



# KVU OSLO- NAVET

## Benchmarking Oslo vs other European cities

---

<b>Ferdigstilt:</b>	8. juni 2015
<b>Prosjekt:</b>	KVU Oslo-Navet
<b>Forfattere:</b>	Axel Kuehn, Karlsruhe og Bernt Nielsen, Göteborg
<b>Prosjektkontakter:</b>	Terje Grytbakk, KVU-staben
<b>Vedlegg til:</b>	Delrapport 3

---

### Sammendrag:

Dette notatet tar for seg en sammenligning av Oslo og ni europeiske byer. Kriteriene som er brukt er blant annet befolkningstall, bilhold, alderssammensetning og rolledeling mellom kollektive driftsarter. Notatet tar utgangspunkt i en presentasjon som Axel Kuehn holdt på KVU Oslo-Navets verksted i juni 2014.

## Introduction

Axel Kuehn and Bernt Nielsen have been asked in early 2014 by Jernbaneverket to accompany the KVVU Oslo-Navet as independent experts.

As part of their activities they have delivered a number of reports and presentations which are summarised in their final statement of 29<sup>th</sup> April 2015 (“Anbefalinger fra Kuehn og Nielsen”).

One of the presentations by Axel Kuehn, to which Bernt Nielsen has contributed, has been “**Benchmarking Oslo vs other European cities**”. Contentwise connected to this presentation was a separate one called “**PT-modes, scope, success conditions and capacities**”.

To allow proper integration into the KVVU documentation it has been decided to convert the ppt-files into a proper report format which is presented herewith. The wording and “bullet-point style” of the presentation has been left more or less unchanged. Diagrams and pictures, if not specifically sourced, are © Axel Kuehn.

The idea of the “benchmarking” was to see Oslo in comparison with other European cities.

The benchmarking included 9 cities from 6 European countries with a population in the city ranging from 390000 – 799000 and a population in the agglomeration of 1.0 - 2.5 Mio.

<b>Oslo (No)</b>	<b>630000</b>	/	<b>1502000</b>
<b>Gothenburg (Sw)</b>	<b>530000</b>	/	<b>1580000</b>
<b>Stuttgart (Ger)</b>	<b>613000</b>	/	<b>2416000</b>
<b>Frankfurt (Ger)</b>	<b>690000</b>	/	<b>2222000</b>
<b>Leipzig (Ger)</b>	<b>520000</b>	/	<b>1090000</b>
<b>Zurich (Sui)</b>	<b>390000</b>	/	<b>1490000</b>
<b>Lyon-Villeurbanne (F)</b>	<b>636000</b>	/	<b>2188000</b>
<b>Amsterdam (NL)</b>	<b>799000</b>	/	<b>1428000</b>
<b>Manchester (UK)</b>	<b>510000</b>	/	<b>2553000</b>

The table below gives an overview of the PT-portfolio in these benchmarking agglós.

	Light Rail						
	Railway	Metro	/Tram	Bus	Funicular	Ferry	Other
Oslo/Ruter	✓	✓	✓	✓			✓
Gothenburg/Västtrafik	✓		✓	✓			✓
Stuttgart/VVS	✓		✓	✓			
Frankfurt/TraffiQ	✓	✓	✓	✓			
Leipzig/LVB	✓		✓	✓			
Zürich/ZVV	✓		✓	✓	✓		✓
Lyon/Sytral	✓	✓	✓	✓	✓		
Amsterdam/GVB	✓	✓	✓	✓			✓
Manchester /TfGM	✓		✓	✓			

## Problems to be acknowledged...

Problems or weaknesses:

- Area/agglo definition
- Data availability for area definition
- Data availability for railway share
- Train-kms  $\neq$  vehicle-kms
- Not all data for exactly same year

But: missing scientific perfection is ok as long as message and conclusions are still on safe side!

### **Data availability for area definition**

Service area of urban PT goes beyond city limits- data only available for PT-region.

Examples:

- Oslo – Ruter area 1.2 Mio population; bigger than city, smaller than “total” agglo = something “in between”
- Gothenburg – Västtrafik area bigger than actual Gothenburg agglo
- Lyon – Sytral area, same as for Oslo

### **Data availability for railway share**

For some cities railway data has not been available for the required area.

Examples:

- Leipzig, Lyon and Amsterdam

### **Train-kms $\neq$ vehicle-kms**

For “smaller” modes like bus or tramway there is nearly no difference between train- and vehicle-kms (for tramway only if double traction is used) while for metro and railway services based on multiple vehicle sets the difference is very important (for railways even more than for metros). However, train-kms are less available than vehicle-kms. See also discussion under “PT-modes in more detail”.

## Benchmarking criteria

The following general benchmarking parameters have been evaluated:

- Population
- Area size (=) population density
- Car ownership
- Age structure
- Unemployment
- Working places (=) working places /inhabitant
- Commuters incoming / outgoing
- Modal Split
- Fare single trip

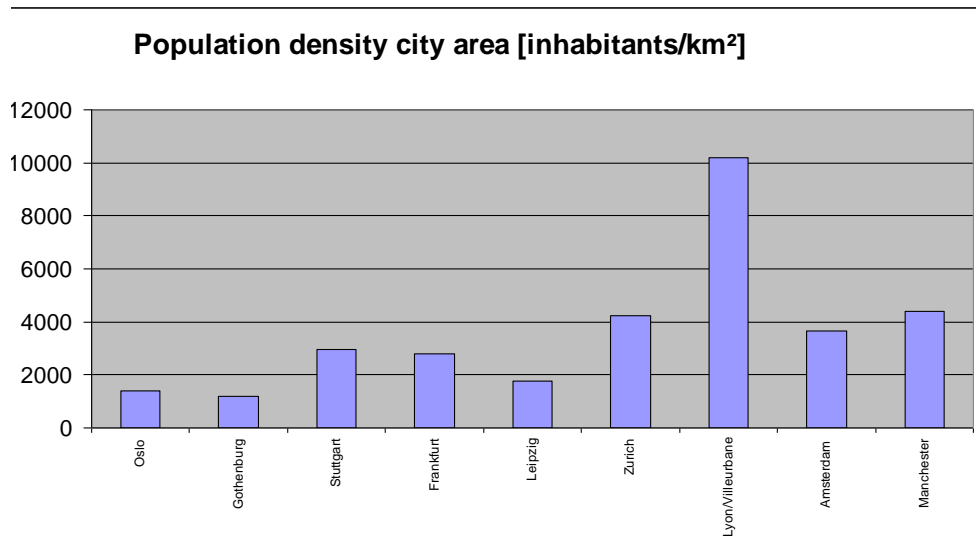
The following PT-related Benchmarking criteria have been evaluated:

- PT-offer (=) vehicle-kms/inhabitant
- PT-trips (=) PT-trips/inhabitant (=) efficiency
- PT-trips (=) PT-trips/vehicle-km (=) efficiency

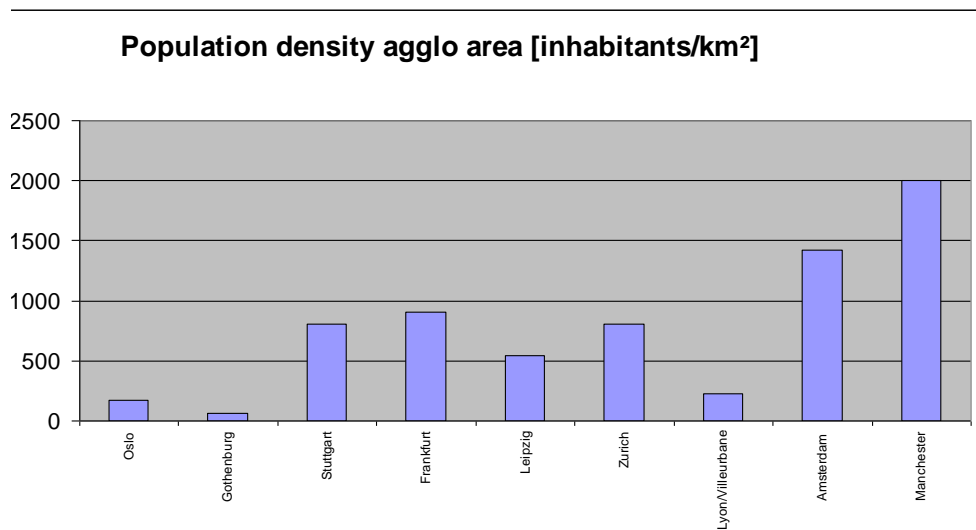
In some cases specific data for specific cities has not been available – this explains why there are some gaps in some of the diagrams in the following chapter.

