

Analysis of Wide-Body Buses in Local Public Transport

A Comparison between Hong Kong and Munich

Submitted by Kevin Golde
ge28joy
kevin.golde@tum.de

Submitted on 26.02.2021

Abstract

There are different types of wide-body buses used in local public transport. In Hong Kong, the vehicles have increased to double-decker buses, while in Munich they are extended to an articulated bus or to a bus train. In view of increasing utilization of buses and traffic areas, it was investigated to what extent the respective extension solution makes sense for the other city and whether the revival of a double-decker articulated bus, which was developed by MAN, makes sense for passenger use.

To investigate, an expert interview was held with an engineer of the bus manufacturer MAN. The advantages of the double-decker buses are that they take up less traffic space than extended buses, offer greater comfort due to more seats, and have the highest capacity of the compared bus types. In turn, articulated buses and bus trains provide a faster passenger flow, which shortens the stop and causes less disruption to the traffic flow. Furthermore, the routes of these buses are less affected by height restrictions.

Height restrictions are particularly an issue in Munich. Hong Kong, on the other hand, has hardly any height problems, but the road space is limited there. For this reason, but also for cultural reasons, the primary use of extended buses in Munich and double-decker buses in Hong Kong makes sense. On specific routes, however, the vehicle types of the other city should be tested. Munich can use double-decker buses on routes where the road capacity is utilized, and Hong Kong can use lengthened buses on routes with short distances between the bus stops.

For MAN it does not make sense to resume the production of double-decker articulated buses for line services. For them, the production would not be economical. Furthermore, high legal hurdles have to be overcome with these vehicles in their markets.

Table of Contents

Abstract	1
1. Introduction.....	3
2. Literature Review.....	4
2.1. Part One: Double-decker buses in Hong Kong	4
2.2. Part Two: Articulated buses and bus trains in Munich	6
3. Methodology	8
4. Results	12
5. Discussion	13
6. Conclusion.....	15
References	16
Appendix	17

1. Introduction

In many cities the local public transportation is expected to become more and more crowded and overcrowded, respectively, in the upcoming years (Yap et al., 2020). Before the beginning of the COVID19 pandemic, the number of passengers was increasing fast in many areas so that many transport companies were reaching their capacity limits (Wagner, 2019). This development results in a big issue for many systems, because for lines with a high demand, railway-based vehicles are often necessary, since they usually have a higher capacity than road-based vehicles like buses. Depending on the country, the infrastructure for railway-based mass transport vehicles usually takes many years or decades between the beginning of the planning and the commissioning.

Buses are a lot faster, and more flexible. However, these vehicles are limited by a small capacity number so that they are often overcrowded. Due to this issue, there are different types of vehicles to counteract the problem. Depending on the location there are two different main solutions to increase the capacity of the different bus types. In this paper buses that have elements to increase the passenger capacity are classified as wide-body buses.

Furthermore, mainly two solutions will be discussed in this paper. First, the solution of Hong Kong and second, the solution of Munich. Thereby, articulated and double-decker buses are the two most common types of wide-body buses (Vik, 1987, p. 12). Due to construction, both types have different advantages and problems. They are frequently used in cities. Beside places like Berlin that are using both kinds of vehicles (Berliner Verkehrsbetriebe, 2016), other cities have themselves specialized to use just one type of wide-body vehicle. Hong Kong, for instance, is only using double-decker buses (Transport Department, 2019) and in the city of Munich only lengthened buses are used to increase the capacity: articulated buses and bus trains. The latter are buses with a passenger trailer (Münchener Verkehrsgesellschaft, 2020b).

Both systems will be compared in this paper to see if also Hong Kong can benefit from operating articulated buses or bus trains and, on the flip side, if the public transport of Munich can benefit from using double-decker buses. Furthermore, it will be analysed whether a combination of articulated and double-decker bus can be built again by MAN to improve the public transport on the lines with the highest demand. MAN built articulated double-decker coaches with the Neoplan Jumbocruiser in the 1970 and 1980s (Lücke, n.D.), so they already have the experience and would most likely be able to build such vehicles for line service again.

