DETERMINANTS OF FUNCTIONING OF TROLLEYBUS TRANSPORT IN SELECTED CITIES OF THE EUROPEAN UNION

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Preface

Trolleybus transport is undoubtedly one of the ecologically clean types of mass urban public transport. Over the years trolleybuses had a variable appeal. There were periods in history when trolleybus transport was widely developed in the world and periods when trolleybuses were replaced with other forms of transport. Nowadays, in 2010 this mode of transport it is in its glory days, what is compounded by the impact of the liquid fuels crisis. Large number of cities, especially in Western Europe return to trolleybus transport as it has great advantages: trolleybuses do not produce pollution, low cost of their operation and considerably lower costs of trolleybus infrastructure in comparison with rail transport.

Nowadays, there are more than 300 trolleybus systems all over the world and over half of them operates in Europe (excluding the Russian Federation, where there are several dozen cities with trolleybus systems). In the last decade some new trolleybus networks were opened in Spain, Sweden and Italy. There are also plans for some new systems in Finland and Great Britain. Already existing trolleybus networks in many cities are being intensively developed and their fleets are being modernized. This process is especially visible in, so called, new members of the European Union as this kind of investments are financed from the Cohesion Fund, which is the EU's financial instrument to reduce economic and social disparities between the old and new members.

This book presents trolleybus systems of nine EU cities: Coimbra (Portugal), Castellón (Spain), Landskrona (Sweden), Szeged (Hungary), Plzeň and Pardubice (The Czech Republic) and Lublin, Tychy and Gdynia (Poland, compare with the map, fig. 1).

The abovementioned systems can be divided into networks that have been operating for several dozen years and bran new ones. They are different networks from Western and Eastern Europe.

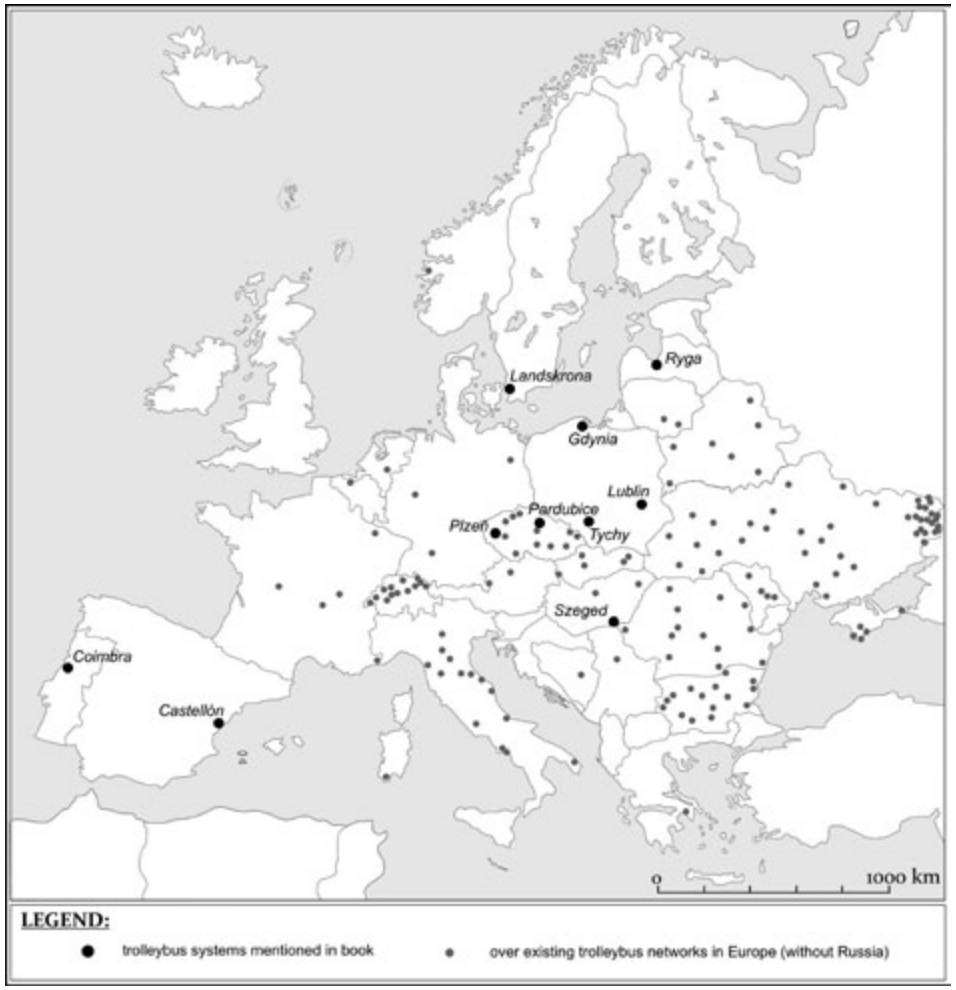

Fig. 1. The trolleybus systems mentioned in book
Author: Maciej Beister

Authors of the particular elaborations have taken up various topics associated with the history, present and future of trolleybus transport. There are also topics connected with the fleet, traction networks, power systems, tariffication and lines operation. Most of the elaborations are illustrated with schemes and photographs.

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Operation of trolleybus transport in Portugal. Revitalization of trolleybus network in Combra and development plans in Amadora

Introduction

The city of Coimbra is located in the central part of Portugal on the Modego River. It has a population of 150000 and including all neighbouring localities the agglomeration has a population of over 400000. This means that Coimbra is the third largest city of Portugal (after Lisbon and Porto). The characteristic feature of its localization is mountainous lie of the land.

Coimbra is an academic city. There is one of the oldest European universities located there. It was founded in 1290 in Lisbon and then in 1308 it was moved to Coimbra. The city is also a tourist centre of the region.

History

The origins of an electric traction in Coimbra date back to 1911, when an electric tram system was opened. Then, it was gradually developed and in 1940's, when tram transportation was very popular, the fleet comprised 20 vehicles. In 1930's some new means of urban transport emerged – buses. From that time on buses were gradually replacing trams.

The tram system of Coimbra was characteristic because of the route network shape. The routes were one-way and circular. They ran round all districts of the city. Routes of the trolleybus system have been planned on the basis of the tram routes and they haven't been changed since then.

The concept of creating a trolleybus system in Coimbra was announced in 1943. What's interesting, contrary to other cities, trolleybuses in Coimbra weren't planned in order to replace the trams but to supplement the urban transportation system. The main determinant of building the first trolleybus line was to improve the transportation service in the Santa Clara district, which is situated on the south bank of the Mondego River. Opening a new tram line wasn't possible because of

technical causes – it would have been necessary to put the railway through the bridge on the Mondego River and up a quite high hill. That's why a trolleybus line was a perfect solution.

Works on building the trolleybus line started at the beginning of 1947. The Kummler Matter company was entrusted with a task of building a traction network. This route connected the railway station (Nova Estacao Ferroviara) with the Santa Clara district. It was 3,2 km long and fed by the "Rua da Alegria" substation.

The first two trolleybuses were produced by a Swiss company – the Secheron on the Saurer body. They were 8,5 m long and they were fitted with a 90kW traction motor.

Test runs begun on 2nd August 1947 and line 6 was opened on 16th August. Trolleybuses became very popular and a decision was made to enlarge the fleet. In 1949 6 British Sunbeam trolleybuses were purchased. They were fitted with the BTH electric apparatus and the Parl Royal body.

Contrary to the initial assumption, popularity of trolleybuses was rapidly growing. That is why a decision was made to gradually replace trams with buses. In 1951 tram line 5 which connected the St. Jose housing estate with the city centre was converted into a trolleybus line. In 1954 a new bridge on the Montego River was opened. In 1958 more British Leyland-BUT trolleybuses were delivered.

During the next few years the trolleybus system was being developed. Trolleybus transportation served the northern part of the city and connected the university campus with the Sao Jose and Santa Clara districts. In the middle of 1970's the fleet comprised 27 trolleybuses which operated on lines: 5, 6, 8 and 10. Lines 5, 6, and 10 served two different routes indicated as "crossed" and "uncrossed". Lines 5 and 8 were formerly trams lines which were extended and converted into trolleybus lines.

In 1979 the tram system was closed down, so the tram lines 3 and 4 were converted into trolleybus lines.

At the beginning of 1980's the fleet was reconstructed. For the political reasons it was decided to produce trolleybuses in Portugal, despite not having any experience in constructing that kind of vehicles. Presentation of the first prototype took place on 18th August 1982 and another 20 vehicles were delivered the same year. Double-door bodies of untypical length of 10,8 m were made by the Salvador Caetano company from Vila Nova de Gia. Electric apparatus was delivered by the EFACEC company from Portugal. The trolleybuses were equipped with 131 kW traction motors and the electrical starting system. They were produced in cooperation with the following companies: the KIEPE (delivery of contactors) and ACEC. Trolleybuses of that series, also the articulated version of them, were delivered to Porto, too.

In 1983 modernization of tram line 4 (Portagem – Cruz de cela) finished and this line was converted into a trolleybus line. Trolleybus line 4 was opened on 8th March 1983. In 1988 lines 4 and 6 were joined and a new line was numbered 46.

In 1991 another modernization of the system took place. On 12th May another trolleybus line to the Tovim housing estate was opened and it was served by lines 7 and 7T.

At the beginning of 1990's trolleybus transportation in Coimbra was in full bloom. In 1991 there were seven lines: 1, 3, 5, 7, 7T, 8 and 46. Trolleybuses covered 890 million vehiclekilometres and they carried 10 million passengers – 31,5% of all passengers. In 1992 it was 34%.

In 1993 a period of ceasing the trolleybus transportation began. During this year Avenida Emídio Navarro Street was being reconstructed and because of that lines 7 and 7T were closed down. In 1993 some rectifires in the Alegria substation were damaged, so the route to the Santa Clara district wasn't fed and buses were introduced on line 46. In 1995, under the pretext of "optimizing functioning of the urban transportation system" it was decided to extend the route of trolleybus line 5 to the Coimbra B railway station, which was situated beyond the existing traction network. In the end line 5 was converted into a bus line as a consequence of this decision. As a result the number of passengers drastically decreased to the level of 3 million a year – 15% of all passengers.

Renaissance of trolleybus transportation started in 2001. In connection with celebrations of the World Environment Day (5th June) all trolleybuses in the fleet were refurbished. They were fitted with new seats, lightning and they were repainted. In 2002 line 4 was reopened, but its route was slightly changed, so it run along former lines 46 and 8. Year 2008 brought more changes. Lines 1 and 3 were joined and a new line was numbered 103. A new line 60 was opened in connection with the 60th anniversary of trolleybuses in Coimbra. This line used the traction network situated near the stadium and a new one-way section of the traction network was built. It was 1,5 km long (see at fig. 1).

In September 2009, after twenty years a brand new trolleybus was purchased. It was a low floor Škoda Solaris Trollino 12 trolleybus. It was equipped with a supplementary 100kW diesel engine.

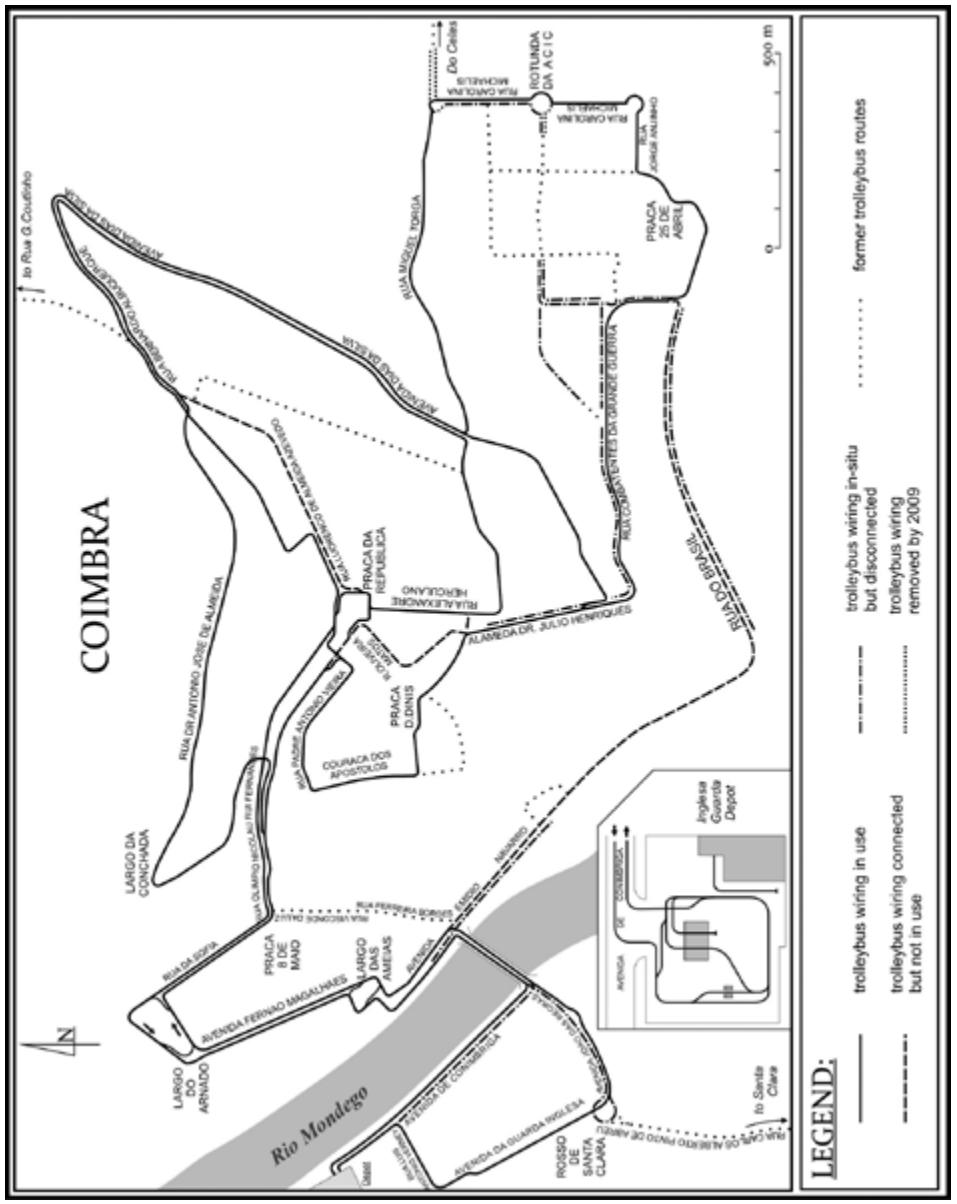

Fig. 1. Scheme of trolleybus network in Coimbra, historical and current status
Author: Maciej Beister

The actual state of the trolleybus system

The trolleybus system of Coimbra is served by the Serviços Municipalizados de Transportes Urbanos de Coimbra (SMTUC). Nowadays trolleybuses operate on three circular lines (see at fig. 2):

- Line 103, 9 km long,
  frequency during the peak hours: 15 min, number of trolleybuses: 3
- Line 4, 8,5 km long,
  frequency during the peak hours: 15 min, number of trolleybuses: 3
- Line 60, 7 km long,
  frequency during the peak hours: 40 min, number of trolleybuses: 1

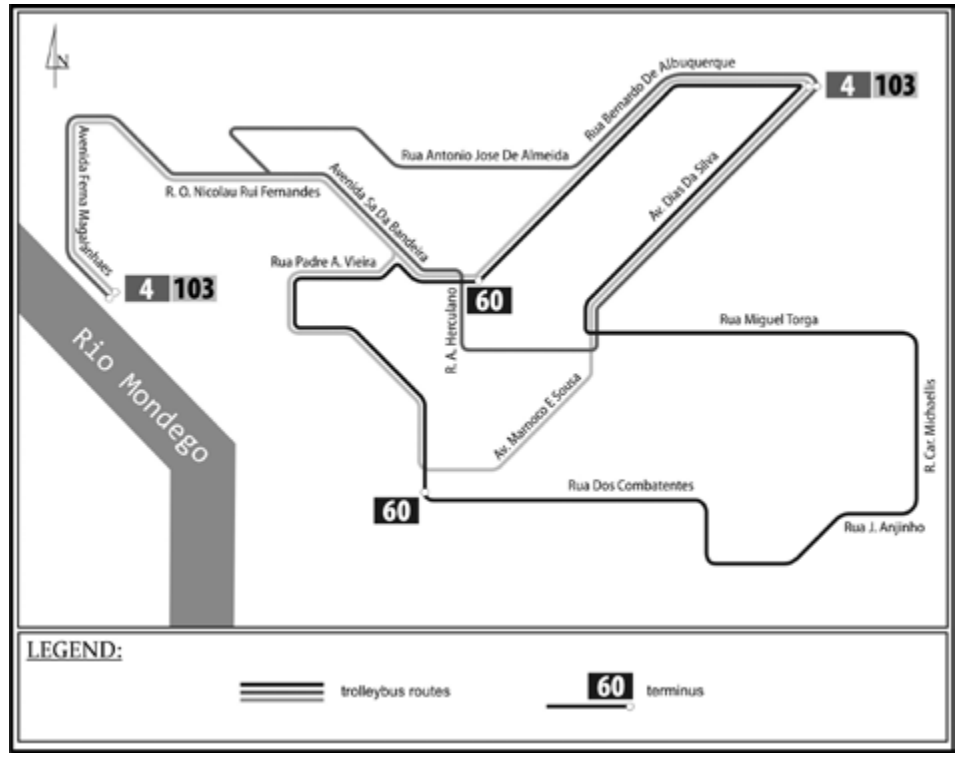

Fig. 2. Trolleybus routes in Coimbra, 2010
Author: Maciej Beister

Above-mentioned lengths refer to full circulation of the lines. On Saturdays, Sundays and holidays those lines are operated by buses.

The fleet comprises 15 Caetano/EFACEC trolleybuses made in the period of 1984-1985 and one Solaris Trollino 12 trolleybus which was delivered in 2009 (see at fig. 3, 4, 5). A technical base for both buses and trolleybuses is situated at the depot on the west bank of the Mondego River.

Fig. 3. Trolleybus Caetano/EFACEC in Coimbra on route 103
Author: Mikołaj Bartłomiejczyk

Total length of all lines is 17 km, but 3 km are not used at present. 78% of the lines are one-way routes (13 km). The trolleybus system is fed by three substations:

- 2x600 kW Montarroio,
- 1 x 600 kW Mercado de Calhabé,
- 1 x 600 kW Depot (It isn't used at present, it is equipped with the electric apparatus from the trolleybus system of Porto).

The substations are remote controlled from the trolleybus depot. It is worth mentioning that the Montarroio substation is equipped with British electric apparatus which was made in 1956 with glass mercury arc rectifiers.

Determinants of changes in the trolleybus system of Coimbra

The history of the trolleybus system of Coimbra can be divided into three periods:

- Period I: 1947-1993, spatial development of the system
- Period II: 1993-2001, the regression of the trolleybus transportation
- Period III: since 2001, renaissance of the system

As it's been mentioned, trolleybuses were introduced to supplement an already existing tram system. The trolleybus system served areas devoided of tram routes: the northern housing estates (Calhabé and Sant José) and the western part of the city (the Santa Clara district).

Fig. 4. Trolleybus Caetano/EFACEC climbs in Coimbra on route 4
Author: Mikołaj Bartłomiejczyk

This situation changed in 1979 when the tram system was closed down and all tram lines were converted into trolleybus lines. The next stage of the spatial development started in 1991 when the trolleybus route to S. Sebastiao was opened. It ran along the former tram line which was closed down in 1979. It is worth mentioning that the trolleybus system of Coimbra was developing incessantly in the period of 1947-1993.

It is something unusual and it has never happened before in countries of Western Europe, which were affected by, so called, "anti-trolleybus wave" of 1960's and 1970's. It was caused by the political isolation of Portugal.

In 1993 the situation of trolleybus transportation in Coimbra changed. The number of passengers decreased by 70% during the next few years, consequently a half of trolleybus lines was closed down. It was caused by two factors:

- Redevelopment of Avenida Emídio Navarro Street,
- Failure of the Alegria substation (an untight rectifier)

It is an example of a typical situation when a few irrelevant factors and lack of good will caused collapse of the transportation system. Both abovementioned factors are substantially irrelevant. Only one kilometer of Avenida Emídio Navarro Street was being redeveloped. The number of lanes was enlarged, so in order to minimize costs of the redevelopment it had been decided to close down the traction

network on the enlarged lane. Because of that trolleybus service ceased operations on 7 km long route. The untight rectifier at the Alegria substation could have been easily replaced with a new one so the trolleybus line to the Santa Clara housing estate didn't have to be closed down.

Unfortunately, those two factors and lack of will of the city leaders caused lots of restrictions in functioning of the trolleybus system of Coimbra. That kind of situation happened in other cities too, for example in Gdynia (Poland) in 1970's when redevelopment of Estakada Kwiatkowskiego Street started and in Olsztyn (Poland) when redevelopment of the interchange near the railway station started.

That dramatic and unjustified closing down of the trolleybus lines in Coimbra was paradoxically stopped by an another factor – lack of buses, so they couldn't replace all trolleybuses. Although more and more trolleybus lines were being closed down, the traction network wasn't dismantled. In 2001 the renaissance of the trolleybus system began. All vehicles in the fleet were refurbished and a brand new trolleybus was purchased that year. A new line was opened in 2001 too, but it doesn't play an important part in the system.

Chances and risks to the trolleybus system of Coimbra

The trolleybus system of Coimbra is having its renaissance now. A new, low floor trolleybus has been acquainted and ten more will be purchased in the nearest future. It is planned to build a new trolleybus depot in the northern part of the city and open a new trolleybus line.

There are some unused sections of the traction Network in the northern part of the city which can be put into service again without high expenditure.

The list of current risks and problems of the trolleybus system of Coimbra includes:

- poor condition of the fleet, which comprises vehicles produced in 1984(85). However, some new vehicles will be purchased in the nearest future, so this problem will be solved soon,
- an ineffective system of the trolleybus lines. Nowadays trolleybuses operate on a circular lines and their routes are quite complicated. The system is unintelligible for the passengers and it doesn't meet the standard needs. What's more, it generates problems with punctuality as a result of congestion.
- an unintelligible passenger information system. The timetables at the trolleybus stops include only information on departure hours from the starting stops. It makes it almost impossible for passengers to use a very long line 60 (40 min intervals),
- a plan to create an underground system in Coimbra poses a threat to the trolleybus system. It is a part of a political game and there are no economic reasons for building the underground system for the city with population of 150 thousand.

Fig. 5. Trolleybus Caetano/EFACEC in the city centre in Coimbra
Author: Mikołaj Bartłomiejczyk

On the basis on abovementioned factors it can be stated that the scheme of the trolleybus lines in Coimbra should be reorganized as follows:

- resignation from the circular lines and creation a classic scheme: two-ways routes with two terminuses (one at the starting stop and one at the ending stop of each route),
- implementing a clear passenger information system,
- using the currently unused sections of the traction network; supplementing the traction system.

When these elements are realized, the trolleybus system will become more effective. Those actions don't need high financial expenditures though.

Summary

In the nearest future Coimbra will lose its status of the one and only trolleybus system in Portugal. In 2010 construction of the trolleybus system in Amadora will start. Amadora is situated near Lisboa. The first trolleybus route will be 7 km long and it will connect the Reboleira railway station with the shopping centre, situated in the northern part of the city. Trolleybuses will operate on separate lines with an optical steering system (that kind of system is used in Castellón in Spain).

Initially it was planned to build a tram but costs were too high. Using the Translohr vehicles was also taken under consideration, but finally it was decided that trolleybuses will be the best solution.

Nowadays, (March 2010) a tender has been put out to purchase seven brand new, articulated, 18 m. long trolleybuses.

Portugese trolleybuses are now having their renaissance and maybe more portugese cities will follow the Coimbra nad Amadora example.

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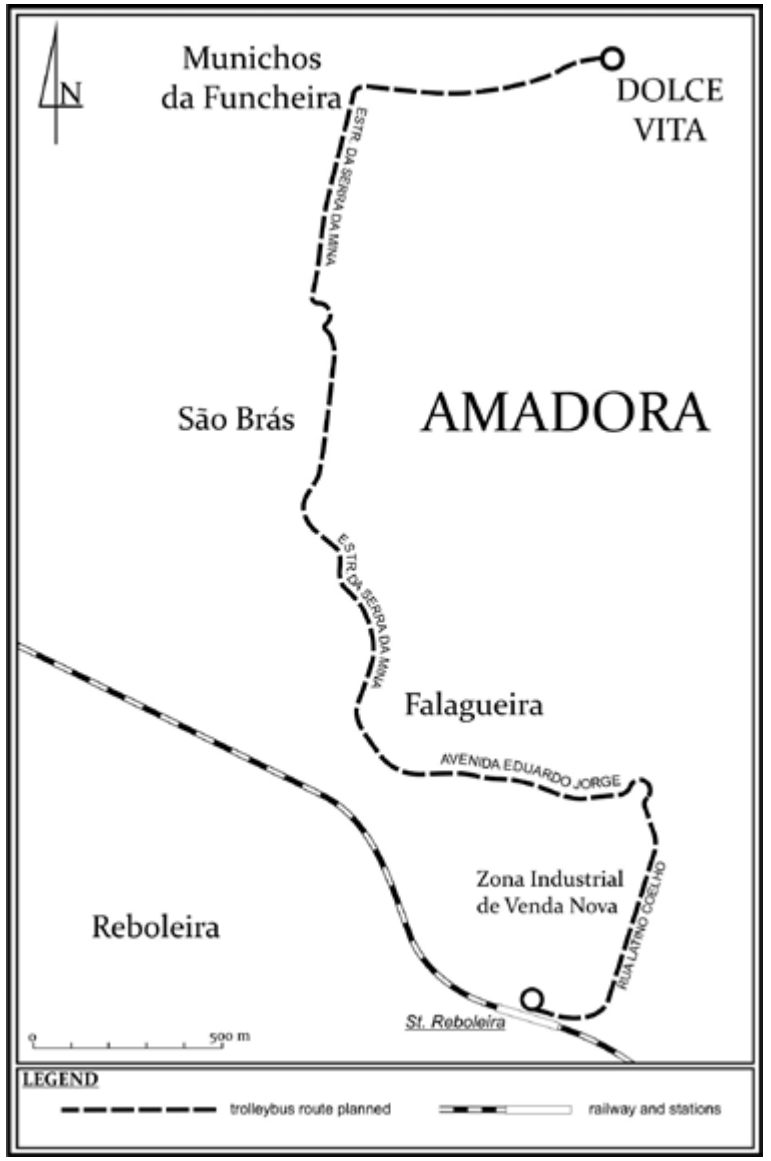

Fig. 6. Trolleybus route planned in Amadora
Author: Maciej Beister

David Moncholí i Badillo, Tadej Brezina

Reintroduction of trolleybus systems in Spain. Case study of Castellón and the region of Valencia

Introduction. Why a trolleybus system in Castellón?

In 1994 a new era in the public transportation sector in Spain was inaugurated by the opening of a "new" tramway line in the city of Valencia. 40 years later the a tramway system was operating anew in one Spanish city in a clear attempt to improve the quality of the public transportation network in an environment on which increasing mobility patterns by car was ruining the living standards of the Mediterranean city.

After Valencia (or València, as it is named in the local official language "valencian"), many Spanish cities followed and nowadays there are nearly ten tramway systems in operation or close to completion, including cities like Barcelona, Bilbao, Madrid, Murcia, Alicante or Zaragoza. Like in other countries of Europe, all these projects have been conceived not only as a solution of a mobility problema but as an integral urban and spatial renewal of the parts of the cities they transit by.

In València, the Authorities of the Regional Autonomous Government (called "Generalitat") started a plan to deploy new public transportation systems throughout the region, in order to meet the requirements of the population of higher quality standards and more sustainable means of transportation. Within this plan, the city of Alicante received a unique train-tram system after the upgrading of an old metric gauged train line. The TRAM in Alicante was again the first experience of such mixed systems to be introduced in Spain and revealed the solution was suitable to middle sized cities with complex and dense suburban regions.

The city of Castellón is a coastal municipality in the northern part of the Valencian Autonomous Region, some 70 km away from the capital city of Valencia, with a population of about 175.000 inhabitants, and is the centre of an urban region that accounts for nearly 300.000 inhabitants which includes the cities of Vila-real, Almassora, Burriana and Benicàssim. The urban region of Castellón is one of the

most dynamic economical centres in the Autonomous Region with a dense and complex network of economic and mobility relations.

When it came to study how to solve the mobility needs of the urban region of Castellón, the planners at the Regional Transportation and Infrastructure Department had to face the fact that the capacity requirements were not going to be as high demanding as in Valencia or Alicante. Castellón enjoys a mobility pattern that is typical of a Mediterranean city: densed populated areas with short distance trip made mainly on foot. Public transport usage is very low because the mid to long distance mobility within the city is made by car.

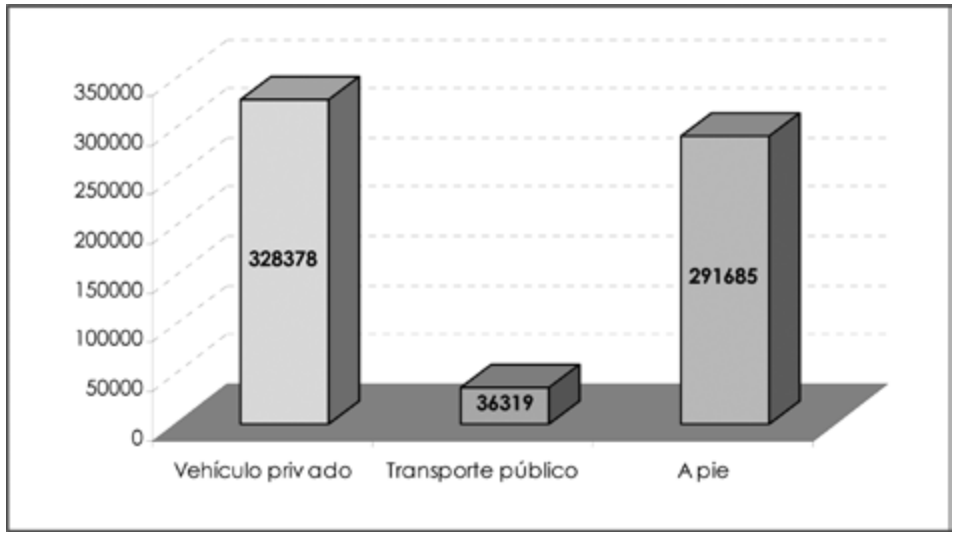

Fig. 1. Modal Split within the urban region of Castellón: 50% car; 6% public transport; 44% foot
Source: author collection

While the tramway line in Valencia was carrying some 20.000 passengers per day, the complete bus network of Castellón carried no more than 15.000 in a day. It soon became evident that a pure tramway system was going to be way too expensive to build and operate with such demand expectations: a new solution to fill in the gap between tramway and pure bus had to be found.

