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Public transport priority in 2020: Lessons from Zurich

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Abstract

Public transport priority is a well-known strategy for improving the attractiveness and efficiency of public transport, but does it still make sense in an era of micro mobility, MAAS, shared mobility and smart cities? Starting in the 1970s Zurich systematically implemented a comprehensive public transport priority program creating one of the world's best public transport systems. While public transport priority is still quite effective, Zurich and other growing cities face fresh challenges: increasing transport demand, calls for more active transport, a need for improved public spaces, and new players, technologies and business models disrupting the urban transport market. This paper investigates Zurich's public transport priority program in light of these challenges and recommends that cities create and implement fully integrated sustainable transport priority programs. These programs would be developed using lessons from Zurich's public transport priority program (taking a fully integrated approach, supporting experimentation and innovation, and building political support for implementation). The programs would strongly prioritise public transport and other sustainable transport modes (e.g., walking, cycling), as well as complimentary urban liveability improvements. In short, cities should follow the approach Zurich took in the 1980s for public transport – but broaden the focus to include all forms of sustainable transport.

Keywords: Public Transport, Priority, Sustainable Transport, Zurich, Urban Transport

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Public transport priority in 2020: Lessons from Zurich

1. Introduction

The introduction of new transport modes, technologies and ideas including vehicle sharing, transport network companies (e.g., Uber), autonomous vehicles, smart cities and the complete streets have opened new possibilities for creating attractive and sustainable cities. And, cities are growing – increasing transport demand. On the other hand, cities still have limited space. The key problem cities face is how to allocate that space to best meet the needs of its residents, organisations and businesses.

This is not a new problem. Cities have always needed to allocate space for transport, and therefore, laying out streets and regulating traffic have always been fundamental to urban planning. The specifics depend on available technology and transport demand.

A good example of consciously allocating space for transport comes from Zurich. In 1973 Zurich citizens voted against a city-sponsored underground metro system, and, in 1977, they voted for a comprehensive public transport priority program developed by citizen activists. (Nash, 2003; Nash and Sylvia, 2001) The first vote would have removed trams from the surface streets and reallocated space for automobiles (a practice followed in many German cities during the 1960s and 1970s). The second vote funded a program for speeding-up buses and trams operating on surface streets.

Today, as a result of its public transport priority program, Zurich has one of the world's best public transport systems. (Arcadis 2017) Service is attractive, punctual, cost effective, well used, and liked by residents. (City of Zurich, 2017) Furthermore, high quality public transport is often cited in Zurich's very high city liveability rating (e.g., number 2 in the Mercer study). (Mercer, 2019)

This paper reassesses Zurich's public transport priority program in the context of today's urban transport challenges. It builds on results of earlier research by Nash (Nash, 2003; Nash and Sylvia, 2001) and uses the same methodology: data analysis, desk research and expert interviews. Consistent with the earlier research, experts were not interviewed for quotation so they could openly discuss problems. Therefore, the analysis and recommendations in this paper represent thoughts of the authors only, not necessarily the interviewed experts or official policy.

The next section presents an introduction to public transport priority. Section 3 describes current transport conditions in Zurich including problems, proposed solutions, and future plans. Section 4 presents conclusions and recommendations.

2. Public transport priority

2.1. What is public transport priority?

Public transport priority consists of implementing measures that give public transport vehicles preference over other vehicles on the street. The goal is to make public transport attractive by increasing its speed and reliability. Public transport priority measures include:

- Dedicated right-of-way;
- Roadway improvements and regulations;
- Traffic signal prioritization;
- Operational improvements (e.g., proof-of-payment, operations centres), and,
- Complimentary measures (e.g., traffic calming) to support public transport.

Public transport priority measures are well known and understood. For example, the National Association of City Transport Officials (NACTO) Transit Street Design Guide provides detailed descriptions of public transport priority measures and their implementation. (NACTO, 2018)

There are three approaches to implementing public transport priority measures:

- Individual approach – apply public transport priority measures at specific locations. A good example is restricting turns at an intersection where buses are delayed by vehicles waiting to turn.

- Route-based approach – apply a comprehensive set of priority measures to specific routes. Good examples include New York's Select Bus Service and San Francisco MTA's Muni Rapid Network.

- Network-wide approach – apply a comprehensive set of priority measures throughout the public transport network. Zurich is the pre-eminent example of this approach. (Nash, 2003) Network-wide application of priority provides greater benefits than route or individual application because it makes travel throughout the network attractive.

