

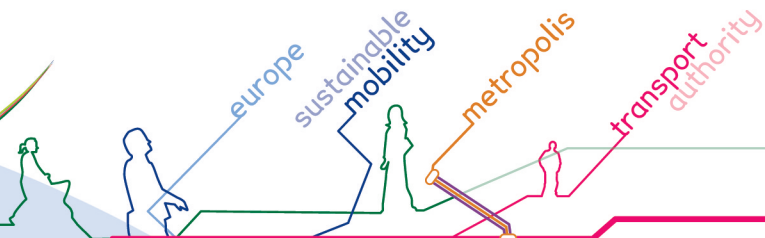
Light Rail Explained

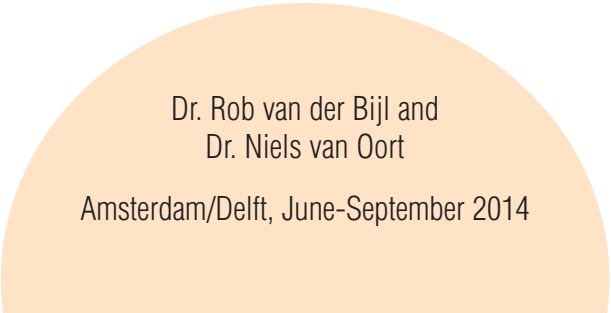
Better public transport
& More than public transport



EMTA

European Metropolitan Transport Authorities



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Amsterdam/Delft, June-September 2014

Foreword



The need for viable, cost effective and attractive public transport in high-density areas is immanent.

Transport Authorities have a responsibility to foster innovations in urban transport and look at smart replies to match the growth of demand for quality mass transit. A good living climate, economic efficiency, social inclusion, sustainability and competitiveness depend on the capacities of a city to invest in high quality transport services. The authors of this paper explain what especially in urbanised areas should be main reasons to persuade cities to improve accessibility and liveability by engage and develop a light rail solution. It comes down to a very basic question: “why light rail?” or more in general “why chose for high quality public transport?”.

City transport authorities are accountable for making the right choices in upgrading or expanding of their infrastructure networks, with the best use of public spending. They feel the urge to innovate and transform but often lack a good perception on why light rail will add value to achieve their transport strategy.

Schemes for investments in light rail infrastructure projects do not deliver many reasons to cheer. By enlarge only few initiatives in European cities can account for successful realisation and deployment. Many initiatives failed, suffering from inability to raise awareness on expectancy of the public, caused even political struggles and battles between ‘disbelievers’ of light rail as a modality.

Another main issue mentioned by the authors is the element of misperception about the possibilities of funding, cooperation with stakeholders, governance and the accomplishment of indirect benefits. Many projects have succumbed due to setbacks not so much in the design or technical layout but in the deficit to manage a smart parallel procedure needed to accommodate the public concern and timely address attention to concerns. This lack of social awareness caused intrinsically viable projects to stumble and fail.

In this paper Van der Bijl and Van Oort present their professional views from lots of research on the topic of light rail. They identify the main reasons why transformation from a car-based system to a public transport based transport system in cities by introducing light rail could be a smart decision. The authors make a sound analysis what are the more particular upsides of light rail and how it brings benefits on a number of different levels: efficiency, effect, environment and energy consumption, economy and equity. Misconceptions on the scope, the illusion of control and technology in devolvement and also financing and funding, and political decision making a justification in general, public engagement, stakeholders’ engagement can be identified as main factors for failure and risks in light rail project schemes. In the report lessons are drawn and recommendations made of why light rail can be a successful answer provided that people involved in putting efforts in these projects take a broader perspective. The illusion of total control and managing a light rail project in a predominantly rational, technocratic way guarantees mischief in the development process. Some lessons drawn earlier by Van der Bijl during an EMTA mini-symposium on Light Rail in The Hague last May.

In a thorough evidence-based description the authors demonstrate how it has been overlooked that light right rail does not only provide benefits that are obvious to all, like speed and comfort, but that in cost-benefit terms also reliability of service should be valued in money. Efficiency benefits thereby are incomplete and therefore impeded chances on smart light rail realisation. If taken into account the social context of projects and awareness of the influence of the difference in types of legal context, governance and institutional legacy a transformation of urban networks by light rail can be an asset to spatial urban revival. The Light Rail can be an impetus to the urban quality of life and more importantly provide a sustainable way of accommodating mobility needs of city denizens and visitors.

Ruud van der Ploeg
(Secretary General)

Summary

Unfortunately characteristics and benefits of light rail are frequently underestimated in decision making. On the bases of our own research and state of the art related research this paper addresses the importance of light rail as efficient means of transport, particularly efficient since light rail is synonym with reliable public transport. This paper elaborates light rail as prerequisite for urban (re)development and its economic, environmental and social assets. The benefits of light rail are explained and methods of incorporating them in decision-making are presented by using a series of cases. Finally this paper addresses reasons for failures of light rail projects as well as lessons to be drawn to overcome them.



IMAGE 0.1 – Stockholm renewed and expanded its light rail system

All photo images by Rob van der Bijl (www.lightrail.nl), Amsterdam, Netherlands 2014.

Introduction

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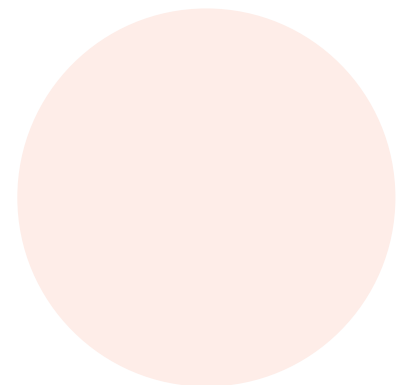
1 Introduction

This paper is about light rail, hence about high quality public transport. In our explanation of light rail however we will particularly focus on a comprehensive view of light rail. Beyond the question of reliable public transport, the meaning of light rail also covers other domains like urban planning, economy, environment and issues regarding social cohesion. These domains will be framed and elaborated on the basis of previous and ongoing work. We particularly take into account: Van der Bijl at al. (2005), Development of principles and strategies for introducing High Quality Public Transport in medium sized cities and regions (HITRANS), Stavanger, Norway, 2005. Best practice guides 1-5, and Van Oort, N. (2011), Service Reliability and Urban Public Transport Design, T2011/2, TRAIL PhD Thesis Series, Delft. Three Dutch cases of our research are highlighted: The Hague (RandstadRail), Utrecht (Uithoflijn) and Groningen (RegioTram). We have taken good notice and benefited where possible of all findings and conclusions of the report 'An Investigation into the Economic Impacts on Cities of Investment in Light Rail systems', by professor Richard Knowles and Fiona Ferbrache (UK Tram, June 2014) and took the liberty of making some remarks to that study report.

Moreover we want to emphasize our inspiration by successful development of existing light rail systems in many European cities such as Amsterdam, Brussels, Budapest, Frankfurt, The Hague, Helsinki, Oslo, Prague, Torino, Vienna and Warsaw, where infrastructure has been renewed and extended and new (low floor) vehicles were introduced. Furthermore we want to underline the importance of urban-regional extensions using a particular form of light rail called 'tram-train' in France, or tren-trams in Spain. Examples that are particularly meaningful for us are Cadiz Bay, Region of Rotterdam/The Hague, Lyon and Paris.

Since we want to cover light rail essentials beyond mere transport in this paper it is almost obvious we are interested in those examples of integrated transport and urban development, like Madrid and Stuttgart, or successfully integrated tramways in public realm, like Barcelona and Bilbao.

The compilation of this paper is assigned by EMTA.



Definitions of light rail

2 Definitions of light rail

2.1 Relation to other modes

Beyond a mere container expression we define light rail in relation to the 'nearby' modes of (classic) tram and (light) metro, as well as heavy rail, particularly regional train. Knowles and Ferbrache (2014) in their report define light rail "as light rail tramway and light metros". In our view however, one of the essential characteristics of light rail is its ability to share (one way or another) its infrastructure with other modes, such as buses or regional tram at its urban sections, or with all kind of traffic in the case its infrastructure is embedded in regular traffic space. Tram-style light rail integrated in public realm even allows sharing space with pedestrians. In other words, modern tram or light rail vehicles are by definition regular traffic vehicles, hence, part of regular traffic and related regulations and practices. In this view metros, including light metros, basically represent another mode. For instance both the London Docklands Light Railway and Tyne and Wear Metro are not forms of light rail, but examples of metro, fully independently from regular traffic. For us it's obvious to consider this kind of systems as forms of metro (or subway according American English), like the Copenhagen Metro (where Knowles and Ferbrache (2014) consider this kind of metros all as light rail).

It's very important to be precise and accurate regarding the definition, because light rail as kind of regular traffic differs in regard to performance, especially if urban planning/design and traffic planning/design is concerned. An urban situation typically served by light rail (e.g. a centre) entails two or three stops, fully integrated in public realm, hence linked to its surroundings by short walking routes at grade. In the very same situation served by metro or regional heavy rail only one station would be available, very likely underground or elevated, hence offering a limited number of links to its surroundings by rather long, non-grade routes. Moreover contrary to light rail as surface tram, metro and heavy rail are not that visible. These typical light rail characteristics are also very relevant to assess the effectiveness as public transport as well as the performance in the domains of economy, environment and equity.

2.2 Backgrounds

Our ultimate definition (Van der Bijl et al., 2010) is based on a cutting edge research in co-operation with the Dutch rail infrastructure provider ProRail, and Railforum, an independent knowledge network representing over 85 companies which operates in the Dutch railway business.

In summary: *"Light rail is a rail-bound mode of public transport for cities and urban regions. Contrary to train (heavy rail) and metro (subway, underground) light rail principally is able to be integrated within public realm, sharing public space with other traffic to some extent"* ¹.

¹ This definition was elaborated in advance between 1998-2010 at the website Light Rail Atlas. Source: RVDB/Lightrail.nl, February 19, 2010, Amsterdam, Netherlands.

Light rail is a relatively new mode, which is a hybrid form of existing modes, serving travel distances about 10-40 km. Figure below positions light rail compared to traditional modes.