2. Literature Review

2.1. Part One: Double-decker buses in Hong Kong

Double-decker buses were invented to improve the economic aspects of transportation (Reinhardt, 2015, p. 381). With this solution, the length of the vehicles are similar to a standard bus (Reinhardt, 2015, p. 598) so that more passengers can be transported, whereby the additional required space in comparison with a standard bus is kept to a minimum (Hancock & Woodcock, 1988, p. 107). By using a double-decker bus instead of a standard bus, the operating company saves money because it is cheaper to operate a few large buses with the same capacity than many standard buses (Hancock & Woodcock, 1988, p. 112). Bus drivers consider a double-decker bus to be easy to drive (Hancock & Woodcock, 1988, p. 115). Due to the low space requirement and the high capacity, double-deckers are often the only opportunity in cities with space limitations on streets (Hancock & Woodcock, 1988, p. 112).

Standing is not allowed in the upper deck, what leads to a higher ratio of seated versus standing passengers (Hancock & Woodcock, 1988, p. 116). Furthermore, people sitting on the upper deck have a better view than people who are sitting on the lower deck (Hancock & Woodcock, 1988, p. 116). Both arguments make double-decker buses more attractive for passengers, especially when they use the bus for a longer distance (Hancock & Woodcock, 1988, p. 116).

However, the main issue for operators of this bus type is in many cases the infrastructure; a normal double-decker bus has a standard height of between 3.8 meters and 4.5 meters (Hancock & Woodcock, 1988, p. 113) so that every tunnel that has to be entered must be higher. Even if there are lower tunnels that are not part of the bus routes, it is a risk factor if buses leave the prescribed route.

For double-decker buses, the construction of a standard bus is usually used as a basic design, whereby an additional headroom is built on top. Only buses that have to be lower or have higher requirements for the upper deck have to be designed separately (Hancock & Woodcock, 1988, p. 116f.).

Although double-decker buses have numerous advantages in the transportation of many people, they were almost only used for the public transport in the United Kingdom until the 1980s (Hancock & Woodcock, 1988, p. 107).

As a former British colony, also the wide-body buses of Hong Kong are double-decker. According to the Hong Kong Special Administrative Region Government (2020) many different franchises are operating the public buses of the city. The largest operator of franchised public bus transport in Hong Kong is The Kowloon Motor Bus Company (1933) Limited with a fleet of 4,081 vehicles in December 2019 (Transport International Holdings Limited, 2020, p. 23).

Almost every bus of the Kowloon Motor Bus Company is a double-decker. In 2019 the company owned 3,938 double deck buses and just 143 single deck buses (Transport International Holdings Limited, 2020, p. 23). In that year the company extended their double-decker fleet by 140 Volvo B8L Euro VI buses and 73 ADL Enviro 500 MMC vehicles (Transport International Holdings Limited, 2020, p. 21).

The Volvo B8L Euro VI has a length of 11.8 meters and a width of 2.5 meters (Volvo Bus Hong Kong Ltd, 2020). The total passenger capacity amounts 133 passengers (Transport Department, 2019). Information about the height and the weight of this bus type are not specified.

More information is available for the Enviro 500. There are two different length versions of this bus: One with a length of 11.3 meters and another with a length of 12 meters. The width is at 2.545 meter (Alexander Dennis Limited & Alexander Dennis (Asia Pacific) Limited, n.D.). The manufacturer has not specified the height of the vehicle. However, according to Vossen (2015) the height of this bus type amounts to 4.12 meters. Though, it must be noted that the height of Hong Kong's version of the Enviro 500 can be different.

According to the bus constructor companies Alexander Dennis Limited and Alexander Dennis (Asia Pacific) Limited (n.D.), the smaller version of the bus has a capacity for 122 passengers, whereby on the lower deck 25 seats and room for 46 standing passengers are installed. Additionally, there are 51 seats and no room for standees in the upper deck. The standard broader version has in total a capacity for 137 passengers. This bus has 31 seats and 47 spaces for standing on the lower deck and 59 seats on the upper deck (Alexander Dennis Limited & Alexander Dennis (Asia Pacific) Limited, n.D.).

2.2. Part Two: Articulated buses and bus trains in Munich

Another type of wide-body bus beside double-deckers are articulated buses (Hancock & Woodcock, 1988, p. 107). This kind of bus is for instance found in Munich.

A standard articulated bus has approximately a 50 to 70 percent higher passenger capacity than a standard bus, whereby the operating costs are almost the same (Vlk, 1987, p. 12). More doors can be added to lengthened buses, which speed up the passenger transfer (MAN, 2010).

