# Sustainable urban development with LRT
## Lessons from Netherlands and Japan

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## Summary

Possibilities for the application of Light Rail Transit (LRT – light rail, tramway) as high-quality public transport in cities, urban regions are countless. Our article opens with the question about the specific characteristics of LRT. Then the question is asked which comprehensive argumentation LRT projects can justify. Finally, we examine the question of how these types of projects can be realized. Each of these three questions - What? Why? How? - is addressed on the basis of a set with two LRT main cases, respectively from the Netherlands and Japan.


Light rail in Japan:
Tram (LRT) and conventional 'heavy' train next to each other at Washizuka- Haribara station (Fukui region, Japan).
Image by author Kiyohito Utsunomiya, March 27, 2016

# 1. Introduction and questions

The social value of high-quality public transport is recognized worldwide (Van der Bijl et al., 2018). To clarify and elaborate this value, three basic questions require an answer: what, why, and how? Firstly, what kind of public transport is available, what technical and functional form can public transport in cities get, what kind of modalities are at stake? Secondly, why is public transport necessary, and why should projects be implemented for this? Thirdly, how does the intended project become feasible, and how can it ultimately be realized?
In order to find the broader, more comprehensive advantages of Light Rail Transit (LRT), an extensive answer to all three questions is given in this paper with the aid of six case studies, three of which are from the Netherlands and three from Japan.

LRT can be regarded as an excellent form of urban public transport (e.g., Lesley, 2011). Other forms of high-quality public transport, such as BRT (bus rapid transit) on the one hand and metro (or mass rapid transit, MRT) on the other hand, have similar, but not necessarily identical characteristics (Cervero, 1998/2013). Ultimately, light rail, BRT, MRT (and train) represent the entire palette that can and should be used for cities around the world, as explained by United Nations (2014).
In Van der Bijl et al. (2018) a modality that corresponds to light rail characteristics is therefore considered a means to achieve a goal (no more and no less). In order to investigate the broader benefits of light rail, it is therefore necessary that a threefold task be brought to a successful conclusion, in other words, that an answer to the three basic questions is found in succession: a precise definition of light rail (what entails this means?), a solid argumentation for LRT (why using this means to achieve the goal?), and finally the answer to the question of how the intended application (in this case the project) can be realized (how the goal becomes reality by using the means?).

## 2. Cases

Our six main cases (and two additional case) were selected on the basis of our experience with light rail projects worldwide. In particular, the selection is based on recent work on current developments within the application of LRT in both Netherlands and Japan (see credits section). In addition, topicality and representativeness have led to the next three-part selection.

*Set 1 – Definition light rail (what?)*

*Case 1a - Netherlands, The Hague / Rotterdam, RandstadRail*. The largest and most successful LRT project in the Netherlands representing a true sample of light rail infrastructures and vehicles. RandstadRail is made up of two networks that overlap on a part of the former regional railway line between The Hague and Rotterdam. From The Hague two tram lines have been extended via the former railway line to a new satellite city (New Town) (with a new route to a new local district). From Rotterdam a metro line has been extended via a new tunnel and the converted railway line to The Hague Central Station.

*Case 1b - Japan, Fukui, Phoenix Tawaranachi*. In Fukui city, the prefectural capital of Fukui along the Japan Sea coast, other than JR, former Japanese National Railway, there are two private local railways. One is the Fukui railway connecting Fukui with two cities of Sabae and Echizen in the south of Fukui. In the city centre in Fukui it runs on the surface of streets and on a segregated track in the suburbs. In 2013 it introduced new LRVs, called “ Fukuram” (which not only abbreviates “Fukuii tram” but also means “growing” in Japanese) and started a tram-train operation, which goes through another private railway company’s line, Mikuni-Awara line of Echizen Railway operating a little bigger train network in the north and east of Fukui city. This new tram-train network is dubbed “Phoenix Tawaranachi Line”

*Set 2 – Light rail argumentation (why?)*

*Case 2a – Netherlands, Utrecht, Uithofline.* The line will be opened in 2019 as a connection between Central Station via a route around the south side of the central city to the Uithof university district. In a second phase, the line will be linked in a continuous operation to the Nieuwegeinlijn (the light rail system from the 1980s) at that time converted to operation with new low-floor trams

*Case 2b – Japan Toyama, Portram*. Toyama, the prefectural capital of Toyama prefecture, is the first city introducing LRT when it faced the risk of closing JR suburban branch line, which connected Toyama city and Iwasehama, the port area of Toyama . Toyama municipal government decided to take over this JR line, replaced the line near JR’s main station with a surface running in streets, which is planned to connect to the existing tramway in the city centre, and rebuild the whole system as LRT instead of conventional railway. The line was officially named “Portram”. To cover all relevant features of LRT the other LRT project of Toyama is used as an additional case. Centram entails a new loop in the city centre that allows a new circular services. A through connection between Portram and Centram will start March 2020.

