



# Roads and Waterways: The First Inland Transport Systems and the Subsequent Major Impact of Road Transport

# 3

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## Abstract

In the 1830s, railway lines began to replace waterways and stagecoach systems as the means of connecting cities, harbours and industrialising regions. At the same time, regional and local governments started to pave the roads used by horse-drawn vehicles in order to create a feeder system for the rail network and to accommodate increased traffic caused by industrialisation.

Transport infrastructures have been increasingly seen as a practical way to make European integration a reality. The construction of integrated transport networks is not only an economic and social need but also a political project. In a famous speech before the League of Nations' tenth assembly on 5 September 1929, the French foreign minister Aristide Briand revealed his dream of a political federation of European states.

This chapter will include H-GIS at two levels: the European scale, based on a database of main roads in Europe from 1835 on, and the national scale, which will include a new H-GIS for Spain of not only the main roads but also the secondary and tertiary levels for years 1861, 1887, 1912, 1940, 1963 and 1999.

## Keywords

Roads · Waterways · Europe · H-GIS

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This study of the development of the main roads and inland navigable waterways in Europe has been unified in this chapter because these were the two main forms of transport used during the pre-Industrial Age. Although their evolution, through to the present day, has been very different, they have shared a common challenge: both had to compete with rail transport when this new mode of transport appeared.

Although modifications of all types of transport tend to be considered positively, and seen as signs of progress, in the case of road transport, there have also been negative consequences. There have basically been three of these: pollution associated with massive-scale motorisation; motor vehicles occupying large areas of public space in cities; and the development of a dispersed city model which consumes lots of territory. However, every new problem also—almost inevitably—tends to generate new solutions. In this case, these have included the promotion of public transport and improvements in inter-modality amongst the different means of transport. Looking to the future, the consolidation of the electric car and of car-sharing should bring further improvements, but this is not a subject that we will discuss here.

In this chapter, we will consider two central themes. The first, which will be examined in the first two sections, relates to the historical evolution of road infrastructure and that of inland waterways. The second, which will be discussed in Sects. 3.3 and 3.4, is a reflection on the impact that the emergence of road transport—which has played a fundamental role over the past 70 years—has had on our territory and society. Here, we seek to study some of the key characteristics of the evolution of transport infrastructure and to relate them to the abusive development of private transport. Finally, and in line with the general focus of this book, in Sect. 3.5, we will present a number of didactic themes and lines for further research. It will be possible to study these, thanks to the data that we have provided in GIS format.

Despite the criticism that this chapter makes of the negative impact that road traffic has in modern-day Europe, I would like to stress that this is not a publication that is against road traffic; in fact, just the opposite is true. A future com-

bined model for transport must include the car, but limiting its use to what is strictly necessary while, at the same time, improving the supply of collective transport.

What is more, it should be added that the heritage and historical components of old roads tend to be increasingly valued. Although this is a subject that will not be treated here, there is now a flourishing line of research into the recovery of inland waterways (Nasiri et al. 2019) and historic roads (Navas 2017) as elements that form an essential part of our heritage. Furthermore, the network of secondary and local roadways is essential for promoting a balanced distribution of population within a given territory. This chapter is closely related to Chap. 1, about borders and population; Chap. 2, about urbanisation; and Chap. 4, about railways.

### 3.1 Considerations Regarding the Historical Relevance of Inland Waterways and Roads and the Absence of an Inter-modal Perspective

The historical perspective promoted by this book allows us to verify the antecedents to the problems that our society is currently facing. Here, we refer to the uncontrolled growth of road transport with respect to other modes of transportation. The perverse effects of this reality are not only environmental in nature; they have affected the quality of life enjoyed in cities and resulted in a disorderly expansion of the built-up space. In this section, we present several antecedents which are relevant for interpreting this reality.

In the study of the process of the modernisation of transport, one factor that is at least as important as the provision of transport infrastructure is the organisation of the services that use it and provide its traffic. For this reason, this section is dedicated to some considerations regarding the role played by transport services and their importance for economic thought, taking Adam Smith as a reference. The importance given to transport by the world of economics has been maintained through Paul Krugman and other modern contributions within the field of the “new economic geography”.

In Europe, numerous transport companies, haulage firms and shipping lines were independent operators and, for centuries, offered their services using carts, stagecoaches or river boats. From the mid-nineteenth century onwards, however, these traditional systems began to face strong competition from railways. Yet, far from disappearing, they adapted to the new circumstances, offering complementary services, often based at the railway stations themselves. With the aim of gaining travellers, the railway companies mainly operated from cities and centres of production and also near river and sea ports (Alvarez-Palau and Martí-Henneberg 2020). The railway network became very dense in some regions, but the

number of access points—the railway stations—remained limited due to the high cost of investment and maintenance. The main limitation on the railway as a form of land transport has always been its incapacity to provide a door-to-door transport service. For this reason, designing a combined transport system based on inter-modal cooperation has always seemed the best solution (Fig. 3.1). However, putting this into practice has always been complicated due to the diversity of the many actors involved: owners of infrastructure, service managers, political powers responsible for passing associated legislation and local interests, amongst others.