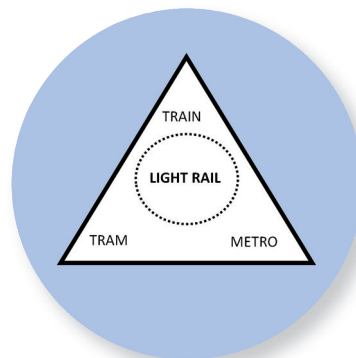


FIGURE 2.1 – Light rail is a hybrid form of train, tram and/or metro.

Although light rail seems to be a very modern mode, it was already defined in the late seventies of the previous century: *“Light rail transit is a metropolitan electric railway system characterized by its ability to operate single cars or short trains along exclusive rights-of-way at ground level, on aerial structures, in subways or, occasionally, in streets, and to board and discharge passengers at track or car-floor level”*. (Transportation Research Board, 1978).

Albeit still valid, we prefer our more recent definition. Figure 2.2 below shows the possible combinations of the three traditional modes (i.e. train, tram and metro). Six new forms are distinguished, which are illustrated by actual examples in table below. Numbers 1-5 are considered to be light rail variants.

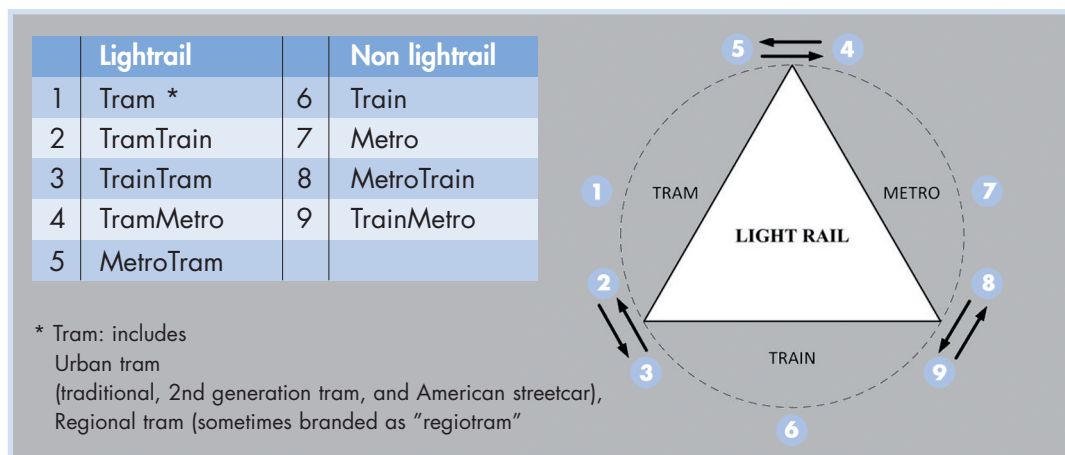


FIGURE 2.2 – Different hybrid forms of light rail and non-light rail

As a hybrid mode, light rail features characteristics of train, tram and metro. It has become an efficient and pragmatic solution for high quality, rail-based public transport. The ability of light rail to serve different transport objectives and levels makes it an adaptive system that can easily be integrated with different types of existing infrastructure. In contrast to other urban rail systems like metro and tram, a light rail system (to some extent) is able to share traffic space with other means of transport (cars, bikes, etc.; including pedestrians) at one part and may have own right of way on another part. Light rail can be pragmatically integrated in different urban environments. Table below shows the main characteristics of light rail compared to the traditional modes.

	Light rail	Train	Tram	Metro
Covering areas	Medium	Large	Small/Medium	Small/Medium
Environment	Integrated	Exclusive	Integrated	Exclusive/closed
Crossings	Several	Few	Many	None
Priority	Often	Always	Sometimes	NA
Stopping distance	0,4-2 km	2-100 km	0,2-0,8 km	0,4-2 km
Signaling	Often	Always	Sometimes	Always
Vehicle capacity	Medium	Hight	Low	Medium/high

TABLE 2.1 – Some characteristics of light rail compared to other modes

Particularly tram-train has been topic of discussion and projects since the early nineties of the previous century when in Germany Karlsruhe launched its dual-mode operation. Despite success of Karlsruhe and successors in Germany (e.g. Saarbrücken, Kassel) and France (e.g. Mulhouse) the first generation of tram-train turned out to be less successful, particularly due to institutional constraints (Kühn and Van der Bijl, 2004) However today's generation of new tram-train schemes still proves to be resilient, as the new and planned systems in France proves (e.g. T4 and tangential oriented projects in the metropolitan region of Paris, but also in the regions of Nantes and Lyon).

RandstadRail in the urban region of The Hague and Rotterdam is a successful Dutch scheme (and one of our cases). Recently Denmark joined the new series of tram-train schemes with the project in Aarhus (successfully tendered and under construction now). The only remaining scheme in Germany is in Chemnitz (partly in operation, partly under construction and in planning).



IMAGE 2.1 – Lyon's tram-train operates in various ways in the urban region



Reasons for light rail

3

3 Reasons for light rail

3.1 Introduction

Reasons for light rail (and other high quality public transport) entail five essential domains of argumentation: 'efficiency' (regarding operation), 'effectiveness' (of urban design/planning and traffic design/planning as effective tools), 'economy' (development, increased land value / real estate value, indirect effects), 'environment' (sustainable development, green policies), and finally 'equity' (social inclusion and cohesion).

3.2 Efficiency

The decision whether light rail is an efficient or suitable mode for given public transport tasks is often subject of a strong ideological motives pervaded debate. That is, a debate between 'schools', or between 'believers' of tram, bus, people mover, or whatever. A sound decision however should be based on a neutral assessment of mode's efficiency, whether it be light rail or any other mode of public transport. Various research made into transport characteristics of common modes (e.g. tram, bus, etc.) shows that suitability, hence efficiency is obviously linked to scale and related demand of the urban environment to be served by the selected mode (e.g. Hass-Klau et al., 2000). In our case of RandstadRail (see next section) we elaborated ideas and principles regarding efficiency of a cutting edge project. For The Netherlands Goudappel-Coffeng explained the next levels (see figure 3.1 below).

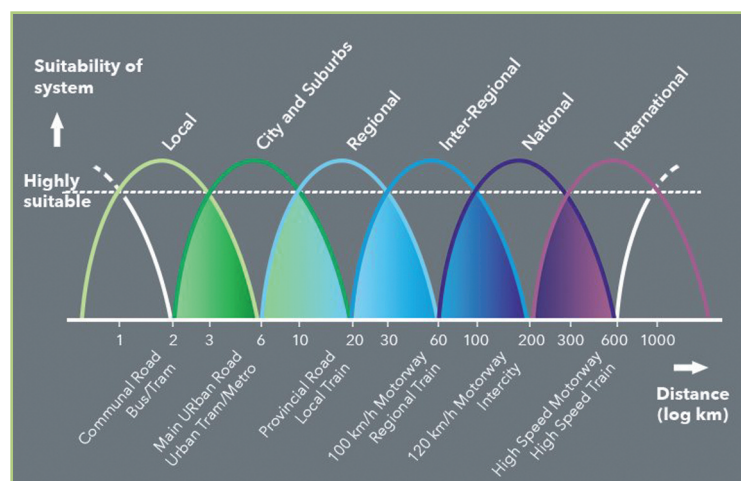


FIGURE 3.1

Light rail corresponds with the first three scales: local, conurbational, regional, with focus however on the (urban) regional scale. It's likely this outcome is also valid for other European countries, while the US accepts lower numbers for the justification of their light rail and streetcar schemes. Some of the recent Chinese tram projects show relatively higher passenger demand numbers. Generally in ill-developed countries the threshold for conversion from bus to tram is too high in any case. For Western Europe the operational

efficiency of light rail is in the range of 20,000 passengers per hour per direction (3-4 times more than conventional buses and about 2 times more than double articulated buses (e.g. Steer Davies Gleave, 2005).

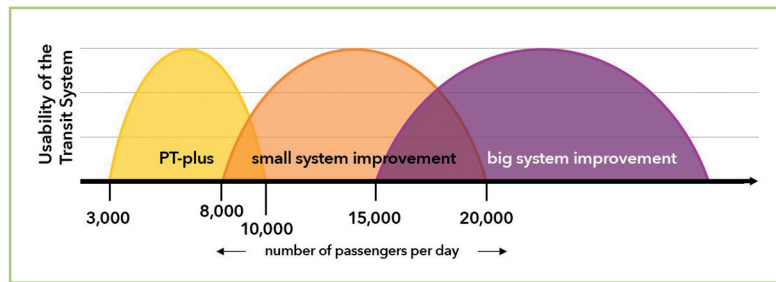


FIGURE 3.2



IMAGE 3.1 – Paris' ring (T3) obviously needed a high capacity tramway (system still being extended)

In other words: in this range one should seriously consider light rail instead of various bus solutions on the one hand and train solutions like metro or regional rail on the other hand ². Sometimes a choice for light rail is beyond any doubt. Our case of Utrecht Uithoflijn is a convincing example of such a project. The operational costs and reliability simply can't be reached efficiently other than by tram. Even cutting edge bus technology proved to be not an option in this case.

Goudappel Coffeng however also shows the substantial overlap between the ranges, as shown by the figure 3.2 above. This implies the final choice for a particular mode is context-dependent. First local conditions could be decisive for the final decision, for instance bus instead of tram. Some of these conditions can favour relative high demands still to be served by bus (e.g. no existing tram infrastructure available), or contrary, lower numbers (e.g. when some historical, narrow sections doesn't allow bus operation). Sometimes the choice for tram, bus or other modes is strongly linked to local cultural and industrial conditions (e.g. the existence of a tram factory or tire factory), or special events (e.g. an expo).