*Set 3 – Light rail implementation (how?)*

*Case 3a – Netherlands, Groningen, RegioTram.* This failed project aimed at the construction of two city tramlines from the main station: a line along the city centre to the university district on the north side of the city, the other through the city centre to a residential area in the northeast. In a second phase, regional trams from the city would serve the 'surrounding country' via existing railway lines.

*Case 3b – Japan, Utsunomiya LRT project.* Utsunomiya is prefectural capital city of Tochigi, which is located in the north of Tokyo. The first phase of the line will be operational in 2022 as a connection from the rear of the main station with Honda Giken Kitamon (North gate to the Honda research and development facility) in the town of Haga to the east. The second phase, which connects the city centre in the western part of the main station is under discussion.

## 3. Definition (cases RandstadRail and Phoenix Tawaranachi Line)


Light rail in The Netherlands:
Randstad Rail (LRT) arriving at Leidschenveen station (The Hague region, Netherlands).
Image by author Rob van der Bijl, November 8, 2006

The term light rail was launched in the mid-1970s by the Transportation Research Board (TRB, 1978). Based on study trips and research in Europe, TRB offered the following definition: *"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."*
In order to integrate infrastructure and accompanying services of light rail flexible and pragmatically into the urban environment, Van der Bijl et al. (2018) drew up the following definition: *"Light rail is a rail-bound form of public transport that is used on the scale of the urban region and the city. In contrast to train and metro, light rail is suitable for integration to a certain extent in public space and, if desired, for mixing with regular road traffic."*
A technical elaboration of the definition is based on the German concept of 'Stadtbahn', which is described in great detail in the handbook 'Stadtbahnen in Deutschland' (Girnau, G., et al., 2000). Based on the three themes (Infrastructure and vehicles, Use and operation, Performance and perception) our definition is elaborated below.

*Infrastructure and vehicles*
Within urban environments LRT as in the cities of The Hague and Fukui can use different types of infrastructure, primarily traditional or upgraded tram infrastructure. If necessary, such tramways can generally be integrated into the public space, or in particular within zones of other road traffic, for example a lane that may or may not be shared with cars. Ground level crossings and junctions with

other traffic can then be given the status of ordinary intersections. Several examples can be found in The Hague where RandstadRail forms part of other road traffic in such ways. Our associated case in Fukui has similar street routes for the regional trams crossing the city.
Under certain conditions, LRT can use existing 'heavy rail' infrastructure. In Europe, in particular, several so-called 'tram-train' systems exist. The trams on these systems use adapted railways, such as the case at RandstadRail (and our case in Toyama, see next section). Our case in Fukui is an example in Japan.
It is rather rare if trams use metro infrastructure. In that respect, RandstadRail, with its combination of trams from The Hague and Rotterdam metros, is an outsider internationally. On the other hand, the Rotterdam metro system to our definition and internationally accepted definitions should rather be regarded as a light rail system.

Van der Bijl et al. (2018) have distinguished six types of infrastructure for a differentiated classification of LRT. Each type represents a characteristic way in which this infrastructure is tailored to the urban environment:

= Traditional street-based
= Shared-space
= Traffic lane
= Separate tramway
= Metro-style tramway
= Railway for tram-train

Each type differs from the other types in the method of alignment, as well as the way in which infrastructure, stops or stations, crossings and facilities are fitted. In practice, LRT infrastructure for a particular tram operation will usually consist of combinations of several types. Within the RandstadRail system all types have been applied with the exception of tram-train. It is true that a large part of the infrastructure consists of a former railway, but no heavy rail vehicles use it anymore. In Fukui there is also a variation of infrastructures. However, the type of shared space (e.g. mixing in pedestrian zone) and metro-style tramway (e.g. use of underground and elevated structures) are missing here. Apart from within the agglomeration of Fukui, the system nevertheless takes the form of a railway with level crossings.

In Van der Bijl et al. (2018) a concise distinction is made between four basic types of tram vehicles (also referred to as light rail vehicles; LRVs). Each type is tailored to infrastructure and urban environment:

= Conventional urban tram vehicle
= New-generation low-floor urban tram vehicle
= High-floor light rail vehicle
= Tram-train vehicle

In practice, the variation in type is much larger and more complex than is suggested here with this simple example typology. For example, RandstadRail is operated with two different types of cars, with low and high floor respectively. For the Fukui system, old high-floor vehicles are used (second hand acquired from the contents of the closed Gifu tram) and modern low-floor trams. For the sake of completeness, it should be noted that our simple typology does not do justice to recent technological innovations, as has now been widely applied in Europe and Asia, for example in Kaohsiung (Taiwan) where the trams run without overhead. They receive their power from supercapacitors placed on the vehicle’s roof, which are recharged at each stop via the pantograph.

