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Night-time public transport: case study of Madrid, Spain

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ABSTRACT

Key words:

Urban, Night public transport,
Network analysis

This paper researches the Night-time public transport in Madrid, one of the most famous by its night-life European city. By explaining the history of its night-time transport since 1974, when 11 night urban lines have been created, an analysis of the current situation is presented, which concerns the night transport extension to the rest of the municipalities inside Madrid area. Based on official statistical data and surveys provided by the corresponding municipality authorities, the efficiency of two interurban night-time lines of interest is analyzed. The methodology uses demographic and network analysis based on the passenger patterns during 2017. Quantitative graph measures of the Madrid's night transport such as diameter and clustering are also presented. Finally, some comments and recommendations for improving the current city's night-time public transport, as well as some future extensions of the analysis are presented.

Introduction

Urban transport and night urban transport has been a focus study of many researchers in order to connect night urban life with different aspects such as sustainability, transport, safety, labor, etc. Many attempts have been devoted to the problems related to the policies of night-time mobility concerning technology, mobility, and the social time and space (Green 2002), youth cultures and consumption in the night-time (Hollands 2002), night-time economies (Hubbard 2005; Duff and Moore 2014) and the urban mobility in the twenty-four hour city (Smith and Hall 2013). Many of these aspects have been researched through the historical aspects of the urban night (Adams et al. 2007; Bissell 2010), the urban renaissance, policing and social regulation (Helms et al. 2007) and the historical evolution of planning the night-time city (Roberts 2009; Shaw 2010).

More recent investigations concern the spatio-temporal patterns of the urban night by using suitable analysis (Cusimano et al. 2010), satellite data (Ting et al. 2015) and mapping changes of anthropogenic night light (Small et al. 2013). Some aspects concerning night road safeness has been also researched (see Fors and Lundkvist 2009 and the references therein). As a general observation, the urban night is being transformed into more dynamic and more diverse than ever before, including night-time lighting, night-time leisure industry or night-time transport among others (Shaw 2018).

In the present publication we focus on the historical evolution and current status of the night-time urban transport in Madrid, Spain. By using data, obtained from the public transport enterprise, corresponding to 2017, we analyze two night lines connecting the capital with different municipalities in Madrid area. An additional analysis, by using methodology of the theory of complex systems, is also presented at the end of the manuscript, which contributes to the better understanding of the quantitative aspects of the problem.

The Night public transport in Madrid, Spain

History of the Madrid's night transport

In October 1974 a night bus circuit was implemented in Madrid as a response of the raise of the taxi's rates. The circuit consisted of 11 radially arranged "N"(Night - Nocturno) lines which linked the center of the city with the peripheral neighborhoods. The night-transport lines operated from 0h to 6h in the morning and costed 10 times less compared to now day prices. They started from Cibeles Square, forming a start itinerary (History night transport Madrid).

Until 1990, the night bus transport was gradually implemented in the main municipalities of the metropolitan area, either by introducing new night lines or by extending the already existing lines.

In 1994, the night urban public transport of the city of Madrid has been extended up to 20 night lines. Later, in 2000 a massive expansion of service coverage, which reached many more municipalities, has been created. However, the interurban night buses were inefficient on weekends and showed important delays, overcrowding buses with an average interval of 60 minutes, without satisfying the necessities at that time.

In 2006, the so called 'Metro Buho (Metro Owl)' has been created, which consisted of 12 Metro lines on the surface.

Finally, in May 2009 the night network was extended with 56 km more, spreading over the extension or the modification of 10 lines. Thus, the radial network once again reached the limits of the urban nucleus, leaving only the Airport of Barajas and El Pardo area without municipality transport service (Fig. 1).

Actually there are 24 night lines in the capital, incorporating 120 buses with a total length of the itinerary of 400 km route, which suppose a cost of 4.3 million euros per year.