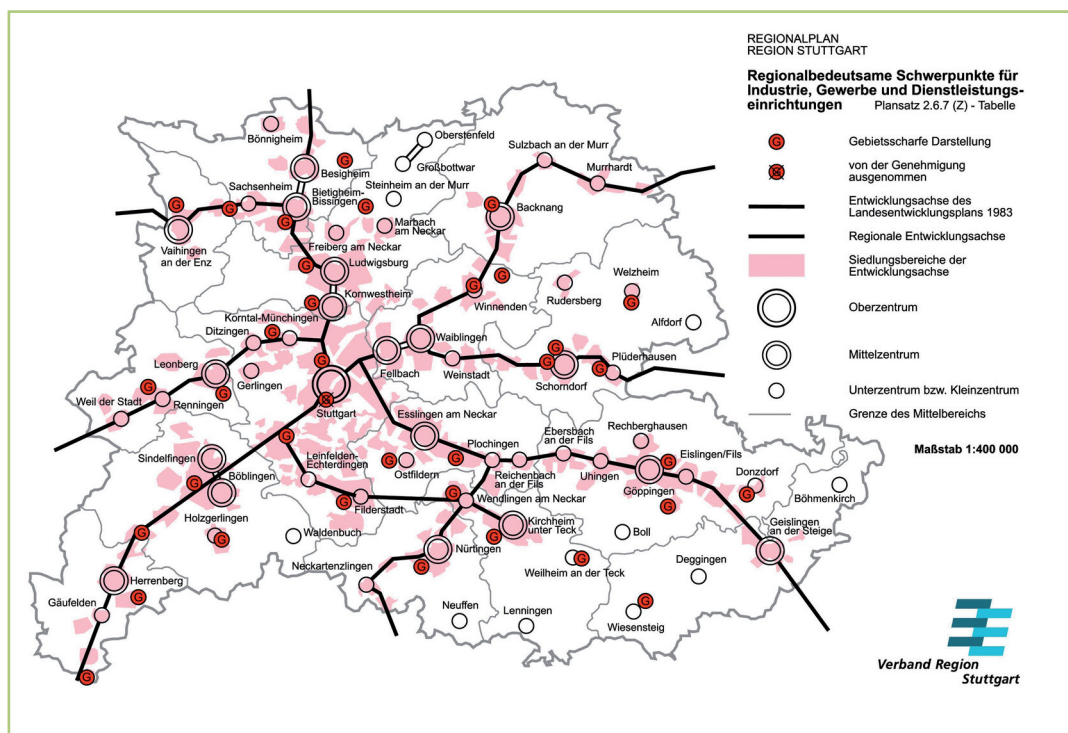
² BRT (Bus Rapid Transit) shares some characteristics with light rail, though we consider BRT as an enhanced bus mode, like light rail in many cases is an improved tram mode. All these modes must be neutrally assessed. In South-America BRT proved to be financially feasible, though in similar situations in North-America or Europe light rail could have been a feasible and cost-effective mode.

Beyond mere transport however, in most cases other types of argumentations are valid which could justify (or not) a preference for light rail. These remaining four 'E's' are discussed in the next paragraphs.

3.3 Effectiveness

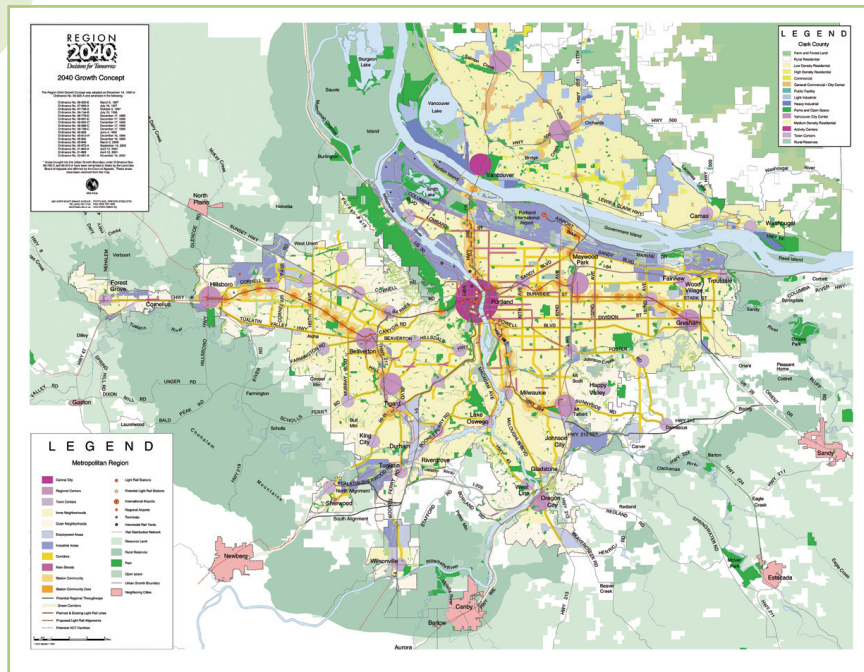
Based on fixed infrastructure light rail and similar high quality public transport modes can play an important role in urban planning/design and traffic planning/design. Particularly when the effective use of urban planning and design is addressed still one tends to reduce this role to matters of aesthetics, or to a so-called 'image of the city', or a 'sense of place'. Knowles and Ferbrache (2014) appreciate these qualities because light rail in this respect can attract "inward investment, employers, business and tourist visitors". Though this is true it certainly would constrain the true role of light rail as effective tool for urban planning/design. Various new tramways show the iconic effect of light rail, hence, cities can develop their own brands, but for urban planning/design and traffic planning/design this kind of effectiveness is still too limited.

First light rail can play a decisive role in design of public realm. Van der Bijl et al. (2005) elaborated many examples and solutions in their HiTrans best practice guides (volume 3 particularly). Though the introduction of light rail in public realm can be perceived as a violation of quality and use (in case of bad design, or in case of a biased perception in case of good design), still on the contrary many examples reveal a challenging potential to use light rail to enhance spatial quality, including use of that space. This also counts for related traffic design that allows improved zoning of public space, as well as improved safety, circulation and accessibility.



MAP 3.1 – Stuttgart (Germany), rail corridors frame economic sites

Second light rail can be an effective tool for land use planning. Again Van der Bijl et al. (2005) elaborated many examples and solutions in their guides (in this case volume 1 particularly). Light rail is able to (re)structure the city, or urban regions, or small parts in cities and regions (precincts, neighbourhoods), including run-down areas. Related to this, from a traffic planning point of view, light rail helps to prevent urban sprawl.



MAP 3.2 – Portland (OR, US). Regional Plan 2040: light rail backs TOD

Third, in more detail light rail can be conceived as a major condition for urban development and planning. Light rail and similar fixed infrastructure based public transport (e.g. heavy rail) improve urban connectivity and accessibility. Their fixed infrastructure (e.g. track-bound) guarantees for at least the technical/economical life span (average minimum of 30 years, though 60 years or more is likely too) the existence of that infrastructure, hence, the connectivity and accessibility offered by the public transport services carried by them. New or formerly remote, hard to reach sites become accessible by light rail.

Knowles and Ferbrache (2014) correctly assess this accessibility as condition for the transformation of these sites. Particularly they recognise improved accessibility by light rail can provide *“a trigger to reorganise or rationalise production, distribution and land use”*.

Fourth light rail and again similar fixed infrastructure based public transport play a crucial role in ‘transit oriented development’ (TOD). Numerous research in America and Europa (and recently also in Asia) proved the value of the TOD concept (e.g. Curtis et al., 2009). In fact TOD integrates the ability of light rail to serve as a tool for urban planning/design, regarding all features mentioned above ³. Moreover, as Knowles and Ferbrache (2014) underline, the impacts of light rail in context of TOD *“focus investment in housing, employment, activity sites and public services around station sites”*.

³ Tram-train projects epitomize the ambition to expand the scope of urban transport network, demonstrated by examples in French and German cities. See EMTA Brief on ‘Metropolisation’ (April 2013)..

Challenges remain how TOD can be effectively implemented. A recent PhD-research (Tan, 2013) recognises many constraints and particularly what Tan calls 'formal barriers', like institutional complexity and fragmentation of governance contributing to lack of clarity in roles and responsibilities. Moreover Tan mentions informal barriers, such as lack of urgency and indifference towards transit. The latter means that the value of light rail isn't fully accepted, which perhaps seduced researchers to focus on other argumentation to justify light rail: economy for instance.

3.4 Economy

Some initiators of light rail expect economic development and growth once their system is in operation. Some research who want to back this kind of expectations act as if they are looking for the holy grail of land, property and real estate values. However, this doesn't mean light rail can't be an instrument to propel and restore economic growth, but never in an autonomous way. Unfortunately there are no direct, let alone causal economic effects that can be linked to introduction of light rail.



IMAGE 3.2 – Portland (OR, US) Pearl District represents a true precedent of urban planning and property development with aid of a new streetcar

Nevertheless, well served light rail stops and stations present favourable conditions (in combination with other conditions, characteristics, events, etc.) that can elicit investments or other economic incentives. Particularly improved accessibility of sites is very meaningful for the development, hence for the (future) land and property value. In some cases the iconic impact of a light rail service (e.g. around well designed stops in highbrow new urban areas like the Pearl District in Portland (Oregon), or in fancy historic centres like downtown Strasbourg (France) certainly has stimulated private and public investments. An overwhelming amount of research (e.g. Carmen Hass-Klau et al. (2004) showed light rail

can represent an important condition for creating urban situations with positive economic effects, but always in combination with other interventions, such as additional actions, initiatives and investments, supportive policies, etc.

In the absence of light rail (i.e. necessary/high quality accessibility) obviously it's harder to provoke other investments and initiatives. Moreover without good public transport the effectiveness of urban development policies is less secure. Knowles and Ferbrache (2014) in this regard rightly consider the absence of what they call 'a well-developed modern transport system' as a serious constraint for economic growth. On the contrary they are aware that improved accessibility by light rail *"usually increase land and property value, and enable developer contribution to be made"*. And we like to add to that this improved accessibility allows other urban actors like local entrepreneurs and in particular public agencies to contribute to economic productiveness.

Knowles and Ferbrache (2014) also mention stimulation of 'inward investments' due to the increased attraction of locations served by light rail. However they underline *"it is difficult to attribute specific investments in economic activity solely to light rail"*.



IMAGE 3.3 – Strasbourg's tramway enhanced retail of city centre

Nevertheless inward investments related to light rail exist, despite they can't be measured unambiguously. These investments are almost obvious in the main centres of medium sized and bigger cities regarding retail, culture and leisure. And to some extent these kind of investments also play a role in the development or regeneration of sub centres.

