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Water Transit and Ferry-Oriented Development in Sweden: Comparisons with System Trends in Australia

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Abstract

Water transit is increasingly becoming an option for cities looking to expand their public transport network and provide an alternative to land-based transport congestion. But there are challenges in realising a functional urban ferry network, especially in Sweden which faces land use policy and weather-related constraints. This paper has three related aims: i) to compare the development of water transit in Swedish and Australian cities, ii) to compare changes in patronage over time, and iii) to analyze the role of ferry-oriented development (FOD) and planning policy effects on water transit development. Our approach is exploratory and comparative, and we use the cases of Stockholm and Gothenburg in Sweden with comparison to Brisbane and Sydney in Australia. Patronage figures indicate that in both countries, water transit systems are a small part of the total public transport network, from 0.5% of total public transport trips in Stockholm to 3.7% in Brisbane. However, there has been modest growth in patronage that in relative terms has exceeded that of urban rail and bus services in all cities except Sydney. Integration of water transit with land use plans in FOD varies, with Brisbane and Sydney embarking on large-scale waterfront and transit plans focused on economic development. In Sweden integration with land use remains in early stages, with ad hoc terminal location and restrictive land use being limiting factors, especially in Stockholm. There are also conflicting strategies toward FOD in Gothenburg. Better conceptualization of land use implications for development of water transit planning is therefore suggested.

Urban water transit is undergoing a small renaissance as cities contend with increasing land-based congestion issues and promote waterfront development (*1*, *2*). In Sweden, the expansion of passenger and freight uses on inland waterways is of interest to address congestion issues, but also to facilitate a new environmentally efficient transport option to reduce urban pollution (*3*, *4*). However, there exist challenges in creating city-wide water transit systems in cities such as Stockholm. A recent International Association of Public Transport (UITP) report has shown how advances in urban water transit are generating patronage in Gothenburg, Stockholm and other water-based cities around the world (*5*). But there is limited detail on how Swedish systems are performing over time in terms of either patronage growth or generation of ferry-oriented development (FOD). By comparison, greater research effort has been placed on key Australian and U.S. urban water transit systems (*2*, *6*, *7*), which can offer insights beneficial to developing systems such as in Sweden. The focus of this paper is to outline the current scope of water transit operations, system planning and land development in Sweden, and to explore its prospects. To consider these issues and illustrate relative performance of Swedish systems, we make limited comparisons with well-established compatriot water transit networks in Brisbane and Sydney. The paper has three inter-related aims:

i. to audit current system operations in select Swedish and Australian cities, detailing operating models and system characteristics,
ii. to compare patronage performance over time from the last six years of operations in each city, and
iii. to review the experience with FOD related planning policies and prospects for the future.

The paper offers several contributions to the study of contemporary water transit. It provides a first analysis of longitudinal patronage trends in Sweden and how this compares to other examples in Australia. The paper also focuses on the significance of FOD land use policies and provides some example best practices, highlighting the subsequent implications for future water transit development in Swedish cities.

The paper is structured as follows; a review of available published literature on water transit in Sweden and Australia is presented, followed by a comparison of system characteristics and patronage. The role of FOD is then introduced and a review of current policies and examples is provided. The