There are different kinds of articulated buses. However, the pusher buses are most common due to anti-kink devices that are most economical on this type (Vlk, 1987, p. 13). According Vlk (1987), who researched about the physics of articulated buses, these buses are more dangerous than standard buses due to the trailer that is causing “pendulum oscillations”. Especially when the bus has a high velocity, the road is slippery, or the street is very curvy that can cause negative impacts when the joint kinks (Vlk, 1987, p. 15ff.). However, elements for kink protection minimize the problem even at a high speed (Vlk, 1987, p. 194f.). Compared to a normal double-decker bus, an articulated bus needs more space on roads. Calculated on a per seat basis, this is more expensive according to Hancock and Woodcock (1988, p. 112).

In the city of Munich, the communal company Münchner Verkehrsgesellschaft plans the public transport and is also the main operator of these services (Münchner Verkehrsgesellschaft, 2020a). According to the Münchner Verkehrsgesellschaft (2020b), the company is using three different types of articulated buses for the public transport: The MAN Lions’s City, the Solaris Urbino and the Mercedes Benz Citaro G. The transport company also has the Lion’s City and the Urbino as solo buses without any extension available (Münchner Verkehrsgesellschaft, 2020b).

According to the data of the Münchner Verkehrsgesellschaft (2020b) the capacity of the articulated version of the buses rises for the Lion’s City from 31 seats to 48 seats and from 28 standing rooms to 55 room for standees, while the length rises from 11.98 meters at a solo bus version to 17.98 meters at the articulated version. In a solo Urbino bus, there are 25 seats and standing room for 30 people available. The seats of the articulated buses are quantified as 43 and the standing area as 55, while the articulated bus is with a length of 18 meters 6 meters longer than the Urbino solo bus (Münchner Verkehrsgesellschaft, 2020b). Also the turning circle of the articulated differs from the standard version: The Lion’s City has a turning circle with a diameter of 23.39 meters instead of 22.14 meters, and the articulated Solaris

Urbino buses need a turning loop of 23.00 meters instead of 21.14 meters (Münchner Verkehrsgesellschaft, 2020b).

The Münchner Verkehrsgesellschaft also uses the standard Urbino bus with a trailer type Göppel Go4City as bus train. With the trailer, the bus has a capacity for around 70 additional people. In total, the capacity amounts for around 130 people. Thereby the buses come to a total length of 23 meters (Münchner Verkehrsgesellschaft, 2016). However, the advantages of this kind of vehicle are, besides the higher capacity, according to Leuthardt (2008) that the turning circle is smaller than from an articulated vehicle and that the trailer can be flexibly added to a vehicle when it is necessary which saves energy. Additionally, buses with trailer do not “swing” as much as articulated buses do (Leuthardt, 2008, 1ff.). However, the benefit of an articulated bus is that the joint can be used as passenger area.

3. Methodology

The literature evaluation shows that both types of wide-body buses offer their specific advantages and limitations. To compare both types from a neutral and recent perspective, an interview was conducted with M.Eng. Florian Rott. He is product communicator of the bus manufacturer MAN (Rott, 2021) who are producing double-decker and articulated buses. Additionally in the 1970s, with the Neoplan Jumbocruiser they have developed an articulated double-decker bus, a combination of both bus types (Lücke, n.D.).

However, it has to be noted that MAN produces buses primarily for the Central European market (Rott, 2021). In Hong Kong, the company participates only as a supplier of chassis (Rott, 2021). Smaller companies are contracted to design and build the buses for these markets (Rott, 2021). Accordingly, it must be noted that the interview tends to refer more to the European market, although MAN is also involved in the Asian bus market.

Due to a lockdown caused by the COVID19 pandemic the interview was held digitally via the platform Microsoft Teams in German on January 11, 2021. First, Rott was asked for the reason why in some cities only double-decker buses and in others only articulated buses are used in line service.

According to Rott (2021) there are several aspects to be considered. In many places the infrastructure consisting of bridges and tunnels makes it impossible to use double-decker buses. In other cities, however, the height is not an issue, but the space on the street is limited (Rott, 2021). In such cases, height is preferred to length (Rott, 2021).

However, in Germany height is the bigger issue, since there is a maximum height of 4 meters, which is low for double-decker buses (Rott, 2021). This also affects the interior and the passenger compartment that has to be relatively low and narrow. This low height is not a problem for coaches, but it is unsuitable for the frequent transfer of passengers (Rott, 2021).