Carmen Hass-Klau et al. (2004) examine the transformation of retail in the centre of Strasbourg due to the introduction of the tramway. They note the displacement of small shops by high end chain stores. CERTU (2005) confirms this kind of transitions in Strasbourg (and other new French tramway city centres), and emphasizes the change in quality. Poorer shops are replaced by fancier amenities.

We like to summarize this phenomenon as 'gentrification' of town centre's retail system. Knowles and Ferbrache (2014) in this regard points out inward investment 'at a smaller

scale'. They also mention Strasbourg where light rail *"was associated with a change in the type of retail outlets being established in the city centre. Rental and property prices increased after the light rail line (Tramway A, RvdB/NvO) opened in 1994 and it became impossible for smaller shops to remain in the area"*. Referring to Hass-Klau et al. (2004) they note the inward investments from large retailing agents and confirm surveys that show an increased number of shoppers in the centre of Strasbourg.

However, economic success and related increased land and property values due to the favourable conditions created by light rail are rarely balanced with the investments made to build and operate the light rail system. Various research confirms this phenomenon, also Knowles and Ferbrache (2014): *"Light rail systems improve accessibility, usually increase land and property values, and enable developer contributions to be made. Despite various mechanisms that can (be) adopted, increases in land and property value are often not captured"*.

In this paper we don't touch the existing value capture mechanisms and their opportunities to use the captured values for building and operating the light rail system (e.g. Smith and Gihring, 2010). This subject deserves an independent second paper.

The economic meaning of light rail for cities and urban regions is quite evident. Though it is easy to imagine exhausting discussions on measuring economic effects and capturing values, still the existing knowledge should be enough - and not be used (not to say misused) to question light rail investments over again. Certainly not if one recalls the importance of the remaining principle arguments to consider light rail very seriously: environment and equity.

3.5 Environment

It's remarkable that generally environment (i.e. sustainability, green policies and alike) lacks in many (applied) research. Knowles and Ferbrache (2014) note this problem. *"It has difficulty in valuing environmental, social and wider economic effects even after a New Approach to Appraisal (NATA) was adopted."* They recognise the fact that light rail as an electrified form of public transport *"can be linked to lower levels of air pollution"*. And they underline light rail *"emits less noise and vibration than buses"*. Their conclusion: *"these positive factors not only improve the image of the city, but can bring additional benefits to the economy"*.

Generally environmental factors are not comprehensively assessed when light rail as future mode is subject of debate. Moreover in several European countries (e.g. Netherlands and UK) these factors are not part of current appraisal methodology (see also the section containing our case Utrecht Uithoflijn), while light rail represents favourable conditions for local environments as well as for the city and its region as a whole. Through the reduction of air pollution due to less particles and greenhouse gas emissions, as well as less noise and vibration light rail substantially can improve local environments that were previously served by buses. Also the fact that light rail allows reduction of vehicle movements up to the introduction of car free public realm can improve local environments tremendously. This kind of measures becomes meaningful for larger urban areas when on full scale the volume of traffic is reduced. In case of green electricity the benefits of light rail could even surpass the scale of the city and its urban region.

In order to understand and assess comprehensively the environmental values of light rail (and similar high quality public transport) Van der Bijl (2012) compiled four principles. Inspired by the 'green transportation hierarchy' used by New York City's advocacy group for cycling, walking and environmentally sensible transport (see also Bradshaw, 2004), the four principles are situated in a hierarchical sequence.



IMAGE 3.4 – Barcelona's new tramway supports dense urban development

First principle: less transport and reducing need

From an environmental point of view urban footprints should be as small as possible. Basically this means size of cities should be constrained while density is maximised. Light rail can favour smaller urban footprints/sizes since it requires high demand volumes hence dense environments. Complementary measures, urban planning and land use politics can enhance and enforce such an effective use of light rail. Example: Atlanta (USA) and Barcelona (Spain) both have about 5.3 million inhabitants, though the urban area of Atlanta covers 4280 km², contrary to just 162 km² of Barcelona⁴. It comes to no surprise that CO₂ emissions due to transport (public and private) differ accordingly: 7.5 ton (/ha/an) for Atlanta (GA, US) against 0.7 ton/ha/an for Barcelona (Spain).



IMAGE 3.5 – Budapest ring tramway offers high capacity collective transport

⁴ Unfortunately the figures about Barcelona of our American source (Bertaud and Poole, 2007) are not exact. One should distinguish three concentric circles, whose populations and surfaces are as follows (courtesy: Xavier Roselló, ATM Barcelona): Municipality of Barcelona – 1.62 inhab./101 km², Àrea Metropolitana de Barcelona (AMB) – 3.24 inhab./636 km², Regió Metropolitana de Barcelona (RMB) – 5.05 inhab./3,235 km². For light rail systems (e.g. in Barcelona) the conurbation (e.g. AMB, see also our figure 3.1) should be assessed.

Second principle: collective transport

A model shift from individual to collective transport forms the foundation of sustainable transport, which in this regard is more efficient for all green issues, such as energy consumption and greenhouse emissions. Light rail as pragmatic and efficient mode of public transport contributes to development and sustainable operation of collective transport in cities and urban regions. Examples: Budapest (Hungary), Lyon (France), Vienna (Austria).

Third principle: fixed infrastructure

By focusing growth and redevelopment in transport corridors both urban size and density (see first principle) can be limited. Moreover the collective public transport (see second principle) in these corridors on the one hand can be operated more efficiently and the other hand, if their infrastructure is fixed (this third principle) can sustain the urban focus in the corridors. In other words, fixed infrastructure-based public transport structures urban areas sustainably.



IMAGE 3.6 – Paris' T2 uses former heavy railway alignment

Light rail is an excellent example of that kind of public transport. The use of existing infrastructure, or former infrastructure alignments enhances the use of light rail. Examples: tramway T2 in Paris (France) along former railway corridor in the Seine valley; light rail Exposition Line in Los Angeles (CA, US) along former Pacific Electric Santa Monica Air Line corridor; Birmingham (UK), using old railway for the very first stage of the project.

Fourth principle: sustainable technologies

Other sustainable ways of transport (e.g. walking, cycling ⁵) and sustainable technologies (e.g. electric engines, smart freight logistics, information systems) complementary strengthen the use of public transport or reduce transport demand. It's obvious that light rail operation could benefit from this kind of sustainable technologies. Examples: Amsterdam (Netherlands), Barcelona (Spain), Copenhagen (Denmark), Lyon (France), Seville (Spain).

3.6 Equity

Like in the case of environmental issues it's also remarkable that generally equity (i.e. social inclusion, or cohesion) lacks in many (applied) research. Knowles and Ferbrache

⁵ See also Van der Bijl's 'Go Dutch Cycling' (www.lightrail.nl/bicycles/). "High quality public transport (i.e. light rail) ... should be linked to high quality bicycles and infrastructures."

(2014) recognise that so far it has been difficult to assess 'social effects', again, despite NATA (New Approach to Appraisal). Nevertheless new generation of light rail projects (e.g. new British and French tramways) have been justified (partly) from the point of view of equity. One expected to restore and sustain social cohesions with the aid of these systems. For instance Steer Davies Gleave (2005) considered 'key roles' that light rail (in Leeds) could play in the promotion of inclusion. Common equity considerations relates primarily to (quick) access to jobs and secondly to facilities and shopping. Also mentioned are social connections generally and family-connections particularly. In summary connectivity and accessibility should prevent social exclusion.

Access to jobs as basic condition for inclusion is plausible since public transport's main task is and has been to serve commuting. An ongoing case study to the history of light rail in Los Angeles examines the notorious riots of Watts in 1965. It seems to confirm this statement (Van der Bijl, 2013-2014; not published yet). The last 'Red Car' from the famous 'Pacific Electric' (LA's light rail system avant la lettre) run in April 1961, only four years before the riots. Since then citizens of Watts lacked their connection with jobs in downtown Los Angeles. Watt's unemployment certainly nourished the riots and made the lack of sufficient public transport one of the (though many) reasons for social exclusion and turmoil.

The lack of access to jobs is evident in urban areas with a (very) low share of car ownership. Particularly in deprived urban areas this feature entails exclusion in case of insufficient or missing public transport. Our case study of Detroit shows not or badly served corridors in central Detroit who combines low figures of car ownership with high potential for job (and job seeking) related public transport potential, such as Woodward Avenue which is selected by the city as major route for a new tramway (Van der Bijl and Berkers, 2013-2014; not published yet).



IMAGE 3.7 – Strasbourg's tramway enhanced local social inclusion

The enhancement of social inclusion has been an important aim of the new generation of tram projects in France. Unfortunately the use of new tramways for city-wide social cohesion turned out to be ambiguous. Various assessments made after some years after the introduction of the new tram services (e.g. CERTU, 2005) confirm the general notion that the new tramways must perform in a dynamic situation instead of a static situation. In Strasbourg it was observed that the new tram in this context acted as amplifier and accelerator of already existing tendencies.

Though these tendencies weren't specified regarding the equity issue still this observation give ground to the idea that the tram also can amplify the existing social segregation (instead of the expected opposite). This presupposition was confirmed (though not officially) in an interview with one of Strasbourg's urban planners (Van der Bijl, 2004; not published). Since the introduction of the tram the city centre of Strasbourg has become more luxurious (e.g. Hass-Klau et al., 2004). Due to this 'gentrification' citizens from the 'banlieues' got less keen visiting the centre. The shops became perhaps too expensive, but certainly these shops and centre's public realm were transformed into 'strange territory' for them. Hence the tram had restored segregation.

Nevertheless it's beyond any doubt that the tram of Strasbourg serves as a necessary and excellent link from the outskirts to jobs in the city centre. And for that matter, the tram is also heavily used for local connections between home and neighbourhood's amenities. So the local inclusion has benefited from the introduction of the tramway.