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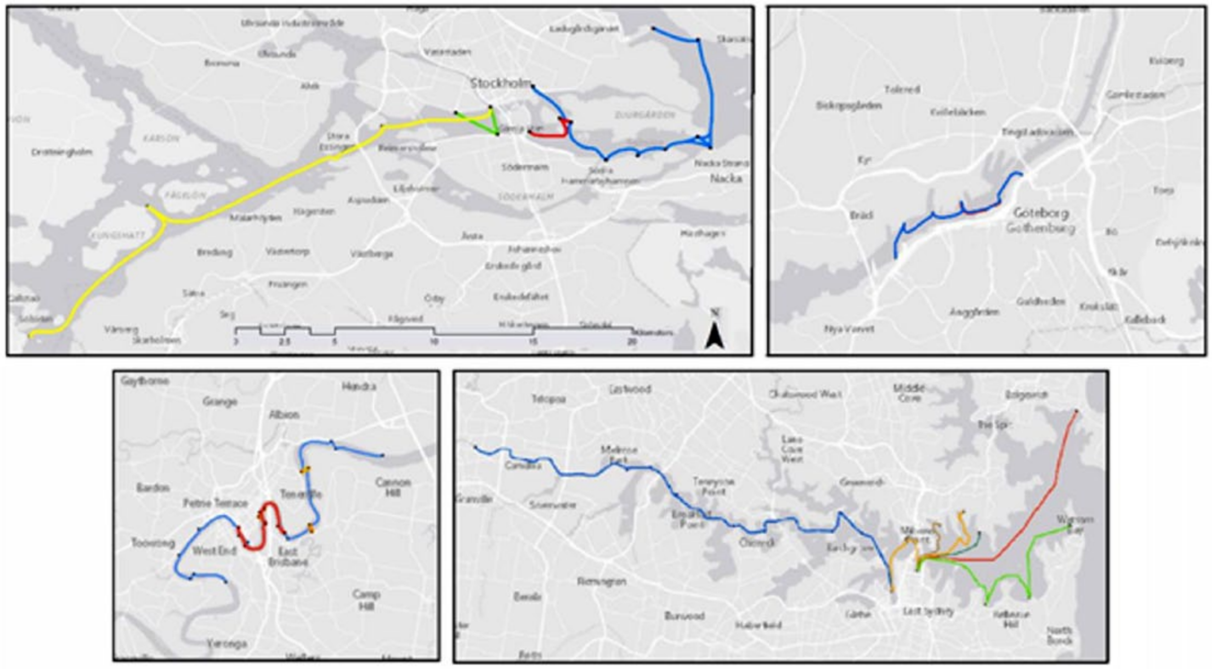

Figure 1. Clockwise from top left: Stockholm, Gothenburg, Sydney, and Brisbane.

paper concludes with a discussion of the implications of these findings for future water transit planning and FOD policy development in Sweden and suggestions for further research.

Research Context

As the two largest cities in Sweden, both Stockholm and Gothenburg possess large public transport networks incorporating bus, tram, ferry and, in Stockholm, urban rail. Both cities also feature water transport networks servicing both the inner-city region and outward toward large archipelago networks. The focus of this study is on water transit services within the inner city that are incorporated into the local public transport planning network. In Stockholm the public transport agency SL (*Storstockholms Lokaltrafik*) manages the transport provision within Stockholm County, a population of approximately 2.2 million (*8*). Boat services operated by SL include five lines: 80, 82, 84, 85 and 89. These services are contracted out to three private operators, who run the *Djurgårdsfärjan* and *Sjövägen* services, while *Waxholmbolaget* is another company who runs an inner-city service in addition to its outer archipelago services (*9*, *10*). These services share common ticketing with the wider transport network via either rechargeable smart card or individual tickets (*11*). In Gothenburg the public authority *Västtrafik* operates two commuter boat lines on the inner harbor of the Göta River. They include a linear route and a free cross-river service between Lindholmen and Stenpiren, a key transport hub where a new ferry terminal and transfer station was completed in 2016 (*12*). Services also allow transfer to other public transport modes. Brisbane and Sydney's water transport are also integrated into their public transport networks, which include bus, urban rail, ferry and, in Sydney, light rail. For a detailed overview of Australian networks see previous research on Brisbane (*2*, *13*) and Sydney (*14*).

Systems and Performance

Figure 1 illustrates the route networks of the water transit systems in Sweden (Stockholm and Gothenburg) and Australia (Brisbane and Sydney) using at-scale maps. Different colors indicate individual routes within each network. Table 1 presents an overview of the existing system characteristics. Stockholm has the larger network in Sweden which includes five routes covering 30 km, operated by a total fleet of 12 vessels (*5*). Two new routes were introduced in 2016. The first was an inner-city shuttle service connecting the southern residential and business island Södermalm with the central business district (CBD) (green line). The other was a longer suburban route west to Ekerö which has traditionally been a transport-deprived region (yellow line). As a secondary city, Gothenburg operates a smaller network mostly confined to the inner core of the city, anchored by key terminals at Stenpiren and Lindholmen, the latter of which serves as the waterfront technology hub of Gothenburg (*15*).