*Use and operation*

LRT in all its variants is a typical urban form of public transport. This feature is proved by all our cases. In the event that a rural light rail system is at stake, this usually involves a connection with the local big city. Our tram-train case in Fukui with its long route to Echizen-Takefu is an appealing example of this.
Like most other public transport (BRT for example), LRT systems serve multiple target groups, which can be distinguished in different ways, at least by category (forced, choice, potential traveller, etc.), by type (residential work / study, shopping recreation, etc.). Our case RandstadRail shows that public transport plays an important role for commuters and students. Apart this dominant users, mainly shop visitors from the Hague or Rotterdam centre use the system. In Fukui, students are dominant for the time being because Fukui is a car dependent regional city, but new tram-train scheme has attracted more and more passengers other than students.

In order to offer high quality, it is important to give extra attention to the planning and execution, with a view to reliability and efficient use of the infrastructure. At RandstadRail it was decided at that time to apply a control philosophy'' (Van Oort & Van Nes, 2009). The most important steps in this are: preventing, absorbing and adjusting the distribution and operation respectively. The punctuality is shown to the driver via a display in the cabin, so that he can adapt his driving style to the timetable. Moreover, the Central Traffic Control has visibility on all vehicles and their punctuality. In case of disruptions they can adjust the service execution. RandstadRail has a large share of segregated infrastructure and is often a priority at traffic lights. The vehicles have wide doors and offer boarding without height differences, which positively influences the halting process.
After the start of RandstadRail, all measures from the ‘control philosophy’ were analysed on the basis of current data from the service execution. It appears that the variation in driving time has decreased compared to the old situation and that the punctuality has increased. Due to a higher reliability, the average travel time of passengers has been shortened. Improved regularity has also increased the chances of a (sitting) place and the uncertainty among travellers has been reduced.
Reliability of service delivery and efficient use of infrastructure play a much less prominent role in the Fukui system. That has in any case to do with the much lower frequencies offered here. The volume of transport is also significantly less that in the RandstadRail case. In addition, no priority is given in trams in Japanese cities to other traffic. The city of Fukui is no exception to this. On the other hand, the trams get absolute priority at railway crossings outside the city, just as ordinary trains.

*Performence and perception*
Transport volumes of LRT vary substantially. That depends on their success, but also on the size and density of the area they serve. Some systems perform according to the demand of a small city, other systems perform on a metropolitan scale and achieve results that are comparable to a metro system. Beyond such achievements, the broader benefits of light rail are increasingly being recognized (Van der Bijl et al., 2018). Unfortunately, that is often not the case in Japan.
As a result of typical light rail characteristics (urban, high quality, visually present, etc.), the transport performance is usually higher than expected or calculated. This phenomenon is sometimes referred to as the 'rail bonus', which has been determined to be 5% to 15% (Bunschoten et al., 2013). For other non-rail public transport services such as BRT there is no evidence of a comparable bonus. On the contrary, it is confirmed in various research (for example, Currie & Delbosc, 2013) that normally light rail yields proportionately more passengers than high-quality bus (such as BRT). Moreover, no BRT projects have been realized in Japan yet.
Our case RandstadRail has replaced traditional heavy rail trains and has a transport volume that has exceeded the old system many times, hence RandstadRail is considered to be very successful. For example the Rotterdam line of the system carried in 2014 already over 5 times more passengers (37.000/day) than the old system in its last year (2007; 7.000/day). The success of LRT in Japan and thus also in Fukui is less obvious than in the Netherlands and other European countries. Japan is aging and the continued existence of railways and LRT systems is not self-evident. This is mainly because public transport in Japan must be fully cost-effective. Nevertheless, the boundaries of this

(political) base are becoming increasingly clearer. After the commercial operation of both the 'Fukui Railway' and the 'Echizen Railway' staggered in 2000 and the private owners ceased part of the services, in 2003 rail transport was taken over by a joint venture between municipalities along the line and private parties. Something like that in Japan is called a 'quasi-public' company, funded with money from municipalities and, among other things, the Chamber of Commerce. However, the municipality of Fukui and its neighbouring municipalities have clearly recognized the socio-economic importance of light rail and underlined it by improving the service with new equipment and new infrastructure after 13 years of 'quasi-public' operation and expanding it as a tram train. Go-through operation between different private/quasi-public companies is popular in metropolitan areas in Japan (e.g. Tokyo), but Fukui is the first case in regional area. While other regional cities are still struggling to keep public transportation, the situation in Fukui is changing especially due to the introduction of tram-train service with modern stylish low floor vehicles.

The obvious presence of LRT (infrastructure, facilities, etc.) lends these systems well for providing a brand, the so-called 'branding'. Names and logos are typically used to underline the urban quality and presence. The performance of a LRT system can be increased if 'branding' takes place in a coherent and effective manner, which also strengthens the legibility and comprehensibility of the system (Van der Bijl et al., 2018). A consistent, strong, unified brand, such as 'RandstadRail', proves this. The same applies to the strong image of a Phoenix in Fukui. Brands of this kind can actually make a public transport system recognizable (NACTO, 2016).