From a manufacturer's point of view, in Germany double-decker buses are also unattractive, since they are difficult to fit into a "modular system" (Rott, 2021) due to the height restriction. While an articulated bus is "merely an extension of a 12-meter bus" (Rott, 2021), a "double-decker bus has to be built from scratch" (Rott, 2021). Due to the low height limitation in Germany, the engine takes up space from the passenger compartment (Rott, 2021). In addition,

in electric buses of MAN, the batteries are mounted on the roof. Hence, an electric double-decker would require a special design in Germany; a further argument against it (Rott, 2021).

According to Rott (2021), the issue of the passenger flow is another argument against double-decker buses. Even on buses with two or three stairs, boarding and alighting is difficult (Rott, 2021). Regarding safety, passengers cannot stand on the upper deck of a double-decker bus. Though, traffic room for standees are important for buses in the city, they have to be limited to the lower deck (Rott, 2021). On the other hand, one advantage of a double-decker bus is that there are usually more seats available than in a lengthened bus (Rott, 2021).

Another point is that cities like Hong Kong, which rely on double-decker buses, have no problem regarding the height of double-decker buses (Rott, 2021). Hence, the height can be built in a way that there is enough headroom for the passengers when they are standing and there is no need for special designs (Rott, 2021). Instead the disadvantage of an articulated bus, the requirement of more space as well as the installation, and the expensive maintenance of a connecting piece can be relevant in Hong Kong (Rott, 2021).

Overall, the local conditions must be considered when deciding whether to go for height or for length (Rott, 2021). Hence, double-decker buses are preferred in cities which regard traffic space to be more important than passenger flow (Rott, 2021).

The next two questions focused on the examples of Munich and Hong Kong. Rott was asked whether in Munich it makes sense to use double-decker buses in places where the traffic capacity is exhausted and, vice versa, if in Hong Kong an articulated bus or a bus with trailer makes more sense for a faster transfer on lines with short distances between stops.

Rott (2021) answered both questions positive. With a double-decker bus in Munich, traffic space and capacity would be gained. However, the Munich transport company Münchner Verkehrsgesellschaft is using bus trains to counteract the problem of insufficient capacity (Rott, 2021). Though, at stops like Trudering or Ostbahnhof, where capacity bottlenecks exist, bus trains take up even more space than articulated buses (Rott, 2021).

Rott (2021) explained that Munich has decided against the use of double-decker buses in the urban area due to the points that make the bus less attractive than bus trains. For Munich accessibility also for disabled people and passenger flow have a high priority (Rott, 2021). The density of the bus stops must be taken into account, since the longer distances are usually not covered by bus, but by the underground as well as by the suburban train (Rott, 2021).

However, people who sit on the top of a double-decker usually travel longer distances (Rott, 2021).

Though, to relieve the underground system, Munich introduced express buses in recent years. Especially on these lines, where extended buses are used and the traffic capacity is limited, it makes sense to use double-decker vehicles instead of lengthened buses (Rott, 2021). In comparable cities this is already implemented. In Rome, for instance, there is an operator who runs 100 MAN double-decker buses on express lines (Rott, 2021).

However, normally operators of double-decker buses have to use coach models that are not optimal for line services in aspects like passenger flow and standing as well as seating space, because the major manufacturers do not produce stand-alone regular-service double-decker buses (Rott, 2021). On the other hand, for Hong Kong independent double-decker buses are being developed. They are developed by small, local companies that do not build complete buses, but buy chassis from other suppliers like MAN and build the vehicles on them (Rott, 2021). This allows the manufacturer to respond more flexibly to the needs of a customer. For big companies such special orders would be less attractive (Rott, 2021).

Nevertheless, it is possible that also in Hong Kong it would make sense to use lengthened buses instead of double-decker buses. The fact that only double-decker buses are used there “can be attributed to tradition or the lack of traffic space” (Rott, 2021). In Hong Kong many double-decker buses are in use, so it is possible that the road network would be too small for a change to longer buses (Rott, 2021). However, it must be considered that lengthened buses lead to a shorter stopover, which has a positive effect on the traffic flow (Rott, 2021).

Regarding tradition, Rott (2021) referred to the example of London. Although articulated buses were also used there in the 2000s, only double-decker buses are used there today (Rott, 2021). It is unusual that the passenger flow is not a problem there, even though the buses have only one stairway: When the bus starts, the passengers go up; when it stops, they go down (Rott, 2021). It is questionable whether this behavior can be generalized or if the British have adopted this behavior over time (Rott, 2021).