The planning principles to be applied on the new solution were that the system had to be environmental friendly; had to be flexible enough to allow partial openings and operation; had to have capacity enough to meet the expected demand at peak hours and had to be cost efficient by its construction and further operation. At the end, it was clear that the most suitable system for Castellón was one that had sadly disappeared from the city's landscape thirty years before: the trolleybus!

So, again, the Valencian Regional Government decided to make one step forward in the (re)introduction of proved public transportation systems and decided

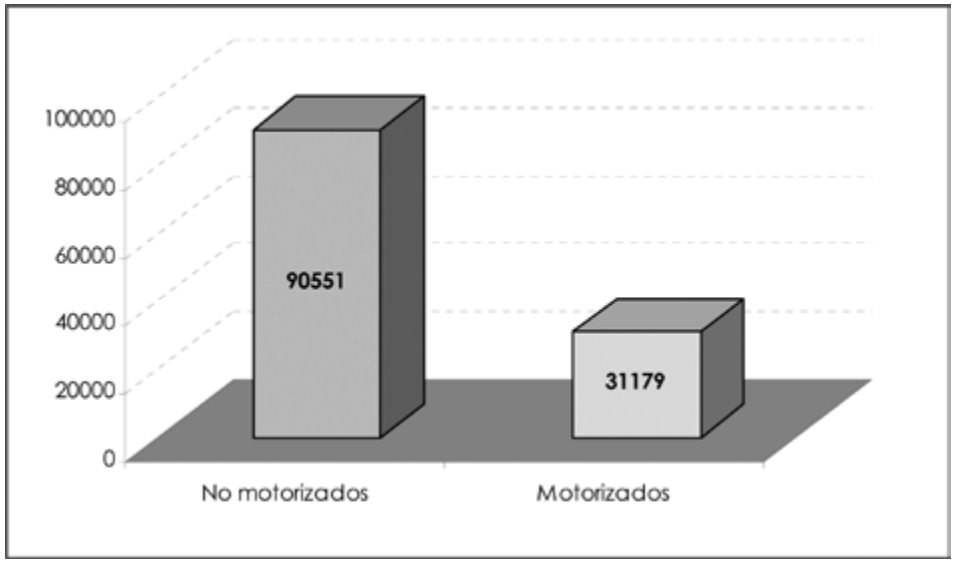

Fig. 2. Modal Split within the city of Castellón: 74% foot; 26% motorized
Source: author collection

the one for Castellón was to be a new 35 km long trolleybus network for the entire urban region and the city itself.

The network would consist on two main lines linking the main spots of demand generation of the urban area. Line 1 was to run from west to east to north between the University "Jaume I" (UJI), the main train and bus station, the city centre, the harbor and the municipality of Benicàssim alongside the coast. On the other hand, line 2 was to run north to south from the important transport node of the main train and bus station towards Vila-real, Burriana and Almassora municipalities, linking important points such as commercial centres, train stations, industrial areas and the main hospital in the area: "Hospital de la Plana".

The technical planning process of the network once the decision was made began by the middle of 2005, when a contract to the engineering firma "IDOM, Ingeniería y Arquitectura" was awarded by the Valencian Transportation and Infrastructure Department. Within this contract, several milestones had to be achieved:

- definition of all technical characteristics and requirements for the system to be implemented in the whole network: energy supply, electrical infrastructure, dedicated bus lane, platforms, general layout of the network.
- definition of all technical base characteristics and prescriptions the trolleybus vehicles were to meet in the public tender for their delivery.
- demand studies for the whole network and raw definition of services and stops.
- General traffic study of the city of Castellón to take into account all possible interactions when implementing the trace inside the old and narrow city streets.

- construction project of the first part of line 1 between the University and the harbor, splitted into seven different and independent sections:
  - Section I between UJI and Ribalta Park
  - Section II throughout Colón street
  - Section III along Ribalta Park
  - Section IV inner-city ring
  - Section V between city centre to city edge.
  - Section VI from city edge to harbor
  - Section VII along harbor neighborhood until Pinar Park.

The investment on infrastructure of the whole network was estimated in some 140 million €, not considering the cost of the vehicles, which are object of separate delivery tenders.

The project of the first section was ready by the middle of 2006 and thus construction works could begin after summer. In a record time of just one year the whole section was ready to enter into operation, including a new span bridge over the Seco river. The system was opened on June 25th, 2008 with a base headway service of 8 minutes on peak hour, getting students to the University in less than 7 minutes reducing thus the trip time in more than 70% from the previous 20 minutes of the old bus line.

Main characteristics of the system

The characteristics of the first section in operation were established so that they could set up the general technical framework of the complete network.

The system in Castellón is not a typical trolleybus system in a sense that it has some particularities from other systems that make it unique (at the moment) in Europe:

- The systems disposes of a dedicated bus lane with priority at all traffic junctions in order to offer and keep a high commercial speed.
- The stops are located on the dedicated lane and configured as tramway-like stops, with at-grade boarding to guarantee a high accessibility standard for all passengers.
- The system is optically guided. The trolleybus driver must not maneuver all the time, as the optical guidance would drive the vehicle to perform curves. This was introduced to allow the vehicle to always halt at the very same point on each stop.
- The vehicles are dual-powered trolleybuses as some sections on the city centre will not have electrical supply available in order to avoid catenary installation.
- The name itself of the system introduces a new transport concept in the city. It is not a bus, not a trolleybus, but "something more". The system is commercially known as "TRAM" ("**TRA**nsporte **M**etropolitano de la Plana" or Metropolitan Transport of La Plana area)

Fig. 3. The first section of the trolleybus system in Castellón links the UJI University (south) through a new span bridge with the train station and the city center (Ribalta Park)
Source: author collection

The main aspects of the first section as well as the whole system are described below:

Dedicated Bus Lane

The system uses a dedicated bus platform in order to guarantee high commercial speed. This bus lane was originally designed as a concrete platform with coloured finishing to offer a smooth ride for passengers while assuring a long term performance. Prior to the design, a benchmark of other solutions throughout Europe proved that concrete (rigid) platforms were more suitable for such requirements and that paved (flexible) solutions often resulted in a rapid degradation of the surface and the appearance of wheel marks.

The colour chosen for the finishing was red, and this color has resulted in a standard for those dedicated lanes in the Valencia Region.

The standard cross-section of the platform is made of three different layers, as shown on the picture From down to top:

- 20 cm of artificial gravel at 98% modified proctor.
- 20 cm of concrete layer (in some cases reinforced with metallic fibres, otherwise with regular reinforcement). Concrete type = HF – 4,5 with 30 kg of metallic fibres per m^2.
- 8 cm of pressed concrete for finishing. In the city centre this layer is made out of paving stone

Fig. 4. The results of the designed dedicated lane can be seen at the University track, where the trolleybus line enjoys full preference to all motorized means of transportation
Source: author collection

Fig. 5. The "red stripe" is clearly identifiable along the track: here at "Avenida de la Universitat" and the new bridge over the "Seco" river
Source: author collection

Special stops

All the stops along the track were "tramway-alike" designed. The platform is 27 cm above lane level, in order to facilitate boarding and alighting of all kind of passengers. A special designed concrete kerb has been used in order to facilitate the aligning of the vehicles to the stops. All the stops where prepared to hold the new passengers' information system, to be implemented in a second phase.

The standard layout of a stop is 3 m wide and 25 long, in order to allow simultaneous boarding of articulated and simple trolleybuses.

The shelters where specially design for the city of Castellón and will become a standard atribute of the system.

Fig. 6. The stop concept resembles that of the tramway in many cities of Europe: at-grade boarding, specially designed shelters
Source: author collection

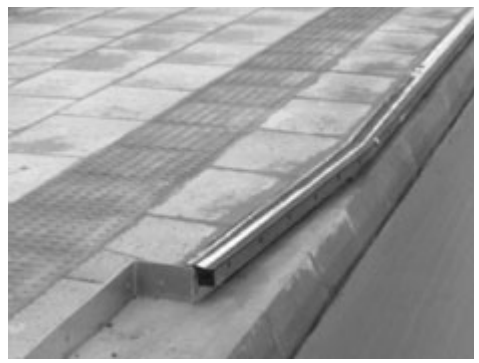

Fig. 7 and 8. In Castellón a particular concrete kerb was designed to help the guidance system align the vehicles to the stops
Source: author collection

Preference at traffic junctions

The whole dedicated lane is equipped with a preference system at every traffic junction. This allows the vehicles to achieve a considerable commercial speed. From the opening on, the mean daily speed on the first section is over 17 km/h, high above that of the bus system of 11 km/h. The preference system uses four different detectors that concatenate each other. The first detector detects a new vehicle is approaching to a traffic junction. The second one confirms the vehicle has been detected and indicates the driver whether he is going to be granted preference or not, according to the regulations' rules of the particular junction. The third detector in the row effectively "opens" the traffic light to the trolleybus and the last one rearms the whole system once the vehicle has crossed the junction.

The different detectors can act as primary, secondary, arming and disarming devices, so that the number of spires needed decreases. The detection is made under the basis of a selective detection of the trolleybus frequency, avoiding other vehicles to enjoy the priority if they run on the lane.

Optical guidance system

To make the system fully accessible to all passengers, it was decided to go for an optical guidance system so that the vehicles could exactly align to the platform edge and thus diminish the gap between vehicle and stop.

The system was provided by Siemens and had already been proved in the French city of Rouen. In Castellón the decision was not only to use the system at the stops but along the track, so that the benefits of the optical guidance could be extended to the rest of the trip: the ride feeling is equal to a rigid guided system such as railways or tramways. Special tests had to be made during the construction phase,

Fig. 9. Optical guidance system in trolleybus Irisbus
Source: author collection

as the particular shinny and sunny conditions of the weather in Castellón made it necessary to use some filters for the system to work properly.

Electrical system

The electrical feeding system is typical of a trolleybus one: two overhead contact lines, the negative been located on the right in the direction of movement. The system is 750 volt DC, and has one substation in operation right by the new bridge.

In order to keep the city centre free of catenary lines, it was decided to acquire dual-system trolleybuses. The ones in operation at the moment are diesel-electric but it is expected to buy for battery-electric vehicles in future. To avoid the line west of the city centre be electrically isolated with the rest of the network, a feeder connection has been foreseen. With this connection, the current substation and the new ones to be put into operation when the tracks reach the harbor will be electrically connected and will allow to have redundancy in energy supply.

Fig. 10. The vertical elements were specifically designed for Castellón and hold the lighting system and the catenary
Source: author collection

The overhead contact system is of a flexible type from Kummler und Matter. This system allows a more reliable operation, low maintenance and operation costs and a lower need of vertical elements.

Urban integration

One of the key elements of succeed that the new trolleybus has achieved is the smooth urban integration of the system in the city.

This was one of the strictest constraints of the design process. The whole urban concept was made under the premises of a total restoration and renewal of the parts of the city the trolleybus platform passed by. As a part of the global mobility concept of the TRAM project, priority to pedestrian and bike connections was yielded. A totally new pedestrian path was designed to link the University with the train station and the city centre, allowing people, pedestrians, bikers enjoy parts of the city that were completely stolen by the lasting vehicle traffic. New trees, bushes, banks, relax areas and so on where spread along the track.

The city centre of Castellón is maybe the best example some important decisions were taken. It was decided to give full priority to the implementation of the trolleybus inside the dense and narrow streets of the old city. Colón Street, which

Fig. 11. Lots of new trees, banks, bicycle paths: all parts of the city where the lines passes by have been renovated
Source: author collection

Fig. 12. Colón Street has in some points only 5,5 m width. The big decision here was to convert a 22.000-vehicle-per-day street into a pedestrian and public transport one
Source: author collection

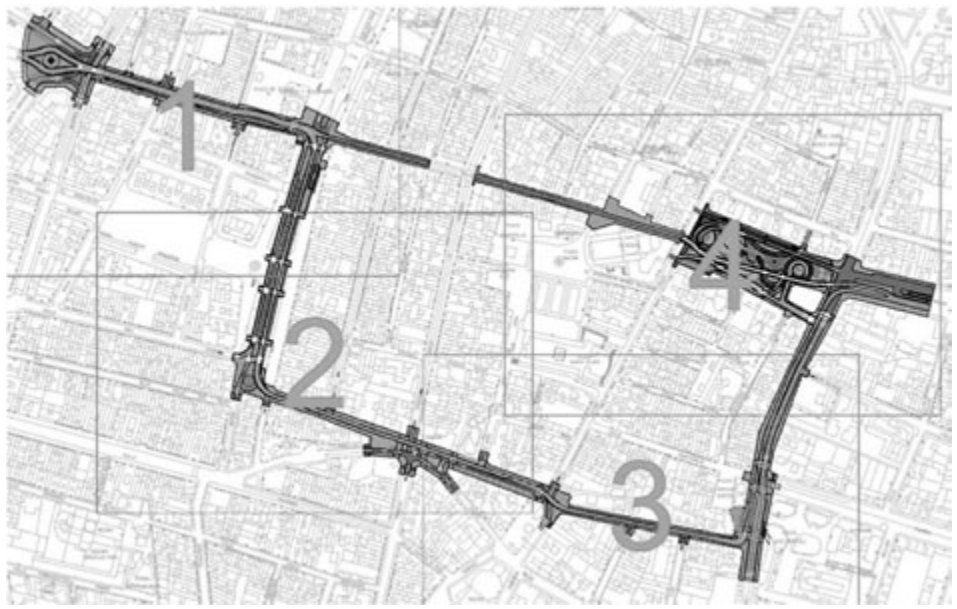

Fig. 13. The city centre ring will close some more streets to the private traffic and alliberate them to pedestrians and public transport. In this part of the city the vehicles will have to operate without direct electric connection: with batteries or combustion engines
Source: author collection

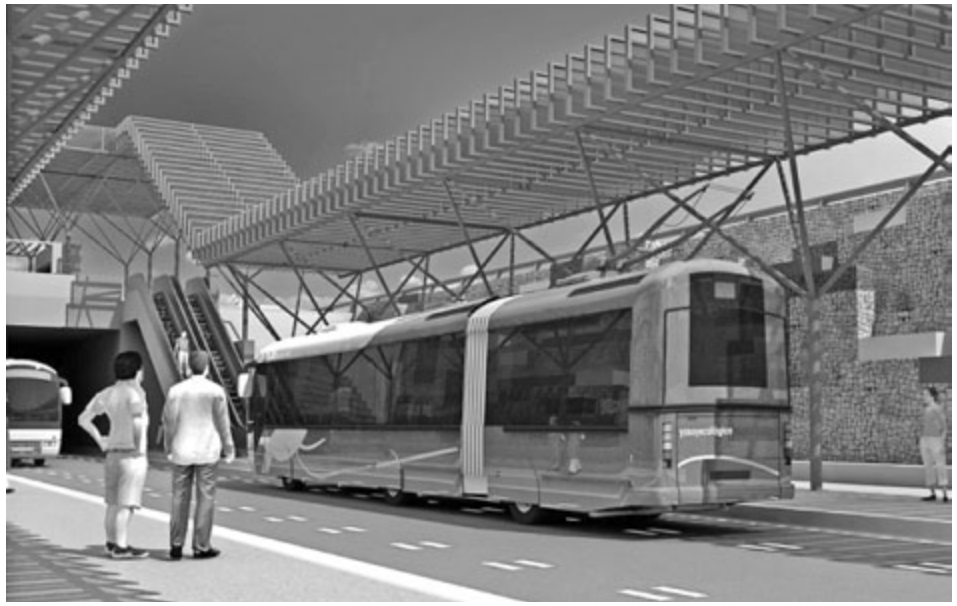

Fig. 14. The future station "Recinte Castelló" will change the city's image once more: located underground between two roundabouts it will allow the trolleybus to quickly overpass a very condensed traffic point in the city
Source: author collection

Fig. 15. The new bridge over the "Seco" (dry) river was also design in an attempt to benefit sustainable means of transportation: wide sidewalks, cycle path, only one lane per direction for cars
Source: author collection

was used by more than 22.000 vehicles per day prior to the intervention, was totally predestrianized with the only exception of trolleybus to circulate on it. Commerce and shops soon realized this was the right decision to be made, as the number of potential shoppers dramatically went up.

The ring trolleybus circle is another example of deep urban intervention: only locals can access the city centre and there are some parking possibilities at the centre entrances' to allow people to come and leave the car. Squares and streets have been or will be fully renovated in accordance with the trolleybus architectonic premises.

It is clear that the benefits of the implementation of the new line go far beyond that the pure satisfaction of mobility needs.

Vehicles

For the operation of the first section three trolleybuses were tendered by the Regional Government. Finally it was Irisbus through its subsidiary in Spain IVECO the best bid and so three CIVIS/CRISTALLIS vehicles were purchased. The total amount of seats is 78 per vehicle with room for one passenger with reduced mobil-

ity. They have direct electrical engines that are fed by an automatic aerial collection system. The vehicle is 100% low floor with over dimensioned corridors to allow fully accessibility to all kind of passengers.

The vehicles are equipped with a special device that sends the proper signal to the traffic light's priority system, so that only TRAM units can dispose of it.

Fig. 16. Trolleybus Irisbus on the new bridge in Castellon
Author: Marcin Połom

Fig. 17. The interiors of the vehicle are wide and luminous
Author: Marcin Połom

Conclusions and further developments

The (re)introduction of the trolleybus systems in Spain has proved been a great success in concealing the different requirements of modern and suitable mobility transportation systems: cost effective by the implementation, maintenance and operation under reasonable parameters, demand oriented, universally accessible, clean, noiseless.

The demand predictions have been over passed in the first section of the system into operation: more than 25% of all rides in the public transportation network in Castellón are made in this first trolleybus line, while private traffic between the University and the city centre has decreased.

The system will be extended step by step until fully completion, when it will account for about 35 km of dedicated lanes on which modern trolleybuses will operate.

The success of the system has expelled the Valencian Authorities to extend the benefits of the system to other middle-sized cities in the region: similar systems are under planning in the cities of Sagunto and Elda, and the former planned tramway line between Alicante and San Juan and Muchamiel has been redesigned as a Castellón-alike system.

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Per Gunnar Andersson

First trolleybus system in Sweden after years. A case study of Landskrona

Landskrona is a very old city and it was granted a city charter in 1413. At that time Landskrona was a part of Denmark. After the peace of Roskilde in 1658 Landskrona became a Swedish city. The castle was built 1549 to defend the city and Skåne from enemy attacks. Nowadays Skåne is the most southern part of Sweden. The main reason for development of the city in the late 19th century was the harbour. Population of Landskrona has increased from 14000 to 29000 since 1900. At the beginning of the 20th century Landskrona was the 16th biggest city in Sweden, nowadays Landskrona is on rank 37.

Landskrona is a pioneer in Swedish public transport. As soon as in 1901 the first horse bus line was opened between Borstahusen (a small fishing harbour to the north of Landskrona) to the main square in Landskrona (Rådhustorget). This horse line was converted to a motor bus line (one of the first in Sweden) in 1912. This bus line is still a part of the CNG bus operated line 1.

Landskrona was connected to the railway system in 1865. The railway station was situated to the south of the city centre near the harbour. At the beginning it was a substation and this was the main problem connected with the railway line along the coast between Landskrona and Helsingborg.

At the end of the 1980th there was a plan to modernize of the Swedish West coast line between Malmö and Göteborg. The main object of the plan was to construct a new double track line with the speed of at least 200 km/h. There was also an idea to let the new line pass Landskrona and connect the city to the main railway system of Sweden. In 1997 the Swedish state made the decision to build a new railway passing Landskrona on it's way from Malmö to Helsingborg. It became necessary to move the city's railway station from the old location to a new one to the east of the city. The distance from the station to the city centre was approximately 2 km. The new railway line and the new station in Landskrona were opened in January 2001.

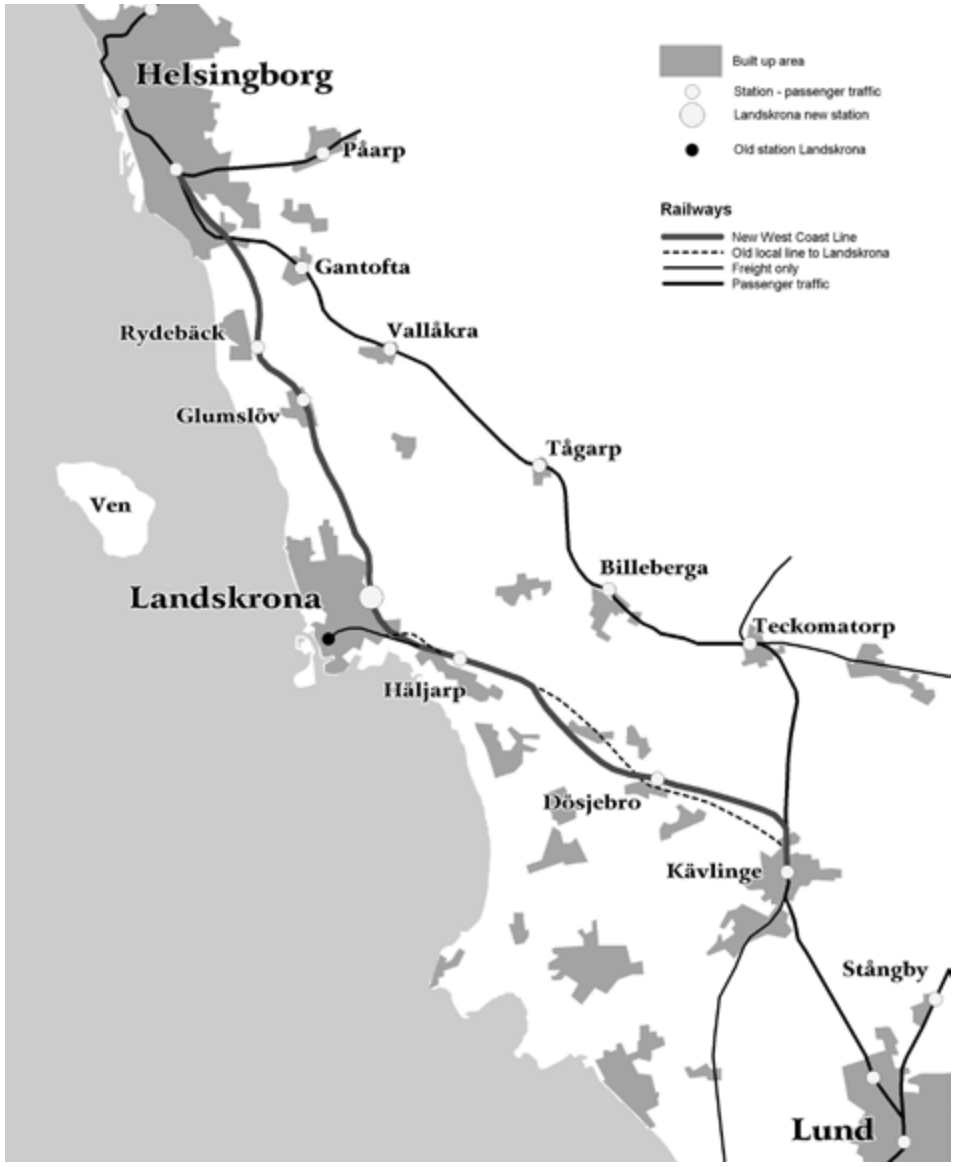

Fig. 1. The red line indicates the railway line opened in 2001. The black dot in the southern part of Landskrona indicates location of the old railway station
Source: author collection

In 1997 it was recommended to keep the old bus system unchanged and add a new bus line between the new station and the city centre. This new line was a feeder line and it was called "Stationspendeln" (Station shuttle). There was also a note in the report that this "shuttle" could be operated by trolleybuses. It wouldn't be expensive and it will also give the shuttle a better image as an electric connection to the electric commuter train system.

This idea of creating a trolleybus line resulted in an application for state support through the so called LIP-program. This program was based on two basis: environment and employment. A trolleybus line will have a positive effect on the environment and it will also create jobs during the construction. The application was approved on 18th March 1999 and the city was granted 12.36 million SEK as a part of the construction costs of the 3 km long trolleybus line between the station and the city centre.

When the application was granted, the political discussion started. Some political parties were against the trolleybus line, claiming that the costs are too high. They thought that it was enough to run the shuttle with modern diesel buses. Other parties were very pro-trolleybuses and the Social democrats, who were in power at that time, had members that were pro-trolleybus but also a lot of members that were against them. Some new studies were carried out and the Swedish state accepted that the grant also could be used for purchasing battery operated electric buses. To investigate operation of different types of zero-emission vehicles a study tour took place in April 2000. After this tour most of the delegates were convinced that trolleybuses were the only vehicles that could be acquainted immediately to provide zero-emission operation of the station shuttle. Both battery buses and fuel cell buses were still in the test and development phase.

As the discussions about trolleybuses still were going on the station shuttle was operated by diesel buses. Finally in September 2001 there was a decision to create a trolleybus line. The tender was put off in TED on 15th October 2001.

The tender procedure started with a prequalification and the result was that 10 companies were interested to bid on the trolleybus line in Landskrona. The prequalified companies were:

Ansaldo Transporti, Italy
Siemens, Sweden
Svenska Neoplan AB, Sweden and Germany
Balfour Beatty Rail, Sweden
O.J. Dahl a/s, Norway
SRS, Sweden
Ganz Transelektro and Solaris Bus & Coach, Hungary and Poland
Skoda Ostrov, Czech Republic
Göteborgs Spårvägar Banteknik, Sweden
MAN Sonderfahrzeuge, Austria and Sweden

The main tender was sent to ten companies in January 2002 and in April 2002 there were four bids from Balfour Beatty Rail, SRS, Ganz Transelektro/Solaris and Göteborgs Spårvägar Banteknik. The last bid didn't meet the basic requirements, which means that there were three bids to consider. Ganz Transelektro together with Solaris offered trolleybuses and Balfour Beatty and SRS the infrastructure. Both Balfour Beatty and SRS were offering the trolleybus system from Furrer + Frey. After the final negotiations the bid from SRS was the most advantageous

regarding the infrastructure and Ganz Transelektro regarding the trolleybuses (only one bid).

The implementation of the trolleybus project started on 3rd September 2002 when the contract was signed between the city of Landskrona and Ganz Transelektro for delivery of three trolleybuses with Solaris Buses & Coaches bodies and chassis. The week before, the contract had been signed with SRS (Swedish Rail System) regarding delivery of overhead and substation.

Work on building the substation and putting the feeder cables/wires started on 16th December in Vattenverksallén. The next date to note was 30th January 2003 when the first digging started for a pole at the new station. Then on 7th March , the first lateral pylon was constructed. Two months later, the night between May 5 and 6, the first overhead wire was drawn from Lasarettet (the hospital) to the new station. After some planning it was decided that the first test run with the Tallinn bus should take place on 2nd July. Using a salvage truck the trolleybus was transported to Kolonigatan, where it was connected to the overhead wire. Construction work then continued with rapid speed and at the end of June, the overhead was finished. At the same time, the substation was finished and all infrastructure was ready to be tested. The problem was that the trolleybuses were not delivered on time. As test run of the line in Landskrona was necessary, Ganz Transelektro offered a loan of a trolleybus from Tallinn for two weeks.

Eventually the first test run with the Tallinn trolleybus took place on 2nd July. Using a salvage truck, the trolleybus was transported to Kolonigatan, where it was connected to the overhead. After almost 39 years, of waiting at 18:45 on 2nd July,

Fig. 2. The first test run with a trolleybus from Tallinn took place on 2 July 2003
Author: Per Gunnar Andersson

Fig. 3. On 27th September 2003 the Swedish Minister of the Environment Lena Sommestad inaugurated the trolleybus line
Author: Per Gunnar Andersson

the driver set his foot on the pedal and put the first trolleybus in motion . The trip to the station went well and from the station back to Kolonigatan, the bus was driven by an inspector from the Swedish Motor Vehicle Inspection. After that, a complete run along the line was driven with a good result. During the test run, many people from Landskrona stopped and looked at the remarkable trolleybus with great interest. A person who lived in a small house along Kolonigatan looked at the bus and remarked spontaneously “How quiet it is – it is worth all the poles!”

On 4th August a trollebus for Landskrona was tested in Budapest and on 21st August three trolleybuses arrived in Trelleborg by ferry from Germany. One day later, they were inspected for registration at the Swedish Motor Vehicle Inspection in Malmö. It took some time before the buses could be tested on the roads, but on 28th August at 13:14, the first Swedish trolleybus after almost 39 years could be set into motion at Skeppsbron in Landskrona. The first run with paying passengers took place on Monday 15th September 2003 at 06:37. After that, trolleybuses went into scheduled service for drivers´ education Monday to Friday up to the opening day on 27th September 2003.

The opening took place on 27th September at Kasernplan when the trolleybuses got women’s names which all started with El and each trolleybus also got a slogan with a game of words in Swedish. The Swedish Minister of the Environment Lena Sommestad inaugurated the trolleybus line at 14:15 in Landskrona 14196 days after Göteborg had abandoned trolleybus operation on November 14, 1964. The Minister of the Environment praised the city of Landskrona because they had taken the decision to build the trolleybus line that reduces pollution as well as the noise in the city.

Fig. 4. The grey line is the trolleybus line connecting the new railway station with the city centre. Blue lines are the three other city bus routes – operated by CNG buses since 2006 Source: author collection

The trolleybus line 3 – or the Station shuttle as it is called is 3.0 km long. The infrastructure consists of two main parts, overhead and the substation. The overhead part consists of poles with foundations as well as lateral pylon and overhead wire. The substation, which is situated in Norra Fördelningsstationen (NF), consists of a transformer and two rectifiers. The rectifiers serve as a reserve for each other – only one is connected.

The overhead construction consists of 160 poles also used for street illumination purposes. A small number of poles are not used for street illumination. Instead, they

have a top made of aluminium. The poles for the overhead wire are of three models with different pulling strength; B poles 0-44 kN (diameter 255 mm), C-poles 44-120 kN (diameter 355 mm) and D- poles 120-250 kN (diameter 355 mm). The majority of the poles are of the B type. The difference between the C and D types is the thickness of the metal in the pole. The D type is only used at a few points where the pulling strength is extremely high.

The foundations for the poles have been vibrated into the ground to a depth of 3 – 6.5 meters. The method is gentle to the nearby utilities and gives minimal pits.

The overhead wire is mounted single-sided on poles with lateral pylon and is fed with 750 V DC. The poles are double isolated between the overhead wire and pole with 1.5 kV. At the Postrondellen roundabout, the junction at Vilan and the loop at Skeppsbron, the overhead wire hang in a span. The nominal height for the overhead wire is 6.0 meters. The overhead wire consists of two copper wires, one for plus and one for minus. The copper thread is 107 mm².

The substation is fed by 10 kV 50 Hz from the city's electricity network. The transformer is an 800 kVA epoxi dry isolated rectifier transformer. The rectifiers from Secheron are two 6 pulse no-fuse diode rectifiers in single mode at 660 kW. The construction and the trolleybuses are adapted in a way that makes it possible for three fully loaded trolleybuses to operate at the same time along the line.

