

# **A PROCESS APPROACH TO PUBLIC TRANSPORT DESIGN**

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## **1. INTRODUCTION**

### **1.1 Metropolitan public transport design, two colliding approaches?**

In the Netherlands (V & W AND VROM, 1992) as elsewhere in the Western world (LEVÈFRE AND OFFNER, 1990) public transport is regarded to be a promising instrument to mitigate the adverse effects of rapidly growing mobility (BANISTER, 1994). This is especially considered valid for urban and metropolitan areas (BERECHMAN, 1993). Here public transport's advantages form a firm condition to keep modern city centres accessible. Public transport can cater for the very dense transport flows, on a relatively limited quantities of the scarce urban land. In addition, the environmental performance of public transport is considered to be higher than that of the car, in the fields of safety, emissions and the possibility to control noise.

Despite governmental support, public transport has not been successful in its role of reducing car traffic yet (JENKINS, 1987). Scientist engaged in public transport have given different reasons for this phenomenon: spatial developments favour the car system (JANSEN, 1985), the dilemma of individual benefits and social costs of transport (NIJKAMP, 1994), a public transport business showing little demand orientation (BERECHMAN, 1993), and the quality of the competing car (NIJKAMP AND PRIEMUS, 1994). Accordingly, they offer different solutions.

Traditionally, transport engineers have developed conceptual models that combine spatial demand patterns with engineering characteristics of different public transport technologies (EGETER E.A., 1989). This resulted in suggestions on a co-ordinated hierarchical network of services, combining the strengths of different public transport techniques (VUTCHIC, 1981). This approach still has fervent supporters in the German language area of Europe.

In addition, economists have targeted the fact that public transport providers have been inflexible and little susceptible to demand. They sought solutions in a redesign of the regulatory regime (BERECHMAN, 1993). Companies should be responsible for the product and should harvest the financial implications, both in positive as in a negative sense. This approach now finds its main advocates in the Anglo-Saxon parts of Europe.

Other scientific fields have projected their theoretical frameworks on to the problems of public transport to provide different types of solutions. But, the two mentioned above have to be regarded as the two most influential lines of thought in public transport policy making today. Throughout Europe they can be recognised in attempts of various governments to restructure public transport (GRÉGOIR AND MAUBOIS, 1994).

The different approaches mentioned offer useful contributions to the search for better public transport on a metropolitan level. Policy makers however are confronted with contradictory recommendations, especially in the field of co-ordination of services. No framework exists to assess the merits and weaknesses of the different approaches when they are used in combination to restructure metropolitan public transport systems.

## **1.2 Need for a comprehensive multi-disciplinary approach**

The multitude recommendations makes it hard for policy makers on a metropolitan level to develop a sound policy, making public transport more efficient and more effective. They understand the line of reasoning of the traffic engineer: public transport has to be a hierarchical network of services to be attractive for the traveller. Co-ordination, in terms of uniform ticketing, clear schedules and interconnection nodes will enhance the quality of the product. In addition, they understand the economist: companies should work efficient and follow trends in demand, and open competition will offer them a strong incentive to do so. Furthermore, they find themselves presented with a dilemma knowing that the design of a network by a single agency for integration sake obscures the possibility of flexible competition between a number of competitors.

In different European countries various directions are pursued to restructure public transport, in order to compete with the car. Switzerland and England show the most extreme examples, Switzerland of the integration of services in a hierarchical network and England of deregulation and privatisation of companies. In other countries choices are less extreme, policies reflect major influences from both theoretical schools, for instance in France and Denmark.

A framework to analyse and evaluate the consequences of a specific policy on these matters does not exist. It should address how regulation, co-ordination and the design of the services should be structured comprehensively in order to achieve synergy on efficiency and effectivity. The development of such an integral framework cannot be undertaken from a single scientific theoretical background. The contributions of different theoretical disciplines have to be assessed in the light of their effect in practice on the efficiency and effectivity of metropolitan public transport systems. The only way this can be procured is by empirical analysis of the efficiency and effectivity of different types of organisation of public transport, that were developed in reaction of the dilemma presented here.