Frequent transit network design helps support network-wide application of public transport priority. Frequent network design restructures public transport from many infrequently operated lines to fewer lines operating more frequently. (Walker, 2018) Although some people need to walk further to a stop and transfer, frequent network design increases overall accessibility and quality of service. Because frequent service lines are used by more vehicles, they become excellent candidates for applying public transport priority measures – which further improves service for passengers.

Bus rapid transit (BRT) extends the route-based approach to public transport priority by combining priority measures with significant investments in buses and stations. The first BRT system opened in Ottawa (1973) and was followed by Curitiba Brazil (1974). (Cervero, 1998) The Institute for Transportation & Development Policy has developed standards for BRT. (IDTP, 2018)

2.2. The battle for street space

Today many cities want to improve public transport and active transport modes to cope with increasing demand in a sustainable manner. The technical solutions are well known, but implementing them often means reducing automobile capacity or parking – both of which are fiercely opposed. In other words, the problem is political, not technical. (Reynolds et. al., 2018) There are several possible solutions to this problem:

- Use creative and high-quality transport engineering to reduce the impact of space reallocation on other users (e.g., traffic flow). This approach was used extensively in Zurich's public transport priority program, and in New York's introduction of select bus service, bike lanes and pedestrian improvements. (Beaton et. al., 2012)
- Establish programs to educate and involve the public in the planning process. While public involvement programs are effective, they are project specific, labour and time intensive, and residents have many competing demands on their time. One approach is to use on-line educational tools, games and involvement techniques. (Nash, 2018)
- Implement temporary projects to demonstrate new designs; change or remove measures if they are unsuccessful. New York is an excellent example: the city carefully measured the benefits and impacts of cycling and pedestrian measures, publicized these data widely, and removed measures that did not work. (NYCDOT, 2013)
- Explicitly pursue political support. Interestingly, there is often more political support for public transport and active modes than elected officials recognise. When surveyed, Zurich's elected officials believed people wanted more automobile access, in fact citizens voted for public transport. The initiative gave Zurich the political support needed to implement its program. (Nash, 2003) There have been similar demonstrations of political support for extensive cycling improvement programs (e.g., Seville and Berlin). (Anderson, 2018; Berlin, 2018; Volksentscheid Fahrrad, 2017)

The important lesson is recognising that reallocating street space for public transport and/or other sustainable modes of transport is not a technical problem, but rather a political problem and treat it as such.

2.3. How does public transport priority fit in today's urban transport environment?

Cities and urban transport have changed significantly in recent years. First, cities are growing. The share of people living in cities grew from 44.8% in 1995 to 55% in 2018. (United Nations, 2018) Furthermore, urban residents are demanding higher quality services and increased liveability. This means increased advocacy for cycling, walking, and better urban design. Unfortunately, cycling, walking and the public realm improvements also require space. As shown in Figure 1, today street space in Zurich is very finely allocated between public transport and private motor vehicles – this creates a dynamic where public transport priority is threatened by its natural complements: active transport and liveable neighbourhoods.

Fig. 1: Public transport lane, motor vehicle lane, bike lane and pedestrian promenade at Central-Platz Zurich, looking towards the Limmatquai. (Photo source: Andrew Nash)

The second change is the rapid development and application of new information technologies. Public transport examples include collecting and using real time data for operations and customer information, more effective infrastructure (e.g., improved traffic signal priority, electronic bus lanes), more efficient fare collection, and better vehicle performance (e.g., through sensor monitoring).

But, more importantly, information technology has supported the revitalisation of cities (leading to increased economic growth and transport demand), and created four new urban transport solutions:

- Vehicle Sharing – from cars to scooters.
- Transport Network Companies (TNCs) – providing taxi-like service from independent drivers (e.g., Uber, Lyft).
- Mobility as a Service (MaaS) – creating a platform of multimodal options for customers.
- Autonomous Vehicles (AVs) – eliminating the need for drivers.

These solutions create challenges and opportunities for public transport. Vehicle sharing and TNCs increase competition but could help solve the first-and-last-mile problem. Importantly, they also increase traffic and thereby reduce the speed and reliability of public transport operating on non-dedicated rights of way. (Schaller, 2018)

The timing and impacts of autonomous vehicles on urban transport are topics of intense speculation and research. Two important questions are how AVs could be used to provide public transport, and how cities will regulate AVs. Research has shown different impacts depending on the regulatory scheme assumed. For example, systems of shared AVs could improve urban transport, while private AVs operating as today's private vehicles could significantly increase vehicle miles travelled and congestion. (Bösch et. al., 2018; Friedrich, 2018)

The key question for MaaS is who will control the platforms: government agencies, private companies or some combination. While it seems logical that a public transport operator (or regional transport agency) would provide the platform, it is also true that private businesses such as TNCs are moving rapidly into MaaS.