The trolley buses reduce the emissions in Landskrona by 275.000 kg carbon dioxide (climate influence), 1.200 kg NOx (acidification) and 5 kg particulates (health) per year in comparison with a diesel bus (Euro 4). The energy consumption is calculated at 65 % less than diesel bus operation. Calculations showed that an energy consumption of 1,6 kWh/km for a trolleybus, 4,5 kWh/km for a diesel bus and 5,6 kWh/km for a CNG bus. The main specifications of the trolleybuses are listed in the table below.

Tab. 1. Characteristic of GANZ Solaris Trollino 12

Vehicle:	Trolleybus	**Type:**	Trollino 12
Number:	3	**Length (mm):**	12150
Manufacturer:	Ganz Transelektro and Solaris	**Width (mm):**	2600
Year of delivery:	2003	**Height (mm):**	3600
Number of axles:	2	**Axle distance (mm):**	5900
Number of motors:	1	**Number of passengers:**	63
Motor type:	Three-phase asynchron	**where of seated:**	27+2
Effect:	165 kW	**where of standees:**	34

Speed, trolley operation:	65 km/h	**Overhead wire**	750 V DC
Speed, battery operation:	30 km/h	**Operational temp.**	-30°C - +40° C
Operational weight:	13,9 t	**Acceleration:**	1,3 m/s^2
To be noted:	Battery: 30 Ah, 360 V, range of battery approximately 4 km without passengers.		

Source: own elaboration

The total cost of the project was 40 million SEK in 2003. In the table cost for the main parts of the project are listed.

Tab. 2. Parts of construction costs

Part	**Cost (mln SEK, 2003)**
Trolleybuses	15.2
Poles and wires	16.8
Substation	3.6
Other	5,2
Total	40,8
	Financing (mln SEK)
LIP-contribution 1	12.4
LIP-contribution 2	3.0
RTI-contribution	4.2
City of Landskrona	21.2

Source: author implementation

There is a need to comment some of the items in the table. The level of "Other costs" was higher than expected. The main reason for this was the need of more expert help regarding building of the overhead wire system in the city. As we don't have a lot of trolleybus and tramway systems in Sweden the companies building overhead wire systems are more familiar with railway systems on free land than constructions in the city.

On the financing side LIP-contribution 1 is the first contribution that was agreed in spring 1999. The second LIP-contribution is a revised contribution for

a battery bus on the island of Ven. As this project wasn't realized the government accepted to use it for extra costs in the trolleybus project (the trolleybuses is fitted with auxiliary batteries!). The RTI-contribution is a regional contribution that can be used for electric overhead systems for public transport.

During the first five years (September 2003 - September 2008) the availability of the trolleybuses and the infrastructure was logged. The main reason was to follow-up the requirements from the contracts, 95% regarding trolleybuses and 99% regarding the infrastructure.

The infrastructure has been working very well and the availability is over 99%. The main problems emerged during the first winter because of the ice on the wires. In February 2005 a new de-icing car was delivered and a Danish professor from the Technical University in Lyngby gave some recommendations on changes in the accepted levels of power spikes in the substation, there have been no problems in winter times since then. The only problems were caused by reconstructions of roads when a new ferry terminal in the harbour was being built.

The availability of the trolleybuses is not that good. There have been a number of problems. In the beginning more normal "bus" problems like doors that are not closing. The main reason that the trolleybuses had an average availability of 92% in September 2008 were problems with the electric system. In the summer of 2005

Fig. 5. In February 2005 this de-icing vehicle was delivered
Author: Per Gunnar Andersson

Fig. 6. The construction of the new terminus at/in Skeppsbron in 2009 resulted in a number of weeks of non trolleybus operation – nevertheless the trolleybuses operated in the building area for a few days
Author: Per Gunnar Andersson

there were a number of small problems. One trolleybus lost its trolley pole during operation. Luckily there were no injuries or damages but the image of the trolleybuses decreased as this accident appeared in the local newspaper. The summer of 2006 was even worse. In June 2006 Ganz Transelektro announced its' bankruptcy and this resulted in lack of spare parts. In the autumn 2006 the agreement with experts in Hungary was signed and the trolleybuses were maintained and they entered service again. In the summer of 2007 there was a number of bus oriented failures, like problems with the suspension. There were also a number of electrical problems which had not been solved before the autumn end.

The unacceptable problems in 2006 and 2007 were the reason for discussion on the organisation and maintenance of the trolleybuses. Since 2008 there is an agreement with experts in Hungary that guarantee a visit to do expert maintenance every 6 months. Since then trolleybuses have been working better. The main problem of 2009 is the fact that the six years old auxiliary batteries need more and more spare parts. The life time of the batteries was sad to be five years so they have already survived one year longer then expected. Due to not working auxiliary batteries there has been diesel/CNG bus operation in 2009. The main reason for unsatisfactory availability of trolleybuses in 2009 is the rebuilding of the terminus at Skeppsbron which has resulted in weeks of non trolleybus operation in 2009.

The organisation of the trolleybus operation in Landskrona is rather complex. The organisation was established in 2003 when the operation started. Since 2003

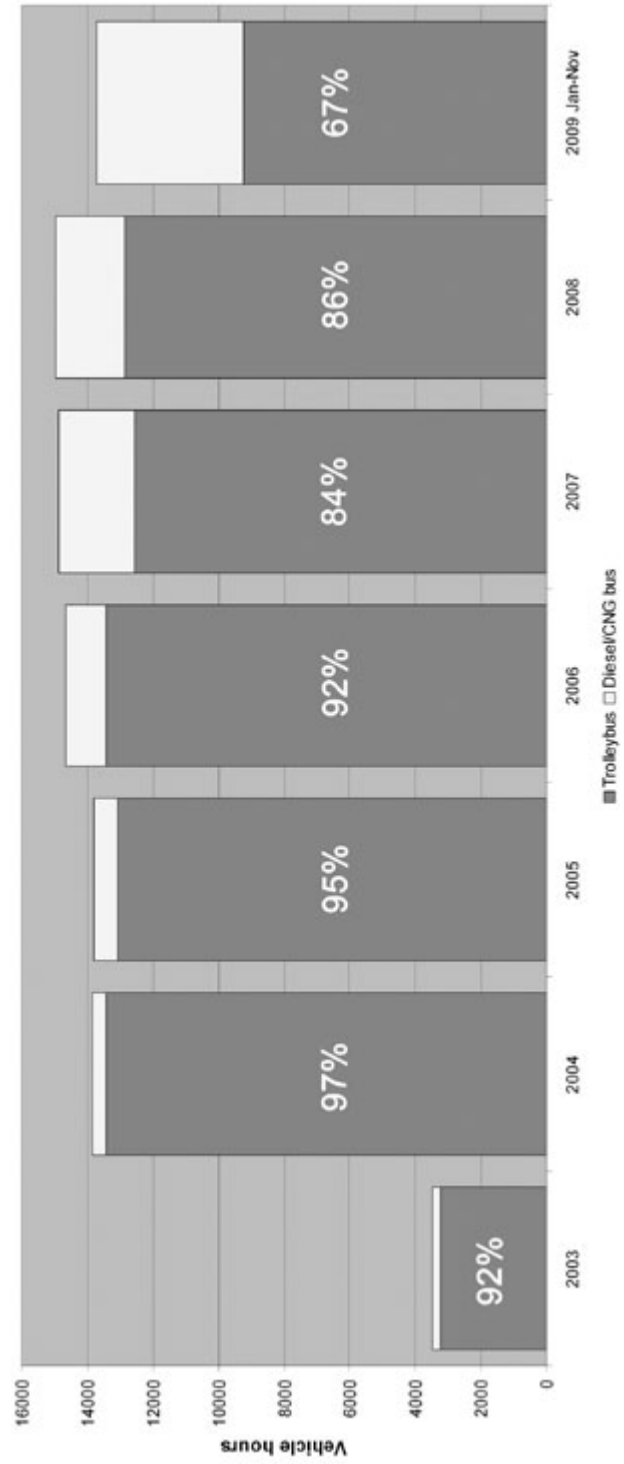

Fig. 7. This chart shows the availability of trolleybuses in percent 2003 to 2009
Source: author implementation

the city of Landskrona is the owner of the infrastructure and the trolleybuses. Skånetrafiken, the regional public transport authority in Skåne, is responsible for planning and tendering the operation. In 2003 the bus operator Orusttrafiken was responsible for operation of the city buses in Landskrona, including the trolleybus line. Orusttrafiken sold the contract to British owned Arriva in April 2004. In 2005 a new tender was put and since June 2006 Swebus (in December 2009 renamed Nobina) is the operator.

Since 2003 the city of Landskrona is responsible for the main maintenance of the trolleybuses. This is done through a contract with a local heavy vehicle workshop. This workshop has a subcontractor that is responsible for the electric parts of the trolleybuses. As there are only three vehicles it is hard to become an expert on trolleybus problems. This is the main reason for long repair time and the low availability of the trolleybuses.

During 2009 negotiations were held between Skånetrafiken and the city of Landskrona resulting in a new organisation solution. Since 2010 Skånetrafiken will own the trolleybuses and Nobina will have the full responsibility for maintenance and operation of the vehicles. Hopefully it will result in faster repairs and building up know-how. The infrastructure is still in the hand of the city and perfectly maintained by the electrical department.

The number of passengers has been rising every year in Landskrona since 1995. In 2001, when the new station and the station shuttle (line 3) were opened, the

Fig. 8. The trolleybus called Ellen passing the roundabout at the former post office in 2007
Author: Per Gunnar Andersson

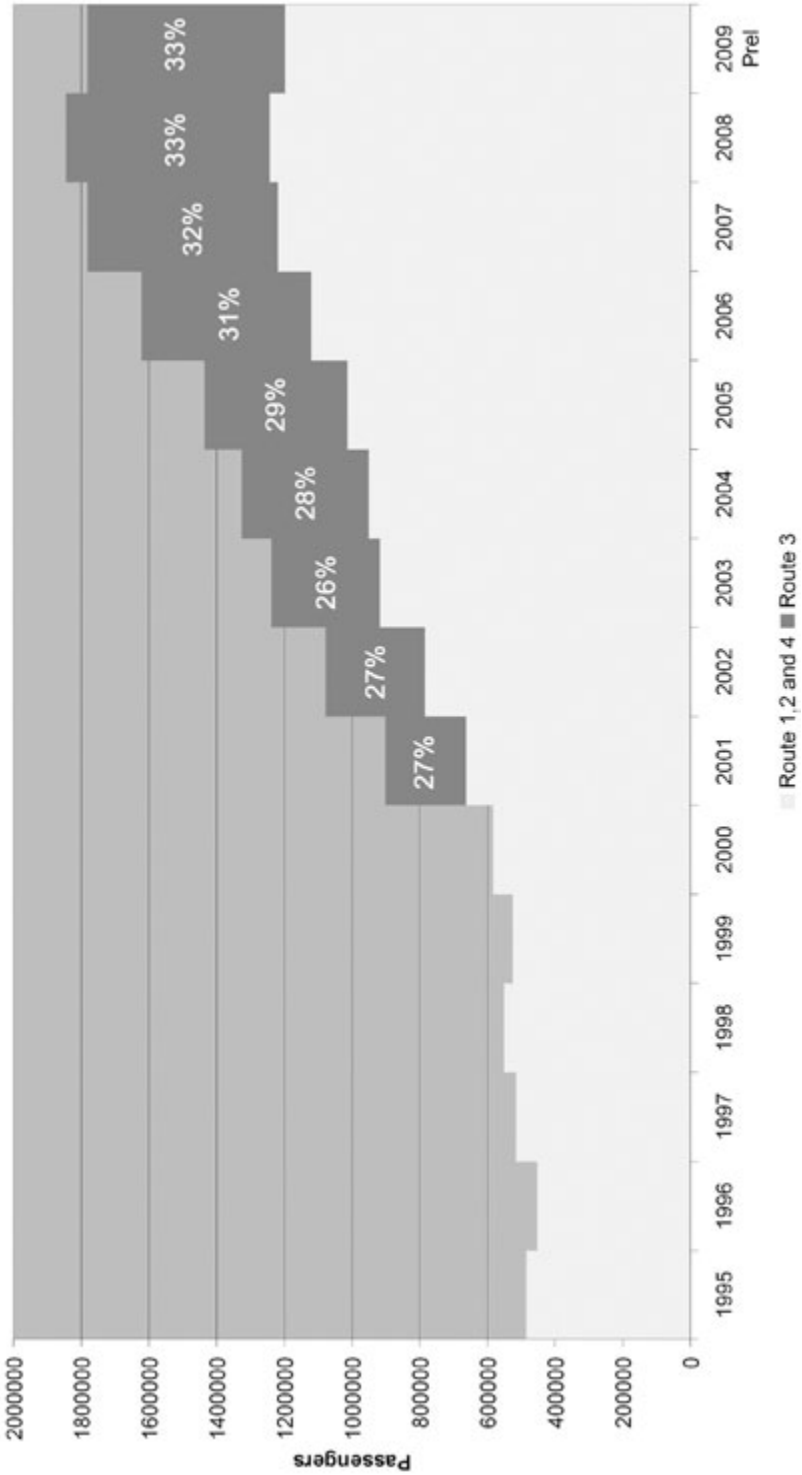

Fig. 9. Number of trips in Landskrona city buses 1995 – 2009 and percentages on line 3, trolleybus operated since 2003.
The figures for 2009 are preliminary
Source: author implementation

number of passengers increased by 86%. This was a result of new routing and better headway. The city and Skånetrafiken has been working together to get more passengers and to increase the accessibility for old and disabled people better. In 2001 there was a good tradition in marketing the public transport. The new railway station makes it possible to use the commuter trains to the north of the city too. Since 2001 the number of departures from the railway station has increased and now there are four trains in each direction every hour. 2001 the number of passengers in the local public transport has increased by 97%. The number of passengers of the station shuttle (trolleybus) increases every year and now it is about 600.000 passengers every year. Between 2001 and 2009 the increase was 144%.

Tab. 3. Public transport trips in Landskrona since 1980

Year	Total passengers	Station shuttle, 3, trolleybus from September 2003.
1980	1000000	
1985	1100000	
1990	925000	
1995	484000	
2000	582000	
2001	901000	239000
2002	1078000	294000
2003	1239000	321000
2004	1326000	376000
2005	1435000	422000
2006	1622000	501000
2007	1781000	564000
2008	1845000	603000
2009 preliminary	1781000	584000

Source: own elaboration

The increasing number of passengers has resulted in a denser timetable on the station shuttle. In 2001 the number of departures was 164 on a weekday. This figure increased and was 187 in 2003 when the trolleybus started operation. Snce December 2009 there is a total of 258 departures on the trolleybus line on a weekday. In November 2009 a new ferry and bus terminal was opened at Skeppsbron, the southern terminus of the trolleybus line. Now the station shuttle connects the train services with the regional buses and ferries to the isle of Ven.

The increase in the number of departures results in the need for more vehicles. In the peak hours at least four trolleybuses should operate. As there are only three

trolleybuses available Skånetrafiken has decided to purchase one more trolleybus. It will be delivered in autumn 2010. The new trolleybus should be similar to the rest of the vehicles in the fleet. It was not easy as Ganz Transelektro is not being produced nowadays, that's why the new trolleybus will be a Solaris Trollino T 12 generation III equipped with the Skoda engine. An order will be put in January 2010.

Fig. 10. January 2010, the trolleybus Elvira picks up passengers at the Vilan stop
Author: Per Gunnar Andersson

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Ádám Zoltán Németh

The trolleybus system of Szeged

Introduction

Szeged is the fourth largest city in Hungary, which is located in the south, near to the border with Serbia and Romania. It has population of 169,000. Szeged is a major administrative center of the south-east region as well as an important university town, but less significant in Hungary as an industrial center, with mainly food industry. The city is situated on the Great Hungarian Plane, on the river Tisza. The area of the city is mostly flat, except the levees that protect the town against flooding, which is not something unusual here. The historical part of the town is situated on the right side of the river, which was mainly built after the 1879 flooding that had destroyed almost all previous buildings. During the reconstruction in the XIXth century the basic street structure was altered, and it was formed into eight wide avenues, from south to north: Boldogasszony sugárút to the railway station, Petőfi sugárút in the direction of Subotica in Serbia, Kálvária sugárút to Baja, Kossuth L. sugárút to Budapest, Csongrádi sugárút to Csongrád, József Attila sugárút to Hódmezővásárhely, Szilléri sugárút and finally the Felső Tisza part (Upper Tisza bank) to Tápé. There are three belting boulevards: the innermost boulevard (Tisza Lajos körút) is the edge of the city center, the second boulevard (Nagykörút – Grand boulevard) serves now as a major international road. The outmost boulevard is partially industrial area on the southern side of the city, however the northern-eastern part became a large residential area, as major housing estate was built alongside it in the 1980s in the area Tarján and Rókus. Beyond this lies the so called "round-levee", this was formed as a major flooding protection in the XXth century. Behind the round-levee there were some villages (Tápé, Gyálarét, Szentmihály, Petőfitelep, Kecskés, Kiskundorozsma), which has grown together with the city as low-density residential areas, and industrial areas.

There are only two bridges over the river, the first one is in the city center built in 1883 (Belvárosi híd – Inner city bridge) with two lanes, and the second with four lanes (Bertalan híd) built in 1979 at the northern end of the second boulevard, which now serves as the international route to Romania. The left side of the city is called Újszeged (New-Szeged), historically there were some smaller settlements here, which have expanded largely into low-density residential areas in the last decades. This includes the village Szőreg, which is now also absorbed into Szeged. About 5 km north to the city center the mouth of the river Maros is situated. Further north now can only be reached by ferry (direction Maroslele), thus it is not inhabited.

Railway service reached Szeged in 1854, with the construction of the first railway bridge in 1858. This was the route from Budapest in the direction of Timisoara and the southern border of Hungary. Szeged was a major railway hub until World War I. It connected six railway lines of four railway companies: Budapest (1854), Timisoara (1857), Arad (1882), Subotica (1869), Békéscsaba (1870) and Nagykikinda (1897). Because of the fragmentation of Hungary after WW I only three routes remained as the other three to Subotica, Timisoara and Nagykikinda lead through newly formed borders so they were irrelevant or closed. The railway bridge was destroyed in 1944 during World War II., and because of lack of its importance it was never restored. Thus the railway line to Makó (formally to Arad) ends now facing the river Tisza at a minor station "Újszeged", while the main station ("Nagyállomás") became also a dead end. Szeged had a third railway station ("Rókus"), located alongside the railway line Békéscsaba-Subotica that also lost its importance after Subotica became part of Serbia.

The road network's expansion followed the increase of car traffic of the XXth Century. Two major routes to Serbia and Romania go through Szeged. In 2006 the route to Serbia was diverted out of the city with the opening of the final section of the M5 motorway (Budapest – Röszke). Because of the wars in Yugoslavia and when Romania became a member of the European Union, the biggest road traffic in any Hungarian provincial city is now goes through Szeged on the Bertalan-bridge crossing the river Tisza to Romania. After the opening the 43 motorway, this traffic will have also been diverted out of the city by 2010, together with the construction of a new bridge on the Tisza about 10 km north to the city center.

The history of the public transport in Szeged and the start of the trolleybus operation

The first public transport vehicles in Szeged were omnibuses. Their operation started in 1857, connecting the city with the main railway station that was opened in 1854. After long negotiations the first horse-tramway was opened in 1884, which connected the two railway companies' railway station (the main station and Rókus) through the inner city. The electric tramway was opened in 1908, the tramway service reached all major wide avenues, and also Újszeged through the Inner city

bridge. During the interwar period the expansion of the tramway network stopped, however in 1926 the first interurban bus service was started reaching the neighboring villages. In the socialist era there were some new developments on the tramway network, and it reached the outskirts of Szeged, after the nationalization of the Szeged Transport Company (SZKV) in 1949. In 1955 the local bus service started in Szeged, at the time as a part of SZKV. In 1963 the Transport Ministry ordered to centralize all bus transport within the counties, and the local bus division was handed over to the 10th Bus Transportation Company (10 sz. AKÖV), which later became the Tisza Volán company. Since the bus and the electric public transport are separated they often compete.

In 1968 the Ministry decided, that the single track, low-passenger number tram routes must be converted to bus service. At the time the trolleybus operation – which only existed in Budapest – was also considered to be reduced. The turning point of this policy was the oil crisis in 1973, which ended the era of cheap fuel also in the socialist countries. The Ministry changed its directives, and again started considering new trolleybus routes also outside the capitol city. With the closing of three single-track tramway lines, there was a spare capacity in power supply for new developments in Szeged, thus in 1977 the preparations started to put the first provincial trolleybus in operation.

Replacing the former tram route 5, which had been closed a decade earlier, the first trolleybus route was opened in 1979, from the inner city to Újszeged, with the same line number. At the beginning the new trolley line wasn't connected with the tramway depot – which at the time was also the trolleybus depot – but in the same year, a bidirectional single wire-pair connection route was built, which also was used for passenger service (route 5/A). Until 1985 the trolleybus network was constantly developing and reaching some new housing areas on the north and north-east side of the city. By 1985, six routes operated, with 47 ZIU-9 solo and 4 articulated IK-280T trolleybuses.

With the expansion of the network, three new power-substations were built just for the trolleybus network. In 1985 a new trolleybus depot was opened in Csáky utca with a large maintenance hall, washing facility, social block and four open sectors for storage. The previously used part of the tramway depot was abandoned and given over to the bus operation. During the construction of the trolleybus routes, SZKV operated already trolleybus replacement buses with separate tickets than regular buses, which established the later operation of the trolleybuses. After 1985, two busy bus routes remained as trolleybus "preparing" bus routes in SZKV operation.

The second decade of operation: stagnation and decay

The fall of Communism in the East-European countries was a significant change of economical environment in Hungary. Important industrial areas, plants were ceasing their operation, the people's living became more insecure, on the other hand there was a great increase in car traffic in all cities. The momentum of the previous era carried the transport companies in the first half of the 90s, however by 2000 the electric public transport in Szeged was facing a great depression.

In 1990 the former state owned Szeged Transport Company (SZKV) became municipality owned company, and was converted into limited company in 1994 (since it is abbreviated SZKT). In 1991-94 the reconstruction of the trolleybus fleet could go on by purchasing 11 Skoda 15Tr and a single 14Tr vehicle, and 6 further Ikarus-280T vehicles. In the second half of the decade there was a major reduction of trolleybus traffic. In 1995 routes 6 and 7 were closed as well as route 5/A in 1996. Further shrinking of SZKT was due to the end of the bus operation, that was handed over to the state owned Tisza Volán in 1998. Because of the state of the infrastructure and the fleet it was seriously considered after 2000 closing down a great chunk of the tram network and the full trolleybus network. Tisza Volán was also willing to take over the full public transport, by posing CNG gas-buses as the alternative for trolleybuses and trams. The general condition of the vehicles was poor. The biggest management mistake was to create a private company which should have maintained the fleet. This company was not operating in normal market economy conditions from the very beginning.

The third decade: modernization and innovation

In 2003 Szeged Transport Company (SZKT) was on the verge of complete shutdown. Because of the huge deficit of both the transport company and the infrastructure company SZKT finally went bankrupt. At the time only 1/3 of the trams and trolleybuses could leave the depots and a new policy was introduced as well as a new Board of the company. Several programs were started with aim to put back the company in operation. The following years led to an unforeseen success, which made the company one of the best managed transport companies in Hungary by the end of the decade.

The SZKT took over the previously partly private infrastructure and maintenance company and sorted out its financial leaks and irregularities. Several revisions were also made and the disadvantageous contracts were renegotiated. Since 2004 the ticketing system in Szeged has became fully unified for the two companies: SZKT and Tisza Volán, however, although the bus company carries only approx 51% of passengers, due to contract it gets 2/3 of the ticket income. On the other hand, an important financial foundation merged to SZKT: the parking system in Szeged (called SZEPARK), which could greatly increase its incomes after the merge. After its restructuring although it is still burdened with loan paybacks, it became a steady income source for the company. The last support of the SZKT: the contract with the municipality still does not include a calculable income source for the SZKT, it is renegotiated once a year, unlike for the Tisza Volán, where after 2007 the municipality guarantees its income. A unique division was formed within SZKT in 2006, with overtaking Szeged Airport that is financed separately by the municipality.

Using this background the SZKT has made an effort to renew its trolleybus infrastructure. Until the end of 2009 many of the switches and crossings were replaced with high speed elements, in order to reduce the number of the derailments of the current collectors. In 2004 the former route 5/A was reopened in Bakay Nándor street reconstructed with double wirings, and this became route 7. Also with the reconstruction of Szent István tér, the overhead wiring was modernized on route 8. This area became dedicated roads for trolleybuses. In 2008 – already as a part of the EU Grand-project, the route 8 wiring is extended to the Anna kút junction (see at fig. 1).

The greatest effort in the trolleybus division was the reconstruction of the fleet. At the beginning of 2003 still old ZIU-9s and Ikarus-280T trolleybuses dominated in the fleet as well as newer Skoda 15Tr and second-hand 14Tr trolleybuses. In the tram division the situation was even worse because of the fleet and the infrastructure condition. Because of lack of a major investment program of fleet reconstruction, which should be created by the municipality, in 2004 SZKT was approved to get a bank loan of 4.6 million Eur for vehicle reconstruction. Those funds allowed to purchase and refurbish 14 second hand trams from Germany, refurbish 10 Skoda 15Tr vehicles (8 came second hand from Czech Republic), and acquire 8 low-floor trolleybuses. In this three years long process SZKT relied mainly on its own resources, which made possible to put 32 modern or relatively modern trams and trolleybuses in service. The trolleybus and tram refurbishment program continued later in self-finance. Since 2003 the following trolleybuses have entered service:

- eight second hand Skoda 15Tr trolleybuses have entered service after refurbishment (see at fig. 2).
- four Skoda 15Tr trolleybuses with new interiors and passenger information systems. Further two are in preparation, and one vehicle like that was refurbished in 2009 for Ustí nad Lábem in Czech Republic as an exterior work.
- Four Skoda 14Tr were refurbished (one as a learner car), two other were made and sold for Haskovo in Bulgaria.
- Four low-floor Skoda 21Tr were put in service after refurbishment. Two more are in preparations, which are reconstructed from similar Skoda 21AB diesel-buses (see at fig. 3).
- A Volvo 7000 low-floor diesel bus was converted into trolleybus in 2004.
- Five second-hand Evobus Citaro low-floor diesel buses was converted into trolleybuses with modern, asynchronous drive made by Cegelec. These became very popular among the passengers too, the sixth vehicle is in preparation (see at fig. 4).
- A Skoda 22Tr low-floor articulated trolleybus entered service in 2008. It was the first articulated low-floor trolleybus in Hungary.
- A new articulated trolleybus is being developed in cooperation with the Auto Rad Controlle company, it will enter service in 2010.

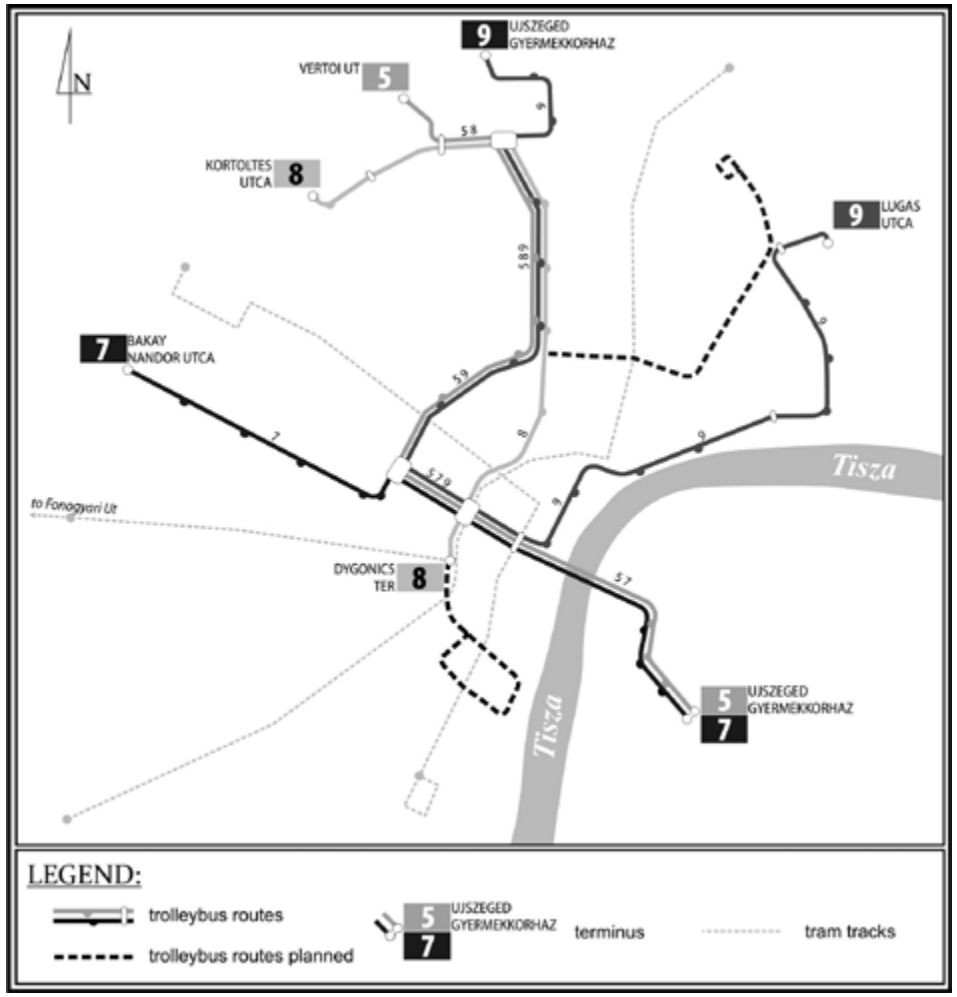

Fig. 1. Scheme of trolleybus routes in Szeged (at 2010)
Author: Maciej Beister

Fig. 2. Skoda 15Tr after refurbishment in Szeged
Author: Marcin Połom

Fig. 3. Skoda 21Tr at the terminus in the tramway depot in Szeged
Author: Marcin Połom

Fig. 4. Converted low floor trolleybus MB Citaro in Szeged
Author: Marcin Połom

It is unique, that a transport company makes an effort to produce new vehicles, however it is not unprecedented: such works were done in Budapest in the 1970s, and similar paths are being followed by Ostrava in Czech Republic and Gdynia and Lublin in Poland. The main advantage of this solution is financial flexibility: it leads to higher quality, brand new and modern low-floor vehicles in the fleet instead of refurbished, but still old-fashioned high-floor vehicles. The financing is much more spread in time and controlled (e.g. in case it is needed, it can be temporarily delayed), the labor can be reallocated from construction to maintenance if it is necessary, the deadlines are softer, making all easier to manage for a smaller company. It is also important, that the SZKT established cooperation with high-skilled industrial partners. Finally, every year something new can be presented to the passengers, which is a very important PR factor.