## 4. Argumentation (cases Uithofline and Portram; including additional case Centram)


Light rail in Japan:
Tram (LRT at terminus station Iwasehama (Toyama, Japan)
Image by author Rob van der Bijl, April 7, 2008

Investments in LRT (or for example BRT) can be justified on the basis of various considerations (Van der Bijl et al., 2018, 2020). Many times the argumentation to favour a certain modality is given by costs (e.g., Bruun, 2005, Tirachini et al., 2010). For example, an important argument for preferring high-quality buses is often based on lower construction costs (Cervero, 2013, Wright & Hook, 2007). This is a valid argument. However, our concerns relate to the wider benefits of light rail. A complete and comprehensive framework of argumentation has been drawn up for this purpose in order to visualize both the characteristics and the specific advantages of LRT (Van der Bijl et al., 2018). This five-part argumentation can be summed up with five E's (see also Figure 1):
Effective mobility (E1) – effectiveness of transport and mobility
Efficient city (E2) – suitability of spatial use and spatial/urban (re)development
Economy (E3) – prosperity and wellbeing in/for cities
Environment (E4) – decreasing carbon footprints; sustainable cities
Equity (E5) – socially inclusive cities

Figure 1: The 5E framework: 5 essential domains of argumentation - © Van der Bijl & Van Oort

Each E represents its own domain within which LRT can be assessed on its characteristics and performance. Our series of five is discussed below, with BRT being briefly mirrored to LRT for each domain. In related manner our framework can also be used for other modalities.

*Effective mobility (E1)*

Early research (for example Hass-Klau et al., 2000) into the usual modalities of public transport, such as tram and bus, shows that within an urban environment, suitability and hence effectiveness are closely related to scale and scope of the specific transport demand. This kind of research has provided insight into the general considerations for a choice between light rail or high-quality bus (such as BRT) - see, for example, the comparison between the performance of various public transport systems by Currie & Delbosc (2013), Rizelioĝlu & Arslan (2016) and Stutsman (2002).
LRT and BRT are ideally suited for the range of 2-20 km. This corresponds to the typical size of a city with suburbs, in other words, the range coincides with the domain of cities, urban regions and (parts of) metropolitan areas. There is a substantial overlap between the scope classes: local, city, agglomeration, region. This implies that the choice for LRT, or other modalities (high-quality bus, metro, or train) depends strongly on local conditions, in particular the characteristics of the urban environment.

It has been accepted in European countries such as the Netherlands that a bandwidth of 20,000 boarding passengers for an urban tram line is already optimal (urban-regional distances allow even lower figures). Nevertheless, many LRT systems with much higher volumes are performing, for example, the expected volume of the new Uithofline in Utrecht is 60 thousand boardings per day in 2020. The double-articulated CAF Urbos 100 low-floor trams of the Utrecht system (2017) have customary dimensions: length: 33 m, width 2.65 m and capacity of 216 passengers (including 154 standing places). For the intended performance in 2020, coupled CAF trams will be deployed with a total length of 75 m and a capacity of 493 passengers. The Niigata Transsys Company trams in Toyama have a much smaller capacity (length: 18.4 m., width 2.4 m.) and capacity of 80 passengers (of which 52 are standing). There are no coupled trams in regular service. *Note)

*Note)
Compared to the Urbos trams in Utrecht the Niigata Transsys Company double articulated F1000 trams in Fukui have a less smaller capacity (length: 27,16 m., width 2.65 m.) and capacity of 155 passengers (of which 102 are standing) They are no coupled trams in regular service. Also used are the Echizen Railway L Series (comparable with the trams in Toyama and in several other cities in Japan).
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Although double-articulated buses, as known from the South American BRT systems, have similarly large capacities (moreover with proportionally more standees), such as the Utrecht Urbos 100 low-floor tram, the capacity of coupled tram sets can’t be achieved on a single line operation (the buses are not connectable). The fact that some of these BRT systems still achieve volumes that even surpass those of metro systems is due to the fact that several lines coincide within urban corridors and the buses of those lines can pass each other at stations. The price that has to be paid for this is unfortunately high, namely overcrowded buses, a large degree of discomfort, insecurity, above all

unreliability and ultimately a saturation of the system, at least that is our conclusion based on research to be published on the BRT from Bogotá in Colombia (Van der Bijl et al., 2020).
In Toyama, the volume of transport is much smaller than in Utrecht (or big South-American cities like Bogotá). The low-floor trams on the converted 7.6 kilometres port railway line (Portram) copes with daily transport volumes in the order of 4,000 passengers.

