Development of the tram network in the big city (on the example of Lviv)

B S Posatskyi, T M Mazur, E I Korol

Department of urban planning, Institute of Architecture and Design, National University of Lviv Polytechnic, 12 S. Bandera street, Lviv, Ukraine

nicmaztam@gmail.com

Abstract. The article presents an analysis of the development of the Lviv tram network from the end of the XIX th century till nowadays and for the near future. The stages of construction of tram depots and development of tram lines in the context of the city territory servicing, their changes, and connection with the configuration of the city street network are shown. City planning approaches to further development of the tram network infrastructure are presented.

1. Introduction

In the developed countries of the world, modern transport policy and practice of urban transport planning are based on the concept of development of the intermodal transport systems. The idea of intermodally involves the balanced and coordinated use of cars and various modes of public passenger transport. Public transport not only offers a wide range of ways to travel in the cities but also integrates well with developed pedestrian areas and gives the urban environment a humanistic look and scale [1].

Tram is one of the oldest types of public passenger transport in the city. From the late 1950s, the increasing level of motorization and the emergence of new types of passenger transport (trolleybus, bus, shuttle taxis) are gradually pushing the tram out of the city streets. However, due to its high transport capacity, the introduction of modern technologies in the production of tramcars, the improvement of their environment-friendly characteristics and, consequently, a more favorable impact on the urban environment, the tram transport has regained its popularity and underwent a real renaissance over the last decades. Trams and light rail systems are rapidly returning to major European cities, where tram tracks have been mostly dismantled for the past 60 years. Today, rail transport remains the only way to preserve large cities with buildings of varying density, especially their central historic districts [2,3].

2. The tram network in Lviv: history and modernity

The tram network in Lviv has a long history of formation and development. The first trial rides on a horse-drawn tram in Lviv took place in 1879 [4]. The regular electric tram line on the main Railway Station – Stryiskyi Park, started in 1894. Lviv became the first in Galicia and the fourth in Austria-Hungary (after Vienna, Budapest, and Prague) to establish a regular tram route. The construction of tram tracks and the construction of a depot were the successive stages of the development of tram infrastructure in the city.

To serve the needs of the electric tram and the Regional General Exhibition in Stryiskyi Park at the beginning of the Vuletskа Street (now - Academician Sakharov Street) the tram depot and the first city power station on the bank of the Mlynivka River was built, which was then flowing in an open channel.
The location for the power plant was chosen based on the needs for using water to cool the steam turbines and equidistant from the terminal stops of the first line of the electric tram (Main Railway Station – Stryiskyi Park). The 300 kW power plant, together with the first tram depot, was built by Siemens-Halske, a firm which was engaged in the construction of the tram lines in Lviv in 1894. This technical solution was very advanced for that time, as it provided a reliable supply of electricity for the tram needs [5]. The project of a complex of buildings of the tram depots and a power plant at the intersection of Pelchynska and Vuletska Streets (now Vitovskyy and Academician Sakharov Streets) was designed "in a brick style" by the famous Lviv architect - A. Kamenobrodsky [6]. The first tram line was extended to the eastern border of the city already in the following 1895, the so-called Lychakiv Slingshot with a branch to the Lychakiv Cemetery; back then the length of the two lines was 8.3 km. In 1906 was built a new line on the Konovalets Street and thus appeared the first three radial directions of the Lviv tram lines.

Figure 1 Lviv. Electric tram network (according to D. Kovalev): A - 1895; B - 1909
1 - Electric tramline; 2 - depot of the electric tram; 3 - terminal tram stop; 4 - horse tramline; 5 - horse tram station

Figure 2 Lviv. The tram depot at the intersection of D. Vitovsky and Academician Sakharov Streets: A - 1906; B – 1927

For the new mean of transport - electric tram, the old depot was expanded, and new depots have been built. The new tramway hangar, built-in 1906 at the intersection of D. Vitovsky and Academician Sakharov Streets, was larger than the first building (1894) and had a big production shop covered by metal trusses with a glass roof lamp. A particular example of industrial architecture in the form of
European Art Nouveau (secession) was the tram depot at Gabriilevka, built in 1908 on the Novoyi Rizni Street (now Promyslova Street). The architect Y. Bogutskyi embodied the structural basis of the building of new at that time material of reinforced concrete in the original flowing forms of the Secession style, popular during that time in Lviv. Exceptionally spectacular was the main facade of the depot house with decorative metal gates, completed with a large parabolic attic on the two pylons [6].

