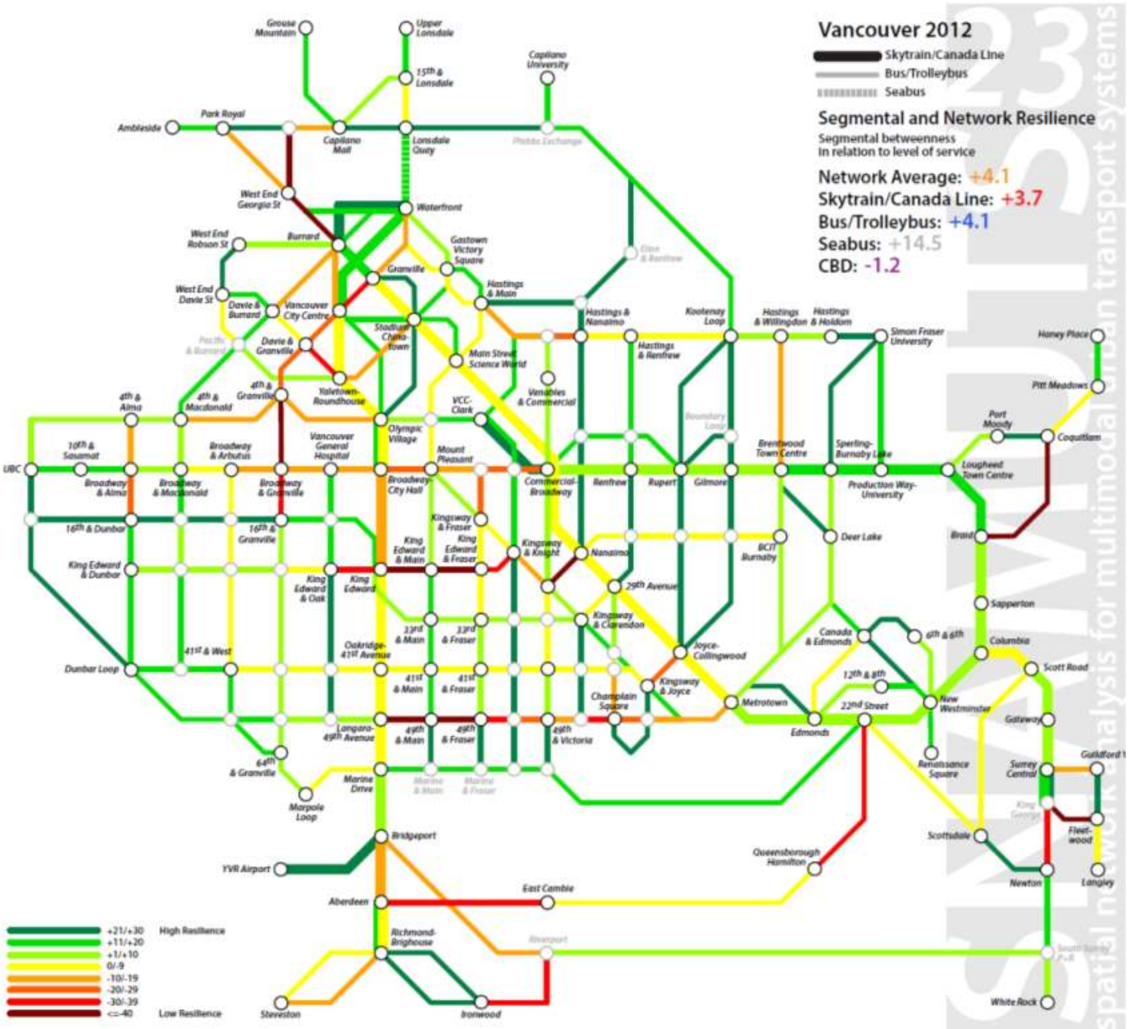
Table 6: Network resilience (segmental congestion index) in Vancouver and ni
World cities.