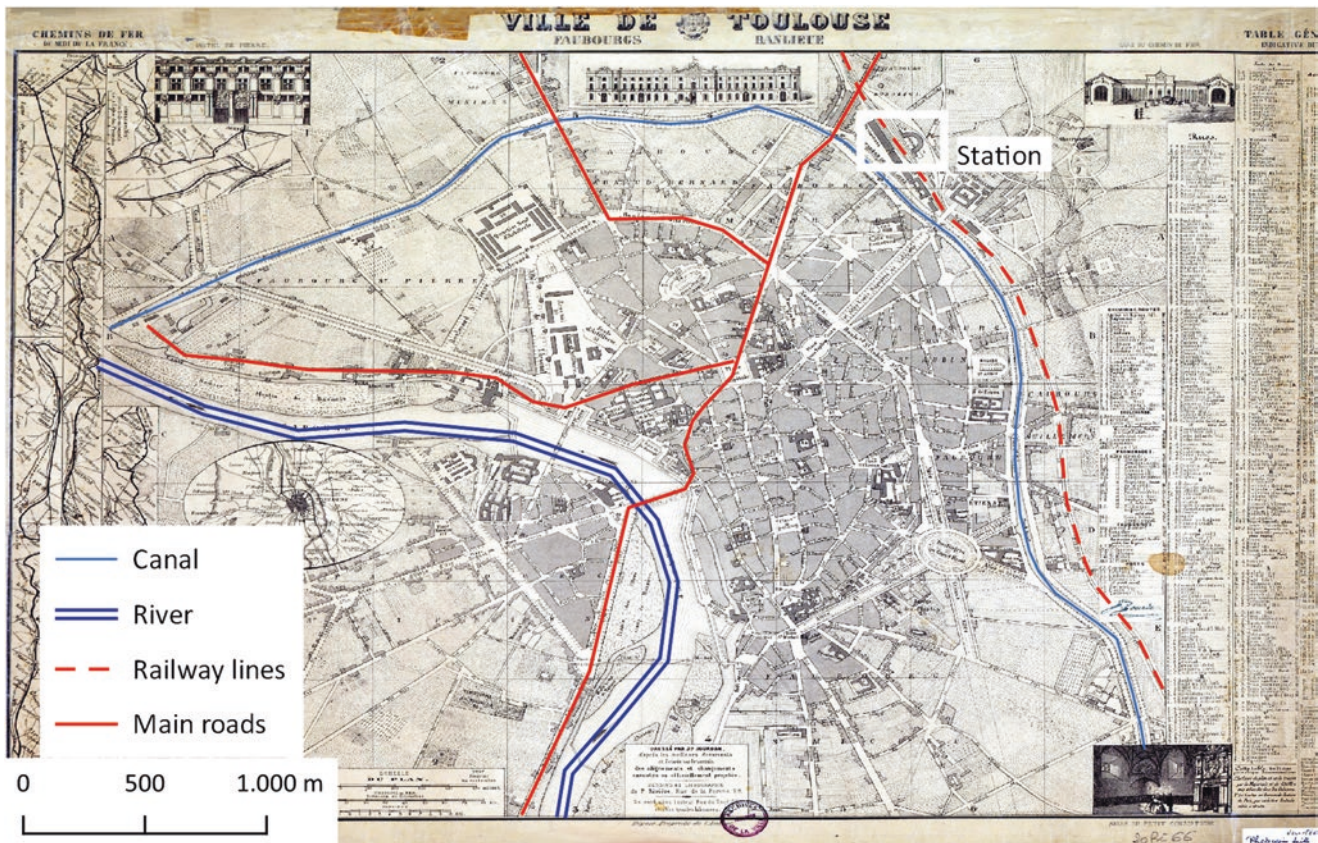
If we take a look back into the past, we see that despite the modernisation and consolidation of a diversified offer of transportation, in the course of the nineteenth century, the challenge still remained the same: how to move goods and people between two different points, as efficiently as possible. This normally called for more than one mode of transport. Adam Smith set a precedent by underlining the importance of the quality of transport services for economic growth. Although he did not explicitly refer to the idea of inter-modality, he referred to the three main systems of internal transport, adding that they were indispensable for breaking monopolies and helping promote economic growth. He subsequently had a decisive influence on both economic thought and practice. Indeed, it is relevant to focus on his memorable text in order to understand the function of transport within the economic model that he advocated. In the following passage, Smith primarily referred to freight transport and to improving it as a way of making it a transforming agent and helping to achieve a liberalised economy:

Good roads, canals, and navigable rivers, by diminishing the expense of carriage, put the remote parts of the country more nearly upon a level with those in the neighbourhood of the town. They are upon that account the greatest of all improvements.<sup>1</sup>

In the following passage, he explained the importance of improving the role of transport in economic life and, more specifically, in defending an economy based on free competition. As a result, in contrast to monopolistic practices:

They [roads] encourage the cultivation of the remote, which must always be the most extensive circle of the country. They are advantageous to the town, by breaking down the monopoly of the country in its neighbourhood. They are advantageous even to that part of the country. Though they introduce some rival commodities into the old market, they open many new markets to its produce. Monopoly, besides, is a great enemy to good management, which can never be universally established but in consequence of that free and universal competition which forces everybody to have recourse to it for the sake of self-defence.

<sup>1</sup>This and the following texts are taken from *The Wealth of Nations*, Chapter XI: On the Rent of Land Part I: On the Produce of Land, which always affords Rent, from page 149.



**Fig. 3.1** Railways, canal and river in Toulouse. (Source: own research from Jourdan and Rivière 1860)

He then went on to provide a telling example of the divergence of interests that improving transport systems could produce:

It is not more than fifty years ago that some of the counties in the neighbourhood of London petitioned the Parliament against the extension of the turnpike roads into the remoter counties. Those remoter counties, they pretended, from the cheapness of labour, would be able to sell their grass and corn cheaper in the London market than themselves, and would thereby reduce their rents, and ruin their cultivation. Their rents, however, have risen, and their cultivation has been improved since that time.

Smith did not say much more about transport in the course of his work, but these paragraphs have served as the basis for defending and developing the idea that the efficiency of the means of transport favours free competition by broadening markets.

This greater competition, from a new road (Bogart 2005) or canal, influenced the demand for alternative products. For example, as Satchell (2017) observed, “When buyers had a choice of raw materials – such as wood, peat and coal – the availability of cheap carriage via a navigable waterway could determine which commodity was used. Coal, for example, could not be sold profitably if it had to be transported more than fifteen miles by road; consequently, waterways mas-

sively increased the relative competitiveness and consumption of coal when it had to be transported over long distances”.

Access to waterways was also closely related to urban growth. It should be remembered that the conditions for using a navigable river, or opening a new canal, are much stricter than those for opening a new road. It is necessary to have a continuous, stable and sufficient flow of water and, in addition, for this to run over relatively flat terrain. For this reason, waterways require considerable investment in construction and maintenance, and they can only be promoted in areas where there is an important level of supply or demand, such as in cities, ports and mining areas. The options for making these types of investment under favourable conditions were relatively limited within a given territory. It has been shown that the availability of waterways and sea transport encouraged the presence of urban nuclei. This can be seen in Table 3.1, relating to England and Wales in 1831. Of the 433 cities at that time, 218 were already connected by inland waterways, 28 by sea and 84 by both.

It must be remembered, however, that having a good endowment of a specific mode of transport was not, in itself, sufficient to ensure an appropriate connection between the points of origin and destination. This has been demonstrated

**Table 3.1** Urban size and proximity to waterways and the sea. England and Wales, 1831

Towns and cities 2 miles from a navigable waterway or the coast	Population	Near waterways	Near coast	Near both	Not near either	Total
1	2000–10,000	162	20	64	99	345
2	10,001–25,000	33	5	14	4	56
3	25,001–50,000	13	1	2	–	16
4	50,001–100,000	6	–	4	–	10
5	>100,000	4	2	–	–	6
<b>Total</b>		<b>218</b>	<b>28</b>	<b>84</b>	<b>103</b>	<b>433</b>

Source: Satchell, Max. 2017. Navigable waterways and the Economy of England and Wales 1600–1835. *The Online Historical Atlas of Transport, Urbanization and Economic Development in England and Wales c. 1680–1911*.