The new depot was intended to meet the needs of the tramway traffic of the well-developed tram network. As of 1909, radial directions were built on the Shevchenko Street (to the so-called Janivska Slingshot), Zamarstynivska, B. Khmelnytskyi, Promyslova. Track on Gorodotska Street connected S. Bandera and T. Shevchenko Streets, and the upper part of Lychakivska Street got a connection with Ivan Franko and Zelena Streets. The new tram tracks have been built on both sides of Svboda Avenue and became ring junctions between Horodotska Street and the diameter West-East (Main Station - Lychakivska Street).

In 1926 - 1927 the need for the reconstruction of an old tram depot at the corner of D. Vitovskyi and Academician Sakharov Streets occured again - the building of one more industrial pavilion, administrative building, and the surrounding fence. The project was executed by A. Kamenobrodskyi in classical forms, thus achieving the stylistic similarity between the buildings of the late XIXth - early XXth centuries [6].

From the time of construction during the 1920s the tram depot at the corner of Vitovskyi and Academician Sakharov Streets was transformed into car repair shops. They were engaged in the repair of rolling stock by the end of the XXth century. In 1911 the tram track from the so-called Lychakiv Slingshot was brought to the Lychakiv Railway Station, thus creating the second transport hub in Lviv, which existed before the Second World War in 1939. Taking into account the tram connection to the Pidzamche railway station, it can be stated that the tram connected the three main Lviv railway stations (Main station, Pidzamche, Lychakiv) with the suburban transport network. Using modern terminology, already at the beginning of the XXth century three transport hubs have been formed in Lviv [7].

Further development of the tram network in Lviv took place under the newly established Polish state in 1920 - 1939. In 1925, a tram line was built from Kropyvnytskyi Square along Horodotska Street to the intersection with Kulparkivska Street on the western outskirts of the city. The tram track was also laid from the Torgova Square along the Shpytalna Street and P. Kulish Street with the turn-on Pid Dubom Street along the railway track to Zamarstynivska Street. A significant addition to the tram network in the city center occurred in 1928 when a two-lane line was built along Kyivska and Vitovskyi Streets between S. Bandera and Ivan Franko Streets. This line formed the southern part of the tram ring around the historic center, which is still heavily used today [7].

The growth of tram connections led to the further development of infrastructure, which is why a new tram depot (today №1) was built near the freight railway station on Horodotska Street, 183 in the 1930s [8]. The production part of the depot consisted of four parallel hangars, each with four tracks, which together made 16 tracks. The construction of the large building was made in a monolithic reinforced concrete frame, the cross spans of hangars covered parabolic reinforced concrete forms with roof lights to provide natural light. In addition to the premises for the maintenance of trams (a dispensary, which conducted daily inspections of trams and workshops for their overhaul), the depot also had two administrative buildings. The traction electrical substation №3, built in the early 1950s, was also located there [8].

Thus, as of 1939, the length of tram lines in Lviv was 32,812 km, with a total length of 60,872 km. During the years 1935-1939, two-lane tram lines with a length of 5,690 km (17.6%) were reconstructed by eliminating one-lane lines on the streets of 29 Lystopada (now E. Konovalets), V. Poninskyi (now Ivan Franko) and Kozelnyska [9]. In the late 1940s tram tracks have been located on both sides of Svboda Avenue and their conjunction made it possible to turn the tram.

The tramway network began to change after the Second World War during the Soviet period of the city’s development. In the early 1950s, streets began to be prepared for the introduction of trolleybuses and, accordingly, the tramway on Svboda Avenue was closed. Instead, in 1951, was built a new two-
lane line from the Torgova Square (behind the Opera House) through the squares of Yaroslav Osmoysl and Danylo Halytskyi, and then along Pidvalna Street to the junction with Ruska Street.

Figure 3. Lviv. Tramlines network (by D. Kovalev): A - 1925; B - 1936
1 - electric tramline; 2 - depot of the electric tram; 3 - terminal tram stop