However, according to Rott (2021), single-deckers are the future of line service due to technical developments. He explained this when he was asked why MAN is not developing a double-decker articulated bus for line service although MAN has developed this kind of bus as a coach already. To answer this question, Rott (2021) foremost explained current efforts and

progresses in bus development. Accordingly, the major manufacturers are working on autonomous driving. This means that the cost for the drivers will play no or a lesser role in the future and large vehicles will not be needed anymore (Rott, 2021). However, especially at the start of this process, buses will not run completely autonomously, but will be electronically coupled (Rott, 2021). Also this step gives a company new flexibility to couple or uncouple vehicles throughout the day (Rott, 2021). Munich is already using bus trains for this reason. However, the Münchner Verkehrsgesellschaft does not take advantage of uncoupling the trailer during the off-peak hours (Rott, 2021).

A traditional wide-body bus, however, is not that flexible and has to be used completely also at times when it is not necessary (Rott, 2021). Accordingly, the future for large buses is not given from the manufacturers' point of view (Rott, 2021), even if the passenger demand has increased and the passenger use of fully autonomous buses is uncertain in 2021.

Though, since it will be a long time before vehicles can drive autonomously, Rott (2021) addressed whether a double-decker articulated bus could act as an interim solution. Using the Neoplan Jumbocruiser as an example, he explained that these vehicles are expensive and are subject to high legal requirements and restrictions. Thus, their use is prohibited for instance in France (Rott, 2021).

Also the general disadvantages of a double-decker bus in the German market, such as height and accessibility, have to be considered for an articulated double-decker (Rott, 2021). Additionally, the ever-increasing legal requirements have put the brakes on such developments (Rott, 2021). Though, the high cost of the production of double-decker articulated buses in particular makes them unattractive to manufacturers and customers (Rott, 2021). However, this refers only to the market of MAN and the major manufacturers. For a small manufacturer for a market outside Europe, such as for Hong Kong, the development of a double-decker articulated bus could be worthwhile due to the different market and regulations.

4. Results

	Standard (Urbino 12)	Double Deck (Enviro 500)	Articulated (Urbino 12)	Bus with trailer (Urbino 12+Go4City)
Height	3.04 m	4.12 m	3.04 m	3.09 m
Length	12 m	12 m	18 m	23 m
Capacity	55	137	98	130
Doors	3	2	4	5

Table 1: Comparison of technical data of different types of recent public transport buses in Hong Kong and Munich (Münchner Verkehrsgesellschaft, 2020b, Münchner Verkehrsgesellschaft, 2016 Alexander Dennis Limited & Alexander Dennis (Asia Pacific) Limited, n.D., Vossen, 2015)

According to the bus types that are compared in table 1, articulated buses have the lowest capacity of the buses with an extended capacity, whereby buses with trailer have almost the same capacity as double-decker buses. According to the comparison by Reinhardt (2015, p. 598), the higher capacity of the double deck is not just valid for this example, but also in general. However, buses with trailer have almost twice the length and have more room for standees instead of seats which are less attractive for passengers especially on longer trips.

Another limitation besides the length of articulated buses is the higher turning radius. However, this issue can be solved by bus trains. Vice versa, the advantages of this bus type is the higher capacity and that it can pass low tunnels (Vlk, 1987, p. 12). According to table 2, the compared single deck buses have more doors than double-decker buses, which results in a faster passenger transfer.

Furthermore, also cultural aspects have to be considered. In Munich, for example, inclusion has a high priority. At double decker buses, this point could be problematic as disabled people would be excluded from the upper deck (Rott, 2021). In Hong Kong, on the other hand, double-decker buses are traditionally used. There, the introduction of lengthened buses could lead to a countermovement, as the example of London shows.

Except for these points, both bus types can be improved by the concept of each other by combining them, which would result in a higher capacity. However, due to recent developments regarding autonomous driving as well as legal restrictions, plus the development and production costs (Rott, 2021), the development of such vehicles are currently irrelevant for MAN despite them having built those already.

5. Discussion

In consideration of the previous chapters, there are specific reasons that some places are making their buses higher to increase the capacity and other cities choose to lengthen their buses. However, just using one option does not mean that the other option is not useful for the other system. Depending on the route, in cities, where usually articulated buses are used, double-decker buses can supplement the system and vice versa.