<https://www.geog.cam.ac.uk/research/projects/transport/onlineatlas/waterways.pdf>

by studies of the evolution of the quality of market access (Bogart et al. 2017) from any point in a given territory, which include and quantify the combined effect of all the means of transport available. However, studies of the history of transport have tended to adopt a predominantly unimodal perspective, which, according to Donovan, needs to be enriched by another multimodal type of study: “Change in the present creates pressure to re-examine older accounts of the past (...). It is time that historians of transportation begin thinking outside the modal box” (Donovan 2000: 4). I insist on inter-modality<sup>2</sup> because I think that we have so far missed the opportunity to take into account its importance over the course of modern history. The shortcomings of this omission have persisted until today, as this is the main difficulty encountered when promoting the use of public transport. It is evident that the railway improved transport, yet only between stations. As a result, the train has always needed paths and roads to finish its routes. The advance that the railway implied was therefore very substantial, but still insufficient. A capillary system was needed to reach all of the corners of a territory and its cities. Waterways and roads also adapted to the requirements of the industrial revolution, but their trajectories were very different. Investment in waterways practically ceased when investors focused on railways instead, due to their future potential. However, thanks to their low maintenance costs, canals were not abandoned (Kunz 1992). The current network is similar to that of the nineteenth century, as we shall discuss later though changes have been calculated

<sup>2</sup>One good example of the concern for inter-modality that already existed in the nineteenth century can be seen in the *Atlas des Ports de la France* (Ministère des Travaux Publics). List of ports: <https://biblioteca.mmb.cat/portades/22313.pdf>. This was a collection of 166 monographic maps of each port, at the scale of 1:50.000, which was published between 1871 and 1897. The central theme of the collection is the morphology of each port and its urban area and the provision of complementary infrastructure at the port: rivers, canals, paths, roads and railways. Each map provides details of great value for managing the complexity of port traffic, which are quintessential inter-modal nodes. This is a source of great value and one endowed with cartography that provides an impressive degree of detail.

(Werther et al. 2021) The largest rivers and canals currently maintain (Radmilovic and Maraš 2011) stretches which are relevant for intensive use for the transportation of merchandise. On the other hand, the narrowest ones offer tourist services which can be enjoyed using pleasure boats.

The next section provides a general overview of the development of inland waterways and main roads of Europe.

### 3.2 The Historical Development of Inland Waterway and Road Networks in Europe

In this section, we present the evolution of inland waterways and roads. These were the means of inland transport that had the widest presence over the course of history, prior to the arrival of railways, but they have tended to be analysed separately within the historiography available. The general bibliography relating to roads across the whole of Europe (Lay 1999; Livet 2003; Schiper 2008) and that relating to navigable waterways (Kunz 1992) constitute two different fields. However, according to a more recent study of transport in England between 1760 and 1830, when complementarity between the two modes of transport was achieved, the whole system exhibited increasing returns (Bogart 2005). For this reason, it is necessary to stop analysing their effects separately and, instead, to study them from the perspective of their inter-modal cooperation. Looking to the future, insisting on this approach will facilitate the development of a culture of cooperation between institutions and companies, which is an area with few examples of good practices.

If we look at infrastructure, it is necessary to start by taking into account the restrictions associated with the construction of both means of transport. Firstly, there is the navigability of waterways, which require a territory that is relatively flat and with abundant water. If we take into account differences in orography and rainfall across Europe, this explains the majority of the territorial inequalities in their distribution.

The function of European canals was to connect points of special relevance. Their use and the development of the first canal projects was therefore initially in largely independent and self-contained sections. It was only later that they were planned as a network. One added problem associated with canal transport was the high cost of trans-shipment, which could not be carried out on platforms, as in the case of rail transport. Even so, in England, the canals were generally profitable (Satchell 2017: 33). It was only competition from railways that limited investment in waterways, although the majority remained available and in service due to their low maintenance costs.

There is, as of yet, no comprehensive and comparable study of inland waterways in Europe with a historical perspective. The studies available (Kunz 1992), combined with other scattered references, show that the construction of canals for irrigation purposes has a very long history. However, if we look at their use for transport, the first navigable canal in Europe was constructed in the twelfth century to carry the marble required to construct the cathedral of Milan. The route included part of the River Ticino, which the Naviglio Grande Canal followed for 50 km. Other stretches of canal were constructed as and when required, but the idea of forming an integrated network only arrived in the seventeenth century, with the Briare Canal (1642), in France, which connected the rivers Seine and Loire. The construction of the Canal du Midi (1681), which connected the Mediterranean Sea to the Atlantic Ocean via 240 km of a new waterway, between the rivers Aude and Garonne, was a much greater task. In Great Britain, the first canal was promoted by the, surprisingly aptly named, Duke of Bridgewater. This was inaugurated in 1871 to transport coal to Manchester from the duke's mines.

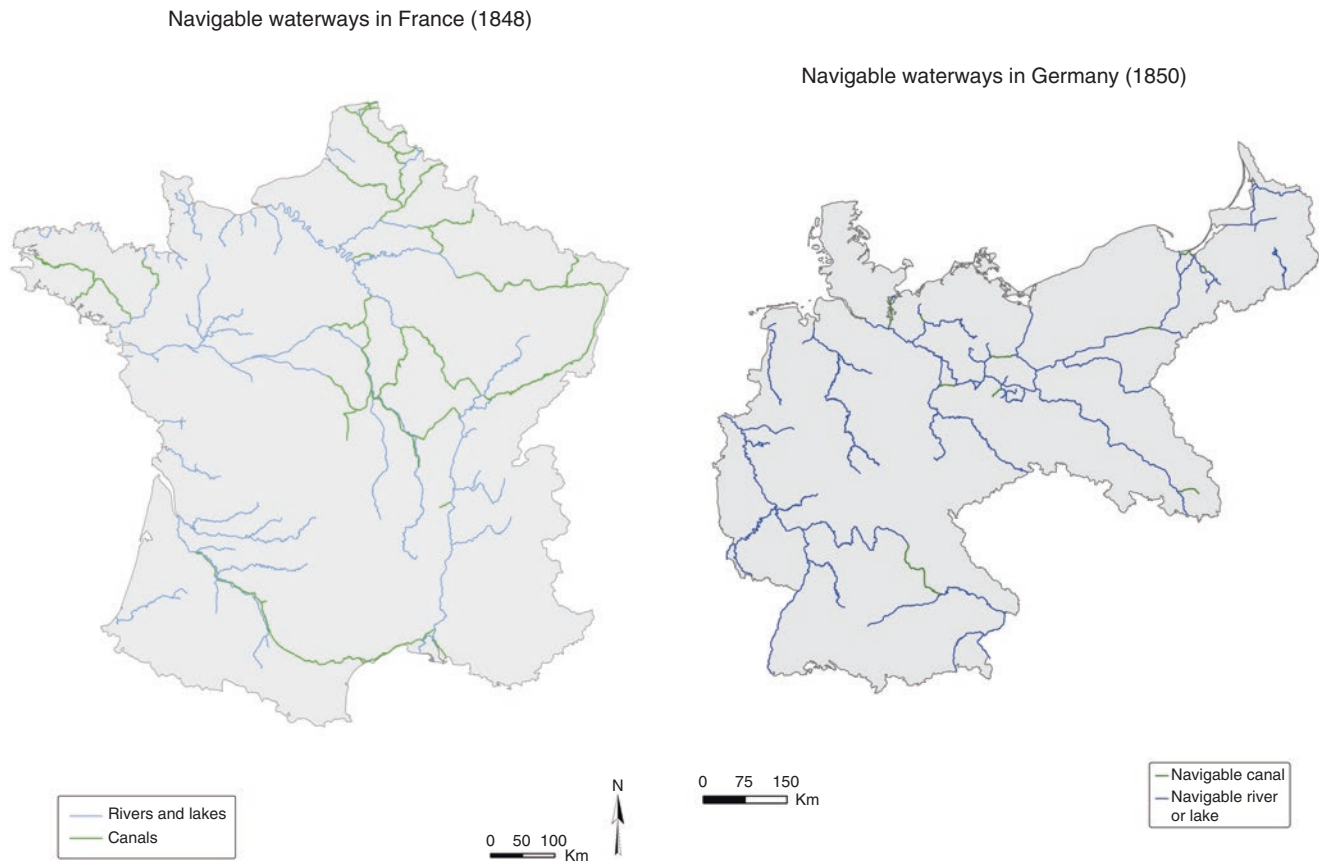
The construction of canals in Europe was complemented by investment to extend navigable stretches of rivers and thereby create integrated networks. This was the result of strategies designed in each country at the national level, whether as public initiatives (as in France) or with private capital (as in the United Kingdom). As already noted, there were basically three essential prerequisites for developing a network of navigable waterways: extensive areas of flat land, a sufficiently large water supply and a consistent economic activity to justify the investment. These conditions were only met in certain areas of Europe: in much of France and the United Kingdom, in the Netherlands and in the—at the time—independent territories which now form part of Germany. In Fig. 3.2, it is possible to observe the waterways of France and Germany, where there was a sufficient level of complementarity between navigable rivers and canals to form an extensive network. Having efficient transport networks at the beginning of the nineteenth century helped both countries consolidate the first Industrial Revolution in these