By comparison, Sydney has the most extensive route combination with eight separate lines. These include inner harbour services operated predominantly by high capacity vessels, and a single linear river route to the nearby city of

Table 1. Water Transit Operations in Gothenburg, Stockholm, Brisbane, and Sydney

City	Route km	Routes	Vessels	Terminals	Frequency	Network integration	Fare (USD)
Stockholm	30	5	12	23 (fixed land, floating pontoon)	12 mins peak 30 mins off peak	Yes	$5.20
Gothenburg	13	2	6	6 (fixed land, floating pontoon)	30 mins peak 60 mins off peak 7–8 mins cross-river service	Yes	$3.25 fixed single for entire route (free cross-river route, no bicycle surcharge)
Brisbane	21	5	30 (21 catamaran, 9 monohull)	25 (pontoon)	10 mins peak 15–30 mins off peak	Yes	$3.50–$4.10 zone based (free inner city "City Hopper" service)
Sydney	45 (34 km inner harbour services) (25 km Parramatta river route)	8	32	36 (fixed land and pontoon)	15–30 mins peak 30–60 mins off peak	Yes	$4.70 < 9 km $5.90 > 9 km

Sources: (*1*, *2*, *4*, *5*, *9*, *12*, *16*, *17*).

Parramatta (blue line) operated by high speed catamarans (*16*). Sydney also possesses the longest route length of the studied systems with 70 km in total. Brisbane's network is dominated by a single linear route stopping at key inner-suburban and CBD activity centers (*2*). Brisbane has the largest fleet with 21 catamarans operating the CityCat route (blue lines) supplemented by nine monohull vessels for other shorter routes (red lines) (*17*).

Table 2 describes the fleet and contextual information for each city. Owing to the need for year-round, all-weather operations in Sweden, vessels in both Stockholm and Gothenburg are monohull and mostly powered by diesel engines, with one hybrid diesel-electric vessel in operation in Stockholm. Striking a balance of efficient year-round vessel operation is an ongoing challenge in planning water transport in Sweden due to ice conditions (*3*). Options to meet this challenge are currently being investigated by Stockholm County Council (*4*). Travel speeds are therefore generally lower in Sweden. There is also a speed limit imposed in the inner harbor of Gothenburg and Stockholm of 6 knots. By comparison, Brisbane has a speed limit in key inner reaches of 8 knots, but the majority of the CityCat route operates upwards of 20 knots.

Table 3 presents patronage comparisons of public transport networks in each city. Figure 2 shows patronage and mode share changes over the study period. As shown, Stockholm and Gothenburg mode shares are dominated by urban metro and bus services, respectively. Water transit provides much less passenger capacity and ridership in the public transport network of each city. The mode share for inner city ferries operated under the public transport in the two cities ranges from approximately 0.5–0.8% in Stockholm and Gothenburg, respectively. However, ridership is relatively strong for the system size and the lower mode share is partly due to very high patronage of rail-based and bus public transport in both cities. Relative to other modes, water transit has seen the most increase in passenger numbers over the study period, with a 49% increase in Stockholm and 78% increase in Gothenburg (*12*).

By comparison, Sydney carries by far the most passengers per year with over 15 million in 2016 (*18*). Brisbane's mode share has increased significantly from 2011 to 2016 to currently holding approximately 3.7% of Brisbane's total public transport mode share (*24*). Brisbane has only seen mode share return to 2010 levels after flooding destroyed many terminals in 2011 and required infrastructure rebuilding in the following years (*13*). Sydney is the only city of the four that experienced a decrease in ferry patronage and mode share during the study period (*18*).

Competing uses of waterways is an ongoing concern in both Gothenburg and Stockholm as they remain active ports. There is still major commercial and shipping activity which causes potential conflicts. Alternatively, much of Brisbane and Sydney's commercial port industry has moved out of the inner city to locations nearby each airport at the Port of Brisbane and Port Botany, respectively (*24*, *25*). Congestion still occurs in Sydney Harbor with cruise ships, water taxis and non-regulated ferries, and remains an ongoing issue (*26*). In Brisbane the most common conflicts arise between leisure craft and other recreational waterway users such as rowers. Weather is another factor that significantly affects operational performance of the networks in Sweden. While in Brisbane it is possible to use high speed, low wake catamarans year-round, in Sweden the need for more robust vessels with ice breaking capacity for year-round operation is a necessity.

Table 2. Water Transit Fleet and Conditions

City	Hull type	Engine type	Max speed (knots)	Speed limit	Hours	Capacity	Crew	On-board facilities	Maximum tidal range	Natural hazards
Stockholm	Monohull	Diesel engine	12	6 knots in inner harbor	6 am–11 pm	225–300	2–3	Coffee; disability access; bicycle storage	0 m	Ice, storm
Gothenburg	Monohull	Diesel engine and diesel electric	11	6 knots in inner harbor	6 am–12 am	298 (160 seated); 80 bicycle spaces; seating in/out	3	Toilets/coffee; on-board bicycle storage; disability access	0 m	Ice, storm
Brisbane	Catamaran (river route) and monohull (cross-river services)	Diesel engine	26	8 knots in inner city reach	5 am–12 am	Catamarans 149–162; Monohull 53–78; seating in/out	1–3	Coffee, snacks; disability access; limited bicycle storage	3 m	Flood, storm, fog, debris
Sydney	Monohull and catamaran (Sydney) and catamaran (Parramatta River route)	Diesel engine	12 knots inner harbor 26 knots river service	–	5 am–12 am	300–400 inner harbor; 1110 Manly route; 150–250 Parramatta route	3–6	Bicycle space, toilets, and WiFi (larger vessels, not-chartered only)	2 m	Storm, fog, flooding (Parramatta river service only)