Figure 4. Lviv. Tram Depot No. 1 on Horodotska Street: A - 1931; B – 2010

The new line, laid in the northeastern part of the boulevards of the late XIXth century, covered the medieval historic center of Lviv with a ring and connected four main radial directions: Horodotska, Bogdan Khmelnitsky, Lychakivska, and Ivan Franko streets [7]. During the 1970s, tram lines in the center of Lviv continued to decline; the tracks that led to Vysokyi Zamok Park and the upper part of Stryiskyi Park by Ivan Franko Street have been dismantled. Today, from the perspective of the tourist traffic development, it can be argued that back then the city lost an attractive tourist object - a tram, which was going up the steep streets of M. Lysenko and M. Kryvonis to the plateau of the High Castle (ukr.: "Vysokyi Zamok"). Relatively recent track dismantling took place in 2003 on the Halytska square and Knyaz Roman Street due to the reconstruction of the square for the installation of the monument to Danylo Halytskyi [7]. At the same time, in the 1970s have been developed projects that foresaw the development of the tram network in Lviv. Based on an elaborated scheme for the development of all types of public urban transport (developed by the Dipromisto Institute in 1975), the technical and economic foundation for the construction of an underground tram was developed. It was planned to create three tram diameters: from the south to the east (Knyagynt Olhy Street - Lychakivska Street), from the southeast to the north
(residential district of Sykhiv - Zamarstynivska Street), from the southeast to the west (residential area of Sykhiv - residential areas Levandivka and Ryasne). Within the central part of Lviv, these diameters were outlined to be laid in tunnels, and at their intersections was planned the construction of underground stations in two levels with escalator crossings and underground lobbies [10].

The concept of an underground tram in Lviv began to be realized with the construction of a landline on a separate lane along the radial streets of Academician Sakharov and Knyahynya Olga to the ring street - Naukova. The portal of the underground entrance was to be located on the territory of the old depot at the intersection of the streets of D. Vitovskyi and Academician Sakharov. The two-lane line was commissioned in 1987 and significantly improved the city’s southern sector transport connection with its historic center. This track was the first to go beyond the built-up during the pre-war period area of the city (until 1939). It is important to note that the population of the city from 1939 to 1989 increased from 320,000 to 786,000 inhabitants [11].

In the eastern part of Lviv in 1984 a two-lane line was built from the I. Mechnikov Street to the Palace of students on A. Vakhanianyn Street, also providing a convenient connection with the forest park "Pohulyanka" [10]. As of 2007, the total length of the tram lines in the city was already 76.43 km, including the passenger lines 67.3 km [12].

Along with the development of the Lviv tramway network infrastructure, appeared the question of the reconstruction of the oldest depot at the intersection of D. Vitovskyi and Academician Sakharov Streets. In 1994, a decision was made to open a depot in one of the hangars of the museum, but even nowadays it is still not fully operational. The question of changing the function of the old tram depot has been repeatedly raised in professional circles and by the Lviv City Council [13]. In 2017, another decision was made to reconstruct it. For this purpose, the depot is leased for 50 years to set up a community center for the development of innovative technologies, recreation, and cultural events [14].

As mentioned above, as early as the middle of the 1970s, it was planned to build a tramline from the city center to the then-designed Sykhiv housing district of 120,000 inhabitants. It became possible to return to the implementation of this project only at the beginning of the XXIst century after the construction of the bridge over the tracks of the Persenkivka Railway Station, thus ensuring the unhindered transport connection between Sykhiv and central part of the city.
The Sykhiv tram track was commissioned in two stages. The first began on the V. Stus Street in the historical center of Lviv and ended in 2016 at the intersection of Chervona Kalyna Avenue with the Sykhivska Street. In the first year of operation, this route was used by almost 5 million passengers. In the second phase in 2017, the line was completed till the final planned stop on the V. Vernadsky Street. As of 2019, nearly 20 million people have benefited from this route, as two lines have been introduced: the first (№8) - Soborna Square - V. Vernadsky Str.; second (№4) - Main railway station - V. Vernadsky Str. [15]. Thus, during 2010 - 2018 the volume of passenger traffic for trams in Lviv increased from 49808 thousand people to 58808 thousand people (similarly for trolleybuses - from 25876 thousand people to 31220 thousand people) [16].

It should be mentioned that the development of the Lviv tramway network at the end of the XXth century and the beginning of the XXIst century still occurs by increasing the length of the radial directions in the absence of their annular connections in the new city districts, which covered the historic area of the city with the ring. Therefore, the proposal for the continuation of the Sykhiv tram line from V. Vernadsky to Naukova Streets with the connection to the bus station on Stryiska Street is being currently discussed. This line will connect the Sykhiv housing district with the residential area along Naukova Street between Stryiska and Knyahynya Olga Streets [17]. And the construction of tram tracks on V. Vernadsky Street will allow taking tram routes to the Arena Lviv stadium, which is now insufficiently connected by public transport.

3. Conclusions
At the present stage, the object of strategic urban planning in the field of land use, construction, and development of transport systems should not be a city within its administrative boundaries, but an agglomeration (metropolitan area), the boundaries of which are determined by the epure of regular passenger traffic.