Besides travel time, reliability and comfort are also important quality aspects for travellers. In many cases, projects are also aimed at improving these features, for example through the introduction of LRT (or BRT). However, these benefits are not explicitly included in many 'social cost-benefit analyses'. In Van Oort (2016), the Uithofline demonstrates that these benefits can be substantial. For this new light rail system benefits were calculated to be more than 2/3 of the total costs, many times greater than the 'classic' travel time benefits. Improved comfort, due to less crowded vehicles, also implies social value. Van Oort et al. (2016) show this value in a new methodology for predicting traveller numbers, in which comfort is explicitly included. They conclude that the classic approach, without comfort benefits, tends to underestimate the order of 20-30%.
In Toyama, reliability and comfort also represent the most important quality aspects for travellers. Passenger numbers at Portram has doubled on weekdays compared with the former JR line and more than tripled on holidays. Interestingly, this leads to the increase in passengers of existing tramways in conjunction with the introduction of Centram, which was enabled by a newly built 0.9 kilometres connecting line. Utsunomiya (2017) shows that residents along Portram find addtionnal values of the LRT by 20 percent to ordinary bus and by 17 percent to BRT.

*Efficient city stad (E2)*
Beyond merely transport LRT has shown that it can contribute to the efficiency and quality of the city. For example, light rail projects were used to improve shape and arrangement of public space. Over time, LRT networks have proven that they can stimulate and structure the spatial and functional (re) development of the city. As an extension of this, LRT is regularly used in urban design and planning as a tool for 'transit-oriented development' (TOD) (Curtis et.al, 2009, Van der Bijl, 2014). However, a sustainable fixed infrastructure is a precondition for this. The minimum thirty years of technical and economic life span of an average light rail system is more than sufficient here (Van der Bijl et al., 2018). This makes the Uithofline also important for the future development of the served urban districts in spatial-urban terms.
In Toyoma TOD has from the outset been an important justification for the development of both Portram and Centram. The surroundings of the renewed and new stops on the former port railway of Portram have been reshaped and partly newly developed. Centram is even primarily intended as an improved access to the city centre that also functions as a regional centre. The Centram project is also used to reshape parts of inner city's public space. According to a survey by Toyama municipal government, 10 percent of the residents, who moved in the city centre after the introduction of Centram, reply that they moved in mainly due to Centram, and one third reply that the existence of Centram is one of the reasons of moving. Portam and Centram will be connect under de new main station in 2020 and integrated as a LRT system under Toyma Chiho railway, which operates existing tramway. From then on, TOD can be applied to an even greater degree.

In the case of BRT, sustainable presence (and therefore spatial-urban significance) is not a foregone conclusion. Despite the fact that a BRT system is characterized by its own infrastructure, in practice it often appears to be (relatively) open to other uses and users, which means that the sustainable condition risks to lose its meaning (Van der Bijl et al., 2020).
When a tram line (or bus line) is pulled through urban areas, the re-materialisation, design and design of public space are always a challenge. When grooved rail with a small tram profile is used, the design and layout options are considerable. Variation in material use (for paving, greening, etc.) is great, while crossings (if correctly designed) can be well facilitated. The various LRT routes in Utrecht and Toyama offer an attractive sampling of possibilities in this respect. Buses in general and

BRT in particular, due to their relatively large profile – a bus does not have a strict fixed track – and heavy tires, impose considerable restrictions on the materialisation, design and layout of the public space (Van der Bijl et al., 2020).

*Economy (E3)*
It is generally assumed that LRT has a positive economic effect. However, direct, let alone causal effects in economically already strongly developed cities are virtually impossible to prove, or even scarcely present. Hass-Klau et al. (2004) emphasizes that economic effects only occur in combination with relevant interventions, initiatives and investments, as well as other forms of support. Private parties play a role here, but also public institutions, and in particular the (local) government that can stimulate, coordinate and which is, above all, capable of facilitating infrastructure and economic development.
Nonetheless, Knowles and Ferbrache (2014, 2016) appreciate the absence of what they call 'a well-developed and modern transport system' as a serious limitation to economic growth. On the other hand, they confirm that land and real estate value generally increase - and that it will be possible for developers to contribute to investments in the area - when the access and accessibility of the area concerned has been improved by the arrival of LRT. For this phenomenon they have coined the expression 'inward investments'. So much is certain, improved connections and access to the area give stakeholders, such as entrepreneurs and governments, the opportunity to contribute to economic activities.
Like LRT, BRT offers comparable improvements in connection and accessibility. For the time being, indications are limited that this has direct or indirect economic effects. This may be due to the fact that the infrastructure of BRT (or high-quality bus systems) is often less durable and time-resistant (Van der Bijl et al., 2020).

The high-quality bus (predecessor of the Uithofline) has been an important condition for the localization and development of the served university district outside the existing city. It is possible that the Uithofline will strengthen the further development, but research into any economic effects only makes sense if the tram has been in operation for several years. However, it is always a question whether the economic development in the vicinity of the stations and stops is not primarily or exclusively due to economic redistribution. This applies to the Uithofline, but also to the LRT system of Toyama. Nevertheless, it is obvious that there are some economic impacts on Toyama. For example, number of tourists visiting Toyama port area increased. Commercial land use has a tendency to increase along the line and land prices in this area bottomed out first in Toyama city when other areas suffered the decline due to decrease in population and economic stagnation. Portram in particular is an encouragement for 'inward investments'.