areas.<sup>3</sup> In contrast, countries on the periphery of Europe, in the Balkans and on Mediterranean peninsulas found themselves in a very different position. Spain, for example, did not have any of the three conditions previously highlighted. As a result, the country had to survive, as best it could, with a poor road network until a railway network was eventually established. This began in the 1850s and was later largely driven by foreign investment.

The subsequent stagnation in investment in canals can be explained by the advantages offered by rail transport. These included being able to overcome the restrictions of topography, very cold temperatures and the availability of water imposed on building canals. In contrast, the railway offered punctuality and speed throughout the year and over the whole national territory.

In the case of roads, it is important to highlight that they have been a reality since human societies first established fixed settlements and found the need for permanent thoroughfares. Given their capillary distribution throughout a territory, this was—and generally remains—the best way to meet the need to move between any two points. The oldest, and perhaps most spectacular, road network was that established by the Roman Empire. Its main function was to facilitate the movement of troops and to thereby ensure effective control over Rome's vast possessions; this called for a good system of land transport. In this way, Rome differed from other Mediterranean powers, which had geographically scattered colonies and whose main, and indeed basic, means of communication were maritime. Establishing the nature of the cause-effect relationship which existed between the road network and the distribution of cities in the Roman Empire is one of the many themes that have yet to be totally resolved. One relevant question relates to what was decided first: the structure of the future network or the locations—whether existing or foreseen—of its cities and strongholds. Another question concerns whether everything always followed a given pattern or depended on the circumstances of each region. Several recent works have cast a little light upon these issues (Carreras and De Soto 2013; De Soto 2019). Although there are no direct primary sources to provide numbers and information about the distribution of the urban population in Roman cities, several very valuable approximations have been published (Zorn, 1994. Carreras 2014). Similarly, we may ask ourselves what knowledge those managing the empire really had about their own territory. Here, it is significant to pick up on the introductory comment that Mary Beard made in her work *SPQR*, which could be equally

<sup>3</sup>In the map series shown at <https://europa.udl.cat/projects/inland-waterways/>, it is possible to observe the situation in 2001, which does not differ greatly from that of the twentieth century. The differences between countries in the endowment of infrastructure are considerable. For a more up-to-date vision, see Činčurak and Biljana (2019).



**Fig. 3.2** Navigable waterways, France and Germany

applied to our current knowledge about the empire’s conception of its territory:

Roman history is always being rewritten, and always has been; in some ways we know more about ancient Rome than the Romans themselves did. Roman history, in other words, is a work in progress. (Beard 2015, Introduction)

The historical study proposed here has enabled us both to adopt a very detailed global perspective and to construct GIS maps in unprecedented detail. This interest in analysing the road network in GIS format, highlighted in this chapter, has also allowed us to study its evolution and relationship with other elements within a territory, such as its cities and ports and other means of transport.

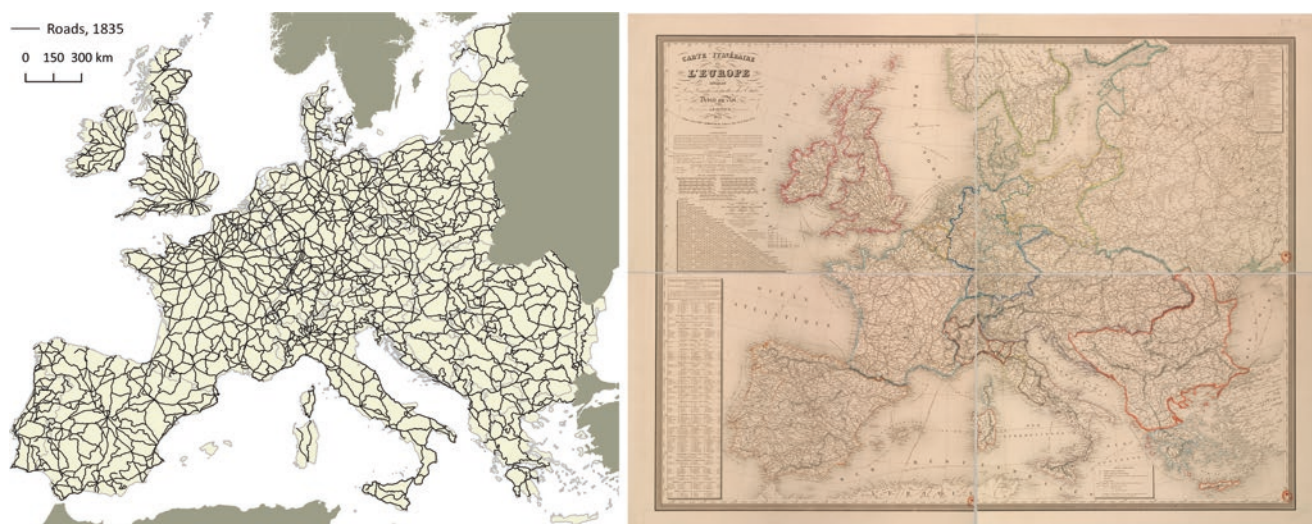
Applying this approach to the whole of Europe (Zhou et al. 2019; De Soto and Carreras 2021; Vitale et al. 2021), it has been possible to study the evolution of accessibility to transport by mapping both the Roman Empire and the situation in the Middle Ages. The resulting maps show that the transport network has changed greatly over time. For the Modern period, other approximations have been made that have enabled us to perfect many of the techniques used in network analysis, albeit only in certain specific countries,

such as the United Kingdom (Bogart et al. 2017) and Spain (Pablo-Martí et al. 2021).