In summary, the combination of rapid urban growth and technological change makes public transport more complicated to plan and produce. Furthermore, public transport operators are facing intense competition from highly entrepreneurial companies and more complex demand from highly engaged public advocates. Cities and their public transport operators must recognize and proactively respond to these challenges to succeed in the future.

3. A contemporary assessment of Zurich's public transport priority program

3.1. Introduction

A fundamental problem for urban transport is space allocation. In the 1970s Zurich acted boldly to reallocate street space from private vehicles to public transport (for example at Paradeplatz, shown in Figure 2). In the 1990s this approach was widely recognised as successful (although rarely imitated). This research assesses the success of Zurich's public transport priority program in light of today's urban transport environment and identifies lessons for solving today's urban transport problems.

Fig. 2: Zurich Paradeplatz (Photo source: Andrew Nash)

3.2. Public transport in Zurich

Zurich's public transport system operates on two levels: buses and trams running on surface streets serving short and intermediate-distance trips, and a grade separated S-Bahn providing regional service. This differs from cities with a third level of public transport: grade separated urban rail (metro) used to provide fast trips over intermediate distances. In Zurich intermediate distance trips are served by increasing the speed of surface buses and trams (using public transport priority) and increasing the number of S-Bahn stops in the city. This two-level approach reduces capital costs (no metro), but has lower capacity than a three-level system. (Orth et. al., 2015)

Since 1990 all public transport service in the Zurich region (over 40 different operators) has been organized by the Zurich Verkehrsverbund (ZVV). The ZVV is responsible for strategic planning and integration of schedules and fares; local companies are responsible for detailed planning and production. The ZVV service area consists of 1839 sq. km in 182 political jurisdictions with a total population of 1.6 million people. The total network is 4650 km. In 2017 the overall farebox recovery ratio was 66.7%. (ZVV, 2017)

The S-Bahn (Figure 3) is the backbone of regional public transport: it provides strong radial service into Zurich and suburban stations serve as local public transport hubs. The S-Bahn consists of 380 km of lines with 485 thousand passengers per day in 2017. S-Bahn ridership has increased significantly since introduction of the first underground S-Bahn line through Zurich (1989). Most of the S-Bahn lines are operated by the Swiss Federal Railways (SBB). (ZVV, 2018)

The Verkersbetreibe Zurich (VBZ) provides tram and bus service within the city. In 2017 the VBZ carried 325 million passengers on 14 tram lines (122.6 km), 6 trolley bus lines (53.8 km), 55 city, neighbourhood and suburban bus lines (109.8 km), and three inclined railways. (VBZ, 2018)

3.3. Zurich: Demographic and transport data

As shown in Table 1, Zurich's population increased by 14% between 2000 and 2015, while the suburban population increased by 18%. Much of the suburban growth represents commuters to Zurich. Employment in Zurich is higher than the city population; it increased by over 77,000 between 2005 and 2015. (City of Zurich, 2017)

Table 1. Zurich demographic and employment data

Population	2000	2005	2010	2015	2016	Change (00 to 15)
Agglomeration	1,132,800		1,248,700	1,334,300		18%
Kanton	1,247,900		1,373,100	1,466,400		18%
City of Zurich	361,000	367,000	385,500	410,400	415,700	14%

Employment			2011	2015		Change (11 to 15)
City of Zurich			444,000	468,600		6%

As shown in Table 2, sustainable transport use increased between 2000 and 2015. Private vehicle mode share has fallen from 40% to 25%, public transport share increased from 30% to 41%, and cycling has increased from 4% to 8%. (Stadt Zurich, 2018; Swiss Federal Office for Spatial Development, 2018)

Table 2. Zurich mode share data

Mode Share	2000	2005	2010	2015	Change (00 to 15)
Auto	40%	36%	30%	25%	-15%
Public Trans	30%	34%	39%	41%	+11%
Bicycle	4%	4%	4%	8%	+4%
Foot	26%	26%	27%	26%	No change
Total	100%	100%	100%	100%	Not applicable

As shown in Table 3, the percentages of people regularly using (defined as two or more times per week) sustainable modes shows public transport use is high and stable (76% use public transport regularly) while cycling has increased significantly (from 20% to 27%).