## Some general benchmarking results

### Population density

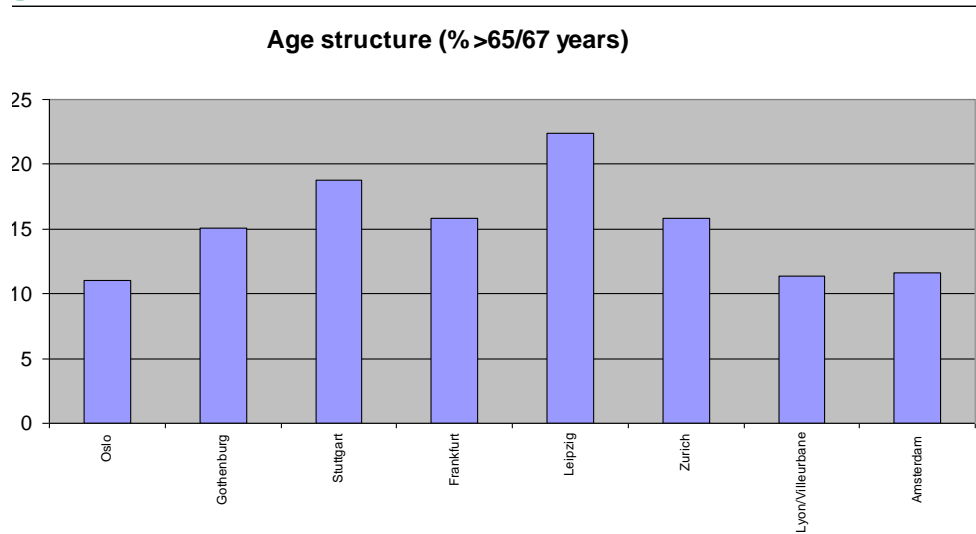


Oslo and Gothenburg owning the lowest density of the cities compared. Lyon together with its neighbouring city Villeurbane representing the high end.



For the aggro areas Oslo and Gothenburg show still the lowest density. It needs to be made the reservation here that the definition of the aggro area and respective data availability is an issue. For e.g. Gothenburg easily accesible data is only available for the whole Västtrafik area which is certainly much bigger than the “real” Gothenburg aggro. This means that the area of Västtrafik includes much more rural areas with low density which explains the low ratio.

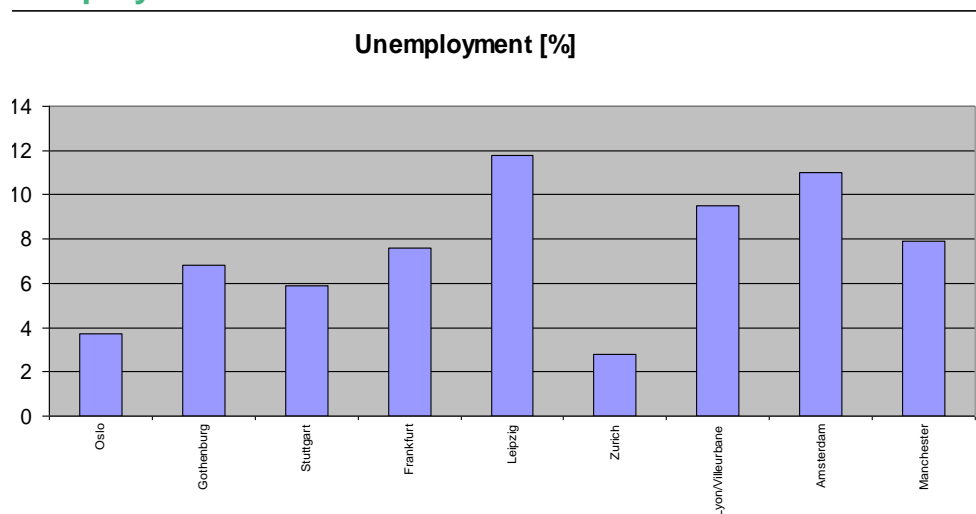
## Age structure



In regard of age structure Oslo appears to be the “youngest” of the cities represented – closely followed by Lyon and Amsterdam. The East-German city of Leipzig shows a share of inhabitants older than 65 years which is about twice as big as the one for Oslo.

Germany in average shows signs of an ageing society, but especially the East has seen considerable “westward” movements of young people since the re-unification. Understandably the opportunities, challenges and attitudes are rather different in “young” and “old” cities.

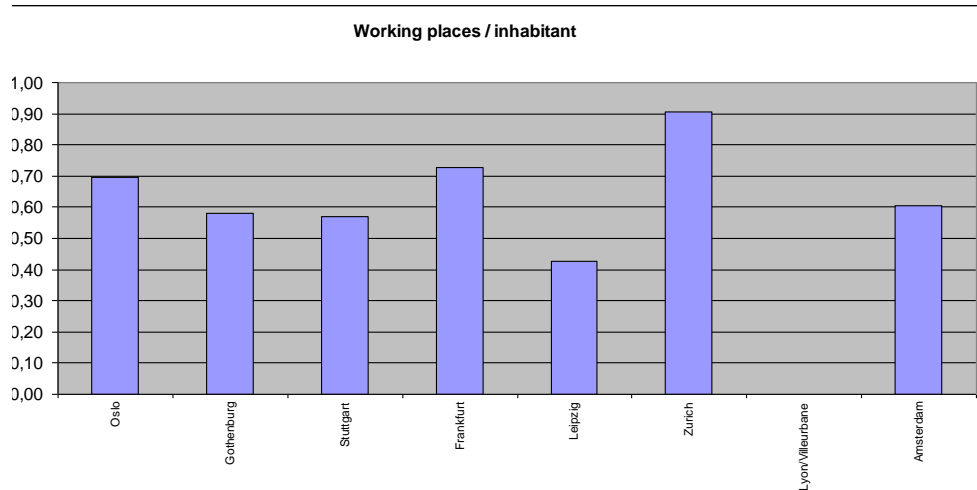
## Unemployment



Looking at unemployment levels Oslo comes in second-lowest behind Zurich. Leipzig shows the highest unemployment rate – three times higher than Oslo.

Together with the age criteria, unemployment is an indicator for lower or higher “activity” and “attractiveness”.

## Working places

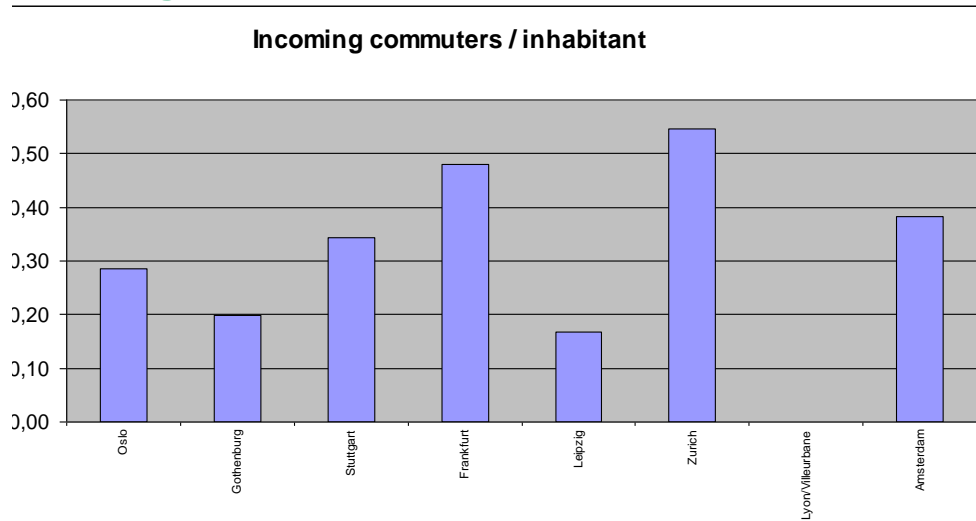


The ratio of working places per inhabitant is an indicator for the availability of working places. The higher the ratio the more work-related commuter traffic can be expected and the bigger the difference between day and night population will be. Zurich is leading here, Oslo is third closely behind Frankfurt.