2011 12	Average network resil
Perth	+11.4
Adelaide	+9.1
Melbourne	+7.6
Auckland	+6.2
Brisbane	+5.6
Portland	+5.6
Vancouver	+4.1
Sydney	+2.4
Seattle	+2.1
Montreal	0.9

Network resilience figures are influenced by the operational input provided (concentration of land uses around public transport relative to levels of servi network to offer several alternative routes for as many origin-destination pa helps distribute the transport task). In the real world, low resilience can t overcrowding of services or into a form of latent or suppressed demand for publi

Vancouver s average network resilience is lower than that of any Australasian is also inferior to Portland; in turn, it is greater than that of Seattle an performance of the Quebec and Washington metropolitan areas on this index can l to their comparatively low level of service intensity (see above), the same is Rather, stress appears to be mounting in three key areas (Map 7). First, there a corridors in outer suburbs such as Port Moody/Coquitlam and Surrey/Langley wher (SkyTrain extensions or light rail) are under way or proposed. Second, there ar trunk lines which experience pressures from the aforementioned sponge effect as well as their design for relatively short train and platform lengths. Third bus corridors in the core city that may not currently meet the potential for movement opportunities that their position in the land use-transport system woul Broadway corridor, this also seems to hold true for KingAEdwardwAiehueuand 49th parallel to Broadway but further south and at a greater distance from the CBD these resilience gaps can manifest as an inability of the public transport passenger growth of the magnitude experienced during the last decade, unless n expansion continue at a rapid pace.

Map 7: Network resilience in Vancouver s public transport network in 2012



5.6 Flexibility of movement (nodal connectivity)

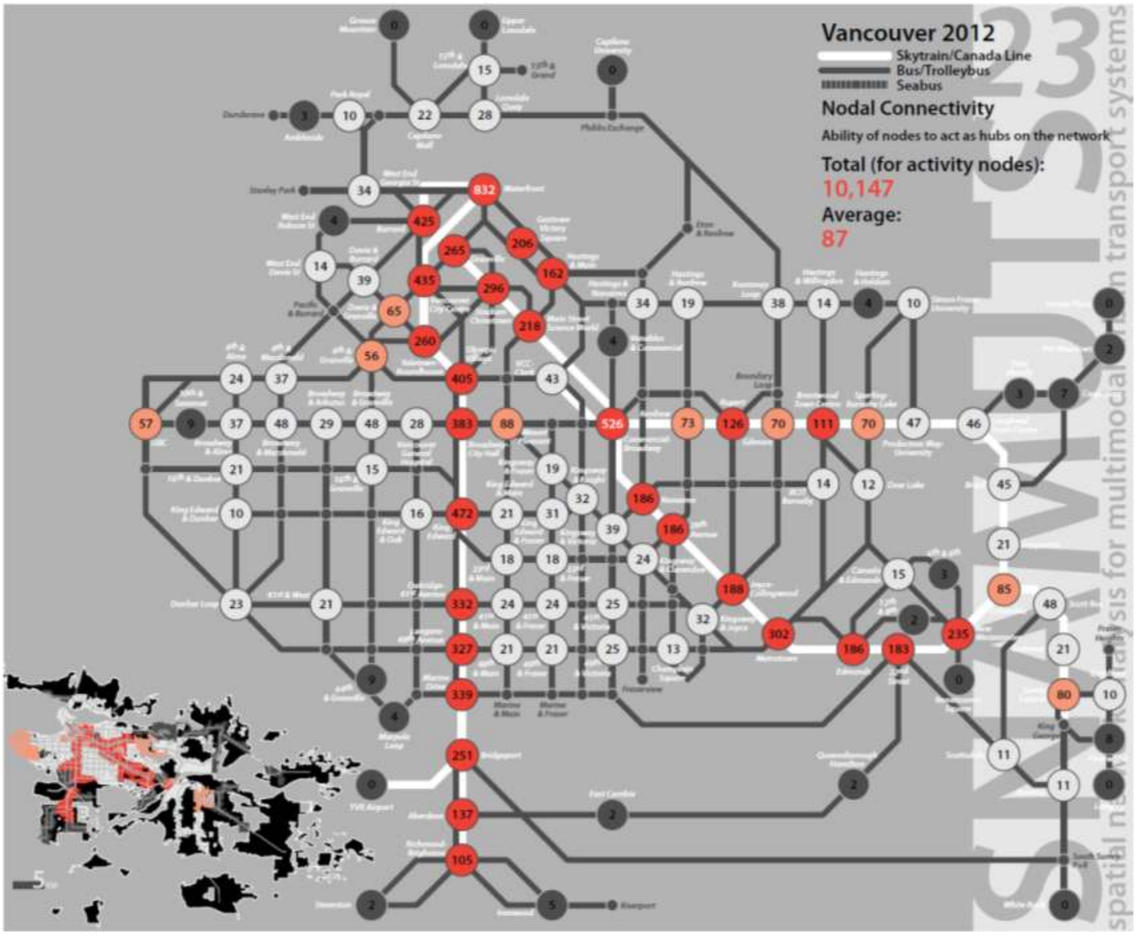
This measure captures the flexibility of users to incorporate particular locatio without having to rely excessively on timetable consultation or other forms of composed of the number of links converging in each node as well as the averag transport mode(s) provided on each link. It is thus designed to assess the suit to enable go anytime, anywhere mobility across the urban structure. It car indicator of the suitability of particular locations for land use intensificat better connectivity, and a node with a result in excess of 100 can generally be perceived as easy to reach on public transport by both trip makers and property