Sources: (*1*, *2*, *4*, *5*, *13*, *16*, *17*).

Table 3. Water Transit Patronage in Gothenburg, Stockholm, Brisbane, and Sydney (000 s)

	2011	2012	2013	2014[1]	2015	2016	% change
Stockholm							
Metro	309000	322000	328000	334000	340700	347400	12.43
Bus	291000	298000	300000	307000	312500	318000	9.28
Ferry	2345	2173	2335	2461	3430	3510	49.68
LRT	45000	45700	47000	49040	52070	54488	21.08
Total	648000	668000	678100	693388	708670	723388	11.74
Metro%	47.61	48.18	48.30	48.11	47.96	47.90	0.61
Bus%	44.82	44.58	44.18	44.22	43.99	43.85	–2.21
Ferry%	0.36	0.33	0.34	0.36	0.48	0.49	33.94
LRT%	6.93	6.73	6.92	7.07	7.33	7.51	8.35
Gothenburg[2]	2011	2012	2013	2014	2015	2016	% change
Bus	177007	178289	183098	176804	178696	196475	11.00
Ferry	1419	1840	2078	2451	2380	2532	78.44
LRT	79293	80911	93002	98996	100904	104025	31.19
Total	258000	261000	278000	278000	282000	303000	17.44
Bus%	68.61	68.31	65.86	63.60	63.37	64.84	–5.49
Ferry%	0.66	0.69	0.68	0.79	0.85	0.83	51.94
LRT%	30.73	31.00	33.45	35.61	35.78	34.33	11.71
Sydney	2011	2012	2013	2014	2015	2016	% change
Metro	294457	303550	306229	315099	326448	361134	22.64
Bus	214273	219221	220151	224063	257015	290297	35.48
Ferry	14503	14768	14943	15977	14794	15410	6.25
LRT	2739	3975	4150	3889	6135	9728	255.17
Total	527983	543526	547486	561042	606407	678585	28.52
Metro%	55.77	55.85	55.93	56.16	53.83	53.22	–4.57
Bus%	40.58	40.33	40.21	39.94	42.38	42.78	5.41
Ferry%	2.75	2.72	2.73	2.85	2.44	2.27	–17.33
LRT%	0.52	0.73	0.76	0.69	1.01	1.43	176.34
Brisbane	2011	2012	2013	2014	2015	2016	% change
Metro	51600	52480	50020	49820	50420	54280	5.19
Bus	124400	120200	119770	118650	113130	119440	-3.99
Ferry	4300[4]	5200	5890	6000	6430	7000	62.79
LRT[3]	–	–	–	–	6280	7600	–
Total	178600	178300	175700	175910	176260	188360	5.46
Metro%	28.89	29.43	28.47	28.32	28.61	28.82	-0.26
Bus%	69.65	67.41	68.17	67.45	64.18	63.41	-8.96
Ferry%	2.41	2.92	3.35	3.41	3.65	3.72	54.36
LRT%	–	–	–	–	3.56	4.03	–

Sources: (*5*, *10*, *12*, *18–23*).
[1]New linear route 85 to Nacka introduced (blue in Figure 1). Green and Yellow routes introduced in 2016 and not included in analysis.
[2]No metro rail service in Gothenburg.
[3]Light rail service introduced in 2014.
[4]Operations suspended and many terminals damaged by the January 2011 Brisbane floods (6.6 m passengers in 2010).