It should be acknowledged, however, that statistics here are slightly influenced by the location of the city limits and whether work place concentrations are in one case just inside or outside.

In Oslo a lot of work places have been created or moved outside of the city limits in recent years (Lysaker, Sandvika, Fornebu...) which are therefore not counted – the fact that despite of such configuration “Oslo city” still shows a rather high ratio speaks definitely for a high economical importance and also for high commuter traffic.

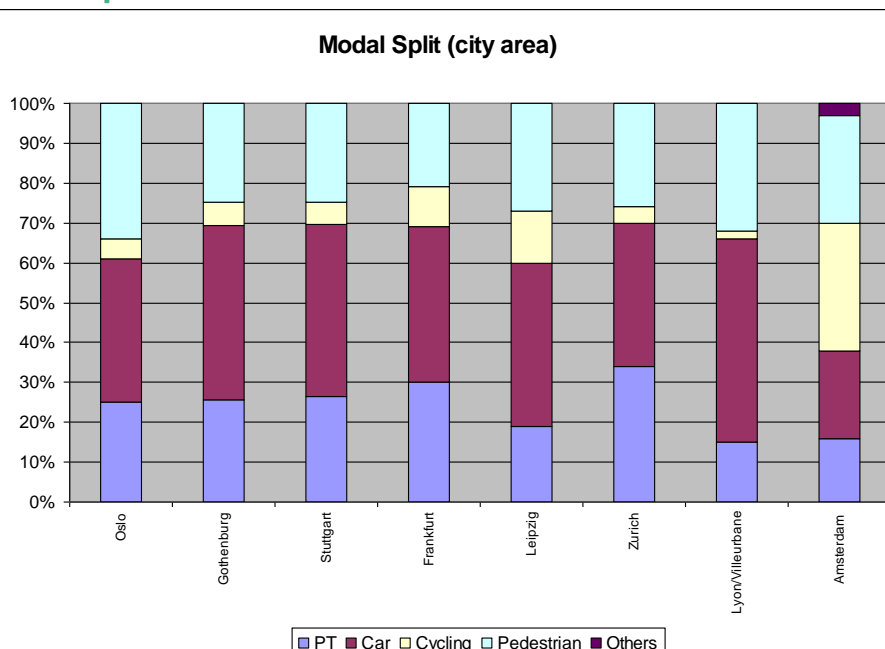
## Commuting



The ratio of incoming commuters per inhabitant is connected to the work place per inhabitant issue discussed above. Zurich and Frankfurt are leading here too while Oslo comes in 5<sup>th</sup> behind Amsterdam and Stuttgart.

Gothenburg, which was higher than Stuttgart in regard of workplaces per inhabitant is now clearly behind Stuttgart. This can be explained by different patterns in regard of work and home locations – in some cases the available working places in a city may be occupied to a higher extent by citizens and thus creating “only” internal traffic. Certainly the city structure and the location of “political” borders will have influence as well.

## Modal Split





In regard of modal split data a clear reservation has to be made as certainly the data used for the above diagram has been derived from a variety of sources which implicates also different years and possibly also different survey qualities. The diagram allows, however, the identification of some significant patterns.

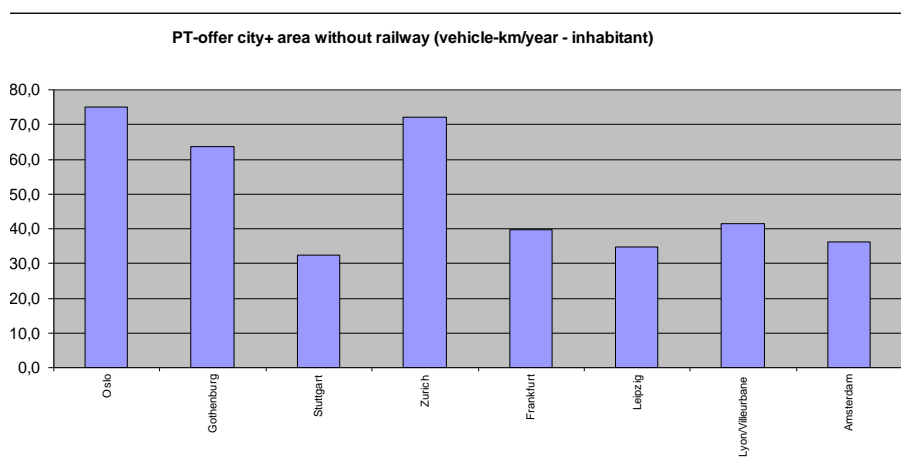
Oslo appears with the highest pedestrian share of all cities reviewed, a rather high public transport (PT) share, a “reasonable” private car share and a rather low cycling share. Lyon/Villeurbane shows a rather low PT-share paired with high car and very low cycling share – rather typical for French cities. Amsterdam, also typical for Dutch cities, shows a remarkably high cycling share which is at least partly responsible for the low PT-share, especially as the car share is also very low. Zurich and Frankfurt are showing the highest PT-shares.

### Some PT-specific benchmarking results

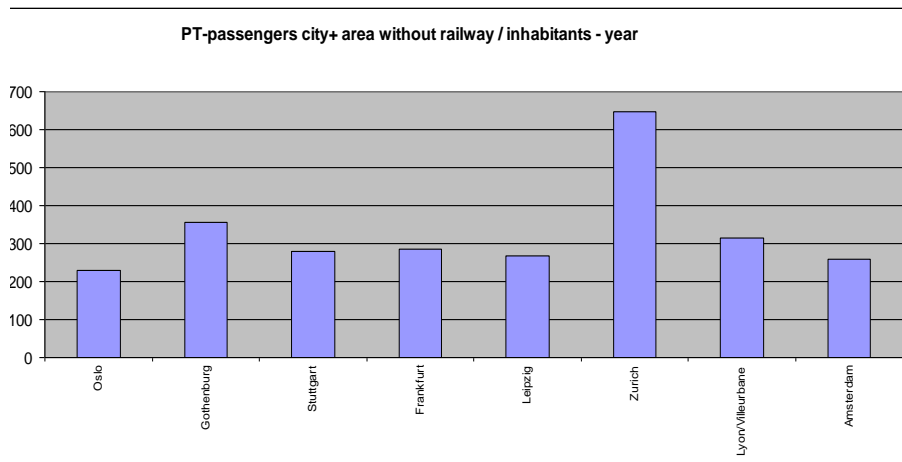
The benchmarking here concentrated on highlighting the input (size of offer) and output (patronage, number of passengers) of the PT-system.

Due to data availability being dependant on PTA-areas, the respective areas are usually larger than the political city but smaller than the agglomeration (therefore “city +”).

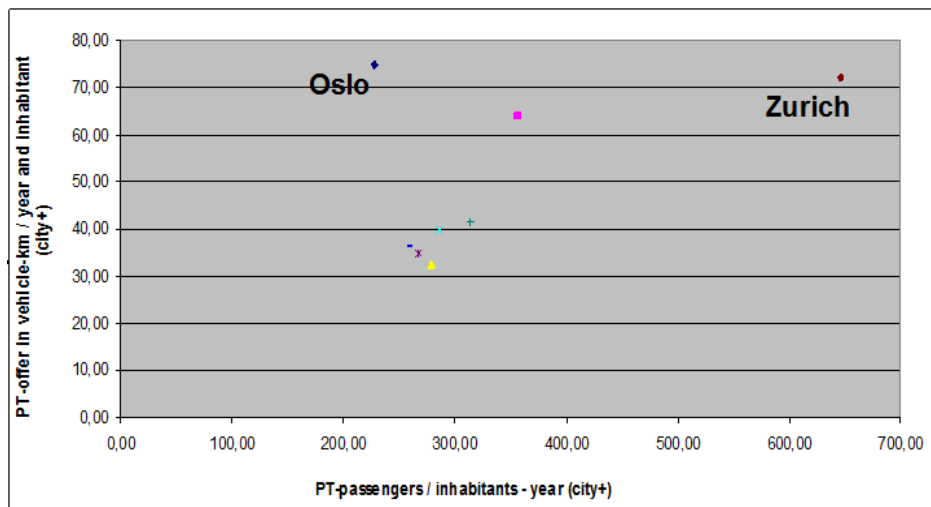
The size of the offer can be described by the amount of vehicle-kms offered. Data availability is also rather high for this parameter. As the exact contribution of railway traffic to the total PT-offer respectively its patronage share showed to be difficult to obtain for a number of cities, the diagrams below exclude railway traffic.