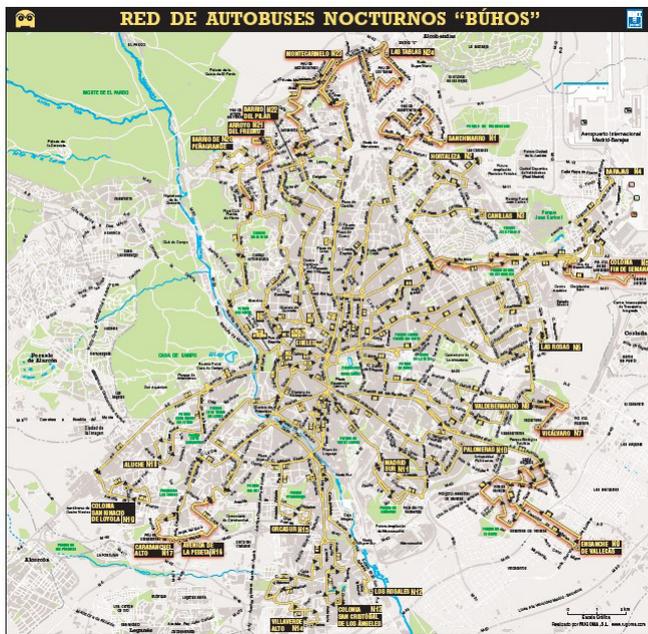


Figure 1. Organization of the night public transport in the city of Madrid. The majority of the buses depart from Cibeles Square and then bifurcate forming a star. (Map taken from the Official Madrid’s Municipality Transport and Mobility web page).

Methodology

The methodology, we have used in the present research, focuses on the analysis of real data concerning the night transport between the city of Madrid and two municipalities of Madrid area. This transport network is of great importance as Madrid’s nightlife attracts people from peripheries and satellite small villages from Madrid area. Moreover, it helps to reduce contamination, night traffic accidents and helps to promote public transport within the young population.

The data have been offered by the Madrid Public Transport enterprise (DGT - Dirección General de Tráfico) in order to analyze the efficiency of two night lines connecting the capital with selected municipalities of important population. The data cover all the night itineraries of lines N602 and N603, connecting the center of Madrid with the municipalities of Collado Villalba and Moralarzaral, situated at 40 km and 50 km respectively.

The case of the municipality night public transport of the Madrid’s area

As it has been stated in the previous section, the extensions of the night transport were absolutely necessary in order to connect in a suitable way the capital with the most populated satellite municipalities from Madrid area, thus reducing accidents and night traffic crowding. Moreover, as can be seen in Fig. 2, an important variation of the density population has been observed in the last decade (Fig. 2 right), which originated the extension of the night transport.

In our study we focused in two night lines of interest N602 and N603. The line N603 is an extension of N602, passing through the Municipality of Collado Villalba and finishing in the Municipality of Moralarzaral. In the following Fig. 3 one easily distinguish the three final bus stations corresponding to Madrid (right-down corner and to Collado Villalba and Moralarzaral (left-up corner).

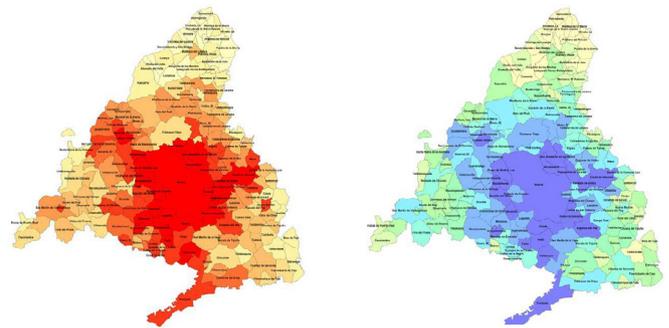


Figure 2. Population of Madrid region in 2012 (left) and population variation between 2004 and 2012 (right). Data from National Institute of Statistics and PMUS (2014).

