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Die Renaissance der Straßenbahn in Granada

Dr. Ing. Francisco Calvo, Dr.-Ing. Juan de Oña, Carlos Peña

Seit dem Ende des 19. Jahrhunderts gab es in vielen spanischen Städten Straßenbahnnetze. Keines überlebte die 1970er Jahre. Seit kurzem haben wieder einige Städte, wie Madrid, Barcelona und Bilbao Straßenbahnsysteme eingeführt. Andere Städte, wie Granada planen neue Netze oder haben mit deren Planung begonnen.

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THE REVIVAL OF TRAMWAYS IN GRANADA

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PRESENTATION

Many Spanish cities had tramways networks since the end of the 19th century. None of them survived the 70's. Currently, some cities have revived the tramway system (Madrid, Barcelona and Bilbao, for instance) and many others, like Vitoria and Granada, are either planning or have started to do so.

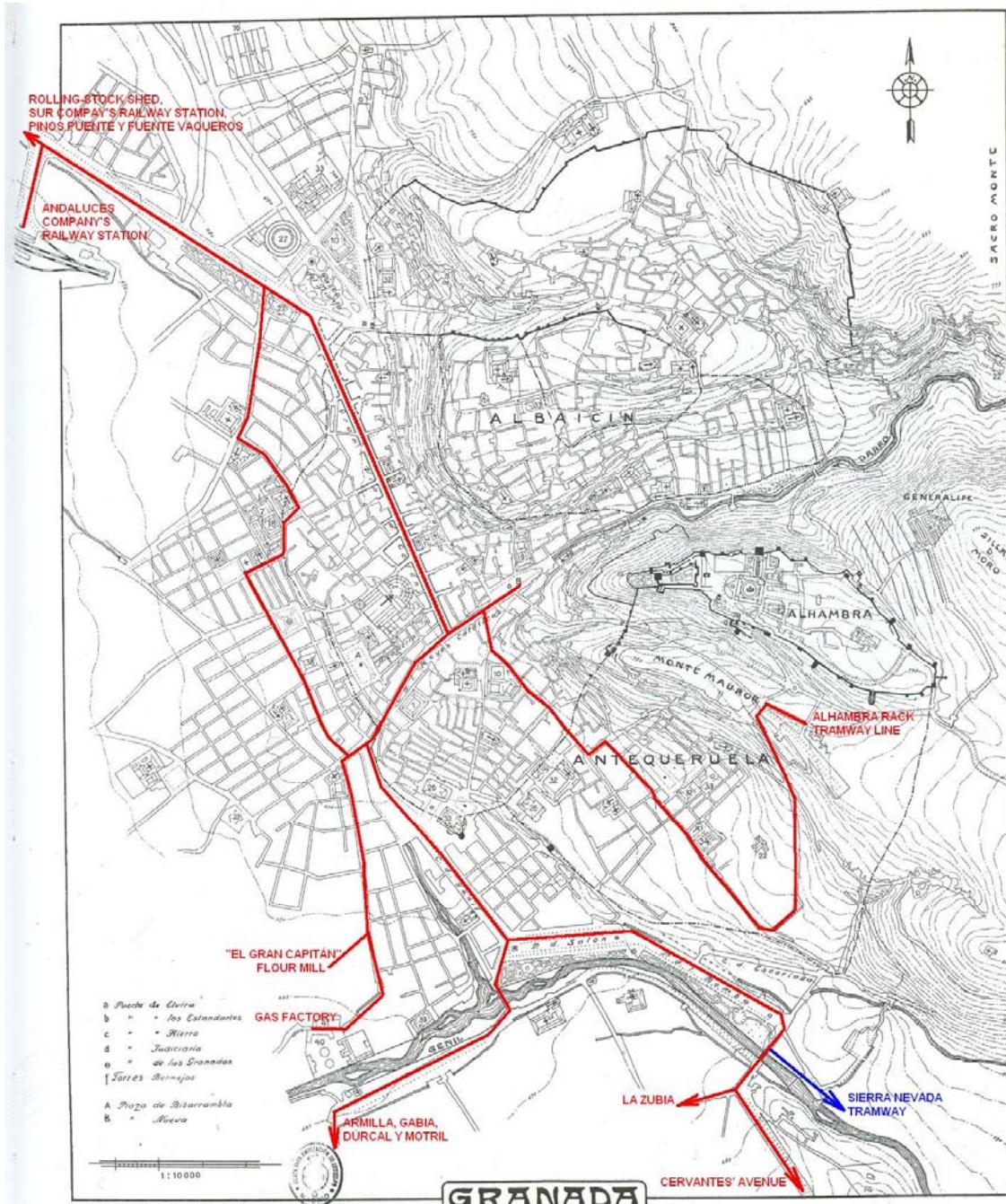
ABSTRACT

An extensive tramway network was developed in Granada at the turn of the 20th century. Until the 50's, the network was a key method of transport between Granada and the province's towns and factories (mainly sugar factories). However, lack of investment, competition from road haulage and marginalization on the part of the local government brought it to a close in the 70's. Traffic was transferred to roads. Lately, a huge increase in mobility has turned roads into an unsustainable method of transport and therefore trams are being reintroduced in Granada. This article compares the two types of networks, whilst keeping in mind their economic, social and urban context.

1. THE 20TH CENTURY TRAMWAY NETWORK

1.1 The urban tramway network