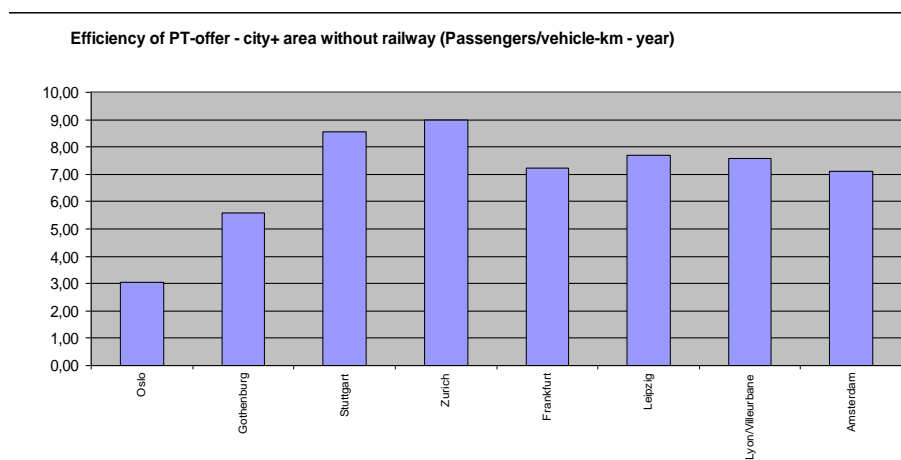
For the input side it is apparent that Oslo comes in first – spending most vehicle-kms per inhabitant and year. Zurich follows closely and also Gothenburg belonging to the “top 3” (65-75). All other cities are in a 30-40 range which has been identified in other benchmarkings for medium-sized cities as kind of a “standard input size”.



Interesting appears to be the look at the output side where Oslo comes out last and Zurich first (Gothenburg third). The following diagram combines input and output in one.

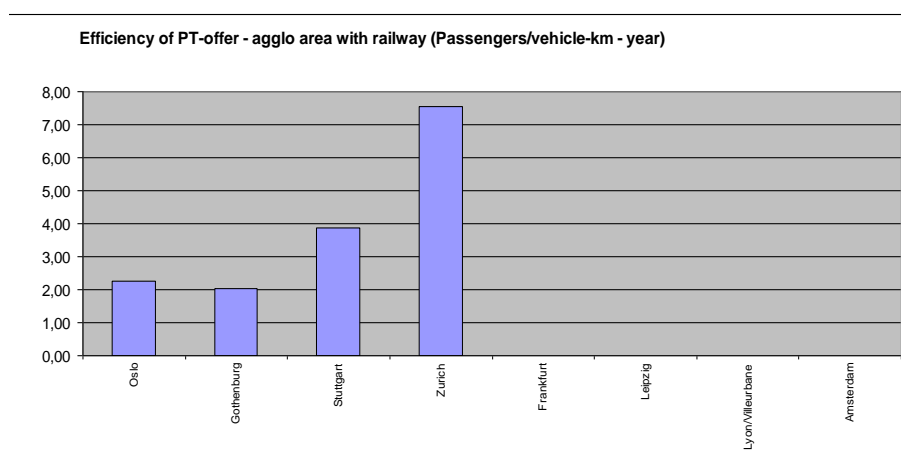


The result makes very clear that Oslo has not really an input problem – it is more an output problem! Or one might speak of an efficiency problem, as described in the diagram below.



The ratio of passengers and vehicle-kms shows again Zurich in the lead position but one could see all cities except the two Scandinavians in a certain corridor (7-9). Gothenburg appears half-way between such corridor and the Oslo-result.

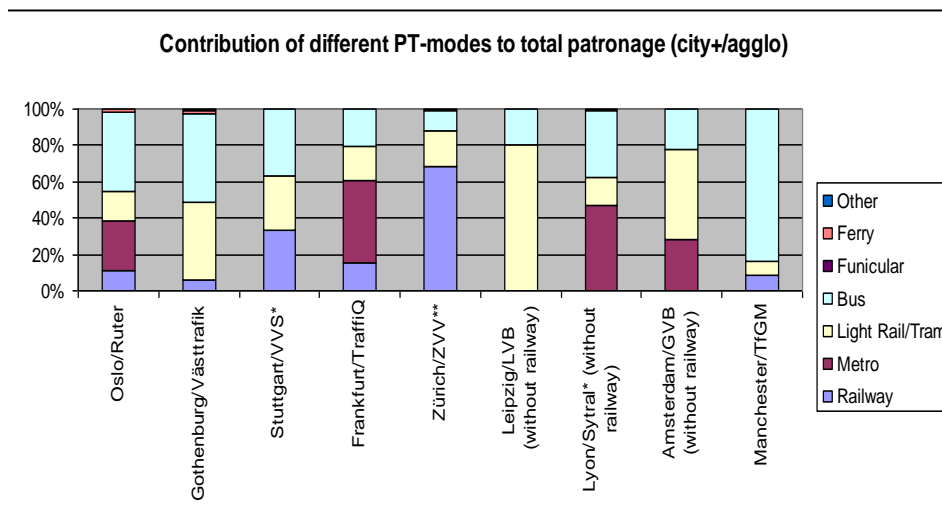
Such differences between Oslo and other cities evaluated here are confirmed when looking at the agglo (respectively PTA-area) and including the railway offer as far as it has been available.



## PT-modes in more detail

The following section of the report refers to the second presentation “**PT-modes, scope, success conditions and capacities**”.

The diagram below highlights the different patronage shares (passengers/trips per year) in the different cities respectively city regions / agglomerations.



For Oslo it is visible that the bus with slightly more than 40 % still plays an important role, metro and tram appear stronger than railway.

For Gothenburg (Västtrafik area!) the light rail share is much larger which is understandable as there is no metro system. Bus appears even more important and railway even smaller, both results are plausible with regard to the much larger Västtrafik area covering a lot of rural region.

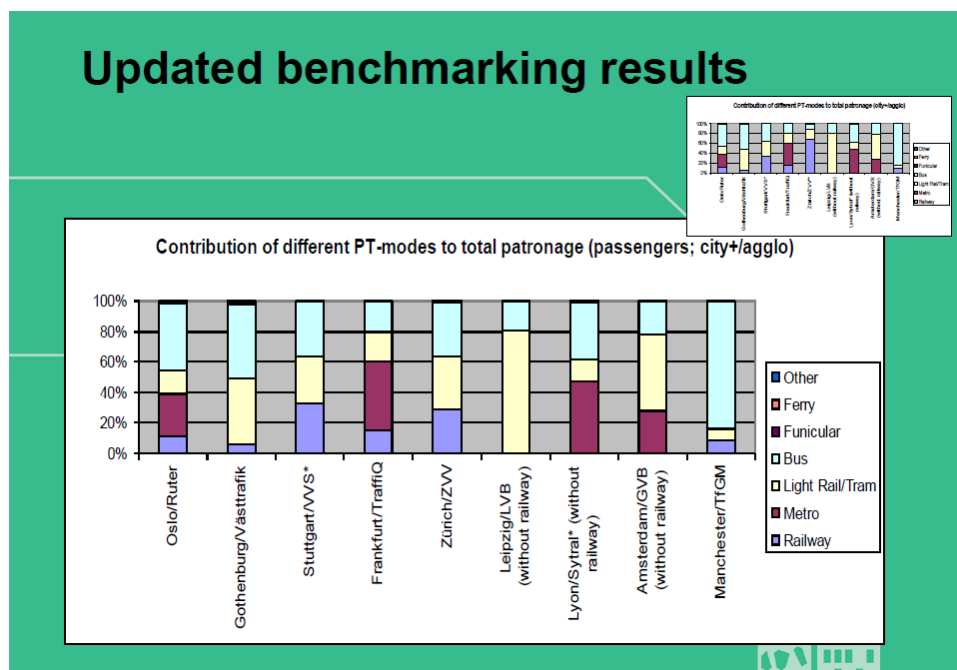
Stuttgart with its S-Bahn scheme shows a much higher railway share on the same level as light rail and bus.