Table 3. Zurich regularly used modes data

Regularly used modes	2009	2013	2015	Change (09 to 15)
Automobile	25%	22%	22%	-3%
Public Transport	75%	76%	76%	+1%
Bicycle	20%	23%	27%	+7%

As shown in Table 4, ridership into Zurich on the regional railway lines (S-Bahn) has increased from a basis of 100 in 1989 (when the first major capital improvement was made) to 304 today (after completion of the second underground line and increased service). (ZVV, 2018)

In terms of patronage, Zurich's public transport company (VBZ) carries just over one million trips on a typical workday. This is almost half of the total ridership carried by public transport in the Zurich transport authority (ZVV) area. Ridership has increased on all three measures between 2005 and 2017: in Zurich by 10%, in the ZVV service area by 29%, and on the S-Bahn by 52%. (ZVV, 2018; VBZ, 2017)

Table 4. Zurich public transport ridership data

S-Bahn	2000	2005	2010	2015	2016	2017	Change (05 to 17)
Border (index)	162	201	248	286	301	304	1989 = 100
Pass/day (000)	242.3	319.8	394.8	456.1	478.9	485.0	52%

Pass/Year (million)	2005	2010	2015	2016	2017	Change (05 to 17)
ZVV	505	582	629	638	651	29%
VBZ	297	318	327	324	325	10%

Residents are also quite well satisfied with public transport service. At the regional level the average customer ranking of ZVV service has risen from 73 to 77 points (of 100) between 2000 and 2016. (ZVV, 2018; ZVV 2017) The VBZ's 2017 customer survey shows that passengers are generally quite satisfied (score: 78 of 100 points), although trolley bus passengers are less satisfied (74 points) than tram passengers (79 points). (VBZ, 2017b) A city population census showed average customer satisfaction with public transport improved from 5.3 to 5.4 (on a scale of 6) between 2013 and 2015. Only 2% of respondents were unsatisfied with public transport, as compared to 5% for walking and 37% for cycling. (City of Zurich, 2017)

As shown in Table 5, auto ownership in Zurich is relatively low with 53% of households owning no cars (2015); this is approximately the same as New York City's rate of 54.5%. (Cutrufo, 2017) Car ownership per capita in the city has decreased by 17% between 2000 and 2017, compared to a slight decrease in the Canton of Zurich. Automobile ownership in Zurich is significantly lower than the average ownership for Switzerland of 537 passenger cars per thousand population. (Eurostat, 2018)

Table 5. Zurich automobile ownership data

Auto Ownership	2000	2005	2010	2015	2016	2017	Change (00 to 17)
% zero car HH			48	53			
Cars/000 - city	411	383	357	348	344	340	-17%
Cars/000 - KT	495	496	489	489	487	484	-2%

Transport from the agglomeration into the city of Zurich is increasingly shifting to public transport. Between 2010 and 2015 the number of private vehicles entering Zurich fell by 4% while the number entering by public transport increased by 5%. Most of this increase (16%) was accommodated by the S-Bahn. (Planungsbuero Jud, 2017)

3.4. Zurich public transport assessment: a victim of its own success

As the data presented above show, public transport in Zurich is currently working very well. Ridership and farebox recovery are increasing on both the city and regional levels. However, increasing ridership and public demands to allocate more street space for walking, cycling and liveability improvements are placing significant pressure on public transport.

On the regional level, the ZVV and SBB are working closely to improve S-Bahn punctuality, reliability, and connections with local public transport. A second underground line through Zurich (Lowenstrasse Station/Weinberg tunnel) was opened in 2014 and new vehicles with higher capacity have been added (Figure 3). As a result, 2017 punctuality was better than ever and customer satisfaction was high (ZVV, 2018b), but many S-Bahn lines are overcrowded and demand continues to increase. (ZVV, 2017) It is difficult to add more S-Bahn trains since they use the same infrastructure as long distance trains (demand for which is also growing rapidly).

Fig. 3: Zurich S-Bahn train in Hauptbahnhof (Photo source: Andrew Nash)

The main problem for Zurich's surface running buses and trams is maintaining reliability with growing traffic congestion caused by increasing demand as well as more cyclists, scooter-riders, and TNC trips. Because the street network is operating very close to capacity, any incident (e.g., snowfall) creates delays that ripple through the system. In 2017 overall VBZ network punctuality (Figure 4) fell slightly to 87% (trips arriving within 2-minutes of schedule), however the reliability of high capacity trolley bus lines fell to 78%. The main reason was lack of separate right of way (trams have 75-100% dedicated lane while the trolley buses have only 10-30%). (VBZ, 2017b)

3.5. Public transport improvement strategy

Zurich and the region have developed comprehensive plans for improving public transport systems to address current problems and increasing travel demand. These plans include capital improvements, continued implementation of public transport priority, and Zurich's sustainable mobility plan (Stadtverkehr 2025). (City of Zurich, 2017)