Ferry-Oriented Development

A key consideration of the success of water transit systems has been supportive land use around terminals and the extent of FOD. Currently, there is limited research on guidance indicating performance standards and best practice for implementing effective FOD. One of the first to link ferry development and land use was Thompson et al. (2006), who identified the potential for a network of ferry terminals to act in a transit-oriented development (TOD) function similar to other transit lines (*6*). Compared to existing TOD, they suggest that for urban water transit and FOD to be successful there should be additional focus on terminal design and proving additional facilities, such as shelter and retail arrangements. Weisbrod and Lawson also identified the potential for ferry services to be a catalyst for economic revitalization in U.S. cities, in conjunction with waterfront rejuvenation plans (*7*). They also observe that ferry passenger are often leisure users less concerned about time and may be more likely to linger around terminals and use

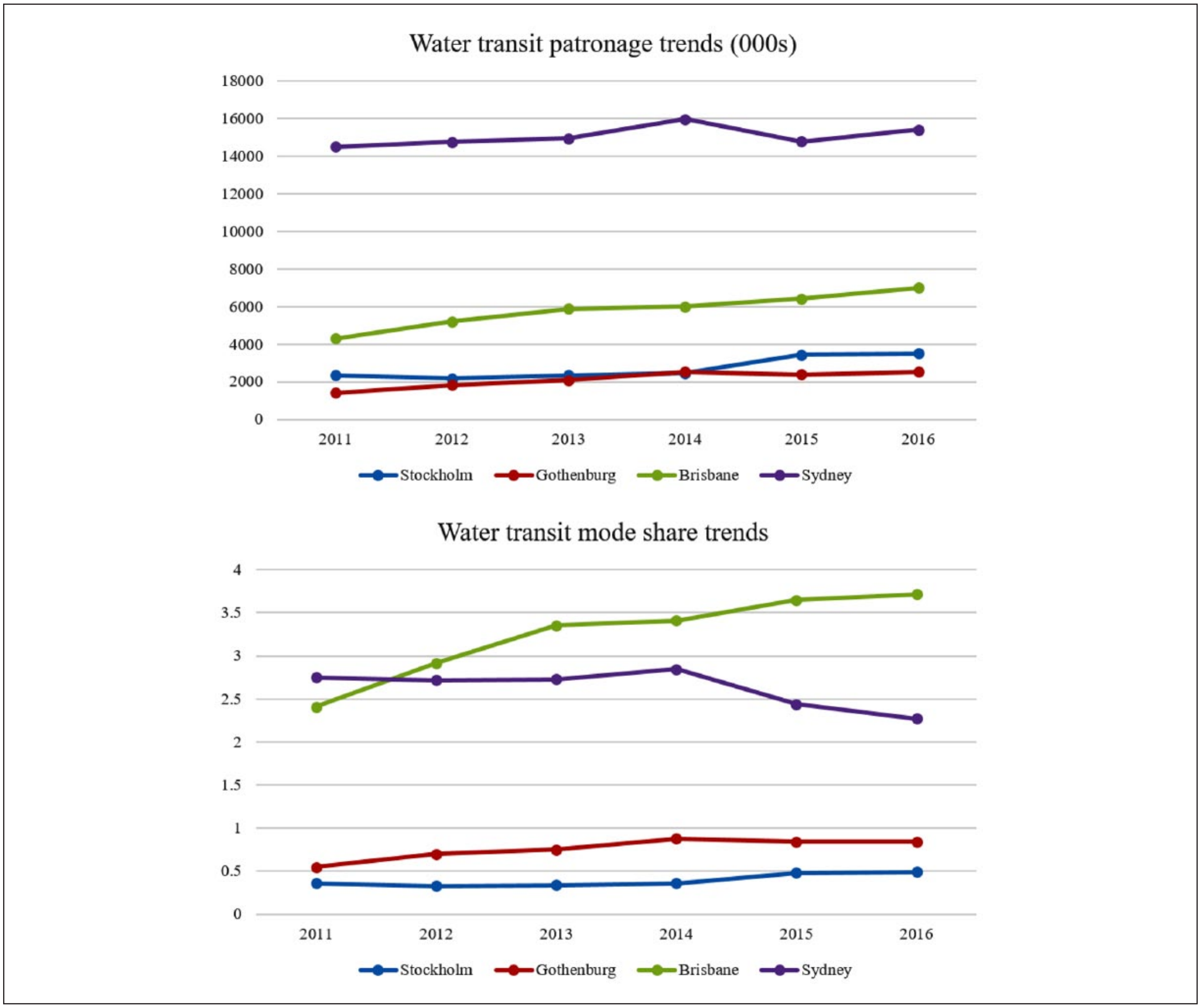

Figure 2. Water transit usage trends 2011–2016.

supporting land uses. These aspects suggest effective FOD may benefit from and creating destination that people are likely to spend more time at.