For instance, double-decker buses have a lower need of space and a higher capacity than articulated buses and a higher comfort than buses with trailer since they have a higher seating capacity, although the bus trains and the articulated buses have a faster passenger transfer due to the higher number of doors. This means that articulated buses and bus trains should be especially used where the bus stops are close to each other, whereby double-decker buses are to be preferred on routes with longer distances between stations and where the space is limited.

Relevant for Hong Kong is the higher passenger capacity compared to articulated buses. To create a comparable capacity to the double-decker buses, Hong Kong needs bus trains that have a similar capacity with their double-decker buses.

Due to the high population density of Hong Kong, traffic space is of high importance. On the one hand, double-decker buses are more space-efficient than single-deckers, so they take up less traffic space. On the other hand, longer buses shorten the time spent at bus stops. To test if this improves the traffic flow, as well as to check whether the inhabitants of Hong Kong accept lengthened buses – unlike the people of London, it could make sense to use these buses on a test basis on lines with a dense sequence of stops. To match the capacity of double-decker buses, the test should be made with bus trains.

In contrast, traffic space is becoming tight in some places of Munich. Double-decker buses instead of articulated buses or bus trains can help here. However, the problem is that it must be ensured that no place is passed that is too low for double-decker buses which limits the possible routes. The most suitable lines for this purpose are bus lines that serve stops which have reached the capacity limit and that are lines where passengers travel over a longer distance like express buses.

To ensure that this offer is accepted by, among others, people who are limited to the lower deck, that the potentially higher time of passenger transfer is justifiable, and that no accidents occur, for example by underpassing a tunnel that is too low upon an inward journey, a test phase is also useful in this case. However, to conduct testing under long-term conditions, the tests would not be valid or efficient until the COVID19 pandemic is reduced, and ridership has returned to normal.

Regarding a combined version of an articulated double-decker bus, the former producer MAN makes it clear that production for regular service is not worthwhile for them and that they see the future more in small vehicles due to the progress in the field of autonomous driving. However, this perspective relates primarily to the European market. This might be different for other markets with small bus manufacturers such as Hong Kong, where also more traffic space is urgently needed.

6. Conclusion

It is recommended that bus trains should be used in Hong Kong on a trial basis on routes with a high density of bus stops. The aims are to measure whether the buses are slowed down as a result, how they affect the traffic capacity and the traffic flow, and whether the buses are accepted by the people of Hong Kong.

On the other hand, double-decker buses should be used in Munich on a test basis on lines that have a high passenger volume, serve at least one stop that is at its capacity limit, and where it is infrastructural possible. Preference will be given to lines where people travel a longer distance or lines with rather long distances between stops, such as express bus lines. Testing should not begin while the use of public transport is severely reduced by the COVID19 pandemic.

Overall, however, it makes sense from an infrastructural as well as from a cultural perspective to primarily run double-decker buses in Hong Kong and lengthened buses on line service in Munich.

Furthermore, it is not worthwhile for MAN to resume production of articulated double-decker buses for the line service bus market. However, this may be different for other, smaller manufacturers and for other markets than those that MAN supplies, such as Hong Kong.

In this regard further analyses are necessary.