In addition, such a research can only focus on a process, incorporating the smaller processes of the set-up of a regulatory regime, devising co-ordination between companies, and the design of a network of services by each company. These different sub processes can be combined in to one process because their successive conditional character. The introduction of such a conceptual meta process makes a more integrated evaluation possible. This avoids that a separate judgement of the service network will prove the transport engineer right. And when only the regulatory regime is judged, who will prove the economist wrong? In practice these two are not linked in decision-making but their functional interdependence makes an analysis as a meta process possible. Section 2.2 will elaborate on the mutual interdependence of the different approaches.

Such a meta-process will have to be evaluated on the efficiency and effectivity of the metropolitan public transport system it generates. Effective is defined, for the purpose of this research, as a relatively high proportion in the modal split for public transport. Efficient is defined here as a relatively low contribution from governmental funds to the operational costs of public transport.

This paper describes the theoretical framework, the research approach and the first case results of a quest for an integral framework for the evaluation of different options of metropolitan public transport design processes, which in addition should help formulate improvements of existing processes.

## **2. THEORETICAL FRAMEWORK**

### **2.1 Operationalisation of multi-disciplinarity**

An empirical analysis without a theoretical framework is like stumbling through a dark closet, bringing out some objects and declaring that they reflect the structure in the closet. To ensure that most of the relevant aspects are represented in the analysis, a literature study was carried out. On the basis of a library search on public transport five scientific rationales were selected that have offered contributions to public transport design. Their contributions were only included to the extent in which they deal with public transport. It also shows that the discussion on public transport between the economist and the engineer in the practice of public transport design reflects only a part of the scientific work done on public transport design.

The five rationales are:

1. *An urban-geographical rationale*

This rationale focuses on urban-geographical developments and planning. Public transport is considered to have a specific role in an urban system. This rationale is very useful for the description of the relation between spatial developments and public transport. Examples can be found in urban-geographical studies that show the different urban structures and the effect of these structures on the possibility to develop a public transport service or network. Or the other way around, what is required of a public transport system when one wants to attain certain goals in spatial development or reduction of mobility. Some keywords are transport planning, land use policy, urban planning.

2. *A human-geographical rationale*

This rationale deals with the spatial behaviour of individuals and is included here as far as it concerns their actual trips and their wishes in the field of transportation in general on the one hand and in the field public transport in specific. This rationale tries to explain the urban-geographical developments described above by looking at why people have a certain spatial behaviour, both in localising themselves as in travelling through the space. The focus is typically on individuals and their travel patterns. Keywords are activity patterns, time space theory and constraints and domains.

3. *A policy rationale*

The success of actions to urge on other actors to show certain behaviour depends on a given set of limitations. These limitations can be understood in

cultural terms, in perception and configuration terms, in institutional terms, in terms of rules, or in process terms. This rationale tries to explain how individuals, or better actors (more or less uniform groups), react to certain stimuli and which stimuli are best used in what way to attain a certain change in behaviour. In the analysis, different perceptions are taken into account. On a more government oriented scale, it tries to explain how policies are developed and should be developed. Keywords are actors, public management, perceptions and steering.

4. *A technical rationale*

In order to attract people into public transport companies construct an (more or less) appealing public transport system and inform people about their product. Under study are the choice for different transportation techniques (bus, tram, underground, train) and their attributes, public transport network design (integration), and the optimisation of these. They are depicted here for as far as these factors are relevant for the development of a metropolitan public transport system. Input for this field are notions and data from urban transportation planning and the human geographical rationale. Keywords are (public transport) network design, optimisation, integration of techniques and transportation technique innovations.

5. *An economic rationale*

In the development of a great deal of policies, the assumption is made that actors behave according to an economics rationale. Actors are thought of as having a more or less economic way to deliberate their choices. The rationale tries to offer a framework which explains the choice processes by different actors. It does this both for individuals as for organisations. On the basis of these analysis it formulates institutional structures, in the form of optimal regulations. Keywords are privatisation, deregulation, regulatory capture and optimal regulation.

In this research, a set of design requirements was selected from these five rationales on which designs of public transport system are judged. This set forms the basis for the empirical data collection, it shows which aspects of the metropolitan public transport system had to be included in further analysis, which shelves of the closet were examined, and which not.