This limitation has been due to the fact that there are no historical databases about roads in Europe. The basic problem here is that each country uses its own classification system for distinguishing between first- (Fig. 3.3), second- and third-order (Fig. 3.4) roads. As different countries do not follow the same criteria, making comparisons between them is a very complicated task. Below, we present an exception to this general rule: the evolution of the motorway system. This is the category which best lends itself to comparisons, as these are always rapid transport routes, with a minimum of two lanes of traffic in each direction.

A recent investigation has produced a GIS for motorways in Europe. This shows both their origins, in 1925, and their rapid densification from the 1960s onwards. This tended to start in the most developed countries and was then followed, through a subsequent “catching up” process, in the more peripheral ones. This study<sup>4</sup> has involved the digitalisation, in GIS format, of the evolution of motorways in Europe, from the 1920s through to the present day. In the tutorial,

<sup>4</sup><http://www.studiofolder.it/european-motorways/>



**Fig. 3.3** Main roads, 1835. (Source: Own research and Dufour 1835)

these questions are explained in greater precision, particularly in exercise 2.

When making a historical study of transport infrastructure, it is necessary to highlight the fact that—together with navigable rivers and ports—roads are the type that has had the greatest permanence over time. Even so, technical advances in locomotion have forced road transport to continuously readapt. For example, it was the invention of the internal combustion engine and of the rubber tyre that opened the way for the current importance, and indeed dominance, of motor vehicle traffic. Thus, the old tracks and roads were replaced by a new, manufactured product, which was characterised by the massive use of tar, and major roads were specifically designed to interconnect the main centres of production, commerce and population.

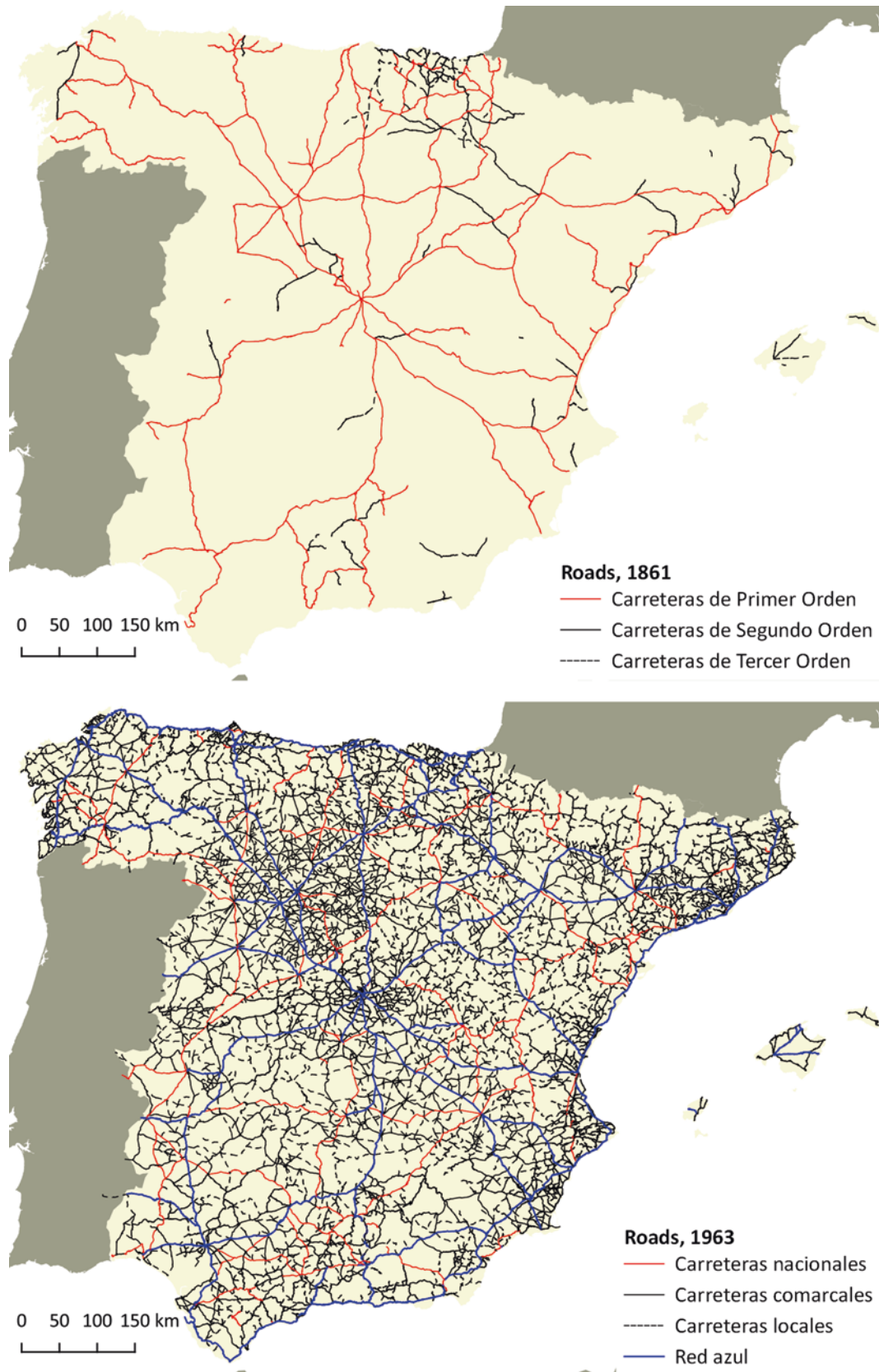
Over time, states assumed increasing protagonism in the creation of road networks. In Europe, there were two models for the organisation of the main national road network: the centralised model and another which took the form of a mesh. Countries with centralised plans for their national road network made their capital its point of origin. In France, this point of origin is just in front of the cathedral of Nôtre-Dame; in Spain, it is in Madrid, at the Puerta del Sol. This organisational logic made little sense in countries which were less centralised. The other tendency could therefore be found in countries like Germany and Italy, which had only recently been united, where the national road networks were based on the needs of a set of states and cities that each had great relevance of their own. This also explains why their respective capitals have never had a predominant role, with respect to other major centres, in the design of their national transport networks.

In Europe, the road network of each country responds to its own historical logic. It is therefore difficult to speak of a

European network of roadways. Where there are cross-border connections which have made it possible to interconnect national networks, this is because the states concerned came to agreements and built border crossings that allowed their control and facilitated the movement of merchandise, after payment of the customs duty charges.