In present days (2009) the cities modal split is around 40%, and every year the total passenger number decreased on average by 1% in the last decade. The trolleybus division carried 23% of the public transport passengers in Szeged (26% was carried by trams, 51% by buses). In terms of daily capacity km of the public transport the trolleybus division made 19% (17% were made by trams, 64% by buses). The network length is 12 km, the route length is 21 km (counted only in one direction). There are four trolleybus routes, one of them served by replacement buses (route 8). There are 42 trolleybuses in the fleet, which carry 19 million passengers a year (see at tab. 1).

Tab. 1. Characteristic of trolleybus lines in Szeged

	Route 5	Route 7	Route 8	Route 9	Total
Running length	5400 m	4500 m	4100 m	7600 m	-
Average headway in peak hour	6 min.	12 min.	8 min.	4 min.	-
Running time	19 min.	15 min.	16 min.	26 min.	-
Courses	262/day	130/day	232/day	325/day	949/day
Daily passenger number	12,414	3540	9430	25,454	50,838
Daily capacitykm	104,432	40,956	85,838	357,210	588,436
Daily passangerkm	21,942	4979	18,979	57,356	103,256
Average journey length	1768 m	1407 m	2013 m	2253 m	2031 m

Source: author elaboration

The future: the "grand project" and development

Hungary became a member of the European Union in 2004 and it started major policy changes and great opportunities for creating modern public transport in our cities. In the budget term 2007-2014 not just regional funds, but also cohesion funds were available for Hungary. An important decision was creating the Transportation Operating Program (KÖZOP), which aims to reconstruct the transport infrastructure of Hungary. The program's 5th priority is the reconstruction of major cities' electric public transport systems, for which 2475 M Euro is allocated. A part of the program is the reconstruction of the electric public transport of Szeged in approx. 107 M Euro value, which is called locally "EU grand project". This program will be self-financed in 13,86%.

The preparatory studies for this program started in 2006, in which process each major public transport directions were considered for an improvement within the densely populated round-levee area. Finally, the following improvements were decided to be implemented:

- The reconstruction of approx. 80% of the tram lines (there were 30 years lacking of major infrastructure investment in the Szeged tram network), with a 1,6 km extension in the Northwest part of the Szeged city, replacing three major bus routes with a new tram route 2.
- Extension of the trolleybus routes in the city center (route 8) and in the Northwest part of the Szeged city – bus route 10 will be converted into a trolleybus route.
- Reconstruction of the Inner city bridge's Újszeged end junction, forming priority lanes for public transport vehicles, including trolleybus routes 5 and 7.
- Reconstruction of the tram depot.
- Construction of a new maintenance hall at the trolleybus depot and reconstructing the washing facility.
- Reconstruction of the power supply grid, with building 8 new substations.

Fig. 5. New type of articulated low floor trolleybus ARC trolleybus assembled at the depot in Szeged
Author: Marcin Połom

- Purchasing 9 new low-floor trams and 10 new articulated low-floor trolleybuses (see at fig. 5).
- Introducing a new dispatching and passenger information system.

Around 15% of the financial resources will be allocated for improving the trolleybus division. The reasons for investing in the trolleybus system were:

1. In 2006 trolleybus route 8 was converted to a diesel-bus one during the reconstruction of the Anna-kút junction, and the route was extended along the small boulevard with two stops to Dugonics tér. This changed the passenger traffic – almost tripling the number of passengers on this route: the original 12-15 minutes headway will be reduced to 6 minutes, with much higher attendance. The decision was made to convert back route 8 to a trolleybus route, with further extension of the route to Aradi vértanúk tere and the hospitals and universities in this area. This extension will have been ready by March 2010, the trolleybuses will have been using the common bus-tram lane at the small boulevard, which was built in 2004.

2. The busiest bus route operated by Tisz Volán is route 10, which partially goes parallel to the existing and extended route 8 at the small boulevard. This route goes through the center of a new housing estate in Tarján, and it is expected that the number of passengers on this route will increase when it will be operated by trolleybuses. The new route should be opened by the end of 2010.

3. The new extensions will require more vehicles, which is the reason for purchasing 10 new, low-floor articulated trolleybuses. Due to problems with the tender, the new vehicles should arrive during the period of 2011-12, in the meantime the SZKT will provide reconstructed trolleybuses or will put diesel buses in service too.

4. A major problem in Szeged public transport is the lack of bridges over the Tisza. Public transport routes use mainly the Inner city bridge. Since it leads to the city center, alomst all Újszeged routes cross here, buses and trolleybuses as well. In the peak hours the capacity of the bridge is limited by the traffic lights in the inner city, which causes 10-15 minutes delays before 8.00 am in the morning. In order to give the priority to the public transport vehicles, a new bus-lane system will be constructed in the Újszeged. The traffic lights will allow to cross the bridge only as many vehicles as can go through it without causing the traffic on it. The bus and trolleybus routes will have a priority lane in the length of 300-800 m (depending on the direction), which makes possible to overtake the cars and cross the bridge faster. The reconstruction will affect also the overhead wires of the trolleybus in a short section near the bridge, since a new bus stop will be built in the middle of the road. This reconstruction will be done in 2011.

5. One of the recurring problems of the existing Szeged electric network is the lack of power supply. In 2008 four substations operated: three small ones solely for one section of trolleybuses, and an old central hub (Zrínyi utca), which is responsible for the whole tram network as well as for more than a half of the trolleybus routes. In order to increase the electric security of the network, the reconstruction of these existing substations were decided to take place, with further six substation's construction. The central hub will remain, but it will feed only the inner city. The rest of the nine sub-stations will form a ring structure around the center, each of them will supply two sections either for trolleybuses (Rózsa utca, Felső-Tisza part, Szilléri sugárút, Csanádi utca), or for trams (Petőfi sugárút, József Attila sugárút), of for both trolleybuses and trams (Csáky utca trolley depot, Pulz utca tram depot). Each substation will have the capability to cross feed within, or can feed the neighboring section with the help of remote controlled switches. In the future, in case the central substation switches down, nine substations will be able to replace it. Currently one substation is ready (Rózsa utca), two are still under construction, and the rest should be ready by the end of 2010.

6. Enlarging the trolleybus fleet has led to the requirement of a further closed maintenance space on the trolleybus depot, and the reconstruction of the over aged washing facility. This was finished in 2009, when a new 2000 m^2 maintenance hall was built. It was opened during the trolleybuses' 30th anniversary celebration.

7. In 2008 the SZKT used only a short-wave radio as a tool for a dispatching, and cameras at the terminus of the trolleybuses. However, the dispatcher had no real-time information on the location of the vehicles in the city. In order to keep to the timetables and give the passengers real-time information, a new dispatching system will be installed. All the SZKT vehicles will be fitted with a GPS antenna and a GPRS connection. A selected number of trolleybuses which stop and the reconstructed tram stops will have an optical cable ending that will make possible to communicate with electronic displayers that will provide information to passengers. The traffic lights will be also affected by remote control.

Apart from the "grand project", there are smaller scale investments funded from the South Great Plane Regional Operational Program (DAOP). This region in 2002 was one of the poorest: the 242nd from 254 regions in terms of GDP/person. This program's 3rd priority is to improve the traffic infrastructure in the region, with 186 M Euros allocated for this purpose. There are already two projects financed from DAOP in Szeged, both are reconstructions of bus and trolleybus terminus? Makkosház and Tarján. In Makkosház with the new terminus also the overhead infrastructure of the trolleybus route 9 will be modernized. At five other stops the pavement and the road surface was strengthened and reconstructed.

Further projects are foreseen for the DAOP financial background: the most important is a new bus lane in the center of the Grand-boulevard. Once the international traffic to Romania is moving out of the city in the end of 2010, the municipality wants to dedicate two lanes for the bus and trolleybus traffic in the middle of this boulevard. The buses and trolleybuses will have a separate lane from Kálvária sugárút to the Bertalan bridge. However, this project is still in the planning stage. There are also other bus lanes under consideration at the time in Szeged, that also could affect the trolleybus traffic (e.g. on the Small boulevard, where there is no common tram-bus lane).

To sum up, Szeged is the most successful city in terms of using the EU-funds to improve its public transport infrastructure in Hungary. Such programs are being run in Budapest, Debrecen and Miskolc. However, only Szeged was able to step into an implementation stage. The "grand project" was approved by the Hungarian government in 2007, and by the EU-commission in 2008. The JASPERS – consulting body of the EU has stated that the Szeged "grand-project" is one of the best prepared projects in the EU, and it is recommended to be shown as an example.

There are plans to improve the trolleybus system of Szeged in the further future. All areas which can be served by the tram system are already served by trams. The only one direction in which the tram system could be extended is to the neighboring towns of Hódmezővásárhely and Makó. However, there are still areas where trolleybuses could provide service and replace buses, e.g. in Újszeged or at the Grand-Boulevard. There are some new commercial areas, which are considered to be served with smaller scale extensions: e.g. route 5 and 7 in Újszeged or route 7 to a proposed interurban transit hub called "bus-port". A major importance would be a third bridge within Szeged which is proposed to close the grand-boulevard ring on the south side that could create an opportunity to make a full circle of a trolleybus route.

With the aging of the vehicles also the reconstruction of the existing fleet is under consideration at the time by the SZKT. The SZKT is planning to get rid of the old high-floor Skoda 14Tr trolleybuses and replace them with Skoda 21Tr vehicles. A similar plan for reconstructing the fleet of articulated vehicles hasn't been made yet, but the old Skoda 15Tr trolleybuses will soon need to be replaced with some new vehicles. Nowadays introducing battery charged duo-buses, which partly could run under wire, partly away from the overhead is being taken under consideration too . Such solo cars could be introduced in the outskirts with low-density residential areas, and could replace those bus routes, which currently run parallel to the trolleybus network.

Fig. 6. Old type – historical trolleybus Ikarus in the trolleybus depot in Szeged during reconstruction works. It could be very good "visit card" of city Szeged
Author: Marcin Połom

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Miroslav Klas, Jiří Kohout

Plzeň – the city of modern and ecology public transport

Introduction

Pilzno is situated 90 km North of Prague and it is the largest city of the western part of Czech Republic. It was founded in 1295 in a valley of four rivers. In 1869 Emil Škoda established one of the largest factory of military equipment in Europe. His company producted steam and electric locomotives too. During the Interwar Period the factory begun production of trolleybuses and trams. After World War II the production of trams was suspended and trolleybuses were manufactured in a new plant in Ostrov on the Ohří river. In 1990's the largest employer in Pilzno had to face economic and social transformations. A redundancy plan was implemented and the factory started manufacturing trams again. At first, they were made as a reconstruction of T3 vehicles. Then, since 1997 Škoda has produced low-floor Astra trams of its own construction. In 2004 the plant in Ostrov on the Ohří river was closed down. Since then also trolleybuses have been manufactured in Pilzno.

Trams

In 1899 a new era in the urban transportation sector in Pilzno begun when Františka Křižíka constructed the first tram system. His company, which was located in Prague, delivered 20 trams with Brožík bodies. The system was opened on 29th June 1899.

Three tram lines were opened simoultaneously: Bory – Lochotín, Skvrňany – Slovany i Náměstí – Plynárna (gas-works). Those radial lines, numbered 1, 2 and 4 (now slightly extended) are the backbone of the urban transportation system of Pilzno. The present tram fleet comprises 122 vehicles, mostly T3 and KT8D5 trams and some low-floor ASTRA trams, bearing the Škoda badge. A great number of old T3 trams have been modernized, including fitting them with thyristor drive. Some of vehicles has been fitted with new, partially low-floor Vario chassises.

The newest section of the tram network was opened in 1990. The extension of the line from Bory loop to Západočeská univerzity (1,5 km in length) has being prepared for the last 15 years. The construction of this line will be started in 2011 if it is partially funded by the World Bank. A plan has been put forward to construct a new tram renewal plant. The existing one, in Cukrovarské Street, isn't spatial enough and it isn't connected with the tram network, so trams have to be towed when they need any fixing.

Buses

The first bus route from the city centre to the main cementary (Ústřední hřbitov) was opened in 1929. There are two important bus lines in Pilzno at present: line 30 and line 41, which connects the Vilnice housing estate with the Borská pole industrial district.

The bus fleet comprises a few older B731 and B 732 buses, low-floor Solaris Urbino 15 and Solaris Urbino 18 buses and Renault Citybus (Irisbus Citelis) vehicles. This year Škoda 21 Ab buses will be withdrawn. They have been constructed on the basis of Škoda 21 Tr trolleybus.

History of the trolleybus system

The first conception of converting the main bus lines to trolleybus lines emerged in 1937. A project was presented in 1939 and on 9th April 1941 the first six three-axle Škoda 3 Tr trolleybuses started operating on line A: Městské lázne – Doubravka – Hebrmannovo máměstí.

On 1st May 1941 line H was opened from Městské lázne to Ústřední hřbitov. For the first two years a temporary technical base was located at Městské lázne loop until 1943, when the construction of Slovany depot was finished. On the route from Slovany depot to Městské lázne loop trolleybuses operated under the tram traction network, which was additionaly fitted with one polarized wire. It was placed between two tram lines. This temporary solution was used until 1949, when redevelopment of a former tram depot in Cukrovarské Street was finished.

After World War II a plan was approved to develop the trolleybus system in the city. In a short time two trolleybus lines were opened: Božkov – Skvrňany (1948) and Dulevice – Bolevec (1949). The tram line from Doublevce to Lochotín was closed in 1949. In 1950 an extension of the bolevicka route to the Košutka housing estate was finished. In 1953 the route from Doudlevców to Černic was extended. In 1955 the route from Skvrňan to Nowa Hospoda.

Shortage of traction wire was the reason why a tram line to Bíla Hora wasn't constructed. However, in 1943 a manipulative route from Městské lázne, along Anglické nábřeží to the depot in Cukrovarská Street was constructed, although it hadn't been planned before. From 1948 excellent Kumler & Matter traction network equipment was used so the system of Pilzno, as well as the system of Zlín, were considered the most modern trolleybus systems in Czechoslovakia. The

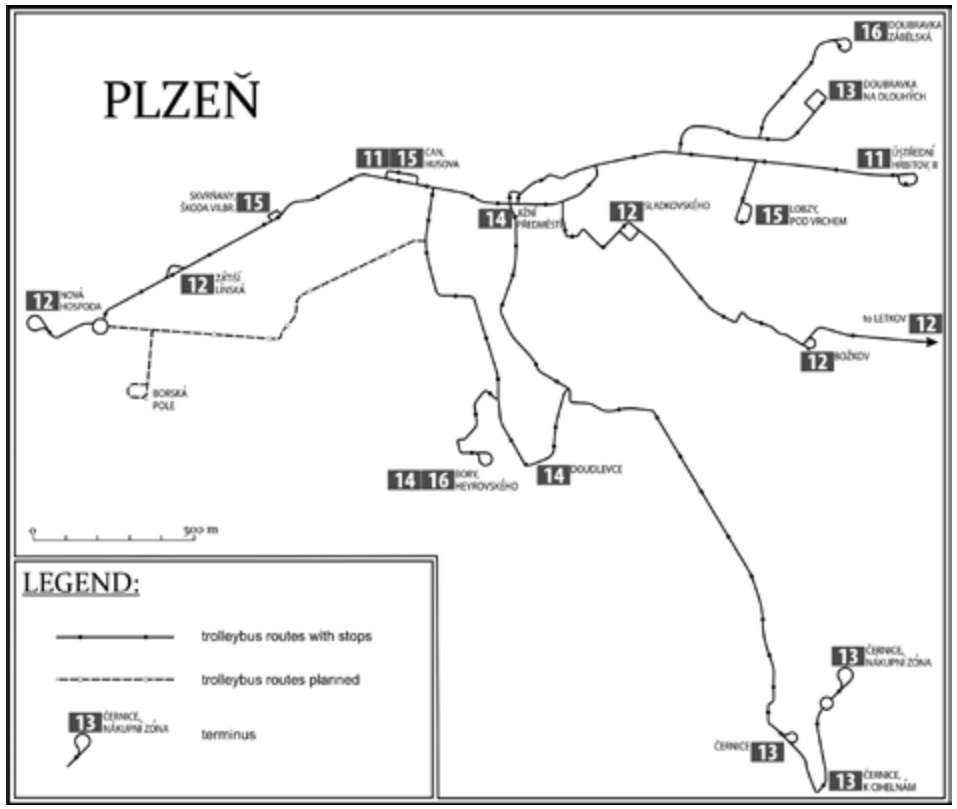

Fig. 1. Scheme of trolleybus routes in Plzeň
Author: Maciej Beister

system was developed once again in 1975, when the Pietas – Lobzy section and line 15 from Městské lázne to Lobzy were opened. One year later a short extension of the line from Habvmannovo náměstí to the loop in Zábělská Street was opened. All routes to the Košutka housing estate were closed the same year and one year later the line to the Bolevce housing estate was closed too, because a new Severní předměstí housing estate was built with a completely new transportation system. When those lines were closed, trolleybuses disappeared from the historical Náměstí Republiky. A/The former central Městské lázne loop was closed too in 1977. From that time on the Hamburk loop in Nádražní Street has become the main loop. At the beginning of 1988 trolleybus line 16 was opened and in time it has become the most overloaded line of the system. Sections of traction Bory, Heyrovskegho-Tylova str. had to be reopened again.

From 1986 to 1992 trollyebuses weren't operating on line 11 because of reconstruction Rokycanske str. and this line was eventually converted into a bus line. In 1998 a short passage was constructed, which provides an additional access to the trolleybus depot while Prokopovy Street is being reconstructed.

The last significant change in the trolleybus network took place in 2002, when the loop was shifted from the Husova náměstí to the bus station. In November 2009 the first stage of optimization of the Pilzno's urban transportation began. The main trollyebus line (line 16) started to operate at weekends, with a frequency of 7,5 minutes and the loop of line 13 was shifted from Lobzy to the Doubravka housing estate. Line 10 was closed and line 15 from Lobzy to the bus station took its place. Further changes will be introduced during the second stage of optimization of the Pilzno's urban transportation in 2010. Anew trolleybus route to the Borská Pole will be opened that year (see at fig. 1).

The fleet

The first six trolleybuses, which were operating during the early days of the system were carrying Škoda badges. They were 3Tr1 vehicles with two traction motors (45 kW), 30 seats and room for 50 standing passengers. Two years later four 3Tr2 trolleybuses joined the fleet. During the bombing of Pilzno which took place at the beginning of 1945, some of vehicles were seriously damaged. The oldest models were in service from 1967 to 1970.

Twenty-four Brand new 3Tr3 vehicles were delivered in 1948. One year later a prototype of two-axle 6Tr trolleybus was introduced. It was powered by one DC motor (96 kW). It was withdrawn after service in 1971 and handed over to the

Fig. 2. Trolleybus network is operated along with the trams
Author: Mikołaj Bartłomiejczyk

Fig. 3. Two of old type trolleybus Skoda 14Tr at the terminus
Author: Mikołaj Bartłomiejczyk

Technical Museum in Brno. Twenty-six 7Tr trolleybuses were delivered during the period of 1952-1956. From 1957 to 1959 twenty-eight 8Tr trolleybuses joined the fleet. In 1960 a prototype of the first Czechoslovakian 9Tr trolleybus was brought into use. They were consecutively delivered for the next 20 years in total number of 151. Apart from that, some other prototypes were tested in Plzeň – the first prototype fitted with the thyristor-pulse control system appliances. The last vehicles of that series were withdrawn after service in 1994.

During the period of 1966-1970 four experimental T11 trolleybuses were delivered to Pilzno. They were unified with Karosa ŠM11 buses. One of those trolleybuses can be seen in Technical Museum in Brno. In 1981 deliveries of 14Tr trolleybuses began and by 1991 116 vehicles of that series had been delivered (see at fig. 2 and 3).

They have being refurbished/have been consequently refurbished since 1997. From 1987 to 1996 nineteen 15Tr trolleybuses were delivered. They were articulated version of 14Tr vehicles. During the ceremony of 100th anniversary of the urban transportation in Pilzno a prototype of low-floor 21TrACI trolleybus was presented to public. It was fitted with the Kirsch 45 kW aggregate. Eighteen trolleybuses of that type were delivered to Pilzno from 2001 to 2004 (see at fig. 4).

Since 2004 only Škoda 24Tr trolleybuses with IRISBUS bodies (IRISBUS Citelis bodies from 2006) have been acquainted (see at fig. 5). The first batch of

Fig. 4. Low floor trolleybus Skoda 21Tr which is fitted with the diesel aggregate is operated as dual-mode vehicle
Author: Mikołaj Bartłomiejczyk

Škoda 25Tr citelis trolleybuses was delivered in 2009. Škoda 24Tr and Škoda 25Tr vehicles are equipped with the Kirsch 100kW aggregates. Dual-mode trolleybuses operate when roads are repaired, partially closed or in case of an overhead failure. Single routes of line 12 and line 13 (the routes, which were extended to Letkov and the Olympia shopping centre in Cernice) are operated by dual-mode vehicles too.

Infrastructure

At the end of 2009 the DPMP, a company which operates the services in Pilzno, owned 97 trolleybuses. 47% of them were low-floor models. All both-ways routes of the trolleybus system were 29, 3 km long; one-way routes were 13,5 km long (loops, depot, manipulative routes). The system was powered by 5 traction substations. The traction network is elastic type, without static compensators. All points are steered via radio. Most traction poles is made of steel with a circular cross section. In the city centre for aesthetic reasons octagonal poles are used. All substations are remote-controlled from a power centre, which is located at Denisovo nábřeží. The central substation Hydro is located in the same building. The containers station EPOS is a new technical solution. It is located at the intersection of Domažlická and Vejprnická Streets, where tram and trolleybus systems meet. The station is equipped with a supercondensator container and a static converter, which allows conntrolled flow of energy between the two systems.

Fig. 5. Low floor trolleybus Skoda 24Tr in Plzeň
Author: Mikołaj Bartłomiejczyk

The future

In 1990's the system didn't received any government funds so its development rate decreased. The last important trolleybus line was opened in 1988 and all city's funds were allocated only for maintenance and modernization of already existing trolleybus system's infrastructure. The individual transportation boom in 1990's caused the necessity of development of the city's road system and almost all city's funds were allocated for that. A new street was opened at that time in the southern part of the city. It was called U Trati Street and it took over/intercepted the traffic from the historical city centre. This street was partly prepared for trolleybus operation, but overhead hasn't been installed yet. This route was to be an alternative route in case of a traction network failure in the city cetre.

Since 1970's it has been planned to reopen trolleybus routes to the Severní předměstí housing estate, which is now operated by trams. A plan has been put forward to construct two trolleybus lines: one from the city cetre via Náměstí Republiky, the Rooseveltův bridge and Roudnou to the Vinice housing estate. The second one will connect Roudná with Fakultní Nemocnice Lochotín (the hospital) and in the future it will be extended to the Bolevec housing estate. Some traction poles has been already put, but the opening date of those routes is not known yet. In case of the route to Vinic this plan is still under discussion whether this route should be operated by trolleybuses or not. There is a possibility that the route would be

operated by trams. In order to construct the route leading to the hospital, the road system should be redeveloped and this provokes a strong public outcry. Traction poles are located near the Švábiny shopping cetre too, where trolleybus line 11 would have been extended by approximately 300 m. This line terminates at the cementary at present.

The SPVD organization (Society of fans of public transport) wanted to support this project but the agreement between the Pilzno City Council and representatives of the shopping centre hasn't been signed eventually. The City Council had denied founding this investment because of its commercial character and the shopping centre board hadn't been interested in it. Finally, a non-revenue bus line has been opened. It has been funded entirely by the shopping centre board and it overlaps the trolleybus route in 95%. Nowadays, there is a chance of finding a solution to this stalemate, because work has started on construction of a new housing estate recently and a trolleybus line could operate on a route to it.

A new trolleybus line is being constructed at present from the Jižní předměstí via Borska Street to the Borská Pole industrial district. The first conception of this line emerged in the middle of 1990's, when the industrial district was being constructed. The Borská Pole housing estate is operated mainly by bus line 30 and line 41 along Borská Street.

Funds from the Regional Operational Programme for Jihozápad allowed to end the construction of the route including construction of a substation and missing traction poles. The entire route from the Jižní předměstí to Tesowy Street with a passage to the Nová Hospoda housing estate is 4 km long. The investment cost is 160 million crowns. The route will be finished in the first part of 2010 and it will be opened on 1st July 2010. In the future the trolleybus line to Borská pole will be also an access route to a new trolleybus depot, which will be located in Folmavská or Borska Street. The decision on the location of the depot will be made in 2010. Nowadays trolleybuses station at the historical complex in Cukrovarská Street and servicing is held in the building, where in 1899 the tram depot was located. However, in Cukrovarská Street buses station too and tram servicing is held. This depot isn't spatial enough and it should be closed down. According to the current city development plan for Pilzno the bus and trolleybus depot will be moved to Borská Pole and the Slovany tram depot will be redeveloped. However, this conception may change in the face of public protests.

Summary

The ecological trolleybus system has become a significant part of the urban public transport in Pilzno. Trolleybuses have met social approval and the existence of the Skoda factory in the city guarantees that the fleet will be of high standard.

In order to improve the economic effectiveness of the trolleybus system, it should be developed. It concerns the line to Borská pole and lines to the Severní Předměstí and Vinice housing estates. Electrification of bus line 30 should be also

taken under consideration, as its' route runs along the overhead wiring and only a short (2,5 km) section must be constructed to convert this line into a trolleybus one.

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Ladislav Podivín

A case study of Pardubice. One of the main trolleybus transport system in Czech Republic

History of the city

Pardubice is situated in the northern part of the Chech Republic on a fertile lowland near the mouths of Labe and Chrudimka Rivers. The city's seven hundredth history is very interesting. The city gathered momentum in XV and XVI centuries during the reign of the sovereigns from Pernštejna, who left behind gorgeous architecture, supported development of trades, built a great number of hydrotechnical objects and fish ponds.

In 1560 Pardubice became the Chech sovereigns' possession. During the Thirty Years' Was the city was almost completely destroyed by the Swedish army. It took the city lots of time to regain its strength and position after this fall and for some time it was in the shadow of neighboring cities – Chrudim and Hradec Králove. In 1845 the railway was opened, connecting Prague with Vienna. In time more and more railways were being opened thus Pardubice became an important rail hub. The city's importance started to increase. Some factories and plants were opened, too. Pardubice also became famous for some sports achievements. The city is a centre of chemical, engineering, electrotechnical and food industries. Pardubice are well known all over the world not only for producing gingerbread, computers, radars and explosives, but also for horse and motocross races. The city has also tennis, hockey and basketball traditions.

The railway station, as well as the first factories were located near the city centre, so at the turn of the 19th and 20th centuries there weren't any determinants of creating an urban transport system in the city. Despite this, a project has emerged to electrify the local North-South railway link, which construction would start in 1903. In the same year an engineering company Křižík from Praque presented the first non-rails vehicle which could be connected to the local energetic network (440V) via two trolley poles – it was a prototype of a trolleybus. But the members

of an emerging transport company were divided into two groups: those who were in favor of using classical technology and those who were in favor of trolleybuses. However, there was a large and powerful refinery in Pardubice at that time and it caused that the conception of introducing electric urban transport system was withdrawn. Electric traction wasn't introduced even after opening a heat and power station by Křižík. Its power exceeded local needs for electric energy. In 1906 a project to build a tram line from the railway station through the city centre to the city of Sezenice was created by Křižík, but it wasn't introduced either. Despite those initial problems, Pardubice eventually gained an urban transport system. In 1908 two state mail bus lines in the Vltava part of the Austro-Hungarian Monarchy were opened. Those routes ran from Pardubice to Lázně Bogdaneč and Holice.

Fig. 1. Construction of the first trolleybus line to Lázně Bohdaneč
Source: author collection

The early years of Pardubice's trolleybuses

The first conception of introducing trolleybuses to Pardubice emerged in 1940's and after nine years of discussion in 1949 a technical-economic analysis was created. On the basis of this analysis the first lines were constructed. The first line was opened on 20th January 1952. It led from the railway station through the city centre to the Synthesia chemical plant in Semitin and further to the health-resort in Lázně Bogdaneč (see at fig. 1).

This route was fed by two 600V traction substations (MR1 and MR2), which were fitted with mercury arc rectifiers. Both substations were fed from 6kV network.

The first line was served by 6 Škoda 7 Tr1 trolleybuses. They were two axle vehicles 10,2 m in length. They were fitted with one 96 kW traction motor with speed of 1700 r/min. In summer of 1952 an interurban line Jesničánky – the railway station – the city centre – the hospital with a branch to the Dukla depot was practically ready to enter service, but due to lack of sufficient number of trolleybuses it was opened in June 1953. In April 1954 a line to Slovany was opened.

In 1955 the public transport company had 20 trolleybuses: seventeen 7 Tr 1 trolleybuses and three 7 Tr 4 trolleybuses. 12 vehicles had been bought brand new and 8 second hand (6 vehicles from Ostrawa and 2 from Teplice/Most). All routes were approximately 19 km long. There were three routes at that time. There were also 6 buses and 10 trailers in the fleet. 10 million passengers were carried during 1955.

In 1956 four prewar Tatra T86 trolleybuses were purchased from Prague. They were withdrawn in two years time because of their failure frequency. In January 1958 the third substation (MR3) was opened near the city centre. It was fitted with two mercury rectifiers (3 x 1200 A each). The substations was fed from 35 kV network.

During the following nine years the following sections of the traction network were opened and closed:

1958 – the section near the old railway station was closed (-1,4 km)
1959 – the section from the city centre to the new railway station was opened (+1,1 km)
1960 – the section which ran across the old bridge was closed (-1,7 km)
1960 – the section which ran across the new bridge was opened (+2,0 km)
1961 – the section to the hospital was closed (-0,3 km)
1961 – a one-one way route along Ke Kamenci Street was opened (+0,4 km)
1964 – a new line to Ohrazenic was opened (+1,1 km)
1965 – a new line to Židova was opened (+1,3 km)
1965 – a new line to the Dukla housing estate was opened (+0,7 km)
1967 – a new line to Ohrazenice was opened (-1,1 km)

The length of the whole network was 23 km in 1967.

Fig. 2. Opening of the first line in 1952
Source: author collection

In 1965 there were 6 trolleybus lines and 6 bus line in Pardubice. The fleet comprised 48 two axle Škoda 7Tr trolleybuses (16 vehicles, see at fig. 3), Škoda 8Tr trolleybuses (14 vehicles, see at fig. 4) and Škoda 9Tr trolleybuses (18 vehicles, see at fig. 5). There were also 29 buses and 6 trailers. The trailers didn't operate on trolleybus routes at that time.

Stagnation time

At the end of 1967 one of the trolleybus lines was closed and a long-lasting stagnation period started. There was even a project to close the whole trolleybus system in Pardubice. It was caused by easy access to cheap Russian oil and buses gained an advantage over trolleybuses. Is some towns trolleybus abandonment programmes were implemented.

The trolleybus substations were reconstructed and their power was enlarged at that time. Substation MR 2 gained power of 2x1500 A and substation MR 3 gained power of 3x1500 A. They were also fitted with silicon rectifiers. The overhead was extender too. The small substation MR 2 was closed down. Unfortunately, technical condition of the traction network was rather poor and at the beginning of 1980's lots of failures occurred.