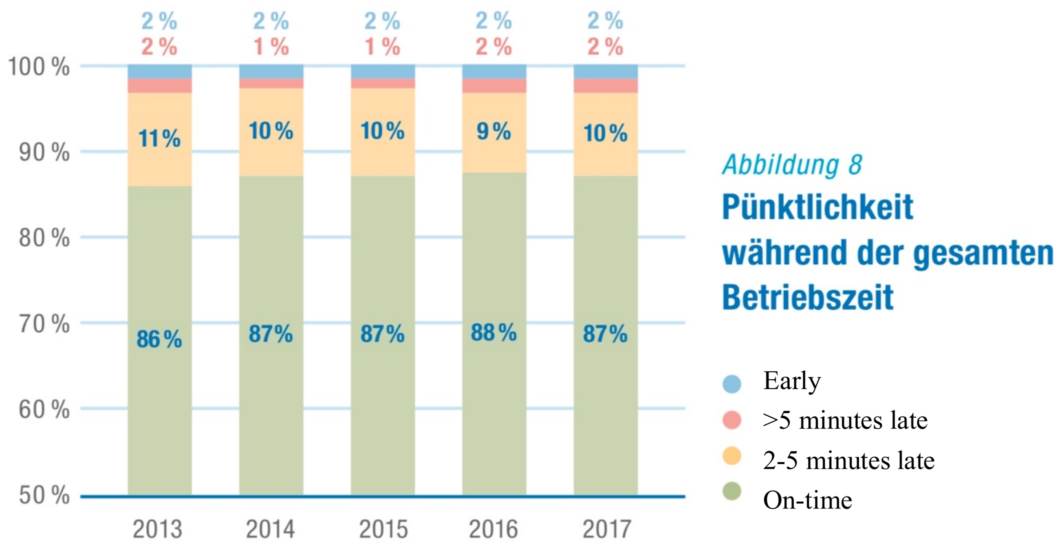

Fig. 4: VBZ punctuality (average all lines and time periods). Source: (VBZ, 2017b)

3.5.1. Capital improvements

The city of Zurich and ZVV have developed long-term capital improvement programs to increase capacity and make service more attractive. On the regional level these improvements consist of S-Bahn and bus system expansion, while the city is pursuing an aggressive program of tram and bus improvements. (ZVV, 2017; ZVV, 2018c) Key improvements include:

- S-Bahn Second Generation – major capital improvements and operating changes implemented over the next 10-15 years to provide more frequent service but with increased transferring (Orth, 2015).
- Limmatalbahn – new 13.4 km high capacity regional tram serving a suburban environment (similar to the Glattalbahn (Schneebeli et. al., 2010)) at a cost of 755 million CHF; timing: 2022.
- Rosengartenstrasse Tunnel – places a major arterial street in a tunnel and builds a tram line on the surface at a cost of about 1 billion CHF; timing: post 2030.
- Zurich Tram and Bus Extensions – several extension and capacity improvement projects including tangential lines, tram 2 extension, and increased bus service. (VBZ, 2014)
- S-Bahn, tram and bus stations are being rebuilt throughout the region and city to improve accessibility, customer service and operational efficiency. (ZVV, 2017)
- New Vehicles – with increased capacity and accessibility to speed-up passenger boarding and alighting making service more efficient and attractive (e.g., Bombardier Flexity trams).
- New Technology – for example using digitalization to make access to public transport easier and reduce costs (e.g., electronic ticketing). (ZVV, 2017) The VBZ has organized an inter-agency working group to comprehensively reconsider how data and digitalization can be used to improve service. Both agencies have high quality travel planning apps and extensive open data access.

In short, Zurich will invest a significant amount of money maintaining and extending its already excellent public transport system over the next 15-20 years. As outlined in the next two sub-sections, these investments will be supported by continued implementation of public transport priority and the city's sustainable transport plan.

3.5.2. Continuing Implementation of Public Transport Priority Program

The city of Zurich is continuing its strong commitment to public transport priority. City departments have worked closely with the VBZ in planning and implementing priority measures for new public transport route extensions (e.g., tram line 17) and as part of street rebuilding and/or neighbourhood improvement programs.

However, traffic congestion has increased and residents want more space for walking, cycling and local liveability improvements. This has made planning and implementing public transport priority measures (even) more difficult.

Planners must work closely together to find solutions defined in terms of a few centimetres of lane width or a few seconds of traffic signal green time. The process is slow and requires very detailed analysis.