**Increased quality
of service due to
light rail**

4 Increased quality of service due to light rail

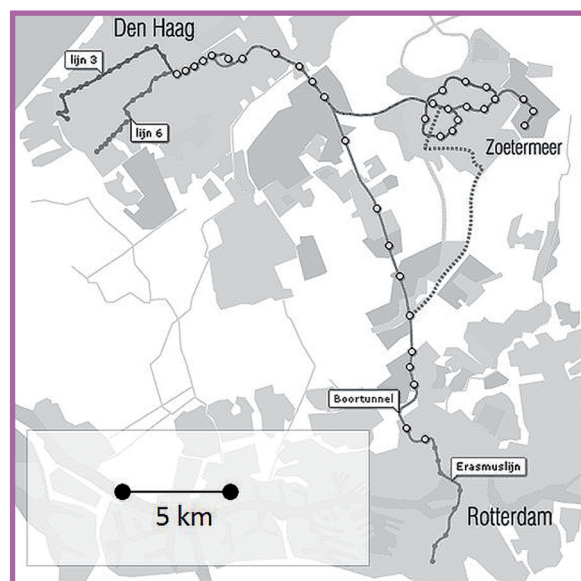
4.1 Light rail in The Netherlands: RandstadRail

Light rail enables a leap in quality of service of public transport. The main potential contributions are increased travel speed, higher frequencies and enhanced service reliability. By presenting a case of an recent light rail project, we would like to demonstrate the potential benefits with regard to service reliability.



IMAGE 4.1 – RandstadRail, low floor tram on the common The Hague-Rotterdam section

In the west of The Netherlands, the urban region in and around the cities of The Hague and Rotterdam, a new light rail system has been developed: RandstadRail (Van Oort and Van Nes 2009a). This is a new regional public transport system with high quality standards: high frequencies, fast, comfortable and reliable. RandstadRail replaces and connects former tram, metro and heavy rail lines. RandstadRail consists of two main networks (see map 4.1 below). This case study however is constraint to the The Hague section (i.e. the low floor tram project). The Rotterdam light rail section (using high floor vehicles) will be discussed in another paper.



MAP 4.1 – RandstadRail Network (The Hague low floor – Rotterdam high floor)

The RandstadRail low floor tram network in The Hague consists of two lines, one of 33.4 km and 41 stops and one of 26.8 km and 31 stops. To offer high-quality service in terms of punctuality and regularity and to make efficient use of the infrastructure, it is decided to apply a new control strategy. Preventing, coping and adjusting are the main elements of the control philosophy. The punctuality of the vehicle is shown to the driver, so he can adjust his driving style. On top of that, all vehicles with positions and punctuality are shown in the central dispatch room. The dispatchers use a system, supporting them in adjusting operations, if necessary. RandstadRail has a high percentage of exclusive right of way and priority at traffic lights. The vehicles have got low floors and wide doors, which reduces deviations in dwell time.

Before the start of RandstadRail, the operation of the public transport in The Hague was not controlled in a sophisticated way. The driver knows the departure time of the first stop and the arrival time of the last stop. During the trip some deviations will occur: this results in a distribution of driving times.

RandstadRail between The Hague and Zoetermeer is operated by two lines, both offering 12 trips an hour in both directions, during peak hours. This results in headways of 2.5 minutes on the shared section. Moreover, in the city centre, regular trams operate on the same track as RandstadRail: two lines with a frequency of 6 and 8 vehicles per hour per direction.

4.2 Increasing quality of service: the control philosophy

According to the control philosophy, the departure at the first stop is very important. RandstadRail drivers are not permitted to run ahead of schedule. They have a display in their cabin that provides real-time information about their punctuality to adjust their on-time performance. RandstadRail confirms an improvement of departure punctuality. The percentage of trips departing with a deviation between -1 and $+1$ minute increased from 70% to 95%. RandstadRail does not permit running ahead of schedule. Trip times are planned shorter than they used to be and the cabin display helps drivers to adjust their performance. The number of trips departing ahead of schedule decreased from 50% to 5%, after the introduction of this new rule.

Two main sources for variability in driving time are: dwelling at a stop and unplanned stops (e.g. at traffic lights). Research (Van Oort 2011) shows that the distribution in these elements leads to a wide distribution in driving times. It is necessary though to reduce all deviations to achieve a smaller distribution of total driving time.

To achieve a high quality of service, stopping at locations other than the stops must be avoided as much as possible. Infrastructure is reconstructed for RandstadRail: own right of way and priority at intersections is applied. Table below shows the average total delay per trip before and after the introduction of RandstadRail on the same route. The average value of delay has decreased and the standard deviation is also smaller, enabling a higher level of reliability.

	Average total delays	Standard deviation
Tram	90 s.	60 s.
RandstadRail	20 s.	30 s.

TABLE 4.1 – Average Stopping Time Tram and RandstadRail

The main advantage of the new RandstadRail vehicle is the low-level floor. Boarding and alighting is much easier, especially for the elderly and people with trolleys and suitcases. Figure below shows the standard deviation of the dwell time of all stops in the city before and after the transformation to RandstadRail.

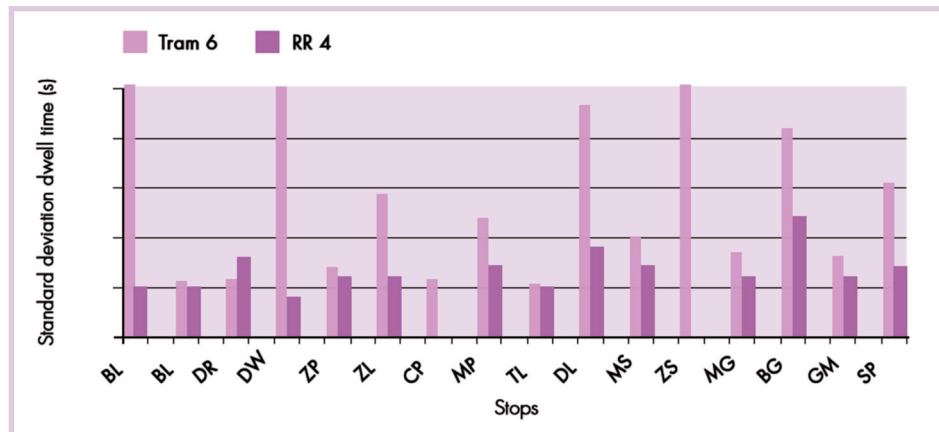


FIGURE 4.1 – Standard Deviations of Dwell Times per Stop before and after the introduction of RandstadRail

For most stops the standard deviation decreased. Table below shows that the standard deviation is reduced from 20 to 7s. The average dwell time is improved from 28 to 24s. per stop. This enables more reliable operations with a higher level of service.

	Average dwell time	Average standard deviation
Tram	28 s.	20 s.
RandstadRail	24 s.	7 s.

TABLE 4.2 – Average Dwell Time Tram and RandstadRail

The goal of the control philosophy is to improve the level of reliability by decreasing the distribution in driving times and improving the punctuality. Figure 4.2 below shows the 15th and 85th value of driving times of tram line 6 before and after the application. As predicted, the distribution of deviation has decreased. In addition, punctuality has improved: the deviation is decreased and negative delays are almost disappeared.

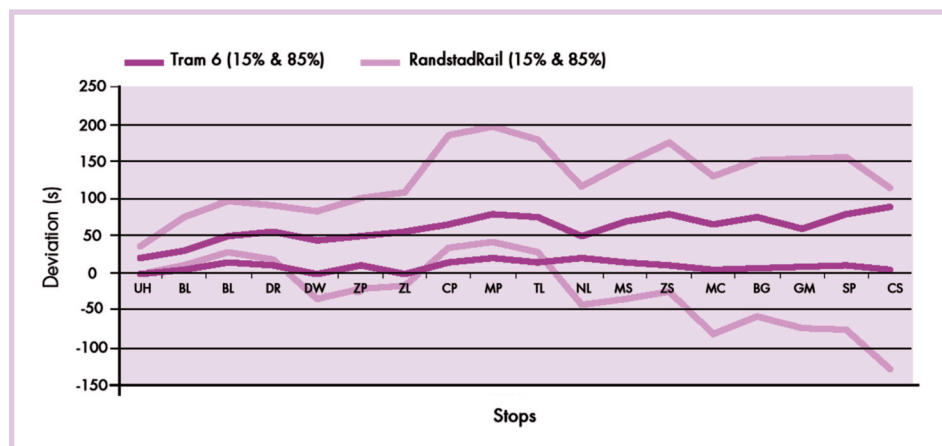


FIGURE 4.2 – Schedule Deviation Tram and RandstadRail (15- and 85- Percentile Values)



Shortcomings of CBAs with regard to light rail planning

5 Shortcomings of CBAs with regard to light rail planning

5.1 Missing aspects of CBAs

A Cost Benefit Analysis (CBA), see for instance Johansen (1991) is a frequently used tool to quantify and clarify the cost-effectiveness of projects. In Knowles and Ferbrache (2014), the instrument of cost-benefit analyses with regard to light rail planning is considered. The authors mention shortcomings of this instrument, such as limited attention to wider economic impacts and non-user benefits (see also in section 3 above). However, they mainly focus on external aspects, thereby neglecting internal aspects of public transport. We think that concerning those aspects, current cost-benefit analyses for light rail have some major shortcomings as well. First of all, the impact of the additional attractiveness of a rail system over a bus system is often neglected. Bunschoten et al. (2013) investigated this rail bonus, which they considered to be “the extra value it generates for travellers, which causes a new rail service to gain more passengers when compared to an equivalent bus service”. They found “that the tram is preferred over bus in the three major tram cities in the Netherlands (Amsterdam, Rotterdam and The Hague) but that the extent of these preference differences varies among these cities”. Their investigation illustrated that in case of a rail system up to 10% more passengers are to be expected, compared to a bus system, having similar quality characteristics (such as frequency, speed and reliability).

Another aspect, that is often missing or underestimated is the reduction of crowding due to the introduction of (light)rail systems. This may be the effect of additional vehicle capacity and/or increased service reliability. Haywood and Koning (2011) show an example of public transport passengers in Paris who are willing to travel 8 minutes longer in case of less crowded vehicles. The main shortcoming however in most light rail CBAs is neglecting the impacts of increased service reliability, as also mentioned by Knowles and Ferbrache (2014).