Frankfurt shows the largest share for the metro (about 40 %), railway share rather low (understandable for the rather small, urban TraffiQ area), a very small bus share and a tramway share on the same level. Frankfurt has the same mode configuration as Oslo and is therefore suitable for direct comparison.

Zurich shows a dominating railway share (for the total ZVV-area!) and rather small bus and tramway shares. When investigating this further it became clear that the Zurich shares in the diagram above were actually based on passenger-km and not passengers/trips which understandably gives a much higher railway share as trips are longer there.

With new data made available by ZVV the share of the railway (now based on passengers/trips) turned to a more normal picture. With data for the other cities unchanged the revised diagram below was shown at the June 18<sup>th</sup> workshop.

## Updated benchmarking results



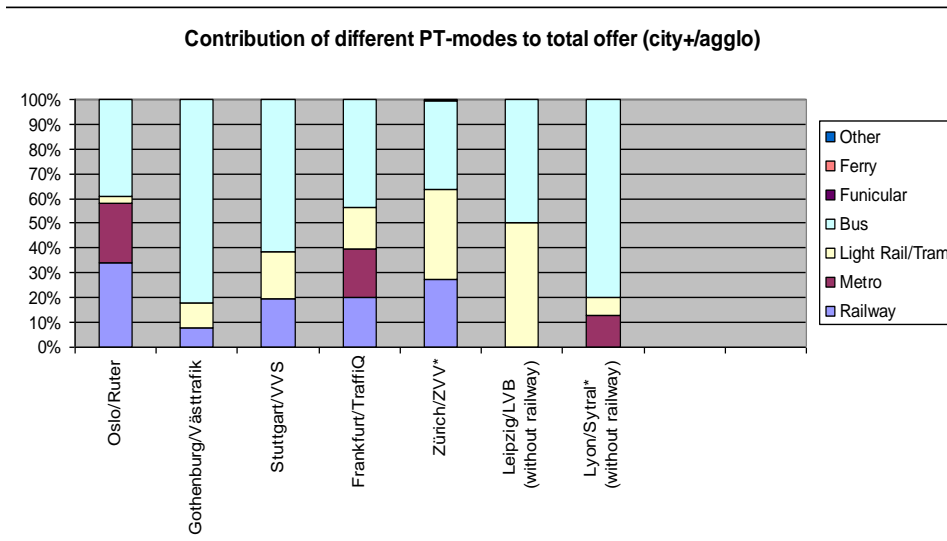
Leipzig is difficult to use as railway data for the urban region (LVB) was not available. It can be assumed that the (unknown) railway role will grow even on urban level with regard to the newly opened city railway tunnel. Interesting is the absolutely dominating light rail share against the bus on urban level.

Lyon like Leipzig doesn't give railway patronage numbers but shows a rather high metro share (like in Frankfurt) but a considerably higher bus share. The tramway role will likely further grow when further network extensions will be in service – one should acknowledge that the first tramway line was opened in 2000.

Amsterdam shows a dominating tramway role with metro as the second and bus as the third player. Again railway data wasn't available for the GVB area.

Manchester gives a surprising picture with an absolutely dominating bus share of over 80% for the Greater Manchester area.

The following diagram highlights the contribution of the different modes to the total offer (vehicle-kms/year). Unfortunately data was not available for Amsterdam and Manchester.

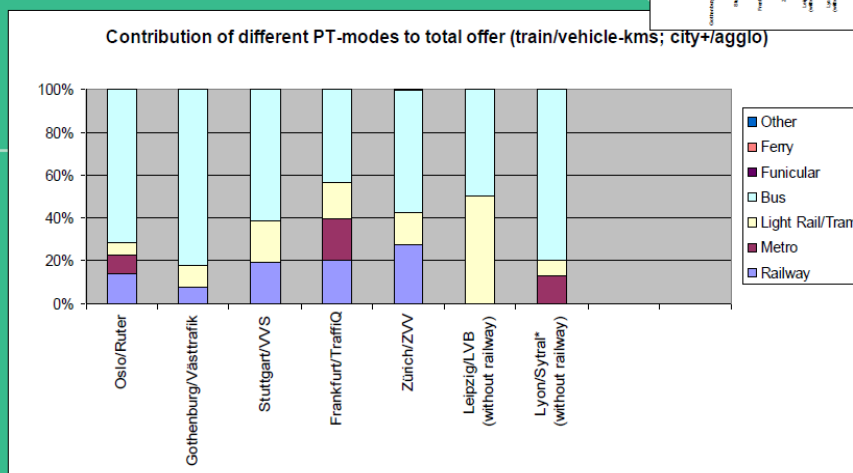


For Oslo it is first of all remarkable that the tramway share to the total offer is very low! Taking this and the patronage share in account one should acknowledge a very efficient and well used tramway. The railway share on the opposite appears on first sight rather high – see below! The bus and metro shares appear more linked to their patronage outputs.

However, there was some criticism to the Oslo railway picture in above diagram raised during the June 4<sup>th</sup> 2014 workshop and such related to the use of vehicle-kms for the railway. See for reservations made in “Problems to be acknowledged ...”.

## Updated benchmarking results

Oslo: now train kms Railway/Metro



In the diagram above, which was presented as an update at the June 18<sup>th</sup> 2014 workshop, train-kms have been used for the Oslo metro and railway services. Unfortunately train-kms are not generally available for all benchmarking cities.

The revised Oslo picture confirms now a very dominating bus share to the total offer (like in several other cities) and a much smaller metro and railway share, much more comparable to the results of other cities.

For Gothenburg respectively the widespread and largely rural Västtrafik area it becomes apparent that the bus share is absolutely dominating. Also visible that the light rail system gives a much better input/output ratio (like for Oslo).

Stuttgart gives similar evidence. The bus share of 60 % results in a patronage share of just 40 % while railway and light rail with together 40 % of the offer delivers 60 % of the total patronage.

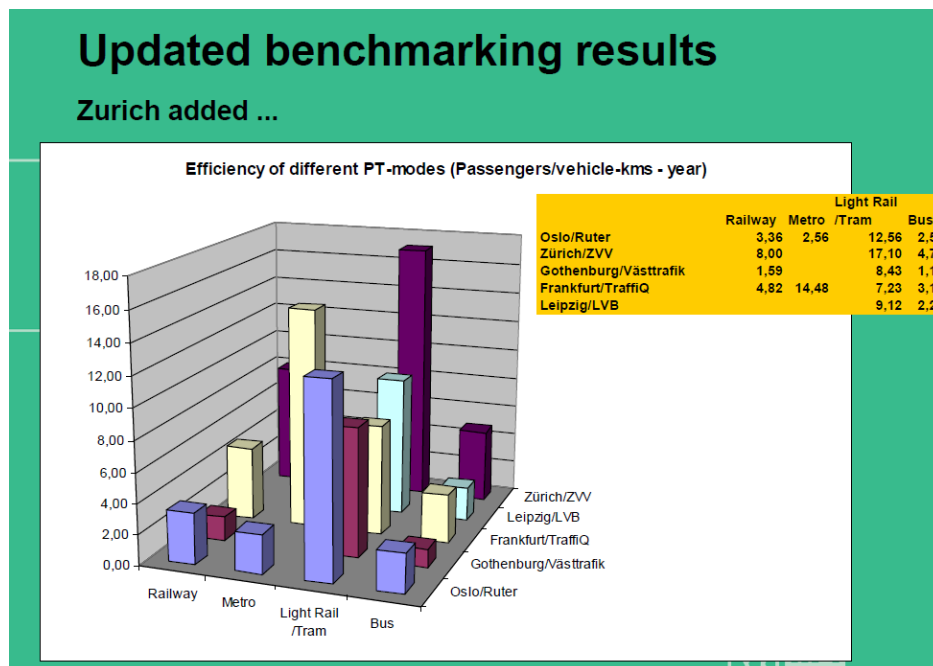
Frankfurt again confirms the “efficiency weakness” of the bus and shows a rather efficient metro system.