Research on economic benefits surrounding ferry terminals also suggests that they may differ from TOD and offer more development potential. Two key studies have so far explored the property value uplift effects around terminals of such systems. In Brisbane, where the system has operated since 1996, Tsai et al. (2015) found that value uplift of 4% has occurred around terminals (*27*). The New York City Economic Development Corporation, the lead organization responsible for the initial East River Ferry, found that after a three-year trial there was an 8% value uplift around ferry terminals (*28*). This result was a contributing factor in the expansion to a city-wide urban ferry system connecting all five boroughs. The development model used in New York highlights the importance of FOD success as a key factor facilitating the overall success of a water transit system.

Other models of FOD have also been increasing. In Brisbane property developers agreed to finance a new terminal in exchange for ferry service to attract potential residents. In London, similar arrangements are occurring, with discussions ongoing to service the new Battersea Power Station development. Some cities have also sought to promote the image of a 'river city' through city branding and tourism initiatives, where water transport has been one of a suite of policies coordinated with new residential and commercial land uses centered around rivers (*7*). Such results suggest there may be an increased potential for FOD, especially in conjunction with such redevelopment plans where water transport services are included early in discussions and innovative financing solutions are employed.

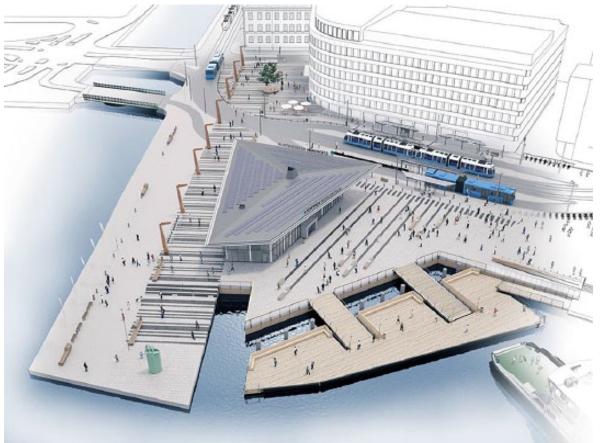

Figure 3. Stenpiren ferry terminal and transit hub in Gothenburg.

On the other hand, there have been concerns raised that developers are perhaps less willing to invest in FOD which are seen as less permanent than other TOD projects (*6*). While this may be seen as an advantage for the flexibility and adaptability of water transit systems, it may discourage investment around terminals. From current examples of successful water transit systems, best practice in terms of both economic benefits and patronage growth suggests investment in permanent fixtures is preferred. These should also be planned with the existing transport network, not only with integrated ticketing, but including uniform signage and wayfinding to and from other transit modes. In a study of Brisbane's network, it was found that 15% of all ferry journeys included another mode (*29*), therefore facilitating transfers should be a priority.

Looking at the contexts under investigation, Sweden and Australia have so far differed in the development of FOD. In Sweden, the *Gothenburg River Vision* report has set out a plan to develop the waterfront areas to provide better river access for residents and to encourage business and activity center creation along the waterfront. A key project has been the opening in 2016 of the new Stenpiren ferry terminal where it was envisioned that "an entire neighborhood will be developed with housing, businesses and meeting places" (*15*) on the FOD model, to change the perception of the river as a barrier. This has been an initiative of the municipal authority *River Bank Development*, with a new transport hub developed featuring transfer options between tram and bus services (Figure 3). There has also been collaboration with private industry in locating business in the area as part of a renewal policy agenda. Such urban strategies are increasingly common, often promoted by the urban regimes and growth coalitions that operate in most cities (*29*). Ferries are often promoted in such strategies not just for their transport function but for the imagery they provide (*1*, *6*). Gothenburg's renewal project objectives envision "*the river for everyone, not only some specific target groups, selective economic activities or some luxurious, mono-functional housing development. It is about diversity of environments and economies alongside the river*" (*30*). However, simultaneous promotion of the area as a new technology and cultural hub of the city has conflicted with this goal. A longitudinal ethnographic study of preliminary outcomes of the plan analyzing the makeup of the residential population within the redevelopment concluded that it has so far failed to achieve a more integrated and equitable population mix (*31*).

In Stockholm the waterfront development at Hammarby Sjöstad (Lake City) has been the flagship waterfront redevelopment, much discussed for its ecologically sustainable design focus. The project initially was conceived as an athlete village as part of Stockholm's unsuccessful 2012 Olympic Games bid but has subsequently been developed as a model for mixed used waterfront development. A key early consideration was transport provision. Part of this was a purpose-built pier and subsidized ferry services to connect passengers to the CBD 5 km away. However, there is currently a new train line being built nearby to connect the city to the eastern region, raising questions as to the viability of ferry services in the future.