The Lviv City Council plans a comprehensive approach to the development of the Lviv tramway network through its development in the residential areas of the 1960s and 1980s, where the number of inhabitants continues to grow due to the building densification and increase in the height of new residential buildings. It is planned to lay the tram tracks for the new routes, such as tracks on A. Lincoln Street (from Zamarstynivska St. to Promyslova Street), from Promyslova Street to B. Khmelnytskyi Street, on I. Mykolaychuk Street (from Promyslova Street to P. Orlyk Street), on Pasichna Street (from Lychakivska St. to Medova Pechera St.), on Lychakivska Street (to the town of Vynnyky). "Lvivelectrotrans" also plans to continue the route of tram №8, putting the track on Knyahynya Olga Street (from the Aquapark to Truskavetska Street, and Stryiska Street), and on V. Vernadsky Street (from Stryiska Str. to Chervona Kalyna Avenue) [18].

This approach will encompass both the planned changes in the administrative structure of Lviv for 2020 after the organization of the Lviv United Territorial Community and, accordingly, the prospects for a significant increase in the population and territory of the city.

4. References:
[1] Vuchic V R 2017 Transportation for Livable Cities (New York: Routledge) p 388
[2] In praise of the tram: Britain's lost network and the future of transport Cities / The Guardian 2018 URL: https://www.theguardian.com/cities/2018/aug/24/in-praise-of-the-tram-britains-lost-network-and-the-future-of-transport
[3] Kohl S 2015 150 years of tram in Berlin URL: https://t2m.org/newsletter/view-from-the-street/150-years-of-trams-in-berlin/
[4] Kotlobulatova I P 2009 Dates and events in the history of Lviv (Lviv: Avers) p 208
[5] Kryzhanivskyi A 2015 History of electrification of Lviv region (Lviv: Halytska vydavnycha spilka) p 360
[6] Biriulov Yu O 2008 Arkhitektura Lvova: Chas i styli. XIII – XXI st. (Lviv: Tsentr Yevropy) p 720
[7] Posatskyi B S, Mazur T M, Korol Ye I 2018 Tram network in the historical center of a large city (on the example of Lviv) Mistobuduvannia ta terytorialne planuvannia 67 (K.: KNUBA) pp 391–397
[8] Liahushkin A, Yankivskyi D 2018 Lviv tram depot. History and contemporary’s URL: https://photo-lviv.in.ua/livivski-tramvajni-depo-istorya-i-suchasnist/
[9] Lwów 1934 – 1939. Development paths of the urban economy 1939 (Lwów) p 80
[10] Trehubova T O, Mykh R M 1989 Lviv. Architectural and historical essay (Kiev: Budivelnyk) p 272
[11] Lozynskyi R 2005 Ethnic warehouse of the population of Lviv (Lviv: Vydav. Tsentr LNU imeni Ivana Franka) p 357
[12] Nazaruk M M 2008 Lviv in the twentieth century: socio-ecological analysis (Lviv: Ukr. akad. drukarstva, vyd. tsentr LNU im. Ivana Franka) p 348
[13] Mazur T M, Korol Ye I 2018 The problem of preservation and modern use of industrial culture objects (on the example of Lviv) National scientific space: perspective, innovations, technologies: Proceedings of the VAll-Ukrainian correspondence scientific-practical conference (Kharkiv) pp.15-26
[14] Rievunova I 2017 Why invest $ 7 million in an old depot. What will be the innovative space of LEM Station in the Lviv tram depot URL: https://zaxid.net/navishhovkladati 7_mln_u_stare_depo_n1436739
[15] Three years ago, a tram was launched in Lviv to Sykhiv 2019 URL: http://tvoemisto.tv/news/try_roky_tomu_u_lvovi_zapustyli_tramvay_na_syhiv_video_104524. html
[16] Transport, information society. The structure of the freight turnover URL: http://www.lv.ukrstat.gov.ua/ukr/themes/09/theme_09.php?code=9
[17] The petition to extend the tram from Sykhiv to Naukova received the required number of votes 2018 URL: http://tvoemisto.tv/news/petytsya_pro_prodovzhennya_tramvaya_z_syhova_do_naukovoii_nabrala_neobhidnu_kilkist_golosiv_97298.html
[18] Rodak K 2019 New tram and trolleybus lines are planned to be built in Lviv URL: https://zaxid.net/u_lvovi_planuyut_proklasti_novi_tramvayni_i_troleibusni_liniyi_n1474625