Hass-Klau et al. (2004) have studied the transformation of inner-city shops ('retail') through the arrival of light rail on the basis of the new tram line through the centre of the French city of Strasbourg. Smaller shops have been replaced by retail chains from the premium segment, while rents and real estate values have increased. This has been confirmed in a national study of the former CERTU ('Le Centre d'études sur les réseaux, les transports, l'urbanisme et les constructions publiques', 2005). The Uithofline does not serve the inner city of Utrecht and is of no importance for the development of retail there. However, the already strong development of catering establishments in the vicinity of the new Leidsche Vaart station deserves attention in the coming years. This also applies to (new or renewed) facilities in the Uithof university district.
In Toyama it is found that visitors using Centram stay longer and spend more money than those driving cars. Urban redevelopment projects along Centram have started., though commercial effects are not clear yet.
By the way, Hass-Klau et al. (2004) have shown that with the arrival of a new tram, shopping streets can also deteriorate. Apparently there are 'winners' and 'losers', which is an indication for the validity

of the same findings of CERTU (2005), which established that the new tram lines through the French inner cities are strengthening strong retail and pushing the weaker.
It is not likely, however, that BRT (or buses in general) have such an effect on the inner-city shop apparatus, given their disturbing influence (noise nuisance, land take, etc.).

*Environment (E4)*
Light rail contributes substantially along the routes formerly served by buses to the improvement of the local environment (Van der Bijl et al., 2018). The electrically powered trams reduce CO2 emissions and air pollution. Sound nuisance can also decrease. In addition, the higher capacity of an operation with light rail makes it possible to reduce the number of vehicle movements considerably (compared to the old bus service), and even more when car drivers switch to the new tram.

If BRT (or high-quality bus) is driven electrically or otherwise emission-free, comparable positive environmental effects can occur (Van der Bijl et al., 2020). However, these bus technologies are still at the beginning of their development, while the problem of the relatively large number of vehicle movements remains unsolved.

In the argumentation for the Uithofline the environment did not play a role, despite the fact that in the nineties, when the discussion about the usefulness and necessity of a tram to the Uithof took place, international attention was already paid to energy and environmental implications of LRT systems (e.g., Commission of the European Communities, 1994). Now, incidentally, because in the current appreciation of light rail in the Netherlands (Uithoflijn, RandstadRail), little or no attention is paid to environmental benefits (we are not aware of any research about this).
The environmental issue in Japan, especially regarding regional cities, is important. 11.5 percent of Portram passengers used to drive a car and 3.5 used taxies before the introduction of Portram. Hence, the new tramway has changed travel behaviour along the former railway line. On top of this Toyama city was designated as “Environmental model city” by Ministry of the Environment in July 2008.

*Equity (E5)*
New light rail systems such as those in France and England are generally regarded as contributing to the restoration of social cohesion and social inclusiveness. The importance of these systems is emphasized for the accessibility of work, shops and public facilities. Access to social networks and family are also mentioned in this context (Van der Bijl et al., 2018). Many commuters could not keep their work if public transport were to be stopped (Crain & Associates, 1999). It is therefore not surprising that the availability of public transport, such as LRT, is decisive for many to seek, find, or retain work. In some cases, more than half of jobseekers say that poor public transport is a decisive barrier for them to get work (Social Exclusion Unit, 2003). Looking from 'the other side of the table', this implies that missing public transport has a direct negative effect on the available labour pool for companies (Knowles and Ferbrache, 2016). LRT can therefore have a positive effect here. This also applies to BRT, which compared with LRT has the advantage that its construction is less complex and costly (Van der Bijl et al., 2020).
In order to evaluate LRT and BRT (or public transport in general) within a more extensive framework on the theme of inclusivity, Lucas (2004 & 2012) offers a comprehensive perspective on social inclusion / exclusion and environmental justice. Martens (2017) has further developed the 'right to transport', showing the benefits of fair transport systems.
Utsunomiya (2016) also investigated the relationship between public transportation and social capital and, based on a survey research on residents along Portram, shows that the new LRT have considerably changed more than half of residents’ activities and has tended to promote more opportunities to come into contact with others than before. For example, 20 percent of residents “meet friends and acquaintances more often than before” the introduction of Portram and 6 percent “expand new networks.” Social impacts of LRT should not be ignored in its appraisal.