The city of Granada's first urban tramway network dates back to 1904. It was built (in metric gauge and electrified at 750 v) by the Granada tram company Tranvías Eléctricos de Granada Sociedad Anónima (TEGSA). Initially, it ran from the Compañía de los Ferrocarriles Andaluces's train station to the Santa Juliana sugar factory, which was close to the town of Armilla, and had branches to Plaza Nueva Square, Paseo de la Bomba Avenue and the gas factory (Figure 1). In the beginning, TEGSA planned to complete the urban network with new projects. In 1907, the company built a rack tramway line that linked the city to the Alhambra. Later would come a line giving direct access to the city centre along the newly built GranVía de Colón Avenue and the doubling of the track along the rolling-stock shed line. A hydroelectric power station was set up in 1907 as a convenient source of power. These improvements were intended for an extension of the tramway lines to the nearby towns, in view of the unsatisfactory results of the urban network.



Source: author's compilation based on [1]

Figure 1 — Granada's urban tramway network in 1950

1.2 The regional network

Towards the end of the 19th century, Granada and the surrounding region (La Vega) experienced important demographic and economic growth when several sugar factories were set up in the area. TEGSA attempted to capture the important flow of passengers and freight generated by the sugar factories by building two regional lines: One through Armilla and Churriana to Gabia la Grande (which was completed in 1912) and the other through Maracena and Albolote to Atarfe (inaugurated in 1917) (Figure 3). The roads in La Vega were unpaved and often impossible for carts to negotiate, so the incipient network meant a considerable improvement in the speed and capacity of transport.

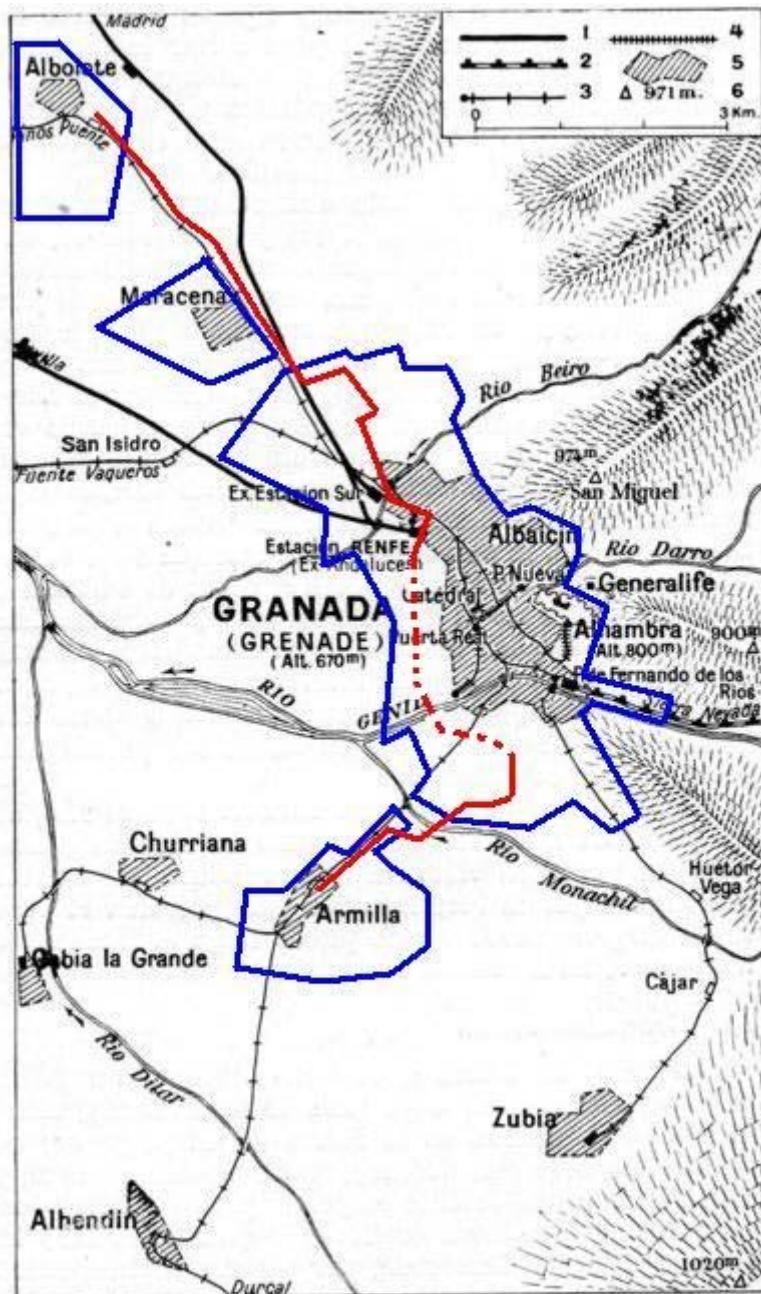
Furthermore, a direct line from Granada city to the town of Santa Fe was inaugurated in 1914.