5.2 Service reliability impacts often neglected

Service reliability is an important quality characteristic in public transport. Both passengers and operators benefit from enhanced service reliability by decreased and predictable travel times, and by lower costs, respectively. However, in cost-benefit analyses, this quality aspect is rarely taken into account explicitly. Figure below shows the results of a quick scan of randomly selected CBAs of public transport projects in the Netherlands. It is demonstrated that the attention to calculating service reliability effects is limited. Most of the time, a qualitative assessment or expert judgement is used, while proper calculations would be more appropriate since most public transport projects aim at improving service reliability.

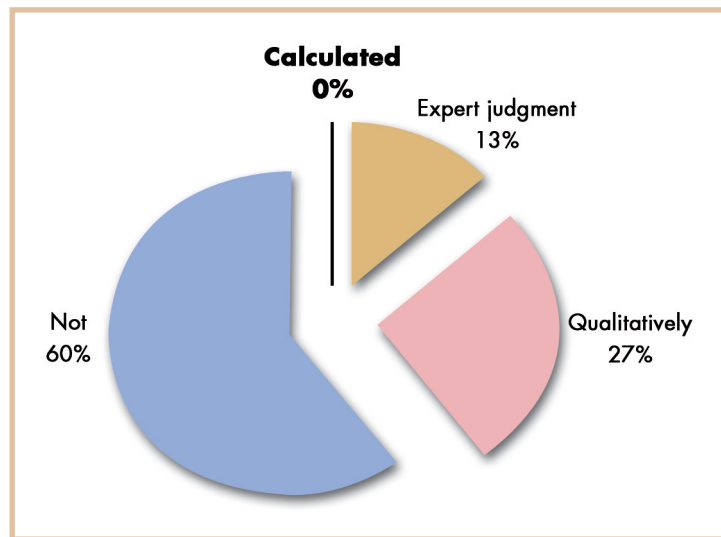


FIGURE 5.1 – Results of survey on incorporating service reliability impacts in Dutch CBAs

Service reliability effects are seldom explicitly taken into account in public transport projects. In both OECD/ITF (2009) and Li et al. (2010), developments concerning CBAs and reliability all over the world are presented. It is stated that incorporating reliability in CBAs is only applied in a limited number of countries such as United Kingdom, the Netherlands, Denmark, New Zealand, Australia, Norway and Sweden. However, the main applications are focussing on road traffic instead of public transport.

In road traffic, more attention is paid to the phenomenon. Snelder and Tavasszy (2010) discussed this issue as well and they state that the method to deal with this in road traffic projects in The Netherlands (i.e. travel time variability gains are assumed to be 25% of the travel time gains (Besseling et al. 2004) is an underestimation and is very project specific. Although, similarities exist, application in public transport is more complex since a schedule is involved and a passenger trip chain consists of waiting, transferring, access and egress time in addition to in-vehicle trip time. One of the main reasons to neglect these effects so far is that it is complex to calculate them and much data is needed. However, since Van Oort (2011) provided a method to calculate the unreliability effects for passengers, it is possible to consider them in a CBA.

We defined service reliability in terms of the certainty of service aspects compared to the schedule (such as travel time (including waiting), arrival time and seat availability) as perceived by the user. Service variability is defined by the distribution of output values of the supply side of public transport, such as vehicle trip time, vehicle departure time and headways. Improved service reliability increases the overall quality of public transport, thereby ensuring accessible and liveable cities for future generations and reducing the growth of car mobility.

In literature, much research is available with regard to passenger choices as a function of service reliability. Bates et al. (2001) and Rietveld et al. (2001) state that service reliability of public transport systems has been considered critically important by most public transport users because passengers are adversely affected by the consequences associated with unreliability such as additional waiting time, late or early arrival at destinations and missed connections, which increases their anxiety and discomfort. Route choice might be

affected by unreliability, as presented by Abdel-Aty (1994), Schmöcker and Bell (2002) and Liu and Sinha (2007). Service reliability is also been identified as important in determining the mode choice (Turnquist and Bowman 1980). Therefore, it may be stated that unreliability in public transport drives away existing and prospective passengers. Passengers mainly experience the following three effects of unreliability (Noland and Small 1995, Noland and Polak 2002, Van Oort and Van Nes 2009b). Note that due to the stochastic nature ⁶, the impacts on individual passengers may differ from average values:

- Impacts on duration of travel time components, being in-vehicle time and waiting time, which lead to arriving early or late;
- Impacts on variability of travel time components, being departure time, arrival time, in-vehicle time and waiting time, which lead to uncertainty of the actual travel time;
- Impact on probability of finding a seat and crowding, which affects the level of comfort of the journey.

In cost-benefit analyses, these three impacts are often neglected, thereby underestimating the impacts of high quality public transport, such as light rail.

To calculate the passenger effects of unreliability, it is important to gain insights into the quality of service of public transport operations. This consists of characteristics of the service supply, such as actual departure times per stop, actual dwell times, actual headways and actual trip times. In the calculation of service reliability effects, this vehicle related data (available by Automated Vehicle Location (AVL)-systems or forecast tools such as illustrated in Kanacilo and Van Oort 2008) is translated to passenger effects, using Automated Passenger Counter (APC) data. Figure (nr. ?) below illustrates both the demand and supply sides and the link of vehicle trip elements with the passenger journey elements. Note that a relationship also exists in the other direction. Dwell time for instance is strongly affected by passenger behaviour. Passenger waiting time is determined by actual headways and departure times as well as passenger arrival time at the stop. Passenger in-vehicle time is equal to the trip time of the vehicle and sets the arrival time at the destination, in combination with the departure time. If a passenger makes a transfer, a new waiting time for the passenger will arise. This new waiting time is affected by the planned synchronization between the two connecting vehicles, the actual performance of this synchronization and the waiting regime of the connecting vehicle.

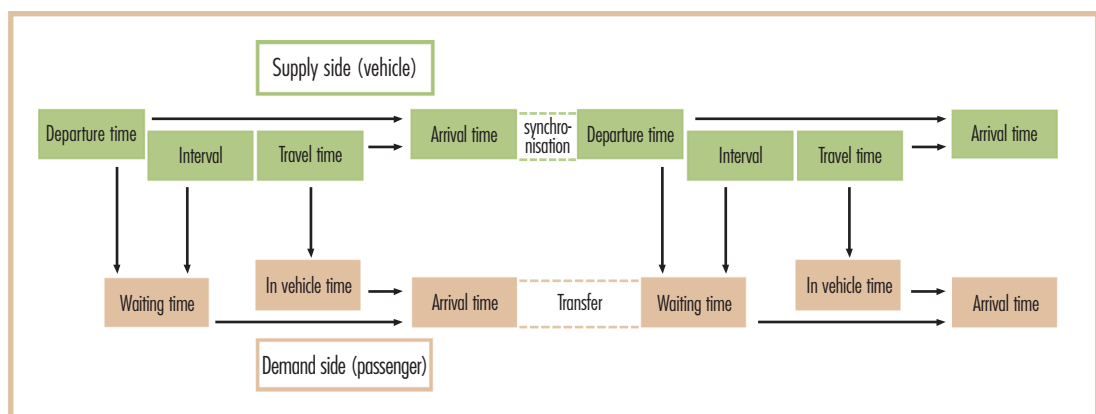


FIGURE 5.2 – (Interaction of) passenger trip chain (below) and vehicle characteristics (above)

⁶ In other words, the actual reliability faced by a particular passenger is not determined (a stochastic process is an undetermined process).

In order to improve service reliability it is essential to monitor and predict the level of service reliability of a public transport system. For this we need proper indicators. The commonly used indicators, which are supposed to express reliability, do not completely focus on the passenger impacts of service reliability. In fact, they focus more on service variability of the system (and the deviation of the schedule) than on the actual impacts on passengers. Well known examples of supply side indicators are punctuality (indicating the level of schedule deviation) and regularity (indicating the level of headway deviation; Van Oort 2011). Although the supply-side indicators often help to illustrate the level of service provided to the passenger, they do not completely match the customer perception.

Vehicles driving ahead or being late for example affect passenger travel time in a completely different way. Since it is important to take the demand side into account while assessing service reliability, we introduced a new indicator enabling enhanced quantifying of service reliability. This new indicator is the basis for quantifying service reliability effects in a CBA.

Service variability may lead to an extension of passenger average travel time, since average waiting time per passenger may be extended due to irregular, early or late vehicles. To express this effect of service variability on passengers more effectively than punctuality and regularity, we introduced a new indicator, called average additional travel time per passenger (Van Oort and Van Nes 2009b). Using the average additional travel time per passenger as an unreliability impact indicator, the focus on quantifying service reliability shifts from the supply side (variability) to the impacts on the demand side. Using this indicator, increase or decrease of average total travel time due to changes in service variability may be properly expressed, enabling analyses of introducing new instruments and comparing several network designs and timetable proposals in for instance cost-benefit analyses. At this moment, proper expressing of passenger reliability benefits is hardly possible (Snelder and Tavasszy 2010). The additional travel time indicator also enables to deal properly with the trade-off between speed and service reliability (as also discussed by Furth and Muller 2009). Using supply oriented indicators would lead to a focus on the match between schedule and operations which might lead to suboptimal timetables. For instance, the timetable is the reference indicating the match and decreasing the speed in the timetable might improve this match. As schedules (and operations) might become slow, it is obvious that this will not necessarily lead to an increase in overall service quality.

Additional travel time is neither used in theory nor in practice. An international survey (Van Oort 2009b) showed that only London seems to use a comparable indicator: excess journey time (Frumin et al. 2009). This indicator also expresses the additional travel time due to unreliability, but it compares actual and free-flow travel times instead of actual and scheduled travel times.

In addition to the extension of the waiting time, our approach also enables to calculate the distribution of travel times. For incorporation in a CBA, we may calculate the standard deviation of (additional) travel times, as suggested by for instance Turnquist and Bowman (1980), Rietveld et al. (2001) and Tseng (2008), since it is transferrable into monetary values using the value of reliability (Rand and AVV 2005). When the additional travel time and travel time distributions are calculated, using both vehicle and passenger data, the next step is to express these values in money to incorporate them into a CBA.