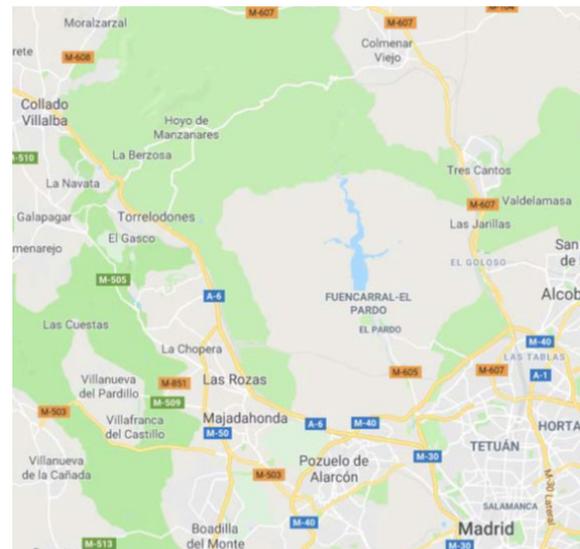


Figure 3. Stations of Buses N602 (Madrid-Collado Villalba) and N603 (Madrid-Moralzarzal).

As an initial hypothesis, we regarded the night public transport in the capital and the municipalities under investigation, as a modern and well organized public transport. However, we also supposed that some improvement and optimization are desirable. Along the next section we will discuss these points in detail.

Analysis of the results

We have analyzed the data, provided by DGT, taking into consideration the night bus frequencies, given below.

N603 / N602 from Madrid	N603 / N602 to Madrid
01:00 / 00:45	00:00 / 1:30
03:00 / 02:15	02:00 / 3:30
05:00 / 04:15	04:00 / 5:00
/06:00	

The analysis of the results is presented in the following Figs. 4 - 9. In the first three figures (Figs. 4, 5 and 6), we have plotted the annual evolution as number of passengers who have used night transport of the above bus lines.

As can be seen in Fig.4, the number of all passengers to and from Madrid for both line is comparable along 2017. However, when plotting the corresponding numbers of passengers in both directions (Fig. 5 for N602 and Fig. 6 for N603), it is clearly seen that the number

of passengers who have used the night transport is much higher for those who came back from Madrid, compared to those who went to Madrid, thus identifying the city as a night attraction point for the people living in the municipalities of Madrid area.

Total passengers N602/N603 per month 2017

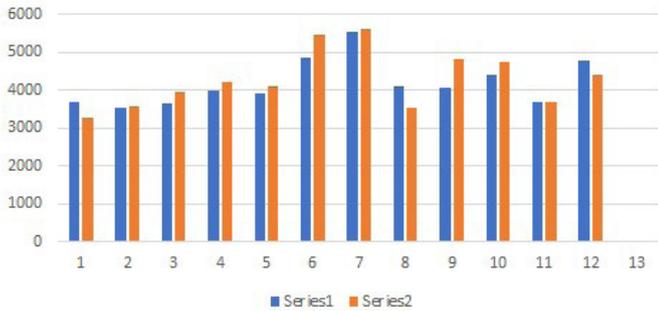


Figure 4. Total number of monthly passengers, who have used both lines in 2017. The statistics includes the passengers who went and who came back from Madrid. Data from DGT. Own elaboration.

N602 From / To Madrid per month 2017

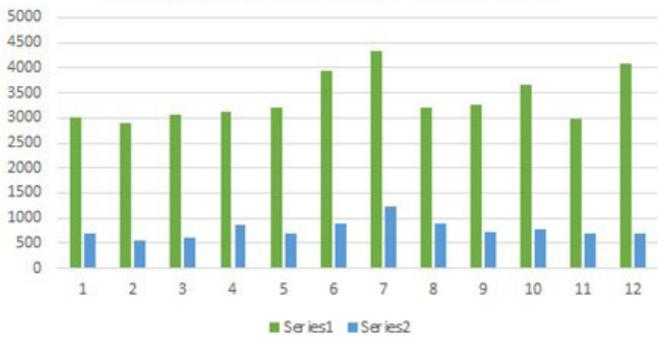


Figure 5. Total number of monthly passengers, who have used line 602 (Madrid-Collado Villalba-Madrid) in 2017. The statistics includes the passengers who went to (blue color) or who came back (green color) from Madrid. Data from DGT. Own elaboration.