Table 7: Nodal connectivity in Vancouver and nine other New World cities.

2011 12	Nodal connect (average)
Vancouver	87
Melbourne	82
Sydney	77
Montreal	52
Brisbane	42
Seattle	26
Portland	26
Perth	19
Auckland	13
Adelaide	12

Nodal connectivity results are influenced by the frequency and utilisation of p as well as the configuration of the network: the more multi-modal transf opportunities to travel in a range of directions there are, the higher the nodal illustrates that all but two nodes with a count on this index higher than the r are located along the SkyTrain network, highlighting the importance of this inf land use-transport integration in Vancouver. The very high scores along the Car are supportive of the proactive plan for land use intensification along the C Vancouver, 2011). Vancouver leads the sample on this index (Table 7), even th can be expected to drop with declining city size and hence, network comple underscores the relative success of transit-oriented development strategies in unplanned passenger movement between a many centres along Vancouver s key urb most other New World cities of Vancouver s population size or smaller, re scores (100 or above) are confined to the respective CBD areas.

Map 8: Nodal connectivity in Vancouver s public transport network in 2012



5.7 Composite accessibility index

The composite index is designed to provide a benchmark measure. It is derived several individual indicators (closeness centrality, degree centrality, aver catchment, nodal betweenness, nodal connectivity and resilience) weighed by a c of the absolute presence of travel opportunities (global betweenness) in rel population and employment, and network coverage in relation to network res geographical congruity of the network. A high score in the composite index ind integration of land use and public transport is strong, and a score in excess o node in the highest (dark green) colour bracket on Map 9.