The evolution of the quality of factory-made roads was associated with the development of completely new transport artefacts, such as the internal combustion engine for cars, lorries, coaches and motorcycles. The exponential growth of its use in the course of the twentieth century helped it to reach all corners of the territory, with the sole exception of certain high-mountain areas. However, this unquestionable technical advance has not been exempted from a certain degree of controversy due—as is often the case—to its abuse. The number of vehicles in circulation in the world has grown exponentially, and Europe has not been an exception. Table 3.2 presents the number of private cars (PC) and commercial vehicles (CV) that were on the road in European countries between 1900 and 2018. It can be seen that the period with the greatest acceleration in their use was that between 1960 and 2018, although the indicators were initially more modest in countries such as Greece, Hungary, Poland, Portugal, Spain and Yugoslavia. In other words, the countries which began their economic take-off earliest saw a parallel increase in the growth of their motor vehicle fleet. By the 1990s, however, all of them had reached very high per capita levels.

The motor vehicle fleet that uses this infrastructure has always exhibited a high degree of complementarity between private initiatives and those of the public sector. The manufacturing of motor vehicles was the result of private initiative, while the state took the lead in constructing roads, extending and improving the road network and regulating



**Fig. 3.4** Main, secondary and tertiary roads, the case of Spain: 1861 and 1963



Table 3.2 Number of vehicles in the European countries

	Private Cars		Commercial vehicles											
	PC	CV	PC	CV										
	(thousands)													
	Austria		Belgium		Czechoslovakia		Denmark		Finland		France		Germany	
1900		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9			
1910		0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	53.7		31.7	4.2
1920	6.4	2.8	0.0	0.0	0.0	13.9	3.8	0.0	0.0	0.0	157.0		79.4	
1930	17.4	14.6	99.3	58.7	41.0	78.5	31.8	24.3	12.4	1,109.0	412.0		489.0	169.0
1940			110.0	58.8		7.0	23.3			1,800.0	500.0			
1950	48.5	43.9	274.0	145.0		118.0	61.4	26.8	34.4	2,150.0			591.7	468.8
1960	400.0	73.9	753.0	177.0	247.0	408.0	170.0	183.0	75.2	5,546.0	1,634.0		4,788.0	835.0
1970	1,197.0	121.0	2,060.0	376.0	826.0	1,077.0	252.0	712.0	116.0	12,900.0	2,745.0		15,101.0	2,198.0
1980	2,247.0	184.0	3,159.0	482.0	2,274.0	1,390.0	260.0	1,226.0	167.0	19,130.0	2,332.0		25,870.0	1,625.0
1990	2,991.0	253.0	3,864.0	591.0	3,242.0	1,590.0	301.0	1,940.0	294.0	23,550.0	3,567.0		35,502.0	1,826.0
	Greece		Hungary		Southern Ireland		Italy		Netherlands		Norway		Poland	
1900														
1910														
1920														
1930	18.7	9.4			32.6	183.0	62.1	11.0	68.0	44.0	6.7	2.4	19.9	19.5
1940					50.2	270.0	87.5				48.8	38.7		
1950	9.3	22.4			85.1	342.0	229.0	139.0	82.0	60.1	60.1	56.3	40.1	46.4
1960	43.2	37.0			170.0	1,995.0	465.0	522.0	157.0	219.0	119.0	120.0	117.0	120.0
1970	227.0	118.0			389.0	10,181.0	904.0	2,600.0	302.0	748.0	152.0	260.0	479.0	260.0
1980	859.0	406.0			736.0	17,686.0	1,338.0	4,515.0	375.0	1,234.0	164.0	618.0	2,383.0	618.0
1990	1,736.0	793.0			796.0	27,416.0	2,495.0	5,509.0	582.0	1,612.0	331.0	1,045.0	5,261.0	1,045.0
	Portugal		Romania		Spain		Sweden		Switzerland		UK		Yugoslavia	
1900														
1910														
1920														
1930							21.3							
1940	39.1	11.0				104.0	40.9	2.3	8.9	3.3	53.0	54.0		
1950	60.5	28.8				34.6	46.7	8.9	60.7	15.5	187.0	176.0		
1960	158.0	50.4				252.0	94.5	65.9	147.0	18.1	1,056.0	449.0	8.5	3.5
1970	551.0	147.0				1,194.0	130.0	147.0	147.0	38.5	2,258.0	1,032.0	6.4	17.1
1980	1,269.0	465.0				2,289.0	159.0	485.0	1,239.0	255.0	5,526.0	1,491.0	53.0	38.7
1990	2,552.0	813.0				2,883.0	194.0	2,247.0	2,247.0	318.0	14,772.0	2,146.0	721.0	122.0
						3,601.0	325.0	2,994.0	2,994.0	482.0	19,742.0	2,844.0	2,434.0	243.0
	TOTAL													
1900														
1910														
1920														
1930														
1940														
1950														
1960														
1970														
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1900														
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Sources: Mitchel (1998)

concessions for motorways. As a result, transport policy is currently a central axis of the economic and regional policy of European states. Indeed, the EU has progressively acquired competences in the field of transport. It was initially involved in the liberalisation of services under the Treaty of Rome. Then, more recently, the EU has played a relevant role in coordinating transport policies in different member states.<sup>5</sup> There are numerous precedents for this vision of Europe as a single management area.

According to Mom (2005), transport infrastructure has been increasingly seen as a practical way to make European Integration a reality. The construction of integrated transport networks is not only an economic and social need but also a political project. In a famous speech addressed to the League of Nations' tenth assembly, on 5 September 1929, the French Minister for Foreign Affairs, Aristide Briand, explained his dream of a political federation of European states. Albert Thomas, director of the International Labour Organisation had previously formulated a plan for a European system which Briand's initiative detailed. His plan was a good example of seeking to mobilise the construction of large-scale infrastructure to achieve European integration, tackle the economic problems of the time and promote long-lasting peace on the continent. In this sense, Thomas was an "artisan of European union". With the support of Thomas and the ILO, road builders organised two European motorway congresses, in 1931 and 1932, and founded the Bureau International des Autoroutes (which was subsequently renamed the *Office International des Autoroutes*, or OIAR, in 1932) to promote pan-European motorway construction. At the same time, the subcommittee on road traffic of the League of Nations Communications and Transit Organisation took up the challenge of achieving greater European integration through road transport. This political context influenced the construction of the previously mentioned motorway project.

However, it was only after WWII that the ideas of these system builders were taken up. In July 1948, representatives of Belgium, Denmark, France, the United Kingdom, Italy, the Netherlands, Poland, Czechoslovakia, the United States, Sweden and Switzerland established an international highway network within the framework of the United Nations Economic Commission for Europe. By the autumn of 1950, 18 countries (including occupied Germany) were involved in planning a network.