N603 From / To Madrid per month 2017

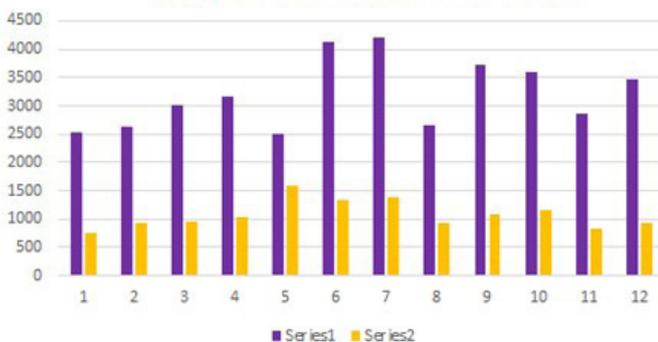


Figure 6. Total number of monthly passengers, who have used line 603 (Madrid-Moralzarzal-Madrid) in 2017. The statistics includes the passengers who went to (yellow color) or who came back (violet color) from Madrid. Data from DGT. Own elaboration.

The data, corresponding to Bus N602, which itinerary consists of four courses to Madrid, reveal that there were about 440 passengers in July 1st from Madrid, i.e. in average of about 110 passengers per course. This is much higher than the usually allowed 60 passengers.

Similar is the situation in July 2nd (330 passengers), February 18 (367 passengers) or October 10th (330 passengers).

In the case of the Bus N603 with three courses to Madrid, (i.e. max. of 180 passengers in one way), one observes certain anomalies similar to those in the case of Bus N602. The overcrowding correspond to February 4th (312 passengers), February 10th (327 passengers), April 28th (233 passengers), July 1st (250 passengers), September 23th (327 passengers), October 13th (351 passengers) and December 22nd (256 passengers). The results show similar patterns in both lines: in February, coinciding with San Valentin, in May - with 1st of May, in July - with the beginning of the holidays, in October, coinciding with the Hispanic Heritage day (12 of October) and in December - with the usual dinner with friends and colleagues. From the other side, these results are coherent with our initial hypothesis concerning the quality and optimization of the night public transport. Actually, they confirm that Madrid night public transport is well organized and modern, however some improvements seem to be desirable concerning specific periods along the year. Among them, one could suggest an increase of the bus fleet during special days for the same or for an extended bus schedule.

In the next Figs. 7, 8 and 9, we represent the same passenger dynamics, but by focusing on special months such as January, July and August and restricting only to line N602. For line N603 one observes similar results.

Passengers N602 to and from Madrid January 2017

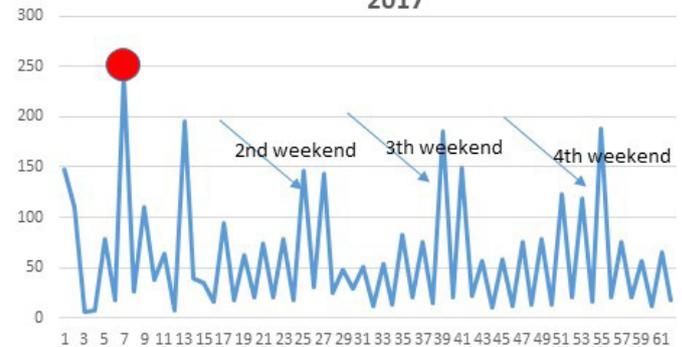


Figure 7. Traffic of night passengers who have used line N602 during January 2017. The increase of the number of passengers is clearly seen during the weekends. The case with an important increase of the passengers is marked by a circle. Data from DGT. Own elaboration.

Passengers N602 to and from Madrid July 2017

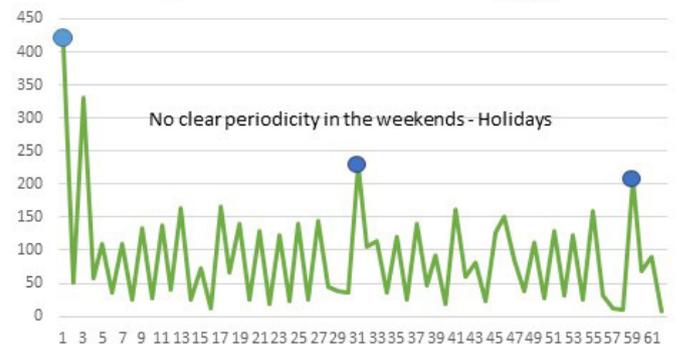


Figure 8. Traffic of night passengers who have used line N602 during July 2017. During the holidays, no clear periodicity is observed. The cases with an important increase of the passengers are marked by circles. Data from DGT. Own elaboration.