Zurich gives evidence of the very high railway efficiency in this scheme.

Leipzig, even with data being available for two modes only, is another nice evidence for the very different input/output ratios of bus and tramway/light rail – such evidence can be found in most French tramway cities btw.

Lyon hints into the same direction: a very high bus share on the offer side paired with a much smaller patronage share while the metro appears to deliver a much higher patronage share with much smaller input.

The diagram below represents the final version presented during the June 18<sup>th</sup> 2014 workshop. It was based on the updated data (as discussed above) and gives kind of an efficiency picture combining input and output data.

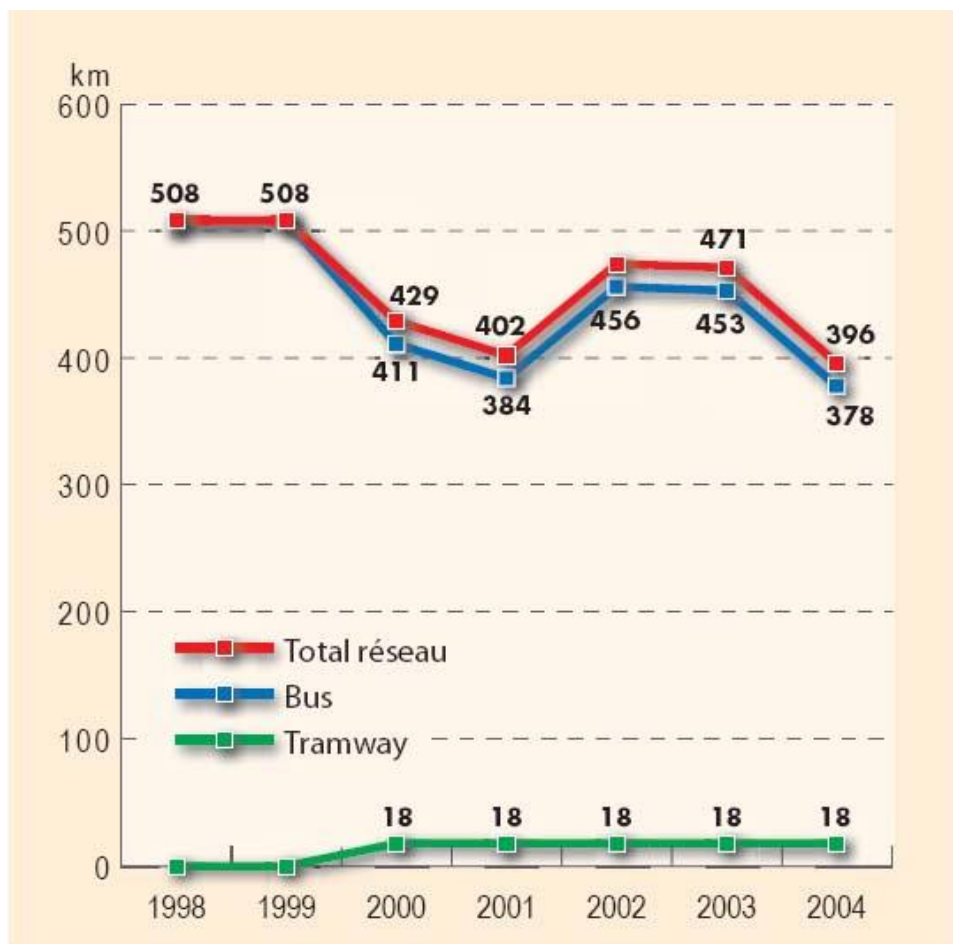


Visible is the big efficiency difference between bus and tram/light rail for all 5 cities for which data could be obtained. The Oslo tramway is only topped by the Zurich scheme!

Visible is also a rather high difference between the Frankfurt and Oslo metro system which appears reasoned by the much different network patterns which “force” the Oslo scheme to operate far into the countryside with rather low patronage at the outer ends while the Frankfurt metro concentrates much more on a “core” metro market.

The bus-tram comparison deserves a more detailed look at one of the French cases mentioned further above.

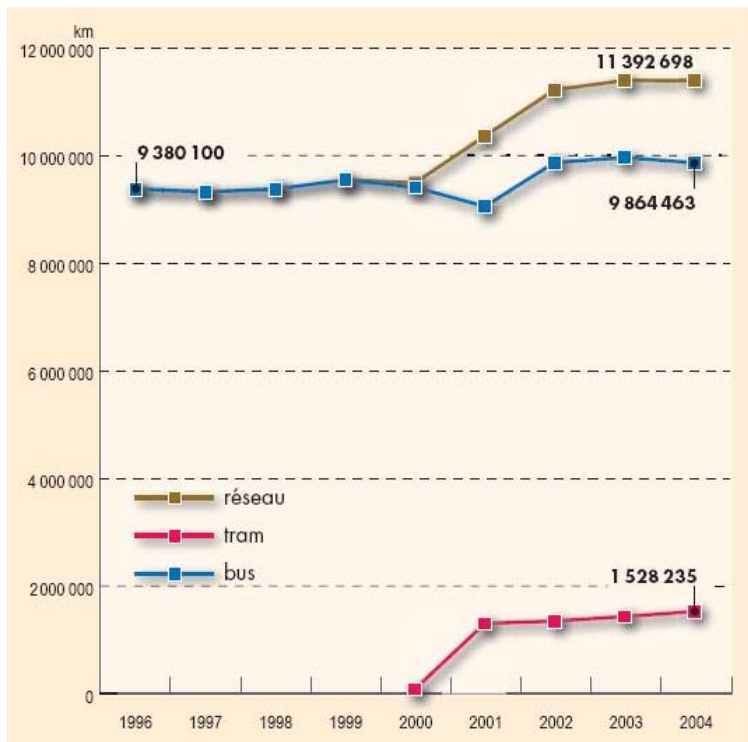
The diagrams below are taken from the Transport Masterplan of Orleans which presented the changes from pure bus network to a bus + tramway network over a seven year period.



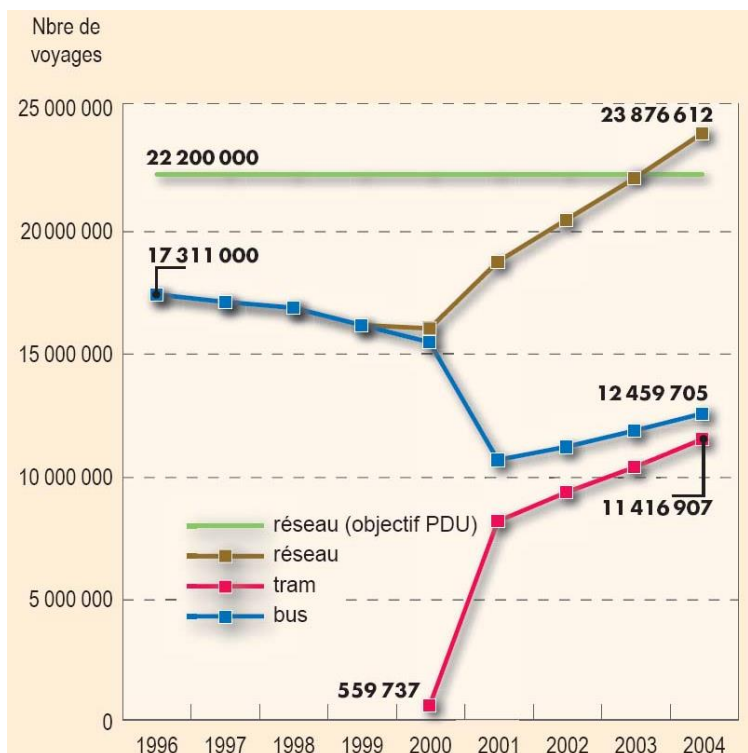
(Source: AUAO - PDU2005)

The first diagram above highlights the network kilometres (total line lengths) and shows a total of 508kms before the opening of the first tramway line. With the 18km tramway opened in 2000, the bus network was adapted to a more feeder system and the total line length was reduced. The following two diagrams highlight the vehicle-kms spent and the passengers / trips produced in the Orleans system during the period 1996-2004.