One technological solution to the shortage of street space is to combine traffic signals with roadway improvements to create electronic bus lanes. Zurich started using innovative traffic signal control techniques in the 1990s including queue jumping, electronic bus lanes (Langestrasse two-way bus lane) and area-wide traffic control. (Nash, 2003; City of Zurich-Traffic, 2012, and 2013) Today Zurich is extending these ideas by:

- Applying electronic bus lanes to two-way streets (buses in two directions use a centre lane) for example on the frequently delayed trolley bus 31.
- Studying new ideas for improving Zurich's area-wide traffic control system. Area wide traffic control reduces the amount of traffic entering central Zurich by reducing green time on access streets located outside the centre (Figure 5). This reduces delays to public transport by reducing overall congestion. Today the system uses highly customized algorithms from the 1990s and works very well but it may be possible to increase its sensitivity and flexibility by linking it directly to macroscopic flow diagram (MFD) control. (Ambühl et. al. 2018)
- Investigating ideas for using dynamic traffic signal control, which uses sensors to detect demand and optimises signal operation to achieve a predetermined objective (e.g., some combination of public transport priority, minimised wait times for pedestrians, cyclists and automobiles). Zurich's existing traffic signal system is similar, but programmers adjust the parameters manually, the dynamic traffic signals would adjust signal phasing and timing automatically in real time. (Lämmer, 2016)

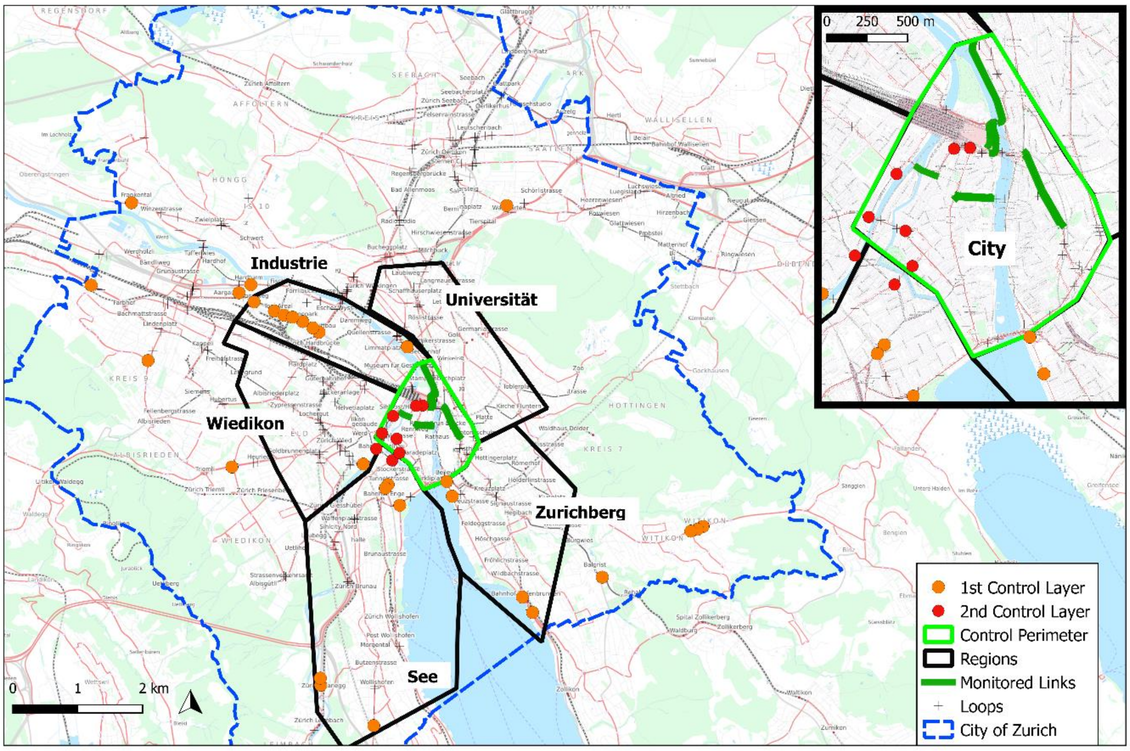

Fig 5: Overview of perimeter control scheme of the city of Zurich. Source: Ambühl et. al. 2018

On the regional level the ZVV is strongly supporting implementation of public transport priority. The ZVV assesses punctuality as part of its annual service quality monitoring and identifies locations where public transport is significantly delayed. ZVV then works with local public transport operators and planners to identify and implement solutions including new technologies such as electronic bus lanes and dynamic traffic signal control.