Both effects mentioned above (additional travel time and its distribution) imply disbenefits for both existing and new passengers. Rand and AVV (2005) showed that passengers value a minute standard deviation of travel time 40% higher than a minute of regular travel time. Table 5.1 below shows both the value of time and value of reliability as used in The Netherlands in 2011. Note that these numbers depend on many factors, such as motive, year and transport mode.

Travel purpose	Value of time	Value of reliability
Business	€ 10.00	€ 14.00
Commuter	€ 17.44	€ 24.42
Other	€ 6.33	€ 8.86

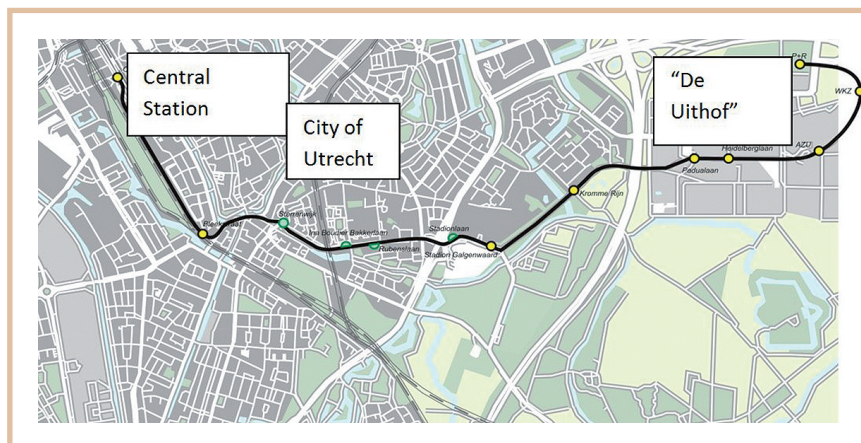
TABLE 5.1 – Value of time and value of reliability in 2011 (Ecorys 2011)

The reduced (societal) costs of service reliability may be calculated using both the value of a unit of travel time extension or variation (P) and the quantity of it (per passenger or summarized; Q)

Most research concerning public transport reliability and CBAs (for instance Li et al. 2013 and Hensher et al. 2011) focuses on the P(rice) element. The Q(uality), for instance reduction in standard variation of travel time, still lacks insights (Van Oort 2011). In contrary to car traffic, where traveller and car are directly connected, calculating the Q for public transport passengers is complex. In addition to vehicle performance, the timetable and passenger behaviour are relevant.

5.3 Case study: light rail line “Uithoflijn”

In addition to the theoretical framework, mentioned above, we also performed a case study in the city of Utrecht (Netherlands). Utrecht is the fourth largest city in The Netherlands with over 300,000 inhabitants. The Dutch government required a societal cost benefit analysis to financially support the construction of a light rail line in Utrecht between the central station and the Uithof, where the hospital and university are situated. At this moment the quality of service of the public transport between Utrecht Central Station and the Uithof is quite poor. Map 5.1 below shows the current line, which has a total scheduled trip time of approximately 18 minutes.



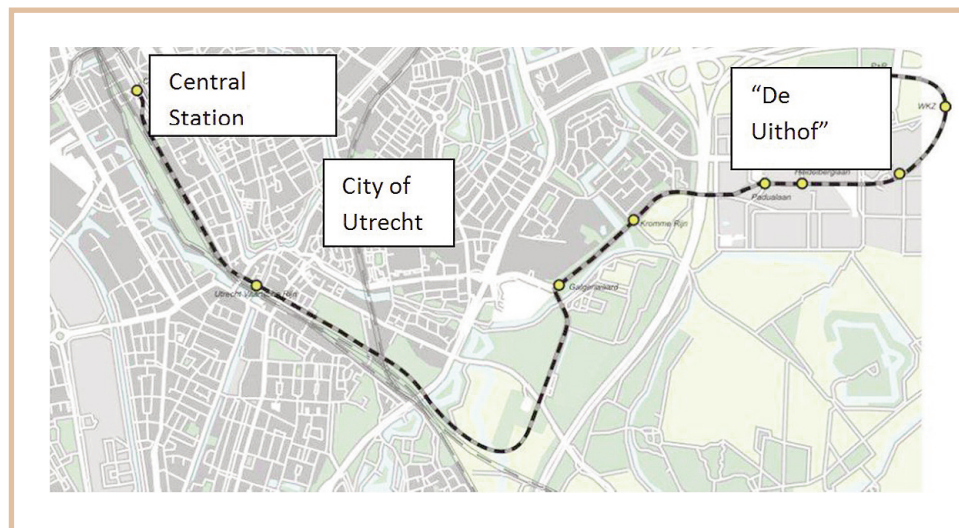
MAP 5.1 – Current route of bus line Central Station-Uithof and vv.

Although the service is operated by double articulated buses with a scheduled frequency of 23x per hour per direction, passenger capacity falls short. On a daily basis, passengers have to wait for 2 or 3 buses to board during the peak moments in the rush hour. Only on small parts of the route, own right of way is provided, which leads to conflicts and hindrance with cars and cyclists and violates reliability. This occurs especially at the border of the old town, where space is limited.

Due to the interaction with other traffic, busses are delayed all the time and often bunching of two or even three buses occurs. The hindrance and the large amount of passengers using the service result in very unreliable bus operations. The average deviation of the timetable is 4 minutes and thus exceeds the scheduled headway (about 2.5 minutes). The line is currently used by about 30.000 passengers per day.

The Uithof is situated in the East of Utrecht, a so called 'knowledge cluster', consisting of the University and other educational centres, the hospital and several related companies. The plans of the city of Utrecht are to expand this area by 25%. In the end, 53,000 students and 30,000 employees among visitors will use this area. Another objective of the city is to handle the growth in mobility by stimulating the usage of bike and public transport. No additional parking lots will be constructed. Demand forecasts (Goudappel Coffeng 2011) show a growth towards 45,000 passengers per day in 2020, which will require over 50 buses an hour per direction to provide adequate capacity. The existing infrastructure is not able to support this number of buses.

To deal with this large increase of public transport use, thereby ensuring high level of service, a new connection was designed. This new line is a fast and reliable connection between the central station and the Uithof. To facilitate reliable services, plans are made to shift from bus to light rail services. This line is called the Uithoflijn and is shown by map 5.2 below. It is about 8 km long and will operate about 16-20 x per hour per direction during the morning peak.



MAP 5.2 – Proposed route of light rail line Central Station-Uithof and vv.

The main benefit of transferring the bus line into a light rail line is, next to less direct emissions, the service can be provided by fewer vehicles than in the case of bus operations. And since fewer vehicles are needed, the hindrance for crossing traffic (i.e. car and bike traffic) is less, and more importantly, the probability of bunching of vehicles will decrease. However, the construction and operation costs of light rail may be higher than bus operations, especially since Utrecht does not have an extensive rail network that is already available.

5.4 The CBA of the Uithoflijn

To construct the light rail line, the Dutch ministry of Infrastructure and Environment had €110 million available. However, the Minister required a positive CBA (indicating a cost-effective project) before supporting this project. In The Netherlands, it is not common practice to incorporate service reliability effects in a CBA, since the algorithms were lacking. However, the expectation was that the service reliability effects would play a major role in the CBA of the light rail line. And since research concerning service reliability (Van Oort 2011) was just published, it was possible to apply the results of that research directly into practice.

In the cost benefit analysis of this case, we calculated the service reliability benefits of transferring the existing bus system into a light rail system. We compared 5 future situations (in 2020), but in this paper we will only focus on the reference and the preferred alternative. These two cases are described below:

Reference case

No additional infrastructure will be constructed and the capacity of it is limited. Since ridership will increase and the number of buses accordingly, it is expected that unreliability will increase.

Light rail case

In this case the service is operated by light rail with own right of way operations. Due to sufficient capacity on the track and at the stops and little interaction with other traffic, the expected level of service reliability will be high. In addition, compared to the required number of buses (over 50), the number of vehicles is limited, thereby reducing the probability of bunching and delay propagation.

To support the CBA with insights in the passenger impacts of service reliability, we analysed the actual (2008) performance, which we used as the base for the 2020 predictions. In the reference case, the level of service will be very low due to high passenger demand and insufficient bus infrastructure. In case of the light rail line, sufficient infrastructure is provided and light rail services require fewer vehicles thereby reducing the probability of bunching. Table 5.2 below summarizes the details of the (expected) level of service in the investigated cases. The level of irregularity is expressed as the average deviation of the headway as a percentage of the scheduled headway (i.e. PRDM, as illustrated by Van Oort and Van Nes (2009b)). These numbers show a poor level of reliability in 2008, which will even decrease substantially in the reference case.

	2008	Reference case	Light rail case
Level of irregularity (%)	100%	150%	100%
Average additional journey time (delays per journey)	1.5 min	2 min	≈ 0 min
Distribution of trip time (standard deviation)	1.5 min	2 min	≈ 0 min

TABLE 5.2 – Actual and expected level of service

In the following step, we calculated the passenger impacts: the average additional travel time per passenger and the distribution of travel times as shown in the next table (5.3). Due to the high level of service reliability in the light rail case, the negative passenger effects of unreliability are neglectable.

	Reference case	Light rail case
Average additional travel time per passenger due to unreliable services	4.9 min	≈ 0 min
Distribution of travel times (standard deviation)	2.4 min	≈ 0 min

TABLE 5.3 – Passenger effects of unreliability of services in reference and light rail case

The investigated reference case shows a very poor level of service reliability, which implies that passengers may have to wait for a second or third bus during a short period in the rush hour. After the calculation of these passenger impacts, the monetary values of these effects were calculated, using values of time and values of reliability as shown by the previous table regarding Actual and expected level of service. The table below shows the total costs and benefits of the project (Ecorys 2011), showing the substantial contribution of improved reliability to the positive score of the cost benefit analysis, which is 1.2 (i.e. the benefits are 20% higher than the costs). The impact of less additional waiting time due to enhanced service reliability of the light rail line is €123 (calculated over the complete life cycle) and the reduction of distribution in travel time results in €78 million less societal costs. So, service reliability related benefits account for 2/3 of the total project benefits of €336 million.