One of the key issues impacting on FOD in Stockholm is that terminals have poor land use integration. Current piers have been located in existing available locations and not planned for future integration with waterfront development plans of the city. The new cross-river route in Södemalm exemplifies this, where there is little to signify that there is a ferry service available. This has been coupled with poor access owing to the unfavorable location which has led to criticisms of the piers and their convenience for actual commuting use (Figure 4) (*32*).

Despite these example projects, FOD is still in its infancy in Sweden. There are several factors that have contributed to this. Firstly, quite restrictive land use policies in waterfront areas exist. Regulations specify that developments must generally not infringe on public access; this creates benefits in that 80% of Stockholm's shoreline is publicly accessible (*33*). Further, additional consideration is given to the watershed when planning for urban development. Municipal authorities are also retreating in part from playing a lead role in the redevelopment process, with reduced land ownership in public hands and the cost to acquire new waterfront land for redevelopment in many cases prohibitively expensive. But urban regimes continue to look to FOD as a way to unlock new territories for redevelopment. Recently there has been interest from the Stockholm Chamber of Commerce in exploring options for development of waterfront districts for business and tourism purposes, in combination with new ferry terminal locations (*34*).

Figure 4. Stockholm route 85 pier and accessibility.

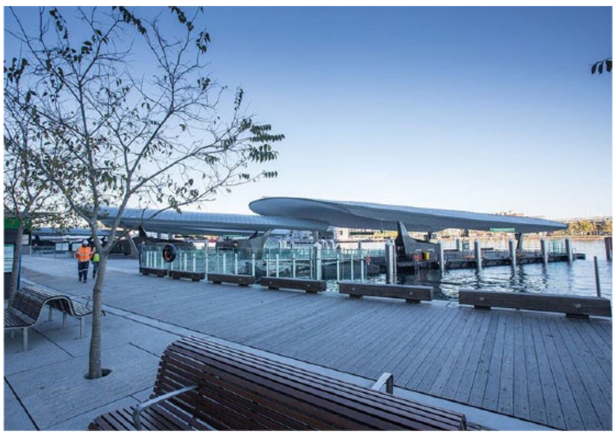

Figure 5. New Barangaroo ferry terminal, Sydney.

Australia's history with FOD has parallels. Brisbane has seen rapid redevelopment around existing and newly planned terminals as part of continuing riverfront renewals programs in different areas of the city (*2*, *13*). Similar to Gothenburg, the renewal of areas such as Tenerife and New Farm, partly on the FOD model, has seen gentrification and the displacement of low-income groups, despite early council rhetoric around equity. As noted previously property developers have paid for new ferry terminals and this has further contributed to inequalities.

Though the most recent Hamilton North-Shore development is primarily targeting higher-income populations, the state land developer involved uses profits from the site to help subsidize affordable and social housing in their other projects. As such, Brisbane has struggled to create inclusive FOD but is finding other ways to use FOD to overcome inequality. Sydney has also been actively developing new projects around water transit. An ongoing issue with the Sydney network has been capacity at single key exchange terminal at Circular Quay (*35*). A new two pier hub at Barangaroo opened in 2017 to service the newly developed precinct of commercial, hotel, residential and casino operations (Figure 5).

Discussion of Findings

Despite being a relatively minor mode of transport in Sweden there has been modest progress in development of water transit networks. Patronage is growing and in Stockholm continues to be in excess of planning authority expectations; there is also growing recognition of its potential role in future city plans (*3*). However, the conceptualization of FOD in Sweden and what it might deliver remains vague. In Gothenburg, the vision of inclusive development is proving problematic; in Stockholm interest in ferries remains more on transport functions than land development. This raises major questions for the field as to how water transit and effective FOD may be achieved. Links between government and the land development sector in ferry system development are important, as seen in Brisbane, New York and London.

But FOD should be more than just an agent of urban regimes for gentrification and eventually displacement of the poor in cities being reclaimed by the wealthy. With Sweden being in the early phases of development there is an opportunity to develop a more coherent strategy including more socially inclusive FOD.