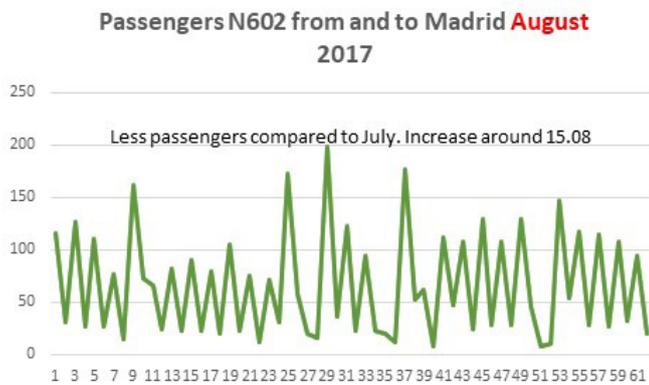


Figure 9. Traffic of night passengers who have used line N602 during August 2017. No clear periodicity during the weekends is observed due to the holidays. However, an increase of the passengers is observed around 15.08.2017. Data from DGT. Own elaboration.

In Fig. 7, corresponding to the January data, we have marked with a red circle, the number of passengers who are on the limit of the bus capacity. One can clearly observe an increase of the night passengers during the weekends, especially the first one, coinciding with the end of the Christmas holidays.

One can also see that the periodicity during the weekends, where the number of passengers increases, is not observed during July (Fig. 8) neither in August (Fig. 9). These both months coincide with the summer holidays when the young people, who are the main users of both lines, are free to go more often to the city of Madrid and to enjoy its rich cultural life.

We have also extended our research by introducing some concepts of network analysis. For this aim, we calculated some network characteristics of the Madrid capital night transport network graph such as its diameter and clustering coefficient (Albert and Barabasi 2002; Dorogovtsev 2010). The diameter of Madrid night transport network is given by the maximal distance on the graph, which is the distance between Las Tablas and Villaverde Alto. This distance is approximately of 24 km, which identifies with the diameter of the night transport Madrid's graph.

From the other side the clustering coefficient of Madrid night transport graph is zero due to its radial topology. No clusters (triangles) are formed. The majority of the buses start from Cibeles Square, go together at the beginning as a "STAR" and bifurcate later.

Conclusions and future recommendations

In this work we have investigated the night-time public transport in Madrid, Spain. After presenting a discussion about its historical evolution since 1974, we have analyzed real data corresponding to the night public transport between the city of Madrid and the municipalities of Collado Villalba and Morzarzal, known as their high demographic density and relatively young population. We have analyzed the annual use, corresponding to 2017, of the night buses N602 and N603 to Collado Villalba and Morzarzal, respectively, as well as the use of N602 during several months coinciding with school holidays and official holiday periods.

Our results confirm the good organization and effectiveness of the night-time public transport concerning the connections of the center with the peripheries of the Madrid area. Some suggestions are given regarding specific periods in order to improve the night transport during them. An additional analysis by using the methodology of the modern theory of complex systems has given new insights into the internal structure and the dynamics of the night public transport

Madrid's graph.

Finally, among future directions, we are interested to expand our analysis by using Neural Network approaches based on historical data (Hertz et al. 1991). The corresponding methods will give more information about the internal structure of the data and will permit a future prediction of possible scenarios. Such approach could give a knowledge how to optimize the night public transport and how to avoid saturation in the service. It would be very interesting as well to connect night transport issues with leisure and cultural activities, offered by the capital. The corresponding analysis could be very useful in order to design in an optimal way the mobility of the young population living in the peripheral municipalities of Madrid area (Study Night Tourism 2014).

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