	Value compared to reference case (millions in 2011)
Investment costs	- € 222
Operating costs	€ 66
Total costs	€ 288
Additional ticket revenues	€ 40
Increased travel time	€ 67
Service reliability effects	
- Less waiting time	€ 123
- Reduction in distribution	€ 78
- Increased probability of finding a seat in the vehicle	€ 4
External effects (emissions, safety, etc...)	€ 8
Total benefits	€ 336
Benefits-costs	+ € 48
Benefit cost ratio	€ 1,2

TABLE 5.4 – Additional costs and benefits of light rail line compared to reference case (Ecorys 2011)

Since the CBA score was 1,2, hence larger than 1,0, the Dutch Minister of Infrastructure and Environment supported the project with €110 Million. Without the explicit consideration of service reliability the CBA score wouldn't have exceeded 1,0 and the Minister wouldn't have supported this project.

Cases

6

6 Cases

6.1 Introduction

Our research into light rail basics is backed by many cases and examples. Two of them from The Netherlands have been presented in the sections above: RandstadRail (The Hague) and Uithoflijn (Utrecht). In this section we want to elaborate some more cases in order to address all relevant reasons for failures and lessons for success.



IMAGE 6.1 – Stockholm's Spårväg City restarted as a traditional tramway project

6.2 Overview and analysis

Though the importance and meaning of light rail can be well considered (see previous sections) the practice of projects is not that evident as one would expect. The history of urban and transport planning projects proves the implementation of urban infrastructure tend to be very difficult, as the classic study of Hall (1982) showed. Unfortunately tramway projects encountered many problems. Even new tramways that proved to be very successful were troubled tremendously during the project phase, as for instance McDonald (2000) shows for the Luas tramway project of Dublin. Luas is certainly not an exception since many other troublesome projects easily could be reviewed such as Edinburgh, UK (only partly implemented), Jerusalem, Israel (long project delays, many problems), Paris' T1 first stage (long planning process and relatively high costs like most of the Paris' projects), in Sweden Stockholm's Spårväg City (needed an adapted restart), Saarbrücken, Germany (final stage delayed over ten years), Tel Aviv, again Israel (delays and restart).

Some other light rail projects were killed but were replaced by another type of project about ten years later. For instance: Luxembourg (tram-train killed 2004, but city tramway in planning now), tramway Reims (killed 1995), but new project opened 2010 and Utrecht central city tramway (killed 1995), but now new project in planning along

non-centre route (see also our case in previous section). Unfortunately the plug seems definitively been pulled on light rail projects for cities such as Bristol (UK), La Réunion (France/TOM), Kiel (Germany), Leeds (UK), Liverpool (UK), two schemes in London (UK), South Hampshire (UK), Stavanger (Norway), Zwolle-Kampen (Netherlands). The German cities of Aachen and Hamburg tried to re-introduce an urban tramway twice, but failed so far. Two examples in Spain are really sad. The tramways in Vélez-Málaga and Jaén were built, operated very shortly and ultimately abandoned. Moreover, construction of the tram-train project of León (also Spain) was ceased recently.

Our recent research (publications in preparation by Van Oort et al.) to projects of the Dutch cities of Groningen, Utrecht, and the region of Leiden (RijnGouwelijn), as well as the French case of Strasbourg, unfortunately entails two killed projects. RijnGouwelijn was ambiguously stopped 2011-2012 even though construction was partly started while planning processes covered a period of about fifteen years. The sad history of Groningen RegioTram (killed late 2012) is subject of a pending case study (Van der Bijl, 2013, and book in preparation by Van der Bijl and Van Oort).

6.3 Reasons for failure and risks

Though our research is still pending we are able to present some intermediary results on bases of the partly finalised study of Groningen RegioTram (Van der Bijl, 2013) and our in-depth knowledge of RandstadRail and Uithoflijn (see previous sections). These results are also backed by a research assigned by the former project office of Groningen RegioTram (2010-2012, not published) into a number of tramway projects that used Design Built Finance Maintain and Operate (DBFMO-)contracts (or similar integrated contracts). This latter study revealed some serious risks of complex tendering and project risk management. These specific risks as well as those risks that popped up in our ongoing research into successful cases (e.g. RandstadRail) and the many failed cases are mirrored in the next series of reasons for failure.

Traditionally risk management deals with the scope and the context of a project. Our checklist (6.1) reflects the issues at stake in many light rail projects.

- = Scope, content, interfaces, content, design/engineering*
- = Technology, safety*
- = Financing, funding, business case*
- = Justification (transport value, economy, ..., cost-benefits)*
- = Decision-making politics and administration*
- = Stakeholder involvement*
- = Citizens involvement*
- = Planning and (project-)organisation*
- = Tendering, contracting*
- = Construction, operation*

CHECKLIST 6.1 – Traditional risk management tramway / light rail projects (Van der Bijl and Van Oort, 2014)

Managing these issues properly represents a basic condition for any successful project. However, that's not enough. Our research revealed that, what we like to call a 'technocratic attitude' of decision makers and project agents implies a serious risk. Hiding behind management and engineering they fail to act emphatically regarding all stake holders and particularly citizens and opposing politicians. A second non-traditional risk is embedded in an attitude conceiving the planning process as a rational process. Such an attitude could to a large extent fail to understand, hence to handle social dynamics in and around a project. Irrational behaviour of stakeholders and pressure groups is common practice. Actually this is a main risk in almost every urban tramway project. Finally, a too limited delineation of the project implies severe risks. It's true that the scope of a project should be precisely defined (see checklist 6.1), but on the other hand the developing focus and context of a project should be as open as necessary. While the project is progressing and at the same time not taking into account changing social, spatial and temporal characteristics can kill a project easily (and often suddenly).

6.4 Lessons

Once all reasons and risks have been determined still the question remains how to deal with them.

Some of the presented (successful) cases imply lessons for an improved approach. Generally a lesson is to focus as much as possible on the 'why' of the project instead primarily on 'how' and 'what' (that's traditionally being done). In other words elaborate constantly all five essential domains of argumentation: 'efficiency' (for operation), 'effectiveness' (for the city and its region), 'economy' (of the city and its region), 'environment' (for sustainable development), and finally 'equity' (for all citizens).

From project management point of view acceptance and application of a kind of incremental planning (instead of technocratic and naive 'would-be-rational' planning) is a very important lesson. Furthermore a traditional lesson is embedded in a project conception that frames the size of a project to a minimum, and using proven technologies wherever possible. While handling the project requires a broad view and perception, there should the actual project being chopped in smaller projects when possible. A smaller (starter) project can be implemented faster and more reliable than bigger ones, hence creating 'faits accomplis'. Once something is built and used, it becomes much more difficult to kill the project in its subsequent stages.

However, while opportunistically a project should be small and defined, the social context should be approached as comprehensively as possible. This lesson implies socially involved project management, opportunistic stakeholder management and most of all an unconventional approach towards politics and administration.

Key findings

7 Key findings

7.1 Conclusions

Our comprehensive argumentation, including economic arguments as (Knowles and Ferbrache, 2014) has been putting forward, prove the importance of light rail in urban contexts. First of all light rail can be applied as an efficient mode of public transport. It allows cost effective operations, specifically regarding service reliability, which proved to be a key quality aspect, both from passenger and cost-benefit perspective. This property deserves priority in any assessment of projects or considered alterations and improvements of existing public transport networks. Second it should be recognised that rail-based public transport like light rail represents a strong and effective tool for urban planning and design, including traffic planning and design. The post-war generation of new tramways (e.g. in France) and light rail systems (e.g. in the US) obviously demonstrated the value as such of light rail to improve the quality of cities and urban regions. This counts for aesthetic ameliorations and what is called the 'image' of the city (e.g. (Knowles and Ferbrache, 2014)), but more importantly, for functional and social improvements. Light rail in other words helps to structure the city. It focuses urban growth and development, hence it prevents sprawl, and it can contribute to social inclusion. Moreover it enhances sustainable developments expressed in environmental terms. This means light rail as an electric mode helps to reduce the amount of particles and traffic noise within local settings. Moreover light rail contributes to modal shift from private car to collective modes of transport, hence to the reduction of traffic volumes and vehicle movements. Therefore light rail helps to reduce consumption of energy as well as harmful emissions. And last, light rail favours economic conditions. (e.g. Knowles and Ferbrache, 2014).

It's remarkable that all benefits of light rail should be expressed in measurable terms. But if something can't be measured it's not necessarily true that it's of no value. It's also remarkable that light rail (including other high quality rail-based public transport) according many decision makers and scientists should be justified primarily in financial and economic terms. Though any mode of public transport should be justified according financially healthy objectives (i.e. traffic demand, operational costs, etc.) it should be recognised that public transport (e.g. light rail) is a basic condition for any city and its urban region. It's an essential public amenity. In many countries in Europe, America and particular economic successful countries in Asia this is broadly recognised and accepted. In this respect the UK and in some extent also Netherlands and Scandinavian countries exaggerate the importance of economy. Certainly the UK with its very low investments in urban public transport doesn't seem to recognise the obvious benefits and necessity of light rail in at least all medium-sized and bigger cities and their urban regions (e.g. Liverpool).

7.2 Recommendations

This paper addressed the importance of light rail. First of all as efficient means of transport, particularly efficient since light rail is synonym with reliable public transport. Second as crucial condition of urban (re)development and its economic, environmental and social

assets. Unfortunately we must recognise that the benefits of light rail are underestimated in many cases. Therefore we recommended EMTA (and all transport agencies) to boost improved and new appraisal methods, including the necessary efforts and particularly research to accomplish shift to comprehensive and full assessment of light rail projects. Second we recommend that EMTA review our findings in past and ongoing projects of their members (or projects that contain interests of their members).

Third, extensive data collection (both from a vehicle and passenger side) and analysis should be encouraged for two reasons: it is important to quantify and illustrate the benefits of existing systems (concerning increased patronage and level of service for instance) and moreover: proper data collection will increase our understanding of mechanisms and passenger behaviour, thereby enhancing future decision making.

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