(Source: AUAO - PDU2005)



(Source: AUAO - PDU2005)

Input:

The bus network before the opening of the tramway spent 9.38 Mio vehicle-kms.

After a slight decrease of the bus share after the opening it showed a small increase until 2004 to 9.86 Mio vehicle-kms. The new tramway adds 1.53 Mio vehicle-kms to a total of 11.39 Mio vehicle-kms.

#### Output:

The total patronage before the opening of the tramway was 17.31 Mio in 1996. The patronage target for the tramway project was set at 22.2 Mio within 5 years after the opening. The years of the construction of the tramway showed a slight decrease of patronage but afterwards a steep increase to 23.88 Mio in 2004 can be noted.

The total patronage is composed by 12.46 Mio in the bus network and 11.42 Mio in the tram network.

#### Input vs output:

Bus: 9.86 Mio vehicle-kms produce 12.46 Mio passengers / trips

Tram: 1.53 Mio vehicle-kms produce 11.42 Mio passengers /trips

The backbone role of the new tramway is clearly visible: it produces with only 13% of the vehicle-kms 48% of the total patronage.

Such backbone role is only possible if the tramway corridor allows effective operation (= high enough demands + segregation/priority) and if the bus network is restructured accordingly.

## Success criteria for surface modes

Most important feature: Priority and independence from car traffic



## Tramway priority at junctions



Avoiding being stuck in car traffic jams...



... by creating car-free environments (e.g. pedestrian zones in central areas) ...





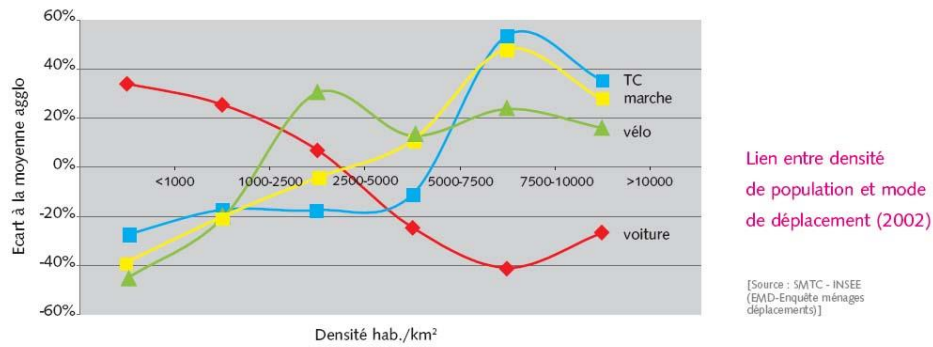
... or by segregated alignments (road space taken from car traffic).



Busway solutions mean also segregated alignments!

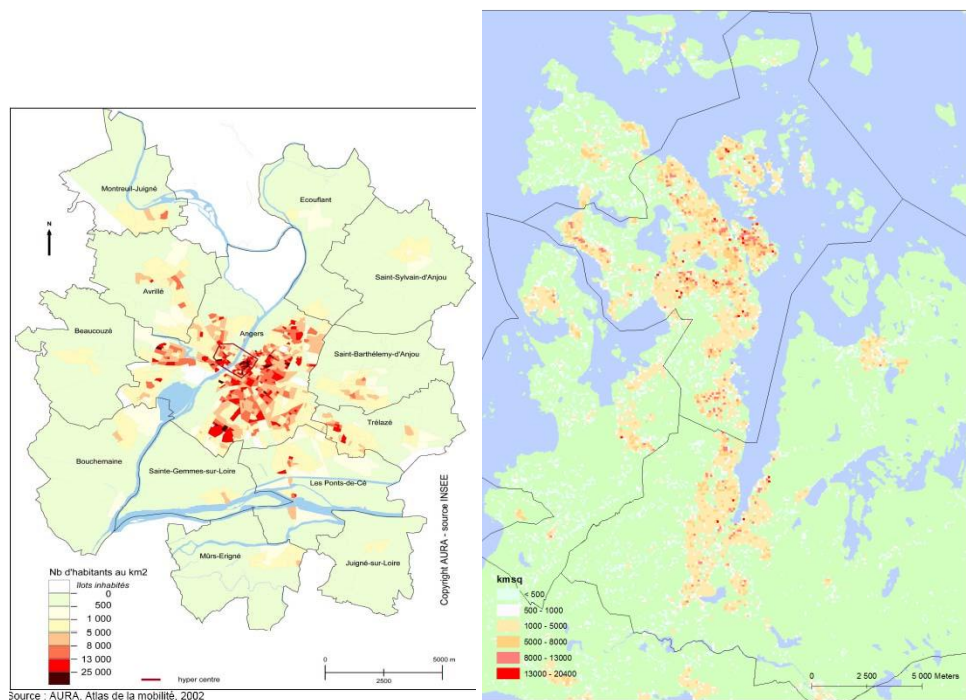
**“Surface” modes can play an important role in PT-systems – even on agglomeration level! But they need to be “treated well” ...**

**... and land use patterns (housing) are of big influence (not only for “surface” modes)!**



(Source: SMTIC/INSEE (PDU Grenoble))

This diagram presents empiric evidence from Grenoble / France. Population density is directly influencing car respectively PT-use: low densities favour car traffic, high densities favour PT-use.

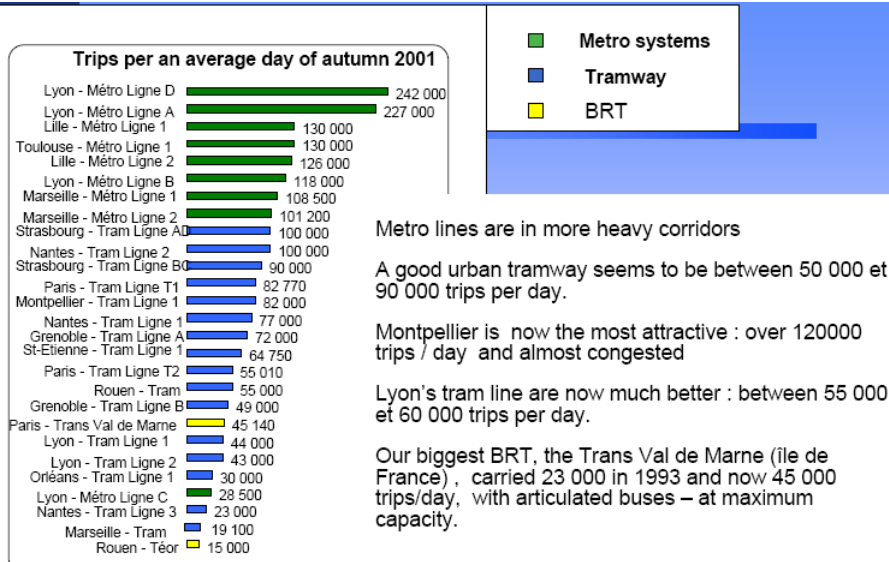


(Source: SYTRA & Angers Agglomération (left), Rogaland Fylkeskommune (right))

The two maps show densities in Angers / France (left, one of the newer French tramway cities) and Stavanger and Sandnes region (right). It is easily visible that city structures and densities are offering very different success conditions.

## Capacities of different PT-modes

When discussing the role of different PT-modes within a network it is important to have an understanding of the capacities linked to specific modes. The slide below gives an overview of French metros, tramways and busways and their daily passenger load per line.



Metro lines are in more heavy corridors

A good urban tramway seems to be between 50 000 et 90 000 trips per day.