In order to avoid a confusion of tongues, because of the five different rationales, a terminology was defined, avoiding as much as possible conflicts in the language of the different rationales. A simple example of the problem is the term “network”, which is constructed of urban nodes and infrastructure in the urban-geographical rational, of actors and relations in the policy rational and of public transport services and interconnection points in the technical rationale.

## 2.2 Three level of analysis

In order to structure the search through the closet an analytical framework was developed. It consists of the process viewpoint as presented and three different levels, with a macro, meso and micro perspective (not concurrent with the economic use of these terms)

The levels are defined by the actors between which the main interaction occurs when the design is operational. For example, when governments demand the securing of certain interchanges between train and bus, governments participate in the co-ordination process on a tactical level. However, on an operational level the train and bus companies have to interact to secure the interconnection between their services. Companies operating together form the meso level. The direct involvement on an operational level of the government is nihil, though it can be significant in the design phase.

On the macro level interactions on an operational level are between governmental bodies and companies. It generally represents the regulatory regime. Though the design of the institutional framework is generally a governmental matter, often companies are involved in the design process to ensure their expertise and co-operation is fed into the process. It results generally in a legal framework or, for example, a tendering system or subsidising scheme for public transport services. In some cases interference of the governments exists also on the level of physical structures, for example when they provide special infrastructure for public transport or the design of a spatial structure best fitted to public transport.

On the meso level interactions operate reciprocally between companies. At an operational level, they have to ensure together that interconnections are secured. The design process on this level comes to a more or less integrated public transport system. It finds its justification in the fact that customers often don't just use the services of a single company, but of more companies in one trip. They consider public transport as a single product. How an integrated public transport network of services is constructed is dependent on the possibilities created by the regulatory framework on the macro level. Different forms exist: governments, can define a time-table with interconnection and carry the services out. When tendering public transport services, they can put forward a design of an elaborated time-table or they can demand certain connections, synchronisation points or a common traffic control.. Furthermore, they can rely on competition to ensure that people are transported at an interchange point, because demand exists.

Finally, on the micro level standard interactions operate between a company and the traveller. A service is offered and tickets are sold, supported by the design of a network of services, routing of busses, planning of drivers. Sometimes governments are involved in this design process but the final design operates between the customer and the company (be it a public or a private company). Meso and macro designs offer the framework in which the planner can design the network of services.

This stratified description of the public transport design process is a simplified one. In the real world processes on the three levels develop parallel and often completely detached. They do not follow on each other, though the fact that they present a set of constraints to each other might imply this. It is the structuration by this framework which makes the mutual influences of the processes visible by separating them. In addition, the framework makes it possible to scrutinise how the different types of decisions on regulation, on co-ordination between companies and on the design of the schedule influence each other.

The process approach offers another advantage. By taking a process perspective all rationales can be given their own place in the process finalising in a set of public transport services. Each rationale focuses on a specific level, but the solutions offered

bear implications for the other levels. For instance, the economical rationale focuses on the macro level, it suggest an optimal type of regulation. This bears implications for the meso level: from an economic rationale, competing bus companies should not be allowed work together to avoid the evolvement of a cartel. They can co-ordinate their schedules with other techniques (intercity trains, metro), but regional monopolies on a single techniques should be avoided. On the other hand, engineers from a technical rationale would start at the micro level, designing an integrated network of services to optimise the product. To produce such a network, a co-ordanative structure would be useful to design the network, and control its execution. Little can be left to the companies. This makes competition on the road is virtually inoperable. The proposed research approach makes it possible to come to an empirical evaluation of different applications of the rationales in the whole process.

### **3. RESEARCH APPROACH**

#### **3.1 Empirical analysis**

The first step of the research is to understand the meta process. On the integral approach incorporating public transport issues and process view, little theory is available. The main questions under consideration are how does such a process work, how is it structured, what or who structures it for what reasons and what product does it lead to. These questions and the object of study ask for case study research. (YIN, 1993) From the list of design requirements from the different rationales and the analytical framework (on macro, meso and micro level) a protocol was developed which is carried out in every single case study.