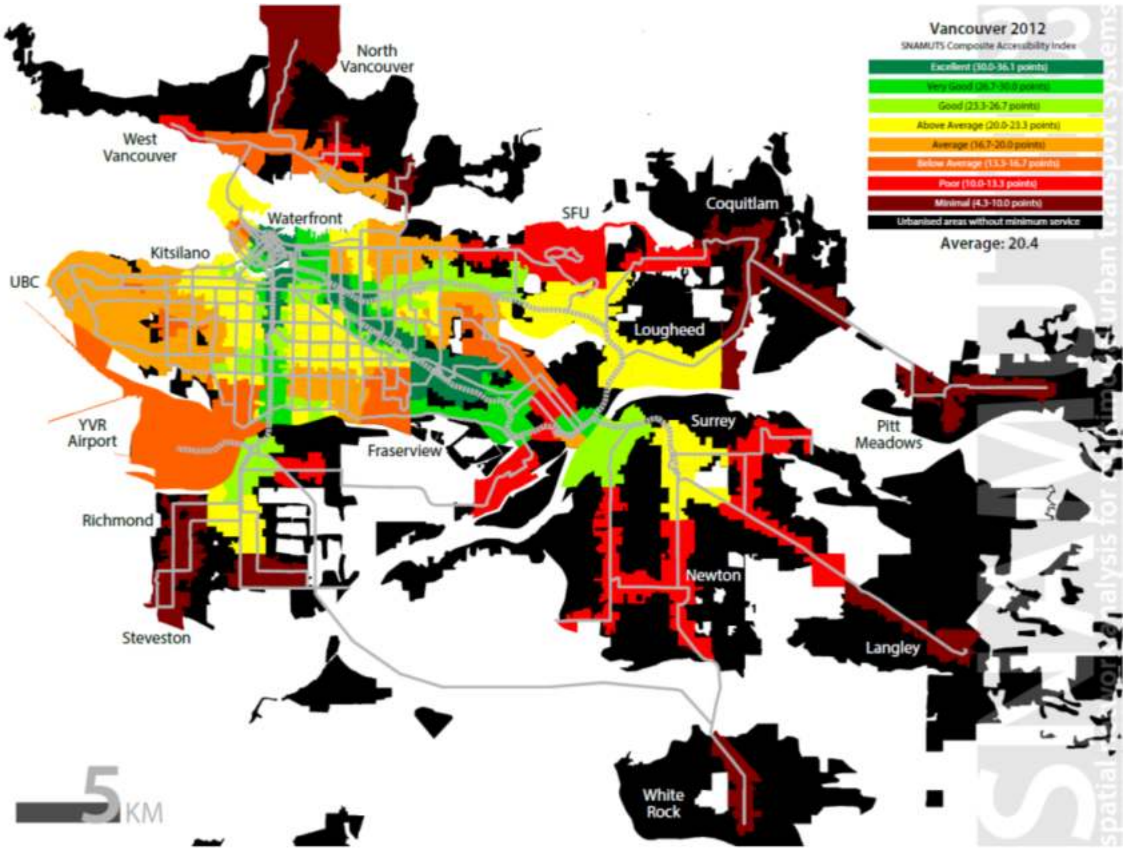
Table 8: SNAMUTS benchmark composite accessibility index in Vancouver and nine other cities.

2011 12	Benchmark compos (average)
Vancouver	20.4
Montreal	17.1
Melbourne	14.9
Portland	14.5
Brisbane	13.7

2011 12	Benchmark compos (average)
Perth	13.5
Sydney	13.2
Adelaide	12.9
Auckland	12.4
Seattle	12.2

On the average result for this index, Vancouver leads its cohort of New World c considerable margin. This is primarily the outcome of a comparatively widespre network facilitating relatively fast and frequent movement over an urbanised compactness is achieved by both topographical factors and a long-standing intensification around public transport nodes. This is most visible along the almost all activity centres return composite scores above Vancouver s high a neighbourhoods of Kitsilano-West Broadway, Shaughnessy, Mount Pleasant-Riley Pa Cedar Cottage, South Hill-Sunset and Hastings-Sunrise are located away from th their above-average accessibility results to the multi-directional grid formed and trolleybus lines. In contrast, composite accessibility drops towards the including in the CBD fringe neighbourhood of the West End as well as in the UI and Marpole. North and West Vancouver suffer in accessibility terms from their core city by way of the Burrard Inlet, while the outlying suburbs of Richmond, Coquitlam, Langley and White Rock are characterised by a public transport acces familiar from other New World cities where corridors with reasonable bus servic accessibility in city-wide terms) alternate with sizeable patches of disperse where public transport services fail to meet the SNAMUTS minimum standard (if th

Map 9: SNAMUTS Benchmarking Composite Index in Vancouver s metropolitan area in 2012



6. Conclusion

The SNAMUTS analysis characterises Vancouver s public transport accessibility a
a New World context, albeit with a mounting resilience problem that calls int
ability to sustain its recent rate of growth in transit patronage without
accelerating, the pace of network and service expansion. Of interest from
integration perspective, however, is the degree of consistency of these trends
regional growth strategy. Did the infrastructure program of the past three dec
transit supply in already transit-rich areas (see Walker s thesis above) while
so, this would contradict the finding for Vancouver having the best network cov
and Asia.