## 5. Implementation (cases RegioTram and Utsunomiya LRT project; including additional case Olsztyn)

Naturally, definition and argumentation for a LRT project are important (see above), but the question on implementation also deserves an adequate answer. The classical study by Sir Peter Hall (1982) is highly relevant in this respect. The title of his book 'Great planning disasters' speaks for itself. Many large projects are doomed to failure. If they are already realized, then for unexpectedly high costs and rarely without defects. Delays and cost overruns appear to be the rule rather than the exception. In particular, construction costs seem to be underestimated, as well as organizational and institutional complexity. Flyvbjerg (2007) observes in his study that in many cases, rail projects often involve considerable cost overruns. It is striking that Flyvbjerg's research does not pay attention to the large differences between infrastructure projects. In any case, he does not seem to do justice to the specific characteristics associated with the implementation of LRT projects.
Our cases in Groningen and Utsunomiya represent attempts to do justice to this. The Groningen project (2006-2012) was seriously prepared, but ultimately failed (Van der Bijl, 2013). The project in the city of Utsunomiya has been subject of debate for decades (Utsunomiya, 2015). Nevertheless, the city council decided in 2015 to build the tramway. Construction started in 2018 and the tram will be commissioned in 2022 as planned.
It would be too easy to put administration and politics to blame for the failure of the project in Groningen and the very long preparatory discussion in Utsunomiya, since the inevitable planning processes were and are very complicated. There are several causes at stake. The most important points for each of the projects are summarized here. Moreover a note is added to explain and to evaluate implementation of LRT in Europe, including the use of additional case Olsztyn (Poland).

*Groningen*

= It is remarkable how narrow the argumentation for the project has been. Of the five domains (see above, E1-5) is exclusively and continually hammered at the first: the tram would be necessary because buses would no longer be able to cope with the large streams to the university (which today does not turn out right; Van der Bijl et al., 2018). Honesty requires that the forecasted transport values were not low, but not spectacularly high. In Groningen, the tram was in spatial sense (E2) predominantly seen as a problem or as an infringement. For example, the tree plan was not expressed as a nice addition to the project and the city, but as 'compensation' of what would be lost with the arrival of the tram. Economic value (E3), environmental benefits (E4) and social inclusiveness (E5) were never used as arguments.

= The support has gradually crumbled. For example, local residents and shopkeepers feared inconvenience and problems with supplies in an important inner-city street. After careful consideration, an alternative was developed that provided a single track with which the complicated puzzle was largely resolved. Nevertheless, the resistance remained. Initially communication with the population was good, but with the rise of Twitter the information officers got caught up, which was reinforced by the chosen contract form (see the second point below). The official support was also narrow (for various reasons that we do not consider here for the sake of brevity), but killing for the project was the opposition in the official top of the municipality of Groningen.

= LRT projects are always complicated, so projects like that have to be made as small as possible. In Groningen, however, the opposite happened, the 'scope', as it is called, was enlarged. Moreover, as a city tram project it was loaded from the outset with the status as a regional project (hence the name RegioTram) and in the specifications of the first city tram phase, track characteristics had to be taken into account. Nevertheless, the projected line, after already being worked on, was supplemented with a second line. As a result, the planning process was extended by at least one year. New procedures had to be set in motion and the second line gave rise to discussions with local residents, other interest groups and services from the municipality of Groningen.

= A new form of tendering, DBFMO, was chosen that provides a long term (25.5 year business case) with a consortium that takes care of design, construction ('build'), partial financing ('finance'), maintenance and operation, including acquisition and maintenance of the tram vehicles. The choice of Groningen for DBFMO was absolutely frivolous. After all, with this complex, innovative contract form, no experience was gained for the construction of a new tram line in the Netherlands (and many other countries too). Moreover, a DBFMO procedure usually takes more time for various reasons. At DBFMO, once the actual tendering process has started, it is only difficult to communicate with the outside world. All information exchanged between project organization and market parties is confidential.

= The project organization was very professional, but undeniably struggled with a technocratic attitude. In general, the project was seen too much as a technical task, but a new tram line through a city centre is not only a matter of civil engineering but also a matter of urban development and social enterprising. Instead of putting more emphasis on 'design', in order to make social demands and wishes become clear and evident, priority was given to 'engineering' from the start, i.e., to technical specification. The dominance in the project of the latter was partly due to the choice of DBFMO, which requires that all specifications be made explicit in advance, and therefore at an early stage.

= Finally, the ultimate cause for the loss of the project: the political context changed, as usual after elections. The new politicians thought the tram project was an expensive toy. The financial construction with DBFMO remained a misunderstood 'black box' for them. Moreover, the city faced financial problems as a result of the financial crisis that, from 2008, seriously weakened the municipal land and real estate position. The new politicians also had preferences for other projects and other issues, etc., etc. In short, they blew the project off.

*Utsunomiya*

= The case of Utsunomiya is fundamentally different from the situation in Groningen. First of all, Utsunomiya city with a population of more than 500 thousands is much larger than ordinary regional cities in Europe. In addition, because there is a wide industrial area in neighbouring town, Haga, around 30 thousand people commute from Utsunomiya city centre to Haga every day. Although there are some bus services between them, most of the commuters drive cars, causing serious road congestions.  Therefore, in the early 90s some elevated transportation systems such as monorail and AGT (Automated Guided Transit) were considered. After that LRT became a candidate to solve road congestions.