The interest of the EU in promoting a road network covering the whole of Europe was the result of policies of regional rebalancing (Crescenzi et al. 2016). Policies following this

line have since intensified over time and currently centre around the TEN-T programmes, which cover all transport systems, but particularly roads, motorways and railways (Gutiérrez et al. 2011). The EU has been particularly concerned with the primary-level roads that provide the main transport axes in Europe, while secondary and local roads fall within the competences of each member state.

The rapid growth in the use of the private car, associated with the availability of roads, has given rise to important debates about the accumulation of vehicles in specific spaces, and particularly in cities. The next section is dedicated to presenting and commenting on Mumford's (1895–1990) opinions about this phenomenon, as they have had a major impact. It is significant that the debates that he set in motion are still very valid. It is only relatively recently, however, that his views regarding the imperative need to change the current transport model have really come to the fore. The confirmation of the threat of climate change has been fundamental in getting society and the political establishment to take measures to limit the use of private motor vehicles. One of its derivatives has been the Smart City and plans to revitalise the provision of collective transport. However, the damage has already been done, and it is going to be very complicated to change the existing model. It is, however, important to bear in mind the current strategy of the automobile industry, which consists of developing the electric car. Its promotion is expected to receive a huge amount of public money, and this will further reinforce the massive use of motor vehicles. As we shall see in the next two sections, this also implies consolidating the model of the dispersed city and the perverse loop between the expansion of road transport and a city model that is not only dehumanising but which also destroys the environment.

There has been much criticism of the alliance between car manufacturers, petrol companies and political and other influential centres of power to place the car at the centre of the day-to-day life of citizens. It is true that these interests support and help perpetuate the feelings of personal status and independence that the private motor vehicle provides. However, its perverse result has been the massification of road transport which has, without exception, had an adverse impact on urban morphology (Chap. 12). It has also encouraged new personal habits that have produced an excessively intensive use of territory. The creation of enormous, low-density, urban suburbs would not have been possible without people being able to use the private car to go to work, go shopping and do other activities. Warnings of the potential counterproductive effects of this dynamic had already been given by Lewis Mumford (1895–1990), back in 1958, in a well-argued publication that we shall now examine in detail.

<sup>5</sup>Through its Regional Policy and ambitious programmes like the TEN-T.

### 3.3 The Premonitory Vision of Lewis Mumford Regarding the Negative Consequences of the Massive Use of the Private Motor Vehicle

Mumford was a sociologist and urbanist from the United States who was very critical of the way in which urban expansion was taking place in developed countries. In this section, we present his ideas and look at how the predominant commitment to a means of land transport—the motor car—has degraded the quality of life of the population. This is relevant to this chapter because roads and motorways do not only connect cities; they also enter them, totally modifying their ways of life. This theme is therefore also related to Chaps. 2 and 12. For a better understanding of this question, it is perhaps best to reproduce a selection of Mumford’s emblematic writing on this subject, entitled: “The Highway and the City” (1958). Later, in Sect. 3.3, I shall refer to other recent authors who have denounced similar issues over 50 years later. This problem has only got worse because of the abusive application of supply-side approaches relating to the construction of new roads. This focus has been based on just one consideration: whenever the number of cars has been predicted to increase, the solution has been to provide more and more roads, seemingly *ad infinitum*. This implies a conceptual loop of “building more roads to meet a demand for mobility that is predicted to increase” which has dominated both public and private investment related to this means of transport. The considerations of Mumford and other authors are essential for interpreting the relevance of the historical perspective when looking for answers to some of the controversial questions posed by modern society. We must remember that the criteria employed in this book relate to a historical vision and that this is not just an introduction to the analysis of current themes, but something that teaches us that many of the problems encountered are not necessarily recent in origin. It demonstrates that there were discordant voices in the past, who suggested other alternatives. This could have led to a better society and one that we perhaps still have time to recover.

Mumford began his text by referring to road development policy in the United States, which he saw as the root of the problem. The most relevant thing to note here is that these policies, and their application, were subsequently followed and developed in Europe, in a cultural context that helped to coin a new term: “Americanisation” (Kipping and Tiratsoo 2018). In reality, the disproportional expansion of the use of the private car must be interpreted as the promotion of the cult of individualism. Only in this way is it possible to understand why we are prepared to accept the problems that this causes for our health, the natural environment and our rural and urban surroundings. Mumford’s plea began as follows:

When the American people, through their Congress, voted last year for a twenty-six-billion-dollar highway program, the most charitable thing to assume about this action is that they hadn’t the faintest notion of what they were doing. Within the next fifteen years they will doubtless find out; but by that time, it will be too late to correct all the damage to our cities and our countryside, to say nothing of the efficient organization of industry and transportation, that this ill-conceived and absurdly unbalanced program will have wrought. (...).

To put these first affirmations into context, it is necessary to add that these policies were based on the North-American Law of Federal Aid to Highways, of 1944, and that they were consolidated through the formulation of the first models for traffic prediction, the transport study carried out by Thomas J. Fratar (1949) and the Highway Capacity Manual (National Research Council 1950). The latter was the first manual on motorways and was published in the following year.

Mumford continued:

As long as motorcars were few in number, he who had one was a king: he could go where he pleased and halt where he pleased; and this machine itself appeared as a compensatory device for enlarging an ego which had been shrunken by our very success in mechanization. That sense of freedom and power remains a fact today only in low-density areas, in the open country; the popularity of this method of escape has ruined the promise it once held forth. In using the car to flee from the metropolis the motorist finds that he has merely transferred congestion to the highway; and when he reaches his destination, in a distant suburb, he finds that the countryside he sought has disappeared: beyond him, thanks to the motorway, lies only another suburb, just as dull as his own. (...)

For most Americans, progress means accepting what is new because it is new, and discarding what is old because it is old. This may be good for a rapid turnover in business, but it is bad for continuity and stability in life. Progress, in an organic sense, should be cumulative, and though a certain amount of rubbish-clearing is always necessary, we lose part of the gain offered by a new invention if we automatically discard all the still valuable inventions that preceded it. In transportation, unfortunately, the old-fashioned linear notion of progress prevails. (...)

What’s transportation for? This is a question that highway engineers apparently never ask themselves (...) the essential purpose of transportation, which is to bring people or goods to places where they are needed, and to concentrate the greatest variety of goods and people within a limited area, in order to widen the possibility of choice without making it necessary to travel. A good transportation system minimizes unnecessary transportation; and in any event, it offers a change of speed and mode to fit a diversity of human purposes. (...)

As a result, the best solution would have been an efficient inter-modal system. However, as Mumford then explained, it was not planned along these lines. In fact, he affirmed that “The projectors of our national highway program plainly had little interest in transportation”. This was a devastating criticism. It insinuated that, at that time, there were intellectual collaborators who were in favour of promoting motorways and who acted in favour of private interests rather than those of society as a whole.