References

- Alexander Dennis Limited, & Alexander Dennis (Asia Pacific) Limited (Eds.). (n.D.). *Enviro500: Low Floor High Capacity 12m Double Decker Bus*. <https://www.alexander-dennis.com/media/69786/enviro500-asia-pacific-spec.pdf>
- Berliner Verkehrsbetriebe (Ed.). (2016). *Die Omnibusflotte der BVG*.
- Hancock, B. S., & Woodcock, E. J. (1988). The history and design of double-deck buses and coaches. *International Journal of Vehicle Design*(Vol.9(1)), 107–121.
- Hong Kong Special Administrative Region Government (Ed.). (2020). *Public Transport in Hong Kong*. <https://www.gov.hk/en/residents/transport/publictransport/companies.htm>
- Leuthardt, H. (2008). *Evaluierung Buszug: Bestimmung unterschiedlicher Aspekte sowie Bewertung des Einsatzes von Buszügen im Main-Kinzig-Kreis* (KreisVerkehrsgesellschaft Main-Kinzig, Ed.).
- Lücke, N. (n.D.). *Der Jumbocruiser*. <https://www.reisedienst-luecke.de/jumbocruiser.html>
- MAN (Ed.). (2010). *Achtzehn neue MAN Busse für MVG*. <https://www.bus.man.eu/de/de/man-welt/man-in-deutschland/presse-und-medien/Achtzehn-neue-MAN-Busse-fuer-MVG-69953.html>
- Münchener Verkehrsgesellschaft (Ed.). (2020a). *Nachhaltigkeit: Nachhaltige Mobilität für München*. <https://www.mvg.de/ueber/engagement/nachhaltigkeit.html>
- Münchener Verkehrsgesellschaft (Ed.). (2020b). *Unsere Fahrzeuge*. <https://www.mvg.de/ueber/das-unternehmen/fahrzeuge.html>
- Münchener Verkehrsgesellschaft (Ed.). (2016). *Der Buszug*. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahU-KEwjH5cPWu7HtAhUBC-wKHUIGA_cQFjABegQIB-hAC&url=https%3A%2F%2Fwww.mvg.de%2Fdam%2Fmvg%2Fueber%2Ffahrzeuge%2FBuszug-Flyer.pdf&usg=AOvVaw2MT_hONhMDuXerHqXXAKkD
- Reinhardt, W. (2015). *Geschichte des öffentlichen Personenverkehrs von den Anfängen bis 2014: Mobilität in Deutschland mit Eisenbahn, U-Bahn, Straßenbahn und Bus*. Springer Vieweg.
- Rott, F. (2021, January 11). Interview by K. Golde.
- Transport Department (Ed.). (2019). *Section 5. Public Transport: The Kowloon Motor Bus Company (1933) Limited*. https://www.td.gov.hk/mini_site/atd/2020/en/section5_t_5.html
- Transport International Holdings Limited (Ed.). (2020). *Business Review: Hong Kong Franchised Public Bus Operations*. http://iis.aastocks.com/20200417/HKEX-EPS_20200417_9239124_12.pdf
- Vlk, F. (1987). *Fahrverhalten von Gelenkbussen: Quer- und Längsdynamik. Fahrzeugtechnische Schriftenreihe*. Verl. TÜV Rheinland.
- Volvo Bus Hong Kong Ltd (Ed.). (2020). *Volvo B8L Double Decker: Specification*. <https://www.volvobuses.hk/en-hk/our-offering/buses/volvo-b8l/specifications.html>
- Vossen, L. (2015). *Ein britischer Doppeldecker will Berlin erobern*. <https://www.morgenpost.de/berlin/article206287969/Ein-britischer-Doppeldecker-will-Berlin-erobern.html>
- Wagner, L. (2019). *ÖPNV-Bilanz 2018: erneuter Fahrgastrekord im Nahverkehr*. <https://www.vdv.de/190213-pm-bilanz-2018.pdf?forced=true>
- Yap, M., Cats, O., & van Arem, B. (2020). Crowding valuation in urban tram and bus transportation based on smart card data. *Transportmetrica a: Transport Science*, 16(1), 23–42. <https://doi.org/10.1080/23249935.2018.1537319>

Appendix

Interview questions for Florian Rott (MAN)

- In manchen Städten fahren im Linienverkehr Doppeldeckerbusse, in anderen Gelenkbusse. Was sind die Hintergründe für den unterschiedlichen Umgang und inwieweit ist es sinnvoll, entweder ausschließlich Gelenkbusse oder ausschließlich Doppeldeckerbusse einzusetzen?
- In München fahren ausschließlich Gelenkbusse. Dabei kommen Knotenpunkte wie Ostbahnhof oder Trudering an ihre Kapazitätsgrenzen. Wäre an diesen Stellen nicht der Einsatz von Doppeldeckerbussen sinnvoll? [Tunnelproblem | Fahrgastfluss | Expressbus]
- Städte wie Hong Kong setzen dagegen nur auf Doppeldeckerbusse. Wäre dort auf Linien mit kurzen Distanzen zwischen den Haltestellen nicht ein Gelenkbus oder Buszug zum schnelleren Umsteigen sinnvoller? [Fahrgastfluss | Fahrgastkapazität | Straßenkapazität]
- MAN stellt sowohl Gelenkbusse als auch Doppeldeckerbusse für den Linienverkehr her. Ebenfalls hat MAN mit dem Neoplan Jumbocruiser eine Kombi-Variante für den Reisebusverkehr entwickelt. Wieso gibt es für den ÖPNV keine Kombi-Variante? [Technische Hürden? | Rechtliche Hürden? | Wartung? | Wirtschaftliche Hürden? | Sicherheit? | Nachfrage?]