The ZVV monitoring results are described in a public report which attracts media attention thus helping create political support for making the needed improvements (Figure 6). Most of the ZVV's focus is on suburban bus lines since the VBZ is already proactive in working to solve bus and tram delay problems in Zurich. The most recent ZVV study found 64 problems with 14 in Zurich and 19 in Winterthur, a much smaller city. (ZVV, 2017)

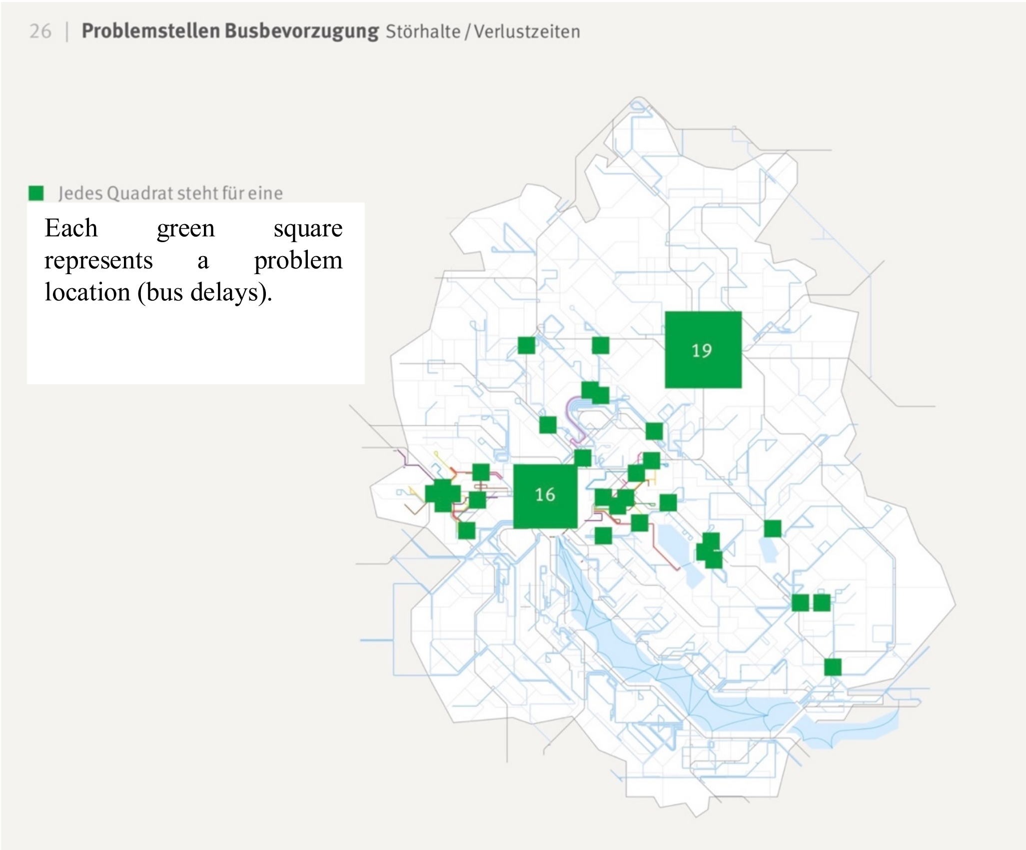

Fig. 6: ZVV annual bus monitoring problem locations. Source: ZVV, 2017

3.5.3. Sustainable mobility plan: Stadtverkehr 2025

Zurich began working on its sustainable mobility plan (Stadtverkehr 2025) after passage of a nationwide citizen’s initiative in September 2011 calling for more sustainable transport. (umverkehR, 2018) The Stadtverkehr 2025 report describes the plan and progress on achieving its goals. (City of Zurich, 2017)

The focus of Stadtverkehr 2025 is to consistently promote public transport, pedestrian and bicycle transport, limit private transport capacity growth on the road network and reduce the negative environmental impacts of transport on the population. The plan describes 39 measures in 9 categories designed to increase the mode share of sustainable transport (public transport, biking and walking) in Zurich to 80% by 2025 (Figure 7).

Fig. 7: Improvement measures from Stadtverkehr 2025 – Source: City of Zurich, 2017.