After 1973 the fleet comprised forty-eight 9 Tr trolleybuses with resistor steering.

Fig. 3. A Škoda 7 Tr trolleybus in the city centre in 1964 (in Míru str.)
Source: author collection

Fig. 4. A Škoda 8 Tr trolleybus as a vehicle for kindergarten kids in 1962
Source: author collection

Fig. 5. The first delivered Škoda 9 Tr at the Jesičánky loop in 1963
Source: author collection

Bringing Back the trolleybuses

Thanks to the 1970's oil crisis trolleybuses started to be supported by the state again. Lots of cities considered bringing back trolleybus systems. The existing trolleybus networks were going to be extended but this was only formal support rather than practical help. Trolleybus systems was eventually reopened only in Ústí on Labe (1988), where trolleybuses replaced trams, in Ceske Budejovice (1991), where trolleybuses were in operation during the periods of 1909 – 1914 and 1948 – 1971. A brand new trolleybus system was opened only in Chomutov – Jirkov agglomeration, where initially had been a plan to introduce a tram system. Trolleybuses have never come back to Praque (system closed down in 1972), Děčín (system closed down in 1973), Most and Litvínov (systems closed down in 1959). At the end of 1970's constructions of a new trolleybus line to the Polabiny housing estate and a substation MR7 at the Dukla depot started in Pardubice. Both investments weren't accomplished because of lack of funds and material resources.

In the period of 1979-1981 the last batch of Škoda 9 Tr trolleybuses with thyristor aparatus was purchased. In 1980's modernization of the traction network finally began. Modernized sections of the traction network were fitted with an elastic suspension, arc tracks, Kummler & Matter points and junctions (manufactured by the Elektrovod Kremnica factory in Slovakia). Škoda 14 Tr trolleybuses were gradually replacing old Škoda 9 Tr vehicles (see at fig. 6 and 7).

Paradoxically two unexpected events had a positive impast on development of the trolleybus system of Pardubice at that time: damage of so called „new bridge",

Fig. 6. Škoda 9 Tr trolleybuses at the depot in 1995
Source: author collection

which was built in 1960 and an explosion at the chemical plant. The region was donated by the government and some of those funds were allocated for the trolleybus infrastructure. At first, in 1984 substation MR7 was finished (specifications: 1 x 1500 A, 35 kV). In 1986 a trolleybus line to the Polabiny housing estate (1,3 km) was finished, which initially was a diversion during the reconstruction of Hradecka Street. In 1987 the second line was opened from the railway station to Polabiny through the narrow steel bridge built in 1882 (about 2,1 km), which was a diversion during the reconstruction of the "labský" bridge. Both abovementioned lines had one disadvantage – they had been built before substation MR5 was constructed. After the reconstruction of the "labský" bridge only two round trolleybus lines used the modernized network during peak hours. Eventually, those lines were closed too and trolleybuses weren't operating on the new routes for a few years. After many years of planning and assessing, finally in 1990 substation MR 5 in Polabiny was opened. The problem of feeding the trolleybus lines from the station through Polabiany to the chemical plant was eventually solved. Bus line 11 and partially bus line 4 were converted to trolleybus lines. Works on reconstructing and modernizing the trolleybus lines and substations MR 2 and MR3 were continued in 1990's. Admittedly both substations were fitted with silicon rectifiers, but the rest of equipment dated from 1950's. Thanks to that the trolleybus line from Pardubice to the UMA factory could work reliably and trolleybuses could carry workers to the chemical

Fig. 7. Two of Škoda 14 Tr trolleybus in service in 2006
Source: Mikolaj Bartłomiejczyk

plant. Unfortunately, the number of employees who worked in the plant started to decrease rapidly and new trolleybus lines weren't needed. In 1992 a short extension (0,3 km) of trolleybus line 4 was opened, leading to the Polabiny Sluneční terminus. In 1996 line 2 was extended to Polabiny.

The period of creating new lines

In 1990's there was a discussion on the future of the trolleybus operation in the city centre along Míru str., where a pedestrian area was planned to be created. Cost of moving the traction network in the city centre was very high, thus the trolleybus abandonment conception was again taken into consideration, but eventually it was rejected and in 2000 a new parallel route was opened from the ice rink to the theatre along Sukově str. (approx. 0,5 km).

However, because of the need to economize the necessary wiring wasn't built, so only line 11 runs along Sukova str. and all remaining lines still run along Míru str. In summer of 2000 a new substation MR 4 was opened in Na Drážce Street. It was fitted with the SMr-35 compact carrying unit (specifications: 1x1500 A, 35kV), which was used during the reconstruction of substation MR 3 in 1997. This substation was built to support feeding of the existing trolleybus lines which run near the Chrudimka River. It also made it possible to build a new line to the Dubin housing estate in 2002. This line aroused public interest and it had many political

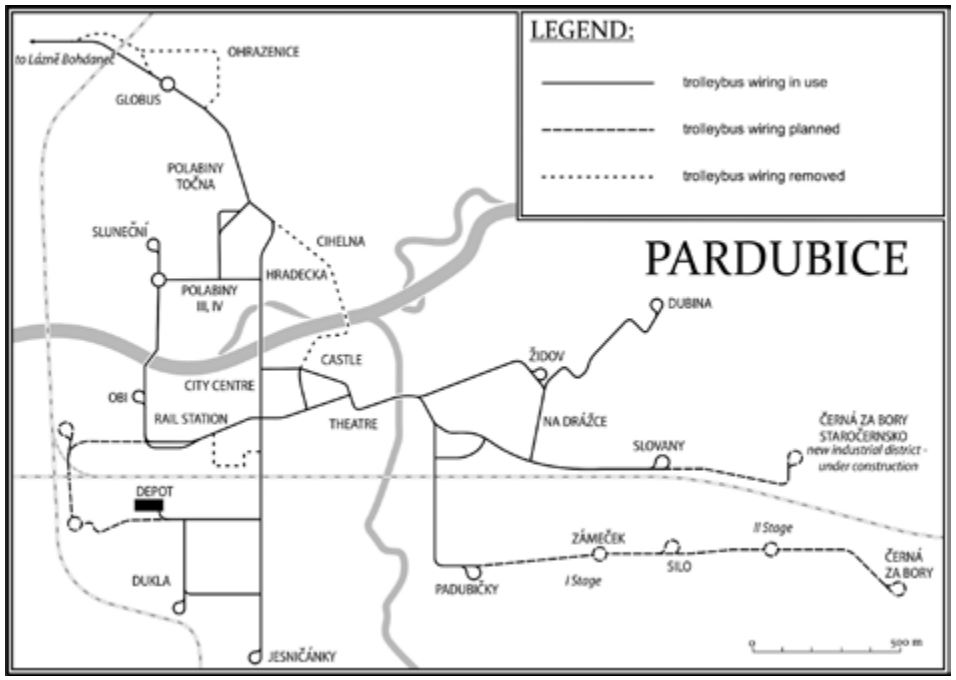

Fig. 8. The scheme of trolleybus network in Pardubice
Author: Maciej Beister

opponents. After its opening it was possible to convert bus line 13 to a trolleybus line. Line 5 was extended to this housing estate to, improving communication services in this part of the city. In the autumn of 2002 another new trolleybus line was opened (0,9 km long). It connected the Dukla housing estate and Skřivánky. This line didn't arouse any public interest (see at fig. 8).

Actual state of the trolleybus system – the traction network

All trolleybus routes in Pardubice are 30,2 km long (measured along the axles of the routes, see at fig. 9). The traction network is fitted with elastic suspension where possible with one, two or three fixing points. The whole network comprises 55 electric points, 9 of them are situated in the depot. 39 electric points are so called fastdrivable, so it is possible to drive over them with the speed of 40 km/h (see at fig. 10). 48 points are fitted with the Elektroline radio steered system.

The last electric steered points are in the depot. New or modernized points are equipped with 24 V motors. Nowadays the main plan connected with the modernization of the network is to introduce an automatic system of route planning for trolleybuses, which works in cooperation with trolleybus on-board-computers. It hasn't been decided which system will be introduced yet. The network comprises 57 mechanic switches. 11 of them are at the depot. 34 of them are so called fastdriveable. There are 50 trolleybus junctions. The network comprises 67 section

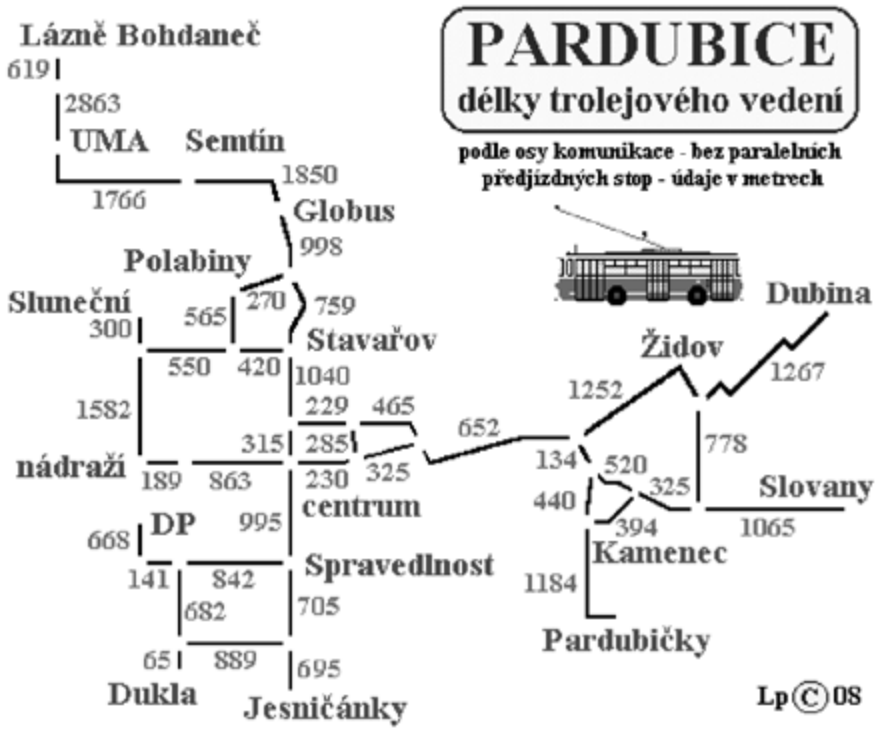

Fig. 9. Lengths of the particular sections of the trolleybus system
Author: Ladislav Podivín

insulators and 6 of them are fitted with diodes and they can be driven through with electric current. Some borders of feeding sections are framed directly in junctions or switches. Cooper trolleybus wire has a cross sections of 100mm^2. The traction network is suspended on steel or concrete poles. In the inner city lots of crosspieces are attached to the front walls of the buildings. Old silencers with rubber inserts are replaced with some new materials. The most effective are two metres long inserts made of parafil. The crosspieces are made of steel lines (zinced and stainless) or paraffin. There are still many cantilevers in use and some older ones are made of steel. The new ones are plastic.

Older insulators are made of porcelain, newer ones are made of glass, laminate, parafil, minoroc or plastic. The traction network is suspended 5,5 m above the road. Only under bridges and in depot halls it is suspended lower. The lower place is a passage under the flyover in 17th of November Street, where the traction network is suspended only 3,8 metres above the road.

With regard to Pardubice geographic location no measures are taken in order to prevent hoarfrosting during the winter season. However, it doesn't mean that it won't be needed in the future.

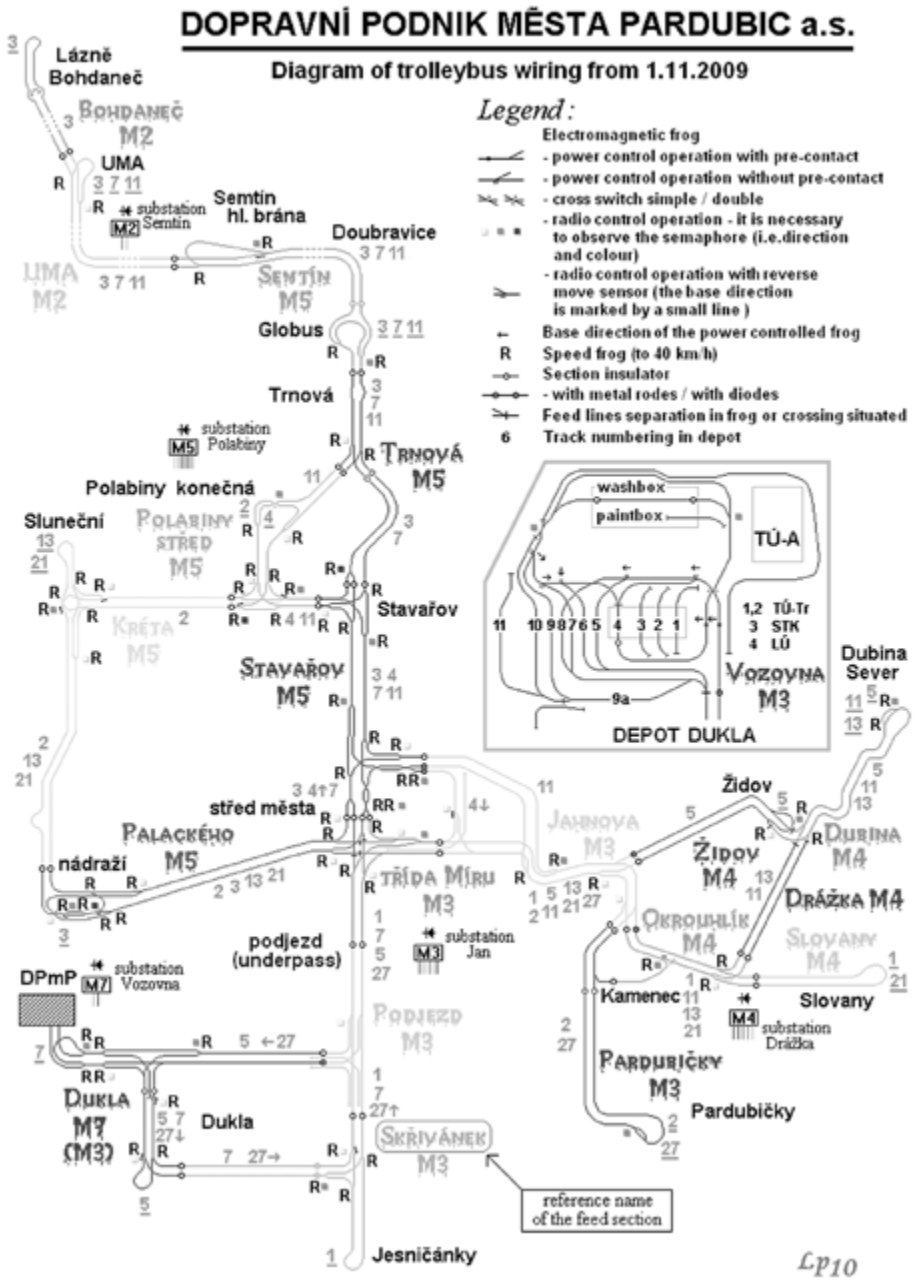

Fig. 10. The scheme of trolleybus network in Pardubice
Author: Ladislav Podivín

Substations and feeding wires

The traction network is fed by five substations with a power of 16500 A. The table 1 shows historical collation of all substations (see at fig. 11):

Tab. 1. List of substations in Pardubice

Substation, name	Used from	Used to	Power output	Sections / Power supply points	Transformers	Remarks
MR1 Stadion	1952	1972	In the future this substation will be reintroduce			
MR2 Semtín	1952	Still in use	2 x 1500 A	2 / 2	2 dry 1100 kVA	ČKD, Siemens and ADtranz equipment
MR3 Jan	1958	Still in use	2 x 2250 A	6 / 6	2 dry 1650 kVA	
MR4 Drážka	2000	Still in use	1 x 1500 A	5 / 5	1 dry 1100 kVA	SMR-35
MR5 Polabiny	1990	Still in use	2 x 3000 A	6 / 12	2 oil 2200 kVA	Remote steering centre
MR6 Zámeček	A planned small substation for the route between Černé za Boryia to Staročernska					
MR7 Vozovna	1984	Still in use	1 x 1500 A	2 / 2	1 oil 1100 kVA	Probationary use of the ČKD thyristor apparatus until 1985.
MR8 Trojice	A small substation for a new line Dukla – Nádraží.					

Source: author elaboration

Substation MR2 is fed from the 6kV system, the rest of substations are fed from the 35 kV system. Total length of 660V feeding wires is 93 km (single-wire cable). Only aluminium wires with a cross sections of 500 mm^2 are used. Those wires are put in pairs in wire routes with total length of 16,2 km. There are 21 power supply sections and 27 power supply points.

There are five dry and three oil transformers in the substations. Medium voltage disconnect switches with the sulfur hexafluoride are used. The traction network power supply system is isolated, thus the substations are equipped with short circuit detectors.

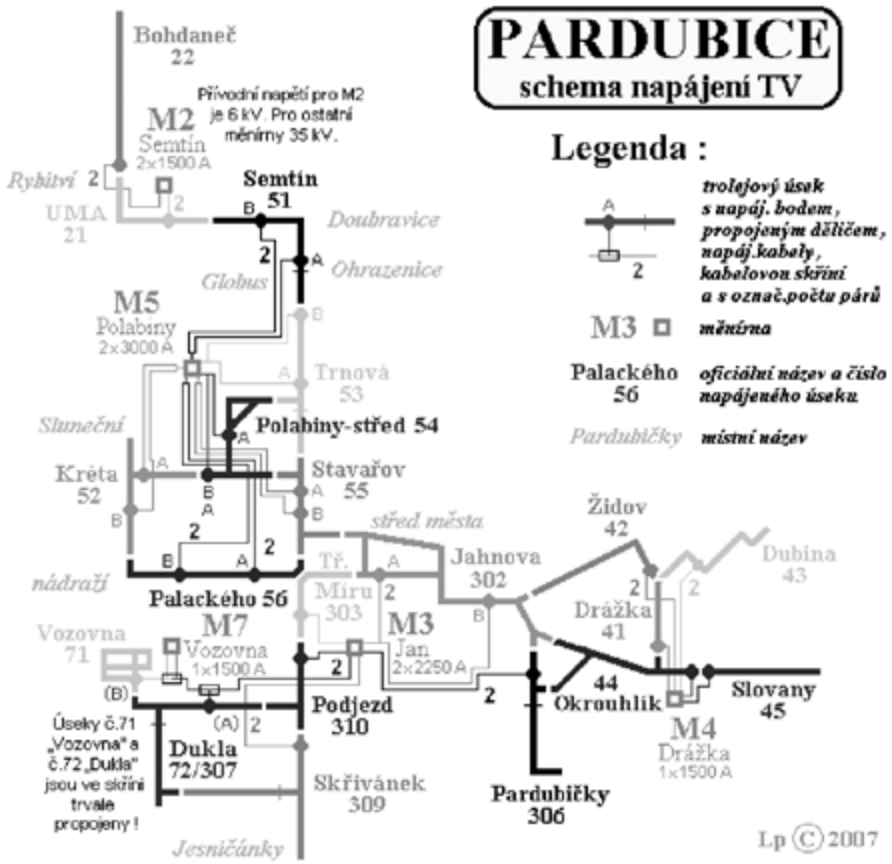

Fig. 11. The actual power scheme in Pardubice
Author: Ladislav Podivín

The fleet

The fleet comprises of 54 trolleybusses (see at tab. 2).

Tab. 2. List of the trolleybus fleet in Pardubice (as at 2010)

Type	Total number	Entered service	Fleet numbers	Remarks
Škoda 14Tr	2	1992 1994	306 362	Not used at present
Škoda 14Tr (modernised)	8 + *1*	1991 1994	340-343, 345-348 *349*	Modernization in Plzno 2006-7 modernization in Pardubice 2001 -not used at present

Škoda 14TrM	19	1995 1996 1997 1998	365-368, 370 371-374 375-376 377-384	
Škoda 21Tr (see at fig. 12)	15	2001 2002 2003 2004	385-387 388-391 392-395 396-399	Low floor, DC motors
Škoda 24Tr – Irisbus (Citelis)	6	2006 2007	317-319 320-322	Low floor, AC motors
Škoda 28Tr – Solaris (see at fig. 14)	6	2008 2009	400-403 404-405	Low floor, AC motors, three axle, 15 m in length

Source: author elaboration

There aren't any articulated trolleybuses. 54 vehicles are used at present. 27 of them are low floor vehicles. 12 of them are big capacity. EU funds have been used to support the purchase of six Škoda 24Tr trolleybuses (see at fig. 13). All trolleybuses are fitted with light plastic collectors and collector heads made by the Esko Praha. All trolleybuses in service are equipped with electronic destination indicator boxes

Fig. 12. A low floor Škoda 21 Tr trolleybus at the central intersection in 2007
Author: Ladislav Podivín

Fig. 13. A low floor Škoda 24 Tr Citelis trolleybus at the depot in 2009
Author: Ladislav Podivín

Fig. 14. The celebration of hanging over of four Škoda 28 Tr trolleybuses in the city centre in December 2008
Author: Ladislav Podivín

Tariff and tickets

The EM-TEST system was introduced in 2006. Thanks to this system passengers can use traditional paper tickets or chip cards. The fee depends on the number of stops travelled.

I band – distance between 1-3 stops travelled
II band – distance between 4-10 stops travelled
III band – more than 10 stops travelled

An electronic chip card can be used for all kinds of tickets (monthly, yearly, normal, half-price, student's, etc.) and some amount of money can be put on the card. The owner of the card can use it not only for himself, but also for two passengers that travel with him. When you use the money that have been put on the card to buy a ticket, you can get a discount, for example during weekends. The card operates in check-in/check-out regime. It can be used also as a pay card (it isn't very popular at present) or to other purposes (as a key, as a work card). The card arouse a great interest among passengers since 80 000 card has been made out so far and Pardubice has a population of 90 000. There are 5 card readers in each trolleybus. Users can charge their cards in customers service points or in certain ticket machines ant this year it will be possible to charge cards via Internet. However, purchasing tickets via SMS is not possible at present. A paper ticket purchased on advanced sale (in shops, newsagents or supermarkets too) or in a tickets machine has two basic price levels corresponding with two bands. Tickets must be punched on the trolleybus. There are three punches in each trolleybus. There is also a possibility to purchase a ticket on a trolleybus. It is printed by a trolleybus driver. It is the most expensive, but the passenger can travel to the end of the route. You can pay for it in cash or use the money that are on the card, which is a good idea when you have to pay for a group of passengers. Each vehicle is equipped with a computer, where timetables for all brigades and tasks are stored. The computer steers the destination indicator boxes and the ticket system, it also keeps records of all sold and punched tickets, it controls keeping the timetable using the GPS system. After returning to the depot all data are send to the main computer by the radio. Controlling and updating the on-boards timetables are also held this way. Commission on sold tickets can be collected next day by drivers or it can be added to their wages. There are more functions of the on-board computer and the GPS module that will be introduced in the future, e.g. tracking the vehicles on the routes. The computer could be connected with an automatic system of trolleybus switches setting. The passengers service system has been introduced with financial support from the UE. A special group of employees of the controlling department is accountable for checking tickets. The conductors are equipped with chip cards readers and special cards for blocking the punches.

The tables 3 and 4 show prices of tickets valid from 1.01.2010 (prices are given in CZK).

Tab. 3. Prices of single tickets valid from 1.01.2010

Single tickets	**chip card**			**paper ticket**	
	I band	II band	III band	II band	III band
Normal	6,-	11,-	13,-	13,-	16,-
Half-price or luggage	3,-	6,-	7,-	7,-	8,-
Normal ticket purchased on the trolleybus				20,-	
Half-price or luggage ticket purchased on the trolleybus				15,-	
Night ticket	20,-		25,- (can be purchased only on the trolleybus)		

Source: www.dpmp.cz

Tab. 4. Prices of season tickets valid from 1.01.2010

Season tickets	**7 days**	**14 days**	**30 days**	**90 days**	**120 days**	**365 days**	**6 months**	**10 months**
Normal	135,-	250,-	400,-	1080,-	1430,-	3700,-	-	-
Half-price	75,-	-	255,-	650,-	-	2250,-	-	-
Schoolchild	65,-	125,-	180,-	510,-	620,-	-	280,-	1400,-
Student's	70,-	130,-	200,-	540,-	715,-	-	1050,-	1500,-

Source: www.dpmp.cz

Economic aspects of functioning of the trolleybus system

Nowadays (data at the date of 1.01.2010) there are 10 trolleybus lines in Pardubice. The trolleybus system doesn't operate at night. During the peak hours 39 trolleybuses operates on the routes. Seven lines, served by 20 vehicles are in operation on Saturdays, Sundays and holidays. In summer an additional historic line is in operation.

The table 5 contains detailed information on all trolleybus lines.

Tab. 5. Detailed information on all trolleybus lines

Line nr	**Route**	**Length**	**type**	**Max number of vehicles**	**Min. interwal**	**remarks**
1	**Jesničánky** – Zborovské nám. – tř.Míru – **Slovany**	11,3	all-day long all-week long	5	12 min.	

2	**Polabiny točna** – hl.nádraží – tř.Míru – **Pardubičky**	13,4	all-day long all-week long	4	15 min.	
3	**Hl.nádraží** – Masarykovo nám. – Hradecká – **Globus** – **UMA** – **Lázně Bohdaneč**	22,5 (8,3)g (15,6)u	all-day long all-week long	8	10 min.	To the Globus to the UMA terminus; only selected connections on weekdays
4	**Polabiny točna** – Sukova – tř.Míru – Masarykovo nám. – **Polabiny točna**	5,1	weekdays 6 – 19:30	1	30 min.	Roundabout line
5	**Dukla točna** – Dukla nám. – tř.Míru – **Židov** – **Dubina sever**	12,6 (10,1)ž	all-day long all-week long	6	10 min.	To Židovo between peak hours on weekdays
7	**Dukla vozovna** – Dukla nám. – Zborovské nám. – Masarykovo nám. – Hradecká – **Globus** – **UMA**	13,0 (20,3)u	all-day long all-week long until 9:30 p.m.	3	Ø 30 min.	To the UMA terminy on weekdays,only selected connections
11	**Dubina sever** – Na Drážce – Sukova – **Polabiny točna** – **Globus** – **UMA**	15,3 (22,6)u (12,8)p	all-day long all-week long until 10:00 p.m.	4 dop. 3 odp.	20 – 30 min.	To Polabin and the UMA terminus; only selected connections
13	**Dubina sever** – Na Drážce – tř.Míru – hl.nádraží – **Polabiny Sluneční**	14,3	all-day long all-week long	6 dop. 7 odp.	10 min.	
21	**Polabiny Sluneční** – hl.nádraží – tř.Míru – **Slovany**	12,4	weekdays 6 . 10:30 13 – 17:30	1	60 min.	Roundabout line

27	**Pardubičky** – tř.Míru – Dukla nám. – Zborovské nám. – tř.Míru – **Pardubičky**	11,0	weekdays 7 – 11:30 13 – 16:30	1	60 min.	Operated by low floor vehicles
51	***Dubina sever*** *– Na Drážce – tř.Míru – hl.nádraží – Polabiny točna – Globus – UMA –* ***Lázně Bohdaneč***	32,7	Only on selected Sundays during the summer season	1	120 min.	Historic line

Source: author elaboration

In 2009 trolleybuses in Pardubice made the distance of 2,3 mln vehiclekilometers and it is 40% of the carriage work that was made by all vehicles of the Dopravní Podnik Pardubice – the only passenger carrier in the city. This undertaking is a joint-stock company owned by the city of Pardubice.

The basic assumption during creation of timetables is to maintain permanent frequency of operation on the section which are operated by both trolleybuses and buses. Trolleybuses and buses share the same depot and are served by the same controlling center. All trolleybus drivers are qualified to drive both buses and trolleybuses, so they can drive two different vehicles during the same workday. This way of organizing the work is advantageous during all kinds of construction work or unexpected traffic disturbance. On the other hand, most bus drivers are qualified to drive trolleybuses. Employees with that kind of professional qualifications are promoted by the motivation system.

In comparison with the bus system, the calculation of a single vehicle per kilometer is as follows in tab. 6 (data for ten months of the year).

Tab. 6. Comparison of the cost of vehicle/km in bus and trolleybus transport

Cost CZK / 1 km from 1.1.2009 to 31.10.2009	**Trolleybuses**	**Buses**
Traction energy	5,32	0,00
Fuel	0,00	8,05
Materials	0,59	0,62
Salaries and wages	12,18	10,51
Amortization	12,61	5,65
Repairs	12,71	7,99
Remaining expenditures	7,50	6,22
Using costs	1,61	1,57
Administrative costs	2,88	2,88
Total	55,40	43,49

Source: author elaboration

The table 6 shows that electrical energy is much cheaper than liquid fuels, so it is reasonable to use the existing infrastructure as effectively as possible. Although hourly wage is the same for trolleybus and bus drivers, expenditures on maintaining of the bus system are lower in terms of one vehicle per kilometre. It is caused by the fact that trolleybuses operate in the city center, where the distance between stops in relatively short and there are many other factors that slow down the communication speed of trolleybuses.

Trolleybuses carry about 60% of all passengers. Buses operate on the rarely used lines, which usually lead to distant districts or neighbouring communes, so the distance between stops is much longer. If the trolleybus lines were replaced with bus lines, costs will be higher because of decrease in communication speed and necessity of increasing the amount of vehicle per kilometers driven.

Concepts of development

There is a concept of opening three new trolleybus lines and building two or three new substations in Pardubice. The trolleybus line from the Dukla depot to the railway station through the flyover next to the PARAMO refinery (1,9 km) will be a strategic one. Nowadays all trolleybuses have to drive under this low railway flyover on their way to and from the depot. This new line will also provide access to the depot in case of the network failure under the flyover in 17th of November Street. This will be fed by substation MR 8 U Trojice. This substation will also improve feeding of the network in the city centre. Works on construction of the new line will start immediately after finishing the reconstruction of the road system and construction of new flyovers. All those works are coordinated. A new route is planned to be opened from the industrial distrct of Pardubiček to Černé za Bory (approximately 3,6 km). However, it has been planned for the last 20 years. At the beginning of the new century the **right to** use the real property for building purposes was granted but the building permit wasn't issued because at first, the problem of connection with the southeast ring road of the city must be solved. This route will be fed by substation MR6, which will be located near Zámeček. A new logistic centre, a housing estate and a shopping mall are planned to be constructed on the meadow near Staročernsko. There is a railway station in this area too. It will be served by a trolleybus line – an extension of the line from the Slovany terminus (approximately 1,7 km in length). This line will be fed by substation MR6.

If the trolleybus transporation is withdrawn from the pedestrian area in the city centre, the traction network along Míru str. will be closed down. This line could be replaced with the already existing route, but there are some problems with the feeding. The best solution to this problem will be reconstruction of substation MR1, which building is owned by the energetic plant but if the substation is equipped with small dimensions aparatus, it will be possible to localize it there. In the past there was a plan to construct trolleybus lines to Svitkowo, to the cementary and to the city of Chrudim. Nowadays there are plans to extend the existing lines to Lázně Bohdaneč and to reopen the line to Ohrazenice. Electrification of bus lines 6 and partly 8 was taken under consideration too. In the 1980's an analysis of an atomic power station construction in Opatovice was made and connection of the trolleybus systems of Pardubice and Hradec Kralove was a part of this plan. However, it was never realized.