Source: [2]

Figure 2 — Motor coach on the Alhambra line in 1908.

In 1912, TEGSA was run by a new Management Board (with close ties to the previous Board chaired by Nicolás de Escoriaza) comprising representatives of the German-Swiss electrical engineering industry, concretely the Sociedad Española del Acumulador Tudor Company, a branch of the Accumulatoren Fabrik A. G. in Berlin, as well as a representation of Granada companies. When it took over, the new Board made a proposal to extend the regional network to the boundaries of La Vega and to lay the bases for a railway link to the port of Motril, on the coast of Granada province (in the Mediterranean Sea). Thus, the regional line to Atarfe was extended to Pinos Puente in 1918, thereby linking the province's major industrial hub to the capital city. In 1919 the Santa Fe line was extended to Chauchina. In 1921, the south line was extended from Armilla to Alhendín (en route to Motril) and a new line to La Zubia was inaugurated (Figure 3).



1. Main railway lines (non-electrified, 1,668 mm track gauge); 2. Sierra Nevada Tramway (electrified, 750 mm); 3. Granada trams (electrified, 1,000 mm); 4. Rack railway section of the Granada Tramway system; 5: Population centres in 1950. Blue line: Boundaries of population centres in 2005. Red line: Light railway line. Broken red line: Underground section.

Source: author's compilation based on [3]

Figure 3 — Granada regional tramway network in 1950 and new light railway line

By 1920, the regional expansion programme was nearly complete, creating the conditions to go beyond regional boundaries and begin the link to Granada's coastline. The Alhendín line was extended to Dúrcal in 1924 (Figure 4), which completed the first section of the link to Motril's port. Due to its length and freight transport potential, the line was electrified at 1,200 v. The regional network was used to provide a passenger service to the above-mentioned towns and also to link the freight transport service to the area's main production centres: the Santa Juliana, La Purísima Concepción and San

Isidro sugar factories, the Centauro cement factory, the gas factory, and the El Capitán flour mill, among others.



Source: [4]

Figure 4 — A tram crossing the viaduct of Dúrcal (1971)

Everything seemed ready for the completion of the railway line to the coast, but the link to Motril's port was to have a very different fate: in 1924, TEGSA held a Board Meeting at which a decision was made to build a cable railway (for freight only) from Dúrcal to Motril instead of extending the tram line from Dúrcal. The Company's drastic change of plans cannot be fully explained with the available data. Obviously, due to the complex relief of the land and, consequently, the very high costs involved, extending the railway line to the sea would have implied an enormous investment which TEGSA was probably unable to assume. Furthermore, a railway connection between the inland and Motril's port apparently would have meant competition for Malaga's port and that may have been another reason for the final decision. In the end, the cable tram was inaugurated in 1927.

During those years, TEGSA promoted freight transport and began to diversify its business. However, global depression in 1929, political instability and the company's share in the sugar industry, which was already beginning to show signs of a slump in the La Vega area during the 30's, led TEGSA to complete ruin. The outbreak of the Spanish Civil War (1936-1939) only made matters worse.