The categories and selected measures from Stadtverkehr are:

- Public transport – many of the VBZ's public transport improvements outlined above;
- Public space improvements to enhance walking and cycling – urban design improvements and new links (e.g., pedestrian path to the lake at Tiefenbrunen S-Bahn station);
- Bicycle Master Plan – implementation of measures from bicycling master plan;
- Mobility management program;
- Noise reduction program – measures to reduce noise impacts (e.g., Tempo 30, i.e. areas with maximum allowed speed of 30 km/h);
- Parking planning and control – measures to reduce the use of public space for parking and use it instead to enhance the public realm;
- Traffic management – traffic control measures to support sustainable transport modes (e.g., cycling and public transport);
- Railway station improvement program – measures to improve connectivity and environmental quality at S-Bahn stations; and,
- Goods transport – measures to enhance loading zones and support electric propulsion.

As this summary shows, the Stadtverkehr 2025 proposes a broad set of measures designed to support sustainable transport. The 2016 report ends with a summary of progress and an outlook. It recognizes that progress has been made: the mode split for sustainable modes has increased from 70% to 75% between 2010 and 2015, but also that it will be difficult to reach the 80% goal soon. Especially critical will be implementation of measures to improve traffic safety and noise reduction, increasing public transport, building the bike network, and supporting sustainable goods transport. (City of Zurich, 2017)

Stadtverkehr 2025 shares several of the problems found in almost all sustainable urban transportation plans. While the individual measures are excellent in and of themselves, they are not always well coordinated with other measures and therefore miss the opportunity to be mutually supporting. Similarly, the plan does not fully acknowledge and address the major problem that many measures will require reallocating street space, which is highly political. These problems are further discussed below.

4. Conclusions and recommendations

Zurich's systematic implementation of public transport priority during the 1980s and 1990s has been extremely successful. In combination with S-Bahn improvements, public transport priority helped create one of the highest quality urban transport systems in the world. Remarkably, this combination continues to work successfully.

On the other hand, like other cities, Zurich faces significant transport challenges. Transport demand is increasing with the city's rapid growth. Residents are demanding better active transport and improved public spaces. New players, technologies and business models are rapidly disrupting the transport market.

Looking back, Zurich's public transport priority program was developed and implemented in an exceptionally favourable age: there was very strong political support for public transport and there were city staff willing to develop, test and implement innovative ideas such as Zurich's unique traffic signal control program (Nash, 2003; City of Zurich Traffic, 2012, and 2013).

Today the challenge is continuing to improve public transport, while developing and implementing measures to support increased walking and cycling, and to improve the urban environment – on an already highly optimized and spatially constrained street network. In this context, the most important lessons to be learned from Zurich's public transport priority program is the benefit of developing a fully integrated approach, creating an environment that supports experimentation and innovation, and building political support for solving complex problems. Today these same lessons should be applied towards implementing a coordinated plan for public transport, cycling, walking and urban liveability improvements. In other words, cities should move from creating and implementing *public* transport priority programs to *sustainable mobility* priority programs.

Many cities have developed and have started implementing sustainable mobility plans. But, as mentioned in the context of Zurich's Stadtverkehr 2025, many of these plans pay too little attention to how the measures work together and how specific sustainable measures can impact network-wide transport quality. One reason is a lack of analytical tools (e.g., travel demand models) that can accurately estimate the transport benefits of many sustainable transport measures (e.g., how does a new bike lane change travel demand?) (Fenton and Nash, 2018)

Furthermore, many sustainable urban mobility plans duck the highly political process of actually implementing sustainable transport priorities by, for example, reallocating street space away from private motor vehicles. While there are good examples (e.g., New York) of cities implementing sustainable transport improvements without affecting motor vehicle traffic, often private traffic needs to be reduced to provide space for public transport, cycling, scooters, walking and improving public spaces.

Developing multi-modal sustainable mobility priorities in cities like Zurich, where public transport has long been the key player is difficult. Many public transport agencies are under such strong pressure to reduce costs that it's difficult to even discuss ideas for reallocating space from public transport to cycling or pedestrian space, although these negative changes could be balanced by positive changes in other areas. This is in spite of the fact that cyclists and pedestrians are the natural allies of public transport. In short, developing new priorities will require education, careful stakeholder involvement and creativity.

Agencies in Zurich have started the process of reconsidering some long held positions which could form a foundation for developing new multi-modal sustainable transport priorities. Some questions currently being discussed include:

- Can public transport operate effectively (enough) in Tempo 30 zones?
- How can Zurich's public transport network better serve tangential and inner-suburb demand?
- How should private vehicle transport be managed in a network with severe bottlenecks?
- Should Zurich's traffic signal priority program be replaced with a new approach?

In short, Zurich's experience shows that it is possible to successfully implement an innovative and effective public transport priority program. Today cities could use these same strategies to successfully develop and implement a coordinated multi-modal sustainable mobility program.

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