Five cases were selected on in a four step process: first, four different types of structuring of the process were distinguished, the paraphrase between brackets gives a depiction from a governmental perspective:

- Swiss model, governmental driven design and execution, (*"We define and produce public transport"* )
- English model, market driven design and execution, market control (*"Let the market define and produce public transport"*)
- Danish model, governmental driven design, market driven execution (*"We define public transport, but let the market produce it"*)
- French model, market driven design, governmental execution (*"Let the market define it, we'll produce it"*)

Second, the performance of a number metropolitan public transport systems reflecting the models above was assessed in terms of modal split and cost-effectiveness. Cases with the best performance were selected. Thirdly, cases were selected on comparability, focusing on a number of issues, including the spatial structure of the metropolitan area, number of inhabitants, size of the area, and the public transport services on offer. Fourthly, a Dutch case was added as a critical case.

In every case, processes on macro, meso and micro level are mapped, as is the quality of the public transport services, modal split and cost-effectiveness. At the point of writing this paper, the first case study in Zürich is completed, and one in Newcastle upon Tyne is planned, as is the Dutch critical case.

### **3.2 Towards a the design and examination of an enhanced process**

The research project will go on from the case studies. The case studies will have to lead to a design framework to assess the integral performance on macro, meso and micro level. It will be developed to redesign contemporary meso and micro level structures. The quality of this proposed design framework will be tested in a Dutch case. The design framework will be used to restructure meso and micro level designs, as the macro design of is mostly not under the authority or influence of metropolitan actors. Because of the inability to test the design framework in a real life case, a gaming setting will be used with actual representatives of the actors involved and a model predicting traveller behaviour. Evaluation will be carried out using expert analysis and an assessment of the effects on modal split and efficiency in production.

## **4. FIRST CASE RESULTS**

### **4.1 Zürich**

The canton of Zürich is positioned in the central northern part of Switzerland. The canton area covers about 1700 square kilometres, on which 1,2 million people find residence. Of these people 343.000 live in the city of Zürich (92 square kilometres), the rest is spread out over 170 other municipalities, throughout the canton.. The focus of the canton is strongly on the city of Zürich, though some larger cities in the canton Aarau to the west also serve as relatively strong and attractive urban cores. Within the canton only Winterthur (87000 inhabitants.) is a major urban centre. Other cities all have less than 30.000 inhabitants (ZVV, 1995).

The natural landscape (mountainous areas and the lake) divides the canton clearly in corridors which are relatively narrow and offer good possibilities for public transport service. Eight corridors can be distinguished, stretching from the city of Zürich to Pfäffikon, Knonau, Dietikon, Otelfingen, Niederweningen, Rafz, Winterthur, Wetzikon, and Rapperswil. Public transport is oriented along these lobes. *S-bahn* (an agglomerative train system) services track through the valleys and over the lake shores.

The case of the canton (province) of Zürich was selected as exemplary for strong governmental control on the design process on macro, meso and micro level. Because of the extensive list of issues that were considered during a four week stay in the canton and the restricted length of this paper, only a abridged account can be given here. It will focus on the key issues in the organisation of public transport design on the three levels in the canton of Zürich. Because a comparable analysis of one of the other cases is not yet available, no solid statement can be given on the relative quality of the system and its costs. Occasionally, 1993 figures will be given for Amsterdam, though a comparison between the two cities is problematic.

In accordance with most other European countries, the government controls the design structuring on a macro level. Regulation on entry is executed at a confederate level by the *Bundesamt für Verkehr* (Federal Traffic Office) of the *Eidgenössische Verkehrs- und Energiewirtschaftsdepartement* (Ministry of Transport and Energy). The cantonal government of Zürich (provincial level) has a strong influence over other macro issues and has used that influence to take firm control over the design on meso and micro level.

This control was institutionalised in 1991 with the set-up of a special body, *the Zürcher Verkehrsverbund (ZVV)*, holding full responsibility on practically all matters of public transport. In 1991 it had designed an integrated network of services, it introduced a single ticketing system and a zonal fare system, and from then on it collects all fairbox revenues from the companies, it can start marketing initiatives, it arranges all financial transactions between canton, confederation and companies, and it controls the cost-effectiveness of the companies.