A mention of the Sierra Nevada tramway (Figures 1 and 3) will complete the description of Granada's regional network at the beginning of the 20th century. The line was part of a series of works whose ultimate purpose was to use the Sierra Nevada mountains as a tourist attraction. The line followed the valley of the Genil River to Estrella, where it was to connect with a cable railway that would go to 2,500 m above sea level, with two intermediate stations. Plans were made to build hostels for tourists

and sportspeople at the height of the intermediate stations and the upper station. The tramway line had a 750mm track gauge and was electrified to 1,200 v. It was inaugurated in 1925 and extended to the Barranco de San Juan ravine in 1947. The line was 20 Km long and went through a stunningly beautiful landscape, with very steep ramps, 15 tunnels and 21 bridges. It carried passengers and freight, although its main purpose, the tourist trade, could not be fully developed because the line and the cable railway link were never completed.

1.3 Over-exploitation during the Spanish Civil War and decline of the 60's

After the civil war, the lack of other means of transport obliged Granada's tramway system to meet an increased demand for passenger transport (around 20 million passengers per year) which remained constant until the city service was closed in 1959. TEGSA did all it could to keep the permanent facilities and rolling stock in repair, despite its limited budget and the lack of replacements. The only network extension that could be made was from Santa Fe to Fuente Vaqueros in 1939. Major reform projects were planned in the city of Granada in the 50's, but TEGSA was not invited to participate. The city network was closed almost entirely at the beginning of the 60's when the city transport was awarded to a private bus company. Increasingly, the regional network was also experiencing lawful and unlawful competition from roads. Tramway rolling stock and installations were fast becoming obsolete, and financial losses followed shortly thereafter. In view of the situation, the Management Board decided to abandon operations in 1971. The government took over what was left of the network and, making no plans for modernization, closed it permanently in 1974. Thus, one of the most extensive tramways network in Spain was lost (134 Km).

2. THE 21ST CENTURY TRAMWAY NETWORK

2.1 The necessary return of the tramway

Over the past three decades (just immediately after the tramway disappeared), the city of Granada and the surrounding towns have multiplied their population by 1.6. The metropolitan area has grown to a population of close to 500,000 inhabitants, half of which live in the city. The towns grew to nearly twice their size [5], thereby increasing traffic to and from the city. Rapid population growth and the more mobility caused a huge increase in the use of private vehicles instead of an adequate provision of infrastructures and public transport. This in turn caused serious congestion, atmospheric and noise pollution, a barrier effect and accidents. This worrying situation in Granada, arising only 15 years after closing the Granada tramways, caused the authorities to consider a revival.

However, once a tramway line is dismantled, it is very difficult to set it up again. Generally, former railway land has been developed and, despite of the popular call for the revival of trams, citizens tend to view them as a threat to their cars rather than an instrument for improving quality of life in their city. Thus, it took another 15 years of talks between stakeholders before the new tramway (currently called a "light railway") became a reality. The planned line would go under ground along Camino de Ronda (Figure 3) due to the opposition by certain groups, despite the fact that the street is an urban dual carriageway and therefore wide enough for a light rail line. Furthermore, Granada is a middle-size city, so a line at ground level would have been a more appropriate solution [6].

2.2 The light rail project

As Figure 3 shows, the light rail line (under construction from both ends in 2008) links the three most important towns in the Granada Metropolitan Area (Albolote, Maracena and Armilla) to the capital. It starts in Albolote, goes through Maracena and, when it reaches Granada city, makes a detour to the bus station and then goes on to the railway station, which will have high-speed trains in 2013. It then goes on to the university campus, continues along Camino de Ronda (an underground section) to the Zaidín district and to the Campus de la Salud complex (this complex is an important area of urban development, with areas for public and institutional use) before reaching the end of the line in Armilla. The line has a 1,435mm track gauge and is 16.2 Km long: 13.5 Km at ground level and 2.7 Km underground. There will be 26 stations, 3 of which will be underground. The layout parameters are a minimum curve radius of 30m and a maximum gradient of 40%. The main features of Granada's light rail trains (Figure 5) are:

- Articulated electric train units, operating on 750-volt direct current.
- Low-floor cars at a maximum height of 350 mm above the rail. Inside, the entire floor is at the same level.
- The box is 31m long and 2.65 metres wide, with capacity for 200 passengers and room for wheel chairs and bicycles.
- The commercial speed would be around 24 Km per hour (a top speed of 50 Km per hour at ground level and 70 Km per hour in the underground sections).

The demand forecasted for 2011 (the estimated completion date) is 12 million passengers per year. To meet the demand, the planned tram frequency is every 8 minutes for peak periods, 11 for intermediate periods and 15 for off-peak periods [7 y 8].