= In Japan public transportation is usually operated in commercial basis and public money is used in special cases. Every LRT plan always faces its profitability including capital costs. Even though so many commuters are expected in Utsunomiya, initial costs are not so low and the plan has been a target of criticism. At the first stage Kanto Bus, a private bus company, which have had a dense network in Utsunomiya and surrounding areas, opposed the plan in fear that it would lose passengers due to LRT.

= In Utsunomiya city the criticism also relates to political power game.  When ruling Liberal Democratic Party (LDP) planed the LRT, opposition parties including Communist Party were against the plan. The opponents insisted on spending more money for welfare instead of LRT. In general, people have no idea that the introduction of LRT enhances their welfare. Unlike European cities, LRT is not familiar to ordinary people. Particularly older generations still have old-fashioned street car image (like in Groningen by the way).

However, the construction of LRT started successfully in 2017 after pro-LRT candidate who had struggled LRT project as Mayor since 2008 won in mayoral election. There are three main reasons. Firstly, Utsunomiya municipal government seriously had reviewed the criticism and started disclosing much more information and having dialogs with residents. Secondly, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), sending vice mayor to Utsunomiya, strongly supported the project. Around half of initial costs are financed by MLIT. Thirdly, some citizen's groups including academic experts also supported the project and mediated the local government and ordinary people, who are not familiar with LRT. The citizen's movement also changed mass media, which had been criticizing the government.

*A note on implementation of LRT in Europe*

Unfortunately the failed project of Groningen is no exception. Especially the UK witnessed a series of failed projects – even after many years of preparation (e.g. Leeds, Liverpool and Southampton). However we should underline that overall many projects have been a success since LRT became again a dominant mode of public transport in Europe during the early eighties of the previous century. In this regard one should mention for example the dozens of new tramways in cities of France and Spain. And still, also UK with for instance new large, successful systems in Manchester, Nottingham and Sheffield. Recently Denmark introduced LRT in Aarhus, while project are under construction in Odense and Copenhagen. To mention just a few countries!

Van der Bijl et al. (2018) assessed the Polish LRT project in Olsztyn to mirror the Groningen project. Contrary to Groningen RegioTram the tramway project of Olsztyn has been successful, at least eventually. This case is very useful to grab the necessary pragmatics of tramway projects. Additionally Olsztyn allowed us a better understanding of the tragic planning and tender process in Groningen.

Like Groningen in the Netherlands the city of Olsztyn in Poland became very serious with their tramway project in 2010, when they launched a tender, and a year later when they awarded a Design & Construct contract for a 3-line system (11,5 km). And like Groningen this Polish city chose a non-classic contract, though their D&C was far less complicated than the DMFMO of Groningen (for a 2-line system of 11,7 km, also tendered in 2010).

But while Groningen ended up in a complicated contract formation process (2011-2012) Olsztyn commenced construction in 2011 short after the Spanish firm FCC got a contract of 62,5 million euro. Unfortunately the relationship between this construction company and the assigning authority soon became very bad. In August 2013 after several months of worsening co-operation the contract was officially terminated. However, contrary to Groningen, this didn't mean the end of the project. Olsztyn didn't want to spoil the already invested money, nor jeopardise their EU funding (as Groningen did). Hence, they decided to retender and to remove the design component from the new, now classic contract. Moreover, they concluded that it was necessary to split up the new contract into six independently tendered contracts. This pragmatic approach turned out to be successful.

Moreover, by separating the design from the tramway construction tender the city authorities created more flexibility for themselves. For instance they could reconsider the design task in the city centre for enhanced improvement of public realm and usages by pedestrians and cyclists. It was hard work for them, because the approach acquired a lot of additional work for reviewed contract formation and related interface management. The reward however was there when 19 December 2015 the system officially opened. During the first few weeks the operation patterns and traffic management system required adaptions. The journey times had to be increased a bit. Again it was hard, though successful work.

Most important lesson from this LRT case: in many circumstances complicated tramway projects should be split up, particularly in the tendering and construction stage, and as Olsztyn proved, even in the stage of operation. An open, flexible approach is unavoidable to review planning, design, tendering, construction and operation when necessary.

## 6. Conclusion

LRT represents a wide range of rail-bound, urban public transport. There are different types of infrastructure available and the industry provides numerous vehicle types. This wide range makes it possible to operate urban areas with LRT. This is also possible with BRT, but it is precisely the application within urban areas which has disadvantages. For example, the integration into the public space is problematic, where LRT can have a positive effect. This applies to Dutch and Japanese cities. The realization of LRT projects appears to be complicated. A project can indeed fail, or only after a very long time become reality. An open, flexible and phased approach is conditional to success. However, the comprehensive argumentation with the 5E framework above mentioned fully and conclusively illustrates why LRT and, to a certain extent, BRT are also important for urban transport, in particular the reliability of public transport, the quality of urban space, the structuring of urban development, as well as the sustainability of cities in economic, environmental and social terms.

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