Because of its responsibility for the definition of services in the canton, the ZVV was able to interconnect services where possible. A top-down approach was chosen: the schedules of intercity trains rendered the synchronisation times at interconnection nodes for the *S-bahn* system, the *S-bahn* schedule in its turn rendered the synchronisation times for regional bus services. Especially the interconnections between busses and *S-bahn* train services improved dramatically.

Credit frame 1995 - 1997	1995/1996	1996/1997
Operational cost compensation to transport companies	613	637
Loss of earnings payments to transport companies (e.g. SBB)	172	178
Administrative costs ZVV	15	16
Total expenditure	800	831
Operating income	377	395
Additional income	73	73
Total income	450	468
Cost under-absorption	350	363

Table 1 Credit frame ZVV in millions of Swiss francs for 1995-1997 (source ZVV, 1996)

The direct control over the production costs of the public transport companies by the ZVV offered possibilities to improve cost-effectiveness. The ZVV was able to improve the product considerably, and at the same time reduce production costs. Costs of public transport provision in the canton were brought down 60 million francs (39 million ECU), and 30 million of rationalisations more are expected for the coming years. The rationalisations that were realised correspond with approximately 10 percent of all compensation of operational costs to public transport in the canton of Zürich in 1995: 613 million francs (see table 1) or 498 ECU (Amsterdam: 253 million ECU). After the new integrated schedule and ticketing system demand has risen 20 percent on average, though demand in the city of Zürich dropped slightly. *S-bahn* patronage rose 40 percent compared to existing train services. Revenues in terms of ticket sales are expected to reach 377 million francs or 244 million ECU in 1996. (estimated revenues Amsterdam 59 million ECU). This gives a cost-effectiveness of about 53 percent (Amsterdam: 23 percent).

		Modal split	
		1980	1990
City of Zürich	Internal	66	78
	Commuting out	50	59
	Commuting in	35	43
Rest of the canton	Internal	18	18
	Commuting out	23	25
	Commuting in	37	40
The whole canton	Internal	52	62
	Commuting out	39	42
	Commuting in	37	40

Table 2 Modal split in the city and canton of Zürich, (source ZVV, 1995)

At this time Zürich has one of the highest percentages for public transport in the modal split in terms of travellers in Europe (see table 2). It reaches 62 percent within the whole canton on trips to work, and 78 percent in the city of Zürich, bicycles, mopeds and walking excluded (Amsterdam 31 percent, different calculation method).

Though at the start the schedule functioned quite well, problems occurred in the planning of services. Companies encountered problems when planning the ZVV schedules, though ZVV claimed that execution of the given schedule was possible. In terms of the analytic framework: the design of services at the meso level, presented problems at the planning of those services at the micro level. It became clear that companies should have a bigger say in the development of the schedules, to enable them to adapt the schedule to the restrictions of their personnel and vehicle planning.

In addition, the fully integrated network of services appeared to be very rigid. The system of interconnections made small adaptations of the schedule of a single line in the network virtually impossible, because of its immense implication for the rest of the network. Local public transport companies could not easily react to small changes in demand by changing the schedule.

Furthermore, recently ZVV itself recognised its inability to control the schedule from a meso level and be responsive to direct demands from the market, observable on a micro level. This has led to a new distribution of responsibilities for the development of the 1997-1998 schedule. The six largest companies become responsible again for the planning of routes and schedules, in addition to their existent responsibilities of planning vehicles and personnel. These six have to guide the other 37 companies in the canton to a more flexible and market-responsive approach. Other changes in responsibilities (companies also become responsible for revenues) are still under scrutiny.

It is remarkable to see how the Zürich approach recently has had a follow up at the confederate level (DER SCHWEIZERISCHE BUNDESRAT, 1993). The confederation has changed the regulatory system, following the Zürich example and facilitating this approach even more. Part of the responsibilities for the supply of services by the national railway SBB (*Schweizerischen Bundesbahn*) was regionalised in the new railway law. Public transport regulation now gives a strong influence to cantons and has come to an equalisation of different types of public transport to facilitate an integral financial settlement at the regional level for all types of public transport. In addition the new law makes it easier to tender services on a cantonal level to others than the original concessionaire.