Furthermore, did transit supply increases favour the metropolitan strategy s
The result of this appears mixed. Four categories are evident:

- designated centres that grew strongly in transit supply (central Vancou
Westminster)
- designated centres that grew moderately in transit supply and/or infrastruc
Coquitlam)
- designated centres that grew weakly in transit supply (Langley, Pitt Meadow
Vancouver)
- and centres without a strategic designation that still grew strongly in tr
Broadway, 29th Avenue/Joyce-Collingwood, Edmonds-22nd Street, Marine Drive, UBC)

Are these outcomes primarily a result of market forces or of planning regimes?
accessibility play in this? Other than UBC, all examples of the fourth type a

excellent categories of the SNAMUTS composite index. This brings us back to the has Vancouver s investment program since the 1980s divided the city more in transit-poor components? Or is the situation more aptly described as a case of corridors of transit-richness into what was previously a uniformly transit-poor not possible to improve the situation in every neighbourhood simultaneously w major infrastructure is involved, but what is evident is that most of the Sk historic regional light rail lines that likely had a considerable impact on sett 20th century and thus laid the groundwork for the urban intensification around r was also more continuity with the surface transit system (and possibly, associat Vancouver than elsewhere due to the survival of the fixed infrastructure trolle research endeavours, we hope to explore howthese transitions from early 20th century transit orientation to 21st century transit orientation in the same locations can be character fit into evident transit supply and accessibility trends.

7 References

Berelowitz L (2005) Dream City. Vancouver and the Global Imagination. Vancouver:Dou

City of Vancouver (2011) Cambie Corridor Plan. Vancouver (BC), Canada

Curtis C, Low N (2012) Institutional Barriers for Sustainable Transport. Aldershot: A

Curtis C, Scheurer J (2010) Planning for Sustainable Accessibility: Developing Tool Decision-Making. Progress in Planning, Vol 74, pp 53-106

Curtis C, Scheurer J (2015, forthcoming) Planning for Public Transport Accessibilit

Filion P, Kramer A (2012) Transformative Metropolitan Development Models in Large C Areas: The Predominance of Nodes. Urban Studies, Vol 49, No 10, pp 2237-2264

Greater Vancouver Regional District (GVRD, 1976). The Livable Region, 1976-1986: Pro Managing the Growth of Greater Vancouver. Vancouver (BC), Canada

Greater Vancouver Regional District (GVRD, 1993) A Long-Range Transportation Plan f Vancouver: Transport 2021. Vancouver (BC), Canada

Greater Vancouver Regional District (GVRD, 1999) Livable Region Strategic Plan. Van

Kenworthy J, Laube F (2001) The Millennium Cities Database for Sustainable Cities.

Lash, H. (1976). Planning in a human way: personal reflections on the regional plan Greater Vancouver. Ottawa: Ministry of State for Urban Affairs.

Legacy, C. (2012) Achieving legitimacy through deliberative plan-making processes Practice, 13(1), pp71-87

Mees P (2007) Can Australian Cities Learn from a Great Planning Success 3rd State of Australian Cities Conference (SOAC), Adelaide (SA), Australia, 28-30 November 2007

Pendakur, V.S. (1972). Cities, citizens and freeways. Vancouver: Publisher.

Price G (2012) Vancouver and the Insatiable Automobile. Inroads: A Journal of Opini

Punter J (2003) The Vancouver Achievement: Urban Planning and Design. Vancouver: UB

Scheurer J, Curtis C (2013) Public transport accessibility in European and North Am pursuit of best practice? AESOP/ACSP Joint Congress, 15-19 July, Dublin, Ireland

Schiller, P L, Bruun E, Kenworthy J R (2010) An Introduction to Sustainable Transpo Planning and Implementation. Earthscan, London, UK

Statistics Canada (2006) The Time it Takes to Get to Work and Back. Statistics Cana

Statistics Canada (2013) National Household Survey, 2011: Commuting to Work.

Stone J (2013) Continuity and Change in Urban Transport Policy: Politics, Instituti Melbourne and Vancouver since 1970. Planning, Practice and Research

Translink (2013) South Coast British Columbia Transportation Authority - TransLink Burnaby (BC), Canada, available online at www.translink.ca

Walker, J. (2012) Human Transit. How Clearer Thinking about Public Transit Can Enrich Communities and Our Lives. Washington DC: Island Press.