Photograph: Marcos Maté (2007)

Figure 5 — The light rail in Seville, similar to the one that will operate in Granada

3. CONCLUSIONS

At the start of the 20th century, due to the industrial development in Granada city and the surrounding La Vega region, a tramway network was designed to transport freight between the main centres of production (sugar cane factories) and transport facilities (railway stations and port). The network also carried passengers travelling to and from the factories, and between the towns and the city. Today there is little industry left in Granada, whose economy is now primarily services-based (tourism, the University and as a hub for public services). These factors, and the above-mentioned increase in population, and car and bus traffic over the past 30 years, are the reason behind the revival of the tramway in the Granada Metropolitan Area, albeit for passengers only.

The 20th century network was star-shaped, with its centre in Granada city (inside of which ran the urban network) and branches leading to the surrounding factories and towns. The light rail, by contrast, will consist in a single line that will link the three most important towns in Granada's Metropolitan Area to the city. Therefore, the metropolitan line (16 Km) is much shorter than the old network line (134 Km).

Another significant difference between the two lines is that the 20th century urban network ran through the heart of Granada's old quarter (Figure 1) which now concentrates tourism, shops and services and has the highest potential for attracting passengers, whereas the light rail runs along Camino de Ronda (Figure 3) and is therefore removed from the centre. The new layout not only fails to resolve the issue of traffic in the city centre but also contributes little to securing the highest number of passengers. Furthermore, the fact that it runs under ground along Camino de Ronda makes it less accessible, another aspect that counts when it comes to capturing passengers in a middle-sized city like Granada.

The re-establishment of a railway makes it obvious that with the sudden dismantling of an entire tramway system, cities lose a valuable public asset. Granada and other Spanish cities should have maintained and updated their tramway networks (at least the main lines) instead of transferring all transport to the roads. Two considerations support this assertion:

- Reintroducing the tramway involves a much higher cost than what maintaining the existing one through its decline and subsequent updating to modern standards would have implied, as seen in the cities of Valencia and Alicante. This is not only true in economic terms, due to the investment involved, but also in social terms, due to the external costs of dense car and bus traffic.
- Aside from being more expensive, reviving tramways in a city tends to involve long-term planning, heated discussions among stakeholders, and opposition from private vehicle owners and citizens affected by the undertaking. Construction work generally goes on for longer than expected and projects become even more expensive, as in the case of Granada.

Finally, plans for constructing a cable railway from Granada to the Sierra Nevada mountains are currently under way. The old tramway line to Sierra Nevada, which wound its way through a stunningly beautiful landscape, would have been a strong tourist attraction in Granada, particularly if the planned cable railway had been added to the end of the line. It would also have prevented dense car and bus traffic to Sierra Nevada, which frequently clogs the road and pollutes the natural environment. In line with the above, if the rack railway to the Alhambra had been preserved, it would have

provided sustainable transport to the monument, aside from being a tourist attraction in its own right. Currently, improving the city's link to the Alhambra is a major concern in Granada, which is why plans are underway for a cable railway.

BOXED QUOTATION

The current projects for resolving mobility issues in Granada (light railway and link to the Alhambra and Sierra Nevada) were already in place or being planned over 60 years ago.

4. REFERENCES

- [1] Jürgens, O.: Ciudades españolas: su desarrollo y configuración urbanística. Ministerio para las Administraciones Públicas, Madrid (1992).
- [2] Castillo, A., Giménez, M., González, L. Martín, M., Núñez, G., Peña C., Piñar, J., Reyes, J., Rubio, M. y Titos, M.: Granada. El tiempo de los tranvías. CajaGranada, Granada (2004).
- [3] Lartilleux, H.: Geografía de los Ferrocarriles Españoles. Servicio de Estudios del Consejo de Administración de la R.E.N.F.E., Madrid (1954).
- [4] Wiseman, J.: Trenes y tranvías en el sur de España. Ediciones TREA, Gijón (Asturias) (2008).
- [5] Spanish National Statistics Institute. www.ine.es (2007)
- [6] University of Granada: Estudio de la viabilidad, sostenibilidad e integración en la ciudad del metro ligero de Granada. Ente Público de Gestión de Ferrocarriles Andaluces, Sevilla (2004).
- [7] AYESA: Estudio Informativo de la Línea de metro ligero de Granada. Junta de Andalucía, Sevilla (2002).
- [8] Ente Público de Gestión Ferrocarriles Andaluces. Consejería de Obras Públicas y Transportes. Junta de Andalucía. www.ferrocarrilesandaluces.com (2008)