In terms of the different rationales, in Zürich a strong case was made for the technical rationale. The original institutional design of the ZVV were clearly influenced by the conviction that an integrated network was the only way to improve the quality of public transport. This approach concentrated power into one body, controlling the design of the schedule, marketing, financial settlements, cost-effectiveness of the companies, and strategies. At this point in time, we see a swing away from this rationale to a more economic approach. Market orientation is regarded of utmost importance, experiments with tendering are executed, a holding structure is developed for the ZVV, leaving more responsibilities at the company level.

At some specific points in the process the influence is observed from the human-geographical rationale. The *Verkehrsbetriebe Zürich* (VBZ), public transport company of the city Zürich, uses travellers models to device new lines and plan lines for the future. This reflects the relative independence of this company from the ZVV, which it claims on its sheer size and its special role as intra-city transporter offering high frequencies. This binds its schedule less tightly into the integrated network. It focuses on integration of its own network. Other, smaller companies do not often use modelling tools, but rely on ZVV travellers counting and their own assessment of demand, based on prior demand patterns.

When one looks at public transport in Zürich from an urban-geographical rationale, it can not be denied that the structure of the natural landscape favours public transport. Habitation and traffic is concentrated in the corridors in the valleys and along the lake shores. This makes traffic flow on the road in peak hours difficult and public transport more attractive.

Finally, from a policy rationale perspective two important observations can be made. First, a strong informal network exists between companies, legislative and executive cantonal bodies, and the ZVV. From the interviews it became quite clear that this facilitates decision-making immensely. Second, one might expect that the set-up of a body as the ZVV, based totally on the intention to integrate the network, might hamper developments in new directions, like the implementation of competition. In the case of Zürich this proved to be not true. The ZVV itself convincingly claimed its new role as a holding for the six market responsible companies. It reduced its control and its personnel swiftly to adapt to this new role. This shows that institutional design choices based on design requirements from the technical rationale not always hamper changes in direction, i.e. an economic rationale. In this sense the ZVV has proven to be a robust institutional design.

## 5. DISCUSSION

It is hard to draw conclusion on the basis of a single case. At the presentation of the paper the analysis can be enriched, using the cases of Groningen and Newcastle upon Tyne, which will be finished at that point. In the mean time the discussion here will focus on two aspects. First, what does the case tell us about the utility of the research approach? A second question is, what can be learned from the single case of Zürich?

The more comprehensive research approach was not chosen because of the conviction that the introduction of more issues or viewpoints into the analysis automatically leads to a better quality of the solutions found. Sometimes the understanding of the object of study is blurred, which might lead to less adequate policies. The framework presented was set-up to better understand the way policy alternatives interact. In this it is considered reasonably successful. Links between the macro, meso and micro level designs were under scrutiny, and the interaction between the levels could be shown. The case report describes how the knowledge of different rationales is used in the process, how policies based on different rationales can interact, how basic policy choices from one rationale can be supported and strengthened by the use of knowledge from other rationales, and how a robust institutional design from a policy rationale (the ZVV) can support both technical rationale policies as economic rationale policies.

This learns us more about the whole process that finalises into a specific set of services. It tries to show how regulatory choices, institutional choices, spatial choices,

and choices in the services offered can be used in combination to improve the quality of public transport. In addition, it tries to understand how synergy's can be found, by not subjecting all choices to a single rationale. It tries to give policy makers additional tools and understanding on how policies interact, in order to make public transport a success in its competition with the car.

From the Zürich case at least one conclusion can be drawn, which the people in Zürich have already drawn themselves. A concentration of responsibilities in one body operating on a metropolitan scale leads to the detachment of service and schedule design on the one hand and the understanding of the market on the other. The ZVV itself has concluded that it was not able to fulfil its role as a developer of services adequately. It lacked knowledge of the market and the detachment of schedule design by the ZVV and vehicle and personnel planning by the companies lead to conflicts.

The existing design of the integrated network of services though is now accepted by all actors as valuable for the customer. Though competition is introduced, most companies adhere to the integrated network and are not planning on a different course, though planning of the services in the integrated network is a difficult matter. This means that the original set-up of the ZVV created an integrated network, which now should be produced efficiently, introducing competition. If this succeeds this might be considered the best of both worlds.

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Glenthorne House, Hammersmith Grove, London W6 0LG.

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