The fatal mistake we have been making is to sacrifice every other form of transportation to the private motorcar - and to offer, as the only long-distance alternative, the airplane. But the fact is that each type of transportation has its special use; and a good transportation policy must seek to improve each type and make the most of it. (...) There is no one ideal mode or speed: human purpose should govern the choice of the means of transportation. That is why we need a better transportation system, not just more highways. The projectors of our national highway program plainly had little interest in transportation. In their fanatical zeal to expand our highways, the very allocation of funds indicates that they are ready to liquidate all other forms of land and water transportation. (...)

By way of a conclusion, Mumford attacked the central theme of urban form and how the all-powerful and omnipresent motorcar had transformed people's ways of life. "We cannot have an efficient form for our transportation system until we can envisage a better permanent structure for our cities. And the first lesson we have to learn is that the city exists, not for the facile passage of motorcars, but for the care and culture of men".

Mumford's premonitory vision came true, as we shall explain in the next section. The essence of the supply-side approach was based on the belief that building more roads would not only favour the car-manufacturing industry and its lobbies but that it would also make transport policies popular. The next chapter presents some more recent transport policies and makes a number of reflections related to this problem.

### 3.4 Supply-Side Approaches, the Persistence of the Loop Between the Promotion of Motorways and the Car Invading the City

A jump in time shows us that this invasion by motorways is currently viewed in similar terms, 70 years after Mumford's warning. Manuel Herce and other authors have pointed out the contradiction that exists between the need to consolidate models for sustainable life and the approval of large public budgets destined for road transport infrastructure. The alternative should consist of drawing up previous, independent reports to evaluate the impact that each of these projects would have on the economy (cost-benefit studies), the natural environment and the way of life of the society in question. From this base, it would be possible to ponder the alternatives (opportunity cost studies) before taking final decisions about which items of infrastructure should be given priority. Some authors (Rus 2021) have made an enormous contribution to developing this line of work, which is so necessary and which is now being applied in modern-day projects. It would also be interesting to apply this approach to past works in order to obtain a broader critical vision, as we will comment later. Somewhat surprisingly, carrying out cost-

benefit analysis before taking decisions is not mandatory. Furthermore, the obligation to present projects to the public does not resolve the problem. This is because citizens cannot be given responsibility for carrying out something as complex as making a reasoned critique of comparative opportunity costs relating to different options for how to invest public money. As Herce pointed out (2019), this system has facilitated the simplistic "approaches to demand that have guided urban transport research and planning over the last 50 years".

To interpret why demand-based approaches have been pre-eminent, it is necessary to look back to the origins of the urban planning movement, at the time of the International Conference on Modern Architecture (*Congres Internationaux d'Architecture Moderne*, CIAM), in 1928. Following this influential reference, it is possible to understand the reasons behind the planning guidelines that have governed urban planning and each of the other disciplines associated with it—including the planning of transport infrastructure—since that time. From then on, the dominant criteria that have governed interventions in the city have been:

1. Conceiving the city as a space divided into areas with land uses differentiated between residential, work, commercial and leisure activities. The problem deriving from this type of urban planning is that it creates a need for continuous movement between these different areas.
2. Giving exclusive priority to the road system and leaving the supporting role of building as a secondary consideration. The solution to this problem would be to limit transport axes to performing the basic function of providing cities with an organisational structure.
3. Giving the private motor vehicle pride of place as the instrument in which to entrust everything related to mobility. This has been done to the extreme that formal solutions have been designed that revolve around the space reserved for the car.

The predominant city model allows us to verify the important role that the development of road transport networks has played in their exaggerated expansion (Chap. 2) and in the highly dispersed location of different activities. The sum of these two factors has implied the massive use of private vehicles. The resulting problems have provoked a reaction: the application of demand-based methods—as opposed to supply-based methods—which are aimed at achieving a new model for the city and for urban transport. This new mindset implies understanding that the location of activities and their interrelationships depend on the form and organisation of infrastructure. Well-planned transport should therefore play a central role in limiting disorderly growth.

Overcoming the demand approach would make it possible to avoid the perversion implicit in using public invest-

ment for electoral purposes, such as planning public works in constituencies where the governing party has calculated that it is close to gaining a new representative in forthcoming elections. This is nothing new; similar practices also existed in the past. In the case of Spain, this has been the object of an interesting study conducted by Curto-Grau et al. in 2012 (see also Milligan and Smart 2005), who highlighted the interest in pork-barrel roads (1880–1914): roads that were not initially priorities but which were constructed to meet principally electoral interests.

The line of action required to combat such practices and to promote efficient and coherent transport networks has identified works that develop and apply an approach that consists of combining cost-benefit analysis (CBA) and multi-criteria analysis (MCA). This can be applied to any transport infrastructure. In the case of road infrastructure, this has been done with the aim of supporting an implementation of transport policy when prioritising projects (Gühnemann et al. 2012).

Despite studies carried out by independent institutions, investments are often decided by politicians who make decisions based on short-term electoral strategies. For this reason, public policies are often influenced by what is an essentially populist vision of the field of transport. This is based on a rather simplistic cause-effect relationship which equates more motorways with more activity, wealth and population. This argument has also been presented in relation to new railway stations for the modern high-speed train. However, the moment has now come to promote new opportunities in low-density areas; this is now much easier to do, thanks to access to the Internet across the whole territory. An appropriate level of inter-modality will also be a key element in these policies.

Having highlighted the problems and the conceptual antecedents of large infrastructure projects, in the next section, readers will be able to do some practical GIS exercises, using road data available in HGIS format.

### 3.5 Tutorial

Interest in the European road network is not recent, and there are numerous examples of this in existing cartography. In this chapter, we shall start by providing readers with the GIS corresponding to the work carried out by General Henri Dufour. He was the author of a series of European road maps which were produced during the first half of the nineteenth century. For these exercises, we have digitised a map corresponding to the year 1835, as this was produced just prior to the opening of a series of new railway lines.

This section will include H-GIS exercises at two levels: The European scale, based on a database of major roads in Europe (1835) and waterways in Western Europe, which

were in service by 1850. We will also work at the national scale, using a new H-GIS for Spain that includes not only the main roads but also the secondary and tertiary level roads in service.

When we work with geographic information systems, road data tend to take the form of lines. As they are spatial data (they have coordinates), it is possible to do different types of analysis: calculate length, make analyses of networks and calculate optimal routes, calculate measures of centrality, etc. In this chapter, we will do the following:

1. We will create a map of roads (those operative in 1835) and of navigable waterways (in service in 1850) in Europe. We will add a base map with the relief, and we shall see how these communication routes took advantage of minimal slope.
2. Next, we will leave aside the historical perspective and focus on modern day motorways and dual carriageways. We will see which countries have constructed the densest networks of high-capacity highways.
3. Roads can also be represented using a quantitative variable. In the third chapter, we will use intensity as a measure of the importance of each road.
4. Roads can also explain the centrality of a municipality, based on the number of roadways that cross the municipal area and head towards the urban nucleus. We will work with the example of four Spanish cities, but it would be possible to apply this approach to any part of the world and also to any means of transport.

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