Although we looked at Australian comparators, cities elsewhere also show ways forward. In New York, the primary goal was to stimulate waterfront precincts through a trial ferry route. Ferries have provided transit accessibility to locations that previously had effectively very little, including some socially disadvantaged communities. Stockholm is somewhat following this trail, with new suburban lines and current investigations into routes to connect inaccessible locations in the inner archipelago. The subsidising of a ferry route in Hammarby Sjöstad in conjunction with a new mixed-use development is also a positive sign for increasing feasibility of water transport in the future. This may encourage the formation of a model for linking inner archipelago islands that currently have poor accessibility to central Stockholm. While outer archipelago ferry services are often the only option in regional areas outside of the urban area, there is the possibility for introducing ferries on inner archipelagos to compete with other commuting modes such as private cars, which often travel longer on a less direct route. However, Sweden may need to loosen some land use regulations on the waterfront to encourage better FOD outcomes, whilst still maintaining through-movement on the landside and public access.

The effect of city configurations is also worth noting. Stockholm and Sydney may be considered similar in terms of the hub and spoke pattern of service to inner harbors and archipelago islands connecting to a central city hub. Brisbane and Gothenburg's structure are also similar, based around a more linear route that travels parallel to the shoreline to key activity centers, and offers cross-river connections. Locations at the end of these routes in suburban areas are being actively developed for more residential and commercial uses in both cities. Planning for water transit in either city configuration needs to be considered, with the complexity of Stockholm's archipelago network needing careful planning to design route structures that emphasize multidirectional travel, to avoid capacity issues at the central pier as has occurred in Circular Quay in Sydney.

Finally, political and institutional arrangements are worth considering. Despite government support and positive intentions, political barriers can arise in implementing water transport when land use and marine departments can result in conflicting goals, as has been the challenge in Bangkok in its efforts to expand and modernize its network (*36*). Stockholm is made up of 48 separate municipal authorities, each with the responsibility to enact a land use plan for their respective district. Therefore, while development in one key localized area was able to be achieved, this may not be the case when operating in larger context. A particular challenge is the coordination of waterfront land use policies to facilitate a uniform network across these respective boundaries.

Conclusion

This paper has looked at the development of Swedish and Australia water transit systems and provided the first comparative analysis of patronage and longitudinal performance. It has also provided a look at the importance of FOD within the Swedish political context and some examples of progress that has been made, and challenges in the future. So far Sweden has a focus on water transit development and aspirations toward inclusive FOD but has had mixed success in Gothenburg, with promotion at the same time as a technology hub being a conflicted strategy. However, the change of location for a new pier and transit hub from a previous location with little supportive land use is a positive sign. In Stockholm, a different environmental efficiency driven agenda exists. In this case the challenge is to more tightly integrate land use considerations in a clear FOD vision if success is to be achieved in expanding the water transport network.

There are limitations to the current research, though. Perhaps foremost is the lack of disaggregate analysis of water transit within the two Swedish cities. The descriptive approach used lacks power to isolate the effects of the water transit system on user behavior or land development. There remains a paucity of research in water transit systems. Our recommendations for future research to assist the Swedish systems involve several items that would assist the broader field of urban ferry planning and operations. These include:

i) Disaggregate analysis of patronage in Gothenburg and Stockholm, perhaps using fare transaction in a similar way to the previous work on Brisbane of Soltani et al. 2015 (*29*) to better understand passenger movements and inter-modal journeys within the cities.
ii) Extending the longitudinal research framework to explore such issues as network effects within water transit systems, particularly as new routes are added to the Stockholm system. Similarly, use of longitudinal pre-/post-intervention studies on the effects of new water transit piers on residential travel behavior may provide useful insights to assist future planning and policy, especially if controlled for travel attitudes and other known influences on travel behavior.
iii) The benefits that accrue in terms of property value uplift around Swedish water transit piers are not well understood. Hedonic value studies may help reveal what effects these systems are having on property values and if the results are consistent with effects seen in other cities.
iv) Work on vessel design and operations to overcome the particular problems of ice in Swedish winters that may impede high speed operations.
v) Analysis and simulation of alternative route structures to maximize patronage and efficiency, especially in Stockholm, and the differing contexts such as archipelago/island/bay configurations and their unique challenges, building on the work of Sandell (2015) in Sydney (*35*) and the recent city-wide ferry study in New York (*28*).

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Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: Michael Tanko, Matthew Burke; data collection: Michael Tanko, Matthew Burke, Harsha Cheemakurthy; analysis and interpretation of results: Michael Tanko, Matthew

Burke; draft manuscript preparation: Michael Tanko, Matthew Burke. All authors reviewed the results and approved the final version of the manuscript.

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