Summary

The trolleybus system of Pardubice has great history. There were some abandonment programmes in the past, but they weren't implemented. Optimization of the urban transportation system has been systematically carried out since 2002. Functioning of particular trolleybus lines has been coordinated and intervals have been uniformed, so the carriage work is gradually decreasing. The financial condition of the city budget has got worse and the number of passengers has decreased lately. The economic crisis has influenced the urban transportation system of Pardubice too. On 1st November 2009 the timetables were corrected and less vehicles are in operation at present. In 2009 a CNG station was opened at the depot and 7 CNG buses were purchased. They replaced petroleum buses.

Trolleybuses are a permanent part of Pardubice's landscape and large amounts of money are donated to the trolleybus infrastructure every year. The average life of traction network is thirty years, so every year a 1 km long section of the network should be replaced with a new one but it isn't possible for financial reasons. Thanks to light trolley poles and high quality network apparatus only, the trolleybus system can work without any bigger problems. It is worth mentioning that some traction poles are 60 years old.

References:

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Bohdan Turżański

History of trolleybus transport in Lublin

In 2010 a plan was approved by the city council under which 100 brand new trolleybuses will be purchased, 35,7 km of new trolleybus routes will be opened, the traction network will be modernized and a new depot will be built. If this plan is accomplished, urban transportation will become more popular, especially the trolleybuses.

There is a Chance that above-mentioned investment will by partially funded (approx. 60%) by the European Union from the Operational Programme Development of Eastern Poland and the Lubelskie Regional Operational Programme.

Lublin is tenth largest city of Poland and the largest city situated to the east of the Vistula River. It is also the largest Polish city without a tram system. The city council considered several times, but finally rejected, a plan to implement the tram system. Trams are considered to be a factor which stimulates the growth of cities. The lack of the tram system could be one of the reasons why Lublin developed relatively slow until the second part of XX century. Before World War II started, the fleet of 18 buses only was enough to provide service in the city. Lublin had a population of 120 000 at that time.

The situation changed diametrically after World War II. It became clear that the expansion of the system was needed to cope with the rapidly increasing population, which raised by 400% during 1938-1950. There were announced several plans to purchase new Chausson buses, but because of financial difficulties those plans were never implemented.

Finally, the city council made the decision to replace buses with trolleybuses. The reasons for this decision aren't clear and they are difficult to evaluate nowadays.

It's hard to say whether it was perspective thinking or not, but the decision was right. Maybe the city council's aim was to improve its public image after they hadn't kept the former promise of improving the urban transport "in the future".

Some years later it turned out that it was easier to acquaint trolleybuses than buses under the centrally planned economy. However, although the city council didn't make the most of that opportunity, trolleybuses literally saved the urban transport from collapse at the beginning of 1960s. Later they became the major means of transport in Lublin. As early as 1955, 10 trolleybuses carried 7,8 million passengers and 27 buses only 9,6 million.

All the same, the early days of the trolleybus system in Lublin were difficult. When in autumn 1948 the decision was made to introduce trolleybuses, it was planned that they will operate on the route between Racławickie Lane and Abramowice in two years time. But this line was opened not before 21st July 1953. It was only 4 km long and it connected Uniwersytecka Street with the railway station. The new line was numbered 15 and this number distinguished it from the bus lines which were numbered in the range 0 – 8. It was essential, because trolleybus fare was lower than bus fare.

On 7th November the section along Kunickiego Street to the loop at the intersection of Kunickiego and Mickiewicza Streets was brought into use. The same year overhead was installed along the route to the depot in Garbarska Street. From that time on it wasn't necessary to tow trolleybuses by buses or tractors. The route form Uniwersytecka Street to Mickiewicza Street (line 16) was operated trolleybuses too.

In June 1954 the loop at the railway station was replaces with a new one at Dworcowy Square. One month later line 15 was extended to the new loop at Racławickie Lane. The construction of the first section of the trolleybus system in Lublin was finished. At that time all the routes of the system were 7 km long. They were powered by a single substation situated in the city cetre (in Szczerbowskiego Street).

There was no chance for further development because there weren't vehicles in the fleet. Then, in early 50. the decision was made not to purchase French trolleybuses no more and the first batch of Czechoslovakian vehicles was delivered in 1955. The first lines were operated by second-hand JaTB-2 trolleybuses made in the Soviet Union, which were acquired from Warsaw and Gdynia. Those vehicles were in such poor technical condition they couldn't operate on both lines thus Line 16 was operated by buses only at that time. In the second half of 1954 6 Vetra trolleybuses were borrowed from Gdynia.

In the 1950s and 1960s only Skoda trolleybuses were purchased. In 1959 the line to Unick Street was introduced, in 1960 – to Abramowice, in 1961 to Lipowa Street and Piłsudkiego Lane, in 1963 – to Sławinek and Filaretów Street. At the end of this development period the route joining Filaretów Street and Racławickie Lane and a new depot in Helenów were constructed. The depot was brought into use in early 1960s.

Although the trolleybus fleet was smaller, trolleybuses carried more passengers than buses during 1960s. In 1967 they carried 48,5 million passengers, whereas

buses only 28,9 million. The situation changed completely in 1971, when the buses started carrying/to carry more passengers.

In April 1970 14 lines were operated by 62 trolleybuses during the peak hours (in that year the fleet comprised 78 vehicles in that year, see at tab. 1).

Tab 1. Trolleybus routes in 1970

No.	Route	Vehicles			Frequency		
15	Al. Warszawska – Zamojska – Railway Station	5	4	4	9	11	11
16	Al. Warszawska – Zamojska – Abramowice	7	5	3	9	12	20
17	Unicka – Zamojska – Abramowice	7	3	3	11	18	18
18	Al. Warszawska – Krakowskie Przedmieście – Unicka	4	3	3	10	14	14
19	Al. Warszawska – Lipowa – Abramowice	3	2	2	20	30	30
20	Sławinek – Lipowa – Mickiewicza	3	2	2	20	30	30
21	Filaretów – Lipowa – Zamojska – Mickiewicza	4	4	3	16	16	24
22	Al. Warszawska – Lipowa* – Majdanek	4	4	4	15	15	15
22 bis	Majdanek – Zamojska – Lipowa – Majdanek**	3	-	-	13	-	-
23	Filaretów – Lipowa – Zamojska – Dworzec PKP	3	2	2	18	27	27
24	Filaretów – Lipowa – Unicka	4	3	2	12	16	25
25	Filaretów – Al. Racławickie – Lipowa - Mełgiewska	6	5	5	13	16	16
26	Unicka – Lipowa* – Mełgiewska	6	5	4	10	12	15
28	Sławinek – Krakowskie Przedmieście – Unicka	2	2	2	25	25	25

Frequency is given in minutes and both these and the vehicle requirements show the situation during the peak hours, weekday slack hours and Sundays respectively.
** – returns via Zamojska*
*** – in this direction only*
Source: author elaboration

It was the end of the greatest period of the Lublin trolleybus system. Great success of licensed Jelcz buses, which were called "cucumbers" and higher operating costs were the main causes of closing the system in the mid 60's. Contrary to Poznań, Olsztyn, Wałbrzych and Warsaw systems, which were closed immediately, trolleybus operation in Gdynia and Lublin ceased gradually. Those systems were closed during 1960-1970. Under the policy of abandonment of the trolleybus system no more trolleybus routes were constructed including those along Kalinowszczyzna and Krochmalna Streets.

By 1973 the fleet had declined to 56 serviceable trolleybuses. Only one section of the system was closed (Sławinek) and in 1973 six trolleybus lines were in operation. Trolleybuses were replaced with buses on lines 17, 18 and 20 and they were withdrawn from all overlapping or minor routes after service that year. The following routes were in operation in 1973 (see at tab. 2).

Tab 2. Trolleybus routes in 1973

No.	Route	Vehicles			Frequency		
50 (15)	Al. Warszawska – Zamojska – Railway Station	8	8	8	6	5	5
51 (16)	Al. Warszawska – Zamojska – Abramowice	10	7	7	6-7	8-9	9
52 (21)	Wileńska – Lipowa – Zamojska – Mickiewicza	8	6	6	9	12	12
53 (22)	Al. Warszawska – Lipowa* – Majdanek	10	7	6	6	8	9
54 (24)	Wileńska – Lipowa – Unicka	6	6	5	9	9	11
55 (25)	Wileńska – Al. Racławickie – Lipowa - Mełgiewska	14	10	7	5	7	10

Frequency is given in minutes and both these and the vehicle requirements show the situation during the peak hours, weekday slack hours and Sundays respectively.
** – returns via Zamojska*
Source: author elaboration

The energy crisis of the 70's, which caused the rise in oil prices, didn't influence Poland directly but it caused the resumption of the trolleybus operation in Lublin.

An order was placed with Soviet Union for new trolleybuses. After the delivery no more Skoda trolleybuses remained in service in 1980. A large batch of new vehicles joined the fleet and it became as large as in the 70's. Several years later the fleet comprised 100 trolleybuses.

However, only 72 vehicles operated during the peak hours in 1985. In the 70's and 80's the city developed and new residential and industry areas were served only by buses. The trolleybus system served only the city centre. Although trolleybuses operated on the main streets, they were carrying less passengers than buses, so it was not necessary to enlarge the fleet. In the face of public opposition and with the aim to use the traction network and power supply system evenly, new trolleybus services were introduced. In 1984 trolleybuses operated on 13 lines once again (fig.) and a new plan of the system development was announced.

Construction of a route to Węglin and a short section along Wolska Street started under this plan and it was funded by MPK. However, due to financing problems the construction was not finished on time. Additionally, the power supply system was modernized and developed at that time and it became possible to introduce up to 80 vehicles.

Both above-mentioned router were opened after the political system had changed. When the route to Węglin was opened, the following routes were in operation (see at tab. 3).

Tab 3. Trolleybus routes in 1984

No.	Route	Vehicles			Frequency		
150 (50)	Filaretów - Lipowa – Railway Station	5	5	5	13	13	13
151 (51)	Węglin – Lipowa – Abramowice	10	5	5	9	18	18
152 (52)	Wileńska – Lipowa – Zamojska – Abramowice	12	4	2	7	22	40
153 (53)	Węglin – Zamojska – Majdanek	6	3	3	15	30	30
154 (54)	Wileńska – Lipowa – Unicka	8	4	2	7	14	29
155 (55)	Filaretów – Al. Racławickie – Lipowa - Mełgiewska	12	7	5	7	12	17
156	Unicka – Zamojska - Abramowice	4	2	2	12	24	24
157	Węglin – Zamojska – Mełgiewska	4	2	2	22	45	45
158	Filaretów – Al. Racławickie – Zamojska - Majdanek	8	4	4	11	21	21
160	Unicka – Zamojska – Abramowice	4	2	2	13	26	26
161	Filaretów – Al. Racławickie – Lipowa - Mełgiewska	2	-	-	30	-	-

Frequency is given in minutes and both these and the vehicle requirements show the situation during the peak hours, weekday slack hours and Sundays respectively.
Source: author elaboration

Fig. 1. First low floor trolleybus in Lublin – type Jelcz 121MTE
Author: Marcin Połom

However, even opening the route to Węglin didn't prevent the marginalization of trolleybus transportation. What is more, next city council's decisions increased this process. In 1994 when the pedestrian zone was built, the route along the main street of the city (Krakowskie Przedmieście) was closed. It resulted in closing two important lines: 154 and 161. After 13 years the unused overhead wiring of those lines was eventually dismantled in 2008.

In 2000 the line to Unicka Street was slightly extended. The extension was necessary because the old trolleybus loop was closed down, but generally any actions haven't been taken to develop the system. The fleet hasn't been modernized either since the end of the 1980's. At the beginning of 21th century there was even a threat of closing the trolleybus system down.

Prospects for development of the system emerged when Poland joined the European Union. At first, modernization of the traction network along Królewska Street was funded by the EU from the Instrument for Structural Policies for Pre-Accession. In 2006/7 a new route, 5 km in length, was constructed in Czuby district. At present the maximum number of 48 trolleybuses operates on 8 lines (see at tab. 4).

Tab. 4. Trolleybus routes in 2006/2007

No.	Route	Vehicles			Frequency		
150	Węglin - Lipowa – Railway Station	5	4	4	20	20	30/20
151	Węglin – Lipowa – Abramowice	6	5	5	20	20	30/20
152	Abramowice – Lipowa – Zana – Abramowice*	5	4	4	20	20	30/20
153	Węglin – Orkana – Głęboka – Majdanek	6	5	5	20	20	30/20
155	Filaretów – Al. Racławickie – Lipowa – Mełgiewska	6	5	5	20	20	30/20
156	Chodźki – Zamojska – Abramowice	4	4	4	20	20	30/20
158	Filaretów – Al. Racławickie – Lipowa – Majdanek	11	5	5	10	20	20/20
160	Chodźki – Zamojska – Abramowice	5	4	4	20	20	30/20

The vehicle requirement illustrates the situation on weekdays, Saturdays and Sundays respectively (always maximum numbers during a day are given).
Frequency is given in minutes and show the situation during the morning peak hours, on Saturdays and on Sundays mornings/afternoons respectively.
** – in this direction only*
Source: author elaboration

Development of the Lublin trolleybus system is also funded by the European Union from the Operational Programme Development of Eastern Poland and the Lubelskie Regional Operational Programme.

Fig. 2. Construction of the new trolleybus line founded by money from the EU
Author: Marcin Połom

Fig. 3. New type of low floor trolleybus Solaris Trollino with electric drive from polish company Medcom
Author: Marcin Połom

The most significant element of the Operational Programme Development of Eastern Poland is construction of new trolleybus routes, approximately 35 km in length. Those routes will cover the residential area of Czuby district and following housing estates: Czechów, Kalinowszczyzna, Kruczkowskiego, Nałkowskich and Felin (Jagiellońskie). The trolleybus system of Lublin will also provide services to industrial areas of the city along Krochmalna, Mełgiewskiej, Grygowskiej, Zemborzyckiej and Diamentowa Streets (see at tab. 5).

Tab. 5. The planned length of the trolleybus lines

	Route	Length	Year of construction
1	Majdanek – Doświadczalna – os. Jagiellońskie	1,5	2010-2011
2	Abramowice – Abramowicka – Szymonowica	1,1	2010-2011
3	Unii Lubelskiej – Podzamcze – Unicka	2,1	2012
4	Chodźki – Szeligowskiego – Choiny	2,5	2012
5	Wileńska – Głęboka (second track)	1,4	2012
6	Mełgiewska – Grygowej	4,2	2012
7	Lwowska – Andersa – Mełgiewska	3,0	2012
8	Muzyczna – Młyńska	1,7	2012
9	Armii Krajowej – Jana Pawła II	4,4	2013
10	Jana Pawła II – Krochmalna	3,9	2013
11	Bohaterów Monte Cassino	0,5	2013
12	Nadbystrzycka	2,2	2013
13	Filaretów – Zana	2,3	2013-2014
14	Zemborzycka – Diamentowa	4,9	2013-2014
	Total	**35,7**	

Source: author elaboration

Those routes will be operated by 70 new trolleybuses (12 metres in length) which are to be acquired during 2011-2014. The 20 of them will be fitted with the diesel-electric propulsion and operating system. If this project is executed, the trolleybus network of Lublin will be twice as large as it is now and this is its main objective. It will cover the largest housing estates and a group of factories in the industrial area. But the project isn't as perfect as it seems to be. There will be some problems with planning new sections.

Almost all routes will be constructed only in the northern and southwestern parts of the city. What's more the system will be divided into two parts, because there will be no connections via the city centre, so problems of the present trolleybus system won't be solved. Nowadays the system is clearly divided into two

parts, which are connected via the "narrow throat" along Piłsudskiego Street and the trolleybuses don't operate in the city centre.

Trolleybuses, which provide services in the city centre should be able to operate in diesel mode and it seem to be the only one logical solution to this problem.

Then, it would be possible to create trolleybus routes along the most popular bus lines: Racławickie Lane, Krakowskie Przedmieście, 3 Maja Street, Solidarności and Tysiąclecia Lanes. These lines are numbered: 10, 18, 26, 31 and 57 (see at tab. 6).

Tab. 6. Plans for transport development in Lublin

Indicator	2010	2015	growth (%)
Distance covered by both types of vehicles per kilometers performed	18 789 000	22 531 000	19,92
By buses only	15 932 000	16 135 000	1,27
By trolleybuses only	2 857 000	6 396 000	223,87
Trolleybus carriage work (%)	15,2	28,3	86,18
Total number of passengers carried by both types of vehicles	90 000 000	94 000 000	4,44
By buses only	75 850 000	72 750 000	- 4,09
By trolleybuses only	14 150 000	21 250 000	50,18
The percentage share of transport	15,8	23,1	46,20

Source: ZPRTP for 2010-2015, an attachment to the City Council Resolution of 28.01.2010

The table above shows that even if distance covered by trolleybuses increases, they will not carry more passengers respectively. It means that if the project is entirely executed, 60% of its total cost will be funded by the European Union. A smaller project has been put forward too. It concerns modernization of the present system. The infrastructure of three substations will be modernized. One of them, which is located in Szczerbowskiego street will be converted to a substation control centre. A redundancy programme will be implemented too.

The most spectacular part of the plan will be a purchase of 30 brand new trolleybuses, which will replace a half of the present fleet. The fleet comprises 59 Jelcz trolleybuses, constructed in 1980's and only five of them are low-floor models. Almost all vehicles are in poor technical condition. Delivery of a batch of 15 new trolleybuses is planned to be put out to tender in the second quarter of 2010.

Another planned actions are:

- purchase and assembly of 128 tram shelters and 368 trolleybus stop posts, including 28 tram shelters and 15 trolleybus stop posts of high standard, which are fitted with two displayers.
- GPS based passenger information system
- passenger counting system
- construction and redevelopment of trolleybus stops and loops

All those actions will increase functionality and esthetics of urban transport infrastructure as well as its public image.

Almost whole it's length except for both recently opened routes to Chodźki and to Węglin and some shorter sections, mainly junctions, rebuilt in recent years, It was to be thoroughly modernized using modern components made by Czech firm Elektroline.

At first the project assumed that 24 km of the traction network will be modernized but this action wad eventually rejected. Nowadays, only three sections of the traction network and some high-speed frogs are modern. Rest of the network is in very poor condition and it requires immediate modernization. What's more, according to a amended plan less than 53 trolleybuses will be purchased. All those amendments are result of some financial difficulties and shortage of funds from the Lubelskie Regional Operational Programme which are allocated for urban transportation (23 million euro). Total value of all Lublin's project is about 62 million zl.

It is possible that a contract for delivery new vehicles will be awarded to the MAZ company from Belarus. A new plan of cheap modernization of the fleet has been put forward under which a prototype trolleybus will be constructed in cooperation with the Polish representative of MAZ Poland. Chassis 203T is fitted with propulsion systems designed in Medcom (AC drive) and Emit electric traction motors (just like Solaris 12M trolleybuses). This model was certified save and fit for use in February 2009. The present fleet (at 1.01.2010) consists of vehicles listed in table 7.

Tab. 7. List of trolleybuses (at 1.01.2010) in Lublin

Fleet nos.	Model and type	Manufacturing year	Remarks
1223	Jelcz PR110E	1989	ex driver's training vehicle
3748, 3750-3753, 3755	Jelcz PR110E	1988	
3761, 3762, 3764-3766, 3768	Jelcz PR110E	1989	
3769	Jelcz PR110E	1990	
3771, 3775	Jelcz PR110T	1990	
3776, 3780, 3782, 3784	Jelcz PR110E	1991	
3781, 3783, 3785	Jelcz PR110T	1991	
3791-3793	Jelcz PR110E	1992	
3795, 3797, 3798	Jelcz PR110E	1987	1993 ex Dębica
3802	Jelcz PR110E	1984	1998 ex dieselbus
3803-3805	Jelcz 120MT	1998	
3807	Jelcz PR110T	1984	1998 ex dieselbus
3808	Jelcz 120MT	1999	
3809	Jelcz PR110E	1999	1999
3810, 3811	Jelcz PR110E	1990	1999 ex dieselbus

3813	Jelcz PR110E	1983	1999 ex Słupsk
3815	Jelcz PR110E	1987	1999 ex Słupsk
3816, 3817	Jelcz PR110T	2000	
3818	Jelcz M121M	2001	
3819, 3821, 3826, 3831, 3832	Jelcz PR110E	1991	2001 ex Warszawa
3822, 3824, 3825, 3830	Jelcz PR110E	1989	2001 ex Warszawa
3833	Jelcz 120MT	2005	
3834-3835	Jelcz 120MT	2006	
3836-3837	Solaris 12M	2007	
3838	Solaris 12AC	2008	
3839	Solaris 12M	2007	2009 ex prototype

Trolleybuses 3752, 3826 and 3830 were fitted with an experimental AC drive during 2005-207 (see at fig. 4)
Source: author elaboration

Fig. 4. Jelcz Pr110 after modernization and replacing electric drive to asynchron
Author: Marcin Połom

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Anna Powałka, Andrzej Soczówka

The trolleybus system of Tychy – past, present and perspectives on development

Introduction

Tychy is one of the largest cities of the Śląskie Voivodeship. It is situated in the central part of the voivodeship. The city spans a total of 82 km^2 and has a population of over 130 thous. The city borders on Katowice in the north, on Lędziny and Bieruń in the east, on Bojszowy and Kobiór communes in the south, on Miłków and Wyry commune in the west. The areas of present cities: Bieruń, Lędziny and communes: Bojszowy, Kobiór and Wyry were component parts of Tychy from 1975 to 1991. Tychy is one of 14 cities of the Upper Silesian Agglomeration, which are called the Metropolitan Association of Upper Silesia.

The city is surrounded with woodland. The largest one is the former Pszczyńska forest, which lies to the north of Tychy. The landscape of the city is dominated by green areas, such as forests, parks and squares, which cover approximately 30% of the city area. That is why Tychy is often called the "green city". The transportation system for the commune of Tychy is dominated by buses. There are 43 bus lines and 5 trolleybus lines in the city at present.

The bus system is operated by four companies: Miejski Zarząd Komunikacji (MZK) in Tychy (32 lines), Komunikacyjny Związek Komunalny GOP in Katowice (2 lines), Przedsiębiorstwo Komunikacji Miejskiej i Spedycji in Oświęcim as freelance work for Bieruń commune (7 lines) and Tesco hipermarket (2 free of charge lines). The MZK lines include: 24 normal/regular lines, 2 minibus lines, 2 fast lines and 1 school line.

MZK Tychy regular and Fast lines are operated by Przedsiębiorstwo Komunikacji Miejskiej (PKM) in Tychy (2 lines are operated by subconstractors); the minibus lines are operated by private carriers. Moreover, when train service was reinstated from 16th December 2008, all passenger trains operated by a company Przewozy Regionalne which provide services to Katowice are integrated with MZK

Tychy bus and trolleybus fees. The reopened route is operated by the most modern vehicles EN-75, colloquially called "Flirt".

This article focuses on the trolleybus system only, which was opened in 1982 as an alternative passenger transportation system. Initially, trolleybuses in Tychy were operated by Wojewódzkie Przedsiębiorstwo Komunikacyjne in Katowice, then (from 1991) by Przedsiębiorstwo Komunikacji Miejskiej in Tychy and nowadays the trolleybus system in Tychy is operated by Tyskie Linie Trolejbusowe Ltd. This company has existed on the market since 1st February 1998. Miejski Zarząd Komunikacji in Tychy signed a contract with Tyskie Linie Trolejbusowe to provide carriage services the same year.

The origins of Tychy trolleybus system

In connection with the energy crisis of the 70's it was essential to decrease the number of buses operating in the passenger transportation system of Tychy. Initially, a tram network was taken under consideration, but this plan involved large capital investment (the nearest tram network is about twenty kilometres away from Tychy, thus it wasn't possible to develop already existing infrastructure) and long investment cycle. That is why that plan was rejected and the operator took trolleybus transportation into consideration. Besides, trolleybuses have already operated in Gdynia and Lublin.

On 11th February 1982 the decision was made to create an experimental trolleybus line in Tychy (Grzywocz, 1984). Tychy was chosen for this project for the reason of well developed system of roads (wide streets) without any junctions with other means of transport that use overhead wiring (trams, trains) and large passengers streams. The introduction of trolleybus transportation was supported with other arguments (20 lat..., 2003), e.g.:

- ecology (low noise and no pollution),
- larger traffic capacity (it was assumed that vehicles of larger capacity would have been introduced in the future)
- lower operating costs (electric energy was cheaper than liquid fuel in the 80s.)

The analysis of all above-mentioned arguments has shown that it has to be stated that last two of them has appeared incorrect because articulated trolleybuses were never introduced in Tychy and the operating costs of overhead wiring were very high from the very beginning (in comparison with bus transportation operating costs). However, despite this raised level of operating costs and high capital spending other advantages of trolleybus transportation were very important at that time. Ecological, social and health regards are still very prominent.

Stages of trolleybus router development in Tychy

On 11th Februrary 1982 a decision was made considering the construction of trolleybus infrastructure by the provincial governor of Katowice. The first section (4 km in length) was constructed along former Hanki Sawickiej Str. (now Piłsudskiego Str.) and Zawaszkiego Str. (Dmowskiego Str.) to the bus depot WPK in former Krasickiego Str. (Jana Pawła II Str.).

Test-runs began on 16th September 1982 and on 30th September the first line was opened. The official inauguration of the first trolleybus line in Tychy took place on 1st October 1982. On that day trolleybuses carried the first passengers via line 1from Tychy WPD Depot to Tychy Krasickiego. Thanks to that line it was possible to acquaint with trolleybus (line) operating conditions. After ending of the test-runs, on 27th October 1982 the decision was made to accomplish all remaining stages of construction of trolleybus infrastructure in Tychy (Grzywocz, 1984). The second stage of the investment included construction of a loop length of 3 km along Towarowa, Przemysłowa and Metalowa Str. The loop was opened on 29th July 1983 and it extended line 1.

On 30th December 1983 a new trolleybus line (length of 6 km) was opened along former Hanki Sawickiej Str. (now Piłsudskiego Str.), Jaśkowicka Str., Stoczniowców 70. Str., Harcerska Str., Begonii Str. and Budowlanych Str. with a loop near the railway station: former Świerczewskiego Str. (now Burschego Str.), Lenina Str. (Andersa Str.), 1 Maja Str. (Asnyka Str.) and Budowlanych Str. This line connected housing estates in the Southern parts of the downtown with the railway station and the "Wschód" ["East"] industrial area of the city. The route from the industrial area to the railway station was operated by line 2.

In 1984 a route length of 3,6 km was opened along former Koniewa Str. (now Armii Krajowej), Fornalskiej Str. (Wyszyńskiego Str.), Engelsa Str. (Edukacji Str.) and Budowlanych Str. This new built section was operated by line 3, which connected housing estates in the Northern parts of the downtown.

In 1985 some new routes were opened (with a total length of 5,3 km). The first one connected Paprocan with the downtown along former Koniewa Str. (now Armii Krajowej Str.) to Paprocany Lake. This route was operated by line 4. At the same time the route of line 1 was extender to the railway station along Żwakowska Str., where overhead wiring had been constructed. Overhead wiring was also constructed along former Dzierżyńskiego Str. (now Grota-Roweckiego Str.), but this section was not used until 2002.

The last stage of the trolleybus system development plan assumed that the overhead wiring will have been constructed along Sikorskiego Str. and Glinczańska Str. by 1986. This section could have provided faster connection from Paprocan to the railway station. According to the plan, total length of trolleybus routes in Tychy would be 28 km. They were going to be served by 7 lines in 10 minutes intervals (Grzywocz, 1984). The trolleybus system development plan assumed that the trolleybus network will be extended to new housing estates: Cielmice, Jaroszowiec, Mąkołowiec, the "Północ" industrial area and the former Fabryka Samochodów Małolitrażowych (now Fiat Auto Poland). Those plans were never implemented. Any major changes to the trolleybus system didn't take place from 1985 to 2002.

Finally, in 2002 overhead wiring was constructed along Jana Pawła II Str. and the fifth trolleybus line (line E) was opened between Paprocany and the city centre.

Trolleybus lines

Until 1992 the trolleybus lines were numbered from 1 to 4 just like some of the bus lines (20 lat..., 2003). At first, this problem was solved by putting an additional "T-bus" sign on the destination indicator boxes. In 1992 the system of trolleybus numeration was change into A-D. Line 1 was changed into line C, line 2 into line A and line 4 into line B. At the same time line 3 was suspended for economic reasons. This line was reopened and named D on 9th March 1998.

The original, numerical system of trolleybus numeration was in accordance with the chronological order of opening the lines. The alphabet numeration system illustrated the significance of each line – line A and line B were basic lines, which generated large passengers traffic. Line C and line D (and line E, that was opened in 2002) are supplementary lines of less importance in the transportation system of the city. Line E became more important when it was integrated with the railway line from Tychy Miasto to Katowice. Nowadays, line E and line A carry passengers mainly to minor railway stations in Tychy: Tychy Miasto (line E) and Tychy Zachodnie (line A).

With the aim of providing greater flexibility of peration, timetables of line A and line E were adjusted to the railway timetable. Additionally, service frequency and the hours of operation of line E were increased (fig. 1 and fig. 3). What's more trolleybuses started to operate on Sundays and holidays. When the system continued to expand major changes took place in the frequency of the trolleybus service. Line 1 from Tychy WPK Depot to Tychy Krasickiego was opened on 1st October 1982. It was operated by 4 vehicles in 8 minutes intervals on weekdays and by 2 vehicles in 16 minutes intervals on Sundays and holidays. On 29th July 1983 the line was extended by a loop located in industrial areas and from that day on, it was operated by 5 vehicles in 12 minutes intervals and 2 vehicles in 20 minutes intervals on Sundays and holidays. Line 2 (Tychy Tereny Przemysłowe – Jaśkowicka – Tychy Dworzec PKP) was operated by 5 vehicles in 12 minutes intervals until 3.00 p.m. and then by 3 vehicles with frequency of 20 minutes. When line 2 became more popular among passengers the line 1 timetable was changed. It started to be operated by 2 vehicles in 20 minutes intervals on weekdays only. Line 3 between industry areas and the main railway station and above-mentioned line 2 were operated by 5 vehicles in 12 minutes intervals until 3.00 p.m. on weekdays and by 3 vehicles in 20 minutes intervals after 3.00 p.m. and on Sundays and holidays.

Since line 4 was opened (from Paprocany Pętla – Edukacji – Tychy Dworzec PKP) it captured some of passenger traffic of line 3. In the process the service frequency of line 3 was decreased, just like it happened in case of line 1.

In 1985 the route of line 1 was extended to the railway station, but still it was operated by 2 vehicles only, thus the service frequency was decreased by 20-30 minutes. Table 1 shows a summary of service frequency of each line in 1985.