Montpellier is now the most attractive : over 120000 trips / day and almost congested

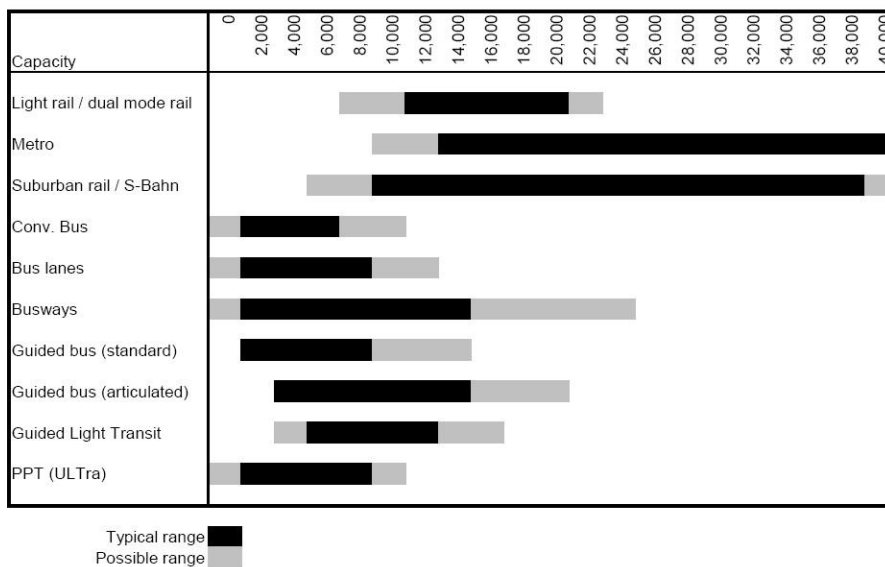
Lyon's tram line are now much better : between 55 000 et 60 000 trips per day.

Our biggest BRT, the Trans Val de Marne (île de France) , carried 23 000 in 1993 and now 45 000 trips/day, with articulated buses – at maximum capacity.

(Source: CERTU)

It is clearly visible that metro lines form the top end with passenger loads ranging normally from 100000-240000 while “good urban tramway lines” are seen in a range from 50000 and 90000 passengers / trips per day. Some top tramways, however, can reach metro levels and there are busways which reach the low end of tramways.

Figure 2: Carrying capacities for selected PT systems (passengers/hour/direction)

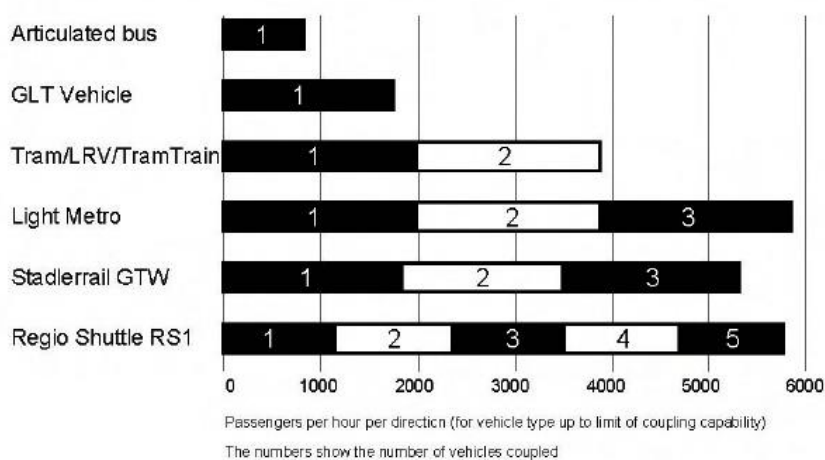


(Source: TEST-project)

The diagram above highlights the carrying capacity of different modes related to hourly passengers per direction for “typical” and “possible ranges”. It is visible that light rail, metros and suburban railways principally start in the same range but show differing maximum limits. The rather high capacities shown for Light Rail / Dual Mode rail (TramTrain) are certainly related to long vehicles and double traction (eg 80m trains) and not to a classic urban tramway.

A weakness of the diagram, however, is the lacking of information regarding the assumed frequencies of different modes. The diagram below works with a different approach and uses a standard 5 minute frequency for all modes – resulting in considerably lower capacities!

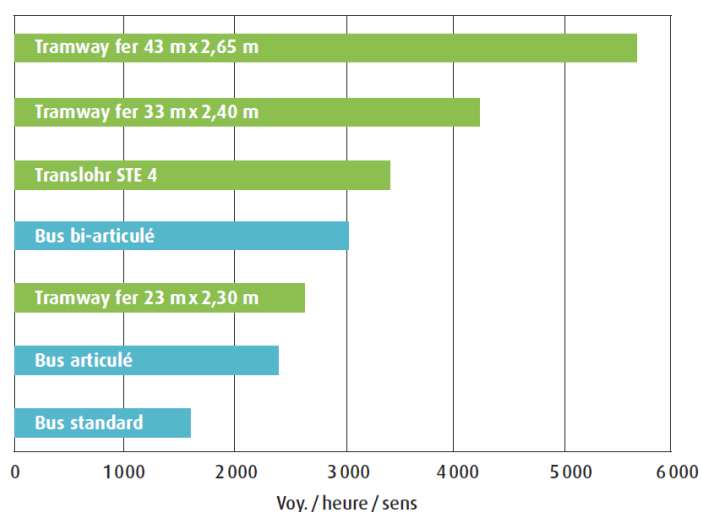
### CAPACITY OF A 5 MINUTE INTERVAL SERVICE



(Source: HITRANS / Interfleet)

The following diagram goes more into detail with the capacity of different vehicle dimensions for urban areas (tramway/bus).

### Capacité maximale des matériels (4 pers./ m<sup>2</sup> - fréq. 3 min.) (source: Certu)



(Source: CERTU)



The results are more confirming the HITRANS-diagram.







This is only a small selection - there are quite many diagrams from different sources which clearly recommend not just to believe in one!

But there seems to be general evidence and agreement that there are “gray zones” or overlaps both between the bus and tramway world and the light rail, metro and railway worlds. If demands are meeting such overlapping capacity ranges there is no “automatic” decision for the “one and only” mode.

## Vehicle trends and varieties

The two slides below are just meant to give a glimpse on vehicle and train varieties in the tramway and railway world.

The first diagram presents the changes within the Leipzig fleet between 2002 and 2011 with a clear trend towards replacing multiple sets of small tramways by large light rail vehicles.

Fahrzeugtyp (15m-Einheiten)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
T6A2/B6A2 	42	42	42	42							
B4DM/T4DM/B4D-NF 	304	287	275	257	238	197	175	175	170	152	
NB4 	38	38	38	38	38	38	38	38	38	38	
NGT8 	112	112	112	112	112	112	112	112	112	112	
LeoLiner 				3	3	19,5	33	48	48	64,5	75
Classic XXL 					18	48	72	72	72	72	81

(Source: LVB)

The second slide shows the variety of S-Bahn train compositions used in the Zurich system. All major S-Bahn corridors are served by double-deck trains but within those there are several variations depending on the required features.





## Die Flotte: über 200 S-Bahn Kompositionen

DPZ Plus (112)



DTZ (61)



Regio Dosto (ca. 50)



HVZ Dosto (ca. 15)



(Source: ZVV)

## Conclusions + lessons (to be) learnt

The benchmarking, despite of any data weaknesses, allows some basic findings:

- Oslo owns low density patterns which favour car traffic
- Oslo requires therefore a rather high PT-offer to reach (all) citizens
- Oslo appears to run considerable amounts of parallel PT-services into the centre
- Oslo patronage mismatches with offer (high input – low output)

Resulting questions:

**Should (Could) the development of a new future-oriented PT-strategy be used for strategic changes?**

**Is PT-efficiency a target?**

**Attention:**

**A new infrastructure is not automatically implying a new strategy!**

Further conclusions can be drawn when looking at the different modes which are available within the Oslo network.

**The input/output ratio of Oslo PT-modes is telling something...**

Railway: scope for better role/use  
Metro: outside peak-hours likely lots of surplus capacity  
– operational patterns to be checked  
Tram: appears to be popular and promising for playing a better role  
Bus: too dominant role

**Don't forget the surface modes when composing the future network!**

Axel Kuehn, Karlsruhe

10 June 2015