Tab. 1. Service frequency of trolleybus lines in 1985

Line	Route	Service Frequency [min.]		Number of vehicles in service [pcs.]	
		weekdays	Sundays and holidays	weekdays	Sundays and holidays
1	Tereny Przemysłowe – Krasickiego – Dworzec PKP	30	–––	2	–––
2	Tereny Przemysłowe – Jaśkowicka – Dworzec PKP	12 (20)	20	5 (3)	3
3	Tereny Przemysłowe – Edukacji – Dworzec PKP	30	–––	2	–––
4	Paprocany Pętla – Edukacji – Dworzec PKP	12 (20)	20	5 (3)	3

Explanatory note: numbers in brackets refer to the service frequency during off-peak hours
Source: own elaboration based on materials of TLT (20 lat..., 2003)

Current service frequency for each trolleybus line is showed in tab. 2. The analysis of table 2 has shown that lines: A, B and E are of the greatest significance for the citizens of Tychy. The service frequency is the greatest on weekdays as well as at weekends. Additionally, some of the routes are operated by low-floor trolleybuses. Fig. 1. shows the number of trolleybus routes in Tychy in 2009.

Tab. 2. Service frequency of trolleybus lines at 31st December 2009

Line	Route	Service Frequency [min.]			Number of vehicles in service [pcs.]		
		weekdays	Saturdays	Sundays and holidays	weekdays	Saturdays	Sundays and holidays
A	Nexteer (Zajezdnia) – Dworzec PKP	10-12 (15-20)	20	20	6 (5)	4	4
B	Paprocany Pętla – Dworzec PKP	15 (15-30)	20	20	4	3	3
C	Nexteer (Zajezdnia) – Dworzec PKP	20-40 (60)	nie kursuje	2	nie kursuje		
D	Nexteer (Zajezdnia) – Dworzec PKP	20-40 (60)	nie kursuje	2	nie kursuje		
E	Paprocany Pętla – Dworzec PKP	30	30-60	60	3	3	3

Explanatory note: numbers in brackets refer to the service frequency during off-peak hours
Source: own elaboration based on MZK Tychy timetables (www.mzk.pl)

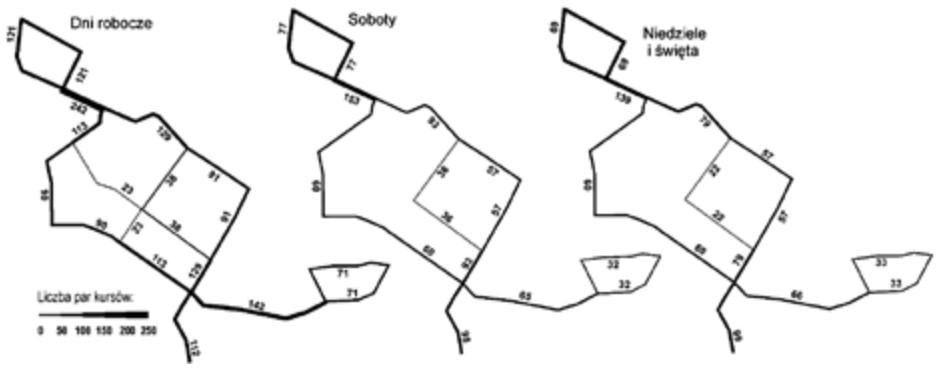

Fig. 1. The number of two-way trolleybus routes on all sections of the trolleybus network at 31st December 2009. Dni robocze – Weekdays, Soboty – Saturdays, Niedziele i święta – Sundays and Bank holidays
Source: own elaboration

Figure 2. shows a current scheme of the trolleybus system. Nowadays, there are 5 trolleybus lines in Tychy.

A: Tychy Nexteer (Zajezdnia) – (Towarowa – Metalowa – Przemysłowa <) – Towarowa – Piłsudskiego – Jaśkowicka – Stoczniowców 70 – Harcerska – Begonii – Budowlanych – (> Burschego – Andersa / Asnyka <) – **Tychy Dworzec PKP**

B: Paprocany Pętla – Sikorskiego – Armii Krajowej – Wyszyńskiego – Edukacji – Budowlanych – (> Burschego – Andersa / Asnyka <) – **Tychy Dworzec PKP**

C: Tychy Nexteer (Zajezdnia) – (Towarowa – Metalowa – Przemysłowa <) – Towarowa – Piłsudskiego – Dmowskiego – Jana Pawła II – Żwakowska – Harcerska – Begonii – Budowlanych – (> Burschego – Andersa / Asnyka <) – **Tychy Dworzec PKP**

D: Tychy Nexteer – (Towarowa – Metalowa – Przemysłowa <) – Towarowa – Piłsudskiego – Armii Krajowej – Wyszyńskiego – Edukacji – Budowlanych – (> Burschego – Andersa / Asnyka <) – **Tychy Dworzec PKP**

E: Paprocany Pętla T-bus – Sikorskiego – Armii Krajowej – Jana Pawła II – Grota Roweckiego – Edukacji – Budowlanych – (> Burschego – Andersa / Asnyka <) – **Tychy Dworzec PKP**.

The cartodiagram in figure 3 illustrates the comparison between the bus transportation offer and the trolleybus transportation offer at 1st January 2008. The number of two-way router has been used as an indicator.[1] It is clear that both buses and trolleybuses cover the same router of the transportation network in Tychy. Practically, the number of two-way bus routes surpasses the number of two-way trolleybus routes. However, any bus route isn't marked out identically or conver-

Fig. 2. A current scheme of the trolleybus system at 31st December 2009 (black line – trolleybus route, grey line – bus route)
Source: own elaboration

gently with trolleybus routes. There is only one section of the trolleybus network that is not duplicated by the bus network – along Jana Pawła II Lane. It can be stated that the trolleybus and bus subsystems aren't complementary systems. From the very beginning those subsystems have been competing and the bus subsystem is the winner of that competition. That has been proved by the TOWS/SWOT analysis that was carried out for the trolleybus system in Tychy by E. Drob-Żaba (2006). The analysis has shown that although the Tyskie Linie Trolejbuspwe has lots of advantages, some external factors aren't creating a proper environment for the trolleybus system development. The most significant external factor is the competition between the bus and trolleybus systems.

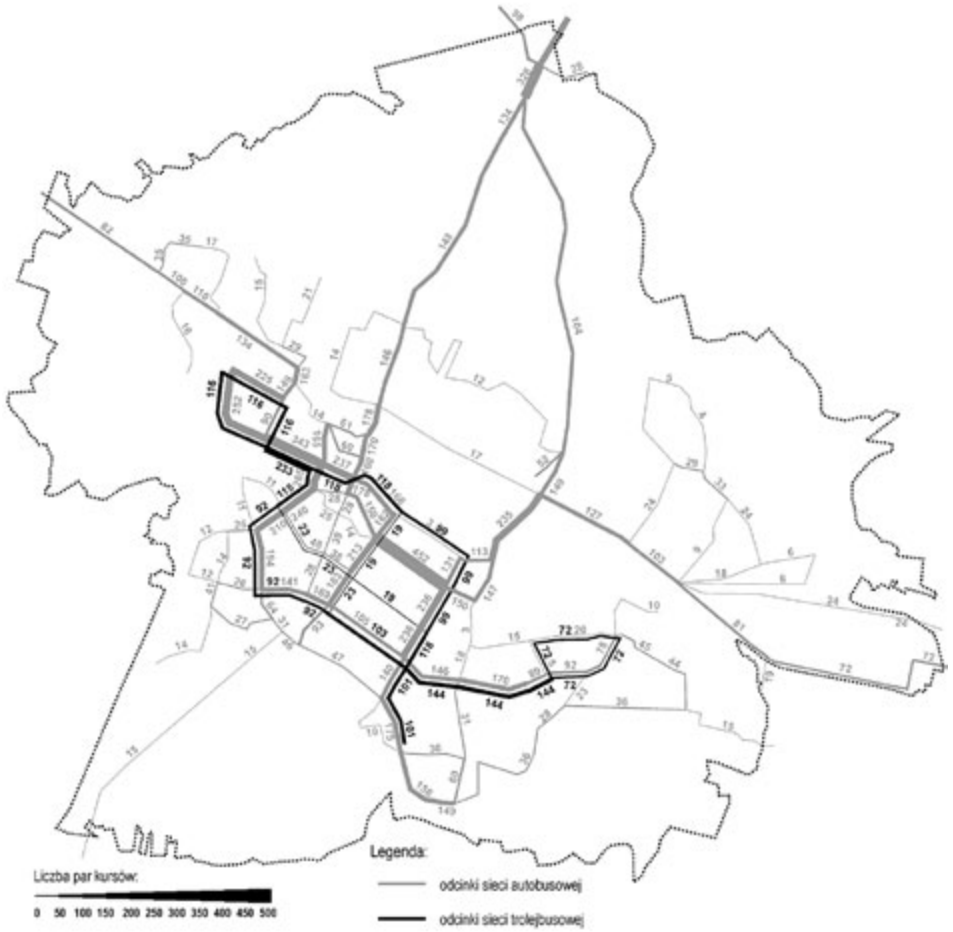

Fig. 3. The number of two-way trolleybus and bus routes on weekdays at 1st January 2008 (black line – trolleybus route, grey line – bus route)
Source: own elaboration

The fleet

In connection with the dynamic expansion of the trolleybus system in Tychy, in 1982 21 ZIU 9B trolleybuses were enquired. The vehicles were numbered in the range 701-712.

In 1985 the another batch of 12 ZIU 682 UP trolleybuses were delivered and numbered in the range of 713 – 724. The ZIU 682 UP trolleybuses were technically the same as the former type and the change of the type number has been made because they were designed to be sold abroad. Some operational technical difficulties and spare parts shortage were main reasons for purchasing the first trolleybus which was made in Poland. It was assembled by Komunalne Przedsiębiorstwo Naprawy Autobusów in Słupsk on the Jelcz bus chassis. The vehicle was numbered

725 and it entered service on 31st July 1989. Its satisfactory operational parameters were the reason why ZIU trolleybuses were gradually withdrawn. This process began in 1990 and lasted 8 years.

In 1992 two trolleybus with experimental thiristor drive joined the fleet and they were numbered 001 and 002. In 1993 4 trolleybus were purchased from Dębica. They were in very poor technical condition, thus they couldn't enter service right away. Those vehicles entered service after they had undergone full refurbishment and they were numbered in the range of 004 – 007. Another two trolleybuses were acquired from Kapena in Słupsk the same year. They were numbered 003 and 008. One year later additional two trolleybuses were purchased from Słupsk and numbered 009 and 010. An unusual exchange between PKM Tychy and MZK Słupsk took place in 1997. It was called "buses for trolleybuses". Seven buses were exchanged for seven trolleybuses that year. The new acquainted vehicles were numbered in the range of 011-017 (see at fig. 4).

Fig. 4. Jelcz Pr110E was converted from bus to trolleybus
Author: Marcin Połom

In the same year a decision was made to purchase some new vehicles from Przedsiębiorstwo Naprawy Taboru Komunikacji Miejskiej in Gdynia. By the end of 1998 TLT had acquainted 7 new Jelcz 120MT trolleybuses, which were numbered in the range of 018 – 024. Additionally, those vehicles were fitted with panoramic windscreens and digital displayers.

It is worth mentioning that during 1998-99 there was a brand new Skoda trolleybus at the depot in Tychy. It was earmarked for promotion of Skoda brand in

Poland. Unfortunately, this vehicle never entered service and it was returned to the manufacturer as being unsatisfactory. That trolleybus has provided service in the capital of Latvia since 2000. Since 2001 TLT has begun purchasing new vehicles again. At first, Jelcz 120 MT trolleybus was acquired. It had been assembled by the Trobus company (former PNTKM) in Gdynia. It was numbered 001 (see at fig. 5).

Fig. 5. Last Jelcz 120MT which was produced in Trobus Company in Gdynia for Trolleybus Transport Company in Tychy
Author: Marcin Połom

A new period of development of the trolleybus system in Tychy started in 2002. The contract for the delivery of new trolleybuses was awarded that year to the Solaris Bus&Coach company from Bolechów near Poznań. In cooperation with the Trobus company from Gdynia Solaris Trollino 12T trolleybus was assembled on Solaris Urbino 12 chasis (see at fig. 6).

The system's first low-floor trolleybus was numbered 004 and it was presented to public on 8th November 2002. From that time on TLT invests in energy-efficient low-floor vehicles. During 2009 six vehicles of that kind were purchased by Tyskie Linie Trolejbusowe Sp. z o.o. The prezent fleet comprises 21 vehicles: 6 low-floor Solaris Trollino 12 trolleybuses and 15 Jelcz trolleybuses (including 9 120MT or 120E type and 6 PR 110E type). The average age of the fleet is 12,6 years. Low-floor vehicles account for almost one third of the fleet (29%). On the citizens' initiative all new Solaris trolleybuses have been given names, so there are "Jaś", "Małgosia", "Tyszek" and "Tysia" in Tychy (see at fig. 7).

Fig. 6. Solaris Trollino 12T was produced in Gdynia in 2003
Author: Marcin Połom

Fig. 7. Trolleybus Solaris Trollino type 12DCR was made in the depot of TLT in Tychy. It has been given name "Tyszek"
Author: Mikołaj Bartłomiejczyk

Investments

In 2008 two companies: Tramwaje Śląskie S.A. and Tyskie Linie Trolejbusowe Sp. z o.o. put forward a proposal on subsidies for the project "*Modernization of the tram and trolleybus infrastructure in the Upper Silesian Agglomeration"*.

This project was accepted by the Ministry of Regional Developmnet. It has been placed on the list of individual projects under the Infrastructure and Environment Operational Program, within Priority 7: Environment-friendly transport, Measure 7.3 Transport in agglomeration, number POIiŚ 7.4-1.4. The project will be partially funded by the European Union form the Cohesion Fund. Company Tramwaje Śląskie S.A. is the beneficiary and Tychy commune is the partner. The qualified spending will be covered by Company Tyskie Linie Trolejbusowe.

The main objective of the project is to modernize the tram and trolleybus systems in cities of the Upper Silesian Agglomeration and purchase new vehicles in order to increase the flexibility of the existing public transport system. Another objective is to make the public transport system eco-friendly.

The main three tasks of the project *Modernization of the tram and trolleybus infrastructure in the Upper Silesian Agglomeration* are:

Task 1. Redevelopment of the tram network,

Task 2. Redevelopment of the trolleybus network,

Task 3. Construction of "Park and Ride" base.

Modernization of the trolleybus system will include (*Opis techniczny*..., 2009):

- intake of 15 brand new low-floor trolleybus with diesel mode, which... battery
- installation of a new overhead from the intersection of Begonii and Budowlanych Streets to the railway station and the intersection of Budowlanych and Burschego Streets.
- installation of a new overhead along Piłsudskiego and Towarowa Streets from the intersection of Armii Krajowej and Metalowa Streets.
- replacement of 19 traditional points with computer-steered points
- replacement of 51 section isolators,
- sandblasting and painting of 1260 trolleybus traction poles
- redevelopment of following intersections:
  1. the intersection of Armii Krajowej and Piłsudskiego Streets (Paprocany Roundabout) – trolleybuses can't operate north-east in two directions,
  2. the intersection of Edukacji and Grota Roweckiego Streets,
  3. the intersection of Budowlanych and Begonii Streets – trolleybuses can't operate east-south in two directions.

Total investment cost of the above-mentioned investment is 50,000,000 zl. Half of the amount will be covered by the city and the second half will be funded by the European Union form the Cohesion Fund. The investment will have been finished by 2012.

Thanks to the modernized trolleybus system, the amount of failures and breakdowns will be decreased as well as the operating costs. The redevelopment of the intersections will allow to open a new trolleybus line, which will improve the connection between Tychy and Katowice. However, the intake of new vehicles won't increase the flexibility of system's operation, because those trolleybuses won't operate on the sections without overhead. Models fitted with batteries or additional diesel propulsion should be acquired, so trolleybuses could operate on unwired sections. Otherwise, only costly development of the trolleybus infrastructure will solve the problem of overlapping the trolleybus and bus networks.

Summary

The trolleybus system of Tychy is the youngest and the smallest trolleybus system in Poland – it is only 40 km long (by a single track). Tyskie Linie Trolejbusowe is the second important operator in Tychy (the first one is PKM Sp. z o.o.) and its vehicles cover the distance of 1,2 million km every year and it is 13% of the passenger service in Tychy.

TLT has a task realization level of 99,7%. The trolleybus network covers most residential areas and it connects them with the major railway station, industrial areas (including the Special Economic Zone) and recreation areas in Paprocany district. Trolleybuses are main means of transport for E, H and R housing estates.

The main disadvatage of the trolleybus system in Tychy is the current shortage of low-floor vehicles and the system's worn-out infrastructure. There's hope that the project *Modernization of the tram and trolleybus infrastructure in the Upper Silesian Agglomeration* will improve the system's condition. Under this project the system will receive 15 brand new low-floor trolleybuses. Additionally, 30% of traction network will be replaced and computer-steered points will be installed. This investment will cause the improvement of technical condition of the traction network.

There is a possibility that in the near future Tychy will be the first city, where low-floor trolleybuses will account for 100% of the fleet. The accomplishment of this project will improve TLT's market position and improve the company's public image. Trolleybuses in Tychy have become a part of the local landscape and they make the city unique. Thanks to them Tychy is regarded as an environmentally friendly city. What's more, the citizens of Tychy like trolleybuses and they have increased their ecological awareness. When in 1999 decision was made to replace trolleybuses with buses, it provoked a strong public outcry.

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Trolleybuses in the city of Gdynia. A historical and geographical study

Conditions for developing urban transport in Gdynia

Development of urban transport is inevitably connected with the process of a city's population growth and its spatial development. The more citizens, the more transportation needs. The larger city, the bigger need to develop mass urban transport. Shaping of the landscape is one of the most important factors in the process of choosing a form of transport.

The first urban transport network in Gdynia emerged at the end of 1927 and at the beginning of 1928 when a private company "Szandrach i Czarnowski" opened a bus line from Śródmieście to Oksywie. Then the company started operating on a new line connecting Gdynia and Sopot (M. Gwiazda, 1983). In connection with unsatisfying conditions of the existiong network and an urgent need for developing it, the Municipal Council of Gdynia decided to create an urban bus transport system (M. Gwiazda, 1983). The Municipal Council submitted an offer to the Ministry of Industry and Trade and in cooperation with Towarzystwo Komunikacji Automobilowej in Poland, having its registered office in Poznań, a transport company was opened. The company's shares were owned by the city (50%) and a company that was managing the transport network.

From 1st January 1930 the urban transport system in Gdynia was managed by Towarzystwo Komunikacji Autobusowej (TKA), which later changed its name to Miejskie Towarzystwo Komunikacyjne (MTK).

During the first few years of functioning the urban transport system in Gdynia the leaders of MTK suggested introduction of a mass transport system powered by electric current. The first route to be converted into an electric line was the route from the railway station to Oksywie. It was also suggested that trolleybuses should have operated on this line, but they were called "trams without tram lines, trams on tires" (M. Gwiazda, 1983). However, this solution was rejected as it was

considered economically unprofitable at that time. Finally, some new diesel buses were purchased to operate on the system's lines.

In 1930's the urban mass transport system was developing very quickly as it was the period of dynamic harbour development and Gdynia's population growth. People started to inhabit areas that were located further from the city centre and the harbour.

The year of 1938 was a significant year in the history of Gdynia's urban transport system. It was the year when a modern depot was built at the crossing of Gdańska (nowadays Zwycięstwa Street) and Sportowa Street (not existing nowadays, but in the past it was a street that connected Sportowa Street with Redłowska Street).

When the second world war started on 1st September 1939 the transport network of Gdynia was involved in defense actions: transporting of injured soldiers and regrouping of military divisions. Most of MTK fleet was destroyed during the war (M. Gwiazda, 1983).

Gdynia was being occupied by Germans and they immediately started converting many factories into military objects and the harbour became a base for Krigsmarine. In connection with that actions it was necessary to transport people to work for the Third Reich. It was the task of the transport company from Gdańsk - Gdańskie Tramwaje Elektryczne S.A. (Danziger Elektrische Straßenbahn AG). This company was forced to hand over some of its busses to Gdynia as all Gdynia's fleet was requisited by Wehrmacht.

A maintenance base was created in halls of former Gdynia Fair, at 1, Derdowskiego Street. The company was named Zakłady Komunikacyjne Gdańsk – Gdynia (Verkehrstriebe Danzig-Gotenhafen) and many employees of MTK were employed there.

However, transportation needs were growing and a problem with liquid fuels emerged, so the occupant started to prepare for electrification of all transport lines. This investment was started in 1942. The important factor for choosing a mode of transport was the landscape. In Gdynia, where the main axis run through a valley between the edge of the upland and the hillock it was nearly impossible to build tram lines. That is why the idea of trolleybus lines was again taken under consideration (M. Gromadzki, M. Józefowicz, 2004).

Development of trolleybus transport

1943-1958 – the period of its creation and reconstruction after the Second World War

On 18th September 1943 the first trolleybus line was opened in Gdynia. It connected the Municipal Council building in the city centre and the railway station in Chylonia. Then, this line was extended to Orłowo (M. Gwiazda, 1983). The first trolleybus line was operated by Henschel trolleybuses (11 vehicles, including 10 complete ones and 1 used a source of spare parts) with AEG electrical equipment and 10 trailers that had been built by Gdańska Fabryka Wagonów. A depot for both, buses and trolleybuses was situated in halls of former Gdynia Fair.

Vehicles frequency on this unnumbered section of the first trolleybus line was very high in the peak hours – 7,5 min. (M. Gromadzki, M. Józefowicz, 2004). In the period of 1943-1944 the fleet was enlarged by trolleybuses confiscated in Kijów, Mediolan and Rome, but they all entered service after the war ended (M. Gwiazda, 1984).

The trolleybus system was operating regularly during the war and no earlier than in 1945 operation ceased as a result of the struggle for liberation. During the struggle some of the vehicles were used as barricades and they were completely destroyed and burned (M. Gwiazda, 1983).

When the military action was over, the period of restoration of the urban transport started. A newly-created institution – Zarząd Miast Wybrzeża decided that the transport companies had to be joined into one company named Międzykomunalne Zakłady Komunikacyjne Gdańsk-Gdynia (M. Gwiazda, 1984). Then, the attention was mainly put on the bus transport system because it did not require high financial outlays as the trolleybus system did. Most of the trolleybus traction and many substations were destroyed during the war. Finally, on 19th March 1946 the first post-war trolleybus route was opened (M. Gwiazda, 1984). It was unnumbered and rather short (1,5 km long) and it ran along Świętojańska Street, from the depot in Derdowskiego Street to the building of the Municipal Council (M. Gromadzki, M. Józefowicz, 2003). Three refurbished GFW/Henschel/AEG trolleybuses were operating on this route. On 27th April 1946 next section of the trolleybus network was opened. It connected the building of the Municipal Council with Orłowo – this line was numbered 11 (M. Gromadzki, M. Józefowicz, 2003). On the same day a new loop in Kaszubski Square was opened (M. Gwiazda, 1984). On 2nd October 1946 line 12 was opened which connected Kaszubski Square with the loop in Grabówek (there is St. Joseph Church nowadays at the crossing of Morska and Zakręt Do Oksywia Street) along Świętojańska and Śląska Street. It could not run along 10 Lutego Street, as it was planned during the war, because the railway viaduct over Podjazd Street was destroyed. At the end of 1946 the fleet comprised 11 trolleybuses (M. Gwiazda, 1984).

The fleet of the Trolleybus Department consisted of vehicles with different bodies and electric systems what caused some operating problems. The fleet comprised of post-war refurbished vehicles and trolleybuses acquainted from other cities that had trolleybus systems at that time or from cities that had the fleet bud did not want to develop trolleybus transport.

On 17th January 1974 line 11 was extended from Orłowo to Sopot and in September 1947 Miejskie Zakłady Komunikacyjne Gdańsk – Gdynia (MZK GG) got a new base in Al. Zwycięstwa Street. At the same time the fleet was enlarged by two refurbished Büssing 900 vehicles. The electric systems were taken from damaged

post-war trolleybuses (M. Gwiazda, 1984). It was considered as quite unusual way of converting buses into trolleybuses, but this solution is still associated with the trolleybus system in Gdynia.

In 1948 both trolleybus lines: 11 and 12 were renumbered into 21 and 22. It was done in order to avoid misunderstandings as two tram lines in Gdańsk were numbered the same. At the end of 1948 the fleet of MZK GG consisted of 45 trolleybuses (M. Gromadzki, M. Józefowicz, 2004).

In 1949 the city needed a larger transport system and the Trolleybus Department was renamed into the Bus-Trolleybus Department. Its task was to manage the urban transport system in all Gdynia. But, what is the most important, on 22nd July 1949 the trolleybus network was extended to Mały Kack and on 29th October a new line to Orłowo was opened. It was numbered 24. As a result of an agreement with MZK Wrocław, Gdynia got 8 Fiat 672 F101 Tallero-Millano trolleybuses. Two trolleybuses of this type were operating on Gynia's lines during the war. What is more, 13 modern Vetra VBR4 vehicles were bought. All of them were operating on line 23 (M. Gwiazda, 1984).

Some new changes were introduced In 1955 when the viaduct over Podjazd Street was rebuild. In that year a new line was opened. It was numbered 25 and connected Kaszubski Square with the loop in Cisowa (Janowska Street). It was possible because the traction network was extended to Cisowa along Chylońska Street. After opening line 25 (1st July 1955), line 22 was shorten and it ended at the loop in Grabówek. At the same time two night trolleybus lines were opened: line 210 which ran along the route of day line 21 and line 220 which ran along the day route of line 22.

The trolleybus network remained in the abovementioned shape until the 1960's. There had been some minor changes introduced: the routes had been slightly modified, they were also several times closed and opened again (R. Anisiewicz, 2004).

In the period of 1946-1950 the old vehicles were gradually replaced with modern ones – AT first Vetra and then Škoda 8Tr trolleybuses. The post-war Henschel trolleybuses were the last old vehicles in operation.

1958-1970 – the period of dynamic development

The year 1958 opened a new period in the history of Gdynia trolleybus transport. This year the city bought some brand new Škoda 8Tr trolleybuses for the first time. Construction of a new trolleybus depot for 150 vehicles started the same year. It was situated next to the already existing base in Al. Zwycięstwa Street (M. Gromadzki, M. Józefowicz, 2003).

On 30th May 1959 the sixth trolleybus Line was opened. It was numbered 26 and it connected Kaszubski Square and Orłowo. On 7th November 1962 it was extended to the loop in Grabówek. During the next few years lots of changes were introduced and some lines ceased operation in connection with modernization of

the main streets of the city. In 1961, when Al. Zwycięstwa Street was being modernized and converted into two-lines street, line 201 was closed and line 21 changed its route several times in the period of 1962-1964 (M. Gromadzki, M. Józefowicz, 2003).

The trolleybus network infrastructure was enlarged again in 1964 when a new branch of the traction was built. It connected Obłuże with Stare Obłuże along Bosmańska Street and further to the loop at the headquarter of Polish Navy. The new traction section created some kind of a street loop around the districts of the northern terrace of Gdynia. A new line was numbered 28 and it was opened on 23rd may 1964 (M. Gwiazda, 1984). There were also some other lines opened – numbered 29 and 30. The routes of the already existing lines were changed what was marked by crossing out their numbers (so called "crossed numbers"). After opening the traction section in Oksywie Górne, the trolleybus network was 34 km long (measured along double tracks) and it was the longest trolleybus network in Poland (H. Bianga, O. Wyszomirski, 1990).

In March 1965 line 27 was opened. It started at the loop in Mały Kack, ran along Świętojańska Street, 10 Lutego Street and Dworcowa Street to the loop in Oksywie Dolne.

As the infrastructure was developed, so the fleet must have been enlarged. From 1962 Škoda 8Tr supplies were replaced with modern Škoda 9Tr vehicles. In the whole history of Gdynia trolleybus transport 113 Czechoslovakian trolleybuses were delivered, including 42 Škoda 8Tr and 71 Škoda 9Tr vehicles (M. Gromadzki, M. Józefowicz, 2004). All those vehicles replaced old post-war trolleybuses, including French Vetra vehicles, that were eventually scrapped.

Until the first half of 1960's the trolleybus transport system was developed. In 1966 a new trolleybus depot was opened along with a fully equipped maintenance base. The depot was so big that 150 vehicles could park there, but the fleet has never comprised so many vehicles.

1970-1981 – the period of stagnation and regression

After the post-war period of dynamic development of trolleybus transport, a period of stagnation came. At the end of 1960's many trolleybus systems in Poland were closed (Poznań – 1970, Olsztyn – 1971, Warszawa – 1973, Wałbrzych – 1973). It was believed that trolleybus transport was unfriendly, obsolete, inefficient, impractical and oldfashion. It was speculated that a trolleybus fleet was twice as expensive as a bus fleet and that its operation costs are 25% higher. Nobody mentioned about ecological aspects of trolleybus operation and about the fact that they can operate 3 times longer than buses (M. Rataj, 1988). The main argument against trolleybuses was their poor technical condition. It is hard to assess whether this argument was legitimate or not because it was forbidden to fix old and faulty vehicles or buy new ones. It was believed that buses would be the future of mass urban transport (M. Gwiazda, 1984).

The last batch of 12 Škoda 9Tr trolleybuses was delivered to Gdynia in 1970. In that year the fleet of the Bus-Trolleybus Department comprised 99 trolleybuses. They were all Czechoslovakian vehicles.

In Gdynia where both, municipal leaders and transport companies wanted to develop trolleybus transport, it was very difficult to accept the central leaders' aversion to trolleybuses. The leaders of WPK GG offered another solution: they wanted to produce their own trolleybuses. The solution was rejected as it was claimed that the best way of enlarging the fleet was to import them from so called "friendly" countries. At the same time the agreement with Czechoslovakia was not prolonged, causing depreciation of the existing fleet and lowering the number of vehicles in use (J. Kaczmarczyk, 1994).

The year 1972 started the worst period in the history of trolleybus transport in Gdynia. When modernization of Marchlewskiego Sreet (nowadays Janka Wiśniewskiego Street) began, the line to Oksywie was closed. Line 23 – to Komuny Paryskiej Shipyard was closed, too and the whole infrastructure was dismantled as well. One year later the trolleybus traction was moved from Śląska to Warszawska Street in connection with construction of Pokoju Overpass. This route which had been planned as a temporary solution is still in use (2008). At that time the whole system consisted of only three lines:

- Line 21: Konstytucji Square (the railway station) – Sopot (Reja Street),
- Line 22: Kaszubski Square – Świętojańska – Warszawska – Chylonia (the railway station),
- Line 25: Kaszubski Square – Świętojańska – Warszawska – Grabówek.

In 1975 all transport companies of the voivodship were joined into Wojewódzkie Przedsiębiorstwo Komunikacyjne in Gdańsk (WPK). In 1976 WPK introduced a project to liquidate the trolleybus system of Gdynia until the end of 1978. The number of buses in Gdynia WPK Department was gradually growing (241 buses and only 49 trolleybuses) (M. Gromadzki, M. Józefowicz, 2003). However, this project was not implemented, mainly because energy supplies problems and some ecological reasons.

The main problem of functioning the trolleybus network in Gdynia was lack of vehicles as they were not delivered from Czechoslovakia since the trade agreement had been dissolved. As a result of this situation a new plan was created. The plan suggested that vehicles for the trolleybus system of Gdynia should have been produced in the company's workshop on the basis of Polish Jelcz-Berliet Pr110U body, electric equipment from ELTA (having its registered office in Łódź) and Škoda engines taken from the old fleet vehicles (J. Cypel, 1982).

As a result of the project two prototypical trolleybuses were constructed and the first one was presented on an exhibition of the fleet of the urban transport system of Gdańsk. In 1976 another project emerged – the project for construction of a new trolleybus with old Škoda SM11 body and the most modern system of impulse drive (M. Gwiazda, 1984; J. Kaczmarczyk, 1994).

But the leaders of the central headquarters were not interested in these Project as well as in the idea of lowering the costs of enlarging the fleet. Russian trolleybuses were purchased instead of Polish vehicles, despite the fact that they were not as durable and modern as Polish ones, constructed in Gdynia. In 1975 the first two ZIU trolleybuses were delivered to WPK and in October 1976 the next 20 if the same type.

It was planned that in the period of 1976-190 twenty Russian trolleybuses would be purchased.

In accordance with a ministry plan, modernization of the traction network in Gdynia started in 1976. As a part of this plan the traction network along Wielkopolska Street to Mały Kack (ceased in 1974) was modernized and the section to the loop at the Komuna Paryska Shipyard (the traction network was dismantled here in 1972) was built.

The new Russian trolleybuses were not delivered on time and this fact had a negative impact on the condition of Gdynia's system fleet. What is more, spare parts to the Czechoslovakian vehicles were not available at that time. It was necessary to wind up some trolleybuses for the spare parts – it was some kind of "cannibalism". As a result of this actions, in 1978 there were only 41 vehicles in the WPK department in Gdynia and line 21 had to be converted into a bus line. It became obvious that the only way to keep the trolleybus system running is to produce Polish vehicles and finally, the ministry approved this solution. Construction works on 20 vehicles started and in the period 1980 – 1982 a whole batch of Polish trolleybuses was produces, what improved the image of the trolleybus system in Gdynia.

1981-1998 – the second period of dynamic development

In the period of 1975 – 1985 103 ZIU 9 trolleybuses were purchased and in combination with the native production it was possible to reopen line 29 to Orłowo and construct trolleybus traction network along Jana z Kolna Street (9th March, 1981) and along Migały Street (nowadays Wójta Radkego Street) on 13th October. During the next few years lines 23 and 29 were prolonged to the section with the loop at the Komuna Paryska Shipyard (opened on 21st July, 1982).

In 1984 the trolleybus fleet comprised of 102 vehicles (it was the largest fleet in the history of the trolleybus system in Gdynia until 2008). Unfortunately, the ZIU trolleybuses were poorly constructed and there were lots of problems with their usage. It was necessary to maintain large technical reserves.

As the fleet was gradually developing, new lines were being opened (M. Józefowicz, M. Gromadzki, 2003). At the beginning of May 1983 the traction network along the Czerwonych Kosynierów Street (nowadays Morska Street) from Działdowska to Kartuska Street was constructed. After 11 years line 26 to Orłowo was reopened.

In July 1985 line 26 was prolonged to the loop in Cisowa Sibeliusa – it was the second section of the route along Czerwonych Kosynierów Street.

In the first half of 1980's the trolleybus system of Gdynia was planned to be developed. Many routes were electrified (including the routes to Pustki Cisowskie, Witomino, Redłowo, Demptowo) and some new sections were opened leading to housing estates in the west part of the city (Karwiny, Wielki Kack). On 1st August 1989 a new section of the trolleybus traction was built – along Wielkopolska and Chwaszczyńska Street to a new loop in Nowowiczlińska Street.

When WPK Gdańsk was divided into four smaller companies on 1st May 1989 Miejskie Przedsiębiorstwo Komunikacyjne in Gdynia (MPK) was created. It was an extremely important event in the history of urban transport in Gdynia. The new company had some financial problems and the trolleybus system with its worn out fleet and infrastructure had to wait for its time to be developed and modernized. In fact, buses were again in the centre of attention (M. Gromadzki, M. Józefowicz, 2004). In 1990, as a part of a project of enlarging capacity of trolleybuses and buses the first articulated trolleybus was produced. It had an Ikarus 280 body and the electric system taken from old ZIU trolleybuses (J. Kaczmarczyk, 1994).

In accordance with the act passed on 8th March 1990 organizing and maintaining of urban transport were duties of municipal authorities. As a result of this act MPK was transformed into Miejski Zakład Komunikacyjny (MZK). At the same time local authorities in cooperation with the Transport Economic Department at the University of Gdańsk created a project of the urban transport system reorganization. MPK was divided into several smaller companies: Przedsiębiorstwo Komunikacji Autobusowej Sp. z o.o. (PKA) (depot in Pogórze Dolne), Przedsiębiorstwo Komunikacji Miejskiej Sp. z o.o. (PKM) (depot in Kacze Buki), and Przedsiębiorstwo Komunikacji Trolejbusowej Sp. z o.o. (PKT) (depot in Grabówek).

This new structure had a positive impact on image of the urban transport system. On 5th September 1995 a new trolleybus loop at the station of the fast urban train station (SKM) was opened and a section of the traction network along Owsiana Street (in Cisowa) was finished. The route of line 25 was changed, so it ran along Morska and Owsiana Street from the loop at Cisowa SKM station to Kaszubski Square. The route of line 27 was changed twice this year, at first it ran from Kaszubski Square to the railway station in Chylonia and then it was extended to Cisowa (after opening the modernized section of the traction network along Chylońska Street, from Kartuska to Owsiana Street).

More changes were introduced on 6th May 1996 – on the day when the route to Pustki Cisowskie was opened. This route was partly built in the 1980's. A new line, that was numbered 28 was opened. It ran along 10 Lutego, Podjazd, Morska, Chylońska and Kartuska Street to the loop in Chabrowa Street. Routes of lines 23, 24 and 30 were slightly changed, too. Lines 22 and 27 were suspended because Chylońska Street was being modernized at that time.

From 1995 PNTKM in Gdynia produced 6 new PNTKM/Jelcz 120 MTE trolleybuses a year in cooperation with Zakłady Samochodowe in Jelcz-Laskowice.

1998 – the year when the trolleybus system became independent

Until 31st December 1997 the trolleybus transport system was a part of Przedsiębiorstwo Komunikacji Miejskiej (PKM) and there was a shared depot for buses and trolleybuses (in 2000 PKM got a new depot in Kacze Buki and PKT moved to the depot in Grabówek). According to K. Szałucki and O. Wyszomirski (1998) establishment of Przedsiębiorstwo Komunikacji Trolejbusowej (PKT) on 1st January 1998 was an important stage of restructuring of mass urban transport in Gdynia.

Since 1998 the board of Przedsiębiorstwo Komunikacji Trolejbusowej was trying to make up for investment arrears – the fleet and trolleybus traction was being modernized (J. Bogusławski and others, 1998). As it came up later, modernization of the traction network was an essential issue. As a public opinion poll showed (this kind of marketing research was being carried out every two years from 1994) trolleybuses were negatively perceived in Gdynia, mostly because of unreliability of their collectors. When some modern solutions of Electroline were implemented, this negative image was changed. Modern remote controlled network switches and crossings allowed trolleybuses to drive smoothly and without unnecessary stops. Arch-type runners provided an excellent work of the collectors and the traction network (M. Józefowicz, O. Wyszomirski, 2004).

The fleet was also enlarged, but the purchased middle floor vehicles made by a local producer were obsolete and their propulsion systems were inefficient as they were designed in the 1070's. Trolleybuses produced by PNTKM in the 1990's were very similar to the vehicles produced in 1980's by KPNA in Słupsk and to those 20 trolleybuses produced in Gdynia in the period of 1980 – 1982.

In connection with a burning need to improve the condition of the trolleybus fleet in 1999 it was decided that PNTKM would build (for PKT) a low entrance trolleybus on Jelcz M121 body and a chopper propulsion system made in cooperation with Electrotechnical Institue in Warsaw and Woltan – a company from Łódź. The first PNTKM/Jelcz M121MR trolleybus (fig. 1) was constructed this way and its modern energy reclaim system allowed to reclaim the energy consumed during each braking. Unfortunately, the interior was not ergonomic as it was a combination of a low (between I and II doors) and a high floor (between II and III doors) with two quite steep stairs. That is why only one prototypical vehicle of this type was constructed. The second PNTKM/Jelcz M121MR trolleybus was exported to Kowno (Lithuania) in 2001 when PNTKM was trying to acquire some new clients (J. Cisłak, 2003).

The next project for developing the trolleybus system in Gdynia was favourably received by the municipal authorities and on 6th December 1999 two new lines were opened:

- Line 20: Kaszubski Square – 10 Lutego Street – Cisowa SKM,
- Line 27: Karwiny „Euromarket" – Warszawska Street – Cisowa SKM.

Fig. 1. Low entrance trolleybus PNTKM/Jelcz M121MT
Author: Krystian Jacobson

The year 2001 brought some more significant changes when a new trolleybus loop at Węzeł im. F. Cegielskiej was opened as a part of a "Droga Różowa" road investment. What is more, four low floor Solaris Trollino 12T trolleybuses (fig. 2) entered service in the same year. These vehicles were considered a worldwide novelty. At the same time 18 articulated GANZ/Solaris Trollino 18 trolleybuses were constructed for the trolleybus system of Ryga by the company named GANZ Transelektro Traction Electrics from Hungary (J. Goździewicz, 2001; G. Rutka, 2001).

Solaris Bus&Coach (former Neoplan Polska) – a company having its registered office near Poznań started producing vehicles for trolleybus transport at the very beginning of the XXI century, but the cooperation between PNTKM and Solaris Bus&Coach was impossible due to a tight budget of PNTKM. Despite that, Solaris and its co-producers produce vehicles for numerous trolleybus systems in Europe (M. Józefowicz, M. Połom, 2004).

When PNTKM stopped producing trolleybuses, the board of Przedsiębiorstwo Komunikacji Trolejbusowej had to introduce another type of Solaris vehicles. There were two available solutions: a Hungarian GANZ and a Chech DPO. The Czech vehicle was chosen and on 22nd September 2003 the first Solaris Trollino 12AC trolleybus entered service – it was the day of the 60th anniversary of opening the trolleybus traction in Gdynia (M. Gromadzki, M. Józefowicz, 2003).

Fig. 2. Low floor Solaris Trollino 12T trolleybus constructed by PNTKM in Gdynia
Author: Mikołaj Bartłomiejczyk

In 2003 PKT owned about 80 trolleybuses, including 6 low floor vehicles and one historical Saurer 4TIILM, that had been acquired from Warsaw (fig. 3) (J. Goździewicz, 2003).

The fact that the Gdynia's fleet comprised such a small number of low floor trolleybuses arouse a wide discussion among those who were involved in creation and management of mass transport in Gdynia. In December 2003 it was decided to enlarge the low floor vehicles by converting old bus bodies (M. Połom, 2005). It was a risky decision, but it was necessary as the PKT budget was very tight and there were no money to purchase brand new trolleybuses. An additional motivating factor was the fact that according to the another public opinion poll the trolleybus network was not perceived positively by the citizens of Gdynia (both bus companies: PKA and PKM had a 100% low floor fleet and their vehicles were disabled-friendly) (comp. M. Gromadzki, J. Wensierski, 2004). Construction works on the first vehicle of that type took over three months and on 6th December 2004 it entered service. It was built on the basis of a Mercedes Benz O405N body (fig. 4). Until the end of 2010 twenty-three more vehicles were built and the next two (with Mercedes Citaro bodies) were in production.

Fig. 3. Saurer 4TIILM historical trolleybus
Author: Bartosz Milczarczyk

Fig. 4. One of the group of the last five Mercedes O405N converted into trolleybuses in Gdynia, and fitted with a modern asynchronous propulsion system
Author: Marcin Połom

The project entitled
"Development of pro-ecological public transport in Gdynia"

The next important stage of development of trolleybus transport in Gdynia started in 2004, when at Zarząd Komunikacji Miejskiej prompting, Gdynia City Council passed "Integrated Development Plan of Public Transport in Gdynia for years 2004-2013". In this document there is a development policy concerning trolleybus transport in Gdynia.

According to the plan, until the end of 2013 trolleybuses would cover 35% of public road transport operations – 11% more than in 2004 (J. Bogusławski, 2006).

The main assumptions of the plan:

- growth in a total length of the trolleybus routes from 36,4 km to 53,7 km;
- enlarging the fleet by 21 vehicles (from 64 to 85 vehicles);
- creating a fleet consisting of low floor trolleybuses only.

The municipal authorities of Gdynia accepted the development program in 2004. The project entitled "Development of pro-ecological public transport in Gdynia" was created. It was assumed that it would be co-founded in 50% from the EU Regional Development Operational Programme. The project was highly ranked by the commission and it was one of the first projects co-funded by The European Union.

Tasks for the period of 2005-2006:

- building a new trolleybus depot in Grabówek along with a covered car park for 90 trolleybuses,
- opening 10,6 km of new trolleybus routes to Dąbrowa, Dąbrówka, Kacze Buki and a route along Zakręt do Oksywia Street,
- building a new trolleybus loop in Kacze Buki,
- purchasing 10 low floor trolleybuses.

Total project value was 53 276 718 złoty and Gdynia got about 25 000 000 from the EU (T. Dyr, 2006).

When the Ministry of Regional Development accepted the financial plan for the project, it was finalized in two years time from the date of signing the agreement with the general contractor (10th March 2005). The last phase of the project was opening the trolleybus depot on 27th April 2007.

Before the depot was opened two new trolleybus routes were created. The first one was the route in Dąbrowa opened on 19th December 2005. It was reactivated line 24 – the tenth line of the trolleybus system (fig. 5, fig. 6).

Eight months later the second route was opened along Rdestowa, Chwaszczyńska and Starochwaszczyńska Streets to a new loop in Kacze Buki. This route was opened on 7th August 2006 and trolleybuses from lines 23, 27 and 31 started to operate on it. It replaced bus line 121 and line 31 was extended to Sopot, where line 121 had ended (fig. 7).

Fig. 5. Opening of the route to Dąbrowa in 2005
Author: Marcin Połom

EU financial support made it possible to create very favourable communication link to remote districts having the environmental factors in mind. It was an important issue, as Dąbrowa and Kacze Buki are located in close proximity of Tricity Landscape Park.

The project "Development of pro-ecological public transport in Gdynia" was the first stage of ZPRTP realization. When the EU budget period ended in 2006, the municipal authorities of Gdynia became aware of the financial possibilities for the period 2007-2013. They tried to grab the chance and in 2008 another project was created. Its total value was over 98 million zl.

The project entitled
"Development of pro-ecological public transport
in Tricity Metropolitan Area"

The project entitled "Development of pro-ecological public transport in Tricity Metropolitan Area" was co-founded in 70% from the European Regional Development Fund as a part of the Regional Operational Programme for Pomorskie Voivodeship. Total value of the project was over 98 million zloty. Przedsiębiorstwo Komunikacji Trolejbusowej Sp. z o.o. was a final beneficiary.

The main objective of the project was to: modernize the traction network along Al. Zwycięstwa Street in Gdynia and Al. Niepodległości Street in Sopot with the

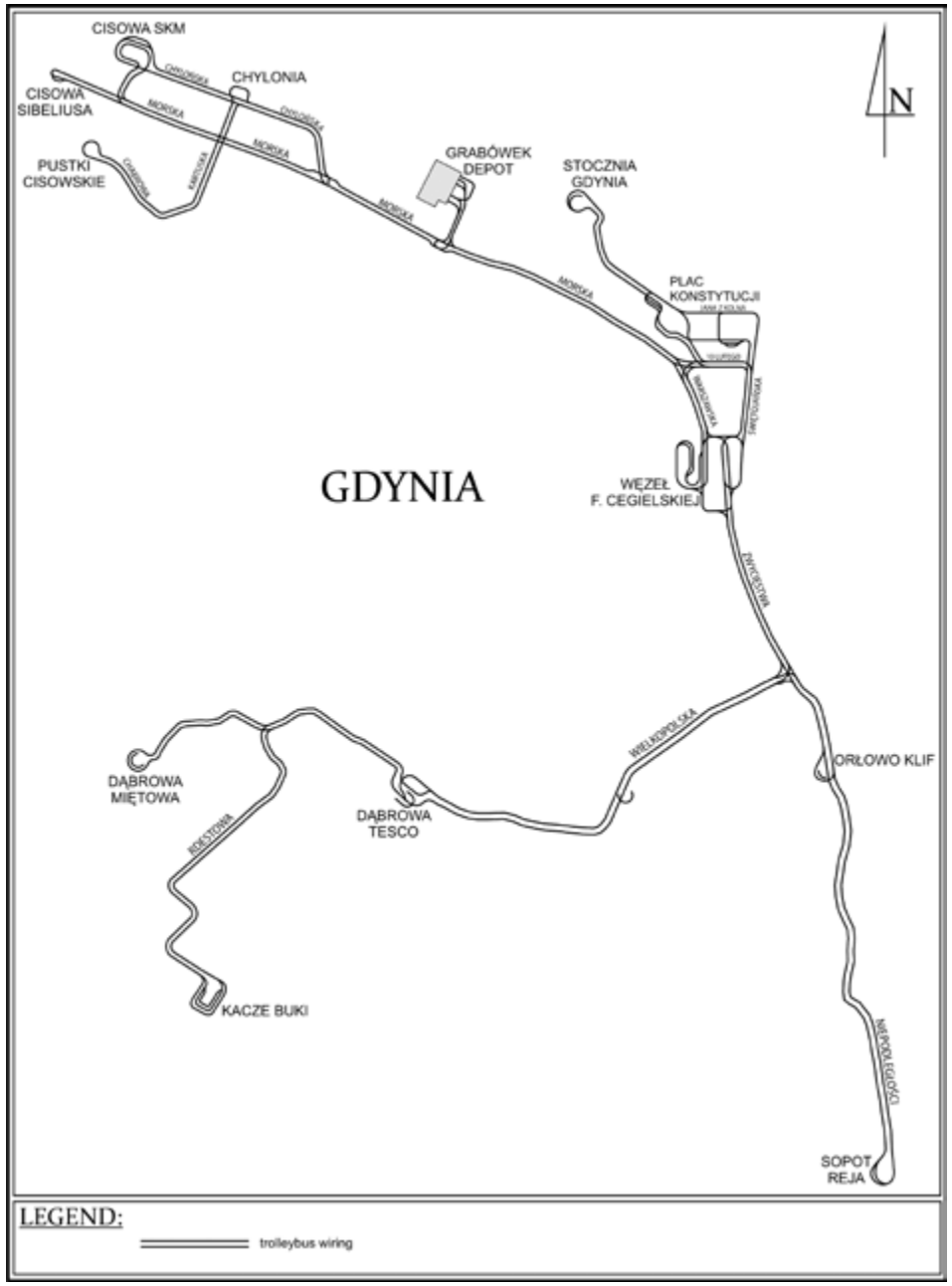

Fig. 6. Scheme of the trolleybus network in Gdynia, 2010
Author: Maciej Beister

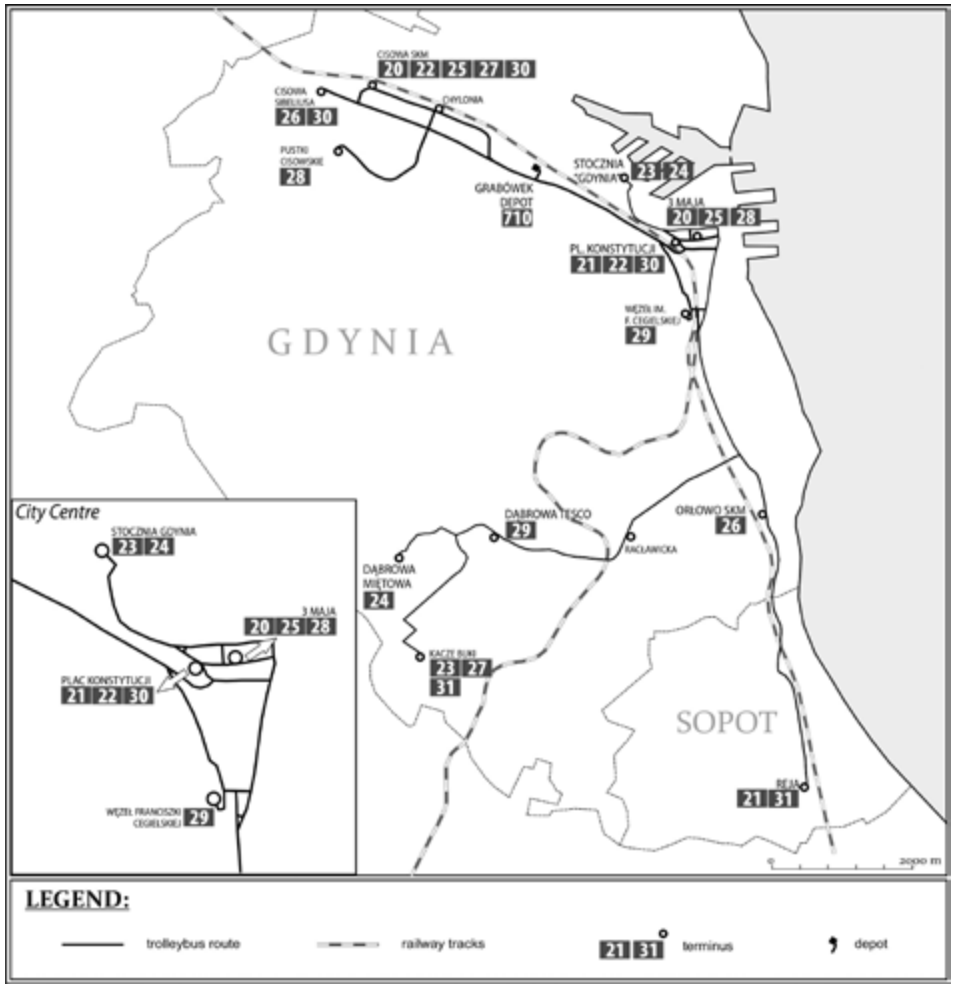

Fig. 7. Scheme of the trolleybus network in Gdynia, after 2006
Author: Maciej Beister

loop in Reja Street; construct four new traction substations; modernize 5 existing traction substations; build a substation remote control centre and purchase 25 new low floor trolleybuses (fig. 8).

Preparations for implementation of the project started when the final beneficiary was sure that the project would be co-funded as a part of the Regional Operational Programme for Pomorskie Voivodeship for 2007-2013. Implementation of the project started on 26th January 2010 when a co-financing agreement was signed at the Office of the Marshal. The estimated total cost of the project was 98.647.644,72 zl and the eligible cost was 78.464.576,00 zl. 70% of the eligible cost was co-funded as a part of the Regional Operational Programme for Pomorskie Voivodeship for 2007-2013. 31st October 2011 – it was Planned date of project completion.

Fig. 8. A low floor Solaris Trollino 12M trolleybus
Author: Karol Grzonka

All the expenses were divided into 10 tasks connected with the project's objectives: building works (substations, the substations remote control centre; fig. 9), investment supervision, author's supervision, purchase of 25 new trolleybuses, promotion of the project, documentation, promotion and marketing campaigns on sustainable mass transport (organized by Zarząd Komunikacji Miejskiej in Gdynia), feasibility study and salaries.

Przedsiębiorstwo Komunikacji Trolejbusowej has already put three tasks out to tender (tab. 1) and another one is in a preparation stage. The educational campaign is carried out by Zarząd Komunikacji Miejskiej and this institution is responsible for its settlement. All other expenses involve refund of the money that had been spent on the project before (according to the project documentation) or the tasks that do not have to be put out to tender (promotion of the project, author's supervision).

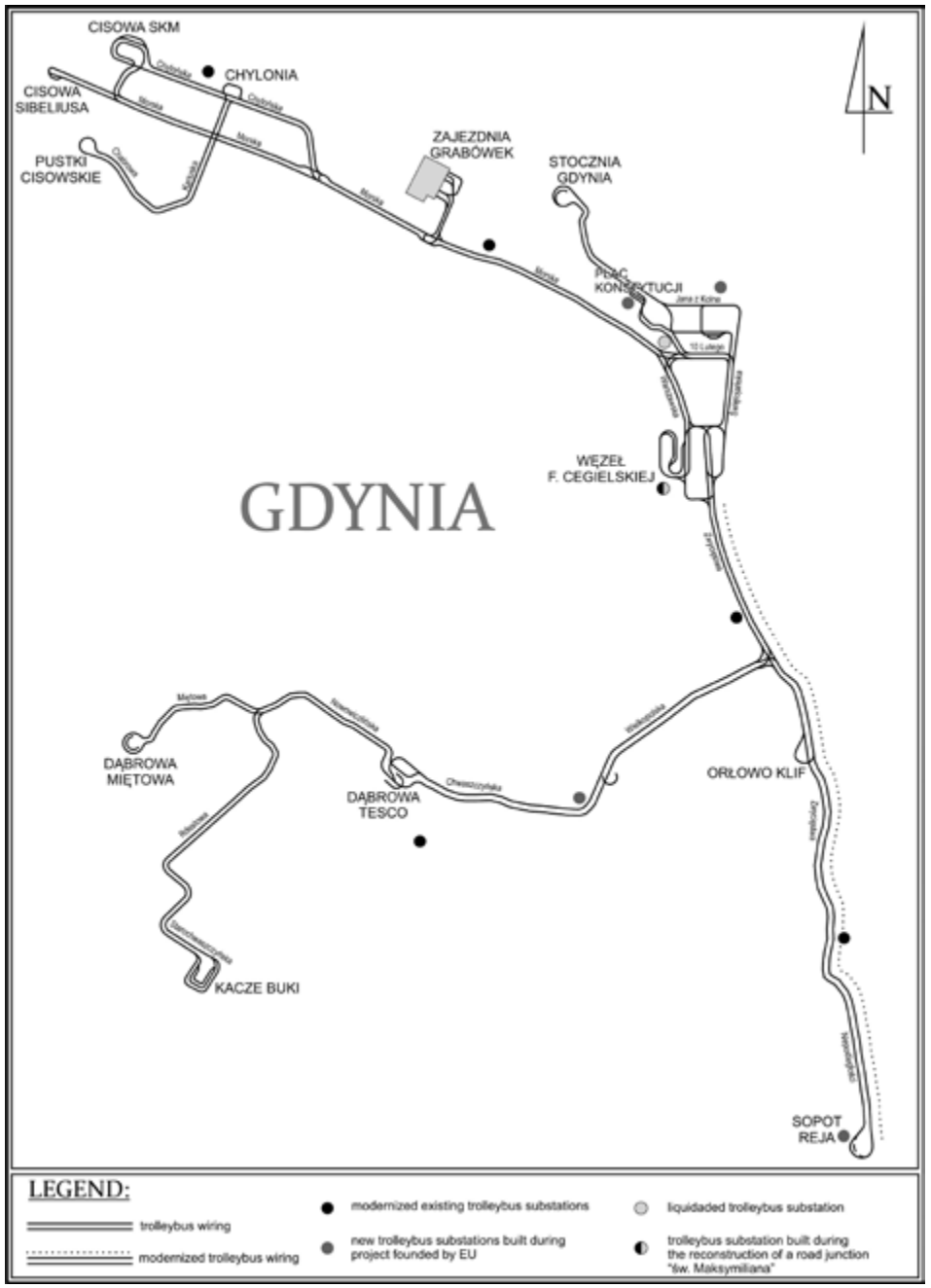

Fig. 9. Scheme of the trolleybus network in Gdynia with the investments realized as a part of the Regional Operational Programme for Pomorskie Voivodeship
Author: Marcin Połom, Maciej Beister

Tab. 1. The tasks that have been put out to tender by Przedsiębiorstwo Komuniacji Trolebusowej

	Name of the task	Estimated cost (gross, PLN)	Signature of the tender	The name of the contractor (the winner of the tender), the date of signing the agreement	contractual price (gross, PLN)
1.	Modernization the traction network along Al. Zwycięstwa Street in Gdynia and Al. Niepodległości Street in Sopot with the loop in Reja Street	17.202.000,00	Under preparation		
2.	Modernization of five substations: Północna, Grabówek, Redłowo, Chwaszczyńska and Sopot; Construction of four new substations: Plac Konstytucji and Tadeusza Wendy (as a replacement for the Dworzec substation); Construction of the substation remote control centre.	27.558.794,72	3/RPO/2010	Elektrobudowa S.A. 20.05.2010	15.742.344,41
3.	Purchase of 25 low floor trolleybuses	48.800.000,00	2/RPO/2010	Solaris Bus & Coach S.A. 10.06.2010 r.	48.464.500,00
4.	Investment supervision	915.000,00	1/I/RPO/2010	Tebodin SAP-Projekt Sp. z o.o. 26.07.2010	605.120,00

Source: own work on the basis of www.pktgdynia.pl

As the table above shows, the contractors for three tasks are already known:
- modernization and construction of the substations and the substation remote control centre,
- delivery of 25 low floor trolleybuses,
- investment supervision.

As a consequence of all tenders it was possible to save some money, concerning especially the task 2 ("Modernization of five substations..."). There were several reasons for this: strong competition in this market section, higher demand for construction and building services and the fact that the project estimate had been prepared in the period of an unfavourable exchange rate period (PLN/EUR).

The project "Development of pro-ecological public transport in Tricity Metropolitan Area" will allow to stop an unfavourable process of extending the travel time on the line between Gdynia and Sopot. As a result of equipping trolleybuses with an alternative power source the number of delayed or cancelled trolleybuses

will decrease. Modern trolleybuses are more comfortable and safe for passengers thanks to interior monitoring systems. They will be more friendly to the elderly and disabled. Modernization of the power system will eliminate most of the breakdowns, including voltage drops. Changing the centralized power system to more decentralized one will increase reliability of trolleybus transport. The remote control centre will allow to react quickly in an emergency.

Summary

In the past trolleybus transport was the most undercapitalized form of public transport, not only in Gdynia. Relatively high costs of trolleybus infrastructure discouraged local authorities to invest in trolleybus transport and Przedsiębiorstwo Komunikacji Trolejbusowej did not have enough money to develop it on its own. Buildings, substation apparatus, traction network and the fleet have definite durability and they need modernization. Thanks to EU funds it is now possible to make the trolleybus system of Gdynia modern. Gdynia has made the most of this chance as two abovementioned projects have been co-funded from the Regional Operational Programme. Trolleybus transport should be developed as it is one of the most ecological form of transport. When the project "Development of pro-ecological public transport in Tricity Metropolitan Area" ends, the entire fleet of Przedsiębiorstwo Komunikacji Trolejbusowej will be low floor, the power system and the traction network will be modern and reliable.

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